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Geotechnical Investigation Report
Proposed Multi-Storey Buildings
770 Brookfield Road - Phase 2
Ottawa, Ontario

Prepared For

Campus Developments Global Inc.

May 30, 2022

Report: PG4112-2

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Campus Developments Global Inc. to conduct a Geotechnical Investigation for Phase 2 of the proposed development to be located at 770 Brookfield Road in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan presented in Appendix 2).

The objectives of the geotechnical investigation were to:

- ❑ Determine the subsoil and groundwater conditions at this site by means of boreholes.
- ❑ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

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

2.0 Proposed Development

Based on the available drawings, it is understood that the proposed development will be located immediately to the east of the Phase 1 development, and will consist of 3 multi-storey buildings with 1 level of shared underground parking. At finished grades, it is further understood that the proposed buildings will be surrounded by asphalt-paved access lanes and parking areas, with a landscaped courtyard located between the proposed buildings. It is also anticipated that the proposed development will be municipality serviced.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

Paterson conducted a geotechnical investigation at the Phase 2 development site on May 4 and 5, 2022. The current investigation consisted of drilling 6 boreholes extending to a maximum depth of 9 m below the existing ground surface.

The borehole locations were distributed in a manner to provide general coverage of the Phase 2 development. The locations of the test holes are shown on Drawing PG4412-2 - Test Hole Location Plan included in Appendix 2.

Previously, a total of 16 boreholes were also drilled at the Phase 1 development site.

The bore holes were advanced using a CME-55 low clearance drill rig operated by a two-person crew. The drilling procedure consisted of augering to the required depths at the selected locations, and sampling and testing the overburden. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer.

Sampling and In Situ Testing

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

The Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are recorded as “N” values on the Soil Profile and Test Data sheets. The “N” value is the number of blows required to drive the split-spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

The overburden thickness was evaluated by a dynamic cone penetration test (DCPT) at BH 6-22. 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.

Undrained shear strength testing was carried out in cohesive soils using a field vane apparatus.

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

Groundwater

Groundwater monitoring wells were installed in boreholes BH 1-22, BH 2-22 and BH 3-22 to monitor the groundwater levels subsequent to the completion of the sampling program.

The groundwater observations are discussed in Section 4.3 and are presented in the Soil Profile and Test Data Sheets in Appendix 1.

3.2 Field Survey

The borehole locations were selected by Paterson to provide general coverage of the proposed development taking into consideration the existing site features and underground utilities. The borehole locations and ground surface elevation at each borehole location were surveyed by Paterson with respect to a geodetic datum. The location of the boreholes and ground surface elevation at each borehole location are presented on Drawing PG4412-2 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. All samples will be stored in the laboratory for a period of one (1) month after issuance of this report. They will then be discarded unless we are otherwise directed.

3.4 Analytical Testing

One (1) soil sample was submitted for analytical testing to assess the potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was analyzed to determine its concentration of sulphate and chloride along with its resistivity and pH. The laboratory test results are shown in Appendix 1 and are discussed in Section 6.7.

4.0 Observations

4.1 Surface Conditions

The subject Phase 2 site is undeveloped and generally vacant, and is bordered by Brookfield Road to the north, Hobson Road to the east, residential properties to the south, and the Phase 1 development to the west. The existing ground surface across the site is relatively level at approximate elevation 78 to 79 m, as referenced to a geodetic datum.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile encountered at the borehole locations consists of fill layer underlain by a deep silty clay deposit.

The fill was generally observed to consist of crushed stone to silty sand with some gravel, extending to approximate depths of 1.3 to 2.3 m below the existing ground surface. Fill consisting of brown silty sand with tar and rigid insulation was also encountered in borehole BH 2-22, at an approximate depth between 1.0 to 1.3 m. At boreholes BH 2-22 and BH 3-22, concrete slabs were encountered underlying the fill at approximate depths of 1 and 2 m, respectively.

Hard to very stiff, brown silty clay was encountered underlying the fill, becoming stiff to firm, grey silty clay at approximate depths of 3.5 to 4 m below the existing ground surface.

Practical refusal to the DCPT was encountered at a depth of about 24.6 m in borehole BH 6-22.

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 bedrock on the western portion of the site consists of limestone of the Bobcaygeon Formation, while the bedrock on the eastern portion of the site consists of interbedded limestone and shale of the Verulam Formation, with overburden drift thicknesses ranging between approximately 15 to 25 m.

4.3 Groundwater

Groundwater level readings were recorded on May 11, 2022, and are presented in Table 1 below, and on the Soil Profile and Test Data sheets in Appendix 1.

Table 1 – Summary of Groundwater Levels

Test Hole Number	Ground Surface Elevation (m)	Measured Groundwater Level		Dated Recorded
		Depth (m)	Elevation (m)	
Current Investigation				
BH 1-22	78.74	2.87	75.87	May 11, 2022
BH 2-22	78.43	2.34	76.09	
BH 3-22	78.97	2.96	76.01	

Note: The ground surface elevation at each borehole location during the current investigation was surveyed using a handheld GPS using a geodetic datum.

Long-term groundwater level can also be estimated based on the observed color, moisture levels and consistency of the recovered soil samples. Based on these observations, the long-term groundwater level is expected to be between an approximate 2.5 to 3.5 m depth.

However, it should be noted that the groundwater levels are subject to seasonal fluctuations, therefore, the groundwater levels could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed development. Due to the anticipated building loads, a raft foundation or deep foundation, such as end-bearing piles, is recommended for support of the proposed multi-storey buildings. For the portions of the underground parking level extending beyond the multi-storey building footprints, it is recommended that foundation support consist of conventional spread footings.

Due to the presence of a silty clay layer, the proposed development will be subjected to permissible grade raise restrictions. Our permissible grade raise recommendations are discussed in Section 5.3.

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

5.2 Site Grading and Preparation

Stripping Depth

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

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

Fill Placement

Fill used for grading beneath the proposed buildings should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the building and paved areas should be compacted to at least 98% of the material's standard Proctor maximum dry density (SPMDD).

Non-specified existing fill, along with site-excavated soil, can be used as general landscaping fill where settlement of the ground surface is of minor concern. This material should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If this material is to be used to build up the subgrade level for areas to be paved, it should be compacted in thin lifts to at least 95% of the material's SPMDD.

Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls, unless used in conjunction with a composite drainage membrane.

Protection of Subgrade (Raft Foundation)

Since the subgrade material will most likely consist of a silty clay deposit, it is recommended that a minimum 75 mm thick lean concrete mud slab be placed on the undisturbed silty clay subgrade shortly after the completion of the excavation. The main purpose of the mudslab is to reduce the risk of disturbance of the subgrade under the traffic of workers and equipment.

The final excavation to the raft bearing surface level and the placing of the mud slab should be done in smaller sections to avoid exposing large areas of the silty clay to potential disturbance due to drying.

Compacted Granular Fill Working Platform (Pile Foundation)

Where the proposed building will be supported on a driven pile foundation, which requires the use of heavy equipment (i.e. pile driving crane), it is conventional practice to install a compacted granular fill layer at a convenient elevation to allow the equipment to access the site without getting stuck and causing significant disturbance.

A typical working platform could consist of 600 mm thickness of OPSS Granular A or Granular B, Type II material placed and compacted to a minimum of 98% of its standard Proctor maximum dry density (SPMDD) in lifts not exceeding 300 mm in thickness.

Once the piles have been driven and cut off, the working platform can be regraded, and soil tracked in, or soil pumping up from the pile installation locations, can be bladed off and the surface can be topped up, if necessary, and recompacted to act as the substrate for further fill placement for the lowest level floor slab.

5.3 Foundation Design

As noted above, it is expected that the proposed multi-storey buildings will be founded on raft foundations or end-bearing piles, while the portions of the underground parking level extending beyond the proposed multi-storey building footprints will be founded on conventional spread footings. Detailed recommendations are provided in the following subsections.

Spread Footing Foundations

Strip footings, up to 3 m wide, and pad footings, up to 5 m wide, placed on an undisturbed, stiff to firm 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**. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance value at ULS.

Footings designed using the above-noted bearing resistance value at SLS will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively.

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.

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to the above noted bearing medium when a plane extending down and out from the bottom edge of the footing, at a minimum of 1.5H:1V, passes only through in situ soil or engineered fill of the same or higher capacity as the soil.

Raft Foundation – Multi-Storey Buildings

For design purposes, it is anticipated that the proposed founding elevation of the raft slab will be approximately 4 to 5 m below the existing ground surface.

The amount of settlement of the raft slab will be dependent on the sustained raft contact pressure. The bearing resistance value at SLS (contact pressure) of **170 kPa** will be considered acceptable, for a raft foundation bearing approximately 4 to 5 m below the existing ground surface. The loading conditions for the contact pressure are based on sustained loads, that are generally taken to be 100% Dead Load and 50% Live Load. The contact pressure provided considers the stress relief associated with the soil removal required for the proposed building. The factored bearing resistance (contact pressure) at ULS can be taken as **260 kPa**. A geotechnical resistance factor of 0.5 was applied to the bearing resistance value at ULS.

The modulus of subgrade reaction was calculated to be **6 MPa/m** for a contact pressure of **170 kPa**. The raft foundation design is required to consider the relative stiffness of the reinforced concrete slab and the supporting bearing medium.

Based on the following assumptions for the raft foundation, the proposed buildings can be designed using the above parameters with a total and differential settlement of 25 and 15 mm, respectively.

Deep Foundation - Multi-Storey Buildings

Deep foundations, such as end bearing piles, can be considered as an alternative method for the proposed multi-storey buildings if the design building loads exceed the bearing resistance values provided for a raft foundation. Concrete filled steel pipe piles driven to refusal on a bedrock surface are a typical deep foundation option in Ottawa.

Applicable pile resistance at SLS values and factored pile resistance at ULS values are provided in Table 2 below. Additional resistance values can be provided if available pile sizes vary from those detailed in Table 2. A resistance factor of 0.4 has been incorporated into the factored ULS values. Note that these are all geotechnical axial resistance values.

The geotechnical pile resistance values were estimated calculating the Hiley dynamic formula. The piles should be confirmed during pile installation with a program of dynamic testing. For this project, the dynamic testing of two to four piles is recommended. This is considered to be the minimum testing program, as the piles under shear walls may be required to be driven using the maximum recommended driving energy to achieve the greatest factored resistance at ULS values. Re-striking of all piles will also be required after at least 48 hours have elapsed since initial driving.

Table 2 - End Bearing Pile Foundation Design Data

Pile Outside Diameter (mm)	Pile Wall Thickness (mm)	Geotechnical Axial Resistance		Final Set (blows/ 25 mm)	Transferred Hammer Energy (kJ)
		SLS (kN)	Factored at ULS (kN)		
245	10	975	1460	10	35.9
245	12	1100	1650	10	42
245	13	1175	1760	10	45.4

Permissible Grade Raise Recommendation

Due to the presence of a silty clay deposit below the proposed founding level, a permissible grade raise restriction of **1 m** is recommended for grading within 6 m of the proposed building footprints.

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 site class for seismic site response can be taken as **Class D** for the foundations considered at this site. Soils underlying the subject 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

With the removal of all topsoil and/or fill, containing significant amounts of organic or deleterious materials, within the footprints of the proposed buildings, the native soil subgrade is considered to be an acceptable subgrade surface on which to commence backfilling for floor slab construction. It is expected that the basement area will be mostly parking and the recommended pavement structure noted in Section 5.7 will be applicable.

However, for storage or other uses of the lower level where a concrete floor slab will be used, it is recommended that the upper 200 mm of sub-slab fill consists of 19 mm clear crushed stone.

In consideration of the groundwater conditions encountered at the time of the geotechnical investigation, an underslab drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the clear crushed stone layer under the lowest level floor slab.

5.6 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and a bulk (drained) unit weight of 20 kN/m3.

Lateral Earth Pressures

The static horizontal earth pressure (p_o) can be calculated using a triangular earth pressure distribution equal to $K_o \cdot \gamma \cdot H$ where:

K_o = at-rest earth pressure coefficient of the applicable retained soil (0.5)
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)

An additional pressure having a magnitude equal to $K_o \cdot q$ and acting on the entire height of the wall, should be added to the above diagram for any surcharge loading, q (kPa), that may be placed at ground surface adjacent to the wall. The surcharge pressure will only be applicable for static analyses and should not be used in conjunction with the seismic loading case.

Actual earth pressures could be higher than the “at-rest” case if care is not exercised during the compaction of the backfill materials to maintain a minimum separation of 0.3 m from the walls with the compaction equipment.

Seismic Earth Pressures

The total seismic force (P_{AE}) includes both the earth force component (P_o) and the seismic component (ΔP_{AE}).

The seismic earth force (ΔP_{AE}) can be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ where:

a_c = $(1.45-a_{max}/g)a_{max}$
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)
g = gravity, 9.81 m/s^2

The peak ground acceleration, (a_{max}), for the Ottawa area is 0.32 g according to the OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

The earth force component (P_o) under seismic conditions can be calculated using $P_o = 0.5\ K_o\ \gamma\ H^2$, where $K_o = 0.5$ for the soil conditions noted above.

