Geotechnical Engineering

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Geotechnical Investigation
Proposed Warehouse Complex
1966 Roger Stevens Drive
Ottawa, Ontario

Prepared For

Broccolini

July 12, 2019

Report PG4870-1 Revision 1

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Broccolini to conduct a geotechnical investigation for the proposed warehouse complex to be located at 1966 Roger Stevens Drive in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the investigation were to:

- ❑ Determine the subsoil and groundwater conditions at this site by means of test holes.

- ❑ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are understood at the time of writing this report.

2.0 Proposed Project

Based on the available drawings, it's our understanding that the proposed building will consist of a slab-on-grade warehouse building with a footprint of approximately 65,000 m^2. It is anticipated that associated paved access lanes, vehicle parking areas and landscaped areas will surround the proposed building, and that the building will be municipally serviced.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the current investigation was conducted during the period of June June 7 to 14, 2019. The field program consisted of advancing a total of 35 boreholes to a maximum depth of 5.4 m below existing ground surface. The test hole locations were distributed in a manner to provide general coverage of the subject site taking into consideration underground utilities and site features. The locations of the test holes are shown on Drawing PG4870-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were completed with a track-mounted auger drill rig operated by a two-person crew. All fieldwork was conducted under the full-time supervision of our personnel under the direction of a senior engineer. The test hole procedure consisted of augering to the required depths at the selected locations, and sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were recovered using a 50 mm diameter split-spoon sampler, a Shelby tube, or from the auger flights. The split-spoon and auger samples were classified on site and placed in sealed plastic bags. All samples were transported to our laboratory. The depths at which the split-spoon, Shelby tubes and auger samples were recovered from the boreholes are shown as SS, TW and AU, respectively, on the Soil Profile and Test Data sheets in Appendix 1.

A Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split spoon samples. The SPT results are recorded as "N" values on the Soil Profile and Test Data sheets. The "N" value is the number of blows required to drive the split spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm. This testing was done in general accordance with ASTM D1586-11 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

Undrained shear strength testing, using a vane apparatus, was carried out at regular intervals of depth in cohesive soils.

The overburden thickness was evaluated by a dynamic cone penetration test (DCPT) at 4 borehole locations. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at the tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

The subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are presented on the Soil Profile and Test Data sheets in Appendix 1 of this report.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of this report. They will then be discarded unless we are directed otherwise.

3.2 Field Survey

The test hole locations were selected by Paterson personnel in a manner to provide general coverage of the proposed development, taking into consideration site features.

The borehole locations and ground surface elevations were surveyed by Annis, O'Sullivan, Vollebekk Ltd. and are presented on Drawing PG4870-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging.

3.4 Analytical Testing

Two (2) soil samples was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The samples were submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the samples. The results are presented in Appendix 1 and are discussed further in Subsection 6.8.

4.0 Observations

4.1 Surface Conditions

The subject site is currently undeveloped and consists of agricultural land with a sparsely wooded farm compound that includes a dwelling, a barn and sheds. The farm lands are relatively flat with at a geodetic elevation of 87 to 88 m, whereas the farm compound is built on a hill which crosses between the southwest and northeast corners across the site at a geodetic elevation of 94 to 96 m. The site is bordered by Highway 416 to the east, Roger Stevens Drive to the north, treed off residential properties to the west and a forested area along the south and southwest borders. Excavated drainage ditches were also encountered along the south and east border of the subject site.

4.2 Subsurface Profile

Overburden

The subsurface profile encountered at the borehole locations within the farm land area at a geodetic elevation of approximately 88 m consisted of a topsoil layer overlying a native silty clay layer or a silty sand layer underlain by a silty clay layer, which is in turn underlain by a glacial till deposit. The subsoil profile encountered at the borehole locations along the hill and farm compound generally consisted of a topsoil layer overlying a glacial till deposit. The fine matrix of the glacial till was observed to consist of silty sand to sandy silt or silty clay with gravel, cobbles and boulders. Practical refusal to DCPT was encountered at depths ranging from 6.5 to 7.4 m below ground surface. Practical refusal to augering was encountered at depths ranging from 3.5 to 5.4 m below ground surface.

Bedrock

Based on available geological mapping, the local bedrock consists of dolomite of the Oxford formation with an overburden drift thickness of 10 to 15 m.

4.3 Groundwater

Groundwater levels were measured in the standpipes at the borehole locations on June 21, 2019. The measured groundwater level (GWL) readings are presented in Table 1 below. Based on our field observations, experience with the local area, moisture levels and the colouring of the recovered samples, it is expected that the long-term groundwater level can be estimated between 3 to 4 m below existing grade. It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction.

Table 1 - Summary of Groundwater Levels

Borehole Number	Ground Surface Elev. (m)	Measured Groundwater Level		Recording Date
		Depth (m)	Elevation (m)	
BH 1	88.08	1.05	87.03	June 21, 2019
BH 2	88.19	1.99	86.20	June 21, 2019
BH 3	87.58	0.35	87.23	June 21, 2019
BH 4	88.28	0.23	88.05	June 21, 2019
BH 5	87.70	0.80	86.90	June 21, 2019
BH 6	87.86	4.99	82.87	June 21, 2019
BH 7	89.26	1.16	88.10	June 21, 2019
BH 8	88.89	1.31	87.58	June 21, 2019
BH 9	84.47	Blocked and dry at 2.22 m	-	June 21, 2019
BH 10	82.67	1.99	80.68	June 21, 2019
BH 11	89.20	1.32	87.88	June 21, 2019
BH 12	92.08	0.81	91.27	June 21, 2019
BH 13	91.70	2.47	89.23	June 21, 2019
BH 14	95.77	Blocked and dry at 2.47 m	-	June 21, 2019
BH 15	92.49	2.27	90.22	June 21, 2019
BH 16	88.98	1.43	87.55	June 21, 2019
BH 17	88.86	1.13	87.73	June 21, 2019
BH 18	88.32	2.42	85.90	June 21, 2019

Table 1 - Summary of Groundwater Levels (continued)

Borehole Number	Ground Surface Elev. (m)	Measured Groundwater Level		Recording Date
		Depth (m)	Elevation (m)	
BH 19	94.89	Blocked and dry at 5.09 m	-	June 21, 2019
BH 20	94.89	1.45	93.44	June 21, 2019
BH 21	91.07	1.88	89.19	June 21, 2019
BH 22	88.31	1.37	86.94	June 21, 2019
BH 23	87.81	0.27	87.54	June 21, 2019
BH 24	88.46	1.37	87.09	June 21, 2019
BH 25	89.43	1.19	88.24	June 21, 2019
BH 26	90.88	1.85	89.03	June 21, 2019
BH 27	88.72	1.65	87.07	June 21, 2019
BH 28	88.31	0.86	87.45	June 21, 2019
BH 29	88.06	1.16	86.90	June 21, 2019
BH 30	88.27	0.92	87.35	June 21, 2019

Note: Ground surface elevations at the test hole locations were provided by Annis, O'Sullivan, Vollebekk, Ltd. and are assumed to be referenced to a geodetic datum.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed warehouse. It is expected that the proposed building will be founded on conventional spread footings placed on an undisturbed, stiff to very stiff silty clay and compact to dense glacial till glacial till bearing surfaces.

Due to the presence of the silty clay layer, the proposed development will be subject to grade raise restrictions. Permissible grade raise recommendations are discussed in Subsection 5.3. If higher than permissible grade raises are required, preloading with or without surcharge, lightweight fill and/or other measures should be investigated to reduce the unacceptable long-term post construction total and differential settlements.

The above and other considerations are further discussed in the following sections.

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and any fill containing significant amounts of deleterious or organic materials should be stripped from under the proposed building, paved areas, pipe bedding and other settlement sensitive structures.

Fill Placement

Fill used for grading beneath the building footprint, unless otherwise specified, should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using heavy vibratory compaction equipment. Fill placed beneath the building area should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. The site-generated silty sand/glacial till material may be used to build up the subgrade level for areas to be paved. This material, under dry and above freezing conditions, should be placed in maximum 300 mm lifts and compacted to a minimum density of 95% of its SPMDD.

Boulders larger than 300 mm in their longest dimensions should be removed from the glacial till prior to being reused.

Placement of site-generated fill material during winter months increases the risk of placing frozen material which may result in poor performing areas that may require sub-excavation of the material and subsequent reinstatement. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless used in conjunction with a composite drainage blanket connected to a perimeter drainage system.

5.3 Foundation Design

Bearing Resistance Values (Shallow Foundation)

Footings placed on a compact to dense silty sand/glacial till bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **200 kPa** and a factored bearing resistance value at ULS of **350 kPa**. A geotechnical resistance factor of 0.5 was applied to the bearing resistance at ULS.

Strip footings, up to 3 m wide, and pad footings, up to 5 m wide, placed in the southeast portion of the building over an undisturbed, firm to stiff silty clay and/or compact silty sand bearing surface can be designed using a bearing resistance value at Serviceability Limit States (SLS) of **150 kPa** and a factored bearing resistance value at Ultimate Limit States (ULS) of **250 kPa**, incorporating a geotechnical resistance factor of 0.5.

Where the silty sand bearing surface is found to be in a loose state of compactness, the area should be proof-rolled using a vibratory compactor and approved by the geotechnical consultant prior to placing footings.

An undisturbed, soil bearing surface consists of a surface from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

Settlement

The total and differential settlements associated with the footing loading conditions using the bearing resistance value at SLS provided are estimated to be 25 and 20 mm, respectively.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to a compact to dense silty sand, stiff to very stiff silty clay or compact to dense glacial till above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

Permissible Grade Raise

Based on the existing borehole coverage and results of the undrained shear strength testing completed within the underlying cohesive soils, a permissible grade raise restriction of **2.0 m** is recommended for grading within 6 m of the proposed building and **2.5 m** is recommended for access roadways and parking areas.

5.4 Design for Earthquakes

Shear wave velocity testing was completed at the subject site to accurately determine the applicable seismic site classification for the proposed building from Table 4.1.8.4.A of the Ontario Building Code (OBC) 2012. The shear wave velocity testing was completed by Paterson personnel. Two seismic shear wave velocity profiles from the testing are presented in Appendix 2.

Field Program

The seismic array location is presented on Drawing PG4870-1 - Test Hole Location Plan in Appendix 2. Paterson personnel placed 24 horizontal geophones in a straight line in an approximately north-south orientation. The 4.5 Hz geophones were mounted to the surface by two 75 mm ground spikes attached to the geophone land case. The geophones were spaced at 3 m intervals and connected by a geophone spread cable to a Geode 24 channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between 4 to 8 times at each shot location to improve signal to noise ratio. The shot locations are also completed in forward and reverse directions (i.e. striking both sides of the I-beam seated parallel to the geophone array). The shot locations are located 3, 4.5 and 30 m away from the first geophone, 3, 4.5 and 30 m away from the last geophone, and at the centre of the seismic array.

The methods of testing completed by Paterson are guided by the standard testing procedures used by the expert seismologists at Carleton University and Geological Survey of Canada.

Data Processing and Interpretation

Interpretation for the shear wave velocity results were completed by Paterson personnel. Shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity, Vs_{30}, of the upper 30 m profile immediately below the building's foundation. The bedrock velocity was interpreted using the main refractor wave velocity, which is considered a conservative estimate of the bedrock velocity due to the increasing quality of the bedrock with depth. It should be noted that as bedrock quality increases, the bedrock shear wave velocity also increases.

$$V_{s30} = \frac{Depth_{OfInterest}(m)}{\left(\frac{(Depth_{Layer1}(m)}{Vs_{Layer1}(m/s)} + \frac{Depth_{Layer2}(m)}{Vs_{Layer2}(m/s)}\right)}$$

$$V_{s30} = \frac{30m}{\left(\frac{14.6m}{164.2\,m/s} + \frac{15.4m}{2{,}462\,m/s}\right)}$$

$$V_{s30} = 315m/s$$

Based on the results of the seismic testing, the average shear wave velocity, Vs_{30}, for foundations placed on the overburden materials is 315 m/s. Therefore, a **Site Class D** is applicable for design of the proposed building, as per Table 4.1.8.4.A of the OBC 2012. The soils underlying the subject site are not susceptible to liquefaction.

5.5 Slab-on-Grade Construction

With the removal of all topsoil and fill, containing deleterious or organic materials, within the footprint of the proposed building, the native soil and/or approved fill pad will be considered to be an acceptable subgrade surface on which to commence backfilling for the floor slab. The upper 300 mm of sub-slab fill should consist of an OPSS Granular A crushed stone. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose lifts and compacted to at least 98% of its SPMDD.

Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab.

5.6 Pavement Structure

Frost Tapers

For utility trenches and other subgrade structures backfilled with non-frost susceptible granular material, consideration should be given to installing frost tapers (1V:5H or 1V:10H) in hard landscaped areas and below pavement structures to lessen the effects of differential frost heaving. Consideration could also be given to installing rigid insulation which requires tapering with various insulation thicknesses.

Pavement Structures

Car only parking areas, heavy truck parking areas and access lanes are anticipated at this site. The proposed pavement structures are presented in Tables 2 and 3.

Table 2 - Recommended Pavement Structure - Car Only Parking Areas

Thickness (mm)	Material Description
50	Wear Course - HL-3 or Superpave 12.5 Asphaltic Concrete
150	BASE - OPSS Granular A Crushed Stone
450	SUBBASE - OPSS Granular B Type II
One Layer	Woven geotextile
SUBGRADE - Either fill, in situ soil, or OPSS Granular B Type I or II material placed over in situ soil or fill	

Table 3 - Recommended Pavement Structure
Access Lanes and Heavy Truck Parking Areas

Thickness (mm)	Material Description
40	Wear Course - HL-3 or Superpave 12.5 Asphaltic Concrete
50	Binder Course - HL-8 or Superpave 19.0 Asphaltic Concrete
50	Base Course - HL-8 or Superpave 19.0 Asphaltic Concrete
150	BASE - OPSS Granular A Crushed Stone
450	SUBBASE - OPSS Granular B Type II
One Layer	Woven geotextile
SUBGRADE - Either fill, in situ soil, or OPSS Granular B Type I or II material placed over in situ soil or fill	

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with an OPSS Granular B Type II material. The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the material's SPMDD using suitable vibratory equipment.

Pavement Structure Drainage

The pavement structure performance is dependent on the moisture condition at the contact zone between the subgrade material and granular base. Failure to provide adequate drainage under conditions of heavy wheel loading could result in the subgrade fines pumped into the stone subbase voids, thereby reducing the load bearing capacity.

Due to the impervious nature of the subgrade materials consideration should be provided to installing subdrains during the pavement construction. The subdrains should extend in four orthogonal directions and longitudinally when placed along a curb. The clear crushed stone surrounding the drainage lines or the pipe, should be wrapped with suitable filter cloth. The subdrain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be shaped to promote water flow to the drainage lines. Discharge of the subdrains should be directed by gravity to storm sewers or deeper drainage ditches.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

A perimeter foundation drainage system is considered optional for the proposed building. If implemented, the system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Foundation Backfill

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a drainage geocomposite, such as Delta Drain 6000, connected to the perimeter foundation drainage system. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effects of frost action. A minimum of 1.5 m of soil cover should be provided for adequate frost protection of heated structures.

Exterior unheated footings, such as those for isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the heated structure and require additional protection, such as soil cover of 2.1 m or an equivalent combination of soil cover and foundation insulation.

6.3 Excavation Side Slopes

The side slopes of excavations at the site should be either cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is expected that sufficient room will be available for the excavation to be undertaken by open-cut methods.

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be excavated at 1H:1V or shallower. The shallower slope is required for excavation below groundwater level.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

A trench box is recommended to protect personnel working in trenches with steep or vertical sides. Services are expected to be installed by “cut and cover” methods and excavations should not remain open for extended periods of time

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications and Standard Detail Drawings from the Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa.

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe, should consist of OPSS Granular A or Granular B Type II with a maximum size of 25 mm. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to 95% of the material’s standard Proctor maximum dry density.

It should generally be possible to re-use the site materials above the cover material if the operations are carried out in dry weather conditions.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) and above the cover material should match the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material standard Proctor maximum dry density.

6.5 Groundwater Control

It is anticipated that groundwater infiltration into the excavations should be controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations. The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

A temporary Ministry of the Environment, Conservation and Parks (MECP) permit to take water (PTTW) Category 3 may be required for this project if more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. A minimum of 4 to 5 months should be allowed for completion of the PTTW Category 3 application package and issuance of the permit by the MECP.

For typical ground or surface water volumes being pumped during the construction phase, between 50,000 to 400,000 L/day, it's required to register on the Environmental Activity and Sector Registry (EASR). A minimum of two to four weeks should be allotted for completion of the EASR registration and the Water Taking and Discharge Plan to be prepared by a Qualified Person as stipulated under O.Reg. 63/16. If a project qualifies for a PTTW based upon anticipated conditions, an EASR will not be allowed as a temporary dewatering measure while awaiting the MECP review of the PTTW application.

6.6 Winter Construction

Precautions must be taken if winter construction is considered for this project.

The subsoil conditions at this site mostly consist of frost susceptible materials. In the presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the use of straw, propane heaters, tarpaulins or other suitable means. In this regard, the base of the excavations should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

The trench excavations should be carried out in a manner to avoid the introduction of frozen materials, snow or ice into the trenches.

6.7 Slope Stability Analysis

Field Observations

Paterson personnel conducted a site visit on May 30, 2019 to review the slope located along the existing hill crossing between the southwest and northeast corners of the subject site. The current slope conditions and existing topogrphic mapping grades were also assessed.

Two slope cross-sections were reviewed as part of our analysis as the worst case scenarios based on topography and site observations. The cross section locations are presented on Drawing PG4870-1 - Test Hole Location Plan in Appendix 2. Generally, the slopes along both sides of the existing hill are currently well vegetated and were observed in an acceptable condition. The slope along each side of the hill ranged in height between 8 and 9 m with an inclination ranging between 2H:1V and greater than 5H:1V. The upper and lower slope was observed to be well vegetated with no signs of active surficial erosion.

Slope Stability Analysis

The analysis of the stability of the slope was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favouring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain than the risks of failure are acceptable. A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures.

