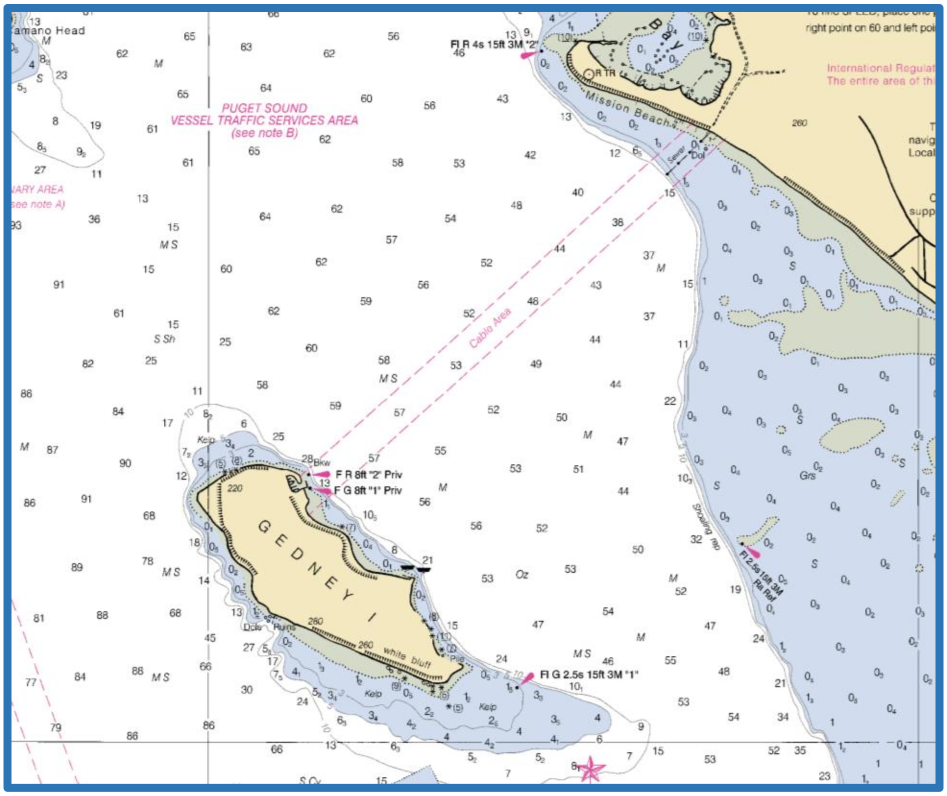

Gedney (Hat) Island
Marine Cable Replacement Project Overview and Routing Study

SNOHOMISH COUNTY
PUD
PUBLIC UTILITY DISTRICT NO. 1

PUD No. 1 of Snohomish County

January 2024

Executive Summary

Executive Summary

Snohomish County Public Utility District (the District) provides electrical service to Hat (Gedney) Island, near Everett, WA, via a 49-year old submarine power distribution cable. The existing 3-phase cable was installed in 1974. It is nearing the end of its serviceable life and is at risk of failure. A new cable installation is proposed to avoid a potential emergency which would isolate the residents of Hat Island from electric service. The 12kV electrical distribution cable will extend from the Port of Everett to Hat Island, approximately 32,000 feet. The District currently serves Hat Island from Tulalip substation, circuit 12-507. The District provides service to approximately 250 residential and business customers on Hat Island, and its population fluctuates seasonally. The island's electric service also powers its drinking water system.

This Project Overview and Routing Study describes the purpose, materials, methods, and location for the project. The location was selected after evaluating four alternate routes, A through D, and then additionally with a fifth route (Route E, a variation of Route D), for bringing the electric cable to Hat Island. Route A runs parallel to the existing cable, from the northeast point of Hat Island to Mission Beach, Marysville, within the Tulalip Reservation. Route B runs from the northern tip of Hat Island to the southern tip of Camano Island. Route C is the shortest alternative route, and runs from the northwest part of Hat Island to Whidbey Island south of Langley, which is outside Snohomish PUD's service territory. Route D runs from the north side of Hat Island to north Everett near the marina. Route E runs from the north side of Hat Island to the south end of the Port of Everett operations. Route A was originally selected due to its feasibility, however the District was unable to secure easements. Subsequently, the District deferred to Route E, to the south end of the Port of Everett property, which is the now the preferred alternative.

The project will upgrade the existing 1974 subsea cable through the installation of approximately 32,200 feet of subsea cable with two landfall approaches: 1) Port of Everett (POE) and 2) Hat Island. Horizontal Directional Drilling (HDD), a trenchless pipeline installation method, will be used to install a landfall conduit at both POE and Hat Island such that the overlying soil and vegetation is not disturbed. A High Density Polyethylene (HDPE) conduit with approximate inside diameter of 12 inches will be installed approximately 1,000 lineal feet from entry to exit point at POE and approximately 600 lineal feet from entry to exit point at Hat Island. The submarine cable can then be installed inside the conduit such that excavation or disturbance of the overlying tidelands is not required. The installation has been designed to exit beyond the eelgrass mapped on both sides of the channel that extends approximately 260 feet offshore of Hat Island and 900 feet offshore of POE. Between the two HDD exit points, the cable will be directly laid on the sea floor, held in place by gravity only. No pinning or anchors will be required for the subsea cable.

Environmental, cultural, and geotechnical considerations for the overall project were evaluated in studies conducted by consultants to the District. Route evaluation considerations are included in this report as Appendices A through C.

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Appendices

1 Introduction

Hat Island (also known as Gedney Island) is located near Everett, Snohomish County, Washington. The island is only accessible by boat, no bridges exist, and ferry service is limited. Snohomish County PUD (the District) provides electrical service to Hat Island via a submarine power distribution cable. The existing 3-phase cable was installed in 1974. The 12kV electrical distribution cable extends from Mission Beach (west of Marysville, WA on the Tulalip reservation) to Hat Island, approximately 16,000 feet. The District serves Hat Island from Tulalip substation, circuit 12-507. The District provides service to approximately 250 residential and business customers on Hat Island, and its population fluctuates seasonally. The island's electric service also powers its drinking water system.

The existing submarine cable is nearing the end of its serviceable life and is at risk of failure. To avoid a potential emergency situation which would isolate the residents of Hat Island from electric service, the District plans to install a new 3-phase electric submarine cable along the same subsea route. To continue reliable service to District customers, the existing cable will remain energized while the new line is installed. The new cable will be installed via horizontal directional drilling (HDD), which would allow the cable conduit to run subsurface beneath the sensitive nearshore and shoreline environment on both the mainland and the cable's Hat Island connection. The HDD would exit the sea floor beyond the delineated eelgrass off the shoreline of Mission Beach and Hat Island, then will be directly laid on the sea floor between those points.

The Project Overview offers a high-level discussion of the goals for the project, together a description of the materials that will be used, and the construction methodologies that will be employed to complete the objectives.

The Routing Study defines alternatives to supply electric power to Hat Island: on-island generation, installation of a new marine electric cable to replace the existing aging cable, and a no-action alternative. Alternatives were evaluated with regard to environmental constraints, project complexity, cost range, required coordination with other agencies and reliability of electric service, among others. The alternatives were then compared and the selection of the best alternatives for further review was made. Once this list was established, a more detailed evaluation was performed.

2 Need and Purpose

The purpose of the Project is to provide an electric utility connection to Hat Island that will provide continuous, reliable electric service to customers. The project will replace the existing power system feed from the mainland at Mission Beach to Hat Island, which involves installation of approximately six miles of new marine cable across the Puget Sound between Hat Island and the Port of Everett.

This report summarizes the results of studies, investigation and analysis related to the selected route of the new cable as well as to the evaluation of other routing alternatives.

3 Project Overview

3.1 Electrical power Requirements

Hat Island is rural and does not use a large amount of electric power. However, the Island's population is growing and will need additional electric power as population growth on the island continues. The District performed a conservative peak forecast to adequately size the marine power cable. Actual power demand is likely to be less but will not significantly change the final cable size.

A medium-voltage cable, capable of between 5 and 25 kilovolts is proposed.

3.2 Marine Cable Design

3.2.1 Length

The proposed marine cable is roughly 32,000 feet long. Along with this amount of 3-phase armored marine cable, approximately 3,000 additional feet of spare cable should be ordered so that in the event of a future outage a repair can be made that properly replaces the fault.

3.2.2 Material

The proposed marine cable will consist of copper conductors and steel armor wire with a significant neutral/ground return path. The submarine cable will also have a form of shielding to protect the insulation material from potential contamination.

The submarine/land cable shall be a 3-core cable with a common armor overall. The conductor insulation shall be unfilled Cross-linked Polyethylene (XLPE) or an Ethylene Propylene Rubber (EPR) blend. Each cable phase shall have a sealed metallic moisture barrier applied directly over the extruded insulation shield. The completed cable shall be delivered in one continuous length for the entire submarine crossing and land crossing. Factory joints are not desirable. However, if used, factory joints will be of a proven design with a good history of reliability. Each factory joint shall be tested after it is made to demonstrate that it is installed properly. The cable shall be capable of meeting the requirements of Electra No. 171.

The proposed cable will meet the requirements of AEIC CS8 OR ICEA S-93-639. A Type I, II, or III polyethylene anti-corrosion jacket meeting the requirements of lCEA S-93-639 shall be extruded over the sheath.

The cables, including all components, will be designed for a normal maximum conductor operating temperature of 90° C and an emergency operating temperature of 105° C as well as a short circuit operation temperature of 250° C for the duration indicated.

The conductor shield, insulation, and insulation shield will be extruded at the same time with a true triple head extruder. The continuous vulcanization line shall be a vertical line or a catenary line. The conductor shield, insulation, and insulation shield shall be in accordance with AEIC CS8 or ICEA S-93-639.

3.2.3 Voltage

The Voltage recommended is 12.47 kV or 15 kV class cable with an option bid of 25 kV class cable.

3.2.4 Ampacity

The ampacity of the cable is to be a minimum of 100 Amps per phase, at rated voltage and a conductor hottest spot temperature of 90 degree C at the design air, water and ground temperatures.

3.2.5 Fiber Optic Option

The District is planning that fiber optic cable(s) be included within the submarine cable. This fiber can be used for power control, metering and future smart grid utility applications.

3.3 Project Location

The District originally evaluated four potential cable routes, and subsequently added a fifth due to an inability to reach agreement on easement terms with the underlying property owners. The locations are described in the attached Routing Study from environmental, reliability and financial perspectives. The District has now concluded that route E (Port of Everett to Hat Island Marina) is preferred

3.4 Construction Methodology

The installation of a submarine cable consists of two primary operations. The first is a conduit installation via Horizontal Direction Drilling (HDD) and the other is Marine Cable Lay.

3.4.1 Horizontal Directional Drilling

Due to the sensitive nature of the marine environment, and in particular the shorelines and eelgrass areas that need to be crossed in order to complete the proposed installation, the use of Horizontal Directional Drilling (HDD) is proposed at both landing sites. The proposed HDD will result in a conduit that is initiated on dry land and is bored beneath the shoreline and the eelgrass to a predetermined exit point under water. The Port of Everett and Hat Island HDD operations are anticipated to be approximately 1,000 feet and 600-feet respectively.

On the Port of Everett side, crews would prepare the temporary staging area with high-visibility construction barrier fencing. The work is primarily within the “Boneyard” which is a fenced area primarily used for storing industrial/surplus materials in support of The Port’s operations. Once the limits of construction are defined, workers will begin the process of clearing space necessary to create a roughly 20,000 square foot area. Erosion Control Best Management Practices (ie. Straw, strawbales, silt fencing, sandbags and straw-wattles) will be stored onsite and employed on an as needed basis to prevent any silt laden water from leaving the worksite. The drill rig and supporting equipment will be delivered using flatbed trailers with access through the Port’s facility, following the general setup described above. All construction generated waste will be held onsite and disposed of offsite and in accordance with state and local guidelines.

A similar operation, in preparation for the HDD work, would take place on the Hat Island side. Due to the sand and gravelly nature of the soils that exist at the HDD termination site on the Island, there will be no need to amend the native soils to accommodate construction traffic.

HDD is a trenchless pipeline installation technique where a horizontal directional drill rig is used to install the pipeline in three phases. In the first phase, a “pilot bore” is advanced along a predetermined alignment from the launch point to the exit point using hollow threaded steel drill pipe segments (drill string) to advance a steerable drilling bit along a predetermined alignment. The tooling which is at the leading edge of the excavation is collectively known as the downhole assembly (DHA). The DHA consists of a bit to excavate the soil, fluid jets through which drilling fluid is pumped, and location tracking equipment. While the pilot bore is advanced, measurements from the tracking equipment inform steering decisions by the drill operator. A pilot bore diameter of 5 to 10 inches is common for this size of installation. The pilot bore is advanced from the drilling rig (launch) to an identified exit location (exit point).

Upon completion of the pilot bore, the bore size is increased to a size approximately 1.5x the outer diameter of the pipeline. This is done by removing the pilot bore bit from the drill pipe and adding tooling called a “reamer”. Reamers have bits to mechanically excavate the soil and fluid jets to pump drilling fluid to remove soil from the borehole.

After the borehole is prepared to the required diameter, the product pipeline is installed (pullback). Concurrent with pilot bore and reaming operations, the product pipe is fused, ideally into a continuous length. At the completion of the borehole preparation, the pipeline is connected to the pull-head which is then attached to the drill string at the exit point. The drill string is simultaneously removed from the borehole while pulling the product pipe into place. A continuous pull phase wherein the product pipe is pulled in with no stops is typically desired to reduce risks associated with borehole collapse during pull.

The above operation will take place both at t2ǌű 2Ŧ 9ǾŜǌŜűű and Hat Island.

3.4.2 Marine Cable Lay

The cable laying process could begin at either side. For the purposes of this narrative, we will describe the operation as starting on the Port of Everett side and ending on Hat Island. While preliminary indication is that two tugboats would be used to direct the cable laying barge across the channel, it could very well be an alternate assemblage of vessels capable of deploying the proposed 32,000 linear feet of continuous cable.

The cable lay operation would begin with the mobilization of the cable lay vessel to a position adjacent to the Port HDD conduit termination. The cable lay vessel would then anchor and prepare the submarine cable to be pulled through the conduit to the land termination. A motorized winch assembly on land will be used to pull it through. Divers will be onsite to confirm that the pulling operation does not damage the cable as it enters the conduit.

Once a suitable length of submarine cable has been received on land, the cable laying operation across the channel begins. The slow and methodical installation from one HDD exit point to the next, guided by a remotely operated vehicle (ROV) with satellite GPS tracking is expected to occur continuously for up to 24-hours. Upon reaching the HDD conduit on the Hat Island side, operators would once again anchor in the vicinity of the HDD exit point. Crews would then pay out the remaining cable using floats to keep it on the surface. Assist boats and divers would then guide the cable-end into the HDD exit point. The floating end of the cable would then be attached to a pulling cable and ultimately pulled through the HDD conduits to shore. Divers would continue to monitor the cable installation through the HDD conduit. Once all the floating cable (slack) is pulled through the conduit, the cable lay operation is complete. GPS coordinates are recorded during the entire operation and any deviations from the planned route are corrected with the agencies.

3.4.3 Connection to Existing

At both landing sites there will be connections that will need to be made to the local infrastructure. On the Port of Everett side, approximately 100 lineal feet of 4" conduit and conductors will be installed together with a splice vault and a new power pole. Similarly, on the Hat Island side, there will be a splice vault, a fiber vault and a new switch, however the 4" conduit required is approximately 200-feet.

All vaults will be pre-cast, modular, reinforced concrete, and delivered to the site by truck. Material deliveries and equipment mobilizations to Hat Island will be by barge. San Juan Enterprise freight service, or others provide semi-regular service to the Island.

3.5 Project Permitting

Permits and authorizations necessary for the Project are summarized below. Snohomish County has jurisdictional authority for Hat Island, the city of Everett, and the Port of Everett. The District will serves as lead agency for State Environmental Policy Act (SEPA) evaluation and determination. Anticipated permits and authorizations needed:

a. State Environmental Policy Act (SEPA) Checklist and determination
b. Shoreline Substantial Development Permit - Snohomish County
c. Flood Hazard Permit - Snohomish County
d. Land Disturbing Activity Permit (Hat Island) – Snohomish County
e. Land Disturbing Activity Permit (Port of Everett) – Everett
f. Hydraulic Project Approval - Washington State Department of Fish and Wildlife
g. Nationwide Permit - U.S. Army Corps of Engineers, Seattle District
h. Section 401 Water Quality Certification- Washington State Department of Ecology
i. Aquatic lands easement – Washington Department of Natural Resources
j. Biological Assessment for federal review of demonstrated compliance with the Endangered Species Act
k. Section I06 review for compliance with the National Historic Preservation Act

3.6 Project Schedule

The District is planning to construct the project in the summer of 2024. Milestone schedule events are listed below:

1. Permitting Complete in Fall 2024
2. Horizontal Directional Drilling Summer 2025
3. Marine Cable Lay Fall/Winter 2025/2025
4. Completion of End Terminations Spring 2026

3.7 Cost Estimate

Construction costs have been estimated based on the preliminary engineering specifications and the route previously described. Standard unit costs for necessary overhead and underground distribution additions have been used for these system elements. The marine installation estimates were provided by Harbor Offshore, Inc. and compared to earlier costs received from two other marine cable firms to insure reasonableness. The anticipated cost for the selected project is approximately ten million dollars.

4 Routing Study

4.1 Alternatives Evaluated

4.1.1 On-Island Generation

A micro-grid generation alternative was recently evaluated for Hat Island. This alternative considered a combination of wind, solar, and diesel generation with battery storage since there are no other on-island sources of generation (coal, natural gas, shallow geothermal). With less than ideal solar and wind resources available at Hat Island, an 8MW back-up battery storage system still required more than 50% of the power be supplied from diesel fuel to fire either a generator or a combustion turbine. Based on recent District experience with supplying diesel fuel to the island, concerns over air pollution and noise deemed on-island conventional generation not feasible. The cost of a micro-grid was also estimated to be more than twice the cost of a new cable and would have a shorter life.

4.1.2 Alternative Cable Routes

There are five marine cable routes considered for this project (See figure below).

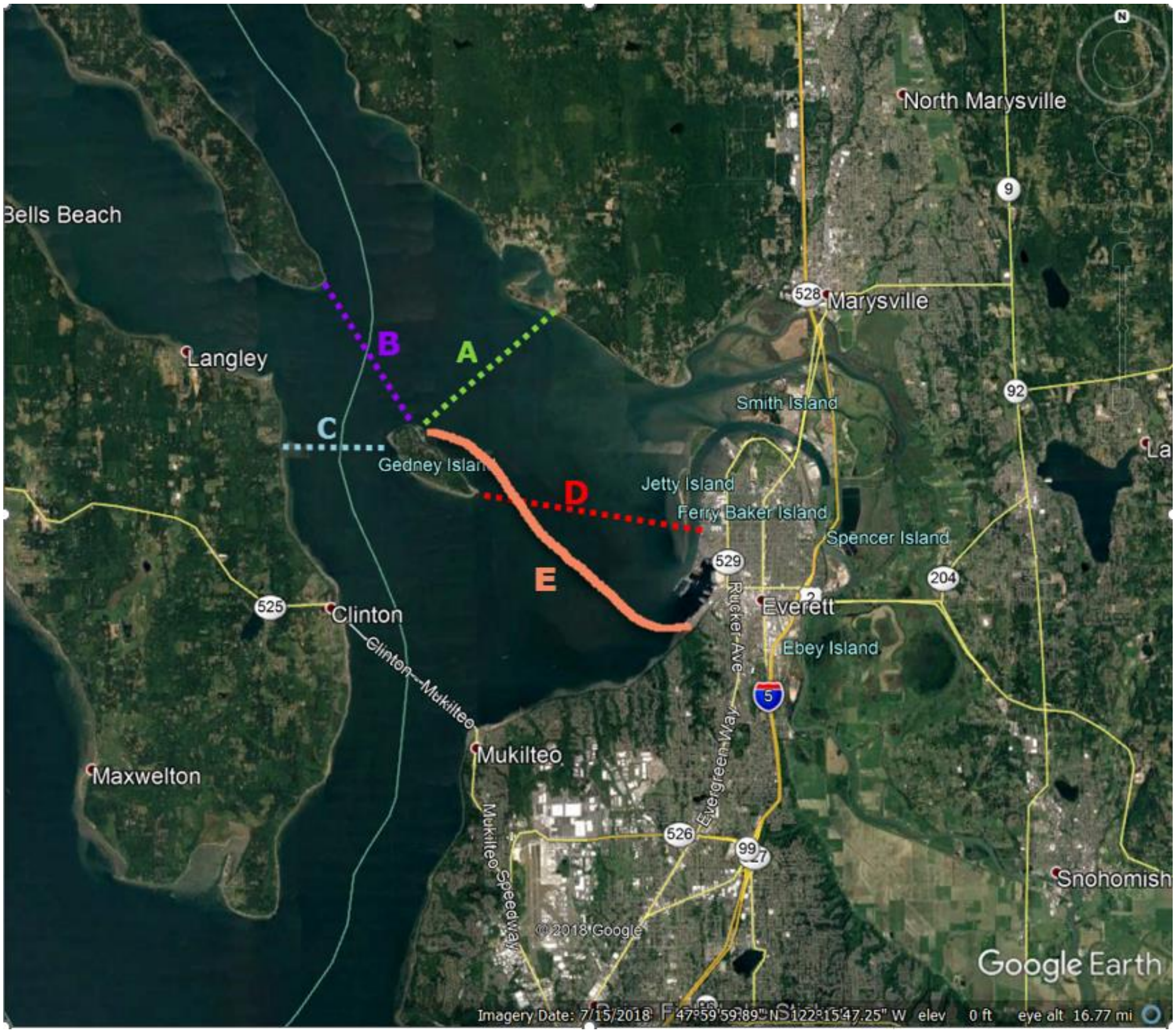

Figure 4.1.2 Alternative Routes Selected for Study

4.1.3 Route-A Mission Beach to Hat Marina

Route-A is parallel with the existing cable. This route begins at a point approximately 1-mile southeast of the tip of the Tulalip Bay peninsula (48° 02’ 56” N ; 122° 16’ 34” W) and ends immediately southeast of the Hat island marina (48° 01’ 08” / 122° 19’ 19”). See Figure below.

