Geotechnical Engineering

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Hydrogeology

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Materials Testing

Building Science

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Geotechnical Investigation

Proposed Multi-Storey Residential Building
425 McLeod Street at Kent Street
Ottawa, Ontario

Prepared For

CHSS International Investment and Management

March 22, 2018

Report PG4397-2

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by CHSS International Investment and Management to undertake a geotechnical investigation for a proposed multi-storey residential building to be located at 425 McLeod Street at Kent Street in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2).

The objectives of the current investigation were to:

- ❏ Determine the subsurface soil and groundwater conditions by means of boreholes.
- ❏ Provide geotechnical recommendations for the design of the proposed building 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. This report contains the findings and recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work for this geotechnical investigation.

2.0 Proposed Development

The proposed development is understood to consist of a 4 storey residential building with one level of underground parking. The footprint of the proposed parking garage will occupy the entire boundary of the subject site. The proposed development is further understood to include associated at-grade paved access lanes and landscaped areas.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the current investigation was carried out on February 13 and 16, 2018. At that time, 3 boreholes were drilled to a maximum depth of 9.6 m below the existing ground surface. The test hole locations were selected in a manner to provide general coverage of the subject site.

The boreholes completed by Paterson were drilled with 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.

The borehole locations are presented on Drawing PG4397-1 - Test Hole Location Plan appended to this report.

Sampling and In Situ Testing

Soil samples were recovered with 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 the 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 and 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, using a vane apparatus, was carried out at regular intervals of depth in cohesive soils.

The overburden soil thickness was evaluated during the course of the investigation by dynamic cone penetration testing (DCPT) at BH 1-10. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at its tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm depth increment.

Subsurface conditions observed in the test holes were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

Monitoring wells, consisting of 50 mm diameter rigid PVC standpipes, were installed in each of the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the current field program.

Sample Storage

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

3.2 Field Survey

The test hole locations for the current geotechnical investigation were selected, determined in the field and surveyed by Paterson personnel. The ground surface elevation at each borehole location was referenced to a temporary benchmark (TBM), consisting of the top of spindle of a fire hydrant located on McLeod Street adjacent to the subject property. An arbitrary elevation of 100.0 m was assigned to the TBM.

The ground surface elevation and location of each borehole, as well as the location of the TBM is presented on the attached Drawing PG4397-1 - Test Hole Location Plan.

3.3 Laboratory Testing

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

3.4 Analytical Testing

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

4.0 Observations

4.1 Surface Conditions

Currently, the subject site is occupied by several existing low-rise residential buildings which will be demolished as part of the proposed development. The site is relatively flat and at grade with Kent Street and McLeod Street.

4.2 Subsurface Profile

The subsurface profile at the current borehole locations consists of a topsoil layer or pavement structure underlain by a sand layer to approximately 3 m depth, and further underlain by a stiff to very stiff silty clay deposit. Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

Based on available geological mapping, the subject site is located in an area where the bedrock consists of shale of the Billings formation. The overburden drift thickness is estimated to be between 5 to 15 m.

4.3 Groundwater

Groundwater levels were measured in the monitoring wells installed in the boreholes upon completion of the sampling program. The groundwater level readings at each borehole location are presented in Table 1.

Table 1 - Summary of Groundwater Level Readings

Borehole Number	Ground Elevation (m)	Groundwater Levels		Recording Date
		Depth (m)	Elevation (m)	
BH 1	100.35	3.05	97.30	February 22, 2018
BH 2	99.77	3.72	96.05	February 22, 2018
BH 3	99.49	8.50	90.99	February 22, 2018

Note: Ground surface elevations at borehole locations were referenced to a TBM, consisting of the top spindle of a fire hydrant located on McLeod Street adjacent to the subject property.

Long-term groundwater levels can also be estimated based on the observed colour and consistency of the recovered soil samples. Based on these observations, it is estimated that the long-term groundwater table an be expected at approximately 3 to 4 m depth.

It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

The subject site is considered satisfactory from a geotechnical perspective for the proposed residential building. It is anticipated that the proposed building will be founded on conventional spread footings placed on an undisturbed, stiff silty clay bearing surface.

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

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and deleterious fill, such as those containing organic materials, should be stripped from within the building footprint, paved areas, pipe bedding and other settlement sensitive structures.

Existing foundation walls and other construction debris should be entirely removed from within the building perimeter.

