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# WOODARD BAY PARK RESTORATION OLYMPIA, WA

## Geotechnical Investigation

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Resource Stewardship & Land Use

Resource Stewardship & Land Use

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Resource Stewardship & Land Use

# 1 INTRODUCTION

In accordance with your authorization, Stantec has completed a geotechnical investigation for the proposed Woodard Bay NRCA Park improvements located north and east of the intersection of Whitham Road NE and Woodard Bay Road NE in Olympia, Washington (Figure 1).

The purpose of the geotechnical investigation was to identify subsurface conditions and to provide geotechnical recommendations for design and construction of a proposed shelter building, stormwater systems, retaining wall, and an access road and expanded parking lot area. The scope of work for the geotechnical investigation consisted of a site investigation followed by engineering analyses to prepare this report. Recommendations presented herein pertain to various geotechnical aspects of the proposed development.

# 2 PROJECT DESCRIPTION

We have reviewed the Layout Plans for Areas 1 and 2 dated January 16, 2013 which shows the extents of the proposed development. Area 1 includes a new retaining wall and an asphalt paved parking lot area at the intersection of Whitham Road and Woodard Bay Road. Area 2 includes an ADA parking area with new asphalt paving as well as trails, signs, picnic tables, and a learning shelter. We anticipate that the structure will be wood framed and that footing loads will generally be light.

Stormwater management will be necessary at both site areas due to the addition of impervious asphalt for parking lots and roadways. Stormwater will likely be managed through the use of bioretention, dispersion, rain gardens, Filterra, and/or a combination of these methods.

We anticipate that site grading will include cuts and/or fills on the order of 2 feet or less. Deeper excavations, on the order of 4 to 8 feet will be necessary for construction of the retaining wall along the west side of the new parking lot.

# 3 SITE DESCRIPTION

The site includes two areas connected by Whitham Road NE within the Woodard Bay NRCA. The site areas have approximate dimensions of 80 feet east to west and 160 feet north to south for Area 1, and 120 feet east to west and 500 feet north to south.

The majority of Area 1 is nearly level to slightly sloping to the southeast. The east side of Area 1 slopes downward to the east and Woodard Bay at magnitudes of 100 to 150 percent with a vertical relief of 4 to 5 feet. The west side of Area 1 slopes steeply downward to the east at magnitudes of up to 100 percent and a vertical relief of 15 to 30 feet, extending to more than 50 feet off site. Area 2 is mostly level with slope areas along its margins. Many slopes that were previously present have been recently re-graded to 2H:1V (horizontal to vertical) slopes during removal of old railroad fill in the south part of Area 2.

The entire site is vegetated with Maple, Alder, Fir, Hemlock, and Madrona trees with an understory of blackberries, grasses, ferns, and other herbaceous vegetation.

# 4 GEOTECHNICAL SUBSURFACE INVESTIGATION

## 4.1 Site Investigation Program

The geotechnical field investigation program was completed on January 17, 2013 and included advancing six hand auger borings and additional soil probing at strategic locations within the proposed development areas.

A Stantec field representative directed the subsurface investigation program, collected disturbed soil samples, classified the encountered soils, kept a detailed log of each hand boring, and observed and recorded pertinent site features.

The results of the hand boring and sampling program are presented on the hand boring logs enclosed in Appendix C.

# 5 SOIL AND GROUNDWATER CONDITIONS

## 5.1 Area Geology

The site lies within the southern portion of the Puget Lowland. The lowland is part of a regional north-south trending trough that extends from southwestern British Columbia to near Eugene, Oregon. North of Olympia, Washington, this lowland is glacially carved, with a depositional and erosional history including at least four separate glacial advances/retreats. The Puget Lowland is bounded to the west by the Olympic Mountains and to the east by the Cascade Range. The lowland is filled with glacial and nonglacial sediments consisting of interbedded gravel, sand, silt, till, and peat lenses.

The South Half of the Tacoma Quadrangle indicates that the site is underlain by Pre-Fraser Drift. Pre-Fraser Drift includes silt and clay with variable amounts of sand and local gravel and cobbles. These materials are typically stiff to hard and can include deposits similar in composition and appearance as glacial till.

## 5.2 Soil Conditions

Details of the encountered soil conditions are presented on the hand boring logs in Appendix C. The detailed soil description on these logs should be referred to in preference to the generalized descriptions below.

### Hand Auger Borings HB-1 through HB-3

We encountered approximately 6 to 18 inches of topsoil and vegetation underlain by approximately 1 to 2 feet of medium stiff to stiff, silt with trace clay along with areas of silt with sand (Pre-Fraser Drift). This layer was underlain by generally stiff silt with trace clay along with areas of silt with sand (Pre-Fraser Drift). These materials continued to the termination depth of these Hand Borings.

### Hand borings HB-4 through HB-6

We encountered approximately 8 to 10 inches of topsoil and vegetation underlain by approximately 8 feet of very soft to soft silt with sand (Fill). This layer was underlain by approximately 1 to 2 feet of loose to medium dense sand with silt (Beach Deposits?). This layer was underlain by generally soft to medium stiff silt and sand (Beach Deposits?). These materials continued to the termination depth of these Hand Borings.

Based on our observations and review of the site history, Area 2 is likely underlain by Pre-Fraser Drift below the undocumented fill that was placed during railroad construction in the early 20$^{th}$ century. Our equipment limited our ability to reach these materials (budget constraints on drilling); however, it is our opinion that they are within about 20 feet of the ground surface and the depth to these materials likely decreases toward the existing peninsula (toward the south).

### Soil Probing

Additional soil probing was performed in the area of the existing Skid Shack (Area 2) and in the existing kayak boat launch (Area 1). We were able to probe 8 feet at the kayak boat launch area at about the level of the OHWM and to the extent of the probe length (12 feet) at the Skid Shack. We used a ½ inch diameter steel probe with extensions.

### Groundwater

At the time of our investigation, groundwater was encountered in Hand Borings HB-4 through HB-6 at approximate 3, 8 and 8.5 feet below the existing site grades, respectively. Groundwater was not encountered in the other hand borings at the time of our investigation. The groundwater elevation observed is consistent with the level of the adjacent inlet (Puget Sound).

We anticipate that perched groundwater may develop in low lying areas between upper topsoil and weathered soils and underlying silt deposits (Drift), especially during the wetter months of the year (typically October through June).

Groundwater table elevations often fluctuate over time. The groundwater level will depend on a variety of factors that may include seasonal precipitation, tidal fluctuations, land use, climatic conditions and soil permeability. Water levels at the time of the field investigation may be different from those encountered during the construction phase of the project. Groundwater monitoring wells were installed as part of this investigation for use in environmental monitoring. Groundwater elevation data from these wells can be used to determine seasonal fluctuations if necessary.


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# 6 GEOLOGICAL HAZARDS

## 6.1

It is our opinion that area slopes with magnitudes greater than about 40 percent and vertical relief of at least 10 feet can qualify as landslide hazard areas depending on the soil characteristics, density, groundwater conditions, as well as other factors. It is our opinion portions of the site are located within a Landslide Hazard Area due to the magnitude of the slope (80 to 100 percent or more) and soil conditions present along the west side of Area 1.

