Geotechnical Engineering

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Geotechnical Investigation

Proposed Residential Development
Riverside South - Phase 17
Spratt Road
Ottawa, Ontario

Prepared For

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Riverside South Development Corporation to conduct a geotechnical investigation for Phase 17 of the Riverside South residential development to be located at Spratt Road and Earl Armstrong Road in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objectives of the geotechnical investigation were to:

☐ determine the subsurface soil and groundwater conditions by means of boreholes.

☐ provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect its design.

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

2.0 Proposed Development

It is understood that Phase 17 of the proposed development will consist of single and townhouse style residential dwellings with basement or slab-on-grade construction, attached garages, associated driveways, local roadways and landscaped areas. It is further anticipated that the site will be serviced by future municipal services.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the current geotechnical investigation was conducted between January 27 and February 4, 2020 and consisted of 28 boreholes advanced to a maximum depth of 5.9 m below the existing ground surface. Where refusal to augering was encountered less than 4.7 m below the existing ground surface, an additional borehole was put down within 1 m of the original to confirm refusal depth. These additional boreholes are denoted by A in the Soil Profile and Test Data Sheets.

The test hole locations were determined in the field by Paterson personnel and distributed in a manner to provide general coverage of the proposed residential development taking into consideration site features and underground utilities. The test hole locations are presented on Drawing PG5131-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were advanced using a track-mounted auger drill rig operated by a two-person crew. The drilling procedure consisted of augering to the required depths at the selected locations and sampling the overburden. All fieldwork was conducted under the full-time supervision of our personnel under the direction of a senior engineer from our geotechnical department.

Sampling and In Situ Testing

Soil samples from the boreholes were recovered from the auger flights or a 50 mm diameter split-spoon sampler. All soil samples were classified on site, placed in sealed plastic bags and transported to the laboratory for further review. The depths at which the auger and split spoon samples were recovered from the test holes are presented as AU and SS, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

Standard Penetration Testing (SPT) was conducted and 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 sample 300 mm into the soil after a 150 mm initial penetration with a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength testing was conducted at regular intervals in cohesive soils and completed using a MTO field vane apparatus.

The overburden thickness was evaluated by dynamic cone penetration tests (DCPTs) at boreholes BH 7, BH 12 and BH 21. 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.

Groundwater

Flexible standpipes were installed in the boreholes during the field investigation to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

Sample Storage

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

3.2 Field Survey

The test hole locations were selected by Paterson to provide general coverage of the current phase of the residential development taking into consideration existing site features and underground utilities. The test hole locations and ground surface elevation at each test hole location were surveyed by Paterson. The ground surface elevations at the borehole locations were referenced to a geodetic datum. The test hole locations are presented on Drawing PG5131-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the subject site were visually examined in our laboratory to review the results of the field logging. Gradation and Atterberg Limits testing were also completed on select samples obtained from the geotechnical investigation. The results of this testing are provided in Section 4.2.

3.4 Analytical Testing

One (1) soil sample 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 sample was submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

The subject site consists mostly of agricultural lands and is presently undeveloped with treed areas located in the northeast corner of the site. The site is bordered by a residential development to the north, agricultural properties to the east and south, and Spratt Road to the west. Existing ground surface across the site slopes downward gradually from southeast to northwest, from approximate geodetic elevation 102 to 94 m.

Based on available aerial photos, an agricultural building was previously located in the northwest portion of the site as recently as 1991 and was no longer present in 1999.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile encountered at the test hole locations consists of an approximate 0.2 to 0.6 m topsoil layer underlain by a glacial till deposit. The glacial till was generally observed to consist of a compact to very dense silty sand or sandy silt with clay, gravel, cobbles and boulders. Running sand was observed at approximate depths of 5.8 m and 3.8 m in test holes BH 5A and BH 18, respectively.

A deposit of stiff brown silty clay was encountered either at surface or directly underlying the topsoil in the northern half of the subject site. A layer of brown clayey silt was observed below the topsoil and underlain by the silty clay deposit at BH 28. Where encountered, the clayey silt to silty clay layer had an approximate thickness of 0.6 to 2.1 m and was underlain by the glacial till deposit.

A loose to compact silty sand layer was observed either at surface or directly below the topsoil in the northern half of the subject site in boreholes BH 23, BH 24 and BH 26. Where encountered, the silty sand deposit had an approximate thickness of 0.8 to 0.9 m and was underlain by the glacial till deposit.

Practical refusal to the DCPTs was encountered at depths of 6.6 m, 6.8 m and 7.1 m in boreholes BH 7, BH 12 and BH 21, respectively.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Bedrock

Based on available geological mapping, the subject site is located in an area where the bedrock consists of interbedded sandstone and dolomite of the March formation with a drift thicknesses between 0 to 15 m.

Laboratory Testing

Atterberg limits testing, as well as associated moisture content testing, was completed on the recovered silty clay/clayey silt samples at selected locations throughout the subject site. The results of the Atterberg limits tests are presented in Table 1 and on the Atterberg Limits Results sheet in Appendix 1. The tested samples classify as inorganic clays of high plasticity (CH), inorganic clay of low plasticity (CL), inorganic silts of high plasticity (MH) and inorganic silts of low plasticity (ML) in accordance with the Unified Soil Classification System.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)	Classification
BH 18	1.07	48	31	17	13.8	ML
BH 19	1.07	45	28	18	14.6	ML
BH 22	2.59	39	19	20	8.51	CL
BH 27	1.07	59	33	26	22.8	MH
BH 28	1.8	70	31	38	26.8	CH

Notes: LL: Liquid Limit; PL: Plastic Limit; PI: Plasticity Index; w: water content;
CH: Inorganic Clay of High Plasticity CL: Inorganic Clay of Low Plasticity
MH: Inorganic Silt of High Plasticity ML: Inorganic Silt of Low Plasticity

Grain size distribution analysis was also completed on one selected soil sample. The results of the grain size analysis are summarized in Table 2 and presented on the Grain Size Distribution Results sheets in Appendix 1.

Table 2 - Summary of Grain Size Distribution Analysis

Test Hole	Sample	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH 28	SS4A	0	5.1	52.9	42

4.3 Groundwater

Groundwater level readings were measured at the piezometer locations on February 11, 2020. The observed groundwater levels are summarized in Table 3.

Table 3 - Summary of Groundwater Level Readings

Test Hole Number	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date
BH 1A	98.37	Piezometer Blocked	-	February 11, 2020
BH 2	99.16	3.35	95.81	February 11, 2020
BH 3	99.95	3.25	96.70	February 11, 2020
BH 4A	99.55	3.58	96.37	February 11, 2020
BH 5A	99.08	2.56	97.24	February 11, 2020
BH 6	98.68	Piezometer Blocked	-	February 11, 2020
BH7	102.53	4.34	98.19	February 11, 2020
BH8A	96.97	0.98	95.99	February 11, 2020
BH9A	97.97	1.13	96.84	February 11, 2020
BH10	98.70	0.69	98.01	February 11, 2020
BH11A	99.45	Piezometer Blocked	-	February 11, 2020
BH12	100.35	Piezometer Blocked	-	February 11, 2020
BH13	99.99	Piezometer Blocked	-	February 11, 2020
BH14A	97.48	Piezometer Blocked	-	February 11, 2020
BH15	98.55	Piezometer Blocked	-	February 11, 2020
BH16A	97.28	1.77	95.51	February 11, 2020
BH17	98.09	Piezometer Blocked	-	February 11, 2020
BH18A	96.41	1.78	94.63	February 11, 2020
BH19	95.95	1.49	94.46	February 11, 2020
BH20	96.34	2.30	94.04	February 11, 2020
BH21	96.93	3.93	93.00	February 11, 2020
BH22	95.53	2.65	92.88	February 11, 2020
BH23	98.15	1.44	96.71	February 11, 2020
BH24A	96.53	1.97	94.56	February 11, 2020
BH25	95.59	1.35	94.24	February 11, 2020
BH26	96.82	3.07	93.75	February 11, 2020
BH27	94.96	2.42	92.54	February 11, 2020

Table 3 - Summary of Groundwater Level Readings

Test Hole Number	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date
BH28	93.75	4.10	89.65	February 11, 2020

Note: Ground surface elevations at test hole locations were surveyed by Paterson and are referenced to a geodetic datum.

It should be noted that surface water can become perched within a backfilled borehole, which can lead to higher than normal groundwater level readings. The long-term groundwater level can also be estimated based on the recovered soil samples' moisture levels, colouring and consistency. Based on these observations, the long-term groundwater level is anticipated at a depth of approximately 3 to 4 m below ground surface. Groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is adequate for the proposed residential development. It is expected that the proposed residential dwellings will be founded on conventional spread footings placed on an undisturbed, silty sand, clayey silt, silty clay, glacial till, engineered fill and/or surface-sounded bedrock bearing surface.

Should existing grades be raised at the site for the proposed development, it is expected that several options, such as engineered fill or well graded blast rock, would act as suitable subgrade material for the proposed buildings provided the material is adequately placed and approved by the geotechnical consultant at the time of placement.

It is anticipated that some bedrock removal will be required for basement construction and site servicing activities. All contractors should be prepared for bedrock removal within the subject site.

Due to the presence of a silty clay deposit throughout the northern half of the subject site, a permissible grade raise restriction will be required for grading around the proposed buildings founded within the silty clay deposit.

Due to the groundwater level within the glacial till layer, a significantly high groundwater in-flux may be observed during the installation of site servicing, where trench excavation extends below the groundwater table. Excavations below the water level in non-cohesive soils, such as silty sand, have the potential for basal heave if groundwater is not controlled during the excavation work. A series of well points may be required to control groundwater in-flow for service trenches that extend below the water table. It is assumed that the excavations will be carried out within the confines of a fully braced trench box or other acceptable shoring systems design by a qualified engineer to resist the design lateral earth pressures and potential basal heave issues.

The above and other considerations are discussed in the following paragraphs.

5.2 Site Grading and Preparation

Stripping Depth

Topsoil, and any deleterious fill, such as those containing organic materials, should be stripped from under any buildings and other settlement sensitive structures.

Existing foundation walls and other construction debris should be entirely removed from within the proposed building footprints. Under paved areas, existing construction remnants, such as foundation walls should be excavated to a minimum depth of 1 m below final grade.

Fill Placement

Fill used for grading beneath the building areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II material. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the buildings 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 placed as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts compacted by the tracks of the spreading equipment to minimize voids. If the material is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of the material's SPMDD. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

Where blast rock it to be used as fill to build up the bearing medium, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 400 mm placed in maximum 600 mm loose lifts and compacted using a large smooth drum vibratory roller making several passes per lift and approved by the geotechnical consultant at the time of placement. Any blast rock greater than 400 mm in diameter should be segregated and hoe rammed into acceptable fragments. The blast rock fill should be capped with a minimum of 300 mm of Granular B Type II or Granular A crushed stone material and should be compacted to at least 98% of its SPMDD.

Bedrock Removal

In areas where shallow bedrock is encountered, and only a small quantity of bedrock is to be removed, bedrock removal may be possible by hoe-ramming. However, dependent on the quantity and condition of the bedrock, line-drilling in conjunction with hoe-ramming may be required to remove the bedrock. All contractors should be prepared ofr bedrock removal within the subject site.

Vibration Considerations

Construction operations could cause vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels as much as possible should be incorporated in the construction operations to maintain a cooperative environment with the residents.

Two parameters determine the recommended vibration limit: the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As a guideline, the peak particle velocity should be less than 15 mm/s between frequencies of 4 to 12 Hz, and 50 mm/s above a frequency of 40 Hz (interpolate between 12 and 40 Hz). These guidelines are for current construction standards. These guidelines are above perceptible human level and, in some cases, could be very disturbing to some people. A pre-construction survey is recommended to minimize the risks of claims during or following the construction of the proposed buildings.

5.3 Foundation Design

Bearing Resistance Values

Strip footings, up to 2 m wide, and pad footings, up to 4 m wide, placed on an undisturbed, clayey silt or firm to stiff silty clay bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **100 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **150 kPa**.

Footings placed on an undisturbed, compact silty sand and/or glacial till bearing surface can be designed using a bearing resistance value at SLS of **150 kPa** and a factored bearing resistance value at ULS of **225 kPa**.

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.

Footings placed on clean, surface-sounded bedrock can be designed using a bearing resistance value at SLS of **500 kPa** and a factored bearing resistance value at ULS of **750 kPa**. A clean, weathered bedrock surface consists of one from which all topsoil, soils, deleterious materials and loose rock have been removed prior to concrete placement.

Footings placed over an approved engineered fill bearing surface can be designed using a bearing resistance value at SLS of **150 kPa** and a factored bearing resistance value at ULS of **225 kPa**.

Footings designed using the bearing resistance value at SLS given above will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance value at ULS.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support. Adequate lateral support is provided to a silty sand, clayey silt, silty clay, glacial till or engineered fill bearing medium above the groundwater table when a plane extending down and out from the bottom edge of the footing, at a minimum of 1.5H:1V passes through in situ soil of the same or high bearing medium soil.

Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending horizontally and vertically from the footing perimeter at a minimum of 1H:6V (or shallower) passing through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete.

Permissible Grade Raise Restrictions

Consideration must also be given to potential settlements which could occur due to the presence of the silty clay deposit encountered throughout the northern half of the subject site and the combined loads from the proposed footings, any groundwater lowering effects, and grade raise fill. The foundation loads to be considered for the settlement case are the continuously applied loads which consist of the unfactored dead loads and the portion of the unfactored live load that is considered to be continuously applied. For buildings, a minimum value of 50% of the live load is often recommended by Paterson. A post-development groundwater lowering of 0.5 m was assumed.

Our permissible grade raise recommendations for the proposed residential development are presented in Drawing PG5131-2 - Permissible Grade Raise Plan in Appendix 2.

If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill, and/or other measures should be investigated to reduce the risks of unacceptable long-term post construction total and differential settlements.

5.4 Design for Earthquakes

The subject site can be taken as seismic site response **Class C** as defined in Table 4.1.8.4.A of the Ontario Building Code (OBC) 2012 for foundations considered at this site. A site specific shear wave velocity test may be completed to accurately determine the applicable seismic site classification for foundation design of the proposed residential development.

The soils underlying the site are not susceptible to liquefaction. Reference should be made to the latest revision of the Ontario Building Code for a full discussion of the earthquake design requirements.

5.5 Basement Slab / Slab-on-Grade Construction

With the removal of all topsoil and deleterious fill from within the footprint of the proposed buildings, the native soil surface or approved engineered fill surface will be considered to be an acceptable subgrade on which to commence backfilling for floor slab construction.

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

For structures with basement slabs, it is recommended that the upper 200 mm of sub-floor fill consists of 19 mm clear crushed stone.

For structures with slab-on-grade construction, the upper 200 mm of sub-slab fill is recommended to consist of OPSS Granular A crushed stone. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

5.6 Pavement Structure

For design purposes, the following pavement structures, presented below, are recommended for the design of car parking areas, local and collector roadways.

Table 4 - Recommended Pavement Structure - Driveways

Thickness (mm)	Material Description
50	**Wear Course** - HL 3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill **Note:** Minimum Performance Graded (PG) 58-34 asphalt cement should be used for driveways.	

Table 5 - Recommended Pavement Structure - Local Residential Roadways

Thickness (mm)	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Binder Course -** Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
400	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill **Note:** Minimum Performance Graded (PG) 58-34 asphalt cement should be used for local roadways.	

Table 6 - Recommended Pavement Structure - Roadways with Bus Traffic

Thickness (mm)	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Upper Binder Course** - Superpave 19.0 Asphaltic Concrete
50	**Lower Binder Course -** Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
600	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill **Note:** Minimum Performance Graded (PG) 64-34 asphalt cement should be used for roadways with bus traffic.	

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type I or Type II material.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 99% of the material's SPMDD using suitable compaction equipment.

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on keeping the contact zone between the subgrade material and the base stone in a dry condition. Failure to provide adequate drainage under conditions of heavy wheel loading can result in the fine subgrade soil being pumped into the voids in the stone subbase, thereby reducing its load carrying capacity.

Where silty clay is anticipated at subgrade level, consideration should be given to installing subdrains during the pavement construction. The sub-drain inverts should be approximately 300 mm below subgrade level and run longitudinal along the curblines. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed structures. The system should consist of a 100 to 150 mm diameter perforated and 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.

Backfill against the exterior sides of the foundation walls should consist of free-draining, non frost susceptible granular materials. The site materials will be frost susceptible and, as such, are not recommended for re-use as backfill unless a composite drainage system (such as Miradrain G100N) connected to a drainage system is provided.

6.2 Protection Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum of 1.5 m thick soil cover (or equivalent) should be provided in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for other exterior unheated footings.

6.3 Excavation Side Slopes

The side slopes of excavations in the soil and fill overburden materials should either be 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 assumed that sufficient room will be available for the greater part of the excavations to be undertaken by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below groundwater level. The subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

It is recommended that a dewatering program, such as a series of well points design and installed by a licensed contractor specializing in dewatering, be completed for service installations completed below the groundwater level for areas in non-cohesive soils.

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.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by "cut and cover" methods and excavations will not be left open for extended periods of time.

Excavation Base Stability

The base of supported excavations can fail by three general modes:

❏ Shear failure within the ground caused by inadequate resistance to loads imposed by grade difference inside and outside of the excavation,
❏ Piping from water seepage through granular soils, and
❏ Heave of layered soils due to water pressures confined by intervening low permeability soils.

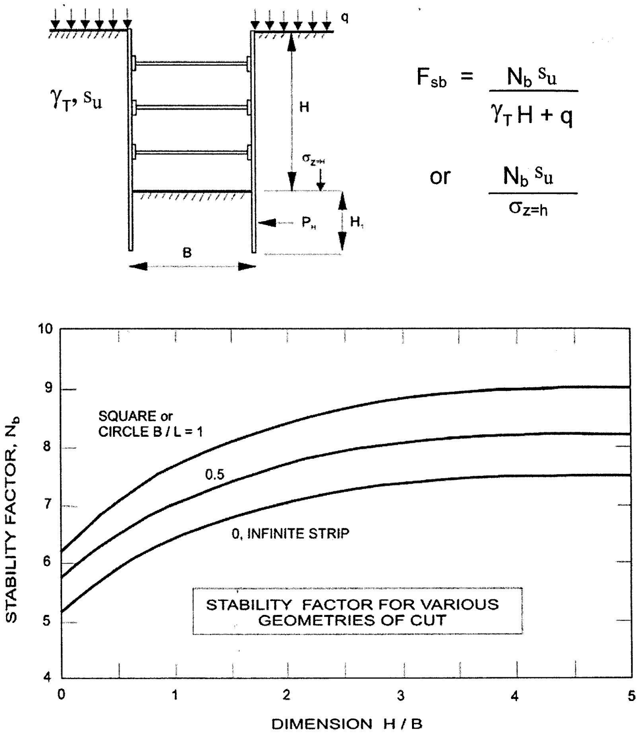
Shear failure of excavation bases is typically rare in granular soils if adequate lateral support is provided. Inadequate dewatering can cause instability in excavations made through granular or layered soils. The potential for base heave in cohesive soils should be determined for stability of flexible retaining systems.