Fill Placement

Fill placed for grading beneath the building area should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill material should be tested and approved prior to delivery to the site. The fill should be placed in maximum 300 mm thick lifts and compacted to 98% of the material's standard Proctor maximum dry density (SPMDD).

Fill used for grading beneath the base and subbase layers of paved areas should consist, unless otherwise specified, of clean imported granular fill, such as OPSS Granular A, Granular B Type II or select subgrade material. This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the paved areas should be compacted to at least 95% of its SPMDD.

5.3 Foundation Design

Conventional Shallow Footings

Strip footings, up to 3 m wide, and pad footings, up to 6 m wide, placed over 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 values at ULS.

An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, have been removed 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 20 mm, respectively.

Lateral Support

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

Permissible Grade Raise

Although the finished grades will remain the same as surrounding grades, a permissible grade raise restriction of **2 m** can be used for design purposes. Therefore, no issues are expected with permissible grade raises.

5.4 Design for Earthquakes

The proposed site can be taken as seismic site response **Class D** as defined in the Ontario Building Code 2012 (OBC 2012; Table 4.1.8.4.A) for foundations considered at this site. The soils underlying the site are not susceptible to liquefaction. A higher site class, such as Class C could be applicable for this site, but would have to be determined based on site-specific seismic testing, such as shear wave velocity testing.

5.5 Basement Slab Construction

With the removal of all topsoil and/or fill, containing significant amounts of organic or deleterious materials, within the footprint of the proposed buildings, the native soil will be considered to be an acceptable subgrade surface on which to commence backfilling for floor slab construction.

Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular B Type II is recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-floor fill consists of 19 mm clear crushed stone below the basement floor slab. The upper 200 mm of sub-slab fill should consist of a Granular A crushed stone for slab on grade construction.

It may be possible that the garage level will consist of a flexible asphaltic pavement structure which will follow the recommendations stipulated in Subsection 5.7 of this report.

All backfill materials within the footprint of the proposed building should be placed in maximum 300 mm loose lifts and compacted to, at least, 98% of the material's SPMDD.

5.6 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and a dry unit weight of 20 kN/m^3. The applicable effective unit weight of the retained soil can be estimated as 13 kN/m^3, where applicable. A hydrostatic pressure should be added to the total static earth pressure when calculating the effective unit weight.

Lateral Earth Pressures

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

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

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

Actual earth pressures could be higher than the "at-rest" case if care is not exercised during the compaction of the backfill materials to stay at least 0.3 m away from the walls with the compaction equipment.

Seismic Earth Pressures

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

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

a_c = $(1.45\text{-}a_{max}/g)a_{max}$
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. The vertical seismic coefficient is assumed to be zero.

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

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

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

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

5.7 Pavement Structure

Minimum Pavement Structure

For design purposes, the pavement structures presented in the following tables could be used for the design of car only parking areas and access lanes within the parking garage.

Table 2 - Recommended Pavement Structure - Car Only Parking Areas	
Thickness mm	**Material Description**
50	**Wear Course -** HL-3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil, select subgrade material or OPSS Granular B Type I or II material placed over in situ soil or fill	

Table 3 - Recommended Pavement Structure - Access Lanes and Heavy Truck Parking Areas	
Thickness mm	**Material Description**
40	**Wear Course -** HL-3 or Superpave 12.5 Asphaltic Concrete
50	**Binder Course** - HL-8 or Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
450	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil, select subgrade material or OPSS Granular B Type I or II material placed over in situ soil or fill	

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

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

Pavement Structure Drainage

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

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

A perimeter foundation drainage system is recommended to be provided for the proposed buildings. 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 have a positive outlet, such as a gravity connection to the storm sewer.

Foundation Backfill

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls. A drainage geocomposite, such as Miradrain G100N or Delta Drain 6000, connected to the perimeter foundation drainage system with a positive outlet to the site storm sewer is also recommended. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose. As an alternative along entrances, consideration can be given to using rigid insulation with granular material to lessen the effects of differential frost movement.

Concrete Sidewalks Adjacent to Building(s)

To avoid differential settlements within the proposed sidewalks adjacent to the proposed buildings, it is recommended that the upper 600 mm of backfill placed below the concrete sidewalks to consist of free draining, non-frost susceptible material such as Granular A or Granular B Type II, instead of site excavated material which in most cases considered frost susceptible. The granular material should be placed in maximum 300 mm loose lifts and compacted to 95% of the material's SPMDD using suitable compaction equipment. The subgrade material should be shaped to promote positive drainage towards the building's perimeter drainage pipe.