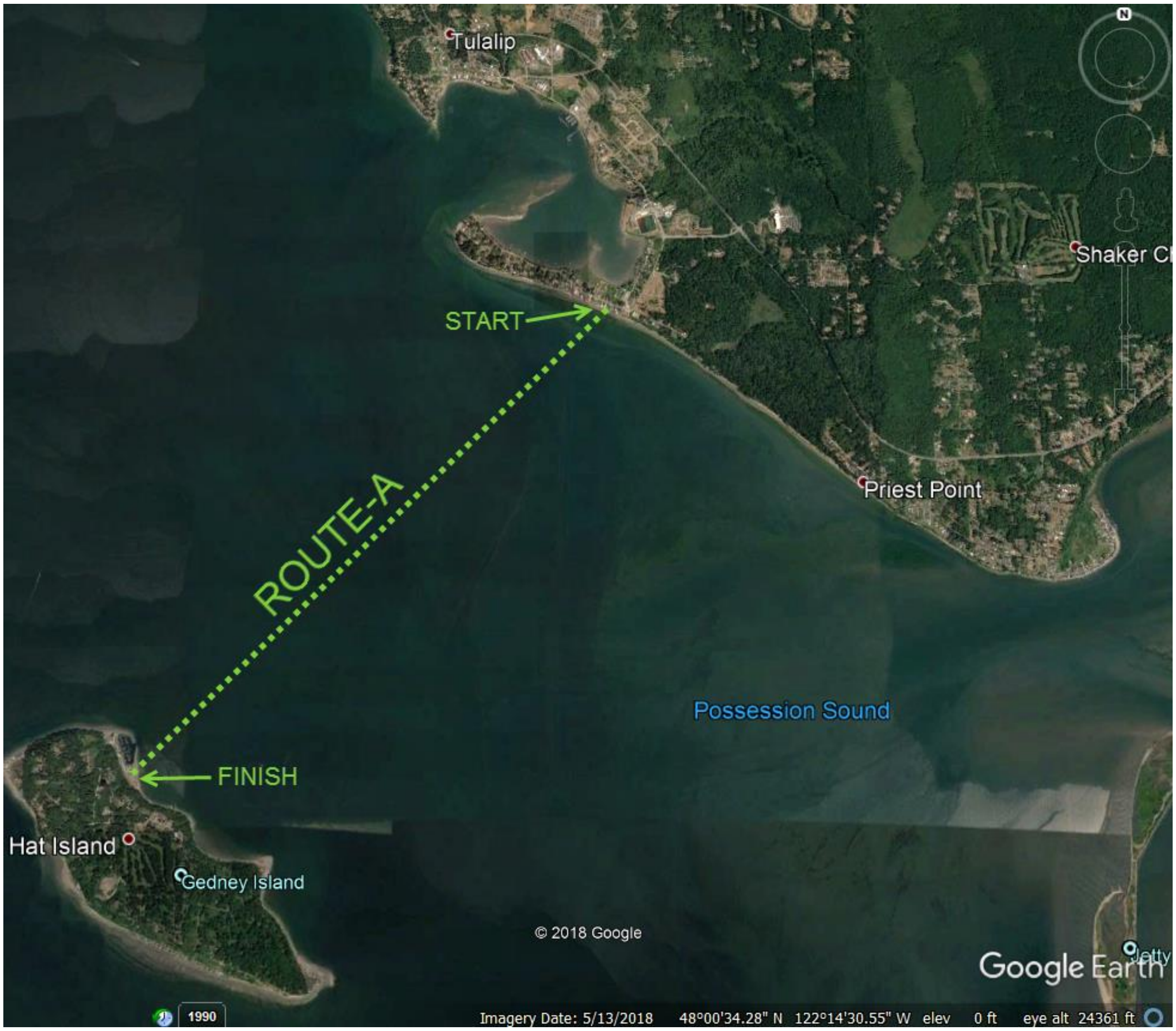

Figure 4.1.3 Alternative Route-A

4.1.4 Route-B Camano Head to North Shore of Hat Island

Route-B is the second alternative route. It extends from the southernmost tip of Camano Island (Camano Head), to the northeast tip of Hat Island. See Figure below.

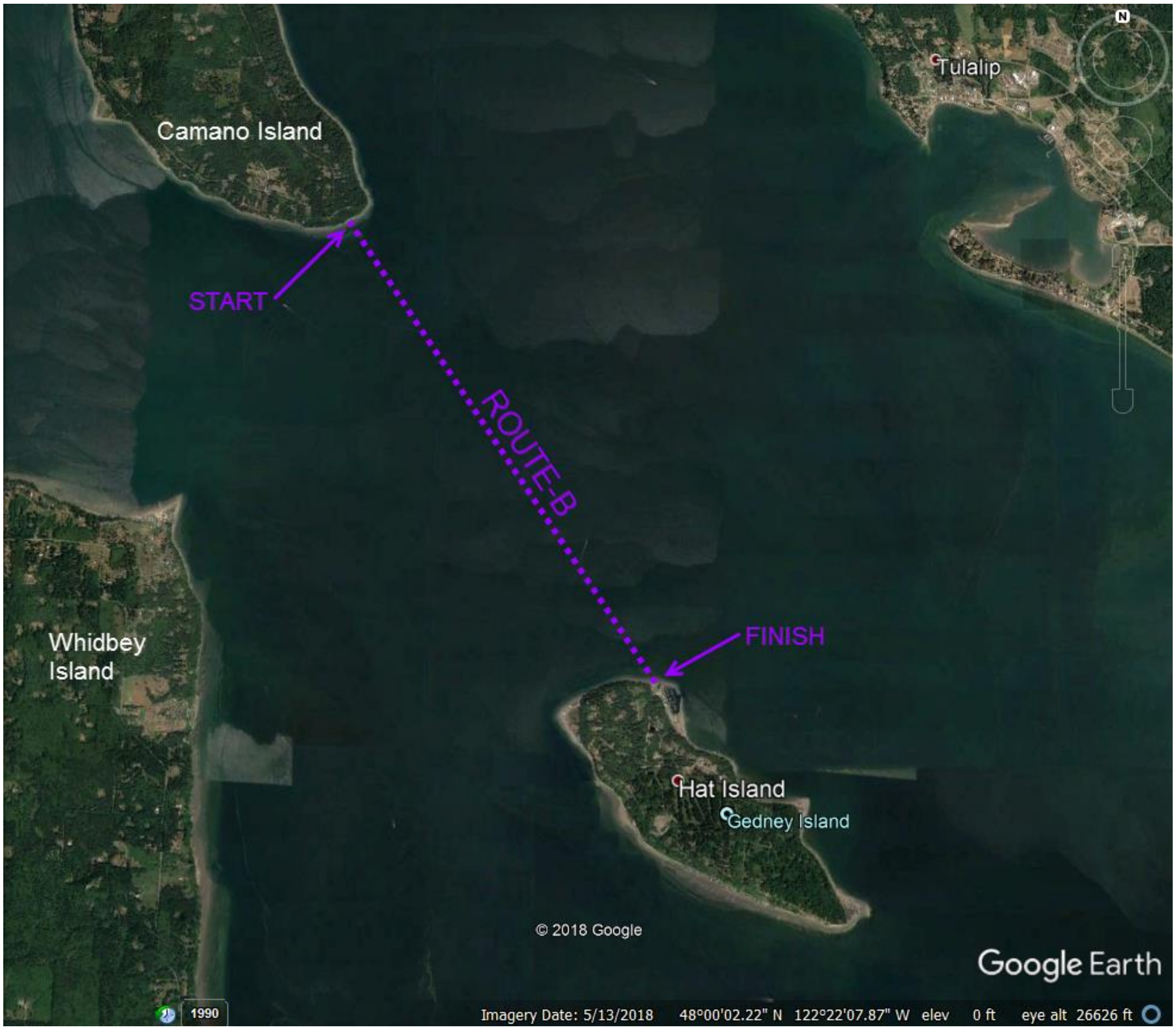

Figure 4.1.4 Alternative Route-B

4.1.5 Route-C Whidbey Island to South shore of Hat Island

Route-C is the third alternative route. It extends from the northern shore of Whidbey Island to the west tip of Hat Island. See Figure below.

Figure 4.1.5 Alternative Route-C

4.1.6 Route-D Everett Marina to the East shore of Hat Island

Route-D is the fourth alternative route. It extends from the Port of Everett to the easternmost tip of Hat Island. See Figure below.

Figure 4.1.6 Alternative Route-D

4.1.7 Route-E Port of Everett to the Hat Island Marina

Route-E is the fifth alternative route. It extends from the Port of Everett's storage facility to the Hat Island Marina. See Figure below.

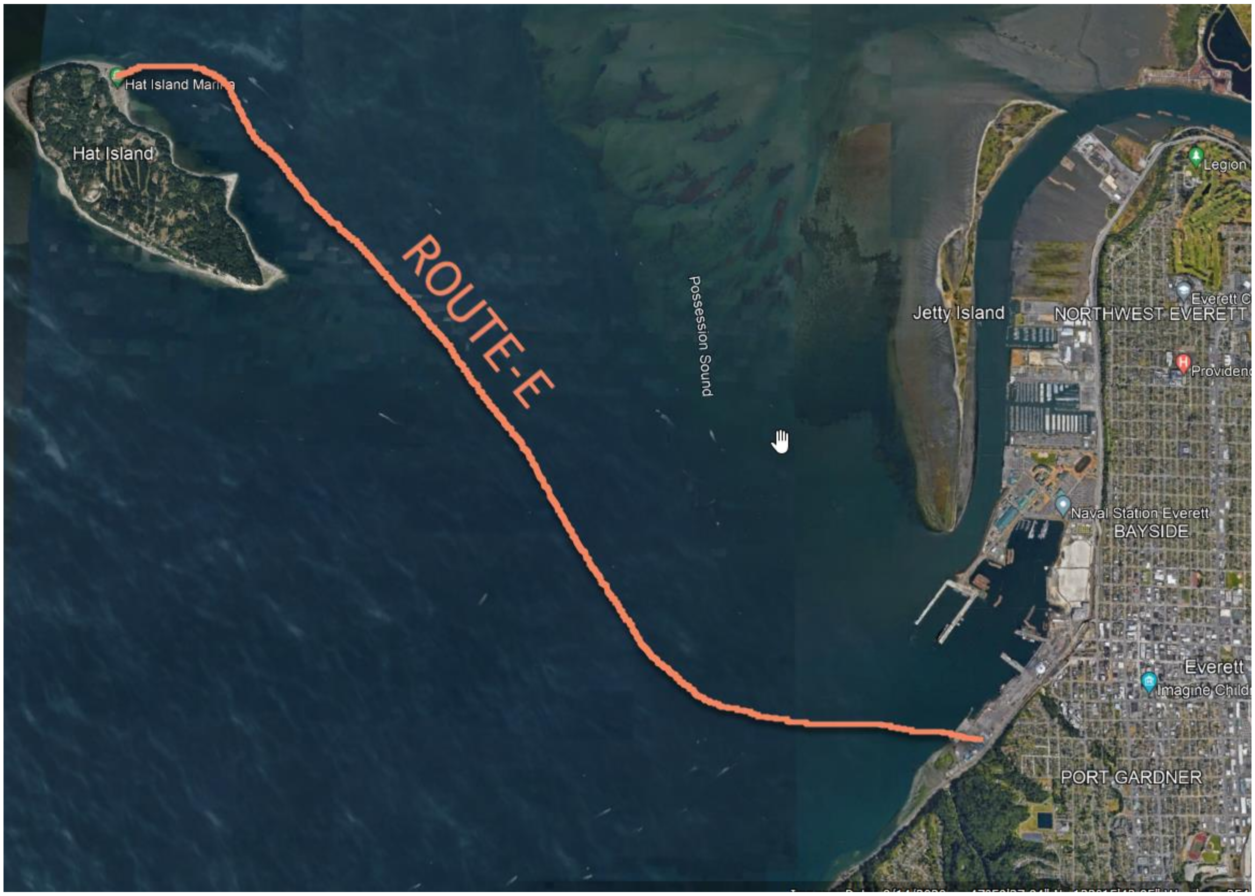

Figure 4.1.7 Alternative Route-E

4.1.8 No-Action Alternative

If no action is taken, the residents of Hat Island would be at risk of losing reliable electric service. The island's water supply, currently being powered by diesel generator, would continue needing three-phase power and would need the diesel generator indefinitely. With the no-action alternative, the existing submarine cable would be left in place, with uncertainty as to its date of failure. The District would not risk disturbing marine habitat by installing a new submarine cable, and would avoid the risk of encountering cultural resources buried in the proposed project area.

However, the no-action alternative leaves the marine environment vulnerable to emergency, unplanned work, which would potentially take place without the extensive protective measures put in place for planned work.

4.2 Alternatives Evaluation

The alternatives describe in the section above are evaluated in this section.

4.2.1 On Island Generation

The initial analysis ruled out on-island generation. With no natural gas, coal, hydroelectric potential, significant wind resource, or shallow geothermal heat source there are few viable alternatives available for on-island generation. Tidal power, while promising in the future is not yet a proven technology that could be relied upon to provide the necessary amount of power within the 1 to 2-year horizon that is needed due to the repaired cable's condition. Therefore, the only viable electric power generation alternative is oil-fired (diesel fuel) generation. A demand of this size would require the need for a minimum of two large generators. There would be the need to mitigate for air pollution from the burning of fuel oil and the need to minimize any potential noise pollution. A major concern would also be the risk of fuel spills in the shipment of fuel oil in large quantities to Hat Island on a weekly basis. Because of the costs and risks associated with on-island oil-fired generation, this alternative was also quickly determined to not be feasible.

4.2.2 Cable Routes A-D

High level evaluations where performed on each route alternative. The matrix below was completed in an effort to provide a side-by-side comparison for all of the primary criteria being evaluated.

Criteria/Alternative	Route-A	Route-B	Route-C	Route-D	Route-E
Description	Tulalip (Mission Beach) to Hat Island	Camano Head to Hat Island	Whidbey Island to Hat Island	Everett Marina to Hat Island	Port of Everett to Hat Island
Initial Cost (Construction)	$8M	$8M	$7.5M	$11M	$10M
Terrestrial Electrical Outage Risk	Low	Medium	Medium	Low	Low
Underwater Outage risk	Medium	Medium	High	Medium	Medium
On-going Operations Costs (tree trimming and wheeling)	Low	High	High	High	Low
Archeological Cultural potential Impact risk	Medium	Medium	Medium	Medium	Medium
Risk to Eelgrass	Medium	Medium	Medium	Medium	Medium
Environmental Impacts to due to tree clearing and new power lines	Low	High	High	High	Low
Aquatic and terrestrial listed, threatened and endangered species impacts	Medium	Medium	Medium	Medium	Medium
Overall Complexity of Construction and design	Medium	Medium/High	Medium	Medium/High	Medium

Complexity for District to Restore Power	Medium	Medium/High	Medium	Medium	Medium
Presence of under-water challenges or obstructions	Medium	Medium	High	Medium	Medium

4.2.3 No-Action Alternative

The no action alternative is not feasible as it would result in the loss of reliable sources of power and water. The Islands water system is reliant upon power for filling the islands drinking water reservoirs. The water system also consists of a water treatment plant that utilizes 3-phase power. While reliable water service is needed to meet basic sanitation needs, water is an essential utility for the island residents. Because of these concerns, it is the District opinion that the no-action alternative would eventually result in on-site generation, which is not preferred for the reasons mentioned in the prior section.

4.3 Route Selection

The District evaluated the five potential cable routes described in section 1. From environmental, reliability and financial perspectives, the District originally concluded that route A is preferred, with a slight offset from the existing route. It is assumed route A was selected for the original cable installed in 1974 based on a similar evaluation. Subsequently, after failed attempts to secure right-of way at the Tulalip landing site, the District has refocused its efforts on its second choice (Alternative – E). The principal advantages of the preferred route include:

4.3.1 Principal Advantages

a. Better shore electric power reliability of the primary power system along the mainland than Routes B and C.
b. Does not require substantial line construction upgrades to bring 3-phase power to the mainland or Hat Island termination locations like Routes B, C, and D.
c. Does not cross another submarine cable route or require power to the island be “wheeled” through another utility like Route C.
d. Is not as deep as route C so there is less stress on the cable while it is being laid.
e. The cable route is flatter and smoother than Routes B, C and D and does not have as steep of slopes on the shore ends making it more likely to be exposed to slides or suspensions.
f. The route has less eel grass exposure than Routes B and D.
g. Requires minimal changes to the existing District power system
h. Minimal impact on marine organisms due to HDD
i. Requires negligible conversion of beach areas from existing uses
j. Underlying land owner has expressed willingness to convey an easement to the District , and
k. Overall cost is comparable.

4.3.2 Principal Disadvantages

a. Longer cable route will increase cost.

b. Port of Everett site is located on the former Weyerhaeuser Mill-A site and the soils encountered for horizontal directional drilling will be contaminated. This soil can be managed, but with additional cost.

Appendices

Appendix-A Geophysical Considerations

DESKTOP STUDY FOR REPLACEMENT OF SNOPUD HAT ISLAND POWER CABLE

Contract No. CW2247013

February 2024

Prepared for:
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Reference: DESKTOP STUDY FOR REPLACEMENT OF SNOPUD TULALIP TO HAT (GEDNEY) ISLAND, POWER CABLE, SNOHOMISH COUNTY, WASHINGTON

1.0 INTRODUCTION

The Snohomish Public Utility District provides electrical service to Hat (Gedney) Island, near Everett, WA, via a 45-year-old submarine power distribution cable. The existing 3-phase cable was installed in 1974. The 12kV electrical distribution cable extends from Mission Beach (west of Marysville, WA, on the Tulalip reservation) to Hat Island, a distance of approximately 16,000 feet. The District serves Hat Island from Tulalip substation, circuit 12-507. The District provides service to approximately 250 residential and business customers on Hat Island, and its population fluctuates seasonally. The island's electric service also powers its drinking water system.

The existing submarine cable is nearing the end of its serviceable life and is at risk of failure. To avoid a potential emergency situation which would isolate the residents of Hat Island from electric service, the District plans to install a new 3-phase electric submarine cable along a route from Everett to Hat Island (Fig. 1).

Figure 1. Location of existing power cable crossing and proposed corridor for new cable

This desktop study provides preliminary information on the interpreted geologic and geophysical characteristics of seabed and sub-seabed conditions along a proposed cable corridor from Everett to Hat Island. In addition, supplemental information is provided on three proposed alternative routes. The compiled information will be used by others to assist in selecting a final route for a replacement power cable and for evaluating cable installation methods.

Sources for the geological and geophysical information presented in this document include: Washington State Department of Natural Resources (DNR) geologic information databases, Washington State Department of Ecology, the United States Geologic Survey office of Marine Geology data bases, the University of Washington Department of Oceanography, published papers, reports from several geophysical investigations for pipeline and cable route studies in Puget Sound and a reconnaissance seismic reflection survey conducted for this study.

2.0 BRIFE SUMMARY OF PUGET SOUND GEOLOGIC HISTORY

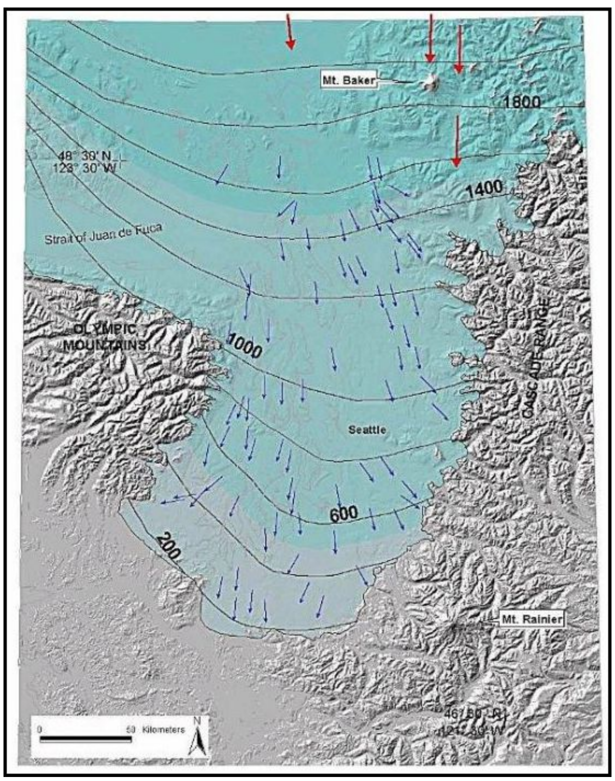


Figure 2. Thickness of continental glacier (m) over Puget Sound 16,000 years ago (Easterbrook, 1966).

The geologic history of the Puget Sound Lowlands (Puget Sound trough and marine waters, adjacent rivers, valleys and islands) was predominated by continental glaciation (Bretz, 1913). Ice sheets and glaciers expanded south from Canada due to increased accumulation of snow and ice with an associated decrease in sea-level. Glacial advance and subsequent retreat occurred at least 4 times over the past 2 million years. The last advance and retreat (16,000 to 12,000 years before present) of the Cordilleran glacier was the Fraser glaciation that produced most of the present day geologic and topographic features (Thorson, 1980).

During the maximum advance the ice thickness in Puget Sound was over 3,000 feet and there was a subsequent sea level lowering of 300 feet (Fig 2).

During the glacier advance, sediments composed of proglacial lake deposits (silt and clay), advance outwash material (sand and gravel) were deposited on older Pre-Vashon deposits. The older Pre-Vashon deposit are predominantly glacial and nonglacial sediments deposited during repeated glacial and interglacial periods during the past 2 million years.

As the Puget Lobe of the Vashon Stade glacier retreated northward it deposited a discontinuous veneer of recessional outwash (sand and gravel) and local deposits of ablation till upon the glacial landscape. As the ice receded northward it thinned and begin to float on the waters flooding in from the Strait of Juan de Fuca resulting in glaciomarine drift being deposited offshore over earlier deposits of recessional outwash.

The geology of Whidbey and Camano Islands and the Everett area south of Deception Pass is glacial and interglacial. Along the shoreline the bluff deposits range from laminated silty clay to pebbly silt, stratified sand and gravel to well sorted sand and silt. The sea has been gradually eroding these coastal bluffs since the Vashon glacier began to melt. These eroded sediments are now found on the wave cut benches (beaches) and cover the glacial sediment that underlie the offshore slopes.

Offshore, in deep-water, the seafloor is mantled with 10 to 30 feet of recent, fine-grained marine sediment overlain on glaciomarine and older glacial deposits that are thousands of feet thick in what is known as the Everett Basin (Barnett, 2010, Chang et.al., 2014)

There is no evidence of bedrock outcrops along the Everett shoreline or in the seismic reflection data obtained on this geophysical study. However, Hat Island apparently has a bedrock core, the Fidalgo formation, that is an intrusive igneous mass characteristic of other rock formations on the San Juan Islands (McClellan, 1927). There is also evidence of exposed bedrock offshore on a seismic reflection profile obtained by the USGS that traversed from Possession Sound northward into Saratoga passing on the west side of Hat Island (Harding et.al., 1988).

3.0 POTENTIAL SUBMARINE GEOLOGIC HAZARDS

Several events and processes can occur that may have an adverse effect on the marine cable at the shore landings, on the adjacent offshore slopes and/or on the deep-water crossing. The following is a brief summary of these potential events.

3.1 Earthquakes: Earthquakes are the primary driver for most of the events and processes discussed below (Figure 3). Earthquakes may occur along any of the numerous faults found in Puget Sound as well as on the major Cascadia subduction zone located on the west coast of Washington. An earthquake associated with this subduction zone, 50 miles off the Washington coast, occurred approximately 300 years ago and is estimated to have produced a magnitude 9. Based on historical geologic investigation and related recent studies, the maximum recurrence interval for large ground-rupturing crustal-fault earthquakes in the Puget Lowland is about 400 to 600 years (Pratt, 1997).