The factor of safety with respect to base heave, FS_b, is:

$$FS_b = N_b s_u / \sigma_z$$

where:

N_b - stability factor dependent upon the geometry of the excavation and given in Figure 1 on the following page.
s_u - undrained shear strength of the soil below the base level
σ_z - total overburden and surcharge pressures at the bottom of the excavation



$$F_{sb} = \frac{N_b s_u}{\gamma_T H + q} \quad \text{or} \quad \frac{N_b s_u}{\sigma_{z=h}}$$

Figure 1 - Stability Factor for Various Geometries of Cut

In the case of soft to firm clays, a factor of safety of 2 is recommended for base stability.

6.4 Pipe Bedding and Backfill

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

It is expected that the invert level of the municipal services will be installed at or below the long term groundwater level within the glacial till deposit. As a result, it is recommended that a dewatering program should be implemented prior to construction to temporarily draw down the long term groundwater level during the construction phase. It is recommended that the dewatering program consisting of a series of well points be designed and installed by a licensed contractor specialized in dewatering.

At least 150 mm of OPSS Granular A crushed stone should be used for pipe bedding for sewer and water pipes. However, the bedding thickness should be increased to 300 mm for areas over a bedrock subgrade. 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 98% of the material's SPMDD.

Based on the soil profile encountered, the subgrade for the services will be placed in both bedrock and overburden soils. It is recommended that the subgrade medium be inspected in the field to determine how steeply the bedrock surface, where encountered, drops off. A transition should be provided where the bedrock slopes more than 3H:1V. At these locations, the bedrock should be excavated and replaced with additional bedding materials to provide a 3H:1V (or flatter) transition from the bedrock subgrade towards the soil subgrade. This treatment reduces the propensity for bending stress to occur in the services.

Generally, it should be possible to re-use the moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Wet silty clay should be given a sufficient drying period to decrease its moisture content to an acceptable level to make compaction possible prior to being re-used. All cobbles greater than 200 mm in the longest direction should be removed prior to the site materials being reused.

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) should consist of the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD.

To reduce long-term lowering of the groundwater level at the subject site, clay seals should be provided in the servicing trenches. The seals should be at least 1.5 m long and should extend from trench wall to trench wall. Generally, the seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of a relatively dry brown silty clay placed in maximum 225 mm thick loose layers and compacted to a minimum of 95% of the material's SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 60 m intervals in the service trenches.

6.5 Groundwater Control

Due to the permeable glacial till deposit encountered within the groundwater table within the subject site, it is anticipated that conventional pumping with open sumps will be difficult to control the groundwater influx through the sides of the temporary excavation. As a result, it is recommended that a dewatering specialist be consulted to review the most effective dewatering methods.

Permit to Take Water

A temporary MOECC permit to take water (PTTW) is recommended for this project if more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. At least 4 to 5 months should be allowed for completion of the application and issuance of the permit by the MOECC.

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.

6.6 Winter Construction

The subsurface soil conditions 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 installation of straw, propane heaters and tarpaulins or other suitable means. 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 constructed to avoid the introduction of frozen materials, snow or ice into the trenches. As well, pavement construction is difficult during winter. The subgrade consists of frost susceptible soils which will experience total and differential frost heaving during construction. Also, the introduction of frost, snow or ice into the pavement materials, which is difficult to avoid, could adversely affect the performance of the pavement structure.

6.7 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 non-aggressive to slightly aggressive corrosive environment.

6.8 Landscaping Considerations

Paterson completed a soils review of the site to determine applicable tree planting setbacks, in accordance with the City of Ottawa Tree Planting in Sensitive Marine Clay Soils (2017 Guidelines) for trees planted within a public right-of-way (ROW). Atterberg limits testing was completed for recovered silty clay samples where encountered. Sieve analysis testing was also completed on one soil sample. The above-noted test results were completed on samples taken at depths between the anticipated underside of footing elevation and a 3.5 m depth below finished grade. The results of our testing are presented in Tables 2 and 3 in Subsection 4.2 and in Appendix 1.

Based on the results of our review, the following tree planting setbacks are required within the northern half of the proposed development. The recommended tree planting setbacks should be reviewed by Paterson, once the proposed grading plan has been prepared.

Area 1 - Low to Medium Sensitivity Clay Area

A low to medium sensitivity clay soil was encountered between the anticipated design underside of footing elevations and 3.5 m below finished grade as per City Guidelines in the areas outlined in Drawing PG5131-3 - Tree Planting Setback Recommendations in Appendix 2. Based on our Atterberg limits test results, the modified plasticity index does not exceed 40% in these areas. The following tree planting setbacks are recommended for the low to medium sensitivity area. Large trees (mature height over 14 m) can be planted within these areas provided a tree to foundation setback equal to the full mature height of the tree can be provided (e.g. in a park or other green space). Tree planting setback limits may be reduced to **4.5 m** for small (mature height up to 7.5 m) and medium size trees (mature tree height 7.5 to 14 m), provided that the conditions noted below are met.

☐ The underside of footing (USF) is 2.1 m or greater below the lowest finished grade for footings within 10 m from the tree, as measured from the centre of the tree trunk and verified by means of the Grading Plan.

☐ A small tree must be provided with a minimum of 25 m^3 of available soils volume while a medium tree must be provided with a minimum of 30 m^3 of available soil volume, as determined by the Landscape Architect. The developer is to ensure that the soil is generally un-compacted when backfilling in street tree planting locations.

☐ The tree species must be small (mature tree height up to 7.5 m) to medium size (mature tree height 7.5 m to 14 m) as confirmed by the Landscape Architect.

☐ The foundation walls are to be reinforced at least nominally (minimum of two upper and two lower 15M bars in the foundation wall).

☐ Grading surrounding the tree must promote drainage to the tree root zone (in such a manner as not to be detrimental to the tree), as noted on the subdivision Grading Plan.

Aboveground Swimming Pools

The in-situ soils are considered to be acceptable for in-ground swimming pools. Above ground swimming pools must be placed at least 5 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer's recommendations.

Aboveground Hot Tubs

Additional grading around hot tubs should not exceed permissible grade raises. Otherwise, hot tub construction is considered routine, and can be constructed in accordance with the manufacturer's specifications.

Decks and Building Additions

Additional grading around proposed decks or additions should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

7.0 Recommendations

The following is recommended to be completed once the site plan and development are determined:

☐ Review detailed grading plan(s) from a geotechnical perspective.

☐ Observation of all bearing surfaces prior to the placement of concrete.

☐ Sampling and testing of the concrete and fill materials used.

☐ Review and inspection of all foundation drainage systems.

☐ Observation of all subgrades prior to backfilling.

☐ Observation of clay seal placement at specified locations

☐ Field density tests to ensure that the specified level of compaction has been achieved.

☐ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.

☐ Sampling and testing of the bituminous concrete including mix design reviews.

A report confirming the construction has been completed in general accordance with Paterson's recommendations could be issued upon request, following the completion of a satisfactory material 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 its 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 Riverside South Development Corporation, or their agents, is not authorized without review by Paterson for the applicability of our recommendations to the alternative use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
June 24, 2020
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Kevin A. Pickard, EIT

David J. Gilbert, P.Eng.

Report Distribution

- ☐ Riverside South Development Corporation
- ☐ Paterson Group

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ATTERBERG LIMITS RESULTS

GRAIN SIZE DISTRIBUTION ANALYSIS RESULTS

ANALYTICAL TESTING RESULTS

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5131**

REMARKS

HOLE NO. **BH 1**

BORINGS BY CME 55 Power Auger

DATE January 27, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	98.37		
TOPSOIL		AU	1						
0.40									
		SS	2	75	69	1	97.37		
GLACIAL TILL: Very dense, brown sand, trace silt, gravel and cobbles		SS	3	62	42				
						2	96.37		
		SS	4	71	27				
						3	95.37		
3.20		SS	5	100	50+				
End of Borehole Practical refusal to augering at 3.20m depth.									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5131

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 27, 2020

HOLE NO. BH 1A

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	98.37
TOPSOIL 0.40						
GLACIAL TILL: Very dense, brown sand, trace silt, gravel and cobbles					1	97.37
					2	96.37
					3	95.37
3.18	SS	1	100	50+		

End of Borehole

Practical refusal to augering at 3.18m depth.

(Piezometer dry/blocked at 2.76m depth - Feb. 11, 2020)

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 27, 2020

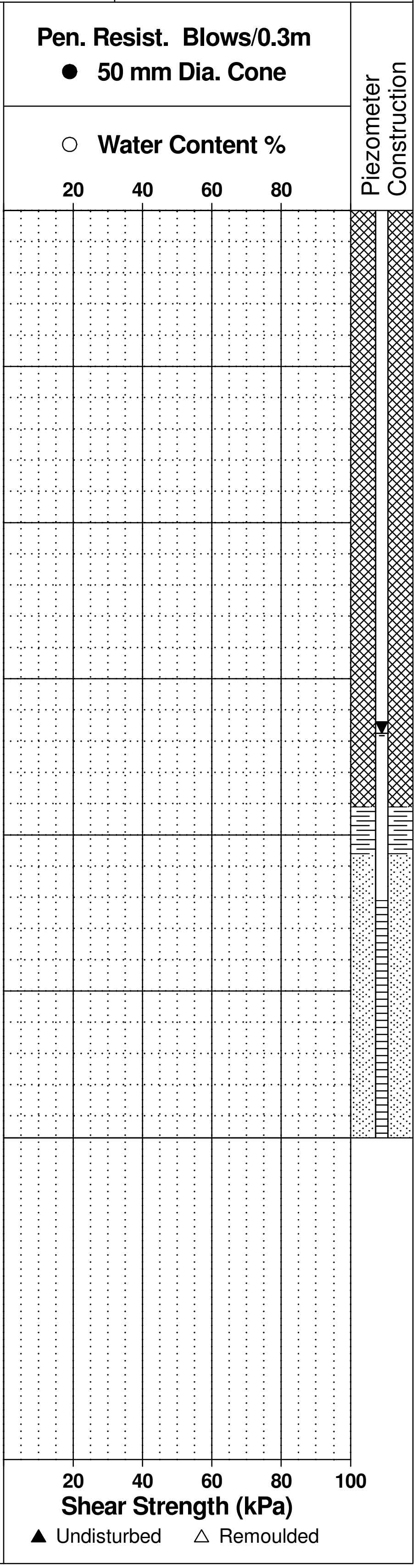
FILE NO. PG5131

HOLE NO. BH 2

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.16
TOPSOIL 0.33	AU	1				
GLACIAL TILL: Brown silty clay, some sand, trace gravel	SS	2	50	14	1	98.16
	SS	3	38	50+	2	97.16
2.29						
GLACIAL TILL: Compact to very dense, brown sandy silt, trace clay, gravel and cobbles	SS	4	79	41	3	96.16
	SS	5	67	24	4	95.16
	SS	6	67	26		
	SS	7	100	50+	5	94.16
5.33						
GLACIAL TILL: Brown silty clay with sand, trace gravel and cobbles	SS	8	67	46		
5.94						

End of Borehole

(GWL @ 3.35m - Feb. 11, 2020)



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Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 27, 2020

FILE NO. PG5131

HOLE NO. BH 3

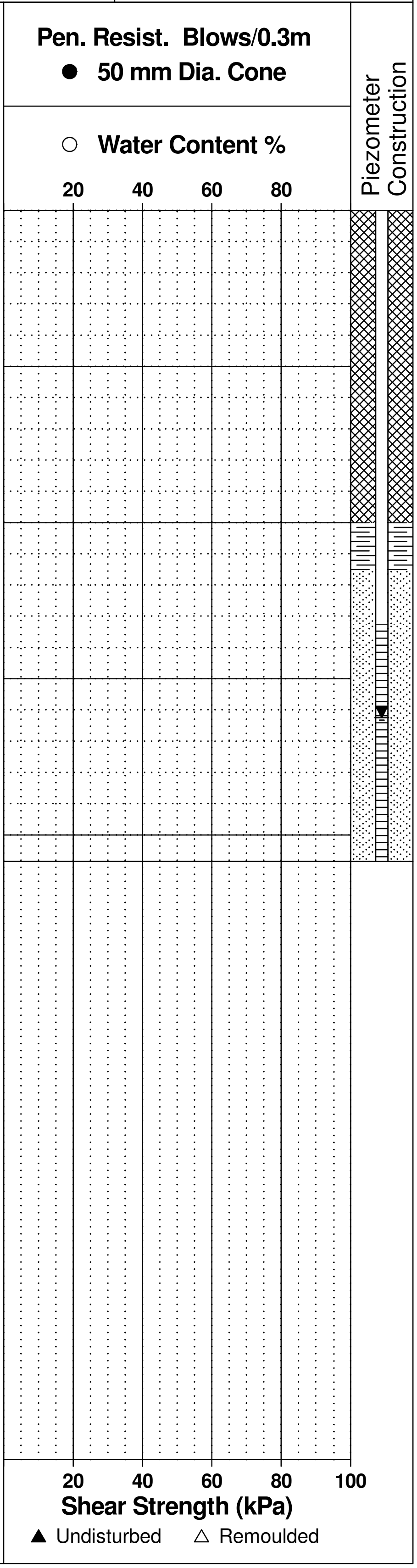
SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL (to 0.36)	AU	1		
GLACIAL TILL: Dense, brown sand, some gravel and cobbles (0.36 to 4.17)	SS	2	76	33
	SS	3	67	41
	SS	4	71	28
	SS	5	60	50+
	SS	6	0	50+

DEPTH (m)	ELEV. (m)
0	99.95
1	98.95
2	97.95
3	96.95
4	95.95

End of Borehole

Practical refusal to augering at 4.17m depth.

(GWL @ 3.25m - Feb. 11, 2020)



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Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 28, 2020

FILE NO. PG5131

HOLE NO. BH 3A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	99.95		
TOPSOIL 0.36									
Inferred **GLACIAL TILL:** Dense, brown sand, some gravel and cobbles						1	98.95		
						2	97.95		
2.62									
End of Borehole Practical refusal to augering at 2.62m depth.									

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 January 27, 2020

FILE NO. PG5131

HOLE NO. BH 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	99.55		
TOPSOIL 0.33		AU	1						
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, trace cobbles and boulders		SS	2	62	32	1	98.55		
		SS	3	54	20	2	97.55		
2.49		SS	4	100	50+				
End of Borehole Practical refusal to augering at 2.49m depth.									

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. **PG5131**

REMARKS

HOLE NO. **BH 4A**

BORINGS BY CME 55 Power Auger

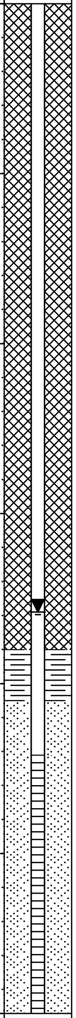
DATE January 27, 2020

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.55
TOPSOIL 0.33						
Inferred **GLACIAL TILL:** Dense to very dense, brown silty sand with gravel, trace cobbles and boulders					1	98.55
					2	97.55
3.05					3	96.55
GLACIAL TILL: Brown clayey silt with sand, trace gravel 3.45	SS	1	100	26		
GLACIAL TILL: Brown silty clay, trace sand 3.81						
GLACIAL TILL: Dense to compact, brown sand, trace silt, gravel and cobbles	SS	2	71	31	4	95.55
	SS	3	100	45	5	94.55
5.94	SS	4	54	23		
End of Borehole (GWL @ 3.58m - Feb. 11, 2020)						

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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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 28, 2020

FILE NO. PG5131

HOLE NO. BH 5

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.08
TOPSOIL 0.20		AU	1				
FILL: Brown silty sand, trace clay and gravel 1.37		SS	2	54	34	1	98.08
GLACIAL TILL: Brown silty sand, trace gravel 2.13		SS	3	50	38	2	97.08
GLACIAL TILL: Brown sandy silt, trace clay, gravel and cobbles		SS	4	67	43		
		SS	5	67	50+	3	96.08
3.76							
End of Borehole Practical refusal to augering at 3.76m depth.							

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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Ottawa, Ontario

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FILE NO. **PG5131**

REMARKS

HOLE NO. **BH 5A**

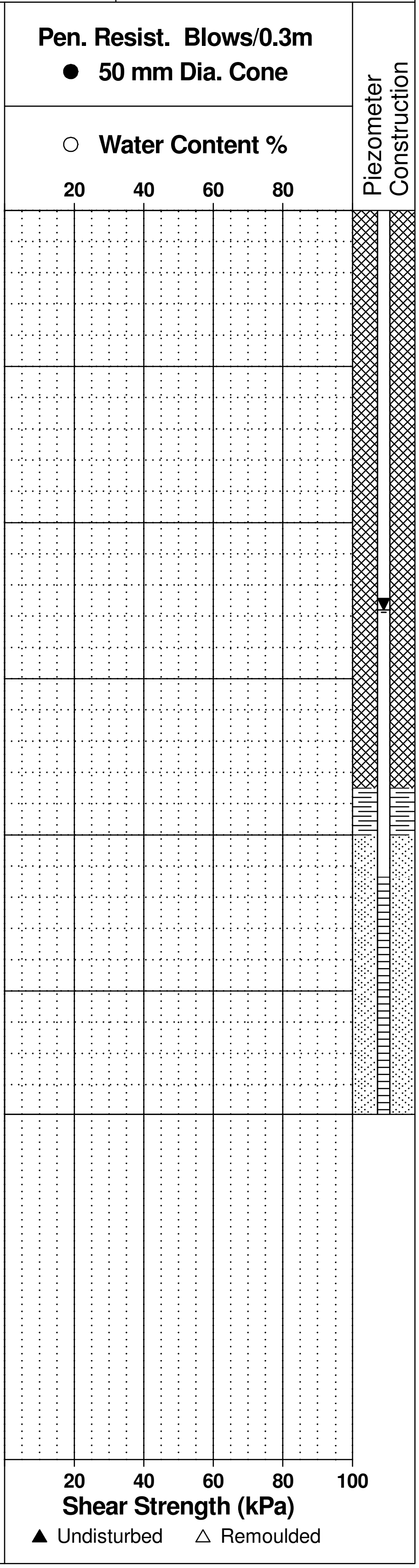
BORINGS BY CME 55 Power Auger

DATE January 28, 2020

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.08
TOPSOIL 0.20						
Inferred **FILL:** Brown silty sand, trace clay and gravel 1.37					1	98.08
Inferred **GLACIAL TILL:** Brown silty sand, trace gravel 2.13					2	97.08
GLACIAL TILL: Brown sandy silt, trace clay, gravel and cobbles 4.57	SS	1	100	50+	3	96.08
	SS	2	29	30	4	95.08
GLACIAL TILL: Brown clayey silt to silty clay, trace sand 5.79	SS	3	83	4	5	94.08
	SS	4	79	9		

Running sand encountered at 5.79m depth, borehole terminated.

