Shoreline Geotechnical Assessment

Red Barnacle Shoreline – 4 Parcels

25820 & 25832 120th Lane SW
Parcels 2522029058, et. al.
Vashon, Washington

February 17, 2026
Project #25019

Prepared For:

Red Barnacle, LLC
Joy Brooks

Prepared By:

Envirotech Engineering, PLLC
PO Box 984
Belfair, Washington 98528
Phone: 360-275-9374

2/17/26

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1.0 INTRODUCTION

Envirotech Engineering, PLLC (Envirotech) has completed this shoreline geotechnical assessment in support of proposed bulkhead repair on 4 parcels located at 25820 & 25832 120th Lane SW (parcel numbers 2522029058, 2522029055, 2522029057 & 2522029010) in Vashon, Washington. As presented herein, this assessment includes information pertaining to the project in this Introduction Section; observations of the property and surrounding terrain in the Surface Conditions Section; soils and geological descriptions in the Subsurface Investigation Section; and, assessments and considerations for the development of this project in the Conclusions and Recommendations Section.

1.1 Project Information

Information pertaining to the project was provided by the proponent of the property and professional representatives of the property owner. Other project information is provided by Envirotech upon conducting a site visit on March 4, 2025. The proposed project is planned to consist of a new soldier pile wall directly behind the existing concrete bulkhead that is failing within Quartermaster Harbor of the Puget Sound. This is deemed as a repair to help stabilize the existing seawall and increase its longevity.

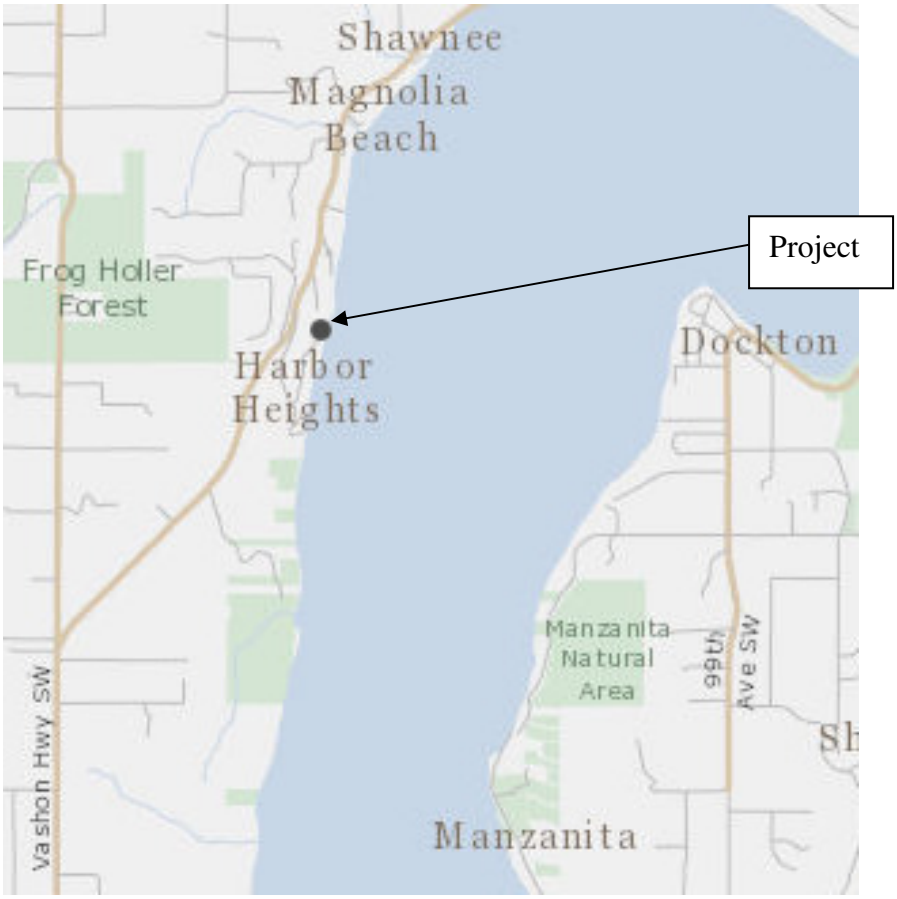
The purpose of repairing the shoreline armoring is to benefit the integrity of the property infrastructure including 2 homes, 2 septic drainfield between the existing residences and the bulkhead, sole ingress/ egress for the southern lot, and other established infrastructure. Approximate site development with relation to site features are illustrated in the Site Map in Appendix A.

1.2 Purpose of Investigation and Scope of Work

The purpose of this shoreline geotechnical assessment was to evaluate the proposed project with relation to erosion, geologic hazards, shoreline alternatives, site adequacy, and geological and hydrological impacts to the property and adjacent/ downstream properties.

In order to fulfill the purpose of investigation, the geotechnical program completed for the proposed improvements include:

- Review project information provided by the proponents of the property;
- Conduct a site visit to document the site conditions that may influence the construction and performance of the proposed improvements;
- Define general subsurface conditions of the site by observing near surface soils, the exposed shoreline bank, review nearby geotechnical reports and well logs prepared by others, and review soil/ geological maps for the vicinity of the project;
- Complete an engineering assessment supported by planned site alterations and the surface and subsurface conditions that were identified by the field investigation, soil testing, and applicable project research; and,
- Establish engineering conclusions and recommendations based on findings and the anticipated development.



Vicinity Map from King County Website

2.0 SURFACE CONDITIONS

Information pertaining to the existing surface conditions for the project was gathered on March 4, 2025 by a representative with Envirotech. During the site visit, site features were documented that may influence construction or reveal potential geological or hydrologic hazards. This Surface Conditions Section provides information on general observations, vegetation, topography, drainage and slope/ erosion conditions for the project and surrounding areas.

