

**Geotechnical  
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**paterson**group

**Geotechnical and  
Preliminary Hydrogeological Investigation**

Proposed Hi-Rise Complex  
400 Albert Street and 383 Slater Street  
Ottawa, Ontario

Prepared For

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## **1.0 Introduction**

Paterson Group (Paterson) was commissioned by Main and Main to conduct a geotechnical investigation for a proposed high rise complex located at 400 Albert Street and 383 Slater Street in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the current investigation were to:

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

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

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work for this geotechnical investigation. An environmental program was carried out and the information is presented under separate cover.

## **2.0 Proposed Development**

Based on current plans, it is understood that the proposed development will consist of 3 high rise mixed-use buildings. Towers A, B and C will have 14, 32 and 34 storeys, respectively, and will share an underground parking garage with 4 to 6 levels below the existing grade. The underground parking will occupy the majority of the site. It is further understood that the proposed building will be municipally serviced.

## **3.0 Method of Investigation**

### **3.1 Field Investigation**

#### **Field Program**

The field program for the current investigation was carried out on March 28, 29 and April 1, 2019. At that time, 3 boreholes were advanced to a maximum depth of 19.4 m below existing grade across the subject site to provide general coverage of the proposed development. A previous geotechnical investigation was completed in June 2015. The locations of all the test holes are shown on Drawing PG4793-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were drilled using a truck-mounted auger drill rig operated by a two person crew. The test hole procedure consisted of augering to the required depths at the selected locations and sampling the overburden soils. All fieldwork was conducted under the full-time supervision of personnel from Paterson's geotechnical division under the direction of a senior engineer.

#### **Sampling and In Situ Testing**

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler, or drill cuttings from the auger flights. The split-spoon and auger samples were placed in sealed plastic bags and transported to our laboratory for further examination and classification. The depths at which the split-spoon and auger samples were recovered from the test holes are shown as SS and AU, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

Standard Penetration Testing (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.

Diamond drilling was carried out at 3 borehole locations to assess the bedrock quality. A recovery value and a Rock Quality Designation (RQD) value were calculated for each drilled section of bedrock and are shown on the Soil Profile and Test Data sheets in Appendix 1. The recovery value is the ratio, in percentage, of the length of the bedrock sample recovered over the length of the drilled section. The RQD value is the ratio, in percentage, of the total length of intact rock pieces longer than 100 mm in one drilled section over the length of the drilled section. These values are indicative of the bedrock quality.

Subsurface conditions observed in the boreholes 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**

51 mm diameter PVC groundwater monitoring wells were installed in each of the current boreholes to permit monitoring of the groundwater levels subsequent to the completion of the drilling program. Monitoring wells will be decommissioned prior to the commencement of construction and during the excavation program. Typical monitoring well construction details are described below:

- ☐ Slotted 51 mm diameter PVC screen at base of borehole for 3 m length.
- ☐ 51 mm diameter PVC riser pipe from top of the screen to ground surface.
- ☐ No. 3 silica sand backfill within annular space around screen.
- ☐ 300 mm thick bentonite hole plug directly above PVC slotted screen.
- ☐ Clean backfill from top of bentonite plug to ground surface.

Refer to the Soil Profile and Test Data sheets in Appendix 1 for specific monitoring well construction details.

## **3.2 Field Survey**

The borehole locations were determined by Paterson personnel taking into consideration the presence of underground and aboveground services. The location and ground surface elevation at each borehole location was surveyed by Paterson personnel. The ground surface elevations at the borehole locations were surveyed with respect to a temporary benchmark (TBM), consisting of the top of a manhole cover located at the west side of the subject site. A geodetic elevation of 72.77 m was provided for the TBM. The test hole locations and ground surface elevations at the test hole locations are presented on Drawing PG4793-1 - Test Hole Location Plan in Appendix 2.

## **3.3 Laboratory Testing**

Soil and bedrock 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 month after issuance of this report. They will then be discarded unless we are otherwise directed.

## **4.0 Observations**

### **4.1 Surface Conditions**

The majority of the subject site currently consists of a gravel surfaced at-grade parking lot. Two 3-storey apartment buildings are located in the northwest corner of the site. A 2-storey building is located near the northeast corner of the site. The ground surface across the subject site generally slopes down from north to south. The ground surface was observed to be at grade with the adjacent roadways.

The site is bordered by Albert Street to the north, Lyon Street to the east, Slater Street to the south and Bay Street to the west.

### **4.2 Subsurface Profile**

#### **Overburden**

The subsurface profile encountered at the borehole locations consists of crushed stone gravel surfacing, followed by a layer of silty sand fill. Glacial till was encountered below the above noted soils at BH 1 and BH 2, which was observed to generally consist of clayey silt with sand and gravel. The fill layer was underlain by a concrete slab at BH 3. Practical refusal to augering was encountered at depths ranging between 2.8 and 4.3 m below existing grade.

It should be noted that several test pits were excavated within the proposed building footprint of Tower C to assess the fill material used to backfill the building demolition. A fill layer consisting of crushed stone was encountered at each of the test pit locations, followed by practical refusal to excavation on concrete at 200 to 400 mm depth.

#### **Bedrock**

Grey limestone bedrock was cored at each of the borehole locations. Based on our observations, the majority of the bedrock core was noted to be of good to excellent quality.

Based on available geological mapping, the local bedrock consists of interbedded grey and black limestone of the Ottawa and Eastview formations with an overburden drift thickness of 2 to 5 m.

Specific details of the subsurface profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

### 4.3 Groundwater

A total of 3 groundwater monitoring wells were installed as part of our geotechnical investigation. Groundwater level measurements were recorded at the monitoring well locations and our observations are presented in Table 1.

<b>Table 1 - Summary of Groundwater Level Readings</b>				
<b>Test Hole Number</b>	<b>Ground Elevation (m)</b>	<b>Groundwater Levels (m)</b>		<b>Recording Date</b>
		<b>Depth</b>	<b>Elevation</b>	
BH 1	73.24	4.37	68.87	April 9, 2019
BH 2	71.99	2.20	69.79	April 9, 2019
BH 3	72.77	3.50	69.27	April 9, 2019

The groundwater levels measured in the monitoring well locations, it may be possible that these elevated groundwater levels represent a perched groundwater condition at the soil/bedrock interface. The LRT Confederation Line is approximately one block from the subject site and is a partially tanked tunnel which is drawing the groundwater to a depth of approximately 20 m. It's expected that the drawdown of the groundwater from surrounding buildings have also lowered the general groundwater table in this area. Based on the above, the long-term groundwater table can be expected to be at a depth of 12 to 15 m below the existing grade. It should be noted that groundwater levels are subject to seasonal fluctuations and therefore levels could vary at the time of construction.



## **5.0 Discussion**

### **5.1 Geotechnical Assessment**

From a geotechnical perspective, the subject site is considered satisfactory for the proposed development. It is anticipated that the proposed development will be founded on spread footings placed on a clean, surface sounded bedrock bearing surface.

Bedrock removal will be required to complete the underground parking levels. Line drilling and controlled blasting is recommended where large quantities of bedrock need to be removed. The blasting operations should be planned and completed under the guidance of a professional engineer with experience in blasting operations. Grinding of the bedrock will be carried out next to sensitive structures and to lessen the potential for over breaking of the bedrock vertical surface for architectural drainage details.

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

### **5.2 Site Grading and Preparation**

#### **Stripping Depth**

Due to the depth of the bedrock, it is anticipated that all existing overburden material will be excavated from within the footprint of the proposed development. It should be noted that concrete was encountered within the overburden fill material during the field program, and therefore building remnants such as concrete slabs and/or foundation walls should be anticipated.

#### **Bedrock Removal**

It is expected that line-drilling in conjunction with hoe-ramming or controlled blasting will be required to remove the bedrock for the underground parking levels. In areas of weathered bedrock and where only a small quantity of bedrock is to be removed, bedrock removal may be possible by hoe-ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in proximity of the blasting operations should be carried out prior to commencing site activities. The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries/claims related to the blasting operations.

As a general guideline, peak particle velocities (measured at the structures) should not exceed 25 mm per second during the blasting program to reduce the risks of damage to the existing structures.

The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

Excavation side slopes in sound bedrock can be carried out using almost vertical side walls. When possible, a minimum 1 m horizontal ledge should be left between the bottom of the overburden excavation and the top of the bedrock surface to provide an area to allow for potential sloughing or to provide a stable base for the overburden shoring system. Consideration can also be given to providing a vertical excavation provided the temporary shoring can accommodate a vertical face with satisfactory bedrock anchoring.

### **Vibration Considerations**

Construction operations are also the cause of 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, as much as possible, a cooperative environment with the residents.

The following construction equipments could be a source of vibrations: piling rig, hoe ram, compactor, dozer, crane, truck traffic, etc. The construction of the shoring system using soldier piles or sheet piling will require the use of these equipments. Vibrations, whether caused by blasting operations or by construction operations, could be the source of detrimental vibrations on the adjoining buildings and structures. Therefore, it is recommended that all vibrations be limited.

Two parameters are used to determine the permissible vibrations, namely, 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). It should be noted that these guidelines are for today's construction standards. Considering that several old or sensitive buildings are encountered in the vicinity of the subject site, considerations should be given to lowering these guidelines. Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, it is recommended that a pre-construction survey be completed to minimize the risks of claims during or following the construction of the proposed building.

## **Fill Placement**

Excavated limestone bedrock could be used as select subgrade material around the proposed building footings, provided the excavated bedrock is suitably crushed to 50 mm in its longest dimension and approved by the geotechnical consultant at the time of placement. Alternatively, an engineered fill such as an OPSS Granular A or Granular B Type II compacted to 98% of the material's SPMDD could be placed around the proposed footings.

## **Bedrock Stabilization**

Rock anchors or rock bolts may be required at specific locations to stabilize the vertical bedrock excavated face to prevent pop-outs of the bedrock and slippage of the rock mass due to the dip in the bedrock planes. Furthermore, the upper levels of the bedrock is typically fractured and weathered and often requires some form of protections using geotextile with a chain link to deal with minor raveling.

The requirements for rock stabilization will be evaluated by the geotechnical engineer during the excavation program when the bedrock condition can be better evaluated.

## **5.3 Foundation Design**

### **Bearing Resistance Values**

A factored bearing resistance value at ultimate limit states (ULS) of **6,000 kPa** can be used for footings founded on limestone bedrock at the proposed founding elevation of the parking garage provided the bedrock is free of seams, fractures and voids within 1.5 m below the founding level. This could be verified by completing and probing 50 mm diameter drill holes to a depth of 1.5 m below the founding level within the footprint(s) of the footing(s). At least one drill hole should be completed per major footing. The drill hole inspection should be carried out by the geotechnical consultant. As an alternative to probing the bedrock, the bedrock vertical face, along the excavation sides and within depressed areas such as the elevator pit, can be assessed by the geotechnical engineer to confirm the soundness of the bedrock at depth.

Footings placed on the upper levels of the limestone bedrock surface for shallow building structures (canopy and garage ramp) should be cleaned and surface sounded. This bearing medium can be designed using a bearing resistance value at ULS of **3,000 kPa**.

A geotechnical resistance factor of 0.5 was incorporated into the above noted bearing resistance values reported at ULS.

A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

### **Lateral Support**

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:6V (or flatter) passes only through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete. A weathered bedrock bearing medium will require a lateral support zone of 1H:1V (or flatter).

### **Settlement**

Footings bearing on an acceptable bedrock bearing surface and designed using the bearing resistance values provided herein will be subjected to negligible potential post-construction total and differential settlements.

## **5.4 Design for Earthquakes**

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

### **Field Program**

The seismic array location is presented on Drawing PG4793-1 - Test Hole Location Plan in Appendix 2. Paterson field personnel placed 18 horizontal geophones in a straight line in an approximately east-west orientation. The 4.5 Hz geophones were mounted to the surface with two 75 mm ground spikes attached to the geophone land case. The geophones were spaced at 2 m intervals and connected by a geophone spread cable to a Geode 24 channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between 5 to 10 times at each shot location to improve signal to noise ratio. The shot locations are also completed in forward and reverse directions (i.e. striking both sides of the I-beam seated parallel to the geophone array). The shot locations are located 3 and 4.5 m from the first geophone and 3, 4.5 and 15 m from the last geophone.

## Data Processing and Interpretation

Interpretation for the shear wave velocity test results was completed by Paterson personnel. Shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity,  $V_{s30}$ , of the upper 30 m profile immediately below the building foundations. The bedrock velocity was interpreted using the main refractor wave velocity, which is considered a conservative estimate of the bedrock velocity due to the increasing quality of the bedrock with depth. It should be noted that as bedrock quality increases, the bedrock shear wave velocity also increases.

Given the bedrock depth encountered in the test holes at this site, it is anticipated that the proposed building will be founded directly on the bedrock. Based on our testing results, the bedrock shear wave velocity is **2,339 m/s**.

The  $V_{s30}$  was calculated using the standard equation for average shear wave velocity calculation from the OBC 2012, as presented below.

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

$$V_{s30} = \frac{30m}{\left( \frac{30m}{2,339m / s} \right)}$$

$$V_{s30} = 2,339m / s$$

Based on the results of the seismic testing, the average shear wave velocity,  $V_{s_{30}}$ , for the proposed building is 2,339 m/s provided the footings are placed directly on the bedrock surface. Therefore, a **Site Class A** is applicable for the proposed buildings, as per Table 4.1.8.4.A of the OBC 2012. The soils underlying the subject site are not susceptible to liquefaction.

## 5.5 Basement Slab

All overburden soil will be removed from the subject site leaving the bedrock as the founding medium for the lower basement floor slab. If 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 for finished space areas and 300 mm of OPSS Granular A for the parking garage areas. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMD.

In consideration of the groundwater conditions encountered at the time of the fieldwork, a subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the clear stone under the lower basement floor. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

## 5.6 Basement Wall

It is understood that the basement walls are to be poured against a waterproofing system, which will be placed against the exposed bedrock face. Below the bedrock surface, a nominal coefficient for at-rest earth pressure of 0.05 is recommended in conjunction with a bulk unit weight of  $24.5 \text{ kN/m}^3$  (effective  $15.5 \text{ kN/m}^3$ ). A seismic earth pressure component will not be applicable for the foundation wall, which is to be poured against the bedrock face. It is expected that the seismic earth pressure will be transferred to the underground floor slabs, which should be designed to accommodate these pressures. A hydrostatic groundwater pressure should be added for the portion below the groundwater level.