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 adequate foundation insulation, should be provided.

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

6.3 Excavation Side Slopes

Temporary Side Slopes

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

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

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

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

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

Temporary Shoring

The shoring requirements will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations and underground services. It is expected that a shoring contractor will be responsible for the design and installation of the shoring system based on information provided by the contractor’s engineers, including the geotechnical consultant.

For preliminary design purposes, the temporary system may consist of a soldier pile and lagging system 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 cantilevered, anchored or braced. Earth pressures acting on the shoring system may be calculated using the parameters provided in Table 4.

Table 4 - Soil Parameters	
Parameters	**Values**
Active Earth Pressure Coefficient (K_a)	0.33
Passive Earth Pressure Coefficient (K_p)	3
At-Rest Earth Pressure Coefficient (K_o)	0.5
Unit Weight (γ), kN/m^3	20
Submerged Unit Weight(γ), kN/m^3	13

Soldier Pile and Lagging System

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

The active earth pressure should be used where wall movements are permissible while the at-rest pressure should be used if no movement is permissible.

The total unit weight should be used above the groundwater level while the submerged unit weight should be used below the groundwater level.

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

If a soldier pile and lagging system is used, the piles could be socketed in the bedrock in pre-augered holes. The augered holes should be advanced at least 2 m into the bedrock and at least 2 m below the bottom of the excavation. A minimum factor of safety of 1.5 should be used.

Damage to Adjacent Structures

There is a possibility of disturbance to adjacent subsoil which may cause damage to adjacent structures due to the installation of the temporary shoring system. The sole responsibility of any damage caused by the installation of the temporary shoring system will be with the shoring contractor. The geotechnical engineering consultant will not be liable for any damages arising from the temporary shoring installation and will be indemnified by the owner and shoring contractor.

6.4 Pipe Bedding and Backfill

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

A minimum of 150 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on soil subgrade. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to a minimum of 300 mm above the obvert of the pipe should consist of OPSS Granular A (concrete or PSM PVC pipes) or sand (concrete pipe). The bedding and cover materials should be placed in maximum 225 mm thick lifts and compacted to 95% of the material's SPMDD.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) should match the soils exposed at the trench walls to reduce the potential for differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD.

6.5 Groundwater Control

Groundwater Control for Building Construction

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

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

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

6.6 Winter Construction

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

The subsurface conditions 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 installation of straw, propane heaters and tarpaulins or other suitable means. The base of the excavations should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

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

6.7 Corrosion Potential and Sulphate

The results of the analytical testing show that the sulphate content is less than 0.1%. These results are indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The results of the chloride content, pH and resistivity indicate the presence of a non-aggressive to slightly aggressive environment for exposed ferrous metals at this site.

7.0 Recommendations

For the foundation design data provided herein to be applicable that a materials testing and observation services program is required to be completed. The following aspects be performed by the geotechnical consultant:

- ❑ Observation of all bearing surfaces prior to the placement of concrete.
- ❑ Sampling and testing of the concrete and fill materials.
- ❑ Observation of the placement of the foundation insulation, if applicable.
- ❑ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.
- ❑ Observation of all subgrades prior to backfilling.
- ❑ Field density tests to determine the level of compaction achieved.
- ❑ Sampling and testing of the bituminous concrete including mix design reviews.

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

8.0 Statement of Limitations

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

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

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

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

Paterson Group Inc.

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

Nathan F. S. Christie, P.Eng.

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Report Distribution

- ❏ CHSS International Investment and Management (3 copies)
- ❏ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-463 Gladstone Avenue
Ottawa, Ontario

DATUM Top spindle of fire hydrant, along Florence Street, in front of subject site. Geodetic elevation = 71.75m, as provided by Tega Homes.