2.1 General Observations

The parcel is currently developed with single family residences, each on the northern and southern parcels, driveway that traverses the middle 2 lots in order to access the southern parcel, concrete bulkhead, septic systems between both homes and the bulkhead, and other ancillary features typical of this type of development. Vegetation consists mainly of landscaping, firs, maples and other vegetation typical of the Pacific Northwest. Beach flora was not observed at the time of our site visit.

The concrete bulkhead was observed to have severe cracks, minor bleeding of the reinforcement corrosion, and have substantial degradation of the concrete.

An aerial photo of the project and immediate vicinity is provided below. See the photographs in Appendix B for illustrations of site conditions.

2.2 Topography

The topographic information provided in this section was extrapolated from a public lidar source, and incorporated observations and field measurements, where necessary. Slopes are mostly steep upland from the residences with grades of up to 154% for vertical reliefs of about 10 to 20 feet. The overall vertical relief of critical grades are approximately 80 feet. The bulkhead has a vertical height of 6.5 feet.

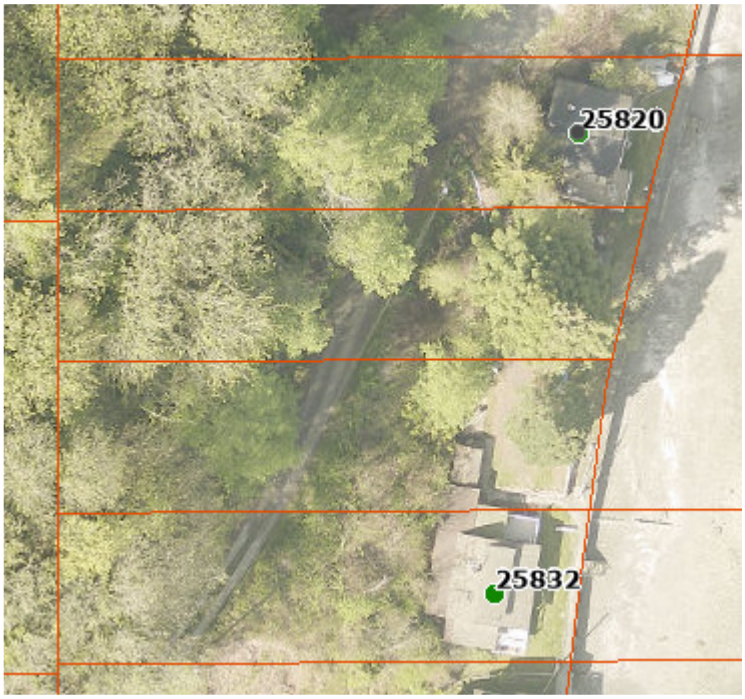
2.3 Surface Drainage and Hydrology

Surface water such as streams or wetlands do not affect the property. The upslope watershed from the property is relatively small with intercepting characteristics due to upland development. Storm runoff entering the site appears to be negligible. Seepage or indications of excessive seepage along the shoreline bank was not observed.

The ordinary high water mark of the Puget Sound is approximately 4 feet up the face of the adjacent timber bulkhead from existing beach grade. It is apparent that the shoreline area is within the FEMA flood zone.

2.4 Slope and Erosion Observations

Shoreline erosion that we observed included very minor erosion directly behind the bulkhead in isolated places, and some toe ersosion at the base of the bulkhead. A pre-historic landslide on and within the vicinity of the properties is evident from an upland scarp and hummocky/ stepped terrain.



Aerial Photo from King County Website

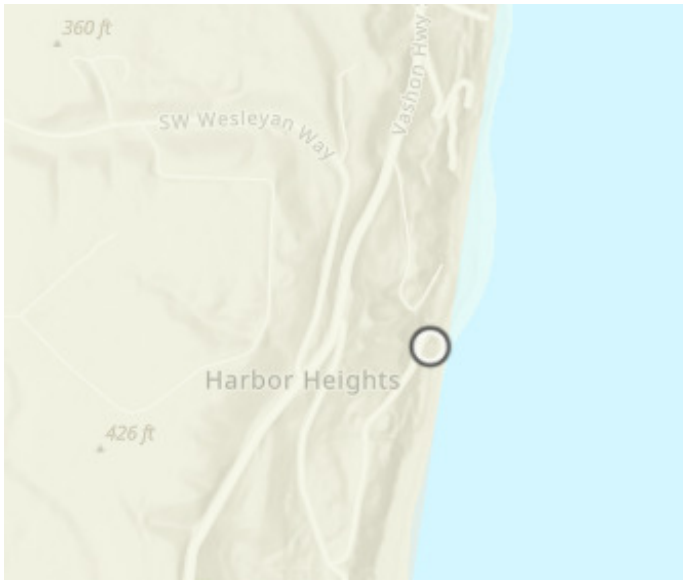
3.0 SUBSURFACE INVESTIGATION

Information on subsurface conditions pertaining to the project was gathered during research and a site reconnaissance. We also reviewed a geotechnical report originating to the south of the property. Our site visit was accomplished on March 4, 2025 by a representative with Envirotech. Specific information on field methods, sampling, field testing, subsurface conditions, and results from soil testing are presented in this section of the report.

3.1 Geologic Conditions

In general, soils at the project are composed of materials from glacial advances. The geologic conditions as presented in the "Geologic Map of Washington," compiled by J. Eric Schuster, 2002 indicates Quaternary sediments, Q_g. Quaternary sediments are generally unconsolidated deposits, and dominantly deposited from glacial drift, including alluvium deposits. This project is located within the Puget Lowland. Typically, "lower tertiary sedimentary rocks unconformably overlie the Crescent Formation." as revealed in the Geologic Map. Initial sedimentary rocks were formed from shales, sandstones and coal deposits from rivers. During the Quaternary period, the Puget Lowland was covered by numerous ice sheets, with the most recent being the Fraser glacier with a peak of approximately 14,000 years ago. Upon the glacial retreat, the landscape was formed by glacial erosion glacial drift deposits. The "Interactive Geologic Map" from the Department of Natural Resources provides the following caption(s) for the project area:

Map Unit: Qgd
Name: Pleistocene continental glacial drift
Full Name: Pleistocene continental glacial drift
Age: Quaternary (Pleistocene)
Description: Pleistocene till and outwash clay, silt, sand, gravel, cobbles, and boulders deposited by or originating from continental glaciers; locally includes peat, nonglacial sediments, modified land, and artificial fill.



