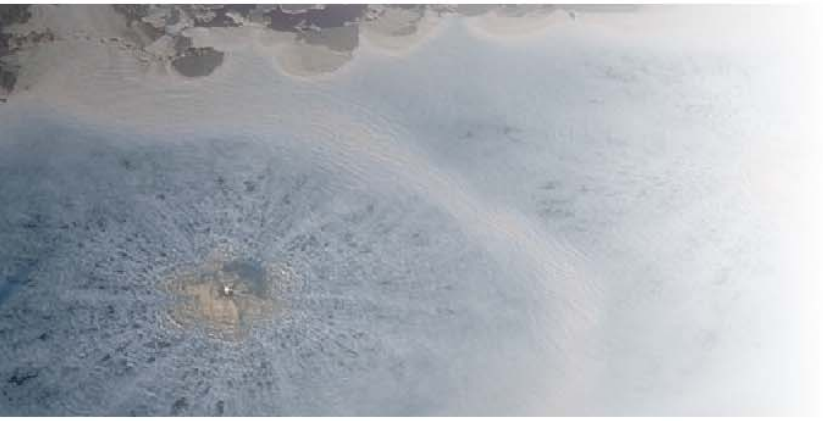

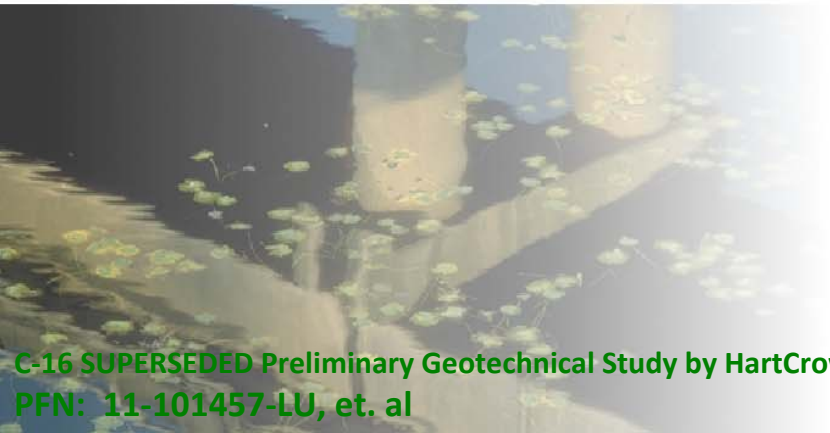

Preliminary Geotechnical Engineering Study
Point Wells Development
Richmond Beach, Washington

Prepared for
Paramount Petroleum Corporation

November 16, 2010
17203-38

HARTCROWSER

C-16 SUPERSEDED Preliminary Geotechnical Study by HartCrowser dated November 16, 2010
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Prepared by
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PRELIMINARY GEOTECHNICAL ENGINEERING STUDY
POINT WELLS DEVELOPMENT
RICHMOND BEACH, WASHINGTON

1.0 INTRODUCTION

This report presents our preliminary geotechnical engineering study for the proposed development at Point Wells in Richmond Beach, Washington. At this time, we understand that the site is being considered for a waterfront community of mixed-use office, retail and residential development. This study provides preliminary findings and recommendations on the feasibility of future development at the site.

This report contains several sections. The main body of the report presents our recommendations and is organized as follows:

- Introduction
- Purpose, Scope, and The Use of This Report
- Site and Project Descriptions
- Subsurface Conditions
- Critical Areas Discussion
- Conceptual Geotechnical Engineering Recommendations
- Recommended Additional Geotechnical Services

Tables are presented in the text following their initial reference, and figures are presented at the end of the text. The field exploration procedures and logs are presented in Appendix A. The laboratory procedures and test results are presented in Appendix B. Appendix C presents field exploration logs performed by Hart Crowser and others previously at this site. Appendix D contains historical aerial photographs of the site. Appendix E provides photographs from the slope reconnaissance performed on the site.

2.0 PURPOSE, SCOPE, AND THE USE OF THIS REPORT

2.1 Purpose

The purpose of our work is to support a land use application and an expanded environmental impact checklist. This includes assessing potential impacts of geologic hazards that may impact the proposed development, as well as how the proposed development would impact the surrounding environment considering these potential geologic hazards. This report provides preliminary geotechnical engineering recommendations at the planning level.

2.2 Scope

Our scope of our work to address the geotechnical engineering aspects at this phase of the project includes the following:

- Review existing subsurface information at the project site;
- Conduct geologic reconnaissance of steep slopes on the site;
- Conduct subsurface explorations at the site;
- Perform laboratory testing on selected soil samples;
- Evaluate impacts of Geologically Hazardous Areas;
- Develop preliminary geotechnical engineering recommendations; and
- Present the results of our study in this report.

We developed our preliminary geotechnical engineering recommendations based on the combined geotechnical data from previous and current explorations, as well as our experience with the local geology.

2.3 The Use of This Report

We completed this work in general accordance with our proposal dated November 18, 2009. We received written authorization to proceed on November 19, 2009. This report is for the exclusive use of Paramount Petroleum Corporation and their consultants for specific application to the subject project and site. We completed this design study in accordance with generally accepted geotechnical practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. We make no other warranty, express or implied.

It should be understood that the explorations performed for this study represent subsurface conditions only at discrete locations across the project site and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations may not become evident until additional explorations are performed or until construction activities begin. If significant variations are observed at that time, we may need to modify our conclusions and recommendations accordingly to reflect actual site conditions.

3.0 SITE AND PROJECT DESCRIPTIONS

The Point Wells facility is located in Snohomish County, Washington, on Puget Sound near the border of King and Snohomish Counties (Figure 1). On the west, the site consists of a lower, semicircular bench comprising about 56 acres that is located adjacent to Puget Sound. On the east is an upper, rectangular bench area comprising about 5 acres. The two areas are separated by the approximately north-south Burlington Northern Santa Fe (BNSF) railroad tracks. On the east side of the site, across the railroad tracks, is a steep ascending slope. The vegetated slope is approximately 150 to 200 feet high and has a slope typically steeper than 33 percent. The slope varies, maximizing at 100 percent. Figure 2 shows the site topography, which was provided by the project team. The elevations provided in this report correspond to NAVD88, unless specified otherwise. Figure 3 provides a site plan of the project site.

Several buildings and a retention pond are located on the upper bench. The upper bench is relatively flat with the steep ascending slope along its eastern perimeter. A short ecology block wall is located on the east portion of the upper bench, adjacent to the toe of the existing slope. The western boundary of the upper bench descends on a short steep slope to the BNSF railroad tracks.

The lower bench is occupied by an asphalt plant and marine fuel terminal. The lower bench is generally flat with less than 10 feet of elevation change across the site. The lower bench is protected from the adjacent Puget Sound by a concrete seawall, sheet pile wall and/or riprap.

Figure 3 shows an aerial photograph of the site. Impervious surfaces and roads are visible on this figure. Over 200 borings and/or monitoring wells have previously been advanced at the site. Please refer to our "2008 Remediation System and Groundwater Quality Evaluation, Richmond Beach Asphalt and Marine Fuels Terminal" report for information regarding the most recent groundwater study conducted by Hart Crowser. We have no knowledge of existing drain fields or drain field reserve areas on the site. Utility and easement information is not part of our scope of work.

We understand that the site is being considered for a waterfront community of mixed-use office, retail, and residential development. Potential development plans call for multiple mid- and high-rise buildings, mixed-use development that includes retail and office space, and residential housing. Building types and locations have not yet been determined. We understand that the general concept is to place buildings set back from the waterfront along the east edge of lower bench, and on the upper bench.

We understand that in this phase of the project, geotechnical work is desired to support a land use application and an expanded environmental impact checklist. This includes assessing potential impacts of geologic hazards on the proposed development, as well as how the proposed development would impact the surrounding environment considering these potential geologic hazards.

Preliminary recommendations are provided at the planning level, given the uncertainty of the development plans at this time. Once specific building layout and structural loads are available, design-level geotechnical explorations and engineering analyses will be necessary to develop specific design criteria and recommendations for the project.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Site Geology

A geologic map, based on the work by Booth et al. (2004), of the site and surrounding vicinity is shown on Figure 4. The surficial geology of the lower and upper benches consists of artificial fill (af) and pre-Fraser deposits (Qpf), respectively. The original ground surface of the lower bench was modified and fill was placed to raise grade for the construction of the existing facility. The artificial fill consists of loose to dense, trace to silty, gravelly Sand. The pre-Fraser deposits are sedimentary deposits typically consisting of poorly to well-sorted gravel, sand, silt and clay.

The surficial geologic units decrease in age to the east of the site, as shown on Figure 4. The pre-Fraser deposits are overlain by Lawton Clay, Advance Outwash, Vashon Till, and Recessional Outwash. The geologic map does not indicate the presence of surficial colluvium deposits from previous landslides that may be encountered based on the history of landslide activity at the site.

4.2 Subsurface Conditions

Our understanding of the subsurface conditions in the area of the proposed development is based on information obtained from three mud rotary borings (B09-1 through B09-3), which were drilled to depths ranging from 34 to 79 feet for the current study. Figure 3 shows the locations of the explorations advanced at the site. Detailed boring logs of the subsurface conditions observed at the new exploration locations are shown on the logs included in Appendix A, and should be referred to for specific information. Results of the laboratory tests conducted for this study are presented in Appendix B.

Previous explorations performed by Hart Crowser and others at the site provided additional geotechnical data for this study. A significant amount of subsurface exploration has occurred at the site, although they are generally shallow borings. We have included the logs of explorations previously advanced to depths greater than 20 feet in Appendix C. The locations of these explorations are shown on Figure 3.

4.3 Soil Conditions

We observed that four basic soil units represent the on-site soils as indicated by our borings. These soil units reflect the geologic depositional history at the site, and are, in order of increasing age, fill, colluvium, and alternating pre-Fraser nonglacial fluvial and lacustrine deposits. Figure 5 is a generalized subsurface cross section based on subsurface conditions encountered in the explorations. Descriptions of these soils are presented in detail below.

Fill. This layer consists of loose to medium dense, gray brown to brown to dark gray, moist to wet, none to silty, none to gravelly, Sand and sandy Gravel. The Fill layer extends to a depth of up to 5 feet below the ground surface. This Fill unit is located below asphalt and concrete in the upper bench, and below a layer of surface Gravel on the lower bench. A possible cobble was encountered in B09-2 at a depth of 4 feet below ground surface. A strong total petroleum hydrocarbon (TPH) odor was observed in this unit in B09-2.

Colluvium. Underlying the Fill in exploration B09-1, this material consists of very soft, moist to wet, gray, none to sandy, Silt and loose to medium dense, very moist, gray silty Sand. Scattered zones of gravelly Sand were observed as well as scattered wood fragments and organic material. The colluvium layer was approximately 15 feet thick; the bottom of the unit corresponds to elevation 27 feet.

Pre-Fraser Nonglacial Fluvial Deposits. Pre-Fraser nonglacial fluvial deposits underlie the Colluvium in the upper bench and the Fill in the lower bench. This unit was observed to alternate with lacustrine deposits (described in the next section) within the borings located in the lower bench. This unit consists of loose to very dense, moist to wet, gray to dark gray, none to gravelly, none to silty Sand and none to silty, sandy Gravel. Possible scattered cobbles were observed in B09-3 at approximately 10 to 12 feet depth (elevation 1 to -1 feet) and in B09-2 and B09-3 between approximately 55 to 59 feet depth (B09-2: elevation -48 to -50 feet; B09-3: elevation -44 to -47 feet). Scattered shell fragments and trace scattered organic material were observed in this unit in the lower bench explorations. In exploration B09-2, TPH odors were observed to a

depth of 20 feet. In exploration B09-3, the soils were observed to be impacted with TPH or had TPH odors to a depth of 23 feet.

Pre-Fraser Nonglacial Lacustrine Deposits. This unit was observed to alternate with fluvial deposits (described in the previous section) within the borings located in the lower bench. This unit consists of medium dense, wet, olive gray, silty Sand to stiff to very stiff, sandy Silt. Traces of scattered shell, gravel, and wood fragments were observed. In exploration B09-02, a strong hydrogen sulfide (H_2S) odor was observed at a depth of 43 to 44 feet and the soil sample was observed to be an organic silt.

4.4 Groundwater

Our understanding of groundwater conditions at the site is based on explorations and water level measurements completed by Hart Crowser and others at the site. The upper and lower bench groundwater conditions are described in the following sections. Note that measured groundwater levels are representative for the times indicated. Fluctuations in groundwater levels may occur due to variations in rainfall, temperature, seasons, and other factors. It is important that the contractor be made aware of the possibility for providing contingencies for dealing with groundwater on this project.

4.4.1 Upper Bench

In exploration B09-1 on the upper bench, groundwater was encountered during drilling at a depth of 2.5 feet. This corresponds to an elevation of 44.5 feet.

As shown on Figure 3, several monitoring wells have been previously advanced on the upper bench. The explorations shown on Figure 3 are 20 feet deep or greater. Water level measurements were conducted at the site on October 5, 2009, in monitoring wells MW-95 and MW-122. At that time, the groundwater in MW-95 was observed at elevation 39.91 feet. Water was observed flowing out of MW-122, indicating artesian conditions. The ground surface elevation in MW-122 is approximately 48 feet.

4.4.2 Lower Bench

In explorations B09-2 and B09-3 on the lower bench, groundwater was observed in B09-2 only at a depth of 1.5 feet below the ground surface. This corresponds to an elevation of 5.5 feet. Wet soil conditions were observed in B09-3 starting at a depth of 7.5 feet below the ground surface, which corresponds to approximate elevation 3.5 feet.

In the vicinity of B09-2, several monitoring wells were previously advanced at the site, as shown on Figure 3. The explorations shown on Figure 3 are 20 feet deep or greater. Water level measurements were conducted by Hart Crowser between October 5 and 7, 2009, for MW-42, MW-103, and MW-110. At that time, the groundwater elevation was observed as 7.96 feet in MW-42; 5.11 feet in MW-103; and 5.2 feet in MW-110.

5.0 CRITICAL AREAS

Snohomish County Code (SCC) includes the protection of critical areas according to the Growth Management Act (RCW 36.70A.060 and 36.70A.170). Our geotechnical study addresses critical areas that are geologic hazards. Specific standards are provided in the Critical Area Regulations (CAR) Section 30.62B.300 for the treatment of erosion, landslide, seismic, mine, volcanic and tsunami hazard areas. The following sections describe applicable hazards and their potential impacts to the proposed development. Figure 6 shows the geologic hazard areas relevant to the site.

Based on the distance between the site and known mine and volcanic hazards, the risk for these particular hazards is considered low for the project site. Tsunami flooding hazards are possible at the site due to the close proximity of Puget Sound. Tsunami hazards are not addressed in detail in this report other than acknowledging that the SCC 1) requires that development activities comply with associated tsunami disclosure and recording requirements, and 2) encourages the developers to follow the recommendations in "Designing for Tsunamis.".

5.1 Erosion Hazard Areas

Erosion hazard areas are described in SCC 30.62B to include river-channel migration zones and shorelines of other water bodies subject to wind and wave erosion. The proposed development is not adjacent to any of the rivers listed in the code; however, it is located adjacent to a shoreline. The current influence of wave erosion is likely low due to the presence of a series of steel sheet pile seawalls, concrete seawalls and/or riprap adjacent to the Puget Sound along the shoreline.

Impact. Future site development is expected to include the re-establishment of the beach. Protection of the site from wave erosion will be addressed during design by the project team.

5.2 Landslide Hazard Areas

Landslide hazard areas per SCC 30.62B are defined as "areas subject to mass earth movement based on a combination of geologic, topographic, and hydrologic factors, with a vertical height of 10 feet or more." This includes areas with slopes that are steeper than 33 percent, where the geologic contacts are susceptible to landslide activity, and where springs or groundwater seeps are present. Landslide hazard areas also include areas of historic landslide activity.

According to the SCC, a structural setback is required from the top and bottom of the slope unless the County approves a deviation. The toe of the slope is defined by SCC 30.91S.390 as the lowest first significant and regular break in the slope. The top of the slope is defined as the top of the first significant and regular break in a slope. The minimum top of slope setback is 50 feet of the height of the slope divided by three. The minimum toe of slope setback is 50 feet or the height of the slope divided by two.

Impact. Future development of the site should have minimal impact to the existing slope conditions provided that setbacks or engineering solutions are utilized. The amount of impact will depend on the building locations and configurations. Mitigation measures that can be taken to minimize impact to the slope are described in Section 6.3.

5.2.1 Existing Geologic Information

We reviewed existing geologic information relevant to landslide activity for the area. The information reviewed included historical site photos (Aero-Metric 2008), the Washington State Department of Ecology Coastal Atlas, USGS Historic Landslide Activity (Baum et. al, 2000), and Snohomish County Landscape Imaging (SnoScape). Figure 7 illustrates existing geological information related to landslide hazard areas.

We reviewed historical aerial photographs from the site, and observed that a landslide appeared to have occurred above the upper bench between 1936 and 1946. The estimated extent of the slide area, as observed in the 1946 photograph, is shown on Figure 7. Comparison of these two photographs for the upper bench indicates that a large amount of development occurred in this time period, including cutting back the toe of the original slope. The slope cut most likely contributed to the landslide, although other factors may have contributed as well. Historical photographs from 1936, 1946, 1956, 1969, 1990 and 2004 are provided in Appendix D.

The Washington State Department of Ecology Coastal Atlas indicates that the entire slope east of the BNSF railroad and project site vicinity is unstable. The Department of Ecology slope stability maps are based on data between 1978 and 1980. The atlas also indicates that the slope north of the upper bench and adjacent to the railroad is a recent or historically active landslide area. The areas characterized by the Department of Ecology as unstable are shown on Figure 7.

The USGS developed a map illustrating the locations of recent and historic landslide activity on coastal bluffs in the project vicinity. The map was developed by Baum et. al in 2000 following a large number of landslides in the winters of 1996 and 1997. The closest large slide near the project was located approximately one mile north. This slide is known as the 1997 Woodway landslide which began as a deep-seated rotational slide which affected an area 600 feet wide and 200 feet high. The map indicates that three shallow earth or debris flows occurred in 1996 to 1997 within the project vicinity slope east of the BNSF railroad tracks.

Snohomish County Landscape Imaging data for the area is based on Light Detection and Ranging (LIDAR) imagery. LIDAR imagery produces topographic maps with virtual deforestation by the use of filtering to remove the tree canopy. The data illustrates areas where the slope is steeper than 33 percent and has vertical height of 10 feet or more. Figure 6 illustrates the areas considered to currently meet the steep slope criteria; however, actual conditions may vary. LIDAR hill shading is visible on Figure 4. The shading is prevalent in the area north of the site where the Woodway landslide occurred in 1997. LIDAR also highlights several slope length drainage areas within the slope east of BNSF railroad tracks, adjacent to the project site.

5.2.2 Geologic Reconnaissance

We conducted a field reconnaissance of the site with a primary focus on the condition of the steep slopes east of the BNSF railroad tracks on December 14, 2009. No significant rainfall had occurred in the previous week, and freezing temperatures were recorded the entire previous week.

The reconnaissance was performed by an engineering geologist and geotechnical engineer from Hart Crowser. The geologic reconnaissance was limited to areas that were accessible from the site. This reconnaissance is preliminary; a full scale reconnaissance survey of the slope would include several weeks or more of fieldwork and would include extensive surveying. A full-scale reconnaissance survey was not needed for the purposes of the permit application and environmental impact checklist.

The Snohomish County Code Section 30.62B requires specific information relevant to the geologic hazards be provided in the geotechnical report. The following sections provide relevant information for landslide hazards based on our field reconnaissance performed at the site. Appendix E provides photographs documenting some of the observations described in the following sections.

Significant geologic contacts, landslides, or downslope soil movement. Evidence of historic landslide activity was observed during our field reconnaissance of the steep coastal slope east of the BNSF railroad tracks. A clearly defined head scarp was observed on the slope north of the upper bench. Immediately below the scarp or crest, an oversteepened slope was observed, followed by hummocky terrain to the toe of the slope. We observed trees of similar ages grouped together, trees leaning downslope—indicating downslope soil movement, and trees tilted upslope—indicating potential soil block rotation as part of landslide activity (Figure E-1). These observations are consistent with the landslide descriptions from the Coastal Atlas of the area, as shown on Figure 7.

Due to slope vegetation, the observation of significant geologic contacts was limited. In the lower third of the slope, a contact was observed between the pre-Fraser Formation and the overlying Lawton Clay. A trickle of water was observed running down a channel carved out below the Lawton Clay (Figure E-2).

In other areas of the slope, soil exposures were observed that were consistent with the expected geology. On the slope between the upper bench and the BNSF railroad tracks, and south of the abandoned bridge, an exposed colluvium face was observed. The presence of the colluvium is consistent with the area being the site of past landslide activity. In the northern drainage way (Figure 2), an exposure of Lawton Clay was observed at approximately mid-height to the upper 1/3 of the height of the slope. This exposure is consistent with the geologic map of the area.

Along the toe of the slope, evidence of creep was observed east of the BNSF railroad tracks, and where a wood retaining wall is located, as shown on Figure 2. In some locations, a small amount of soil had made its way from behind the wall. In one area, the wall itself appeared to bulge out slightly due to soil movement (Figure E-3).

A concrete ecology block wall was observed at the toe of the slope in the upper bench area. Its presence suggests that soil needed to be retained in this area

due to cutting of the toe of the slope and/or past landslide activity. The slope in this area was not explored during the site visit due to access limitations.

Location or evidence of any springs, seeps, or other surface expressions of groundwater. Groundwater was observed at the toe of the slope located along the east side of the BNSF railroad tracks. Due to cold weather the previous week, some of the water had frozen in this area, which made the presence of the saturated toe more visible. Seeps were also observed on the short retaining walls at the toe of the slope (Figure E-4).

Topographic survey data indicated two drainage ways that extended from the top to the toe of the slope, as shown on Figure 2. The southern drainage way appeared to empty into a 6-foot-deep retention pond located on the northeastern part of the upper bench. At the time of the field visit, the retention pond was full and water was continuously flowing through it, despite the lack of recent rainfall.

The vertical extents of the northern drainage way were not determined during the site visit, but are generally estimated on Figure 2. At approximately mid-height to the upper 1/3 height of the slope, water was observed to be flowing downslope over exposed native clay (Figure E-5). The contact limits could not be determined, but the clay unit appear to continue to higher elevation.

Areas of saturated soil and visible surface water were observed in several isolated areas on the slope, potentially in close proximity to the vacated Heberlein Road that was shown on the LIDAR image.

Location or evidence of any surface water. Surface water was observed west of the existing detention pond. The water was observed to have migrated to the surface from below existing asphalt (Figure E-6). We understand that the water had previously been tested and the results indicated that the water was most likely linked to a water pipe that exists in the perimeter of the upper bench.