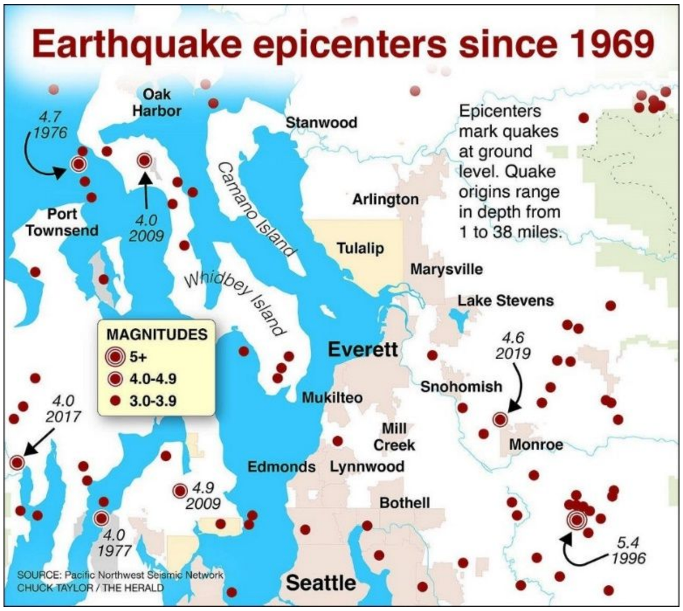
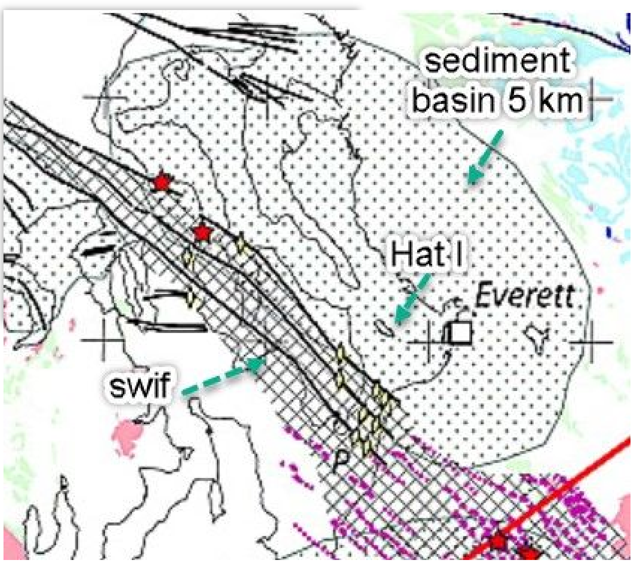


Figure 3. Epicenter for earthquakes.

An added problem associated with Puget Sound earthquakes is the presence of deep sedimentary basins. The sediment in these basins amplify long-period shaking from earthquakes increasing the seismic hazards for cities and structures sited on such basins. This issue is particularly important for the Puget Sound region which is underlain by three large sedimentary basins—the Seattle, Tacoma, and Everett basin (Fig 4). These regions have substantial seismic hazard from three source regions: (1) large, shallow earthquakes from the Cascadia megathrust located mostly offshore; (2) deep earthquakes within the subducting Juan de Fuca plate; and (3) shallow earthquakes from various crustal faults throughout the region. The strength and spatial pattern of basin amplification from these source regions may differ because of their different earthquake source mechanisms, depths, and azimuths. The exact magnitude and pattern of basin amplification are likely regionally specific



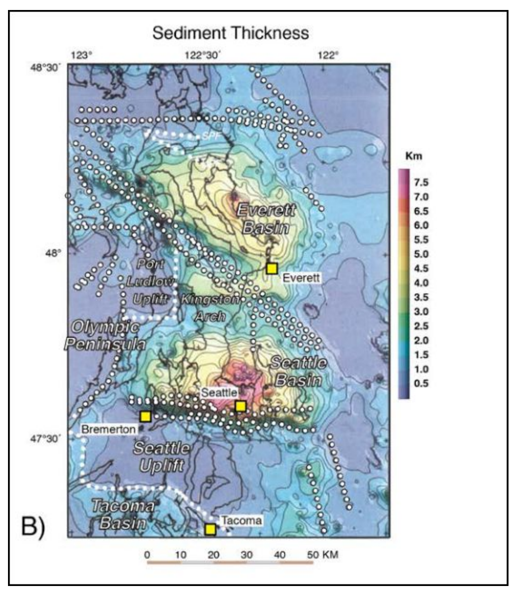
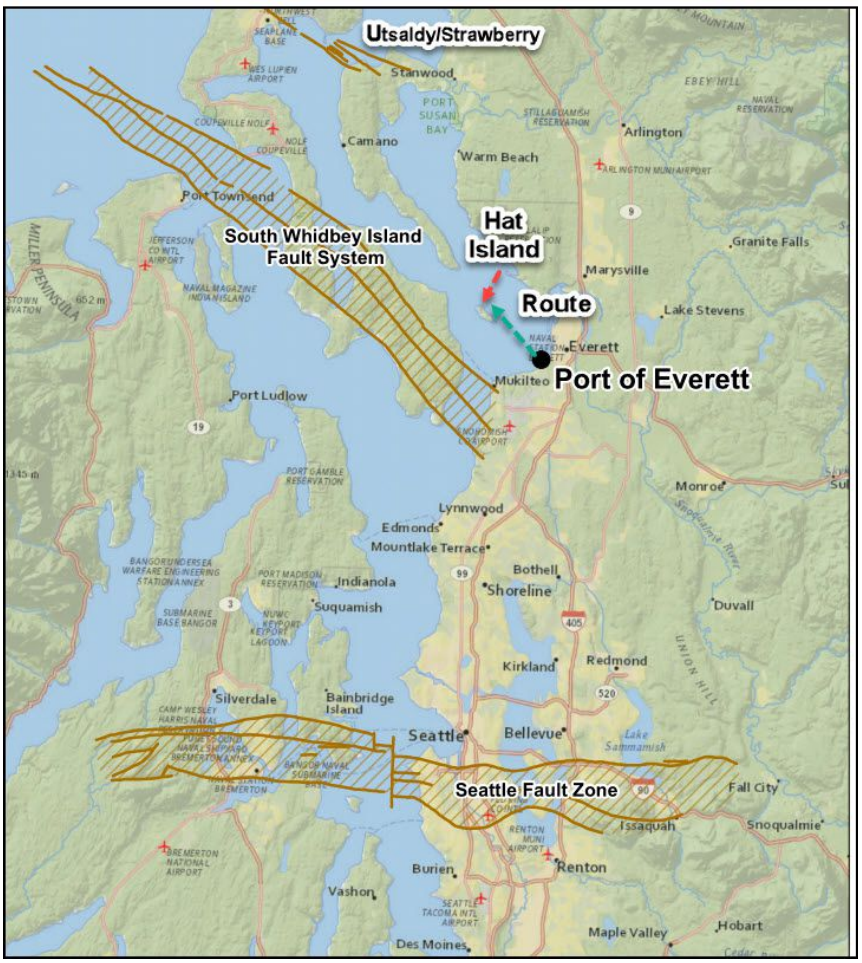


Figure 4. The Everett sediment basin (5 km deep) may result in intensification of ground motion due to seismic event along several faults. (Chang et.al., 2014).

3.2 Faults: Beneath the heavily populated Puget Sound region (Puget Lowland) is a regional complex of interrelated seismogenic (earthquake-causing) geologic faults (Fig. 3, Wikipedia-Puget Sound Faults). From north to south these include:

- *Devils Mountain Fault*
- *Strawberry Point and Utsalady Point Faults*
- *Mount Vernon/Woods Creek fault (Rogers Belt)*
- *Cherry Creek Fault Zone*
- *Southern Whidbey Island Fault (SWIF)*
- *Rattlesnake Mountain Fault Zone*
- *Seattle Fault*
- *Tacoma Fault*
- *Saddle Mountain Faults*
- *Olympia structure*
- *Doty Fault*
- *Saint Helens Zone and Western Rainier Zone*



Three fault zones, located relatively close to the cable crossing corridor potentially provide the greatest risk to the cable. These are the Seattle Fault Zone, South Whidbey Island Fault Zone and the Utsalady/Strawberry Fault Zone. Seismic events on these faults and subsequent ground surface movement, liquefaction, and currents, inundation in the area of the cable route may be magnified in the Everett Sedimentary Basin.

Figure 5. Major fault zones that of most concern to proposed cable route.

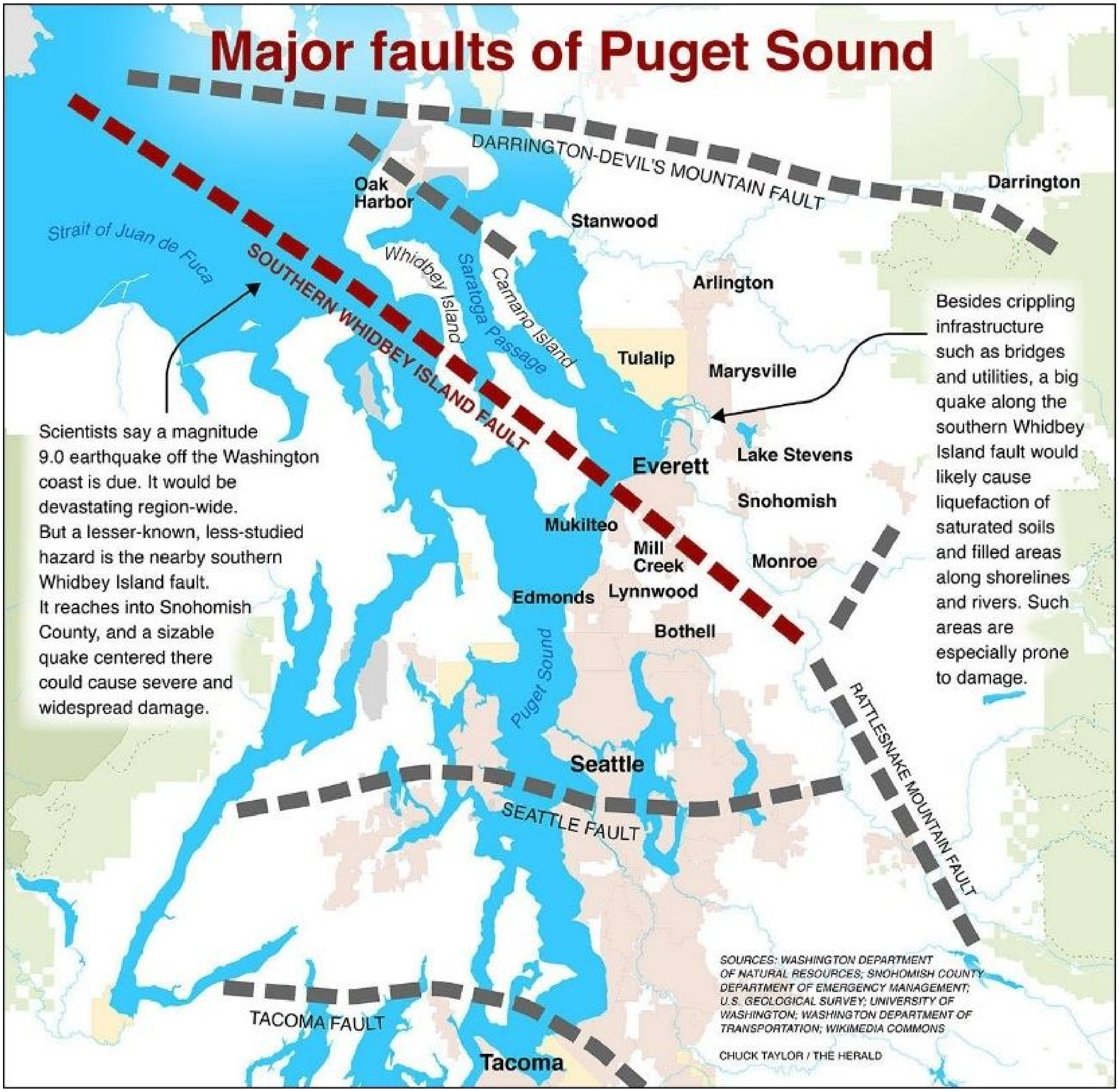
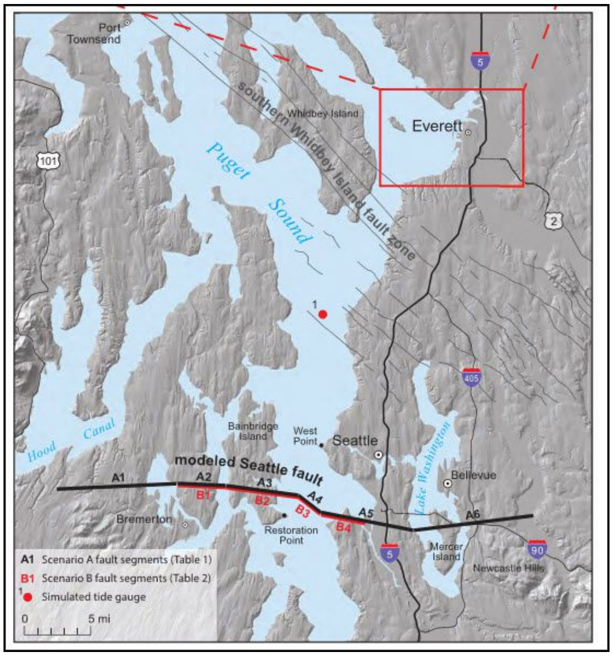


Figure 6. Major faults and their potential damage (Sanders 2021)

3.2.1 Seattle Fault Zone: The Seattle Fault is an east-west zone of complex thrust and reverse faults. The zone is up to 4 miles in width and over 45 miles in length. Although located the furthest of the three fault zones it has the greatest release of energy and displacement. Movement within this fault zone will most likely generate submarine landslides along the shorelines that have the potential to generate tsunami waves. The most recent movement was 1100 years ago, with a magnitude of 7+ and resulted in rockslides in the Olympics, landslides into Lake Washington, and a tsunami on Puget Sound. Model studies (Walsh et.al. 2019) showed the potential tsunamis amplitude, maximum currents and inundations in the Everett area based on a M7 earthquake along the Seattle Fault Zone (Figures 7a, b, and c).



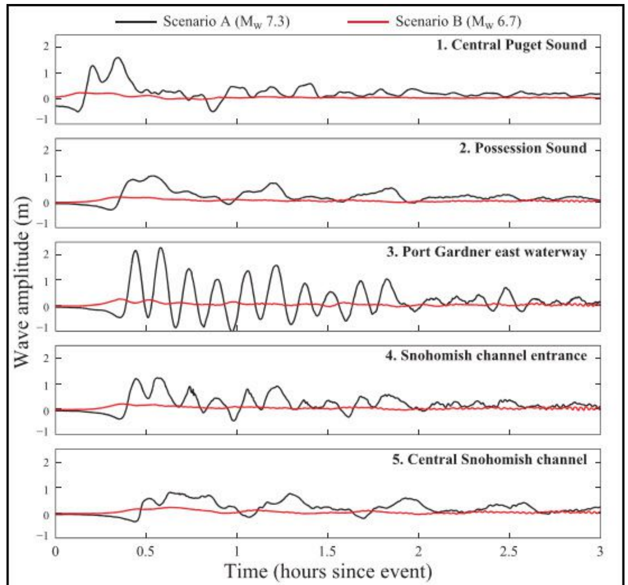


Figure 6. Modeled tsunami amplitudes at the simulated tide gauges shown in Figure 5, arranged by proximity to the Seattle fault.

Figure 7a. Modeled affect of Seattle fault movement on tsunami amplitude, maximum currents and inundation of sediment in Everett. Does not include potentially magnification of movement in Everett Sedimentary Basin (Walsh et.al., 2019)

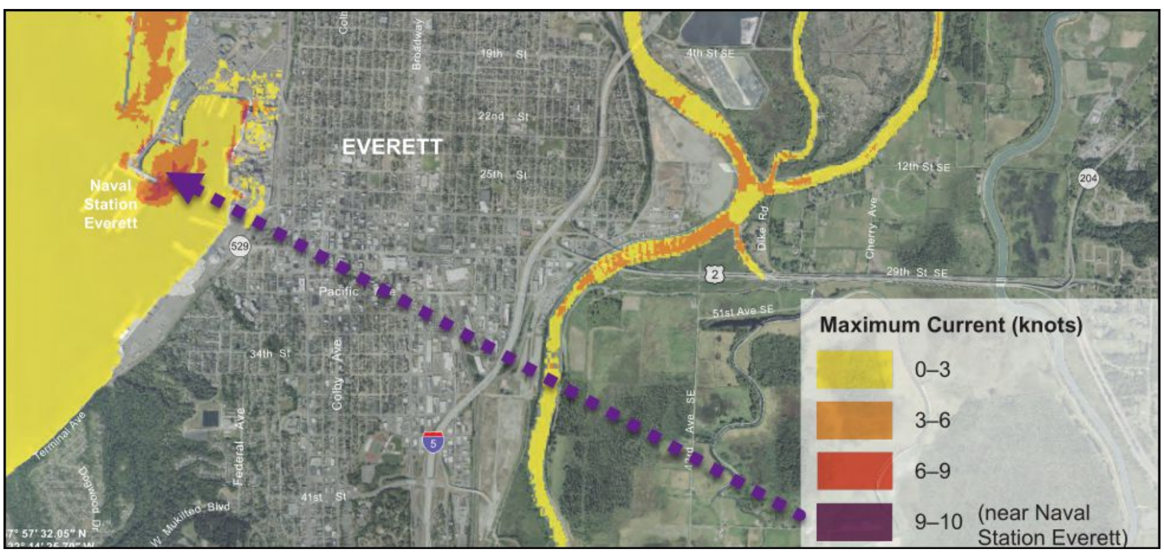


Figure 7b Currents produced by magnitude 7 fault along Seattle Fault Zone (Walsh et.al., 2019)

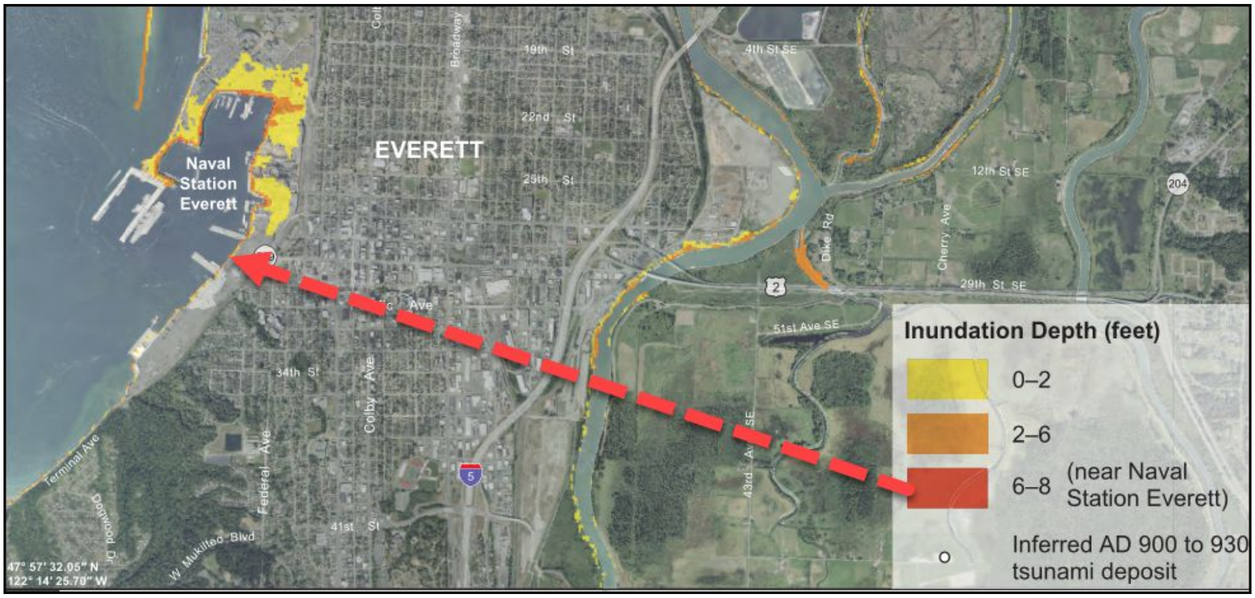


Figure 7c Inundation depth produced by magnitude 7 fault along Seattle Fault Zone (Walsh et.al., 2019

3.2.2 South Whidbey Island Fault Zone: SWIF is a broad, north-side-up fault zone (6–11 kilometers; 4–7 miles wide) dipping steeply to the northeast (Johnson 1996). The magnitude 7.4 earthquake modeled for the SWIF zone is a shallow or crustal earthquake (Fig. 8). The black box shows the area of the modeled rupture and the intensity within the rupture zone varies from severe to violent (Intensity of VIII to IX).

Shallow quakes tend to be much more damaging than deep quakes of comparable magnitude (such as the M6.8 Nisqually earthquake in 2001). Excavations across several scarps near Woodinville revealed evidence of at least four earthquakes since deglaciation about 16,000 years ago, the most recent being less than 2,700 years ago.

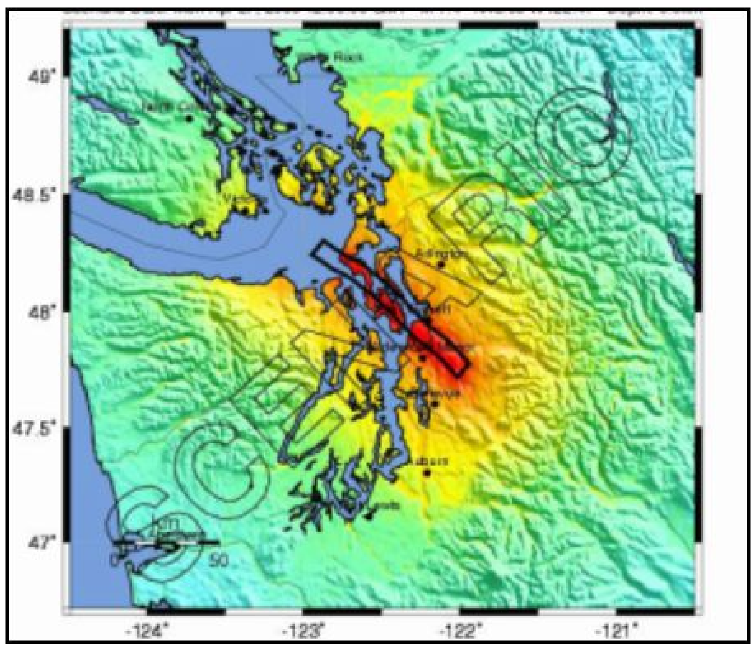


Figure 8. Intensity along rupture of SWIF (Sanders)

3.2.3 Utsalady Fault Zone

This fault (Fig. 6) is an oblique-slip and shows both horizontal and vertical slip as the crustal blocks are pressed together (Johnson 2004). Trenching on the UPF (at a scarp identified by LIDAR) shows at least one and probably two Holocene earthquakes of magnitude 6.7 or more. The most recent one occurred between AD 1550 to 1850 and was possibly triggered by the 1700 Cascadia Subduction Zone fault located off the Washington coast. These earthquakes probably produced tsunamis.

