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Geotechnical Investigation

Proposed Hi-Rise Residential Complex
151 Chapel Street
Ottawa, Ontario

Prepared For

Trinity Development Group

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Report: PG2933-3

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Table of Contents

Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Trinity Development Group to conduct a geotechnical investigation for the proposed hi-rise residential complex to be located at 151 Chapel Street in the City of Ottawa (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 boreholes.
- ❏ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

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

2.0 Proposed Development

It is understood that the proposed development will consist of two 25 storey structures with 2 and 4 levels of underground parking which will have a footprint that occupies the majority of the subject site. The project will be divided into two phases with the first phase being constructed on the south portion. Based on the latest conceptual drawing provided by Trinity Development, the finished floor slab of P2 (Phase 1) and P4 (Phase 2) levels of the underground parking garage will be at a geodetic elevations of 56 and 53 m, respectively.

The former two to three storey institutional building, which included one deep basement level, was previously demolished. The subject site is approximately at grade along the perimeter with neighbouring properties and adjacent roadways which all slope downwards to Beausoleil Drive. There is a significant depressed area in the central portion of the site due to the previous demolition.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

Several field programs were completed for the geotechnical investigation which were carried out on March 21, 22 and 25, 2013, February 26, 2015, October 13 to 16, 19 to 23, 26 and 27, 2015. During that time, a total of 28 boreholes were advanced to a maximum depth of 20.7 m below existing ground surface. The previous boreholes completed during the preliminary geotechnical investigation have also been included in this geotechnical report. The borehole locations were distributed in a manner to provide general coverage of the subject site. The locations of the boreholes are shown on Drawing PG2933-2 - 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. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer. The drilling procedure consisted of augering to the required depths at the selected locations, sampling and testing the overburden.

Sampling and In Situ Testing

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

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

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

Coring the bedrock using diamond drilling was carried out at BH 4-15, BH 5-15, BH 8-15, BH 10-15, BH 14-15, BH 16-15, BH 17-15, BH 21A-15 and BH 1-13 to confirm bedrock depths, determine the nature of the bedrock and to assess its 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 quality of the bedrock.

The overburden thickness was evaluated during the course of the previous investigation by dynamic cone penetration test (DCPT) at BH 2. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at the tip. The steel drill rod is struck by a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

The subsurface conditions observed in the boreholes were recorded in detail in the field. The soil profiles are logged on the Soil Profile and Test Data sheets presented in Appendix 1.

Groundwater

A 51 mm in diameter PVC groundwater monitoring well was installed in BH 1-15, BH 20-15, BH 21A-15, BH 22-15, BH 24-15, BH 1-13, BH 2-13, BH 3-13 and BH 1 to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

Monitoring Well Installation

Typical monitoring well construction details are described below:

- ❏ 3 m of slotted 51 mm diameter PVC screen at base the base of the boreholes
- ❏ 51 mm diameter PVC riser pipe from the top of the screen to the 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 the ground surface.

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

Sample Storage

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

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 boreholes were surveyed with respect to a temporary benchmark (TBM), consisting of the top spindle of the fire hydrant located on the east side of Chapel Street along the west boundary of the subject site. A geodetic elevation of 65.12 m was provided to the TBM on the drawing prepared by Annis, O'Sullivan, Vollebekk Limited. The location of the TBM, boreholes, and the ground surface elevation at each borehole location are presented on Drawing PG2933-2 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil and rock core samples were recovered from the subject site and visually examined in our laboratory to review the field logs. The results are presented on the Soil Profile and Test Data sheets in Appendix 1.

Three bedrock samples were submitted for unconfined compressive strength testing.

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.

3.4 Analytical Testing

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

4.0 Observations

4.1 Surface Conditions

The subject site was formerly occupied by a two to three storey institutional building with one basement level along with associated at grade asphalt parking areas. The subject site is approximately at grade with neighboring properties and adjacent roadways with the exception of the north-central portion of the site which is approximately 3 m lower in elevation.

The site is bordered to the south by Rideau Street, to the west by Chapel Street and to the north by Beausoleil Drive and to the east by a two storey motel building which is located in close proximity to the east property limit.

4.2 Subsurface Profile

Generally, the subsoil profile encountered at the borehole locations consists of an asphaltic concrete surface followed by sand fill material mixed with gravel, cobbles and various construction debris overlying a native sand and/or a stiff to very stiff silty clay layer. A compact to very dense glacial till overlying bedrock was encountered below the silty clay deposit.

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

Fill

Fill of varying thicknesses was encountered at each of the borehole locations throughout the subject site. The overlying fill layer extended to depths varying between 0.2 and 4.6 m below the existing ground surface at BH12-15 and BH21A-15, respectively. The fill generally consists of granular crushed stone with sand, gravel, crushed concrete, brick, steel, asphalt, trace glass, ash, coal and/or slag overlying brown silty sand and/or silty clay. Practical refusal to augering was encountered within the overlying fill material at a depth of 3.1 and 3.7 at BH 21-15 and BH 4-13, respectively on inferred concrete.

Silty Sand

A 0.4 to 3.2 m thick layer of loose to compact silty sand was encountered underlying the fill material at BH 1-15 to BH 6-15, BH 9-15 to BH 12-15, BH 15-15, BH 16-15, BH 24-15, BH 2-13, BH 3-13 and BH 3 overlying the very stiff to stiff silty clay.

Silty Clay/Clayey Silty

A very stiff to stiff silty clay was encountered below the fill at all borehole locations with the exception of BH 21-15 and BH 4-13 which terminated within the fill material on inferred concrete. The upper portion of the silty clay has been weathered to a brown very stiff to stiff crust which in turn is overlying a grey silty clay.

The very stiff to stiff grey silty clay exists below the weathered crust at all borehole locations and extends to depths varying from 6.9 to 14.5 m below existing ground surface. A relatively thin layer of clayey silty was encountered below the grey silty clay at BH 5-15 to BH 9-15, BH 11-15 to BH 13-15, BH 15-15, BH 17-15, BH 18-15, BH 21A-15 and BH 23-15.

In situ shear vane tests carried out in the grey silty clay yielded undrained shear strength values ranging from 55 to 140 kPa. These values are indicative of a stiff to very stiff consistency. The bulk unit weight of the clay is estimated to be 17.5 kN/m^3.

Glacial Till

A glacial till deposit extending to a maximum depth of 18.9 m below existing ground surface was encountered below the silty clay at all deep borehole locations. The glacial till consists of a fine silty sand to silty clay soil matrix mixed with gravel, cobbles and trace boulders.

Based on the SPT results, which yielded 11 to 69 blows/300 mm increment of penetration, the state of compactness of the glacial till is estimated to be compact to very dense. The bulk unit weight of the till is estimated to be 21 kN/m^3.

It should be noted that a thin layer of loose sandy silty to a very dense silty sand trace gravel was encountered overlying the glacial till at BH 14-15. Running sand was encountered within the very dense silty sand at a depth of 13.7 and 16.4 m below existing ground surface at BH 14-15. Furthermore, a 0.5 m thick layer of running sand was also encountered at BH 21A-15 at a depth of 11.9 to 12.4 m.

Bedrock

Based on the available geological mapping, practical auger refusal on inferred bedrock depths and bedrock samples recovered during our geotechnical investigations, the bedrock was encountered at geodetic elevations ranging between 47.3 to 49.7 m across the subject site.

The bedrock was cored at BH4-15, BH5-15, BH8-15, BH10-15, BH14-15, BH16-15, BH17-15, BH21A-15 and BH1-13 to confirm bedrock depths, determine the nature of the bedrock and to assess its quality. Based on the results of coring, the bedrock consists of a weathered interbedded grey limestone and shale. Values for TCR, SCR and RQD were calculated for the rock core and the quality of the bedrock was assessed based on these results. Based on the observations, the upper 2 m of the bedrock is poor (RQD 25 to 50%) to excellent (RQD 90 to 100%) quality.

Unconfined compressive strength (UCS) testing was carried out on three (3) bedrock samples recovered from the boreholes.

Table 1 - Bedrock Unconfined Compressive Strength

Sample Numer	Bedrock Type	Depth (m)	Elevation (m)	Compressive Strength (MPa)
BH8-15 - RC2	Limestone and Shale	18.82	46.90	126.3
BH14-15 - RC2	Limestone and Shale	17.05	47.34	53.2
BH16-15 - RC1	Limestone and Shale	15.80	48.25	134.2

Based on available geological mapping, the subject site is located in an area where the bedrock consists of limestone and shale of the Lindsay Formation, which is encountered at depths varying between 10 and 20 m.

4.3 Groundwater

Groundwater levels (GWL) were measured in the monitoring wells installed during the geotechnical field investigations are presented in Table 2 below. It should be noted that the groundwater level readings observed in BH 1-15 and BH 22-15 are most likely influenced by perched groundwater conditions within the overlying silty sand and fill material.

The groundwater level can also be estimated based on moisture levels and colour of the recovered soil samples. Based on these observations it is expected that the long term groundwater level within the silty clay deposit is at an approximate Geodetic elevation of 55 to 58 m. It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction. However, for design purposes, the long term groundwater level should be considered at elevation 57.0 m.

Table 2 - Groundwater Level Readings

Borehole Number	Ground Elevation (m)	Depth of Screen (m)	Groundwater Levels		Recording Date
			Depth (m)	Elevation (m)	
BH 1-15	63.50	6.0 to 9.1	5.40	58.10	March 25, 2015
BH 20-15	60.40	4.5 to 7.6	7.48	52.92	November 4, 2015
BH 21A-15	63.59	7.6 to 10.7	10.52	53.07	November 4, 2015
BH 22-15	61.41	4.5 to 7.6	1.11	60.30	November 4, 2015
BH 24-15	63.75	7.6 to 10.70	10.58	53.17	November 4, 2015
BH 1-13	67.73	15.6 to 18.4	15.76	51.97	April 2, 2013
BH 2-13	65.52	6.2 to 9.3	9.20	56.32	April 2, 2013
BH 3-13	63.52	6.1 to 9.2	9.32	54.20	April 2, 2013
BH 1	67.97	6.3 to 9.4	2.64	65.33	April 2, 2013

Note: The boreholes were surveyed with respect to a temporary benchmark (TBM), consisting of the top spindle of the fire hydrant located on the east side of Chapel Street along the west boundary of the subject site. A geodetic elevation of 65.12 m was provided to the TBM on the drawing prepared by Annis, O'Sullivan, Vollebekk Limited.

4.4 Hydraulic Conductivity

On April 2, 2013 falling head hydraulic conductivity tests (falling head test) were carried out on BH 1-13, BH 2 -13, BH 3-13 and BH 1. A falling head test consists of increasing the level of the water column within the well and measuring the gradual drawdown of the water column with respect to time. The data collected from this test can be used to determine the horizontal hydraulic conductivity (K_o) of the screened stratigraphic unit. With the data collected from the falling head test a Hvorslev Analysis was carried out. This method uses a semi-log plot of the dimensionless head on a log scale versus time. From this plot a time, t*, is determined. This time is when the dimensionless head is equal to 0.37. These plots are attached to this report. Using a predetermined shape factor, calculated from the well dimensions, a hydraulic conductivity can be determined.

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Equation 1: Hvorslev Shape Factor

Where: F: Hvorslev Shape Factor (m)
L: Saturated length of screen or open hole (m)
D: Diameter of well (m)

$$K = \frac{\pi r_c^2}{F}\frac{1}{t*}\ln\left(\frac{\Delta H *}{\Delta H_0}\right)$$

Equation 2: Horizontal Hydraulic Conductivity

Where: K: Horizontal Hydraulic Conductivity (m/minute)
r_c: Radius of well (m^2)
F: Hvorslev shape factor (m)
t*: time when $\frac{\Delta H^*}{\Delta H_o}$ is equal to 0.37 (minutes)
ΔH*: Drawdown at time, t* (m)
ΔH_o: Maximum drawdown (m)

Falling head hydraulic conductivity tests (falling head test) performed at BH 2-13, BH 3-13 and BH 1 within the underlying silty clay layer. The estimated hydraulic conductivity values ranged between 1 x 10^{-9} to 4 x 10^{-9} m/sec for the silty clay. This is universally recognized as a suitable hydraulic conductivity for a cohesive silty clay soil strata with a stiff to firm relative density. Falling head test was also performed at BH 1-13 which is installed within the underlying compact to very dense glacial till deposit. The estimated hydraulic conductivity value is 1 x 10^{-4} m/sec.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed development. If 2 to 4 levels of underground parking is considered for the subject development, the following foundation option has been selected by the project team for the subject development:

- ☐ Combination of secant wall and conventional soldier pile and lagging shoring system
- ☐ End bearing piles founded in the bedrock surface or caisson foundations socketed in the bedrock
- ☐ Conventional foundation drainage
- ☐ Class C - seismic site classification

5.2 Site Preparation

Stripping Depth

Since the site excavation will occupy the entire site and will extend to a depth of approximately 12 to 14 m below the existing grade, all topsoil and fill materials will be removed from within the perimeter of the proposed building and other settlement sensitive structures.

Protective Granular Pad

It is our understanding that if the excavation will extend to a depth of approximately 12 to 14 m where the excavation bottom will be on a stiff grey silty clay or glacial till deposit. The excavation bottom will require protection from disturbance due to worker traffic and equipment. It is suggested that a 500 to 600 mm thick granular pad should be placed on the undisturbed clay and glacial till surface once exposed and should consist of an OPSS Granular B Type II material. The purpose of the granular pad is to provide a suitable surface for the piling crane.

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 equipment could be the source of vibrations: hoe ram, compactor, crane, truck traffic, etc. Vibrations caused by construction operations could be the cause of 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 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 reduce the risks of claims during or following the construction of the proposed building.

5.3 Foundation Design

Shallow Auxiliary Footings

Auxiliary footings (for the canopy and garage ramps), founded on an undisturbed, stiff silty clay bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **150 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **225 kPa**. A geotechnical resistance factor of 0.5 was applied to the reported bearing resistance value at ULS. Although, a grade raise is not anticipated, a permissible grade raise restriction of 1 m is recommended for the subject site.

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

The bearing resistance value given for footings at SLS will be subjected to potential post-construction total and differential settlements of 25 and 15 mm, respectively.

End Bearing Piled Foundation

It is expected that the parking garage and buildings will be constructed over concrete filled steel pipe piles driven to refusal on the bedrock surface.

For deep foundations, concrete-filled steel pipe piles are generally utilized in the Ottawa area. Applicable pile resistance at SLS values and factored pile resistance at ULS values are given in Table 2. A resistance factor of 0.4 has been incorporated into the factored ULS values. Note that these are all geotechnical axial resistance values.

The geotechnical pile resistance values were estimated using the Hiley dynamic formula, to be confirmed during pile installation with a program of dynamic monitoring. For this project, the dynamic monitoring of 3 to 4 piles would be recommended. This is considered to be the minimum monitoring program, as the piles under shear walls may be required to be driven using the maximum recommended driving energy to achieve the greatest factored resistance at ULS values. Re-striking of all piles at least once will also be required after at least 48 hours have elapsed since initial driving.

Table 2 - Pile Foundation Design Data

Pile Outside Diameter (mm)	Pile Wall Thickness (mm)	Geotechnical Axial Resistance		Final Set (blows/ 25 mm)	Transferred Hammer Energy (kJ)
		SLS (kN)	Factored at ULS (kN)		
245	9	975	1460	10	35
245	11	1100	1650	10	42
245	13	1200	1760	10	45

Caisson Foundation

For the underground parking garage underlying the tower structures, a caisson foundation could be utilized. It is expected that the caissons will be socketed into the bedrock. The bedrock surface should be free of deleterious materials, loose soils and approved by the geotechnical consultant.

The caissons can be constructed by advancing casing through the overburden soils to the bedrock surface (by vibrator or augering in advance of the casing), seating the casing in the bedrock and then continuing drilling to create a rock socket. It is recommended that one caisson be constructed for each column. Considering the expected difficulty in cleaning and verifying the cleanliness of the bases of the caissons, it is recommended that the capacity of the rock socketed caissons be based solely on side wall resistance or socket shear.

Based on the borehole information, the upper 1 m of the bedrock should be ignored for purposes of socket shear. Below that level, the following values can be used. A socket shear resistance at SLS value of **1,000 kPa** can be used for the sides of clean shale bedrock sockets. A factored socket shear resistance at ULS value of **1,500 kPa** can be used for clean shale bedrock sockets. The latter value incorporates a geotechnical resistance value of 0.4.

It is recommended that the ratio of the length to diameter of the useable socket be at least 3 for the above-noted socket shear resistance values to be applicable. It is recommended that the specified concrete strength for the caissons be at least 35 MPa, in order that the socket shear values are not limited by the concrete strength.

The deformation modulus, E_r, of the sound intact rock material can be taken to be about 400 times the unconfined compressive strength, or approximately 14,400 MPa. However, considering the bedding planes and other discontinuities, the deformation modulus, E_m, of the rock mass is expected to be closer to about 100 times the unconfined compressive strength, or approximately 3,600 MPa. These values are empirical and are not based on specific testing.

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 2012. The shear wave velocity testing was completed by Paterson personnel. Two seismic shear wave velocity profiles from the testing are presented in Appendix 2.

Field Program

The shear wave testing location is presented in Drawing PG2933-2 - Test Hole Location Plan in Appendix 2. Paterson field personnel placed 24 horizontal geophones in a straight line in roughly a north-south orientation. The 4.5 Hz. horizontal geophones were mounted to the surface by means of two 75 mm ground spikes attached to the geophone land case. The geophones were spaced at 3 m intervals and connected by a geophone spread cable to a Geode 24 Channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-Beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between five to ten 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 at the centre of the geophone array, 3 and 5 away from the first and last geophone as well as 20 and 30 m from the first geophone.

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

Data Processing and Interpretation

Interpretation for the shear wave velocity results were completed by Paterson personnel. Shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity, Vs_{30}, of the upper 30 m profile, immediately below the building's foundation. The layer intercept times, velocities from different layers and critical distances are interpreted from the shear wave records to compute the bedrock depth at each location. 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.

Based on our analysis, the bedrock seismic shear wave velocity was calculated to be 2,170 m/s. The overburden seismic shear wave velocity was estimated to be approximately 198 m/s based on intercept times from our survey.

The Vs_{30} was calculated using the standard equation for average shear wave velocity calculation from the Ontario Building Code (OBC) 2012, as presented below.

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

$$V_{s30} = \frac{30m}{\left(\frac{12m}{198m/s} + \frac{18m}{2{,}170m/s}\right)}$$

$$V_{s30} = 435m/s$$

Based on the results of the seismic testing, the average shear wave velocity, Vs_{30}, for the proposed building bearing on caissons at an approximate geodetic elevation of 61.00 m is 435 m/s. Therefore, a **Site Class C** is applicable for the proposed building, as per Table 4.1.8.4.A of the OBC 2012. The soils underlying the subject site are not susceptible to liquefaction.

5.5 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, in our opinion, 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 drained unit weight of 20 kN/m^3. The applicable effective unit weight of the material is 13 kN/m^3, where applicable.

The earth pressures acting on earth retaining structures are dependent on the characteristics of the structure, particularly with respect to whether it is a “yielding” or an “unyielding” structure. A basement wall, which is restrained laterally by the floors of the structure, is generally considered to be an unyielding structure.

Unyielding walls, such as the basement walls of the proposed structure, are considered to be subjected to “at-rest” earth pressures, as they will not deflect enough to allow for the development of “active” earth pressures. It is recommended that the at-rest earth pressure case be used for basement walls.

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

Static Earth Pressures

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

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

Seismic Earth Pressures

The seismic earth pressure (ΔP_{AE}) can be calculated using the earth pressure distribution equal to $0.375a_c \gamma H^2/g$ where:

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

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

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

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

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

5.6 Basement Slab

It is expected that the basement area will be mostly parking and a rigid concrete pavement structure is anticipated. It is recommended that the upper 300 mm of sub-slab fill consists of an OPSS Granular A crushed stone material. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

In consideration of the groundwater conditions encountered at the time of the construction, 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. Furthermore, if managing the groundwater infiltration at the lower floor level is required (lessening the volume of groundwater infiltration), consideration should be given to pouring a 100 mm thick concrete slab over the native soil to create a more impermeable barrier.