Where soil is to be retained, 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  $20 \text{ kN/m}^3$ . Undrained conditions are anticipated (i.e. below the groundwater level). Therefore, the applicable effective (undrained) unit weight of the retained soil can be taken as  $13 \text{ kN/m}^3$ , where applicable. A hydrostatic pressure should be added to the total static earth pressure when using the effective unit weight.

Two distinct conditions, static and seismic, must be reviewed for design calculations. The parameters for design calculations for the two conditions are presented below.

### **Static Conditions**

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, 0.05

$\gamma$  = unit weight of fill of the applicable retained soil ( $\text{kN/m}^3$ )

$H$  = 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 Conditions**

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

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

$a_c$  =  $(1.45 - a_{\max}/g)a_{\max}$

$\gamma$  = unit weight of fill of the applicable retained soil ( $\text{kN/m}^3$ )

$H$  = height of the wall (m)

$g$  = gravity,  $9.81 \text{ m/s}^2$

The peak ground acceleration, ( $a_{\max}$ ), for the Ottawa area is  $0.32g$  according to 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 OBC 2012.

## 5.7 Rock Anchor Design

The geotechnical design of grouted rock anchors in sedimentary bedrock is based upon two possible failure modes. The anchor can fail either by shear failure along the grout/rock interface or by pullout of a 60 to 90 degree cone of rock with the apex of the cone near the middle of the bonded length of the anchor. It should be noted that interaction may develop between the failure cones of anchors that are relatively close to one another resulting in a total group capacity smaller than the sum of the load capacity of each anchor taken individually.

A third failure mode of shear failure along the grout/steel interface should also be reviewed by a qualified structural engineer to ensure all typical failure modes have been reviewed. Typical rock anchor suppliers, such as Dywidag Systems International (DSI Canada), have qualified personnel on staff to recommend appropriate rock anchor size and materials.

It should be further noted that centre to centre spacing between bond lengths be at least four times the anchor hole diameter and greater than 1.2 m to lower the group influence effects. It is also recommended that anchors in close proximity to each other be grouted at the same time to ensure any fractures or voids are completely in-filled and that fluid grout does not flow from one hole to an adjacent empty one.

Anchors can be of the “passive” or the “post-tensioned” type, depending on whether the anchor tendon is provided with post-tensioned load or not prior to being put into service.

Regardless of whether an anchor is of the passive or the post tensioned type, it is recommended that the anchor be provided with a bonded length, or fixed anchor length, at the base of the anchor, which will provide the anchor capacity, as well an unbonded length, or free anchor length, between the rock surface and the start of the bonded length. As the depth at which the apex of the shear failure cone develops is midway along the bonded length, a fully bonded anchor would tend to have a much shallower cone, and therefore less geotechnical resistance, than one where the bonded length is limited to the bottom part of the overall anchor.



Permanent anchors should be provided with corrosion protection. As a minimum, this requires that the entire drill hole be filled with cementitious grout. The free anchor length is provided by installing a plastic sleeve to act as a bond break.

### Grout to Rock Bond

Generally, the unconfined compressive strength of limestone ranges between 60 and 120 MPa, which is stronger than most routine grouts. A factored tensile grout to rock bond resistance value at ULS of **1.0 MPa**, incorporating a resistance factor of 0.3, can be used. A minimum grout strength of 40 MPa is recommended.

### Rock Cone Uplift

As discussed previously, the geotechnical capacity of the rock anchors depends on the dimensions of the rock anchors and the configuration of the anchorage system. Based on existing subsoils information, a **Rock Mass Rating (RMR) of 75** was assigned to the bedrock, and Hoek and Brown parameters (**m and s**) were taken as **1.20 and 0.022**, respectively.

### Recommended Rock Anchor Lengths

Rock anchor lengths can be designed based on the required loads. Rock anchor lengths for some typical loads have been calculated and are presented on the following page. Load specified rock anchor lengths can be provided, if required.

For our calculations the following parameters were used.

<b>Table 2 - Parameters used in Rock Anchor Review</b>	
Grout to Rock Bond Strength - Factored at ULS	1.0 MPa
Compressive Strength - Grout	40 MPa
Rock Mass Rating (RMR) - Good quality Limestone Hoek and Brown parameters	75 m=1.20 and s=0.022
Unconfined compressive strength - Limestone bedrock	80 MPa
Unit weight - Submerged Bedrock	15 kN/m <sup>3</sup>
Apex angle of failure cone	60°
Apex of failure cone	mid-point of fixed anchor length

From a geotechnical perspective, the total anchor length will depend on the diameter of the drill holes. Recommended anchor lengths for a 75 and 125 mm diameter hole are provided in Table 3.

<b>Table 3 - Recommended Rock Anchor Lengths - Grouted Rock Anchor</b>				
<b>Diameter of Drill Hole (mm)</b>	<b>Anchor Lengths (m)</b>			<b>Factored Tensile Resistance (kN)</b>
	<b>Bonded Length</b>	<b>Unbonded Length</b>	<b>Total Length</b>	
75	1.2	0.55	1.75	250
	2	0.8	2.8	500
	3.2	1.4	4.6	1000
	5.3	2.2	7.5	2000
125	1	0.5	1.5	250
	1.7	0.7	2.4	500
	2.6	1.1	3.7	1000
	4.1	1.8	5.9	2000

It is recommended that the anchor drill hole diameter be within 1.5 to 2 times the rock anchor tendon diameter and the anchor drill holes be inspected by geotechnical personnel and should be flushed clean prior to grouting. The use of a grout tube to place grout from the bottom up in the anchor holes is further recommended.

The geotechnical capacity of each rock anchor should be proof tested at the time of construction. More information on testing can be provided upon request. Compressive strength testing is recommended to be completed for the rock anchor grout. A set of grout cubes should be tested for each day grout is prepared.

## 5.8 Pavement Structure

For design purposes, the pavement structure presented in Table 4 could be used for the design of access lanes, if required. The bottom level of the underground parking garage could have the rigid pavement structure recommended in Table 5.

**Table 4 - Recommended Flexible Pavement Structure  
Access Lanes and Heavy Truck Loading Areas**

<b>Thickness (mm)</b>	<b>Material Description</b>
40	<b>Wear Course</b> - Superpave 12.5 or HL-3 Asphaltic Concrete
50	<b>Binder Course</b> - Superpave 19.0 or HL-8 Asphaltic Concrete
150	<b>BASE</b> - OPSS Granular A Crushed Stone
450	<b>SUBBASE</b> - OPSS Granular B Type II
<b>SUBGRADE</b> - Glacial Till or OPSS Granular B Type I or II material placed over bedrock.	

**Table 5 - Recommended Rigid Pavement Structure  
Lower Level of Parking Garage**

<b>Thickness (mm)</b>	<b>Material Description</b>
150	<b>Wear Course</b> - Concrete slab
300	<b>BASE</b> - OPSS Granular A Crushed Stone
<b>SUBGRADE</b> - Bedrock or OPSS Granular B Type II material placed over bedrock.	

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 98% of the material's SPMDD using suitable vibratory equipment.

## **6.0 Design and Construction Precautions**

### **6.1 Foundation Drainage and Backfill**

#### **Foundation Drainage**

It is understood that the underground parking garage footprint will occupy the entirety of the subject site. It is expected that insufficient room will be available for exterior backfill along these walls and, therefore, the foundation wall will be blind poured against a drainage system placed on the bedrock face.

Since the lower levels of underground parking will be located below the expected long term groundwater level, consideration may be given to installing a groundwater infiltration suppression system to manage the groundwater infiltration volumes. By waterproofing the vertical excavation side slopes at these lower levels, it will be possible to lessen the groundwater volumes entering the excavation. This can be accomplished by placing a waterproofing membrane layer (bentonite sheets) against a prepared vertical bedrock surface. The membrane should start from the bottom of the excavation when pouring the perimeter strip footings. A composite drainage system should be incorporated against the waterproofing membrane to act as a protection layer and to drain any water that may breach the waterproofing membrane system.

For preliminary design purposes, the composite drainage system (such as Delta Drain 6000 or equivalent) should extend down to the footing level. It is recommended that 150 mm diameter sleeves at 3 m spacing on centres be cast in the foundation wall at the footing interface to allow the infiltration of water to flow to an interior perimeter drainage pipe. The perimeter drainage pipe should direct water to sump pit(s) within the lower basement area.

The requirement for the waterproofing membrane will be evaluated by the geotechnical engineer once the excavation is close to reaching the bottom.

#### **Underfloor Drainage**

Underfloor drainage will be required to control water infiltration due to groundwater lowering within the bedrock. For design purposes, we recommend that 150 mm diameter perforated PVC pipes be placed at each bay. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

## **Foundation Backfill**

It's expected that the upper 1.5 m will consist of a double sided pour once the shoring system is removed. This portion of the foundation wall should be backfill with free-draining, non frost susceptible granular materials. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material or OPSS Granular A, should otherwise be used for this purpose.

## **Adverse Effects of Dewatering on Adjacent Properties**

The buildings located within adjacent properties are anticipated to be founded within the glacial till or directly on the bedrock. Therefore, no adverse effects to the surrounding buildings or properties are expected with the minor dewatering of the groundwater from this development.

## **6.2 Protection of Footings Against Frost Action**

Perimeter footings of heated structures are required to be insulated against the deleterious effects of frost action. A minimum of 1.5 m of soil cover alone should be provided in this regard.

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

## **6.3 Excavation Side Slopes and Temporary Shoring**

It is expected that insufficient room will be available to permit the excavation to be undertaken by open-cut methods (i.e. unsupported excavations).

## **Rock Stabilization**

Horizontal rock anchors may be required at specific locations to prevent pop-outs of the bedrock, especially in areas where fractures in the bedrock are conducive to the failure of the bedrock surface. The requirement for horizontal rock anchors will be evaluated during the excavation operations and should be discussed with the structural engineer during the design stage.

## **Temporary Shoring**

Temporary shoring will be required to support the overburden for the entire perimeter of the excavation.

The design and approval of the shoring system will be the responsibility of the shoring contractor and the shoring designer 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 any 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. Furthermore, the design of the temporary shoring system should take into consideration, a full hydrostatic condition which can occur during significant precipitation events.

For design purposes, the temporary system will most likely consist of a soldier pile and timber 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 tie-back rock anchors to ensure their stability. It is further recommended that the toe of the shoring be adequately supported to resist toe failure by means of rock bolts or extending the piles into the bedrock through pre-augered holes.

## **Typical Geotechnical Parameters**

Generally, it is expected that the shoring systems will be provided with tie-back rock anchors to ensure their stability.

The geotechnical design of grouted rock anchors in sedimentary bedrock is based upon two possible failure modes. The anchor can fail either by shear failure along the grout/rock interface or by pullout of a 60 to 90 degree cone of rock with the apex of the cone near the middle of the bonded length of the anchor.

The anchor derives its capacity from the bonded portion, or fixed anchor length, at the base of the anchor. An unbonded portion, or free anchor length, is also usually provided between the rock surface and the start of the bonded length. Because the depth at which the apex shear failure cone develops is midway along the bonded length, a fully bonded anchor would tend to have a much shallower cone, and therefore less capacity, than one where the bonded length was only the bottom part of the overall anchor.

The design of the rock anchors for temporary shoring can be based on the values provided in Subsection 5.7 of the present report.

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

<b>Table 6 - Soil Parameters for Shoring System Design</b>	
<b>Parameters</b>	<b>Values</b>
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 ( $\gamma$ ), kN/m <sup>3</sup>	20
Submerged Unit Weight ( $\gamma$ ), kN/m <sup>3</sup>	13

### **Soldier Pile and Timber Lagging System**

The active earth pressure acting on a soldier pile and lagging shoring system can be calculated using a rectangular earth pressure distribution with a maximum pressure of  $0.65 K \gamma H$  for strutted or anchored shoring or a triangular earth pressure distribution with a maximum value of  $K \gamma H$  for a cantilever shoring system.  $H$  is the height of the excavation.

The active earth pressure should be used where wall movements are permissible while the at-rest pressure should be used if no movement is permissible. The total unit weight should be used above the groundwater level while the submerged unit weight should be used below the groundwater level.

The hydrostatic groundwater pressure should be added to the earth pressure distribution wherever the submerged unit weights are used for earth pressure calculations should the level on the groundwater not be lowered below the bottom of the excavation. If the groundwater level is lowered, the total unit weight for the soil should be used full weight, with no hydrostatic groundwater pressure component.

## **6.4 Pipe Bedding and Backfill**

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

At least 150 mm of OPSS Granular A should be used for bedding for sewer and 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 at least 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 compacted to a minimum of 95% 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 potential 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 material's SPMDD.

## **6.5 Groundwater Control**

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.

The rate of flow of groundwater into the excavation through the overburden and bedrock is anticipated to be moderate for the expected subsurface conditions at this site. It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of the excavations.

A temporary MECP permit to take water (PTTW) Category 3 will be required for this project since water infiltration is expected to be greater than 50,000 L/day 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 MECP.

### **Long-term Groundwater Control**

Our recommendations for the proposed building's long-term groundwater control are presented in Subsection 6.1. Any groundwater encountered along the building's perimeter or sub-slab drainage system will be directed to the proposed building's sump pit. Provided that the selected groundwater infiltration control system is properly implemented and approved by Paterson at the time of construction, it is expected that groundwater flow will be low (i.e. less than 40,000 L/day) with peak periods noted after rain events. It is anticipated that the groundwater flow will be controllable using conventional open sumps. For sump pit and sump pump design, consideration should be given to using higher volumes of 200,000 to 300,000 L/day.



## **Impacts on Neighbouring Structures**

It is understood that 4 to 6 underground parking levels are planned for the proposed development, with the lower portion of the foundation having a groundwater infiltration control system in place. Due to the surrounding developments that are founded at greater depths, long-term groundwater lowering is expected to be minimal to negligible for the area once steady state is achieved.

Based on our observations, the groundwater level is anticipated at a 3 to 4 m depth which is considered to be perched over the bedrock surface. Therefore, a local groundwater lowering is expected under short-term conditions due to construction of the proposed building. It should be noted that the extent of any significant groundwater lowering will take place within a limited range of the subject site due to the minimal groundwater lowering.