Geological Map Department of Natural Resources Washington State

3.2 Specific Subsurface Conditions

The following subsurface conditions are estimated descriptions of the project subgrade utilizing information from the depth of penetration at all testing, sampling, observed and investigated locations. Soils for this project were described utilizing the Unified Soil Classification System (USCS). Using the USCS in conjunction with estimated relative densities and other anticipated engineering properties of the soil, susceptibility for potential landslides, erosion and seismic hazards may be assessed.

A total of 3 test pits were observed from a combination of excavations by the contractor, probing the bottom of the excavation, and interpolating hardpan depths from the shallow glacial till observed on the waterside of the bulkhead. See the test pit locations in Appendix A, in which the pits were about 1-foot to 3 feet behind the existing bulkhead. The following soil profiles were observed:

Test Pit #1	0 - 5’	Brown Clay (CL) with some silt and fine sand. Medium plasticity
	42”	Water seepage
	5’ – 6’	Gray/ Blue Silty Clay (CL-ML) (Blue Clay) with some fine sand
Test Pit #2	0 – 2’	Brown Silty Clay (CL-ML). Low plasticity
	2’ – 4’	Brown Clay (CL) with traces of fine sand
	4’ – 6’	Gray/ Blue Silty Clay (CL-ML) (Blue Clay) with some fine sand
	87”	Light Brown, cemented Silty Sand (SM) (Hardpan)
Test Pit #3	0 – 5’	Brown Silty Clay (CL-ML) with pockets of CL. Low plasticity
	5’ – 7’	Gray/ Blue Silty Clay (CL-ML) (Blue Clay) with fine sand
	7’	Light Brown, cemented Silty Sand (SM) (Hardpan)

3.2.1 Groundwater and Hydrogeology

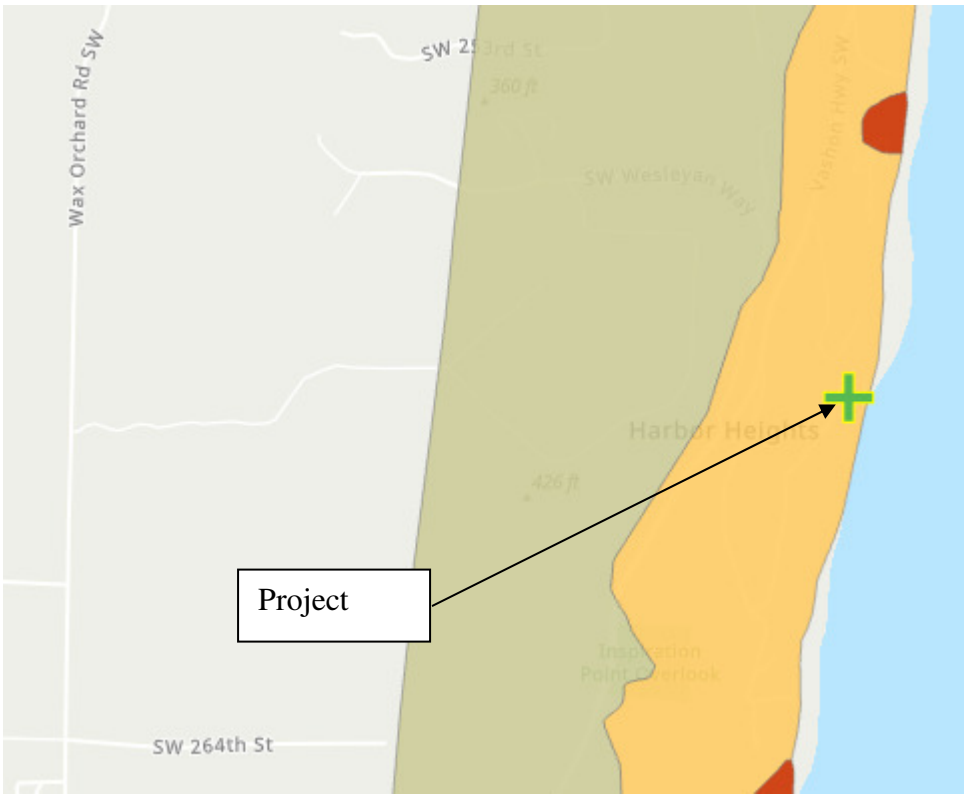
Permanent groundwater is expected to be at least 30 feet directly below the ground surface near the lowlands of the property (beach). Surface seepage was observed in one test pit at a depth of 42 inches at the time of our site visit. Perched groundwater was not observed.

4.0 ENGINEERING CONCLUSIONS & RECOMMENDATIONS

The following sections present engineering assessments and conclusions concerning the project. These conclusions have been made available based on the planned construction activities as outlined in the Introduction Section of this report; general observations of drainage and topography as summarized in the Surface Conditions Section; and, soil conditions that were identified by the field investigation and soils testing as outlined in the Subsurface Investigation Section. Conclusions for the project that is provided herein, includes pertinent information for landslide, erosion and seismic hazards.