5.7 Pavement Design

The proposed parking level slabs will be considered a rigid pavement structure. The following rigid pavement structure is recommended to support car parking only.

Table 3 - Recommended Rigid Pavement Structure - Car Only Parking Areas

Thickness (mm)	Material Description
125	Concrete slab
300	**BASE** - OPSS Granular A
SUBGRADE - OPSS Granular B Type II or glacial till	

If flexible asphalt pavement is required for surface parking and access ramps for the subject site, the recommended pavement structures shown in Tables 4 and 5 would be applicable.

Table 4 - Recommended Pavement Structure - Car Only Parking Areas

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

Table 5 - Recommended Pavement Structure - Access Lanes and Loading Ramp

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

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

The pavement granulars (base and subbase) should be placed in maximum 300 mm thick layers and compacted to a minimum of 100% of the materials' SPMDDs using suitable compaction equipment. Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

6.0 Design and Construction Precautions

6.1 Foundation Drainage, Waterproofing and Backfill

Foundation Drainage

It is understood that the building foundation walls will be placed in close proximity to all the boundaries. 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 against the shoring face.

It is recommended that the composite drainage system (such as Miradrain G100N or equivalent) extend down to the footing level. It is recommended that 150 mm diameter sleeves at 3 m centres be cast in the footing or at the foundation wall/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.

Where space is available, it is recommended that a perimeter foundation drainage system be provided for the proposed structure. If provided the system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 19 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should be connected to sump pit(s) within the lower basement area.

Underfloor Drainage

Underfloor drainage will be required to control water infiltration due to groundwater infiltration at the proposed founding elevation. For design purposes, we recommend that 150 mm in diameter perforated pipes be placed at 8 m centres or one line within 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.

Waterproofing Requirements

Since the long term groundwater level within the silty clay deposit is expected at a depth of 5.7 to 8.7 m adjacent to Beausoleil Drive and a depth of 10.2 to 13.2 m below the existing grade adjacent to Rideau Street, waterproofing will be required from the bottom of the excavation to at a minimum of 0.5 m above the high water level (geodetic elevation 57 m) within the silty clay deposit. It's our understanding that a permanent secant wall may be used at the eastern portion of the site to manage the water tightness where adjacent buildings are more vulnerable to settlement and reduce the effects of long term groundwater lowering. The remaining areas along the soldier pile and lagging shoring system will require a sheet membrane fastened to the shoring system prior to placing the composite drainage layer.

In areas of the lower level below elevation 56.0 m, consideration should also be given to pouring a 100 mm thick concrete mud slab over the subgrade as a means of reducing horizontal groundwater infiltration from the base of the excavation.

Foundation Backfill

Where space is available for conventional wall construction, backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for this purpose.

Adverse Effects from Dewatering on Adjacent Structures

Assuming that the foundation drainage and waterproofing design is carried out as noted above, only minor water infiltration is expected over the long term from the base of the foundation. Based on the review of the general founding conditions existing structures surrounding the subject site and based on the proposed foundation waterproofing program being suggested above, no adverse effects from temporary and long term dewatering are expected for the subject site.

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, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, 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 Temporary Shoring

Temporary shoring will be required for the subject site due to the proximity of the excavation along the property boundaries. 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.

Shoring in the vicinity of the neighbouring building to the east is required to prevent water infiltration in both the short and long term. Therefore, it is recommended to use an interlocking sheet piling for this portion of the excavation. The sheet piling system should be provided along the east boundary of the excavation and extend for 10 m at right angles along the south and north boundaries on each side. Earth pressures acting on the shoring system may be calculated for a temporary wall using the parameters given below.

The remainder of the excavation may consist of socketed soldier pile and lagging, or interlocking steel sheet piling. 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 anchored or braced, if required. Earth pressures acting on the shoring system may be calculated using the parameters provided in Table 6.

Table 6 - Soil Parameters for Calculating Earth Pressures Acting on Shoring System

Parameter	Value
Active Earth Pressure Coefficient (K_a)	0.3
Passive Earth Pressure Coefficient (K_p)	3.3
At-Rest Earth Pressure Coefficient (K_o)	0.5
Unit Weight (γ), kN/m^3	17.2
Submerged Unit Weight(γ'), kN/m^3	13

The total unit weight should be used above the waterproofing level while the submerged or effective unit weight should be used below the waterproofing level. The hydrostatic groundwater pressure should be added to the earth pressure distribution below the waterproofing level. Conventional braced excavation pressure envelopes can also be used by the shoring designer, as applicable.

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

The design of the tie-back rock anchors can be based on an allowable grout to rock bond stress of 700 kPa at this site. It is recommended that the upper 2 m of the bedrock be disregarded. A minimum grout strength of 30 MPa is recommended. A minimum factor of safety of 1.5 should be used.

6.4 Pipe Bedding and Backfill

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. The material should be placed in a maximum lift thickness of 300 mm and compacted to a minimum of 95% of the SPMDD. The bedding material should extend at least to the spring line of the pipe.

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

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.

Due to the relatively impervious nature of the silty clay materials at the anticipated founding level of the 3 to 4 levels of underground parking, it is anticipated that groundwater infiltration into the excavations should be low to moderate and controllable using open sumps within the silty clay. However, it is expected that the groundwater inflow will be controllable using open sumps and pumps.

A temporary Ontario Ministry of Environment, Conservation and Parks (MECP) permit to take water (PTTW Category 3) will be required for this project since more than 400,000 L/day is expected to be pumped during the construction phase. At least 4 to 5 months should be allowed for completion of the application and issuance of the permit by the MECP.

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.

Precaution 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.

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. The base of the excavations should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

Trench excavations and pavement construction are difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be taken if such activities are to be completed during freezing conditions.

6.7 Corrosion Potential and Sulphate

The analytical testing results are presented in Table 7 along with industry standards for the applicable threshold values. These results are indicative that Type 10 Portland cement (Type GU, or normal cement) would be appropriate for this site.

Table 7 - Corrosion Potential

Parameter	Laboratory Results	Threshold	Commentary
	BH 2-13 4.6 to 4.9 m		
Chloride	82 µg/g	Chloride content less than 400 mg/g	Negligible concern
pH	8.12	pH value less than 5.0	Neutral Soil
Resistivity	28.7 ohm.m	Resistivity greater than 1,500 ohm.cm	Moderate Corrosion Potential
Sulphate	302 µg/g	Sulphate value greater than 1 mg/g	Negligible Concern

7.0 Recommendations

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

☐ Inspection of the piling installation.

☐ 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.

☐ Density tests to determine the level of compaction achieved.

A report confirming that the above items have been conducted in general accordance with our recommendations could be issued upon the completion of a satisfactory material testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

The client should be aware that any information pertaining to soils and all borehole logs are furnished as a matter of general information only and borehole descriptions or logs are not to be interpreted as descriptive of conditions at locations other than those of the test holes.

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 that we be notified immediately in order 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 Trinity Development Group and their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

David J. Gilbert, P.Eng.

LICENSED PROFESSIONAL ENGINEER
C. P. DA SILVA
PROVINCE OF ONTARIO

Carlos P. Da Silva, P.Eng., ing., QP_{ESA}

Report Distribution

☐ Trinity Development Group (3 copies)
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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL RESULTS

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

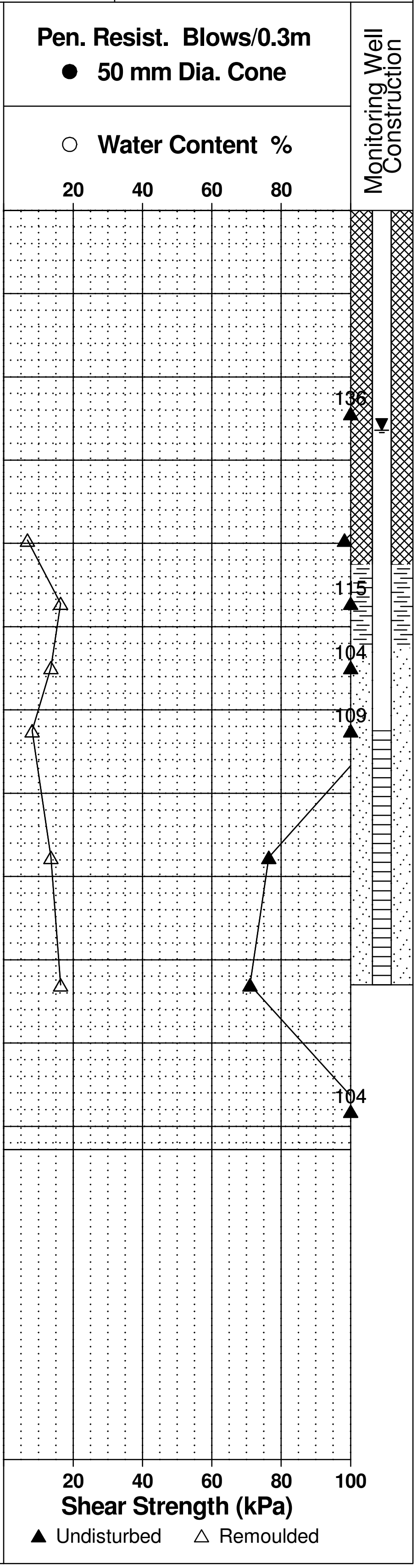
DATE August 14, 2012

FILE NO. PG2757

HOLE NO. BH 1

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.10	AU	1		
FILL: Crushed stone	0.30				
FILL: Brown sand, trace gravel	1.01	SS	2	58	10
Very stiff to stiff, brown **SILTY CLAY** - grey by 3.3m depth - trace sand by 9.8m depth	11.28	SS	3	100	5
		SS	4	100	4
		SS	5	100	3
		SS	6	83	1
		SS	7	100	2
		SS	8	100	P
		SS	9	100	P
		SS	10	100	P
		SS	11	100	P
		SS	12	100	P
End of Borehole (GWL @ 2.64m-April 2, 2013)					

DEPTH (m)	ELEV. (m)
0	67.97
1	66.97
2	65.97
3	64.97
4	63.97
5	62.97
6	61.97
7	60.97
8	59.97
9	58.97
10	57.97
11	56.97



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

FILE NO. PG2933

HOLE NO. BH 2-15

BORINGS BY CME 55 Power Auger **DATE** February 26, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	63.58		
Asphaltic concrete 0.10									
FILL: Crushed stone 0.41									
FILL: Brown silty sand, trace gravel 1.52		SS	1	33		1	62.58		
Compact, brown **SILTY SAND,** trace gravel		SS	2	42		2	61.58		
		SS	3	58		3	60.58		
		SS	4	50	12	4	59.58		
4.70		SS	5	33	15				
Stiff, brown to grey **SILTY CLAY**		SS	6	58	2	5	58.58		
		SS	7	92	3	6	57.58		
		SS	8	100	2	7	56.58		▽
7.62		SS	9	100	1				
End of Borehole (GWL @ 7.0m depth based on field observations)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 26, 2015

FILE NO. PG2933

HOLE NO. BH 3-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE					0	63.66	
Asphaltic concrete 0.08							
FILL: Crushed stone with sand 0.51							
FILL: Brown silty sand with gravel	SS	1	42	24	1	62.66	
2.13	SS	2	33	11	2	61.66	
Compact, brown **SILTY SAND**	SS	3	42	12	3	60.66	
3.96	SS	4	42	16			
Stiff, brown to grey **SILTY CLAY**	SS	5	83		4	59.66	
	SS	6	50	2	5	58.66	
	SS	7	100	3	6	57.66	
	SS	8	100	2	7	56.66	
7.62	SS	9	50	2			∇
End of Borehole (GWL @ 7.2m depth based on field observations)							

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

○ Water Content %
20 40 60 80

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 13, 2015

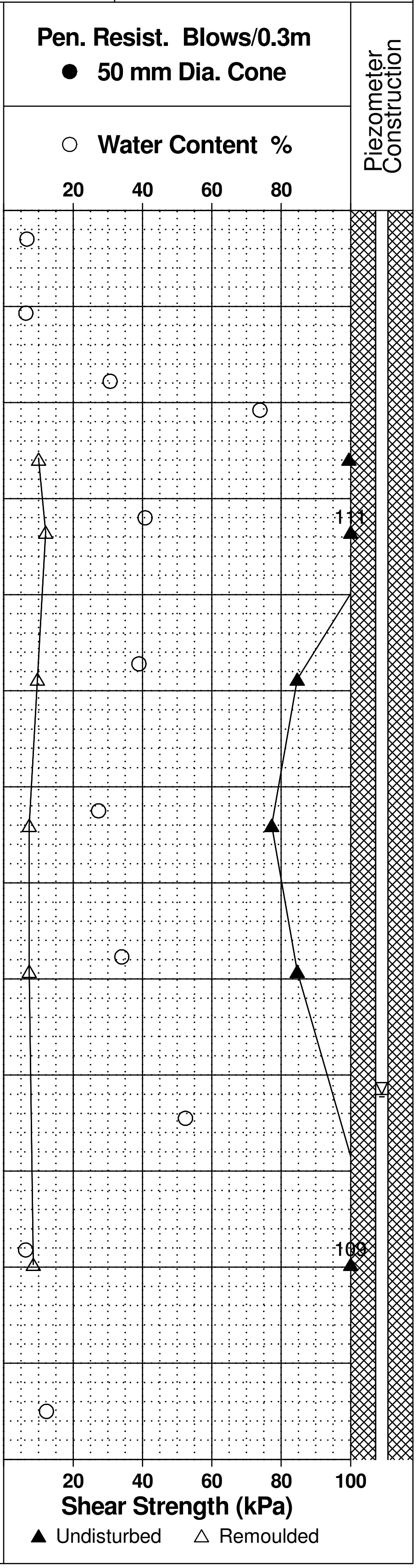
FILE NO. PG2933

HOLE NO. BH 4-15

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
FILL: Brown silty sand with crushed stone, trace cobbles	0.38
Loose, brown **SILTY SAND,** trace gravel	2.03
Stiff, brown to grey **SILTY CLAY** - very stiff by 10.7m depth	11.43
GLACIAL TILL: Compact to very dense, grey silty sand with gravel, cobbles and boulders	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	62	6
SS	3	62	5
SS	4	100	W
SS	5	29	20

DEPTH (m)	ELEV. (m)
0	65.48
1	64.48
2	63.48
3	62.48
4	61.48
5	60.48
6	59.48
7	58.48
8	57.48
9	56.48
10	55.48
11	54.48
12	53.48
13	52.48



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE October 13, 2015

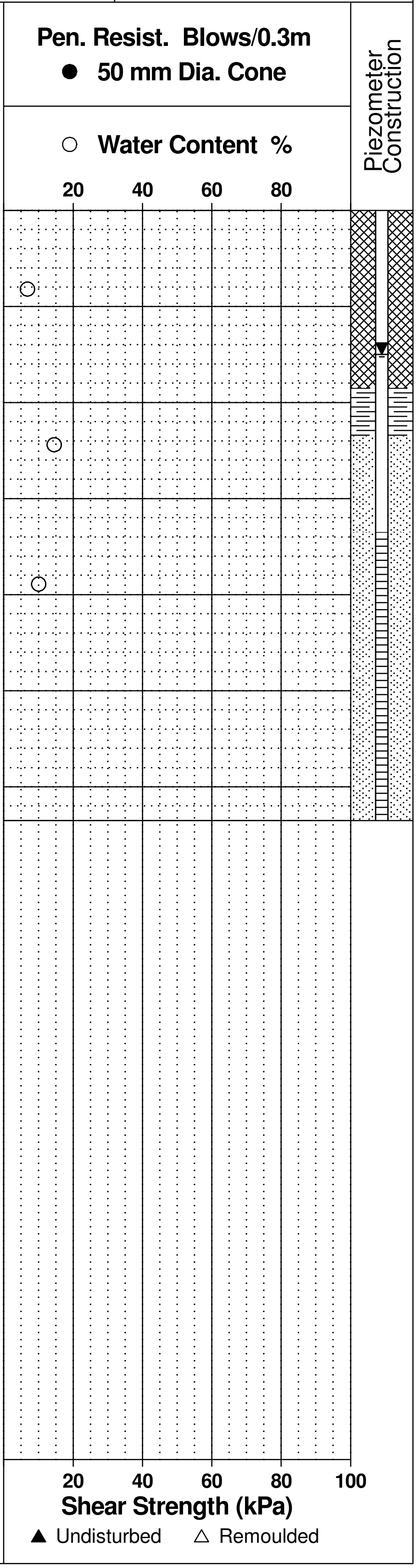
FILE NO. PG2933

HOLE NO. BH 4-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					13	52.48
	SS	6	100	50+		
					14	51.48
GLACIAL TILL: Compact to very dense, grey silty sand with gravel, cobbles and boulders						
					15	50.48
	SS	7	100	50+		
					16	49.48
	SS	8	100	50+		
					17	48.48
17.53						
	RC	1	100	63		
BEDROCK: Interbedded limestone and shale					18	47.48
	RC	2	100	85		
					19	46.48
19.35						
End of Borehole						

(GWL @ 9.5m depth based on field observations)

(GWL @ 14.50m-Nov. 4, 2015)



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SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

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REMARKS

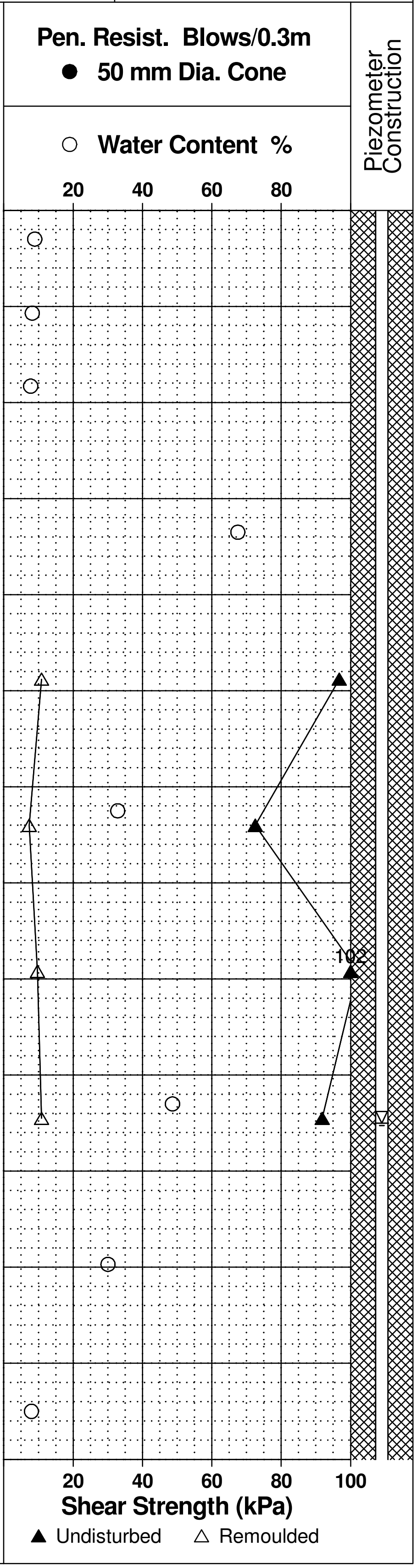
BORINGS BY CME 55 Power Auger

DATE October 22, 2015

FILE NO. PG2933

HOLE NO. BH 5-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	65.31
FILL: Brown silty sand, some crushed stone, trace asphalt	AU	1				
	SS	2	67	10	1	64.31
1.32						
Compact, brown **SILTY SAND**	SS	3	50	19		
					2	63.31
2.44						
					3	62.31
	SS	4	100	3		
					4	61.31
					5	60.31
Stiff to very stiff, brown to grey **SILTY CLAY**					6	59.31
					7	58.31
					8	57.31
					9	56.31
					10	55.31
10.82						
Grey **CLAYEY SILT,** trace sand	SS	5	100	4	11	54.31
11.89						
					12	53.31
GLACIAL TILL: Dense, grey to brown silty sand with gravel, cobbles, boulders	SS	6	42	50		
					13	52.31