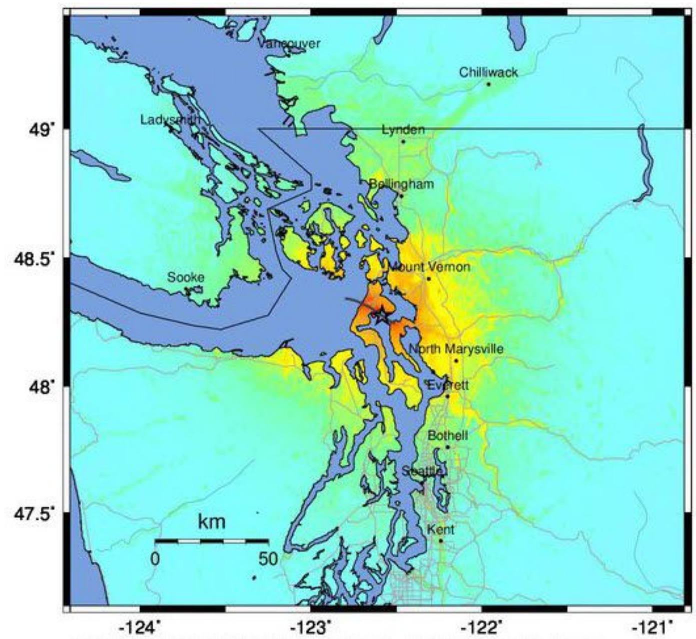


Figure 9. Ultsalday fault zone and intensity for VII earthquake.

3.3 Landslides: Water saturation of loose sediments is the primary trigger of landslides in Puget Sound (Fig.10). Other triggers can result from seismic events (earthquakes), deposition of eroded bluff sediments on the steep slopes, and rapid deposition of sediment offshore from flooding rivers. Slope failures in the loose, fine to medium-grained glaciomarine sediment occur as either retrogressive flow slides (RFS) or spontaneous liquefaction (SL). The RFS start in some area of the slope and develop retrogressively up slope. SL slides initiate at a point and spread in all direction, up and down slope at a very high rate.

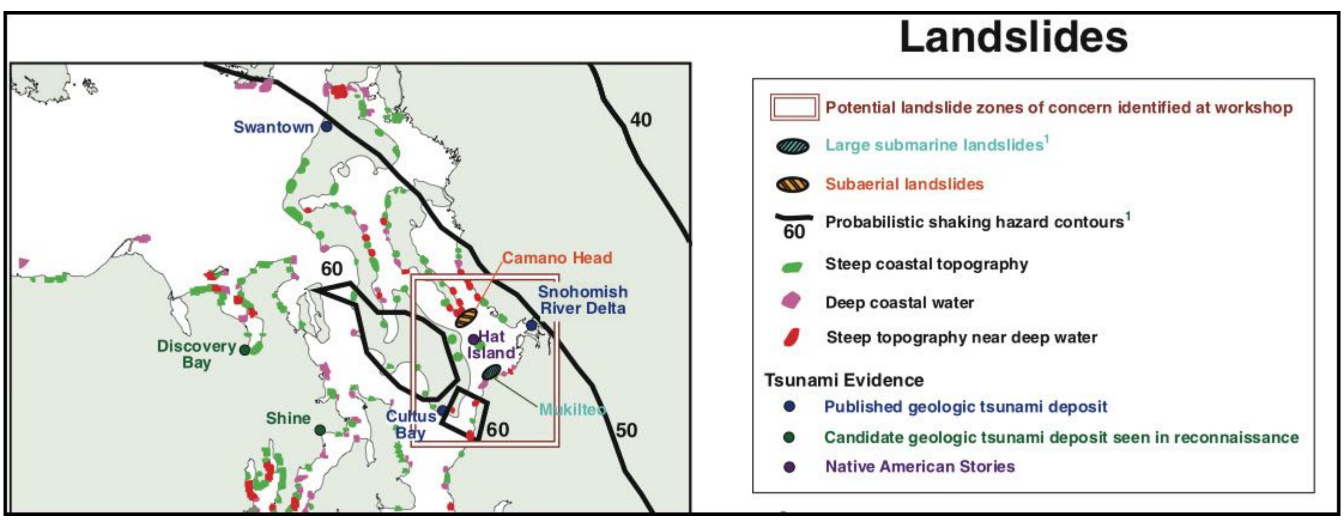


Figure 10. Examples of landslides in Puget Sound (Walsh 2002).

Although steep slopes are very susceptible to landslides, old, deep-seated landslides may be reactivated, even where gradients are low. A change in terrain slope with increased sediment loading, shocks and vibrations, change in water content, groundwater movement, and removing or changing the type of vegetation covering slopes are all contributing factors to submarine landslides.

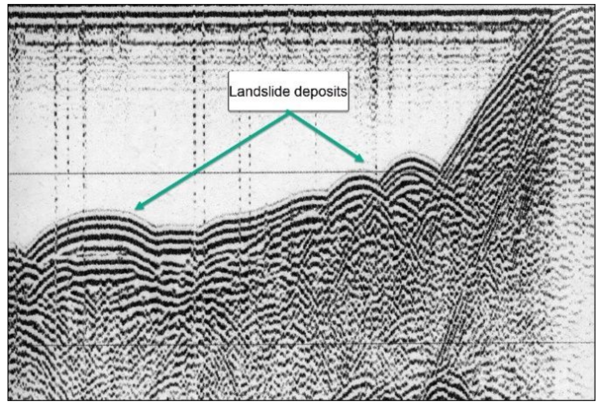


Figure 11. Landslide in Everett area north of site.

In general, landslide hazard areas are where the land has characteristics that contribute to the risk of the downhill movement of material, including the following:

- A slope greater than 40 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Tsunamis: Large coastal underwater landslides and seismic events may produce tsunamis, or tidal waves. These are a series of waves caused by the displacement of a large volume of water that moves away from the area of disturbance (Fig. 12). This creates potential hazards in areas not located near the actual source of the wave. At least nine earthquake related tsunami deposits, dating back 2500 years, have been mapped in Washington with the youngest being from the 1700 A.D. Cascadia earthquake (Haugerud and Kelsey, 2017).

A landslide in 1820 at Camano Head generated a tsunami that inundated a fishing village on Hat Island (Shipmen, 2001, Fig. 12). In addition to offshore landslides the collapses of river deltas have produced tsunamis. There are several potential sources for generating tsunamis in Puget Sound on river delta that are highly susceptible seismic soil liquefaction and potentially prone to submarine land sliding and disintegrative flow failure (Figure 13).

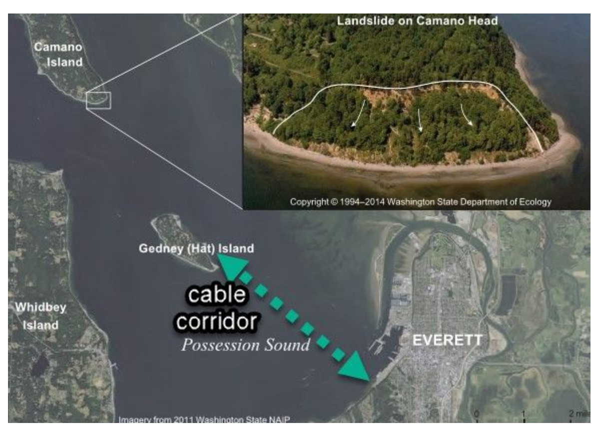


Figure 12. Landslide that inundated Hat Is.

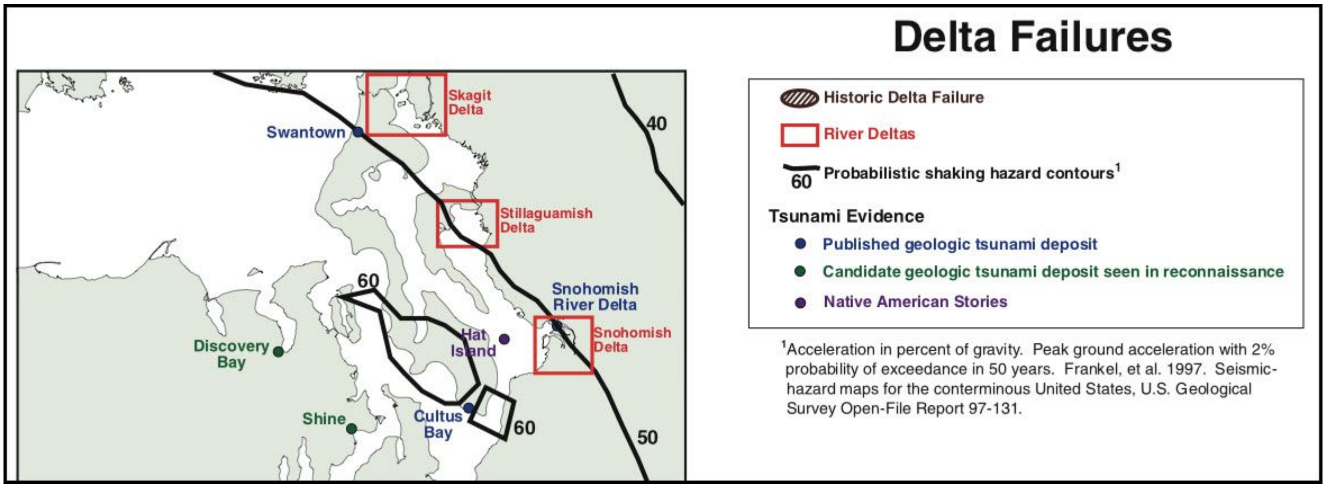


Figure 13. Areas of potential delta failures that may generate tsunamis or turbidity currents (Walsh 2002).

3.5 Liquefaction: This is a phenomenon in which earthquake shaking causes soils to rapidly lose their strength and behave like quicksand. This typically occurs in areas of loose, sandy, saturated soils often found in low-lying coastal areas, underwater marine and riverine deposits, river deltas, artificial fills, and tidal flats. These areas of poorly consolidated soils tend to have a high liquefaction potential. For example, the liquefaction susceptibility of many river valleys and deltas—such as the land on either side of the Stillaguamish and Snohomish rivers is rated moderate to high (Fig. 13). Other areas susceptible to liquefaction in Everett include the city's deep-water marine terminal and everything west of West Marine Drive. The waterfront used to be mud flats that were filled with loose, sandy soil that have a high potential for liquefaction.

3.6 Turbidity Currents and Debris flow: Turbidity currents are sediment laden water that can result from the failure of sediment buildup on delta or steep slopes. They are high-density currents that have considerable scour and erosion capability. For example, in SE Alaska an earthquake triggered the collapse of a delta and the subsequent submarine landslide produced a turbidity current that flowed across a power cable resulting in failure of the cable (personal communication). The submarine delta was fed by a bedload dominated river, such as what occurs on the Snohomish River during heavy run-off. This river adds 500 thousand tons of sediment annually (Port Gardner Bay 2014)

3.6 Ship Traffic and Anchor Drag: Commercial seagoing vessel as well as fishing vessels may drop and drag an anchor in areas such as cable corridors, that are marked as exclusive zones. Since most of the planned cable is laid on the seabed, and not buried, it is susceptible to damage should such an anchor drop event occur.

The offshore area around Hat Island is in the Puget Sound Vessel Traffic Service Area (NOAA Chart 18443 which provides information to vessels regarding obstructions, cables, etc.

4.0 PRESENTATION OF CABLE CORRIDOR SEISMIC REFLECTION DATA

The following presents examples of the seismic reflection data obtained from a previous geophysical survey in the vicinity of the Hat Island (SnoPUD 2020) and the present surveys at the Everett landing site. A detailed bathymetric study was conducted by others (Tetra Tech 2022). The seismic reflection data were obtained with a low-frequency (400 to 800 Hz), low power (60 joules, 120 db re 1 microbar at 1m) seismic reflection system and acquired on a digital acquisition system interfaced with GPS navigation (Sylwester, 1982).

4.1 Hat Island Geophysical Data (SnoPUD 2022 report)

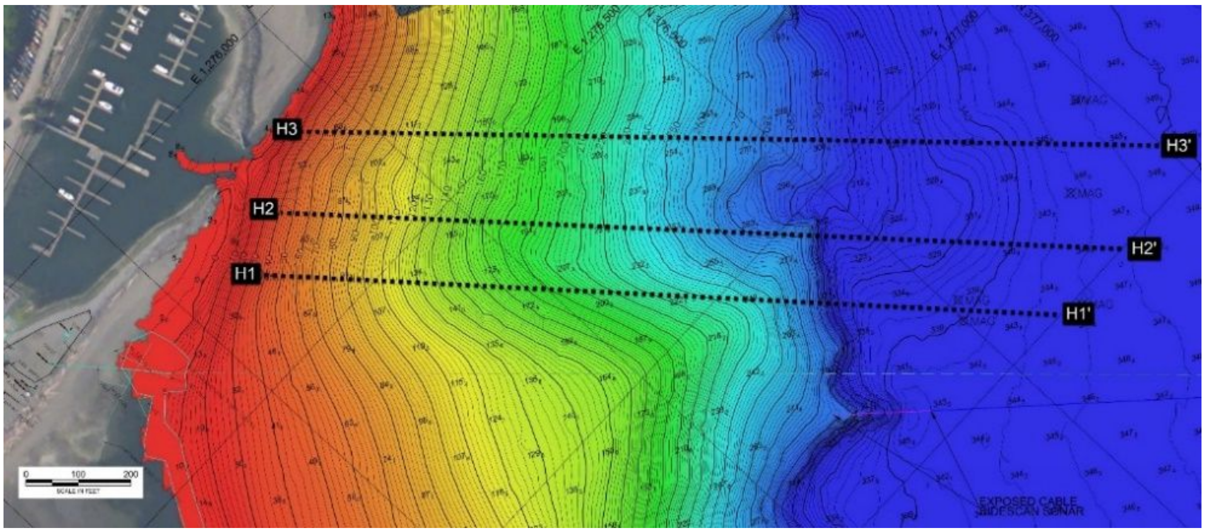


Figure 14. Location of transects for seismic reflection data.

Subbottom seismic reflection data were acquired on several parallel transects offshore of Hat Island (Fig. 14). Images of the subsurface reflection data along the three transects are presented below (Figs. 15, 16 and 17).

The seabed in shallow water appears to be covered with approximately 10 feet of unconsolidated material obtained from bluff erosion and then reworked by wave action. The divers report from the eel grass survey describes the seabed as sand and 0 to 4-inch rock from the shoreline to a depth of approximately 0 feet. From 0 to the -10-foot depth contour the seabed was predominantly sand and eel grass and sand between the -10- and -30-foot depth contour. This material overlays about 30 feet of glaciomarine deposits that rest on a thick sequence (in excess of 200 feet) of horizontally bedded glacial deposits. The slope is covered with unconsolidated sediment of variable thickness that shows hummocky surface expressions that are evidence of submarine slides (Line H1 and H2). A thick deposit of loose material truncates the underlying horizontally stratified glacial sediment (Line H3). Offshore in deep-water the seabed is mantled with approximately 30 feet of fine-grained, marine sediment overlain on glacial marine deposits.

The sequence shown in the three figures is most likely characteristic of the strata that would be observed on seismic data obtained along other areas of Hat Island’s eastern shoreline.

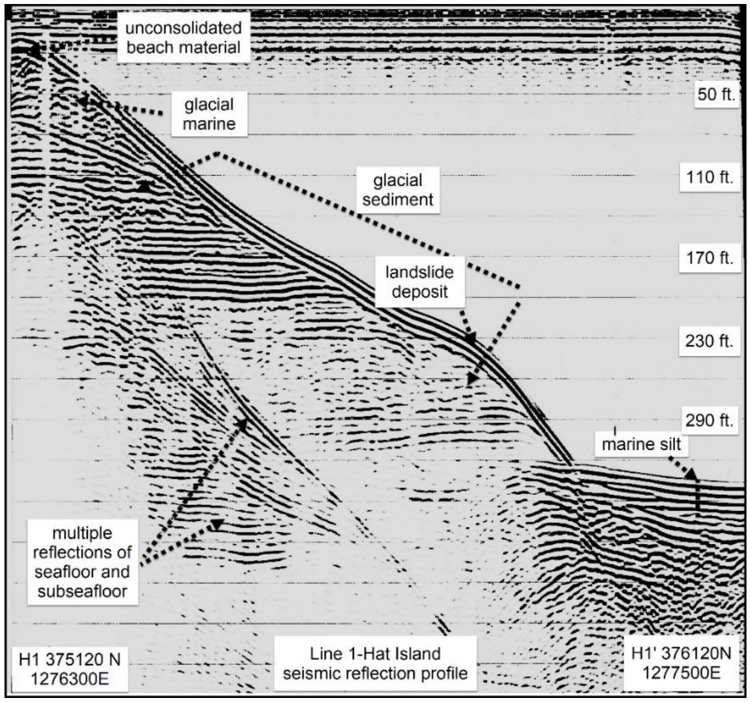


Figure 15. Examples of seismic reflection data on Line H1.

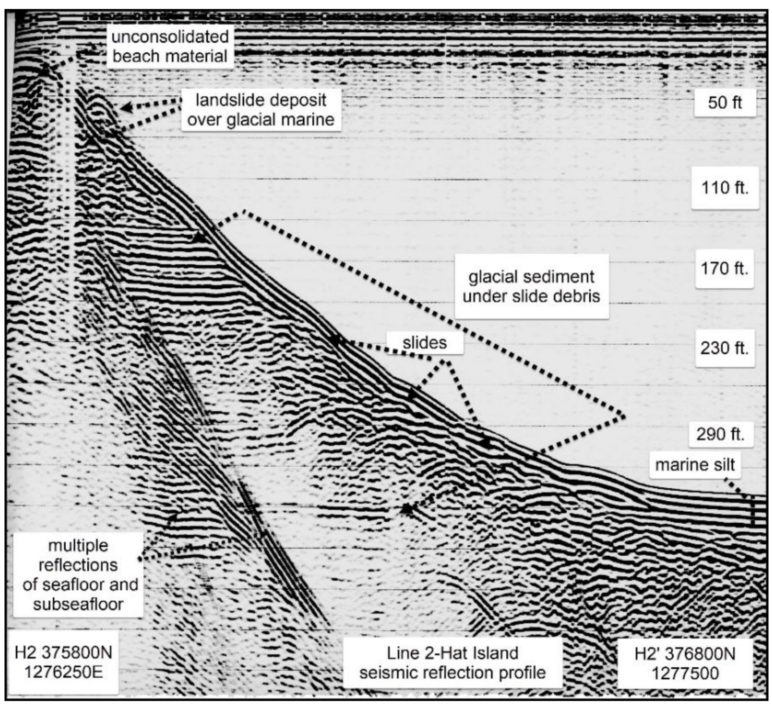


Figure 16. Examples of seismic reflection data on Line H2.

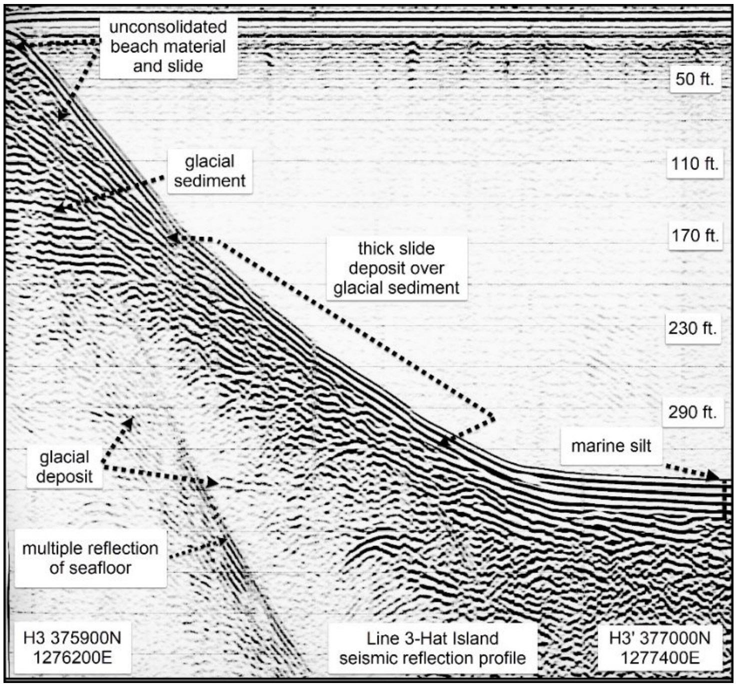
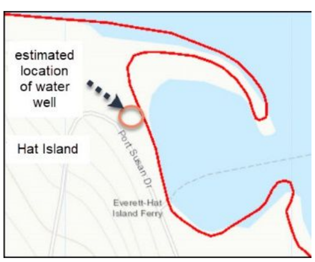
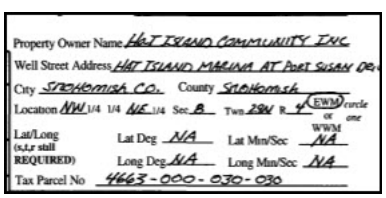
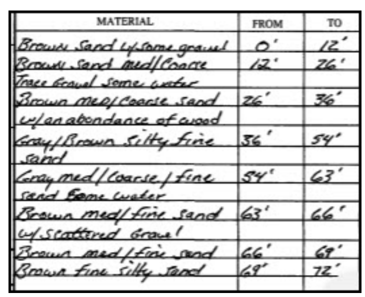


Figure 17. Examples of seismic reflection data on Line H3

Water well data: There is one well on Hat Island that is located between the marine ramp and the shoreline (Steve Stangvik personal communication). Ecology has it mapped offshore but describes the location to be on Port Susan Drive. This is where it is shown on the attached image but needs to be surveyed for an exact location. The borehole log describes 72 feet of fine to medium sand (Fig. 18).




Property Owner Name HAT ISLAND COMMUNITY INC
Well Street Address HAT ISLAND MARINA AT PORT SUSAN DR
City SNOHOMISH CO. County SNOHOMISH
Location NW 1/4 1/4 NE 1/4 Sec B Twn 29N R 4 (EWM) or WWM circle one
Lat/Long (s,t,r still REQUIRED) Lat Deg NA Lat Min/Sec NA
Long Deg NA Long Min/Sec NA
Tax Parcel No 4663-000-030-030



MATERIAL	FROM	TO
Brown Sand w/some gravel	0'	12'
Brown Sand med/Coarse	12'	26'
Trace Gravel some water		
Brown med/Coarse sand	26'	36'
w/an abondance of wood		
Gray/Brown silty fine	36'	54'
sand		
Gray med/Coarse/fine	54'	63'
sand some water		
Brown med/fine sand	63'	66'
w/scattered Gravel		
Brown med/fine sand	66'	69'
Brown fine silty sand	69'	72'

Figure 18. Beach Well 1 on Hat Island.

4.2 Everett Landing Geophysical Data

Geophysical and bathymetric data were collected on nine transects that ran offshore from the top of the slope to approximately 300-foot water depth. In addition, seismic reflection data were obtained on two deep-water transects that ran along the proposed corridor in an area that had anomalous bathymetric geomorphic characteristic (Fig 19).