The neighbouring structures are founded within native glacial till or directly over a bedrock bearing surface based on available soils information. No issues are expected with respect to groundwater lowering that would cause long term damage to adjacent structures surrounding 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 mostly consist of frost susceptible materials. In 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.

The trench excavations should be carried out in a manner to avoid the introduction of frozen materials, snow or ice into the trenches. Precautions must be taken where excavations are carried in proximity of existing structures which may be adversely affected due to the freezing conditions. In particular, it should be recognized that where a shoring system is used, the soil behind the shoring system will be subjected to freezing conditions and could result in heaving of the structure(s) placed within or above frozen soil. Provisions should be made in the contract document to protect the walls of the excavations from freezing, if applicable.

## 7.0 Recommendations

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

- ☐ Review of the geotechnical aspects of the excavation contractor's shoring design, prior to construction.
- ☐ Review the bedrock stabilization and excavation requirements.
- ☐ Review proposed foundation drainage design and waterproofing requirements.
- ☐ Observation of all bearing surfaces prior to the placement of concrete.
- ☐ Sampling and testing of the concrete and fill materials used.
- ☐ Observation of all subgrades prior to backfilling.
- ☐ Field density tests to determine the level of compaction achieved.
- ☐ Sampling and testing of the bituminous concrete including mix design reviews.

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

## 8.0 Statement of Limitations

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

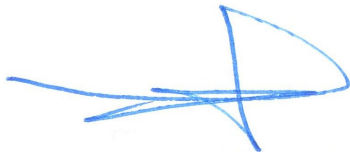
A geotechnical investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request immediate notification to permit reassessment of our recommendations.

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 Main and Main Developments 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.



Nathan F. S. Christie, P.Eng.



Carlos P. Da Silva, P.Eng., ing., QP<sub>ESA</sub>



### Report Distribution

- ☐ Main and Main Developments Inc. (3 copies)
- ☐ Paterson Group (1 copy)

# **APPENDIX 1**

**SOIL PROFILE AND TEST DATA SHEETS**

**SYMBOLS AND TERMS**

**DATUM** TBM - Top of manhole cover located along east side of Bay Street, north of Slater Street. Geodetic elevation = 72.77m

**REMARKS**

**FILE NO.**  
**PG4793**

**HOLE NO.**  
**BH 1**

**BORINGS BY** CME 55 Power Auger

**DATE** March 28, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
								20	40	60	80	
GROUND SURFACE												
25mm Asphaltic concrete over	0.60	AU	1			0	73.24					
FILL: Brown clayey sand with sand and gravel	0.86	SS	2	79	12	1	72.24					
Compact, brown SILTY SAND		SS	3	4	62	2	71.24					
Very stiff, brown SILTY CLAY, some gravel	2.44	SS	4	88	10	3	70.24					
GLACIAL TILL: Brown clayey silt with sand and gravel		SS	5	62	10	4	69.24					
	4.29	SS	6	47	50+	4	69.24					
		RC	1	100	0	5	68.24					
		RC	2	98	96	6	67.24					
		RC	3	100	84	7	66.24					
		RC	4	100	89	8	65.24					
		RC	5	100	100	9	64.24					
BEDROCK: Fair to excellent quality, grey limestone		RC	6	100	97	10	63.24					
		RC	7	100	100	12	61.24					
		RC	8	100	97	14	59.24					
		RC	9	100	100	15	58.24					
		RC	10	100	100	16	57.24					
		RC				17	56.24					
	18.01					18	55.24					
End of Borehole												
(GWL @ 4.37m depth - Apr 9/19)												
								20	40	60	80	100
								Shear Strength (kPa)				
								▲ Undisturbed    △ Remoulded				

## SOIL PROFILE AND TEST DATA

**Geotechnical Investigation**  
**383 Slater St., 400 Albert St. & 156-160 Lyon Street**  
**Ottawa, Ontario**

FILE NO. PG4793

HOLE NO. BH 2

**DATE** March 29, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
								20	40	60	80	
<b>GROUND SURFACE</b>												
Asphaltic concrete	0.06	AU	1			0	71.99					
<b>FILL:</b> Brown silty sand with gravel		SS	2	50	52	1	70.99					
	2.08	SS	3	46	17	2	69.99					
Compact, brown <b>SILTY SAND</b>	2.39	SS	4	33	2	3	68.99					
<b>GLACIAL TILL:</b> Brown clayey silt with sand and gravel	2.84	RC	1	100	87	4	67.99					
		RC	2	100	93	5	66.99					
		RC	3	100	95	6	65.99					
		RC	4	100	95	7	64.99					
		RC	5	100	100	8	63.99					
<b>BEDROCK:</b> Good to excellent quality, grey limestone		RC	6	100	100	9	62.99					
		RC	7	100	100	10	61.99					
		RC	8	100	100	11	60.99					
		RC	9	100	97	12	59.99					
		RC	10	100	100	13	58.99					
						14	57.99					
						15	56.99					
						16	55.99					
						17	54.99					
End of Borehole	17.88											
(GWL @ 2.20m depth - Apr 9/19)												

20 40 60 80 100

**Shear Strength (kPa)**

▲ Undisturbed    △ Remoulded

**DATUM** TBM - Top of manhole cover located along east side of Bay Street, north of Slater Street. Geodetic elevation = 72.77m




**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** April 1, 2019

**FILE NO.** PG4793

**HOLE NO.** BH 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
								20	40	60	80	
GROUND SURFACE						0	72.28					
FILL: Grey silty sand with gravel, some clay		AU	1									
		SS	2	38	66	1	71.28					
		SS	3	46	21	2	70.28					
		SS	4	8	11							
		SS	5	44	50+	3	69.28					
Concrete with rebar and ties												
		RC	1	17	0	4	68.28					
		RC	2	97	83	5	67.28					
		RC	3	100	61	6	66.28					
		RC	4	100	82							
						7	65.28					
		RC	5	100	93	8	64.28					
						9	63.28					
		RC	6	100	100	10	62.28					
		RC	7	100	100	11	61.28					
						12	60.28					
		RC	8	100	100	13	59.28					
						14	58.28					
		RC	9	100	100							
						15	57.28					
		RC	10	100	95	16	56.28					
		RC	11	100	100	17	55.28					
						18	54.28					
		RC	12	100	10	19	53.28					
End of Borehole												
(GWL @ 3.50m depth - Apr 9/19)												
								20	40	60	80	100
								Shear Strength (kPa)				
								▲ Undisturbed    △ Remoulded				

## SOIL PROFILE AND TEST DATA

HOLE NO. **BH 4-16**

[illegible]



## SOIL PROFILE AND TEST DATA

Geotechnical Investigation  
Proposed Multi-Storey Redevelopment  
383 Slater St. & 400 Albert St., Ottawa, Ontario

**DATUM** TBM - Top cover of manhole located along east side of Bay Street, just north of Slate Street. A geodetic elevation of 72.77m was provided to the TBM by Annis, O'Sullivan, Vollebakk Ltd.

**FILE NO.**  
**PG3914**

**HOLE NO.**  
**BH 5-16**

**BORINGS BY** CME 55 Power Auger

**DATE** December 9, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %					
								20	40	60	80		
GROUND SURFACE						0	71.91						
FILL: Crushed stone													
	0.30	AU	1										
FILL: Brown silty sand, some concrete, brick and mortar, trace crushed stone						1	70.91						
	1.42	SS	2	46	6								
FILL: Brown silty fine sand, trace boulders						2	69.91						
	2.64	SS	3	83	7								
GLACIAL TILL: Grey silty sand, some gravel, cobbles and boulders													
	3.00	SS	4	75	27								
End of Borehole						3	68.91						
Practical refusal to augering at 3.00m depth													
(GWL @ 2.7m depth based on field observations)													
				</									

## SOIL PROFILE AND TEST DATA

FILE NO. PG3914

HOLE NO. **BH 6-16**

**DATE** December 9, 2016

[illegible]

<b>DATUM</b>	TBM - Top cover of manhole located along east side of Bay Street, just north of Slate Street. A geodetic elevation of 72.77m was provided to the TBM by Annis, O'Sullivan, Vollebakk Ltd.
<b>REMARKS</b>	

FILE NO. PG3914

HOLE NO. **BH 7-16**

**BORINGS BY** CME 55 Power Auger

**DATE** December 9, 2016

[illegible]

## SOIL PROFILE AND TEST DATA

Geotechnical Investigation  
Proposed Multi-Storey Redevelopment  
383 Slater St. & 400 Albert St., Ottawa, Ontario

**DATUM** TBM - Top cover of manhole located along east side of Bay Street, just north of Slate Street. A geodetic elevation of 72.77m was provided to the TBM by Annis, O'Sullivan, Vollebakk Ltd.

**FILE NO.**  
**PG3914**

**HOLE NO.**  
**BH 8-16**

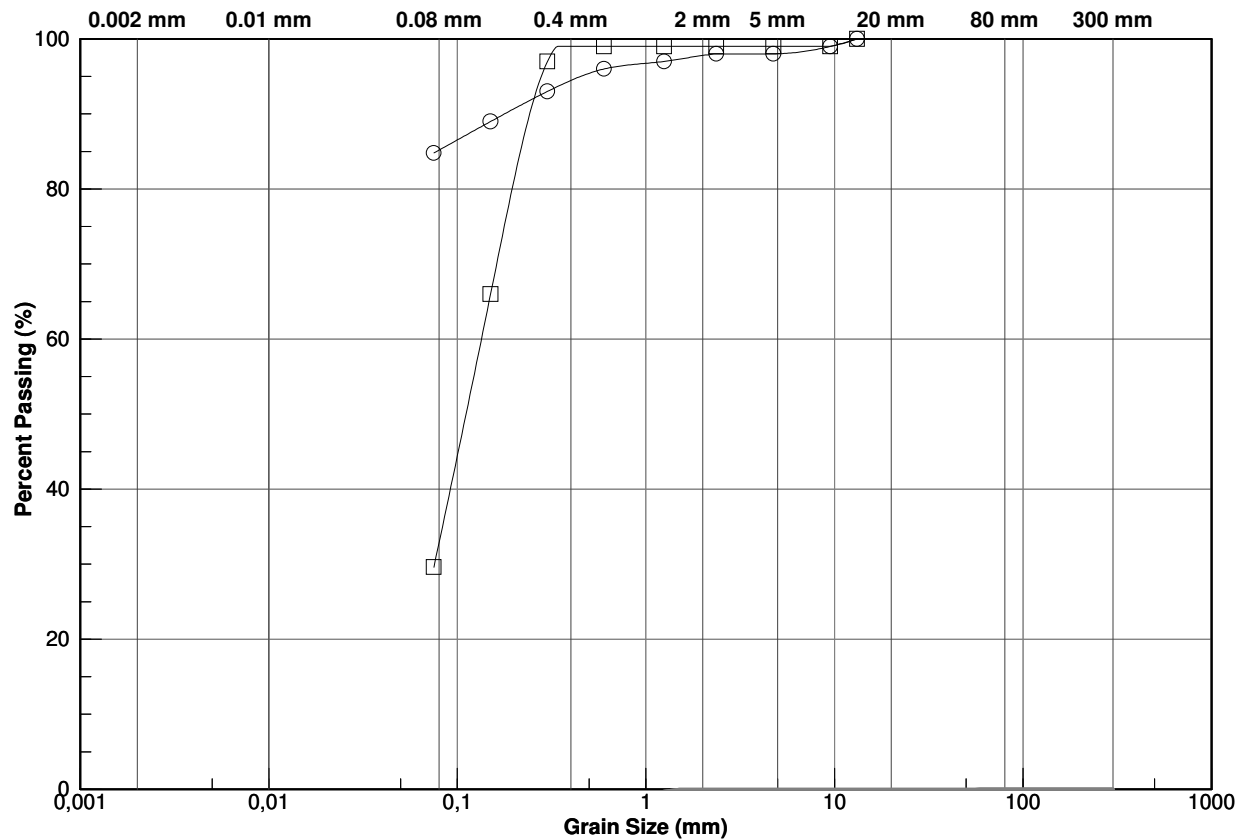
**BORINGS BY** CME 55 Power Auger

**DATE** December 9, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %					
								20	40	60	80		
GROUND SURFACE						0	72.08						
FILL: Crushed stone, trace brick	0.25	AU	1										
FILL: Brown sandy silt with topsoil, some brick, mortar, trace wood and gravel		SS	2	79	11	1	71.08						
	1.62	SS	3	88	13	2	70.08						
FILL: Brown clayey silt with sand, trace gravel and organics		SS	4	79	8								
	2.97	SS	5	50	10	3	69.08						
Brown CLAYEY SILT, trace sand	3.35	SS	6	71	15	4	68.08						
GLACIAL TILL: Grey silty sand with gravel, cobbles and boulders		SS	7	85	50+								
	4.90												
End of Borehole													
Practical refusal to augering at 4.90m depth													
(GWL @ 4.8m depth based on field observations)													
								20	40	60	80	100	
								Shear Strength (kPa)					
								▲ Undisturbed    △ Remoulded					



# GRAIN-SIZE ANALYSIS

Project: **Phase II Environmental Site Investigation and Geotechnical Investigation**Figure n°: **1**Location: **400 Albert street, Ottawa, ON**File n°: **B-0001436-1**

CLAY	SILT	SAND			GRAVEL		COBBLE	BOULDER
		FINE	MEDIUM	COARSE	FINE	COARSE		

Symbol	Borehole n°	Sample n°	Depth (m)	Description	USCS class. (ASTM D-2487)
—○—	BH-01-12	SS-4	2.29 - 2.90	Silty sand, traces of gravel.	SM
—□—	BH-03-12	SS-2	0.76 - 1.37	Silt with some sand, traces of gravel.	ML

The following sounding logs summarize soils and rock geotechnical properties as well as ground water conditions, as collected during field work and/or obtained from laboratory tests. This note explains the different symbols and abbreviations used in these logs.

## STRATIGRAPHIC UNITS

<b>Elevation/Depth:</b>	Reference to the geodesic elevation of the soil or to a bench mark of arbitrary elevation, at the location of the sounding. Depth of the different geological boundaries as measured from ground surface. On the left, the scale is in meters while on the right, it is in feet.
<b>Description of the stratigraphic units:</b>	Every geological formation is detailed. The proportion of the different elements of the soil, defined according to the size of the particles, is given following the classification hereafter. The relative compactness of cohesionless soils is defined by the "N" index of the Standard Penetration Test. The consistency of cohesive soils is defined by their shear resistance.