(GWL @ 2.56m - Feb. 11, 2020)



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DATE January 28, 2020

FILE NO. PG5131

HOLE NO. BH 6

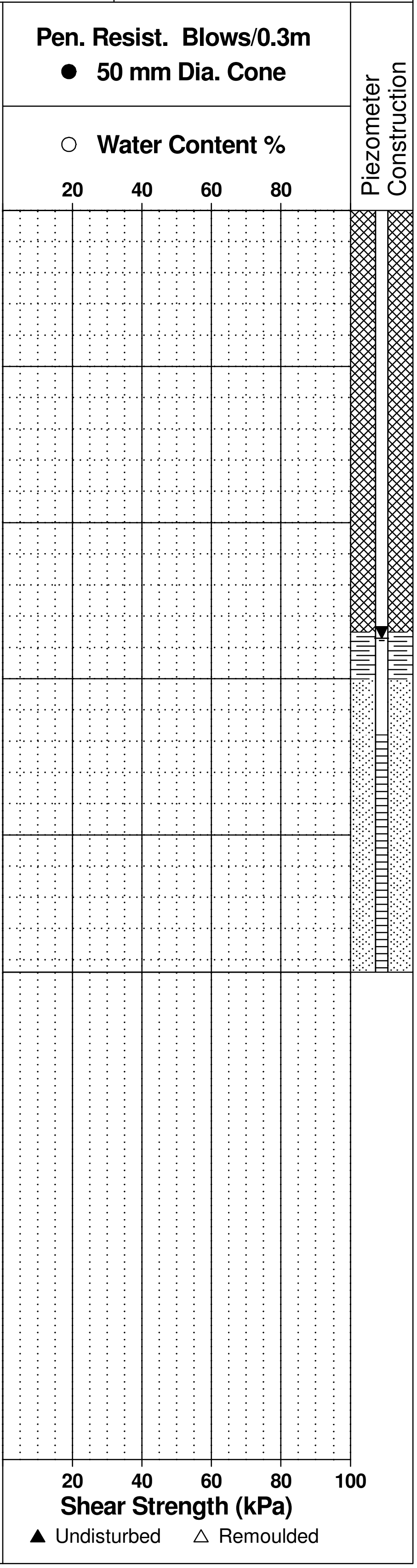
SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.30	AU	1		
GLACIAL TILL: Compact to very dense, brown silty sand, some gravel, trace clay - trace cobbles and boulders by 1.5m depth	SS	2	83	29
	SS	6	91	52
	SS	3	62	85
	SS	4	62	65
	SS	5	71	50+
4.88	SS	7	88	50+

DEPTH (m)	ELEV. (m)
0	98.68
1	97.68
2	96.68
3	95.68
4	94.68

End of Borehole

Practical refusal to augering at 4.88m depth

(GWL @ 2.74m - Feb. 11, 2020)



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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 28, 2020

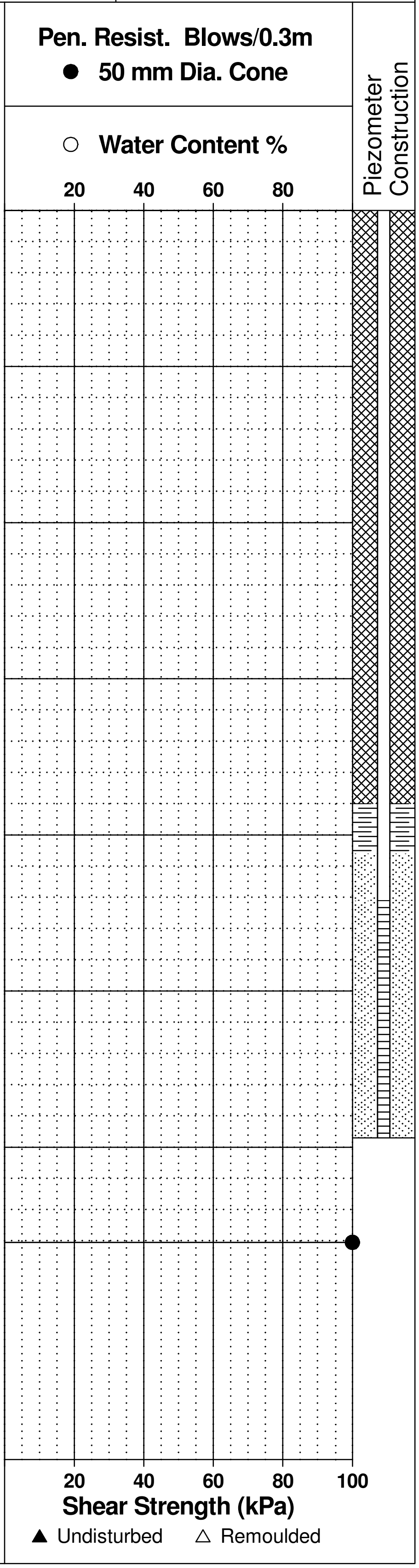
FILE NO. PG5131

HOLE NO. BH 7

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
TOPSOIL	0.28
GLACIAL TILL: Dense to very dense, brown silty sand, some gravel, trace cobbles and boulders	5.94
Dynamic Cone Penetration Test commenced at 5.94m depth. Inferred **GLACIAL TILL**	6.61
End of Borehole Practical DCPT refusal at 6.61m depth (Piezometer dry/blocked at 4.34m depth - Feb. 11, 2020)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	42
SS	3	93	50+
SS	4	100	50+
SS	5	100	50+
SS	6	79	49
SS	7	67	36
SS	8	50	71

DEPTH (m)	ELEV. (m)
0	102.53
1	101.53
2	100.53
3	99.53
4	98.53
5	97.53
6	96.53



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REMARKS

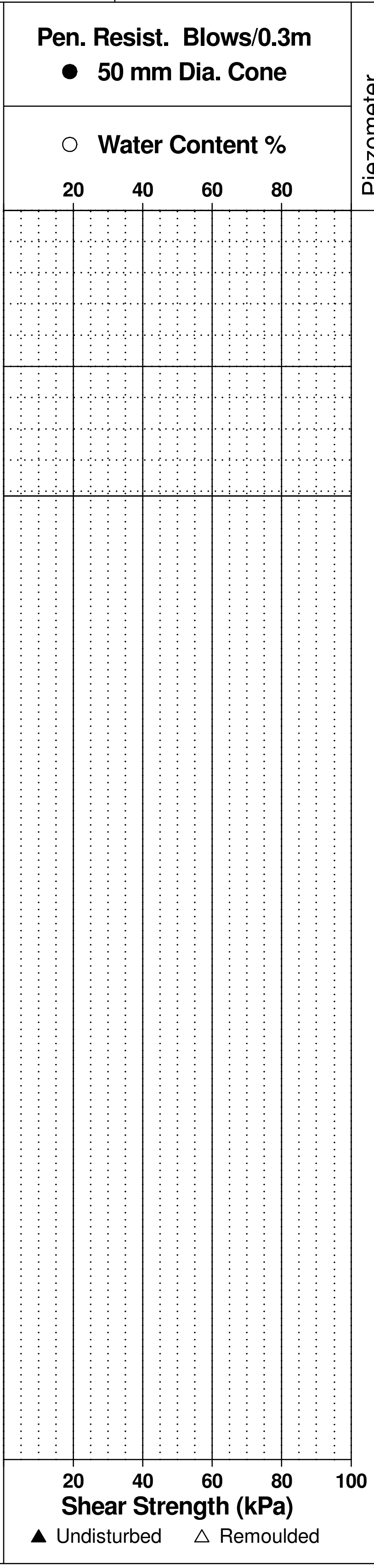
BORINGS BY CME 55 Power Auger

DATE January 28, 2020

FILE NO. PG5131

HOLE NO. BH 8

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			
GROUND SURFACE						0	96.97	
TOPSOIL 0.41		AU	1					
GLACIAL TILL: Very dense, brown sandy silt, some gravel, trace cobbles and boulders		SS	2	56	50+	1	95.97	
1.83		SS	3	67	50+			
End of Borehole Practical refusal to augering at 1.83m depth								



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Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5131**

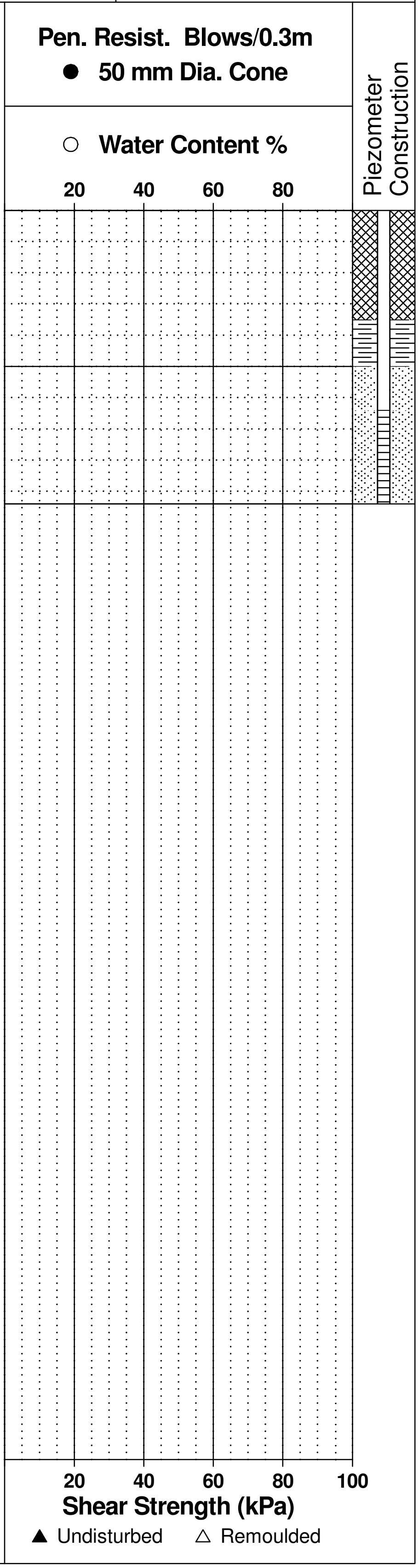
REMARKS

HOLE NO. **BH 8A**

BORINGS BY CME 55 Power Auger

DATE January 28, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	96.97
TOPSOIL 0.41							
Inferred **GLACIAL TILL:** Very dense, brown sandy silt, some gravel, trace cobbles and boulders						1	95.97
1.88							
End of Borehole Practical refusal to augering at 1.88m depth (Piezometer dry/blocked at 0.98m depth - Feb. 11, 2020)							



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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 29, 2020

FILE NO. PG5131

HOLE NO. BH 9

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	97.97		
TOPSOIL 0.30		AU	1						
GLACIAL TILL: Dense to very dense, brown sandy silt, some gravel		SS	2	58	38	1	96.97		
		SS	3	78	69	2	95.97		
2.51		SS	4	100	50+				
End of Borehole Practical refusal to augering at 2.51m depth									

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

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SOIL PROFILE AND TEST DATA

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Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5131

REMARKS

HOLE NO. BH 9A

BORINGS BY CME 55 Power Auger

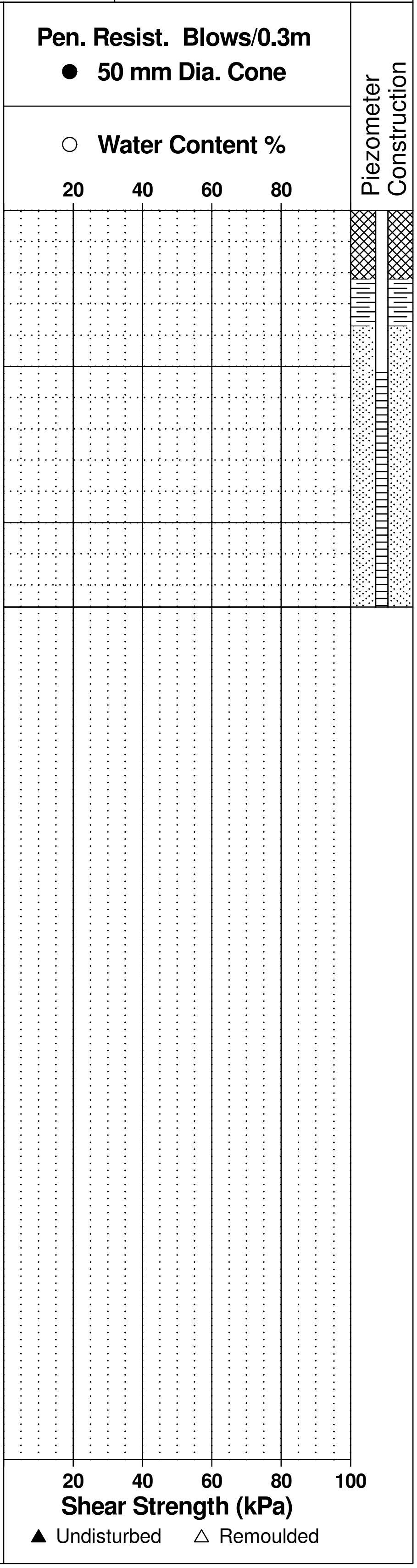
DATE January 29, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
GROUND SURFACE		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
						0	97.97
TOPSOIL 0.30							
Inferred **GLACIAL TILL:** Dense to very dense, brown sandy silt, some gravel						1	96.97
2.29						2	95.97
GLACIAL TILL: Very dense, brown sand with silt, some gravel 2.54		SS	1	100	50+		

End of Borehole

Practical refusal to augering at 2.54m depth

(Piezometer dry/blocked at 1.13m depth - Feb. 11, 2020)



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REMARKS

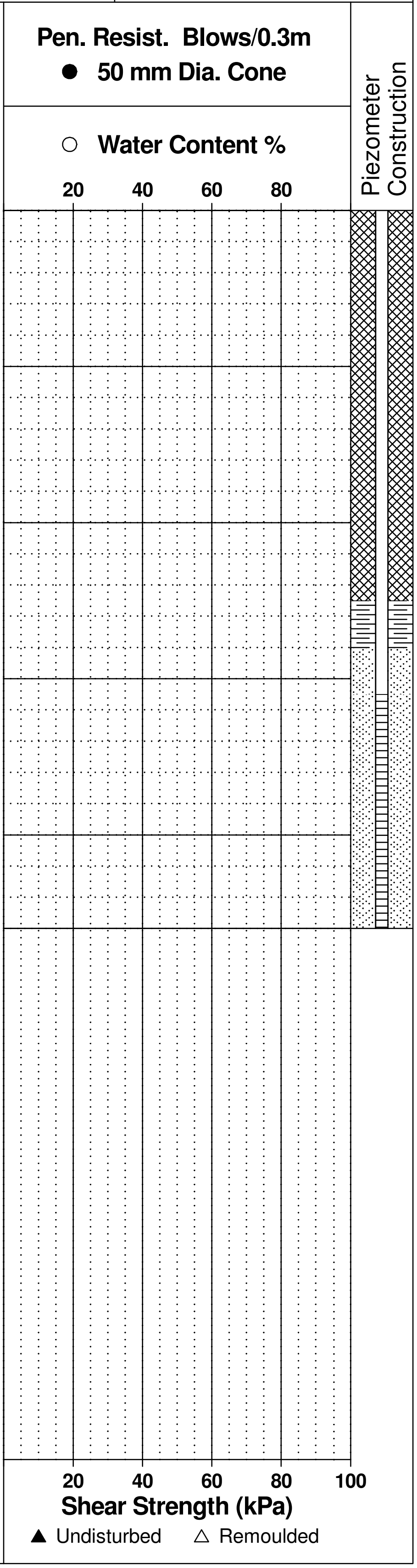
BORINGS BY CME 55 Power Auger

DATE January 29, 2020

FILE NO. PG5131

HOLE NO. BH10

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	98.70
TOPSOIL 0.28	AU	1				
	SS	2	71	38	1	97.70
	SS	3	82	50+		
GLACIAL TILL: Dense to very dense, brown silty sand, some gravel					2	96.70
	SS	4	67	65		
					3	95.70
	SS	5	58	64		
- grey by 3.7m depth						
	SS	6	50	75	4	94.70
4.60	SS	7	100	50+		
End of Borehole (Piezometer dry/blocked at 0.69m depth - Feb. 11, 2020)						



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DATUM Geodetic

FILE NO. PG5131

REMARKS

HOLE NO. BH10A

BORINGS BY CME 55 Power Auger

DATE January 29, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	98.70		
TOPSOIL 0.28									
						1	97.70		
Inferred **GLACIAL TILL:** Dense to very dense, brown silty sand, some gravel						2	96.70		
						3	95.70		
						4	94.70		
4.57									
End of Borehole Practical refusal to augering at 4.57m depth.									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 29, 2020

FILE NO. PG5131

HOLE NO. BH11

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.45
TOPSOIL 0.23		AU	1				
GLACIAL TILL: Very dense, brown silty sand with gravel and cobbles 1.52		SS	2	29	50+	1	98.45
GLACIAL TILL: Very dense, brown sand with gravel and cobbles		SS	3	67	83	2	97.45
2.59		SS	4	100	50+		
End of Borehole Practical refusal to augering at 2.59m depth							

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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DATUM Geodetic