REMARKS

BORINGS BY CME 75 Power Auger

DATE 20 January 2010

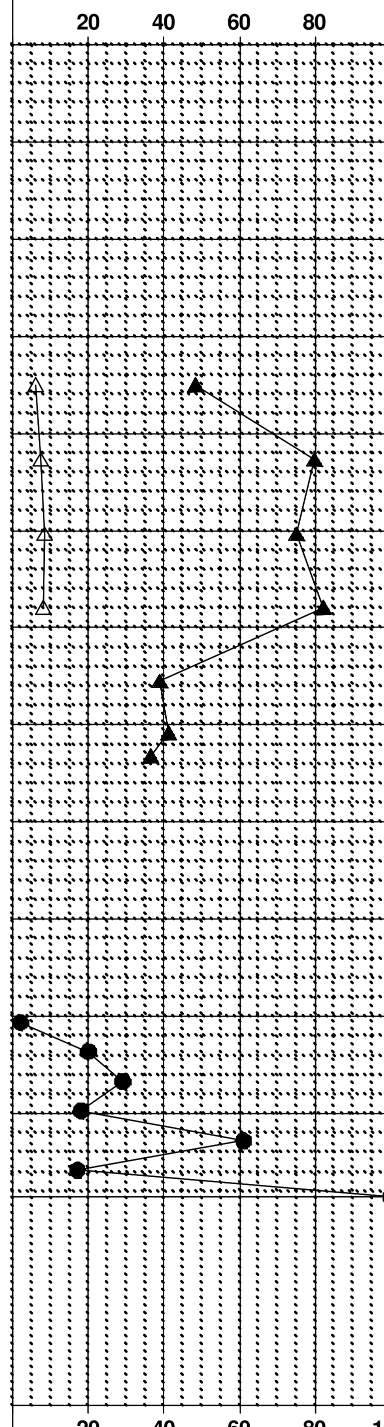
FILE NO. PG2033

HOLE NO. BH 1-10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	70.61
Asphaltic concrete 0.10		AU	1				
FILL: Grey-brown silty sand with crushed stone 0.41		SS	2	22	50+	1	69.61
FILL: Brown silty sand, trace crushed stone, cobbles and boulders 1.37		SS	3	25	1	2	68.61
FILL; Brown silty sand with gravel and clay 1.98		SS	4	50	1		
		SS	5	75		3	67.61
		SS	6	100		4	66.61
		SS	7	25		5	65.61
Stiff to firm, grey **SILTY CLAY**		SS	8			6	64.61
		SS	9	100			
						7	63.61
						8	62.61
		SS	10	100	1	9	61.61
9.75		SS	11		3		
Dynamic Cone Penetration Test commenced @ 9.75m depth						10	60.61
11.86						11	59.61
End of Borehole Practical DCPT refusal @ 11.86m depth (GWL @ 2.4m depth based on field observations)							

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

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-463 Gladstone Avenue
Ottawa, Ontario

DATUM Top spindle of fire hydrant, along Florence Street, in front of subject site. Geodetic elevation = 71.75m, as provided by Tega Homes.