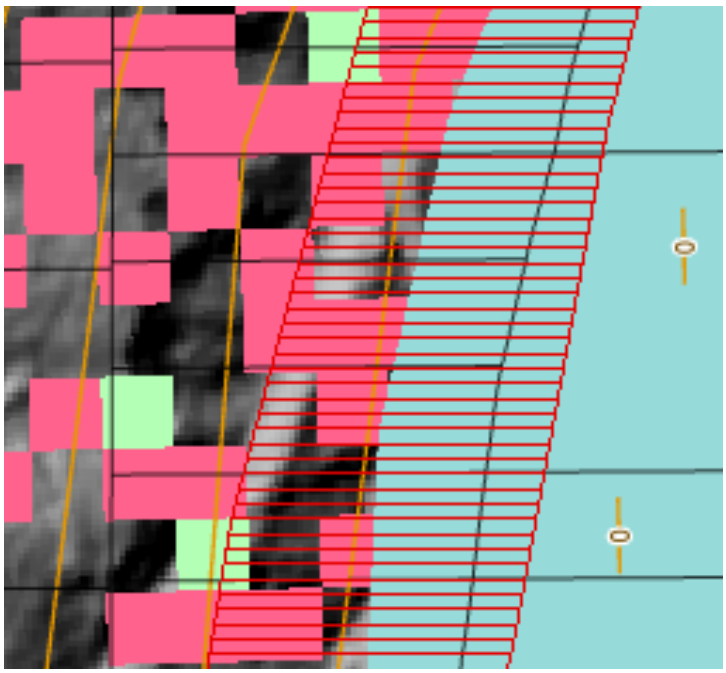
4.1 Landslide Hazards and Effects of Proposed Development

According to the Coastal Zone Atlas of King County, Washington, the project is within terrain labeled 'Unstable' regarding potential landslide activity. A Stability Map from the Coastal Zone Atlas for the general area of this project may be found below.



Map from Washington State Department of Ecology Website

According to the Resource Map from the Washington State Department of Natural Resources (DNR), the project is not within terrain labeled 'highly unstable' relating to soils. DNR labeled portions of this project as medium and high slope instability with relation to slopes. A Resource Map from the DNR Forest Practices Application Review System is provided below:



Map from Washington State Department of Natural Resources Website

4.2 Erosion Hazards

Based on the USCS description and soil density of the near-beach soils and shoreline bank, the surface soils are considered highly erodible. According to the Resource Map from the Washington State DNR, the project is not within terrain labeled 'highly erodible.'

Due to the shoreline dynamics such as waves and currents, especially during storm surges, it is our opinion that this property has a high susceptibility risk for shoreline erosion without a bulkhead. The existing feeder bluff coupled with over-steepened (vertical) soil profile with silts and clay are the primary factors for erosion.

4.3 Seismic Hazards

There appears to be a fault away from the property identified as the Tacoma Fault Zone. This fault is a Class 'B,' and is located outside of the zone of influence concerning fault line hazards. This information is supported by the USGS Quaternary Fault and Fold Database for the United States.

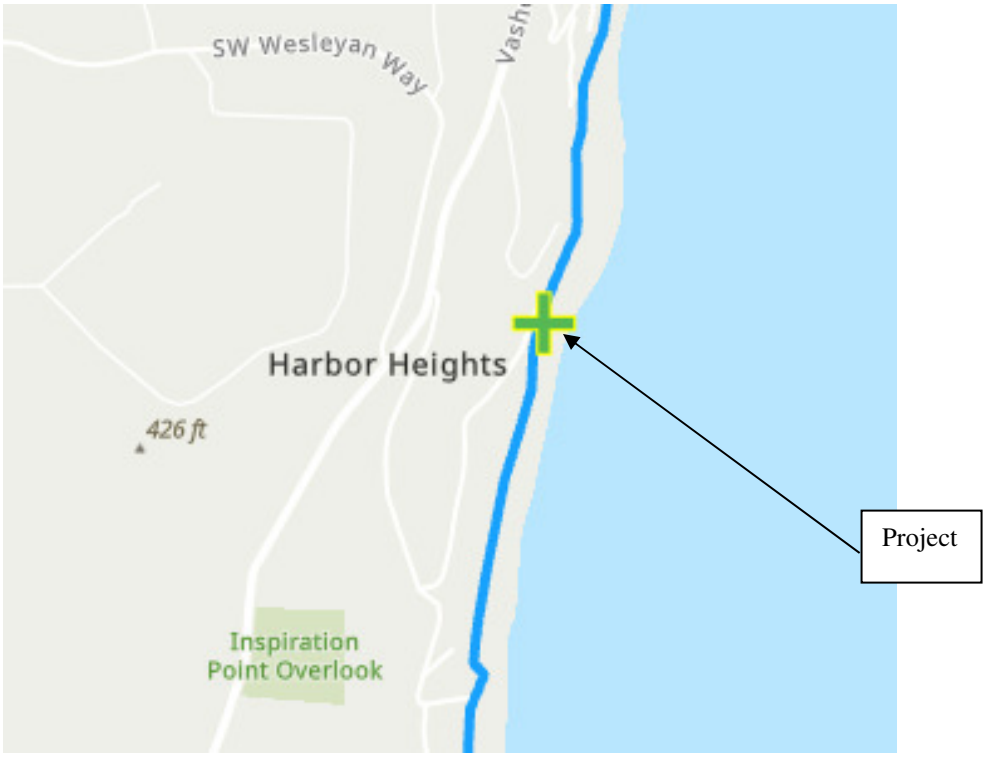
The potential for liquefaction is believed to be low for this project. According to the Interactive Geologic Map of Washington, liquefaction susceptibility is low within the vicinity of this project.

This is also based on subsurface conditions such as soil characteristics and the lack of a permanent and substantial shallow water table. Subgrade characteristics that particularly contribute to problems caused by seismic events include submerged and confined, poorly-graded granular soils. Although gravel- and silt-sized soil particles could be problematic, fine and medium grained sands are typically subjected to these types of seismic hazards.