The total earth force (P_{AE}) is considered to act at a height, h (m), from the base of the wall, where:

$$h = \{P_o \cdot (H/3) + \Delta P_{AE} \cdot (0.6 \cdot H)\}/P_{AE}$$

The earth forces calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per the OBC 2012.

5.7 Pavement Structure

For design purposes, it is recommended that the rigid pavement structure for the underground parking structure should consist of Category C2, 32 MPa concrete at 28 days with air entrainment of 5 to 8%. The rigid pavement structure is presented in Table 3 below, while the flexible pavement structure presented in Table 4 should be used for access roads and heavy loading parking areas.

Table 3 - Recommended Rigid Pavement Structure - Lower Parking Level

Thickness (mm)	Material Description
150	**Exposure Class C2 - 32 MPa Concrete** (5 to 8% Air Entrainment)
300	**BASE** - OPSS Granular A Crushed Stone
SUBGRADE - Either in-situ soil, or OPSS Granular B Type I or II material over in-situ soil.	

To control cracking due to shrinking of the concrete floor slab, it is recommended that strategically located saw cuts be used to create control joints within the concrete floor slab of the underground parking level. The control joints are generally recommended to be located at the center of the column lines and spaced at approximately 24 to 36 times the slab thickness (for example, a 0.15 m thick slab should have control joints spaced between 3.6 and 5.4 m). The joints should be cut between 25 and 30% of the thickness of the concrete floor slab and completed as early as 4 hours after the concrete has been poured during warm temperatures and up to 12 hours during cooler temperatures.

Table 4 – Recommended Pavement Structure – Heavy Truck Parking and Access Lanes

Thickness (mm)	Material Description
40	**Wear Course –** Superpave 12.5 Asphaltic Concrete
50	**Wear Course –** Superpave 19.0 Asphaltic Concrete
150	**BASE –** OPSS Granular A Crushed Stone
400	**SUBBASE –** OPSS Granular B Type II
SUBGRADE – Either in-situ soil, or OPSS Granular B Type I or II material over in-situ soil.	

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project. 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 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 vibratory equipment.

6.0 Design and Construction Precautions

6.1 Foundation Drainage

A perimeter foundation drainage system is recommended for the below-grade level. The system should consist of a 150 mm diameter, geotextile-wrapped, perforated and corrugated plastic pipe which is surrounded on all sides by 150 mm of 19 mm clear crushed stone, placed at the founding level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Underslab Drainage

Underslab drainage is recommended to control water infiltration. For preliminary design purposes, it is recommended that 100 or 150 mm perforated pipes be placed at approximate 6 m centres under the lowest level floor slab. However, the spacing of the underslab drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

Foundation Backfill

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

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum of 1.5 m thick soil cover, or an equivalent combination of soil cover and foundation insulation, should be provided in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for exterior unheated footings, or an equivalent combination of soil cover and foundation insulation.

6.3 Excavation Side Slopes

The temporary excavation side slopes should either be excavated to acceptable slopes or retained by shoring systems from the beginning of the excavation until the structure is backfilled.

Temporary Side Slopes

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 subsurface soil is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should maintain safe working distance from the excavation sides.

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

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

Temporary Shoring

Temporary shoring may be required for the overburden soil to complete the required excavations where insufficient room is available for open cut methods, such as along the northern boundary of the site. The shoring requirements, designed by a structural engineer specializing in those works, will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations and underground services. The design and approval of these temporary systems will be the responsibility of the shoring contractor and the shoring designer who is a licensed professional engineer and is hired by the shoring contractor.

It is the responsibility of the shoring contractor to ensure that the temporary shoring is in compliance with safety requirements, designed to avoid damage to adjacent structures, and include dewatering control measures.

In the event that subsurface conditions differ from the approved design during the actual installation, it is the responsibility of the shoring contractor to commission the required experts to re-assess the design and implement the required changes. The designer should also take into account the impact of a significant precipitation event and designate design measures to ensure that a precipitation will not negatively impact the shoring system or soils supported by the system.

Any changes to the approved shoring design system should be reported immediately to the owner’s structural designer prior to implementation.

For design purposes, the temporary shoring system may generally consist of a soldier pile and lagging system. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be added to the earth pressures described below. These systems can be cantilevered, anchored or braced. Generally, it is expected that the shoring systems will be provided with tieback rock anchors to ensure their stability.

The earth pressures acting on the temporary shoring system may be calculated with the following parameters.

Table 5 – Soils Parameter for Shoring System Design

Parameters	Values
Active Earth Pressure Coefficient (K_a)	0.33
Passive Earth Pressure Coefficient (K_p)	3
At-Rest Earth Pressure Coefficient (K_O)	0.5
Unit Weight (γ), kN/m^3	20
Submerged Unit Weight (γ), kN/m^3	13

The active earth pressure should be calculated where wall movements are permissible while the at-rest pressure should be calculated if minimal movement is permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

The hydrostatic groundwater pressure should be included to the earth pressure distribution wherever the effective unit weights are calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil should be calculated full weight, with no hydrostatic groundwater pressure component.

For design purposes, the minimum factor of safety of 1.5 should be calculated.

6.4 Pipe Bedding and Backfill

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

A minimum of 150 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on soil subgrade. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to a minimum of 300 mm above the obvert of the pipe should consist of OPSS Granular A (concrete or PSM PVC pipes) or sand (concrete pipe). The bedding and cover materials should be placed in maximum 225 mm thick lifts and compacted to 98% of the material's SPMDD.

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 match the soils exposed at the trench walls to reduce the potential for 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.

6.5 Groundwater Control

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

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

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

Potential Impacts to Adjacent Structures

Based on the observed groundwater level, the proposed building construction is not anticipated to extend significantly below the groundwater level. Given the setbacks of the existing buildings from the anticipated limits of the excavation, no issues are expected with respect to groundwater lowering that would cause long term adverse effects to adjacent structures in the vicinity of the proposed building.

6.6 Winter Construction

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

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

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

Trench excavations and pavement construction are also difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be taken if such activities are to be carried out during freezing conditions. Additional information could be provided, if required.

6.7 Corrosion Potential and Sulphate

The results of the analytical testing show that the sulphate content is less than 0.1%. This result indicates that Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and pH of the samples 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 an aggressive corrosive environment.

6.8 Landscaping Considerations

Although a silty clay deposit was encountered at the subject site, tree planting setbacks for small trees (mature height below 7.5 m) and medium sized trees (mature height between 7.5 to 14 m) are not applicable due to the anticipated depths of the proposed building foundations (approximately 4 m below finished grades or greater), which will be below the depths of the tree root structures.

However, for large trees (mature height greater than 14 m), the tree planting setback from the proposed building foundations should be equal to the mature height of the tree. It is well documented in the literature, and is our experience, that fast-growing trees located near buildings founded on cohesive soils that shrink on drying can result in long-term differential settlements of the structures. Tree varieties that have the most pronounced effect on foundations are seen to consist of poplars, willows and some maples (i.e. Manitoba Maples) and, as such, they should not be considered in the landscaping design.

7.0 Recommendations

It is a requirement for the foundation data provided herein to be applicable that the following material testing, and observation program be performed by the geotechnical consultant.

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

All excess soils, with the exception of engineered crushed stone fill, generated by construction activities that will be transported on-site or off-site should be handled as per *Ontario Regulation 406/19: On-Site and Excess Soil Management*.

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

8.0 Statement of Limitations

The recommendations provided are in accordance with the present understanding of the project. Paterson requests permission to review the recommendations when the drawings and specifications are completed.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the borehole locations, Paterson requests immediate notification to permit reassessment of our recommendations.

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

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Campus Developments Global Inc., 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
May 30, 2022
S. S. DENNIS
100519516
Scott Dennis
PROVINCE OF ONTARIO

Scott Dennis

Balaji Nirmala, M.Eng.

Scott S. Dennis, P.Eng.

Report Distribution:

- ☐ Campus Developments Global Inc. (e-mail copy)
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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

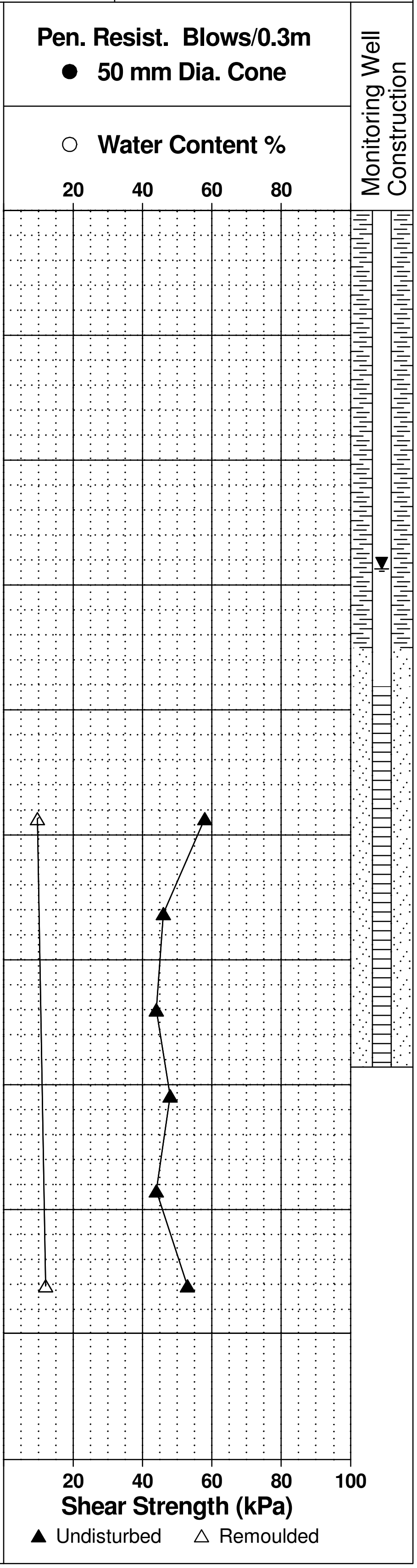
DATE May 4, 2022

FILE NO. **PG4412**

HOLE NO. **BH 1-22**

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Crushed stone	AU	1		
0.60				
FILL: Brown silty sand, trace styrofoam	SS	2	29	3
1.52				
Concrete slab	SS	3	0	50+
1.83				
Hard to very stiff, brown **SILTY CLAY** - stiff to firm and grey by 3.7m depth	SS	4	75	10
	SS	5	100	4
	SS	6	100	
	SS	7	100	W
	SS	8	100	
	SS	9	100	
8.99				
End of Borehole (GWL @ 2.87m - May 11, 2022)				

DEPTH (m)	ELEV. (m)
0	78.74
1	77.74
2	76.74
3	75.74
4	74.74
5	73.74
6	72.74
7	71.74
8	70.74



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

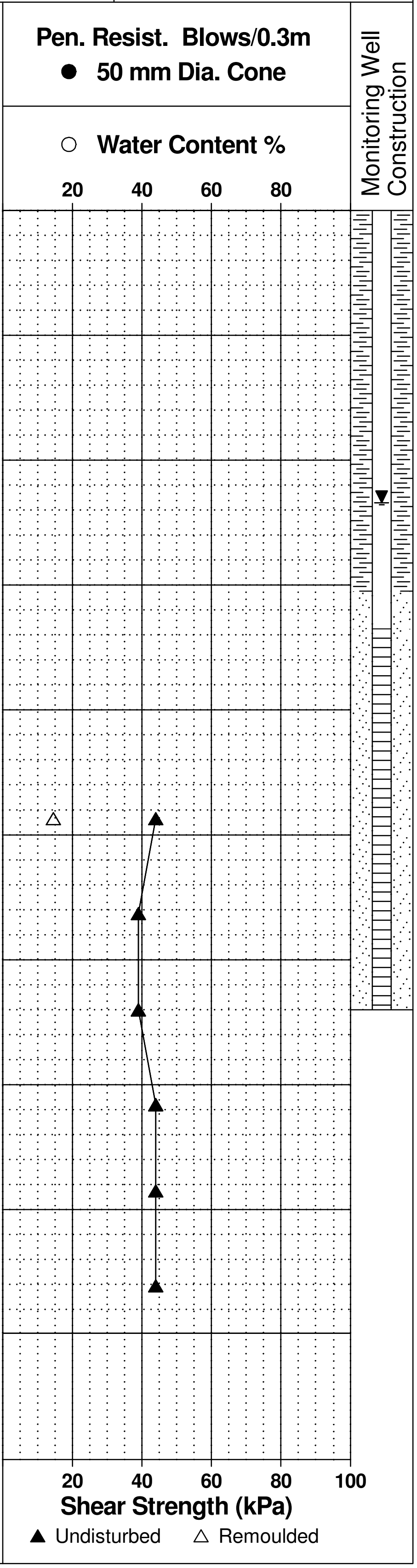
DATE May 4, 2022

FILE NO. **PG4412**

HOLE NO. **BH 2-22**

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Crushed stone, some sand	AU	1		
0.76				
FILL: Brown silty sand, some tar and styrofoam 1.01	SS	2	78	50+
Concrete slab 1.32				
Hard to very stiff, brown **SILTY CLAY** - firm and grey by 3.7m depth	SS	3	79	22
	SS	4	100	8
	SS	5	100	3
	SS	6	100	W
	SS	7	83	
	SS	8	50	
	SS	9	88	
	SS	10	10	50
8.99				
End of Borehole (GWL @ 2.34m - May 11, 2022)				

