HWA GEOSCIENCES INC.
Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing

July 23, 2009
HWA Project No. 2007-098-22 Task 500

Perteet Engineering, Inc.
2707 Colby Avenue, Suite 900
Everett, Washington 98201

Attn: Dan Hansen, P.E.

CC: Tara Olsen, P.E. / PB

SUBJECT: SETTLEMENT ANALYSES AND RECOMMENDATIONS
Fill Embankments near 180th Street NE and Horse Creek
SR 522 - Bothell Crossroads Project
Bothell, Washington

Dear Dan:

At to your request, we submit this letter presenting the results of our evaluations conclusions, and recommendations regarding potential settlements due to construction of new roadway embankment fill associated with the SR 522 Bothell Crossroads Project. This letter presents our estimates of predicted embankment settlements and provides discussion presenting methods of mitigation against these settlements.

Our analyses are based on project sections and profiles provided to us by Parsons-Brinkerhoff (PB) via the Perteet Sharepoint site and dated February 13, 2009, as well as a preliminary copy of the SR 522 60% Submittal Drawings, which were provided to us on July 8, 2009. We also utilize the results of our recently completed explorations and corresponding laboratory consolidation tests on relatively undisturbed samples of compressible materials.

The analyses, conclusions, and recommendations herein supplement those presented in our Draft Geotechnical Report submitted December 9, 2008 and will be incorporated in our Final Geotechnical Report for the SR 522 Crossroads Project.

PROJECT DESCRIPTION

Based on the topography of the site, the realignment of SR 522 will require the construction of fill embankments up to 10 feet thick. Our geotechnical and Phase II geo-environmental explorations for this project indicate portions of the new SR 522 roadway alignment to be underlain by up to 20 feet of compressible

19730 - 64th Avenue W.
Suite 200
Lynnwood, WA 98036.5957

Tel: 425.774.0106
Fax: 425.774.2714
www.hwageo.com

Based on our evaluation of the 60% plans, profiles, and cross sections, three areas are likely to experience significant settlements under the proposed fill embankments.

- The first area with significant fill is between SR 522 **STA 17+20 and 20+00**. The fill thickness rapidly increases from zero near STA 17+20 to 9 feet at STA 17+90. Moving upstation, fill thickness along the profile centerline slowly decrease to zero at STA 20+75. The fill thickness is generally greater along the southeastern edge of the profile, but never exceeds 9 feet.
- Near STA 21+00, the proposed 98th Avenue NE/180th Avenue NE alignment crosses the main SR 522 alignment. The 60% drawings indicate embankment fill up to about 5 feet thick will be placed from approximately NE 180th **STA 404+00 to 406+00,** large enough to be a concern given the compressive materials encountered in the area.
- The third area is near the Horse Creek crossing, from SR 522 **STA 24+40 to 26+80**. Between STA 24+40 and 26+40, the fill thickness is generally uniform across the profile and ranges between 3 and 4 feet. At the Horse Creek crossing, from STA 26+40 to 26+80, the fill is greater along the south side and is up to 10 feet thick.

SUBSURFACE DATA

Since our Draft Geotechnical Report was submitted in December 2008, we drilled two additional geotechnical borings, designated BC-9, near SR 522 STA 19+00, and BC-16 at approximate SR 522 STA 22+30, as shown on Figures 1A and 1B. Figures 1A and 1B also show the thicknesses of compressible materials in selected borings, which we have used in our analyses to estimate the magnitude of settlements at selected locations. Summary logs of these borings are provided in Figure 2 for BC-9 and Figure 3 for BC-16.

In addition to our geotechnical borings, several HWA geo-environmental explorations in the area were utilized in our evaluations. The geo-probes referenced for these analyses were taken from the following HWA Phase II assessments:

(1) Victory Development Property, Parcel No. 9457200081, Bothell, Washington, prepared for City of Bothell and submitted on April 30, 2008;

(2) 116th Street Group, LLC Property, Bothell, Washington, prepared for City of Bothell and submitted on November 19, 2008;

(3) Beta Bothell Landing Property, Parcels No. 9457200015 & 9457200020, Bothell, Washington, prepared for City of Bothell and submitted on November 1, 2007; and

(4) Hertz Rentals Property, Bothell, Washington, prepared for City of Bothell and submitted on October 10, 2008.

We also utilized borings from a previous geotechnical engineering study by Earth Consultants Inc., titled *Geotechnical Engineering Study, Proposed Restaurant, 18001 Bothell Way Northeast, Bothell Washington*, for McDonald's Corporation, dated May 4, 1992.

SUBSURFACE CONDITIONS

The explorations by HWA and others in the area indicate the proposed SR 522 and NE 180th alignments are generally underlain by a sequence of granular fill, compressible alluvial deposits, and relatively incompressible sand or glacial drift deposits. Descriptions of these units are described as:

- **Fill**: Fill materials are generally about 10 feet thick, except at BC-16, where about 15 feet of fill was encountered. The fill is composed primarily of loose to medium dense, silty sand and sandy silt, with scattered wood and construction debris.
- **Alluvial deposits**: Alluvial deposits were encountered below the fill in most borings. The alluvial deposits vary in composition and thickness across the site.
    - Along the northern edge of the site (the arc formed by the existing SR 522), the alluvial deposits are generally sands or sands mixed with organic silt and peat.
    - Near the intersection of SR 522 and SR 527 and Horse Creek, the alluvial deposits are typically organic silt or soft silt and lean clay, with some interbeds of peat. The thicknesses of the alluvial deposits vary in the area from 4 feet in BH-8 to 20 feet in BC-4, with greater thicknesses in the southern portion of the area. The organic silt is moderately to highly compressible.
    - Farther west, peat was encountered in varying stages of decomposition from younger woody peat as noted in BC-16 to fine fibrous peat in BC-9. The water contents of the peat samples tested ranged from 200 up to 535 percent by weight.

      In our explorations, peat layers as much as 12.5 feet thick were encountered, as observed in BC-9. Peat is highly compressible when loaded by new fills. The peat deposits were often underlain by compressible organic silt, as seen in BC-9 and VB-7.

      As would be expected, the thicknesses of compressible materials are greatest along the southern portion of the alignment, i.e. closer to the Sammamish River. At our boring BC-9, we encountered a total of 20 feet

of compressible material (12½ feet of peat underlain by 7 ½ feet of organic silt).

- **Sand or Glacial Drift**: The explorations that extended below the compressible materials were terminated in incompressible sand deposits. One boring, BC-16, however, encountered hard silt, which we identified as glacial drift.

Ground water levels in the area were generally encountered within the fill materials, between about 5 and 10 feet below the existing ground surface, indicating the compressible materials are saturated and will experience consolidation settlement under increased overburden loads.

EMBANKMENT SETTLEMENTS

There are two distinct forms of settlement that these soils will undergo; primary consolidation and long-term secondary compression. Primary consolidation settlement occurs in response to application of load and takes place as excess pore water pressures, generated by the additional load, dissipate. The magnitude and amount of time required for primary consolidation settlement to occur is a function of the soil type, its permeability, and drainage conditions.

Secondary compression occurs after the excess pore pressures have dissipated (i.e., primary consolidation settlement is complete) and is normally due to drained creep-deformation of the soil particles. The rate and magnitude of secondary compression is a function of soil type. Peat, in particular, exhibits very high secondary compression indices. The rate of secondary compression slows with time, but is linear when plotted to a logarithmic time scale. We normally consider a design life of 50 years for our secondary compression settlement calculations.

We conducted one-dimensional consolidation tests on samples of both the peat and organic silt material. Relatively undisturbed (Shelby tube) samples of each of these materials were obtained from our boring BC-9 on May 19, 2009. The tests were performed on a sample of peat taken from 16 feet below the ground surface (bgs) and a specimen of organic silt taken from a depth of 27.5 feet bgs.

Laboratory consolidation test results are presented in Figures 4 and 5 for the peat and organic silt respectively. From these data we computed modified compression indices and coefficients of consolidation for each material, as presented in Table 1. Based on our recent experience at a site along the Snohomish River with similar deposits of peat and organic silt, we considered a range of compression index values for the layers we have identified at this site. Our experience is that these deposits can vary significantly in thickness, organic content, and compressibility over relatively short distances. In addition, our experience is that laboratory consolidation test results can over-predict the magnitude of settlement. The laboratory test results were, therefore, considered a

reasonable upper limit of modified compression indices for the peat and organic silt at the site.