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE October 22, 2015

FILE NO. PG2933

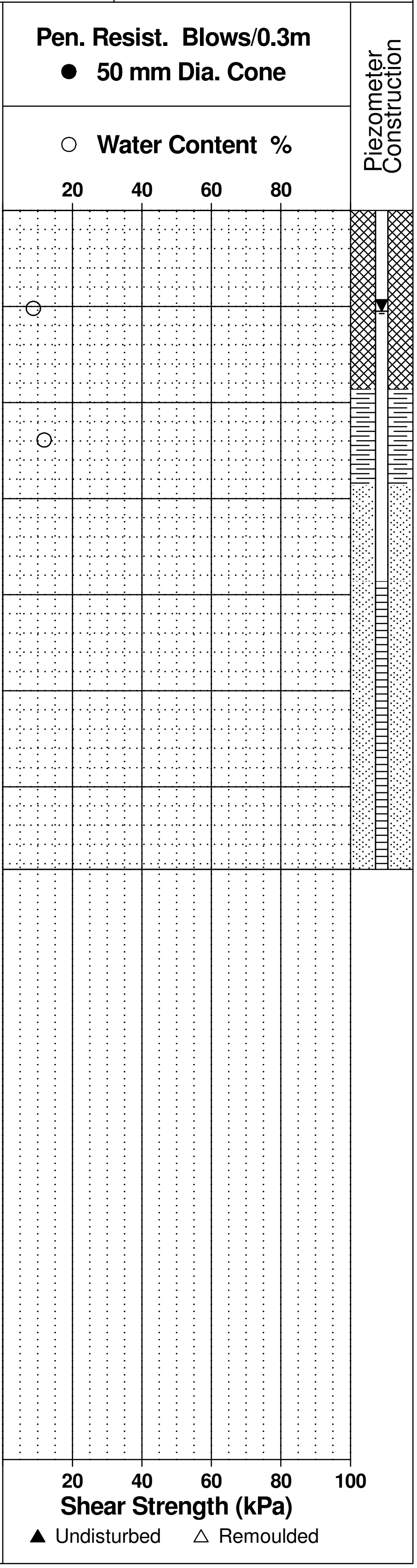
HOLE NO. BH 5-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					13	52.31
	SS	7	54	43	14	51.31
GLACIAL TILL: Dense, grey to brown silty sand with gravel, cobbles, boulders					15	50.31
	SS	8	83	50+		
					16	49.31
	RC	1	100			
					17	48.31
18.00					18	47.31
BEDROCK: Interbedded limestone and shale	RC	2	100	100		
					19	46.31
	RC	3	98	98		
19.86						

End of Borehole

(GWL @ 9.5m depth based on field observations)

(GWL @ 14.05m-Nov. 4, 2015)



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SOIL PROFILE AND TEST DATA

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REMARKS

BORINGS BY CME 55 Power Auger

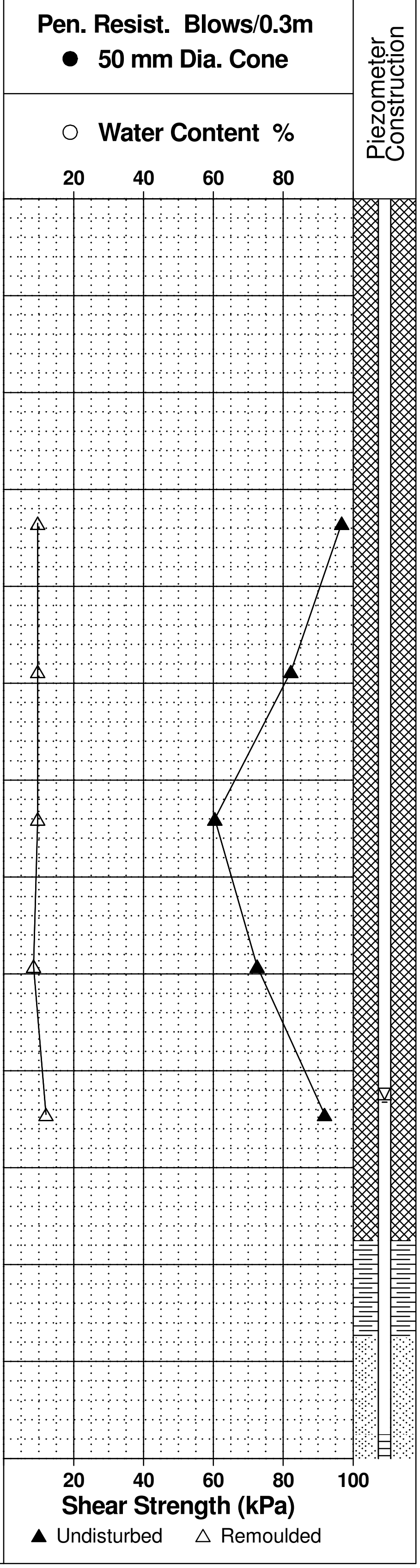
DATE October 23, 2015

FILE NO. PG2933

HOLE NO. BH 6-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL; Brown silty sand with gravel, trace cobbles	AU	1		
	SS	2	46	50+
2.00	SS	3	58	36
Compact, brown **SILTY SAND** 2.44				
Stiff, brown to grey **SILTY CLAY** 10.06				
Grey **CLAYEY SILT,** trace sand 11.73	SS	4	100	2
GLACIAL TILL: Dense to very dense, grey silty sand with gravel, cobbles and boulders	SS	5	67	37

DEPTH (m)	ELEV. (m)
0	65.24
1	64.24
2	63.24
3	62.24
4	61.24
5	60.24
6	59.24
7	58.24
8	57.24
9	56.24
10	55.24
11	54.24
12	53.24
13	52.24



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE October 23, 2015

FILE NO. PG2933

HOLE NO. BH 6-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						13	52.24		
GLACIAL TILL: Dense to very dense, grey silty sand with gravel, cobbles and boulders		SS	6	54	54	14	51.24		
						15	50.24		
		SS	7	100	50+				
15.75									
End of Borehole Practical refusal to augering at 15.75m depth (GWL @ 9.3m depth based on field observations) (Piezometer blocked at 4.07m depth - Nov. 4, 2015)									

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM / **REMARKS** TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG2933**

HOLE NO. **BH 7-15**

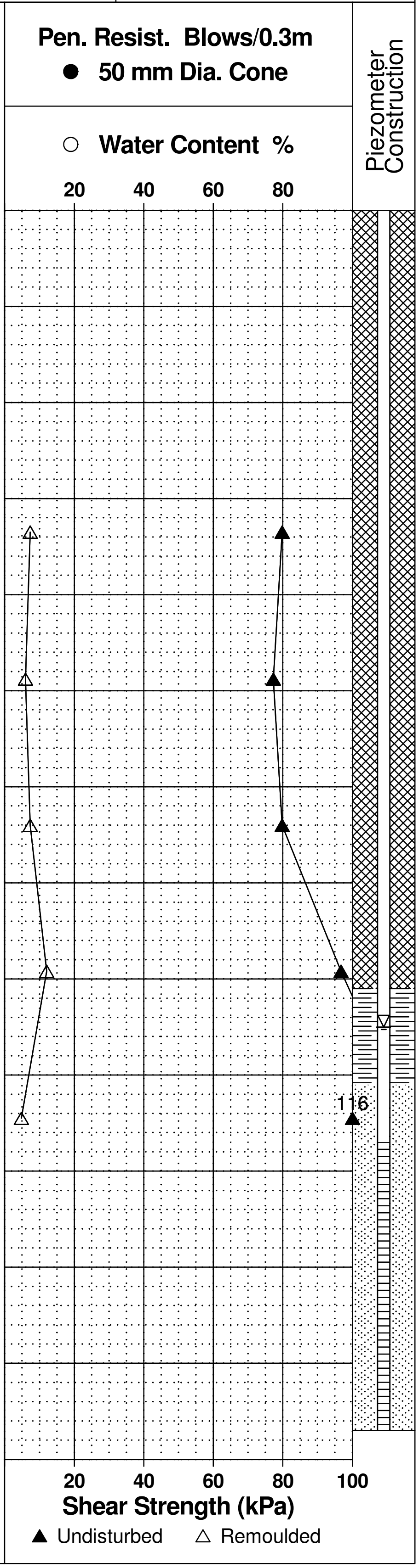
BORINGS BY CME 55 Power Auger

DATE October 26, 2015

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
Asphaltic concrete	0.10
FILL: Crushed stone	0.36
FILL: Brown silty sand, some gravel and organics	2.21
Stiff, brown to grey **SILTY CLAY**	9.14
Very stiff, grey **CLAYEY SILT to SILTY CLAY,** trace sand	11.73
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	67	11
SS	3	83	3
SS	4	100	2
SS	5	100	2
SS	6	75	42

DEPTH (m)	ELEV. (m)
0	64.24
1	63.24
2	62.24
3	61.24
4	60.24
5	59.24
6	58.24
7	57.24
8	56.24
9	55.24
10	54.24
11	53.24
12	52.24
13	51.24



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 26, 2015

FILE NO. PG2933

HOLE NO. BH 7-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						13	51.24		
		SS	7	50	50+				
						14	50.24		
GLACIAL TILL: Dense to very dense, brown silty sand with gravel, cobbles and boulders									
						15	49.24		
		SS	8	100	50+				
						16	48.24		
16.64									
End of Borehole Practical refusal to augering at 16.64m depth (GWL @ 8.5m depth based on field observations) (BH dry - Nov. 4, 2015)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

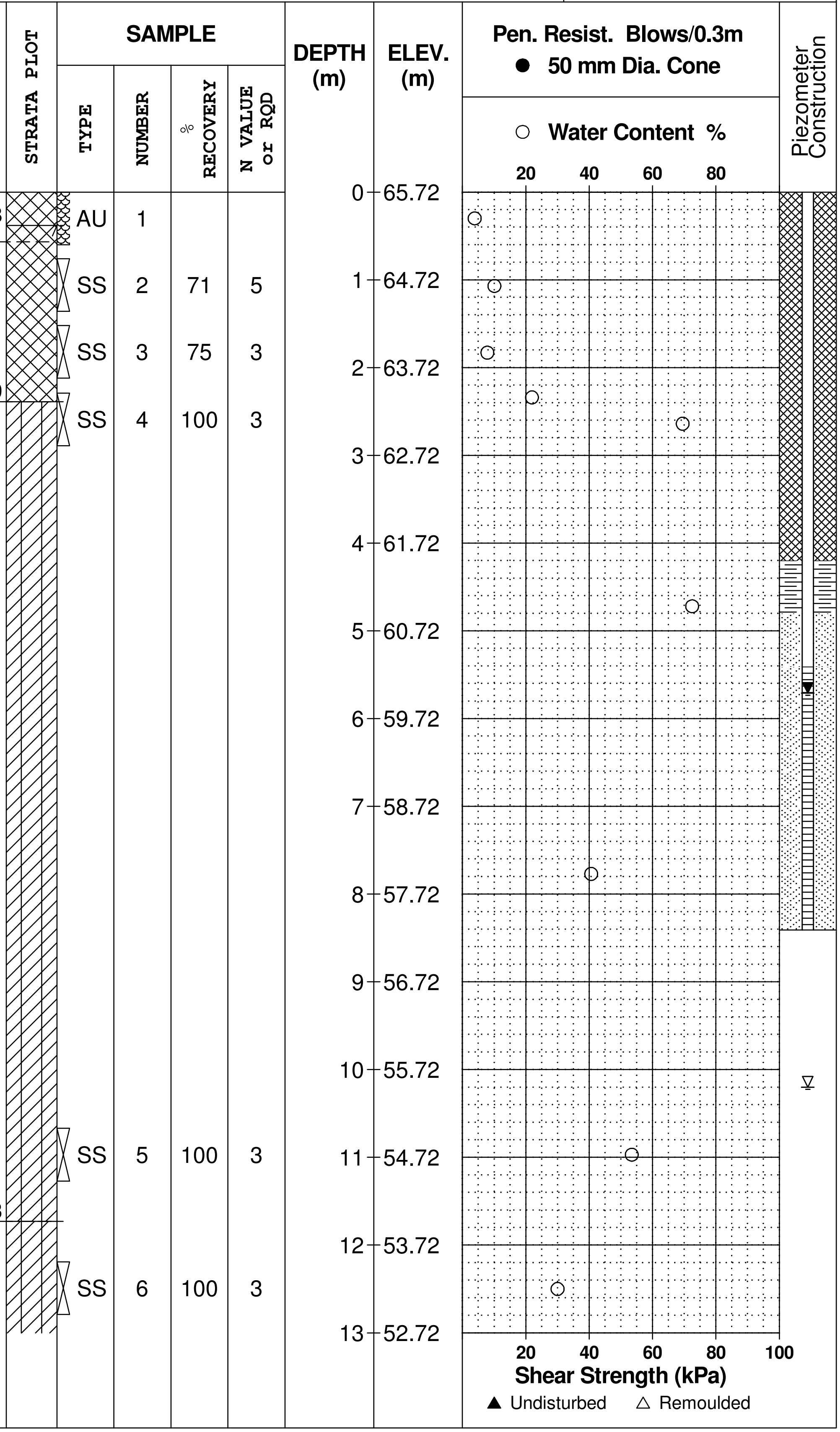
DATE October 27, 2015

FILE NO. PG2933

HOLE NO. BH 8-15

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Brown silty sand with crushed stone — 0.38	AU	1		
FILL: Brown silty sand, trace coal and organics	SS	2	71	5
	SS	3	75	3
— 2.39				
Stiff, brown to grey **SILTY CLAY**	SS	4	100	3
	SS	5	100	3
— 11.73				
Grey **CLAYEY SILT,** some sand	SS	6	100	3

DEPTH (m)	ELEV. (m)
0	65.72
1	64.72
2	63.72
3	62.72
4	61.72
5	60.72
6	59.72
7	58.72
8	57.72
9	56.72
10	55.72
11	54.72
12	53.72
13	52.72



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 27, 2015

FILE NO. PG2933

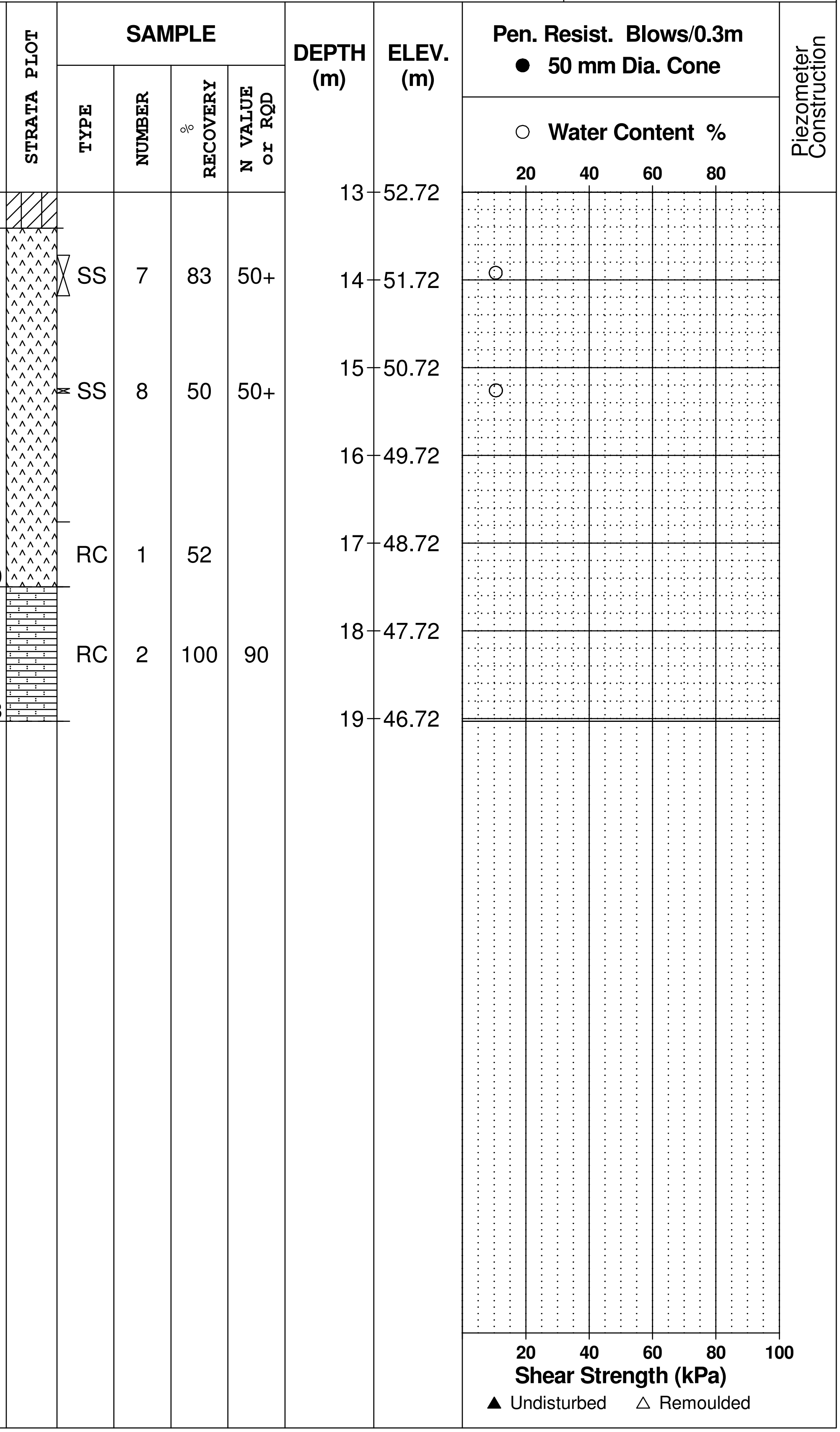
HOLE NO. BH 8-15

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
Grey **CLAYEY SILT,** some sand	13.41					13	52.72
GLACIAL TILL: Very dense, dark grey silty sand with gravel, cobbles and boulders		SS	7	83	50+	14	51.72
		SS	8	50	50+	15	50.72
						16	49.72
	17.50	RC	1	52		17	48.72
BEDROCK: Interbedded limestone and shale		RC	2	100	90	18	47.72
	19.03					19	46.72
End of Borehole							

End of Borehole

(GWL @ 10.2m depth based on field observations)

(GWL @ 5.71m-Nov. 4, 2015)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan
REMARKS provided by Annis, O'Sullivan, Vollebekk Ltd.