FILE NO. PG5131

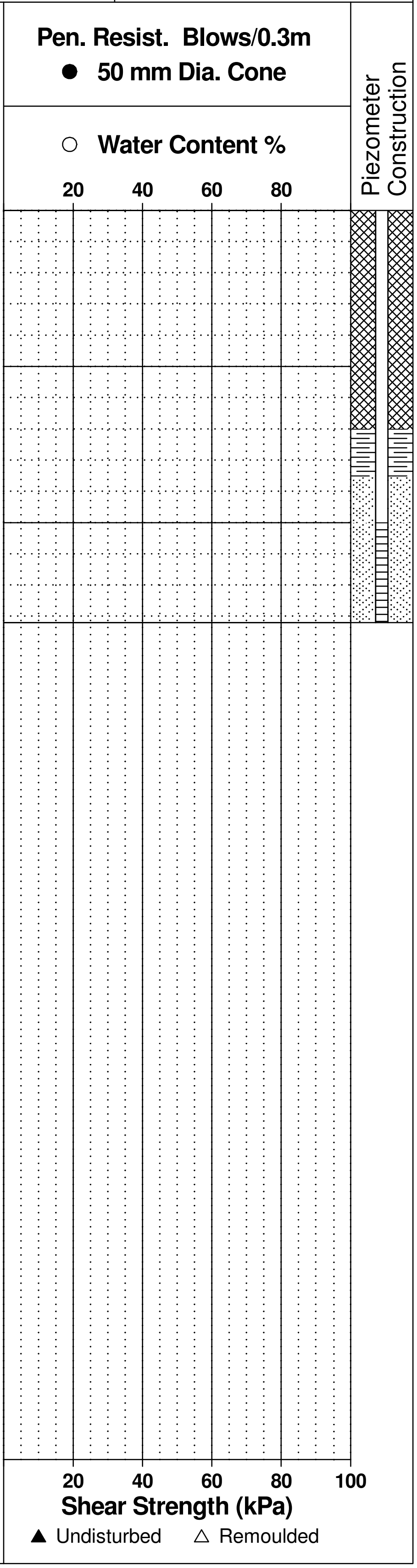
REMARKS

HOLE NO. BH11A

BORINGS BY CME 55 Power Auger

DATE January 29, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.45
TOPSOIL 0.23							
Inferred **GLACIAL TILL:** Very dense, brown silty sand with gravel and cobbles 1.52						1	98.45
Inferred **GLACIAL TILL:** Very dense, brown sand with gravel and cobbles 2.64						2	97.45
End of Borehole Practical refusal to augering at 2.64m depth (Piezometer blocked at ground surface - Feb. 11, 2020)							



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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 29, 2020

FILE NO. PG5131

HOLE NO. BH12

SOIL DESCRIPTION

GROUND SURFACE

SOIL DESCRIPTION	Depth (m)
TOPSOIL	0.23
GLACIAL TILL: Very dense to dense, brown silty sand, some gravel, cobbles and boulders	5.94
Dynamic Cone Penetration Test commenced at 5.94m depth. Inferred **GLACIAL TILL**	6.88

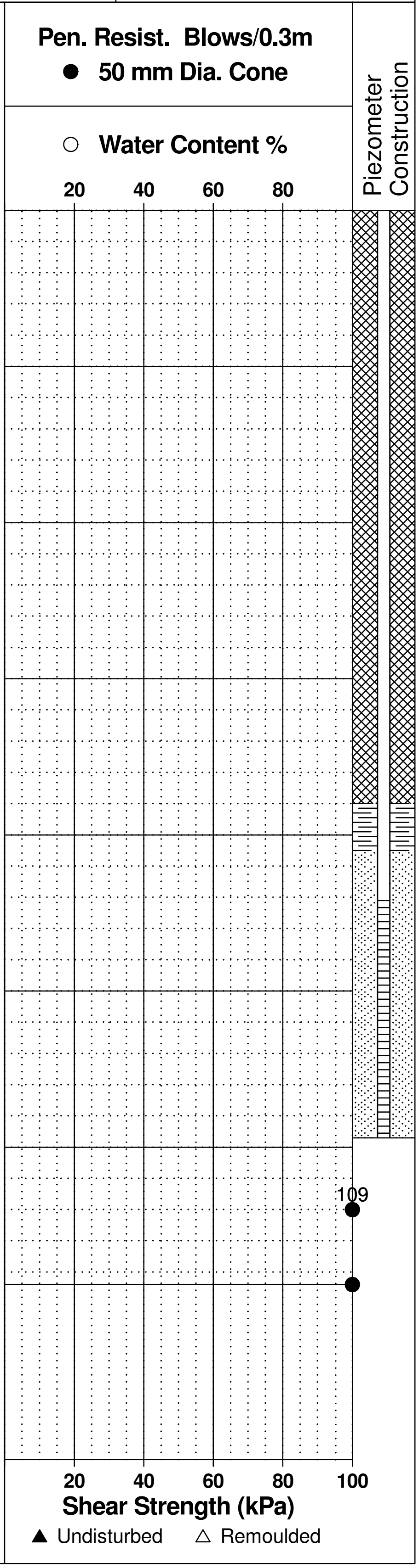
End of Borehole

Practical DCPT refusal at 6.88m depth.

(Piezometer dry/blocked at 4.06m depth - Feb. 11, 2020)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	92	57
SS	3	100	50+
SS	4	75	50+
SS	5	81	50+
SS	6	17	67
SS	7	58	46
SS	8	42	40

DEPTH (m)	ELEV. (m)
0	100.35
1	99.35
2	98.35
3	97.35
4	96.35
5	95.35
6	94.35



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FILE NO. PG5131

REMARKS

HOLE NO. BH13

BORINGS BY CME 55 Power Auger

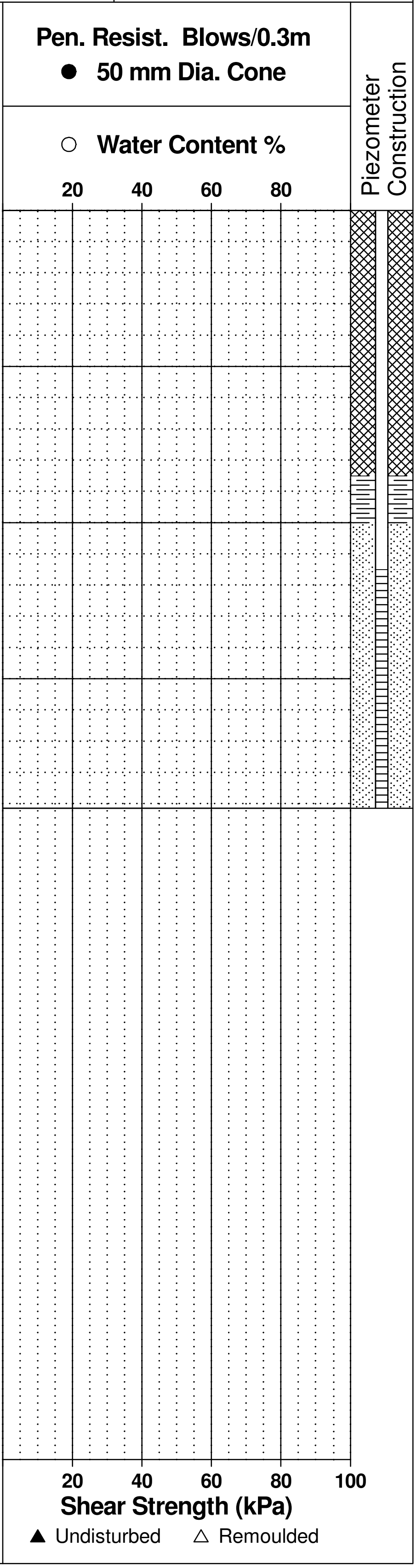
DATE January 30, 2020

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.99
TOPSOIL 0.18	AU	1				
	SS	2	80	50+		
					1	98.99
GLACIAL TILL: Very dense, brown silty sand, some gravel, trace clay, cobbles and boulders	SS	3	100	50+		
					2	97.99
	SS	4	87	73		
	SS	5	0	50+		
					3	96.99
3.83	SS	6	0	50+		

End of Borehole

Practical refusal to augering at 3.83m depth.

(Piezometer dry/blocked at 2.44m depth - Feb. 11, 2020)



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FILE NO. PG5131

REMARKS

HOLE NO. BH13A

BORINGS BY CME 55 Power Auger

DATE January 30, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	99.99		
TOPSOIL 0.18									
Inferred **GLACIAL TILL:** Very dense, brown silty sand, some gravel, trace clay, cobbles and boulders						1	98.99		
						2	97.99		
2.51									
End of Borehole Practical refusal to augering at 2.51m depth.									

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

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BORINGS BY CME 55 Power Auger

DATE January 30, 2020

FILE NO. PG5131

HOLE NO. BH14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	97.48		
TOPSOIL 0.60		AU	1						
GLACIAL TILL: Compact, brown silty sand, trave gravel 1.40		SS	2	67	16	1	96.48		
End of Borehole Practical refusal to augering at 1.40m depth.									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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BORINGS BY CME 55 Power Auger
DATE January 30, 2020
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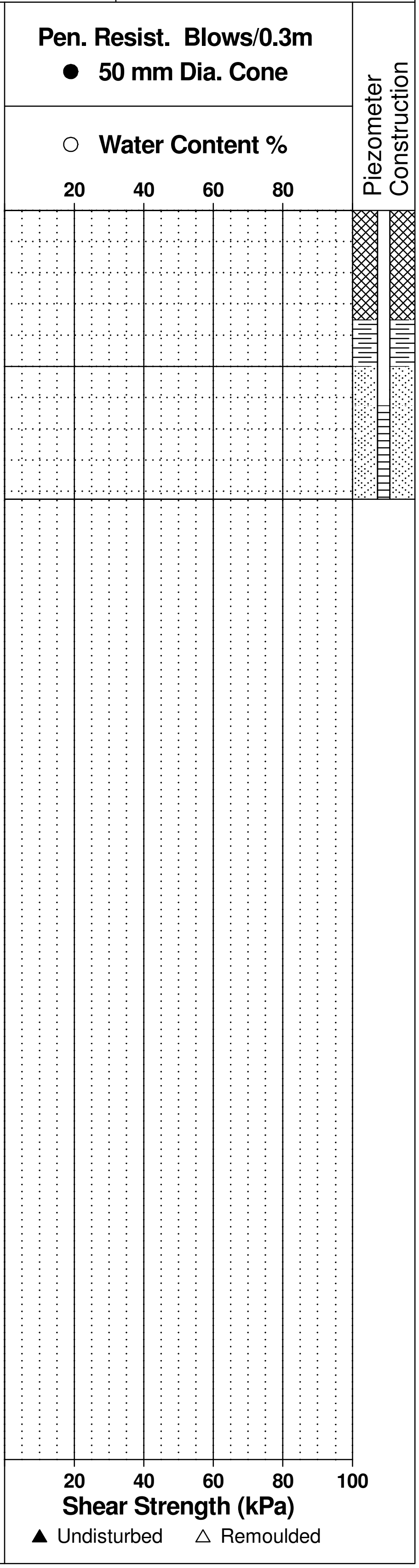
HOLE NO. BH14A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	97.48
TOPSOIL 0.60							
Inferred **GLACIAL TILL:** Compact, brown silty sand, trave gravel						1	96.48
1.85		SS	1		50+		
End of Borehole Practical refusal to augering at 1.85m depth. (Piezometer dry/blocked at 1.17m depth - Feb. 11, 2020)							



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BORINGS BY CME 55 Power Auger

DATE January 30, 2020

FILE NO. PG5131

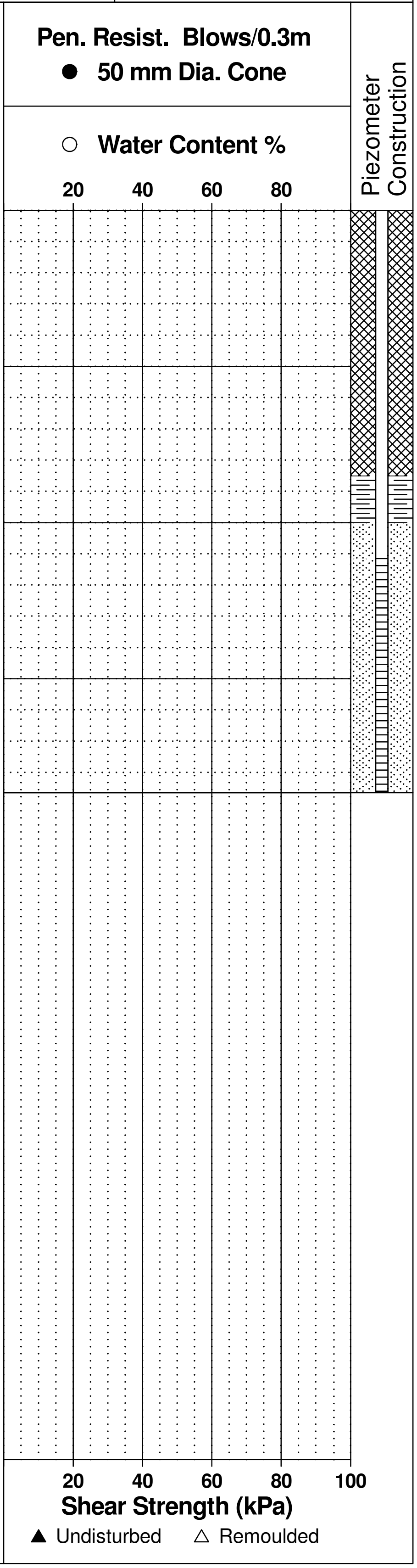
HOLE NO. BH15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.55
TOPSOIL		AU	1				
0.60							
		SS	2	75	39	1	97.55
		SS	3	0	50+		
GLACIAL TILL: Dense to very dense, brown silty sand, trace gravel, cobbles and boulders						2	96.55
		SS	4	100	50+		
						3	95.55
3.73							

End of Borehole

Practical refusal to augering at 3.73m depth

(Piezometer dry/blocked at 2.15m depth - Feb. 11, 2020)



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BORINGS BY CME 55 Power Auger

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HOLE NO. BH15A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	98.55		
TOPSOIL 0.60									
Inferred **GLACIAL TILL:** Dense to very dense, brown silty sand, trace gravel, cobbles and boulders 1.93						1	97.55		
End of Borehole Practical refusal to augering at 1.93m depth									

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

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FILE NO. PG5131

REMARKS

HOLE NO. BH16

BORINGS BY CME 55 Power Auger

DATE January 30, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	97.28		
TOPSOIL 0.33		AU	1						
GLACIAL TILL: Compact to very dense, brown sandy silt with clay, trace gravel and cobbles		SS	2	92	25	1	96.28		
		SS	3	46	65	2	95.28		
2.74		SS	4	92	50+				
End of Borehole Practical refusal to augering at 2.74m depth.									

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

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BORINGS BY CME 55 Power Auger

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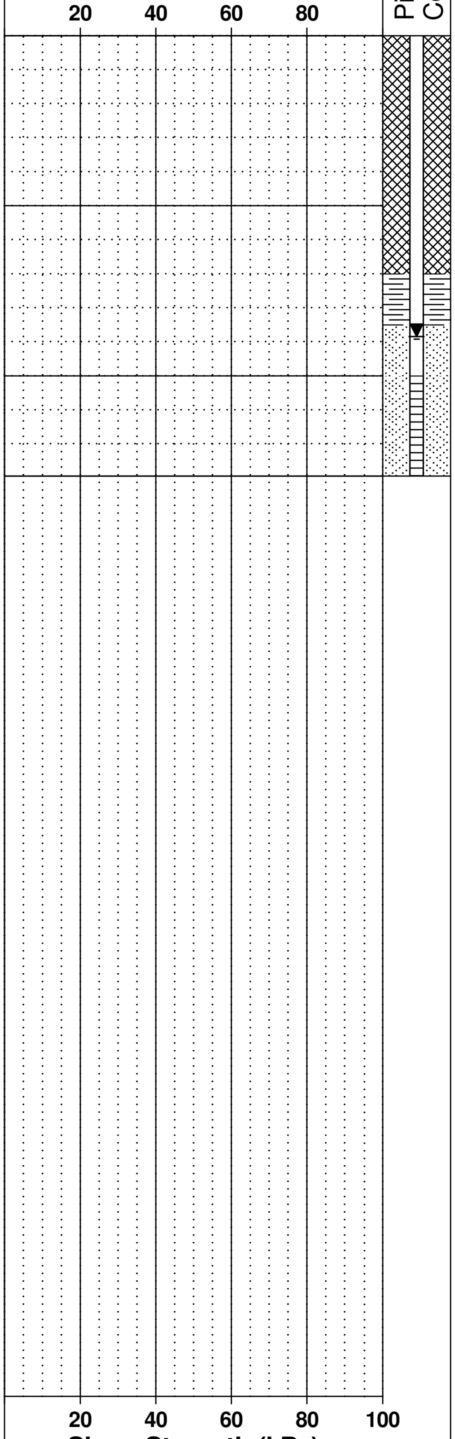
HOLE NO. BH16A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	97.28
TOPSOIL 0.33							
Inferred **GLACIAL TILL:** Compact to very dense, brown sandy silt with clay, trace gravel and cobbles 2.59						1	96.28
						2	95.28
End of Borehole Practical refusal to augering at 2.59m depth. (GWL @ 1.77m - Feb. 11, 2020)							

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

○ **Water Content %**

Piezometer Construction



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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HOLE NO. BH17

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
TOPSOIL	0.25
GLACIAL TILL: Dense to compact, brown silty sand, trace clay, gravel and cobbles	4.20
GLACIAL TILL: Compact to very dense, brown silty sand with gravel	5.69

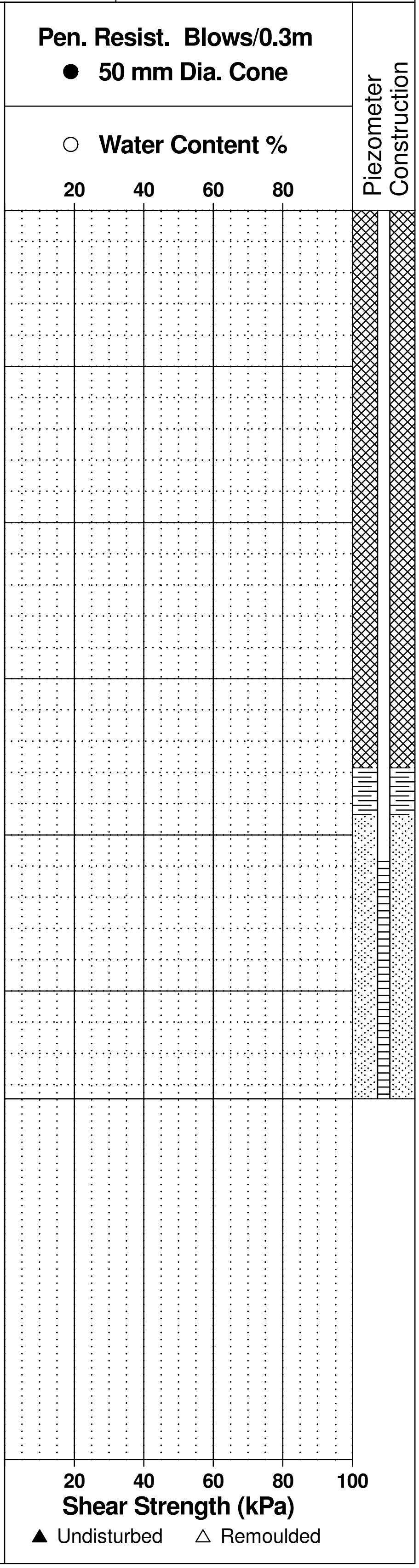
SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
SS	1		
SS	2	33	33
SS	3	71	40
SS	4	50	50+
SS	5	62	16
SS	6	58	15
SS	7	17	42
SS	8	57	50+

DEPTH (m)	ELEV. (m)
0	98.09
1	97.09
2	96.09
3	95.09
4	94.09
5	93.09

End of Borehole

Practical refusal to augering at 5.69m depth.