Table 1. Consolidation Parameters Obtained from Laboratory Testing On Materials at BC-9 with Values Used in Consolidation Computations

Soil Description	Sample Depth Below Ground Surface	Primary Compression Index from Lab Test	Modified Compression Indices ($C_{c\epsilon}$) Used in Computations[(1)]	Coefficient of Consolidation (C_v) from Lab Testing and Used in Computations
Very dark brown PEAT	16 Feet	0.5	0.33 to 0.5	0.05 in^2/min
Dark olive brown SILT	27.5 feet	0.28	0.08 to 0.28	0.015 in^2/min

[(1)] The modified compression index is defined as the compression index divided by the quantity of one plus the initial void ratio ($C_c/(1+e_o)$)

Settlement Estimates for Western Area between STA 17+20 and 21+00

We analyzed two "typical" embankment sections at SR 522 STA 18+20 and 18+80. Settlement analyses conducted for STA 18+20 were based primarily on soil stratigraphy encountered in our geo-environmental exploration VB-7 (Figure 6), a geo-probe conducted for the Phase II study conducted on the site previously owned by Victory Development. Analyses at SR 522 STA 18+80 were conducted based on our geotechnical boring BC-9. The design profiles are presented in Figures 7 and 8 for STA 18+20 and 18+80 respectively. The results of our analyses are provided in Table 1 and replace the estimates provided in Table 1 of our Draft Geotechnical Report. Our current settlement estimates are significantly higher than those presented in our December 2008 draft geotechnical report, mainly because thicker deposits of the peat and organic silt were encountered in our more recent explorations.

Table 1. Estimated Settlements for Fill Embankments Near Project Stations 18+20 and 18+80

Station Location / Nearby Boring	Design Embankment Thickness	Thicknesses/Types of Compressible Soils	Estimated Primary Consolidation	Estimated Secondary Compression over 50 years
STA 18+20 / VB-7	7 Feet	4.5 ft Peat; 2 ft Org. silt;	6 to 13 inches	1.5 to 3 inches
STA 18+80 / BC-9	9 feet	12.5 ft Peat 7.5 ft Org. silt	18 to 33 inches	4 to 7 inches

Our analyses predict settlements, ranging from about ½-foot to almost 3 feet will occur in this area. We expect greater settlement to occur along the southeastern side of the embankment fill due to thicker deposits of compressible material as well as greater embankment fill thicknesses. Nevertheless we estimate settlement as much as about 1 foot is likely on the northwestern side of the proposed alignment as well.

If left unmitigated, such settlements will affect the proposed roadway improvements, causing deformation and possibly failure of underground utilities, vaults, signal pole foundations and roadway pavement. Mitigation techniques include sub-excavation and replacement of all of the compressible soils, in-situ ground improvement, and preloading. Given the thickness and extent of compressible material along the proposed roadway alignment, we consider removal and replacement will likely be too costly. In situ ground improvement methods include grouting and stone columns, and these are also expensive.

Preloading involves building a soil surcharge above the planned final design grade, and allowing expected settlements to occur before the final roadway is graded and constructed. In our experience in similar projects, preloading is typically more cost effective than in-situ ground improvement. However, a trade-off is the time required to allow the preload settlements to occur. For purposes of this memo and future design discussion, we advocate consideration of a preload pretreatment program. A detailed discussion and recommendations on preloading are presented later in this memo.

Settlement Estimates for Area near Horse Creek between 24+40 to 26+80

We analyzed two "typical" embankment sections near Horse Creek at SR 522 STA 25+20 and 26+60. Soil stratigraphy at STA 25+20 was based on materials encountered in our boring BC-8 (Figure 9), while stratigraphy from boring BC-6 (Figure 10) was used for analyses at STA 26+60. The design profiles are presented in Figures 11

and 12 for 25+20 and 26+60 respectively. The results of our analyses are provided in Table 2 and replace the estimates provided in Table 2 of our Draft Geotechnical Report.

Table 2. Estimated Settlements for Fill Embankments Near Project Stations 25+20 and 26+60

Station Location / Nearby Boring	Design Fill Maximum Thickness	Thicknesses/Types of Compressible Soils	Estimated Primary Consolidation	Estimated Secondary Compression over 50 years
STA 25+20 / BC-8	4 feet	2.5 ft Silt w/ peat & org.; 4.5 ft Org. silt; 2.5 ft Silt	2 to 3 inches	Up to 1/2 inch
STA 26+60 / BC-6	7 to 10 feet	5 ft Org. silt 7.5 ft Very soft lean clay	3 to 7 inches	Up to 1 inch

Between STA 24+40 and 26+40, the fill thicknesses are generally less than or equal to about 4 feet. Based on our analyses, we expect settlements to be of the order of 2 to 3 inches. For the localized area between STA 26+40 and 26+80, we larger settlements are expected , confined primarily to the eastbound lanes of SR 522 (southern portion) due to thicker compressible materials coupled with greater fill depths. On average we expect settlements to be of the order of 3 to 4 inches, with up to 6 inches predicted in localized areas where fill heights are up to 10 feet (near STA 26+50 to 26+60).

In our opinion, roadway embankment settlements of a few inches or less are not likely to significantly impact the proposed improvements, and mitigation measures may not be warranted. The design team and the City of Bothell should participate in determining the acceptable magnitude of long term settlement. Between 26+40 and 26+80, where long term settlement of up to 7 inches is predicted, the localized nature of the thicker embankment fill, will probably limit the predicted settlements to this short section of roadway. This would likely lead to a noticeable “dip” in the pavement roadway surface, and cause discomfort to the traveling public. To mitigate this, a limited preload treatment program could be undertaken from STA 26+00 to 27+00, and the crest of the preload would be confined to the eastbound lanes of the proposed roadway, as shown on Figure 13B and discussed in more detail in the following section on *Preload Extents*.

PRELOADING CONCEPTS

For embankments or other developments constructed over compressible soils, preloading is an effective site pretreatment strategy to mitigate long term settlements (i.e., primary

consolidation plus secondary compression settlement over an assumed design life). The concept is to place a temporary soil surcharge above the planned final grade elevation, and wait for settlements to occur in response to this excessive loading. The preload is left in place long enough to induce a settlement of magnitude equal to the primary consolidation settlement plus a significant portion of the secondary compression settlement expected for the final embankment configuration. The progression of settlements would be monitored by regular surveys of settlement gages across the preload area, in addition to two vibrating wire piezometer instruments to monitor dissipation of excess pore water pressure. After a sufficient period of time has elapsed, the settlement monitoring data will show that primary consolidation is essentially complete. At this point, the remaining soil surcharge can be removed and the embankment graded to the final design elevation. With a properly designed preload and sufficient time period, all of the primary consolidation and a majority of the long-term secondary compression settlements will have occurred before the final embankment grading. Experience has shown that preloading significantly reduces, but does not eliminate secondary compression settlement effects.

The amount of time required for the preload period depends on the properties of the subsoils being treated. The preload thickness has little effect on the time required. In general, for a greater net surcharge thickness, a slower rate of secondary compression should result. In our experience on other similar preload projects, an effective net surcharge on the completion of the preload is 10 feet of soil. The preload thickness should, therefore, be 10+S, where S is the predicted settlement due to the site grading plus surcharge thickness. For this project, we recommend a preload thickness of 13 feet above final roadway grade.

EMBANKMENT AND PRELOAD FILL MATERIALS

Embankment structural fill should consist of a granular and freely-draining sand and gravel, such as Gravel Borrow as specified in Section 9-03.14(1) of the *WSDOT Standard Specifications*. This structural fill should be compacted to 95% of Modified Proctor maximum dry density as is standard for roadway construction.

The upper 10 feet of the preload surcharge, which would be removed on completion of the preload period, may consist of a lower-quality fill, such as Common Borrow as specified in Section 9-03.14(3) of the *WSDOT Standard Specifications.* This may be considered a non-structural zone, and there is no need for a minimum required compaction level except it should be sufficiently compacted to handle construction equipment. Excavated materials generated from the Wayne Curve project, or from the large underground detention vault for the Crossroads/Boulevard project would be suitable for use as this non-structural surcharge fill. However, materials with a high proportion of fine-grained (silt and clay size) particles, are moisture sensitive and they will become difficult to impossible to work with during wet weather conditions. If the preload construction is anticipated to be done during the wet winter months of November to

April, it all-weather fill such as Gravel Borrow should be considered for the full depth of the preload.

RECOMMENDED PRELOAD EXTENTS

From the estimated settlements predicted, based on our explorations and the proposed grading plans, we recommend that preloading be undertaken in the western portion of the project beginning near STA 17+60 and extending to 21+00, as shown on Figure 13A. Notice that the preload extent begins at 17+20 along the southern curb (about 50 feet right of the centerline) and at STA 18+00 along the northern curb (about 50 feet left of the centerline). The preload should also extend along 180th Avenue from approximately STA 404+00 to 406+00. If deemed necessary preloading may also be applied from SR 522 STA 26+00 to 27+00, and be confined to the eastbound lanes of the proposed roadway. These extents are shown in Figure 13B.