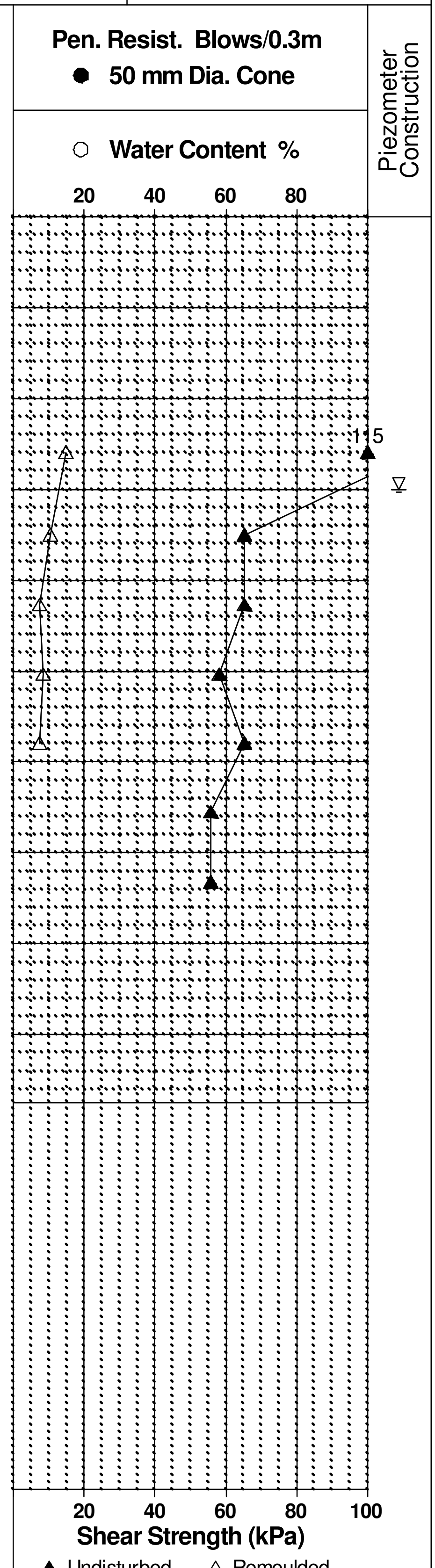
REMARKS

BORINGS BY CME 75 Power Auger **DATE** 20 January 2010

FILE NO. PG2033

HOLE NO. BH 2-10

SOIL DESCRIPTION	Strata depth (m)	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	71.07
Asphaltic concrete	0.08	AU	1				
FILL: Brown silty sand with crushed stone, trace clay	0.51						
FILL: Red-brown silty sand - brown with some clay by 0.5m depth	1.98	SS	2	50	8	1	70.07
		SS	3	50	8	2	69.07
Very stiff to stiff, brown **SILTY CLAY** - grey by 4.3m depth	7.77	SS	4	100		3	68.07
		SS	5	50		4	67.07
		SS	6	100	1	5	66.07
		SS	7	100	1	6	65.07
						7	64.07
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders	9.75	SS	8	58	8	8	63.07
		SS	9	25	9	9	62.07
End of Borehole (GWL @ 3.0m depth based on field observations)							



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-463 Gladstone Avenue
Ottawa, Ontario

DATUM Top spindle of fire hydrant, along Florence Street, in front of subject site. Geodetic elevation = 71.75m, as provided by Tega Homes.

REMARKS

BORINGS BY CME 75 Power Auger

DATE 20 January 2010

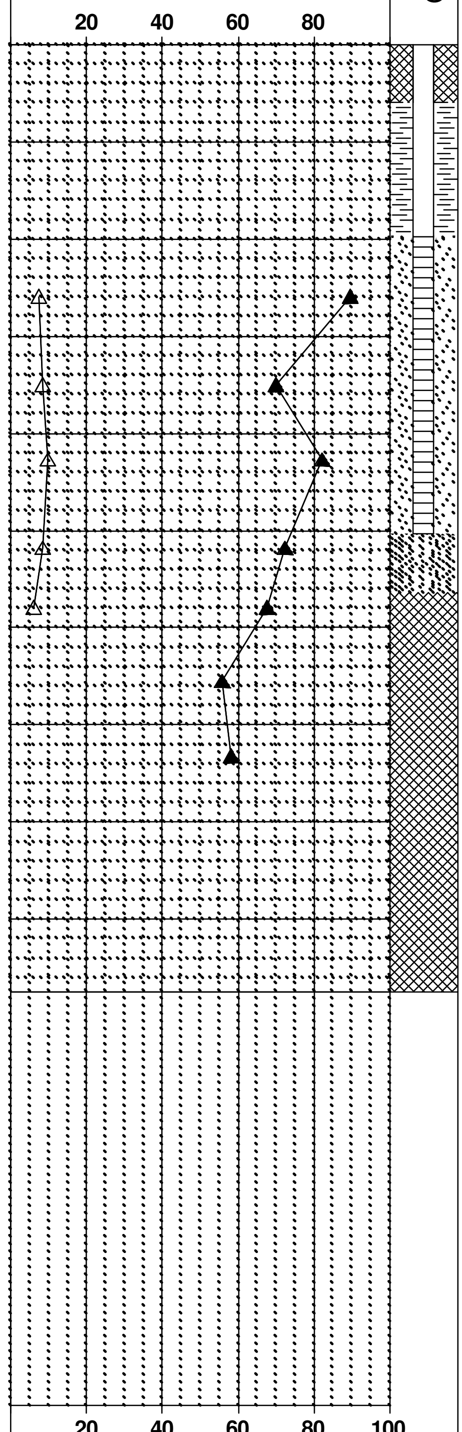
FILE NO. PG2033

HOLE NO. BH 3-10

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
25mm Asphaltic concrete over brown silty sand with crushed stone **FILL**	0.23	AU	1		
FILL: Red-brown silty sand		SS	2	33	5
	1.83	SS	3	50	4
Stiff, brown **SILTY CLAY** - grey by 3.0m depth		SS	4	100	
		SS	5	100	
		SS	6	100	
		SS	7	100	
	8.08	SS	8	100	
Grey **SILTY CLAY** intermittent with sand seams	9.45	SS	9	83	3
GLACIAL TILL: Grey silty sand with clay, gravel, cobbles and boulders	9.75	SS	10		5
End of Borehole					

DEPTH (m)	ELEV. (m)
0	71.10
1	70.10
2	69.10
3	68.10
4	67.10
5	66.10
6	65.10
7	64.10
8	63.10
9	62.10

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-463 Gladstone Avenue
Ottawa, Ontario

DATUM Top spindle of fire hydrant, along Florence Street, in front of subject site. Geodetic elevation = 71.75m, as provided by Tega Homes.