An analysis considering seismic loading was also completed. A horizontal acceleration of 0.16G was considered for the sections for the seismic loading condition. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The cross-sections were analyzed taking into account a groundwater level at ground surface, which represents a worse-case scenario that can be reasonably expected to occur in cohesive soils. The stability analysis assumes full saturation of the soil with groundwater flow parallel to the slope face. Subsoil conditions at the cross-sections were inferred based on the findings at borehole locations along the top of slope and general knowledge of the area's geology.

The effective strength soil parameters used for static analysis were chosen based on the subsoil information recovered during our previously completed geotechnical investigation. The effective strength soil parameters used for static analysis are presented in the figures attached.

The total strength parameters for seismic analysis were chosen based on the in situ, undrained shear strengths recovered within the open boreholes completed at the time of our geotechnical investigation and based on our general knowledge of the areas geology. The strength parameters used for seismic analysis at the slope cross-sections are presented in the figures attached.

Static Loading Analysis

The results for the slope stability static loading analysis at Section A and B is shown in Figures 4 and 6 attached to the present report. The factor of safety was found to be greater than 1.5 at both sections. Based on these results, the slopes are considered to be stable under static loading.

Seismic Loading Analysis

An analysis considering seismic loading was also completed. A horizontal acceleration of 0.16G was considered for all slopes. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The results of the analyses including seismic loading are shown in Figures 5 and 7 and attached to the present report. The results indicate that the factors of safety are greater than 1.1. Based on these results, the slopes are considered to be stable under seismic loading.

Therefore, the overall subject slope has a global slope stability factor of safety of greater than 1.5, and is considered stable from a geotechnical perspective.

6.8 Corrosion Potential and Sulphate

The results of analytical testing show that the sulphate content is less than 0.1%. This result is indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of a moderate to slightly aggressive corrosive environment.

7.0 Recommendations

A materials testing and observation services program is a requirement for the provided foundation design data to be applicable. The following aspects of the program should be performed by the geotechnical consultant:

- ❏ Observation of all bearing surfaces prior to the placement of concrete.
- ❏ Review of the grading plan from a geotechnical perspective.
- ❏ Sampling and testing of the concrete and fill materials used.
- ❏ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.
- ❏ Observation of all subgrades prior to backfilling.
- ❏ Field density tests to determine the level of compaction achieved.
- ❏ Sampling and testing of the bituminous concrete including mix design reviews.

A report confirming that these works have been conducted in general accordance with our recommendations could be issued, upon request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations provided in this report are in accordance with our present understanding of the project. We request permission to review our recommendations when the drawings and specifications are completed.

A geotechnical investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test hole locations, we request immediate notification to permit reassessment of our recommendations.

The recommendations provided herein should only be used by the design professionals associated with this project. They are not intended for contractors bidding on or undertaking the work. The latter should evaluate the factual information provided in this report and determine the suitability and completeness for their intended construction schedule and methods. Additional testing may be required for their purposes.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Broccolini or their agents is not authorized without review by Paterson for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
July 12, 2019
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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 10

FILE NO. PG4870

HOLE NO. BH 1

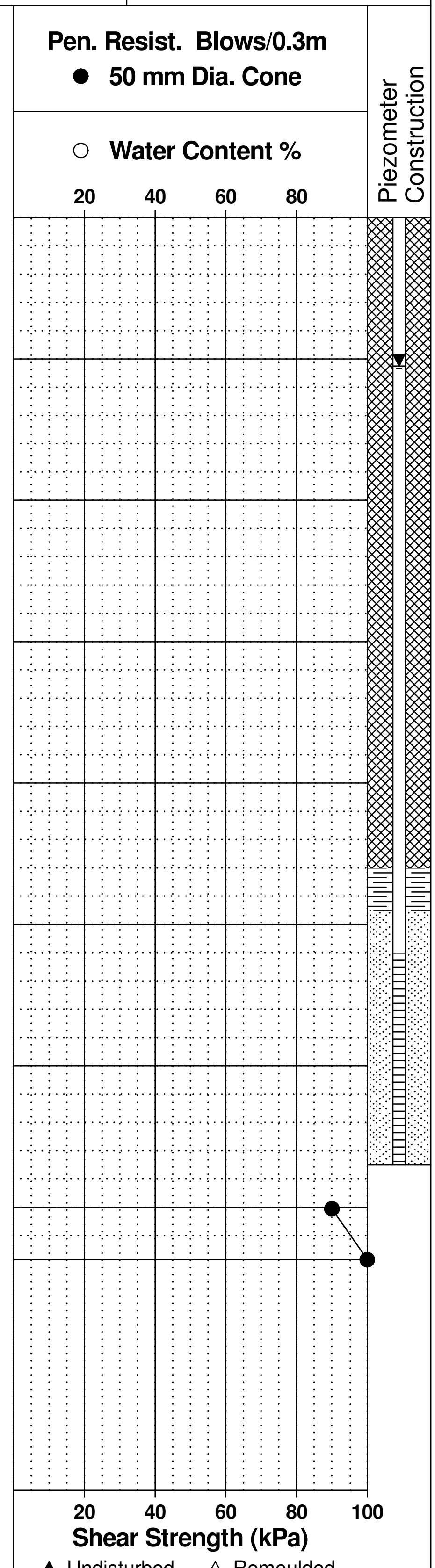
SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.20	AU	1		
Loose, brown **SILTY SAND,** some gravel	2.64	SS	2	100	5
		SS	3	100	3
		SS	4	92	5
Grey **SILTY CLAY** with sand	4.93	SS	5	71	2
		SS	6	38	8
GLACIAL TILL: Compact to dense, grey silty sand with gravel, cobbles and boulders	6.70	SS	7	88	36
		SS	8	83	35
Dynamic Cone Penetration Test commenced at 6.70m depth. Inferred **GLACIAL TILL**	7.37				

End of Borehole

Practical DCPT refusal at 7.37m depth

(GWL @ 1.05m - June 21, 2019)

DEPTH (m)	ELEV. (m)
0	88.08
1	87.08
2	86.08
3	85.08
4	84.08
5	83.08
6	82.08
7	81.08



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

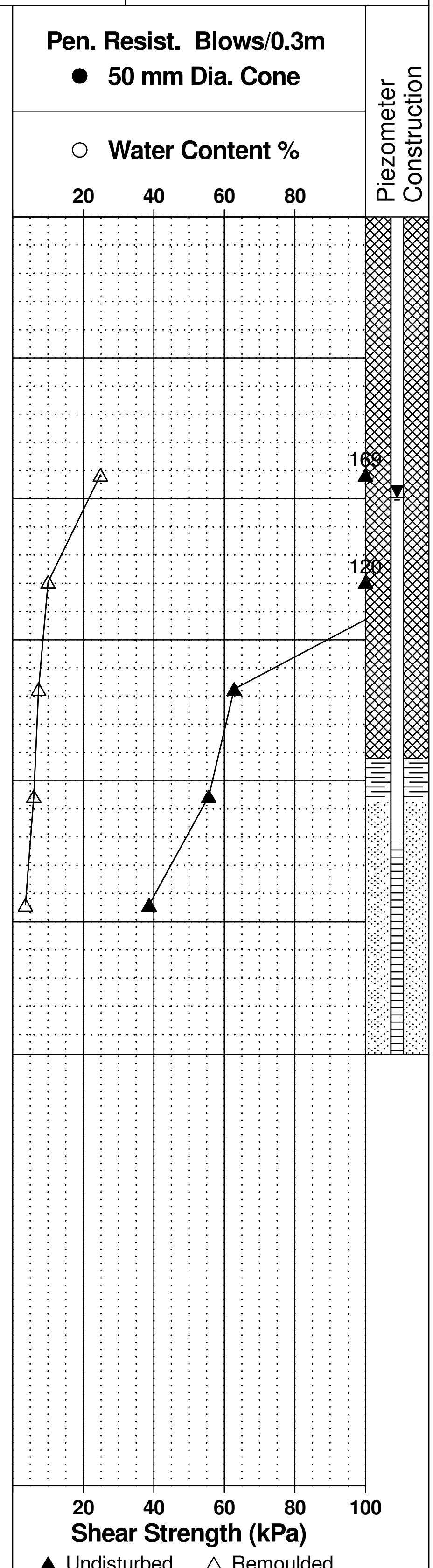
REMARKS

HOLE NO. **BH 2**

BORINGS BY CME 55 Power Auger

DATE 2019 June 11

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.19
TOPSOIL (to 0.28)	AU	1				
	SS	2	100	3	1	87.19
Very stiff to stiff, brown **SILTY CLAY**					2	86.19
					3	85.19
					4	84.19
- firm by 4.5m depth (to 5.33)					5	83.19
Loose, grey **SANDY SILT,** trace clay (to 5.94)	SS	3	100	9		
End of Borehole						
(GWL @ 1.99m - June 21, 2019)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 7

FILE NO. **PG4870**

HOLE NO. **BH 3**

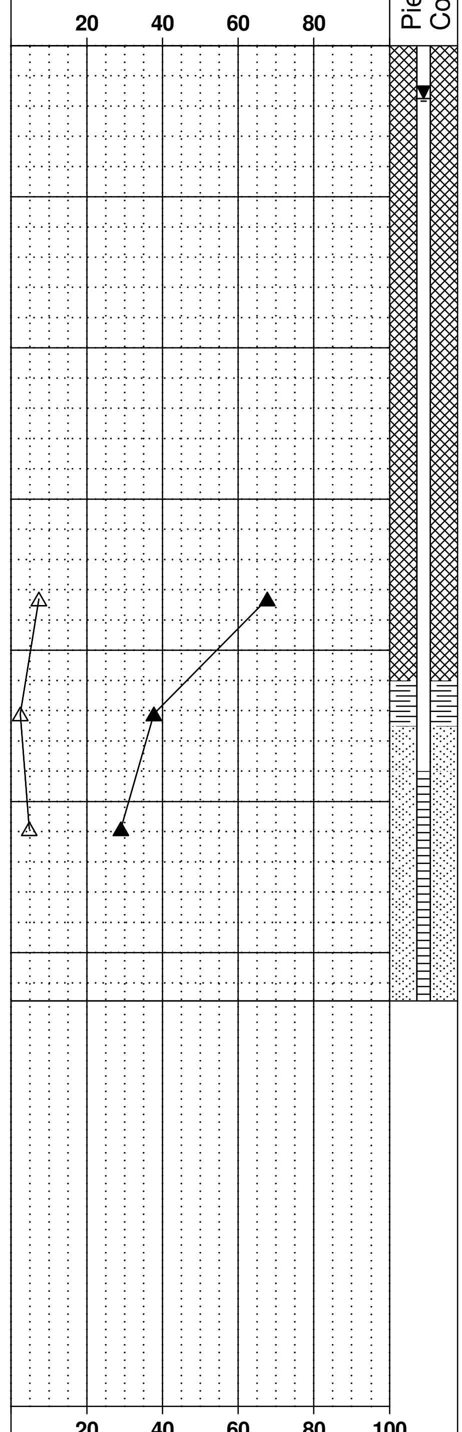
SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
TOPSOIL	0.30
Loose, brown **SILTY SAND,** some gravel	2.29
Stiff to firm, grey-brown **SILTY CLAY,** some sand - grey by 3.8m depth	6.32
End of Borehole (GWL @ 0.35m - June 21, 2019)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	6
SS	3	100	4
SS	4	100	2
SS	5	100	15
SS	6	60	50+

DEPTH (m)	ELEV. (m)
0	87.58
1	86.58
2	85.58
3	84.58
4	83.58
5	82.58
6	81.58

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

REMARKS

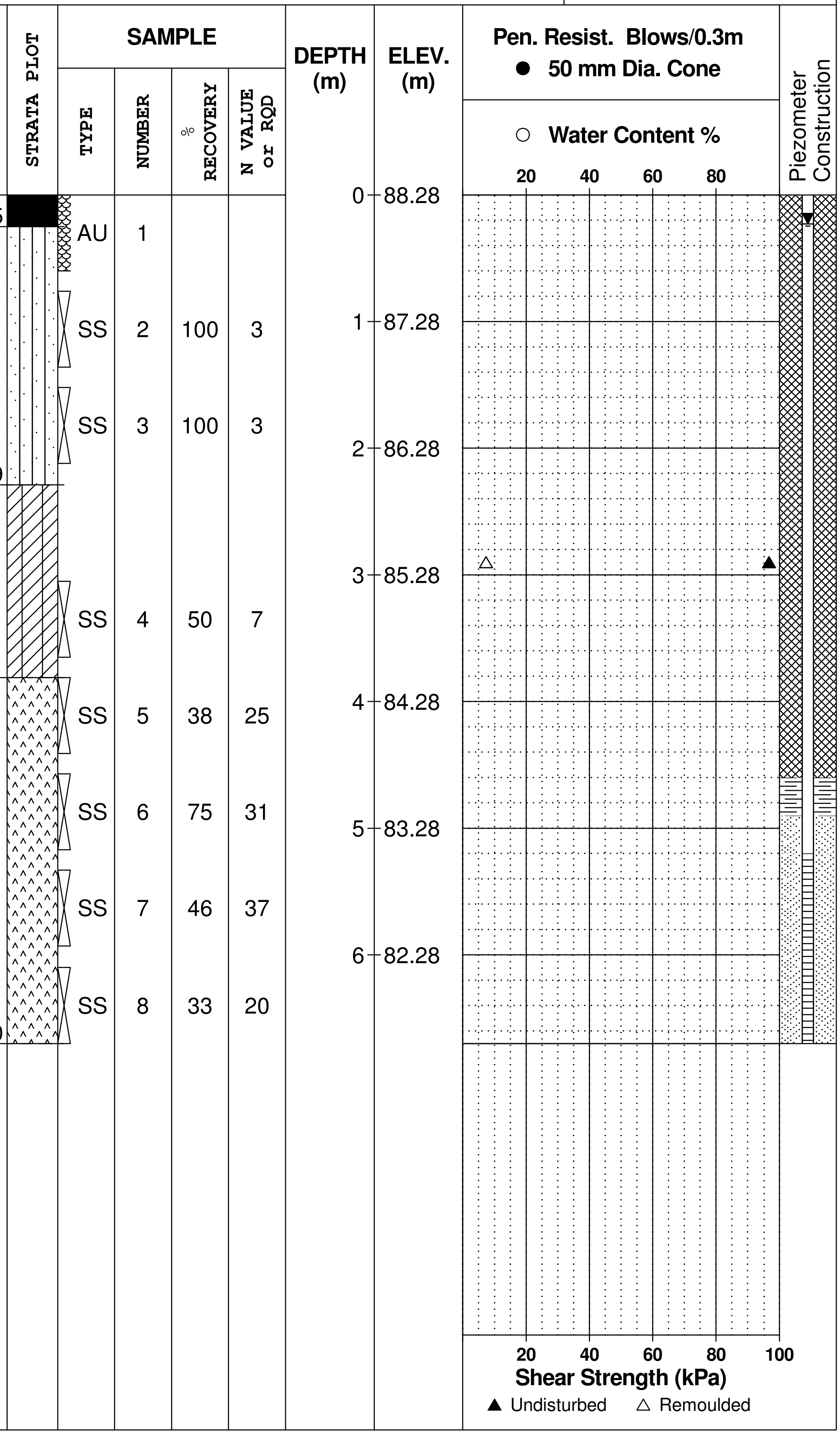
HOLE NO. **BH 4**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 7

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.28
TOPSOIL	0.25	AU	1				
Very loose, brown **SILTY SAND** with clay		SS	2	100	3	1	87.28
	2.29	SS	3	100	3	2	86.28
Stiff, grey **SILTY CLAY**						3	85.28
	3.81	SS	4	50	7		
GLACIAL TILL: Compact, grey silty sand with clay, gravel, cobbles and boulders		SS	5	38	25	4	84.28
		SS	6	75	31	5	83.28
		SS	7	46	37	6	82.28
	6.70	SS	8	33	20		

End of Borehole

(GWL @ 0.23m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

REMARKS

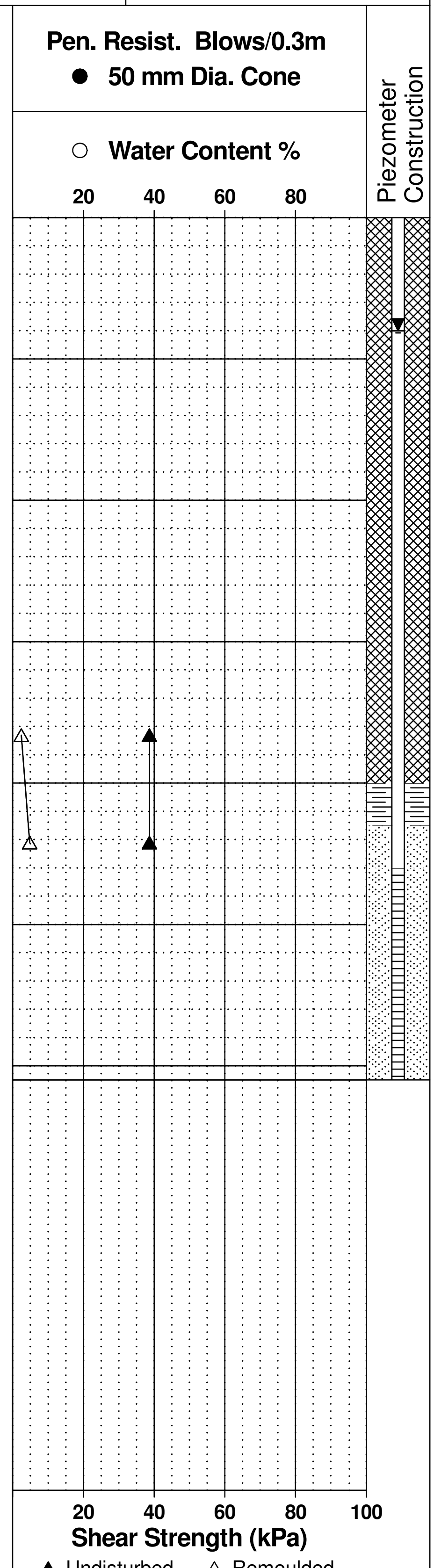
HOLE NO. **BH 5**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 7