## SYMBOLS

<b>TOP SOIL</b>		<b>SAND</b>		<b>COBBLE</b>	
<b>BACKFILL</b>		<b>SILT</b>		<b>BOULDER</b>	
<b>GRAVEL</b>		<b>CLAY</b>		<b>ROCK</b>	

## WATER LEVEL

This column shows the ground water level, as measured at a given time during the geotechnical investigation. The details of the installation (type and depth) are also illustrated in this column.

## SAMPLES

**Type and number:** Each sample is labelled in accordance with the number of this column and the given notation refers to samples types.

**Sub-sample:** When a sample contains two or more different stratigraphic units, it is sometimes necessary to separate it and create sub-samples. This column allows for the identification of the latter and the association to *in situ* or laboratory measurements to these sub-samples.

**Condition:** The position, length and condition of each sample are shown in this column. The symbol shows the condition of the sample, following the legend given on the sounding log.

**Size:** This column indicates the split spoon sampler size.

**"N" index**  
The standard penetration index shown in this column is expressed with the letter "N". This index is obtained with the Standard Penetration Test. It corresponds to the number of blows required to drive the last 300mm of the split spoon, using a 622 Newton hammer falling freely from a height of 762mm (ASTM D-1586). For a 610mm long split spoon, the "N" index is obtained by adding the number of blows required for the driving of the 2<sup>nd</sup> and 3<sup>rd</sup> 150mm of the split spoon. Refusal (R) indicates a number of blows greater than 100. A set of numbers such as 28-30-50/60mm indicates that the number of blows required to drive the 1<sup>st</sup> and 2<sup>nd</sup> 150mm of the split spoon are respectively 28 and 30. Moreover, it indicates that 50 blows were necessary to get a penetration of 60mm, whereupon the test was suspended.

**RQD index:** Rock Quality Designation index: This index is defined as the ratio between the total length of all rock cores of 100mm and more in length over the total length of the core run. The RQD index is an indirect measurement of the number of "natural" fractures and of the amount of the alteration in a rock mass.

## TESTS

**Results:** This column shows, for the corresponding depth, the results of tests carried out in the field or in the laboratory (shear strength, dynamic penetration, Atterberg limits with the cone, etc.). For more information, please refer to the legend in the upper part of the sounding log. However, an abbreviation indicating the type of analysis performed is shown next to the sample tested.

**Graph:** This graph shows the undrained shear strength resistance of cohesive soils, as measured *in situ* or in the laboratory (NQ 2501-200). It is also used to present the Dynamic Cone Penetration Test (NQ 2501-145) results.  
Moreover, this graph is used for the representation of the water content and Atterberg limits test results.

### Classification

### Particle size (mm)

Clay	< 0.002
Clay and silt (undifferentiated)	< 0.08
Sand	0.08 to 5
Gravel	5 to 80
Cobble	80 to 300
Boulder	> 300

### Descriptive terminology

### Proportion (%)

"Traces" (tr.)	1 to 10
"Some" (s.)	10 to 20
Adjective (ex.: sandy, silty)	20 to 35
"And" (ex.: sand and gravel)	35 to 50

### Compactness of cohesionless soils

### Standard Penetration Test index ("N" value), ASTM D-1586 (blows for a 300mm penetration)

Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

### Consistency of cohesive soils

### Undrained shear strength (kPa)

Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

### Plasticity of cohesive soils

### Liquid limit (%)

Low	< 30
Medium	30 to 50
High	> 50

### Sensitivity of cohesive soils

### $S_t = (C_u/C_{ur})$

Low	$S_t < 2$
Medium	$2 < S_t < 4$
High	$4 < S_t < 8$
Extra-sensitive	$8 < S_t < 16$
Quick (sensitive) clay	$S_t > 16$

### Classification of rock

### RQD (%)

Very poor quality	< 25
Poor quality	25 to 50
Fair quality	50 to 75
Good quality	75 to 90
Excellent quality	90 to 100

		Client : <b>BROCCOLINI CONSTRUCTION inc.</b>		<b>BOREHOLE REPORT</b> File n°: <b>B-0001436-1</b> Borehole n°: <b>BH-01-12</b> Date: <b>2012-06-12</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Project: <b>Phase II Environmental Site Investigation and Geotechnical Investigation</b> Location: <b>400 Albert street, Ottawa, ON</b>				Coordinates (m): North 4983184,0 (Y) East 444442,0 (X) Elevation <b>98,90 (Z)</b> Bedrock: 4,27 m End depth: 7,24 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
<b>Sample condition</b> <div style="display: flex; align-items: center; gap: 10px;"> <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Intact           <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Remoulded           <div style="background-color: black; width: 20px; height: 10px;"></div> Lost           <div style="border: 1px solid black; width: 20px; height: 10px; background-color: white;"></div> Core         </div>			<b>Organoleptic soil examination:</b> Visual aspect: Non-existent(N); Disseminated(D); Soaked(S) Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
<b>Sample type</b> SS Split Spoon TM Thin wall Tube PS Piston Tube RC Rock core AS Auger MA Bulk sample TU Transparent tube PW LVM Mega-Sampler FG Frozen ground		<b>Tests</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 33%;">           L Consistency Limits            W<sub>L</sub> Liquid Limit (%)            W<sub>P</sub> Plastic Limit (%)            I<sub>P</sub> Plasticity Index (%)            I<sub>L</sub> Liquidity Index            W Natural Water Content (%)            GS Grain Size Analysis            S Hydrometer analysis            R Refusal            VBS Methylene Blue Value            WR Weight of Rods         </div> <div style="width: 33%;">           O.M. Organic Matter (%)            K Permeability (cm/s)            UW Unit Weight (kN/m³)            A Absorption (l/min. m)            U Uniaxial Compressive strength (MPa)            RQD Rock Quality Designation (%)            CA Chemical Analysis            P<sub>L</sub> Limit Pressure (kPa)            E<sub>m</sub> Pressurometer Modulus (MPa)            E<sub>r</sub> Modulus of subgrade reaction (MPa)            SP<sub>o</sub> Segregation Potential (mm²/H °C)         </div> <div style="width: 33%;">           Water Level            N Std Penetration test (blows/300mm)            N<sub>C</sub> Dyn. Penetration test (blows/300mm) ●            σ'<sub>p</sub> Preconsolidation Pressure (kPa)            SCI Soil Corrosivity Index  <b>Undrained shear strength</b>            C<sub>U</sub> Undisturbed (kPa) ▲            C<sub>UR</sub> Remoulded (kPa) △         </div> </div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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Exam</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">RESULTS</th> <th colspan="2" style="text-align: center;">NATURAL WATER CONTENT AND LIMITS (%)</th> <th colspan="2" style="text-align: center;">UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION</th> </tr> <tr> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Odor</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Visual</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W<sub>p</sub></th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">WL</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">20</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">40</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">60</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">80</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">100</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">120</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td>98,90</td> <td>Asphalt</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>1</td> <td></td> <td>0,00</td> <td rowspan="4"><b>Fill:</b> Gravelly sand, grey, with lump of clay Clayey and gravelly sand with clay lump and concrete fragments</td> <td rowspan="4"></td> <td rowspan="4"></td> <td>SS-1</td> <td></td> <td></td> <td></td> <td>43</td> <td>1-5 5-3</td> <td>10</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td>98,88</td> <td>SS-2</td> <td></td> <td></td> <td>67</td> <td>2-2 3-4</td> <td>5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td>0,03</td> <td>SS-3</td> <td></td> <td></td> <td>48</td> <td>1-3 5-50 / 8 cm</td> <td>8</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>4</td> <td></td> <td>98,14</td> <td>SS-4</td> <td></td> <td></td> <td>58</td> <td>2-1 2-3</td> <td>3</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>5</td> <td></td> <td>97,53</td> <td rowspan="2">Clayey and gravelly sand with clay lump and concrete fragments, moist</td> <td rowspan="2"></td> <td rowspan="2"></td> <td>SS-5</td> <td></td> <td></td> <td></td> <td>42</td> <td>1-3 7-5</td> <td>10</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>6</td> <td></td> <td>1,37</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>7</td> <td></td> <td>95,86</td> <td>Silt and 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        Remarks:       </td> </tr> <tr> <td colspan="20">         Borehole type: <b>Diamond</b>      Boring equipment: <b>CME-75</b> </td> </tr> <tr> <td colspan="10">         Prepared by: <b>S. Séguin, tech.</b> </td> <td colspan="5">         Approved by: <b>T. Lampron</b> </td> <td colspan="2">         2012-07-11       </td> <td colspan="3">         Page: 1 of 1       </td> </tr> </tbody> </table>						STRATIGRAPHY				SAMPLES						FIELD AND LABORATORY TESTS		DEPTH - ft	DEPTH - m	ELEVATION - m DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. 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		Client : <b>BROCCOLINI CONSTRUCTION inc.</b>		<b>BOREHOLE REPORT</b>  File n°: <b>B-0001436-1</b> Borehole n°: <b>BH-03-12</b> Date: <b>2012-06-12</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Project: <b>Phase II Environmental Site Investigation and Geotechnical Investigation</b>  Location: <b>400 Albert street, Ottawa, ON</b>				Coordinates (m): North 4983146,0 (Y) East 444465,0 (X) Elevation <b>99,13 (Z)</b> Bedrock: 3,05 m End depth: 6,33 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
<b>Sample condition</b> <div style="display: flex; align-items: center; gap: 10px;"> <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Intact           <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Remoulded           <div style="background-color: black; width: 20px; height: 10px;"></div> Lost           <div style="border: 1px solid black; width: 20px; height: 10px; background-color: white;"></div> Core         </div>			<b>Organoleptic soil examination:</b> Visual aspect: Non-existent(N); Disseminated(D); Soaked(S) Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
<b>Sample type</b> <b>SS</b> Split Spoon <b>TM</b> Thin wall Tube <b>PS</b> Piston Tube <b>RC</b> Rock core <b>AS</b> Auger <b>MA</b> Bulk sample <b>TU</b> Transparent tube <b>PW</b> LVM Mega-Sampler <b>FG</b> Frozen ground		<b>Tests</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 33%;"> <b>L</b> Consistency Limits  <b>W<sub>L</sub></b> Liquid Limit (%)  <b>W<sub>P</sub></b> Plastic Limit (%)  <b>I<sub>P</sub></b> Plasticity Index (%)  <b>I<sub>L</sub></b> Liquidity Index  <b>W</b> Natural Water Content (%)  <b>GS</b> Grain Size Analysis  <b>S</b> Hydrometer analysis  <b>R</b> Refusal  <b>VBS</b> Methylene Blue Value  <b>WR</b> Weight of Rods           </div> <div style="width: 33%;"> <b>O.M.</b> Organic Matter (%)  <b>K</b> Permeability (cm/s)  <b>UW</b> Unit Weight (kN/m³)  <b>A</b> Absorption (l/min. m)  <b>U</b> Uniaxial Compressive strength (MPa)  <b>RQD</b> Rock Quality Designation (%)  <b>CA</b> Chemical Analysis  <b>P<sub>L</sub></b> Limit Pressure (kPa)  <b>E<sub>m</sub></b> Pressurometer Modulus (MPa)  <b>E<sub>r</sub></b> Modulus of subgrade reaction (MPa)  <b>SP<sub>o</sub></b> Segregation Potential (mm²/H °C)           </div> <div style="width: 33%;"> <b>Water Level</b>  <b>N</b> Std Penetration test (blows/300mm)  <b>N<sub>C</sub></b> Dyn. Penetration test (blows/300mm) ●  <b>σ'<sub>p</sub></b> Preconsolidation Pressure (kPa)  <b>SCI</b> Soil Corrosivity Index   <b>Undrained shear strength</b>  <b>C<sub>u</sub></b> Undisturbed (kPa) ▲  <b>C<sub>ur</sub></b> Remoulded (kPa) △           </div> </div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4" style="text-align: center;">STRATIGRAPHY</th> <th colspan="6" style="text-align: center;">SAMPLES</th> <th colspan="4" style="text-align: center;">FIELD AND LABORATORY TESTS</th> </tr> <tr> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">DEPTH - ft</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">DEPTH - m</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">ELEVATION - m DEPTH - m</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SOIL OR BEDROCK DESCRIPTION</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SYMBOLS</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">WATER LEVEL (m) / DATE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">TYPE AND NUMBER</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SUB-SAMPLE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">CONDITION</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SIZE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">RECOVERY %</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">Blows/150mm</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">"N" or RQD</th> <th colspan="2" style="text-align: center;">Organo. Exam</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">RESULTS</th> <th colspan="2" style="text-align: center;">NATURAL WATER CONTENT AND LIMITS (%)</th> <th colspan="2" style="text-align: center;">UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION</th> </tr> <tr> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Odor</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Visual</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W<sub>p</sub></th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W<sub>L</sub></th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">20</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">40</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">60</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">80</th> <th 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RQD	Organo. Exam		RESULTS	NATURAL WATER CONTENT AND LIMITS (%)		UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION		Odor	Visual	W <sub>p</sub>	W	W <sub>L</sub>	20	40	60	80	100	120			99,13 <b>0,00</b>	Asphalt																	1		99,08 <b>0,05</b>	<b>Fill:</b> Sandy gravel with some silt, grey-black, moist			SS-1				33	2-3 7-2	10							2		98,37 <b>0,76</b>	Fine sand with some silt, beige, dry			SS-2				62	3-2 3-4	5			GS				3						SS-3				67	2-2 4-3	6							4						SS-4				58	4-6 4-50 / 3 cm	10							5		96,84 <b>2,29</b>	Sandy silt with traces of gravel, grey, saturated, with trace of oxydation			SS-5				0	50	R							6		96,08 <b>3,05</b>	<b>Rock :</b> Limestone, black, fine-grained, with clay horizon			CR-6				100		89							7						CR-7				98		83							8						CR-8				100		100							9																			10																			11																			12																			13																			14																			15																			16																			17																			18																			19																			20																			21		92,80 <b>6,33</b>	End of borehole																22																			23																			24																			25																			26																			27																			28																			29																		
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Borehole type: <b>Diamond</b> Boring equipment: <b>CME-75</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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Client :

**BROCCOLINI CONSTRUCTION  
inc.**

# BOREHOLE REPORT

File n°: **B-0001436-1**  
 Borehole n°: **BH-04-12**  
 Date: **2012-06-12**

Project: **Phase II Environmental Site Investigation and Geotechnical Investigation**Location: **400 Albert street, Ottawa, ON**