The removal of native vegetation should be limited, to the greatest extent possible, outside of areas designated for structural development. Erosion control measures should be in place to reduce adverse impacts to neighboring and down slope properties resulting from erosion until permanent landscaping is fully in place. Vegetation should not be removed from steeper slope areas without protection of exposed soils (not anticipated). Surface water should not be allowed to flow over slope surfaces (as feasible). Based on our knowledge of the project, very limited removal of vegetation will be performed.

It is our opinion that the slope is generally stable at this time. During construction, it will be necessary to limit the length of time that any steep cuts are left in place. Wall construction should proceed immediately following excavation of the wall area until backfill has been placed. The native silt will have a tendency to cave and slough if left open for a long period of time. We should be on site during wall construction to verify that the slope area is stable and to monitor the slope stability while wall construction takes place (worker hazards).

## 6.2 Erosion Hazard

The Natural Resources Conservation Services (NRCS) maps for Thurston County indicate that the proposed parking lot area of the site is underlain by Hoogdal silt loam (30-50 percent slopes) and Skipopa silt loam (0-3 percent slopes). These soils have "Severe" and "Slight" erosion potential in a disturbed state, respectively. The area of the site where the structure is to be located is underlain by Indianola loamy sand (15-30 percent slopes) and Skipipa silt loam (3-15 percent slopes). These soils have "Moderate to Severe" and "Slight to Severe" erosion potential in a disturbed state, respectively.

It is our opinion that soil erosion potential at this project site can be reduced through landscaping and surface water runoff control. Typically erosion of exposed soils will be most noticeable during periods of rainfall and may be controlled by the use of normal temporary erosion control measures, such as silt fences, hay bales, mulching, control ditches and diversion trenches. The typical wet weather season, with regard to site grading, is from October 31st to April 1st. Erosion control measures should be in place before the onset of wet weather.

## 6.3 Seismic Hazard

We encountered generally stiff soils at Area 1 and soft to stiff soils at Area 2. The overall subsurface profile for Area 1 corresponds to a Site Class *D* as defined by Table 1613.5.2 of the 2009 International Building Code (2009 IBC). A Site Class *D* applies to a profile consisting of medium dense/stiff to very dense/hard materials within the upper 100 feet.

The overall subsurface profile for Area 2 corresponds to a Site Class *E* as defined by Table 1613.5.2 of the 2009 International Building Code (2009 IBC). A Site Class *E* applies to a profile consisting of soils with an average N value of 15 or less and an undrained shear strength of less than 1,000 psf.

We referenced the U.S. Geological Survey (USGS) Earthquake Hazards Program Website to obtain values for $S_S$, $S_1$, $F_a$, and $F_v$. The USGS website includes the most updated published data on seismic conditions. The site specific seismic design parameters and adjusted maximum spectral response acceleration parameters are as follows:

| | | |
|---|---|---|
| PGA | (Peak Ground Acceleration, in percent of g) | |
| 28.11 | (10% Probability of Exceedence in 50 years) | |
| 52.04 | (2% Probability of Exceedence in 50 years) | |
| $S_S$ | 117.70% of g | |
| $S_1$ | 39.10% of g | |
| $F_A$ | 1.029 (D) | 0.90 (E) |
| $F_V$ | 1.617 (D) | 2.40 (E) |

Additional seismic considerations include liquefaction potential and amplification of ground motions by soft soil deposits. The liquefaction potential is highest for loose sand with a high groundwater table. The fine-grained soil materials that underlie the site have a low potential for liquefaction and/or amplification of ground motions. Portions of Area 2 may have a moderate liquefaction potential; however, the proposed structure will not be inhabited. The owner should understand that there is a risk of structural damage during/following certain magnitude seismic events.

# 7 DISCUSSION

Due to soft soil conditions in the area of the proposed building, ground improvement through the use of structural fill and geotextile fabric and grid will be necessary to provide foundation support. We recommend that the entire building area be overexcavated to a level at least 2.5 feet below the bottom of footing elevations and replaced with geotextiles and structural fill (See Section 8.3). The overexcavations should extend at least 5 feet beyond all footing edges.

We recommend using a mat or raft foundation system with thickened edges for building support. This type of foundation will typically tolerate and resist differential settlement more than continuous perimeter or strip footings.

Detailed analysis and options for ideal deep foundation support can be provided upon request; however, it is our understanding that the most cost effective foundation options would be favored.

Our investigation indicates that the subsurface soils consist of silt with variable amounts of clay and sand. Infiltration in these soils is not feasible. Other means of stormwater management at the site areas should be considered (such as dispersion, rain gardens, bioretention, Filterra filtration methods, or a combination of these).

The native soils are highly moisture sensitive and should not be used as structural fill. Stockpiled fill previously used for the railroad grade (silty-gravel with sand) may be used as structural fill, provided they are within 3 percent of the optimum moisture content and can be compacted to at least 95 percent of the modified proctor (ASTM D 1557 Test Method).

We recommend that a gravity type retaining wall be constructed along the west side of the new parking lot after the proposed grading cuts have been made. These types of walls could include Allen-type interlocking concrete block walls or gabion walls with rock backfill. We understand that other walls types that include vegetated faces are under consideration. We have provided recommendations for gravity walls in subsequent sections. We can provide additional recommendations upon request for aspects of other types of walls (proprietary designs).

# 8 RECOMMENDATIONS

## 8.1 Site Preparation

Trees, shrubs and other vegetation should be removed prior to stripping of surficial organic-rich soil. Based on observations from the site investigation program and the results of the exploration program, it is anticipated that the stripping depth will generally be less than 12 inches within the proposed parking lot area and less than 8 inches in the proposed building footprint and adjacent asphalt pavement areas. The excavated material is not suitable as fill material within the proposed building envelope or the proposed parking areas, but could be used as fill material in non-settlement sensitive areas such as landscaping. In these non-settlement sensitive areas, the fill should be placed in maximum 12 inch thick lifts that should be compacted to at least 90 percent of the modified proctor maximum dry density (ASTM D 1557 Test Method).

The fines content is very high for the relatively cohesive soil that may be excavated as part of site development. The subsurface explorations at this site generally indicate fine grained soils occur throughout the project areas. It is our opinion that the native soils will not be suitable for use as structural fill.

There are areas of previously dredged fill that may be suitable for use as structural fill. These materials consist of silty-gravel with sand and cobbles. All structural fill, imported or on site, should be placed in maximum lift thicknesses of 12 inches. These materials should be compacted to a minimum of 95 percent of the modified proctor maximum dry density, as determined by the ASTM D 1557 test method.

## 8.2 Temporary Excavations

We anticipate the need for cuts on the order of 8 feet for gravity wall construction in Area 1. For temporary cuts that will extend deeper (higher) than 4 feet, the temporary excavations should be sloped no steeper than 1H:1V (Horizontal:Vertical) in stiff to hard native soils. If an excavation is subject to heavy vibration or surcharge loads, we recommend that the excavation be sloped no steeper than 1.5H:1V, where room permits. Temporary excavations in fill soils should be sloped no steeper than 1.5H:1V where room permits, and 2H:1V if subject to heavy vibration or surcharge loads. For any excavations in Area 2, we should be consulted for specific sloping recommendations as the soils in this area are very poor.