Within the recommended extents shown on Figures 13A and 13B, the height of the fill should be equal to the selected preload thickness (10+S). The red line therefore depicts the crest of the temporary preload embankment; rather than its footprint. To limit the extent of the footprint, temporary preload slopes can be as steep as 1.5H:1V. Where needed, temporary retaining walls, may be constructed to retain the preload fill.

PRELOAD DURATION

Based on our laboratory testing and preload monitoring data from previous projects involving preloading of similar peat and organic silt materials, we anticipate the compressible material will require a significant time period for primary consolidation settlement to take place. The time for primary settlement to be essentially complete is related to the thickness of the consolidating layer. We estimate the time for primary consolidation settlement to occur in the thickest peat and silt deposits (found along the southern most eastbound lane) will be on the order of 9 to 12 months, while the areas with thinner deposits could be of the order of 3 to 4 months. Monitoring of the progression of settlement and dissipation of excess pore water pressures in the compressible layers should be performed to determine when it will be appropriate to remove the surcharge. For planning purposes, a minimum preload period of 9 months should be expected.

If a 9 to 12 month preload period would be difficult or impossible to plan for, methods to reduce the time-rate of consolidation could be considered. Such methods, which include vertical wick drains and sand columns, allow more rapid drainage of the compressible deposits by reducing the drainage path of the consolidating materials.

VERTICAL DRAIN CONCEPTS

Between SR 522 Project STA 17+20 and 21+00, pre-fabricated vertical drains (i.e., *wick drains*) could be considered in the areas with the thickest compressible materials. For areas with thinner deposits, the benefit of installing vertical drains is diminished.

A wick drain consists of a ribbed polypropylene strip surrounded by a non-woven polypropylene geotextile filter. The drains provide a shorter path for excess pore water pressures to dissipate; thereby accelerating the consolidation process. Wick drains are typically installed by threading the wick into a specialized mandrel supported on a crane mast or boom. A tapered drive shoe is attached to the drain at the leading end of the mandrel, which is pushed into the soil to the target elevation. Then the mandrel is removed and the wick is left in the ground. The wick drain construction equipment is normally mounted on a crawler excavator. For extremely soft ground, a layer of granular material is needed to provide support for construction equipment.

Alternatively, sand drains could be installed with the same purpose of the wick drains; however in place of pre-fabricated wick drains, material, coarse sand columns with average diameters of 12 to 24 inches are constructed. Typical construction of a sand drain involves driving or pushing a displacement element into the ground, consisting of a 12- to 24-inch diameter steel pipe or mandrel. The mandrel is driven or pushed closed ended by virtue of a specially designed hinged bottom plate. Once at the base of the compressible material, the steel casing is filled with sand material and then the mandrel is raised, leaving a sand column in its place.

Placing the wick drains or sand drains on an equilateral triangular grid pattern optimizes the efficiency of the system. Typical spacings for wick drains are about 4 to 5 feet while spacing for sand drains is about 5 to 6 feet; the tighter the spacing the shorter the estimated time to 90% of consolidation in the compressible materials.

If wick drains or sand drains are employed, a granular drainage layer, about 2 feet thick, should be placed over the ground surface, either before or after the wick drains are installed. The purpose of this layer is to provide a permeable medium that is hydraulically connected to the tops of the drains. Based on final construction costs for a project we provided geotechnical engineering services on, which included pre-fabricated drains installed in Everett and performed in 2007 with a sand drainage blanket; the current cost of the wick drains should be approximately $1.15 per lineal foot; and the current cost of the Sand Drainage Blanket layer should be approximately $16 per ton.

If wick drains or sand drains are selected to decrease necessary preload period, the improvement area should cover the area beneath the sidewalk and two eastbound lanes from STA 17+60 to 20+00, as noted on Figure 13A. The drains should be installed so as to terminate in incompressible sands or silts below the compressible materials. Based on our borings, the lengths of the wick drains should vary between about 15 and 30 feet

below existing grade. Because the site is blanketed with medium dense granular fill, it may be difficult to install wick drains without removal or pre-drilling in advance.

A geotechnical engineer should monitor the wick drain construction to verify that each drain has been installed to a sufficient depth. This will be evaluated based our borings and the penetration resistance presented to the drain installation mandrel assembly.

This memo is intended to express our results and conclusions and to be a starting point or an introductory statement in ongoing design team discussions. We would welcome the opportunity to meet with the Perteet/PB design team and the City of Bothell to discuss these recommendations and to assist in developing an appropriate preload design.

We appreciate this opportunity to be of service. If you have any questions or require additional information, please contact either of the undersigned at (425) 774-0106.

Sincerely,

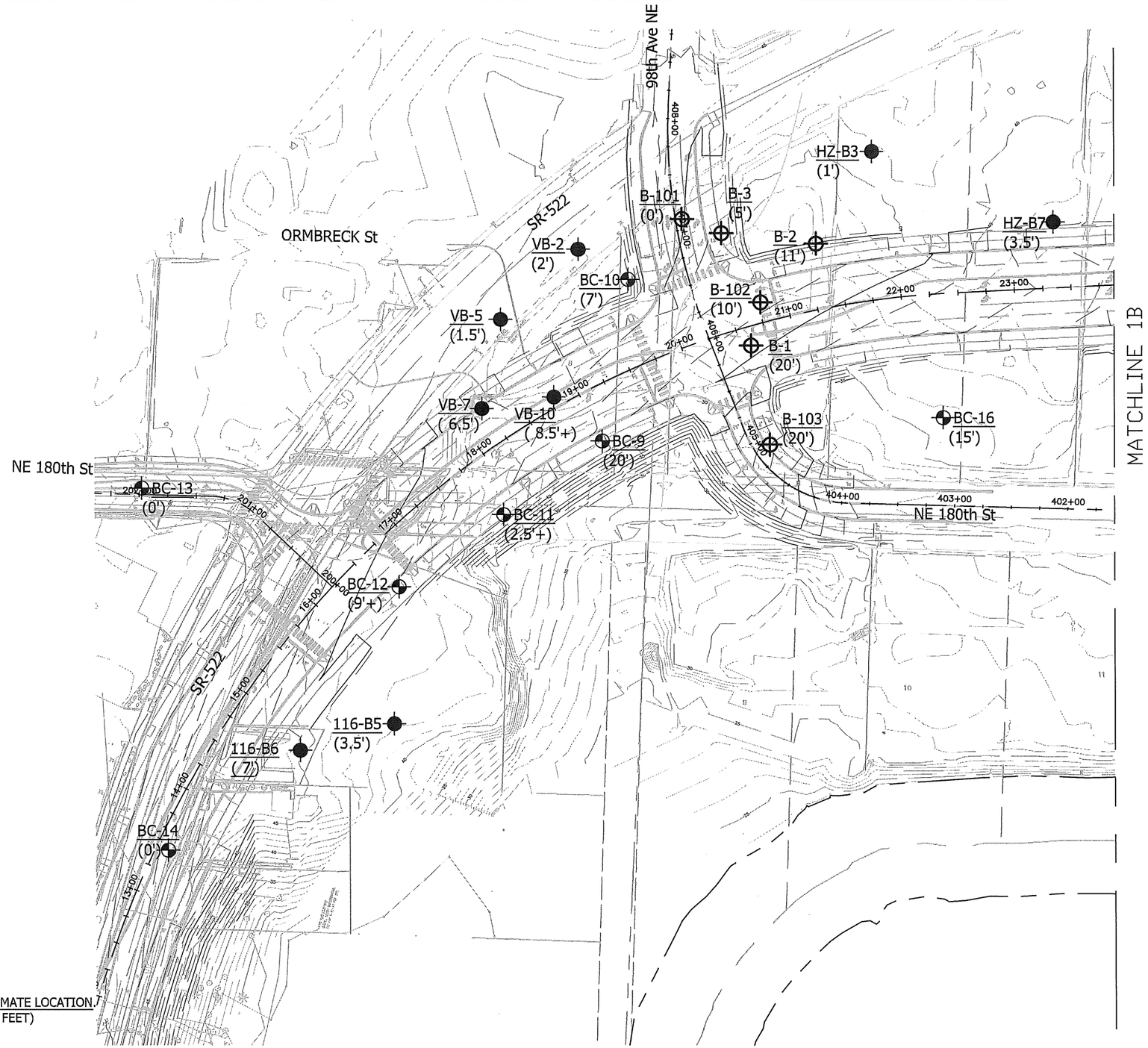
HWA GEOSCIENCES INC.