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
TOPSOIL	0.23
Loose, brown **SILTY SAND,** some gravel	2.29
Firm, grey **SILTY CLAY** with sand	5.33
Dense, grey **SAND** with gravel	6.10
End of Borehole	
(GWL @ 0.80m - June 21, 2019)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	6
SS	3	100	4
SS	4	92	1
SS	6	25	30
SS	7	83	40

DEPTH (m)	ELEV. (m)
0	87.70
1	86.70
2	85.70
3	84.70
4	83.70
5	82.70
6	81.70



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
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REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 14

FILE NO. PG4870

HOLE NO. BH 5A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	87.70		
OVERBURDEN						1	86.70		
						2	85.70		
3.05						3	84.70		
Firm, grey **SILTY CLAY**		TW	1						
4.11						4	83.70		
End of Borehole									

Water Content % axis: 20, 40, 60, 80

Shear Strength (kPa): 20, 40, 60, 80, 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. **PG4870**

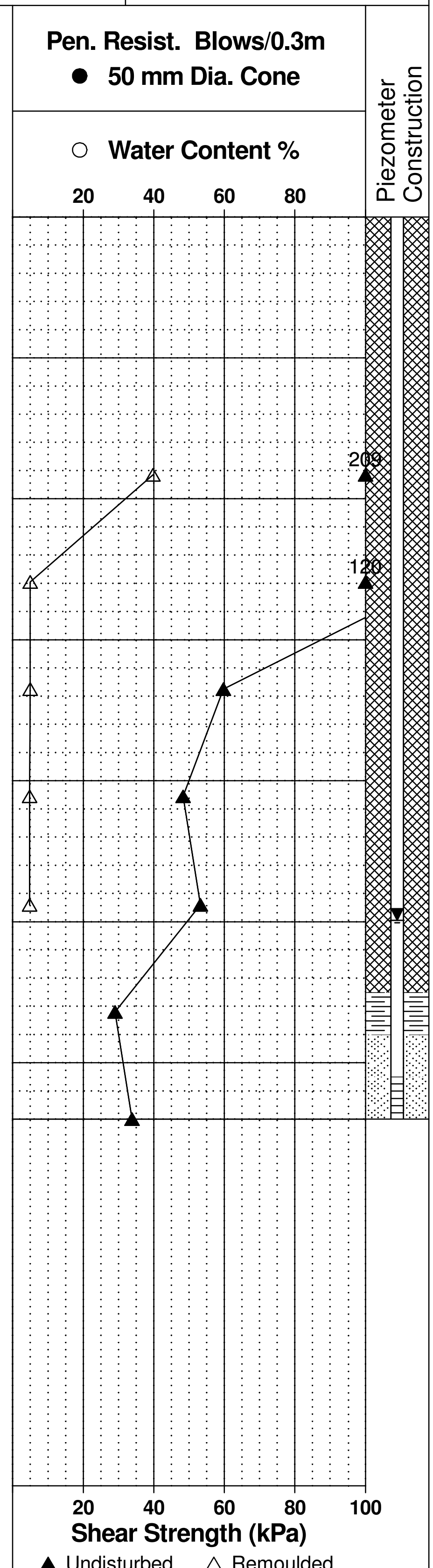
REMARKS

HOLE NO. **BH 6**

BORINGS BY CME 55 Power Auger

DATE 2019 June 11

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	87.86
TOPSOIL (to 0.28)	AU	1				
	SS	2	100	4	1	86.86
					2	85.86
Hard to very stiff, brown **SILTY CLAY**						
					3	84.86
- stiff to firm and grey by 3.0m depth						
					4	83.86
					5	82.86
					6	81.86
(to 6.40)						
End of Borehole						
(GWL @ 4.99m - June 21, 2019)						



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SOIL PROFILE AND TEST DATA

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REMARKS

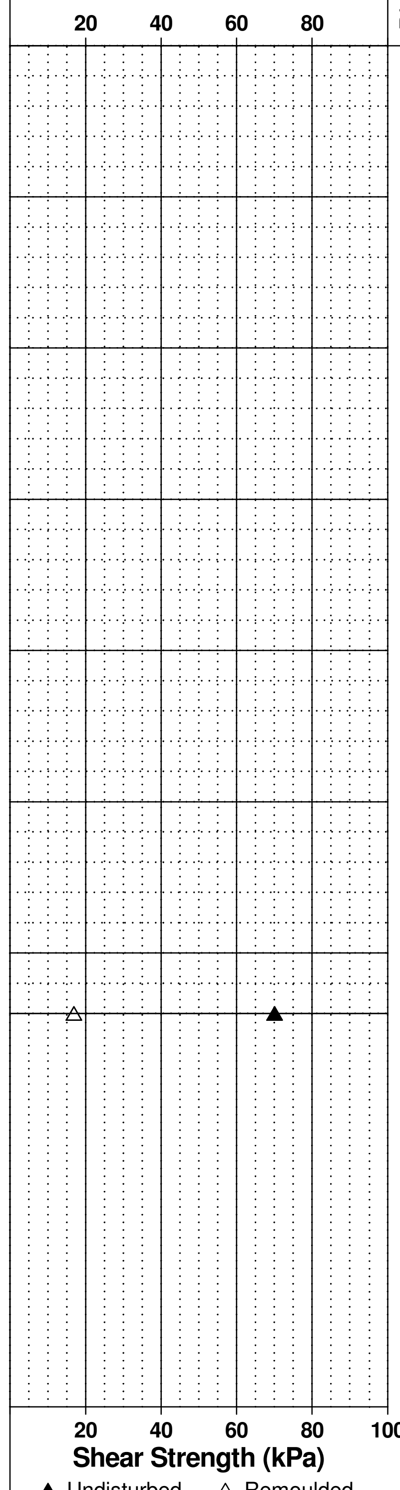
BORINGS BY CME 55 Power Auger

DATE 2019 June 14

FILE NO. PG4870

HOLE NO. BH 6A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	87.86		
						1	86.86		
						2	85.86		
OVERBURDEN						3	84.86		
						4	83.86		
5.33						5	82.86		
Stiff, grey **SILTY CLAY**		TW	1			6	81.86		
6.40									
End of Borehole									



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SOIL PROFILE AND TEST DATA

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FILE NO. PG4870

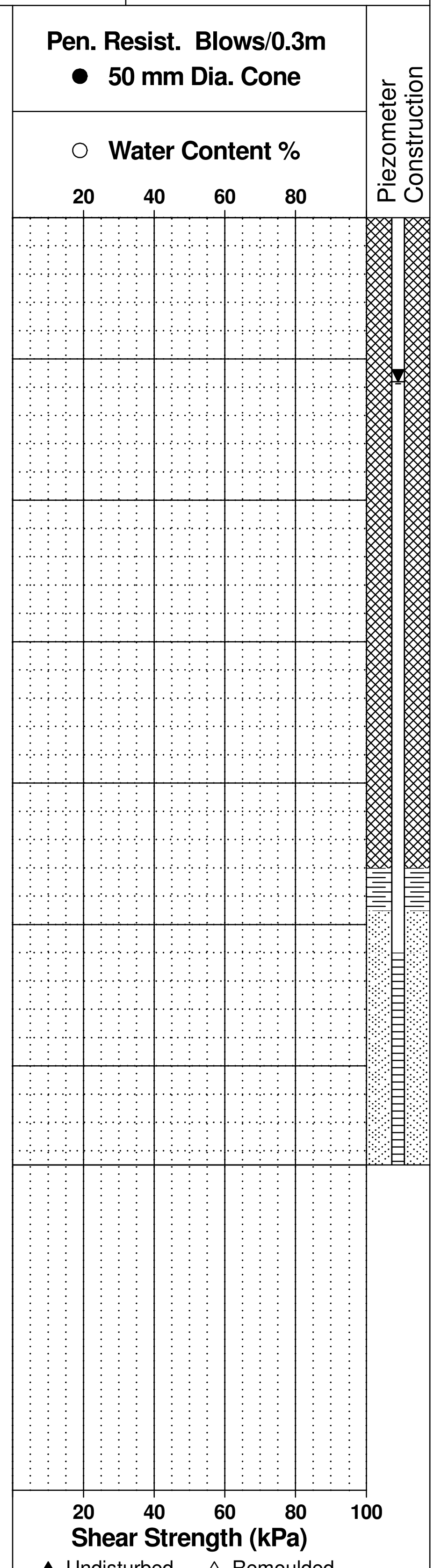
REMARKS

HOLE NO. BH 7

BORINGS BY CME 55 Power Auger **DATE** 2019 June 11

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	89.26
TOPSOIL (to 0.30)	AU	1				
GLACIAL TILL: Very dense to dense, brown **SILTY SAND** with clay, gravel, cobbles and boulders (0.30 to 6.10)	SS	2	83	22	1	88.26
	SS	3	100	50+	2	87.26
	SS	4	100	50+	3	86.26
	SS	5	58	45	4	85.26
	SS	6	62	45	5	84.26
	SS	7	87	62	6	83.26
	SS	8	79	49		
GLACIAL TILL: Grey silty clay with sand and gravel (6.10 to 6.70)	SS	9	75	51		
End of Borehole (6.70)						

(GWL @ 1.16m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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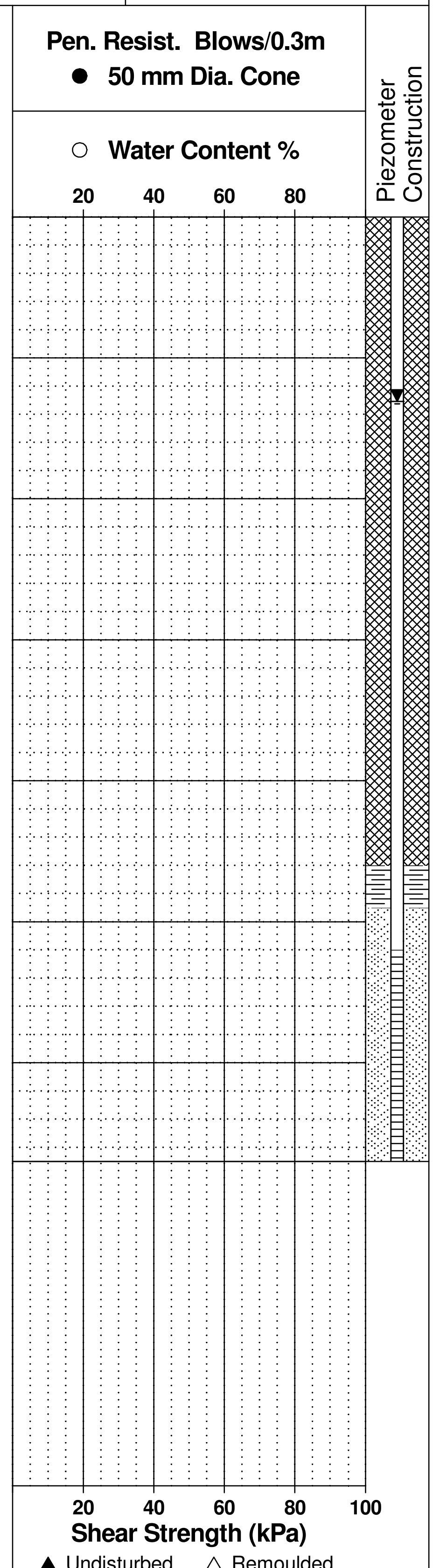
FILE NO. PG4870

REMARKS

HOLE NO. BH 8

BORINGS BY CME 55 Power Auger **DATE** 2019 June 11

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.89
TOPSOIL — 0.36		AU	1				
Very stiff, brown **SILTY CLAY**		SS	2	100	7	1	87.89
		SS	3	100	5	2	86.89
3.05						3	85.89
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders, trace clay		SS	4	67	23		
		SS	5	100	50+	4	84.89
		SS	6	62	18	5	83.89
		SS	7	67	32	6	82.89
		SS	8	100	50+		
6.70 End of Borehole							
(GWL @ 1.31m - June 21, 2019)							



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SOIL PROFILE AND TEST DATA

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FILE NO. PG4870

REMARKS

HOLE NO. BH 9

BORINGS BY CME 55 Power Auger

DATE 2019 June 13

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.47
TOPSOIL (to 0.36)		AU	1				
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders		SS	2	67	48	1	93.47
		SS	3	100	50+		
		SS	4	100	50+	2	92.47
		SS	5	100	50+	3	91.47
(to 3.83)		SS	6	0	50+		

End of Borehole

Practical refusal to augering at 3.83m depth

(Piezometer blocked and dry to 2.22m - June 21, 2019)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. PG4870

REMARKS

HOLE NO. BH10

BORINGS BY CME 55 Power Auger

DATE 2019 June 14

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	92.67
TOPSOIL (to 0.36)	AU	1				
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders (0.36 to 4.78)	SS	2	71	49	1	91.67
	SS	3	75	50+		
					2	90.67
	SS	4	100	50+		
					3	89.67
	SS	5	100	50+		
					4	88.67
	SS	6	42	60		
	SS	6	50	50+		

End of Borehole

Practical refusal to augering at 4.78m depth

(GWL @ 1.99m - June 21, 2019)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 14

FILE NO. PG4870

HOLE NO. BH11

SOIL DESCRIPTION	Bottom depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.30	AU	1		
Loose, brown **SILTY SAND** with clay	0.76				
Brown **CLAYEY SAND** with silt	2.29	SS	2	83	6
		SS	3	75	1
Compact, brown **SILTY SAND** with gravel	3.05	SS	4	79	28
GLACIAL TILL: Very dense, grey sandy silt with gravel, cobbles and boulders	6.70	SS	5	29	50+
		SS	6	67	25
		SS	7	0	50+
		SS	8	75	50+
		SS	9	58	52
End of Borehole					
(GWL @ 1.32m - June 21, 2019)					

DEPTH (m)	ELEV. (m)
0	89.20
1	88.20
2	87.20
3	86.20
4	85.20
5	84.20
6	83.20

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

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SOIL PROFILE AND TEST DATA

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REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 7

FILE NO. PG4870

HOLE NO. BH12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.08
TOPSOIL (to 0.25)		AU	1				
GLACIAL TILL: Compact to very dense, brown silty sand with gravel, cobbles and boulders (0.25 to 6.50)		SS	2	75	23	1	91.08
		SS	3	79	52	2	90.08
		SS	4	67	37		
		SS	5	100	50+	3	89.08
		SS	6	100	50+	4	88.08
		SS	7	67	50+	5	87.08
		SS	8	100	50+		
		SS	9	94	50+	6	86.08

End of Borehole

Practical DCPT refusal at 6.50m depth

(GWL @ 0.81m - June 21, 2019)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. **PG4870**

REMARKS

HOLE NO. **BH13**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	91.70		
TOPSOIL 0.28		AU	1						
Loose, brown **SILTY SAND** with clay and gravel		SS	2	71	4	1	90.70		
1.83		SS	3	67	65				
						2	89.70		
GLACIAL TILL: Compact to very dense, brown silty sand with gravel, cobbles and boulders		SS	4	50	40				
						3	88.70		
		SS	5	83	23				
		SS	6	80	50+	4	87.70		
		SS	7	29	16	5	86.70		
- grey by 5.3m depth		SS	8	41	36				
						6	85.70		
6.70		SS	9	80	50+				
End of Borehole									
(GWL @ 2.47m - June 21, 2019)									

Water Content % axis: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. PG4870

REMARKS

HOLE NO. BH14

BORINGS BY CME 55 Power Auger

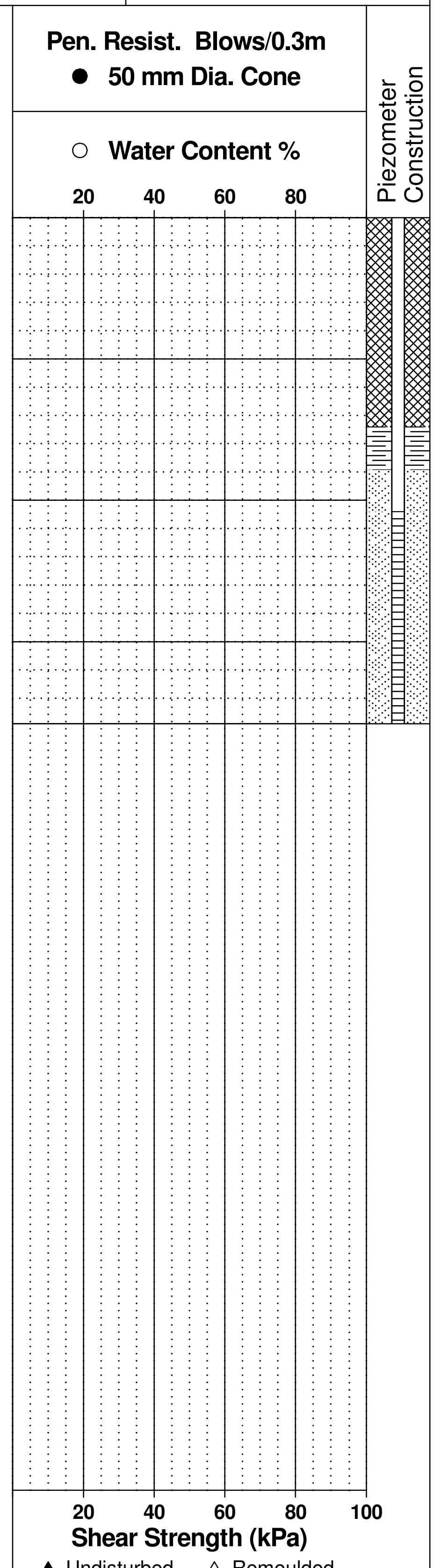
DATE 2019 June 13

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	95.77
TOPSOIL (to 0.33)	AU	1				
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders	SS	2	67	35	1	94.77
	SS	3	0	50+		
					2	93.77
	SS	4	76	62		
					3	92.77
(to 3.58)	SS	5	100	50+		

End of Borehole

Practical refusal to augering at 3.58m depth

(Piezometer blocked and dry to 2.47m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