DEPTH (m)	ELEV. (m)
0	78.43
1	77.43
2	76.43
3	75.43
4	74.43
5	73.43
6	72.43
7	71.43
8	70.43



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill **DATE** May 4, 2022

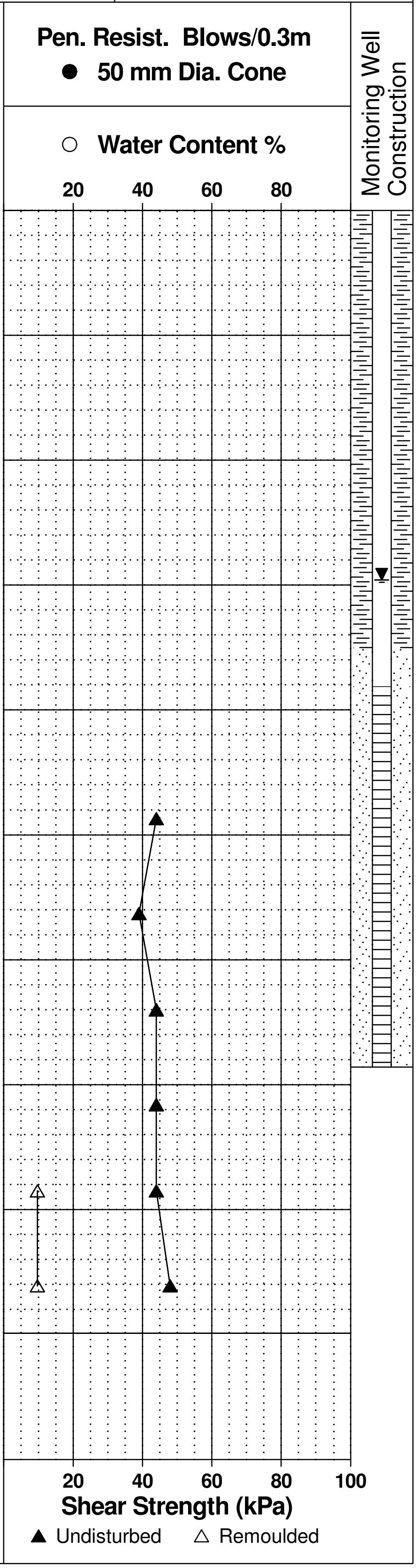
FILE NO. PG4412

HOLE NO. BH 3-22

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
FILL: Crushed stone with silty sand	0.76
FILL: Brown silty sand with gravel, trace concrete	1.96
Concrete slab	2.18
Hard to very stiff, brown **SILTY CLAY** - firm and grey by 3.7m depth	8.99
End of Borehole (GWL @ 2.96m - May 11, 2022)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2		42
SS	3	100	50+
SS	4	12	15
SS	5	92	9
SS	6	100	4
SS	7	100	
SS	8	100	
SS	9	88	
SS	10	83	

DEPTH (m)	ELEV. (m)
0	78.97
1	77.97
2	76.97
3	75.97
4	74.97
5	73.97
6	72.97
7	71.97
8	70.97



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic
REMARKS
BORINGS BY CME-55 Low Clearance Drill
DATE May 4, 2022

FILE NO. PG4412
HOLE NO. BH 4-22

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)	Monitoring Well Construction
GROUND SURFACE						0	78.61		
FILL: Crushed stone, trace sand 0.76	▩	AU	1						
FILL: Brown silty sand 1.52	▩	SS	2	54	15	1	77.61		
Hard to very stiff, brown **SILTY CLAY** - stiff and grey by 3.7m depth	▨	SS	3	25	7	2	76.61		
	▨	SS	4	100	7	3	75.61		
	▨	SS	5	100	4	4	74.61		
	▨	SS	6	100	2				
5.18	▨	SS	7	100	W	5	73.61		
End of Borehole									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE May 5, 2022

FILE NO. PG4412

HOLE NO. BH 5-22

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Monitoring Well Construction
GROUND SURFACE					0	78.68	
FILL: Brown silty sand, some crushed stone	AU	1					
0.76							
FILL: Brown silty sand	SS	2	58	13	1	77.68	
1.83	SS	3	71	6	2	76.68	
Hard to very stiff, brown **SILTY CLAY**	SS	4	100	9	3	75.68	
- stiff and grey by 3.7m depth	SS	5	100	5			∇
	SS	6	100	1	4	74.68	
	SS	7	100	W	5	73.68	
5.18							
End of Borehole (GWL @ 3.7m depth based on field observations)							

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill **DATE** May 5, 2022

FILE NO. PG4412

HOLE NO. BH 6-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Monitoring Well Construction
GROUND SURFACE						0	79.13	
FILL: Brown silty sand, trace crushed stone (to 0.60)		AU	1					
FILL: Brown silty sand, trace gravel		SS	2	62	23	1	78.13	
		SS	3	79	23	2	77.13	
(to 2.29)								
Hard to very stiff, brown **SILTY CLAY**		SS	4	71	10	3	76.13	
		SS	5	92	12			⊻
- stiff and grey by 3.7m depth		SS	6	100	3	4	75.13	
		SS	7	100	W			
(to 5.18)						5	74.13	
Dynamic Cone Penetration Test commenced at 5.18m depth, cone pushed to 13.7m depth.						6	73.13	
						7	72.13	
						8	71.13	
						9	70.13	
						10	69.13	

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

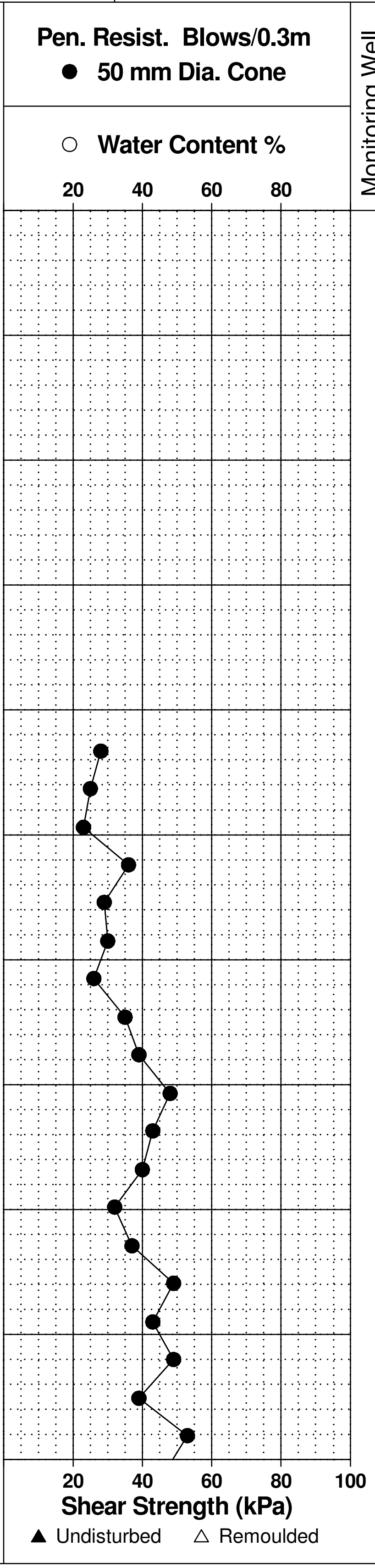
REMARKS

BORINGS BY CME-55 Low Clearance Drill **DATE** May 5, 2022

FILE NO. **PG4412**

HOLE NO. **BH 6-22**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Monitoring Well Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			
GROUND SURFACE						10	69.13	
						11	68.13	
						12	67.13	
						13	66.13	
						14	65.13	
						15	64.13	
						16	63.13	
						17	62.13	
						18	61.13	
						19	60.13	
						20	59.13	



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE May 5, 2022

FILE NO. PG4412

HOLE NO. BH 6-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						20	59.13
						21	58.13
						22	57.13
						23	56.13
						24	55.13
24.64							

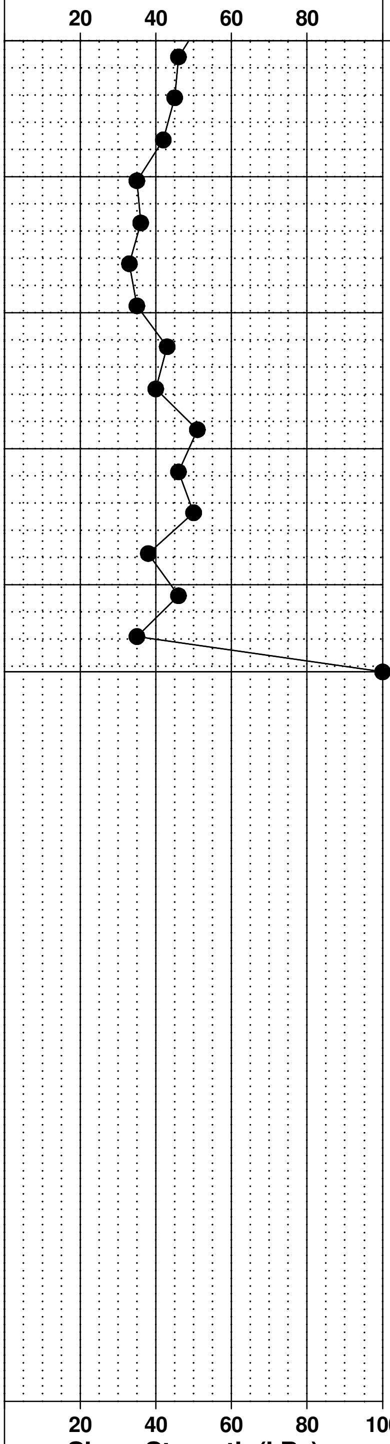
End of Borehole

Practical refusal to augering at 24.64m depth.

(GWL @ 3.4m depth based on field observations)

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

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Monitoring Well Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

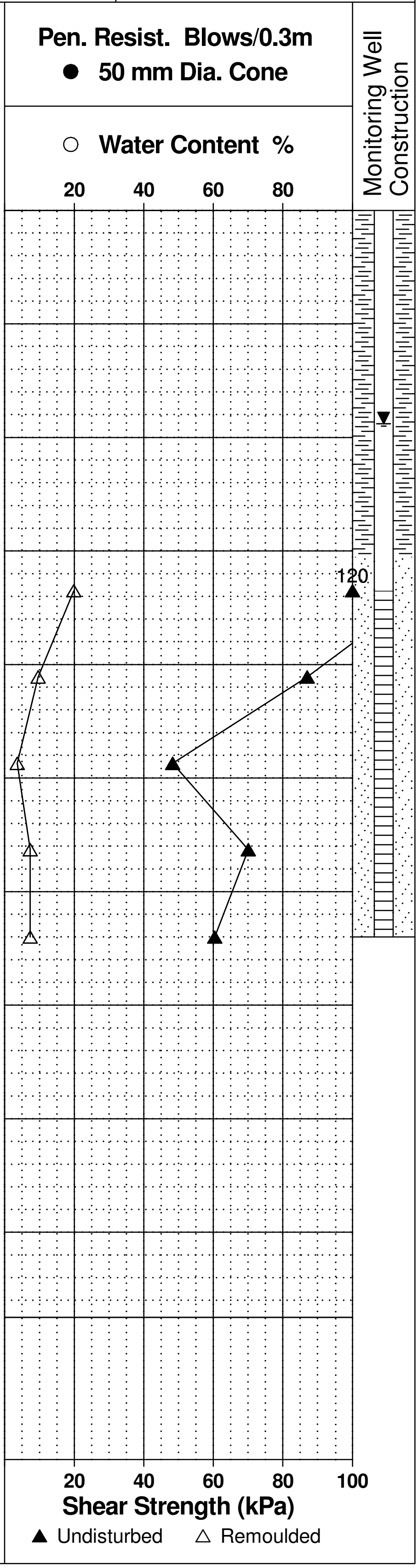
BORINGS BY CME 55 Power Auger

DATE April 6, 2018

FILE NO. **PG4412**

HOLE NO. **BH 1-18**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
GROUND SURFACE		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
Asphaltic concrete 0.04						0	78.65
FILL: Crushed stone with silt and sand 0.43		AU	1				
		SS	2	83	9	1	77.65
		SS	3	83	11		
Very stiff to stiff, brown **SILTY CLAY,** trace clay						2	76.65
		SS	4	100	7		
						3	75.65
		SS	5	100	P		
- firm to stiff and grey by 4.1m depth		SS	6	4	P	4	74.65
		SS	7	100	P	5	73.65
		SS	8	100	P		
						6	72.65
		SS	9	100	P		
7.16						7	71.65
		SS	10	50	50+		
GLACIAL TILL: Grey silty clay, some sand, trace gravel, cobbles and boulders						8	70.65
						9	69.65
9.75		SS	11	54	12		
End of Borehole (GWL @ 1.88m - April 20, 2018)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 6, 2018