Coordinates (m): North 4983177,0 (Y)  
 East 444497,0 (X)  
 Elevation **99,61 (Z)**  
 Bedrock: 4,85 m End depth: 8,86 m

## Sample condition

Intact Remoulded Lost Core

## Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)  
 Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

## Sample type

**SS** Split Spoon  
**TM** Thin wall Tube  
**PS** Piston Tube  
**RC** Rock core  
**AS** Auger  
**MA** Bulk sample  
**TU** Transparent tube  
**PW** LVM Mega-Sampler  
**FG** Frozen ground

## Tests

**L** Consistency Limits  
**W<sub>L</sub>** Liquid Limit (%)  
**W<sub>P</sub>** Plastic Limit (%)  
**I<sub>P</sub>** Plasticity Index (%)  
**I<sub>L</sub>** Liquidity Index  
**W** Natural Water Content (%)  
**GS** Grain Size Analysis  
**S** Hydrometer analysis  
**R** Refusal  
**VBS** Methylene Blue Value  
**WR** Weight of Rods  
**O.M.** Organic Matter (%)  
**K** Permeability (cm/s)  
**UW** Unit Weight (kN/m³)  
**A** Absorption (l/min. m)  
**U** Uniaxial Compressive strength (MPa)  
**RQD** Rock Quality Designation (%)  
**CA** Chemical Analysis  
**P<sub>L</sub>** Limit Pressure (kPa)  
**E<sub>m</sub>** Pressurometer Modulus (MPa)  
**E<sub>r</sub>** Modulus of subgrade reaction (MPa)  
**SP<sub>o</sub>** Segregation Potential (mm²/H °C)

Water Level  
**N** Std Penetration test (blows/300mm)  
**N<sub>C</sub>** Dyn. Penetration test (blows/300mm) ●  
**σ'<sub>p</sub>** Preconsolidation Pressure (kPa)  
**SCI** Soil Corrosivity Index

## Undrained shear strength

**C<sub>U</sub>** Undisturbed (kPa)  
**C<sub>UR</sub>** Remoulded (kPa)

Field Laboratory

DEPTH - ft DEPTH - m		STRATIGRAPHY			SAMPLES								FIELD AND LABORATORY TESTS								
		ELEVATION - m DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	WATER LEVEL (m) / DATE	TYPE AND NUMBER	SUB-SAMPLE	CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam		RESULTS	NATURAL WATER CONTENT AND LIMITS (%)					
													Odor	Visual		W <sub>p</sub>	W	W <sub>L</sub>			
																UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION					
																20	40	60	80	100	120
1		99,61 0,00	Topsoil			SS-1				87	4-7 5-4	12									
2		99,56 0,05	Fill: Sandy silt with some gravel, grey-black																		
3	1	98,85 0,76	Silty fine sand, brown, with clay lump and roots			SS-2				79	4-4 4-4	8									
4																					
5		98,09 1,52	Silty fine sand, beige, with clay lump			SS-3				83	4-3 3-3	6									
6	2																				
7		97,33 2,29	Clay, grey, with roots, moist			SS-4				46	2-2 2-3	4									
8																					
9																					
10	3	96,56 3,05	Clay with trace of coarse gravel, grey, with roots, moist			SS-5				42	2-3 8-12	11									
11																					
12																					
13	4																				
14																					
15		95,04 4,57	Sandy and silty gravel, grey-black			SS-6				60	25-50	R									
16	5	94,76 4,85	Rock: Limestone, black, fine-grained, with clay horizon																		
17						RC-7				87		66									
18																					
19																					
20	6																				
21																					
22						RC-8				100		83									
23	7																				
24																					
25																					
26	8																				
27						RC-9				98		90			U = 107 MPa						
28																					
29		90,75																			

Remarks:

Borehole type: **Diamond**Boring equipment: **CME-75**Prepared by: **S. Séguin, tech.**Approved by: **T. Lampron**

2012-07-11

Page: 1 of 1



Client :

**BROCCOLINI CONSTRUCTION  
inc.**

# BOREHOLE REPORT

File n°: **B-0001436-1**  
Borehole n°: **BH-05-12**  
Date: **2012-06-13**
Project: **Phase II Environmental Site Investigation and Geotechnical Investigation**Location: **400 Albert street, Ottawa, ON**
Coordinates (m): North 4983153,0 (Y)  
East 444477,0 (X)  
Elevation **99,15 (Z)**  
Bedrock: m End depth: 3,43 m

## Sample condition

Intact Remoulded Lost Core

## Organoleptic soil examination:

Visual aspect: Non-existent(N); Disseminated(D); Soaked(S)  
Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)

## Sample type

**SS** Split Spoon  
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**σ'<sub>p</sub>** Preconsolidation Pressure (kPa)  
**SCI** Soil Corrosivity Index

## Undrained shear strength

**C<sub>U</sub>** Undisturbed (kPa)  
**C<sub>UR</sub>** Remoulded (kPa)

Field   
Laboratory 

DEPTH - ft		DEPTH - m		STRATIGRAPHY			WATER LEVEL (m) / DATE	SAMPLES						FIELD AND LABORATORY TESTS							
		ELEVATION - m DEPTH - m	SOIL OR BEDROCK DESCRIPTION	SYMBOLS	TYPE AND NUMBER	SUB-SAMPLE		CONDITION	SIZE	RECOVERY %	Blows/150mm	"N" or RQD	Organo. Exam		RESULTS	NATURAL WATER CONTENT AND LIMITS (%)					
													Odor	Visual		W <sub>p</sub>	W	W <sub>L</sub>			
																UNDRAINED SHEAR STRENGTH (kPa) OR DYNAMIC PENETRATION					
																20	40	60	80	100	120
1		0,00	Asphalt																		
2		99,06	<b>Fill:</b> Sandy silt with some gravel, grey-black		SS-1				49	1-7 9-11	16										
3	-1	98,54	Gravelly sand with some silt, grey, with trace of oxydation		SS-2				58	6-13 6-7	19										
4		97,93	Sand with some silt and trace of gravel, grey-beige, with zone of black sand, moist		SS-3				75	6-12 9-9	21			VOC: 70ppm							
5		97,32	Sand with some silt and trace of gravel, grey, moist		SS-4				71	3-4 5-5	9			VOC: 0ppm							
6	-2	96,71	Silty sand with trace of gravel, grey, very moist		SS-5				58	2-3 4-4	7			VOC: 0ppm							
7		95,72	End of borehole		SS-6				40	2-8 50 /8 cm	R										
8		3,43																			
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28																					
29																					

Remarks:

Borehole type: **Auger**Boring equipment: **CME-75**Prepared by: **S. Séguin, tech.**Approved by: **T. Lampron**

2012-07-11

Page: 1 of 1

		Client : <b>BROCCOLINI CONSTRUCTION inc.</b>		<b>BOREHOLE REPORT</b> File n°: <b>B-0001436-1</b> Borehole n°: <b>BH-06-12</b> Date: <b>2012-06-13</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Project: <b>Phase II Environmental Site Investigation and Geotechnical Investigation</b> Location: <b>400 Albert street, Ottawa, ON</b>				Coordinates (m): North 4983159,0 (Y) East 444468,0 (X) Elevation <b>99,26 (Z)</b> Bedrock: m End depth: 3,12 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
<b>Sample condition</b> <div style="display: flex; align-items: center; gap: 10px;"> <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Intact           <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Remoulded           <div style="width: 20px; height: 10px; background-color: black;"></div> Lost           <div style="border: 1px solid black; width: 20px; height: 10px; background-color: white;"></div> Core         </div>			<b>Organoleptic soil examination:</b> Visual aspect: Non-existent(N); Disseminated(D); Soaked(S) Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
<b>Sample type</b> SS Split Spoon TM Thin wall Tube PS Piston Tube RC Rock core AS Auger MA Bulk sample TU Transparent tube PW LVM Mega-Sampler FG Frozen ground		<b>Tests</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 33%;">           L Consistency Limits            W<sub>L</sub> Liquid Limit (%)            W<sub>P</sub> Plastic Limit (%)            I<sub>P</sub> Plasticity Index (%)            I<sub>L</sub> Liquidity Index            W Natural Water Content (%)            GS Grain Size Analysis            S Hydrometer analysis            R Refusal            VBS Methylene Blue Value            WR Weight of Rods         </div> <div style="width: 33%;">           O.M. Organic Matter (%)            K Permeability (cm/s)            UW Unit Weight (kN/m³)            A Absorption (l/min. m)            U Uniaxial Compressive strength (MPa)            RQD Rock Quality Designation (%)            CA Chemical Analysis            P<sub>L</sub> Limit Pressure (kPa)            E<sub>m</sub> Pressurometer Modulus (MPa)            E<sub>r</sub> Modulus of subgrade reaction (MPa)            SP<sub>o</sub> Segregation Potential (mm²/H °C)         </div> <div style="width: 33%;">           Water Level            N Std Penetration test (blows/300mm)            N<sub>C</sub> Dyn. Penetration test (blows/300mm) ●            σ'<sub>p</sub> Preconsolidation Pressure (kPa)            SCI Soil Corrosivity Index  <b>Undrained shear strength</b>            C<sub>U</sub> Undisturbed (kPa) ▲            C<sub>UR</sub> Remoulded (kPa) △         </div> </div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4" style="text-align: center;">STRATIGRAPHY</th> <th colspan="6" style="text-align: center;">SAMPLES</th> <th colspan="2" style="text-align: center;">FIELD AND LABORATORY TESTS</th> </tr> <tr> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">DEPTH - ft</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">DEPTH - m</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">ELEVATION - m DEPTH - m</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SOIL OR BEDROCK DESCRIPTION</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SYMBOLS</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">WATER LEVEL (m) / DATE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">TYPE AND NUMBER</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SUB-SAMPLE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">CONDITION</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">SIZE</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">RECOVERY %</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">Blows/150mm</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">"N" or RQD</th> <th colspan="2" style="text-align: center;">Organo. Exam</th> <th rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);">RESULTS</th> <th colspan="2" style="text-align: center;">NATURAL WATER CONTENT AND LIMITS (%)</th> </tr> <tr> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Odor</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">Visual</th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W<sub>p</sub></th> <th style="writing-mode: vertical-rl; transform: rotate(180deg);">W<sub>L</sub></th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td>99,26</td> <td>Asphalt</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>1</td> <td></td> <td>0,00</td> <td rowspan="3">Fill: Gravelly sand with some silt, grey Clayey silt, grey</td> <td></td> <td></td> <td>SS-1</td> <td></td> <td></td> <td></td> <td>46</td> <td>1-7 3-2</td> <td>10</td> <td></td> <td></td> <td>VOC: 0ppm</td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td>99,20</td> <td></td> <td></td> <td>SS-2</td> <td></td> <td></td> <td>83</td> <td>2-3 4-7</td> <td>7</td> <td></td> <td></td> <td>VOC: 0ppm</td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td>0,05</td> <td></td> <td></td> <td>SS-3</td> <td></td> <td></td> <td>87</td> <td>3-3 4-4</td> <td>7</td> <td></td> <td></td> <td>VOC: 0ppm</td> <td></td> <td></td> </tr> <tr> <td>4</td> <td></td> <td>98,65</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>5</td> <td></td> <td>0,61</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>6</td> <td></td> <td>97,43</td> <td rowspan="3">Silty sand with trace of gravel and clay, grey, with trace of oxydation, very moist Silty sand with some gravel, grey, very moist Sand with some silt and rock fragment, grey</td> <td></td> <td></td> <td>SS-4</td> <td></td> <td></td> <td></td> <td>46</td> <td>4-2 3-3</td> <td>5</td> <td></td> <td></td> <td rowspan="3">VOC: 30ppm</td> <td></td> <td></td> </tr> <tr> <td>7</td> <td></td> <td>1,83</td> <td></td> <td></td> <td>SS-5</td> <td></td> <td></td> <td>71</td> <td>2-1 4-8</td> <td>5</td> <td></td> <td></td> <td></td> </tr> <tr> <td>8</td> <td></td> <td>96,82</td> <td></td> <td></td> <td>SS-6</td> <td></td> <td></td> <td>100</td> <td>50/8 cm</td> <td>R</td> <td></td> <td></td> <td></td> </tr> <tr> <td>9</td> <td></td> <td>2,44</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>10</td> <td></td> <td>96,21</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> 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Exam		RESULTS	NATURAL WATER CONTENT AND LIMITS (%)		Odor	Visual	W <sub>p</sub>	W <sub>L</sub>			99,26	Asphalt																1		0,00	Fill: Gravelly sand with some silt, grey Clayey silt, grey			SS-1				46	1-7 3-2	10			VOC: 0ppm			2		99,20			SS-2			83	2-3 4-7	7			VOC: 0ppm			3		0,05			SS-3			87	3-3 4-4	7			VOC: 0ppm			4		98,65																5		0,61																6		97,43	Silty sand with trace of gravel and clay, grey, with trace of oxydation, very moist Silty sand with some gravel, grey, very moist Sand with some silt and rock fragment, grey			SS-4				46	4-2 3-3	5			VOC: 30ppm			7		1,83			SS-5			71	2-1 4-8	5				8		96,82			SS-6			100	50/8 cm	R				9		2,44																10		96,21																11		3,05																12		96,13																13		3,12	End of borehole															14																		15																		16																		17																		18																		19																		20																		21																		22																		23																		24																		25																		26																		27																		28																		29																	
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Prepared by: <b>S. Séguin, tech.</b>						Approved by: <b>T. Lampron</b>						2012-07-11		Page: 1 of 1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