(Piezometer dry/blocked at 2.30m depth - Feb. 11, 2020)



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BORINGS BY CME 55 Power Auger

DATE January 31, 2020

FILE NO. PG5131

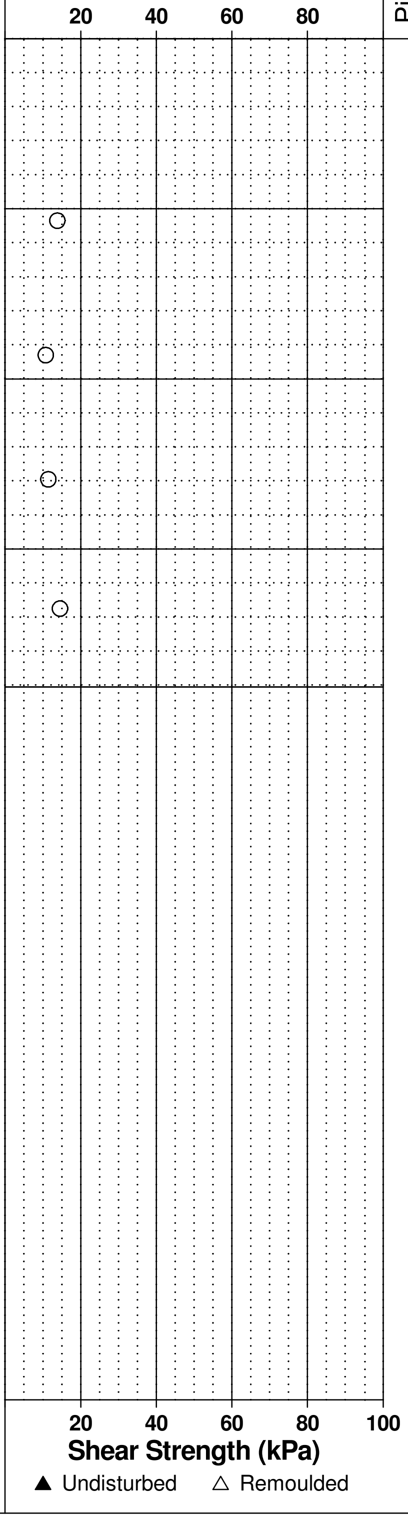
HOLE NO. BH18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	96.41
Brown **SILTY CLAY,** trace organics		AU	1				
1.07		SS	2	96	8	1	95.41
GLACIAL TILL: Brown clayey silt with sand and gravel		SS	3	33	13		
						2	94.41
2.30							
GLACIAL TILL: Compact, brown silty sand, trace clay		SS	4	62	27		
3.00						3	93.41
GLACIAL TILL: Compact, brown sand, trace silt and gravel		SS	5	54	14		
3.81							
Running sand encountered at 3.81m depth, borehole terminated.							

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

○ **Water Content %**

Piezometer Construction



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FILE NO. **PG5131**

REMARKS

HOLE NO. **BH18A**

BORINGS BY CME 55 Power Auger

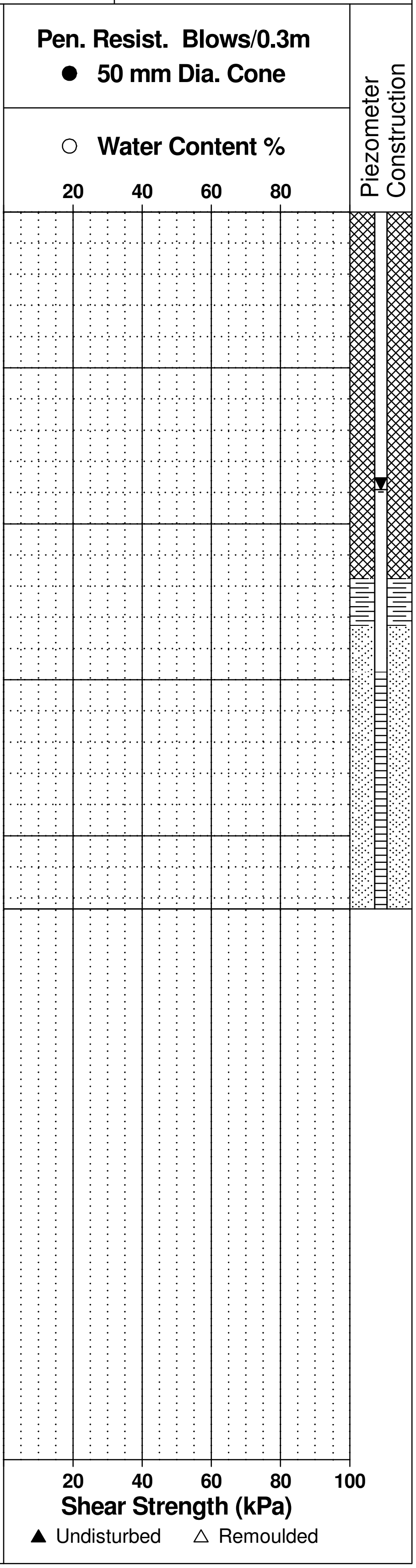
DATE January 31, 2020

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	96.41
Brown **SILTY CLAY,** trace organics						
1.07					1	95.41
Inferred **GLACIAL TILL:** Brown clayey silt with sand and gravel						
2.30					2	94.41
Inferred **GLACIAL TILL:** Compact, brown silty sand, trace clay						
3.00					3	93.41
GLACIAL TILL: Compact to dense, brown sand, trace silt and gravel					4	92.41
	SS	1	33	32		
4.47						

End of Borehole

Practical refusal to augering at 4.47m depth.

(GWL @ 1.78m - Feb. 11, 2020)



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BORINGS BY CME 55 Power Auger

DATE January 31, 2020

FILE NO. PG5131

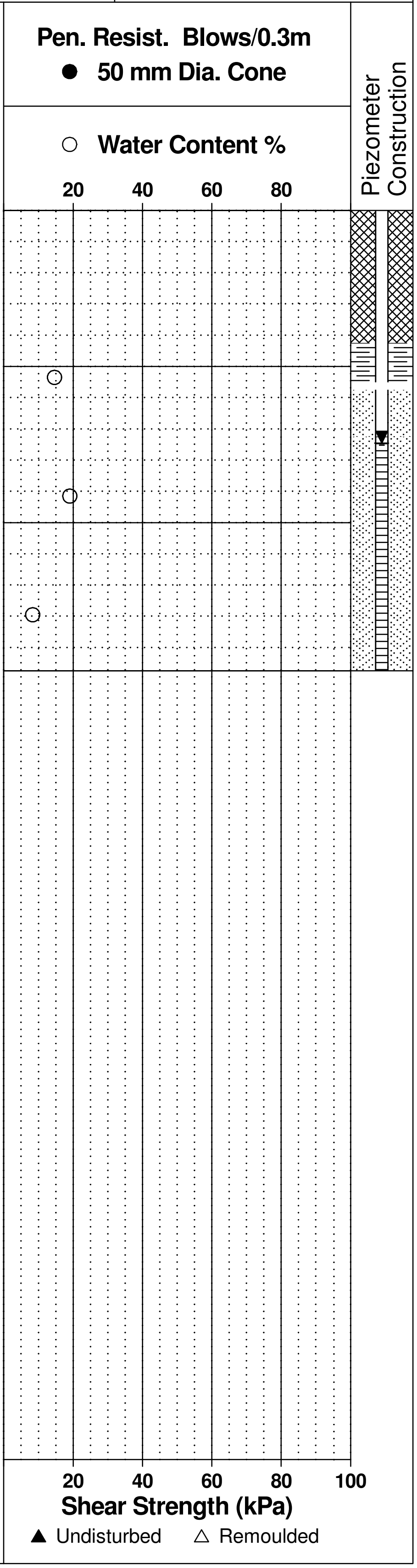
HOLE NO. BH19

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.95
TOPSOIL 0.60		AU	1				
Brown **SILTY CLAY** 1.52		SS	2	100	6	1	94.95
GLACIAL TILL: Brown silty clay, trace sand and gravel 2.30		SS	3	46	13	2	93.95
GLACIAL TILL: Dense, brown silty sand, trace gravel and cobbles 2.95		SS	4	54	32		

End of Borehole

Practical refusal to augering at 2.95m depth.

(GWL @ 1.49m - Feb. 11, 2020)



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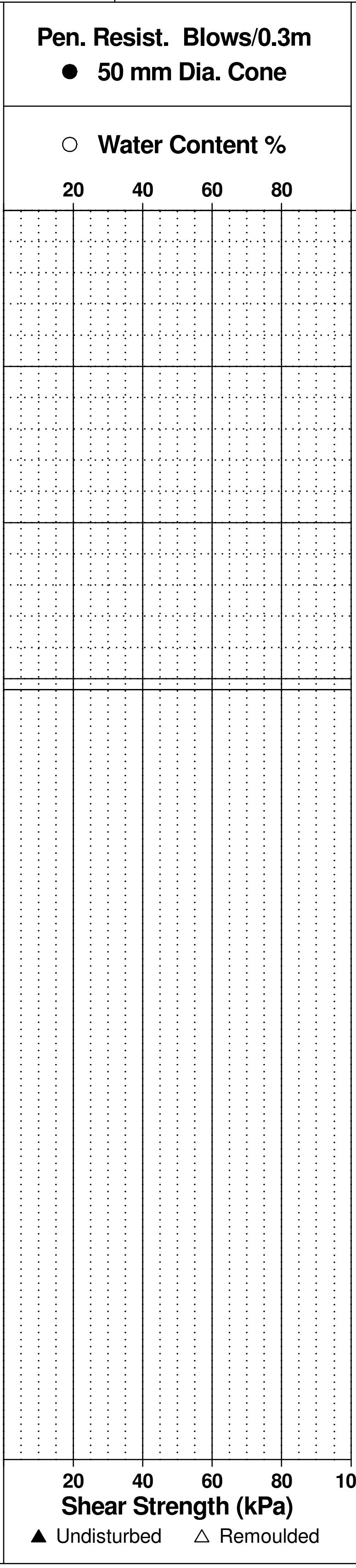
HOLE NO. BH19A

BORINGS BY CME 55 Power Auger

DATE January 31, 2020

SOIL DESCRIPTION GROUND SURFACE	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
						0	95.95
TOPSOIL 0.60							
Inferred brown **SILTY CLAY** 1.52						1	94.95
Inferred **GLACIAL TILL:** Brown silty clay, trace sand and gravel 2.30						2	93.95
GLACIAL TILL: Very dense, brown silty sand, trace gravel and cobbles						3	92.95
3.07		SS	1	0	50+		
End of Borehole Practical refusal to augering at 3.07m depth.							



Piezometer Construction

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BORINGS BY CME 55 Power Auger

DATE January 31, 2020

FILE NO. PG5131

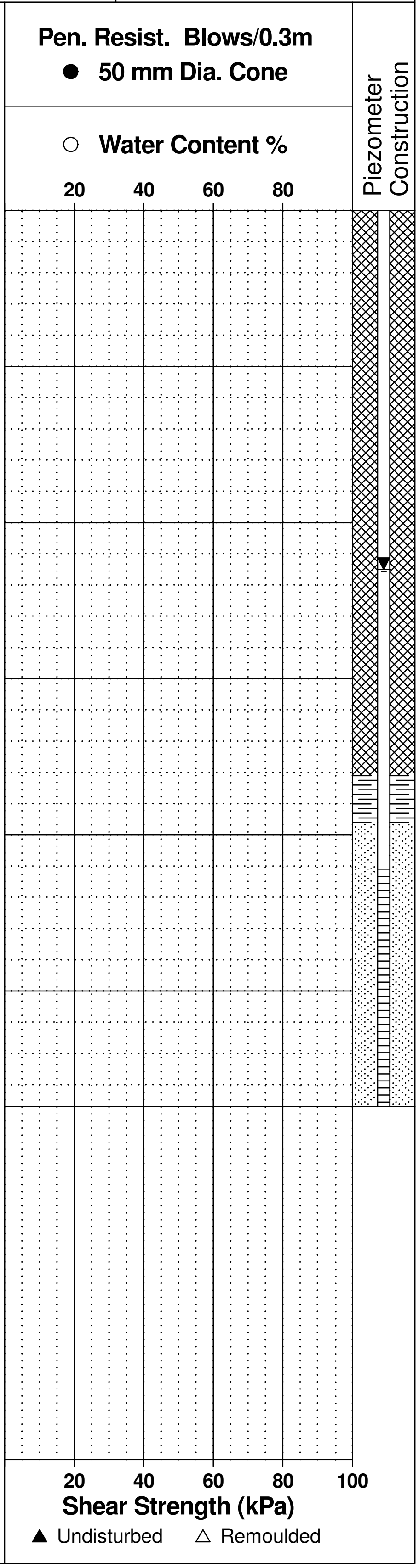
HOLE NO. BH20

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	96.34
TOPSOIL 0.25		AU	1				
GLACIAL TILL: Dense, brown sandy silt, trace clay and gravel		SS	2	92	30	1	95.34
		SS	3	0	50+		
2.30						2	94.34
GLACIAL TILL: Brown clayey silt, some sand, trace gravel and cobbles 3.05		SS	4	83	36		
GLACIAL TILL: Dense, brown sandy silt, trace clay, gravel and cobbles 3.80		SS	5	8	17	3	93.34
GLACIAL TILL: Compact to very dense, grey silty sand to sandy silt, trace gravel and cobbles		SS	6	62	28	4	92.34
		SS	7	50	36	5	91.34
5.74		SS	8	50	50+		

End of Borehole

Practical refusal to augering at 5.74m depth

(GWL @ 2.30m - Feb. 11, 2020)



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DATE January 31, 2020
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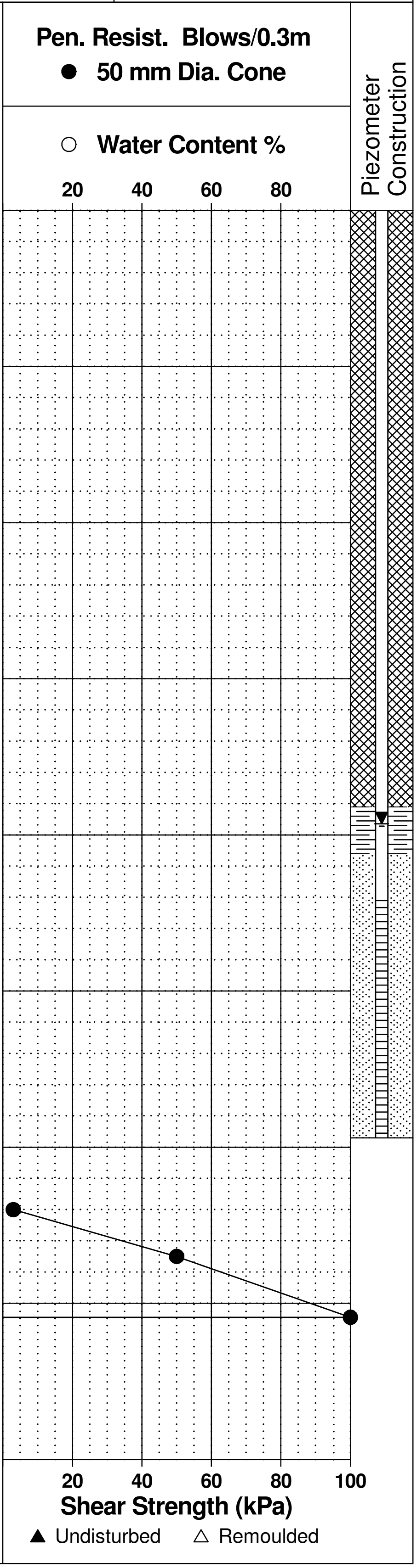
HOLE NO. BH21

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	96.93
Brown **SILTY CLAY,** some sand	AU	1				
	SS	2	62	11	1	95.93
1.52						
GLACIAL TILL: Brown silty clay, some sand, trace gravel and cobbles	SS	3	62	20	2	94.93
	SS	4	92	20		
	SS	5	38	10	3	93.93
	SS	6	71	9	4	92.93
	SS	7	67	9	5	91.93
	SS	8	100	50+		
5.94					6	90.93
Dynamic Cone Penetration Test commenced at 5.94m depth. Inferred **GLACIAL TILL**					7	89.93
7.09						

End of Borehole
Practical DCPT refusal at 7.09m depth

(GWL @ 3.93m - Feb. 11, 2020)



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BORINGS BY CME 55 Power Auger