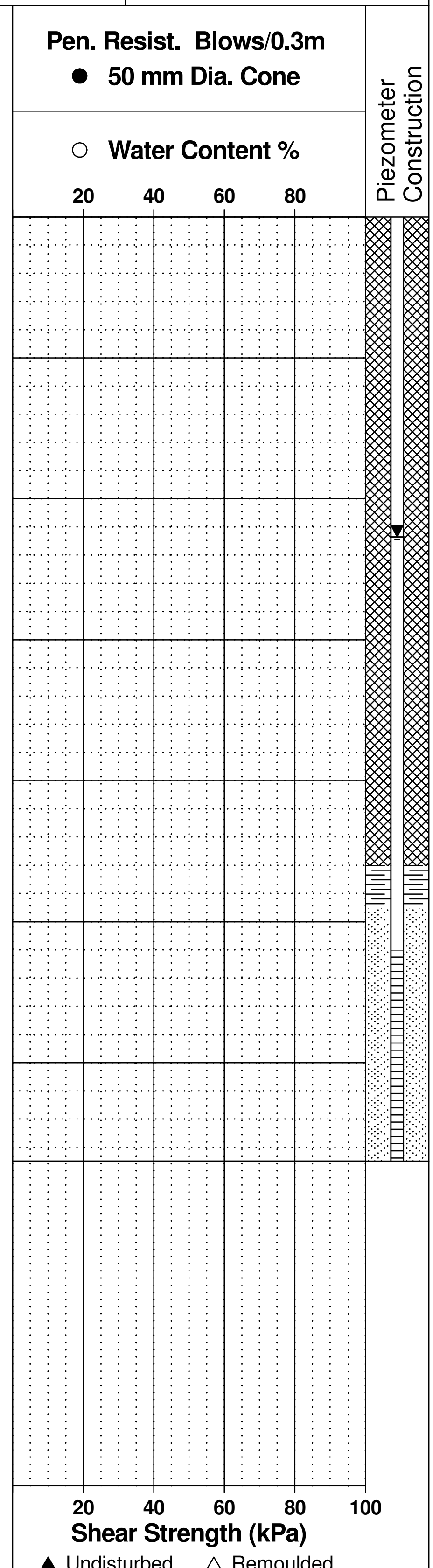
FILE NO. PG4870

REMARKS

HOLE NO. BH15

BORINGS BY CME 55 Power Auger **DATE** 2019 June 14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.49
TOPSOIL 0.36		AU	1				
GLACIAL TILL: Very dense, brown silty sand/sandy silt with gravel, cobbles and boulders		SS	2	78	86	1	91.49
		SS	3	100	50+	2	90.49
		SS	4	75	58	3	89.49
		SS	5	100	50+		
		SS	6	100	50+	4	88.49
		SS	7	62	50+	5	87.49
		SS	8	50	50+		
		SS	9	93	50+	6	86.49
6.70							
End of Borehole (GWL @ 2.27m - June 21, 2019)							



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SOIL PROFILE AND TEST DATA

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FILE NO. **PG4870**

REMARKS

HOLE NO. **BH16**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.98
TOPSOIL — 0.30		AU	1				
Compact, brown **SILTY SAND** with clay — 1.12		SS	2	67	14	1	87.98
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders		SS	3	71	19	2	86.98
		SS	4	75	30		
		SS	5	0	50+	3	85.98
		SS	6	0	50+	4	84.98
- grey by 4.6m depth		SS	7	58	12	5	83.98
		SS	8	67	55	6	82.98
— 6.70		SS	9		24		
End of Borehole							
(GWL @ 1.43m - June 21, 2019)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %
20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Warehouse Complex - 1966 Roger Stevens Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG4870

REMARKS

HOLE NO. BH17

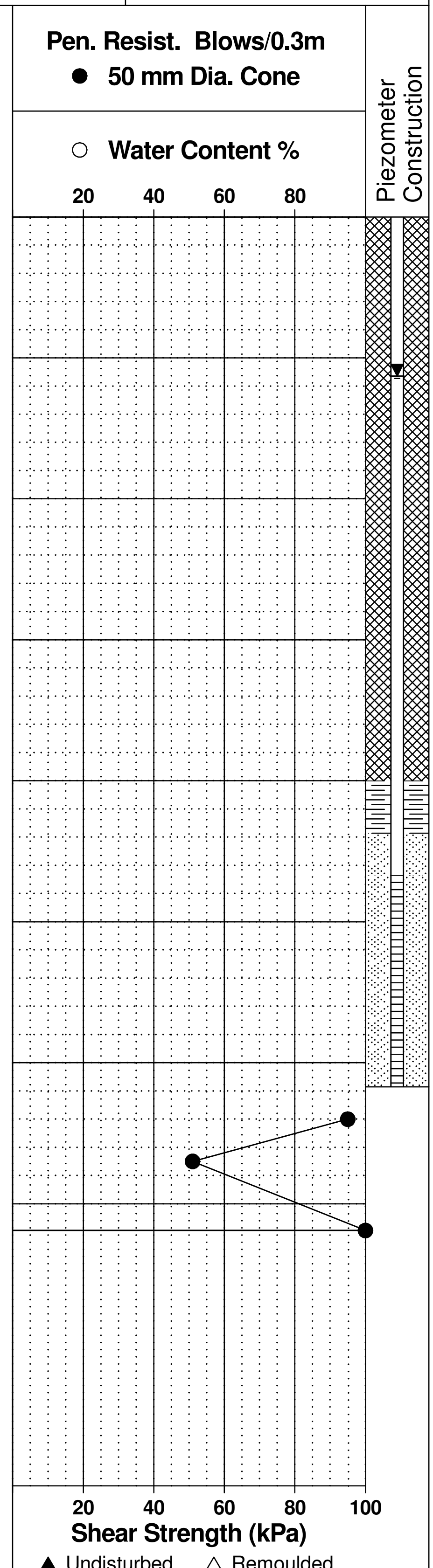
BORINGS BY CME 55 Power Auger **DATE** 2019 June 11

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.86
TOPSOIL	0.30	AU	1				
Brown **SILTY CLAY** with sand seams	1.52	SS	2	100	3	1	87.86
GLACIAL TILL: Dense to very dense, brown silty sand with clay, gravel, cobbles and boulders	6.17	SS	3	88	49	2	86.86
		SS	4	42	68	3	85.86
		SS	5	100	50+	4	84.86
		SS	6	100	65	5	83.86
		SS	7	100	50+	6	82.86
		SS	8	100	50+	7	81.86
		SS	9	100	50+		

End of Borehole

Practical DCPT refusal at 7.19m depth

(GWL @ 1.13m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

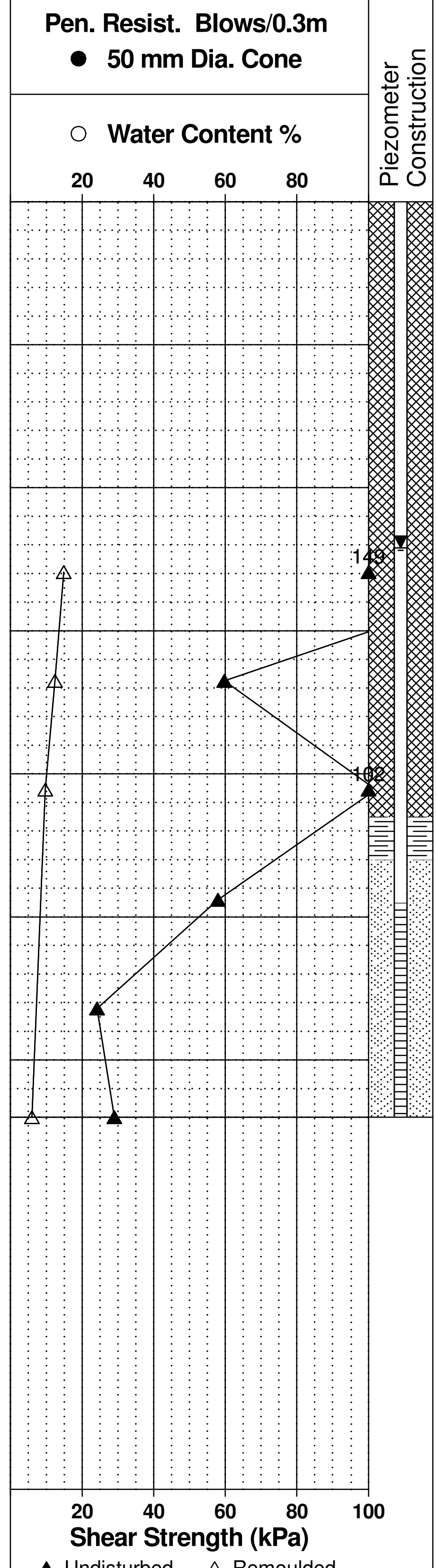
FILE NO. PG4870

REMARKS

HOLE NO. BH18

BORINGS BY CME 55 Power Auger **DATE** 2019 June 11

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.32
TOPSOIL 0.33	AU	1				
	SS	2	100	2	1	87.32
	SS	3	100	5	2	86.32
Very stiff to stiff, brown **SILTY CLAY**						
- grey by 3.0m depth					3	85.32
					4	84.32
					5	83.32
- firm by 5.3m depth						
6.40					6	82.32
End of Borehole						
(GWL @ 2.42m - June 21, 2019)						



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FILE NO. PG4870

REMARKS

HOLE NO. BH18A

BORINGS BY CME 55 Power Auger **DATE** 2019 June 14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	88.32		
						1	87.32		
						2	86.32		
OVERBURDEN Stiff, grey **SILTY CLAY**						3	85.32		
						4	84.32		
5.33						5	83.32		
		TW	1			6	82.32		
6.40 End of Borehole								△ ▲	

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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FILE NO. **PG4870**

REMARKS

HOLE NO. **BH19**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.89
TOPSOIL 0.36		AU	1				
		SS	2	81	66	1	93.89
		SS	3	50	50+		
						2	92.89
		SS	4	89	50+		
GLACIAL TILL: Very dense, brown silty sand with gravel, cobbles and boulders							
		SS	5	100	50+	3	91.89
- grey by 3.8m depth							
		SS	6	100	35	4	90.89
		SS	7	71	55	5	89.89
		SS	8	76	50		
						6	88.89
6.70		SS	9	43	61		
End of Borehole							
(Piezometer blocked and dry to 5.09m - June 21, 2019)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG4870

REMARKS

HOLE NO. BH20

BORINGS BY CME 55 Power Auger **DATE** 2019 June 13

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.89
TOPSOIL (0.25)		AU	1				
GLACIAL TILL: Very dense, brown silty sand with gravel, cobbles and boulders		SS	2	55	50+	1	93.89
		SS	3	40	50+	2	92.89
		SS	4	100	50+		
		SS	5	100	50+	3	91.89
(4.04)		SS	6	71	50+	4	90.89

End of Borehole

Practical refusal to augering at 4.04m depth.

(GWL @ 1.45m - June 21, 2019)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

REMARKS

HOLE NO. **BH21**

BORINGS BY CME 55 Power Auger

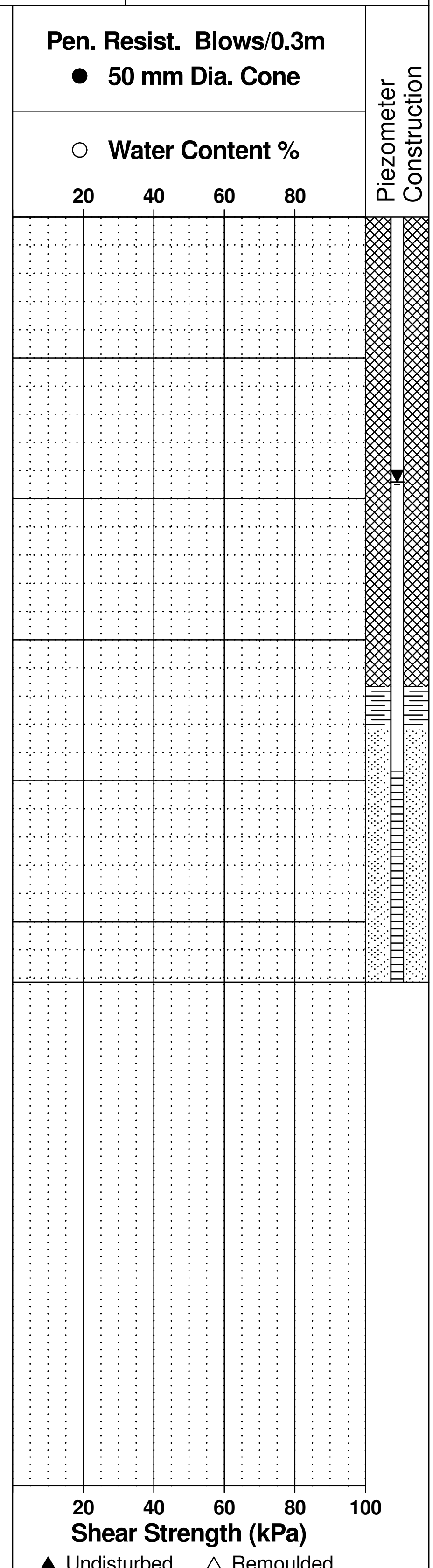
DATE 2019 June 13

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.07
TOPSOIL	0.25	AU	1				
Compact, brown **SAND** with gravel	0.97	SS	2	83	16	1	90.07
Compact, brown **SILTY SAND,** trace clay	1.98	SS	3	67	24	2	89.07
GLACIAL TILL: Compact to very dense, brown silty sand with gravel, cobbles and boulders		SS	4	70	72	3	88.07
		SS	5	64	50+	4	87.07
		SS	6	62	29	5	86.07
		SS	7	42	33		
	5.43	SS	8	100	50+		

End of Borehole

Practical refusal to augering at 5.43m depth

(GWL @ 1.88m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

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FILE NO. PG4870

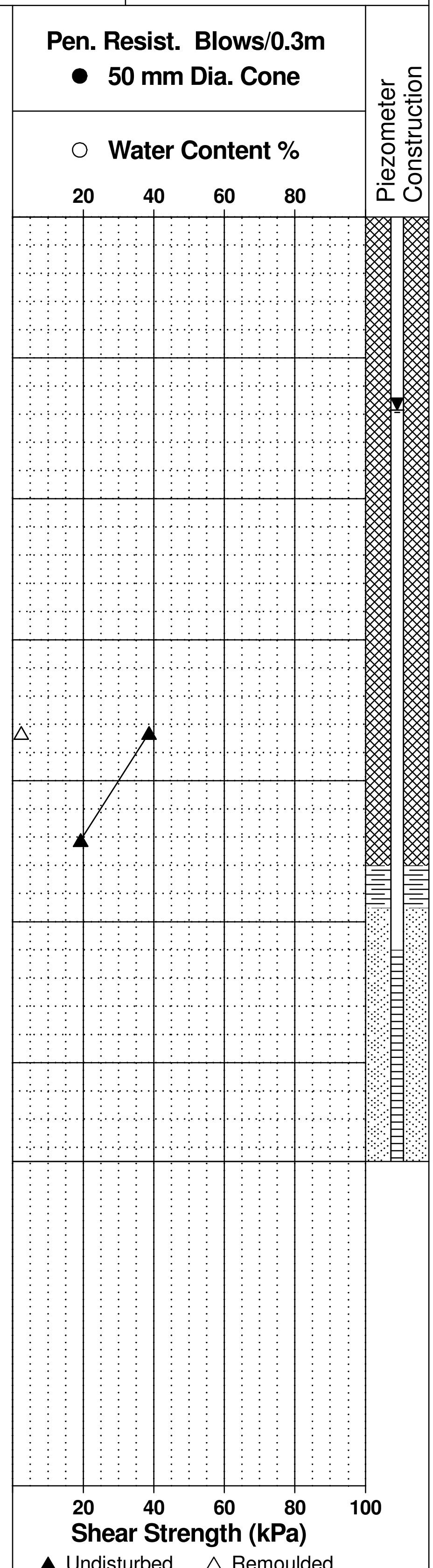
REMARKS

HOLE NO. BH22

BORINGS BY CME 55 Power Auger

DATE 2019 June 13

SOIL DESCRIPTION	Bottom depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.31
TOPSOIL	0.28	AU	1				
Loose, brown **SILTY SAND**, some clay	2.34	SS	2	83	4	1	87.31
		SS	3	100	5	2	86.31
Firm to soft, brown **SILTY CLAY**	4.42	SS	4	100	3	3	85.31
						4	84.31
GLACIAL TILL: Grey silty sand with gravel, cobbles and boulders	6.70	SS	6	21	9	5	83.31
		SS	7	71	22	6	82.31
		SS	8	100	50+		
End of Borehole							
(GWL @ 1.37m - June 21, 2019)							



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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

REMARKS

HOLE NO. **BH22A**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	88.31		
OVERBURDEN						1	87.31		
						2	86.31		
3.05						3	85.31		
Stiff, grey **SILTY CLAY**		TW	1						
3.66									
End of Borehole									

Shear Strength (kPa): 20, 40, 60, 80, 100

▲ Undisturbed △ Remoulded

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Geotechnical Investigation
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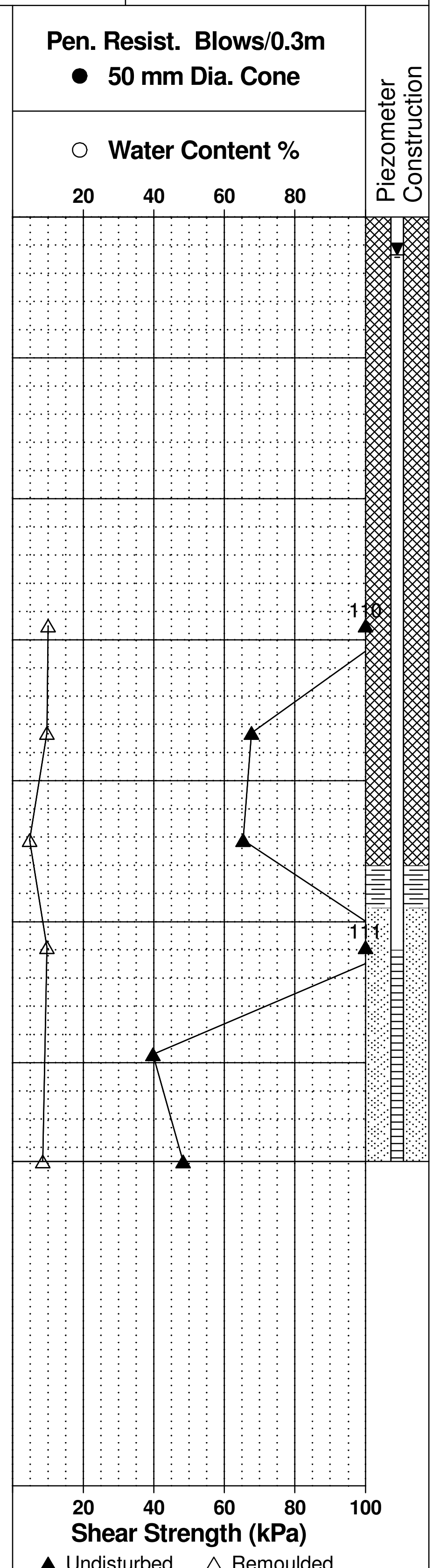
FILE NO. **PG4870**