Erik O. Andersen, P.E.
Senior Geotechnical Engineer

JoLyn Gillie, P.E.
Geotechnical Engineer

ATTACHMENTS:

Figures 1A-1B.	Peat Thickness at Selected Borings
Figures 2 -3.	HWA Exploration Logs for Borings BC-9 and BC-16
Figure 4.	One Dimensional Consolidation Summary Plots for BC-9: Sample S-9 from 15 to 17ft below ground surface
Figure 5.	One Dimensional Consolidation Summary Plots for BC-9: Sample S-16 from 26.5 to 28.5 ft below ground surface
Figure 6.	HWA Exploration Log for Geo-probe VB-7



BC-1 (0') — HWA BOREHOLE DESIGNATION AND APPROXIMATE LOCATION. (THICKNESS OF COMPRESSIBLE MATERIAL IN FEET)

116-B6 (7') — HWA GEOPROBE DESIGNATION AND APPROXIMATE LOCATION. (THICKNESS OF COMPRESSIBLE MATERIAL IN FEET)

B-3 (5') — EXPLORATIONS COMPLETED BY ECI(1989-1992). REMAINDER OF BORINGS ARE HWA GEOTECHNICAL AND ENVIRONMENTAL BORINGS.

BASE MAP PROVIDED BY PERTEET ENGINEERING DATED: 3/20/08

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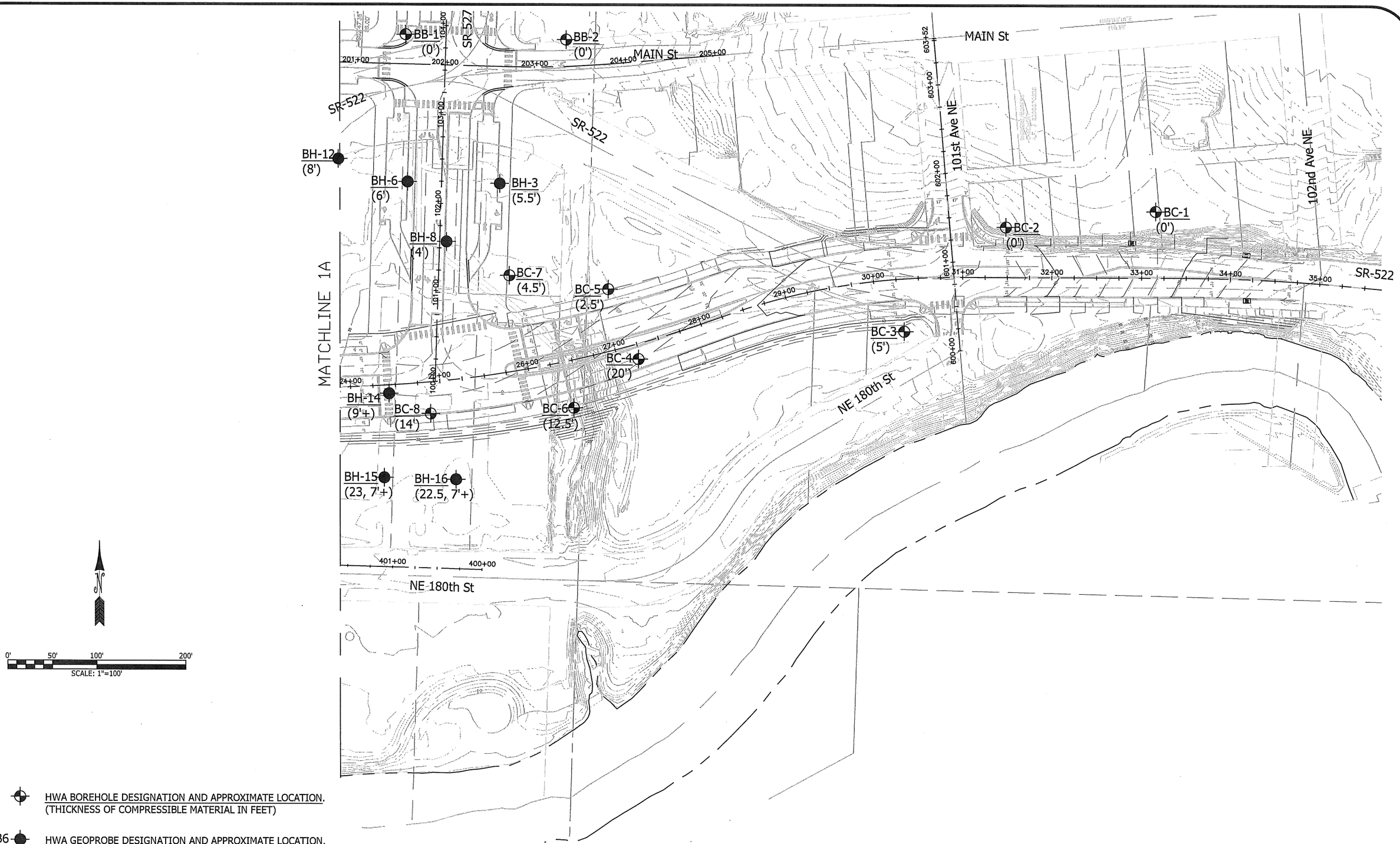
HWA GEOSCIENCES INC.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

PEAT THICKNESS AT SELECTED BORINGS

DRAWN BY EFK
CHECK BY JG
DATE 07.20.09

FIGURE NO. 1A
PROJECT NO. 2007-098-22
TASK 500



BC-1 (0') — HWA BOREHOLE DESIGNATION AND APPROXIMATE LOCATION. (THICKNESS OF COMPRESSIBLE MATERIAL IN FEET)

116-B6 (7') — HWA GEOPROBE DESIGNATION AND APPROXIMATE LOCATION. (THICKNESS OF COMPRESSIBLE MATERIAL IN FEET)

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BASE MAP PROVIDED BY PERTEET ENGINEERING DATED: 3/20/08

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HWA GEOSCIENCES INC.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

PEAT THICKNESS AT SELECTED BORINGS

DRAWN BY EFK
CHECK BY JG
DATE 07.20.09

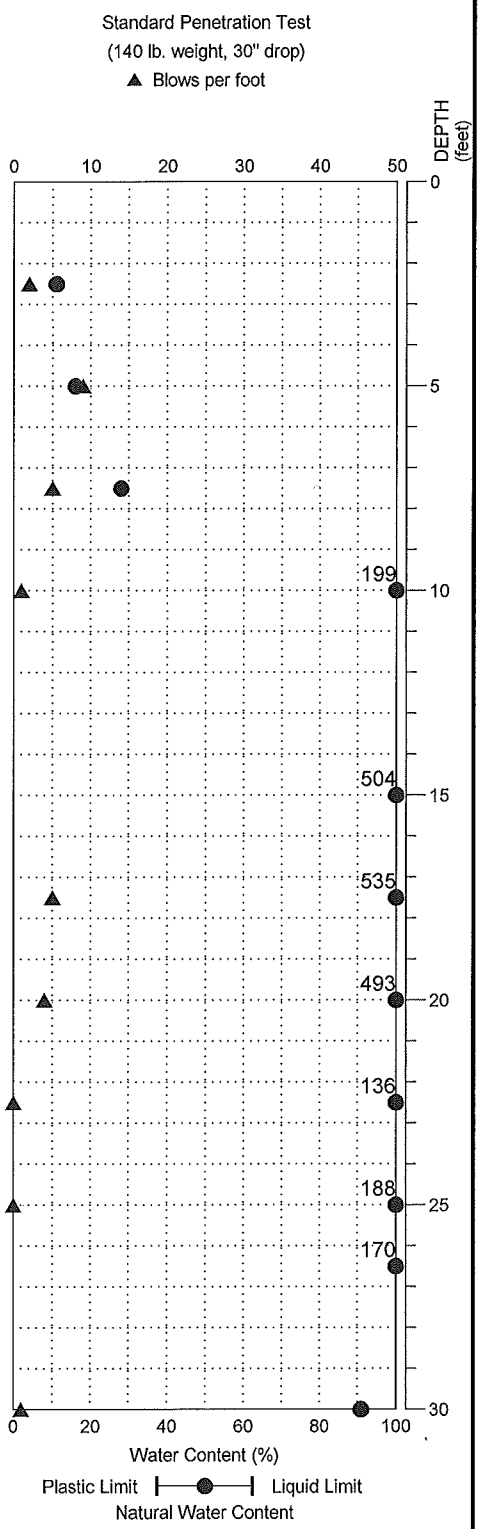
FIGURE NO. 1B
PROJECT NO. 2007-098-22
TASK 500