We observed a pipe whose outlet was on the surface of the slope between the upper bench and the railroad tracks. At the time of the site visit, water was visible flowing from the pipe and ice was present on the ground below the discharge location (Figure E-7).

Extent and type of vegetative cover. The observed vegetation on the slope and at the toe of the slope was similar. Shallow-rooted plants, such as blackberries, were observed at the toe and on the slope. In the areas accessed during the reconnaissance, vegetation density on the slope was predominantly low. This

observation is based on the amount of vegetation observed when leaves on the ground were pulled back from the ground surface (Figure E-8).

Hydrophytic plants such as horsetail, cat tail, and watercress, were observed predominantly at the toe of the slope near the railroad tracks (Figure E-9) and at the base of the slope of the upper bench (Figure E-10). These plants were also observed in isolated areas on the slope, predominantly in flatter areas on the slope where seeps or surface water was also observed.

5.3 Seismic Hazard Area

The site is located in a seismically active area. In this section, we describe the seismic setting at the project site, provide recommendations to develop the code-based design response spectrum, and discuss seismic-induced geological hazards.

5.3.1 Seismic Setting

The seismicity of western Washington is dominated by the Cascadia Subduction Zone (CSZ), in which the offshore Juan de Fuca plate is subducting beneath the continental North American plate. Three main types of earthquakes are typically associated with subduction zone environments—crustal, intraplate, and interplate earthquakes. Seismic records in the Puget Sound area clearly indicate the existence of a distinct shallow zone of crustal seismicity (e.g., the Seattle Fault) that may have surficial expressions and can extend to depths of up to 25 to 30 km (15 to 18 miles). A deeper zone is associated with the subducting Juan de Fuca plate and produces intraplate earthquakes at depths of 40 to 70 km (24 to 42 miles) beneath the Puget Sound region (e.g., the 1949, 1965, and 2001 earthquakes) and interplate earthquakes at shallow depths near the Washington coast (e.g., the 1700 earthquake with an approximate magnitude of 9.0).

5.3.2 Seismic Design

We understand that the seismic design of the proposed development will be performed in accordance with the 2006 International Building Code (IBC). The basis of design for this code is two-thirds of the hazard associated with an earthquake with 2 percent probability of exceedance in a 50-year time period, which corresponds to an average return period of 2,475 years. We obtained the seismic hazard from the United States Geologic Survey 2002 National Seismic Hazard Maps (USGS 2002) for Latitude 47.781 and Longitude –122.395. This location corresponds most closely with the middle of the lower bench of the site. Below, we provide parameters for a code-based seismic design.

- Maximum Considered Earthquake Spectral Response Acceleration at Short Periods, S_S = 1.206 g;

- Maximum Considered Earthquake Spectral Response Acceleration at 1-Second Period, S_1 = 0.423 g; and

- Peak Ground Acceleration for Site Class B, PGA = 0.534 g.

Without consideration of liquefaction-susceptibility, the soil site class was determined for the current explorations advanced in this study. In the upper bench, based on B09-1, the soil class was determined to be Site Class E. Variability was observed in the soil conditions across the upper bench, and other previous borings suggest these soils may be classified as Site Class D. The soils observed in the borings advanced in the lower bench, B09-2 and B09-3, are classified as soil site class D. Variability was observed in the soil conditions across the lower bench, and some of the previous borings suggest the soils may be classified as Site Class E. Following the determination of the building locations, we recommend advancing location-specific borings to better characterize the soil site class.

We performed liquefaction analyses for the three explorations advanced for the current study. The factor of safety against liquefaction in the loose to medium dense, saturated soil layers was less than 1.2 in the upper and lower bench locations. In the upper bench, layers in the fill and colluvium were estimated to be liquefiable. One of the existing explorations on the upper bench suggest that liquefaction potential is low (MW-95), and the other exploration (MW-122) suggests high liquefaction potential.

In the lower bench, layers in the lacustrine deposit (up to 47 feet below the ground surface) were estimated to be liquefiable in B09-2. Isolated layers in the upper 23 feet of B09-3 have the potential to liquefy. The amount of liquefaction depends on the soil density, soil type and soil saturation. Due to the large site area, there is significant variability in the amount of liquefaction expected. Following the determination of the building locations, we recommend advancing location-specific borings to better characterize the liquefaction hazard.

Because the site is potentially liquefiable, the soil is Site Class F. A site-specific site response analysis is required by code for Site Class F sites with building periods of more than 0.5 second. At this time, we expect that future development may include a building that will have a fundamental period of greater than 0.5 second; therefore, a site response analysis would need to be performed at a later stage of design.

5.3.3 Seismic-Induced Hazards

For development applications in Snohomish County, applicable standards of the International Building Code and SCC Chapter 30.51A must be met. Potential seismic-induced geotechnical hazards at the proposed site include surface rupture, liquefaction and subsidence, lateral spread, and seismically induced landslides. Our review of these hazards is based upon the existing soil explorations presented in this report, regional experience, and our knowledge of local seismicity.

5.3.3.1 Surface Rupture

The middle of the lower bench of the site is located approximately 15 km (about 9 miles) south of the Southern Whidbey Island Fault, and approximately 20 km (about 12.5 miles) north of the northern trace of the Seattle Fault (USGS 2002). The probability that these faults would produce surface rupture that would affect the site is low.

5.3.3.2 Liquefaction and Subsidence

When cyclic loading occurs during a seismic event, the shaking can increase the pore pressure in loose to medium dense saturated sands and cause liquefaction, or temporary loss of soil strength. This can lead to surface settlement.

We encountered saturated soils in a loose to medium dense condition in the borings conducted for this project. We estimate the likelihood of widespread liquefaction capable of causing damage to be high in the lower bench of the site, as described in Section 5.3.2. The Washington State Open File Report 2004-20 provides maps of liquefaction susceptibility maps by county. According to this map, the susceptibility to liquefaction at the site is high for the lower bench (Figure 6). This conclusion is in agreement with our preliminary analysis of the soil characteristics for the lower bench.

As described in Section 5.3.2, the soils observed in the current study on the upper bench are potentially liquefiable. The Washington State Open File Report 2004-20 does not consider this location to have high liquefaction potential, as shown on Figure 6. The discrepancy may be attributed to the scale at which the Open File Report was performed, as well as the variability in the soil conditions on the upper bench; specifically, whether the location was in the colluvium deposit (MW-122 and B09-1) or in the native soils (MW-95).

Impact. After building locations are determined, we recommend advancing location-specific borings to better characterize the liquefaction hazard.

Developing on a site that is potentially liquefiable will require engineering solutions to minimize the impacts of liquefaction-induced settlement. Several alternatives would be feasible, including ground improvement or pile-supported structures. Ground improvement can be accomplished by a number of methods and results in engineered soil conditions where liquefaction potential is reduced. As an alternative to performing ground improvement, the proposed structures could be designed to be supported by deep foundations that extend to the dense bearing materials.

5.3.3.3 Lateral Spreading

Lateral spreading is typically associated with slope movement caused by the liquefaction of underlying soils. The site perimeter of the lower bench is currently constructed of retaining walls and shoring. The depth of these elements is understood to extend up to 25 feet below the ground surface. However, as-built plans or further reconnaissance is required to accurately determine the shoring depth. There is no retaining wall around the upper bench. Without consideration of retaining structures, we estimate lateral spread to be on the order of several feet near the existing shoreline. We expect the amount of lateral spread to decrease closer inland. This estimate may be refined by the use of more sophisticated analysis tools, which is not needed for the purposes of the permit application and environmental impact checklist.

Impact. Future site development is expected to include re-establishment of the beach. The existing retaining walls are likely to be removed in this process. Lateral spread can affect the stability of the overlying structures. Appropriate engineering solutions to mitigate lateral spread are described in Section 6.2.1.1. Foundations will need to be designed for the influence of lateral spread. Non-building elements (i.e., walkway, beach) may be affected by lateral spread and maintenance of these elements will be required.

5.3.3.4 Seismically Induced Landslides

Landslides can be triggered by the increase in load from an earthquake. Stability analysis of the slope and project elements can be performed to evaluate the effect of this event.

Impact. The potential of a seismically induced landslide that will affect the site depends on the location and type of development planned at the site. The impact of the development to the site can be mitigated provided that setbacks or engineering solutions are used. Slope stabilization measures to minimize impact to the slope are described in Section 7.3.

6.0 PRELIMINARY GEOTECHNICAL ENGINEERING DESIGN RECOMMENDATIONS

This report was prepared in the preliminary stage of the project prior to determination of the building location, footprint, height or type. We understand that the general concept is to place buildings set back from the waterfront along the east edge of lower bench, and on the upper bench.

6.1 Foundation Considerations

The type of foundations that may be recommended for the proposed site development depends on the nature of the underlying soils and the depth below grade of the structures. General recommendations are described in the following sections.

For locations that basement levels are not desired: (i.e., at grade construction) Because the subsurface soils are potentially liquefiable, shallow foundations are not recommended to support the building loads without first performing ground improvement or overexcavation and replacement. Deep foundations that extend to and are supported by the dense to very dense pre-Fraser Nonglacial Fluvial soils are recommended.

Where daylight basements are desired: (i.e., fill placed partially around existing surface) Retaining walls will be required to resist soil pressures. The foundation type would be similar to that required for structures developed on the ground surface.

Where basement levels are desired: Shoring and deep excavations would be required. Due to the high water table observed in the explorations, a temporary dewatering system would be required in the excavation. Potential alternatives would include a soldier pile with tiebacks or a cement-soil-mix (CSM) or slurry wall.

The type of shoring system would depend on the depth of the excavation as well as the possibility of obtaining discharge permits to discharge the collected water. Foundation types would be determined based on the depth of the excavation and building loads.

Another consideration of excavation below the existing ground surface or construction of drilled foundations is the cost to dispose of potentially contaminated soils that would be encountered. These issues are addressed in other project documentation. Disposal of potentially contaminated soils are likely to be a small percentage of overall cleanup costs.

6.2 Foundation Types

As described in the previous section, several foundation types may be recommended for development. These foundation types are discussed in general in the following sections.

6.2.1 Shallow Foundations

We do not recommend the use of shallow foundations in areas where there are potentially liquefiable soils, unless the soils are treated with ground improvement or the soils are overexcavated and replaced. These methods are discussed in the following sections.

6.2.1.1 Ground Improvement

Ground improvement is the modification of *in situ* soils in order to achieve desirable soil characteristics. In this case, loose, liquefiable soils can be modified to increase the soil's resistance to liquefaction. Several ground improvement options are described below.

Stone Columns. The use of stone columns is a ground improvement technique where stones displace or replace weak soils using either an electrical or hydraulically actuated, cylindrical shaped vibrating probe. In applications related to liquefaction mitigation, stone columns are typically 30 to 42 inches in diameter and spaced 6 to 10 feet on center. Installation of stone columns typically densifies liquefaction-susceptible granular soils surrounding the stone columns. It has been our experience that stone columns installed within shallow depths can cause ground heave (i.e., loosening rather than densifying surrounding soils) if the fines content of the soils exceeds 15 to 35 percent. If this option is considered, we recommend more sampling and laboratory testing be completed to evaluate the feasibility of stone columns.

GeoPiers or Rammed Aggregate Piers. The geopier system consists of augering out undesirable soils to a depth that reaches underlying, more competent material and then filling the augered hole with compacted aggregate. For the subject project, geopiers should extend at least 2 feet into the bearing soils. The design of a geopier system should be completed by a contractor who specializes in geopiers. The spacing and distribution of geopiers depends on the settlement requirements. Geopiers are typically installed as 24 to 30 inches in diameter and spaced 6 to 10 feet on center, depending on loading, settlement, and liquefaction mitigation requirements.

Grouting. Grouting is a ground improvement procedure used to create *in situ* soil-cement formations. In compaction grouting, the surrounding soil is displaced and bulbs of cementatious grout are formed. The result is a soil-cement "column" or, using several grouting locations, a soil-cement mass of variable geometry. The geometry and physical properties of the soil-cement are engineered. We recommend that the grouting be contracted as design-build to allow the contractor to optimize the installation method.

6.2.1.2 Overexcavation

The unsuitable soils may also be excavated and replaced by compact structural fill. Due to the depth of the unsuitable soils and high groundwater table, this option may not be very economical and will generate potentially contaminated soil and groundwater that requires disposal.

6.2.2 Deep Foundations

A variety of deep foundation options will most likely be required to support the proposed development. Vertical compressive loads can be resisted by friction along the pile sides and by end bearing at the tip. Therefore, it is critical that piles be embedded sufficiently into competent soils. We define competent soil (or bearing stratum) as the dense to very dense, pre-Fraser Nonglacial Fluvial Deposits. The depth to the competent soils may vary across the site. The explorations from the current study indicate these soils at a depth of 47 to 50 feet below the ground surface. Additional subsurface explorations are recommended once the building locations are determined to determine pile tip depths.

Several pile types are described in the following sections. The type of pile that would be recommended for this project depends on the loads and locations of the proposed structures. In addition, concerns about vibration or noise during installation should factor into pile type selection.

6.2.2.1 Drilled Shafts

A drilled shaft is a drilled, cast-in-place concrete reinforced pile. It is installed by augering down to the pile depth, lowering a reinforced steel cage into the bored hole, and using a tremie pipe to pump concrete to the base of the hole. Drilled shafts are typically larger in diameter (3 to 10 feet), which may allow penetration though cobbles and boulders where smaller diameter holes may not succeed. Drilled shaft installation is a low-vibration and relatively quiet process. However, due to their generally large diameter, a significant amount of cuttings may be generated.

6.2.2.2 Augercast Piles

An augercast pile is a mid-sized (14 to 24 inches in diameter), drilled and grouted replacement pile that is typically reinforced. Augercast piles are a good alternative to driven piles due to the lower vibration and noise generated by augered piles. Augercast piles are installed by continuously auguring down to the pile depth with a plug in the auger tip. When the pile depth is reached, the plug is removed and grout flows out of the auger under pressure as the auger is extracted from the hole. To increase the uplift pile capacity, a steel bar is usually placed in the center of the pile and a steel cage is placed in the upper portion to provide increased lateral resistance. Augercast piles can be a cost-effective foundation system; however, additional cuttings will be generated.

6.2.2.3 Micropiles

A micropile is a small diameter (6 to 12 inches in diameter), drilled and grouted replacement pile that is typically reinforced. A micropile is installed by rotary drilling a borehole, placing reinforcement, and grouting from the bottom up. The end bearing capacity of micropiles is typically neglected because it is minor compared to the grout-to-ground capacity along the pile's perimeter. The soil conditions and installation procedure strongly influence the grout-to-ground strength. Micropiles, like augercast piles, are bored piles that generate cuttings. Micropiles are typically used when overhead room is limited or when the loads are light.

6.2.2.4 Driven Piles

Because of potential noise impacts, this option is not currently under consideration. Driven piles include prefabricated steel and concrete piles which are installed into the ground using a pile-driving rig equipped with a vibratory or impact hammer. Steel piles typically include H-piles or pipe piles. Concrete piles typically include octagonal or square precast reinforced concrete members. Due to the nature of pile driving, noise and vibration is generated during installation. The benefit of using driven piles is that cuttings are not generated, installation is relatively quick compared to bored piles, and pile capacities can be verified during installation.

6.3 Slope Stability

The slope reconnaissance and the existing historical data suggest that slope stability analysis would need to be performed if construction is planned within the setback distance. The results of the stability analysis could be used to design engineering solutions to minimize impact to structures in the event of a slope

failure. Constructing retaining walls near or at the toe of the slope could potentially enable development within the setback requirements by the Snohomish County Code. Potential wall alternatives for the retaining the slope include soldier pile walls with tiebacks, mechanically stabilize earth (MSE) walls, and concrete gravity walls.

Engineering solutions to improve the existing slope conditions may include increasing slope vegetation, and reducing water discharge and/or infiltration to the site and slope.

6.4 Seismic Design

Based on the soil conditions observed at the site and the identified seismic hazards, development of the site would require seismic design, including site-specific response analysis if the proposed buildings will have building periods greater than 0.5 seconds.

The impacts of liquefaction-induced settlement may be mitigated by the choice of foundation systems used for the proposed structures. The impacts of lateral spreading may be reduced by the selected foundation system and/or improvement of existing seawalls. The impacts of seismically-induced landslides may be mitigated in the manner described in the previous section on Slope Stability.

7.0 RECOMMENDED ADDITIONAL GEOTECHNICAL SERVICES

After proposed building layout, loads and locations are determined, additional design-level geotechnical engineering will be necessary. We understand that design-level analyses are not needed for the purposes of the permit application and environmental impact checklist.

8.0 REFERENCES

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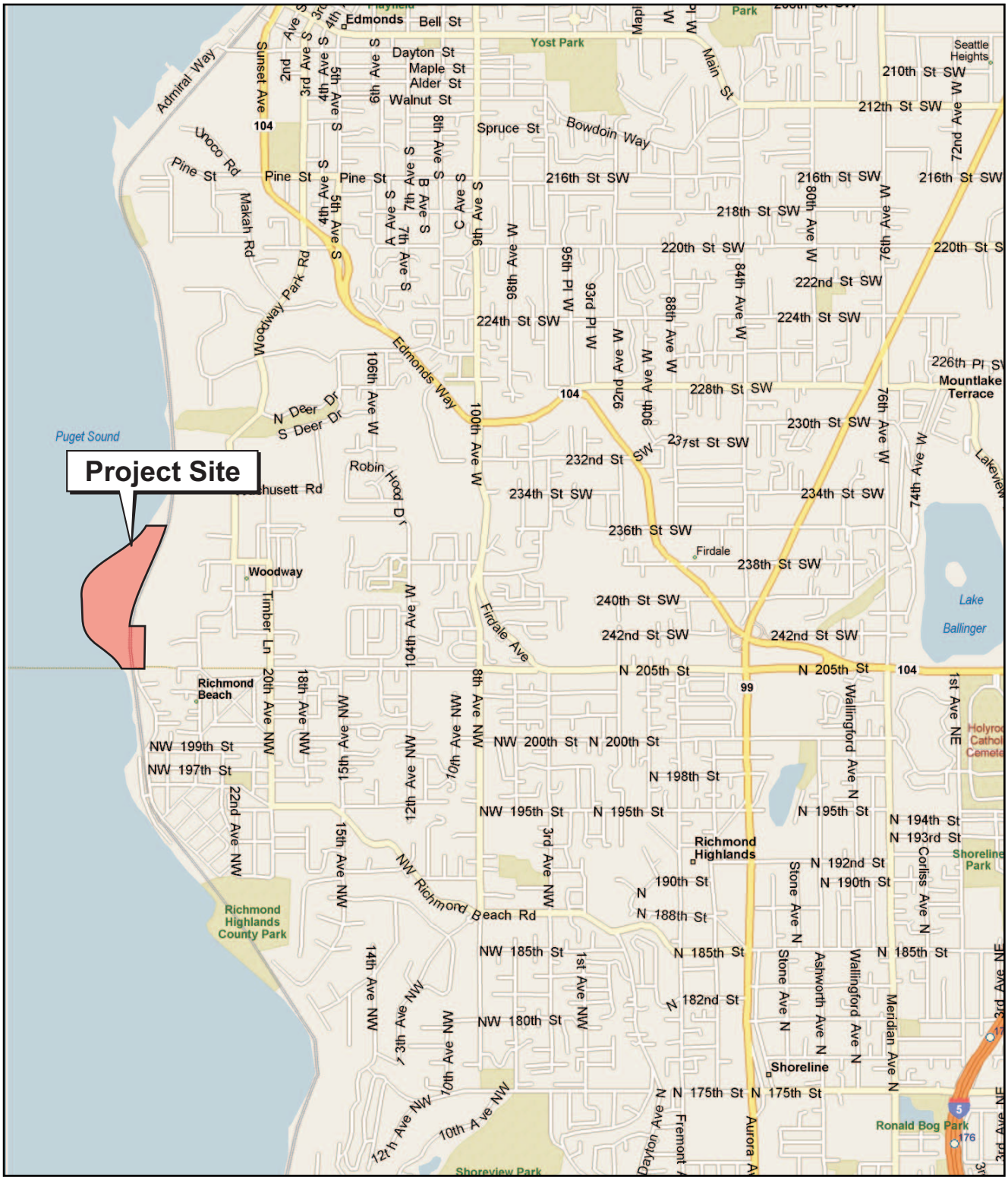

Note: Base map prepared from Microsoft Streets and Trips 2005.