REMARKS

BORINGS BY CME 75 Power Auger

DATE 21 January 2010

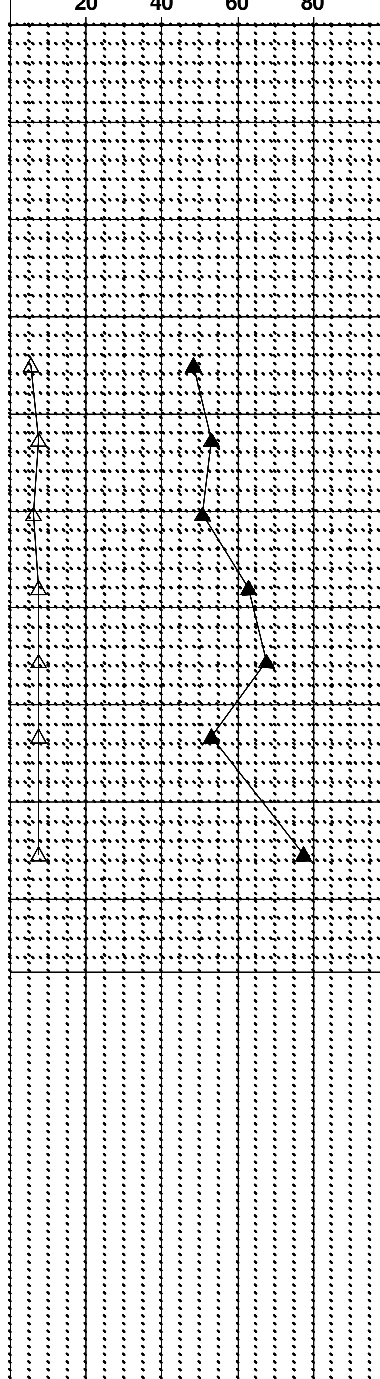
FILE NO. PG2033

HOLE NO. BH 4-10

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	70.53
Asphaltic concrete	0.08	AU	1				
FILL: Grey silty sand with crushed stone	0.30 / 0.84	SS	2	29	50+	1	69.53
FILL: Brown silty sand, trace gravel and asphalt							
FILL: Brown silty sand with gravel and cobbles	1.96	SS	3	17	23	2	68.53
Firm, brown **SILTY CLAY**	2.44	SS	4	100	1		
Stiff, grey **SILTY CLAY**		SS	5	100		3	67.53
		SS	6	100		4	66.53
		SS	7	100		5	65.53
		SS	8	100		6	64.53
						7	63.53
	8.69					8	62.53
Grey **SILTY CLAY** intermittent with sand seams	9.45					9	61.53
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boudlers	9.75	SS	9	75	14		
End of Borehole							
(GWL @ 2.4m depth based on field observations)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %

Piezometer Construction



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

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-463 Gladstone Avenue
Ottawa, Ontario

DATUM Top spindle of fire hydrant, along Florence Street, in front of subject site. Geodetic elevation = 71.75m, as provided by Tega Homes.

REMARKS

BORINGS BY CME 75 Power Auger **DATE** 21 January 2010

FILE NO. PG2033

HOLE NO. BH 5-10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE									
Asphaltic concrete 0.05		AU	1			0	70.76		
FILL: Grey-brown silty sand with crushed stone 0.28									
FILL: Brown silty sand, some gravel, cobbles and boulders 1.52		SS	2	36	50+	1	69.76		
FILL: Topsoil, trace glass, sand, gravel and cobbles 1.83		SS	3	25	50+				
Stiff, brown **SILTY CLAY**						2	68.76		
- grey by 2.7m depth		SS	4	100	5				
		SS	5	100	1	3	67.76		
		SS	6	100	2	4	66.76		
5.18		SS	7	0	7	5	65.76		
End of Borehole									