DRILLING COMPANY: Holocene Drilling, Inc
DRILLING METHOD: 4-1/4" HSA Truck-mounted Mobile B-61
SAMPLING METHOD: SPT with Autohammer
SURFACE ELEVATION: 32.00 ± feet

LOCATION: STA 19+00 45' RT
DATE STARTED: 5/19/2009
DATE COMPLETED: 5/19/2009
LOGGED BY: J. Gillie

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0		SM	Loose, grayish brown, silty SAND, moist. with yellow and red mottling. **(FILL)**		S-1	1-1-1	
5		SM	Loose, dark brownish gray, slightly silty, gravelly SAND, wet, with 1" layers of organic silt with peat on 6" spacing, rotton odor. **(ALLUVIUM)**		S-2	2-4-5	GS
		SM	Loose, dark gray, silty SAND, wet, with interbeds of silty peat.		S-3	0-2-3	
10		PT	Very soft to soft, very dark brown, fine fiberous PEAT, moist, with interbeds of gray silt and silty sand.		S-4	1-1/12"	
			Low Recovery in Shelby sample at 12 feet.		S-5		
15			Organic contect of sample S-6 at 15 feet is 88%.		S-6		CN
			Consistency grades to medium stiff.		S-7	0-2-3	
20			Consistency grades to soft.		S-8	0-2-2	
		OL	Very soft, dark olive brown, ORGANIC SILT, moist.		S-9	0-0-0	
25					S-10	0-0-0	
			Organic contect of sample S-12 at 26.5 feet is 9.9%.		S-12		CN
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.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

BORING:
BC- 9

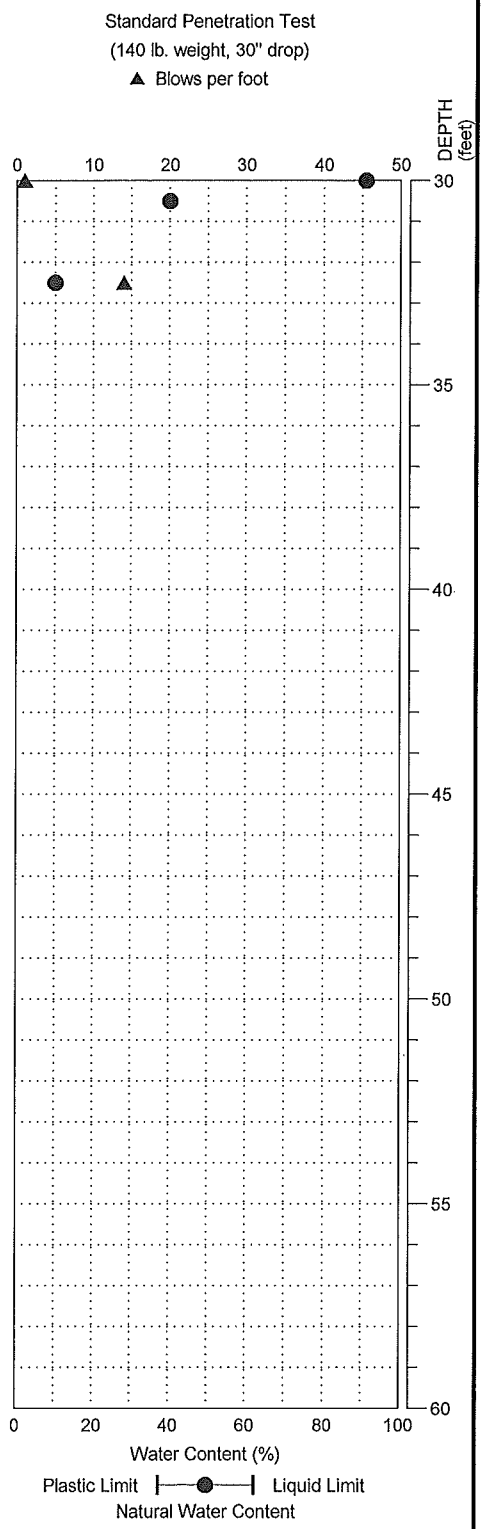
PROJECT NO.: 2007-098 FIGURE: 2

DRILLING COMPANY: Holocene Drilling, Inc
DRILLING METHOD: 4-1/4" HSA Truck-mounted Mobile B-61
SAMPLING METHOD: SPT with Autohammer
SURFACE ELEVATION: 32.00 ± feet

LOCATION: STA 19+00 45' RT
DATE STARTED: 5/19/2009
DATE COMPLETED: 5/19/2009
LOGGED BY: J. Gillie

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
30		SM	Very soft, dark olive brown, SILT, with organics, moist.		S-12a	1-0-1		
		SM	Loose, gray, very silty fine to medium SAND, wet, with interbeds of soft to medium stiff, gray brown to gray, silt approximately 1" thick.		S-12b		GS	
		SP	Medium dense, dark grayish brown, SAND, wet. **(OUTWASH)** Low recovery in sample S-13. Cobble observed in sampler tip.		S-13	1-4-10		
35								
40								
45								
50								
55								
60								

Boring terminated at 34 feet below ground surface. Ground water encountered at 5 feet below ground surface during drilling.



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.

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HWA GEOSCIENCES INC.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

BORING:
BC- 9

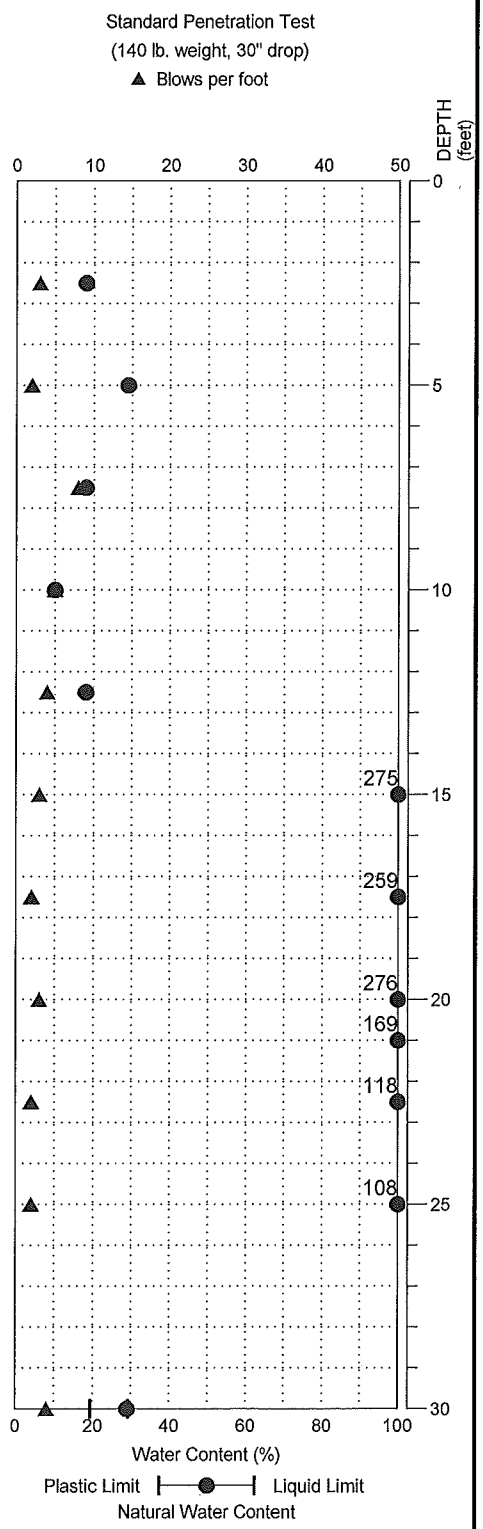
PROJECT NO.: 2007-098 FIGURE: 2

DRILLING COMPANY: Holocene Drilling, Inc
DRILLING METHOD: 4-1/4" HSA Truck-mounted Mobile B-61
SAMPLING METHOD: SPT with Autohammer
SURFACE ELEVATION: 35.00 ± feet

LOCATION: STA 22+30 110' RT
DATE STARTED: 5/20/2009
DATE COMPLETED: 5/20/2009
LOGGED BY: J. Gillie

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE / SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS
0	SM	HMA 1" thick over gravelly, silty SAND 2" thick. Loose, dark gray, gravelly, silty fine to medium SAND, moist. **(FILL)**	S-1	1-1-2	
5		Organics, similar to peat, noted in sample at 5 feet.	S-2	0-0-2	GS
		Interbedded 1" bands of dark gray silt noted at 7.5 feet.	S-3	4-4-4	
10			S-4	2-2-3	
	SM	Loose, very dark brownish gray, gravelly, silty SAND, wet, wood chips noted throughout sample.	S-5	1-2-2	GS
15	PT	Soft, very dark brown to red brown, woody PEAT, moist. **(ALLUVIUM)**	S-6	1-1-2	
		Long rootlets in matrix of sample at 17.5 feet.	S-7	1-1-1	
20			S-8a	0-1-2	
	OL	Soft, very dark brown, ORGANIC SILT, moist, with peat.	S-8b		
		Fiberous organics noted in sample at 22.5 feet.	S-9	1-1-1	
25			S-10	0-1-1	
30					