0 0.5 1

Approximate Scale in Miles

N

Point Wells

Richmond Beach, Washington

Vicinity Map

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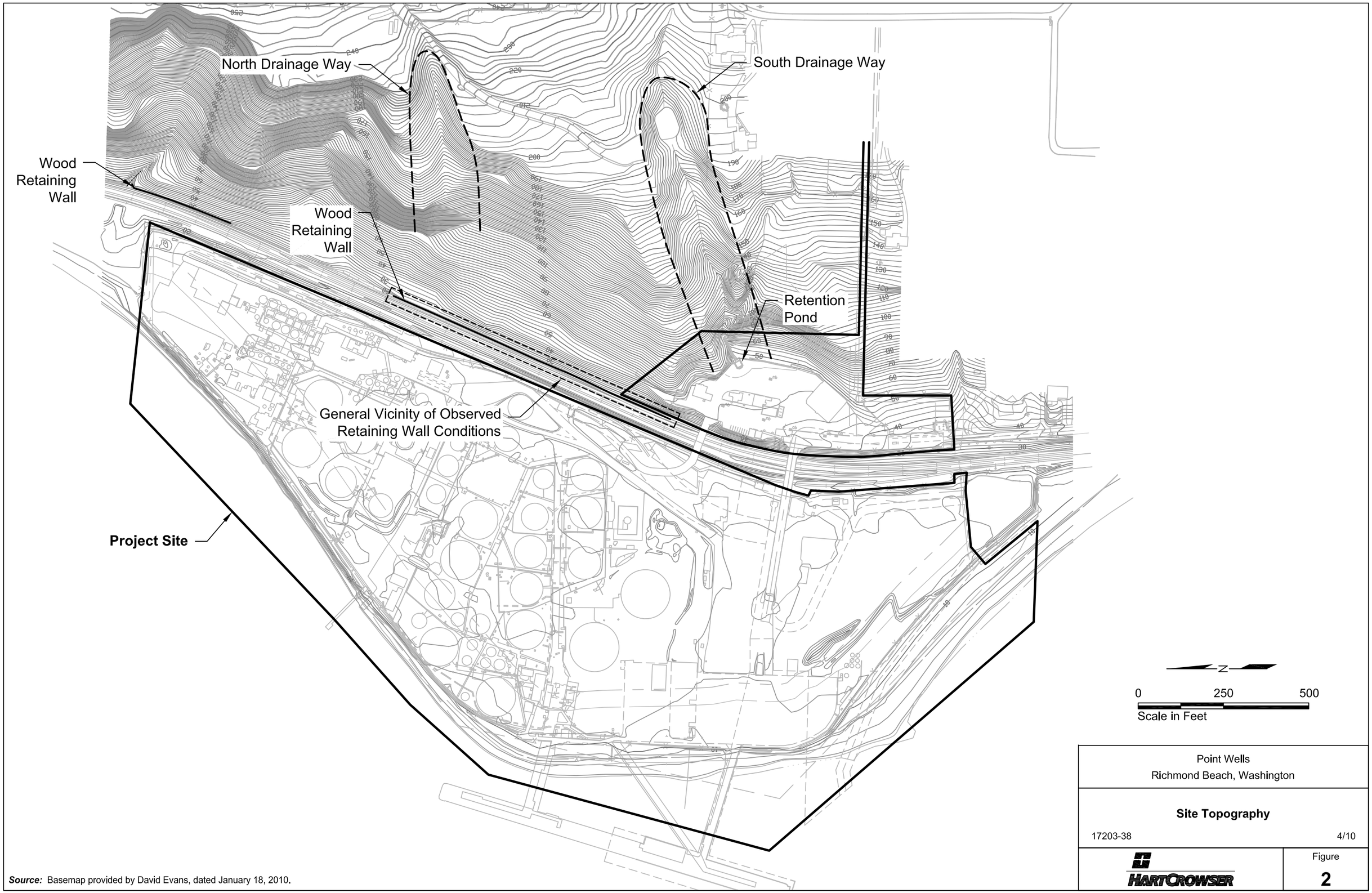
Figure

1

EAL 02/01/10 1720338-AA.cdr



Point Wells
Richmond Beach, Washington

Site Topography

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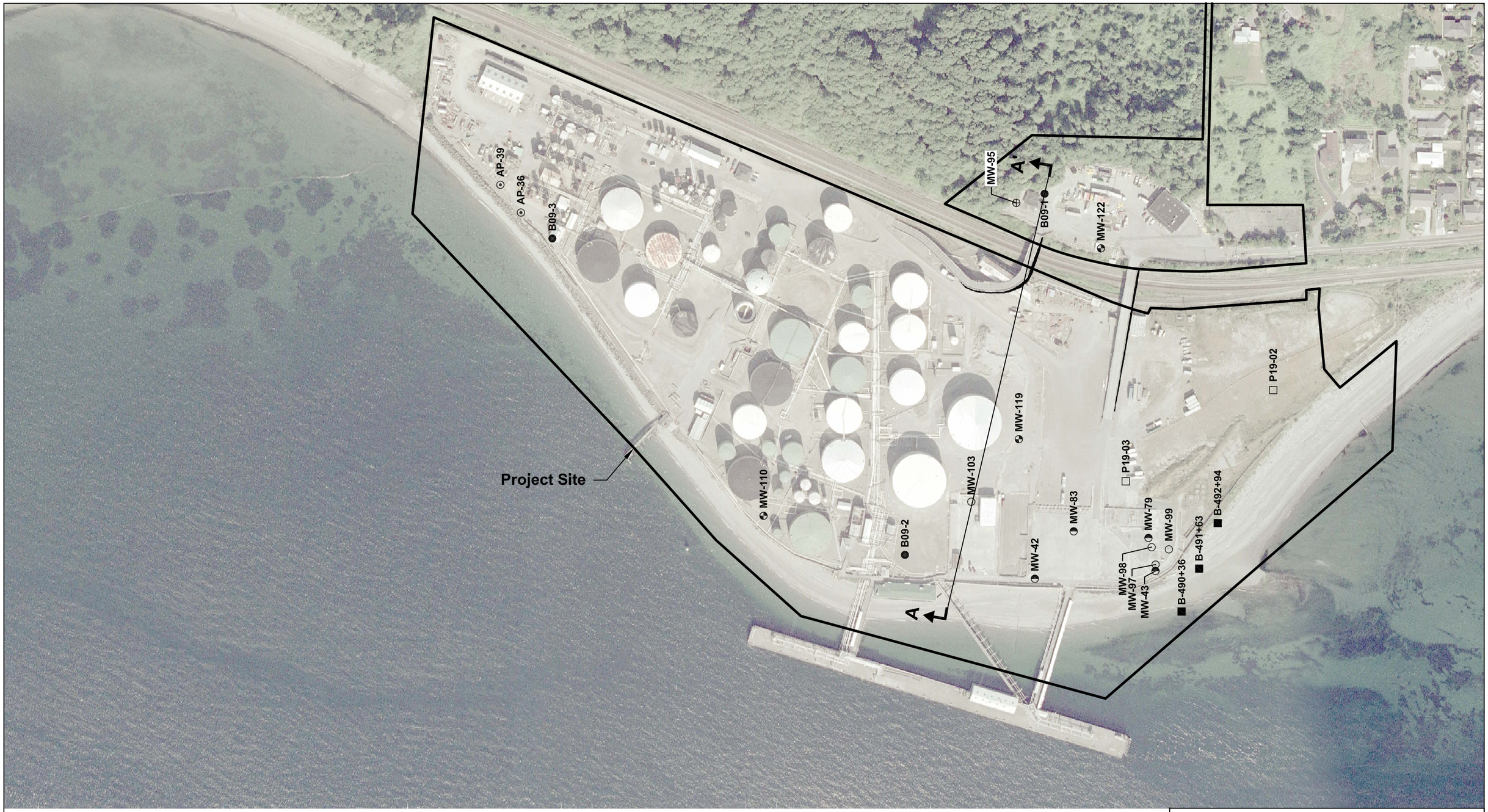
Figure
2

Source: Basemap provided by David Evans, dated January 18, 2010.

EAL 04/6/10 1720338-009.dwg



Exploration Location and Number

B09-1 ●	Hart Crowser Boring, 2009	MW-110 ◐	Hart Crowser Monitoring Well, 2008
B-483+00 ■	HWA Boring, 2007	MW-99 ○	KHM Monitoring Well, 2001
P19-03 □	CDM Boring, 2003	MW-95 ⊕	Pacific Environmental Group Monitoring Well, 1998
AP-39 ⊙	KHM Boring/Well, 2001	MW-79 ◑	Convers NW Monitoring Well, 1991-1992

A A' Approximate Cross Section Location and Designation

Note: Exploration shown on figure are 20 feet or deeper. Additional explorations previously advanced at the site that are shallower are not shown.

N

0 250 500

Scale in Feet

Point Wells
Richmond Beach, Washington

Site and Exploration Plan

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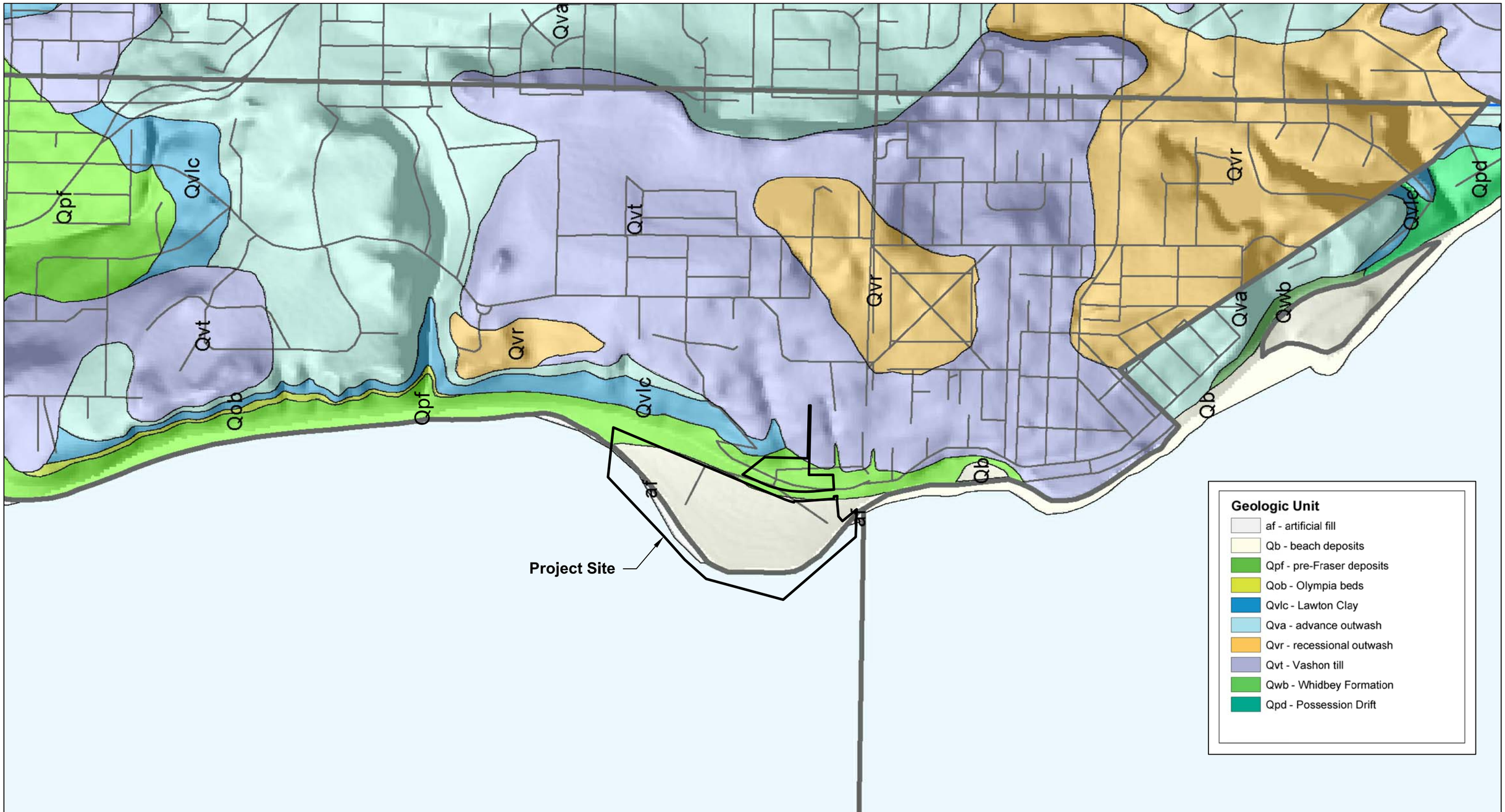
Figure **3**

EAL 04/6/10 1720338-004.dwg



Source: "Composite Geologic Map of the Sno-King Area," Central Puget Lowland, Washington by Derek booth, Brett Cox, Kathy Troost, and Scott Shimel. Seattle-Area Geologic Mapping Project (SGMP), University of Washington, and the United States Geological Survey (USGS) January 5, 2004. Map scale based on 1:24,000.

N

0 1000 2000

Scale in Feet

Point Wells
Richmond Beach, Washington

Geologic Map

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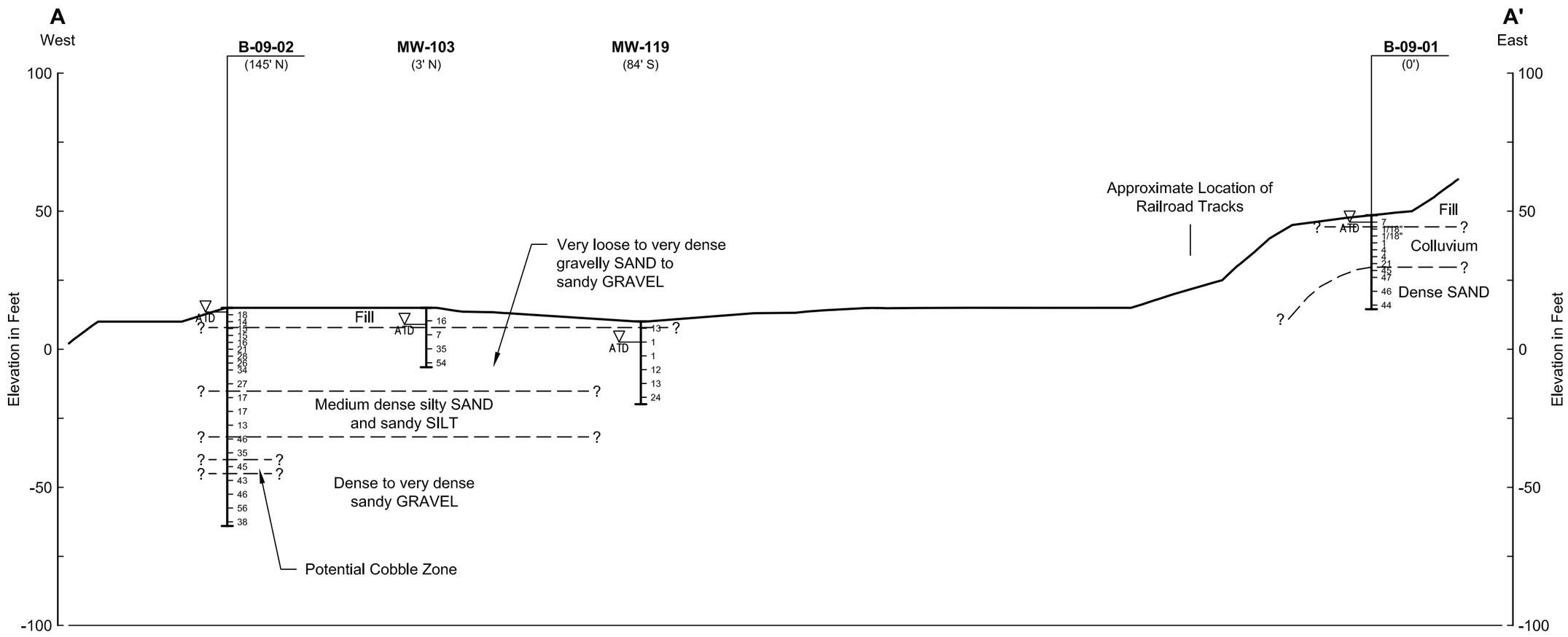
HARTCROWSER

Figure

4

EAL 04/6/10 1720338-002.dwg



HC-102 Exploration Number
(34.5' E) (Offset Distance and Direction)

Exploration Location

ATD Water Level

9 Standard Penetration Resistance in Blows per Foot

Horizontal Scale in Feet
0 100 200
0 40 80
Vertical Scale in Feet
Vertical Exaggeration x 2.5

Point Wells
Richmond Beach, Washington

Generalized Subsurface Cross Section A-A'

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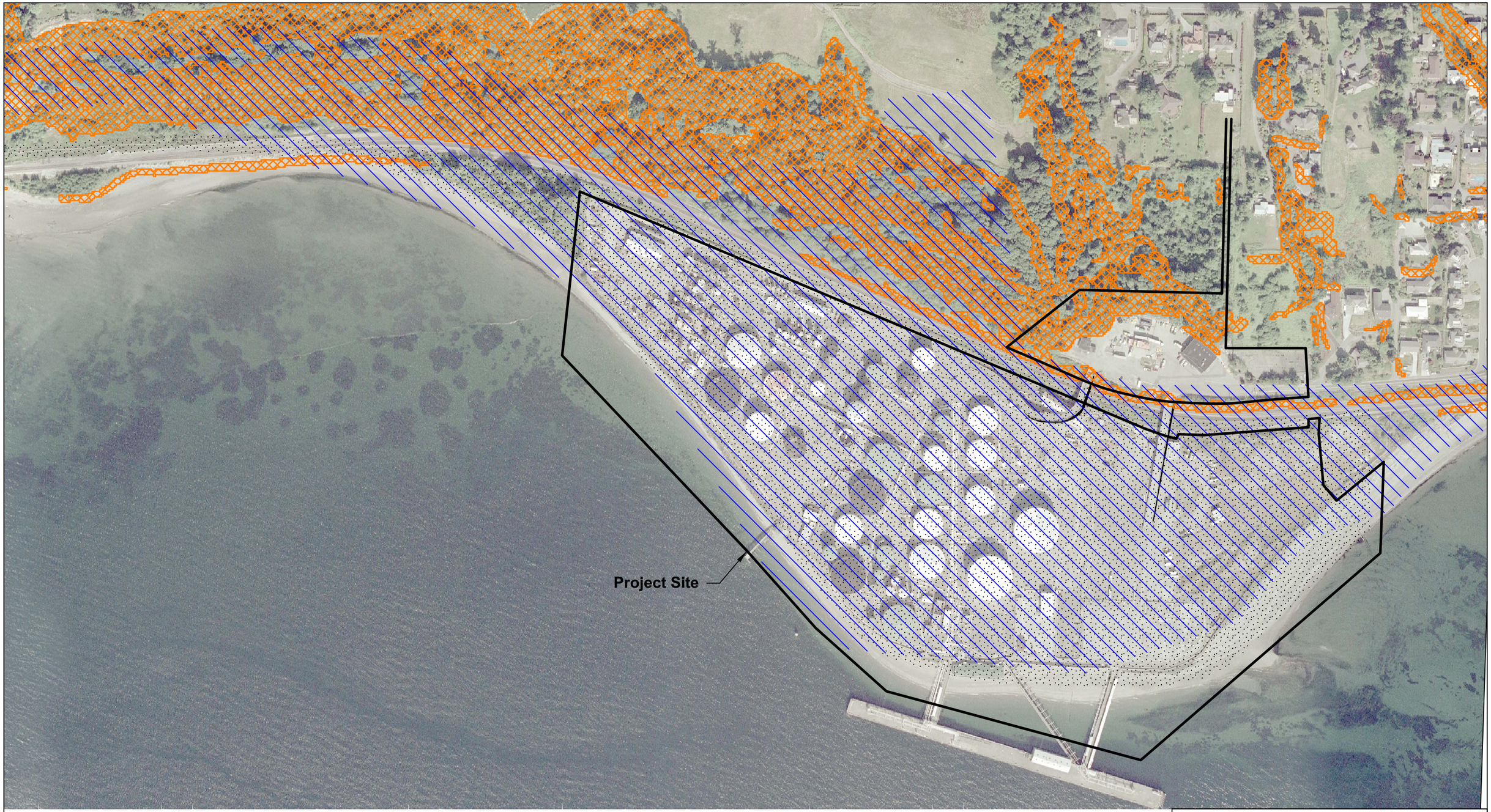
Figure
5

EAL 04/6/10 1720338-005.dwg



Geologic Hazards

- Landslide Hazard Area (>33% Slopes and ≥10-Foot Elevation Change)
- Modified Land
- High Liquefaction Susceptibility

Note:
This map is for information purposes. Data were compiled from multiple sources as listed on this map. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this map. The locations of all features shown are approximate.

Source:
1. Steep Slope Data from Snohomish County.
2. Modified Land Data from Washington State Department of Ecology Coastal Atlas.
3. Liquefaction Susceptibility Map of Snohomish County from Washington State Department of Natural Resources.

N

0 300 600

Scale in Feet

Point Wells
Richmond Beach, Washington

Geologic Hazard Areas

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Figure
6

EAL 04/6/10 1720338-003.dwg

Source: Unstable Area Data from Washington State Department of Ecology Coastal Atlas.

Recent Unstable Area

Unstable Area

0 500 1000

Scale in Feet

N

Point Wells

Richmond Beach, Washington

Existing Geologic Information

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Figure

7

EAL 04/6/10 1720338-008.dwg

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

APPENDIX A
FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser used in determining the nature of the site soils. The discussion includes information on the following subjects:

- Explorations and Their Location;
- Mud Rotary Borings; and
- Standard Penetration Test (SPT) Procedures.

Explorations and Their Location

Subsurface explorations for this project include three mud rotary borings. The exploration logs within this appendix show our interpretation of the drilling, sampling, and testing data. The logs indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure A-1 - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Location of Explorations. Figure 2 shows the location of explorations, located by using a tape measure from existing physical features. The ground surface elevations at these locations were interpreted from elevations obtained from King County LiDAR Digital Ground Model Contour Isolines. The data corresponds to conditions observed between November 2000 – February 2003. The vertical datum is NAVD88. The measurement method used determines the accuracy of the location and elevation of the explorations.

Mud Rotary Borings

With depths ranging from 34 to 79 feet below the ground surface (bgs), three mud rotary borings, designated B-09-1, B-09-2 and B-09-3, were drilled from December 28, 2009, to January 05, 2010. Boring B-09-1 was advanced with a 6-inch-diameter tri-cone bit to the bottom of the boring while borings B-09-2 and B-09-3 used a 6-inch-diameter tri-cone bit to 22-1/2 feet bgs and thereafter with a 4-inch diameter tri-cone bit to the bottom of the boring. The borings were advanced with a truck-mounted drill rig subcontracted by Hart Crowser. The drilling was continuously observed by a geologist from Hart Crowser. Detailed field logs were prepared for each boring. Using the Standard Penetration Test (SPT) and standard split-spoon sampler, we obtained samples at 2-1/2- to 5-foot-depth intervals.

The boring logs are presented on Figures A-2 through A-4 at the end of this appendix.

Standard Penetration Test (SPT) Procedures

This test is an approximate measure of soil density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. The SPT (as described in ASTM D 1586) was used to obtain disturbed samples. This test employs a standard 2-inch outside diameter split-spoon sampler. Using a 140-pound hammer, free-falling 30 inches, the sampler is driven into the soil for 18 inches. The number of blows required to drive the sampler the last 12 inches only is the Standard Penetration Resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive soils. The blow counts are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel sampler, field classified, and placed into watertight jars. They are then taken to Hart Crowser's laboratory for further testing as described in Appendix B.

In the Event of Hard Driving

Occasionally very dense materials preclude driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as follows:

Penetration less than 6 inches. The log indicates the total number of blows over the number of inches of penetration.

Penetration greater than 6 inches. The blow count noted on the log is the sum of the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches. The number of blows needed to drive the first 6 inches are not reported. For example, a blow count series of 12 blows for 6 inches, 30 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 3 inches would be recorded as 80/9.