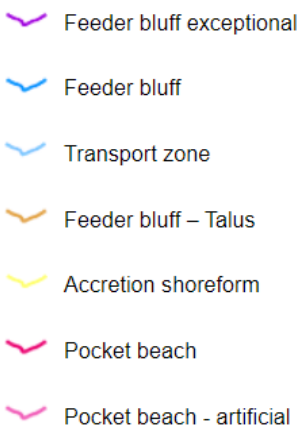
4.4 Shoreline Development Conclusions & Recommendations

Conclusions in this report are based on the type and location of the anticipated development, and existing on-site and off-site conditions. Site development that significantly deviates from the anticipated improvements presented in this report, or future nearby development that influences this project may require a geotechnical re-evaluation.

This Shoreline Development Conclusions and Recommendations Section provides our analysis and conclusions of the local shoreline process and how it relates to the existing infrastructure for when the bulkhead fails. Envirotech analyzed alternative approaches and mitigation measures for the project site. We also included recommendations for the structural aspect and development.



Coastal Landform Map from Washington State Department of Ecology Website



4.4.1 Bulkhead Necessity

As demonstrated in this section, functioning shoreline armoring is needed for the protection of sole ingress/ egress, both of the single family residences and their onsite septic systems.

- An unprotected shoreline is a high erosion hazard for this property. Per the Surface and Subsurface Conditions Sections of this report, Envirotech observed some shoreline erosion and soils with extreme erosion potential. The property is mapped as having a feeder bluff per the Washington State Department of Ecology. See the illustration below. By definition, a feeder bluff is actively contributing or "feeding" sediments to beaches.

- Shoreline erosion is the primary culprit that, if left unrestrained, will endanger the existing residences and its inhabitants. It will also compromise the septic drainfield, the health of the local environment, and contribute to the overall damaging effects of the harbor and Puget Sound.

- The project is designated as 'High Risk' per the Marine Shoreline Design Guidelines (MSDG) by the Washington Department of Fish & Wildlife. It is recommended by the MSDG that high risk sites utilize hard armoring. See Appendix C for a depiction of the cumulative risk model per the MSDG.

- Dynamics of active shoreline erosion includes eroding the bluff toe, thereby further destabilizing the upper bank, which induces a landslide. As provided herein, Envirotech concludes that without the benefit of the bulkhead and retaining structures, that a landslide would severely compromise the septic drainfields and place the homes and access in danger.

4.4.2 Slope Stability Evaluation

Per the slope stability analysis below, erosion of the buttressing toe of the shoreline bank shall not occur. The existing property critical infrastructure that includes the 2 homes, 2

septic systems, and access to the southern parcel cannot afford failure of the existing bulkhead and subsequent shoreline erosion.

Based on soils being predominantly a deep profile of clay and silt, a conservative angle of repose for safety may be estimated as 32 degrees, whereas a safe setback would be a minimum of the intersection of the angle of repose and ground surface. Assuming that no shoreline toe erosion occurs, this intersection would be approximately 21 feet behind the bulkhead, which includes all or a portion of the aforesaid critical infrastructures.

It may be assumed that some rapid toe erosion would occur upon bulkhead failure due to the soil characteristics along the feeder bluff, thereby extending the failure area beyond the 21-foot limit.

4.4.2 Shoreline Stabilization Per King County Code

Shoreline Stabilization per King County Code 21A.25.170 was considered in our geotechnical assessment as outlined below. The following excerpts from the Code that are relevant to geological and shoreline hazards and the need for hard armoring is provided below as italicized type. Below each code provision, we describe how the project satisfies or dissatisfies the key criteria cited in that code provision with respect to our field of study.

21A.25.170 (A). Shoreline stabilization shall not be considered an outright use and shall be permitted only when the department determines that shoreline protection is necessary for the protection of existing legally established primary structures, new or existing non-water-dependent development, new or existing water-dependent development or projects restoring ecological functions or remediating hazardous substance discharges. Vegetation, berms, bioengineering techniques and other nonstructural alternatives that preserve the natural character of the shore shall be preferred over riprap, concrete revetments, bulkheads, breakwaters and other structural stabilization. Riprap using rock or other natural materials shall be preferred over concrete revetments, bulkheads, breakwaters and other structural stabilization. Lesser impacting measures should be used before more impacting measures.

The least impacting shoreline protection measure has been analyzed per the Alternative Approaches Section 4.4.3 of this report.

21A.25.170(B). Structural shoreline stabilization may be permitted subject to the standards in this chapter and as follows:
1. The applicant provides a geotechnical analysis that demonstrates that erosion from waves or currents is imminently threatening or that, unless the structural shoreline stabilization is constructed, damage is expected to occur within three years;
2. The erosion is not caused by upland conditions;
3. The proposed structural shoreline protection will provide greater protection than feasible, nonstructural alternatives such as slope drainage systems, vegetative growth stabilization, gravel berms and beach nourishment;
4. The proposal is the minimum necessary to protect existing legally established primary structures, new or existing non-water-dependent development, new or existing water-

dependent development or projects restoring ecological functions or remediating hazardous substance discharges; and
5. Adequate mitigation measures will be provided to maintain existing shoreline processes and critical fish and wildlife habitat and ensure no net loss or function of intertidal or riparian habitat.

It is our opinion that this geotechnical analysis demonstrates that erosion from waves or currents is imminently threatening or that, unless the structural shoreline stabilization is constructed, damage is expected to occur within three years. See the Bulkhead Necessity Section 4.4.1 outlined earlier in this report for justifications based on published Shoreline Design Guidelines and geotechnical engineering.

Primary erosion for this property is not caused by upland conditions. Besides the property listed as a feeder bluff, see our site observations listed in Section 1.2 of this report.

The proposed structural shoreline protection will provide greater protection than feasible, nonstructural alternatives such as slope drainage systems, vegetative growth stabilization, gravel berms and beach nourishment. See Section 4.4.3 of this report for an analysis on nonstructural alternatives, and why they are not feasible for this project.

The proposed shoreline protection is the minimum necessary to protect existing legally established primary structures, critical ingress/ egress, and the septic systems.