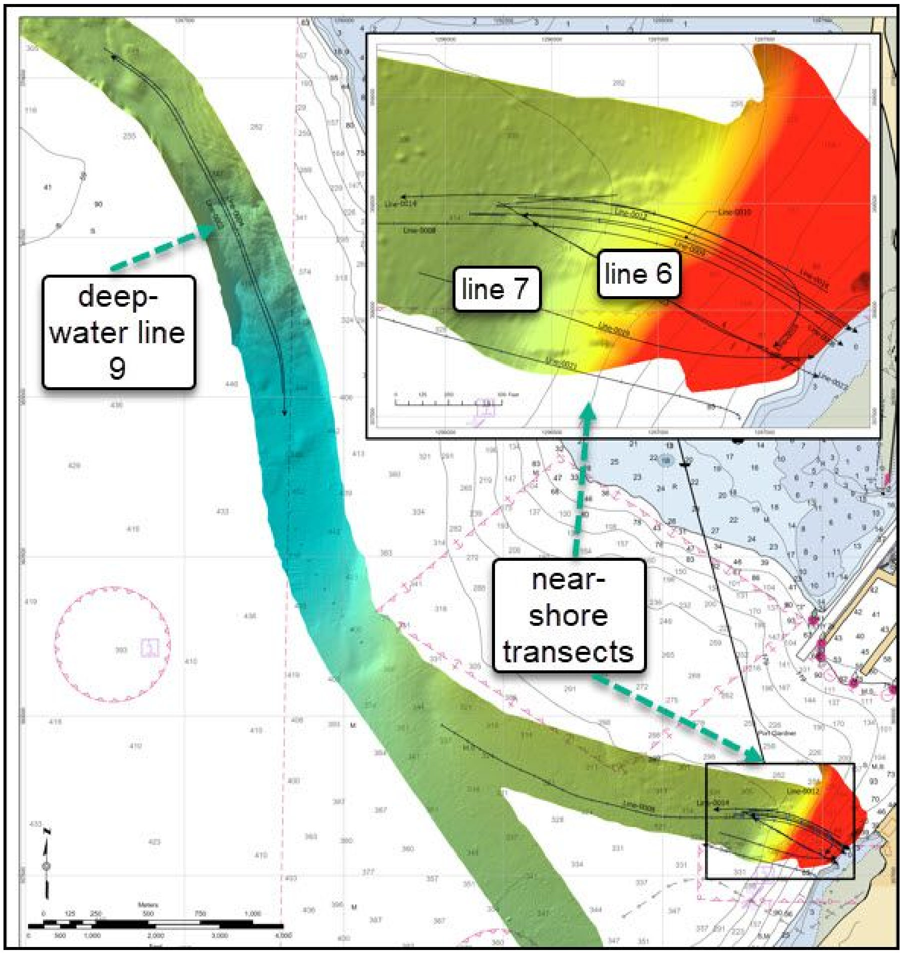


Figure 19. Geophysical survey track lines and location of images

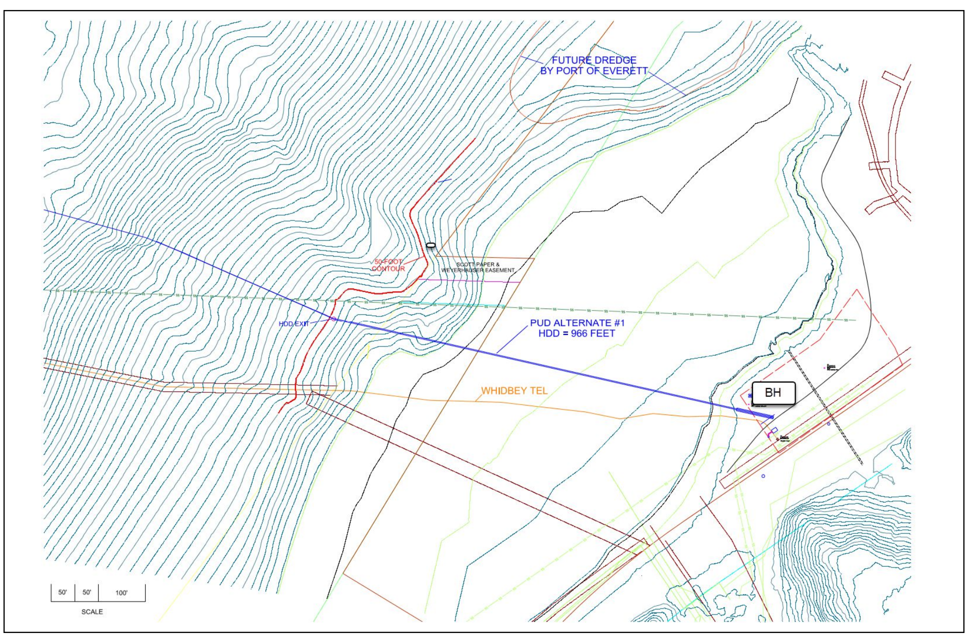


Figure 20. Location of proposed cable landing and other features of possible conflicts

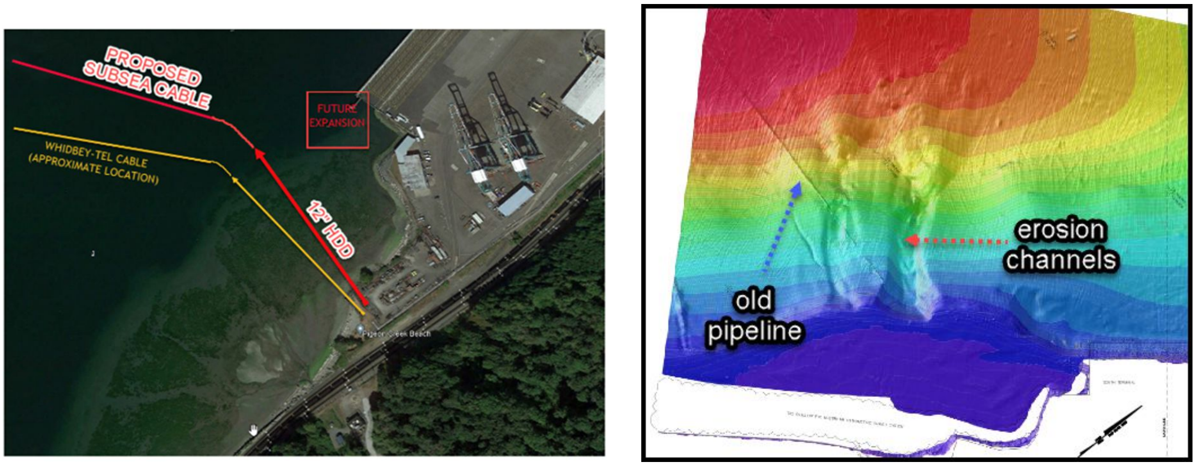


Figure 21. Proposed location for HDD and potential conflicts with cable, abandonded pipeline and erosional channel.

4.2.1 Seismic Reflection Data Examples for Everett Landing

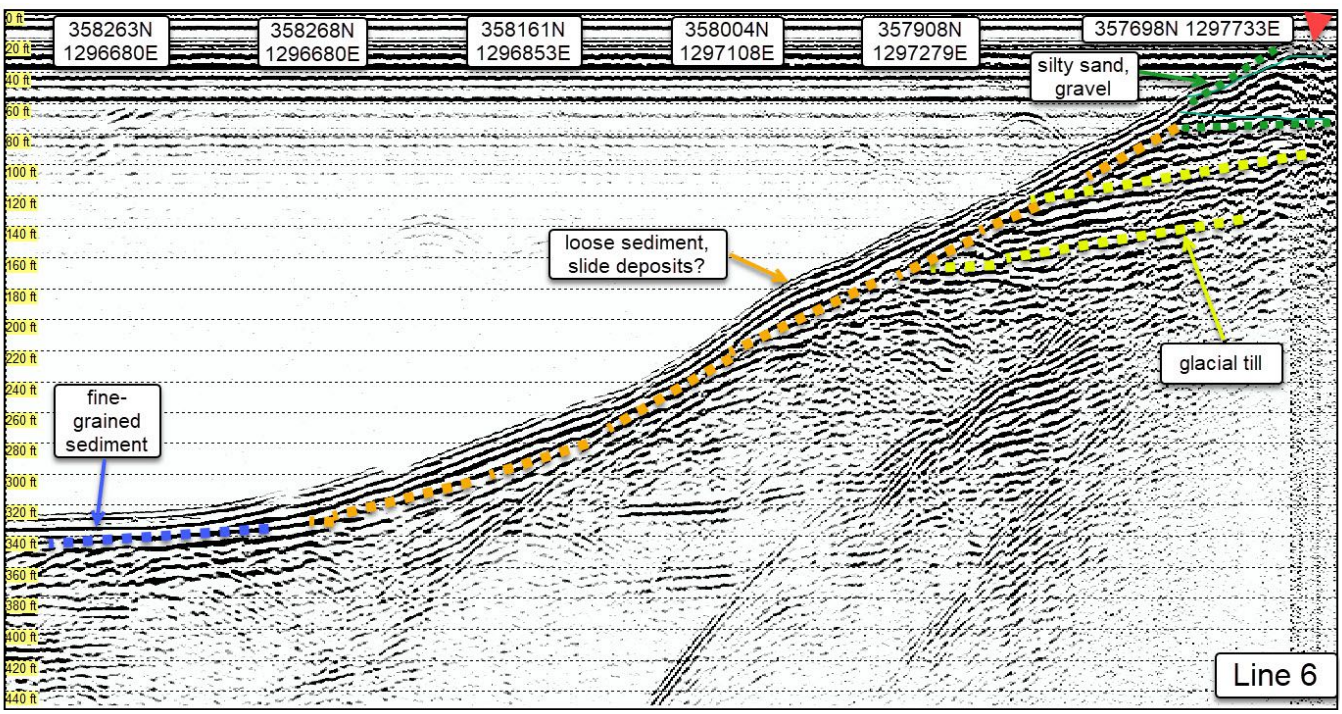


Figure 22. Line 6 seismic reflection data

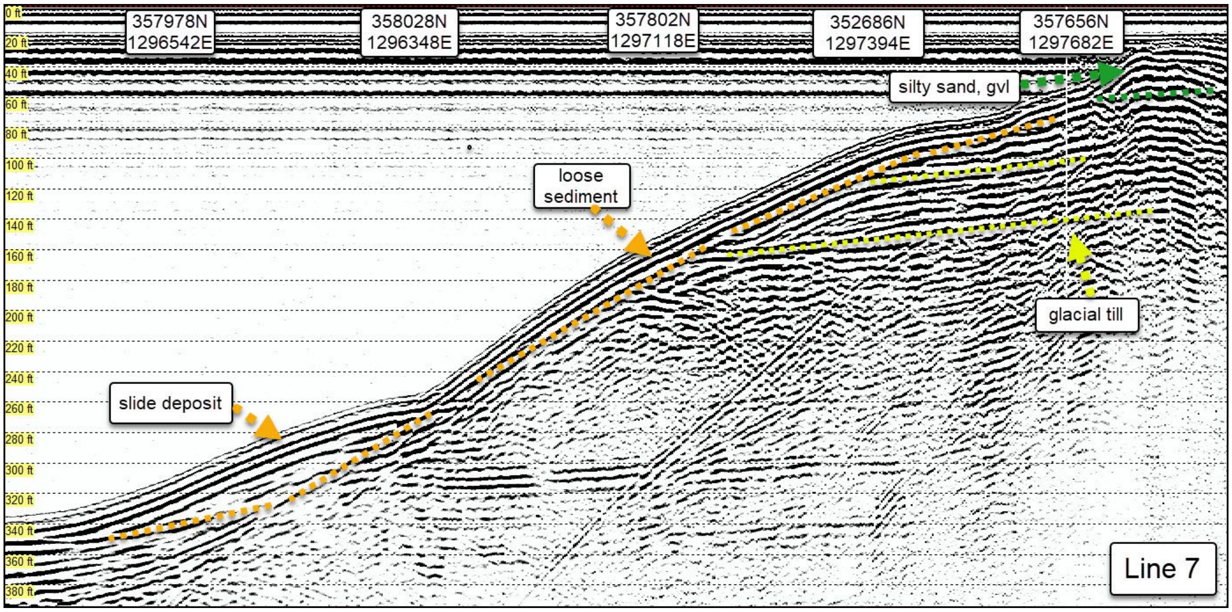


Figure 23. Line 7 seismic reflection data

The subsurface stratigraphy was very uniform with approximately 30 feet of fine-grained marine sediment overlain on glacial marine deposits of unknown thickness (Figures 22.23, 24a b, c.) and deeper glacial till deposits. Surface sediment samples obtained in deep-water by the Department of Ecology in the Port Gardner/Hat Island area classify the seabed sediment as a mixture of silt and clay (Port Gardner, 2014). Additional information on seafloor sediment is shown in several places on NOAA chart 18433.

On the deepwater profile, shown below (24a). the lack of subsurface penetration on the left side of the image is due to the presence of shallow buried organic material and or gas charged sediment. This area corresponds with the region described in the bathymetry as anomalous geomorphology.

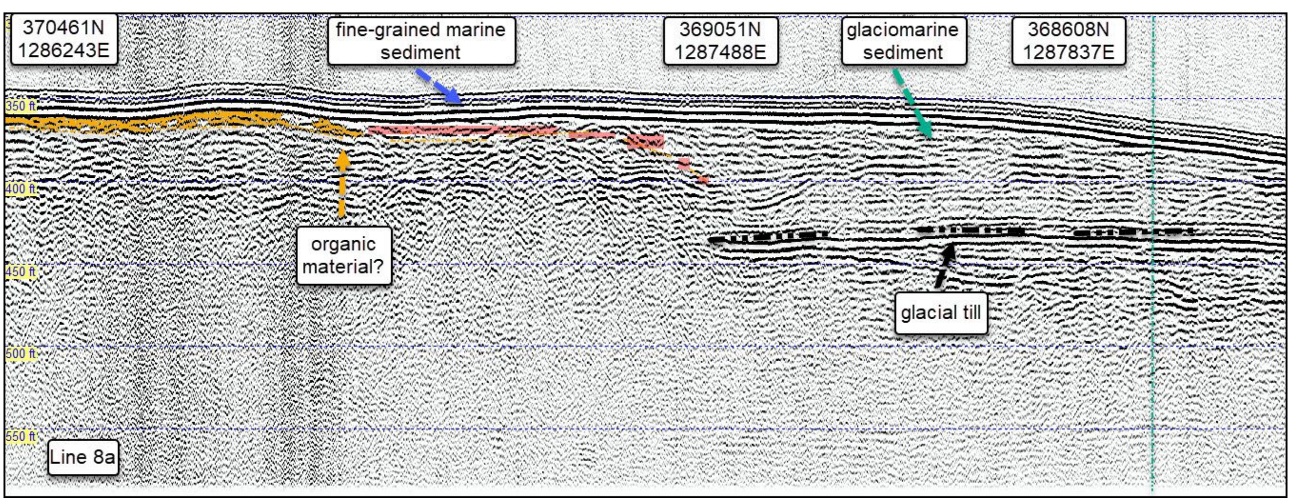


Figure 24a. Line 8a, deep water seismic reflection data

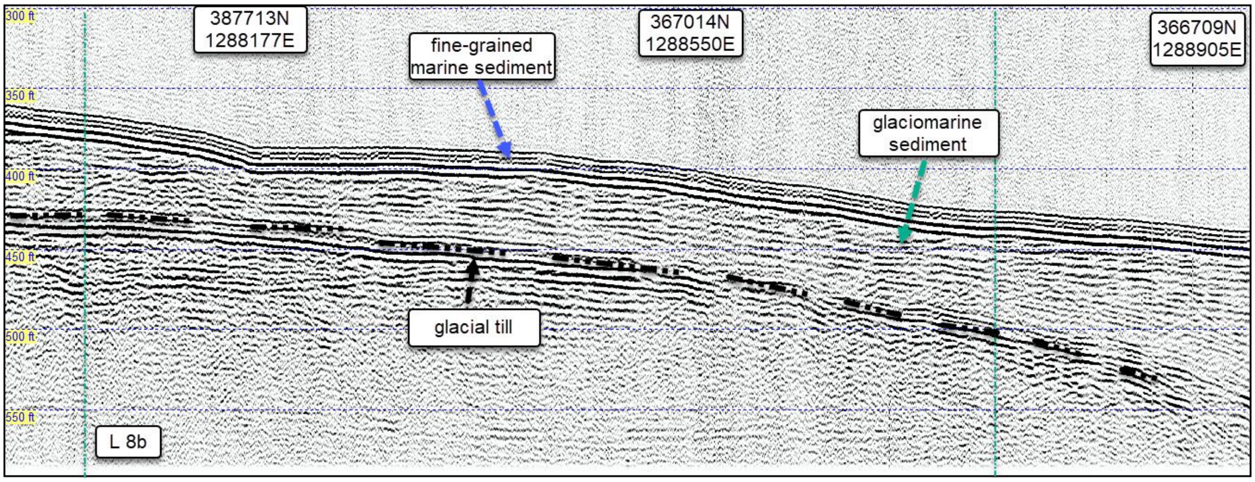


Figure 24b. Deep-water seismic reflection data

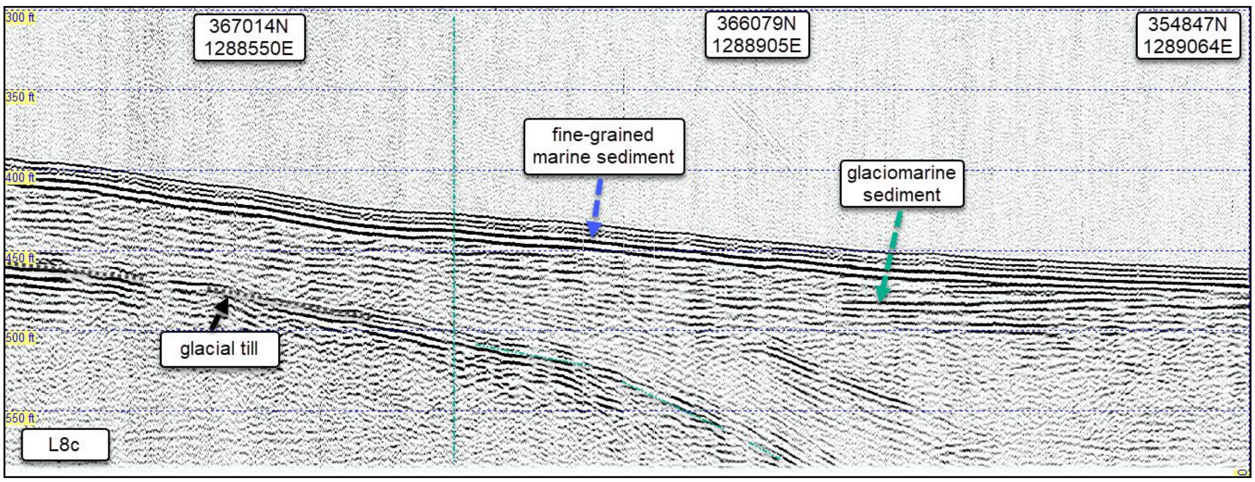


Figure 24c. Deep-water seismic reflection data

5.0 PRESENTATION OF GEOTECHNICAL DATA

A previous geotechnical and geophysical investigation was conducted for the Port that was located very close to the planned HDD landing (Port of Everett, 2017). Two interpreted geologic and geotechnical interpretation from this investigation are presented here as additional information (Figures 25, 26 and 27)

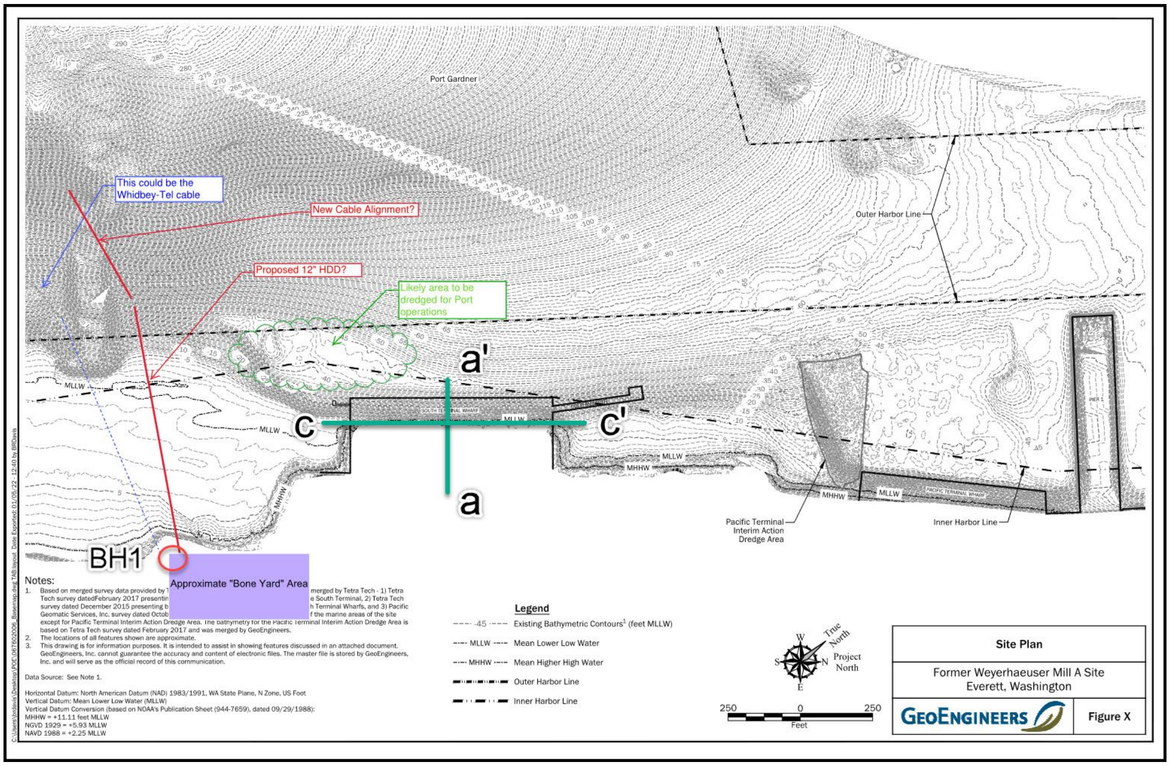


Figure 25. Location of two interpreted geologic profiles from previous investigation (POE, 2017).