DATE February 3, 2020

FILE NO. PG5131

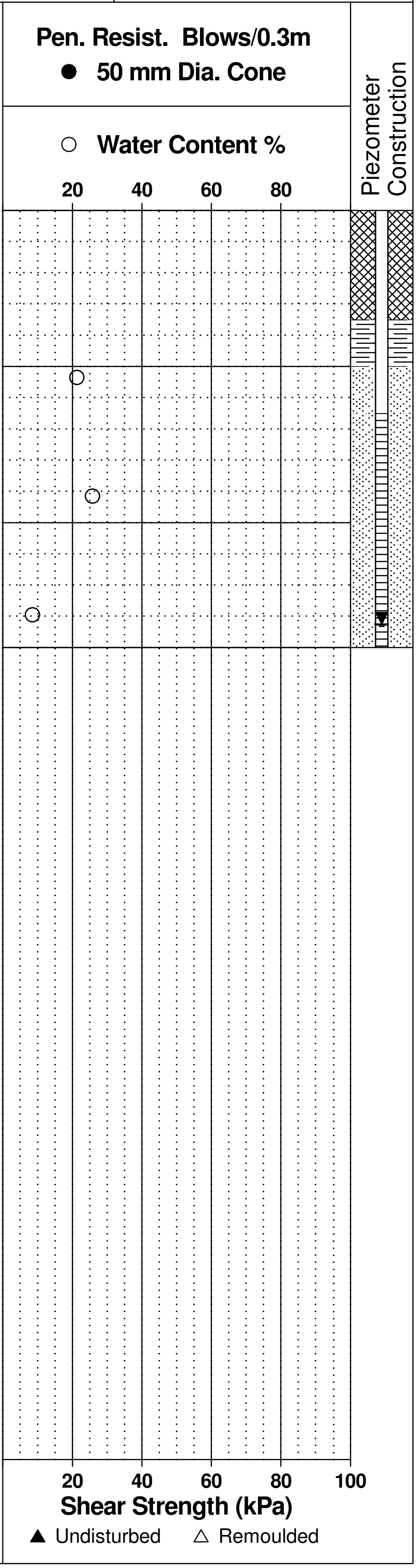
HOLE NO. BH22

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	95.53
FILL: Brown sand with gravel 0.41	AU	1				
FILL: Brown silty clay, trace sand and gravel	SS	2	67	23	1	94.53
1.85	SS	3	96	8	2	93.53
Brown **SILTY CLAY,** trace sand 2.62	SS	3	90	19		
GLACIAL TILL: Brown sand with silt, gravel, some clay 2.80						

End of Borehole

Practical refusal to augering at 2.80m depth

(GWL @ 2.65m - Feb. 11, 2020)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5131

REMARKS

HOLE NO. BH22A

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	95.53		
FILL: Brown sand with gravel 0.41									
Inferred **FILL:** Brown silty clay, trace sand and gravel 1.85						1	94.53		
Inferrred brown **SILTY CLAY,** trace sand 2.62						2	93.53		
Inferred **GLACIAL TILL:** Brown sand with silt, gravel, some clay 2.84									
End of Borehole Practical refusal to augering at 2.84m depth									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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BORINGS BY CME 55 Power Auger

DATE February 3, 2020

FILE NO. PG5131

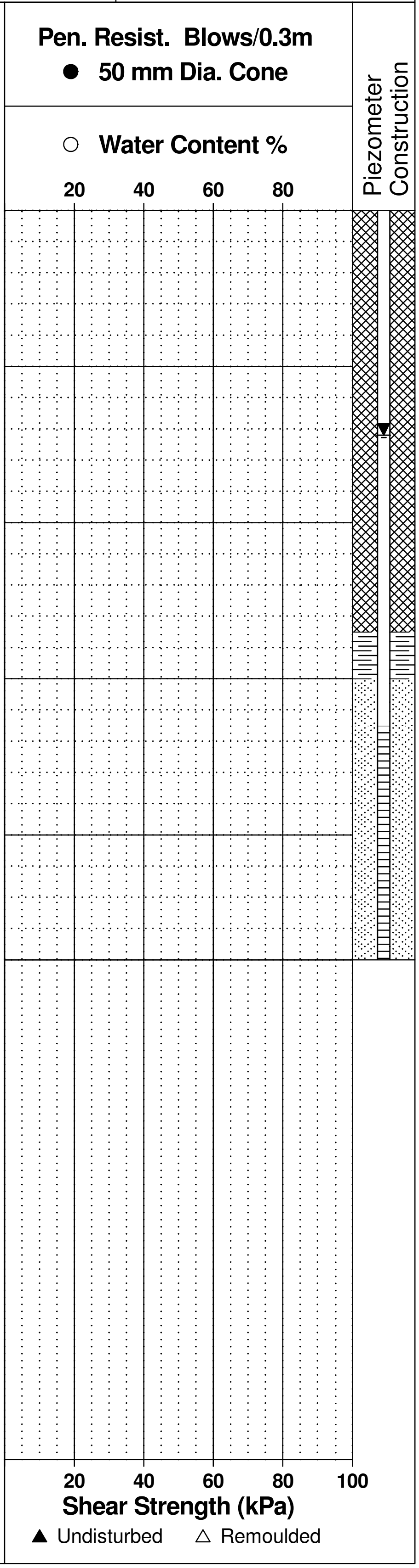
HOLE NO. BH23

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.15
TOPSOIL	0.38	AU	1				
Very loose, brown **SILTY SAND** with clay	1.24	SS	2	58	3	1	97.15
GLACIAL TILL: Very dense, brown sand, some silt and gravel, trace cobbles and boulders	4.57	SS	3	59	50+	2	96.15
		SS	4	92	54	3	95.15
		SS	5	54	75		
		SS	6	0	50+	4	94.15
GLACIAL TILL: Grey clayey silt with gravel and sand, trace cobbles and boulders	4.80	SS	7	100	50+		

End of Borehole

Practical refusal to augering at 4.80m depth

(GWL @ 1.44m - Feb. 11, 2020)



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Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5131

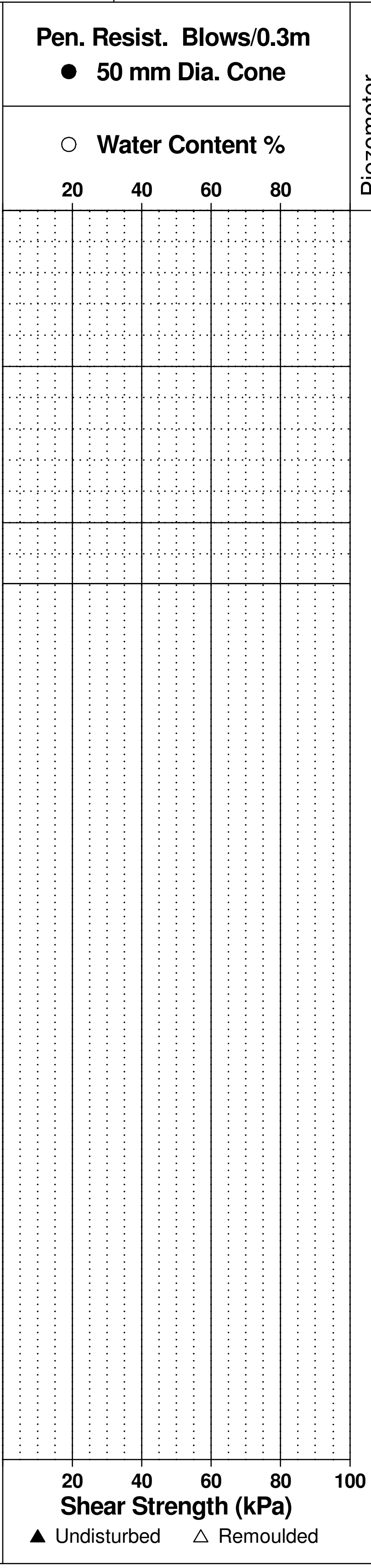
REMARKS

HOLE NO. BH24

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	96.53	
Loose, brown **SAND,** some silt and clay, trace gravel and organics		AU	1					
0.84								
GLACIAL TILL: Very dense, brown silty sand with clay, trace gravel, cobbles and boulders		SS	2	54	8	1	95.53	
		SS	3	12	50+			
						2	94.53	
2.39		SS	4	0	50+			
End of Borehole Practical refusal to augering at 2.39m depth								



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REMARKS

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

FILE NO. PG5131

HOLE NO. BH24A

SOIL DESCRIPTION

GROUND SURFACE

Loose, brown **SAND,** some silt and clay, trace gravel and organics

0.84

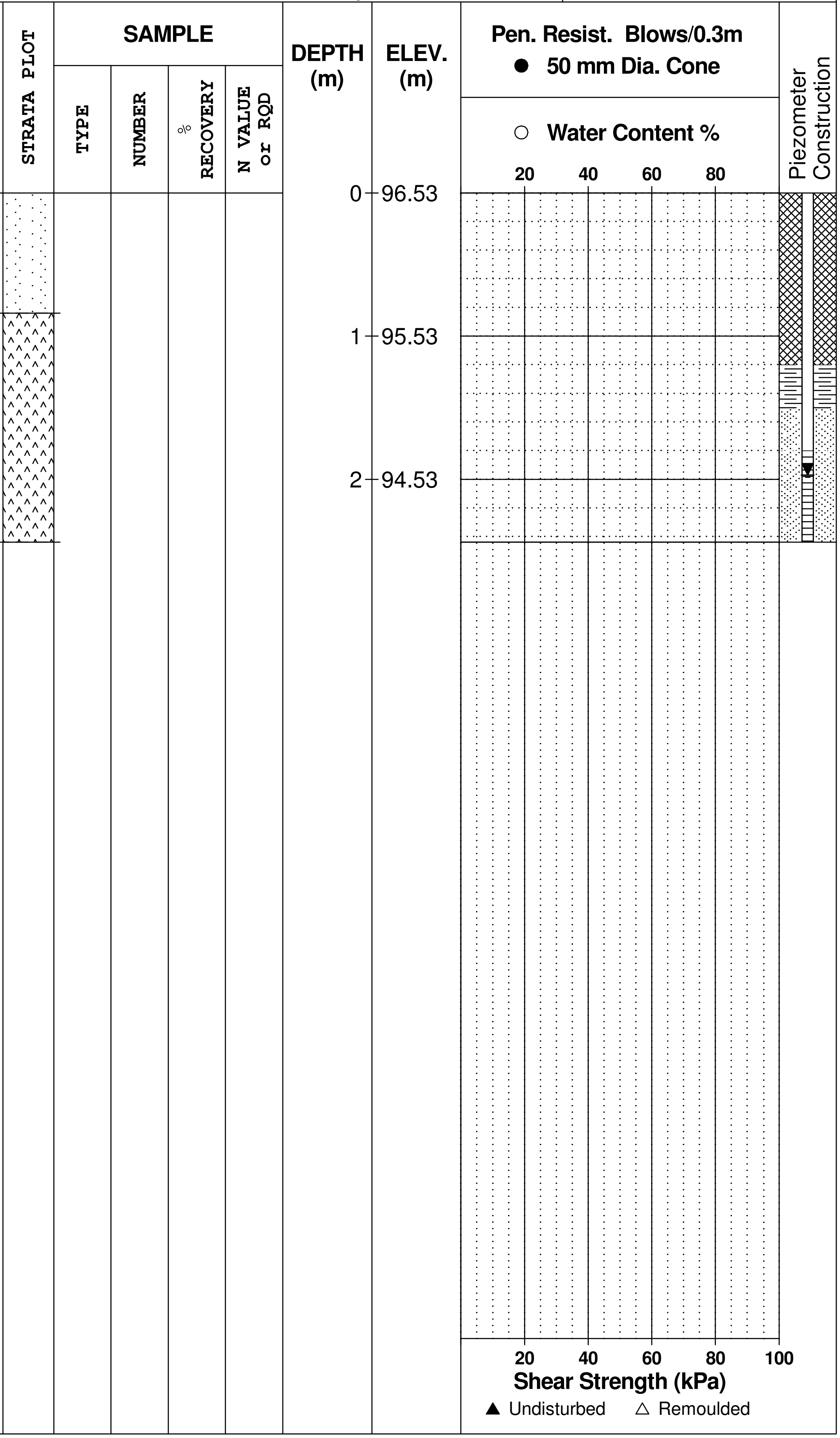
Inferred **GLACIAL TILL:** Very dense, brown silty sand with clay, trace gravel, cobbles and boulders

2.44

End of Borehole

Practical refusal to augering at 2.44m depth

(GWL @ 1.97m - Feb. 11, 2020)



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FILE NO. **PG5131**

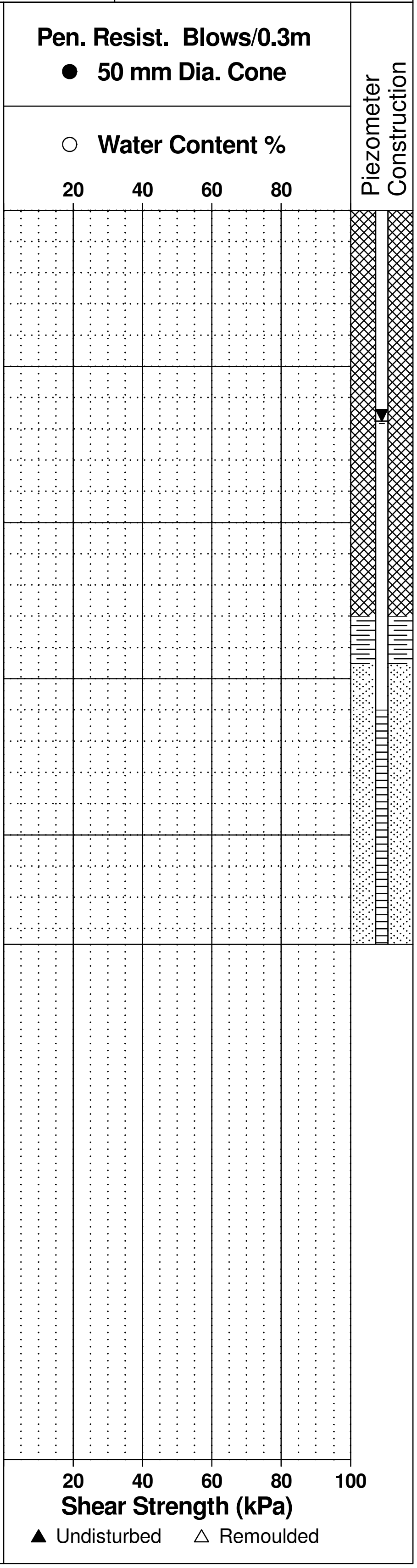
REMARKS

HOLE NO. **BH25**

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.59
Brown **SILTY CLAY**		AU	1				
0.60							
		SS	2	50	16	1	94.59
GLACIAL TILL: Loose to compact, brown sandy silt to silty sand, trace clay and gravel		SS	3	88	26	2	93.59
2.77		SS	4	75	25		
						3	92.59
GLACIAL TILL: Compact to very dense, brown sand, trace clay, silt and gravel		SS	5	58	20		
- grey by 3.2m depth		SS	6	50	24	4	91.59
4.70		SS	7	100	50+		
End of Borehole Practical refusal to augering at 4.70m depth. (GWL @ 1.35m - Feb. 11, 2020)							



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REMARKS

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

FILE NO. PG5131

HOLE NO. BH26

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	96.82
TOPSOIL 0.28	AU	1				
Compact, brown **SILTY SAND,** some clay 1.12	SS	2	67	24	1	95.82
GLACIAL TILL: Compact to very dense, brown sand, some silt and gravel, trace cobbles and boulders 2.29	SS	3	71	55	2	94.82
GLACIAL TILL: Dense to very dense, grey silty sand, some gravel and cobbles	SS	4	62	34	3	93.82
3.43	SS	5	60	50+		

End of Borehole

Practical refusal to augering at 3.43m depth.

(GWL @ 3.07m - Feb. 11, 2020)

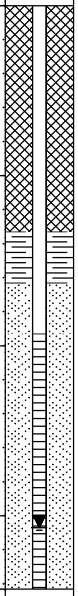
Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

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

Piezometer Construction



SOIL PROFILE AND TEST DATA

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Riverside South Development - Phase 17
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 3, 2020

FILE NO. PG5131

HOLE NO. BH26A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	96.82		
TOPSOIL 0.28									
Inferred compact, brown **SILTY SAND,** some clay 1.12						1	95.82		
Inferred **GLACIAL TILL:** Compact to very dense, brown sand, some silt and gravel, trace cobbles and boulders 2.29						2	94.82		
Inferred **GLACIAL TILL:** Dense to very dense, grey silty sand, some gravel and cobbles 3.48						3	93.82		
End of Borehole Practical refusal to augering at 3.48m depth.									

20 40 60 80

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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REMARKS

BORINGS BY CME 55 Power Auger

DATE February 4, 2020

FILE NO. PG5131

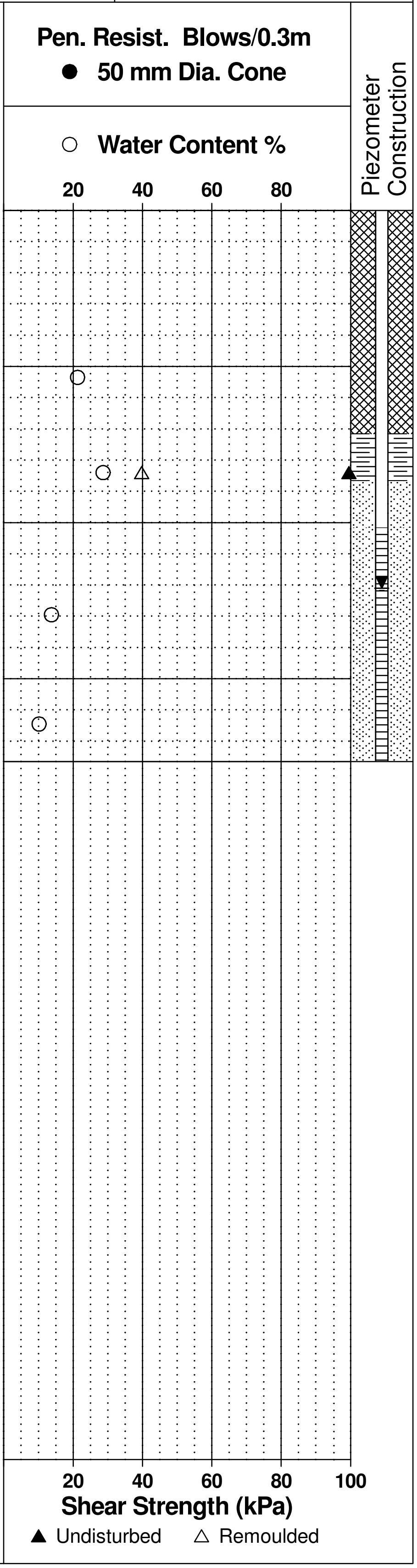
HOLE NO. BH27

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.96
TOPSOIL 0.25		AU	1				
Brown **SILTY CLAY,** trace sand		SS	2	96	6	1	93.96
2.39						2	92.96
GLACIAL TILL: Brown sandy silt to silty sand with clay, some gravel, trace cobbles and boulders		SS	4	62	4	3	91.96
3.53		SS	5	26	50+		

End of Borehole

Practical refusal to augering at 3.53m depth.