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Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits and probes is estimated based on visual observation and is presented parenthetically on the logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 to 4	Very soft	0 to 2	<0.125
Loose	4 to 10	Soft	2 to 4	0.125 to 0.25
Medium dense	10 to 30	Medium stiff	4 to 8	0.25 to 0.5
Dense	30 to 50	Stiff	8 to 15	0.5 to 1.0
Very dense	>50	Very stiff	15 to 30	1.0 to 2.0
		Hard	>30	>2.0

Sampling Test Symbols

- 1.5" I.D. Split Spoon
- Grab (Jar)
- 3.0" I.D. Split Spoon
- Shelby Tube (Pushed)
- Bag
- Cuttings
- Core Run

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

Moisture

- Dry — Little perceptible moisture
- Damp — Some perceptible moisture, likely below optimum
- Moist — Likely near optimum moisture content
- Wet — Much perceptible moisture, likely above optimum

Minor Constituents	Estimated Percentage
Trace	<5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Laboratory Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits

Water Content in Percent
Liquid Limit
Natural
Plastic Limit

PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	In Situ Density in PCF
OT	Tests by Others

Groundwater Indicators

- Groundwater Level on Date or (ATD) At Time of Drilling
- Groundwater Seepage (Test Pits)

Sample Key

Sample Type
Sample Recovery
S-1
12
23
50/3"
Sample Number
Blows per 6 inches

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Figure A-1

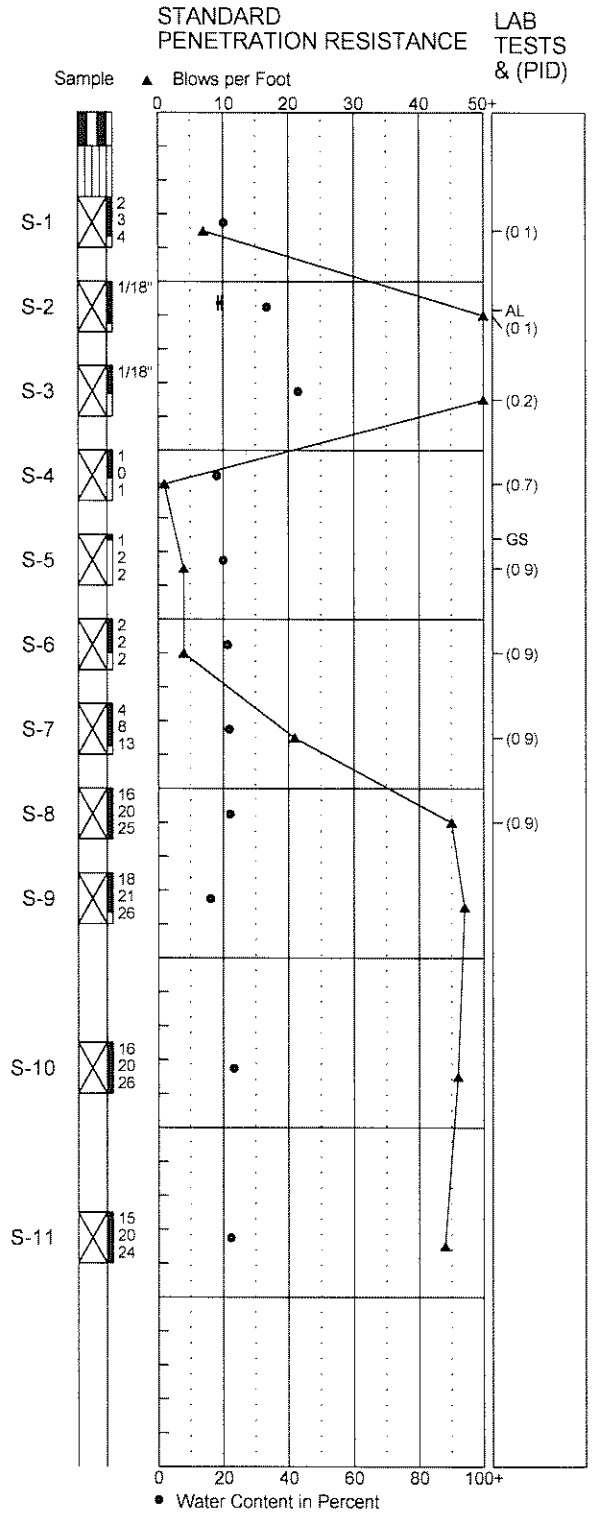
KEY SHEET 1720338.BL.GPJ HC_CORP.GDT 1/15/10

Boring Log B-09-1

Location: See Figure 3.
Approximate Ground Surface Elevation: 47 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

USCS Class	Soil Descriptions	Depth in Feet
	2 inches of Asphalt over 10 inches of Sand over 3 inches of Concrete.	0
SM	Loose, wet, gray-brown, silty SAND with scattered gravel. (FILL)	ATD
	Brown discharge with abundant gravel observed.	5
ML	Very soft, wet, gray SILT and sandy SILT. (Colluvium)	
	Trace of wood fragments observed to 11.5 feet.	
	Scattered organic material and zones of silty gravel observed.	10
SM/GM	Loose, wet, gray, slightly silty, very sandy GRAVEL with trace organic material to 15 feet. (Colluvium)	
	Grades to silty SAND with zones of sandy SILT and scattered gravel to 17.5 feet.	15
	Medium dense, with gravelly SAND zones.	
SP	Dense, wet, gray SAND. (Fluvial)	20
	Gravelly.	25
	Slightly silty.	30
	Occasional silty SAND partings.	
	Bottom of Boring at 34.0 Feet. Started 01/05/10. Completed 01/05/10.	35
		40



NEW BORING LOG 1720338-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17203-38 1/10

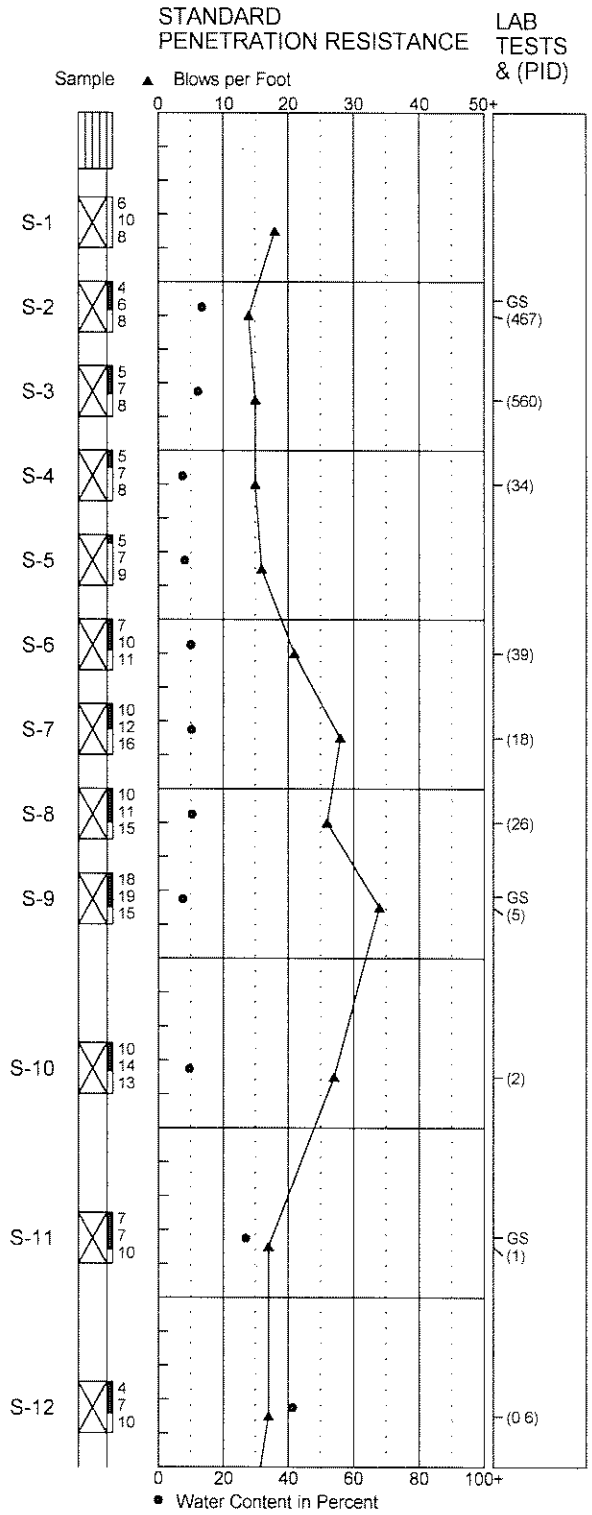
Figure A-2

Boring Log B-09-2

Location: See Figure 3.
Approximate Ground Surface Elevation: 7 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

USCS Class	Soil Descriptions	Depth in Feet
SM/GM	Crushed GRAVEL over (medium dense), moist, brown, gravelly SAND to (medium dense), wet, gray, sandy GRAVEL. (FILL) Large gravel/cobbles observed with petroleum hydrocarbon-like odor to 5 feet.	0
SP	Medium dense, wet, dark gray, very gravelly SAND to silty, gravelly SAND (TPH impacted). (Fluvial)	5
GP	Medium dense, wet, gray to dark gray, slightly silty, sandy GRAVEL. (Fluvial) 12 inches of slough observed. Slight petroleum hydrocarbon-like odor to 20 feet. Very sandy. Slightly silty, gravelly SAND to sandy GRAVEL.	10, 15, 20
SM/GM	Dense, wet, gray, slightly silty, very gravelly SAND to medium dense, sandy GRAVEL. (Fluvial)	25
SM	Medium dense, wet, olive-gray, silty SAND with wood fragments. (Lacustrine) Grades to very silty SAND to sandy SILT with scattered gravel and shells.	30, 35, 40



NEW BORING LOG 1720338-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

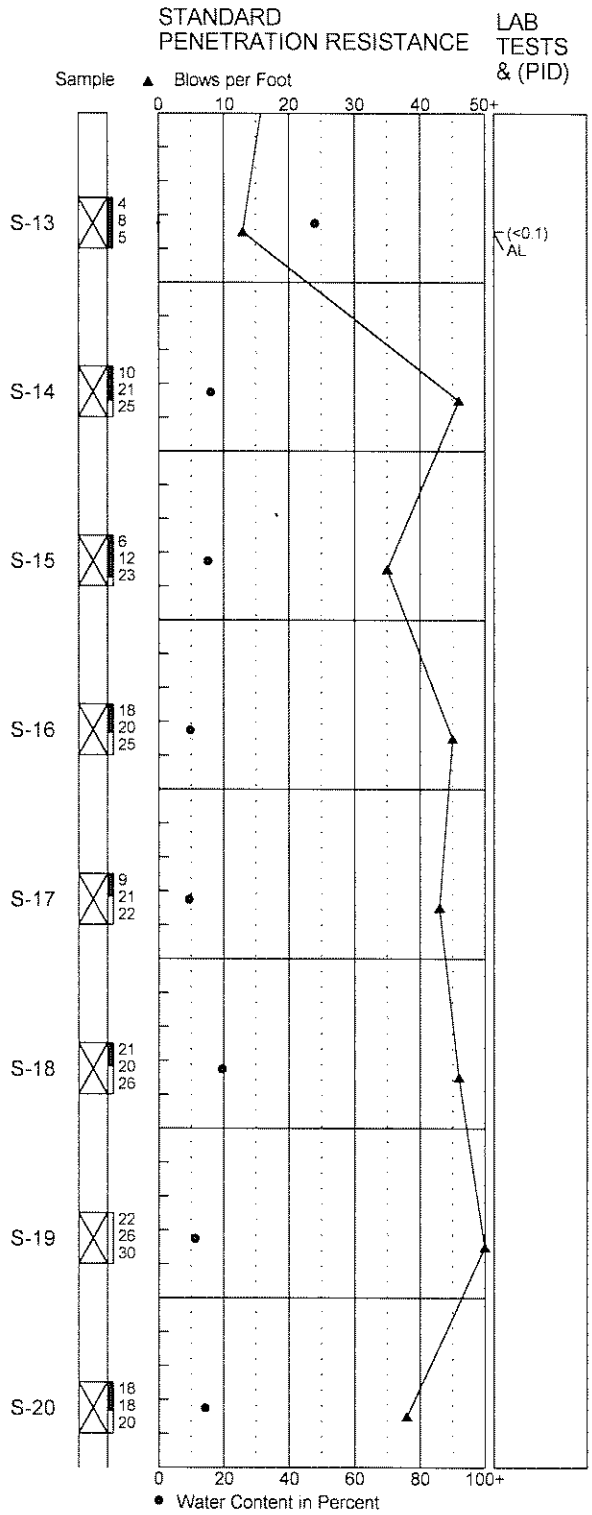
HARTCROWSER

Boring Log B-09-2

Location: See Figure 3.
Approximate Ground Surface Elevation: 7 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SM		Medium dense, wet, olive-gray, silty SAND with wood fragments. (Lacustrine) (cont'd)	40
		Grades to stiff, wet, olive-gray, sandy SILT with scattered wood fragments, trace of shell, and hydrogen sulfide odor. (Non-plastic)	
		Abundant wood fragments observed to 47 feet.	45
GP		Dense, wet, gray to dark gray, sandy GRAVEL with shell fragments to 59 feet. Silty. (Fluvial)	50
		Gravelly SAND.	55
		Drill action indicates possible large gravel/cobbles.	60
			65
		Slightly silty, gravelly SAND.	70
		No recovery with 2-inch diameter SPT. Resampled with 3-inch diameter SPT. Abundant shell fragments to bottom of boring.	75
		Bottom of Boring at 79.0 Feet. Started 12/28/09. Completed 12/30/09.	80



NEW BORING LOG 172033B-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

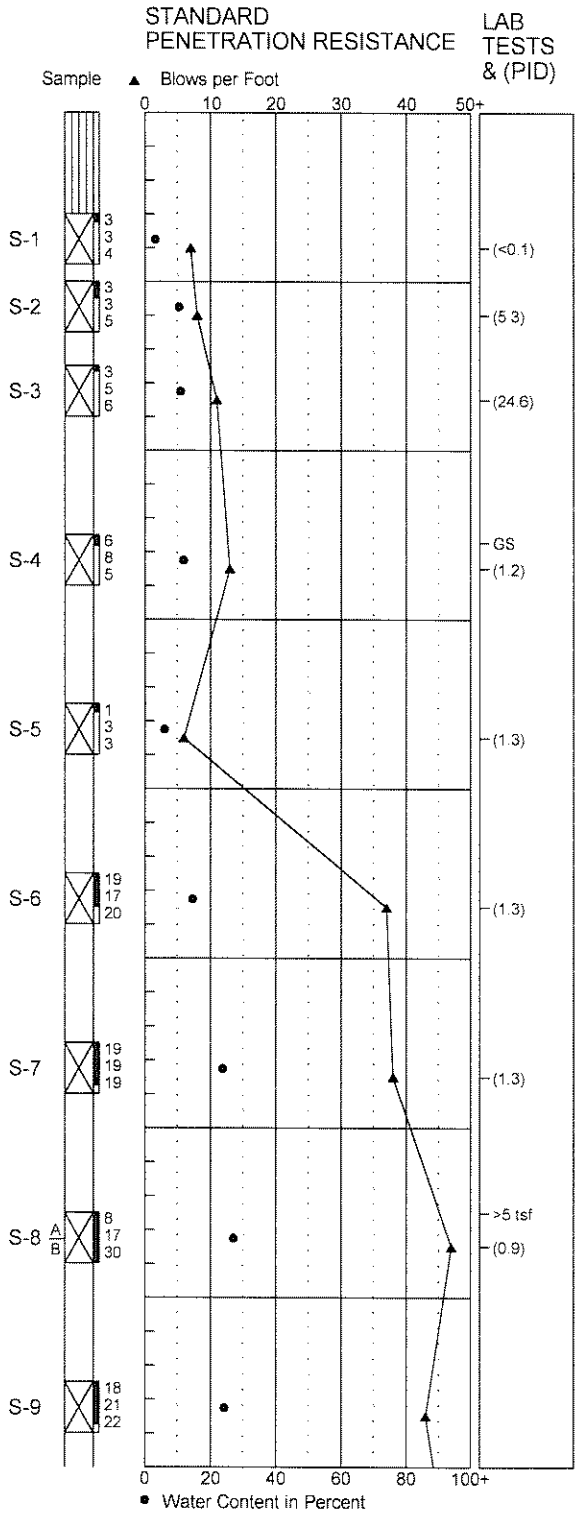
17203-38 12/09
Figure A-3 2/2

Boring Log B-09-3

Location: See Figure 3.
Approximate Ground Surface Elevation: 11 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

USCS Class	Soil Descriptions	Depth in Feet
SP	(Loose), moist, brown to dark gray, silty, gravelly SAND to sandy GRAVEL. (FILL)	0
GW	Loose, moist to wet, gray to dark gray, sandy GRAVEL (TPH impacted). (Fluvial)	5
	Medium dense.	
	Drill action indicates possible scattered cobble.	10
	Abundant gravel to 17.5 feet.	15
	Slightly sandy GRAVEL.	20
	Dense, gravelly SAND with scattered shell fragments.	25
SM	Dense, wet, gray, slightly silty SAND with scattered shell fragments. (Fluvial)	30
ML	Very stiff, wet, gray SILT. (Lacustrine)	
SM	Dense, wet, gray, silty SAND with laminations. (Fluvial)	
	Trace organic material.	35
	Slightly silty.	40



NEW BORING LOG 1720338-BL.GPJ HC_CORP.GDT 1/22/10

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

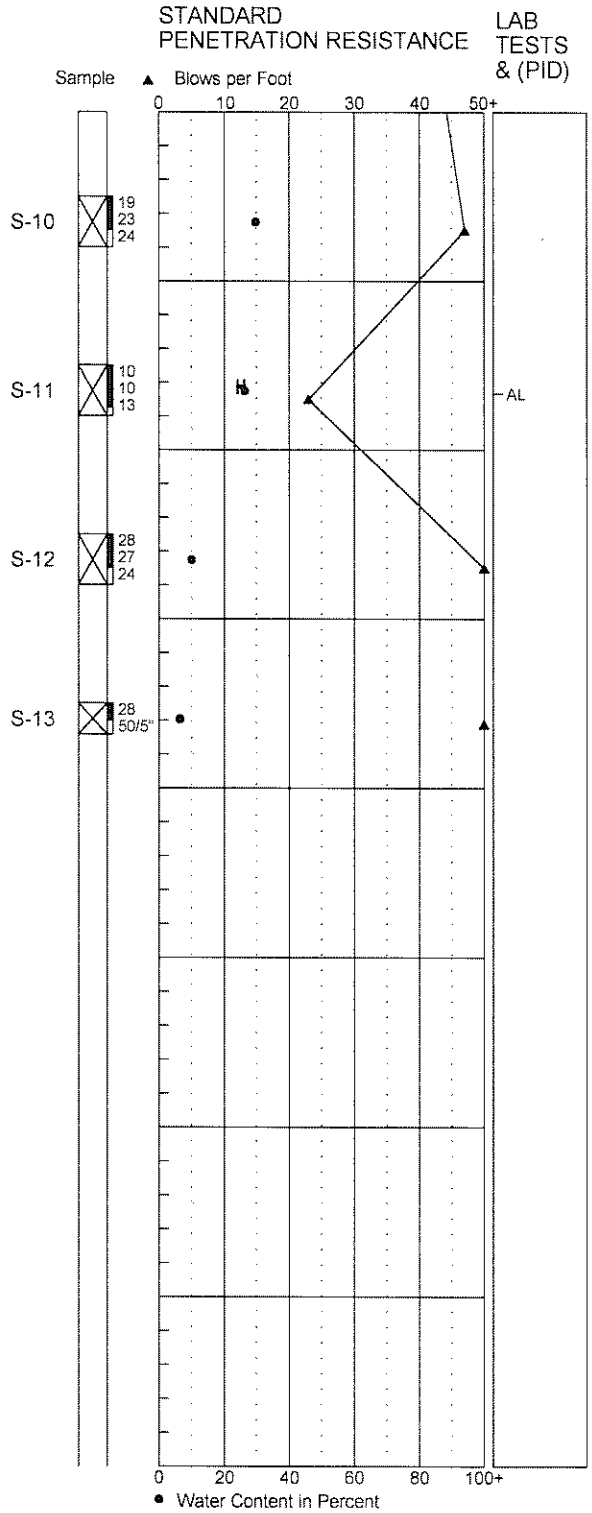
17203-38 12/09
Figure A-4 1/2

Boring Log B-09-3

Location: See Figure 3.
Approximate Ground Surface Elevation: 11 Feet
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88

Drill Equipment: Modified B-61/Mud Rotory
Hammer Type: SPT w/140 lb. automatic hammer
Hole Diameter: 6 inches
Logged By: B. McDonald Reviewed By: K. Shah

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
SM		Dense, wet, gray, silty SAND with laminations. (Fluvial) (cont'd)	40 – 45
SM/ML		Very stiff, wet, gray, sandy SILT and SILT with thin laminations. (Lacustrine)	45 – 50
GP		Very dense, wet, gray, sandy to slightly sandy GRAVEL. (Fluvial)	50 – 58.4
		Bottom of Boring at 58.4 Feet. Started 12/30/09. Completed 12/30/09.	60 – 80



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

17203-38 12/09
Figure A-4 2/2

NEW BORING LOG 1720338-BL.GPJ HC_CORP.GDT 1/22/10

APPENDIX B
LABORATORY TESTING PROGRAM

APPENDIX B
LABORATORY TESTING PROGRAM

A laboratory-testing program was performed for this study to evaluate the basic index and geotechnical engineering properties of the site soils. The tests performed and the procedures followed are outlined below.

Soil Classification

Field Observation and Laboratory Analysis. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by grain size analysis. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure B-1.

Water Content Determinations

Water contents were determined for all samples recovered in the explorations in general accordance with ASTM D 2216, as soon as possible following their arrival in our laboratory. The results of these tests are plotted or presented at the respective sample depth on the exploration logs.

Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422. Wet sieve analysis was used to determine the size distribution greater than the US No. 200 mesh sieve. The results of the tests are presented as curves on Figures B-2 and B-3 plotting percent finer by weight versus grain size.

Atterberg Limits (AL)

We determined Atterberg limits for selected fine-grained soil samples. The liquid limit and plastic limit were determined in general accordance with ASTM D4318-84. The results of the Atterberg limits analysis and the plasticity characteristics are summarized in the Liquid and Plastic Limits Test Report, Figure B-4. This relates the plasticity index (liquid limit minus the plastic limit) to the liquid limit. The results of the Atterberg limits tests are shown graphically on the boring logs.