Adequate mitigation measures will be provided by other professionals to maintain existing shoreline processes and critical fish and wildlife habitat and ensure no net loss or function of intertidal or riparian habitat, if necessary.

21A.25.170 (C). Shoreline stabilization to replace existing shoreline stabilization shall be placed landward of the existing shoreline stabilization, but may be placed waterward directly abutting the old structure only in cases where removal of the old structure would result in greater impact on ecological functions. In critical saltwater habitats, existing shoreline stabilization shall not be allowed to remain in place if the existing shoreline stabilization is resulting in the loss of ecological functions. Adequate mitigation measures that maintain existing shoreline processes and critical fish and wildlife habitat must be provided that ensures no net loss or function of intertidal or riparian habitat.

The proposed bulkhead repair should not encroach waterward of the existing shoreline/ bank stabilization.

21A.25.170 (D). The maximum height of the proposed shoreline stabilization shall be no more than one foot above the elevation of extreme high water on tidal waters, as determined by the National Ocean Survey published by the National Oceanic and Atmospheric Administration, or four feet in height on lakes.

Envirotech concurs that it is not necessary to have the maximum height of the shoreline stabilization structure no more than one foot above the elevation of extreme high water. The structural engineer should take this into account during their design process.

21A.25.170 (E). Shoreline stabilization is prohibited along feeder bluffs and critical saltwater habitat, unless a geotechnical report demonstrates an imminent danger to a legally established structure or public improvement. If allowed, shoreline stabilization along feeder bluffs and critical saltwater habitat must be designed to have the least impact on these resources and on sediment conveyance systems.

This geotechnical report demonstrates an imminent danger to legally established structures, and their access and drainfields. See the rationale and details provided in Section 4.4.1 of this report.

21A.25.170 (F). Shoreline stabilization shall minimize the adverse impact on the property of others to the maximum extent practical.

It is our opinion that the repair plan of soldier piles behind the existing bulkhead for added support will mitigate adverse impacts on the properties of others to the maximum extent practical.

21A.25.170 (G). Shoreline stabilization shall not be used to create new lands.

New lands shall not be created when establishing the bulkhead. From a geotechnical perspective, this would not be required per our recent observations.

21A.25.170 (H). Shoreline stabilization shall not interfere with surface or subsurface drainage into the water body.

As previously stated in this report, surface for subsurface drainage is not a limiting factor for this project, and will not be interfered with.

21A.25.170 (I). Automobile bodies or other junk or waste material that may release undesirable material shall not be used for shoreline stabilization.

Waste material will not be used for shoreline protection.

21A.25.170 (J). Shoreline stabilization shall be designed so as not to constitute a hazard to navigation and to not substantially interfere with visual access to the water.

The bulkhead designer shall design accordingly, and in our belief, will not interfere with navigation or visual access to the water.

21A.25.170 (K). Shoreline stabilization shall be designed so as not to create a need for shoreline stabilization elsewhere.

If recommendations provided in this report is adhered to, the required shoreline stabilization for this project will not be located or designed in such a manner that would create a need for shoreline stabilization elsewhere.

21A.25.170 (L). Shoreline stabilization shall comply with the Integrated Stream Protection Guidelines (Washington state departments of Fish and Wildlife, Ecology and

Transportation, 2003) and shall be designed to allow for appropriate public access to the shoreline.

From a geotechnical perspective, it is our opinion that this portion of the code will be adhered to.

21A.25.170 (M). The department shall provide a notice to an applicant for new development or redevelopment located within the shoreline jurisdiction on Vashon and Maury Island that the development may be impacted by sea level rise and recommend that the applicant voluntarily consider setting the development back further than required by this title to allow for future sea level rise. (Ord. 16985 § 41, 2010: Ord. 5734 § 5, 1981: Ord. 3688 § 413, 1978. Formerly K.C.C. 25.16.180).

The existing residences are sufficiently elevated from impacts of sea level rise.

4.4.3 Alternative Approaches Analysis

Alternative approaches were considered in our geotechnical assessment as outlined in the Washington Administrative Code (WAC) 220-660-370 (3). Per this selection process, the code requires the use of the least impacting technically feasible shoreline stabilization alternative, whereas feasible means available and capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall project purposes. Furthermore, the WAC states that a hard armoring technique should be proposed after considering site characteristics such as the threat to major improvements, wave energy, and other factors in an alternative analysis.

The following key excerpts from that are relevant to geological and shoreline hazards and the need for to maintain a functional, hard armored bulkhead (such as what is proposed in the current plans) is provided below in italics. Below each code provision, we describe how the project satisfies or dissatisfies all of the key criteria cited in that code provision with respect to our field of study.

WAC 220-660-370(3)(c) – Common alternatives for replacement or rehabilitation of residential shoreline stabilization are, from most preferred to least preferred:

(i) Remove the existing shoreline stabilization structure and restore the beach.

This alternative is infeasible because a major improvement (existing residences, access and septic drainfields) are in danger without adequately functioning shorleline protection. As previously substantiated in this report, the home and drainfield could be compromised in less than 3 years if the beach is restored.

(ii) Remove the existing shoreline stabilization structure and install native vegetation.

This alternative is infeasible due to vegetation having a lack of shoreline bank protective qualities for this specific project. Furthermore, the vertical face backfill is not conducive for establishing vegetation or resisting erosion.

(iii) Remove the existing shoreline stabilization structure and control upland drainage.

As previously outlined in Section 2.3 of this report, upland drainage issues are not a problem for this project, therefore this alternative analysis is not feasible.

(iv) Remove the existing shoreline stabilization structure and replace it with a soft structure constructed of natural materials, including bioengineering.