REMARKS

HOLE NO. **BH23**

BORINGS BY CME 55 Power Auger **DATE** 2019 June 12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.81
TOPSOIL 0.23		AU	1				
Loose, brown **SILTY SAND** with clay, some gravel		SS	2	100	4	1	86.81
		SS	3	100	4	2	85.81
2.29							
Very stiff to stiff, brown **SILTY CLAY** with sand						3	84.81
- grey by 3.0m depth						4	83.81
- firm by 5.3m depth						5	82.81
						6	81.81
6.70							
End of Borehole							
(GWL @ 0.27m - June 21, 2019)							



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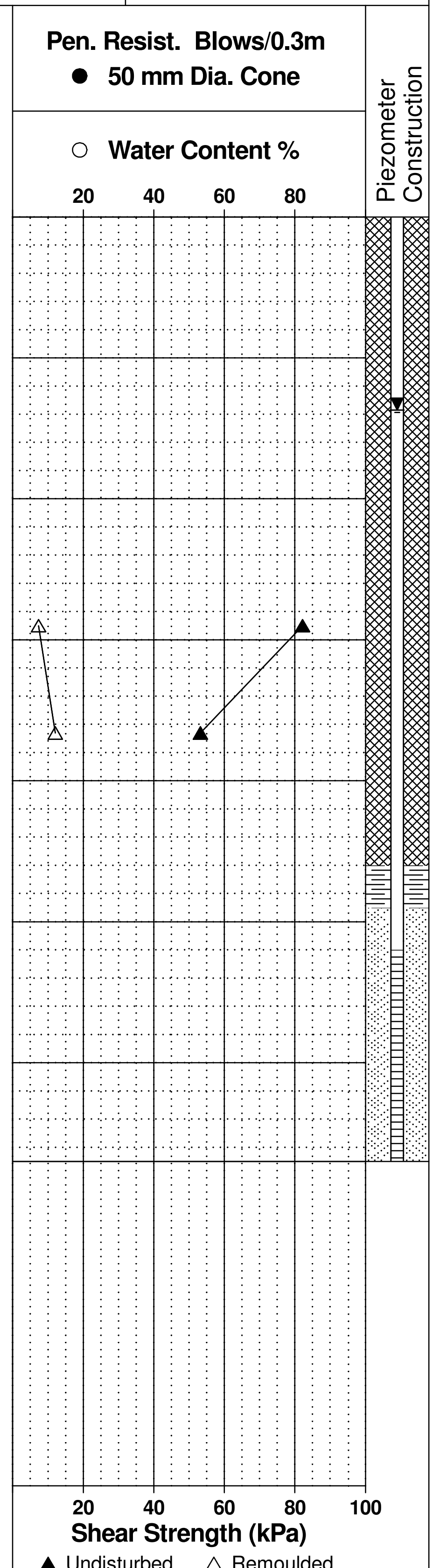
FILE NO. PG4870

REMARKS

HOLE NO. BH24

BORINGS BY CME 55 Power Auger **DATE** 2019 June 12

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.46
TOPSOIL 0.20	AU	1				
Loose, brown **SILTY SAND** with clay	SS	2	100	4	1	87.46
1.62	SS	3	100	2		
Stiff, brown **SILTY CLAY** with sand - grey by 3.0m depth					2	86.46
3.81					3	85.46
Very loose to compact, grey **SILTY SAND**	SS	4	67	3	4	84.46
	SS	5	83	7	5	83.46
	SS	6	100	21	6	82.46
6.70	SS	7	100	16		
End of Borehole (GWL @ 1.37m - June 21, 2019)						



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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG4870**

REMARKS

HOLE NO. **BH25**

BORINGS BY CME 55 Power Auger

DATE 2019 June 10

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	89.43
TOPSOIL (0.30)	AU	1				
Loose, brown **SILTY SAND** with clay (1.17)	SS	2	100	4	1	88.43
Brown **SILTY CLAY** with sand, some gravel (1.83)	SS	3	100	50+		
GLACIAL TILL: Compact to very dense, brown silty sand with gravel, cobbles and boulders					2	87.43
	SS	4	62	28		
- grey by 3.0m depth					3	86.43
	SS	5	65	58		
	SS	6	70	50+	4	85.43
	SS	7	100	50+		
					5	84.43
	SS	8	60	50+		
					6	83.43
	SS	9	80	50+		
(6.70) End of Borehole						
(GWL @ 1.19m - June 21, 2019)						

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. PG4870

REMARKS

HOLE NO. BH26

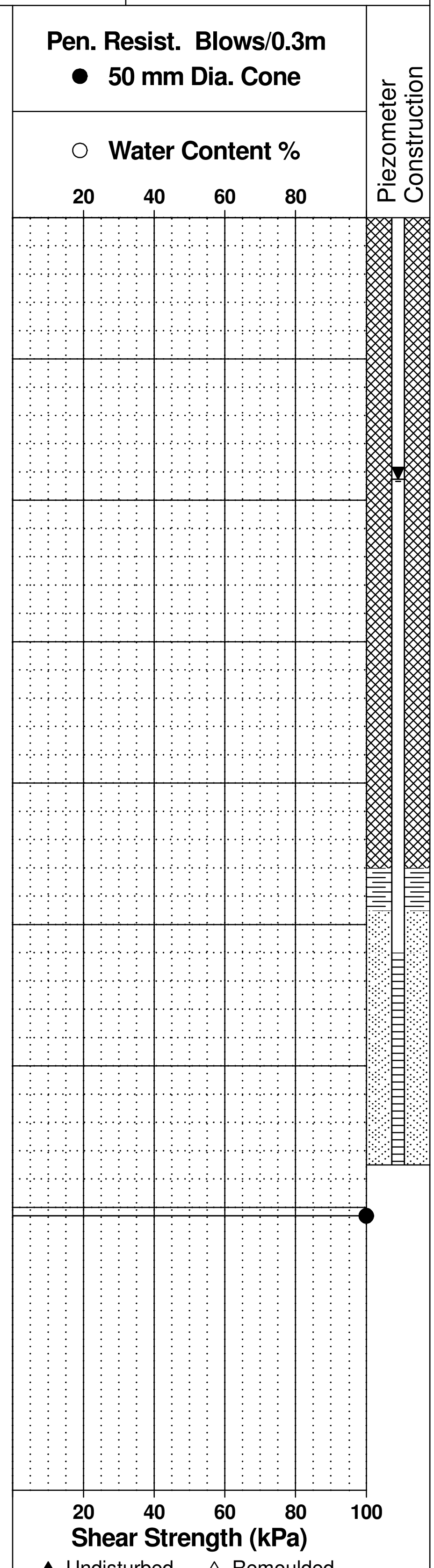
BORINGS BY CME 55 Power Auger **DATE** 2019 June 10

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	90.88
TOPSOIL	0.30	AU	1				
Brown **SAND** with organics	1.01					1	89.88
Compact, brown **SANDY SILT**	1.83	SS	2	92	17		
		SS	3	83	70	2	88.88
GLACIAL TILL: Very dense, brown silty sand with gravel, cobbles and boulders		SS	4	79	48	3	87.88
		SS	5	80	50+		
- grey by 3.8m depth		SS	6	79	88	4	86.88
		SS	7	100	50+	5	85.88
		SS	8	79	44	6	84.88
	6.70	SS	9	100	50+		
Dynamic Cone Penetration Test commenced at 6.70m depth. Inferred **GLACIAL TILL**	7.06					7	83.88

End of Borehole

Practical DCPT refusal at 7.06m depth

(GWL @ 1.85m - June 21, 2019)



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SOIL PROFILE AND TEST DATA

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FILE NO. **PG4870**

REMARKS

HOLE NO. **BH27**

BORINGS BY CME 55 Power Auger

DATE 2019 June 13

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE									
TOPSOIL 0.20		AU	1			0	88.72		
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders		SS	2	92	36	1	87.72		
		SS	3	67	23	2	86.72		
		SS	4	42	17	3	85.72		
		SS	5	79	46	4	84.72		
		SS	6	82	50+				
4.72		SS	7	100	50+				

End of Borehole

Practical refusal to augering at 4.72m depth

(GWL @ 1.65m - June 21, 2019)

Water Content %: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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REMARKS

BORINGS BY CME 55 Power Auger

DATE 2019 June 12

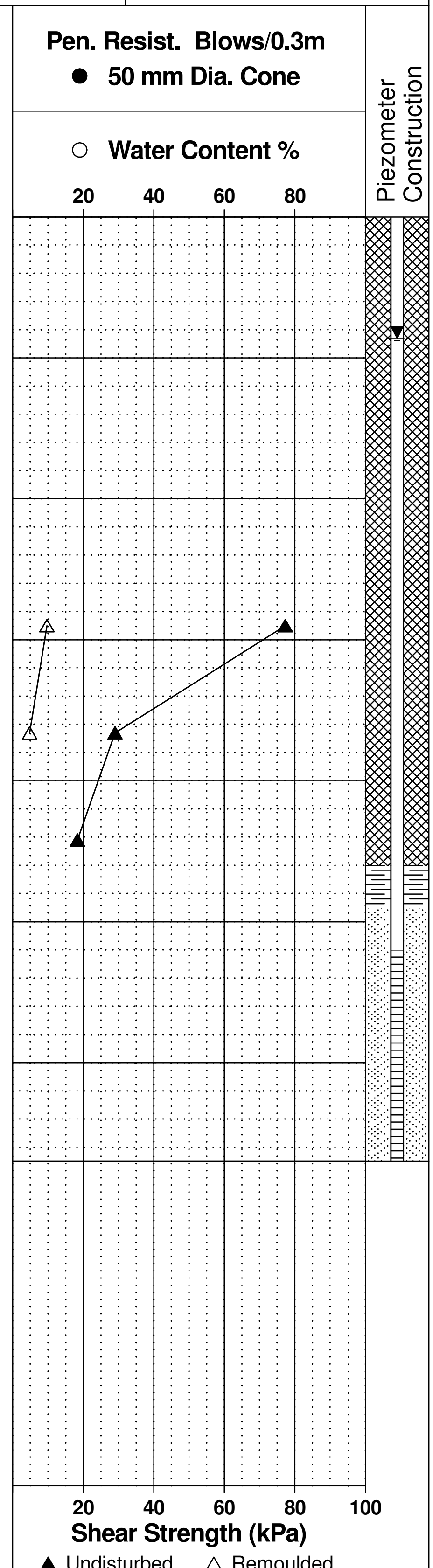
FILE NO. PG4870

HOLE NO. BH28

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.31
TOPSOIL	0.23	AU	1				
Loose, brown **SILTY SAND,** some clay	1.62	SS	2	100	4	1	87.31
Stiff, brown **SILTY CLAY** with sand - grey by 3.0m depth	4.57	SS	3	100	2	2	86.31
						3	85.31
						4	84.31
GLACIAL TILL: Dense to compact, grey silty sand with gravel, cobbles and boulders	6.70	SS	5	67	45	5	83.31
		SS	6	25	19	6	82.31
		SS	7	62	26		

End of Borehole

(GWL @ 0.86m - June 21, 2019)



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FILE NO. PG4870

REMARKS

HOLE NO. BH28A

BORINGS BY CME 55 Power Auger

DATE 2019 June 14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.31
						1	87.31
OVERBURDEN						2	86.31
3.05						3	85.31
Stiff, grey **SILTY CLAY**		TW	1				
4.11						4	84.31
End of Borehole							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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FILE NO. PG4870

REMARKS

HOLE NO. BH29

BORINGS BY CME 55 Power Auger

DATE 2019 June 12

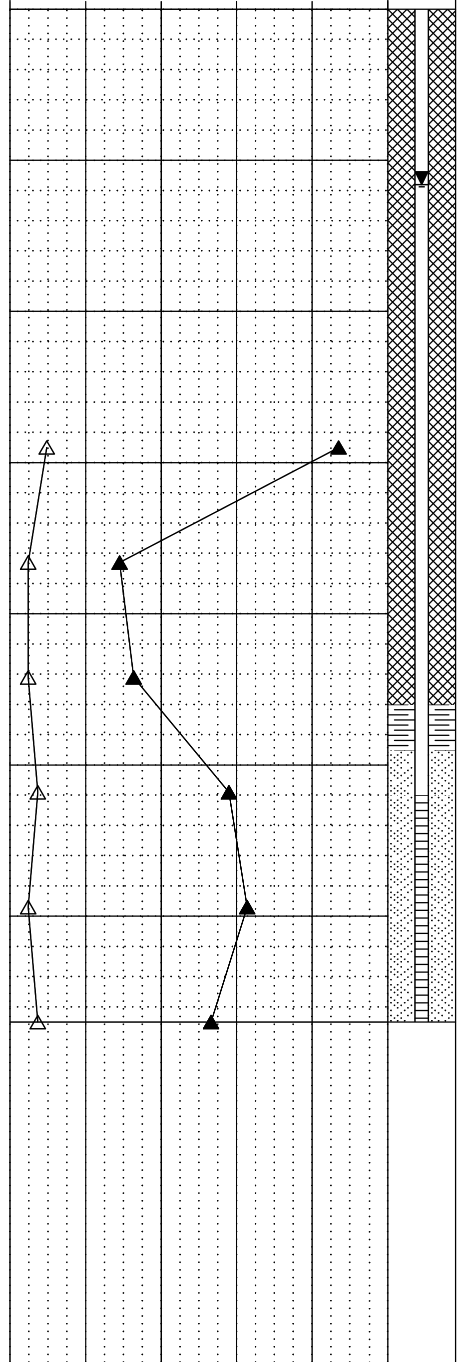
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.06
TOPSOIL 0.23		AU	1				
Loose, brown **SILTY SAND** with gravel		SS	2	100	5	1	87.06
1.52		SS	3	100	3	2	86.06
Stiff, brown **SILTY CLAY**							
- firm to stiff and grey by 3.0m depth						3	85.06
						4	84.06
						5	83.06
						6	82.06
6.70							
End of Borehole							
(GWL @ 1.16m - June 21, 2019)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction



20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. **PG4870**

REMARKS

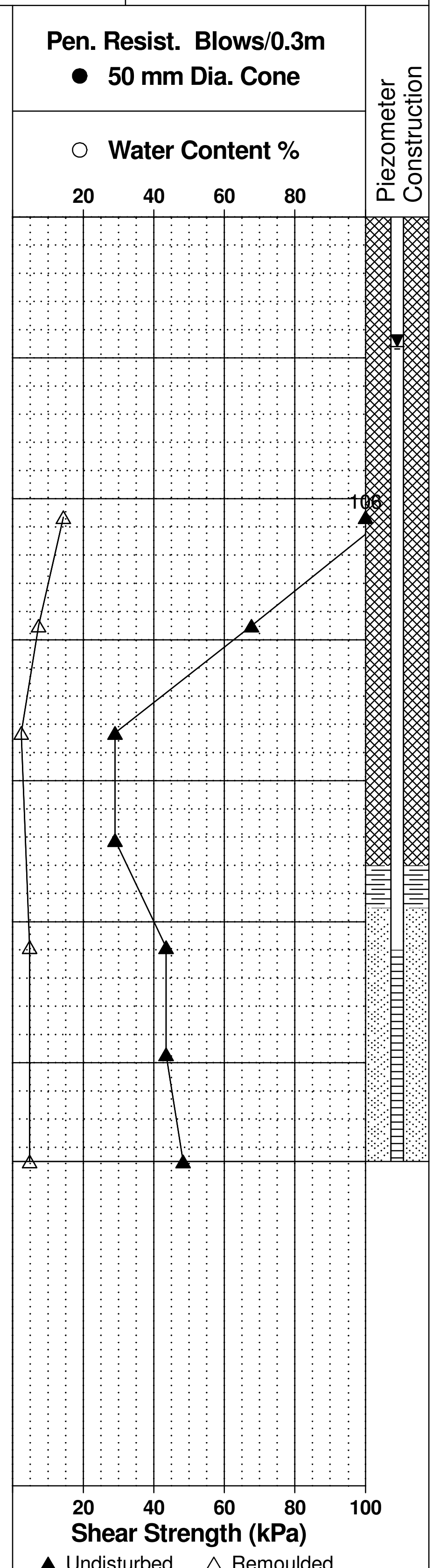
HOLE NO. **BH30**

BORINGS BY CME 55 Power Auger

DATE 2019 June 12

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.28	AU	1		
Very loose, brown **SILTY SAND** with clay	1.52	SS	2	100	1
Very stiff to stiff, brown **SILTY CLAY** with sand - firm and grey by 3.0m depth	6.70				
End of Borehole (GWL @ 0.92m - June 21, 2019)					

DEPTH (m)	ELEV. (m)
0	88.27
1	87.27
2	86.27
3	85.27
4	84.27
5	83.27
6	82.27



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the relative strength of cohesionless soils is the compactness condition, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm. An SPT N value of “P” denotes that the split-spoon sampler was pushed 300 mm into the soil without the use of a falling hammer.

Compactness Condition	‘N’ Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory shear vane tests, unconfined compression tests, or occasionally by the Standard Penetration Test (SPT). Note that the typical correlations of undrained shear strength to SPT N value (tabulated below) tend to underestimate the consistency for sensitive silty clays, so Paterson reviews the applicable split spoon samples in the laboratory to provide a more representative consistency value based on tactile examination.