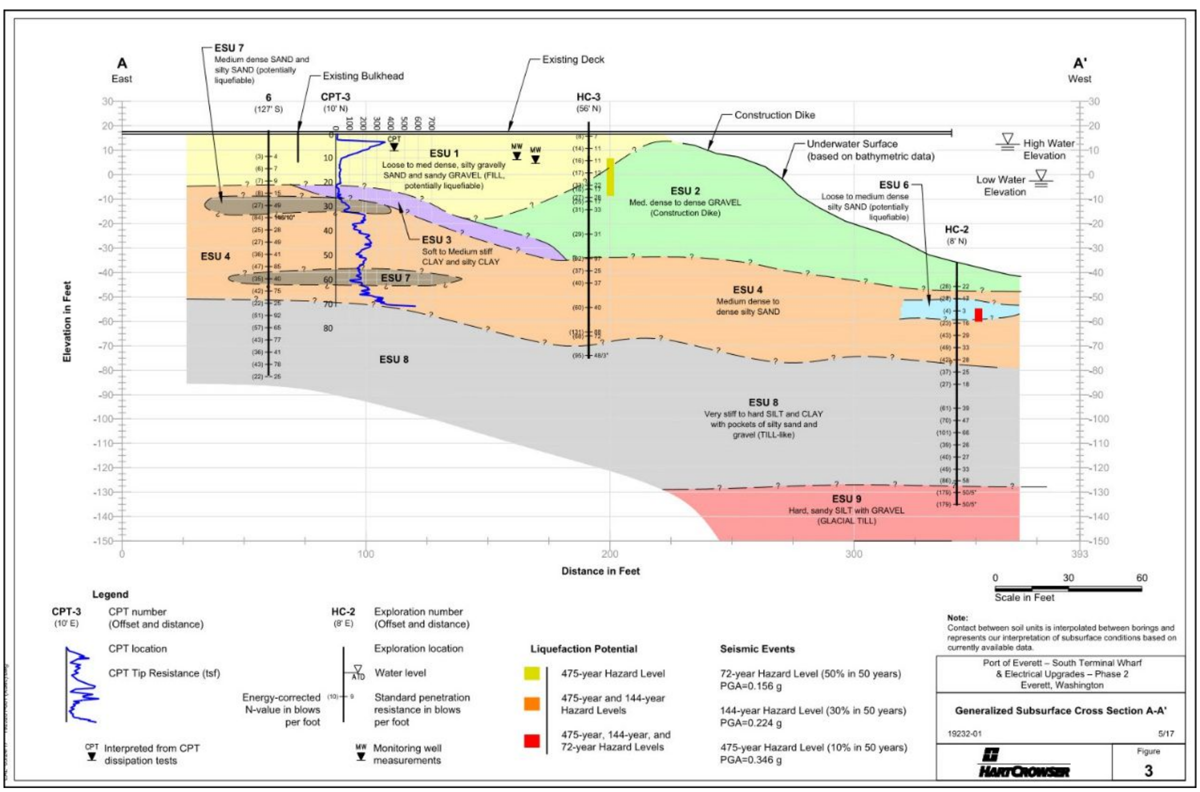


Figure 26. Interpreted profile for transect A-A'.

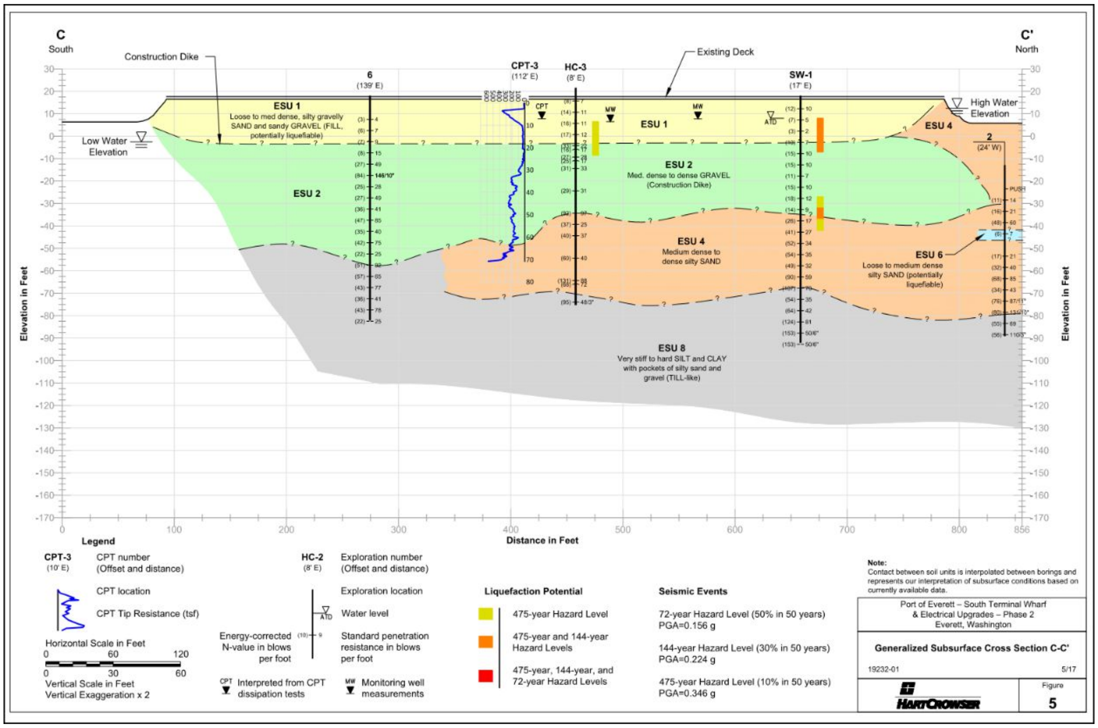


Figure 27. Interpreted profile for transect C-C'

6.0 ALTERNATE ROUTES

Two alternative crossing routes are being evaluated for installation of the replacement marine cable to Hat Island (Fig. 28). These crossings originate at (A) Whidbey Island and (B) Camano Head, and terminate at the appropriate location on Hat Island.

Figure 28. Proposed alternate routes.

6.1 Route A extends from the eastern shore of Whidbey Island to the northwestern tip of Hat Island (Fig. 28)

At this landing impermeable soils, silt or clay, are mixed with granular soils including sand and gravel. This combination is highly prone to failure particularly on the heavily forested, steep slopes. Large trees leaning downslope are evidence of active slope movement and may result in a catastrophic slope failure such as is evident in the right hand image below (Fig. 29).

Figure 29. Eastside of Whidbey Island showing active landslide

Water wells are located on top of the bluff show that the soils are predominantly silty sand and clay (Figure 30)

MATERIAL	FROM	TO
Redish Brown Soil	0	2'
Brown Sandy Gravel	2'	30'
Gray Sand	30'	58'
Browish Gray Sand	58'	62'
Greenish Silty Sand	62'	68'
Gray Sandy Clay	68'	105'
Gray Clay	105'	128'
Gray Sand (w/water)	128	142
Gray Clay	142	

Figure 30. Water well, Whidbey 1870403

https://fortress.wa.gov/ecy/wellconstruction/map/WCLSWebMap/WellConstructionMapSearch.aspx

In addition, there are several other potential problems with this route.

On the westside of Hat Island, in Saratoga Passage, a USGS geophysical seismic survey mapped a bedrock intrusion which must be associated with the igneous intrusive rock forming the core of Hat Island (Harding 1988, McClellan, 1927). This rock obstruction and rock debris on the seabed would require a detailed survey to map a safe and unobstructed route through the area (Fig 31).

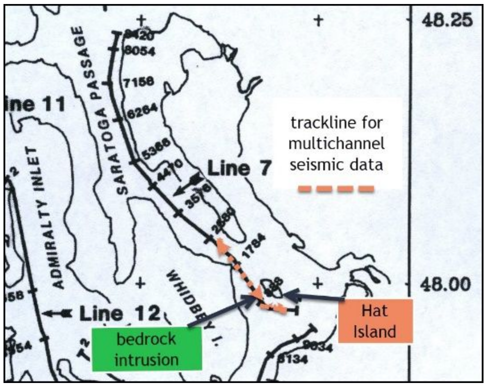
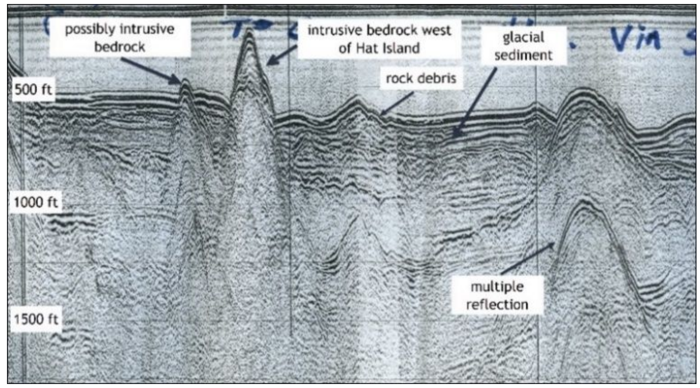


Figure 31. Location of seismic record from west side of Hat Island



Located in Saratoga Passage, approximately 6500 feet west of Hat Island is a 1000-foot-wide cable corridor that runs north-south. This may contain a fiberoptic communications cable and a potential conflict with a power cable (NOAA Chart 18445).

There are documented landslides on western shore of Camano in Saratoga Passage (Whiteaker, 2008) and at the southernmost tip of Camano. These have the potential for producing tsunami wave and turbidity currents on the seabed that could part or bury the cable.

6.2 Route B - extends from the southernmost tip of Camano Island (Camano Head), to the northeastern end of Hat Island (Fig. 32).

Previous recorded landslide at Camano Head suggests this is a very unstable slope. One failure produced a tsunami wave that inundated the north shore of Hat Island. The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel are prone to failure when saturated (Fig. 32). Future landslides would potentially result in burial, suspension or separation of power cable.

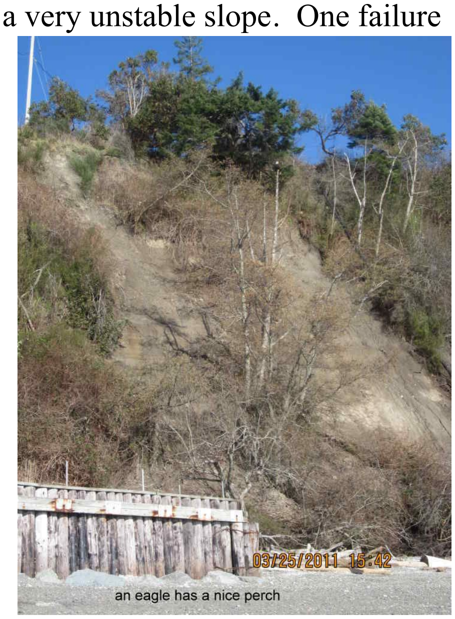


Figure 32. Camano Head

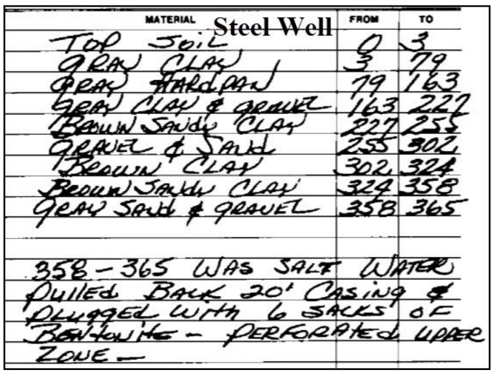
There is also an obstruction, Fish Haven, locate just southeast of Camano Head. This is mapped on NOAA Chart 18443.

Historical Note 1: People at Hat Island in the early summer morning (1820) saw Camano Island bluff smoking; they couldn't see it for the smoke; and there was something black coming toward them, and then they saw it was a wave. They fled to high land. Some the men and women, some of the children were drowned (Tweddell, 1953 p. 67)

Historical Note 2: Camano Island Head landslide and subsequent tsunami (1820). Interview of

Indian tribe conducted by the U.S. Government in 1888. The extreme southern end of Camano Island collapsed and fell into the bay creating a huge tsunami that traveled across Gardner Bay destroying the Snohomish Indian village of Hibulb, located along the western shoreline of what is now Everett, Washington, It also buried an Indian encampment at the base of the collapsed bluff before continuing on and wiping out a seasonal fishing village on Hat Island, (Washington State History/Geology Shipman, 2001).

Water well logs: Several water wells are in the immediate area and the log from the deepest one was selected. All wells showed a sequence of interbedded silt, clay and sand. There was no elevation information on the well log (Fig. 33). Soils are clay, sand and gravel.



Steel Well

MATERIAL	FROM	TO
TOP SOIL	0	3
GRAY CLAY	3	79
GRAY HARDPAN	79	163
GRAY CLAY & GRAVEL	163	227
BROWN SANDY CLAY	227	255
GRAVEL & SAND	255	302
BROWN CLAY	302	324
BROWN SANDY CLAY	324	358
GRAY SAND & GRAVEL	358	365

358 – 365 WAS SALT WATER PULLED BACK 20' CASING & PLUGGED WITH 6 SACKS OF BENTONITE – PERFORATED UPPER ZONE –

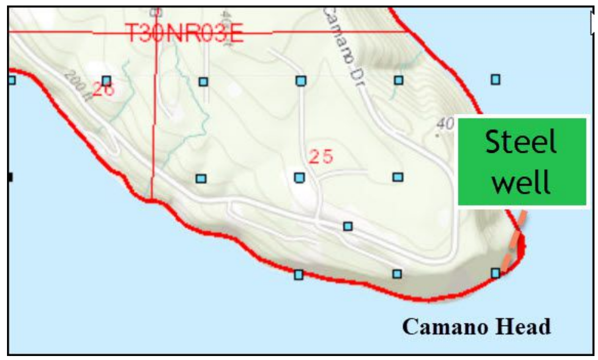


Figure 33. Water well data at Camano Head. Steel Well (ID 83500).
https://fortress.wa.gov/ecy/wellconstruction/map/WCLSWebMap/WellConstructionMapSearch.aspx

7. CLOSING

This work was performed in accordance under Professional Services Contract No. CW2238251 agreement between SNOPUD and Richard Sylwester. I trust this letter report meets your needs and ask that you contact me with any questions or comments on the content.

Sincerely

Richard Sylwester L.E.G., L.G.
Senior Marine Geophysicist
Northwest Geophysical Services

8.0 APPENDIX: BIBLIOGRAPHY AND REFERENCES

Barberopulou, A., A. Qamar, T. Pratt and W.P. Steele, 2006, Long-period effect of the Denali earthquake on water bodies in the Puget Lowland: observations and modeling: Bulletins of Seismological Soc. Of America, Vol 96, No. 20, pp 519-535 April 2006.

Barnett, E.A., R.A. Haugerud, B.L. Sherod, C.S. Weaver, T.L. Pratt and R.J. Blakely, Preliminary atlas of active shallow tectonic deformation in the Puget Lowland, Washington: USGS Open File Report 2010-1149.

Sherrod, Brian, R. Blakely, C. Weaver, L Liberty, 2008, Finding concealed active faults: Extending the southern Whidbey Island fault across the Puget Lowland, Washington: JGR Solid Earth, Volume 113, Issue G5 Seismology.

Booth, D. B., 1994, Glaciofluvial infilling and sour of the Puget Lowland, Washington, during ice-sheet glaciation: Geology, v. 22, p. 695-698.

Bourgeois, J. and S.Y. Johnson, 2008, Geologic evidence of earthquakes at the Snohomish Delta, Washington, in the past 1200 years: Geo. Soc. Amer. Bull 113: 482-494.

Bretz, J. H., 1913, Glaciation of the Puget Sound regions: Washington Geological Survey Bulletin No. 8, 244 p.

Chang, Susan, W., A. D Frankel and Craig Weaver, 2014, Report of workshops to incorporate basin response in design of tall building in the Puget Sound Region, Washington; USGS OFR 2014-1196

Dethier, D.J., Pessel, F., Keuler, R. Dalzarini, M and Pevear, D., 1995, Late Wisconsin glaciomarine deposition and isostatic rebound, northern Puget Lowland, Washington, GSA: Bulletin, v. 74, p 1465-1483.

Fattaruso, Laura, Simpson Strong Tie Fellow, 2022, Faults underneath Seattle could trigger 33-foot tsunami wave, Temblor http://doi.org/10.32858/temblor.267

Findley, D., 2001, Overview of Puget Lowland geology; A training course for Golder Associates, Redmond, WA.

Easterbrook, D.J. 1966, Glaciomarine environments and the Fraser glaciation in northwest Washington, Guidebook for First Pacific Coast Friends of the Pleistocene Field Conference, 52.

Hampton, M.S., H.J. Lee and J. Locate, 1996, Submarine landslides: Rev. Geophysics. 34: 33-59.

Harding, S.T., T.P. Barnhard, and T.C. Urban, 1988. Preliminary data from the Puget Sound multichannel seismic-reflection survey. USGS Open-File Report 88-698.

Haugerud, R.A. and H.M. Kelsey; 2017, From the Puget Lowland to east of the Cascade Range; geologic excursion in the Pacific Northwest: GSR Field Guide 49.

Johnson, S.Y., C.J. Potter, J.M. Armentrout. 1996, The southern Whidbey Island Fault; an active structure in the Puget Lowland, Washington: Geological Society of America Bulletin 108: 334-354.

Johnson, S.Y., S.V. Dadismn, D.C. Mosher, R.J. Blakely and J.R. Child, 2010, Active tectonics of the Devils Mountain Fault and related structures, Northern Puget Lowland and Eastern Strait of Juan de Fuca Region: Pacific Northwest Professional Geological Survey of Canada, Paper 1643.

Johnson, S.Y., A.R. Nelson, S.F. Personius, R.E. Wells, 2004, Evidence for late Holocene earthquakes on the Utsalady Point fault, northern Puget Lowland, Washington: Bull Seis. Soc. Amer. 94: 2299-2316.

Koshimura, S., and Harold Mofjeld, 2001, Inundation modeling of local tsunamis in Puget Sound, Washington, due t potential earthquakes: ITS 2001 Proceedings, Sessions 7, Number 7-18.

Martin, Elisabeth and J. Bourgeois, 2012, Vented sediments and tsunami deposits in the Puget Lowland, Washington-differentiating sedimentary processes: Sedimentology (2012) 59, 419-444.

McLellan, Roy, Davidson, 1927, The Geology of the San Juan Islands, University of Washington Publications in Geology.

NOAA OAR Special Report Puget Sound Tsunami Sources—2002 Workshop Report A contribution to the Inundation Mapping Project of the U.S. National Tsunami Hazard Mitigation Program.

Palmer, S.P., September 2004, Liquefaction susceptibility map of Snohomish County, Washington, DNR.

Port Gardner Bay Regional Background Sediment Characterization: Final Data Evaluation and Summary Report; Publication 14-09-339, 2014.

Port of Everett 2017, South Terminal Wharf and Electrical Upgrade Phase 2-Everert, WA.

Port Gardner Bay, 2014, Regional Background Sediment Characterization Everett, WA Final Data Evaluation and Summary Report December 31, 2014 Publication no. 14-09-339

Pratt, Thomas L., S. Johnson, C. Potter, 1997, Seismic reflection images beneath Puget Sound, western Washington State: The Puget Lowland thrust sheet hypothesis; Journal of Geophysical Research vol. 102, B12, Dec 10, 1997.

Sanders, Julia-Grace, 2021, Buried danger; A slumbering geologic fault beneath us-the southern Whidbey Island fault, Sunday May 16, 2021 local news broadcast.

Sherrod, B., Blakely, R., Weaver, C, Kelsey, H, Barnett, E, 2005, Holocene fault scarps and shallow magnetic anomalies along the southern Whidbey Island fault zone near Woodinville, Washington: American Geophysical Union, Fall Meeting 2005, abstract id. S51C-1022.

Sherrod, Brian, R. Blakely, C. Weaver, L Liberty, 2008, Finding concealed active faults: Extending the southern Whidbey Island fault across the Puget Lowland, Washington: JGR Solid Earth, Volume 113, Issue G5 Seismology.

Shake Geologic Summaries, 2012, Evergreen earthquake exercise scenarios: background summaries, Seattle fault zone M6.7 earthquake scenario. https://earthweb,ess.washington.edu/gomberg/ShakeMap/AhakeMapGeologicSummaries.html

Shipman, Hugh, 2001, The Fall of Camano Head: A Snohomish account of a large landslide and tsunami in Possession Sound during the early 1800s: Tsulnfo Alert, v.3, No. 6, p13-14.

SnoPUD 2020 Desktop study for replacement of SnoPUD Tulalip to Hat (Geney Island Power cable; Contract No. CW2238251.

Sylwester, R.E., and M.L. Holmes, 1987, Marine geophysical evidence of a recent submarine slope failure in Puget Sound Washington: Proceedings, Oceans 89, 5: 1524-1529.

Sylwester, R.E. 1982, Single-channel, high-resolution seismic-reflection profiling: A review of the fundamentals and instrumentation: Geophysical Exploration at Sea, CRC Press, Boca Raton, FL.

Sylwester, R.E., L.C. Bennett, M.A. Sheriff and R.C. Bostrom, 1971, The determination of active fault zones in Puget Sound Washington by means of continuous seismic profiling, in Proceedings: The Int. Symp. On the engineering properties of sea-floor soils and their geophysical identification; National Science Foundation; Seattle, WA 1971.

Terrasond Ltd, 2019, Hat Island to Tulalip Cable Corridor Multibeam Bathymetry.

Tetratech 2020, Draft Hat Island Bathymetric Survey Report

The Geology of the San Juan Island (Igneous Rocks) www.nps.gov/parkhistory

Walsh, T.J., Other Tsunami sources in Washington, Department of Natural Resources.

Walsh, E.A., John Vidale, Arthur Frankel, Thomas Pratt, 2019, Source-dependent amplification of earthquake ground motions in deep sedimentary basins: AGU Geophysical Research Letters, v. 46, Issue 12.

Walsh, T.J., Diego Arcas, V. Titov and C. Chamberlain, 2014, Tsunami hazard map of Everett, Washington: model results for magnitude 7.3 and 6.7 Seattle fault earthquake: WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES OPEN FILE REPORT 2014-03.

Washington State History/Geology March 29, 2017

Whiteaker, William, 2008, Landslide generated tsunamis: A smoking gun in Saratoga Passage, Puget Sound, Washington: Oceanography 499 Senior Thesis, School of Oceanography, Univ. of Washington.

Wikipedia-Puget Sound Faults

https://earthquake.usgs.gov/scenarios/eventpage/bssc2014573_m6p69_se/executive

https://fortress.wa.gov/ecy/wellconstruction/map/WCLSWebMap

https://ecology.wa.gov/Water-Shorelines/Water-supply/Wells

https://fortress.wa.gov/ecy/publications/SummaryPages/1409339

https://www.dnr.wa.gov/geologyportal

https://www.nps.gov/parkhistory/online_books/geology/publications/state/wa/uw-1927-2/sec4.htm

https://www.nps.gov/parkhistory

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Appendix-B Biological Considerations

SNOHOMISH PUD

DECEMBER 2, 2019

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Alternate Route Report

Prepared for:

Snohomish PUD
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2 December 2019

This document should be cited as:
Jen-Jay, Inc. 2019. Snohomish PUD Alternate Route Report. 2 December 2019. Prepared for Snohomish PUD, Eric Schneider, Project Manager

Contents

General Information

Applicant:	Snohomish PUD P.O. Box 1107, M/S E1 Everett, WA 98206
Contact:	Eric Schneider
Office Phone:	(425) 783-8624
Email:	EASchneider@snopud.com

Physical location of proposed work:

Gedney (Hat) Island to Marysville, WA

Lat/Long: 48.019167° N; 122.321110° W
48.049444° N; 122.275277° W

Water body: *Possession Sound*

List of Figures

1. Project Description

Snohomish PUD provides electrical service to Hat (Gedney) Island, near Everett, WA, via a 45-year old submarine power distribution cable. The existing 3-phase cable was installed in 1974. The 12kV electrical distribution cable extends from Mission Beach (west of Marysville, WA on the Tulalip reservation) to Hat Island, a distance of approximately 16,000 feet. Snohomish PUD provides service to approximately 250 residential and business customers on Hat Island from Tulalip substation, Circuit 12-507. Hat Island's electrical service also powers its drinking water system.