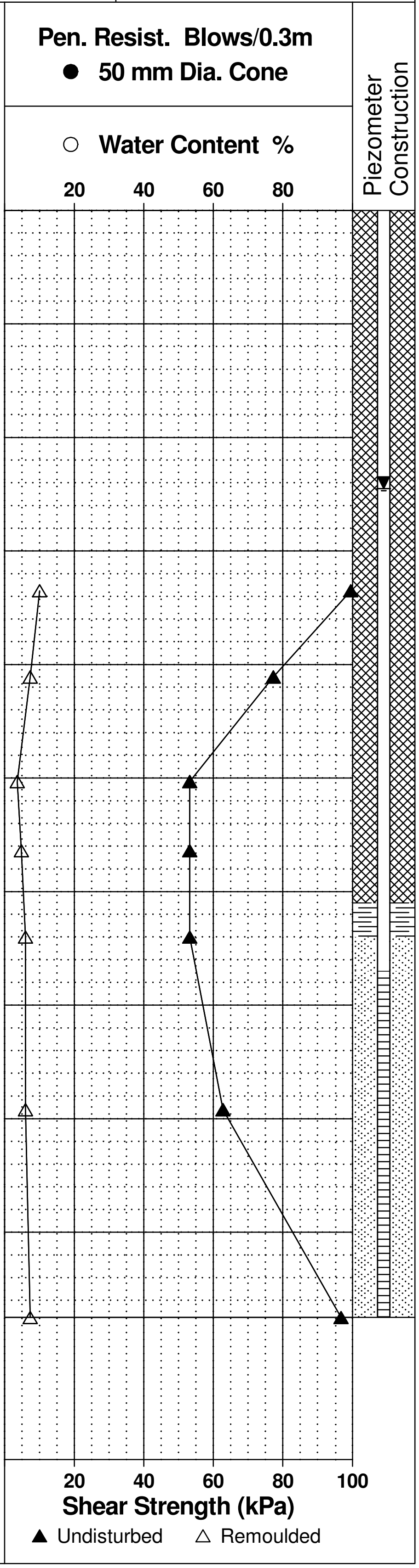
FILE NO. PG4412

HOLE NO. BH 2-18

SOIL DESCRIPTION	
GROUND SURFACE	
Asphaltic concrete	0.03
FILL: Crushed stone with silt and sand	0.59
FILL: Brown silty clay, trace sand and gravel	1.45
Very stiff to stiff, brown **SILTY CLAY,** trace sand - grey by 3.8m depth	8.53
GLACIAL TILL: Grey silty clay, trace sand, gravel, cobbles and boulders	9.75
End of Borehole (GWL @ 2.45m - April 20, 2018)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	58	10
SS	3	100	11
SS	4	100	6
SS	5	100	P

DEPTH (m)	ELEV. (m)
0	78.38
1	77.38
2	76.38
3	75.38
4	74.38
5	73.38
6	72.38
7	71.38
8	70.38
9	69.38



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 9, 2018

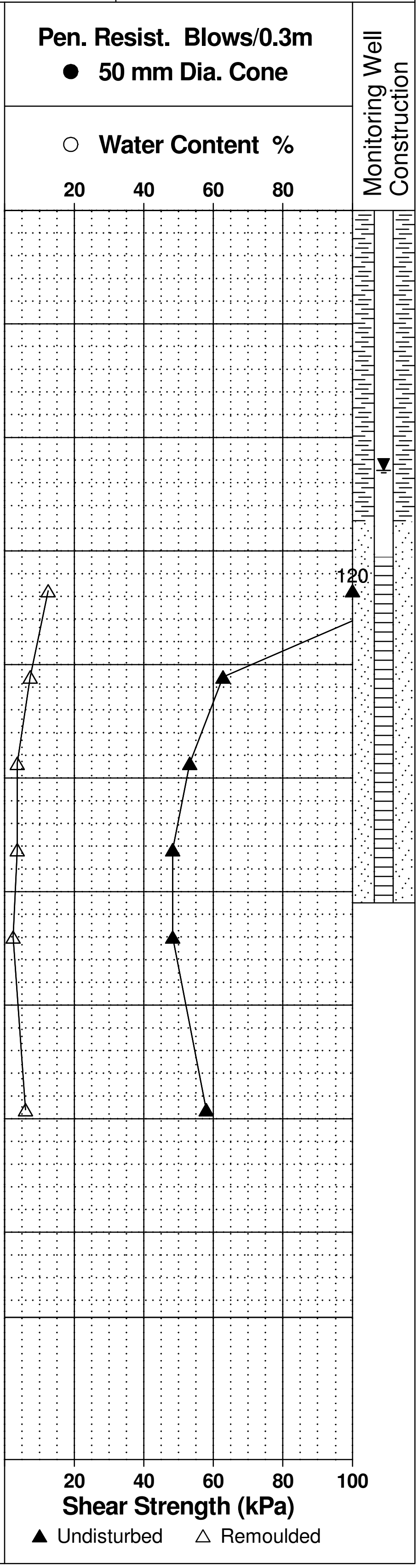
FILE NO. PG4412

HOLE NO. BH 3-18

SOIL DESCRIPTION	
GROUND SURFACE	
Asphaltic concrete	0.11
FILL: Crushed stone with silt and sand	0.46
FILL: Brown silty sand, trace gravel	1.32
FILL: Brown silty clay, some sand, trace organics	1.45
Very stiff to stiff, brown **SILTY CLAY,** trace sand - stiff to firm and grey by 3.8m depth	8.69
GLACIAL TILL: Grey silty clay, some sand, gravel, cobbles and boulders	9.75
End of Borehole (GWL @ 2.29m - April 20, 2018)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	27
SS	3	100	11
SS	4	100	5
SS	5	100	P
SS	6	100	P
SS	7	100	P
SS	8	100	P
SS	9	100	P
SS	10	100	P
SS	11	50	P

DEPTH (m)	ELEV. (m)
0	78.33
1	77.33
2	76.33
3	75.33
4	74.33
5	73.33
6	72.33
7	71.33
8	70.33
9	69.33



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 9, 2018

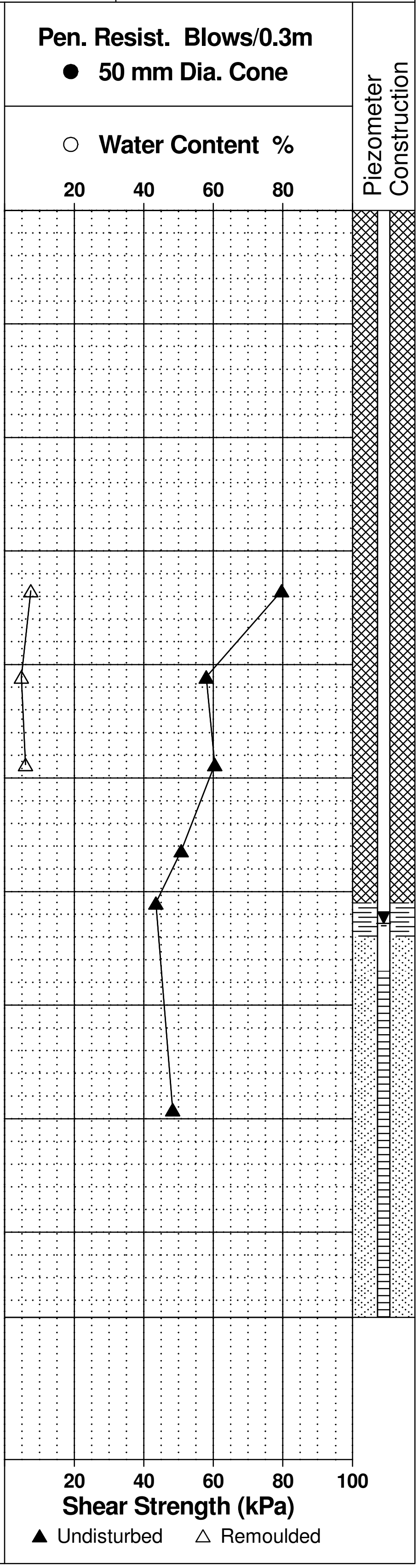
FILE NO. PG4412

HOLE NO. BH 4-18

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
Asphaltic concrete	0.13
FILL: Crushed stone with silt and sand	0.36
FILL: Brown silty sand, trace gravel and cobbles	1.45
Stiff to firm, brown **SILTY CLAY,** trace sand - grey by 3.8m depth	8.53
GLACIAL TILL: Grey silty clay, some sand, trace gravel, cobbles and boulders	9.75
End of Borehole (GWL @ 6.28m - April 20, 2018)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	42	17
SS	3	100	11
SS	4	100	5
SS	5	100	P

DEPTH (m)	ELEV. (m)
0	78.30
1	77.30
2	76.30
3	75.30
4	74.30
5	73.30
6	72.30
7	71.30
8	70.30
9	69.30



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

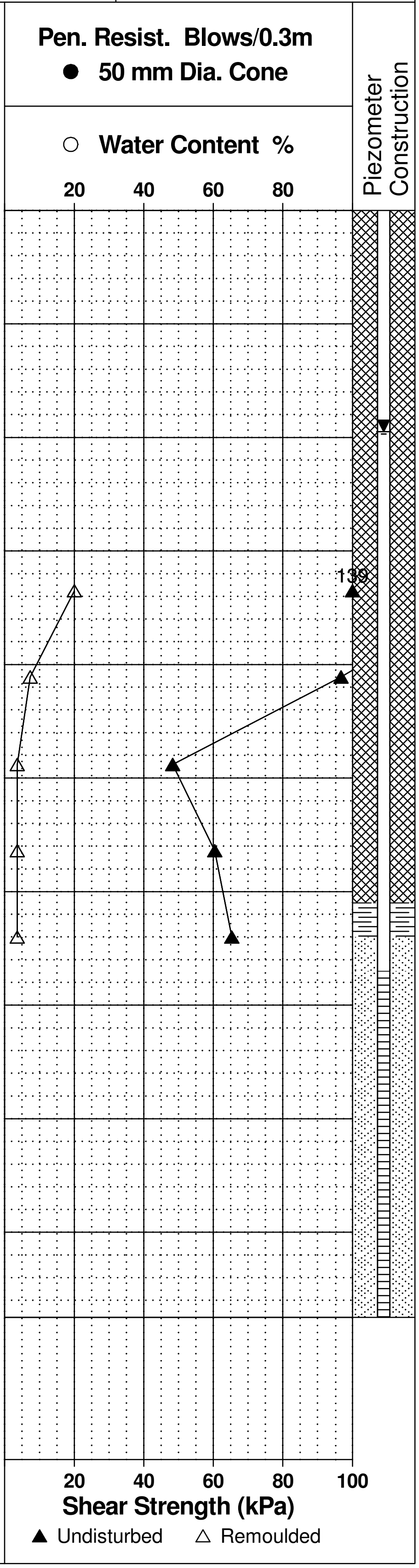
DATE April 9, 2018

FILE NO. PG4412

HOLE NO. BH 5-18

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.04				
FILL: Crushed stone with silt and sand	0.76	AU	1		
Very stiff to stiff, brown **SILTY CLAY,** trace sand - firm to stiff and grey by 4.6m depth	7.32	SS	2	83	12
		SS	3	100	9
		SS	4	100	6
GLACIAL TILL: Grey silty clay, trace sand, gravel, cobbles and boulders	9.75	SS	5	100	2
		SS	6	38	9
End of Borehole (GWL @ 1.95m - April 20, 2018)					

DEPTH (m)	ELEV. (m)
0	78.72
1	77.72
2	76.72
3	75.72
4	74.72
5	73.72
6	72.72
7	71.72
8	70.72
9	69.72



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Phase I Development - 770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hdyrant located near the northeast corner of 716 Brookfiled Road. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