		Client : <b>BROCCOLINI CONSTRUCTION inc.</b>		<b>BOREHOLE REPORT</b>  File n°: <b>B-0001436-1</b> Borehole n°: <b>BH-07-12</b> Date: <b>2012-06-13</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
Project: <b>Phase II Environmental Site Investigation and Geotechnical Investigation</b>  Location: <b>400 Albert street, Ottawa, ON</b>				Coordinates (m): North 4983169,0 (Y) East 444460,0 (X) Elevation <b>99,59 (Z)</b> Bedrock: m End depth: 2,97 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
<b>Sample condition</b> <div style="display: flex; align-items: center; gap: 10px;"> <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Intact                         <div style="border: 1px solid black; width: 20px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px);"></div> Remoulded                         <div style="width: 20px; height: 10px; background-color: black;"></div> Lost                         <div style="border: 1px solid black; width: 20px; height: 10px; background-color: white;"></div> Core                     </div>			<b>Organoleptic soil examination:</b> Visual aspect: Non-existent(N); Disseminated(D); Soaked(S) Odor: Non-existent(N); Light(L); Medium(M); Persistent(P)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
<b>Sample type</b> SS Split Spoon TM Thin wall Tube PS Piston Tube RC Rock core AS Auger MA Bulk sample TU Transparent tube PW LVM Mega-Sampler FG Frozen ground		<b>Tests</b> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 33%;">                     L Consistency Limits                      W<sub>L</sub> Liquid Limit (%)                      W<sub>P</sub> Plastic Limit (%)                      I<sub>P</sub> Plasticity Index (%)                      I<sub>L</sub> Liquidity Index                      W Natural Water Content (%)                      GS Grain Size Analysis                      S Hydrometer analysis                      R Refusal                      VBS Methylene Blue Value                      WR Weight of Rods                 </div> <div style="width: 33%;">                     O.M. Organic Matter (%)                      K Permeability (cm/s)                      UW Unit Weight (kN/m³)                      A Absorption (l/min. m)                      U Uniaxial Compressive strength (MPa)                      RQD Rock Quality Designation (%)                      CA Chemical Analysis                      P<sub>L</sub> Limit Pressure (kPa)                      E<sub>m</sub> Pressurometer Modulus (MPa)                      E<sub>r</sub> Modulus of subgrade reaction (MPa)                      SP<sub>o</sub> Segregation Potential (mm²/H °C)                 </div> <div style="width: 33%;">                     Water Level                      N Std Penetration test (blows/300mm)                      N<sub>C</sub> Dyn. Penetration test (blows/300mm) ●                      σ'<sub>p</sub> Preconsolidation Pressure (kPa)                      SCI Soil Corrosivity Index   <b>Undrained shear strength</b>                      C<sub>u</sub> Undisturbed (kPa) ▲                      C<sub>ur</sub> Remoulded (kPa) △                 </div> </div>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="2" style="text-align: center;">DEPTH - ft</th> <th colspan="2" style="text-align: center;">DEPTH - m</th> <th colspan="2" style="text-align: center;">ELEVATION - m</th> <th colspan="2" style="text-align: center;">SOIL OR BEDROCK DESCRIPTION</th> <th colspan="2" style="text-align: center;">SYMBOLS</th> <th colspan="2" style="text-align: center;">WATER LEVEL (m) / DATE</th> <th colspan="6" style="text-align: center;">SAMPLES</th> <th colspan="2" style="text-align: center;">FIELD AND LABORATORY TESTS</th> </tr> <tr> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2" style="text-align: center;">TYPE AND NUMBER</th> <th colspan="2" style="text-align: center;">SUB-SAMPLE</th> <th colspan="2" style="text-align: center;">CONDITION</th> <th colspan="2" style="text-align: center;">SIZE</th> <th colspan="2" style="text-align: center;">RECOVERY %</th> <th colspan="2" style="text-align: center;">Blows/150mm</th> <th colspan="2" style="text-align: center;">"N" or RQD</th> <th colspan="2" style="text-align: center;">Organo. Exam</th> <th colspan="2" style="text-align: center;">RESULTS</th> <th colspan="2" style="text-align: center;">NATURAL WATER CONTENT AND LIMITS (%)</th> </tr> <tr> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> </tr> <tr> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> <th colspan="2"></th> </tr> </thead> <tbody> <tr> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">99,59</td> <td colspan="2">Asphalt</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td colspan="2">1</td> <td colspan="2">0,00</td> <td colspan="2">99,51</td> <td colspan="2">Fill: Clayey silt with some sand and trace of gravel, grey</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">SS-1</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">48</td> <td colspan="2">2-5 4-3</td> <td colspan="2">9</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td colspan="2">2</td> <td colspan="2">0,08</td> <td colspan="2">98,98</td> <td colspan="2">Clayey silt, grey</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">SS-2</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">83</td> <td colspan="2">3-4 5-4</td> <td colspan="2">9</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">VOC: 10ppm</td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td colspan="2">3</td> <td colspan="2">0,61</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">SS-3</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">87</td> <td colspan="2">2-3 5-5</td> <td colspan="2">8</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">VOC: 0ppm</td> <td colspan="2"></td> <td colspan="2"></td> </tr> <tr> <td colspan="2">4</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">SS-4</td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2">67</td> <td colspan="2">4-5 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# 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.

<b>RQD %</b>	<b>ROCK QUALITY</b>
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 = $(D_{30})^2 / (D_{10} \times D_{60})$
Cu	-	Uniformity coefficient = $D_{60} / D_{10}$

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		Overconsolidation 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.
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## SYMBOLS AND TERMS (continued)

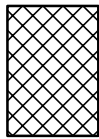
### STRATA PLOT



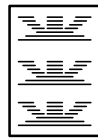
Topsoil



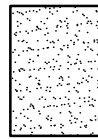
Asphalt



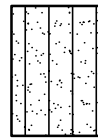
Fill



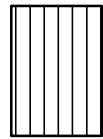
Peat



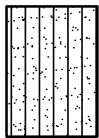
Sand



Silty Sand



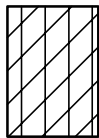
Silt



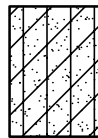
Sandy Silt



Clay



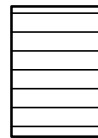
Silty Clay



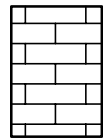
Clayey Silty Sand



Glacial Till



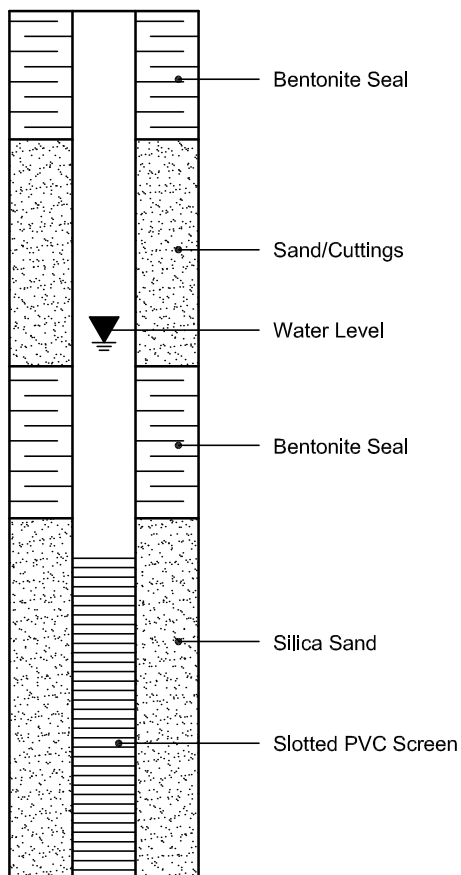
Shale



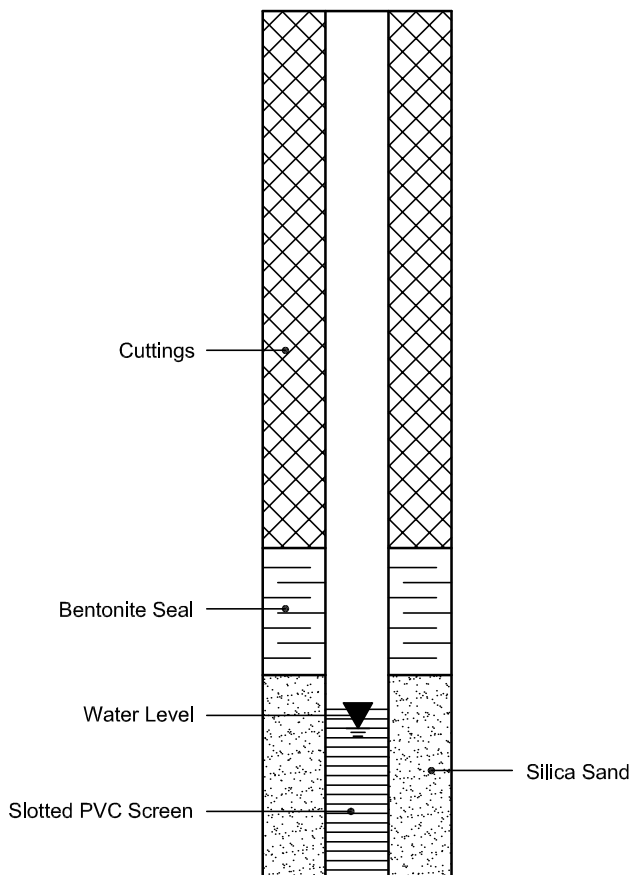
Bedrock

### MONITORING WELL AND PIEZOMETER CONSTRUCTION

#### MONITORING WELL CONSTRUCTION



#### PIEZOMETER CONSTRUCTION





## SOIL PROFILE AND TEST DATA

Phase II - Environmental Site Assessment  
383 Slater Street  
Ottawa, Ontario

**DATUM** Benchmark (BM) - Top cover of manhole located along east side of Bay Street, just north of Slater Street. Geodetic elevation = 72.77m.

**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** December 9, 2016

**FILE NO.**  
**PE3774**

**HOLE NO.**  
**BH 8-16**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Photo Ionization Detector					Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			● Volatile Organic Rdg. (ppm)					
								○ Lower Explosive Limit %					
GROUND SURFACE								20	40	60	80		
FILL: Crushed stone, trace brick	0.25	AU	1			0	72.08						
FILL: Brown sandy silt with topsoil, some brick, mortar, trace wood and gravel		SS	2	79	11	1	71.08						
	1.62	SS	3	88	13	2	70.08						
FILL: Brown clayey silt with sand, trace gravel and organics		SS	4	79	8								
	2.97					3	69.08						
Brown CLAYEY SILT, trace sand	3.35	SS	5	50	10								
GLACIAL TILL: Grey silty sand with gravel, cobbles and boulders		SS	6	71	15	4	68.08						
	4.90	SS	7	85	50+								
End of Borehole													
Practical refusal to augering at 4.90m depth													
(GWL @ 4.8m depth based on field observations)													
								100	200	300	400	500	
								RKI Eagle Rdg. (ppm)					
								▲ Full Gas Resp. △ Methane Elim.					

**DATUM** Benchmark (BM) - Top cover of manhole located along east side of Bay Street, just north of Slater Street. Geodetic elevation = 72.77m.

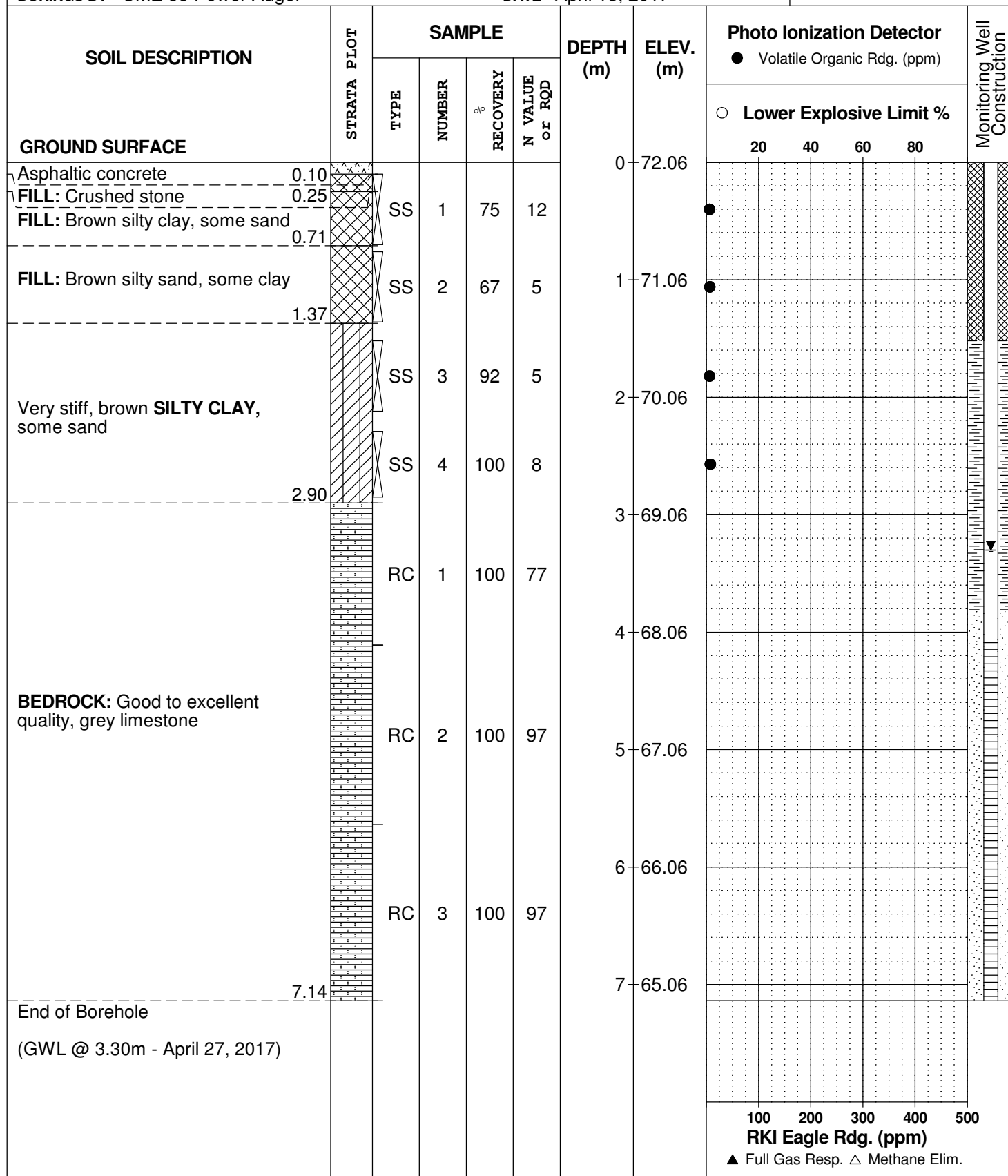
**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** April 18, 2017

**FILE NO.**  
**PE3774**

**HOLE NO.**  
**BH 9**



## SOIL PROFILE AND TEST DATA

Phase II - Environmental Site Assessment  
383 Slater Street  
Ottawa, Ontario

**DATUM** Benchmark (BM) - Top cover of manhole located along east side of Bay Street, just north of Slater Street. Geodetic elevation = 72.77m.