All temporary cuts should be in accordance with the Washington Administrative Code (WAC) Part N, Excavation, Trenching, and Shoring. The temporary slopes should be visually inspected daily by a qualified person during construction activities and the inspections should be documented in daily reports. The contractor is responsible for maintaining the stability of the temporary cut slopes and reducing slope erosion during construction.

The temporary cut slopes should be covered with visqueen to help reduce erosion during wet weather, and the slopes should be closely monitored until the permanent retaining systems or slope configurations are complete. Materials should not be stored or equipment operated within 10 feet of the top of any temporary cut slope.

Soil conditions may not be completely known from the geotechnical investigation. In the case of temporary cuts, the existing soil conditions may not be completely revealed until the excavation work exposes the soil. Typically, as excavation work progresses the maximum inclination of the temporary slopes will need to be re-evaluated by the geotechnical engineer so that supplemental recommendations can be made. Soil and groundwater conditions can be highly variable. Scheduling for soil work will need to be adjustable, to deal with unanticipated conditions, so that the project can proceed and required deadlines can be met.

If any variations or undesirable conditions are encountered during construction, Stantec should be notified so that supplemental recommendations can be made. If room constraints or groundwater conditions do not permit temporary slopes to be cut to the maximum angles allowed by the WAC, temporary shoring systems may be required. The contractor should be responsible for developing temporary shoring systems, if needed. We recommend that Stantec and the project structural engineer review temporary shoring designs prior to installation, to verify the suitability of the proposed systems.

## 8.2 Erosion and Sediment Control

Erosion and sediment control (ESC) is used to reduce the transportation of eroded sediment to wetlands, streams, lakes, drainage systems, and adjacent properties. Erosion and sediment control measures should be implemented and these measures should be in general accordance with local regulations. At a minimum, the following basic recommendations should be incorporated into the design of the erosion and sediment control features for the site:

- Schedule the soil, foundation, utility, and other work requiring excavation or the disturbance of the site soils, to take place during the dry season (generally May through September). However, provided precautions are taken using Best Management Practices (BMP's), grading activities can be undertaken during the wet season (generally October through April). Wet season grading and foundation and utility excavation work typically results in an increased construction cost.

- All site work should be completed and stabilized as quickly as possible.

- Additional perimeter erosion and sediment control features may be required to reduce the possibility of sediment entering the surface water. This may include additional silt fences, silt

fences with a higher Apparent Opening Size (AOS), construction of a berm, or other filtration systems.

- Any runoff generated by dewatering discharge should be treated through construction of a sediment trap if there is sufficient space. If space is limited other filtration methods will need to be incorporated.

## 8.3 Foundation Design

We recommend that the proposed shelter building be supported on a mat or raft foundation system bearing on at least 2.5 feet of structural fill placed and compacted onto geotextile fabric and grid over the native soils.

The entire building pad should be excavated to a level at least 2.5 feet below proposed footing elevations, extending at least 5 feet beyond all footing edges. Mirafi 140N should be placed over the resulting subgrade with at least 2 feet of overlap onto adjacent fabric. Tensar TriAx TX160 geogrid should be placed over the filter fabric and overlapped onto adjacent geogrids at least 2 feet. Following grid placement, we recommend placement and compaction of 18 inches of structural fill to at least 95 percent of the modified proctor. Subsequent lifts should not exceed 12 inches loose thickness and compaction should be performed using a trackhoe mounted ho-pack or minimum 7 ton vibratory roller.

Provided that the mat or raft foundation system is supported as recommended above, a net allowable bearing pressure of 300 pounds per square foot (psf) may be used for design.

Structural fill placed on bearing, native subgrade should be compacted to at least 95 percent of the maximum dry density based on ASTM Test Method D1557. All foundation excavations should be inspected to verify structural fill compaction, geotextile placement, fill thickness, and lateral extents of fill placement.

Exterior footings should have a minimum depth of 18 inches below pad subgrade (soil grade) or adjacent exterior grade, whichever is lower. In general, static settlement on the order of 3 inches is expected for these types of foundations and soil conditions. The foundation should be left in place at least one month prior to framing in order to allow for static consolidation.

If it is desired to limit the total and differential settlements, we recommend applying a surcharge fill preload over the building pad for at least three months prior to building construction. The surcharge thickness can be provided once we have reviewed final building plans (dimensions, location).

Resistance to lateral footing displacement can be determined using an allowable friction factor of 0.20 acting between the base of foundations and the supporting subgrade. Lateral resistance for footings can also be developed using an allowable equivalent fluid passive pressure of 150 pounds per cubic foot (pcf) acting against the appropriate vertical footing faces (neglect the upper 12 inches below grade in exterior areas). The allowable friction factor and allowable equivalent fluid passive pressure values include a factor of safety of 1.5. The frictional and passive resistance of the soil may be combined without reduction in determining the total lateral resistance. A 1/3 increase in the above values may be used for short duration transient loads.

## 8.1 Gravity Retaining Walls

At this time, the type of retaining wall to be utilized along the west side of Area 1 (parking lot) is unknown. From our discussions on site, we understand that walls that could be vegetated or otherwise blend into the forested area west of the wall are preferred.

For Allen or gabion type retaining walls, we recommend that they have a minimum embedment of 12 inches into stiff native soils and be sloped back (battered) at a 8 degree angle from vertical. For wall heights of 6 feet, we recommend that the base level, approximately 1/3 of the wall height, be two-2.5 feet blocks or two (3' wide) baskets in width (approximately 5 to 6 feet). Levels above the base may be single unit widths.

To reduce the potential for the buildup of water pressure behind the wall, continuous drains (with cleanouts) should be provided at the base of the wall. The footing drains should consist of a minimum 4-inch diameter perforated pipe, sloped to drain, with perforations placed down and enveloped by a minimum 6 inches of pea gravel in all directions. Mirafi 140N filter fabric should be placed along the cut native soils and wall backfill materials.

Wall backfill, and basket fill for gabion walls, should consist of 2 inch angular rock placed and bucket compacted. We anticipate that there will be limited space between the wall and the native soil cut; therefore, we are not recommending the use of structural fill that would require compaction in 12 inch thick lifts. Also, we should be on site during wall construction and excavation of the hill side to verify soil conditions as anticipate and to monitor the slope stability during construction.