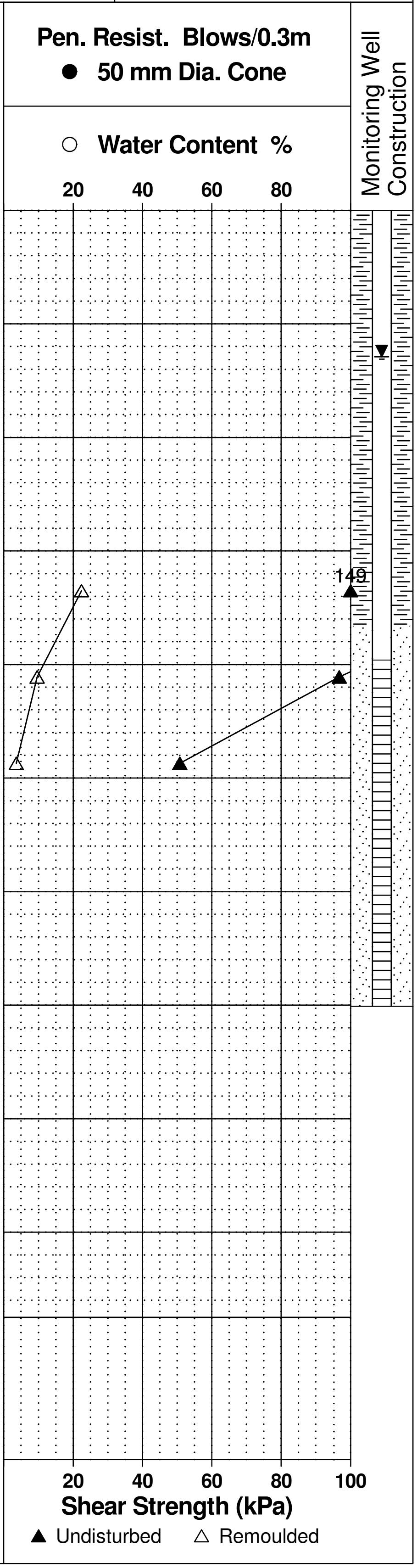
DATE April 6, 2018

FILE NO. PG4412

HOLE NO. BH 6-18

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.03	AU	1		
FILL: Crushed stone with silt and sand	0.56				
FILL: Brown silty clay, trace sand and organics	0.91	SS	2	75	12
Very stiff to stiff, brown **SILTY CLAY,** trace sand		SS	3	100	10
		SS	4	100	6
		SS	5	100	P
		SS	6	100	P
- grey by 4.6m depth	5.26	SS	7	100	P
GLACIAL TILL: Grey silty clay, some sand, trace gravel, cobbles and boulders		SS	8	62	6
		SS	9	25	20
		SS	10	33	12
	9.75	SS	11	100	5
End of Borehole					
(GWL @ 1.29m - April 20, 2018)					

DEPTH (m)	ELEV. (m)
0	79.11
1	78.11
2	77.11
3	76.11
4	75.11
5	74.11
6	73.11
7	72.11
8	71.11
9	70.11



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE July 16, 2014

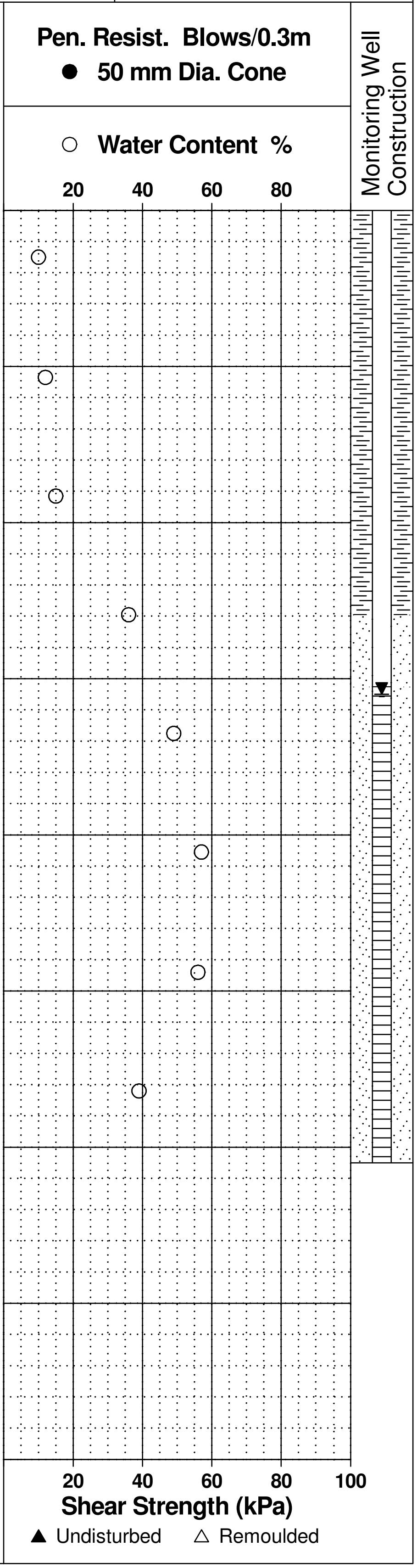
FILE NO. PG3275

HOLE NO. BH 3-14

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
FILL: Brown silty sand, some gravel	2.08	AU	1		
		SS	2	33	17
		SS	3	17	7
Brown to black **SILTY CLAY,** some gravel, trace sand	2.23				
Firm, grey-brown **SILTY CLAY** - soft and grey by 3.8m depth	6.10	SS	4	100	6
		SS	5	100	6
		SS	6	100	2
		SS	7	100	1
		SS	8	100	W

Dynamic Cone Penetration Test commenced at 6.10m depth. Cone pushed to 8.5m depth.

DEPTH (m)	ELEV. (m)
0	78.88
1	77.88
2	76.88
3	75.88
4	74.88
5	73.88
6	72.88
7	71.88
8	70.88



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

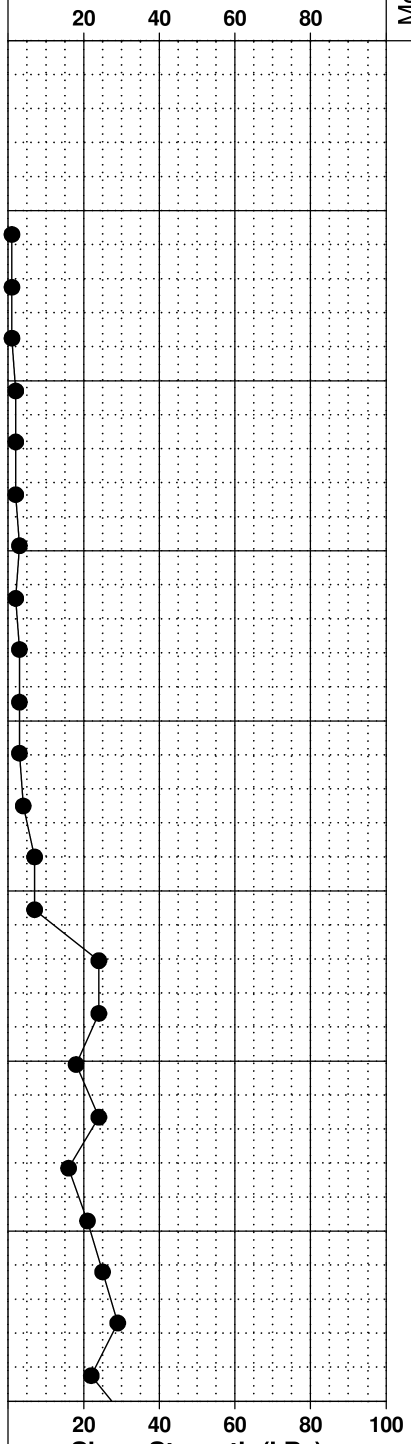
BORINGS BY CME 55 Power Auger

DATE July 16, 2014

FILE NO. PG3275

HOLE NO. BH 3-14

SOIL DESCRIPTION GROUND SURFACE	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 %	Monitoring Well Construction
						8	70.88		
						9	69.88		
						10	68.88		
						11	67.88		
						12	66.88		
						13	65.88		
						14	64.88		
						15	63.88		
						16	62.88		



▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

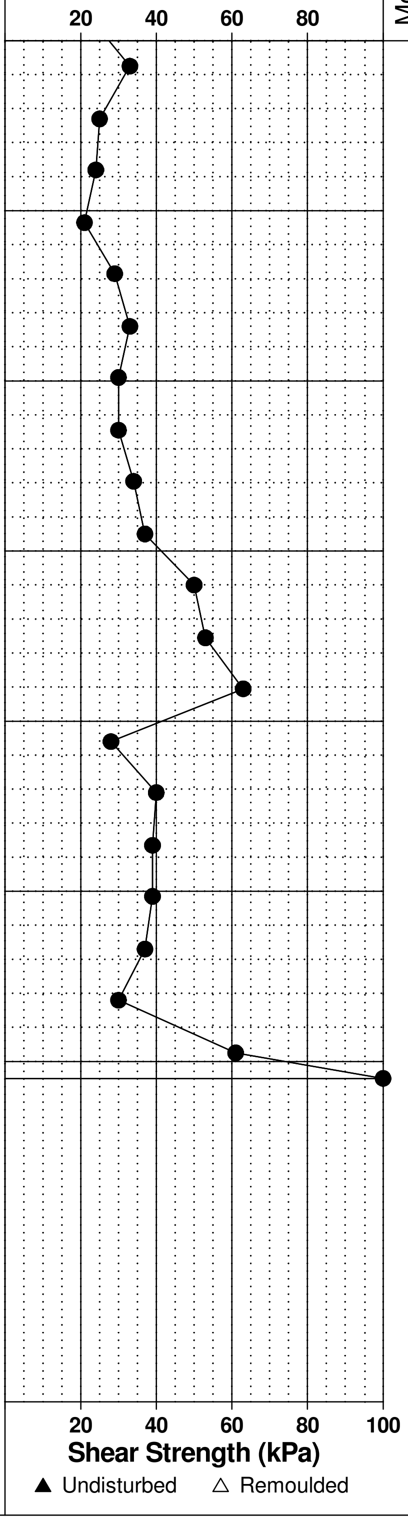
BORINGS BY CME 55 Power Auger

DATE July 16, 2014

FILE NO. PG3275

HOLE NO. BH 3-14

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 %	Monitoring Well Construction
GROUND SURFACE									
						16	62.88		
						17	61.88		
						18	60.88		
						19	59.88		
						20	58.88		
						21	57.88		
						22	56.88		
22.10									



▲ Undisturbed △ Remoulded

End of Borehole

Practical DCPT refusal at 22.10m depth

(GWL @ 3.10m-July 24, 2014)

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

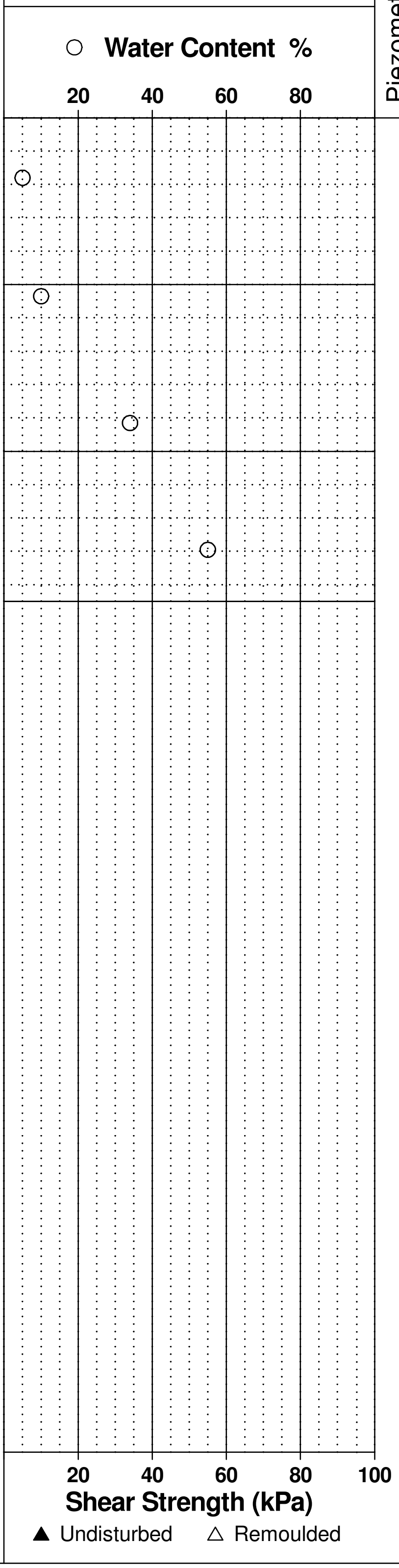
BORINGS BY CME 55 Power Auger

DATE July 16, 2014

FILE NO. PG3275

HOLE NO. BH 4-14

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	78.33
Asphaltic concrete 0.13						
FILL: Brown to black silty sand with gravel	AU	1				
	SS	2	83	22	1	77.33
1.65						
Stiff, brown **SILTY CLAY** - grey-brown by 2.2m depth	SS	3	75	12		
					2	76.33
	SS	4	83	5		
2.90 End of Borehole						