Consistency	Undrained Shear Strength (kPa)	‘N’ Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their "sensitivity". The sensitivity, S_t, is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil. The classes of sensitivity may be defined as follows:

Low Sensitivity:	$S_t < 2$
Medium Sensitivity:	$2 < S_t < 4$
Sensitive:	$4 < S_t < 8$
Extra Sensitive:	$8 < S_t < 16$
Quick Clay:	$S_t > 16$

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NQ or larger size core. However, it can be used on smaller core sizes, such as BQ, if the bulk of the fractures caused by drilling stresses (called "mechanical breaks") are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube, generally recovered using a piston sampler
G	-	"Grab" sample from test pit or surface materials
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size BQ, NQ, HQ, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

PLASTICITY LIMITS AND GRAIN SIZE DISTRIBUTION

WC%	-	Natural water content or water content of sample, %
LL	-	Liquid Limit, % (water content above which soil behaves as a liquid)
PL	-	Plastic Limit, % (water content above which soil behaves plastically)
PI	-	Plasticity Index, % (difference between LL and PL)
Dxx	-	Grain size at which xx% of the soil, by weight, is of finer grain sizes These grain size descriptions are not used below 0.075 mm grain size
D10	-	Grain size at which 10% of the soil is finer (effective grain size)
D60	-	Grain size at which 60% of the soil is finer
Cc	-	Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu	-	Uniformity coefficient = $D60 / D10$

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

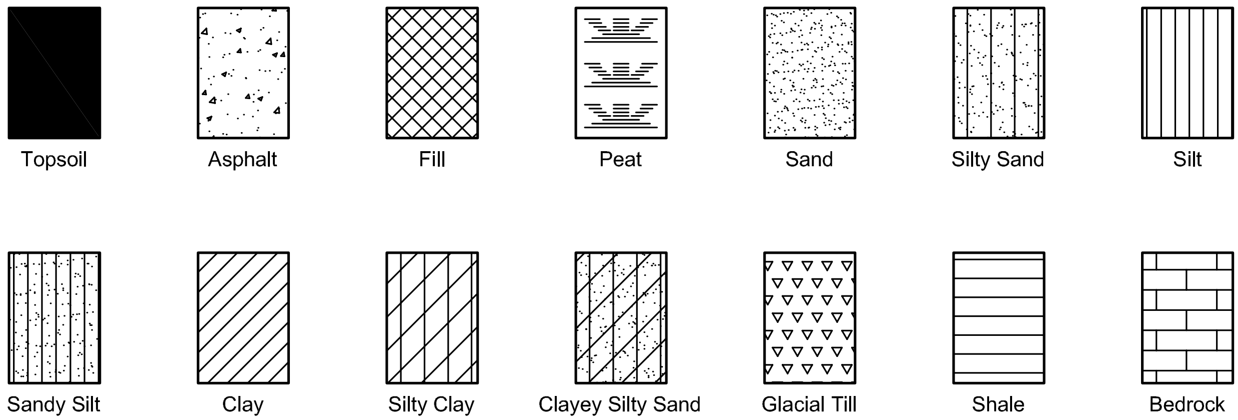
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

k	-	Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

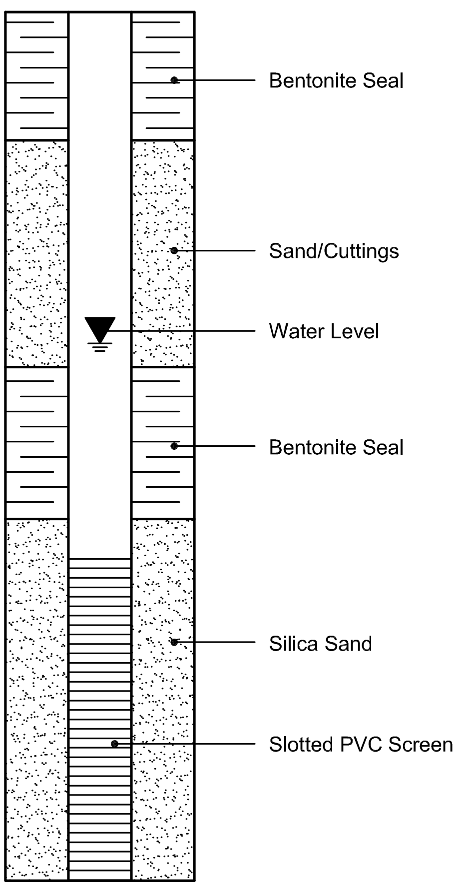
SYMBOLS AND TERMS (continued)

STRATA PLOT

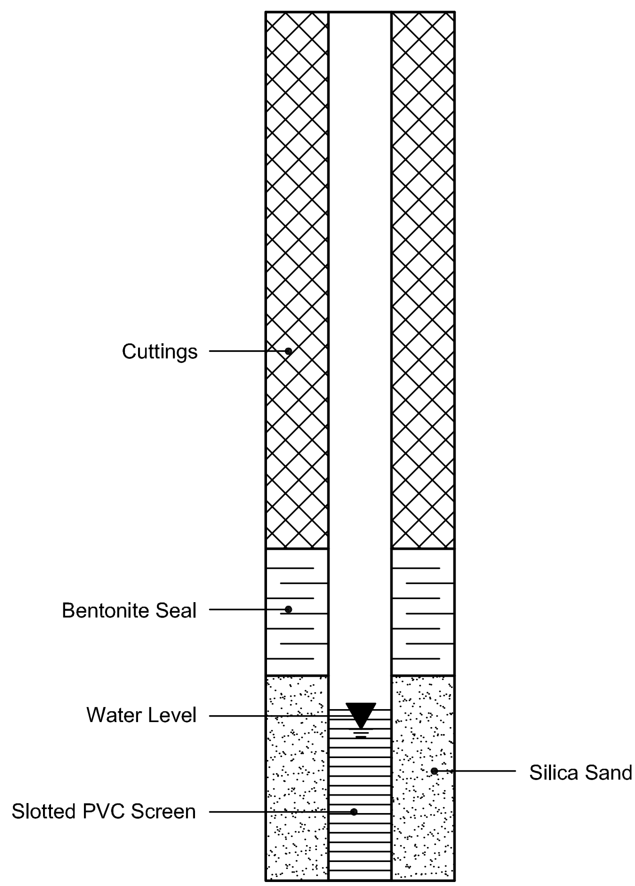


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



PARACEL LABORATORIES LTD.

Order #: 1926348

Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 25647

Report Date: 03-Jul-2019

Order Date: 26-Jun-2019

Project Description: PG4870

Client ID:		BH13 SS6	BH24 SS4	-	-
Sample Date:		10-Jun-19 13:00	12-Jun-19 13:00	-	-
Sample ID:		1926348-01	1926348-02	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	93.5	85.8	-	-
General Inorganics					
pH	0.05 pH Units	7.88	8.04	-	-
Resistivity	0.10 Ohm.m	84.7	70.5	-	-
Anions					
Chloride	5 ug/g dry	11	14	-	-
Sulphate	5 ug/g dry	8	60	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURE 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES