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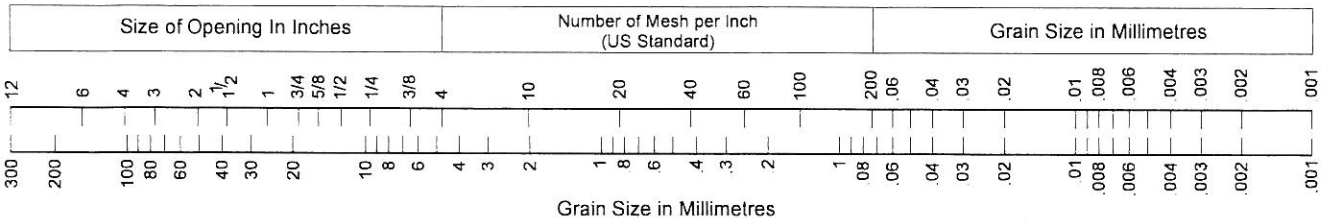
Unified Soil Classification (USC) System
Soil Grain Size



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines	*	GRAVEL with >12% fines		Clean SAND <5% fines	*	SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A line with PI <4

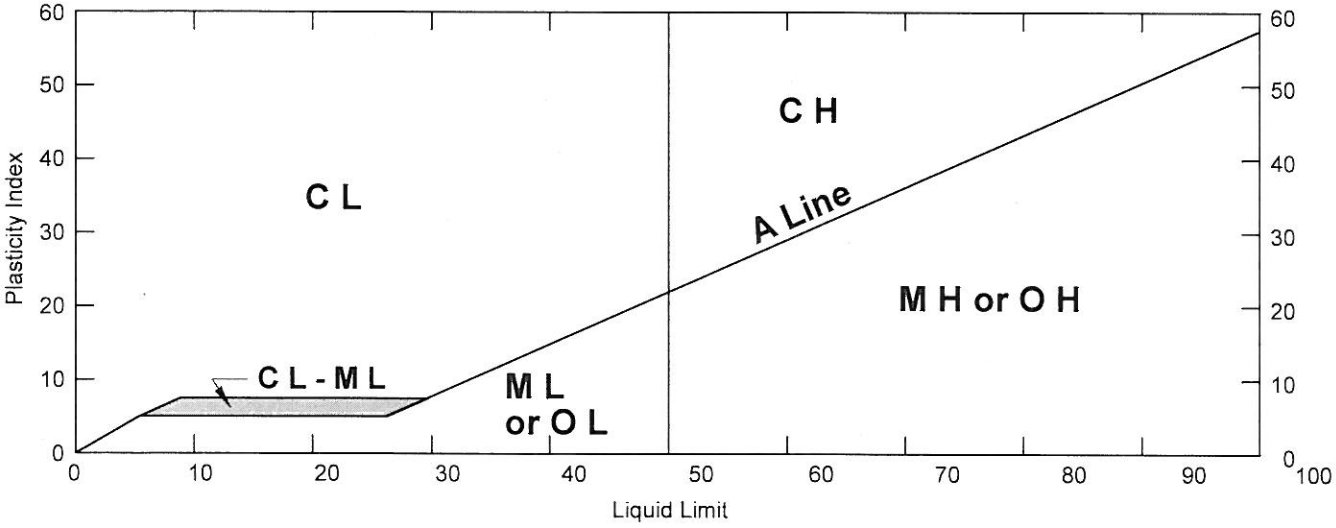
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

D_{10}, D_{30}, and D_{60} are the particles diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						



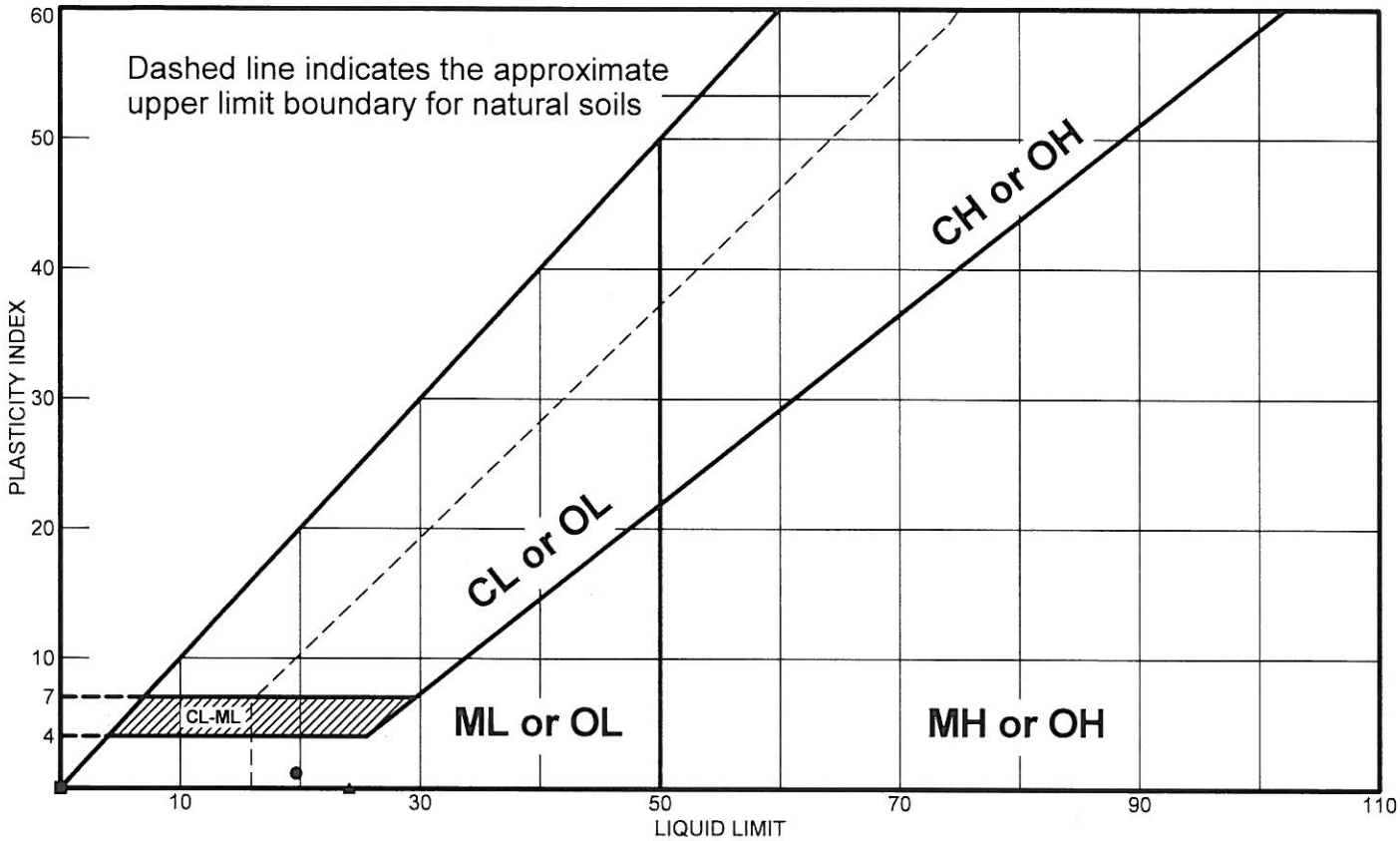
HARTCROWSER

SRF Grain Size (B-1).cdr 3/06

17203-38 1/10

Figure B-1

Liquid and Plastic Limits Test Report



Location + Description	LL	PL	PI	-200	USCS
● Source: B-09-1 Sample No.: S-2 Depth: 5 Sandy SILT	20	19	1		ML
■ Source: B-09-2 Sample No.: S-13 Depth: 42.5 Sandy SILT	NP	NP	NP		ML
▲ Source: B-09-3 Sample No.: S-11 Depth: 47.5 SILT	24	26	NP		ML

Remarks:

●

■ visual classification

▲

Project: Point Wells Development

Client: Paramount Petroleum Corporation

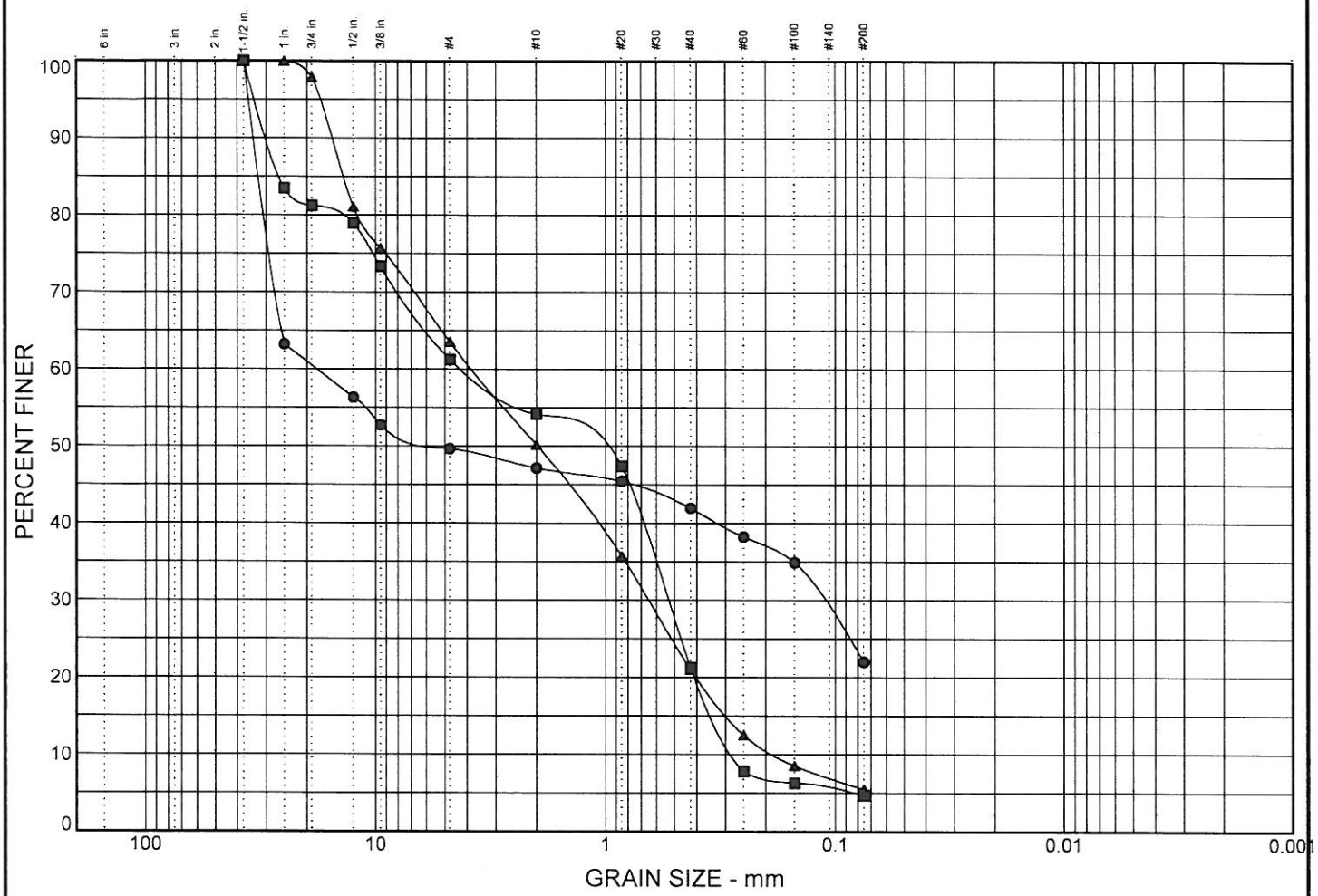
Location: Richmond Beach, WA

HARTCROWSER

17203-38 *1/10*

Figure B- 2

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	50.3	27.6	22.0	
■	0.0	38.7	56.6	4.7	
▲	0.0	36.4	58.1	5.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			31.782	18.059	5.131	0.115				
■			25.934	4.068	1.18	0.536	0.332	0.272	0.26	14.93
▲			13.782	3.773	1.978	0.649	0.292	0.181	0.62	20.89

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Silty, very sandy GRAVEL	GM	20.1%
■ Very gravelly SAND	SP	13.4%
▲ Slightly silty, very gravelly SAND	SP-SM	7.5%

Remarks:

● small sample size

■ strong product odor and sheen

▲

Project: Point Wells Development

Client: Paramount Petroleum Corporation

● Source: B-09-1 Sample No.: S-5 Depth: 12.5 to 14.0
■ Source: B-09-2 Sample No.: S-2 Depth: 5.0 to 6.5
▲ Source: B-09-2 Sample No.: S-9 Depth: 22.5 to 24.0

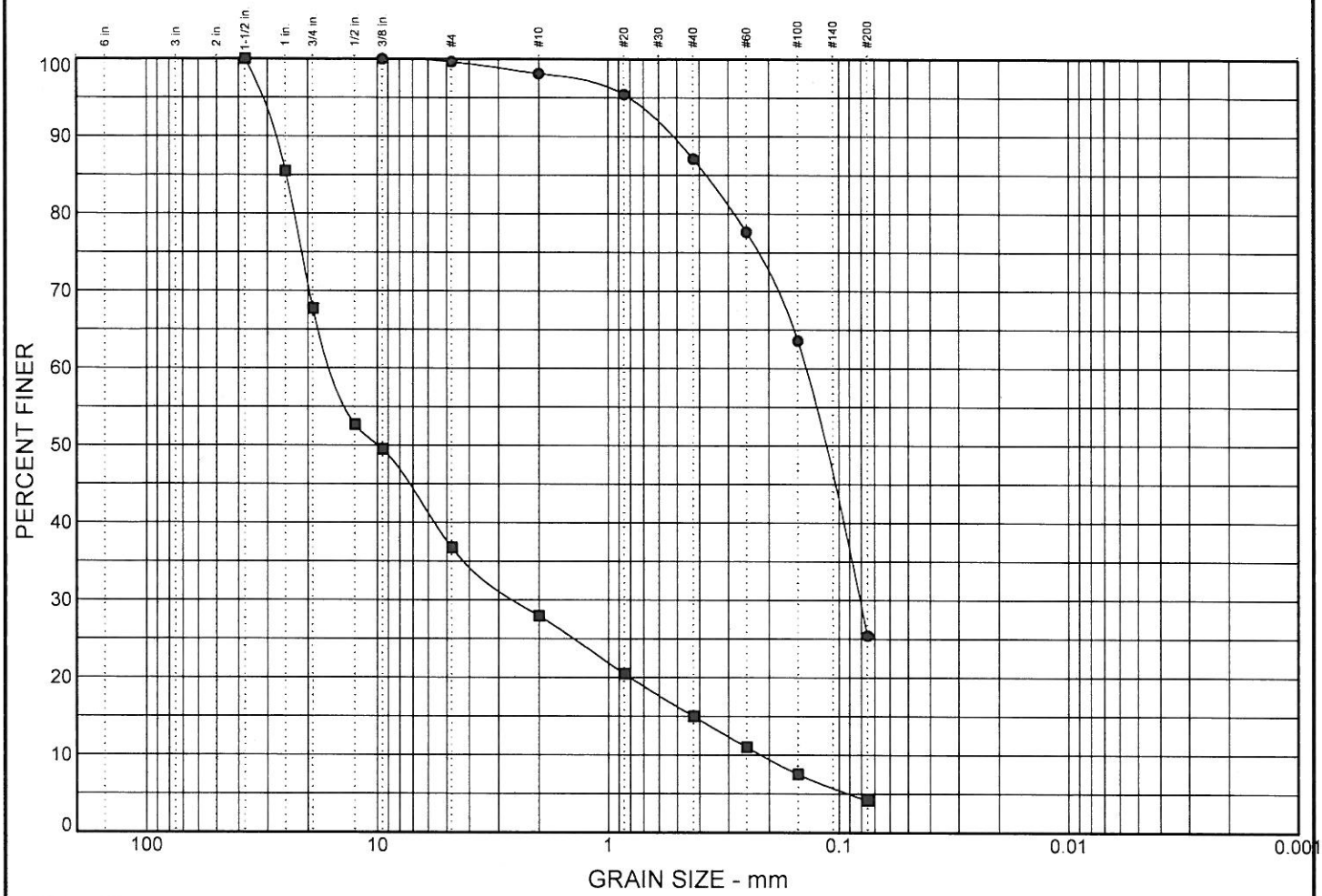
HARTCROWSER

17203-38 1/10

Figure B-3

GRAIN SIZE 1720338-BL.GPJ HC_CORP.GDT 1/15/10

Particle Size Distribution Test Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.3	74.2	25.4	
■	0.0	63.2	32.6	4.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.377	0.14	0.117	0.081				
■			24.811	15.317	9.909	2.445	0.425	0.215	1.81	71.17

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Silty, medium to fine SAND	SM	27.0%
■ Sandy GRAVEL	GW	11.8%

Remarks:

●

■ small sample size

Project: Point Wells Development

Client: Paramount Petroleum Corporation

● Source: B-09-2 Sample No.: S-11 Depth: 32.5 to 34.0
■ Source: B-09-3 Sample No.: S-4 Depth: 12.5 to 14.0

HARTCROWSER

17203-38 1/10

Figure B-4

GRAIN SIZE 1720338-BL.GPJ HC_CORP.GDT 1/15/10

APPENDIX C
EXISTING EXPLORATIONS BY HART CROWSER AND OTHERS

APPENDIX C
EXISTING EXPLORATIONS BY HART CROWSER AND OTHERS

In addition to the explorations and laboratory test results presented in Appendices A and B, respectively, previous soil explorations by Hart Crowser and others were used to gain an understanding of the subsurface conditions at the proposed development at Point Wells.

Borings previously performed by Hart Crowser and others at the project site were consulted for the current report. These logs are included within this appendix, separated by location in the upper and lower bench. Logs produced by others are presented for reference only and Hart Crowser is not responsible for the accuracy or completeness of the information presented in the logs. Approximate locations of these borings are shown on Figure 3; actual locations may differ from those shown.

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UPPER BENCH

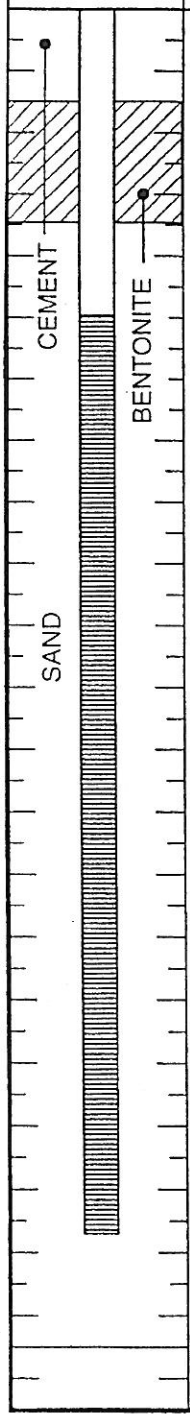
PACIFIC ENVIRONMENTAL GROUP, INC.

WELL NO. MW-95
PAGE 1 OF 1

SEE SITE MAP
FIGURE 2

PROJECT NO: 520-133.1G
LOGGED BY: B.A.
DRILLER: HAYES DRILLING
DRILLING METHOD: HSA
SAMPLING METHOD: SPLIT SPOON
CASING TYPE: SCHD. 40 PVC
SLOT SIZE: 0.020"
GRAVEL PACK: 2 x 12 SAND

CLIENT: CHEVRON
DATE DRILLED: 10-9-98
LOCATION: Point Wells, Richmond Beach
HOLE DIAMETER: 6"
HOLE DEPTH: 21.5'
WELL DIAMETER: 2"
WELL DEPTH: 19.8'
CASING STICKUP: NA



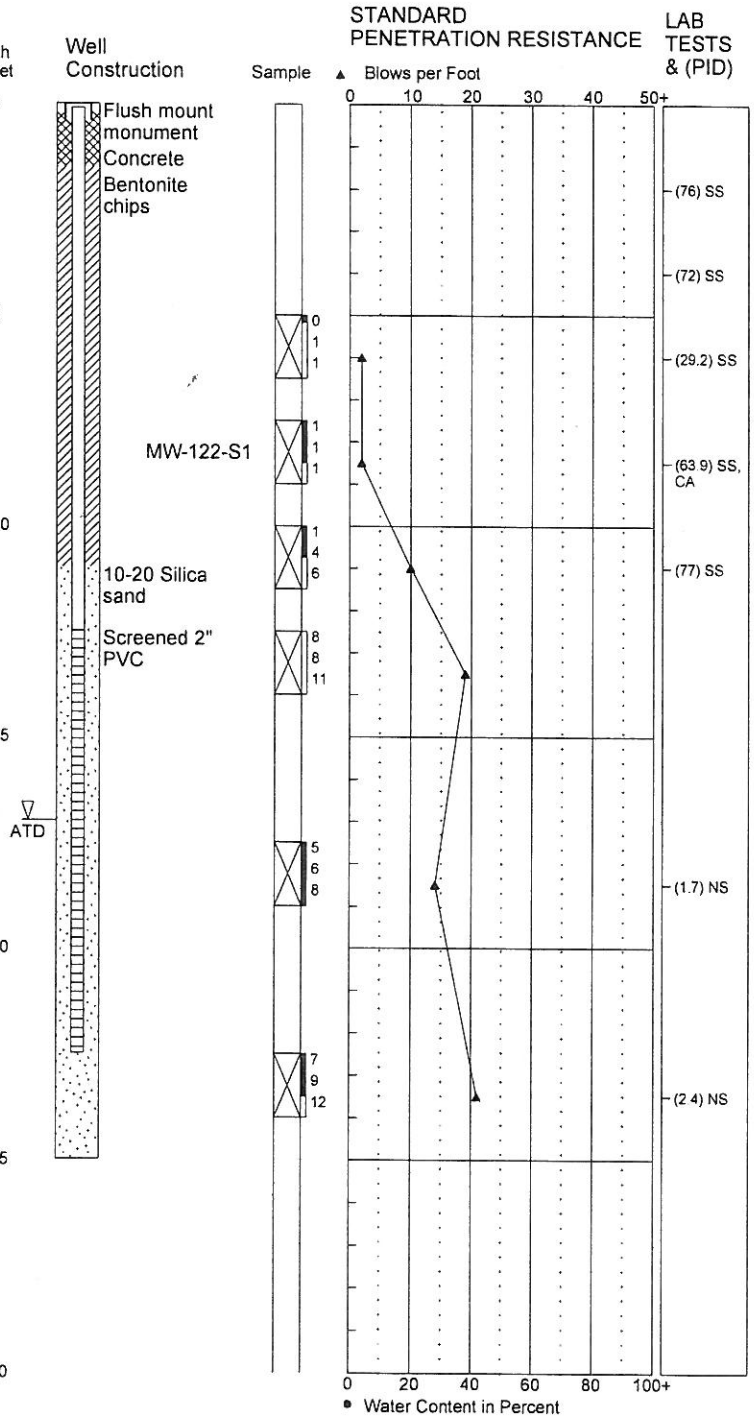
MOISTURE CONTENT	PID (ppm)	PENETRATION (BLOWS/ 6")	DEPTH (FEET)	SOIL TYPE	LITHOLOGY/REMARKS
					GRAVEL COVER.
			1	SM	SILTY SAND: light olive brown; 20% fines; 80% very fine to fine sand.
Dp	-		2, 3, 4		
Dp		67	5, 6, 7		
			8	CL-ML	INTERBEDDED CLAY/SILT: dark olive brown to dark gray; low plasticity; 50% clay; 50% silt.
Dp		42	9, 10		
	0		11	SM	SILTY SAND: dark gray; 15% fines; 85% fine to medium sand.
Wt			12, 13		
			14		@14': as above; 15% fines; 60% very fine to medium sand; 25% coarse sand; trace subangular gravel.
			15		
Wt		53	16	ML	SANDY SILT: dark gray; 80% silt; 20% very fine sand.
Mst			17, 18, 19		
			20		
Wt Sat		45	21	SM	SILTY SAND: 10 to 40% fines; 40 to 60% fine to medium sand.
			22		BOTTOM OF BORING 21.5'

Boring Log & Construction Data for Monitoring Well MW-122

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Hammer Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish/A. Goodwin Reviewed By: A. Goodwin

USCS Class	Soil Descriptions	Depth in Feet
GM	6 inches of Asphalt over (dense), moist, gray, silty, sandy GRAVEL with cobbles and petroleum-like odor.	0
SM	Very loose, moist to wet, gray, slightly gravelly, very silty SAND with petroleum-like odor.	5
	Driller indicated poor recovery due to large rock.	10
SP	Medium dense, wet, gray, slightly silty SAND.	15
	3-inch SILT layer.	20
	Bottom of Boring at 25.0 Feet. Started 05/27/08. Completed 05/27/08. Ecology Tag BAR 274	25
		30



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. While trying to set well, hole was heaving and was unable to reach a depth of 25' (closest was 21'). Moved north 3' and drilled new borehole. Abandoned borehole's water level is 2 - 2.5' bgs showing confined conditions.
7. Analytical water content tabulated in Table 2.