The following engineering parameters are recommended for the proposed gravity wall (if necessary):

Seismic Acceleration Coefficient (a) = 0.3 g

<u>Reinforced Fill – Well compacted Imported Structural Fill according to our Report and Approval</u>

Friction Angle = 32 deg.
Cohesion = 0 psf
Unit Weight = 125 pcf

<u>Retained Fill – Native Soils</u>

Friction Angle = 28 deg.
Cohesion = 0 psf
Unit Weight = 125 pcf

<u>Retained Fill – Well Compacted Imported Structural Fill according to our Report and Approval</u>

Friction Angle = 32 deg.
Cohesion = 0 psf
Unit Weight = 125 pcf

<u>Foundation Materials - Well Compacted Structural Fill/Competent Native Soils according to our Report</u>

Friction Angle = 28 deg.
Cohesion = 0 psf
Unit Weight = 125 pcf
Allowable Static Bearing Pressure = 2,000 psf

## 8.2 Concrete Retaining Walls

If any cast in place concrete retaining walls or below grade walls are planned, the recommendations in this section should apply. The following table, titled **Wall Design Criteria**, presents the recommended soil related design parameters for retaining walls with **level (horizontal) backfill/backslope**. Contact Stantec if an alternate retaining wall system is used.

| **Wall Design Criteria** | |
|---|---|
| "At-rest" Conditions (Lateral Earth Pressure – EFD[+]) | 55 pcf (Equivalent Fluid Density) |
| "Active" Conditions (Lateral Earth Pressure – EFD[+]) | 35 pcf (Equivalent Fluid Density) |
| Seismic Increase for "At-rest" Conditions (Lateral Earth Pressure) | 18H* (Uniform Distribution) |
| Seismic Increase for "Active" Conditions (Lateral Earth Pressure) | 6H* (Uniform Distribution) |
| Passive Earth Pressure on Low Side of Wall (Allowable, includes F.S. = 1.5) | Neglect upper 2 feet, then 200 pcf EFD[+] |
| Soil-Footing Coefficient of Sliding Friction (Allowable; includes F.S. = 1.5) | 0.20 |

*H is the height of the wall; Increase based on one in 2,500 year seismic event (2 percent probability of being exceeded in 50 years), [+] EFD – Equivalent Fluid Density

The stated lateral earth pressures do not include the effects of hydrostatic pressure generated by water accumulation behind the retaining walls or loads imposed by construction equipment, foundations, earth backslope, rockeries above or roadways (surcharge loads). Uniform horizontal lateral active and at-rest pressures on the retaining wall from vertical surcharges behind the wall may be calculated using active and at-rest lateral earth pressure coefficients of 0.3 and 0.5, respectively. The soil unit weight of 120 pcf may be used to calculate vertical earth surcharges.

To reduce the potential for the buildup of water pressure against the walls, continuous footing drains (with cleanouts) should be provided at the bases of the walls. The footing drains should consist of a minimum 4-inch diameter perforated pipe, sloped to drain, with perforations placed down and enveloped by a minimum 6 inches of pea gravel in all directions and filter fabric to reduce the migration of fines into the drainage zone.

The backfill adjacent to and extending a lateral distance, behind the walls, of at least 2 feet should consist of free-draining granular material. All free draining backfill should contain less than 3 percent fines (passing the U.S. Standard No. 200 Sieve) based upon the fraction passing the U.S. Standard No. 4 Sieve with at least 30 percent of the material being retained on the U.S. Standard No. 4 Sieve. The primary purpose of the free-draining material is the reduction of hydrostatic pressure.

Some potential for the moisture to contact the back face of the wall may exist, even with treatment, which may require that more extensive waterproofing be specified for walls, which require interior moisture sensitive finishes.

We recommend that the backfill be compacted to at least 95 percent of the maximum dry density based on ASTM Test Method D1557. In place density tests should be performed to verify adequate compaction. Soil compactors place transient surcharges on the backfill. Consequently, only light hand operated equipment is recommended within 3 feet of walls so that excessive stress is not imposed on the walls.

## 8.3 Pavement Recommendations

The near surface subgrade soils generally consist of silt, silt with clay, silty sand, and poorly graded sand with gravel (local fill areas). These soils are rated as poor for pavement subgrade material (depending on silt content and moisture conditions).

We recommend that, at a minimum, 12 inches of the existing subgrade material be moisture conditioned (as necessary) and re-compacted to prepare for the construction of pavement sections. Deeper levels of recompaction may be necessary in areas where existing utilities and/or fill are present. The subgrade should be compacted to at least 95 percent of the maximum dry density as determined by ASTM Test Method D1557. In place density tests should be performed to verify proper moisture content and adequate compaction. However, if the subgrade soil consists of firm and unyielding native glacial soils a proof roll of the pavement subgrade soil may be performed in lieu of re-compacting the subgrade and compaction tests. The recommended flexible and rigid pavement sections are based on design CBR and modulus of subgrade reaction (k) values that are achieved, only following proper subgrade preparation. It should be noted that subgrade soils that have relatively high silt contents will likely be highly sensitive to moisture conditions. The subgrade strength and performance characteristics of a silty subgrade material may be dramatically reduced if this material becomes wet.

Based on our knowledge of the proposed project, we expect the traffic to range from light duty (passenger automobiles) to potentially heavy duty (loaded dump trucks/equipment). The following tables show generally recommended pavement sections for light duty and heavy duty use.

**ASPHALTIC CONCRETE (FLEXIBLE) PAVEMENT**

**LIGHT DUTY**

| Asphaltic Concrete | Aggregate Base* | Compacted Subgrade* ** |
|---|---|---|
| 2.0 in. | 8.0 in. | 12.0 in. |

** 95% compaction based on ASTM Test Method D1557*
*** A proof roll may be performed in lieu of in place density tests*


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**HEAVY DUTY**

| Asphaltic Concrete | Aggregate Base* | Compacted Subgrade* ** |
|---|---|---|
| 4.0 in. | 8.0 in. | 12.0 in. |

** 95% compaction based on ASTM Test Method D1557*
*** A proof roll may be performed in lieu of in place density tests*

**PORTLAND CEMENT CONCRETE (RIGID) PAVEMENT**

| Min. PCC Depth | Aggregate Base* | Compacted Subgrade* ** |
|---|---|---|
| 6.0 in. | 6.0 in. | 12.0 in. |

** 95% compaction based on ASTM Test Method D1557*
*** A proof roll may be performed in lieu of in place density tests*

The asphaltic concrete depth in the flexible pavement tables should be a surface course type asphalt, such as Washington Department of Transportation (WSDOT) ½ inch HMA. The rigid pavement design is based on a Portland Cement Concrete (PCC) mix that has a 28 day compressive strength of 4,000 pounds per square inch (psi). The design is also based on a concrete flexural strength or modulus of rupture of 550 psi.

# 9 CONSTRUCTION FIELD REVIEWS

Stantec should be retained to provide part time field review during construction in order to verify that the soil conditions encountered are consistent with our design assumptions and that the intent of our recommendations is being met. This will require field and engineering review to:

- Confirm removal of vegetation, topsoil and forest duff within building pads and parking areas
- Verify the soil bearing and overexcation/fill replacement at footing locations
- Density testing to verify compaction of structural fills
- Density testing/proof rolls to verify compaction below slab-on-grade
- Inspection of roadway subgrade areas prior to fill placement
- Wall construction observations
- Inspection of proof-roll testing
- Inspection of subgrade and density testing to verify compaction of sub-base and base layers in pavement areas

Geotechnical design services should also be anticipated during the subsequent final design phase to support the structural design and address specific issues arising during this phase. Field and engineering review services will also be required during the construction phase in order to provide a Final Letter for the project.