Unless a structural engineered system is designed, soft armoring such as logs and root wads are not feasible for this project. This is due to the following:

- MSDG recommends not using soft shore protection as previously outlined in this report.
- Stability and safety of the existing homes, access and drainfields are extremely sensitive to the mitigation technique for bank erosion. Soft armoring has not been proven to mitigate erosion over the long term as compared to hard armoring,
- Soft shore armoring will allow the lower bank soils to erode immediately because shoreline waves and currents fully penetrate soft shore methods, and allows the loose sediments to dissipate through piping failure, and,
- The limited height of soft armoring does not protect the shoreline as would a hard bulkhead during storm surges and wave energy.

(v) Remove the existing hard structure and construct upland retaining walls.

This alternative is not feasible. Upland retaining walls would be within the septic drainfields or its attenuation zone

(vi) Remove the existing hard structure and replace it landward with another hard structure, preferably at or above the ordinary high water line.

For the specific site conditions of this project, this alternative is not feasible in the sense that the entire bank is required to buttress the hillside for protecting the homes, access and septic systems. Removing the existing bulkhead in itself could be detrimental to the hillside. Lack of space is also an issue for these properties.

(vii) Remove the existing hard structure and replace it in the same footprint with another hard structure.

This option is feasible as it will virtually mimic what has been pre-existing which has been protecting the existing home and septic for decades. However, the owner plans to be less intrusive by having a pile system directly behind the bulkhead for added support.

4.4.4 Mitigation Measures

Measures to mitigate potential site specific and cumulative geological and hydrological impacts of the proposed development are provided herein in order to mitigate adverse impacts to adjacent and down-current properties.

From a geotechnical perspective, the same system exposed along the shoreline will not be altered, as the repair will be subsurface. This would provide a no net loss of what is currently existing, and biological recommendations by others could enhance the shoreline in other means. In conclusion, habitat management protocols from the biologist and the reviewing authority should be implemented as per code, if necessary.

4.5 Design and Construction Recommendations

The following recommendations are offered for the proposed project. This includes general wall design recommendations, foundations, earthwork and drainage considerations. It is our opinion that the bulkhead may be replaced with another concrete bulkhead, or repaired in order to extend the life of the bulkhead. A repair plan would be a soldier pile wall directly behind the existing bulkhead.

For existing subsoils, the following equivalent fluid unit weight may be used for the structural design which is estimated as the product of the backfill soil unit weight and the earth pressure coefficient:

	At-Rest	Active	Passive
Native CL/ML Soils	68 pcf	46 pcf	330 pcf
Native Glacial Till	49 pcf	30 pcf	635 pcf

The values provided above shall be increased by 1 pcf for every 1 degree of backfill/ natural slope angle. Upper wall tiers may be calculated into the equation using this formula, or may be determined as stand alone surcharges. These equivalent fluid unit weight values do not include lateral earth pressures induced by earthquakes, groundwater, or surcharges from live loads. These loads should be accounted for at the discretion of the structural engineer.

Cemented hardpan was encountered at a depth of approximately 7 feet below the ground surface. This material is difficult for driven pile walls or shafts without damaging the piers. This type of geology is best suited for rock, standard reinforced concrete walls, or auger cast piles in which the piers that are constructed are within pre-augured holes.

In addition, resistance pressures may not be used as soil support where influenced by existing site features such as the seawall. This includes all soils at an angle of 60 degrees from the bottom of the bulkhead with respect to the vertical plane.

4.5.1 Foundations

Foundations for pile walls generally do not consider bearing capacity as the wall design and safety is dependent upon the lateral earth pressures.

Minimum pile depth shall be determined by the structural engineer after considering the neglected soils as presented in the previous section of this report.

Augercast piles are deep foundations constructed by penetrating through the soil with a hollow stem auger to the required depth. Then a pile is inserted within the hollow auger along with grout immediately prior to carefully removing the auger. This type of pile is successful in nearly all circumstances.

Obstructed piles should be relocated and/ or additional piles should be installed. Piles must be designed by a structural engineer, constructed by an experienced contractor, and construction should be inspected by a geotechnical engineer or his/ her assigns.

Total and differential settlement that a structure will undergo depends primarily on the subsurface conditions, type of structure, amount and duration of pressure exerted by the structure, reduction of pore water pressure, and in some instances, the infiltration of free moisture. Based on the expected native soil conditions, anticipated development, and construction abides by the recommendations in this report, the assumed foundation system may undergo a maximum of 0.50 inch total settlement, and a maximum differential settlement of 0.25 inch over a 50 ft span.

4.5.2 Earthwork Construction Recommendations

The annular space between the pile and side walls of the boring should be filled with grout or compacted soil.

Temporary and permanent earth cuts and fill slopes exceeding 4 feet in height should be limited to a slope of 2:1 (horizontal:vertical). Confined excavations exceeding 4 feet should conform to OSHA safety regulations.

5.0 CLOSURE

Based on the project information and site conditions as presented in this report, it is Envirotech's opinion that additional geotechnical studies are not required to further evaluate this project.

Due to the inherent natural variations of the soil stratification and the nature of the geotechnical subsurface exploration, there is always a possibility that soil conditions encountered during construction are different than those described in this report. Therefore, it is recommended that Envirotech is promptly notified if project and subsurface conditions found on-site are not as presented in this report so that we can re-evaluate our recommendations.

This report presents a geological/ geotechnical assessment, and is intended only for the owner, or owners' representative. Furthermore, this report is only valid for the project information and location described herein. Significant geological or property changes prior to the implementation of this project could render this report outdated, and will require additional geotechnical studies.

The services described in this report were prepared under the responsible charge of Michael Staten, a professional engineer with Envirotech. Michael Staten has appropriate education and experience in the field of geotechnical engineering in order to assess landslide hazards, erosion hazards, earthquake hazards, and shoreline dynamics.