HARTCROWSER

17203-20 5/08

Figure A-93

NEW BORING LOG 1720320BL.GPJ HC_CORP.GDT 7/8/08

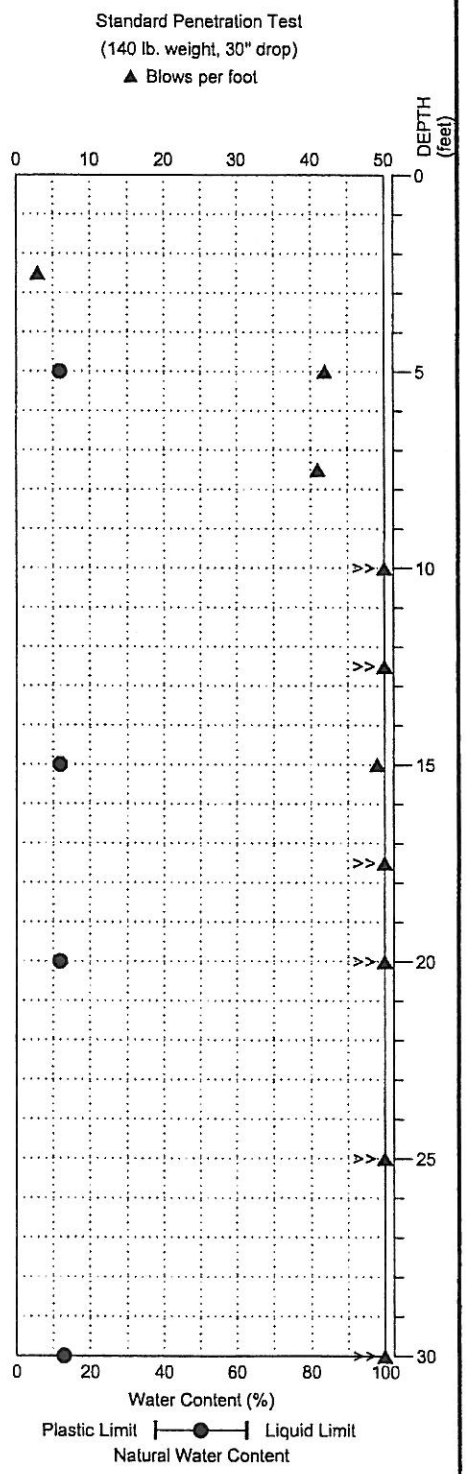
LOWER BENCH

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0	GP	Very loose to dense, dark gray, slightly silty, sandy, fine to coarse GRAVEL, moist.			
		Low recovery in S-1 at 2.5 feet. Gravel lodged in tip.	S-1	3-2-1	
5			S-2	20-20-22	GS
	SP SM	Dense, dark gray to dark olive gray, slightly silty to silty, fine gravelly, fine to coarse SAND, moist. **(PRE-FRASER NON-GLACIOFLUVIAL DEPOSITS)**	S-3	23-21-20	
10	GW	Very dense to dense, dark gray, slightly silty, sandy, well graded GRAVEL, moist. Low recovery in S-4. High blow count probably a result of pounding on a cobble or coarse gravel particle. Driller notes rough, cobbly drilling action.	S-4	27-32-48	
			S-5	32-50/5"	
15			S-6	39-27-22	GS
			S-7	38-37-42	
	SP	Very dense, dark gray, slightly silty, fine to coarse SAND, moist.			
20	GW GM	Very dense, dark gray, slightly silty to silty, sandy, well graded GRAVEL, moist.	S-8	39-37-45	GS
25	GP	Very dense, dark gray, medium to coarse sandy, fine to coarse GRAVEL, moist.	S-9	31-50-39	
30					

GROUNDWATER



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING: B-490+36

PAGE: 1 of 3

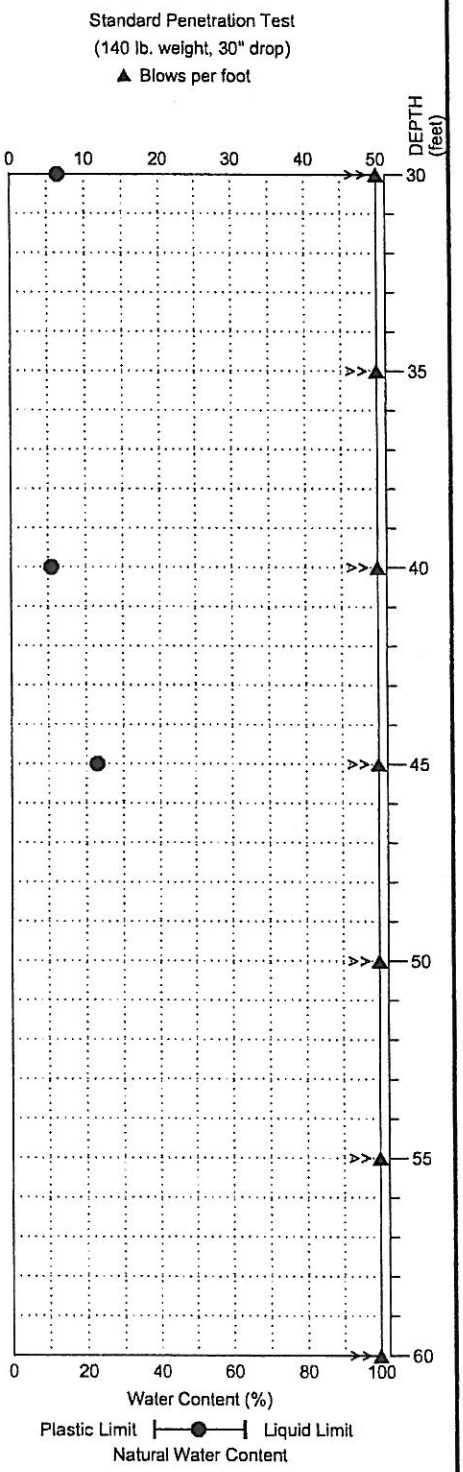
PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
30	SM	Very dense, dark gray, fine to coarse gravelly, silty, fine to coarse SAND, moist.		S-10	45-47-50	GS
		Driller notes sandy drilling, but very dense, slow, constant drilling.				
		Driller notes sandy drilling, but faster.				
35		Drilling and blows are consistent.		S-11	58-50/6"	
		Driller notes off and on gravelly drilling, mostly sand, slow.				
40	GW GM	Very dense, dark gray to dark olive gray, slightly silty, fine to coarse sandy, well-graded GRAVEL, moist.		S-12	38-36-31	GS
		Driller notes constant, smooth, faster drilling.				
45	SM	Very dense, dark gray to dark olive gray, slightly fine gravelly, silty, fine SAND, moist.		S-13	36-48-43	GS
50	GP	Very dense, dark gray, slightly silty, slightly sandy, fine to coarse GRAVEL, moist.		S-14	64-50/5"	
55		Very dense, dark gray, medium to coarse sandy GRAVEL, wet.		S-15	45-40-50/5.5"	
60						

GROUNDWATER



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NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING: B-490+36

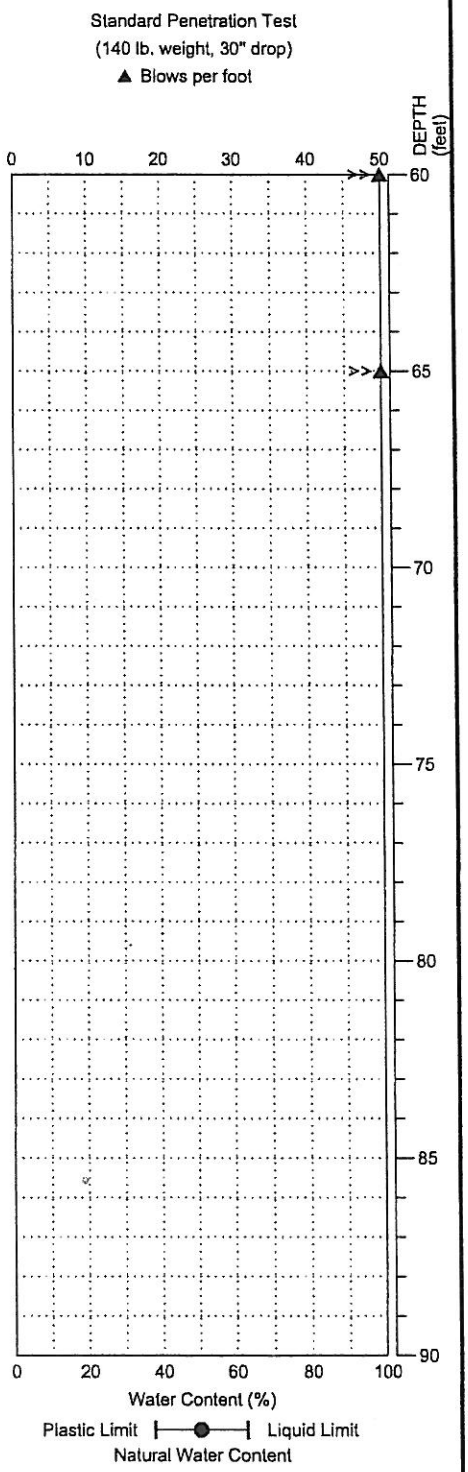
PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Subterranean
DRILLING METHOD: Mud Rotary
SAMPLING METHOD: SPT w/safety hammer
SURFACE ELEVATION: 3 ± feet

LOCATION: N 288249.6, 1255930.7
DATE STARTED: 10/29/2007
DATE COMPLETED: 11/1/2007
LOGGED BY: D. Maloney + J. Gillie

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
60		SP	Very dense, dark gray, gravelly, medium to coarse SAND, wet.		S-16	55-50/6"		
65		GP	Very dense, dark gray, medium to coarse sandy GRAVEL, wet. Some gravel particles fracturing like soft rock.		S-17	46-50/5.5"		

Borehole terminated at 66.0 feet below the existing ground surface.



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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING: B-490+36

PAGE: 3 of 3

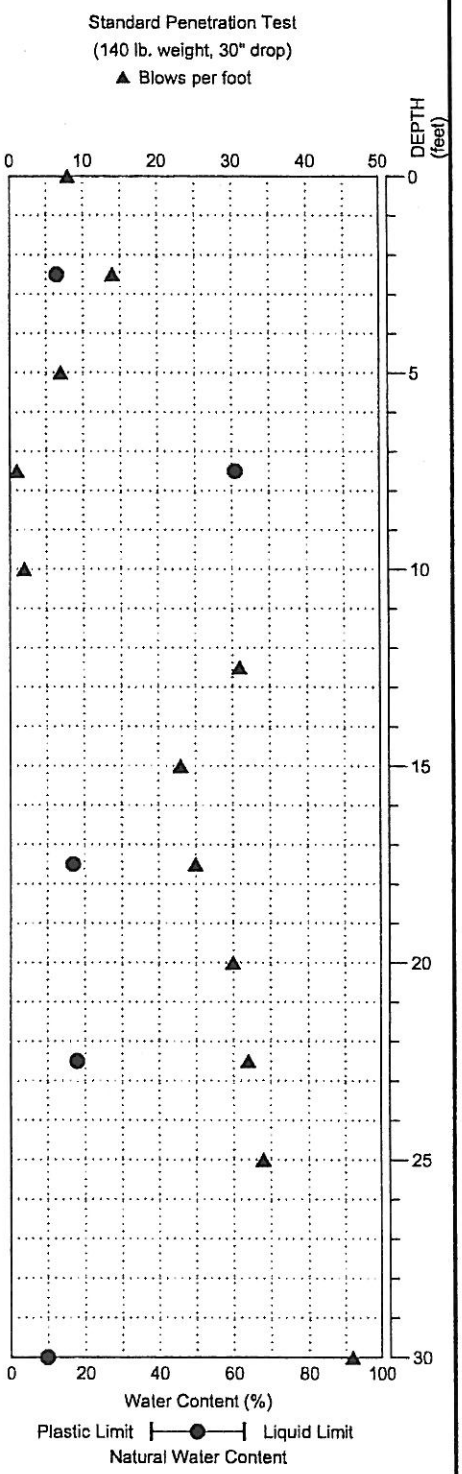
PROJECT NO.: 2007-007-21 FIGURE: 12

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 8 ± feet

LOCATION: N 288202.2, E 1256046.4
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0	SP	Loose, gray, fine to medium SAND, trace coarse sand and shell fragments, wet.		S-1	2-3-5	
		As above, brownish gray, medium dense, trace coarse sand, fine gravel, shell fragments.		S-2	4-8-6	GS
5		Loose, olive gray, fine to coarse SAND, trace silt.		S-3	3-5-2	
	OL	Soft, olive brown to very dark brown, organic SILT, with decomposing wood, trace sand, hydrogen sulfide odor.		S-4	0-0-1	GS
	SP	Loose, olive gray, fine to medium SAND, trace gravel and silt, wet.		S-5	1-1-1	
10		No recovery - coarse gravel or cobbles.		S-6	11-15-16	
15	SP	Medium dense, gray to dark gray, fine to medium SAND, with fine to coarse gravel, wet.		S-7	8-12-11	
				S-8	4-10-15	GS
20		As above, dense.		S-9	11-13-17	
				S-10	14-13-19	GS
25				S-11	12-14-20	
30						

GROUNDWATER



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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-491+63

PAGE: 1 of 2

PROJECT NO.: 2007-007-21 FIGURE: 13

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 8 ± feet

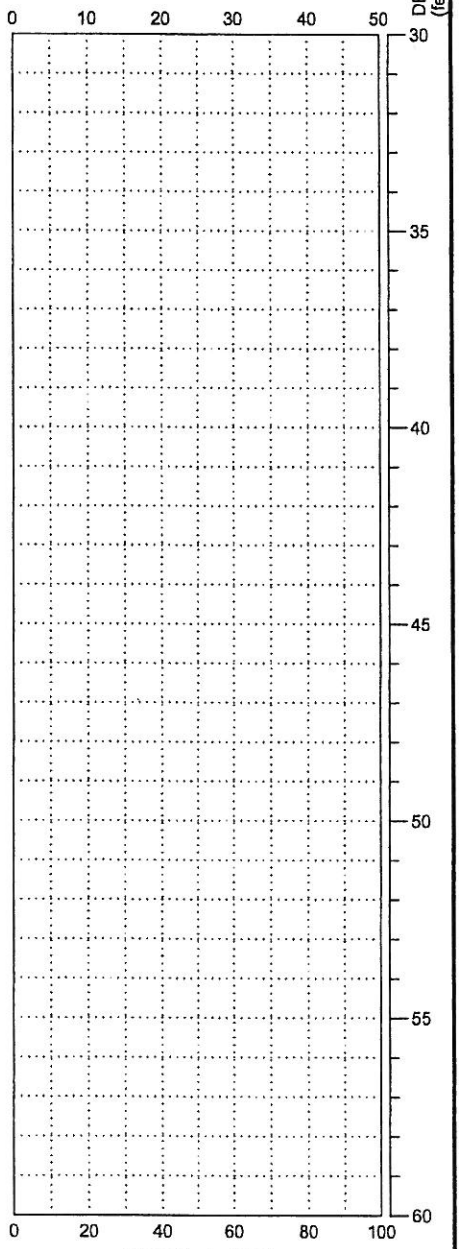
LOCATION: N 288202.2, E 1256046.4
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
30		SW SM	Dense, gray to dark gray, well-graded SAND with silt and gravel, wet.		S-12	21-25-21	GS	

Boring terminated at 31.5 feet below surface.

Ground water observed at 3 feet at time of exploration (ground water tidally influenced).

Standard Penetration Test
(140 lb. weight, 30" drop)
▲ Blows per foot



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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-491+63

PAGE: 2 of 2

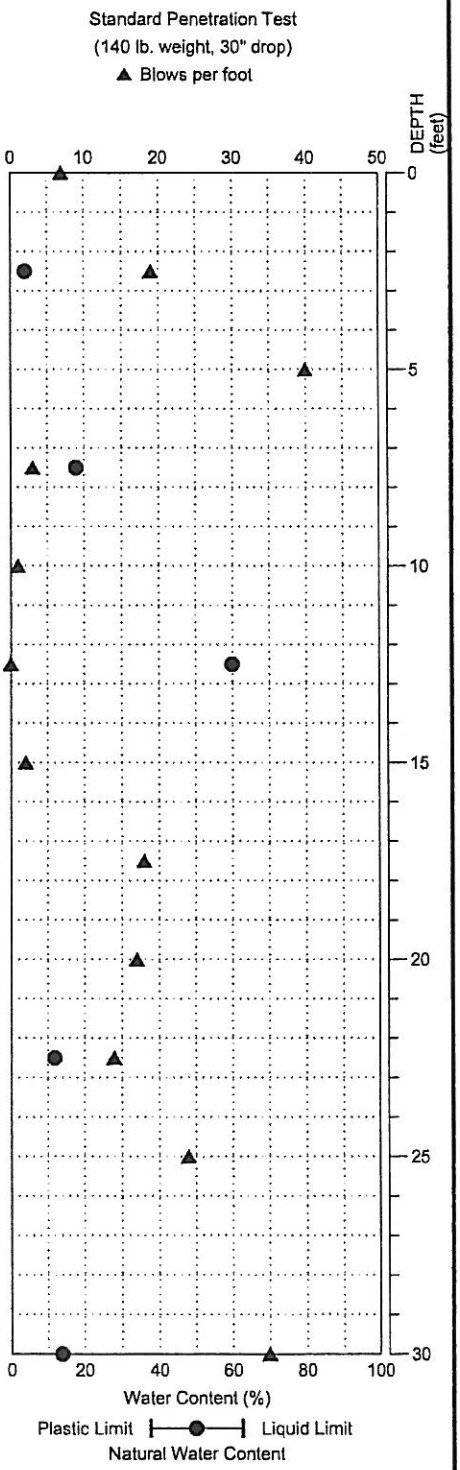
PROJECT NO.: 2007-007-21 FIGURE: 13

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 13 ± feet

LOCATION: N 288151.9, E 1256169.5
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0	SP	Loose, olive gray, slightly fine to coarse gravelly, fine to medium SAND, with trace coarse sand, trace silt, moist.	S-1	2-2-5	
			S-2	6-8-11	GS
5		As above, grayish brown, medium dense, trace shell fragments.	S-3	20-19-21	
	SP SM	Loose to dense, olive gray to dark olive gray, slightly silty to silty, fine to medium SAND, with trace coarse sand and gravel, wet.	S-4	5-2-1	GS
	PT	Soft PEAT with sand interbeds, wet, hydrogen sulfide odor.			
10	OL	Soft, light yellow brown, SILT, decomposed wood fragments, fine to medium sand interbeds, moist.	S-5	0-0-1	
			S-6	0-0-0	GS
		Dark gray to black, wood and sand interbed, faint hydrocarbon odor.			
15		Soft, olive gray SILT, decomposed wood fragments, fine to medium sand interbeds, moist, hydrogen sulfide odor.	S-7	0-0-2	
	SP	Medium dense, olive gray to dark gray, fine to medium, gravelly, SAND, trace silt, wet. Gravel is fine to coarse. Decreasing hydrogen sulfide odor.	S-8	6-8-10	
		As above decreasing odor.			
20			S-9	7-7-10	
	SP	Medium dense, dark gray, fine to medium SAND with fine to coarse gravel, trace coarse sand, wet. No hydrogen sulfide odor.			
			S-10	5-5-9	GS
25		As above with increasing fine sands.	S-11	5-10-14	
30					

GROUNDWATER



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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING: B-492+94

PAGE: 1 of 2

PROJECT NO.: 2007-007-21 FIGURE: 14

DRILLING COMPANY: Gregory Drilling Inc.
DRILLING METHOD: HSA
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 13 ± feet

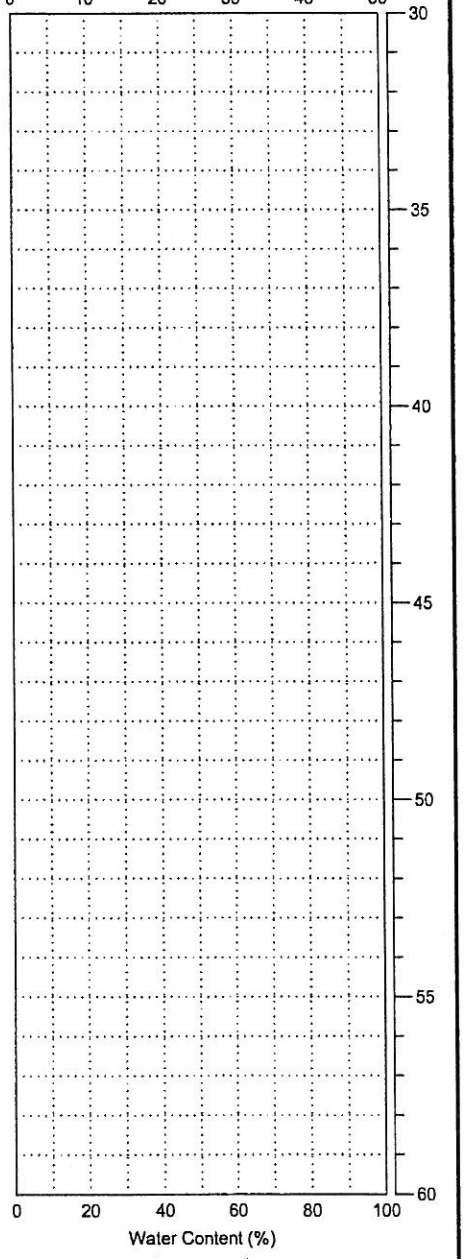
LOCATION: N 288151.9, E 1256169.5
DATE STARTED: 10/8/2007
DATE COMPLETED: 10/8/2007
LOGGED BY: J. Speck

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
30			As above, dense.	X	S-12	8-19-16	GS	

Boring terminated at 31.5 feet below surface.

Ground water observed at 5 feet at time of exploration (ground water tidally influenced).

Standard Penetration Test
(140 lb. weight, 30" drop)
▲ Blows per foot



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HWA GEOSCIENCES INC.