GROUNDWATER



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HWA GEOSCIENCES INC.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

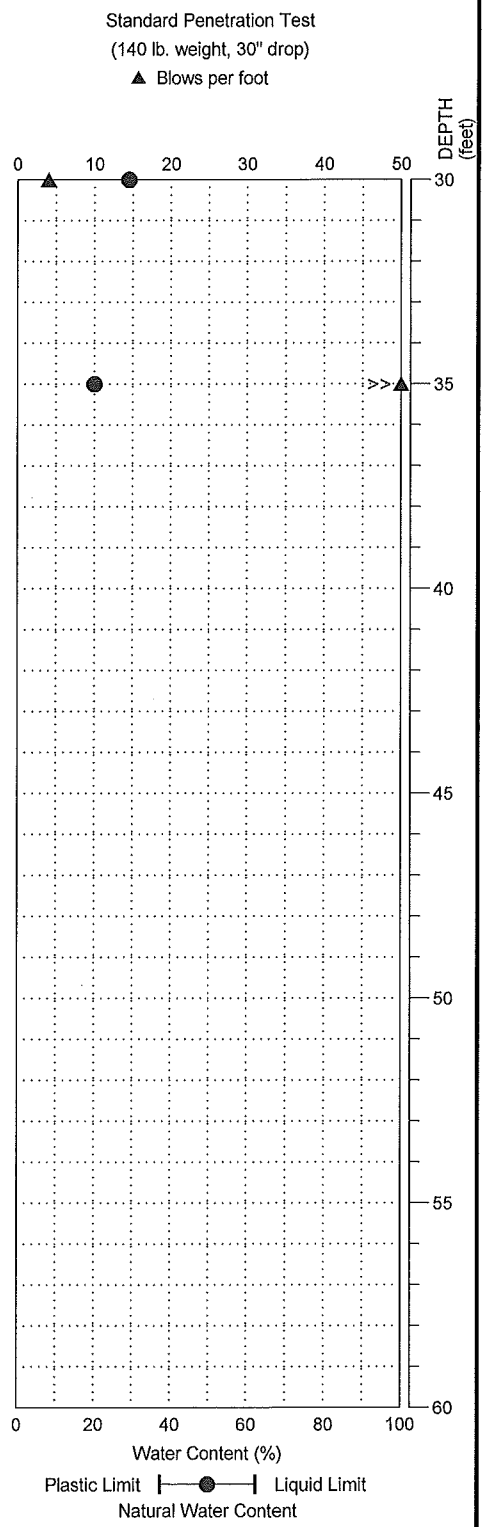
BORING:
BC-16

PROJECT NO.: 2007-098 FIGURE: 3

DRILLING COMPANY: Holocene Drilling, Inc
DRILLING METHOD: 4-1/4" HSA Truck-mounted Mobile B-61
SAMPLING METHOD: SPT with Autohammer
SURFACE ELEVATION: 35.00 ± feet

LOCATION: STA 22+30 110' RT
DATE STARTED: 5/20/2009
DATE COMPLETED: 5/20/2009
LOGGED BY: J. Gillie

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
30		CL	Medium stiff, olive gray, lean CLAY, wet.		S-11	0-0-4	AL	
			Sample grades to fine gravelly, sandy silt at 31.5 feet.					
35		ML	Hard, gray, SILT, moist, with subvertical partings with fine sand. **(GLACIO-MARINE DRIFT)**		S-12	20-50/6"		
			Boring terminated at 36.0 feet below ground surface. Ground water encountered at 5 feet below ground surface during drilling.					
40								
45								
50								
55								
60								



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HWA GEOSCIENCES INC.

SR 522 PRELOAD RECOMMENDATIONS
BOTHELL CROSSROADS PROJECT
BOTHELL, WASHINGTON

BORING:
BC-16

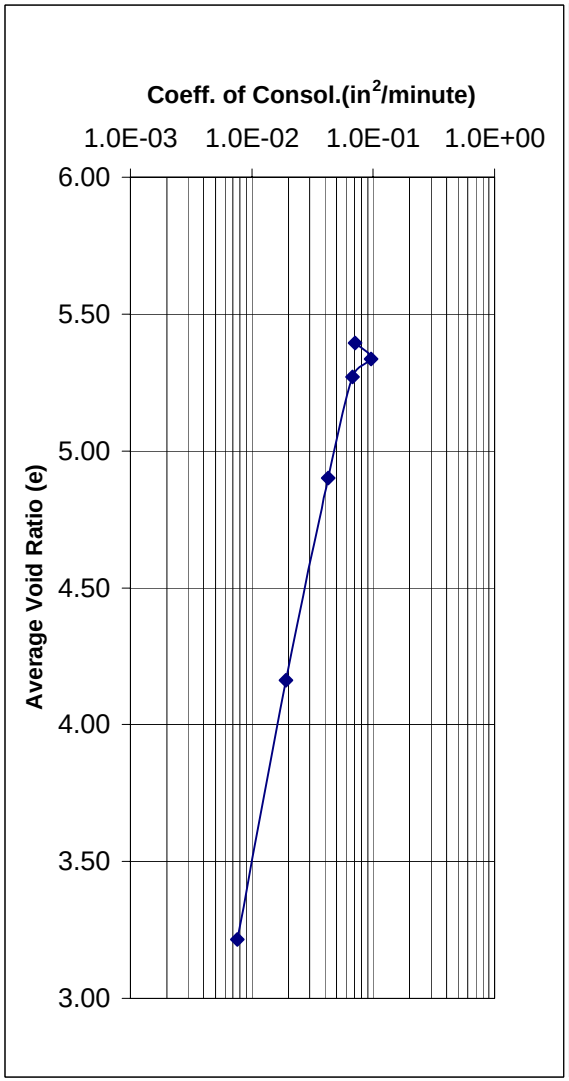
PROJECT NO.: 2007-098 FIGURE: 3

HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION ASTM D 2435

Project Name: Bothell Crossroads
Project Number: 2007098-T500
Borehole Number: BC-9
Sample Number: S-6
Sample Depth: 15-17
Soil Description: Very dark brown, peet, 88.0% organics

	Start	Finish	
Moisture Content	504.4	348.0	%
Saturation	100.9	100.0	%
Dry Density	10.6	14.2	pcf