(GWL @ 2.42m - Feb. 11, 2020)



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REMARKS

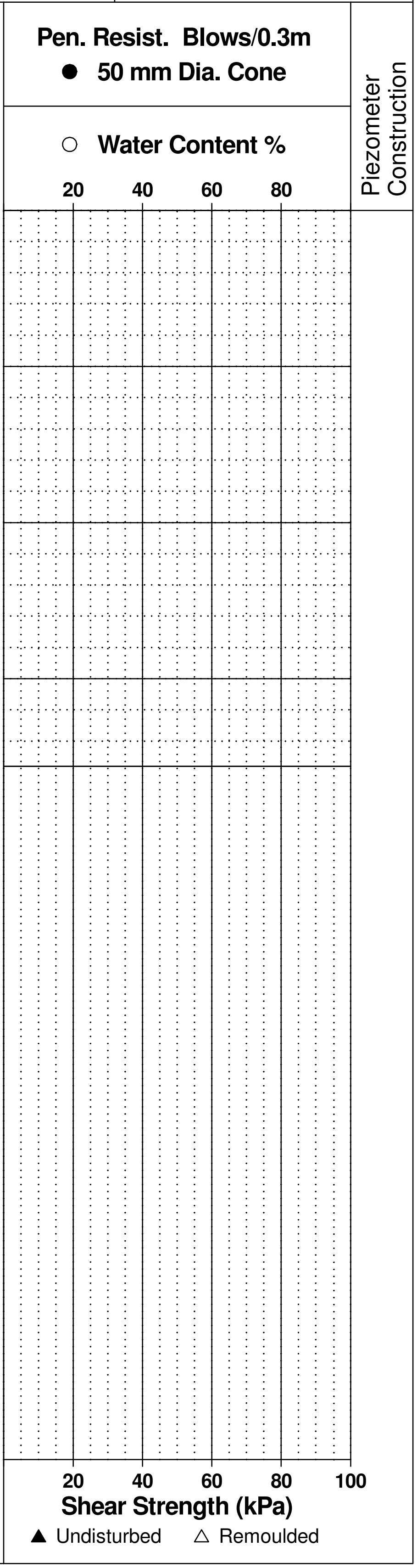
BORINGS BY CME 55 Power Auger

DATE February 4, 2020

FILE NO. PG5131

HOLE NO. BH27A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.96
TOPSOIL 0.25	■						
Inferred brown **SILTY CLAY,** trace sand 2.39	▨					1	93.96
						2	92.96
Inferrred **GLACIAL TILL:** Brown sandy silt to silty sand with clay, some gravel, trace cobbles and boulders 3.56	^^^					3	91.96
End of Borehole Practical refusal to augering at 3.56m depth.							



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Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 4, 2020

FILE NO. PG5131

HOLE NO. BH28

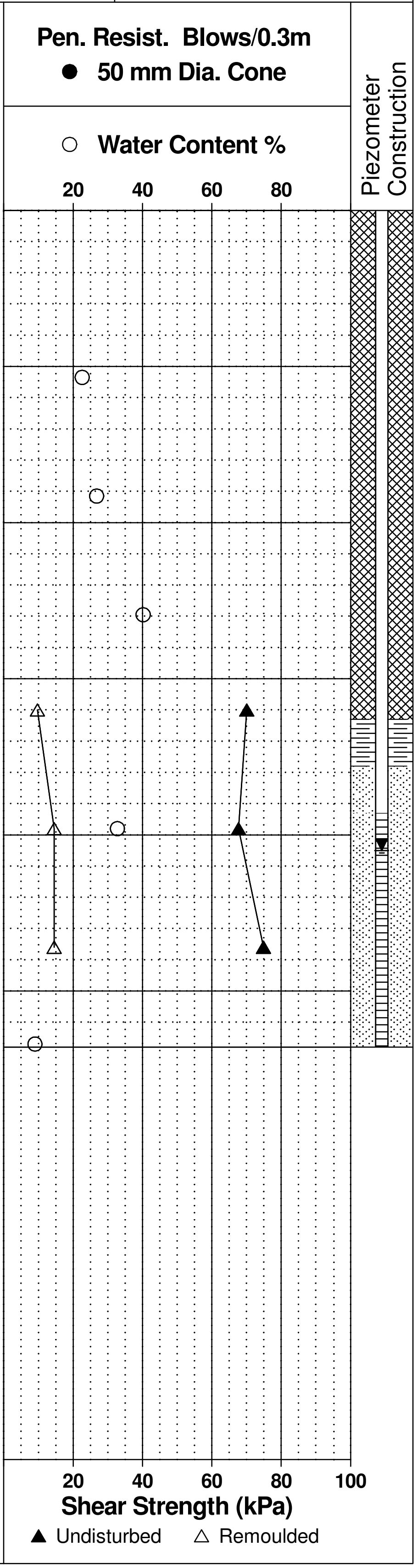
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
TOPSOIL 0.46		AU	1		
Brown **CLAYEY SILT** with sand 1.70		SS	2	79	5
Stiff, brown **SILTY CLAY** - grey by 2.8m depth 5.18		SS	3	79	2
		SS	4	100	2
GLACIAL TILL: Grey clayey silt with sand and gravel 5.36		SS	5	100	50+

DEPTH (m)	ELEV. (m)
0	93.75
1	92.75
2	91.75
3	90.75
4	89.75
5	88.75

End of Borehole

Practical refusal to augering at 5.36m depth.

(GWL @ 4.10m - Feb. 11, 2020)



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 strength of cohesionless soils is the relative density, 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.

Relative Density	‘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 vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

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 is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

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 NXL size core. However, it can be used on smaller core sizes, such as BX, 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

PS - Piston sample

AU - Auger sample or bulk sample

WS - Wash sample

RC - Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture 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 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 x 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)

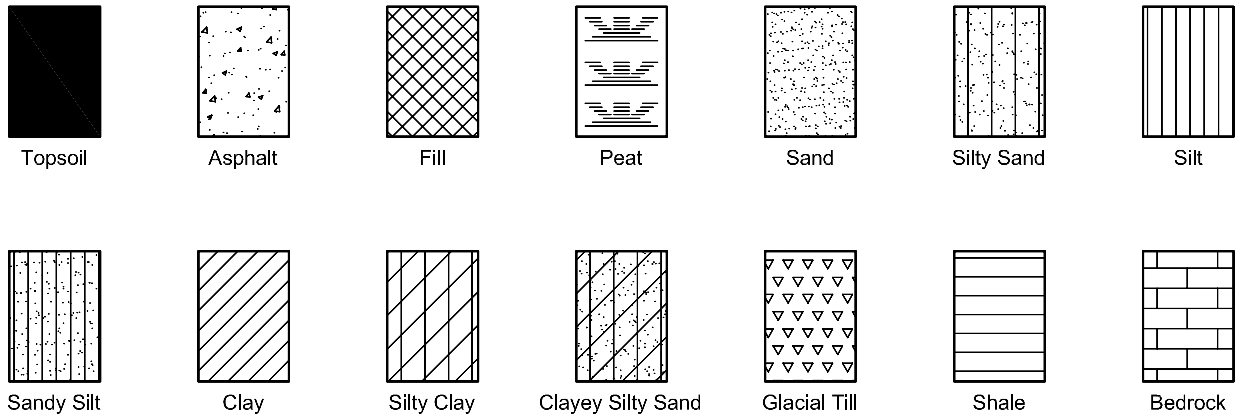
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

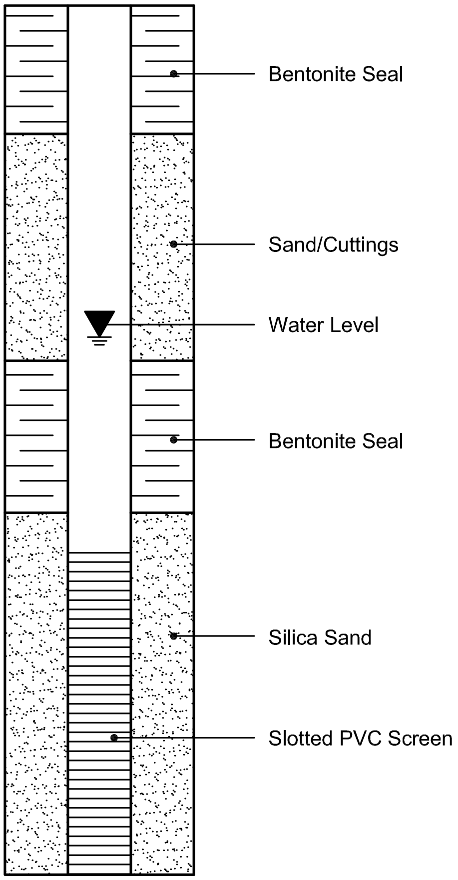
SYMBOLS AND TERMS (continued)

STRATA PLOT

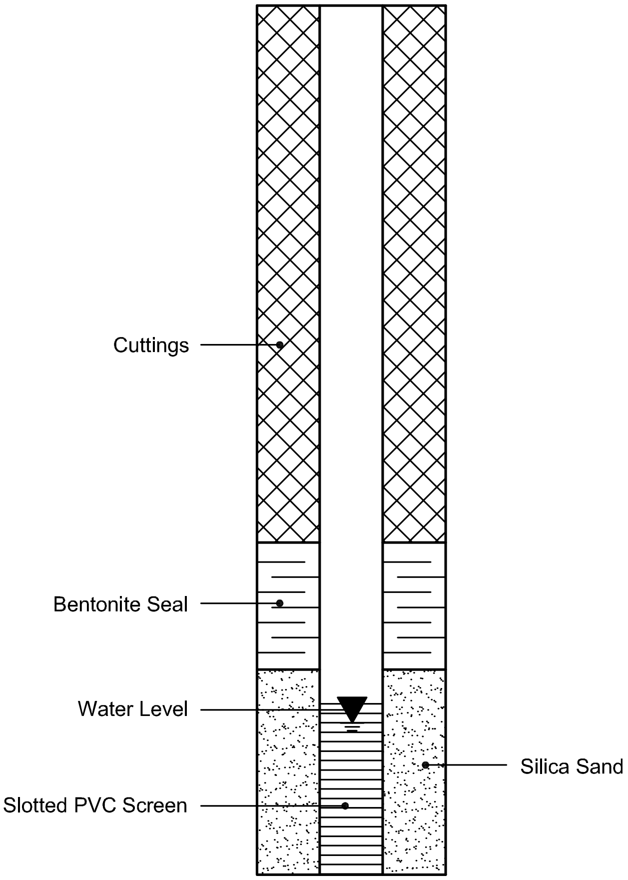


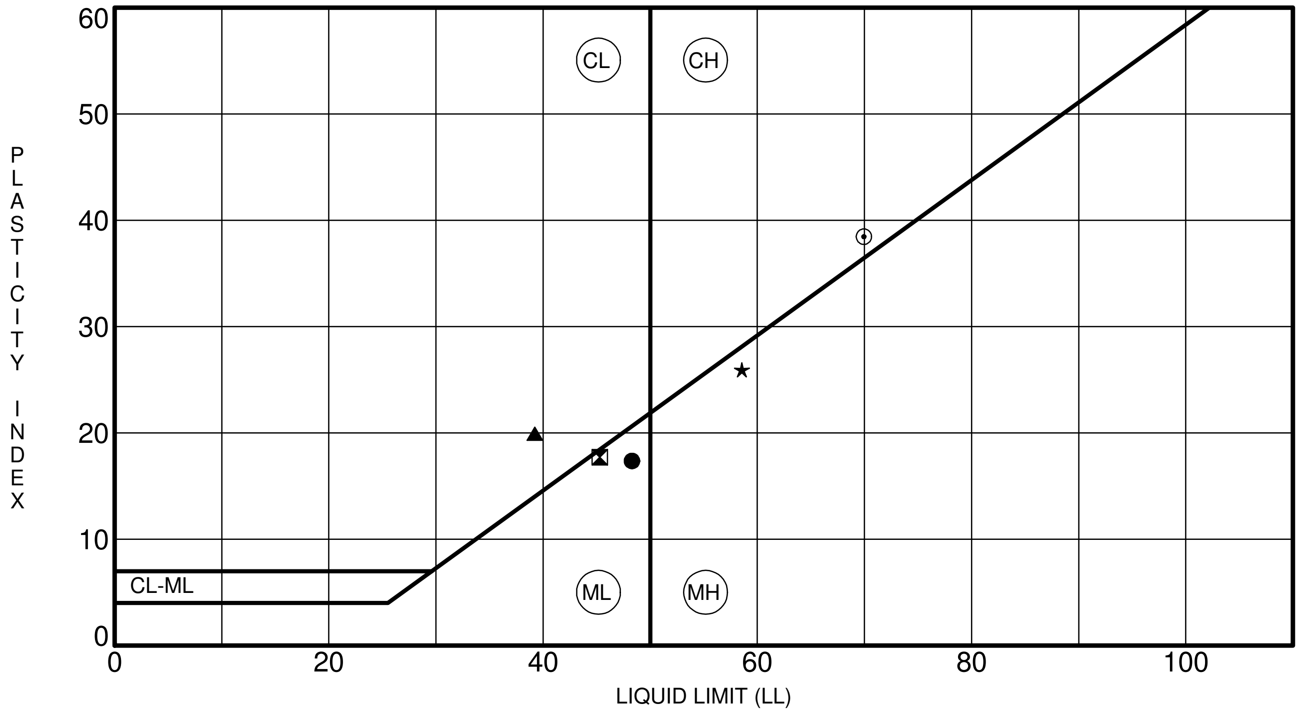
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





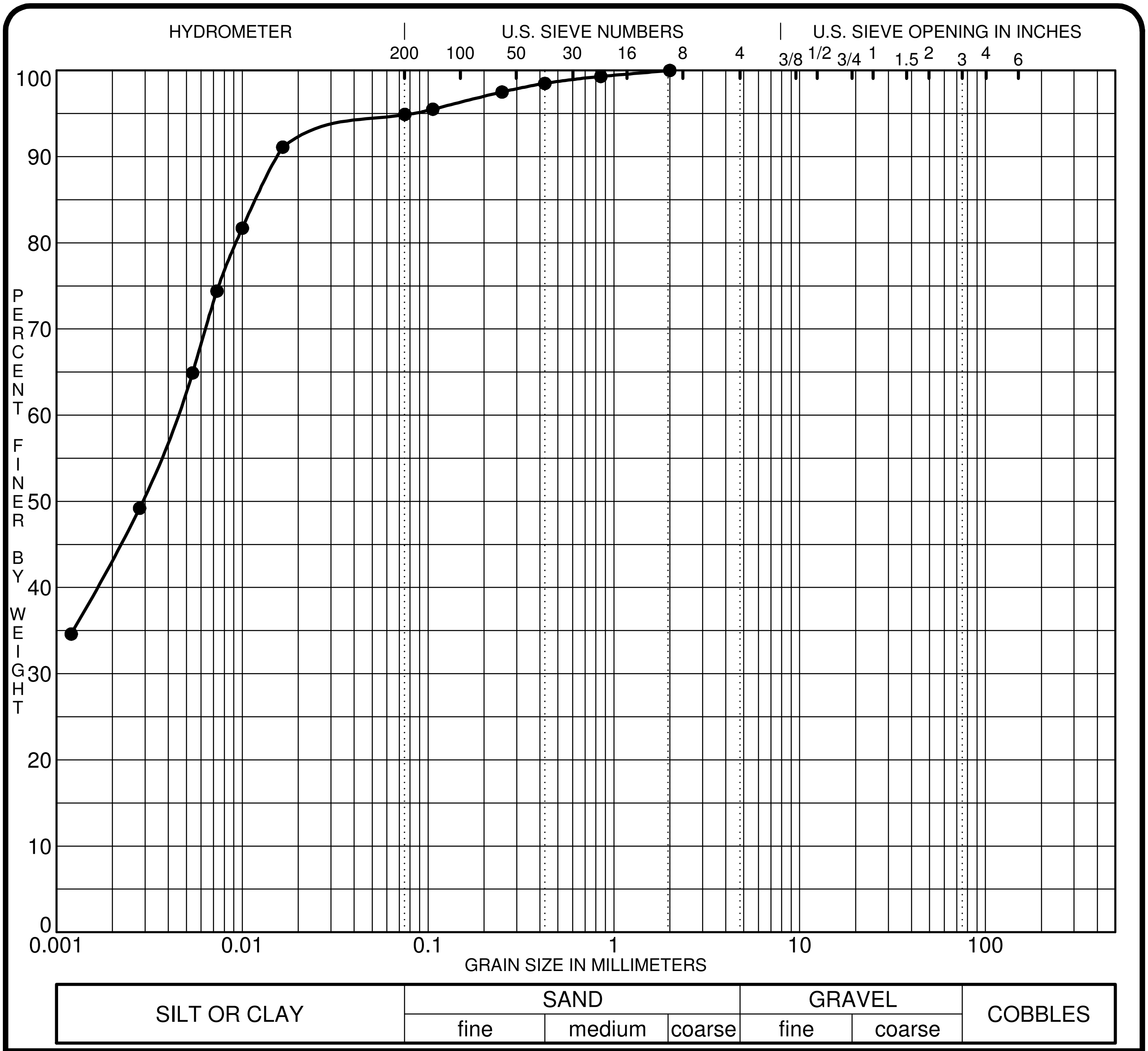
Specimen Identification			LL	PL	PI	Fines	Classification
●	**BH18**	**SS 2**	**48**	**31**	**17**		**ML - Inorganic silts of low plasticity**
⧗	**BH19**	**SS 2**	**45**	**28**	**18**		**ML - Inorganic silts of low plasticity**
▲	**BH22**	**SS 4**	**39**	**19**	**20**		**CL - Inorganic clays of low plasticity**
★	**BH27**	**SS 2**	**59**	**33**	**26**		**MH - Inorganic silts of high plasticity**
⊙	**BH28**	**SS 3**	**70**	**31**	**38**		**CH - Inorganic clays of high plasticity**

CLIENT **Riverside South Development Corp.**
PROJECT **Geotechnical Investigation - Riverside South Development - Phase 17**