Brightwater Marine Outfall Design

BORING:
B-492+94

PROJECT NO.: 2007-007-21 FIGURE: 14

KHM

ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	10/31/01
DRILLING METHOD:	HS	HOLE DIAMETER:	12-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	8 Inches
SLOT SIZE:	0.040"	WELL DEPTH:	20 Feet
GRAVEL PACK:	Pea Gravel	CASING STICKUP:	N/A

BORING/WELL NO: AP-36

PAGE 1 OF 1

LOCATION MAP

SEE FIGURE 3

ELEVATION	NORTHING	EASTING

Well Completion: Backfill, Casing, BENT, PEA GRAVEL

Static Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample: Recovery	Sample: Interval	Soil Type	LITHOLOGY / DESCRIPTION
								SAND & GRAVEL - FILL
				1				
				2			SW	SAND: grayish brown; 5% fines; fine to coarse grained; 20-30% gravel; loose; no odor.
				3				
				4				
				5				
	Dp	2.6	10 14 20	6				@ 5 Feet: as above; dense; faint hydrocarbon odor.
▼				7				
				8				
				9				
				10				
	Wet	16	2 2 1	11				@ 10 feet: as above; increasing gravel; hydrocarbon odor (oil); medium dense; sheen.
				12				
				13				
				14				
				15				
	Wet	8	7 14 20	16				@15 Feet: as above; 10-20% gravel; hydrocarbon odor; sheen.
				17				
				18				
				19			SM	SILTY SAND: gray; 10-20% fines; fine to medium grained; medium dense; faint hydrocarbon odor.
				20				
	Wet	4.1	9 10 17	21				BOTTOM OF BORING AT 21.5 FEET
				22				

KHM

ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	11/8/01
DRILLING METHOD:	HS	HOLE DIAMETER:	12-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	8 Inches
SLOT SIZE:	0.040"	WELL DEPTH:	20 Feet
GRAVEL PACK:	Pea Gravel	CASING STICKUP:	N/A

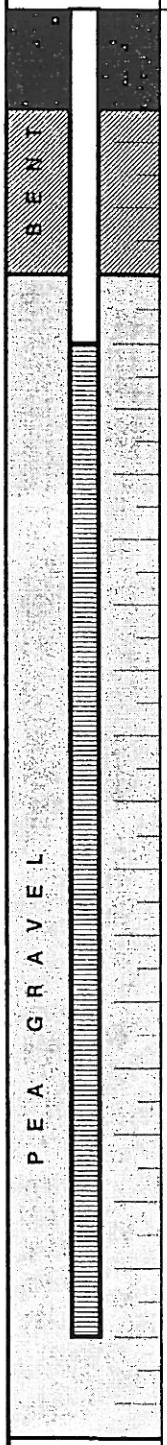
BORING/WELL NO: AP-39

PAGE 1 OF 1

LOCATION MAP

SEE FIGURE 3

ELEVATION	NORTHING	EASTING



Depth (feet)	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Sample Recovery	Sample Interval	Soil Type	LITHOLOGY / DESCRIPTION
							SAND & GRAVEL - FILL
1							
2							
3							
4							
5						GW	Sandy GRAVEL: dark gray; 5% fines; 20-30% sand; fine to medium gravel; medium dense; strong hydrocarbon odor; sheen.
	Mst	39	5 7 6				
6							
7							
8							
9							
10							@ 10 feet: as above; very loose; strong hydrocarbon odor; sheen.
	Wet	8.9	2 2 1				
11							
12							
13							
14						SW	SAND: dark gray; 5% fines; fine to coarse grained; 10-20% gravel; loose; hydrocarbon odor; sheen.
15							
	Wet	12.1	2 3 4				
16							
17							
18							
19						GW	Sandy GRAVEL: dark gray; 5% fines; 20-30% sand; fine to medium gravel; medium dense; hydrocarbon odor.
20							
	Wet	5.8	8 12 15				
21							BOTTOM OF BORING AT 21.5 FEET
22							

Static Water Level ▼

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-06	MW-42	1 of 1

Project: Pt. Wells Monitoring Well Installations
Location: Pt. Wells Distribution Center
Elevation (Top of Well Casing): 11.94
Surface Elevation:
Water Level Elev.: 4.94
Start Date: April 16, 1991
Drilling Contractor: McDonald Holt, Inc.
Finish Date: April 16, 1991
Drilling Method: B-61/HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading	Description
	locking flush-mounted aluminum monument concrete					SILTY SAND (Fill); brown, some fine to coarse gravel; medium dense, very moist
				9		
		C		8		
	bentonite seal			9		
5				2		
				3		
	10/20 silica sand filter pack			2		grades to gray; loose, very moist
	ATD 4/16/91					
				3		grades to black, hydrocarbon like staining and odor
				5		
				6		
10				7		
				10		
				15		
	well screen, 4.0" ID schedule 40 PVC with 0.010" slots					
15				3		SAND (Fill); gray, fine to medium, trace gravel; medium dense, wet; hydrocarbon like odor with sheen
				5		
				12		
20				5		little fine to medium gravel, trace shell fragments; medium dense, wet; hydrocarbon like odor and sheen
				11		
				12		
						Bottom of boring at depth 22.0 feet. Soil sampler driven using a 300-pound hammer falling 30 inches.

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: BCP
Approved by: RAL

Figure No. A-10

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-06	MW-43	1 of 1

Project: Pt. Wells Monitoring Well Installations
Location: Pt. Wells Distribution Center
Elevation (Top of Well Casing): 10.04
Surface Elevation:
Water Level Elev.: 5.04
Start Date: April 16, 1991
Drilling Contractor: McDonald Holt, Inc.
Finish Date: April 16, 1991
Drilling Method: B-61/HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading	Description
	locking flush-mounted aluminum monument concrete					SILTY SAND (Fill); gray to brown, fine sand, trace fine to medium gravel, wood fragments; medium dense, wet; hydrocarbon like odor
	bentonite seal	C		3 5 7		
5	ATD 4/16/91			5 9 6		increasing silt content, decreasing gravel content
	10/20 silica sand filter pack			3 8 12		
10	well screen, 4.0" ID schedule 40 PVC with 0.010" slots			3 5 7		grades to gray, fine to coarse sand, some fine to medium gravel
15				1 2 2		SILT (Fill); dark brown, trace sand, peat and wood fragments; very loose, very moist; hydrocarbon like odor and visible liquid hydrocarbons in sample
20				5 9 14		SILTY SAND (Fill); gray, fine to coarse, some fine to coarse gravel; medium dense, wet; hydrocarbon like odor
						Bottom of boring at depth 21.5 feet. Soil sampler driven using a 300-pound hammer falling 30 inches.

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: BCP
Approved by: RAL

Figure No. A-11

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-11	MW-79	1 of 2

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.16
Surface Elevation: 11.50
Water Level Elev.: 6.25
Start Date: January 21, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 22, 1992
Drilling Method: Skid Mounted / HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading (ppm)	Description
	locking flush-mounted steel monument concrete annular seal bentonite seal					6 inches thick CONCRETE SLAB
						FILL
		C		15 23 20	11	SAND; gray, fine to medium, little coarse sand, trace fine gravel; medium dense, moist unidentified odor
	10/20 silica sand filter pack					
				21 26 28	560	SILTY SAND; gray-brown, fine to medium, some lumps of hard yellow-brown silt, trace coarse sand and mica, trace fine gravel; dense, very moist; hydrocarbon-like odor
	ATD 1/22/92					
		C		22 25 21	600	
5	1/23/92					SANDY SILT; gray, fine sand, little coarse sand, trace wood fragments; very stiff, moist; hydrocarbon-like odor
				1 7 10	500	ESTUARINE DEPOSITS SAND; gray, some silt, medium to coarse, few fine gravel, trace plant fragments; medium dense, wet; hydrocarbon-like odor
	well screen, 2" ID schedule 40 PVC with 0.010" slots					
10						
						ORGANIC SILT; yellow-brown to gray-brown, few plant fibers and fragments; soft, moist; organic-like odor
	threaded end cap			1 2 2	30	
15						
	backfilled with bentonite chips			9 10 10	20	
						SAND; gray, medium to coarse, some fine sand and silt, trace fine gravel; medium dense, wet; organic-like odor

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL
Figure No.

Confidential

RB-5-00001294

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-11	MW-79	2 of 2

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.16
Surface Elevation: 11.50
Water Level Elev.: 6.25
Start Date: January 21, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 22, 1992
Drilling Method: Skid Mounted / HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading	Description
						trace wood fragments and lumps of organic silt
				1 9 19	15	
	backfilled with bentonite chips					grades coarser across sample with depth
25						
				12 15 22	45	
30						Bottom of boring at depth 29.0 feet Bore hole allowed to cave in to 15 feet Monitoring well installed to depth 12.5 feet Soil sampler driven using a 140-pound hammer falling 30 inches
35						

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL

Figure No.

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-11	MW-83	1 of 2

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.45
Surface Elevation: 11.66
Water Level Elev.: 7.04
Start Date: January 27, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 27, 1992
Drilling Method: Skid Mounted / HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading (ppm)	Description
	locking flush-mounted steel monument					6 inches thick CONCRETE SLAB
	concrete annular seal					FILL
	bentonite seal	C		11 16 23	8	SAND; brown, fine to coarse, little fine gravel, trace silt; medium dense, moist
	riser, 2" ID schedule 40 PVC					
	10/20 silica sand filter pack	C		14 20 18	14	SILTY SAND WITH GRAVEL; brown, fine to coarse sand, fine gravel; medium dense, moist hydrocarbon-like odor and staining
	2/13/92			10 11 13	45	
5	well screen, 2" ID schedule 40 PVC, 0.010" slot size					SAND; brown to gray, fine to medium, trace silt; medium dense, wet; hydrocarbon-like odor, sheen on sampler
						BEACH DEPOSITS
				1 0 0	120	SAND; gray, fine to medium, trace silt and shell fragments; very loose, wet; hydrocarbon-like odor
10						
						ESTUARINE DEPOSITS
	threaded end cap			3 6 9		ORGANIC SILT; brown, fibrous, few fine to medium sand, trace shell fragments; stiff, moist; hydrocarbon-like odor
15	mixture of soil and bentonite chips					
				7 11 18		few plant fibers; soft, moist; hydrocarbon-like odor
						BEACH DEPOSITS
						SAND WITH GRAVEL; gray-brown, fine to coarse sand, fine gravel; medium dense, wet; hydrocarbon-like odor

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL

Figure No.

Confidential

RB-5-00001299

Converse NW

Monitoring Well Geologic & Construction Log

Project Number	Well Number	Sheet
91-35101-11	MW-83	2 of 2

Project: South Warehouse-Barrel Facility Environmental Assessment
Location: Chevron Point Wells Distribution Fa
Elevation (Top of Well Casing): 11.45
Surface Elevation: 11.66
Water Level Elev.: 7.04
Start Date: January 27, 1992
Drilling Contractor: Geoboring & Dev. Co.
Finish Date: January 27, 1992
Drilling Method: Skid Mounted / HSA

Depth feet	Well Construction	Lab Tests	ST	Blows/6"	OVM Reading	Description
						ESTUARINE DEPOSITS ORGANIC SILT; brown, few fibers; soft, moist
				8 21 31		**BEACH DEPOSITS** SAND WITH GRAVEL; gray, fine to coarse sand, fine gravel, abundant quartz sand, trace silt; dense, wet
25						
				13 27 43		
30						Bottom of boring at 29.0 feet Boring backfilled with bentonite chips Soil sampler driven using a 140-pound hammer falling 30 inches
35						

ST - Sampler Type:
- 2" OD Split Spoon
- Bulk Grab Sample
- Drive Barrel

Lab Tests:
- S - Soil Properties
- C - Chemical Properties
- Water Level

Logged by: ECR
Approved by: RAL

Figure No.

Confidential

RB-5-00001300

KHM

ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	10/29/01
DRILLING METHOD:	HS	HOLE DIAMETER:	12-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	8 Inches
SLOT SIZE:	0.040"	WELL DEPTH:	20 Feet
GRAVEL PACK:	Pea Gravel	CASING STICKUP:	N/A

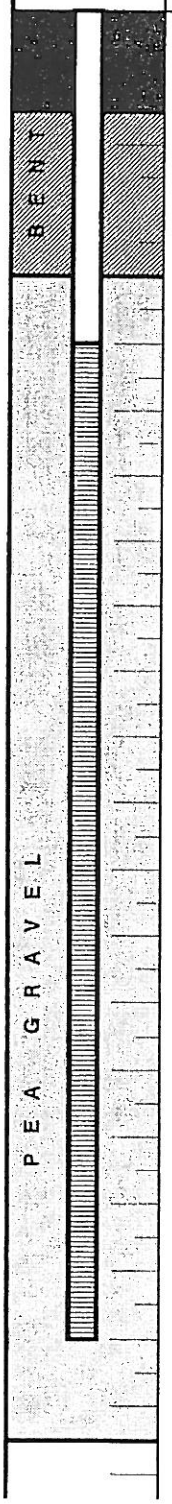
BORING/WELL NO: MW-97

PAGE 1 OF 1

LOCATION MAP

SEE FIGURE 2

ELEVATION	NORTHING	EASTING



Depth (feet)	Sample Recovery	Sample Interval	Soil Type	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	LITHOLOGY / DESCRIPTION
							CONCRETE SLAB
1			SW				SAND: brown; trace fines; fine to coarse grained; 10-20% fine gravel; dense; damp; no hydrocarbon odor.
2							
3							
4							
5						15	
6			ML	Mst	21	18 30	SILT: gray; 15-20% fine sand; hard; organic odor.
7							
8							
9			SW				SAND: gray; 5% fines; fine to coarse grained; 20-30% gravel; cobbles; very dense; strong hydrocarbon odor; sheen.
10				Wet	647	50 (6)	
11							
12							
13							
14			PT				PEAT: brown; damp; strong hydrogen sulfide odor.
15						5	
16			OL	Dp	227	6 7	ORGANIC CLAY: dark gray; stiff; strong hydrogen sulfide odor.
17							
18							
19			SW				SAND: dark gray; 5% fines; medium to coarse grained; 10-20% gravel; dense; hydrogen sulfide odor.
20						6	
21				Wet	217	17 30	BOTTOM OF BORING AT 21.5 FEET
22							

Well Completion: Backfill, Casing

Static Water Level

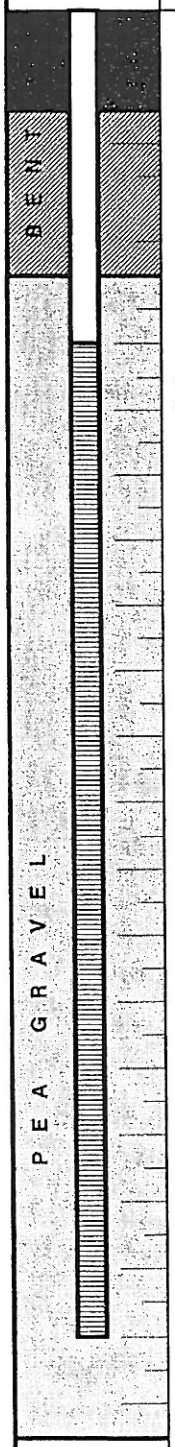
KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	10/29/01
DRILLING METHOD:	HS	HOLE DIAMETER:	12-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	8 Inches
SLOT SIZE:	0.040"	WELL DEPTH:	20 Feet
GRAVEL PACK:	Pea Gravel	CASING STICKUP:	N/A

BORING/WELL NO: MW-98
PAGE 1 OF 1

LOCATION MAP
SEE FIGURE 2

ELEVATION	NORTHING	EASTING



Depth (feet)	Static Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Sample Recovery	Sample Interval	Soil Type	LITHOLOGY / DESCRIPTION
								CONCRETE SLAB
1–5							SW	SAND: brown; trace fines; fine to coarse grained; 10-20% gravel; medium dense; damp; faint hydrocarbon odor.
5–6	▼	Dp	77	8 14 17			ML	SILT: gray; 20-30% fine sand; hard; hydrocarbon odor.
8–13		Wet	202	8 12 7			GW	GRAVEL: dark gray; trace fines; 10-20% fine to coarse sand; fine to coarse gravel; wood fragments; medium dense; strong hydrocarbon odor; sheen.
13–20		Wet	170	16 9 8			SW	SAND: brown; trace fines; fine to coarse grained; 10% gravel; thin peat/organic clay interbed; medium dense; hydrocarbon odor.
20–21		Wet	95	16 18 24				@20 Feet: dark gray; wood fragments; anoxic; dense; hydrocarbon odor.
21								BOTTOM OF BORING AT 21.5 FEET

KHM

ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	10/29/01
DRILLING METHOD:	HS	HOLE DIAMETER:	12-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	8 Inches
SLOT SIZE:	0.040"	WELL DEPTH:	20 Feet
GRAVEL PACK:	Pea Gravel	CASING STICKUP:	N/A

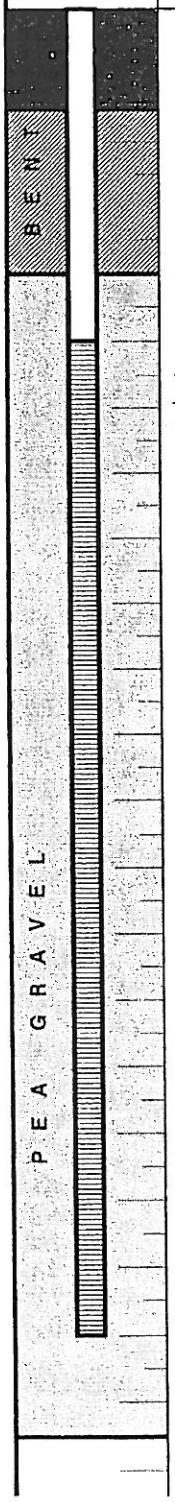
BORING/WELL NO: MW-99

PAGE 1 OF 1

LOCATION MAP

SEE FIGURE 2

ELEVATION	NORTHING	EASTING



Depth (feet)	Static Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Sample Recovery	Sample Interval	Soil Type	LITHOLOGY / DESCRIPTION
								CONCRETE SLAB
1							SW	SAND: brown; trace fines; fine to coarse grained; 10-20% gravel; dense; damp; no odor.
2								
3								
4								
5				9				
6	▼	Dp	146	18 25			ML	SILT: gray; 20-30% fine sand; trace gravel; hard; hydrocarbon odor.
7								
8								
9							GW	GRAVEL: gray; 5% fines; 20-30% fine to coarse sand; fine to medium gravel; medium dense; hydrocarbon odor; sheen; thin peat interbed.
10				6				
11		Wet	311	6 10				
12								
13								
14								
15				3				@15 Feet: no recovery.
16		Wet	NR	3 4				
17								
18								
19							SW	SAND: dark gray; trace fines; fine to coarse grained; 10% gravel; very dense; hydrogen sulfide odor.
20				5				
21		Wet	0	17 21				BOTTOM OF BORING AT 21.5 FEET
22								

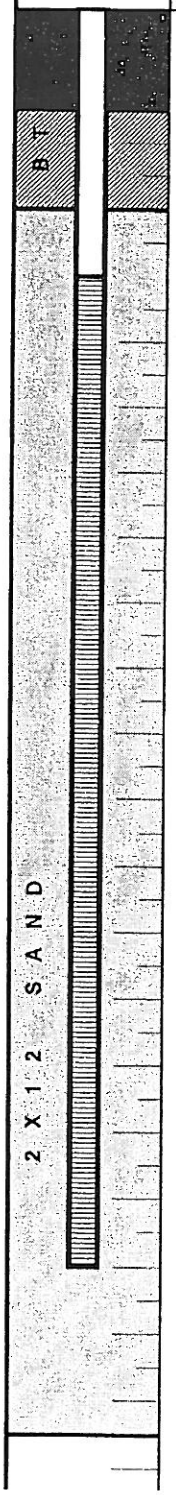
KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	CG29291A	CLIENT:	Chevron
LOGGED BY:	E. Larsen	LOCATION:	Pt. Wells Terminal
DRILLER:	Cascade	DATE DRILLED:	10/30/01
DRILLING METHOD:	HS	HOLE DIAMETER:	8-Inches
SAMPLING METHOD:	D&M	HOLE DEPTH:	21.5 Feet
CASING TYPE:	Sch. 40 PVC	WELL DIAMETER:	4 Inches
SLOT SIZE:	0.020"	WELL DEPTH:	19 Feet
GRAVEL PACK:	2X12 Sand	CASING STICKUP:	N/A

BORING/WELL NO: MW-103
PAGE 1 OF 1

LOCATION MAP
SEE FIGURE 2

ELEVATION	NORTHING	EASTING



Depth (feet)	Static Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Sample Recovery	Sample Interval	Soil Type	LITHOLOGY / DESCRIPTION
								CONCRETE SLAB
1–2							SW	SAND - FILL: trace fines; fine to coarse grained; 20-30% gravel; cobbles; loose; damp; no odor.
5–6	▼	Wet	312	5 6 10				@ 5 Feet: native sand; gray; 5% fines; fine to coarse grained; 5-10% gravel; medium dense; saturated with product (diesel odor).
9–11		Wet	0	2 3 4			SP	SAND: gray; 5% fines; fine grained; loose; micaceous; hydrocarbon odor
15–16		Wet	0	6 17 18				@15 Feet: as above; dense; hydrocarbon odor;
19–21		Wet	0	12 30 24			GW	Sandy GRAVEL: dark gray; 5% fines; 20-30% fine to coarse sand; fine to coarse gravel; very dense; no odor.
21								BOTTOM OF BORING AT 21.5 FEET

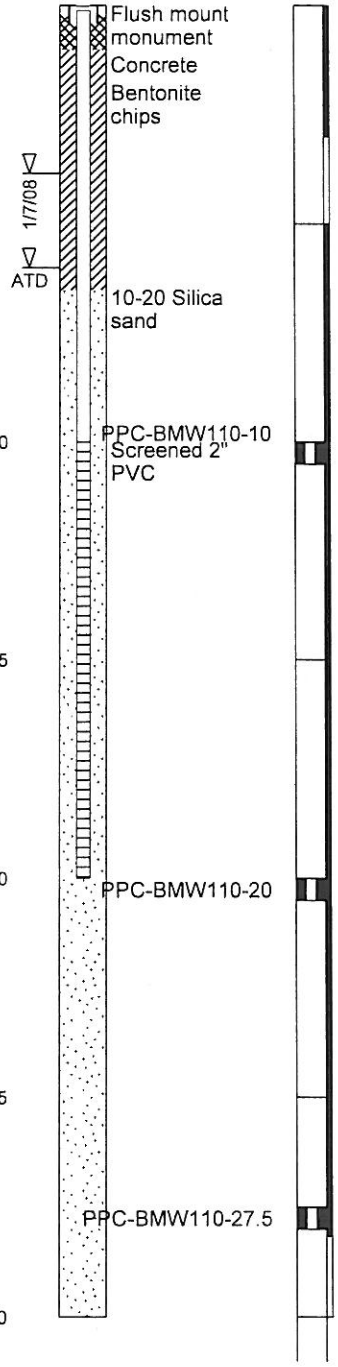
Boring Log & Construction Data for Monitoring Well MW-110

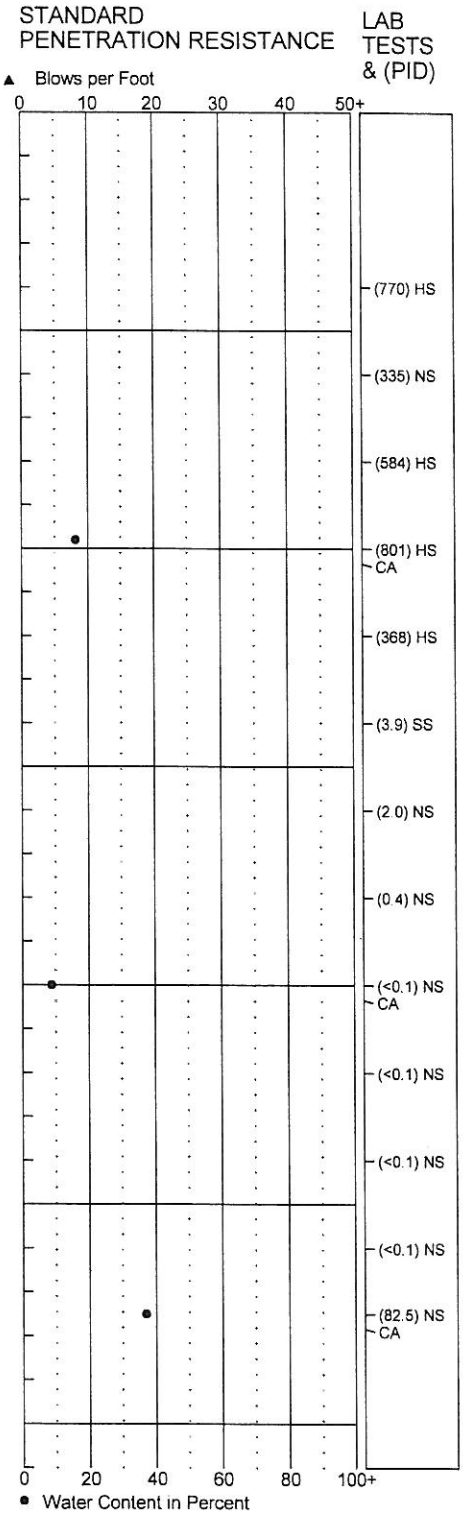
Location: See Figure 1.
Approximate Ground Surface Elevation: 7.96 Feet
Horizontal Datum: Field Located
Vertical Datum: NA

Drill Equipment: Sonic Drill
Hammer Type: Plastic sleeve
Hole Diameter: 6 inches
Logged By: C. Rust Reviewed By: G. Both

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
		Backfill from hand augering.	0
SP		Wet, black, silty, gravelly SAND.	5
		Grades to slightly silty, gravelly SAND.	10
		1- to 4-inch gravel.	15
		Grades to slightly gravelly, silty SAND.	20
		Gravel lens at 22 feet.	
		Dropped drilling stem at 25 feet.	25
ML		Wet, gray, slightly sandy SILT.	
		2- to 4-inch gravel.	30

Bottom of Boring at 30.0 Feet.
Started 12/12/07.
Completed 12/13/07.