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

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

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

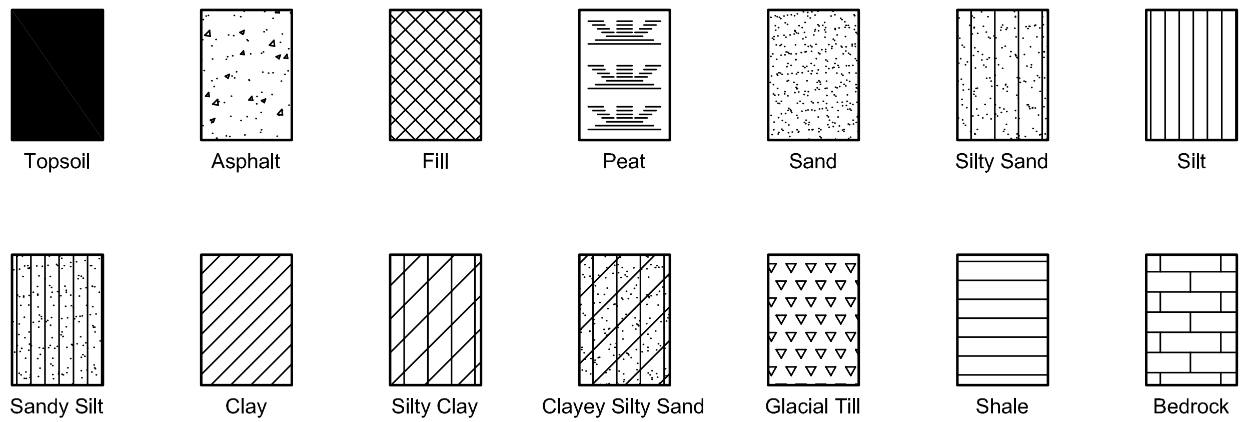
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void 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.

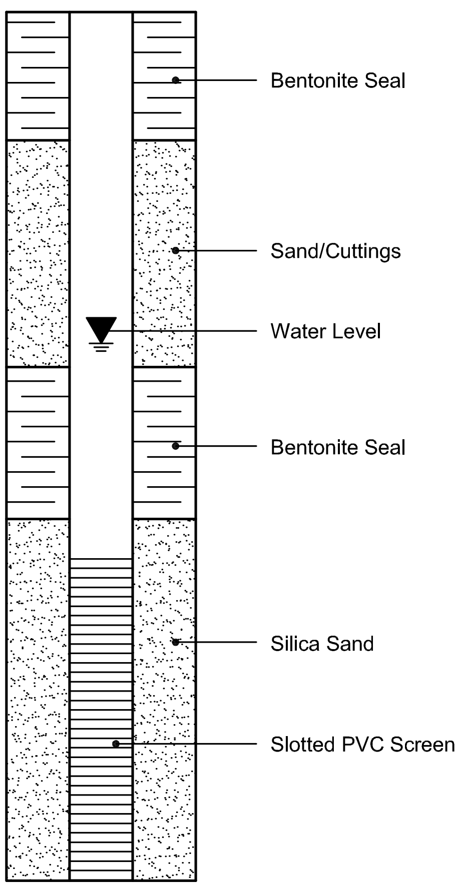
SYMBOLS AND TERMS (continued)