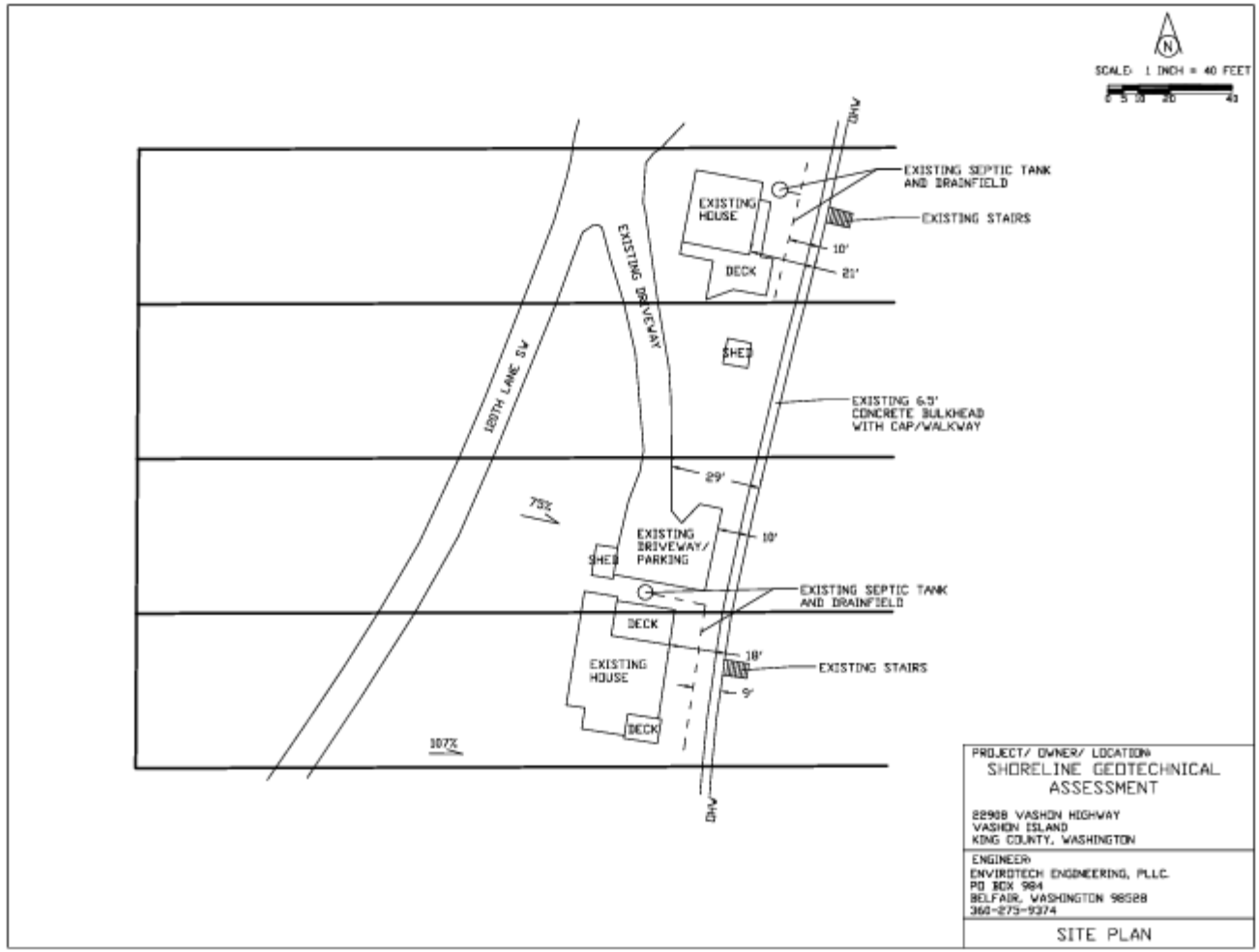
Please contact Michael Staten at 360-275-9374 if you have any questions, comments, or require additional information.

Sincerely,
Envirotech Engineering

Michael Staten, P.E.
Geotechnical Engineer

APPENDIX A

SITE PLAN



PROJECT/ OWNER/ LOCATION:

SHORELINE GEOTECHNICAL ASSESSMENT

22908 VASHON HIGHWAY
VASHON ISLAND
KING COUNTY, WASHINGTON

ENGINEER:
ENVIROTECH ENGINEERING, PLLC.
PO BOX 984
BELFAIR, WASHINGTON 98528
360-275-9374

SITE PLAN

APPENDIX B

PHOTOGRAPHS

Photo 1: Bulkhead Cracking and Reinforcement Bleeding.

Photo 2: Bulkhead Concrete Degradation.

Photo 3: Bulkhead & Beach Erosion

Photo 4: Failing Bulkhead Cap & Slight Backfill Erosion

APPENDIX C

CUMULATIVE RISK MODEL

CUMULATIVE RISK MODEL			
EROSION POTENTIAL			
Shoretype	**Score**	**Fetch**	**Score**
No Appreciable Drift (NAD)-Bedrock/Low Energy	0	0–1 mile	1
Modified, Accretion Shoreform, NAD-Delta	1		
NAD- Artificial , Transport Zone, Pocket Beach	2	1–5 miles	2
Feeder Bluff	3	5–15 miles	3
Feeder Bluff Exceptional	4	15+ miles	4
Erosion Potential Score =	**Shoretype Score + Fetch Score**		6
INFRASTRUCTURE THREAT			
Setback	**Score**	**Infrastructure Type**	**Score**
>60 ft	1	Property without structures	1
36–60 ft	2	Septic drainfield or unattached residential infrastructure, not lived in	2
21–35 ft	3	Home or residential building	3
0–20 ft	4	Major infrastructure	4
Infrastructure Threat Score =	**Setback Score + Infrastructure Type Score**		7
CUMULATIVE RISK TOTAL (product):	**Erosion Potential x Infrastructure Threat**		42

Table 3-4 from the Washington Department of Fish & Wildlife, Marine Shoreline Design Guidelines

- Low risk scores between 0–15
- Moderate risk scores between 16–36
- High risk scores greater than 36

Feeder bluff delination from WA State Department of Ecology Coastal Atlas Map

Fetch is measured as greatest distance of open water to project site from aerial mapping.