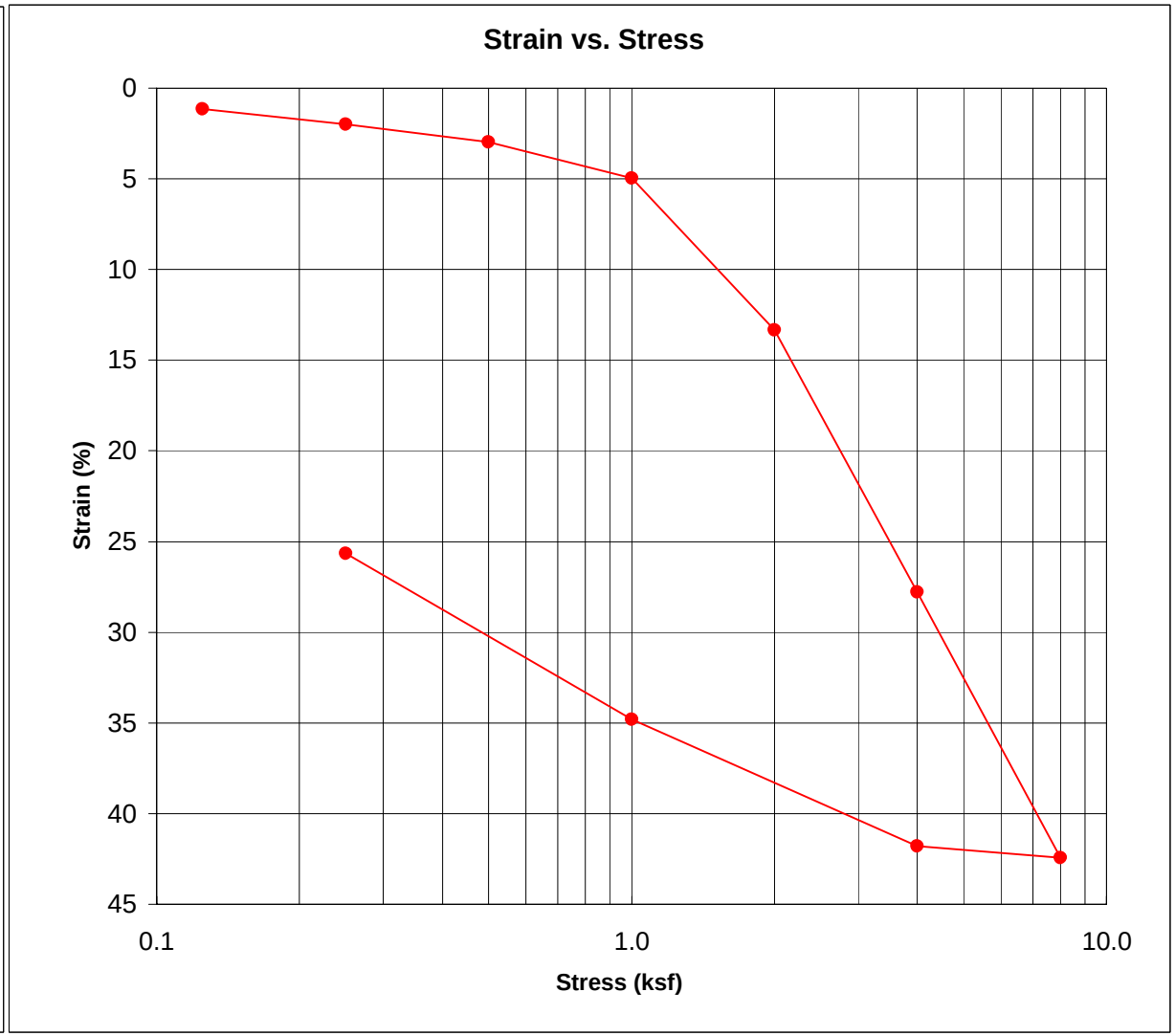


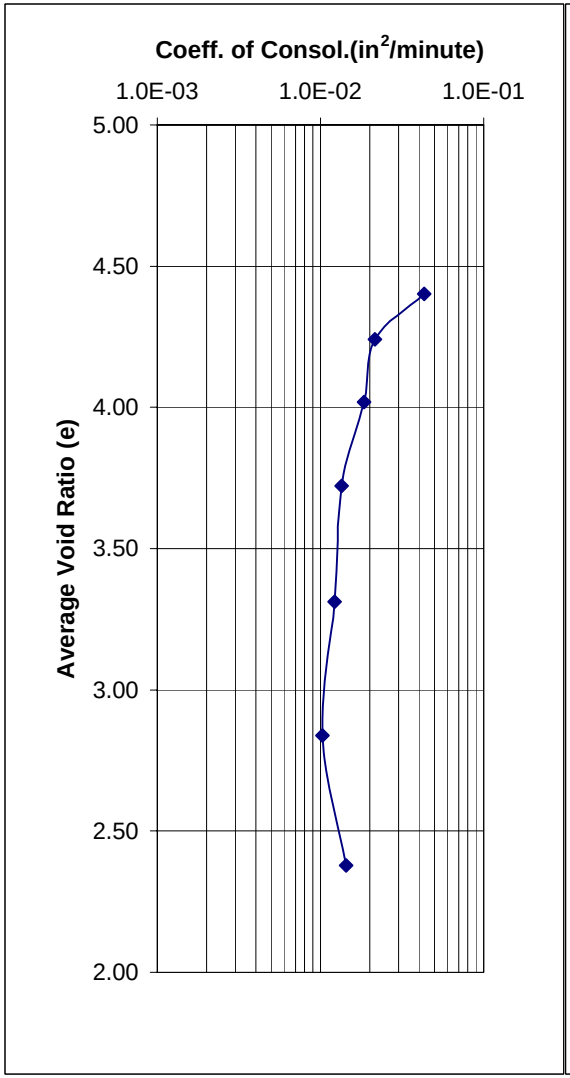
FIGURE 4

HWA GEOSCIENCES INC.

ONE DIMENSIONAL CONSOLIDATION ASTM D 2435

Project Name: Bothell Crossroads
Project Number: 2007098-T500
Borehole Number: BC-9
Sample Number: S-12
Sample Depth: 26.5-28.5
Soil Description: Dark olive brown, SILT with 9.9% organics

	Start	Finish	
Moisture Content	169.2	105.4	%
Saturation	98.6	99.8	%
Dry Density	29.7	43.3	pcf



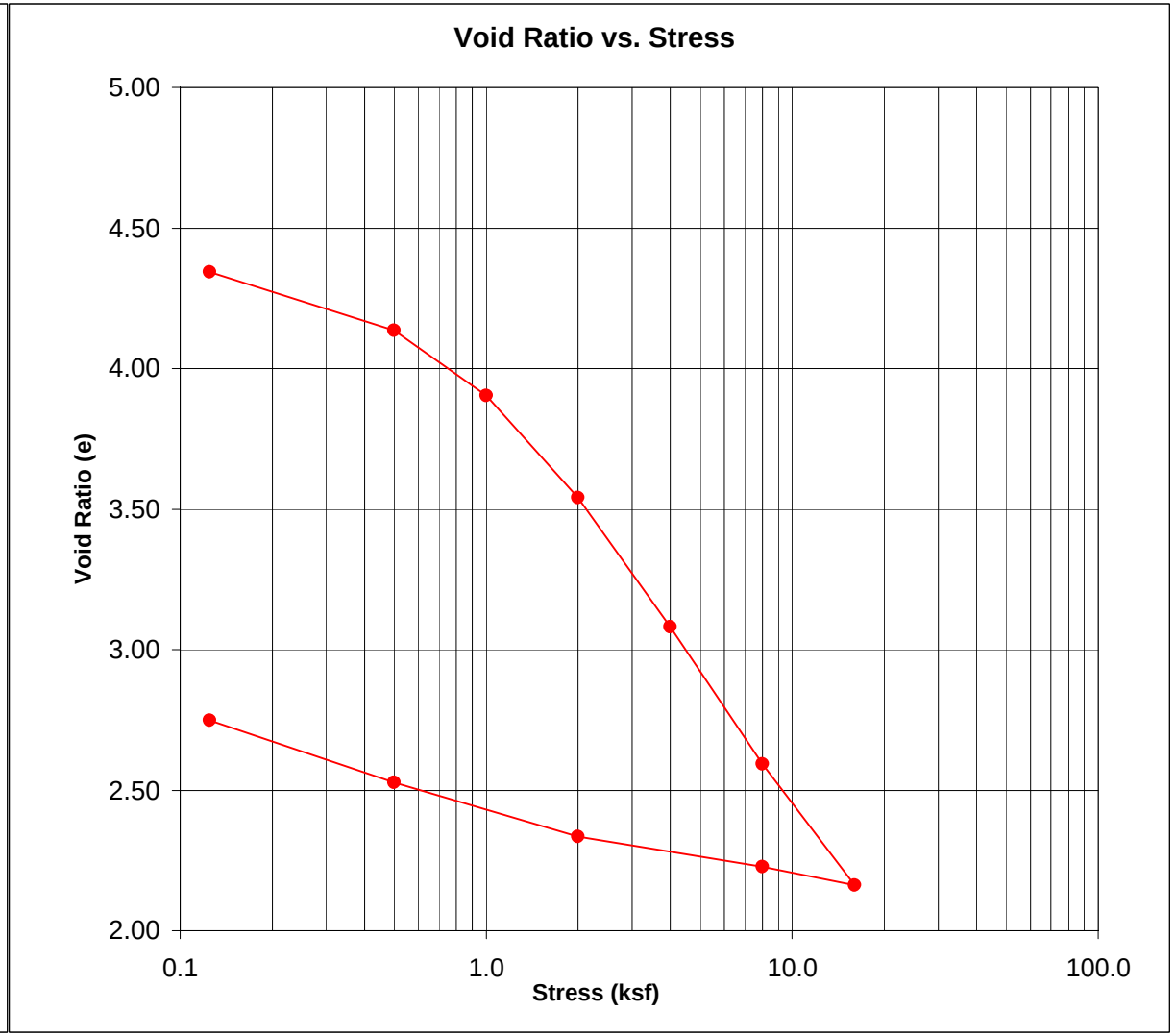


FIGURE 5

DRILLING COMPANY: ESN Northwest
DRILLING METHOD: GeoProbe
SAMPLING METHOD: 48" Macrocore Sampler
LOCATION: Victory Parcel, Former LUST

SURFACE ELEVATION: ± feet

DATE STARTED: 2/14/2008
DATE COMPLETED: 2/14/2008
LOGGED BY: J. Speck

DEPTH (feet)	USCS SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PID (ppm)	NOTES
0		ASPHALT			Set temporary 1-inch PVC screen from 7-12 feet bgs.
	SM	Medium dense gray-brown silty SAND and GRAVEL, dry grading moist. (FILL)	1	0	
	GP	Concrete debris/gravel fragments			
	SM	Medium dense light gray-green silty fine SAND with gravel, moist grading wet. (ALLUVIUM)			
5					
	SM	Dark brown silty SAND and GRAVEL with peat seams, wet.	4	0	
	PT	Poor recovery. Dark brown PEAT, wet. (See Boring VB-6)			
10					
	ML	Stiff gray-brown SILT with fine sand, trace rootlets, moist. Poor recovery	8	0	
	SP	Gray grading olive-gray fine to medium SAND, wet.			
15			12	0	Set temporary 1-inch PVC screen from 15-20 feet bgs.
			16	0	
20		Boring completed to 20 feet bgs. Boring backfilled with hydrated bentonite			
25					

SAMPLE TYPE
PEN. RESISTANCE (blows/6 inches)
OTHER TESTS
WELL COMPLETION SCHEMATIC

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HWA GEOSCIENCES INC.