The existing submarine cable is nearing the end of its serviceable life and is at risk of failure. To avoid a potential emergency situation which would isolate the residents of Hat Island from electrical service, Snohomish PUD plans to install a new 3-phase submarine power cable along the same route. To continue reliable service to Snohomish PUD customers, the existing cable will remain energized while the new line is installed.

The new cable will be installed via horizontal directional drilling (HDD) at the shoreward landfall on each side of the crossing, which will allow the cable conduit to run subsurface beneath sensitive forage fish habitat and eelgrass found in both nearshore environments.

This report details alternate routes considered for the submarine power cable to Hat Island and the conclusion to utilize the existing powerline location.

1.1 Project Sites Description

The shoreline description of the potential project locations was determined using Washington Department of Fish and Wildlife (WDFW) Priority Habitat and Forage Fish Spawning Habitat maps (Figure 1), Washington Department of Ecology Coastal Atlas maps (WDOE) [Figure 2], Geotech Report by Sylvester (2019) and the Eelgrass Macroalgae Habitat Survey conducted by Jen-Jay, Inc. 19 September 2019 (for route A, existing).

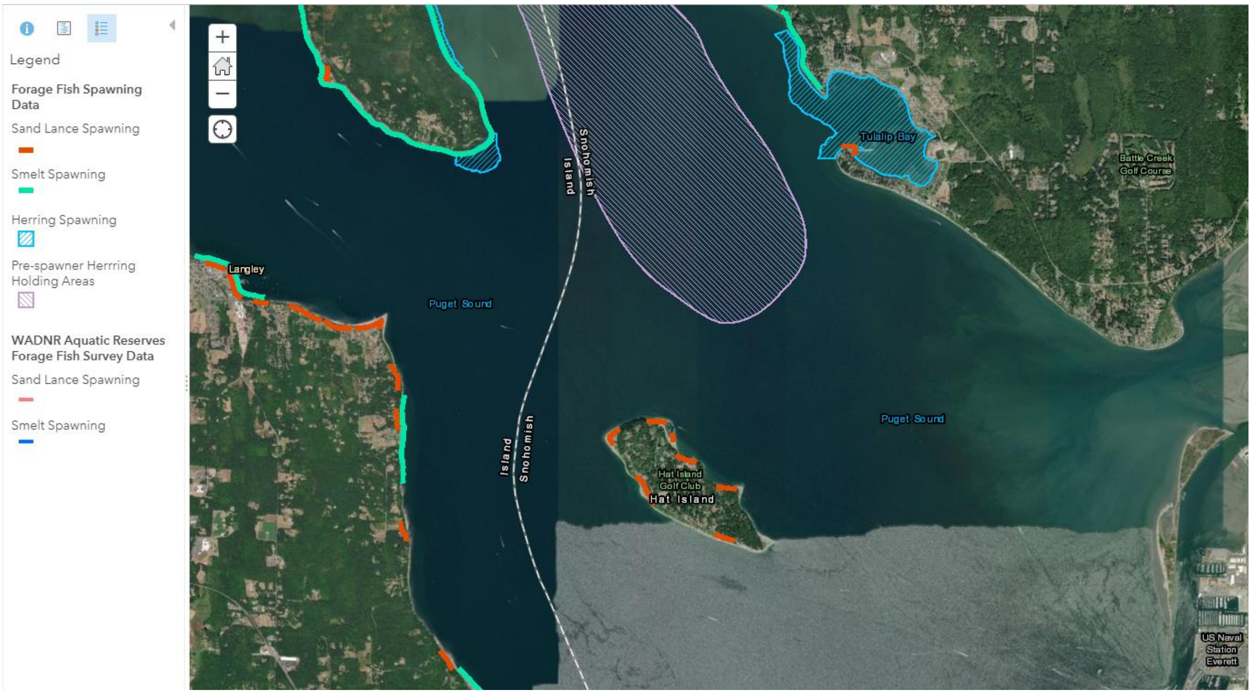

Figure 1: Washington State Forage Fish Spawning Map (Washington Department of Fish and Wildlife, 2013)

Figure 2: Coastal Atlas Map (Washington State Department of Ecology, 2016)

The routes under consideration are the following (Figure 3):

A) The existing cable route from Hat Island northeastward to Mission Beach at Tulalip Bay.
B) An alternative route from Hat Island northward to the southern tip of Camano Island.
C) An alternative route from Hat Island westward to Whidbey Island.
D) An alternative route from Hat Island southeastward to Everett.

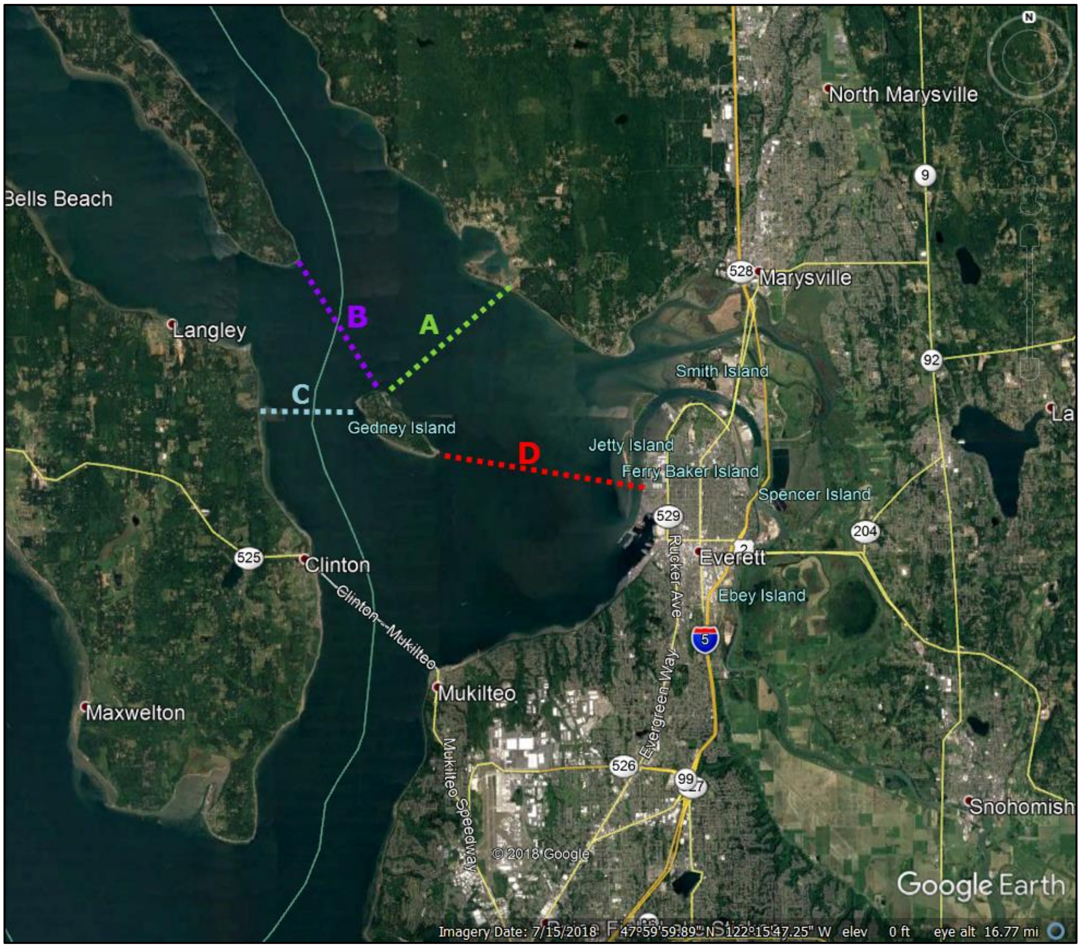

Figure 3: Route Alternatives (Figure borrowed from others)

Route A: Existing cable route between east side of Hat Island to Mission Beach, Marysville, WA

The existing cable is along this route. A preliminary eelgrass and macroalgae habitat survey was conducted on 19 September 2019 by Jen-Jay, Inc. covering both shoreward sections of the cable route. The survey revealed mud/sand substrates with eelgrass in the nearshore on both sides.

On the Hat Island side of the channel, starting approximately 120 feet from shore, begins a band of fringe eelgrass that extends approximately 260 feet offshore. On the Mission Beach side of the channel, eelgrass begins approximately 500 feet offshore and extends approximately 1000 feet offshore. Outside of eelgrass beds, there is generally no macroalgae, with the exception of *Ulva* and *Enteromorpha* growing in the sand/mud on the shoreward portion of the Mission Bay side of the survey.

There is Washington Department of Fish and Wildlife (WDFW) documented sand lance spawning habitat located on the beach at the Hat Island cable landfall (Figure 1). No documented forage fish spawning habitat is present at the Mission Beach landfall. However, Tulalip Bay contains documented Pacific herring and sand lance spawning habitat. The waters outside Tulalip Bay, at the entrance to Port Susan, are a Pacific herring pre-spawner holding area.

There is patchy fringe eelgrass documented on both sides of the existing crossing according to the Washington Department of Ecology (WDOE) Coastal Atlas Map (Figure 2).

The existing aquatic lands easement, which exists from Mission Beach near Tulalip Bay to an area just east of the Hat Island Marina, would remain in place, and the necessary infrastructure to connect the cable is already in place.

Although the Mission Beach area is reported to be vulnerable to landslides, and there is a relatively steep approach on Hat Island, there is no evidence that landslides have impacted the existing cable. Also, there is no information in the cable construction documents that suggest there were difficulties with cable installation at these sites (Sylwester 2019). The WDOE Coastal Atlas does not report slope stability for this loctation. Observations during the eelgrass survey site visit indicates that the Mission Beach landfall is located at a low point in the beach between potentially unstable bluff areas on either side.

Horizontal directional drilling access appears feasibly at both the Mission Beach and Hat Island landfalls. Use of this drilling technique will be useful for protecting sensitive forage fish habitat and submerged aquatic vegetation present in the nearshre along the cable route. The submerged aquatic habitat beyond the eelgrass in this area shows no sign of the existing cable. It is presumed that the cable has self-buried into the extensive mud/sand habitat and that a replacement cable would also self-bury, having minimal impact to deeper submerged habitats, and posing no long-term risk to the cable itself.

Figure 4a: Route A Landing, Mission Beach Side (Washington State Department of Ecology, 2016)

Figure 4b: Route A Landing, Hat Island Side (Washington State Department of Ecology, 2016)

Route B: Between the southern tip of Camano Island (Camano Head) and the northern end of Hat Island.

This option is a shorter route than the existing cable route. However, there is a previous recorded landslide at Camano Head (1820), suggesting that the slope in this location is very unstable. Unstable and impermeable soils mixed with granular soils at this location make future landslides likely, which have the potential to bury, suspend, or even sever the new cable (Sylwester 2019).

There is WDFW documented herring and surf smelt spawning habitat located at Camano Head (Figure 1), and there is patchy fringe eelgrass documented by WDOE at both Camano Head and the northern end of Hat Island (Figure 2). Camano Head shows unstable soils with a recent slide area (Figure 2).

Figure 5a: Route B Landing, Camano Island Side (Washington State Department of Ecology, 2016)

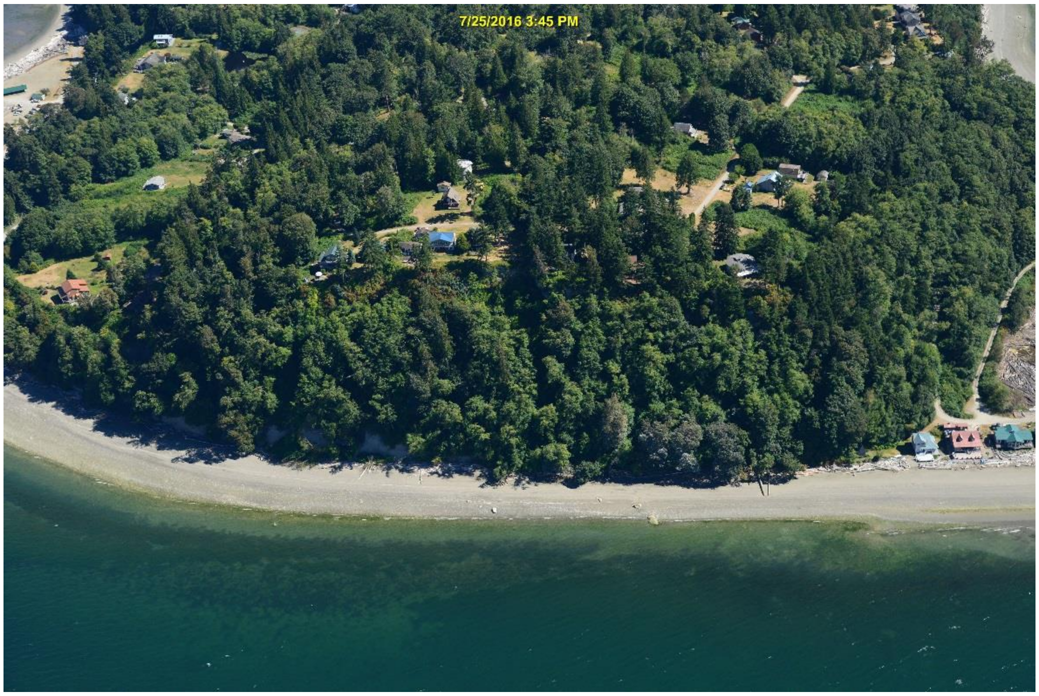

Figure 5b: Route B Landing, Hat Island Side (Washington State Department of Ecology, 2016)

Route C: Between Whidbey Island and the western side of Hat Island.

This option, landing just north of Clinton on Whidbey Island, is the shortest proposed distance. Desipite the simplicity of a shorter cable, this option has complications that make it infeasible. As in Route Option B, the landfall site on Whidbey Island is composed of impermeable soils mixed with granular soils, indicating a high likelihood of landslide. There is a nearby landslide documented in the geotechnical report developed for this project (Sylwester 2019). Additionally, there appears to be a bedrock intrusion in the seabed along the route, which could pose challenges to the cable installation, and the lifespan of the cable (Sylwester 2019).

Surf smelt spawning habitat is documented by WDFW on either side of the proposed landfall location on Whidbey Island (Figure 1) and there is patchy fringe eelgrass on both Whidbey Island and the west side of Hat Island (Figure 2). In addition, there are unstable soils on the west side of Hat Island with a recent slide (Figure 2).

Route C would also cross a charted cable area designation. It is unkown if the cable identified in this area is active, but placing the cable in this area would require a crossing agreement with the owner of the cable, and protections put in place to keep the cables separate from one another. Additionally, Whidbey Island is served by Puget Sound Energy, which would create added expense in coordinating the power supply to Snohomish Public Utilities District who currently serves Hat Island, and areas to the east.

Figure 6a: Route C Landing, Whidbey Island Side (Washington State Department of Ecology, 2016)

Figure 6b: Route C Landing, Hat Island Side (Washington State Department of Ecology, 2016)

Route D: Between the southern end of Hat Island and Everett.

This option is the longest route proposed. This route would place the cable through a known mudflat/wetland complex associated with the Snohomish River and Jetty Island, just west of Everett. The wetland complex is important for providing numerous valuable social and ecological functions. These functions include, but are not limited to the following: stabilization of the shoreline, recreation, priority species habitats, aesthetic value, sediment stabilization, sediment toxics retention, nutrient retention and transformation, export of primary production, fish habitat, bird habitat, invertebrate and other species habitat, research, and potential restoration value (SEWIP 1997). In 2001, areas of this mudflat/wetland complex (on Smith Island) were identified by Snohomish county as the highest priority for acquisition through the ESA Priority Lands Acquisitions Program (CH2MHILL 2004) to promote the recovery of ESA-listed Puget Sound Chinook salmon (Stamey 2008).

Other factors worth consideration at this site concern log debris that is regularly transported during flooding events on the Snohomish River. This debris has the ability to impact the submarine power cable if tangled and accumulated near the mainland cable landing site. Lastly, as in other the areas in the vicinity, the river delta is prone to unstable soils and liquefaction events, and also has a history of being impacted by tsunami (Sylwester 2019).

Figure 7a: Route D Landing, Jetty Island Side (Washington State Department of Ecology, 2016)

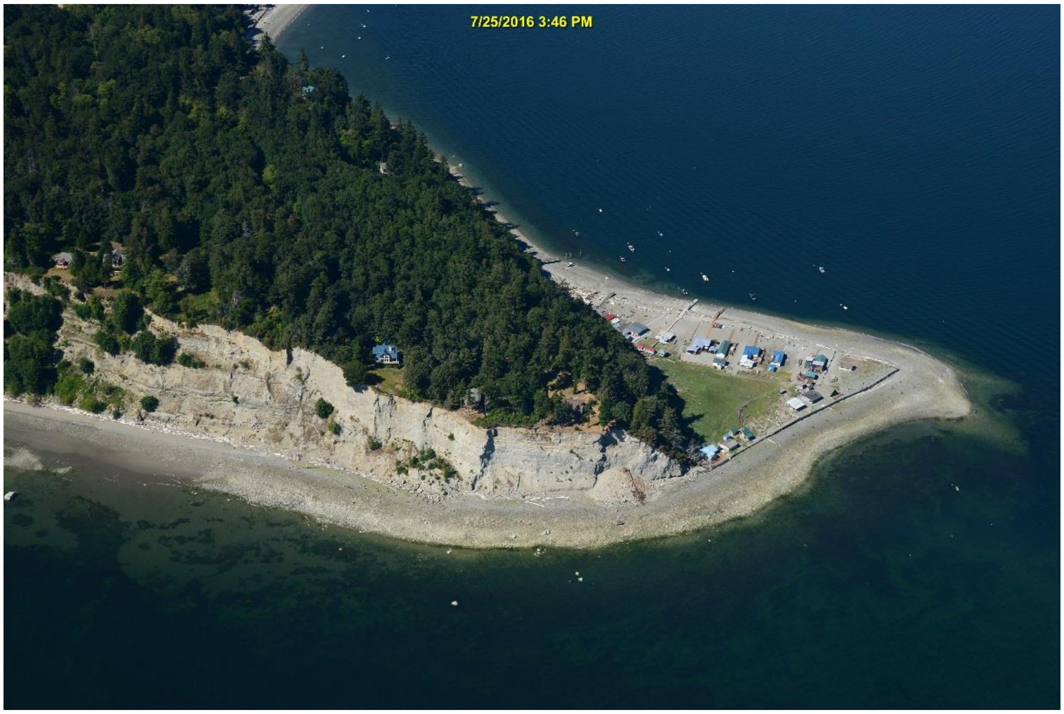

Figure 7b: Route D Landing, Hat Island Side (Washington State Department of Ecology, 2016)

1.2 Conclusions

In addition to the existing cable route, three alternative routes have been considered for the location of the submarine power cable to Hat Island. Our conclusion is that the existing location (Route A) is the best location for the proposed new powerline based upon multiple factors:

Route A

Despite the report of potentially unstable soils at the existing cable landfall at Mission Beach, the existing cable has not experienced difficulties with landslides. The precise location of the mainland landfall is at a low point along the beach, suggesting that landslide concerns at this location are significantly less than those at the bluff areas to the north and south. It is believed that HDD access at this site is feasible. Additionally, the steep, but stable approach on Hat Island, along with the access at the Hat Island Marina, provides reasonable HDD access.

This route is also the existing Snohomish PUD cable route with an appropriate DNR utility easement. All cable infrastructure is already present, with an established network in place.

Route B

There is unstable soil on the Hat Island side and unstable soil with recent slide area on the Camano side. Forage fish Habitat concerns exist on both sides with poor HDD access on Camano Head.

Route C

There is unstable soil on both Hat Island and Whidbey Island sides. Forage fish Habitat concerns exist on both sides. HDD access was not determined at these landing sites. Snohomish PUD does not have service connection to Whidbey Island.

Route D

There are intermediate stable soils on the Hat Island side with modified soil on the Snohomish River side. No forage fish concerns exist on either side, but eelgrass exists at both landfalls. HDD access was not determined on the Hat Island side, but poor access exists on the Snohomish River side. The Snohomish river side is also comprised of an extensive mudflat/wetland complex with special protections.

WDFW requires mitigation sequencing in the following order when considering impacts to wetlands:

1) Avoid the impact
2) Minimize the impact
3) Compensatory mitigation for unavoidable impacts

In considering the value of this mudflat/wetland complex, and given the alternative options, it is not possible to justify impacts which may result from the placement of the new cable in this sensitive habitat.

2. References

Jen-Jay, Inc. 2019. Eelgrass Macroalgae Habitat Survey 19 September 2019. Conducted for Snohomish Public Utility District.

SEWIP. 1997. Snohomish Estuary Wetland Integration Plan. Prepared by the City of Everett, Department of Planning and Community Development with assistance from the Washington Department of Ecology and the Environmental Protection Agency, Region 10. April 1997.

Stamey, Mark. 2008. Smith Island Restoration Project (RR-49206) Wetland Characterization Report. Prepared by Snohomish County Department of Public Works. May 2008.

Sylwester, Richard. 2019. Hat Island Route Evaluation. Developed for Snohomish Public Utility District. November 2019.

Washington Department of Fish and Wildlife. (2013). *Forage Fish Spawning Map-Washington State.* Retrieved from https://www.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3.

Washington Department of Ecology. (2016). *Washington State Coastal Atlas Map.* Retrieved from https://fortress.wa.gov/ecy/coastalatlas/tools/Map.aspx.

Appendix-C Historical and Archaeological Considerations

This document discusses the route alternatives proposed in Snohomish PUD’s Routing Study from an archaeological and cultural perspective, prepared by Kelly R. Bush and Courtney M. Strehlow of ERCI, Inc., Mount Vernon, WA. It is an excerpt from ERCI’s “ARCHAEOLOGICAL INVESTIGATION REPORT FOR SNOHOMISH COUNTY PUD'S SUBMARINE CABLE REPLACEMENT PROJECT, SNOHOMISH COUNTY, WASHINGTON,” dated April 24, 2020.

Discussion for Alternative A

Mission Beach

Our investigation showed considerable surface disturbance across the property. There was a relic shed and some other items on the property. Much of the property was covered in tall, dense blackberry bushes which limited our visibility and access somewhat. We recorded one positive ST that contained a flaked stone cobble in ST 7; however, all other STs (1-6 and 8-12) were negative for cultural resources.

A monitoring plan and archaeological monitoring will need to be done during ground disturbing activities on the Mission Beach side of Alternative A.

Hat Island

Visibility and accessibility of the Hat Island side of Alternative A was much better. All three STs (13-15) were negative for cultural resources. However, the shoreline and the island overall are very high probability for archaeologist resources to be impacted by this project. Monitoring for the work near the shoreline or in the intertidal will be the efficient way to reduce risk to the project in time delays.

Risk Assessments

To assist in the risk assessment for Alternatives B-D, (Figure 1), we researched:

1. previous archaeological records,
2. surface geology and soils (landform type),
3. ethnographic place names, and
4. proximity to freshwater.