# 10 CLOSURE

This report was prepared for the exclusive use of Barker Landscape Architects and their appointed consultants. Any use of this report or the material contained herein by third parties, or for other than the intended purpose, should first be approved in writing by Stantec.

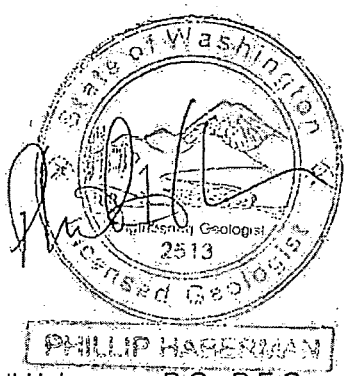
The recommendations contained in this report are based on assumed continuity of soils with those of our test holes, and assumed structural loads. Stantec should be provided with final architectural, civil, and structural drawings when they become available in order that we may review our design recommendations and advise of any revisions, if necessary.

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of Barker Landscape Architects, who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these not be satisfied.

Respectfully submitted,

**Stantec Consulting Services, Inc.**

***Original signed by:***




Phil Haberman, P.G., P.E.G.
Senior Engineering Geologist

***Original signed by:***

Gopal A. Singam, P.E.
Senior Geotechnical Engineer

PH/gs

# APPENDIX A

## Statement of General Conditions


Resource Stewardship & Land Use

## STATEMENT OF GENERAL CONDITIONS

**USE OF THIS REPORT:** This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Services, Inc. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

**BASIS OF THE REPORT:** The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Services present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Services, Inc. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

**STANDARD OF CARE:** Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state of execution for the specific professional service provided to the Client. No other warranty is made.

**INTERPRETATION OF SITE CONDITIONS:** Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Services, Inc. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behaviour. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

**VARYING OR UNEXPECTED CONDITIONS:** Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Services, Inc. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Services, Inc. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Services, Inc. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

**PLANNING, DESIGN, OR CONSTRUCTION:** Development or design plans and specifications should be reviewed by Stantec Consulting Services, Inc., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Services, Inc. cannot be responsible for site work carried out without being present.


Resource Stewardship & Land Use

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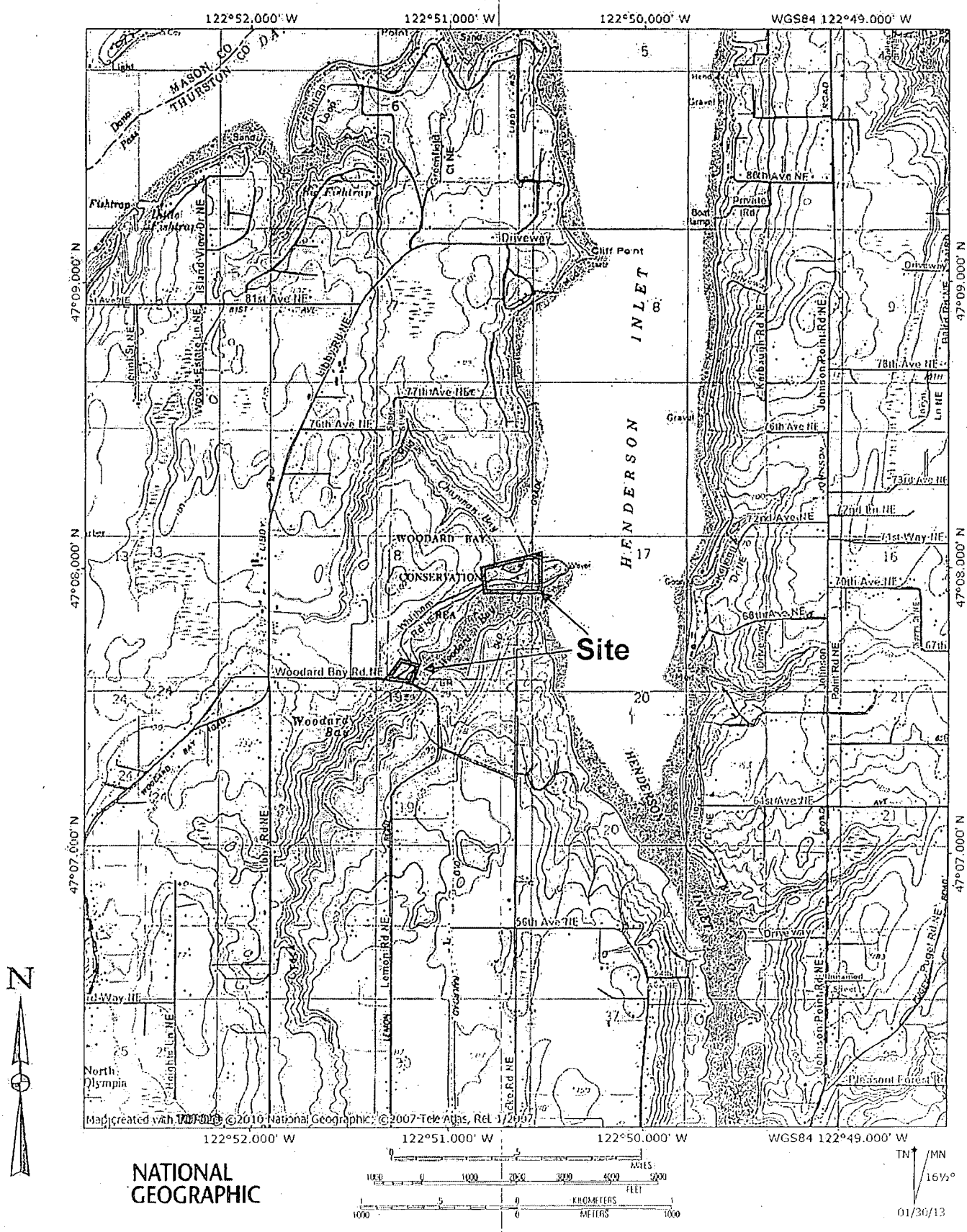
# APPENDIX B

## Figures: Vicinity Map and Site Plans




General Site Location Only

| | | | | |
|---|---|---|---|---|
| Stantec | **Woodard Bay NRCA, Olympia, WA** | | | Figure 1 Vicinity Map |
| | January 3, 2013 | Drawn By: PAH | Checked By: GS | Client: Barker Landscape Arch. |

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# APPENDIX C

## Hand Boring Log Records

PROJECT: **Woodard Bay NRCA**
LOCATION: **Olympia, Washington**
PROJECT NUMBER: **185750093**

WELL / PROBEHOLE / BOREHOLE NO:
**HB-1** PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED: **1/17/13** COMPLETED: **1/17/13**
DRILLING COMPANY:
DRILLING EQUIPMENT: **Hand Auger**
DRILLING METHOD: **Hand Boring**
SAMPLING EQUIPMENT: **Grab**

NORTHING (ft): EASTING (ft):
LAT: LONG:
GROUND ELEV (ft): TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered** WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **6.0**
WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**
LOGGED BY: **PH** CHECKED BY: **GS**