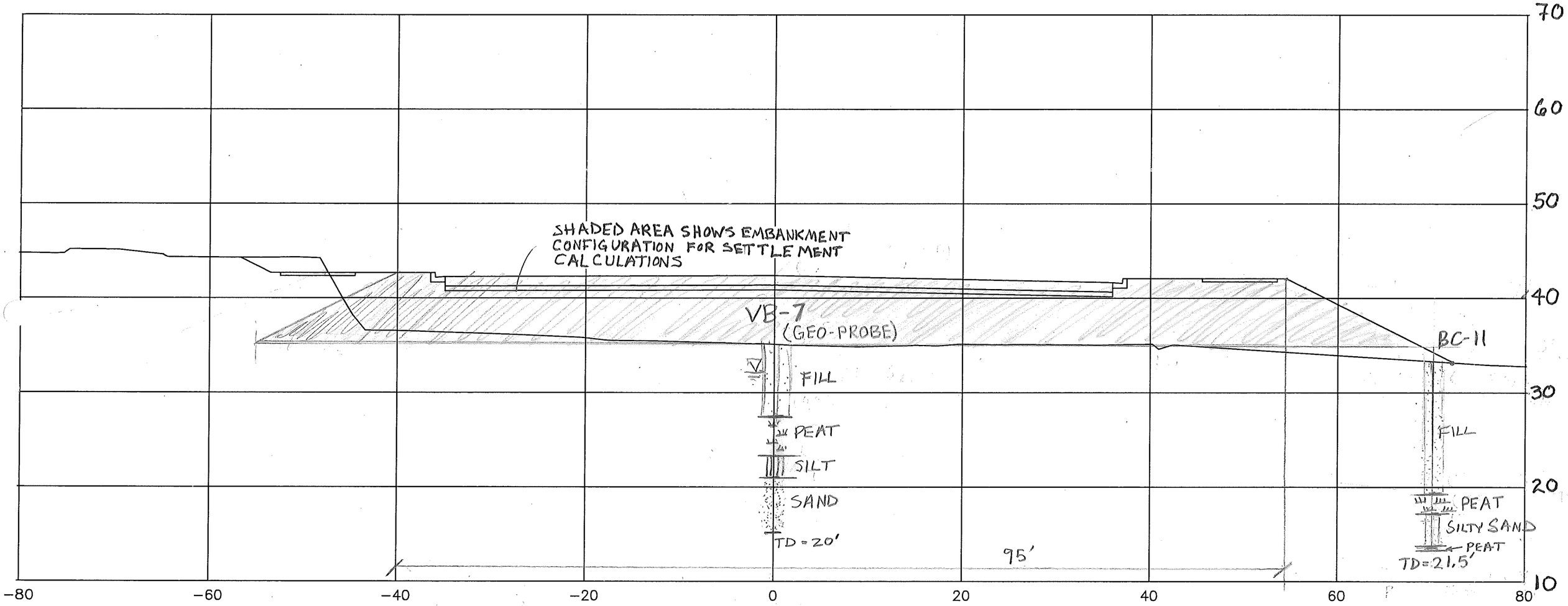
Bothell Crossroads
Victory parcel

MONITORING WELL:
VB-7

PAGE: 1 of 1

PROJECT NO.: 2007-098-210 FIGURE: 6

MWELL 2007-098-210.GPJ 3/27/08



18+20

FIGURE 7

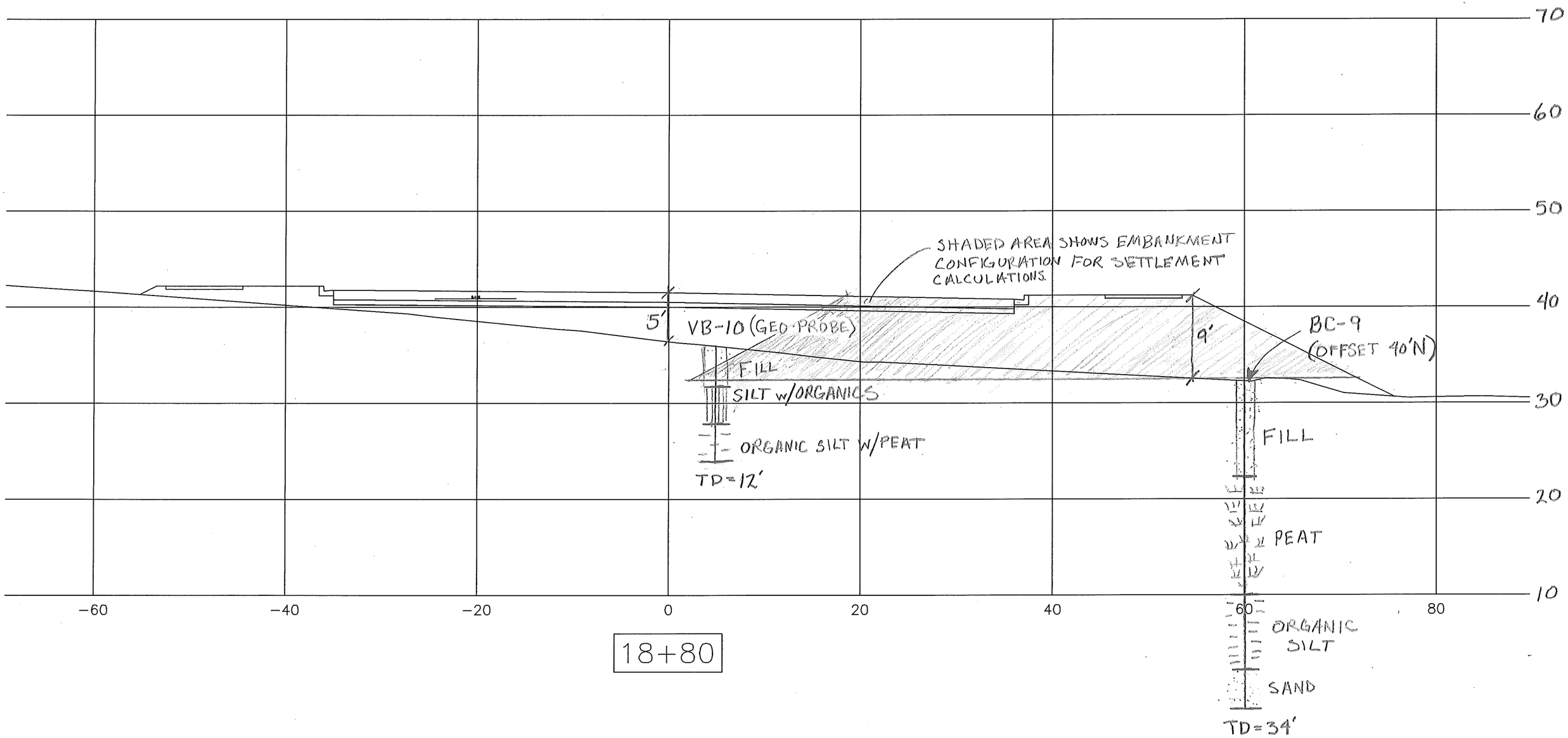

70
60
50
40
30
20
10
SHADED AREA SHOWS EMBANKMENT CONFIGURATION FOR SETTLEMENT CALCULATIONS.
5'
VB-10 (GEO-PROBE)
FILL
SILT w/ORGANICS
ORGANIC SILT W/PEAT
TD=12'
9'
BC-9
(OFFSET 40'N)
FILL
PEAT
ORGANIC SILT
SAND
TD=34'
−60
−40
−20
0
20
40
60
80
18+80

FIGURE 8