BORINGS BY CME 55 Power Auger

DATE October 26, 2015

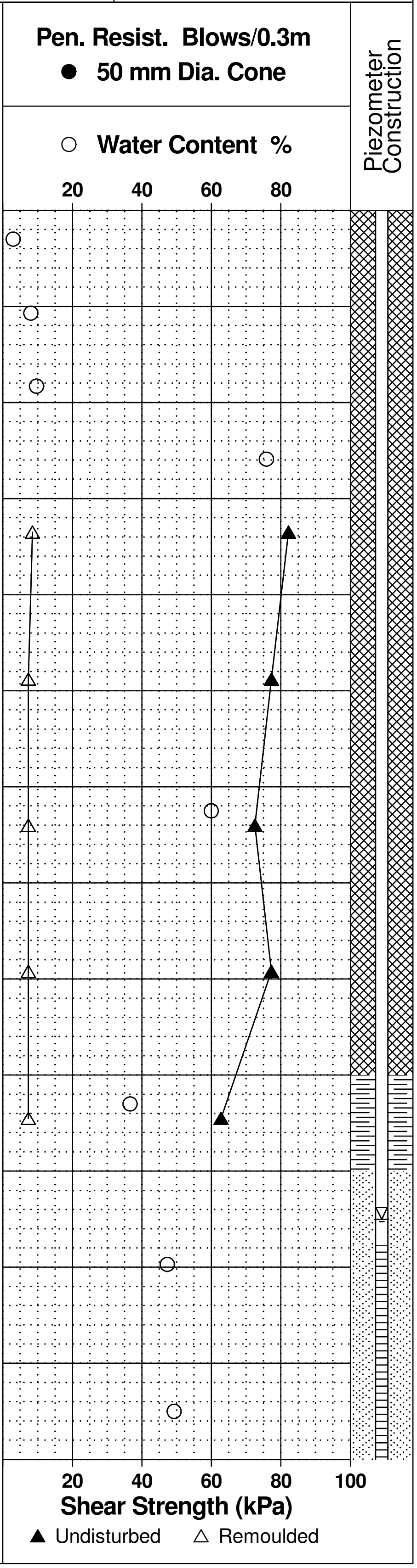
FILE NO. PG2933

HOLE NO. BH 9-15

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
Asphaltic concrete	0.05
FILL: Crushed stone	0.25
Compact, brown **SILTY SAND**	2.21
Stiff, brown to grey **SILTY CLAY**	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	46	16
SS	3	58	30
SS	4	100	2
SS	5	100	2
SS	6	100	2

DEPTH (m)	ELEV. (m)
0	67.16
1	66.16
2	65.16
3	64.16
4	63.16
5	62.16
6	61.16
7	60.16
8	59.16
9	58.16
10	57.16
11	56.16
12	55.16
13	54.16



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 26, 2015

FILE NO. PG2933

HOLE NO. BH 9-15

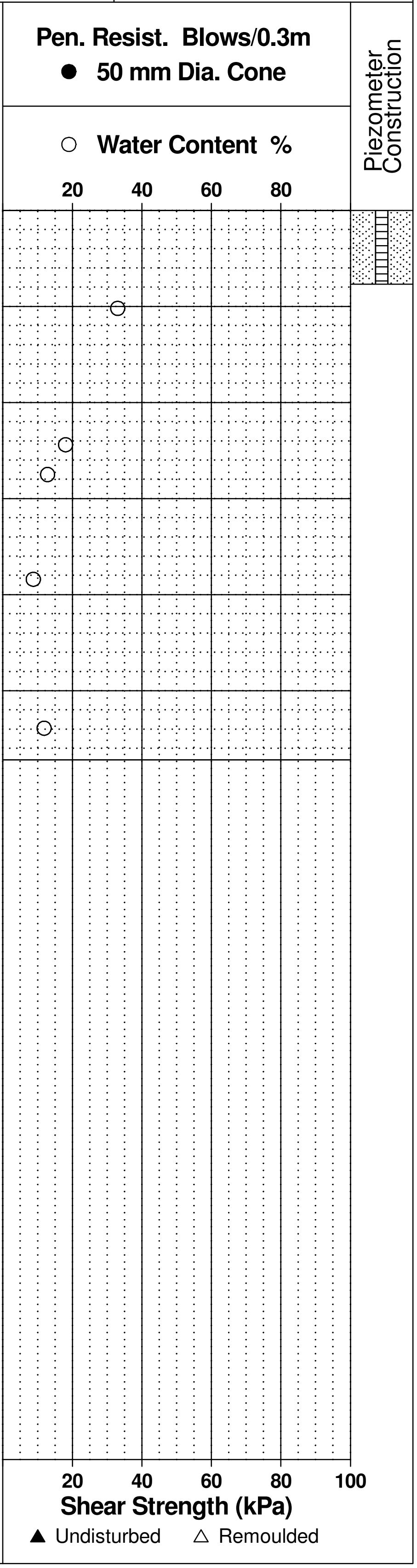
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						13	54.16
Stiff, grey **SILTY CLAY**							
		SS	7	100	2	14	53.16
14.48							
Grey **CLAYEY SILT,** some sand						15	52.16
15.65		SS	8	100	4		
						16	51.16
GLACIAL TILL: Dark grey silty sand with gravel, cobbles and boulders		SS	9	100	50+	17	50.16
						18	49.16
18.72		SS	10	100	50+		

End of Borehole

Practical refusal to augering at 18.72m depth

(GWL @ 10.5m depth based on field observations)

(BH dry - Nov. 4, 2015)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

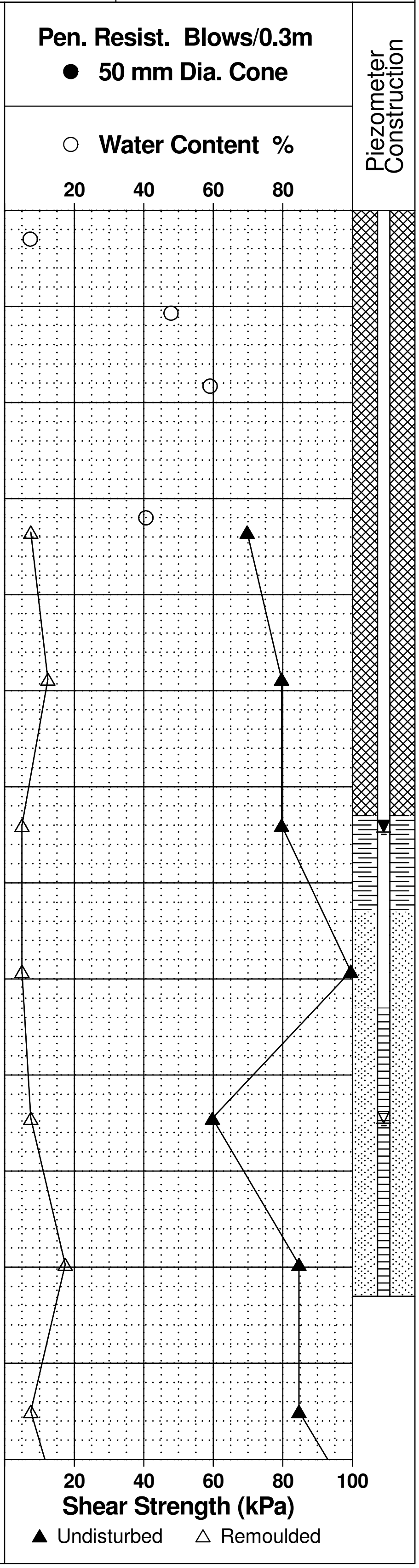
BORINGS BY CME 55 Power Auger

DATE October 16, 2015

FILE NO. **PG2933**

HOLE NO. **BH10-15**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE							
Asphaltic concrete 0.05						0	67.73
FILL: Crushed stone 0.25		AU	1				
Loose, brown **SILTY SAND**		SS	2	75	6	1	66.73
1.98		SS	3	100	4	2	65.73
Stiff, brown to grey **SILTY CLAY**		SS	4	100	1		
						3	64.73
						4	63.73
						5	62.73
						6	61.73
						7	60.73
						8	59.73
						9	58.73
						10	57.73
						11	56.73
						12	55.73
						13	54.73



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

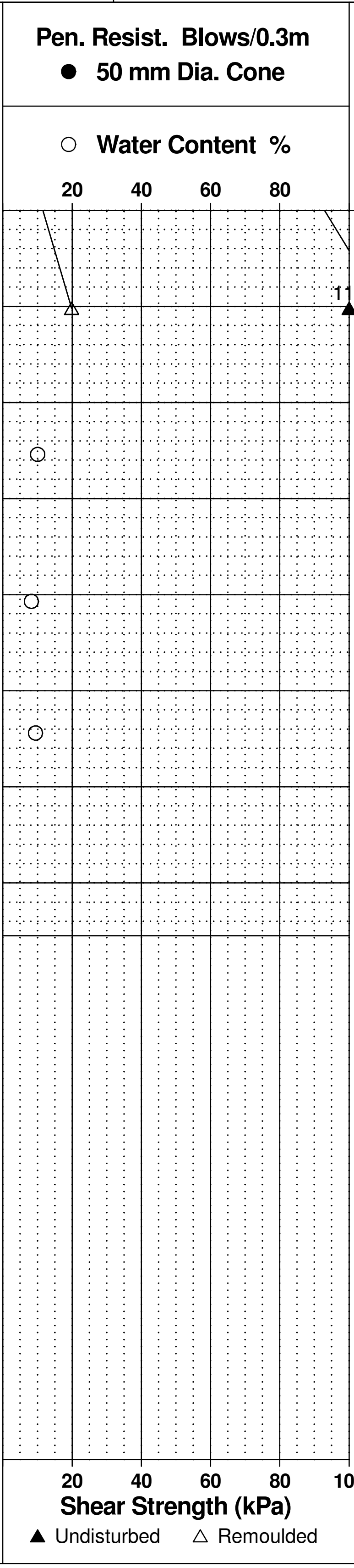
BORINGS BY CME 55 Power Auger

DATE October 16, 2015

FILE NO. PG2933

HOLE NO. BH10-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						13	54.73
Stiff to very stiff, grey **SILTY CLAY**						14	53.73
15.24						15	52.73
		SS	5	29	26		
						16	51.73
GLACIAL TILL: Compact to very dense, grey silty sand with gravel, cobbles and boulders		SS	6	62	93	17	50.73
						18	49.73
		SS	7	83	50+		
18.95						19	48.73
BEDROCK: Interbedded limestone and shale		RC	1	100	76	20	47.73
20.55							
End of Borehole (GWL @ 9.5m depth based on field observations) (GWL @ 6.47m-Nov. 4, 2015)							



Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

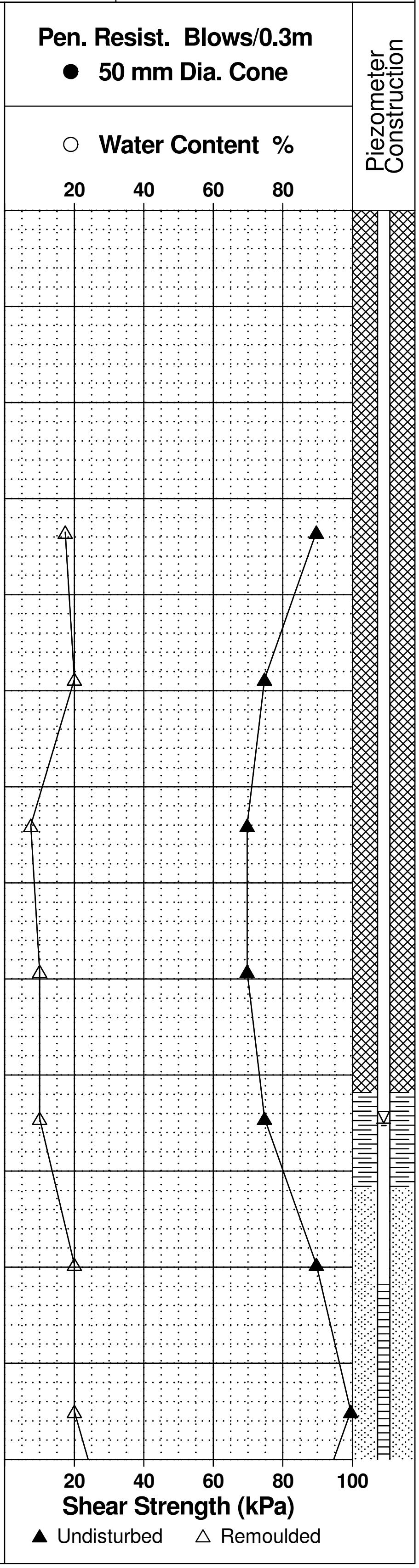
BORINGS BY CME 55 Power Auger

DATE October 15, 2015

FILE NO. **PG2933**

HOLE NO. **BH11-15**

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	67.29
Asphaltic concrete	0.13	AU	1				
FILL: Crushed stone	0.25						
Compact, brown **SILTY SAND**	1.42	SS	2	29	21	1	66.29
Stiff, brown to grey **SILTY CLAY**		SS	3	100	2	2	65.29
		SS	4	100	1	3	64.29
						4	63.29
						5	62.29
						6	61.29
						7	60.29
						8	59.29
						9	58.29
						10	57.29
						11	56.29
						12	55.29
						13	54.29



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 15, 2015

FILE NO. PG2933

HOLE NO. BH11-15

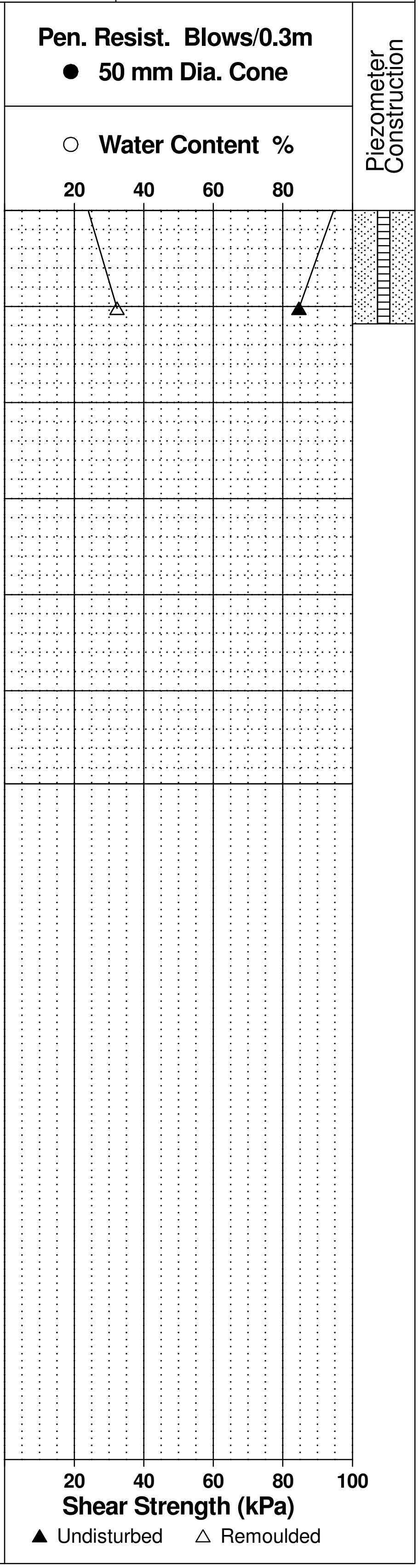
SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						
13.11					13	54.29
Stiff, grey **CLAYEY SILT**					14	53.29
14.63						
					15	52.29
GLACIAL TILL: Dense to very dense, grey silty sand with gravel, cobbles and boulders	SS	5	58	36		
					16	51.29
	SS	6	100	50+		
					17	50.29
					18	49.29
	SS	7	100	50+		
18.97						

End of Borehole

Practical refusal to augering at 18.97m depth

(GWL @ 9.5m depth based on field observations)

(BH dry - Nov. 4, 2015)



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

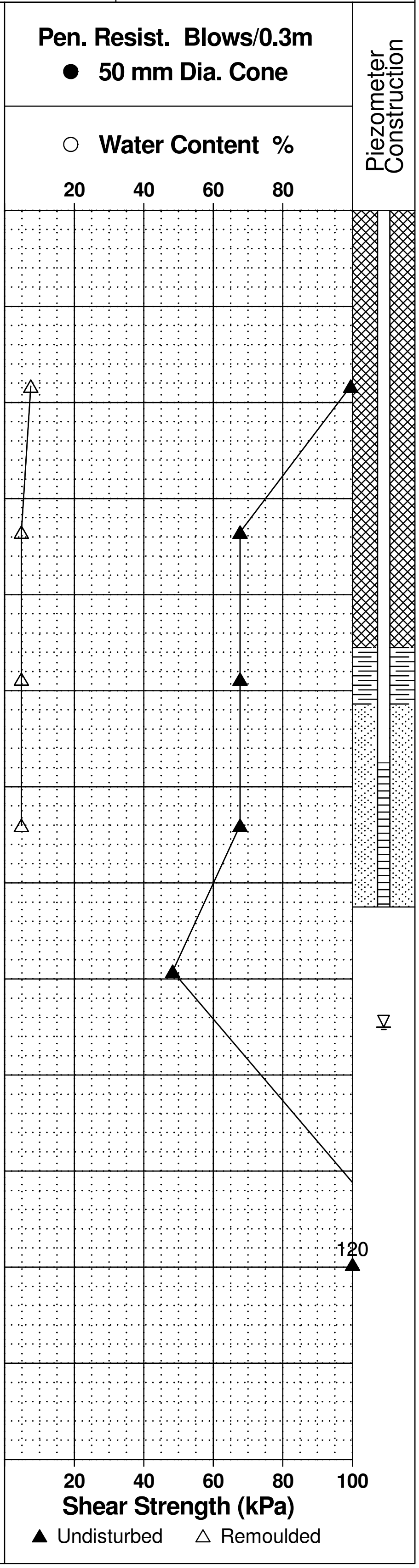
DATE October 16, 2015

FILE NO. PG2933

HOLE NO. BH12-15

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Brown silty sand, some gravel, concrete, boulders, asphalt and glass — 0.15	AU	1		
Compact, brown **SILTY SAND** — 1.30	SS	2	83	15
Stiff, brown to grey **SILTY CLAY** — 10.52	SS	3	100	W
Grey **CLAYEY SILT** with sand — 12.95	SS	4	100	2

DEPTH (m)	ELEV. (m)
0	66.04
1	65.04
2	64.04
3	63.04
4	62.04
5	61.04
6	60.04
7	59.04
8	58.04
9	57.04
10	56.04
11	55.04
12	54.04
13	53.04



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM
REMARKS TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG2933

HOLE NO. BH12-15

BORINGS BY CME 55 Power Auger

DATE October 16, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						13	53.04
		SS	5	0	5		
						14	52.04
		SS	6	67	50+		
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles and boulders						15	51.04
		SS	7	60	50+		
						16	50.04
						17	49.04
17.86		SS	8		50+		

End of Borehole

Practical refusal to augering at 17.86m depth

(GWL @ 8.5m depth based on field observations)

(BH dry - Nov. 4, 2015)

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

○ **Water Content %**

20 40 60 80

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

Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

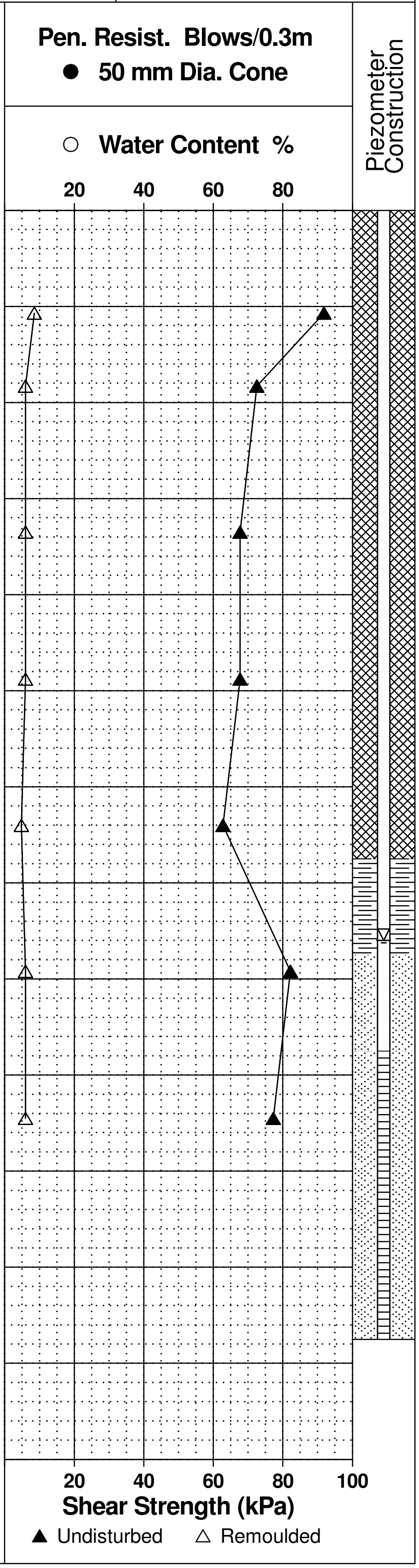
DATE October 15, 2015

FILE NO. PG2933

HOLE NO. BH13-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
FILL: Brown silty sand with crushed stone, concrete, brick and asphalt 0.25		AU	1		
Stiff, brown to grey **SILTY CLAY** 10.06					
Grey **CLAYEY SILT,** trace sand 11.73					
Very dense, grey **SILTY SAND** with gravel		SS	2	100	50+

DEPTH (m)	ELEV. (m)
0	64.20
1	63.20
2	62.20
3	61.20
4	60.20
5	59.20
6	58.20
7	57.20
8	56.20
9	55.20
10	54.20
11	53.20
12	52.20
13	51.20



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 15, 2015

FILE NO. PG2933

HOLE NO. BH13-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						13	51.20		
Very dense, grey **SILTY SAND** with gravel		SS	3	80	50+	14	50.20		
14.78									
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles and boulders		SS	4	83	50+	15	49.20		
15.65									
End of Borehole Practical refusal to augering at 15.65m depth (GWL @ 7.6m depth based on field observations) (BH dry - Nov. 4, 2015)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan

REMARKS provided by Annis, O'Sullivan, Vollebekk Ltd.