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Topsoil and vegetation | | | | | | |
| | | ML | ML; Medium stiff to stiff, silt with sand and trace clay, yellowish brown to dark yellowish brown, moist. (Drift) | | | | | | |
| | | ML | ML; Stiff, silt with sand, yellowish brown to olive brown, moist. (Drift) | | | | | | |
| 5 | | | | | | | | | 5 |
| | | | Borehole terminated at 6 feet. | | | | | | |
| 10 | | | | | | | | | 10 |

GEO FORM 304 WOODARD.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 2/5/13

| | |
|---|---|
| PROJECT: **Woodard Bay NRCA**<br>LOCATION: **Olympia, Washington**<br>PROJECT NUMBER: **185750093** | WELL / PROBEHOLE / BOREHOLE NO:<br>**HB-2** PAGE 1 OF 1 |
| DRILLING / INSTALLATION:<br>STARTED **1/17/13** COMPLETED: **1/17/13**<br>DRILLING COMPANY:<br>DRILLING EQUIPMENT: **Hand Auger**<br>DRILLING METHOD: **Hand Boring**<br>SAMPLING EQUIPMENT: **Grab** | NORTHING (ft): EASTING (ft):<br>LAT: LONG:<br>GROUND ELEV (ft): TOC ELEV (ft):<br>INITIAL DTW (ft): **Not Encountered** WELL DEPTH (ft): **---**<br>STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **4.0**<br>WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**<br>LOGGED BY: **PH** CHECKED BY: **GS** |

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Topsoil and vegetation | | | | | | |
| | | ML | ML; Medium stiff to stiff, silt with sand and trace clay, yellowish brown to dark yellowish brown, moist. (Drift) | | | | | | |
| | | ML | ML; Stiff, silt with sand, yellowish brown to olive brown, moist. (Drift) | | | | | | |
| | | | Borehole terminated at 4 feet. | | | | | | |
| 5 | | | | | | | | | 5 |
| 10 | | | | | | | | | 10 |

GEO FORM 304 WOODARD.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 2/5/13

PROJECT: **Woodard Bay NRCA**
LOCATION: **Olympia, Washington**
PROJECT NUMBER: **185750093**

WELL / PROBEHOLE / BOREHOLE NO: **HB-3** PAGE 1 OF 1

DRILLING / INSTALLATION:
STARTED: **1/17/13** COMPLETED: **1/17/13**
DRILLING COMPANY:
DRILLING EQUIPMENT: **Hand Auger**
DRILLING METHOD: **Hand Boring**
SAMPLING EQUIPMENT: **Grab**

NORTHING (ft): EASTING (ft):
LAT: LONG:
GROUND ELEV (ft): TOC ELEV (ft):
INITIAL DTW (ft): **Not Encountered** WELL DEPTH (ft): **---**
STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **5.0**
WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**
LOGGED BY: **PH** CHECKED BY: **GS**

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Topsoil and vegetation | | | | | | |
| | | ML | ML; Medium stiff to stiff, silt with sand and trace clay, yellowish brown to dark yellowish brown, moist. (Drift) | | | | | | |
| | | ML | ML; Stiff, silt with sand, yellowish brown to olive brown, moist. (Drift) | | | | | | |
| 5 | | | Borehole terminated at 5 feet. | | | | | | 5 |
| 10 | | | | | | | | | 10 |

GEO FORM 304 WOODARD.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 2/5/13

Resource Stewardship & Land Use

| | |
|---|---|
| PROJECT: **Woodard Bay NRCA**<br>LOCATION: **Olympia, Washington**<br>PROJECT NUMBER: **185750093** | WELL / PROBEHOLE / BOREHOLE NO:<br>**HB-4** PAGE 1 OF 1 |
| DRILLING / INSTALLATION:<br>STARTED **1/17/13** COMPLETED: **1/17/13**<br>DRILLING COMPANY:<br>DRILLING EQUIPMENT: **Hand Auger**<br>DRILLING METHOD: **Hand Boring**<br>SAMPLING EQUIPMENT: **Grab** | NORTHING (ft): EASTING (ft):<br>LAT: LONG:<br>GROUND ELEV (ft): TOC ELEV (ft):<br>INITIAL DTW (ft): **3** WELL DEPTH (ft): **---**<br>STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **8.0**<br>WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**<br>LOGGED BY: **PH** CHECKED BY: **GS** |

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | ML | ML; Very soft to soft, silt with trace clay and sand, yellowish brown, wet. (Drift) | | | | | | |
| | | ML | ML; Medium stiff, silt with sand and trace clay, yellowish brown to dark yellowish brown, wet. (Drift) | | | | | | |
| 5 | | | | | | | | | 5 |
| | | | Borehole terminated at 8 feet. | | | | | | |
| 10 | | | | | | | | | 10 |

GEO FORM 304 WOODARD.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 2/5/13