Piezometer Construction

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

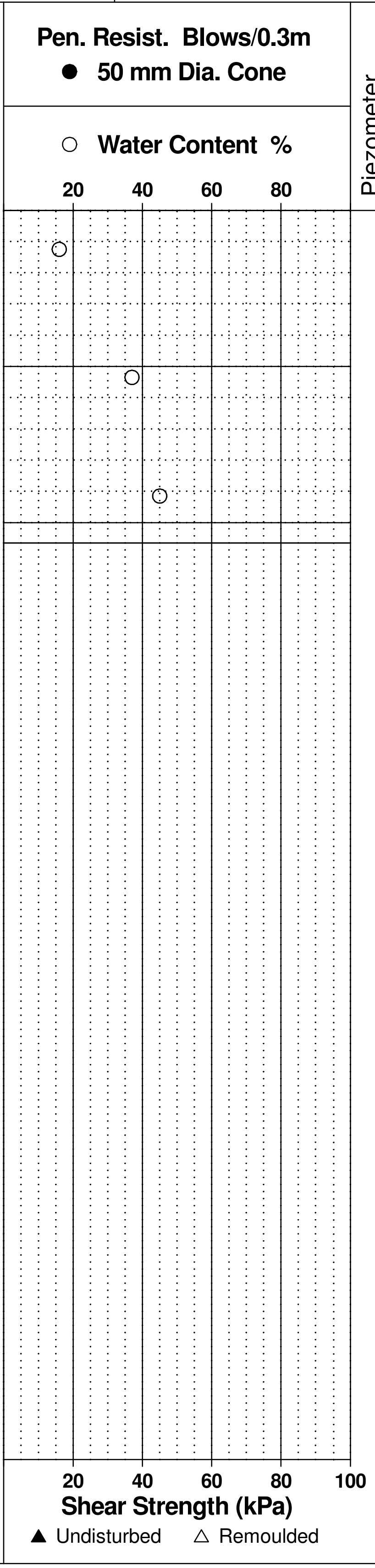
BORINGS BY CME 55 Power Auger

DATE July 16, 2014

FILE NO. PG3275

HOLE NO. BH 5-14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	78.97
Asphaltic concrete 0.10							
FILL: Brown silty sand with gravel 0.66		AU	1				
Firm to stiff, brown **SILTY CLAY,** trace sand		SS	2	92	8	1	77.97
2.13		SS	3	100	11	2	76.97
End of Borehole							



Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

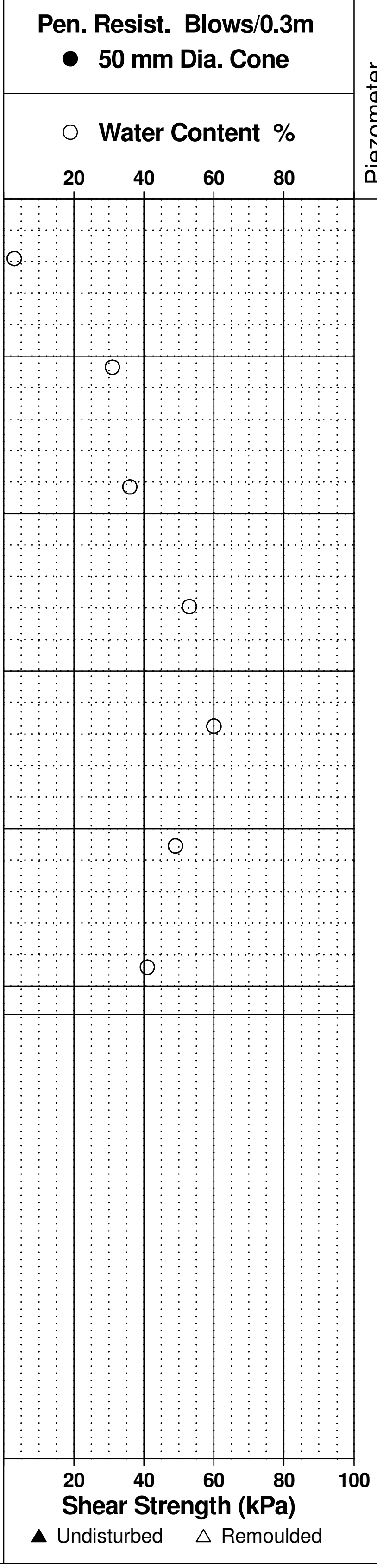
DATE July 16, 2014

FILE NO. PG3275

HOLE NO. BH 6-14

SOIL DESCRIPTION	Depth to base (m)	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.10				
FILL: Brown to black silty sand with gravel	1.52	AU	1		
		SS	2	33	10
Stiff to firm, brown **SILTY CLAY** with sand - grey-brown by 2.9m depth - grey by 3.8m depth	5.18	SS	3	100	10
		SS	4	100	5
		SS	5	100	3
		SS	6	100	2
		SS	7	100	3
End of Borehole					

DEPTH (m)	ELEV. (m)
0	78.56
1	77.56
2	76.56
3	75.56
4	74.56
5	73.56



Piezometer Construction

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential and Commercial Development
770 Brookfield Road, Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the south side of Brookfield Road, near the northeast corner of subject property. Geodetic elevation = 78.769m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE November 6, 2014

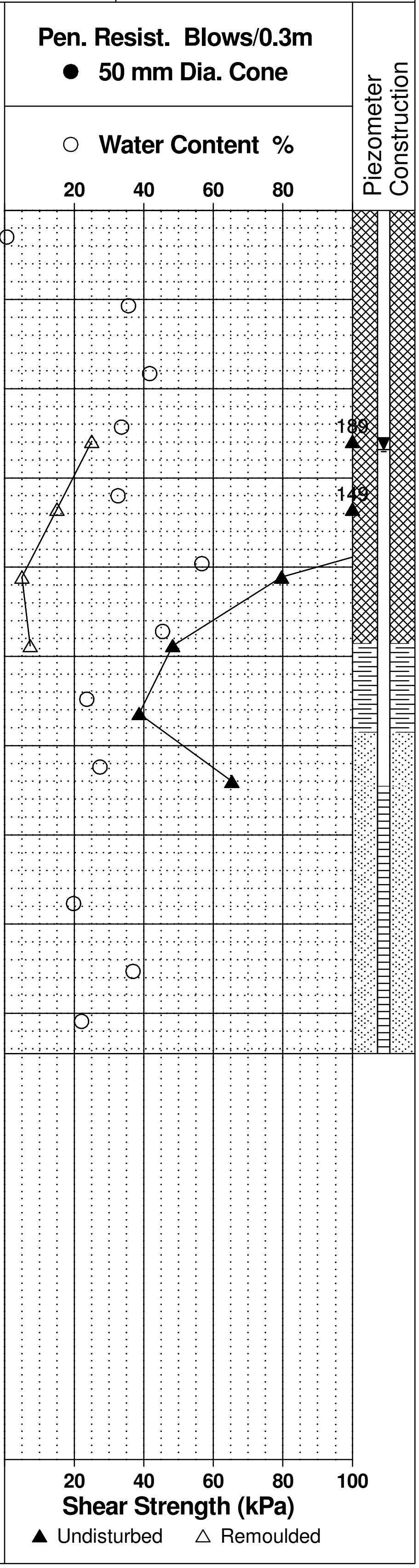
FILE NO. PG3275

HOLE NO. BH 9-14

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
50mm Asphaltic concrete over brown silty sand with crushed stone	0.71
Very stiff to stiff, brown **SILTY CLAY** - firm to stiff and grey by 4.5m depth	7.62
GLACIAL TILL: Grey silty clay with sand and gravel	9.45
End of Borehole (GWL @ 2.68m-Nov. 17, 2014)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	83	13
SS	3	83	10
TW	4	100	

DEPTH (m)	ELEV. (m)
0	78.44
1	77.44
2	76.44
3	75.44
4	74.44
5	73.44
6	72.44
7	71.44
8	70.44
9	69.44



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154 Colonnade Road, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant along Brookfield Road (see plan). Geodetic elevation = 78.76m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE Feb 24, 04

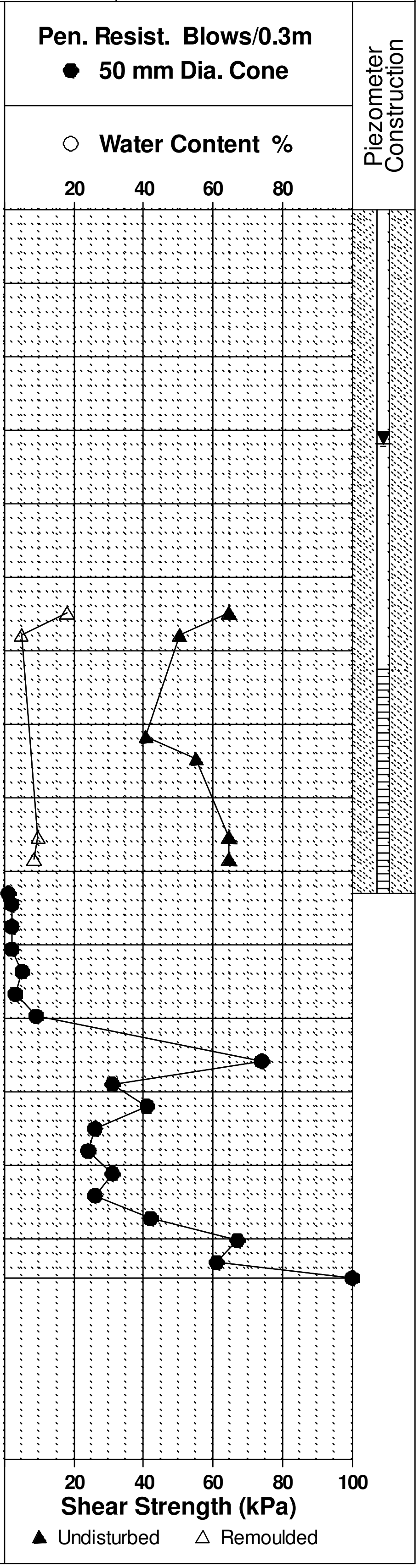
FILE NO. PG0123

HOLE NO. BH 1

SOIL DESCRIPTION	
GROUND SURFACE	
Asphaltic concrete	0.05
FILL: Grey crushed stone	0.28
FILL: Brown clayey silty sand with gravel and asphalt pieces	2.29
Stiff, brown **SILTY CLAY** - grey by 3.8m depth	9.30
Dynamic Cone Penetration Test commenced @ 9.30m depth Inferred **SILTY CLAY**	11.30
Inferred **GLACIAL TILL**	14.53
End of Borehole Cone refusal @ 14.53m depth (GWL @ 3.18m-Mar. 1/04)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
SS	1	100	50+
SS	2	42	29
SS	3	100	10
SS	4	100	6
SS	5	100	1
SS	6	100	1
SS	7	100	1
SS	8	100	1
SS	9	100	P

DEPTH (m)	ELEV. (m)
0	78.32
1	77.32
2	76.32
3	75.32
4	74.32
5	73.32
6	72.32
7	71.32
8	70.32
9	69.32
10	68.32
11	67.32
12	66.32
13	65.32
14	64.32



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154 Colonnade Road, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant along Brookfield Road (see plan). Geodetic elevation = 78.76m.

REMARKS

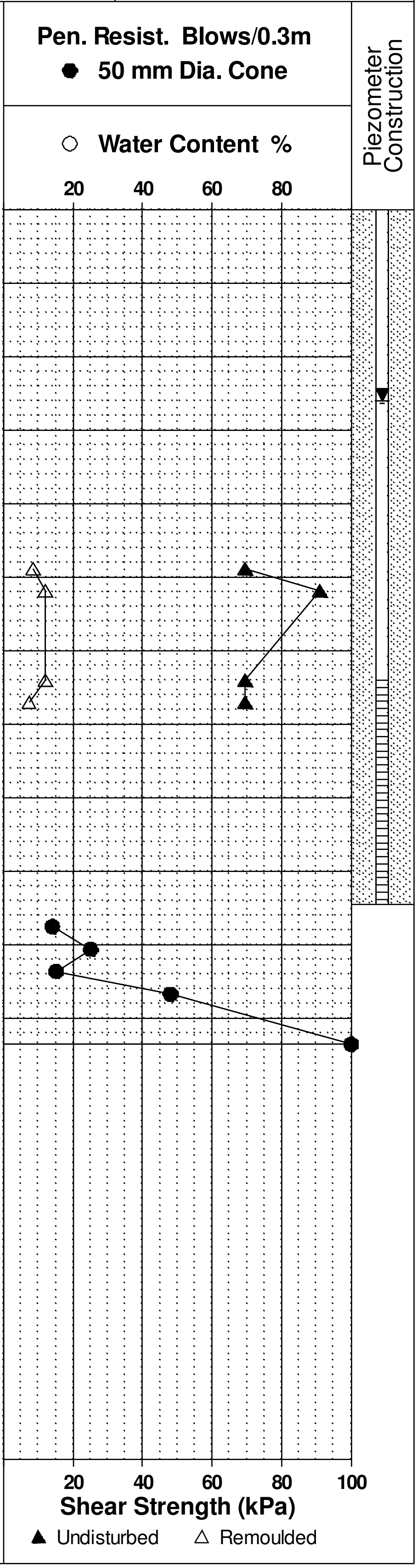
BORINGS BY CME 55 Power Auger

DATE Feb 24, 04

FILE NO. PG0123

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	78.57
Asphaltic concrete 0.05		AU	1				
FILL: Brown clayey silty sand with gravel		SS	2	100	53	1	77.57
		SS	3	92	17	2	76.57
2.29							
Stiff, brown **SILTY CLAY**		SS	4	100	8	3	75.57
		SS	5	100		4	74.57
		SS	6	100	2	5	73.57
- grey by 5.3m depth		SS	7	100	1	6	72.57
						7	71.57
		SS	8	42	9	8	70.57
		SS	9	100	4		
8.64							
GLACIAL TILL: Very stiff, grey clayey silt with gravel, cobbles and boulders 9.45		SS	10	54	23	9	69.57
Dynamic Cone Penetration Test commenced @ 9.45m depth						10	68.57
Inferred **GLACIAL TILL** 11.35						11	67.57
End of Borehole Cone refusal @ 11.35m depth (GWL @ 2.60m-Mar. 1/04)							



patersongroup Consulting Engineers

154 Colonnade Road, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant along Brookfield Road (see plan). Geodetic elevation = 78.76m.