BORINGS BY CME 55 Power Auger

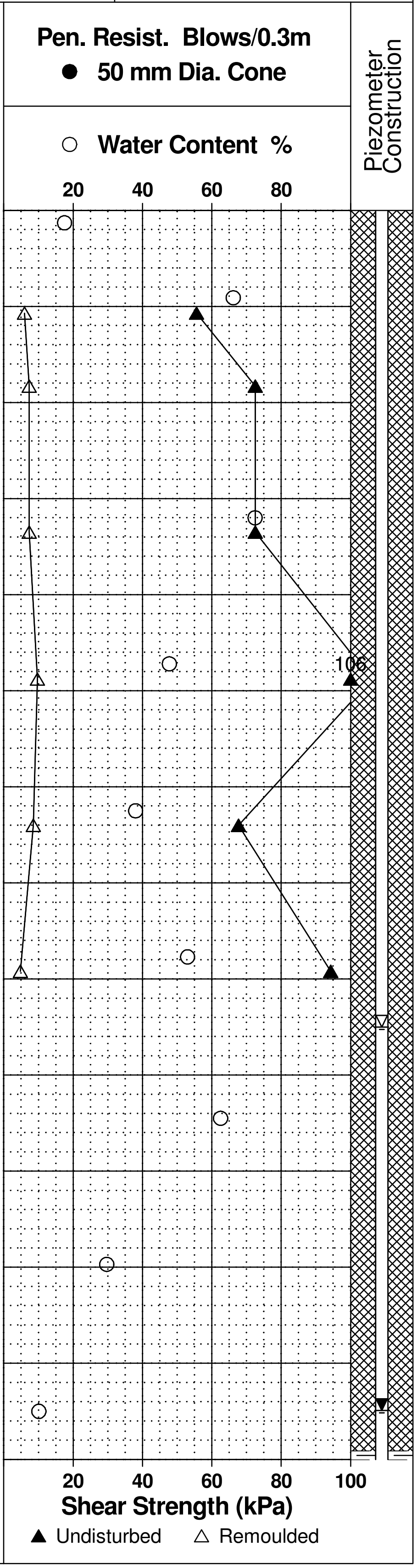
DATE October 14, 2015

FILE NO. PG2933

HOLE NO. BH14-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
FILL: Brown silty sand wtih gravel, cobbles, crushed stone, brick, asphalt, coal 0.25		AU	1		
Stiff, brown to grey **SILTY CLAY**		SS	2	100	2
10.19					
Very loose, grey **SANDY SILT,** some clay		SS	3	29	3
11.79					
Very dense, grey **SILTY SAND** with gravel		SS	4	70	79

DEPTH (m)	ELEV. (m)
0	64.39
1	63.39
2	62.39
3	61.39
4	60.39
5	59.39
6	58.39
7	57.39
8	56.39
9	55.39
10	54.39
11	53.39
12	52.39
13	51.39



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

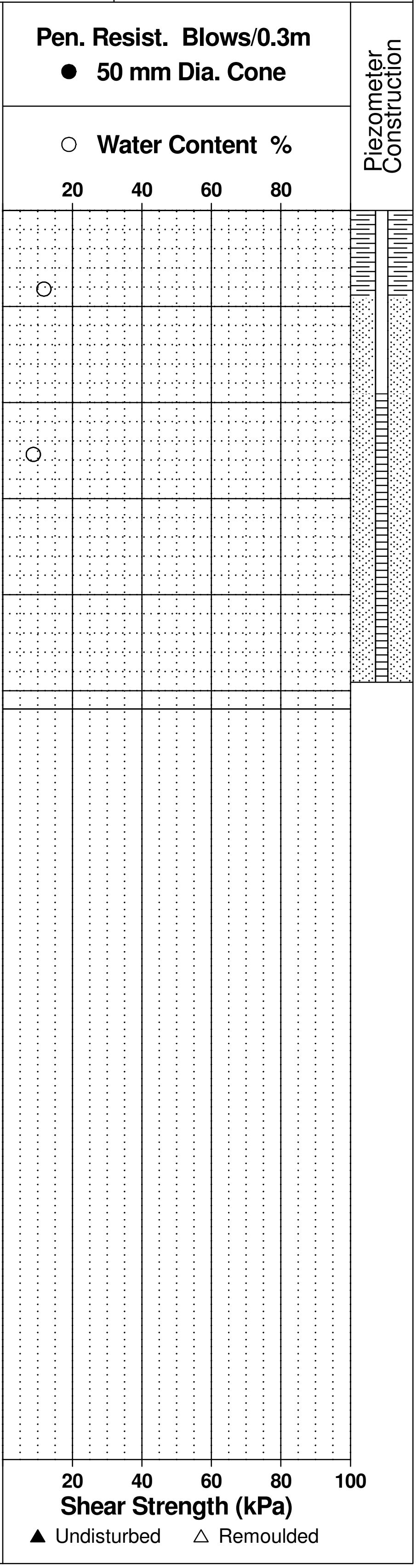
BORINGS BY CME 55 Power Auger

DATE October 14, 2015

FILE NO. PG2933

HOLE NO. BH14-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					13	51.39
Very dense, grey **SILTY SAND** with gravel - some running sand encountered from 13.7 to 16.4m depth	SS	5	100	50+	14	50.39
	SS	6	56	50+	15	49.39
16.36					16	48.39
BEDROCK: Interbedded limestone and shale	SS	7	100	50+	17	47.39
	RC	1	97	33		
18.19					18	46.39
End of Borehole (GWL @ 8.5m depth based on field observations) (GWL @ 12.49m-Nov. 4, 2015)						



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

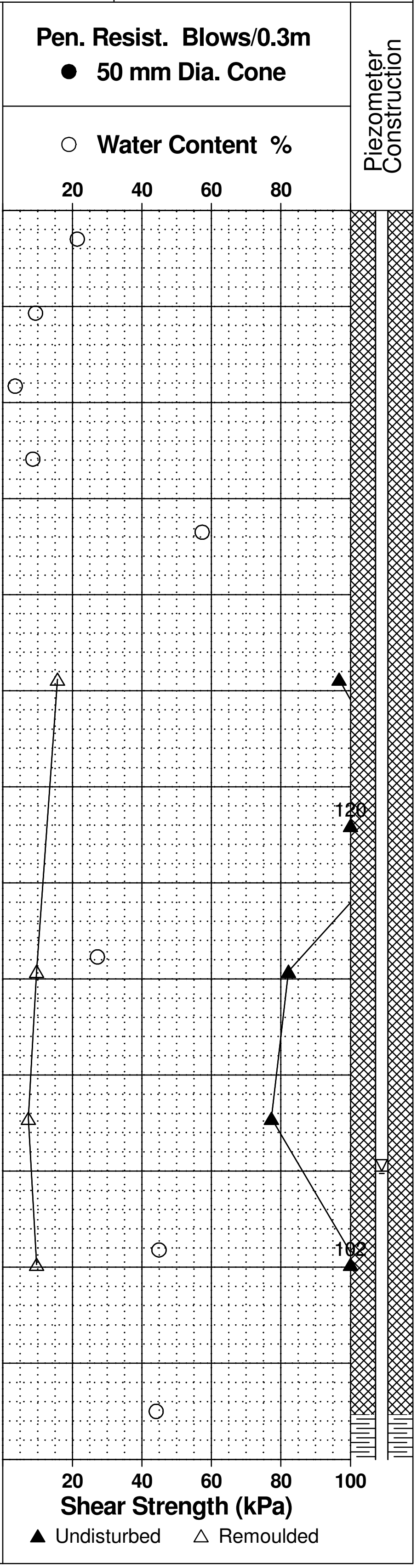
DATE October 19, 2015

FILE NO. PG2933

HOLE NO. BH15-15

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.18	AU	1		
FILL: Brown silty sand, trace organics and brick		SS	2	25	7
	2.03	SS	3	42	8
Compact to very loose, brown **SILTY SAND,** trace organics		SS	4	62	12
	3.40	SS	5	67	2
Stiff to very stiff, brown to grey **SILTY CLAY,** trace sand	11.43				
Grey **CLAYEY SILT,** some sand		SS	6	100	W

DEPTH (m)	ELEV. (m)
0	66.13
1	65.13
2	64.13
3	63.13
4	62.13
5	61.13
6	60.13
7	59.13
8	58.13
9	57.13
10	56.13
11	55.13
12	54.13
13	53.13



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 19, 2015

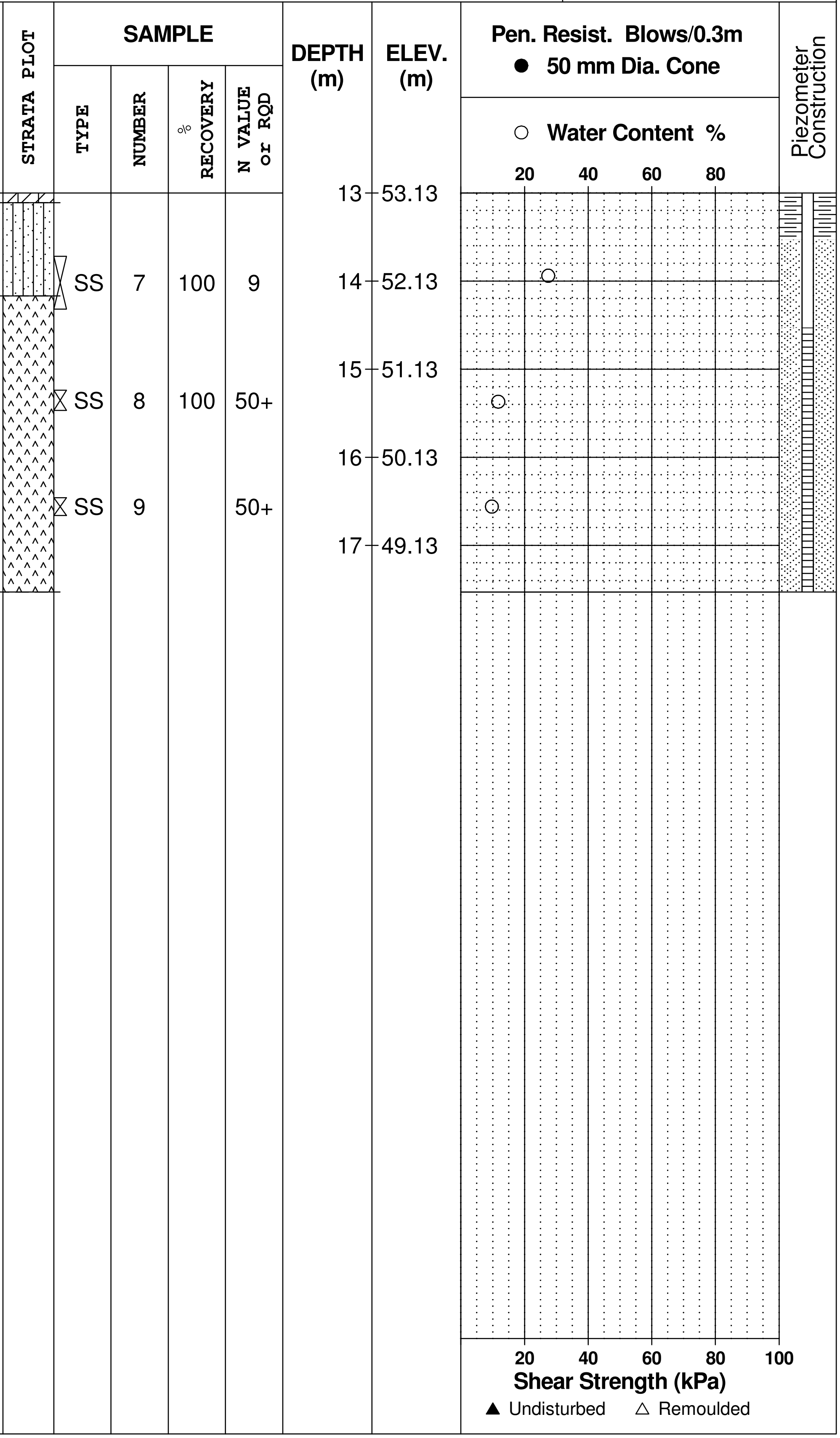
FILE NO. PG2933

HOLE NO. BH15-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					13	53.13
13.11 Loose, grey **SANDY SILT,** trace gravel 14.17	SS	7	100	9	14	52.13
					15	51.13
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles, boulders	SS	8	100	50+		
					16	50.13
	SS	9		50+		
					17	49.13
17.53 End of Borehole						

(GWL @ 10.0m depth based on field observations)

(Piezometer damaged - Nov. 4, 2015)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

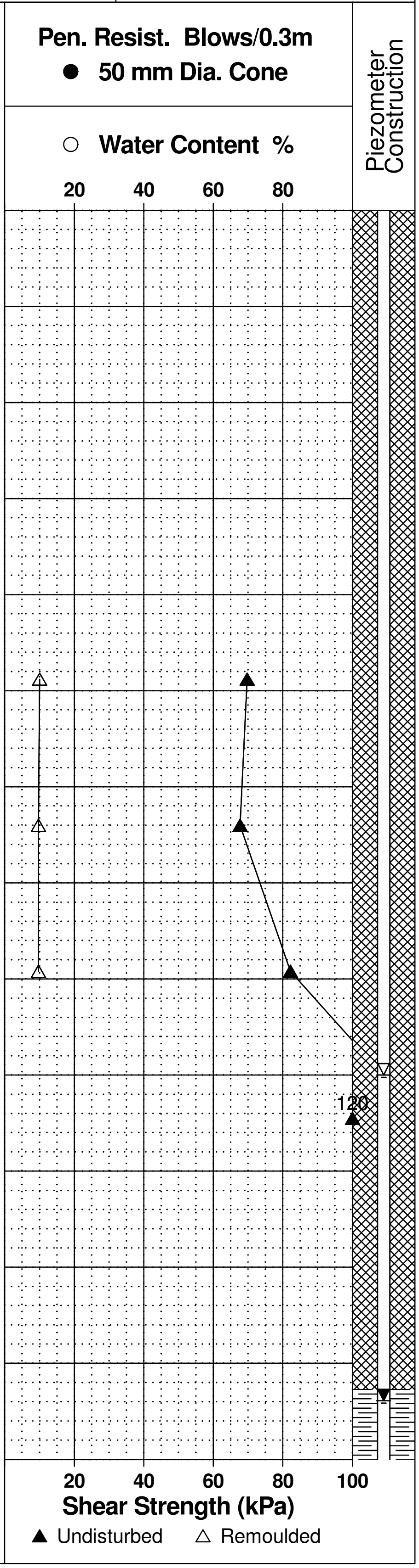
DATE October 14, 2015

FILE NO. PG2933

HOLE NO. BH16-15

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Brown silty sand, trace gravel, concrete, glass	AU	1		
	SS	2	42	6
	SS	3	56	50+
2.16				
Compact to loose, brown **SILTY SAND**	SS	4	75	14
	SS	5	54	11
3.56				
Stiff to very stiff, brown to grey **SILTY CLAY,** trace sand				
	SS	6	100	2
11.23				
GLACIAL TILL: Dense to very dense, grey silty sand with gravel, cobbles, boulders	SS	7	83	5

DEPTH (m)	ELEV. (m)
0	64.05
1	63.05
2	62.05
3	61.05
4	60.05
5	59.05
6	58.05
7	57.05
8	56.05
9	55.05
10	54.05
11	53.05
12	52.05
13	51.05



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 14, 2015

FILE NO. PG2933

HOLE NO. BH16-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					13	51.05
GLACIAL TILL: Dense to very dense, grey silty sand with gravel, cobbles, boulders	SS	8	71	49	14	50.05
15.29	SS	9	100	50+	15	49.05
BEDROCK: Interbedded limestone and shale	RC	1	100	65	16	48.05
17.27	RC	2	78	78	17	47.05

End of Borehole

(GWL @ 9.0m depth based on field observations)

(GWL @ 12.39m-Nov. 4, 2015)

Pen. Resist. Blows/0.3m
● **50 mm Dia. Cone**
○ **Water Content %**
20 40 60 80

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

Piezometer Construction

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

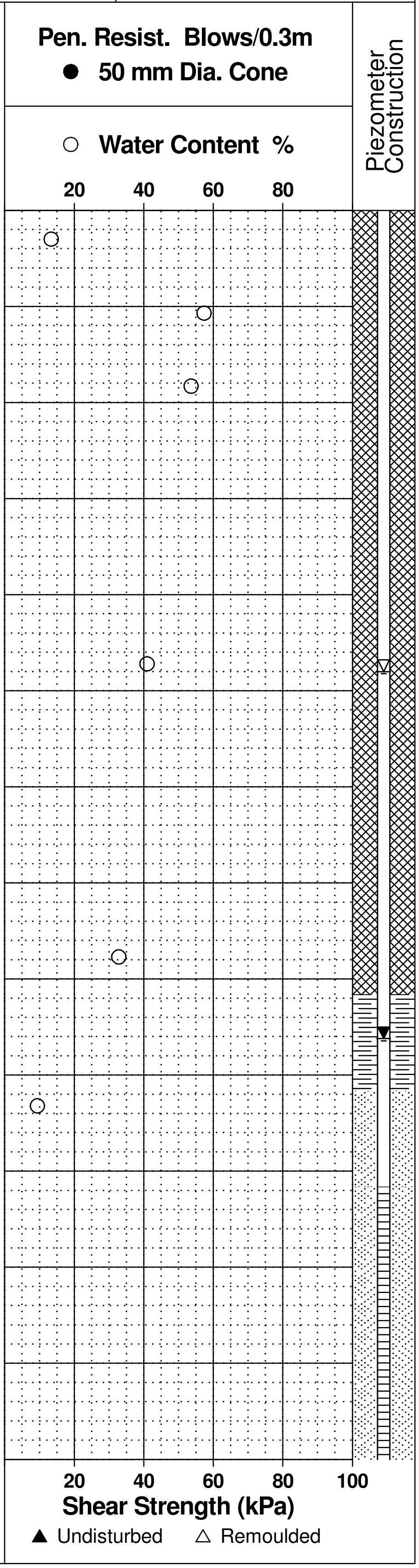
BORINGS BY CME 55 Power Auger

DATE October 19, 2015

FILE NO. PG2933

HOLE NO. BH17-15

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	60.46
FILL: Crushed concrete with sand and gravel, some clay 0.46	AU	1				
FILL: Grey silty clay with sand, some gravel, concrete, brick 1.60	SS	2	67	7	1	59.46
	SS	3	100	2	2	58.46
Stiff, brown to grey **SILTY CLAY**					3	57.46
					4	56.46
					5	55.46
					6	54.46
7.47					7	53.46
Grey **CLAYEY SILT/SILTY CLAY** 8.38					8	52.46
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles, boulders					9	51.46
	SS	4		50+		
					10	50.46
					11	49.46
	RC	1	9			
12.09					12	48.46
BEDROCK: Interbedded limestone and shale						
	RC	2	83	23	13	47.46