FIGURES 4 TO 7 - SLOPE STABILITY ANALYSIS SECTIONS

DRAWING PG4870-1 - TEST HOLE LOCATION PLAN

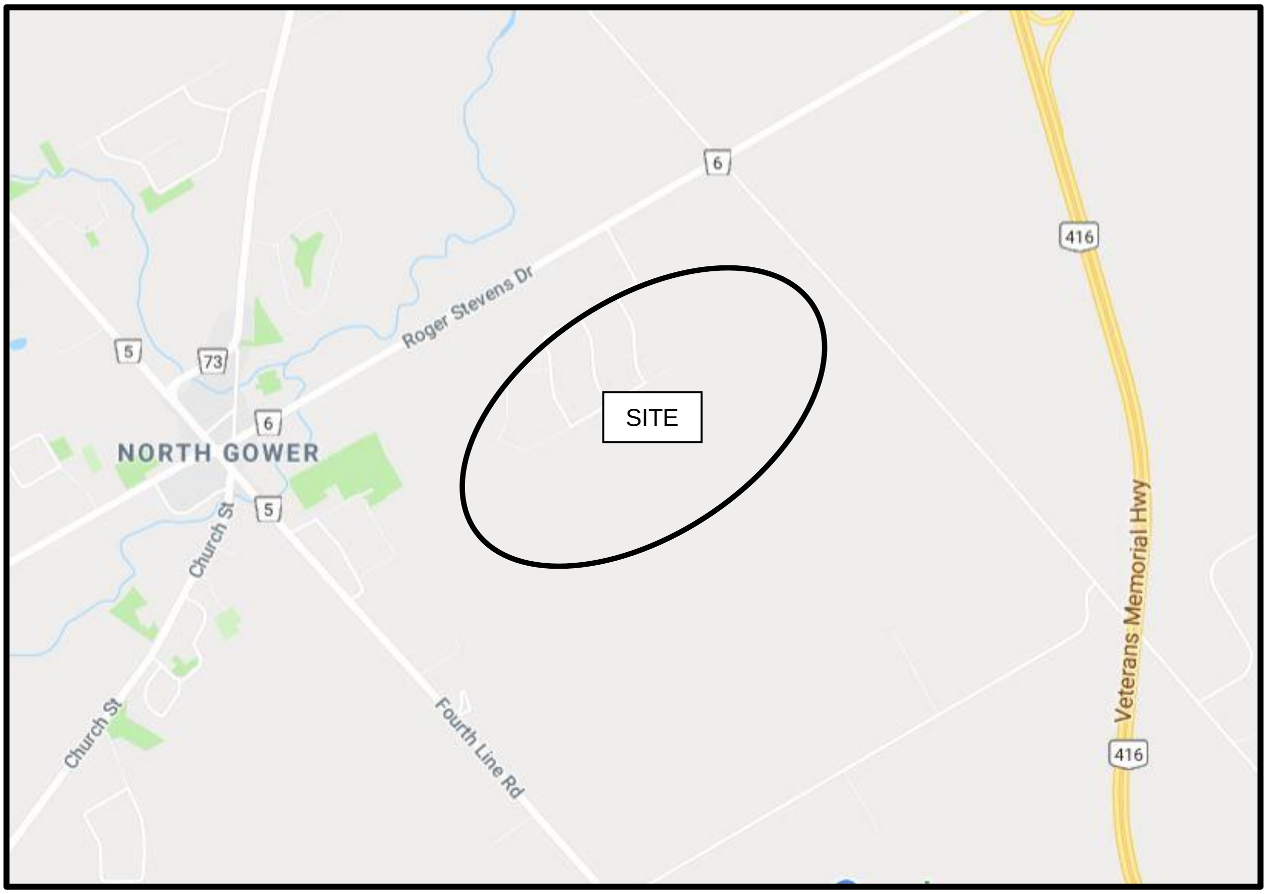


FIGURE 1

KEY PLAN

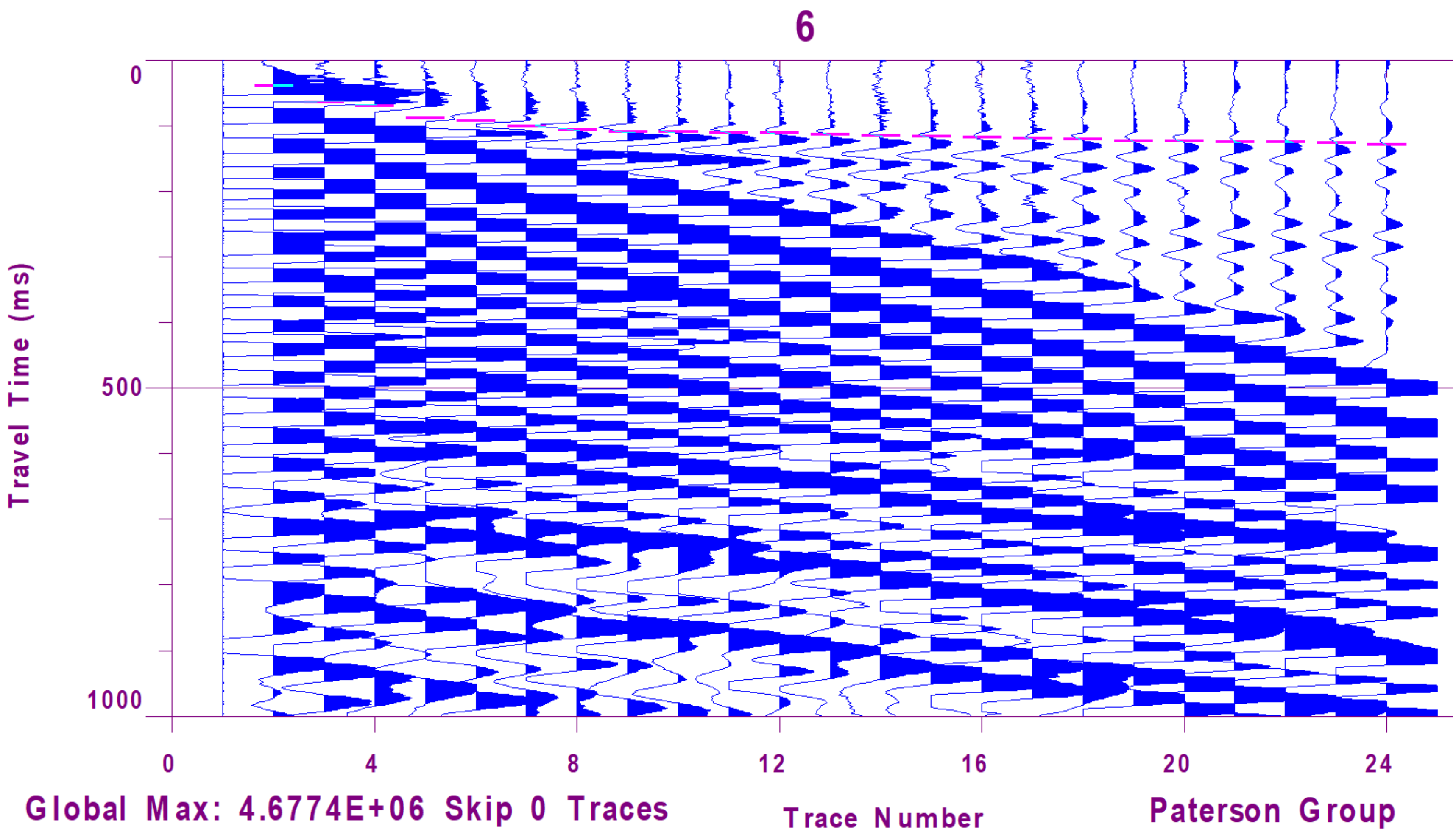


FIGURE 2 –Shear Wave Velocity Profile at Shot Location -4.5 m

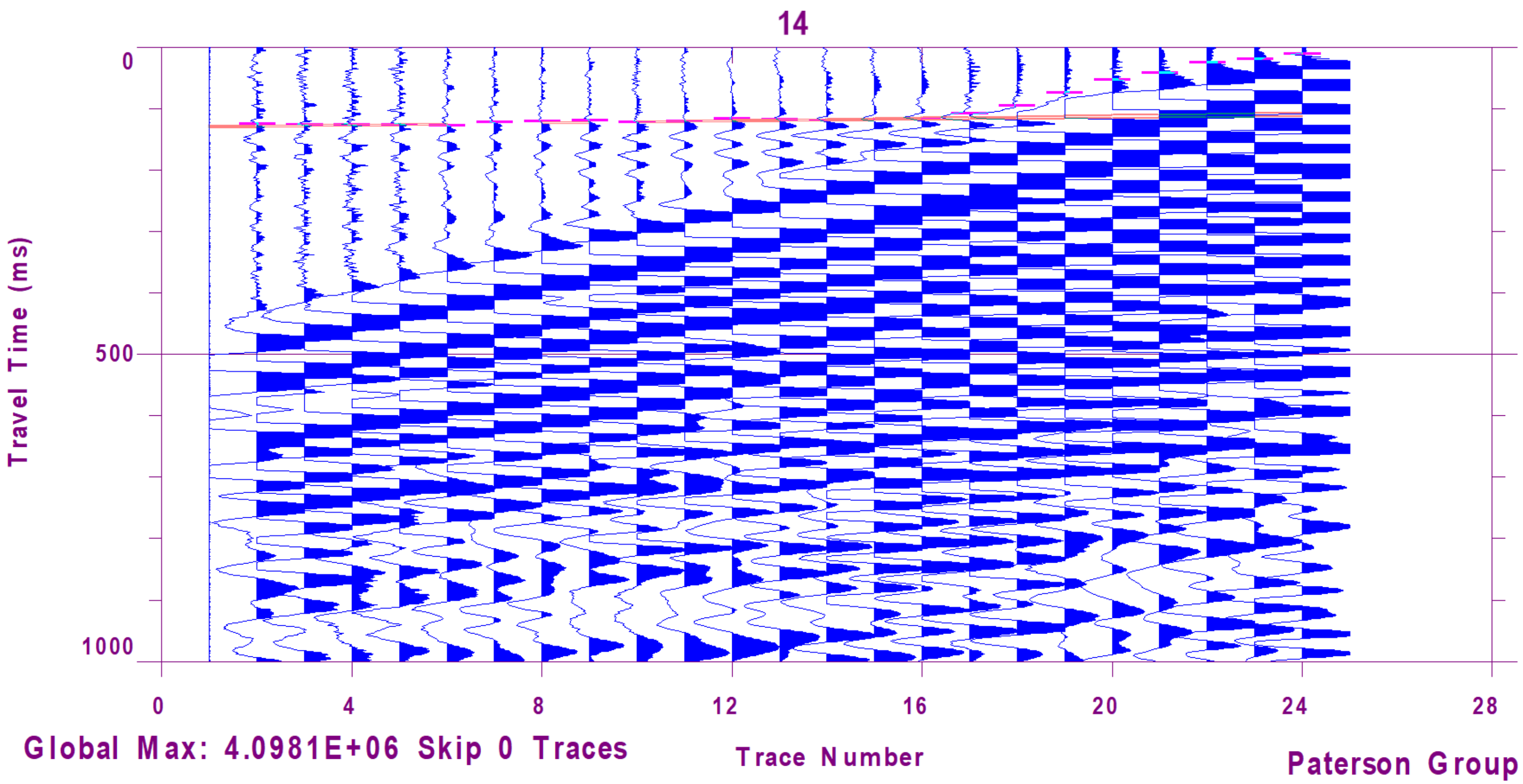


FIGURE 3 – Shear Wave Velocity Profile at Shot Location +73.5 m

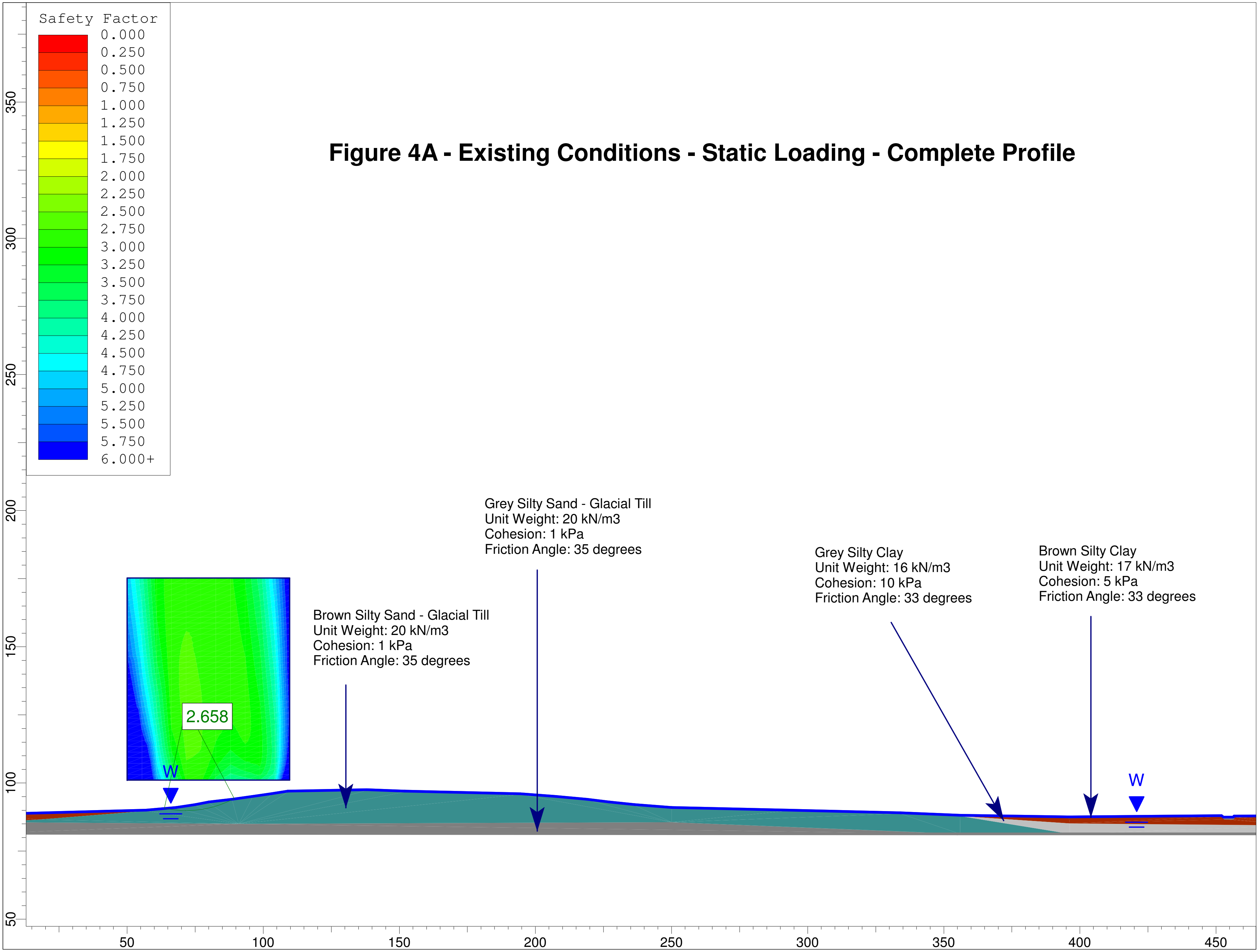


Figure 4A - Existing Conditions - Static Loading - Complete Profile
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
2.658
W
W
Grey Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Brown Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 10 kPa
Friction Angle: 33 degrees
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
350
300
250
200
150
100
50
50
100
150
200
250
300
350
400
450

Figure 4A - Existing Conditions - Static Loading - Enlarged Profile

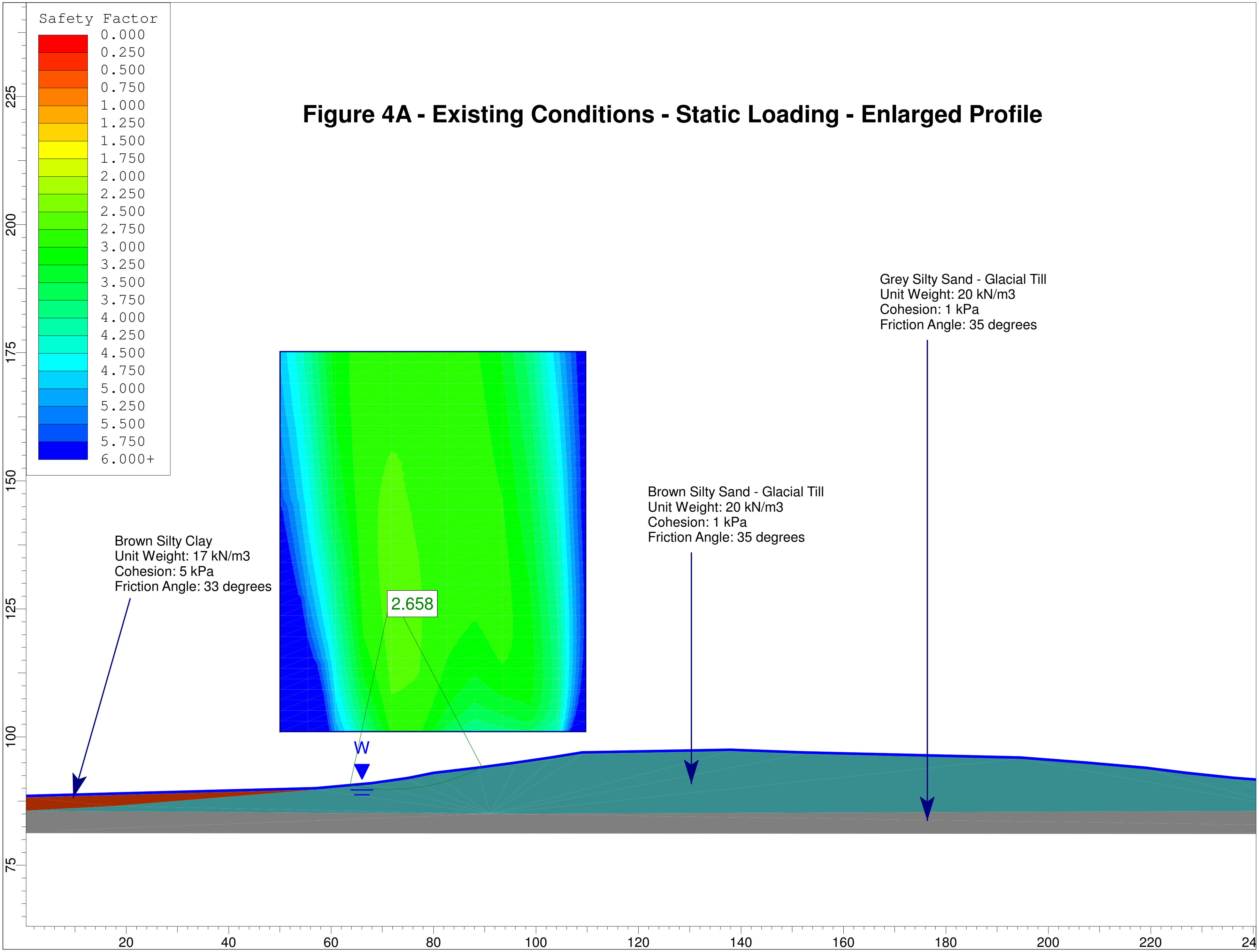
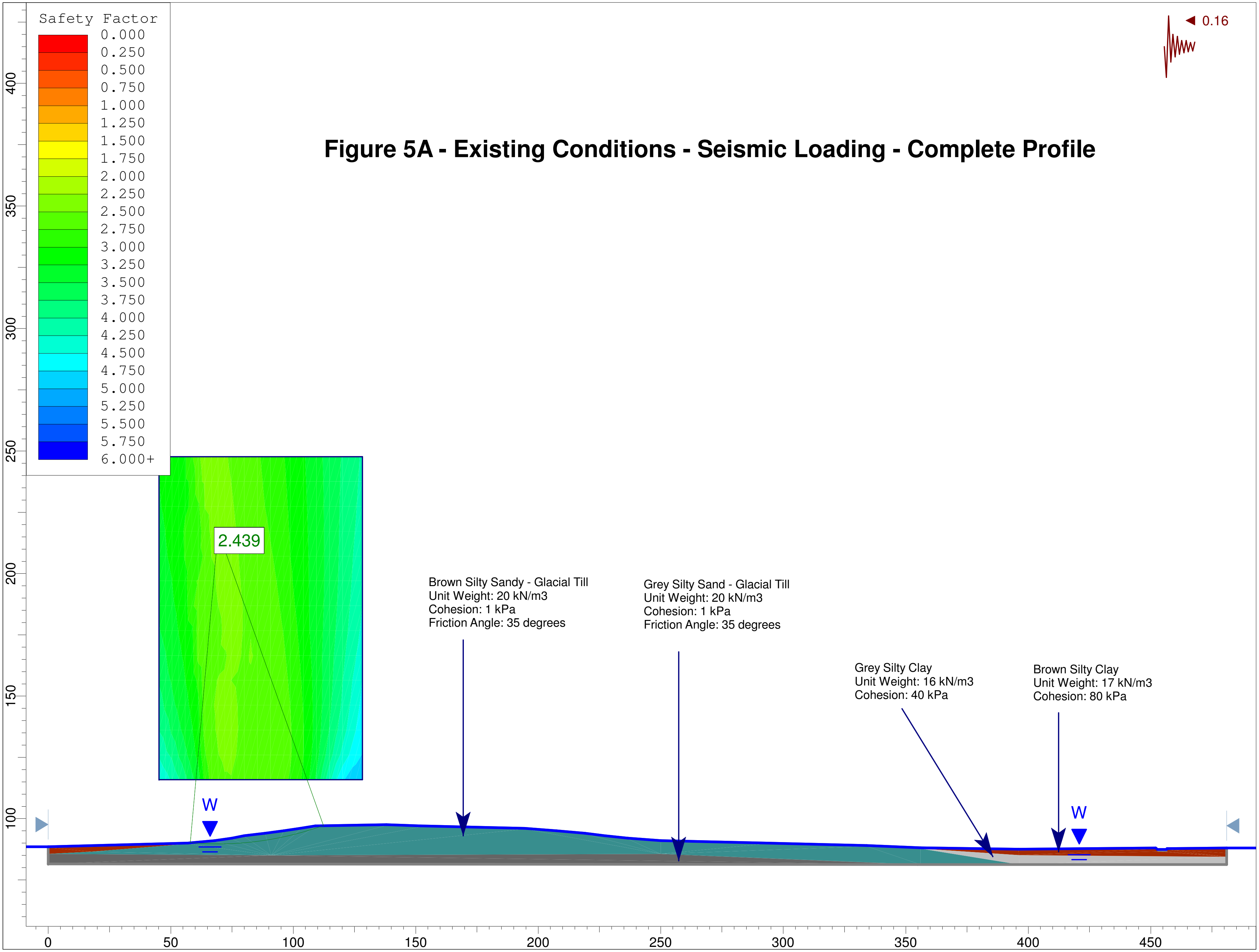


Figure 5A - Existing Conditions - Seismic Loading - Complete Profile



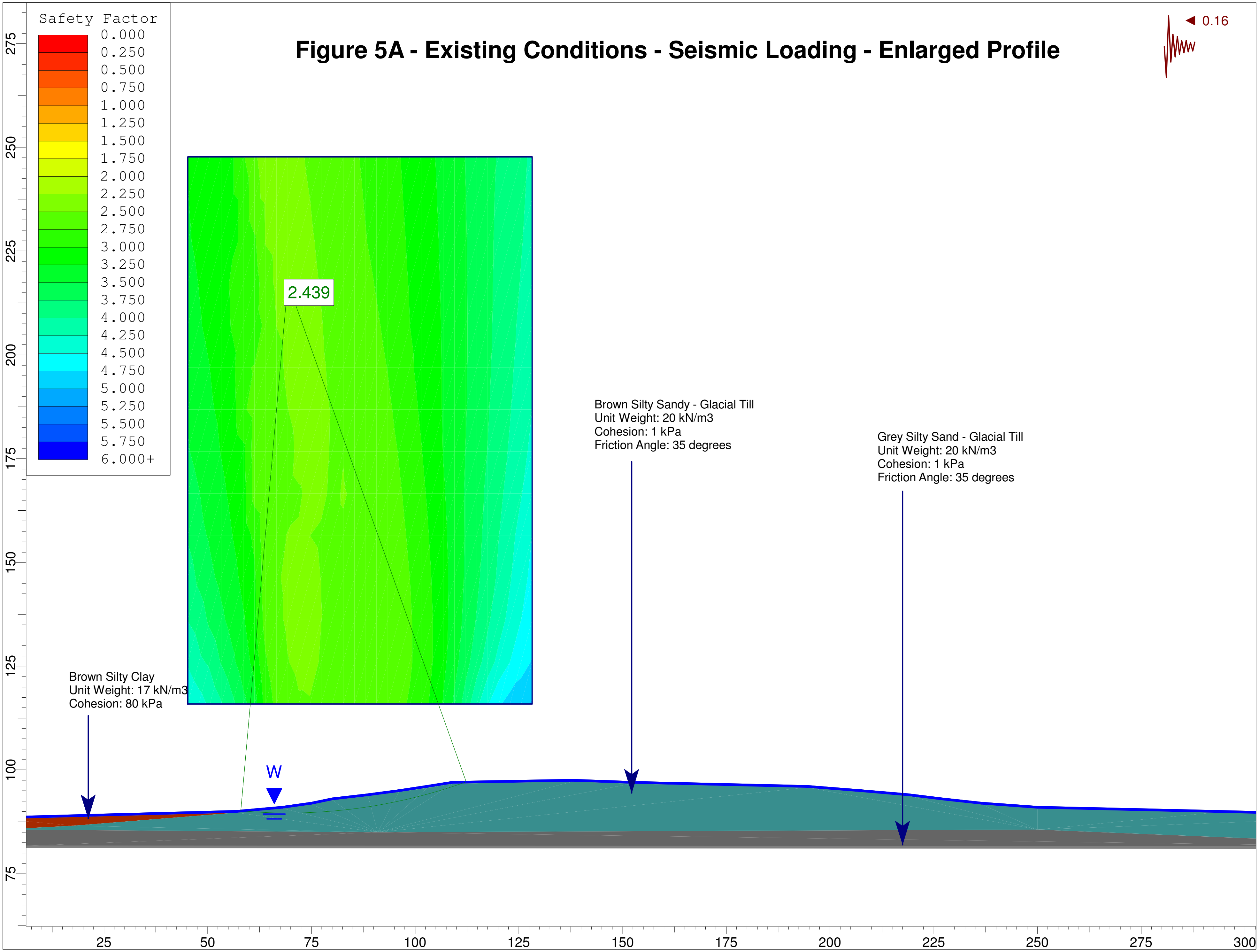


Figure 5A - Existing Conditions - Seismic Loading - Enlarged Profile
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.16
2.439
W
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 80 kPa
Brown Silty Sandy - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Grey Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
275
250
225
200
175
150
125
100
75
25
50
75
100
125
150
175
200
225
250
275
300