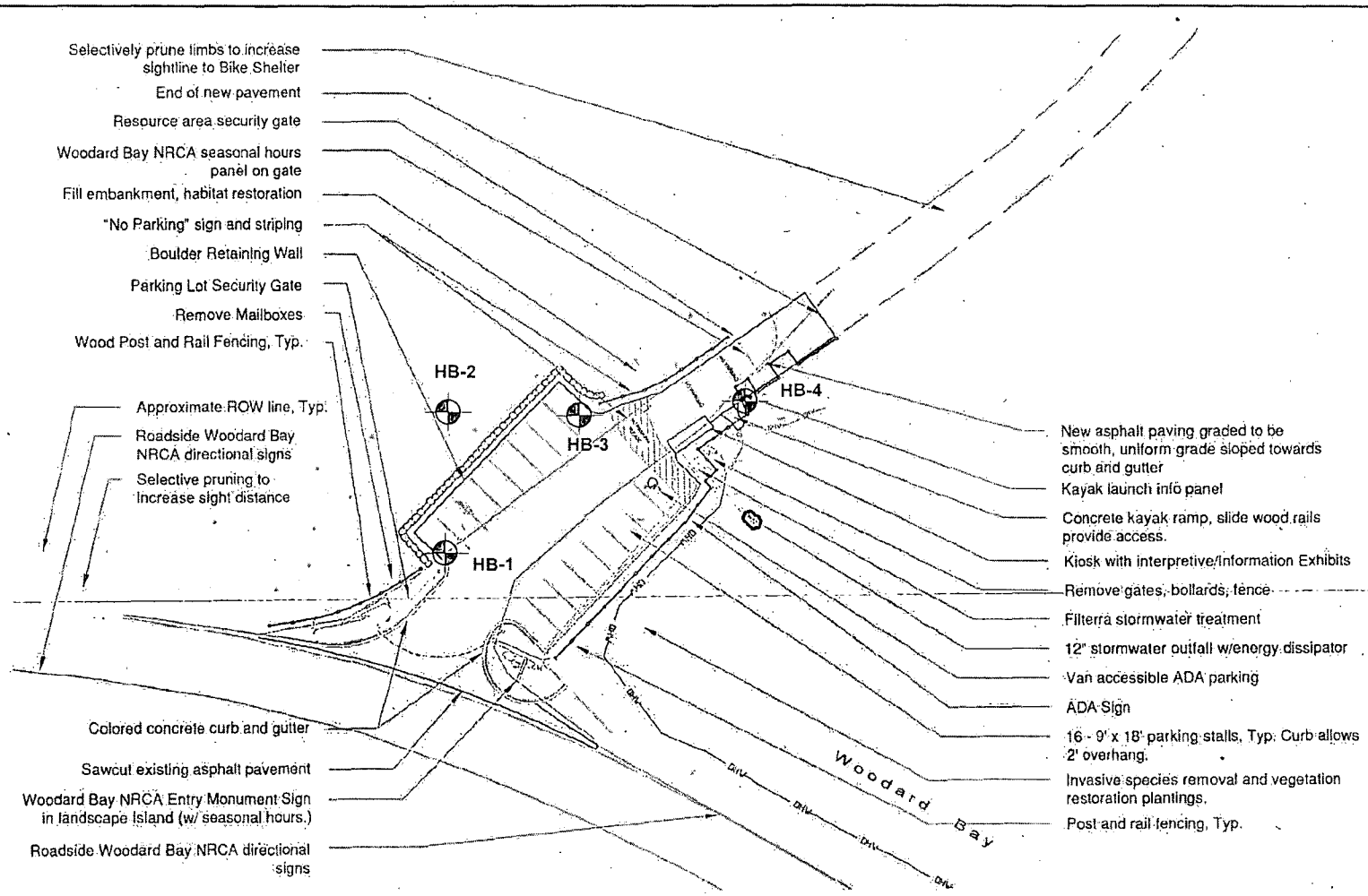
| | |
|---|---|
| PROJECT: **Woodard Bay NRCA**<br>LOCATION: **Olympia, Washington**<br>PROJECT NUMBER: **185750093** | WELL / PROBEHOLE / BOREHOLE NO:<br>**HB-5** PAGE 1 OF 1 |
| DRILLING / INSTALLATION:<br>STARTED: **1/17/13** COMPLETED: **1/17/13**<br>DRILLING COMPANY:<br>DRILLING EQUIPMENT: **Hand Auger**<br>DRILLING METHOD: **Hand Boring**<br>SAMPLING EQUIPMENT: **Grab** | NORTHING (ft): EASTING (ft):<br>LAT: LONG:<br>GROUND ELEV (ft): TOC ELEV (ft):<br>INITIAL DTW (ft): **8** WELL DEPTH (ft): **---**<br>STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **10.0**<br>WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**<br>LOGGED BY: **PH** CHECKED BY: **GS** |

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Topsoil and vegetation | | | | | | |
| | | ML | ML; Very soft to medium stiff, silt with sand, yellowish brown to dark yellowish brown, moist. (Drift) -Becomes less dense with depth | | | | | | |
| 5 | | | | | | | | | 5 |
| | | ML | ML; Medium stiff, silt with sand, yellowish brown to olive brown, moist. (Drift) | | | | | | |
| 10 | | | Borehole terminated at 10 feet. | | | | | | 10 |

| | |
|---|---|
| PROJECT: **Woodard Bay NRCA**<br>LOCATION: **Olympia, Washington**<br>PROJECT NUMBER: **185750093** | WELL / PROBEHOLE / BOREHOLE NO:<br>**HB-6** PAGE 1 OF 1 |
| DRILLING / INSTALLATION:<br>STARTED **1/17/13** COMPLETED: **1/17/13**<br>DRILLING COMPANY:<br>DRILLING EQUIPMENT: **Hand Auger**<br>DRILLING METHOD: **Hand Boring**<br>SAMPLING EQUIPMENT: **Grab** | NORTHING (ft): EASTING (ft):<br>LAT: LONG:<br>GROUND ELEV (ft): TOC ELEV (ft):<br>INITIAL DTW (ft): **8.5** WELL DEPTH (ft): **---**<br>STATIC DTW (ft): **Not Encountered** BOREHOLE DEPTH (ft): **10.0**<br>WELL CASING DIA. (in): **---** BOREHOLE DIA. (in): **4**<br>LOGGED BY: **PH** CHECKED BY: **GS** |

| Time & Depth (feet) | Graphic Log | USCS | Description | Sample | Time Sample ID | Measured Recov. (feet) | Blow Count | Headspace PID (units) | Depth (feet) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Topsoil and vegetation | | | | | | |
| | | ML | ML; Very soft to medium stiff, silt with sand and trace clay, yellowish brown to dark yellowish brown, moist. (Drift) -Becomes less dense with depth | | | | | | |
| 5 | | | | | | | | | 5 |
| | | ML | ML; Medium stiff, silt with sand, yellowish brown to olive brown, moist. (Drift) | | | | | | |
| 10 | | | Borehole terminated at 10 feet. | | | | | | 10 |