The desktop analysis of each location came up with the following matrix with the details of each to follow in each section. Results:

Alternative A	Hat Island High	Mission Beach very high
Alternative B	Hat Island High	Camano Island very high
Alternative C	Hat Island High	Whidbey Island high
Alternative D	Hat Island High	Everett low to moderate

Without visiting the exact location of the cable entry/exit and matching our field testing with the proposed installation method, the desktop assessments are preliminary. The field testing at Mission Beach clearly showed archaeological material confirming that assessment.

Figure 1: Google Earth image showing Alternatives A-D.

Alternative A

The previously recorded archaeological sites and cultural surveys within a half mile of the APEs for Alternative A can be found in Table 3 and Table 4 in Section 4.3 of the main report. Archaeological expectations can also be found in Section 4.3. A summary of the surface geology and soils for Alternative A can be found in the Geology and Soils subsection of Section 4.1. Maps with Place names for both sides of Alternative A can be found in Figure 13 and Figure 14, with corresponding tables with description (Table 1, Table 2).

Risk Statement

This location is within 300 feet of a previously recorded archaeological site and a precontact artifact was uncovered during the survey on the Mission Beach side of Alternative A. This location is also within 300 feet of the Tribal Cemetery, adding to the local significance. The landform is low beach between Tulalip Bay and Possession Sound which is also high probability. The name of the point at the end of the spit just north of this location is Skiyou which is a Lushootseed word that usually refers to burials or human remains. This location is the highest risk for additional artifacts or for features or other archaeological resources.

The Hat Island APE is located on a low bank shoreline of the Puget Sound. Although nothing is recorded there and the three shovel tests didn't have anything in them, this is a high probability location for precontact artifacts or features. Its strategic value as a hub for transportation down the inside of Whidbey Island and that it is within 200 feet of the shoreline increases its risk drastically.

ERCI considers the overall risk of encountering archaeological material to be high to very high for Alternative A.

Alternative B

Previous Archaeology

There are no records of archaeological sites, National Register Properties, or cemeteries within a half mile of either side of Alternative B (Camano Island and Hat Island) on file with DAHP. Although this may suggest a low probability, this negative data reflects the reality that very few actual archaeological surveys have been carried out in the neighborhood. Only two small residential surveys have been completed within 1.5 miles of the Camano location for Alternative B. This can skew the assessment of risk. However, when reviewing the ethnographic data Twedell (1974) writes of the legend of the 'Fall of Camano Head' that describes a landslide from the early 19th century that buried people who were gathering clams on the beach below. Damage and death were also reported in the villages across Possession Sound from the ensuing tidal wave brought on by the landslide. Clearly the south end of Camano was a strategic location for resource gathering.

The overall risk of encountering precontact cultural resources is always high in places near salt water shorelines especially near streams or springs. Shoreline archaeological sites are often associated with resource procurement and may include evidence such as clam beds, fish traps, plant and animal processing and evidence of temporary camps.

Previous Cultural Resource Reports

There is one report on file with DAHP from previous cultural resource surveys within a half mile of the Camano side of Alternative B; they are listed below in Table 4.

Table 1: Previous cultural resource reports on file with DAHP.

Author	Title	Date
Kopperl	*Cultural Resources Assessment for the Sun Mountain Construction Camano Island Parcels, Washington.* **5 Test trenches. No protected cultural resources.**	2004

Surface Geology

The Washington State Department of Natural Resources (2016) map of surface geology shows a mass wasting deposits represented by Qls at the Camano Island side of Alternative B. Based on Twedell's (1974) research, under these mass wasting deposits are the highest probability for archaeological material and that colluvium-beach interface has an increased potential for human remains. The Hat Island side has Holocene beach deposits represented by Qb. As discussed in Alternative A the entire Hat Island shoreline has high probability for archaeological material.

Soils

There is one soil type within the Camano Island side: Aquic Dystroxerepts - Oxyaquic Xerorthents complex (Soil Survey Staff 2019). A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Both soils types have their origins in glacial marine drift.

Glacial drift is an early Holocene depositional matrix that can show little soil development in the sediment profile or a great deal depending on the chemistry of the location. In this case both locations are on beaches that have had active periods relatively recently. At times in the past when the beaches were stable would have been very attractive to people who were harvesting beach resources and other near shore resources.

Freshwater

There is no evident freshwater on maps within half a mile of the either side of Alternative B. It is likely that small wetlands, seeps or other water might be found during a field visit to either of these locations. Additionally, no modern evidence for fresh water doesn't preclude the existence of fresh water in the past. Usually we can see the evidence in topographic maps but not always.

Ethnographic Place Names

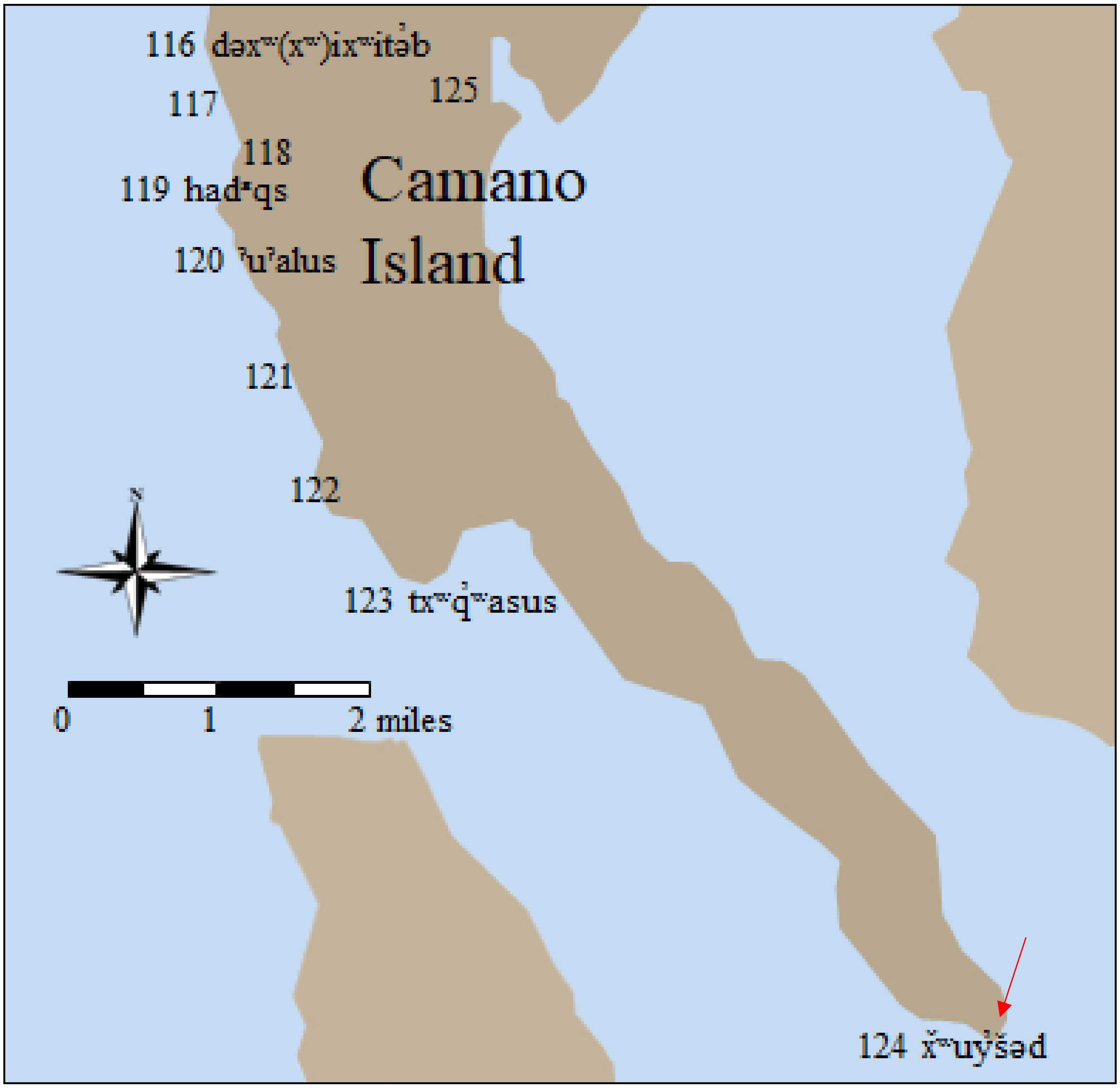

Figure 1: Map showing Waterman's place names with red arrow pointing to approximate location of Camano Island side of Alternative B (after Waterman 1920).

Risk Statement

The Camano side of Alternative B is adjacent or within an ethnographically named place. The landform is low and high bank east and south facing which is also high probability. The south facing landform is strategic as it is defensible and also provides an excellent view of Possession Sound. This location is high risk for additional artifacts or for features or other archaeological resources, especially below the colluvium at the interface with the old beach.

The Hat Island APE is located on a low bank shoreline of the Puget Sound. It is a high probability location due to its strategic value as a hub for transportation between Whidbey and Camano Islands and the mainland. And that it is within 200 feet of the shoreline increases its risk drastically.

ERCI considers the overall risk of encountering precontact cultural resources to be high for both sites of Alternative B.

Alternative C

Previous Archaeology

There are no records of archaeological sites, National Register Properties, or cemeteries within a half mile of either side of Alternative C (Whidbey Island or Hat Island) on file with DAHP. Although this sounds like this might suggest a low probability but really this negative data reflects the reality that very few actual archaeological surveys have been carried out in the neighborhood.

A single survey was carried out 1.5 miles north of the Whidbey location for Alternative C, and that survey recorded an archaeological site. This entire stretch of shoreline has not had any surveys so we don't know if there are any sites here or not. This lack of data can skew the assessment of risk.

The overall risk of encountering precontact cultural resources is always high in places near salt water shorelines especially near streams or springs. Shoreline archaeological sites are often associated with resource procurement and may include evidence such as clam beds, fish traps, plant and animal processing and evidence of temporary camps.

Archaeological Expectations

DAHP also considers the overall risk of encountering precontact cultural resources to be high in places near to the sea or streams. Shoreline archaeological sites are often associated with resource procurement and may include evidence such as fish weirs, plant and animal processing tools and evidence of temporary camps. ERCI could expect to find shoreline archaeological sites or isolates on either side of the Alternative C.

Surface Geology

The Washington State Department of Natural Resources (2016) map of surface geology shows a continental glacial drift represented by Qgpc on the Whidbey Island side and Holocene beach deposits represented by Qb on the Hat Island side of Alternative C.

Soils

There is one soil type within the Hat Island side of Alternative C: Kitsap silt loam (Soil Survey Staff 2019). Kitsap silt loam is distributed on terraces, in lacustrine deposits with a minor amount of volcanic ash. It is moderately well drained, with a depth to the water table of about 18 to 36 inches. The surface does not pond or flood. A typical profile includes: 0 to 24 inches, silt loam; 24 to 60 inches, stratified silt to silty clay loam (Soil Survey Staff 2019).

There is one soil type within the Whidbey Island side of Alternative C: Aquic Dystroxerepts - Oxyaquic Xerorthents complex (Soil Survey Staff 2019).

Both Aquic - Dystroxerepts and Oxyaquic - Xerorthents are distributed on hillslopes and sea cliffs, in colluvium from glacial drift. It is somewhat poorly drained, with a depth to the water table of about 16 to

28 inches. The surface does not flood or pond. A typical profile consists of 0 to 4 inches: moderately decomposed plant material; 4 to 7 inches, slightly decomposed plant material; 7 to 17 inches: loamy sand; 17 to 41 inches: silt loam; 41 to 63 inches, fine sandy loam.

Freshwater

There is no freshwater within half a mile of the Whidbey Island side of Alternative C or the Hat Island APE, however the landform on the Whidbey side suggests that water at one time carved a path through the high bank in or near this location, drastically increasing the probability of precontact use in this location.

Ethnographic Place Names

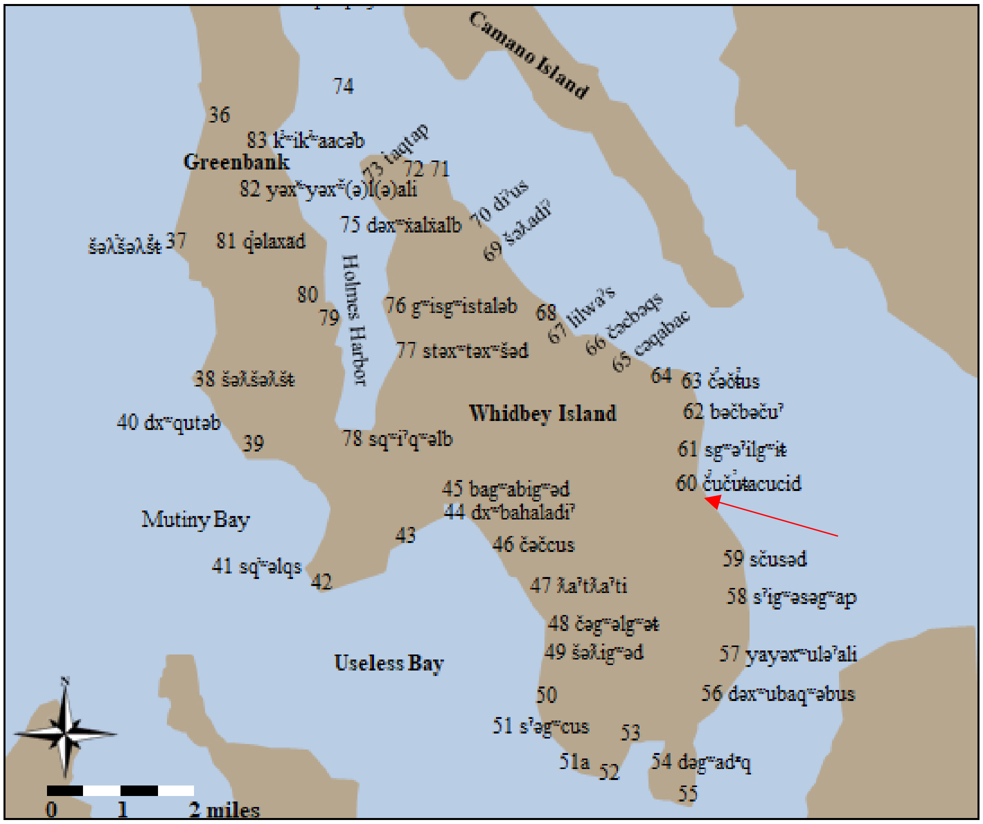

Figure 2: Map showing Waterman's place names with red arrow showing approximate location of Whidbey Island Alternative C location (after Waterman 1920).

Risk Statement

Whidbey side of Alternative C is adjacent or within an ethnographically named place. It suggests a place between the highbank shoreline suggesting that there may have been water in the past if there isn't today. The landform is both low and high bank and east facing over the sound, which is also high probability. The nearby high bank is strategic, as it is defensible and also provides an excellent view of Possession Sound. This location is high risk for additional artifacts or other archaeological resources, especially near any extinct or extant fresh water features.

The Hat Island APE is located on a low bank shoreline of the Puget Sound. It is a high probability location due to its strategic value as a hub for transportation between Whidbey and Camano Islands and the mainland. And that it is within 200 feet of the shoreline increases its risk.

ERCI considers the overall risk of encountering precontact cultural resources to be high for both sites of Alternative C.

Alternative D

Previous Archaeology

There are no records of archaeological sites, or cemeteries within a mile of either end of Alternative D (Hat Island and Everett) on file with DAHP. Although this sounds like this might suggest a low probability but really this negative data reflects the reality that very few actual archaeological surveys have been carried out in the neighborhood. Three archaeological surveys have been completed within 1.5 miles on the Everett side and in 2 of those recorded archaeological sites. State and National Historic register sites are recorded south of the project area along the old historic waterfront.

The overall risk of encountering precontact cultural resources is always high in places near salt water shorelines especially near streams or springs. Shoreline archaeological sites are often associated with resource procurement and may include evidence such as clam beds, fish traps, plant and animal processing and evidence of temporary camps.

Previous Cultural Resource Reports

There are two reports on file with DAHP from previous cultural resource surveys within a half mile of the Everett side of Alternative D; they are listed below in Table 4.

Table 2: Previous cultural resource reports on file with DAHP.

Author	Title	Date
McDaniel	*Cultural Resources Inventory Report, Everett Shipyard Cleanup Project, 1016 14th Street, Everett, Washington.* **No subsurface survey. No protected cultural resources.**	2011
Lewis	*Archaeological Investigation Report: Everett Grand Avenue Park (Utility and Pedestrian) Bridge Project, Snohomish County, Washington.* **25 shovel tests. No protected cultural resources.**	2015

National Register Properties

There are three National Register Properties on file with DAHP within one mile of the Everett side of Alternative D. A short description is provided below.

SN00340—Coaster II is a schooner built in 1933 of white oak, Honduras mahogany, and Burma teak (Stoddard and Stoddard 1989). It is about is ~0.10 miles from the Everett side of Alternative D.

SN00114—Schooner "Equator" was built in 1888 and was abandoned on the Snohomish River jetty in 1958 (Schalka 1969). It is about is ~0.15 miles from the Everett side of Alternative D.

SN00114—North Coast Casket Company Building has significance between 1923 and 1956 (Johnson and Mirro 2005). It is about is ~0.35 miles from the Everett side of Alternative D.

Archaeological Expectations

DAHP considers the overall risk of encountering precontact cultural resources to be high in places near to the sea or streams. The Hat Island site of this alternative is high due to being on a shoreline and in a strategic position. The Everett side of Alternative D may have precontact deposits below any fill deposits and there may be artifacts in fill deposits that would need to be evaluated that could take time during construction.

Soils

The Hat Island APE contains two soil types: gravelly sandy loam and Alderwood-Everett gravelly sandy loams (Soil Survey Staff 2019).

Alderwood gravelly sandy loam is distributed on ridges and hills, in glacial drift and/or glacial outwash over dense glaciomarine deposits. It is moderately well drained, with a depth to the water table of about 18 to 37 inches. The surface does not pond or flood. A typical profile includes: 0 to 7 inches, gravelly sandy loam; 7 to 59 inches, very gravelly sandy loam

Everett very gravelly sandy loam is distributed on eskers, kames and moraines, in sandy and gravelly glacial outwash. It is somewhat excessively drained, with a depth to the water table of more than 80 inches. The surface does not pond or flood. A typical profile includes: 0 to 1 inch, slightly decomposed plant material; 1 to 24 inches, very gravelly sandy loam; 24 to 35 inches, very gravelly loamy sand; 35 to 60 inches, extremely cobbly coarse sand

Freshwater

The Everett side of Alternative D is at the mouth and estuary of the Snohomish River, and the glacial upland probably has small drainages that come down the west side of those high banks.

Ethnographic Place Names

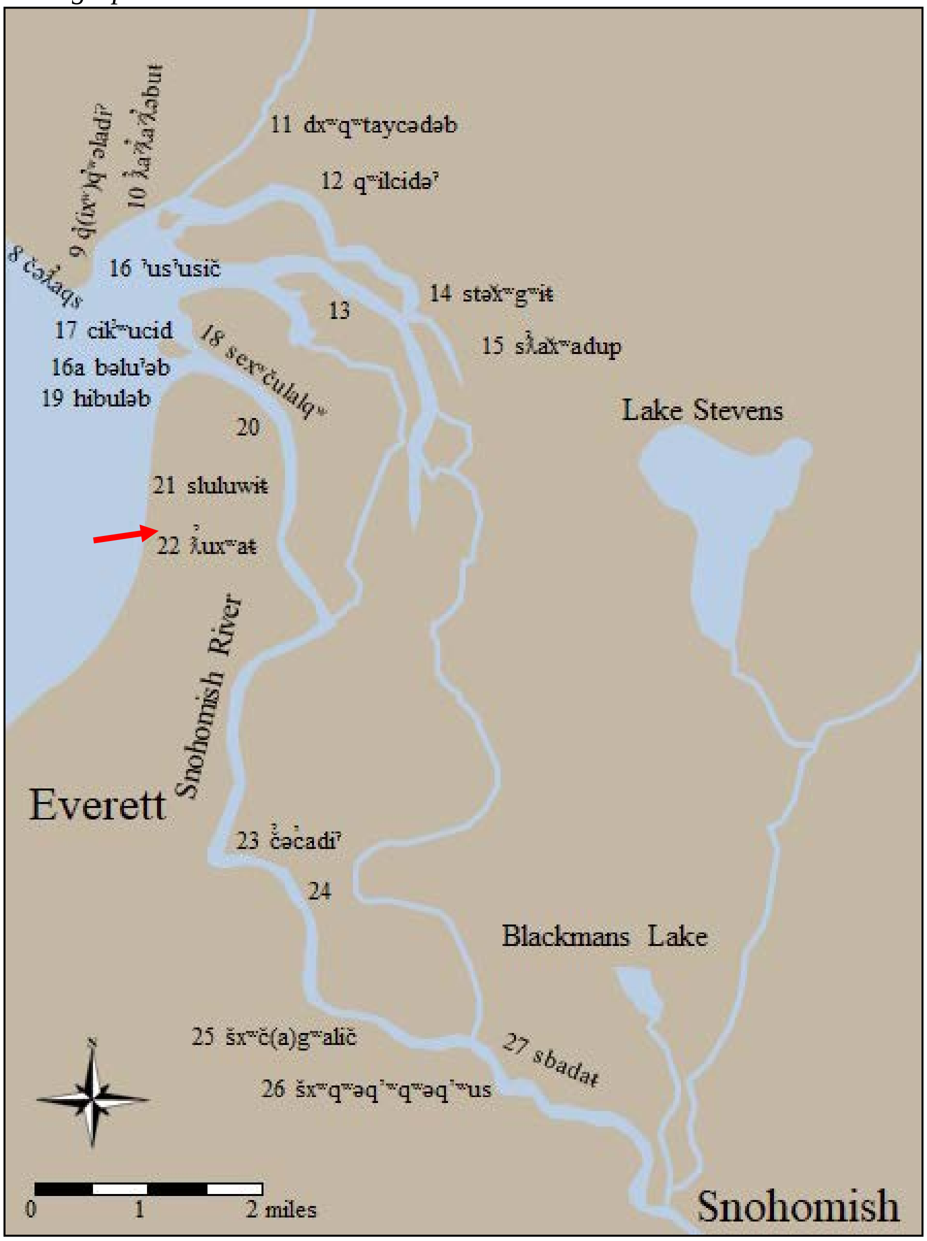

Figure 3: Map showing Waterman's place names with red arrow showing approximate location of Everett side of Alternative D (after Waterman 1920).

Risk Statement

The Everett side of Alternative D may be in or adjacent to two ethnographically named places. It has a jetty island and then a beach on the mainland. Both of these landforms have had a great deal of disturbance which makes predicting where the project could intersect with intact native sediments. Below any local or imported fill would be the highest risk for encountering intact features and objects that would rise to the level of significant. Disturbed deposits that contact either historic or precontact deposits in them could be high probability for other objects that would need evaluation and could slow down installation of a cable.

The Hat Island APE is located on a low bank shoreline of the Puget Sound. It is a high probability location due to its strategic value as a hub for transportation between Whidbey and Camano Islands and the mainland. And that it is within 200 feet of the shoreline increases its risk drastically.

ERCI considers the overall risk of encountering high on Hat Island and low to moderate for the Everett side of Alternative D. Not knowing the nature of the deposits on the Everett side of this alternative creates some risk for the project.