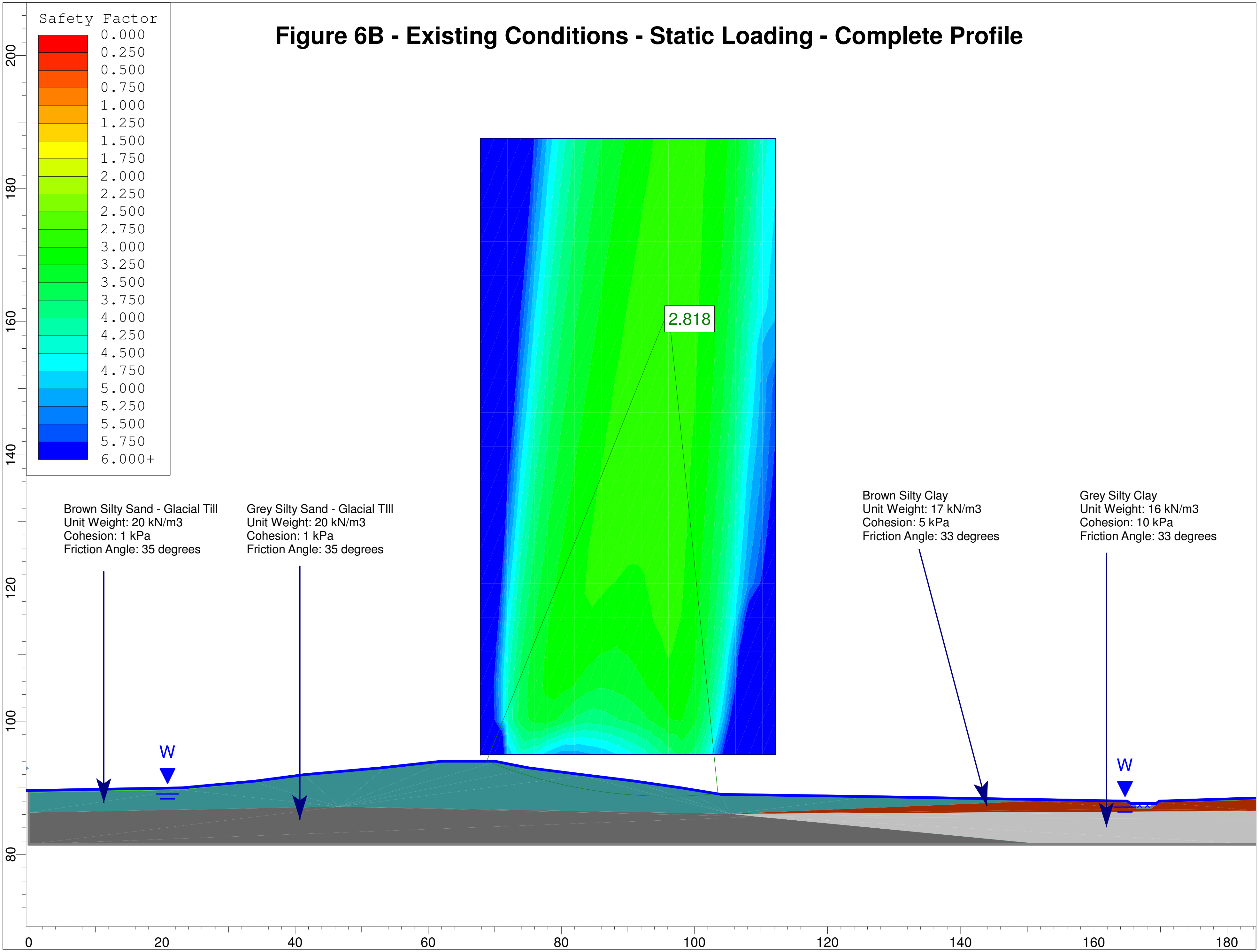
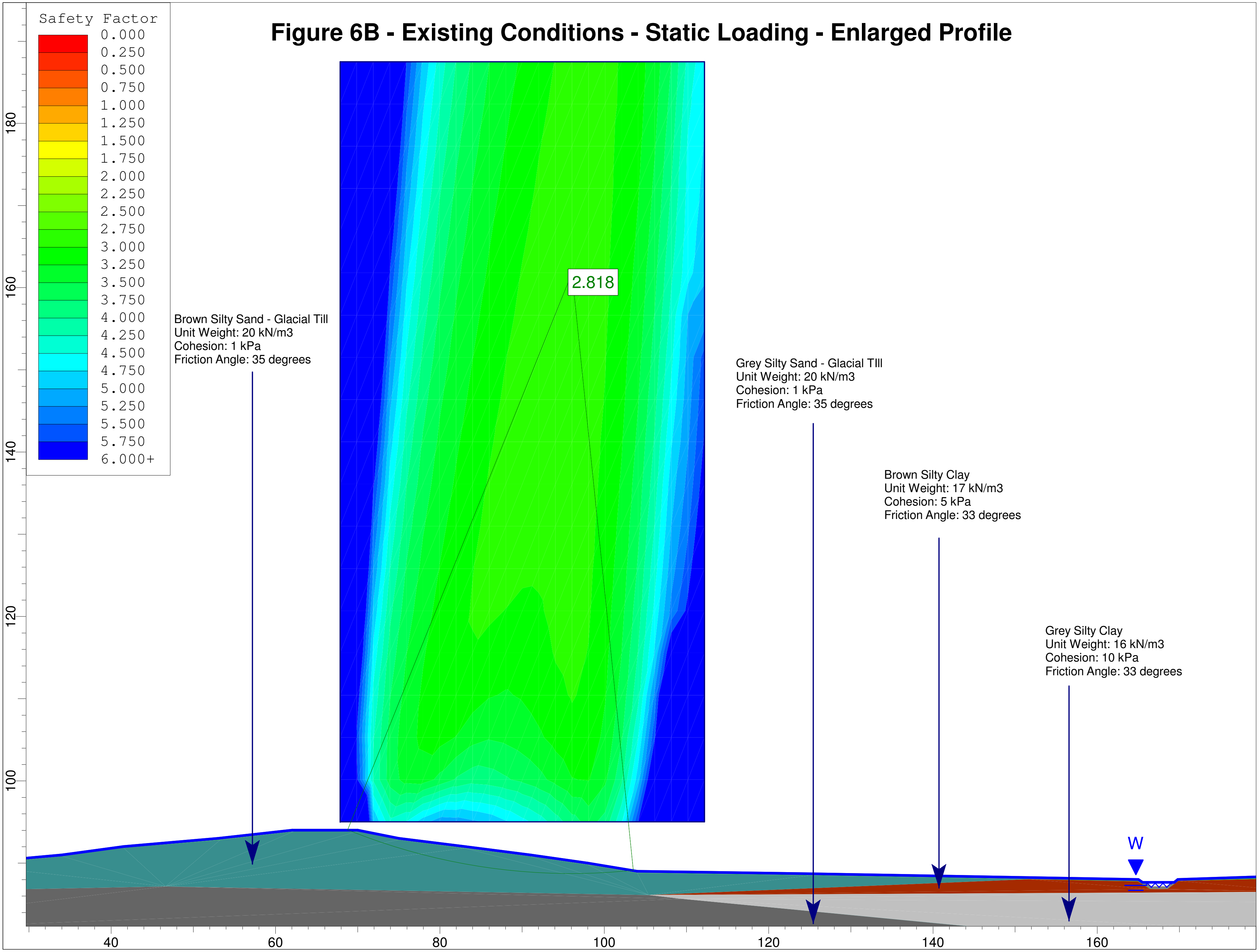


Figure 6B - Existing Conditions - Static Loading - Complete Profile
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
2.818
Brown Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Grey Silty Sand - Glacial TIll
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 10 kPa
Friction Angle: 33 degrees
W
W
200
180
160
140
120
100
80
0
20
40
60
80
100
120
140
160
180



Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Figure 6B - Existing Conditions - Static Loading - Enlarged Profile
2.818
Brown Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Grey Silty Sand - Glacial TIll
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 10 kPa
Friction Angle: 33 degrees
W
180
160
140
120
100
40
60
80
100
120
140
160

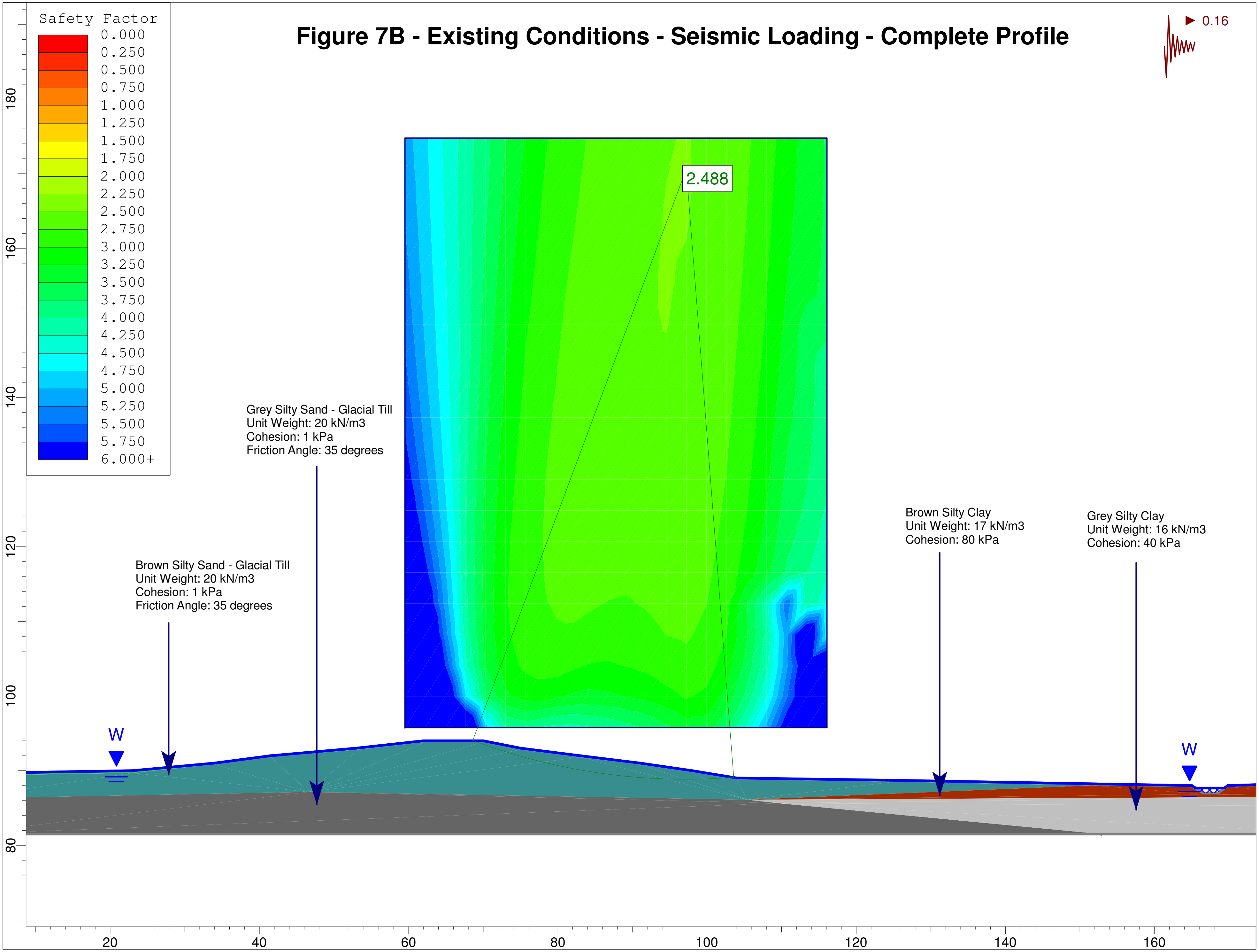
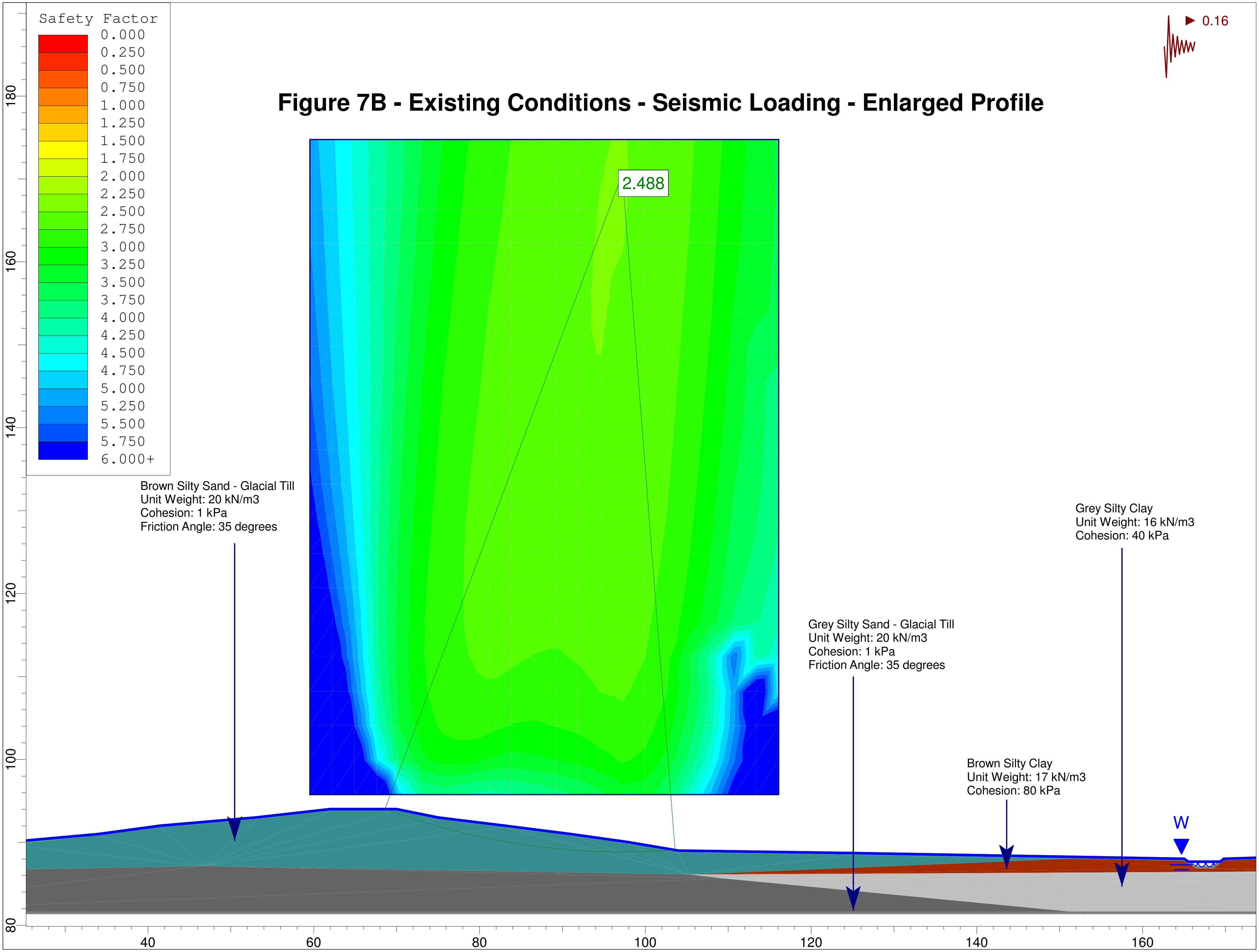
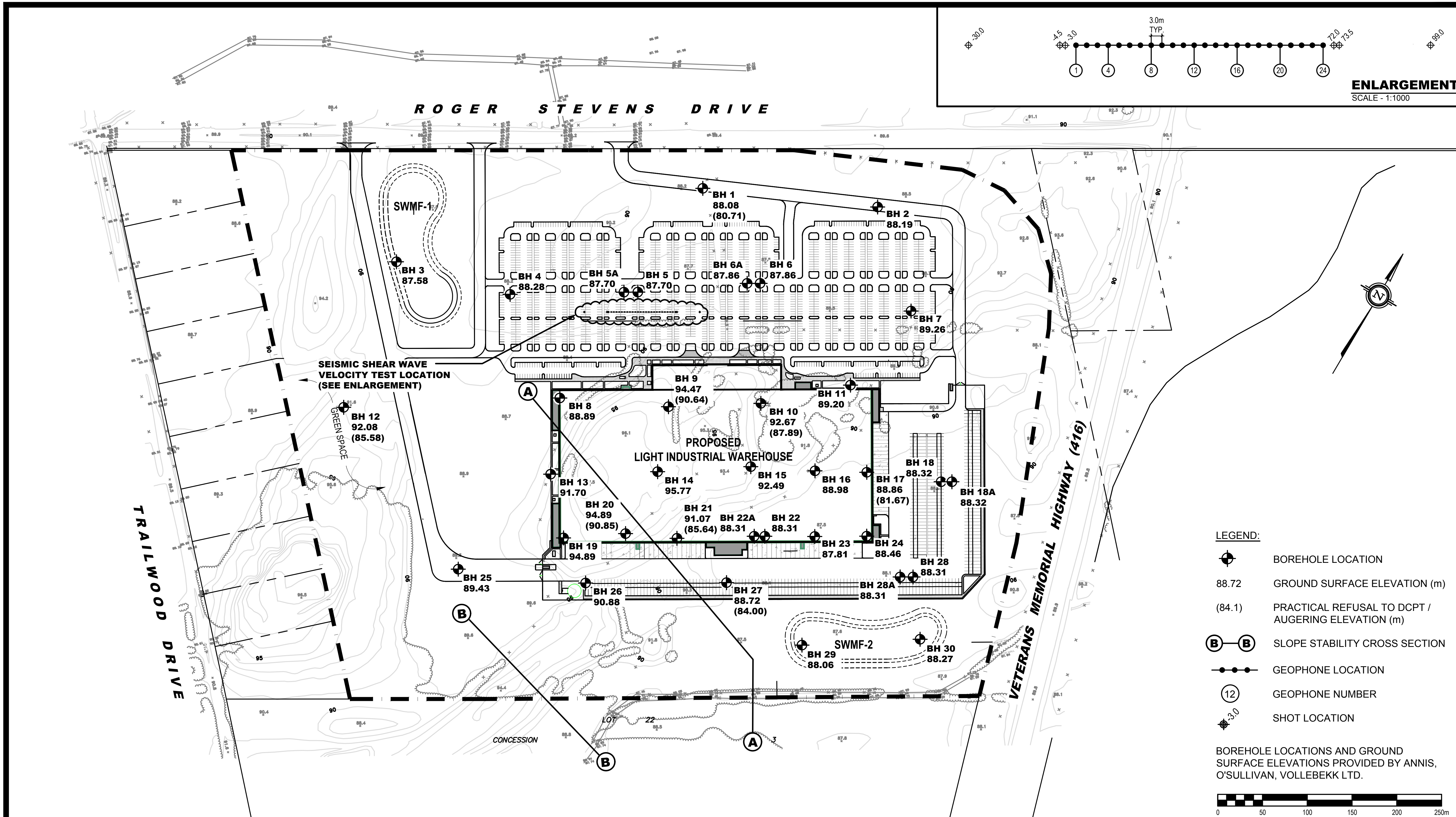


Figure 7B - Existing Conditions - Seismic Loading - Complete Profile
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.16
2.488
Grey Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Brown Silty Sand - Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 1 kPa
Friction Angle: 35 degrees
Brown Silty Clay
Unit Weight: 17 kN/m3
Cohesion: 80 kPa
Grey Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 40 kPa
W
W
180
160
140
120
100
80
20
40
60
80
100
120
140
160

Figure 7B - Existing Conditions - Seismic Loading - Enlarged Profile





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NO.	REVISIONS	DATE	INITIAL
0			

BROCCOLINI

GEOTECHNICAL INVESTIGATION
PROP. WAREHOUSE COMPLEX - 1966 ROGER STEVENS DRIVE
OTTAWA, ONTARIO

Title:
TEST HOLE LOCATION PLAN

Scale: 1:4000	Date: 06/2019
Drawn by: RCG	Report No.: PG4870-1
Checked by: VD	**PG4870-1**
Approved by: DJG	Revision No.:

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