GEO FORM 304 WOODARD.GPJ STANTEC ENVIRO TEMPLATE 010509.GDT 2/5/13



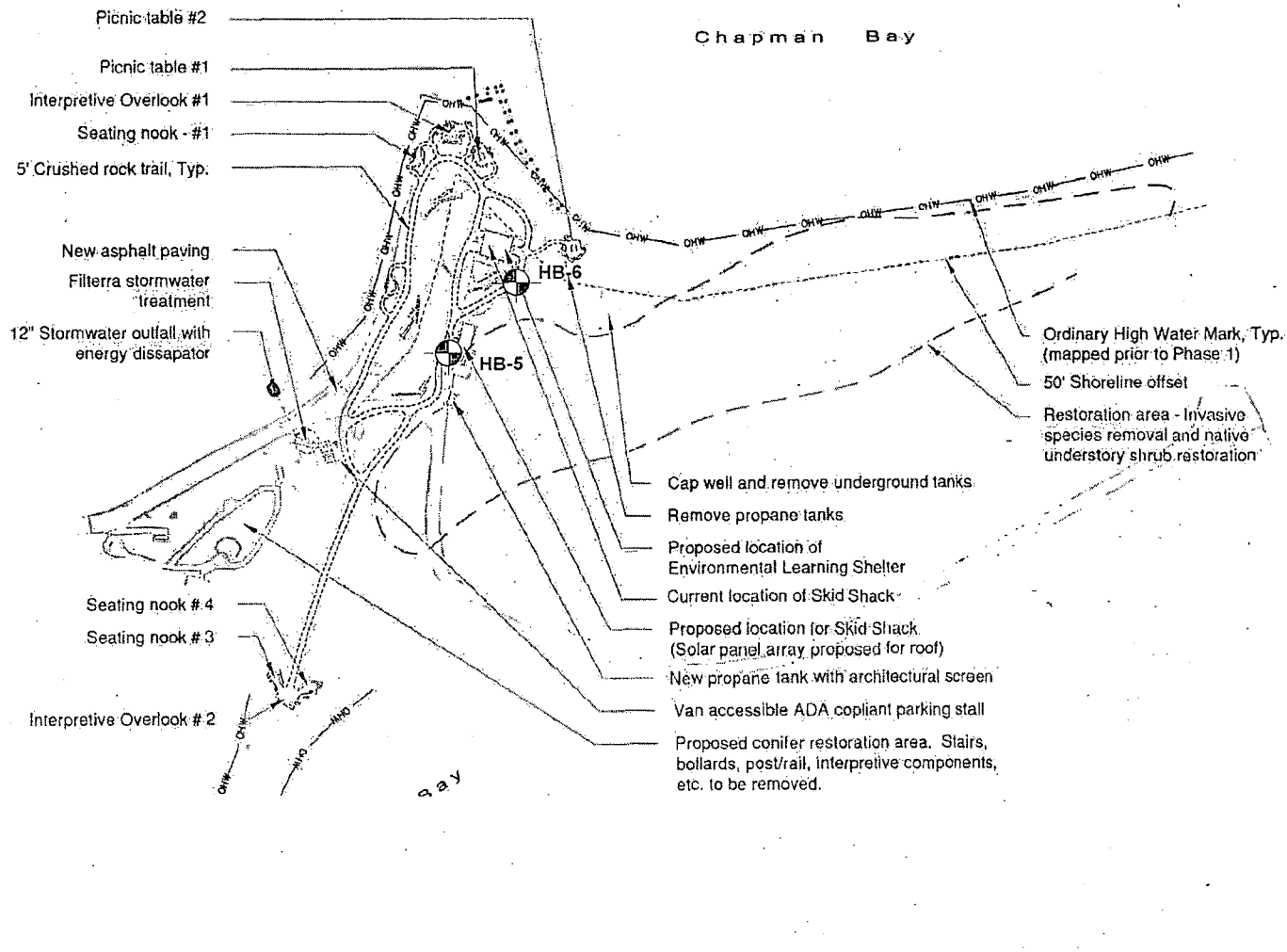

# Layout Plan Area 1

Approximate Hand Boring Location

HB-1

Not to Scale

| Stantec | Woodard Bay NRCA, Olympia, WA | | | Site Plans Figure 2 |
|---|---|---|---|---|
| | 1/31/13 | By: PH | Client: Barker Landscape Arch. | |




Approximate Hand Boring Location
HB-1

Not to Scale

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| Woodard Bay NRCA, Olympia, WA | | | Site Plans Figure 3 |
|---|---|---|---|
| 1/31/13 | By: PH | Client: Barker Landscape Arch. | |

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**Stantec Consulting Services, Inc.**
12034 – 134th Court NE, Suite 102
Redmond, Washington 98052
Tel: (425) 298-1000
Fax: (425) 298-1019

April 22, 2013

John Barker
Barker Landscape Architects
1514 NW 52nd Street
Seattle, WA 98107

**RE: Supplementary Geotechnical Information**
Woodard Bay Park Restoration
Woodard Bay Road Northeast
Olympia, Washington

Dear Mr. Barker,

As requested, we have prepared this letter to provide opinions regarding the general slope stability and setback recommendations for proposed structures at the above referenced site. In preparation of this letter, we have reviewed our geotechnical report for the project (dated February 6, 2013) and the plan sheets for the two site areas prepared by Barker Landscape Architects dated March 25, 2013.

For reference, Area 1 consists of the proposed parking area located north of the intersection of Woodard Bay Road NE and Whitham Road NE. Area 2 consists of the proposed Learning Shelter and accessory structures located at the end of Whitham Road NE. The slopes discussed in this letter report include a steep slope west of the west side of the proposed parking area in Area 1 and a relatively steep slope located southeast of the proposed Learning Shelter in Area 2.

**Landslide Hazards**

Thurston County designates slopes with magnitudes greater than about 40 percent and vertical relief of at least 15 feet as potentially geologically hazardous (steep slope/landslide hazards). Additional field criteria used to determine landslide hazards include, but are not limited to; presence of groundwater and/or springs/seeps, high permeability soils overlying impermeable soils, presence of weak soil planes, and evidence of previous slide activity.

During our field investigation at the project site on January 17, 2013, we traversed the steep slopes where accessible. As we conducted the traverses, we looked for any signs that would indicate past slope failures or features indicating possible future instability. Along the Area 1 slope, we observed local tree trunk curvature, consistent with varying degrees of soil creep. This is consistent with the gradual downward movement of weathered surface soils (Colluvium). We did not observe signs of past slope failures or signs of instability along the two steep slope areas and the soils that compose the slopes are generally medium dense/stiff to dense/very stiff (Glacial Till and Drift).

Reviews of the Coastal Zone Atlas Slope Stability Maps that provide coverage of the site area indicate that the relatively steep slopes located along the west side of the proposed parking area (Area 1) and east of the proposed structure (Learning Center) in Area 2 are designated as **Stable**. Some of the coastal margin slopes elsewhere in the vicinity of Henderson Inlet are designated as having **Intermediate** slope stability. This map can be found at link indicated below. www.ecy.wa.gov/programs/sea/femaweb/Thurston/TH_2iith.jpg.

It is our opinion that the steep slope located along the west side of the proposed parking lot and the slope located east of the proposed Learning Shelter are stable at this time and have a low potential for landslide activity.

**Recommendations**

We recommend that vegetation be removed in only areas where development will occur. At this time, we understand that this includes a portion of the slope west of the proposed parking area. We also understand that a retaining wall will be constructed in this location. We have previously provided recommendations for a gravity-type retaining wall along the base of this slope. We should be on site during construction to monitor the slope stability of temporary excavations, wall construction, and to provide additional recommendations if necessary.

It is our understanding that the steep slope located east of the Learning Shelter will not be altered (grading or vegetation). The International Building Code (2009 IBC Figure 1805.3.1) provides general setback recommendations for structures from the base/toe of steep slope areas. The IBC states that the minimum structure setback should be H/2, where H is the height of the slope, but need not exceed 15 feet for slopes under 100 percent in magnitude. We recommend a minimum setback of 15 feet for this structure (30 feet slope height). The currently proposed location of the Shelter is approximately 30 to 40 feet from the toe of the slope. It is our opinion that this distance is adequate for both a setback and buffer (combined).

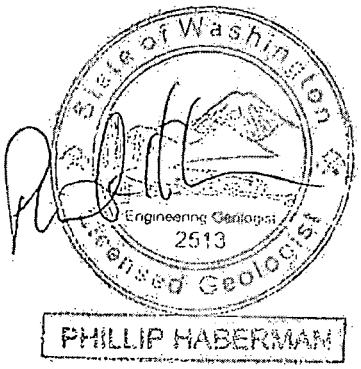
**Limitations**

The information presented herein is based upon professional interpretation utilizing standard practices and a degree of conservatism deemed proper for this project. It is not warranted that such information and interpretation cannot be superseded by future developments in the field of engineering geology and geotechnical engineering. We emphasize that this letter provides preliminary information for this project as outlined above, and should not be used for any other site.

We hope that this report provides the information required at this time. If you have any questions with this information, please contact us at (206) 452-9671.

Sincerely,

**Stantec Consulting Services, Inc.**




Phil Haberman, P.G., P.E.G.
Senior Engineering Geologist

PH/gs