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 19, 2015

FILE NO. PG2933

HOLE NO. BH17-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE									
BEDROCK: Interbedded limestone and shale 13.62						13	47.46		
End of Borehole (GWL @ 4.8m depth based on field observations) (GWL @ 8.62m-Nov. 4, 2015)									

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

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 19, 2015

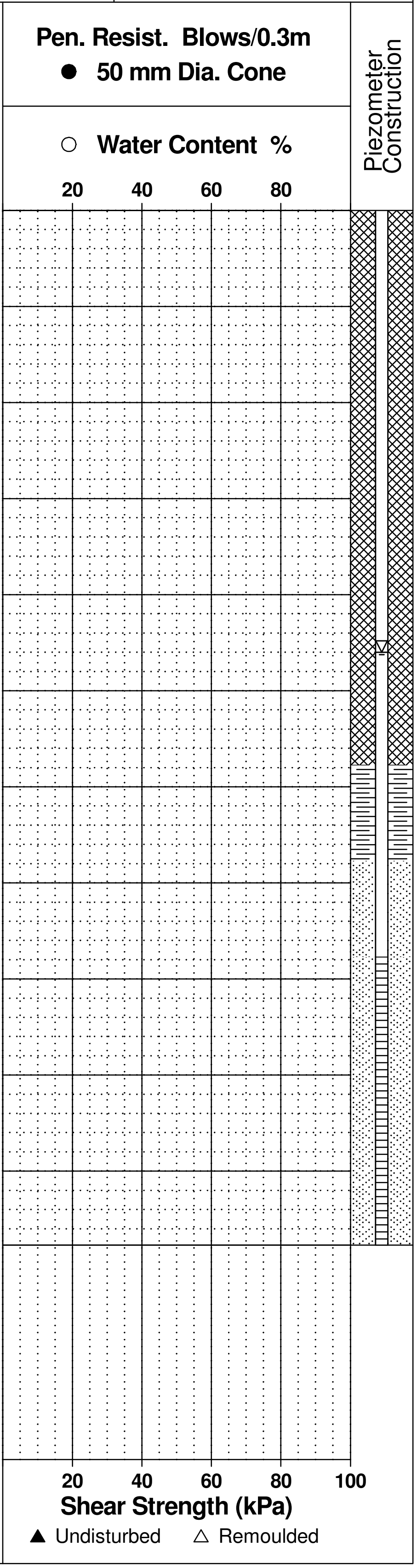
FILE NO. PG2933

HOLE NO. BH18-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	60.05
FILL: Brown silty sand with gravel, concrete, brick, metal, asphalt		AU	1				
		AU	2			1	59.05
1.68							
Stiff, brown to grey **SILTY CLAY,** some sand		SS	3	100	2	2	58.05
						3	57.05
						4	56.05
						5	55.05
						6	54.05
7.16						7	53.05
Grey **CLAYEY SILT/SILTY CLAY**		SS	4	100	3	8	52.05
8.13							
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles and boulders - some running sand encountered from 9.1 to 9.5m depth		SS	5	67	50+	9	51.05
						10	50.05
10.77		SS	6	50	50+		

End fo Borehole
Practical refusal to augering at 10.77m depth

(GWL @ 4.6m depth based on field observations)
(Piezometer damaged - Nov. 4, 2015)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan

REMARKS provided by Annis, O'Sullivan, Vollebekk Ltd.

BORINGS BY CME 55 Power Auger

DATE October 22, 2015

FILE NO. PG2933

HOLE NO. BH19-15

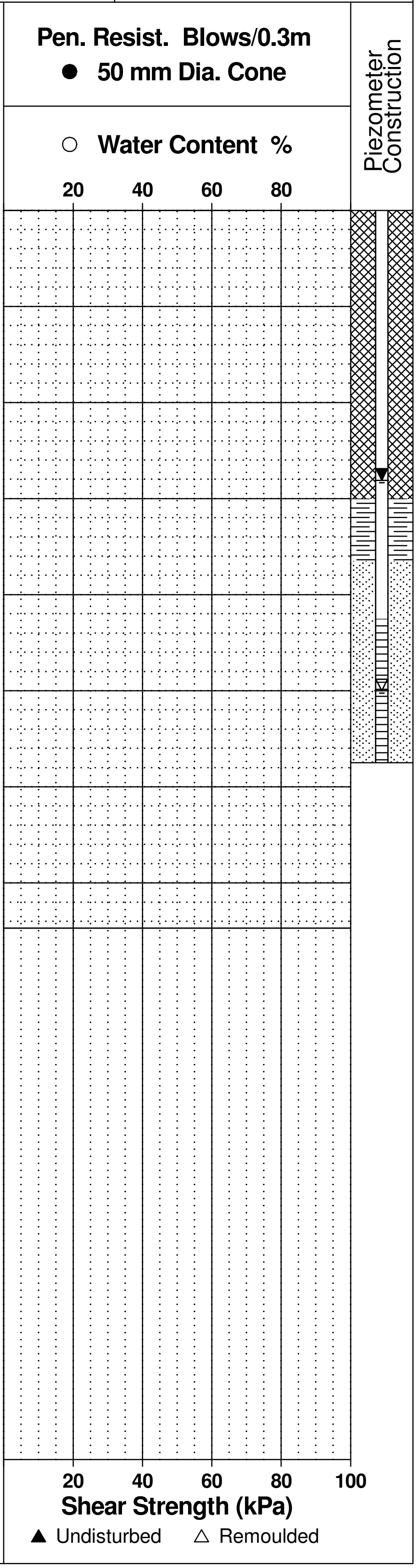
SOIL DESCRIPTION	Depth of base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Concrete	0.20				
FILL: Crushed stone with sand	0.38	AU	1		
Stiff, brown to grey **SILTY CLAY**	7.47	SS	2	100	3
		SS	3	100	2
		SS	4	100	W
		SS	5	100	2
		SS	6	100	3
		SS	7	100	3
		SS	8	100	4
		SS	9	100	3
		SS	10	100	3

End of Borehole

(GWL @ 5.0m depth based on field observations)

(GWL @ 2.81m-Nov. 4, 2015)

DEPTH (m)	ELEV. (m)
0	60.40
1	59.40
2	58.40
3	57.40
4	56.40
5	55.40
6	54.40
7	53.40



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan

REMARKS provided by Annis, O'Sullivan, Vollebekk Ltd.

BORINGS BY CME 55 Power Auger

DATE October 20, 2015

FILE NO. PG2933

HOLE NO. BH20-15

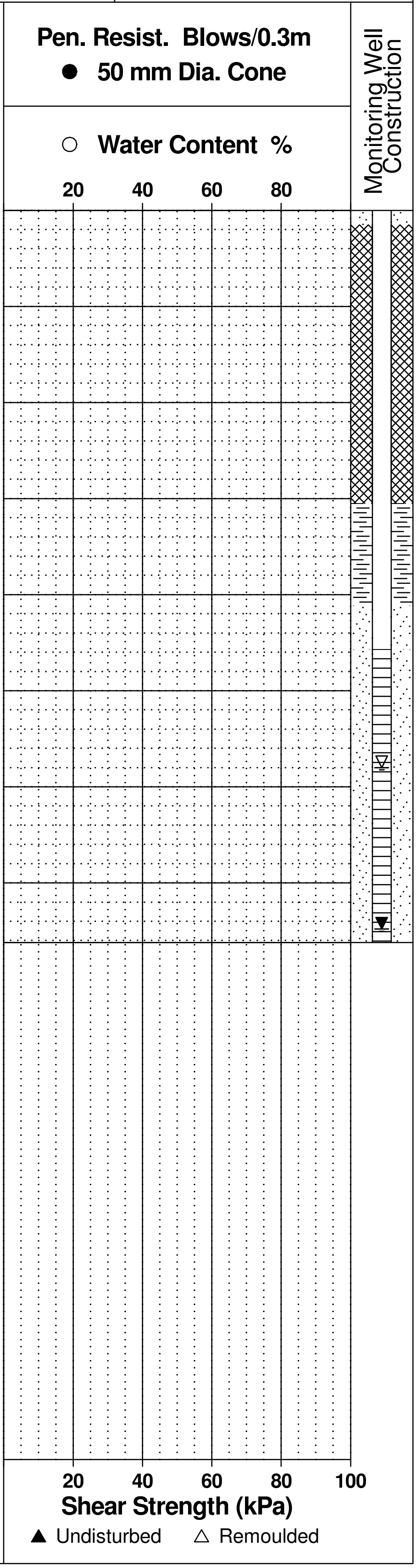
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
FILL: Brown silty sand with gravel, concrete, brick metal, cobbles 0.56	▨	AU	1		
Stiff to firm, brown to grey **SILTY CLAY,** trace sand	▨	SS	2	100	2
		SS	3	100	2
		SS	4	100	W
		SS	5	100	W
		SS	6	100	W
		SS	7	100	W
		SS	8	100	2
		SS	9	100	2
7.62		SS	10	50	2

DEPTH (m)	ELEV. (m)
0	60.40
1	59.40
2	58.40
3	57.40
4	56.40
5	55.40
6	54.40
7	53.40

End of Borehoe

(GWL @ 5.8m depth based on field observations)

(GWL @ 7.48m-Nov. 4, 2015)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 21, 2015

FILE NO. PG2933

HOLE NO. BH21-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	63.34		
FILL: Brown silty sand with gravel, some cobbles, concrete, asphalt, brick, metal and ash	▨	AU	1						
	▨	SS	2	42	16	1	62.34		
	▨	SS	3	25	6	2	61.34		
	▨	SS	4	33	17				
3.07	▨	SS	5	50	50+	3	60.34		
End of Borehole Practical refusal to augering on inferred concrete at 3.07m depth (BH dry based on field observations)									

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 21, 2015

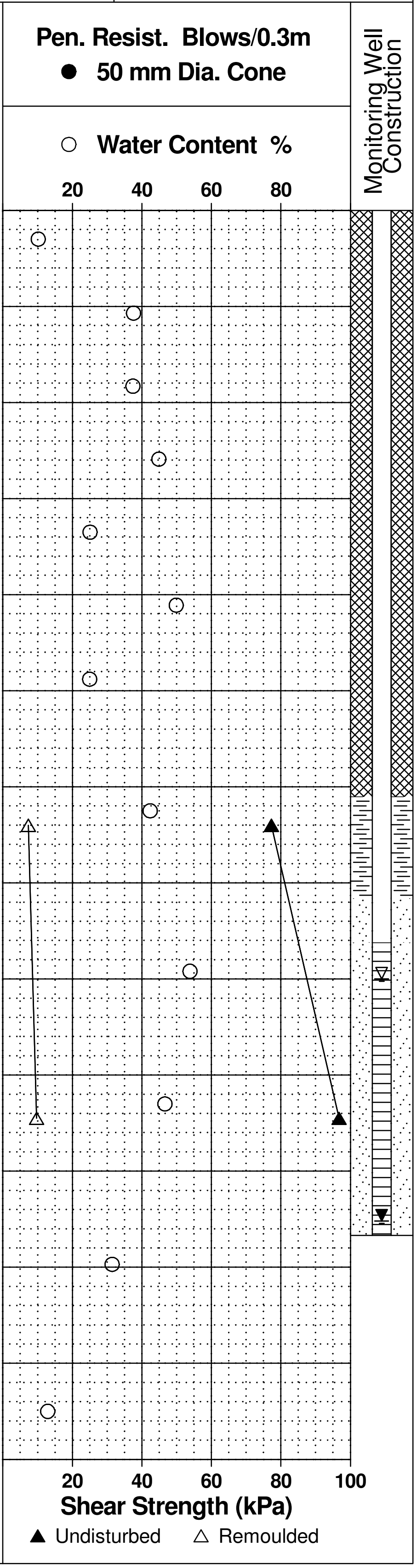
FILE NO. PG2933

HOLE NO. BH21A-15

SOIL DESCRIPTION	
GROUND SURFACE	
Asphaltic concrete	0.10
FILL: Crushed stone	0.51
FILL: Grey-brown silty clay, some sand and gravel, trace concrete	2.87
FILL: Brown silty sand, some clay, coal, tar	4.60
Stiff, brown to grey **SILTY CLAY,** some sand	10.21
Grey **CLAYEY SILT** with sand, trace gravel	11.58
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles, boulders, trace clay	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	62	3
SS	3	62	4
SS	4	71	4
SS	5	50	6
SS	6	58	5
SS	7	100	2
SS	8	100	4
SS	9	100	2
SS	10	100	50+

DEPTH (m)	ELEV. (m)
0	63.59
1	62.59
2	61.59
3	60.59
4	59.59
5	58.59
6	57.59
7	56.59
8	55.59
9	54.59
10	53.59
11	52.59
12	51.59
13	50.59



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE October 21, 2015

FILE NO. PG2933

HOLE NO. BH21A-15

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Monitoring Well Construction
GROUND SURFACE						13	50.59		
GLACIAL TILL: Very dense, grey silty sand with gravel, cobbles, boulders, trace clay - some running sand encountered from 11.9 to 12.4m depth						14	49.59		
		RC	1	83					
		RC	2	100		15	48.59		
15.80									
BEDROCK: Interbedded limestone and shale		RC	3	100	76	16	47.59		
		RC	4	100	92	17	46.59		
17.37									
End of Borehole (GWL @ 8.0m depth based on field observations) (GWL @ 10.52m-Nov. 4, 2015)									

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE October 16, 2015

FILE NO. PG2933

HOLE NO. BH23-15

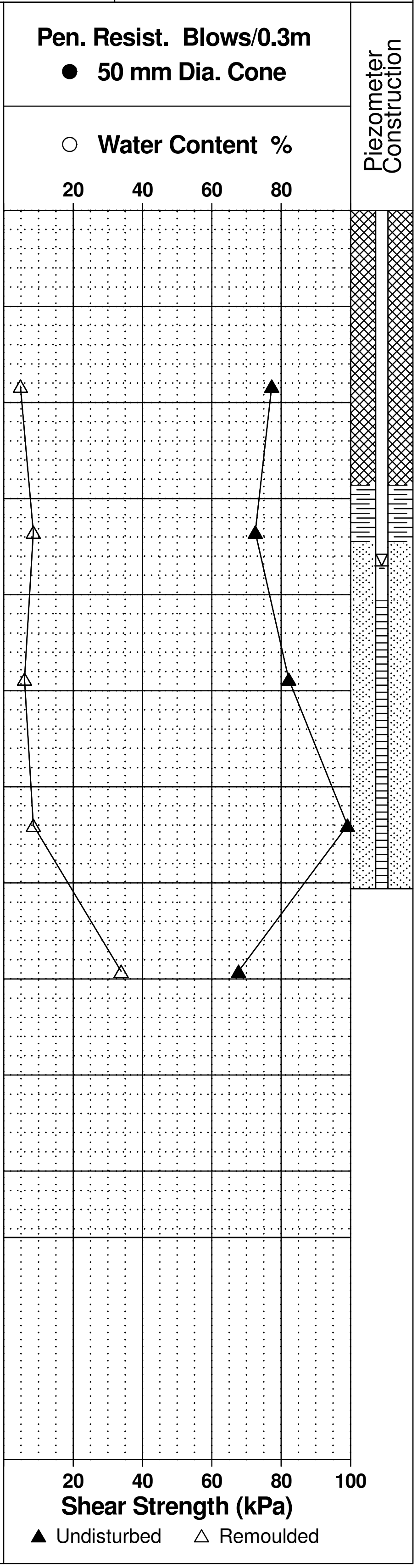
SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
FILL: Brown silty sand with gravel and clay — 0.36	AU	1		
	SS	2	100	W
Stiff, brown to grey **SILTY CLAY** — 7.00				
Stiff, grey **CLAYEY SILT** with sand — 8.69				
GLACIAL TILL: Very dense, grey sand with gravel, cobbles, boulders, some silt	SS	3	100	50+
— 10.69	SS	4	80	50+

End of Borehole
Practical refusal to augering at 10.69m depth

(GWL @ 3.7m depth based on field observations)

(BH dry - Nov. 4, 2015)

DEPTH (m)	ELEV. (m)
0	60.41
1	59.41
2	58.41
3	57.41
4	56.41
5	55.41
6	54.41
7	53.41
8	52.41
9	51.41
10	50.41



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE October 16, 2015

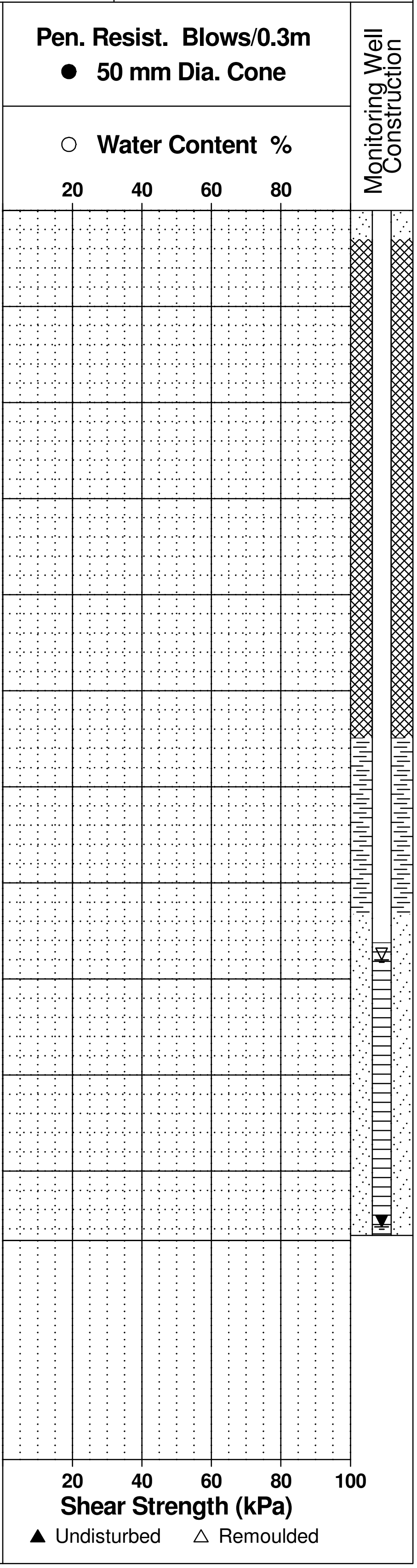
FILE NO. PG2933

HOLE NO. BH24-15

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
Asphaltic concrete	0.05
FILL: Crushed stone	0.30
FILL: Brown silty sand with slag	1.98
Compact to loose, brown **SILTY SAND**	3.05
Stiff, brown to grey **SILTY CLAY** - with sand by 9.9m depth	10.72
End of Borehole (GWL @ 7.8m depth based on field observations) (GWL @ 10.58m-Nov. 4, 2015)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	42	7
SS	3	100	11
SS	4	54	9
SS	5	92	2
SS	6	100	W
SS	7	100	W
SS	8	100	W
SS	9	100	1
SS	10	100	W
SS	11	88	W
SS	12	100	2
SS	13	100	1
SS	14	100	W

DEPTH (m)	ELEV. (m)
0	63.75
1	62.75
2	61.75
3	60.75
4	59.75
5	58.75
6	57.75
7	56.75
8	55.75
9	54.75
10	53.75



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 21, 2013

FILE NO. **PG2933**

HOLE NO. **BH 1-13**

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
25mm Asphaltic concrete over crushed stone	0.30
FILL: Brown silty sand with gravel	0.69
Very stiff to stiff, brown **SILTY CLAY** - grey by 7.2m depth	12.65
GLACIAL TILL: Dense, grey silty sand with clay, gravel, cobbles and boulders	18.87
BEDROCK: Grey limestone interbedded with shale	20.67
End of Borehole (GWL @ 15.76m-Apr. 2, 2013)	

TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
AU	2		
SS	3	75	6
SS	4	100	4
SS	5	50	43
RC	1		
RC	2		
RC	3	100	100
RC	4	100	48

DEPTH (m)	ELEV. (m)
0	67.73
1	66.73
2	65.73
3	64.73
4	63.73
5	62.73
6	61.73
7	60.73
8	59.73
9	58.73
10	57.73
11	56.73
12	55.73
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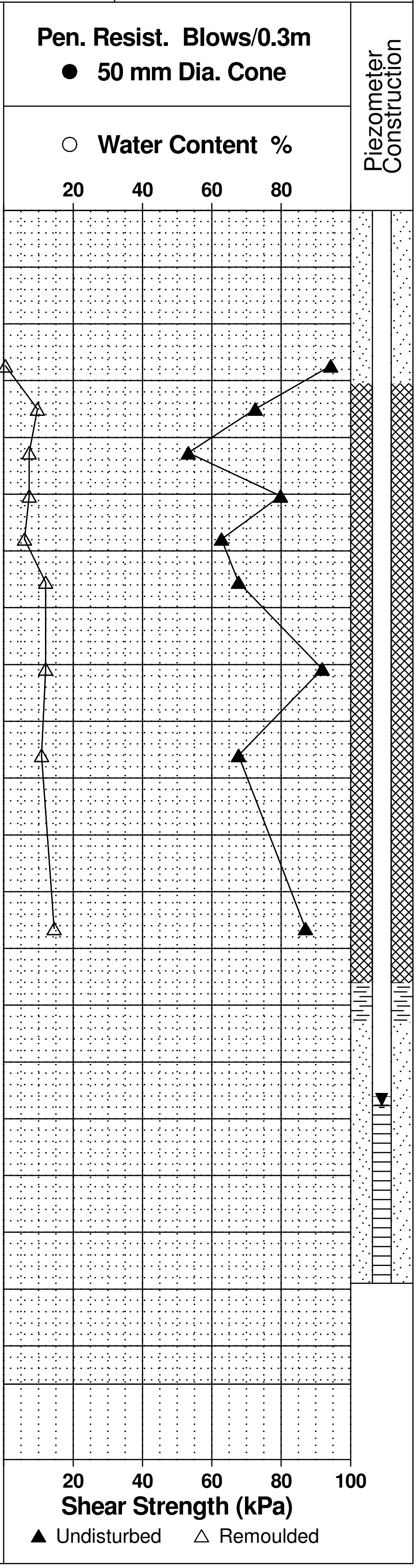
14	53.73
15	52.73
16	51.73
17	50.73
18	49.73
19	48.73
20	47.73



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 22, 2013

FILE NO. PG2933

HOLE NO. BH 2-13

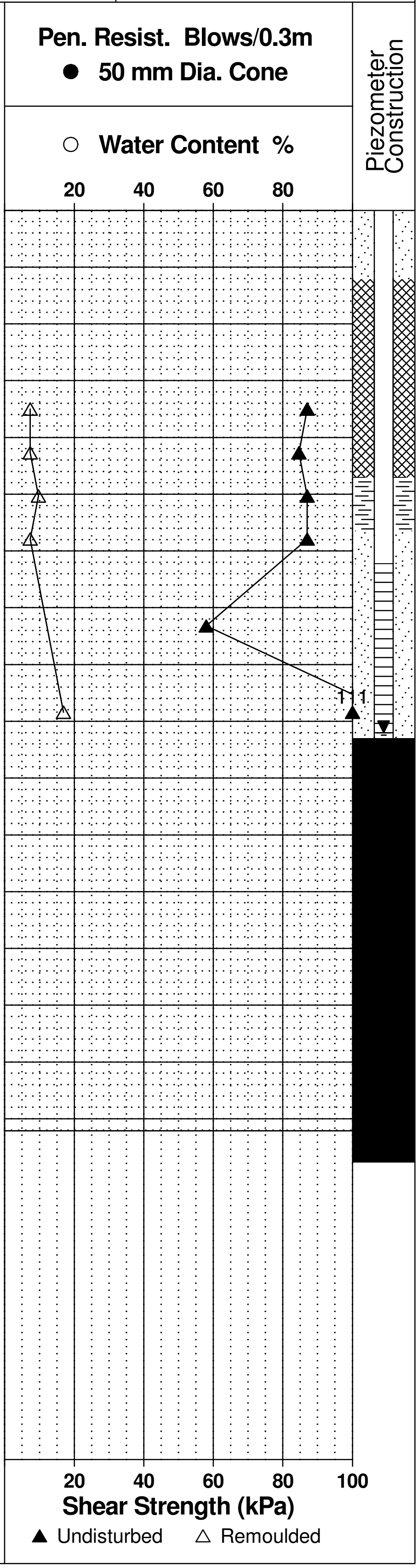
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
FILL: Brown silty clay with sand, gravel and cobbles — 0.69		AU	1		
FILL: Brown silty sand with clay and gravel — 1.45		SS	2	67	9
Compact, brown **SILTY SAND** — 2.21		SS	3	67	13
Stiff, brown **SILTY CLAY** - grey by 6.5m depth 9.37		SS	4	100	1
GLACIAL TILL: Compact to very dense, brown silty sand with gravel, cobbles and boulders		SS	5	100	11
		SS	6		69
16.21		SS	7	0	50+

End of Borehole

Practical refusal to augering at 16.21m depth

(GWL @ 9.20m-Apr. 2, 2013)

DEPTH (m)	ELEV. (m)
0	65.52
1	64.52
2	63.52
3	62.52
4	61.52
5	60.52
6	59.52
7	58.52
8	57.52
9	56.52
10	55.52
11	54.52
12	53.52
13	52.52
14	51.52
15	50.52
16	49.52



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM / **REMARKS** TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG2933

HOLE NO. BH 3-13

BORINGS BY CME 55 Power Auger

DATE March 25, 2013

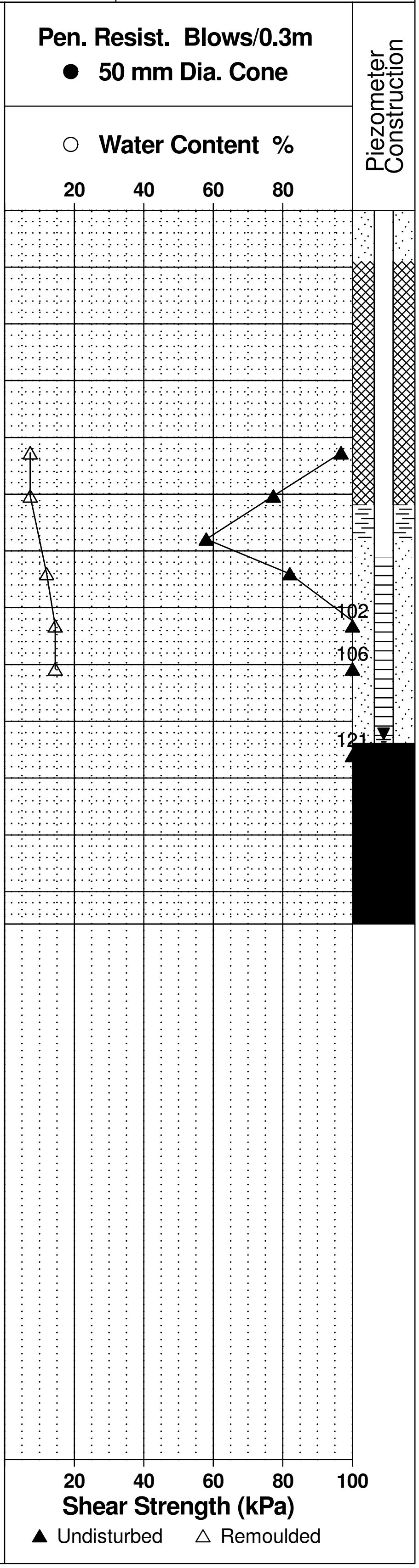
SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
25mm Asphaltic concrete over crushed stone — 0.28	AU	1		
FILL: Brown silty sand, some gravel — 1.45	AU SS	2 3	 50	 6
Loose, brown **SILTY SAND** — 2.97	SS SS	4 5	100 75	6 9
Stiff to very stiff, brown **SILTY CLAY** - grey by 5.2m depth — 12.57	SS	6	83	3

DEPTH (m)	ELEV. (m)
0	63.52
1	62.52
2	61.52
3	60.52
4	59.52
5	58.52
6	57.52
7	56.52
8	55.52
9	54.52
10	53.52
11	52.52
12	51.52

End of Borehole

Practical refusal to augering on inferred boulder at 12.57m depth

(GWL @ 9.32m-Apr. 2, 2013)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

FILE NO. PG2933

HOLE NO. BH 4-13

BORINGS BY CME 55 Power Auger

DATE March 22, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	63.49		
Asphaltic concrete 0.05									
FILL: Crushed stone 0.28						1	62.49		
FILL: Brown to black silty sand with clay, trace gravel and cobbles						2	61.49		
						3	60.49		
3.71		AU	1						
End of Borehole									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

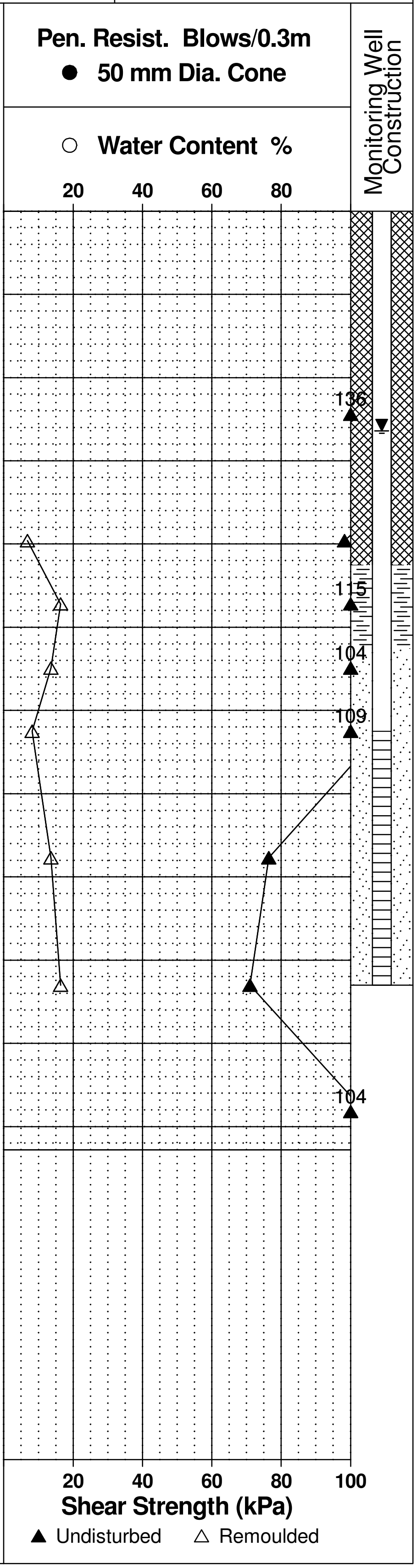
BORINGS BY CME 55 Power Auger

DATE August 14, 2012

FILE NO. PG2757

HOLE NO. BH 1

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	67.97
Asphaltic concrete 0.10						
FILL: Crushed stone 0.30	AU	1				
FILL: Brown sand, trace gravel 1.01						
	SS	2	58	10	1	66.97
	SS	3	100	5	2	65.97
	SS	4	100	4		
Very stiff to stiff, brown **SILTY CLAY**	SS	5	100	3	3	64.97
- grey by 3.3m depth	SS	6	83	1	4	63.97
	SS	7	100	2	5	62.97
	SS	8	100	P		
	SS	9	100	P	6	61.97
					7	60.97
	SS	10	100	P	8	59.97
					9	58.97
	SS	11	100	P		
- trace sand by 9.8m depth					10	57.97
11.28	SS	12	100	P	11	56.97
End of Borehole						
(GWL @ 2.64m-April 2, 2013)						



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan

REMARKS provided by Annis, O'Sullivan, Vollebekk Ltd.

BORINGS BY CME 55 Power Auger

DATE August 14, 2012

FILE NO. PG2757

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
FILL: Grey sand and gravel, trace silt and clay 0.30		AU	1		
FILL: Brown sand with crushed concrete - 75mm thick concrete at 2.4m depth		SS	2	0	10
		SS	3	25	20
2.97		SS	4	4	5
Stiff to very stiff, grey **SILTY CLAY**		SS	5	100	4
		SS	6	100	3
		SS	7	88	P
		SS	8	100	P
		SS	9	100	P
		SS	10	100	P
9.30					
Dynamic Cone Penetration Test commenced at 9.30m depth.					
13.82					
End of Borehole Practical cone refusal on inferred boulder at 13.82m depth					

DEPTH (m)	ELEV. (m)
0	65.47
1	64.47
2	63.47
3	62.47
4	61.47
5	60.47
6	59.47
7	58.47
8	57.47
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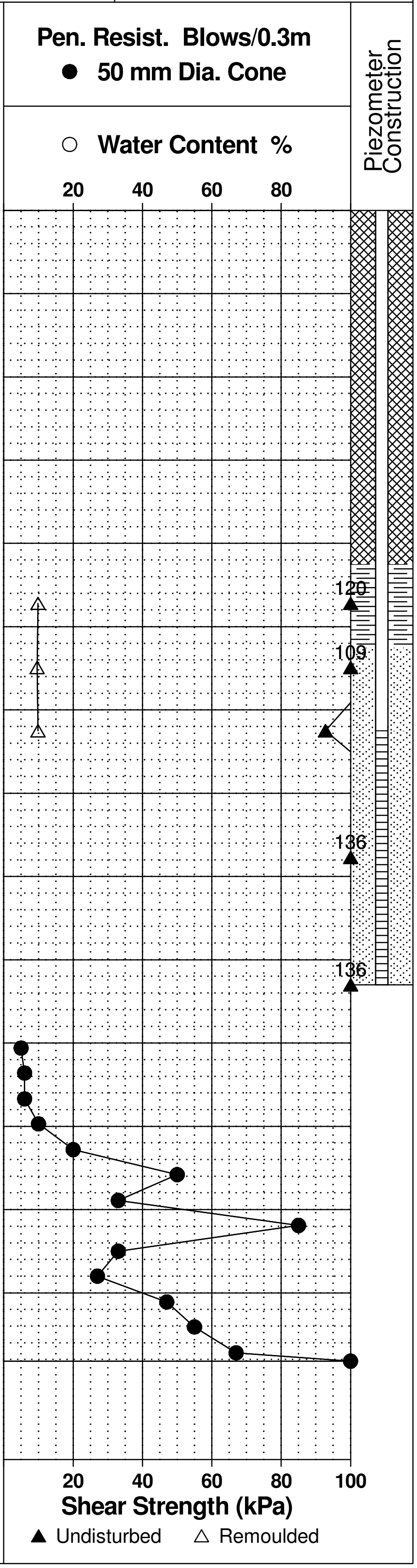
11	54.47
12	53.47
13	52.47



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Building - 151 Chapel Street
Ottawa, Ontario

DATUM / **REMARKS** TBM - Top spindle of fire hydrant located on the east side of Chapel Street, along the west boundary of the subject site. Geodetic elevation = 65.12m, as per plan provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG2757

HOLE NO. BH 3

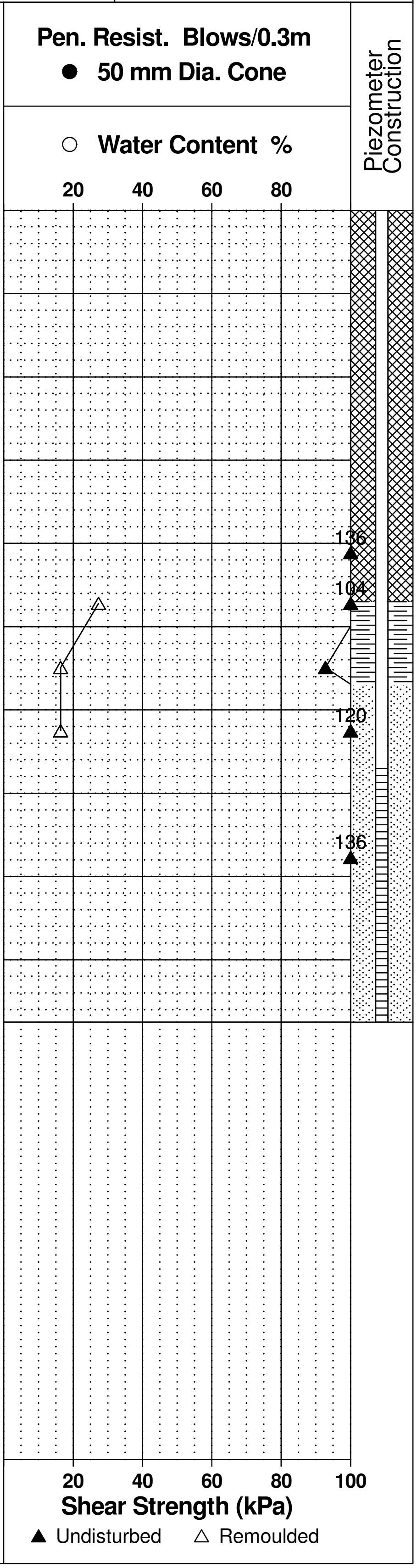
BORINGS BY CME 55 Power Auger

DATE August 14, 2012

SOIL DESCRIPTION	Depth (m)
GROUND SURFACE	
Asphaltic concrete	0.08
FILL: Crushed stone	0.30
FILL: Brown sand, some clay, trace gravel	1.45
Compact to loose, brown **SAND**	3.12
Stiff to very stiff, grey **SILTY CLAY**	9.75
End of Borehole	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	33	10
SS	3	17	8
SS	4	100	13
SS	5	83	5
SS	6	100	P
SS	7	92	P
SS	8	100	P
SS	9	100	P
SS	10	100	P
SS	11	100	3

DEPTH (m)	ELEV. (m)
0	63.61
1	62.61
2	61.61
3	60.61
4	59.61
5	58.61
6	57.61
7	56.61
8	55.61
9	54.61



SYMBOLS AND TERMS

SOIL DESCRIPTION

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

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

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

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

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

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

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

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

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

Cc - Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu - Uniformity coefficient = D60 / D10

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

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

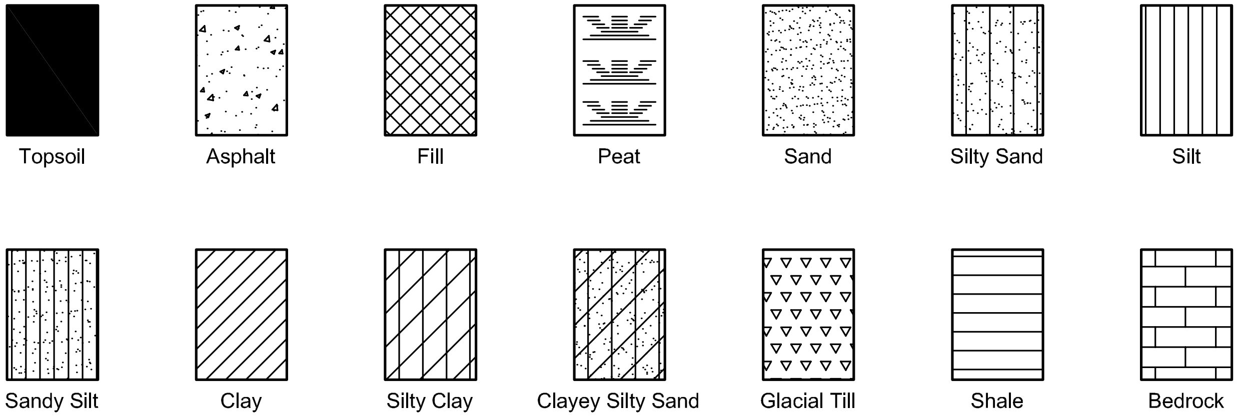
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