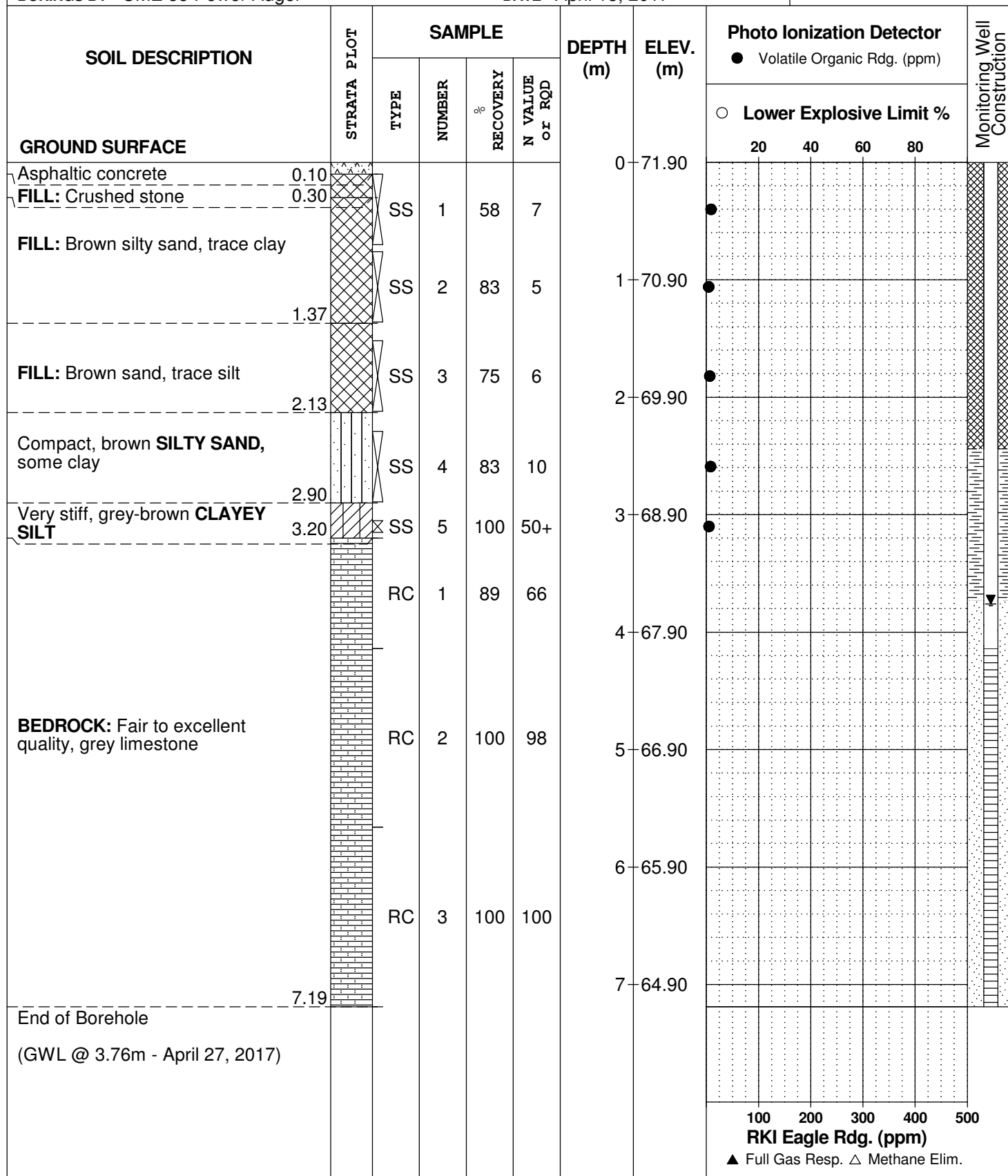
**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** April 18, 2017

**FILE NO.**  
**PE3774**

**HOLE NO.**  
**BH10**



**DATUM** Benchmark (BM) - Top cover of manhole located along east side of Bay Street, just north of Slater Street. Geodetic elevation = 72.77m.

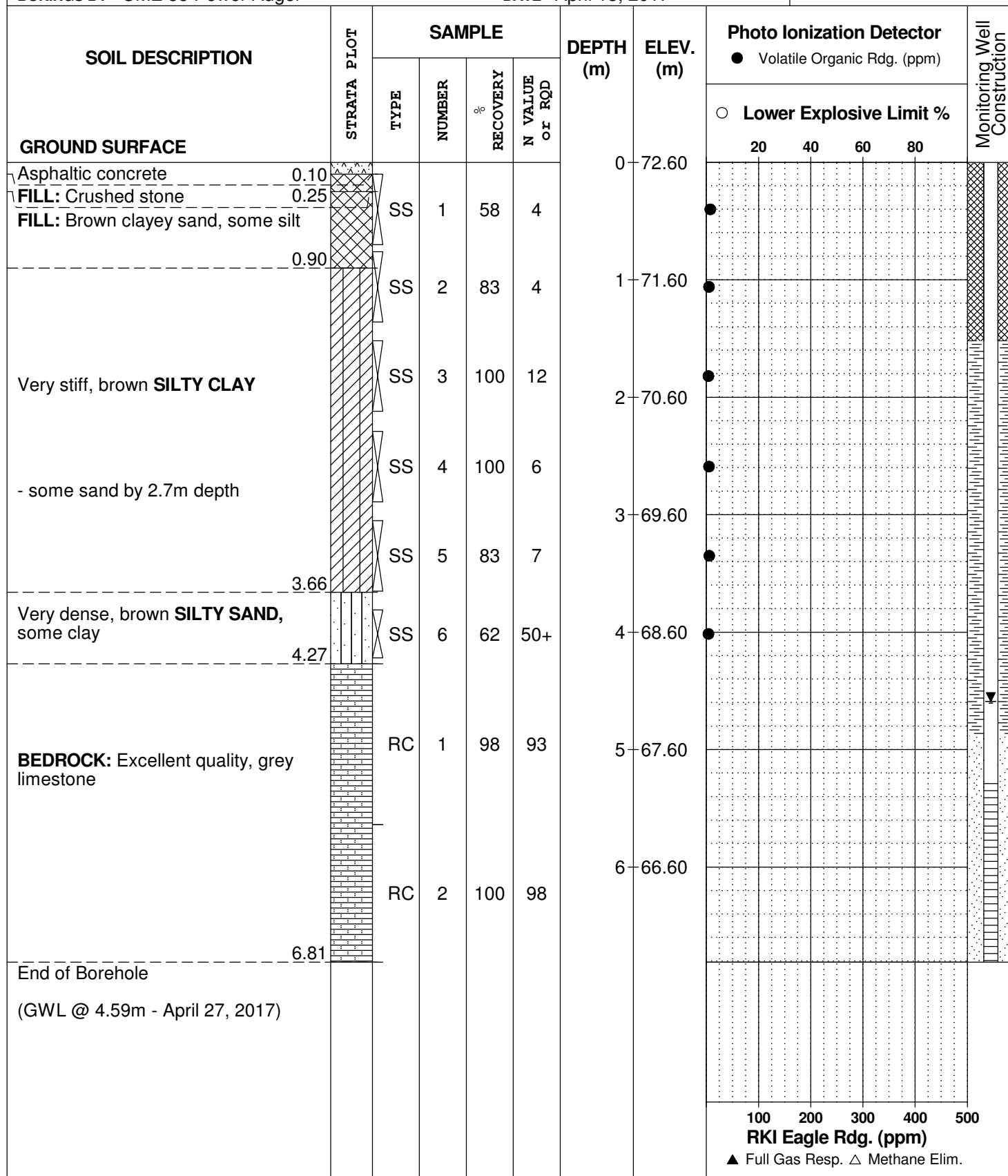
**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** April 18, 2017

**FILE NO.**  
**PE3774**

**HOLE NO.**  
**BH11**



## SOIL PROFILE AND TEST DATA

Phase II - Environmental Site Assessment  
383 Slater Street  
Ottawa, Ontario

**DATUM** Benchmark (BM) - Top cover of manhole located along east side of Bay Street, just north of Slater Street. Geodetic elevation = 72.77m.











**REMARKS**

**BORINGS BY** CME 55 Power Auger

**DATE** April 18, 2017

**FILE NO.**  
**PE3774**

**HOLE NO.**  
**BH12**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Photo Ionization Detector					Monitoring Well Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			● Volatile Organic Rdg. (ppm)						
								○ Lower Explosive Limit %						
GROUND SURFACE								20	40	60	80			
Asphaltic concrete	0.10		SS	1	58	11	0	72.30						
FILL: Crushed stone	0.30													
FILL: Brown silty sand	0.76													
Very stiff, brown <b>SILTY CLAY</b>  - some sand by 2.1m depth			SS	2	100	11	1	71.30						
			SS	3	100	7	2	70.30						
			SS	4	100	3								
Dense, brown <b>SILTY SAND</b> , some clay	2.90		SS	5	67	50+	3	69.30						
End of Borehole	3.20													
Practical refusal to augering at 3.20m depth														

## SOIL PROFILE AND TEST DATA

Groundwater Quality Assessment  
Proposed Development - 383 Slater St. & 400 Albert St.  
Ottawa, Ontario

**DATUM** TBM - Top of manhole located on the east side of Bay Street, just north of Slater Street. A geodetic elevation of 72.77m was provided by Annis, O'Sullivan, Vollebakk Ltd. for the TBM.

**FILE NO.**  
**PG3543**

**HOLE NO.**  
**BH 1**

**BORINGS BY** CME 55 Power Auger

**DATE** June 5, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Photo Ionization Detector				Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			● Volatile Organic Rdg. (ppm)				
								○ Lower Explosive Limit %				
GROUND SURFACE								20	40	60	80	
Asphaltic concrete	0.10	AU	1			0	72.74					
FILL: Brown silty sand, some gravel and cobbles		SS	2	62	3	1	71.74					
- some brick and concrete by 0.4m depth	2.29	SS	3	25	16	2	70.74					
BEDROCK: Grey limestone with shale lenses		RC	1	94	61	3	69.74					
		RC	2	100	86	4	68.74					
		RC	3	97	92	5	67.74					
						6	66.74					
		RC	4	98	95	7	65.74					
						8	64.74					
		RC	5	98	77	9	63.74					
						10	62.74					
		RC	6	97	97	11	61.74					
						12	60.74					
		RC	7	100	97	13	59.74					
						14	58.74					
		RC	8	98	98	15	57.74					
	- calcite noted from 10.5m to 11.9m depth		RC	9	100	100						
End of Borehole	15.16											
(GWL @ 4.61m-August 17, 2015)												
								100	200	300	400	500
								RKI Eagle Rdg. (ppm)				
								▲ Full Gas Resp. △ Methane Elim.				

## SOIL PROFILE AND TEST DATA

Groundwater Quality Assessment  
Proposed Development - 383 Slater St. & 400 Albert St.  
Ottawa, Ontario

**DATUM** TBM - Top of manhole located on the east side of Bay Street, just north of Slater Street. A geodetic elevation of 72.77m was provided by Annis, O'Sullivan, Vollebakk Ltd. for the TBM.

**FILE NO.** PG3543

**HOLE NO.** BH 2

**BORINGS BY** CME 55 Power Auger

**DATE** June 5, 2015

SOIL DESCRIPTION		STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Photo Ionization Detector				Monitoring Well Construction
			TYPE	NUMBER	RECOVERY %	N VALUE or RQD			● Volatile Organic Rdg. (ppm)				
									○ Lower Explosive Limit %				
GROUND SURFACE									20	40	60	80	
Asphaltic concrete	0.05		AU	1			0	73.72					
FILL: Crushed stone with sand	0.25												
FILL: Brown silty sand with crushed stone, trace brick	1.52		SS	2	50	19	1	72.72					
FILL: Gravel and boulders, some silt and sand			SS	3	67	45	2	71.72					
	2.44												
Grey SILTY CLAY, trace sand	2.87		SS	4	70	10							
							3	70.72					
GLACIAL TILL: Grey-brown silty sand with gravel and cobbles			SS	5	42	12							
	4.27		SS	6	72	14	4	69.72					
							5	68.72					
			RC	1	100	97	6	67.72					
			RC	2	98	98	7	66.72					
			RC	3	98	88	8	65.72					
							9	64.72					
BEDROCK: Grey limestone with shale lenses													
			RC	4	95	95	10	63.72					
			RC	5	100	100	11	62.72					
			RC	6	98	98	12	61.72					
			RC	7	97	97	13	60.72					
			RC	8	100	100	14	59.72					
	15.22		RC				15	58.72					
End of Borehole													
(GWL @ 5.41m-August 17, 2015)													
									100	200	300	400	500
									RKI Eagle Rdg. (ppm)				
									▲ Full Gas Resp. △ Methane Elim.				

## SOIL PROFILE AND TEST DATA

Groundwater Quality Assessment  
Proposed Development - 383 Slater St. & 400 Albert St.  
Ottawa, Ontario

**DATUM** TBM - Top of manhole located on the east side of Bay Street, just north of Slater Street. A geodetic elevation of 72.77m was provided by Annis, O'Sullivan, Vollebakk Ltd. for the TBM.

**FILE NO.**  
**PG3543**

**HOLE NO.**  
**BH3**

**BORINGS BY** CME 55 Power Auger

**DATE** June 8, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Photo Ionization Detector				Monitoring Well Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			● Volatile Organic Rdg. (ppm)				
								○ Lower Explosive Limit %				
GROUND SURFACE								20	40	60	80	
Asphaltic concrete 0.10		AU	1			0	72.12					
FILL: Crushed stone with silty sand 0.76		SS	2	67	4	1	71.12					
FILL: Brown silty sand 1.55		SS	3	96	9	2	70.12					
GLACIAL TILL: Grey silty sand, some gravel, cobbles and boulders		SS	4	71	50+							
		RC	1			3	69.12					
		RC	2			4	68.12					
		RC	3	97	90	5	67.12					
		RC	4	100	100	6	66.12					
BEDROCK: Grey limestone with shale lenses		RC	5	97	85	7	65.12					
		RC	6	100	100	8	64.12					
		RC	7	100	90	9	63.12					
		RC	8	100	100	10	62.12					
		RC	9	100	100	11	61.12					
						12	60.12					
						13	59.12					
						14	58.12					
						15	57.12					
End of Borehole 15.24												
(GWL @ 4.50m-August 17, 2015)												
								100	200	300	400	500
								RKI Eagle Rdg. (ppm)				
								▲ Full Gas Resp. △ Methane Elim.				