REMARKS

BORINGS BY CME 55 Power Auger

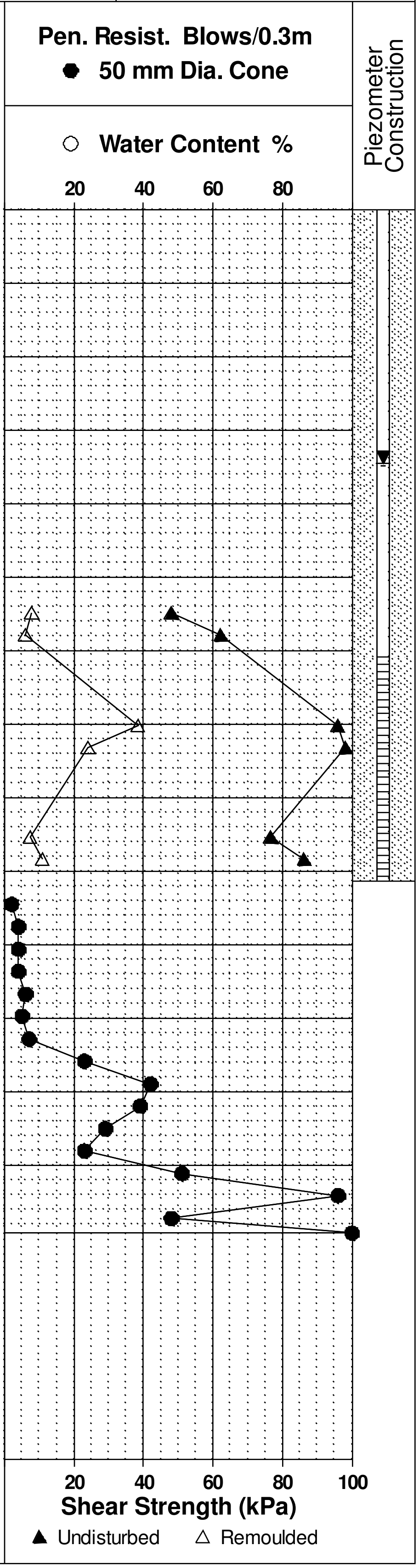
DATE Feb 23, 04

FILE NO. PG0123

HOLE NO. BH 3

SOIL DESCRIPTION		SAMPLE			
GROUND SURFACE		TYPE	NUMBER	% RECOVERY	N VALUE or RQD
Asphaltic concrete	0.10				
FILL: Brown clayey silty sand with gravel		AU	1		
		AU	2		
	4.57	AU	3		
Stiff, brown **SILTY CLAY**		SS	4	100	1
- grey by 6.1m depth		SS	5	100	1
		SS	6	100	1
	9.14	SS	7	100	P
Dynamic Cone Penetration Test commenced @ 9.14m depth Inferred **SILTY CLAY**	11.60				
Inferred **GLACIAL TILL**	13.92				
End of Borehole Cone refusal @ 13.92m depth (GWL @ 3.45m-Mar. 1/04)					

DEPTH (m)	ELEV. (m)
0	78.87
1	77.87
2	76.87
3	75.87
4	74.87
5	73.87
6	72.87
7	71.87
8	70.87
9	69.87
10	68.87
11	67.87
12	66.87
13	65.87



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154 Colonnade Road, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant along Brookfield Road (see plan). Geodetic elevation = 78.76m.

REMARKS

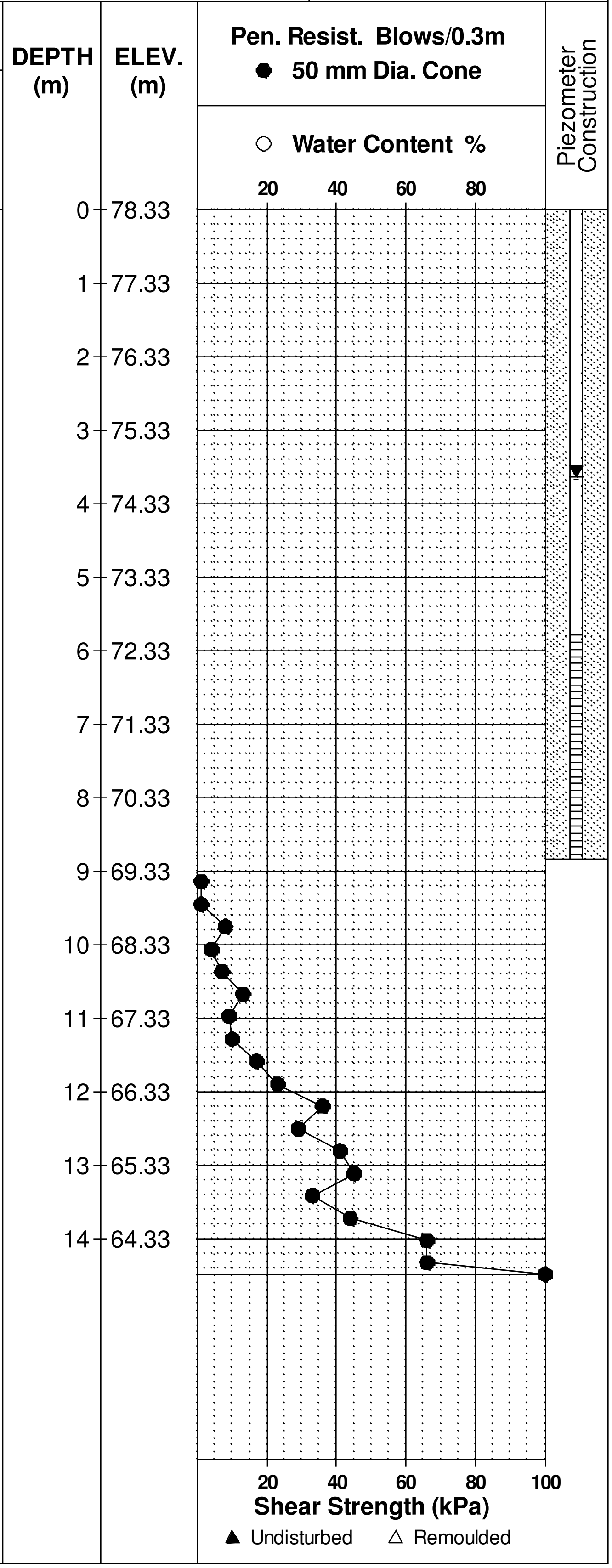
BORINGS BY CME 55 Power Auger

DATE Feb 27, 04

FILE NO. PG0123

HOLE NO. BH 4

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
Asphaltic concrete 0.10				
FILL: Grey crushed stone 0.25	AU	1		
Inferred **FILL**: Brown clayey silty sand with gravel	AU	2		
	AU	3		
5.18				
Stiff, brown **SILTY CLAY**	AU	4		
- grey by 6.1m depth	SS	5	100	1
	SS	6	100	1
	SS	7	100	1
8.84				
Dynamic Cone Penetration Test commenced @ 8.84m depth				
Inferred **SILTY CLAY**				
11.60				
Inferred **GLACIAL TILL**				
14.48				
End of Borehole				
Cone refusal @ 14.48m depth				
(GWL @ 3.64m-Mar. 1/04)				



patersongroup Consulting Engineers

154 Colonnade Road, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
770 Brookfield Road
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant along Brookfield Road (see plan). Geodetic elevation = 78.76m.

REMARKS

BORINGS BY CME 55 Power Auger

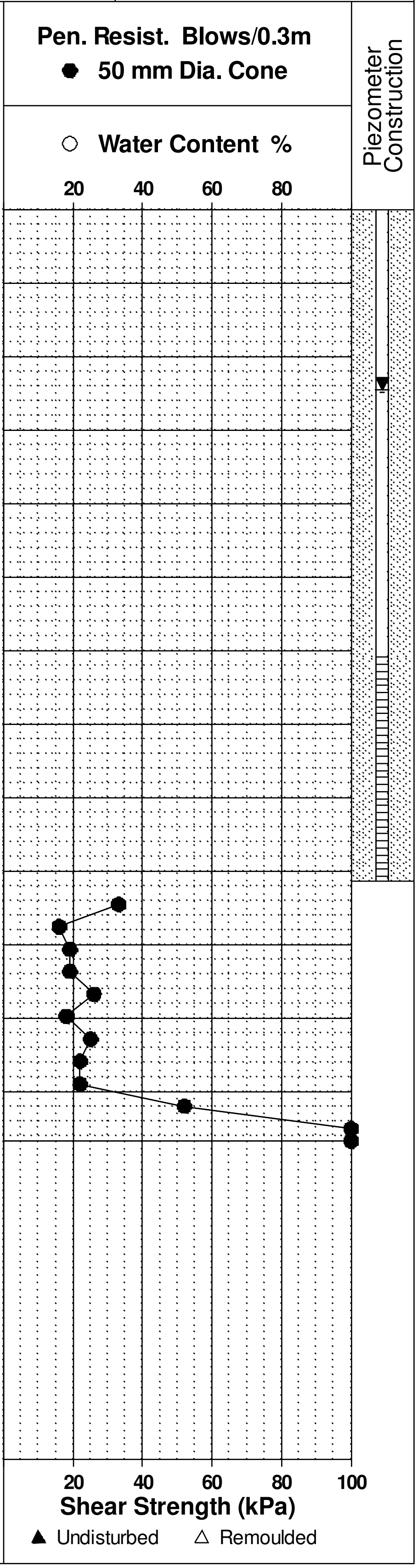
DATE Feb 27, 04

FILE NO. PG0123

HOLE NO. BH 5

SOIL DESCRIPTION	Depth (m)	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.10	AU	1		
FILL: Brown clayey silty sand with gravel	2.44				
Stiff, brown **SILTY CLAY**		AU	2		
		AU	3		
	6.10	AU	4		
GLACIAL TILL: Very stiff, grey clayey silt to silty clay with gravel, cobbles and boulders		SS	5	38	14
		SS	6	33	50+
	9.14	SS	7	29	15
Dynamic Cone Penetration Test commenced @ 9.14m depth Inferred **GLACIAL TILL**	12.67				
End of Borehole Cone refusal @ 12.67m depth (GWL @ 2.45m-Mar. 1/04)					

DEPTH (m)	ELEV. (m)
0	78.91
1	77.91
2	76.91
3	75.91
4	74.91
5	73.91
6	72.91
7	71.91
8	70.91
9	69.91
10	68.91
11	67.91
12	66.91



SYMBOLS AND TERMS

SOIL DESCRIPTION

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

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

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

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

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

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

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

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

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

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

SYMBOLS AND TERMS (continued)

PLASTICITY LIMITS AND GRAIN SIZE DISTRIBUTION

WC% - Natural water content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic Limit, % (water content above which soil behaves plastically)
PI - Plasticity Index, % (difference between LL and PL)

Dxx - Grain size at which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2$ / (D10 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)