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

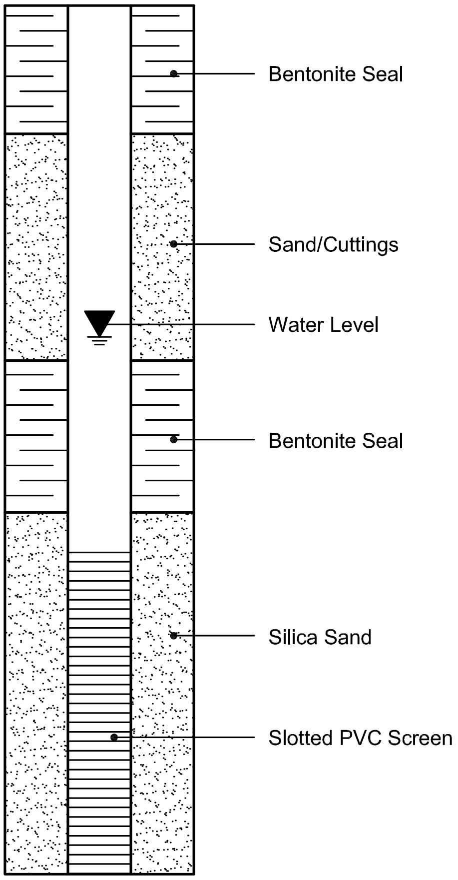
SYMBOLS AND TERMS (continued)

STRATA PLOT

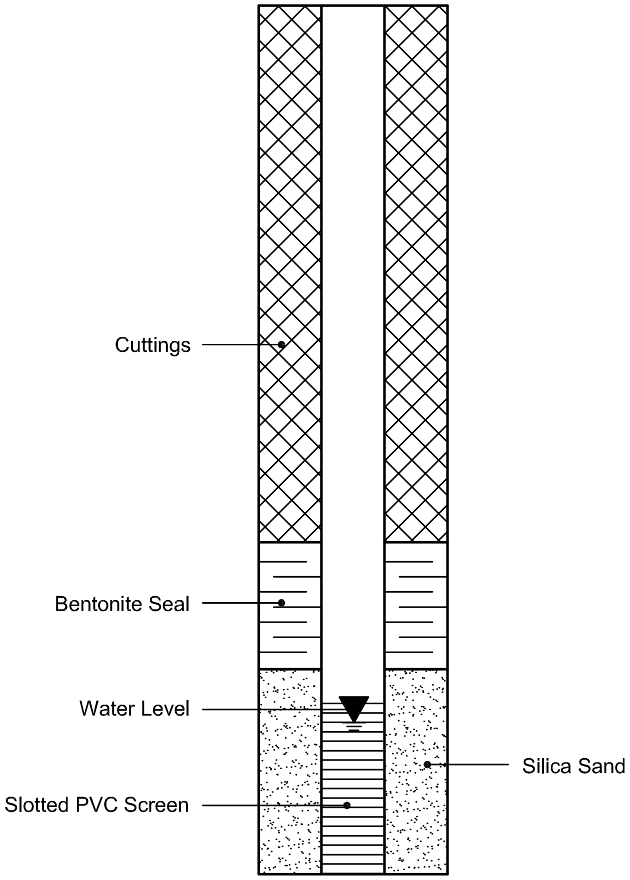


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Report Date: 08-Apr-2013

Client: **Paterson Group Consulting Engineers**

Order Date:5-Apr-2013

Client PO: 13996

Project Description: PG2933

	Client ID:	BH2-13 - 4.6 to 4.9m	-	-	-
	Sample Date:	22-Mar-13	-	-	-
	Sample ID:	1314245-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	62.6	-	-	-
General Inorganics					
pH	0.05 pH Units	8.12	-	-	-
Resistivity	0.10 Ohm.m	28.7	-	-	-
Anions					
Chloride	5 ug/g dry	82	-	-	-
Sulphate	5 ug/g dry	302	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES

DRAWING PG2933-2 - TEST HOLE LOCATION PLAN

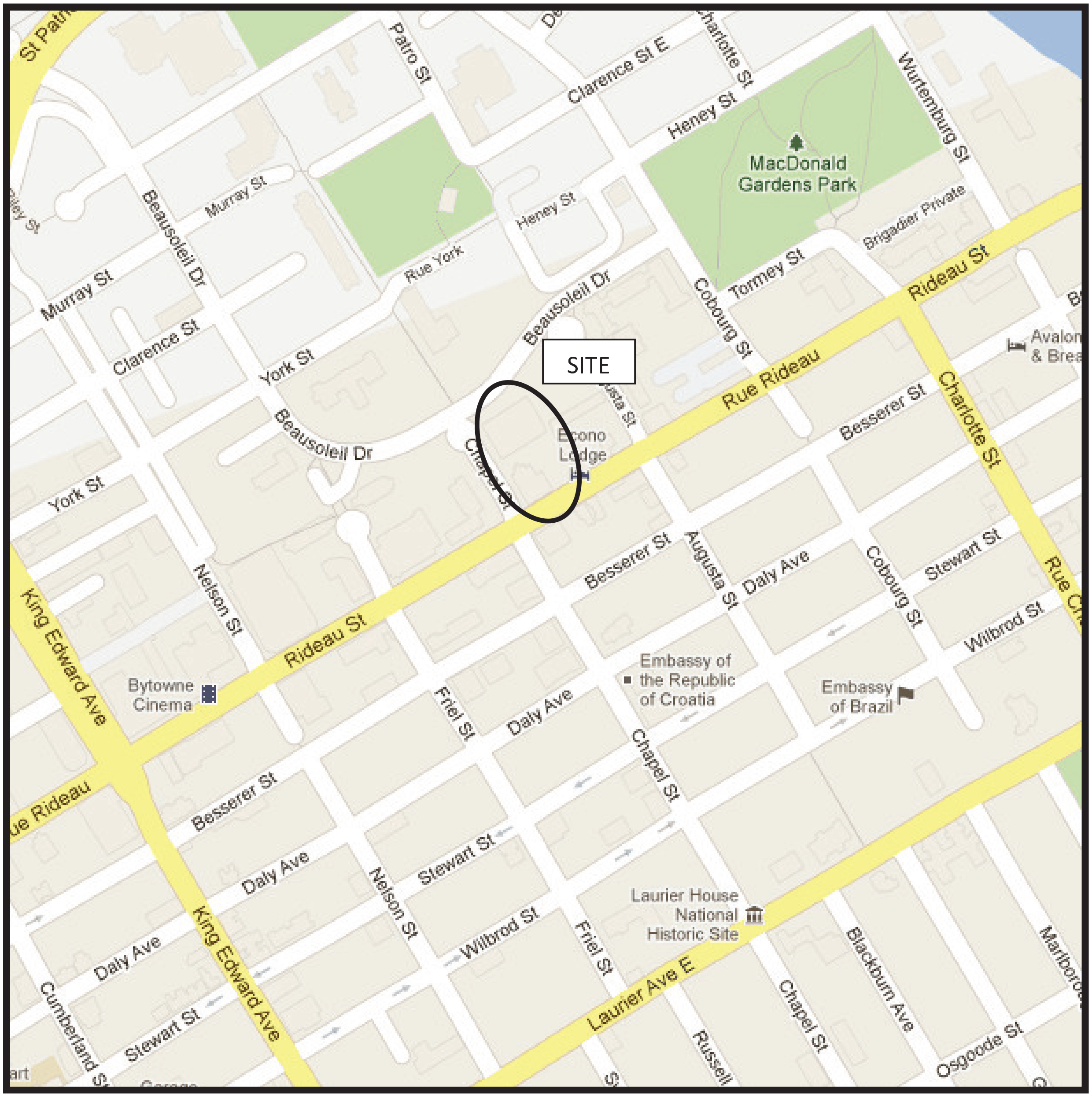


FIGURE 1

KEY PLAN

patersongroup

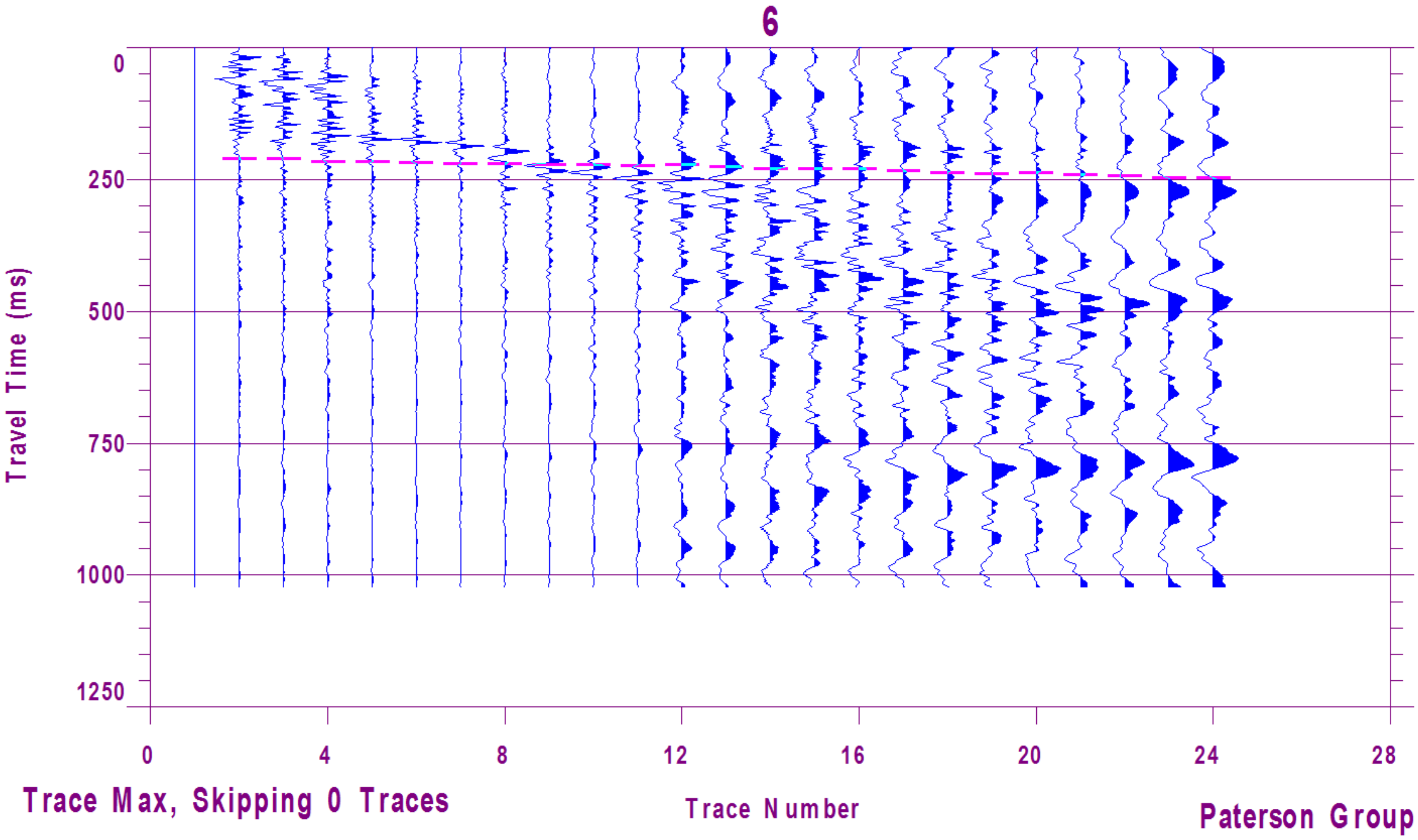


Figure 2 – Shear Wave Velocity Profile at Shot Location -5 m

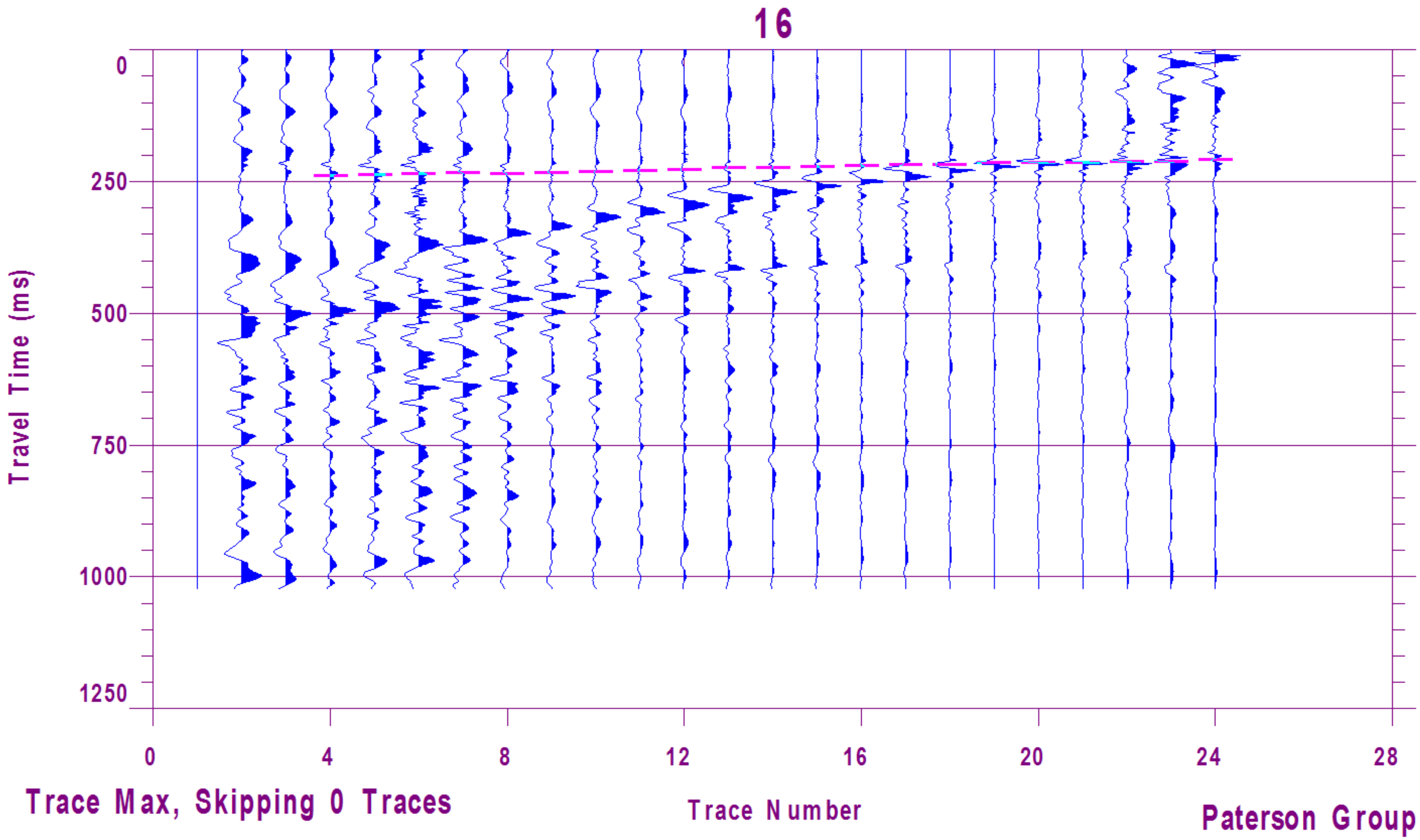
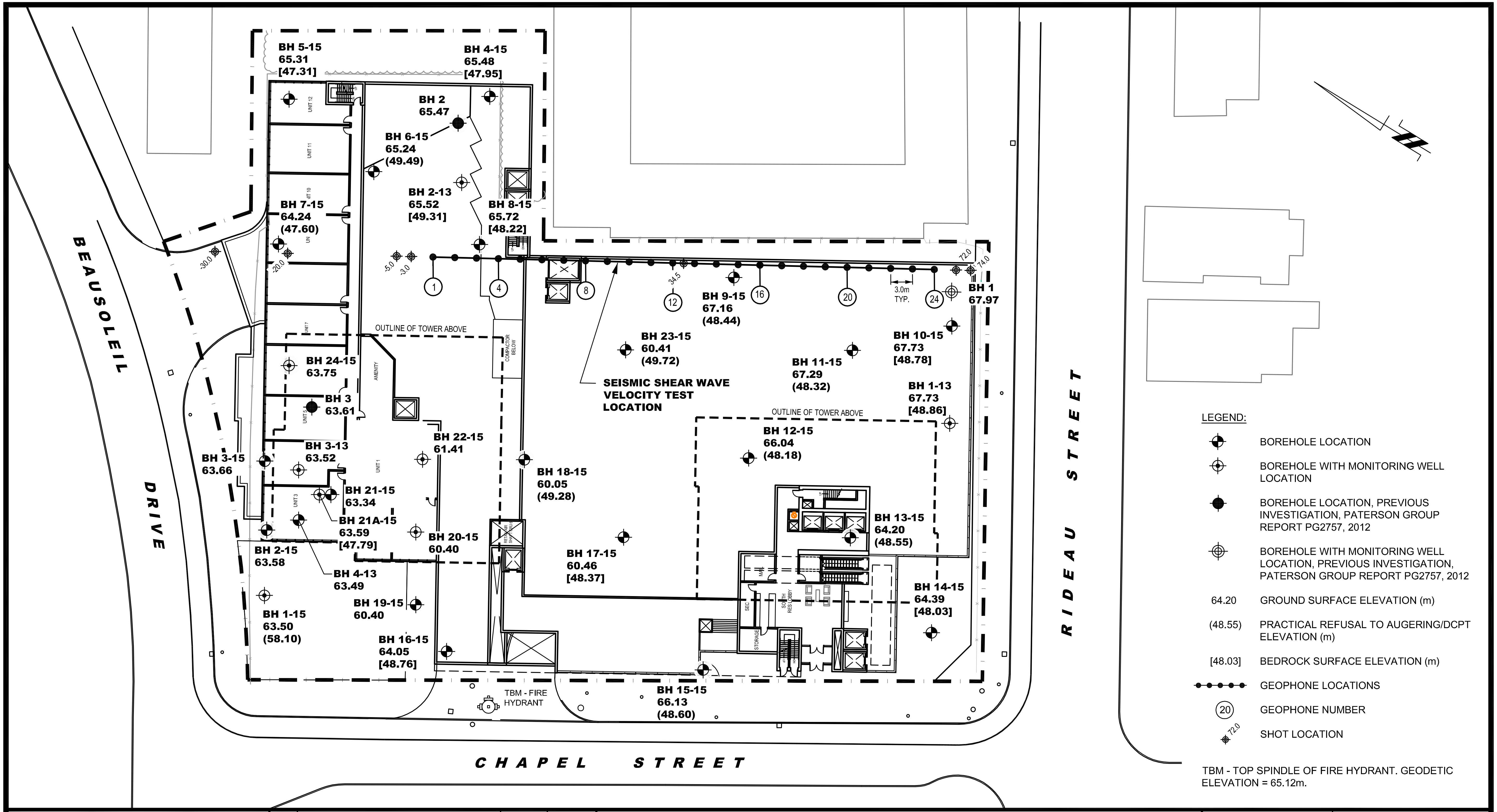


Figure 3 – Shear Wave Velocity Profile at Shot Location 74 m



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NO.	REVISIONS	DATE	INITIAL

TRINITY DEVELOPMENT GROUP

SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
PROP. MULTI-STOREY BUILDING - 151 CHAPEL STREET

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:500	Date: 11/2015
Drawn by: MPG	Report No.: PG2933-2
Checked by: DJG	Drawing No.:
Approved by: DJG	PG2933-2

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