# **APPENDIX 2**

**FIGURE 1 - KEY PLAN**

**FIGURES 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES**

**DRAWING PG4793-1 - TEST HOLE LOCATION PLAN**



**FIGURE 1**

**KEY PLAN**

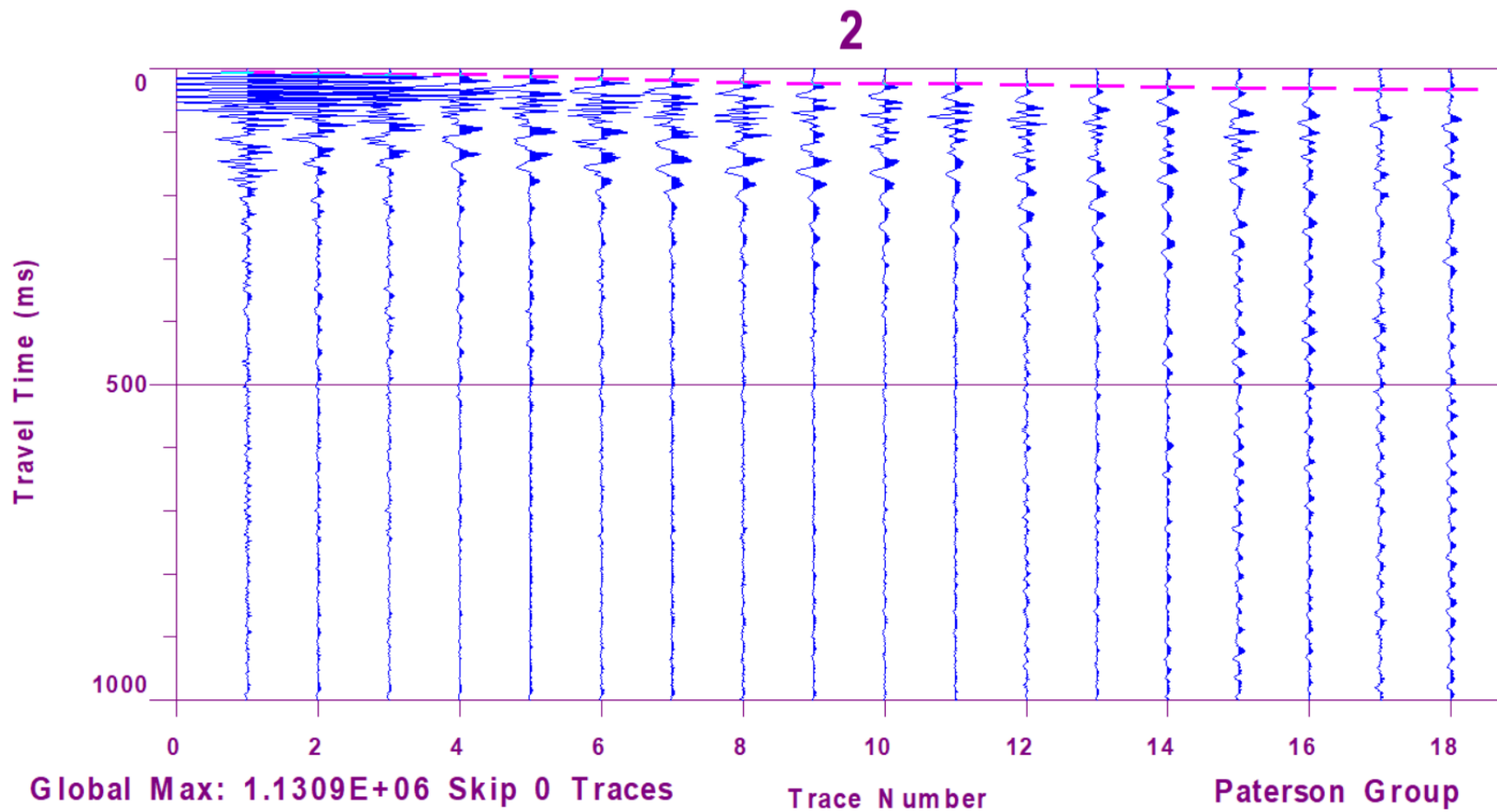


Figure 2 – Shear Wave Velocity Profile at Shot Location -4.5 m

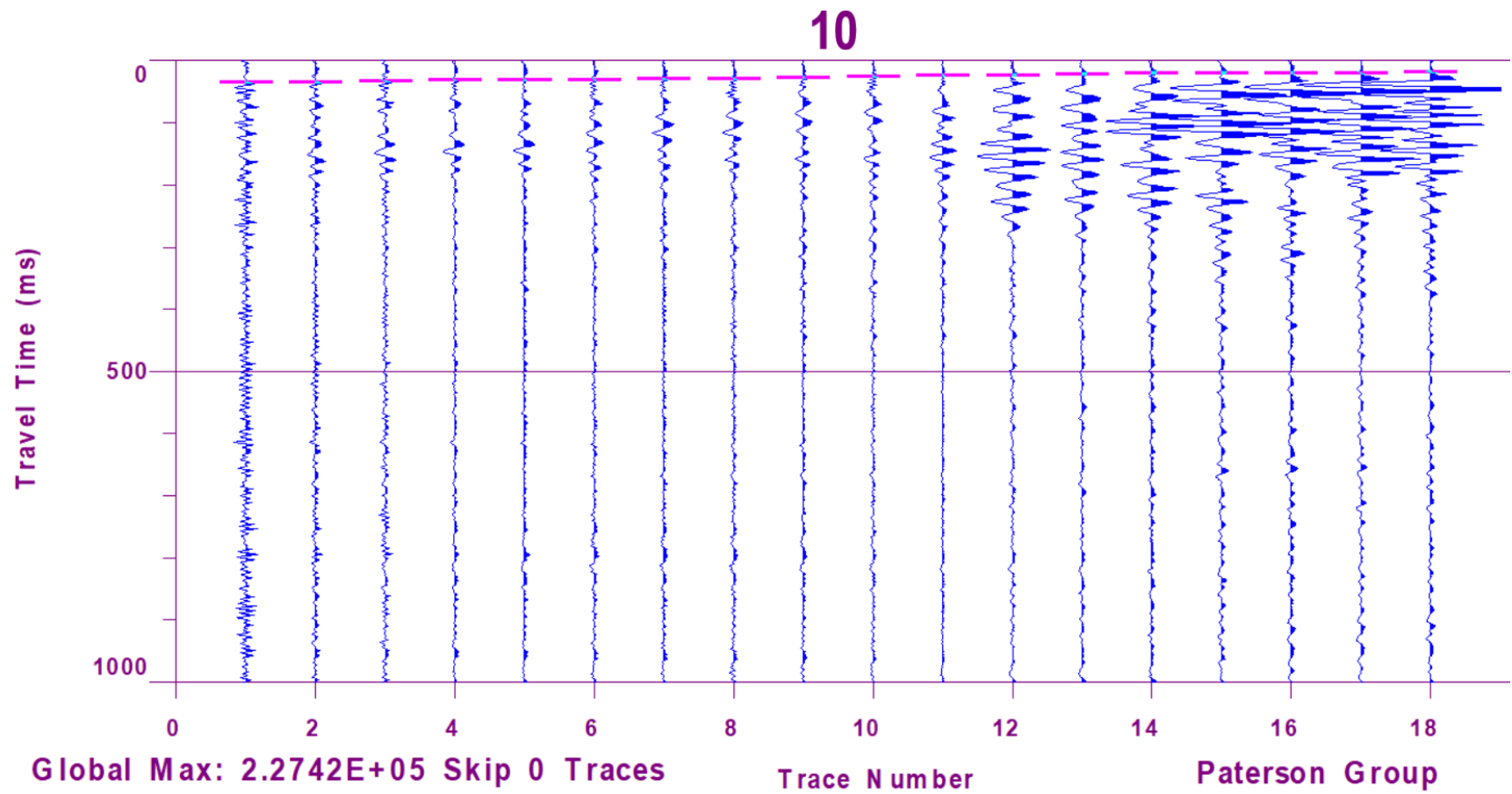
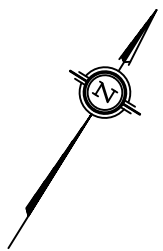
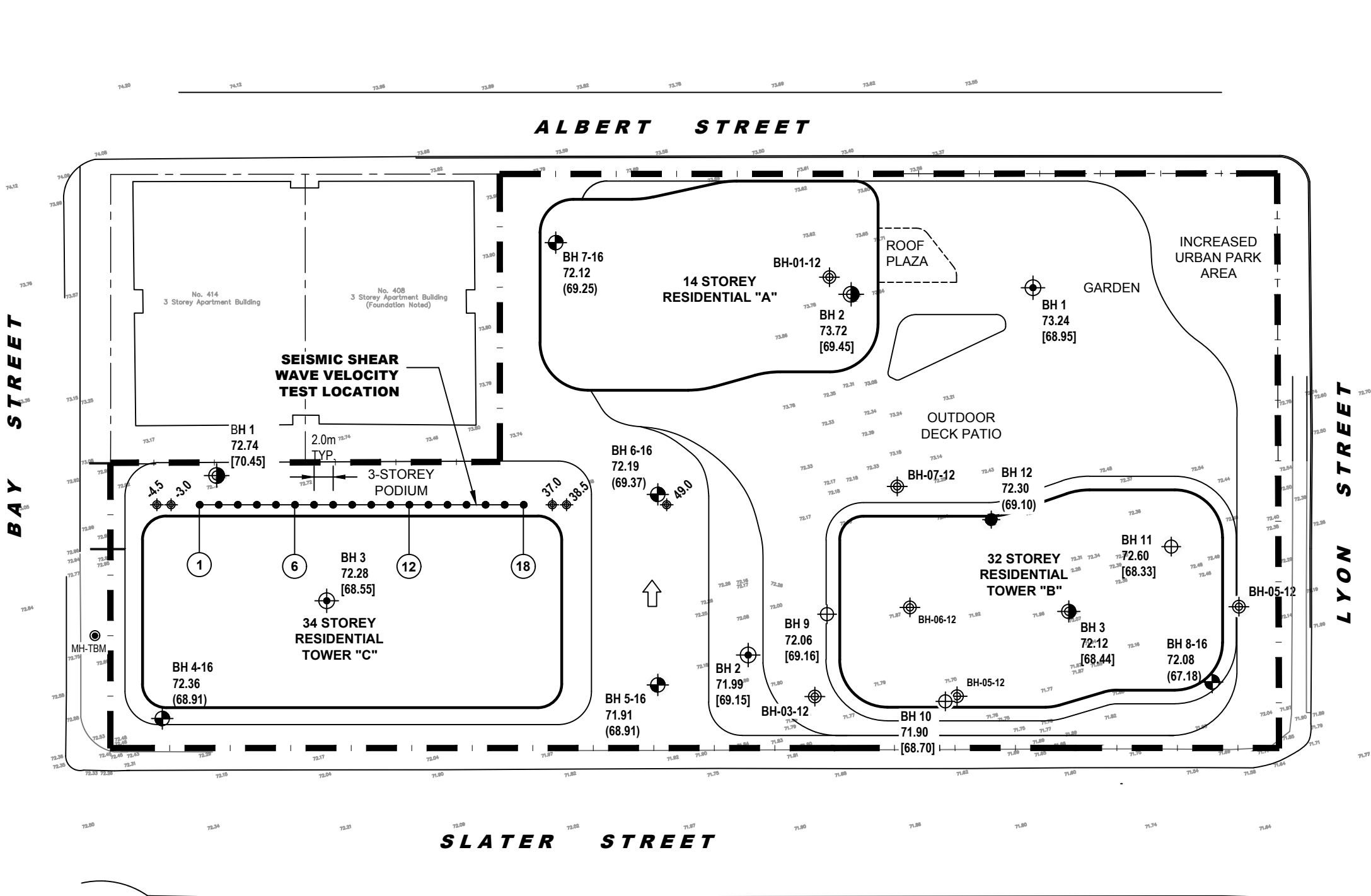


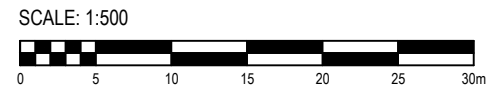
Figure 3 – Shear Wave Velocity Profile at Shot Location 49 m



- LEGEND:**
- BOREHOLE WITH MONITORING WELL LOCATION, CURRENT INVESTIGATION
  - BOREHOLE LOCATION, PATERSON GROUP REPORT PG3914
  - BOREHOLE WITH MONITORING WELL LOCATION, PATERSON GROUP REPORT NO. PE3774
  - BOREHOLE LOCATION, PATERSON GROUP REPORT NO. PE3774
  - BOREHOLE WITH MONITORING WELL LOCATION, PATERSON GROUP REPORT PG3543-08, 2015
  - APPROXIMATE BOREHOLE LOCATION BY OTHERS
  - 72.74 GROUND SURFACE ELEVATION (m)
  - [70.45] BEDROCK SURFACE ELEVATION (m)
  - (68.91) PRACTICAL REFUSAL TO AUGERING ELEV. (m)
  - GEOPHONE LOCATION
  - 18 GEOPHONE NUMBER
  - SHOT LOCATION

TBM - TOP COVER OF MANHOLE LOCATED ALONG EAST SIDE OF BAY STREET, JUST NORTH OF SLATER STREET. A GEODETIC ELEVATION OF 72.77m WAS PROVIDED FOR THE TBM BY ANNIS, O'SULLIVAN, VOLLEBEKK LTD.

BASE PLAN PROVIDED BY WOODMAN ARCHITECT & ASSOCIATES LTD.



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NO.	REVISIONS	DATE	INITIAL

MAIN AND MAIN DEVELOPMENTS

GEOTECHNICAL INVESTIGATION

MULTI-STOREY REDEVELOPMENT - 383 SLATER ST. & 400 ALBERT ST.

OTTAWA, ONTARIO

Title: TEST HOLE LOCATION PLAN

Scale:	1:500	Date:	04/2019
Drawn by:	RCG	Report No.:	PG4793-1
Checked by:	NC	Dwg. No.:	PG4793-1
Approved by:	DJG	Revision No.:	0

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