FILE NO. **PG5131**
DATE **4 Feb 20**

patersongroup **Consulting Engineers**
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS



	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	**BH28**	**SS 4**	**CH - Inorganic clays of high**						
			plasticity						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH28**	**SS 4**	**2.00**	**0.00**			**0.0**	**5.1**	**94.9**	

CLIENT **Riverside South Development Corp.**

FILE NO. **PG5131**

PROJECT **Geotechnical Investigation - Riverside South Development - Phase 17**

DATE **4 Feb 20**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

GRAIN SIZE DISTRIBUTION

Certificate of Analysis

Report Date: 10-Feb-2020

Client: Paterson Group Consulting Engineers

Order Date: 4-Feb-2020

Client PO: 29441

Project Description: PG5131

	Client ID:	BH25- SS3	-	-	-
	Sample Date:	03-Feb-20 11:00	-	-	-
	Sample ID:	2006209-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	91.9	-	-	-
General Inorganics					
pH	0.05 pH Units	7.94	-	-	-
Resistivity	0.10 Ohm.m	89.1	-	-	-
Anions					
Chloride	5 ug/g dry	6	-	-	-
Sulphate	5 ug/g dry	10	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG5131-1 - TEST HOLE LOCATION PLAN

DRAWING PG5131-2 - PERMISSIBLE GRADE RAISE PLAN

DRAWING PG5131-3 - TREE SETBACK RECOMMENDATIONS

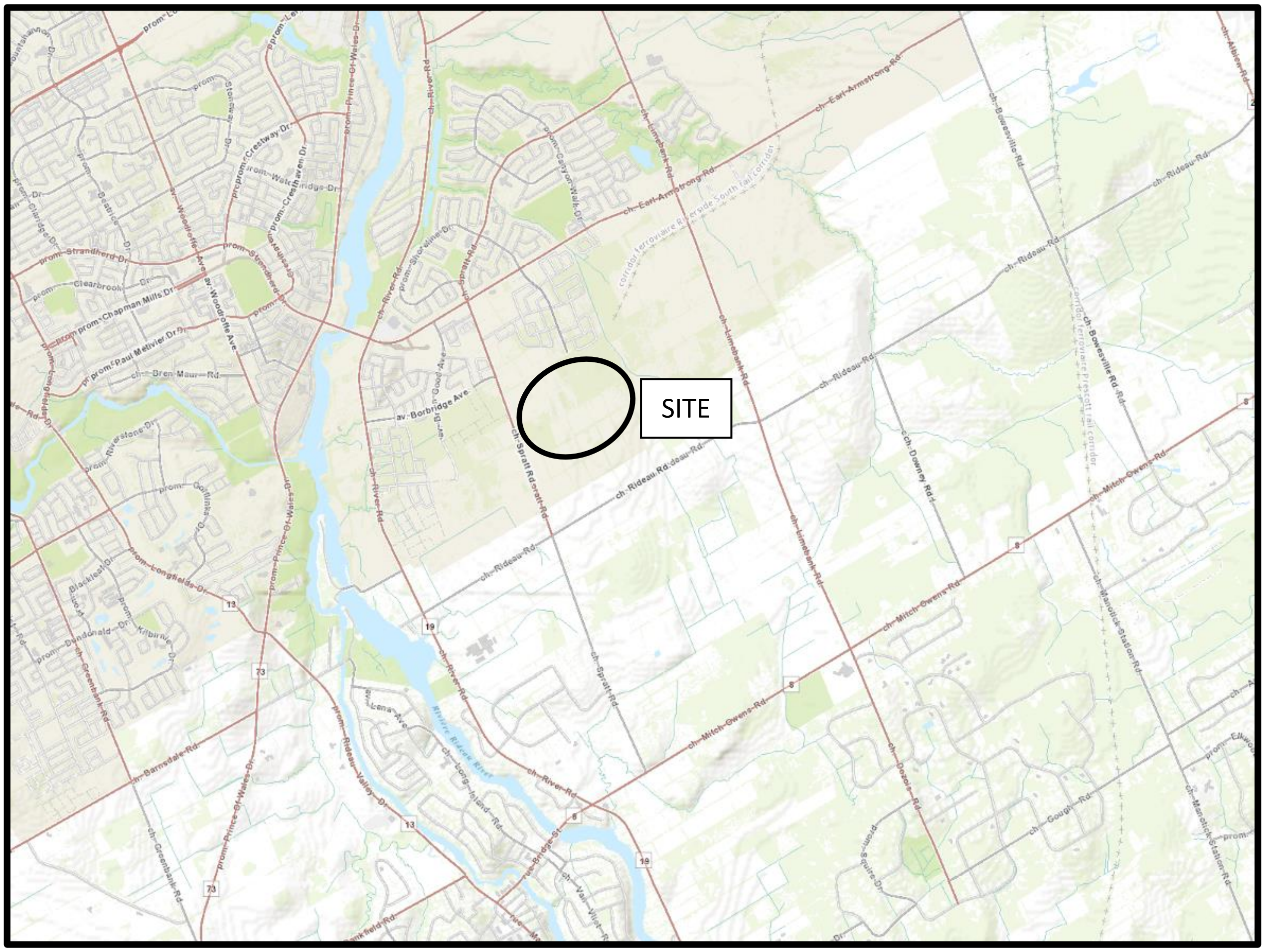
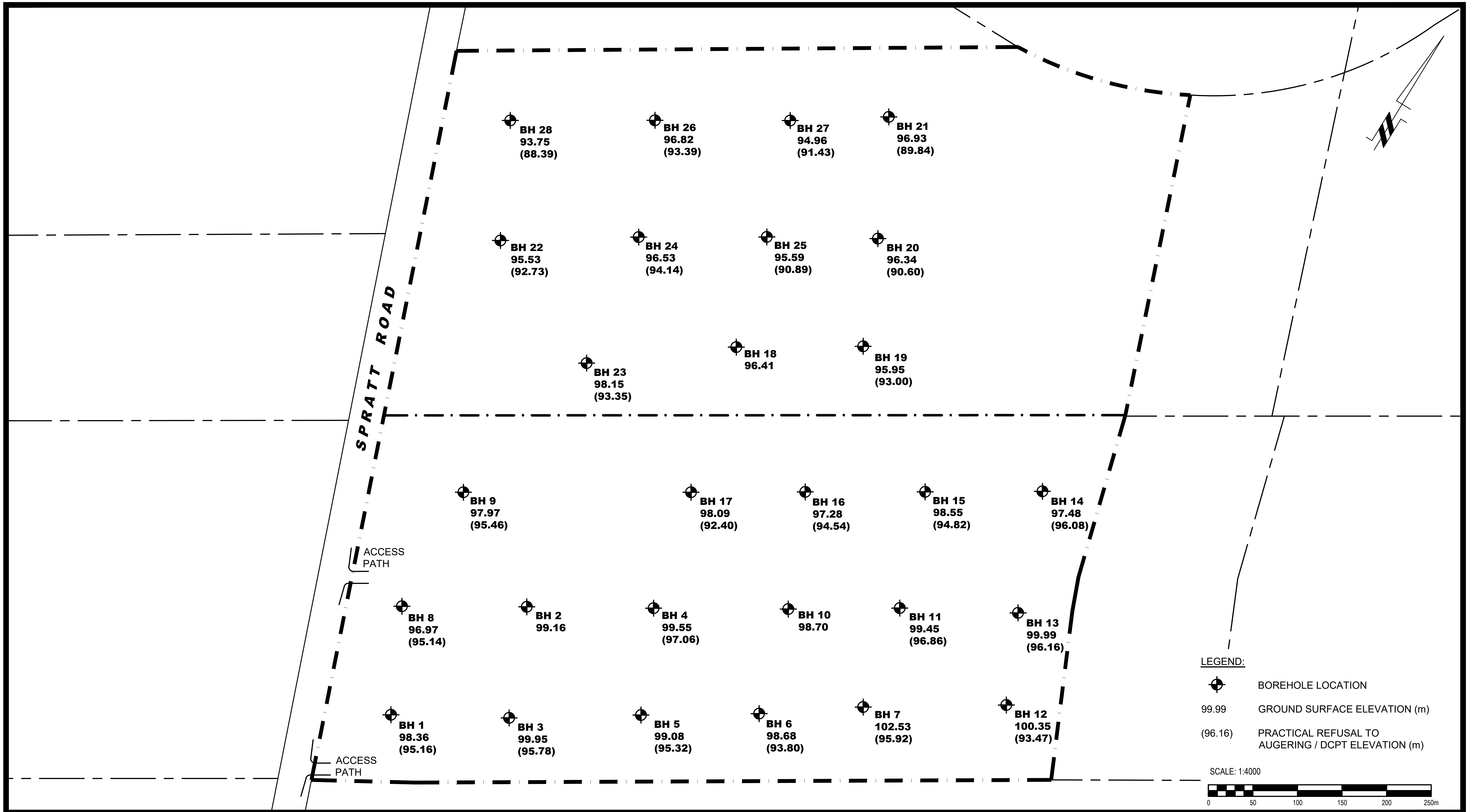


FIGURE 1

KEY PLAN



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Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

RIVERSIDE SOUTH DEVELOPMENTS

GEOTECHNICAL INVESTIGATION
PHASE 17-RIVERSIDE SOUTH RESIDENTIAL DEVELOPMENT-SPRATT ROAD
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:4000
Drawn by: YA
Checked by: KP
Approved by: DJG

Date: 04/2020
Report No.: PG5131-1
Dwg. No.: **PG5131-1**
Revision No.:

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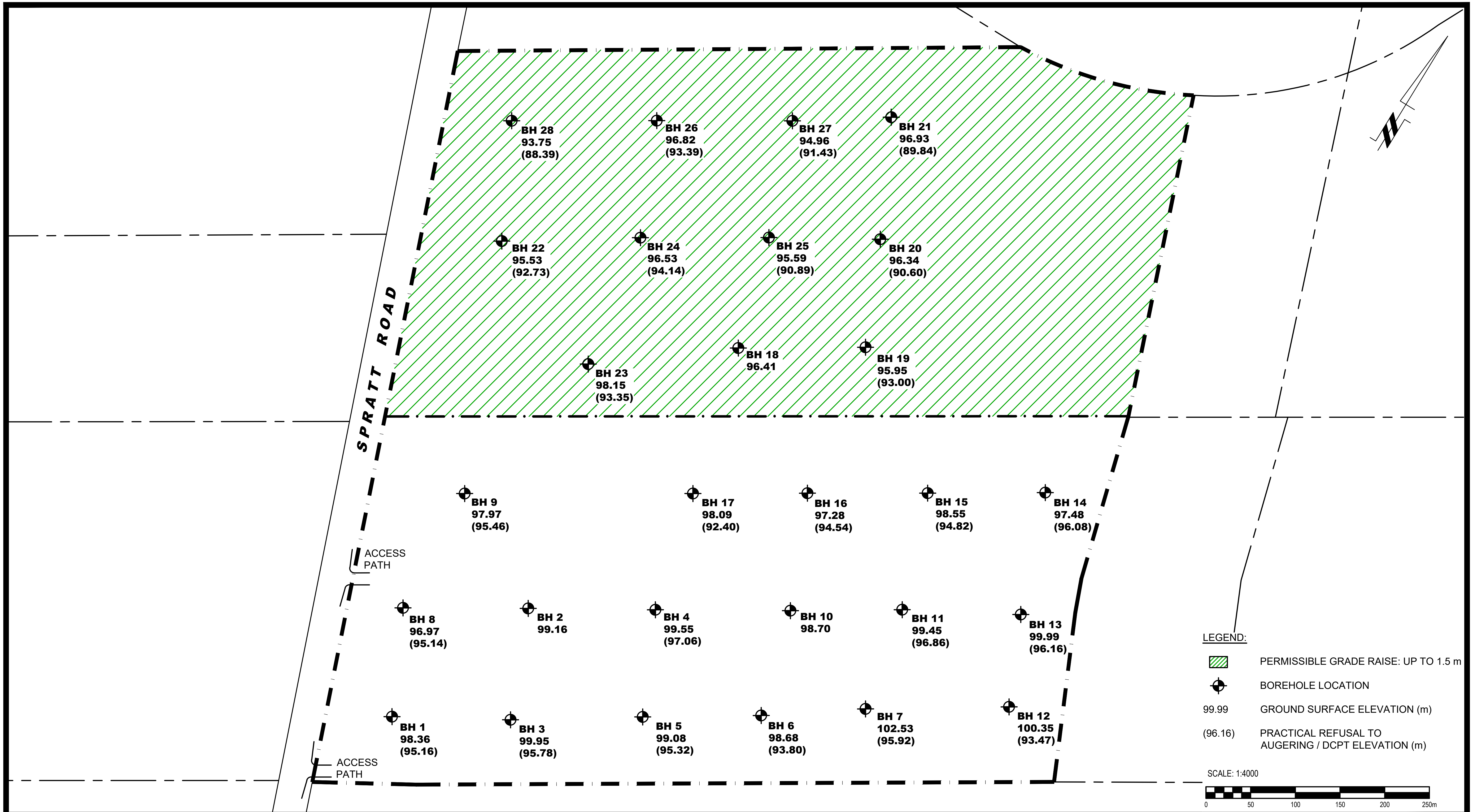

LEGEND:

▨	PERMISSIBLE GRADE RAISE: UP TO 1.5 m
⌖	BOREHOLE LOCATION
99.99	GROUND SURFACE ELEVATION (m)
(96.16)	PRACTICAL REFUSAL TO AUGERING / DCPT ELEVATION (m)

p:\autocad drawings\geotechnical\pg51xx\pg5131\pg5131-2-permissible grade raise plan.dwg

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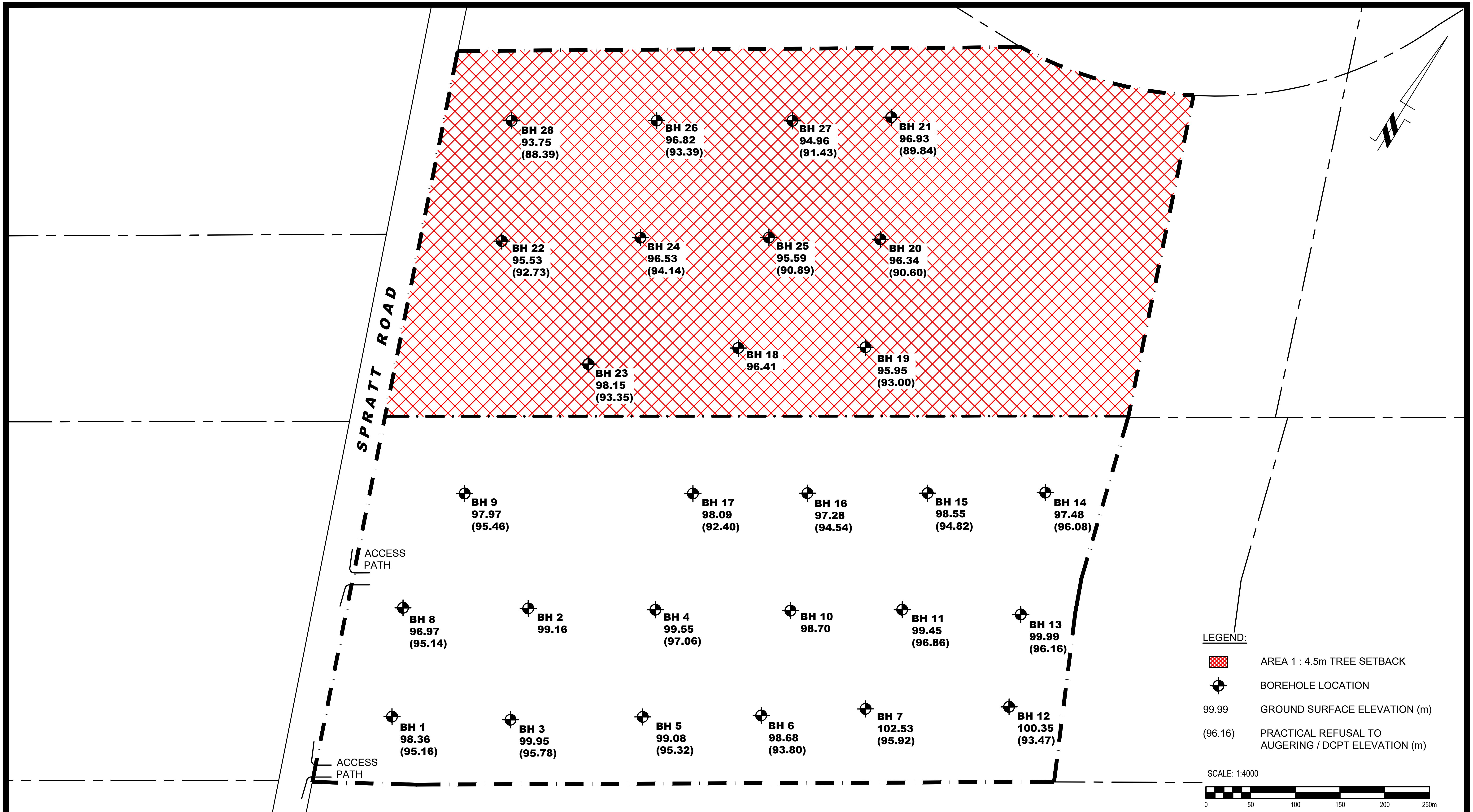
NO.	REVISIONS	DATE	INITIAL

RIVERSIDE SOUTH DEVELOPMENTS

GEOTECHNICAL INVESTIGATION
PHASE 17-RIVERSIDE SOUTH RESIDENTIAL DEVELOPMENT-SPRATT ROAD
OTTAWA, ONTARIO

Title:
PERMISSIBLE GRADE RAISE PLAN

Scale: 1:4000
Drawn by: YA
Checked by: KP
Approved by: DJG
Date: 04/2020
Report No.: PG5131-1
Dwg. No.: **PG5131-2**
Revision No.:



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NO.	REVISIONS	DATE	INITIAL

RIVERSIDE SOUTH DEVELOPMENTS

GEOTECHNICAL INVESTIGATION
PHASE 17-RIVERSIDE SOUTH RESIDENTIAL DEVELOPMENT-SPRATT ROAD
OTTAWA, ONTARIO

Title:
TREE PLANTING SETBACK RECOMMENDATIONS

Scale: 1:4000	Date: 04/2020
Drawn by: YA	Report No.: PG5131-1
Checked by: KP	Dwg. No.: **PG5131-3**
Approved by: DJG	Revision No.:

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