SS = Slight Sheen, MS = Moderate Sheen,
HS = Heavy Sheen, NS = No Sheen

1. Refer to Figure B-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. Water Content was not determined by Hart Crowser.

HARTCROWSER

17203-16 12/07

Figure B-3

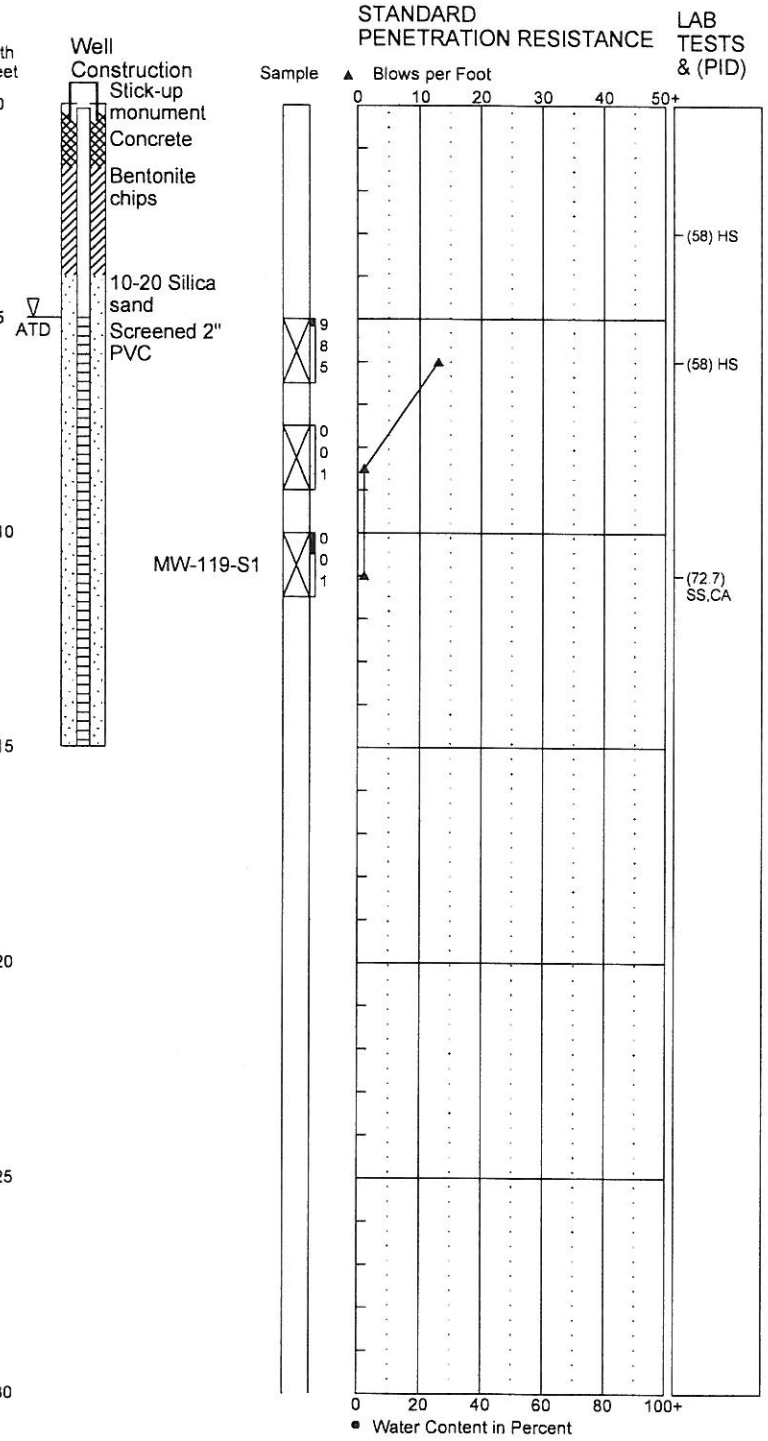
NEW BORING LOG 1720318BL.GPJ HC_CORP.GDT 3/24/08

Boring Log & Construction Data for Monitoring Well MW-119

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Hammer Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish Reviewed By: A. Goodwin

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
GW		(Loose), moist to wet, gray-brown, slightly silty, sandy GRAVEL with cobbles, petroleum-like odor, and free phase product.	0
SW		Medium dense, wet, gray, gravelly SAND. Poor recovery due to rock lodged in sampler.	5
GW		Very loose, wet, dark gray, slightly silty, sandy GRAVEL with petroleum-like odor.	10
		Bottom of Boring at 15.0 Feet. Started 05/28/08. Completed 05/28/08. Ecology Tag BAR 262	15
			20
			25
			30



NEW BORING LOG 1720320BL.GPJ HC_CORP.GDT 7/8/08

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. Analytical water content tabulated in Table 2.

HARTCROWSER

17203-20 5/08

Figure A-89

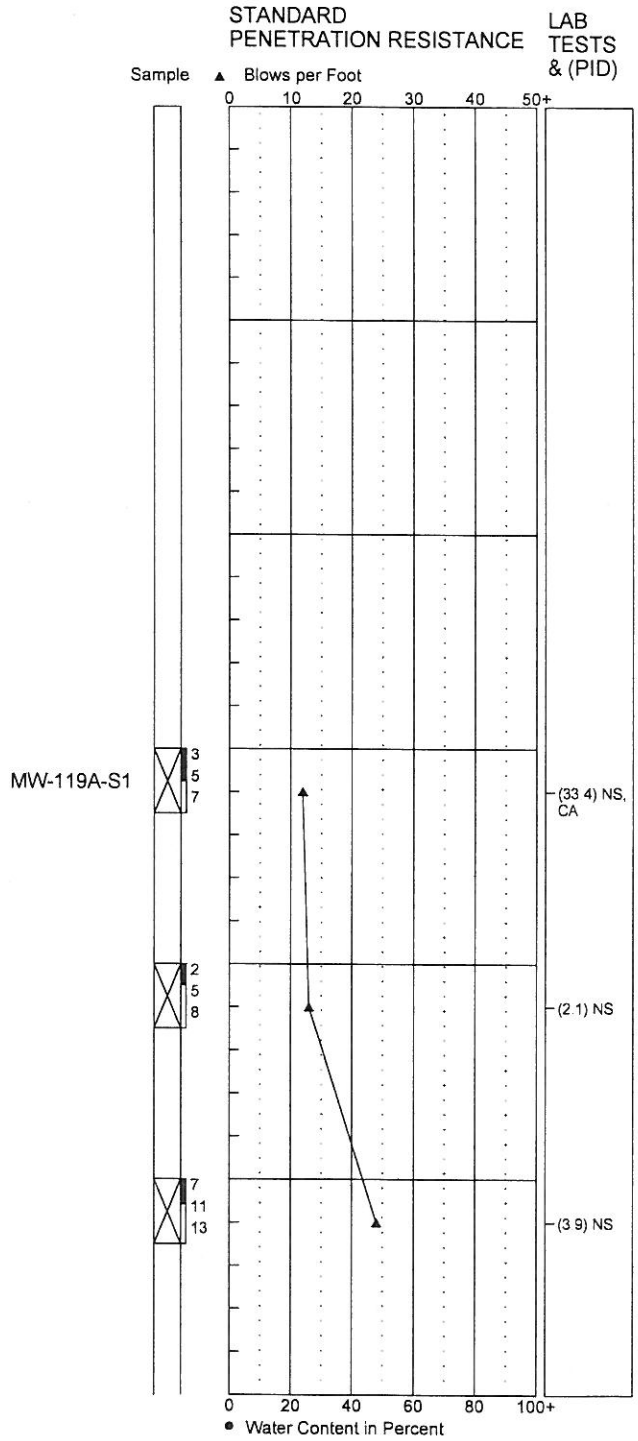
Boring Log B-119A

Location: See Figure 2.
Approximate Ground Surface Elevation: Feet
Horizontal Datum: Field located
Vertical Datum: NA

Drill Equipment: Hollow stem auger
Sample Type: 140 lb. Auto hammer with 30" drop
Hole Diameter: 10 inches
Logged By: A. Inglish Reviewed By: A. Goodwin

USCS Class	Graphic Log	Soil Descriptions	Depth in Feet
		Drilled unsampled to 15 feet. Refer to Boring Log MW-119 for soil classification.	0
			5
		ATD	
			10
SW		Medium dense, wet, gray, slightly gravelly, coarse SAND.	15
		Grading very gravelly	20
			25
			30

Bottom of Boring at 30.0 Feet.
Started 05/30/08.
Completed 05/30/08.



B-119A was originally named MW-119A.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. USCS designations are based on visual manual classification (ASTM D 2488) unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
5. SS = Slight Sheen, NS = No Sheen, MS = Moderate Sheen, HS = Heavy Sheen
6. Analytical water content tabulated in Table 2.

HARTCROWSER

17203-20 5/08

Figure A-90

NEW BORING LOG-ENV 1720320BL.GPJ HC_CORP.GDT 8/8/08

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring P19-02

Date(s) Drilled: 8/18/03 - 8/25/03	Geotechnical Consultant: Camp Dresser & McKee Inc.	Logged By: MJB	Checked By: VJP 02-03-04
Drilling Method/Rig Type: Wireline/ CME 85	Drilling Contractor: Cascade Drilling, Inc.	Total Depth of Borehole: 107.0 feet	
Casing Size/Type: PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.): 300# / 30"	Ground Surface Elevation/Datum: 109.0 feet / Metro	
Location: Pt. Wells	Coordinates: N 288005 E 1256501	Elevation Source: Survey	

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	0					SP-SM	Medium dense to dense, dark gray to light brown, dry to moist, slightly silty, gravelly SAND (SP-SM), poorly-graded, fine to coarse sand, fine to coarse gravel, subrounded to subangular, slight odor **(af)**				
			1	10 - 11 - 11 (22)	100						
105			2	12 - 19 - 19 (38)	100						
	5					SP	Dense, dark gray and black, wet, trace silt to slightly silty SAND (SP), trace gravel, poorly-graded, fine to coarse sand, fine to coarse gravel, subrounded and wood debris **(Qb)**				
			3	10 - 13 - 20 (33)	67						
100						PT	Medium stiff, brown, moist PEAT,(PT), wood debris **(Qw)**				
	10		4	3 - 2 - 3 (5)							
			5	1 - 2 - 3 (5)	100						
95											
	15		6	1 - 3 - 2 (5)	100	OL	Medium stiff, gray, moist ot wet, slightly sandy, organic SILT (OL), low plasticity, scattered to abundant organics/woody material, layers of peat, sandy silt, silty sand **(Qw)**				
			7	17 - 10 - 7 (17)		SM	Dense, brown, wet, silty to very silty SAND (SM), trace fine gravel, fine to coarse sand, numerous organics, organic odor **(Qpfnf)**				
			8	9 - 14 - 24 (38)	100						
90											
	20					GP	Very dense, dark gray, wet, very sandy GRAVEL (GP), trace silt, poorly-graded fine to coarse sand, fine to coarse gravel, angular to subrounded **(Qpfnf)**				
			9	75/6" (100+)	4						
85											
	25										

Groundwater Observation Data:

OW (FT BGS):	11.4 (Low)	3.5 (High)
VWP 1 (FT BGS):	7.7 (Low)	-4.9 (High)

Remarks: Negative Groundwater Data indicates measurements above Ground Surface
Recovery values > 100 indicate sample expansion during sampling.

CDM

Rev. 3 (Ver.1.1 Jan02BRIGHTWATER-BRIGHTWATER.GLB-BRIGHTWATER.GDT) O:\GINT\PROJECTS\19897-37576-BK\GHTWATER.GPJ 5/26/05

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring P19-02

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	25						ML	Very dense, gray green, moist, slightly gravelly, sandy SILT (ML), fine to coarse sand, fine gravel, subrounded to subangular, homogeneous **(Qpfnl)**				
			10	50/6" (100+)	3							
							GP	Very dense, gray, wet, sandy GRAVEL to gravelly SAND (GP-SP) **(Qpfnf)**				Soil description inferred from drill action and cuttings
80	30											
			11	70/6" (100+)	0							
75												Gravelly drilling, sand in cuttings
	35											
			12	100/4" (100+)	0							
70												
	40											Gravelly drilling (4-inch gravels/cobbles), sand in cuttings
			13	100/3" (100+)	0							
65												
	45											
			14	100/4" (100+)	49							Coarse gravel in sampling shoe
60												
	50						ML	Hard, dark brown, moist, gravelly SILT (ML), laminated, numerous organics **(Qpfnl)**				
			15	100/6" (100+)	17							
55												
	55						GM	Very dense, dark gray, wet, silty to very silty, sandy GRAVEL (GM), fine to coarse sand, fine to coarse gravel, subrounded, occasional organics **(Qpfnf)**				Most fines washed from sample
			16	100/5" (100+)	60							
50												
	60											

Rev. Ver.1.1 Jan02BRIGHTWATER-BRIGHTWATER.GLB-BRIGHTWATER.GDT} O:\GINT\PROJECTS\19897-3\BRIGHTWATER.GPJ 5/26/05

CDM

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring P19-02

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	60											
			17	100/5" (100+)	40							Coarse gravel/cobble in shoe, 14 ft of heave, hole cave overnight 65 to 51 ft, case to 53 ft
-45												
	65						GW	Dense, green gray, wet, sandy, GRAVEL (GW), well-graded, fine to coarse sand, subangular to subrounded fine to coarse gravel, with cobbles, possible boulders **(Qpfnf)**				Gravelly drilling, sand in cuttings
												Wood in cuttiings
-40												
	70											4-inch cobbles, clean SW in cuttings, wood fragments
-35												
	75											Cobbles, medium sand, cuttings - cobble/boulder
								Layer of fine to coarse sand, well-graded				12 feet of heave to 66 ft
-30												
	80											High tide, mud mix thinning
-25												
	85											
								Grades green gray, fine to coarse sand, gravel with cobbles				
-20												
	90											
								Grades coarser, gravel/cobble/boulder				
								Medium to coarse sand				Cuttings from cobble/boulder
-15												
	95											

CDM

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring P19-02

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	95											Organics in cuttings
10												16 ft of heave
	100											
5								Green gray, fine to coarse sand and fine gravel, angular to subangular				
	105											Shell fragments
								Terminated boring at 107 feet below ground surface				
0												
	110											
-5												
	115											
-10												
	120											
-15												
	125											
-20												
	130											

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CDM

Project: King County WTD / Brightwater Conveyance System **Project Location:** King & Snohomish Counties, Washington **Contract Number:** E23007E	**Log of Boring P19-03** Sheet 1 of 3

Date(s) Drilled	8/26/03 - 8/29/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	SWC/MJB	Checked By	VJP 02-03-04
Drilling Method/Rig Type	Wireline/ CME 85	Drilling Contractor	Cascade Drilling, Inc.	Total Depth of Borehole	76.0 feet		
Casing Size/Type	PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.)	300# / 30"	Ground Surface Elevation/Datum	108.8 feet / Metro		
Location	Pt. Wells	Coordinates	N 288365 E 1256276	Elevation Source	Survey		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	0						SM	Medium dense, gray, moist, silty SAND (SM), trace fine gravel, fine to medium sand **(af)**				
			1	6 - 9 - 12 (21)	100							
105			2	6 - 6 - 5 (11)	100							
	5											
			3	6 - 5 - 5 (10)	100							
							PT	Medium stiff, brown, moist PEAT (PT), fibrous, and gray olive SILT (ML), low plasticity, slow dilatancy **(Qw)**				
100			4	1 - 2 - 2 (4)	100							
	10											
			5	1 - 2 - 2 (4)	100		OL	Soft to medium stiff, brown to dark gray, moist, organic SILT (OL), low to medium plasticity varying to slightly clayey SILT (MH), numerous organics, medium to high plasticity, slow dilatancy **(Qw)**				
95			6	1 - 2 - 2 (4)	100							
	15											
			7	4 - 4 - 8 (12)	100		SP-SM	Medium dense, dark gray, wet, slightly silty SAND (SP-SM), poorly-graded fine to medium sand **(Qb)**				
90												
	20											
85												
	25											

Groundwater Observation Data:

OW (FT BGS):	7.9 (Low)	4.3 (High)
VWP 1 (FT BGS):	16.0 (Low)	5.6 (High)

Remarks: Negative Groundwater Data indicates measurements above Ground Surface

Recovery values > 100 indicate sample expansion during sampling.

CDM

Rev. 3 (Ver.1.1 Jan02BRIGHTWATER-BRIGHTWATER.GLB.BRIGHTWATER.GDT) O:\GINT\PROJECTS\19897-37576-BRIGHTWATER.GPJ 5/26/05

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring P19-03

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	60											
			15	50/4" (100+)	0							Fine to coarse sand in cuttings, gravelly drilling
-45												
	65											
			16	44 - 50/6" (100+)	25							
-40												
	70											
			14	12 - 14 - 19 (33)	11							Fine to coarse sand in cuttings, gravelly drilling, coarse gravel in sampler tip
-35												
	75											
								Terminated boring at 76 feet below ground surface.				
-30												
	80											
-25												
	85											
-20												
	90											
-15												
	95											

CDM

Rev. 3 (Ver.1.1 Jan02BRIGHTWATER-BRIGHTWATER.GLB-BRIGHTWATER.GDT) O:\GINT\PROJECTS\19897-37576-BRIGHTWATER.GPJ 5/26/05

APPENDIX D
HISTORICAL AERIAL PHOTOGRAPHS OF THE SITE

APPENDIX D
HISTORICAL AERIAL PHOTOGRAPHS OF THE SITE

Historical aerial photographs of the site were obtained from Aero-Metric (2008). In this Appendix, photographs from 1936, 1946, 1956, 1969, 1990 and 2004 are provided.

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Aerial Photo - 1936
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000

Scale in Feet

HARTCROWSER

17203-38 *1/10*

Aerial Photo - 1946
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000

Scale in Feet

HARTCROWSER

17203-38 *1/10*

Aerial Photo - 1956
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000

Scale in Feet

HARTCROWSER

17203-38 *1/10*

Aerial Photo - 1969
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000

Scale in Feet

HARTCROWSER

17203-38 *1/10*

Aerial Photo - 1990
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000
Scale in Feet

HARTCROWSER

17203-38 *1/10*

Aerial Photo - 2004
Paramount - Richmond Beach

EAL 01/20/10 1720304-Aerial_Print.dwg

N

0 500 1000
Scale in Feet

HARTCROWSER

17203-38 *1/10*

APPENDIX E
PHOTOGRAPHS OF SLOPE RECONNAISSANCE

APPENDIX E
PHOTOGRAPHS OF SLOPE RECONNAISSANCE

We conducted a field reconnaissance of the site with a primary focus on the condition of the steep slopes east of the BNSF railroad tracks on December 14, 2009. Photographs were taken during the slope reconnaissance, some of which are provided in this appendix for reference. The geologic reconnaissance was limited to areas that were accessible from the site.

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Figure E-1. View of tree and shrub density. Several trees leaning downslope.

Figure E-2. Exposure of the pre-Fraser and Lawton Clay formations.

Figure E-3. Soil bulging from toe of slope.

Figure E-4. Seeps observed on the face of the retaining wall.

Figure E-5. Lawton clay exposure with water running down from upslope.

Figure E-6. Water present on the ground surface and presence of hydrophytic plants. Asphalt covers the ground surface, and soil has migrated to the surface.

Figure E-7. Output of pipe below the upper bench out to the slope above the railroad. Horsetail plants present.

Figure E-8. View of ground surface showing duff below fallen leaves. Little vegetation observed.

Figure E-9. Cattails observed at the toe of the slope. Water present at the surface.

Figure E-10. View from upper bench towards the north. Horsetail plants observed on ground surface and exposed slope soil face.