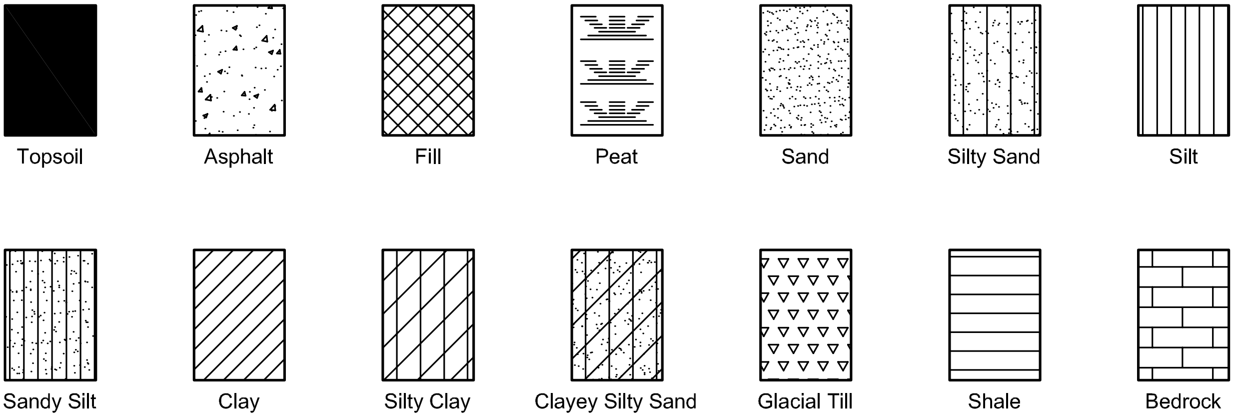
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

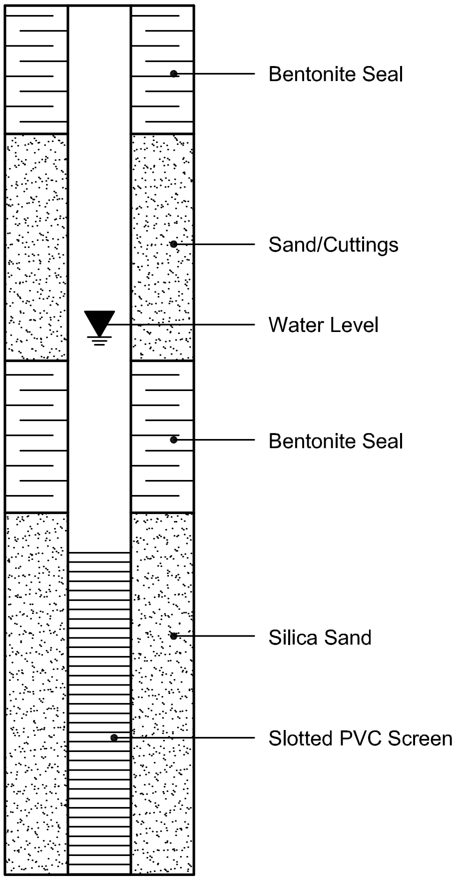
SYMBOLS AND TERMS (continued)

STRATA PLOT

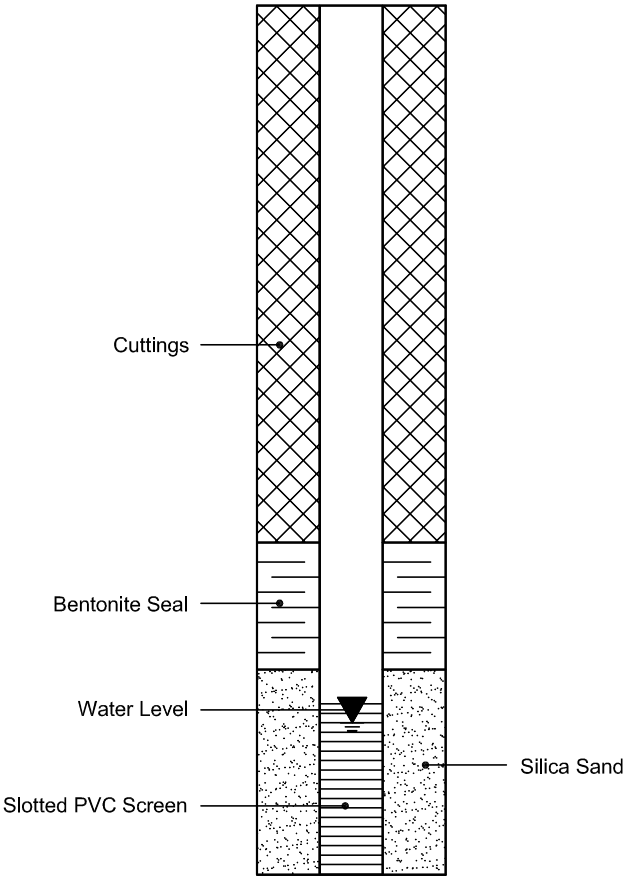


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 54606

Report Date: 18-May-2022

Order Date: 12-May-2022

Project Description: PG4412

	Client ID:	BH2-22 SS7	-	-	-
	Sample Date:	04-May-22 09:00	-	-	-
	Sample ID:	2220545-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	67.2	-	-	-
General Inorganics					
pH	0.05 pH Units	7.78	-	-	-
Resistivity	0.10 Ohm.m	18.6	-	-	-
Anions					
Chloride	5 ug/g dry	73	-	-	-
Sulphate	5 ug/g dry	134	-	-	-

APPENDIX 2

FIGURE 1 – KEY PLAN

DRAWING PG4412-2 – TEST HOLE LOCATION PLAN

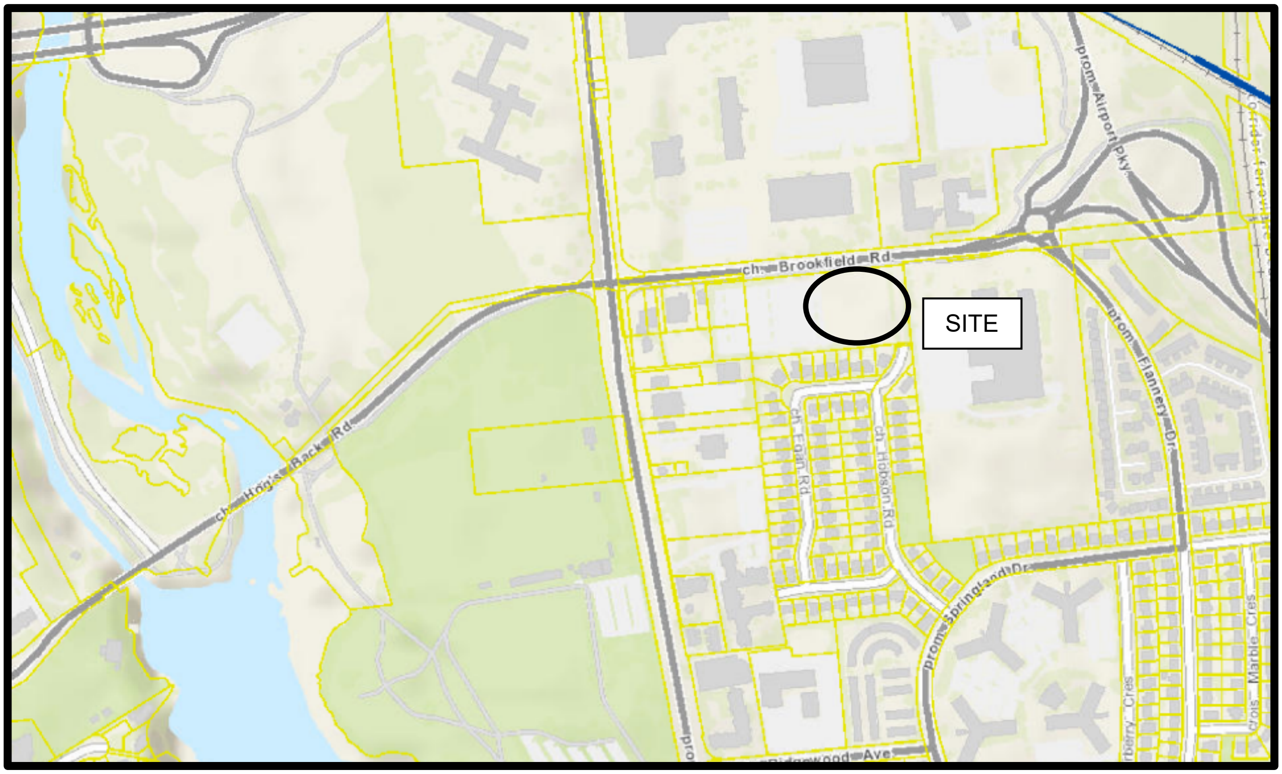
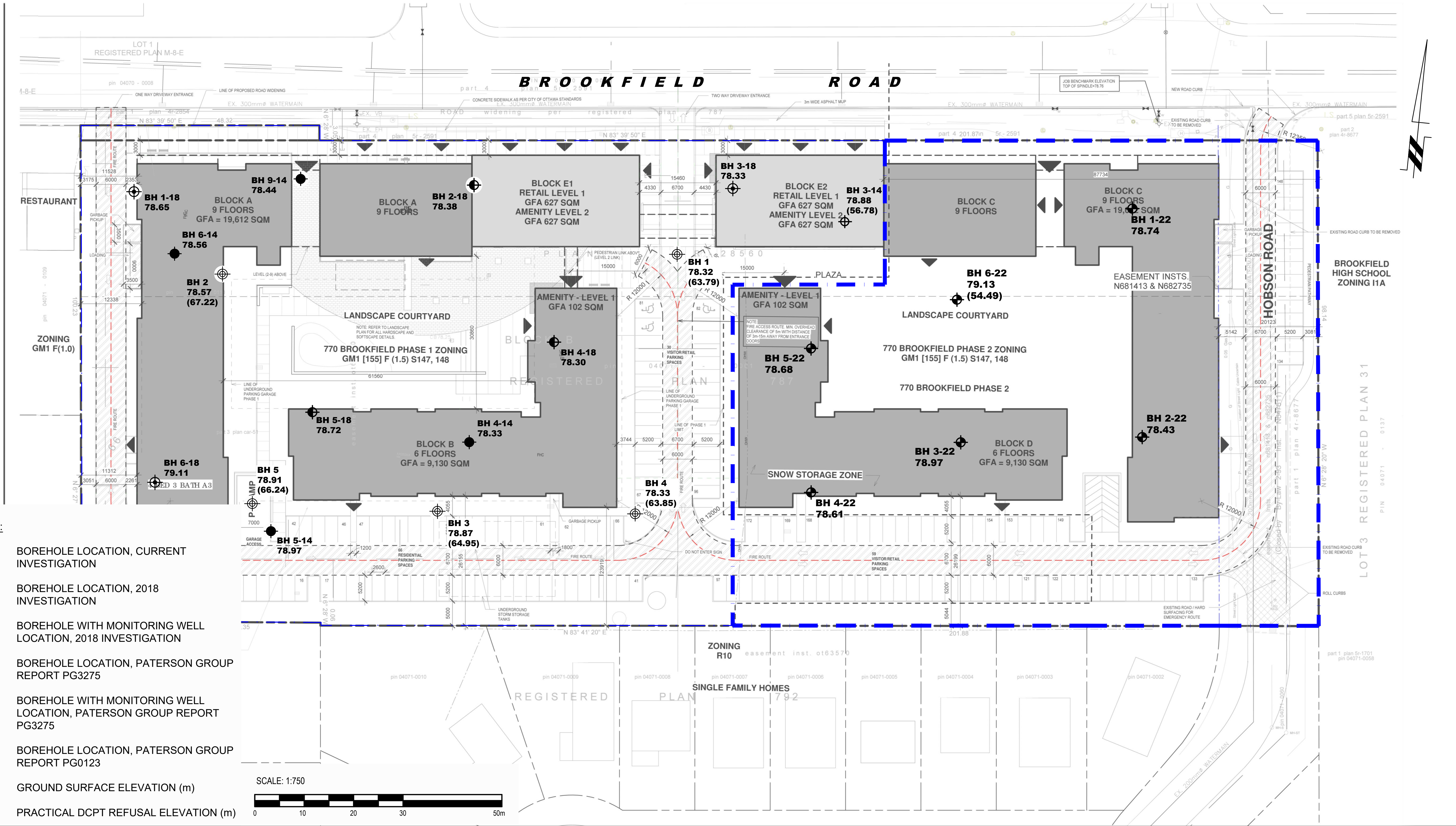


FIGURE 1

KEY PLAN

patersongroup



LEGEND:

⊕ BOREHOLE LOCATION, CURRENT INVESTIGATION

⊕ BOREHOLE LOCATION, 2018 INVESTIGATION

⊕ BOREHOLE WITH MONITORING WELL LOCATION, 2018 INVESTIGATION

● BOREHOLE LOCATION, PATERSON GROUP REPORT PG3275

⊕ BOREHOLE WITH MONITORING WELL LOCATION, PATERSON GROUP REPORT PG3275

⊕ BOREHOLE LOCATION, PATERSON GROUP REPORT PG0123

78.88 GROUND SURFACE ELEVATION (m)

(56.78) PRACTICAL DCPT REFUSAL ELEVATION (m)

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
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NO.	REVISIONS	DATE	INITIAL

CAMPUS DEVELOPMENTS GLOBAL INC.

GEOTECHNICAL INVESTIGATION
PROPOSED DEVELOPMENT
770 BROOKFIELD ROAD - PHASE 2

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:750
Date: 05/2022
Drawn by: NFRV
Report No.: PG4412-1
Checked by: BN
Dwg. No.: PG4412-2
Approved by: SD
Revision No.:

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