STRATA PLOT

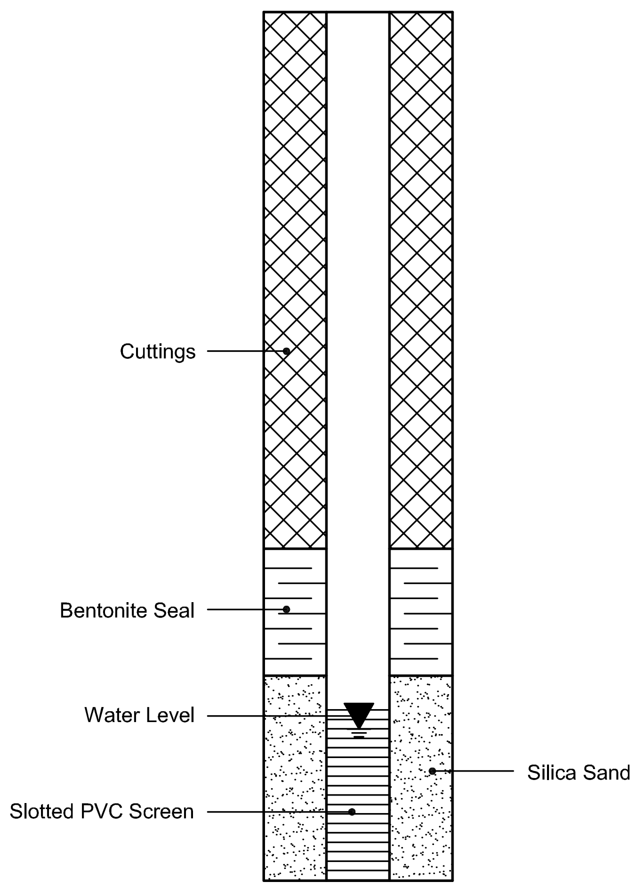


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



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Certificate of Analysis

Paterson Group Consulting Engineers

154 Colonnade Road South
Nepean, ON K2E 7J5
Attn: Nathan Christie

Client PO: 23556
Project: PG4397
Custody: 115552

Report Date: 5-Mar-2018
Order Date: 27-Feb-2018

Order #: 1809229

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1809229-01	BH2 SS3

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	2-Mar-18	5-Mar-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	28-Feb-18	28-Feb-18
Resistivity	EPA 120.1 - probe, water extraction	3-Mar-18	5-Mar-18
Solids, %	Gravimetric, calculation	1-Mar-18	1-Mar-18

Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 23556

Report Date: 05-Mar-2018

Order Date: 27-Feb-2018

Project Description: PG4397

	Client ID:	BH2 SS3	-	-	-
	Sample Date:	13-Feb-18	-	-	-
	Sample ID:	1809229-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	92.6	-	-	-
General Inorganics					
pH	0.05 pH Units	7.30	-	-	-
Resistivity	0.10 Ohm.m	109	-	-	-
Anions					
Chloride	5 ug/g dry	25	-	-	-
Sulphate	5 ug/g dry	21	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	16.9	5	ug/g dry	17.6			3.9	20	
Sulphate	17.2	5	ug/g dry	19.6			13.1	20	
General Inorganics									
pH	5.18	0.05	pH Units	5.18			0.0	10	
Resistivity	19.4	0.10	Ohm.m	19.6			1.0	20	
Physical Characteristics									
% Solids	91.2	0.1	% by Wt.	89.4			2.0	25	

Certificate of Analysis
Client: Paterson Group Consulting Engineers
Client PO: 23556

Report Date: 05-Mar-2018
Order Date: 27-Feb-2018
Project Description: PG4397

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	113	5	ug/g	17.6	95.8	78-113			
Sulphate	123	5	ug/g	19.6	103	78-111			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Nº 115552

Page __ of __

Client Name: Paterson	Project Reference: PG4397
Contact Name: Nathan Christie	Quote #
Address: 154 Colonnade Rd. Ottawa, ON	PO # 23556
Telephone:	Email Address: nchristie@patersongroup.ca

Turnaround Time:

☐ 1 Day ☐ 3 Day

☐ 2 Day ☑ Regular

Date Required: ______

Criteria: ☐ O. Reg. 153/04 (As Amended) Table __ ☐ RSC Filing ☐ O. Reg. 558/00 ☐ PWQO ☐ CCME ☐ SUB (Storm) ☐ SUB (Sanitary) Municipality: ______ ☐ Other: ______

Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Water) SS (Storm/Sanitary Sewer) P (Paint) A (Air) O (Other)

Paracel Order Number: 1809229

Required Analyses

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken Date	Sample Taken Time	PHCs F1-F4+BTEX	VOCs	PAHs	Metals by ICP	Hg	CrVI	B (HWS)	Chloride	Sulphate	pH	Resistivity		
1	BH2 SS3	S		1	Feb.18/18									✓	✓	✓	✓		250mL
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

Comments:

Method of Delivery: Paracel.

Relinquished By (Sign):	Received by Driver/Depot: M. Jeouse	Received at Lab: Rachel Subject	Verified By:
Relinquished By (Print):	Date/Time: 27/02/18 4:05 PM.	Date/Time: Feb 27/18 4:47	Date/Time: 022818 5:06pm
Date/Time:	Temperature: °C	Temperature: 18.4 °C	pH Verified [ ] By:

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG4397-1 - TEST HOLE LOCATION PLAN

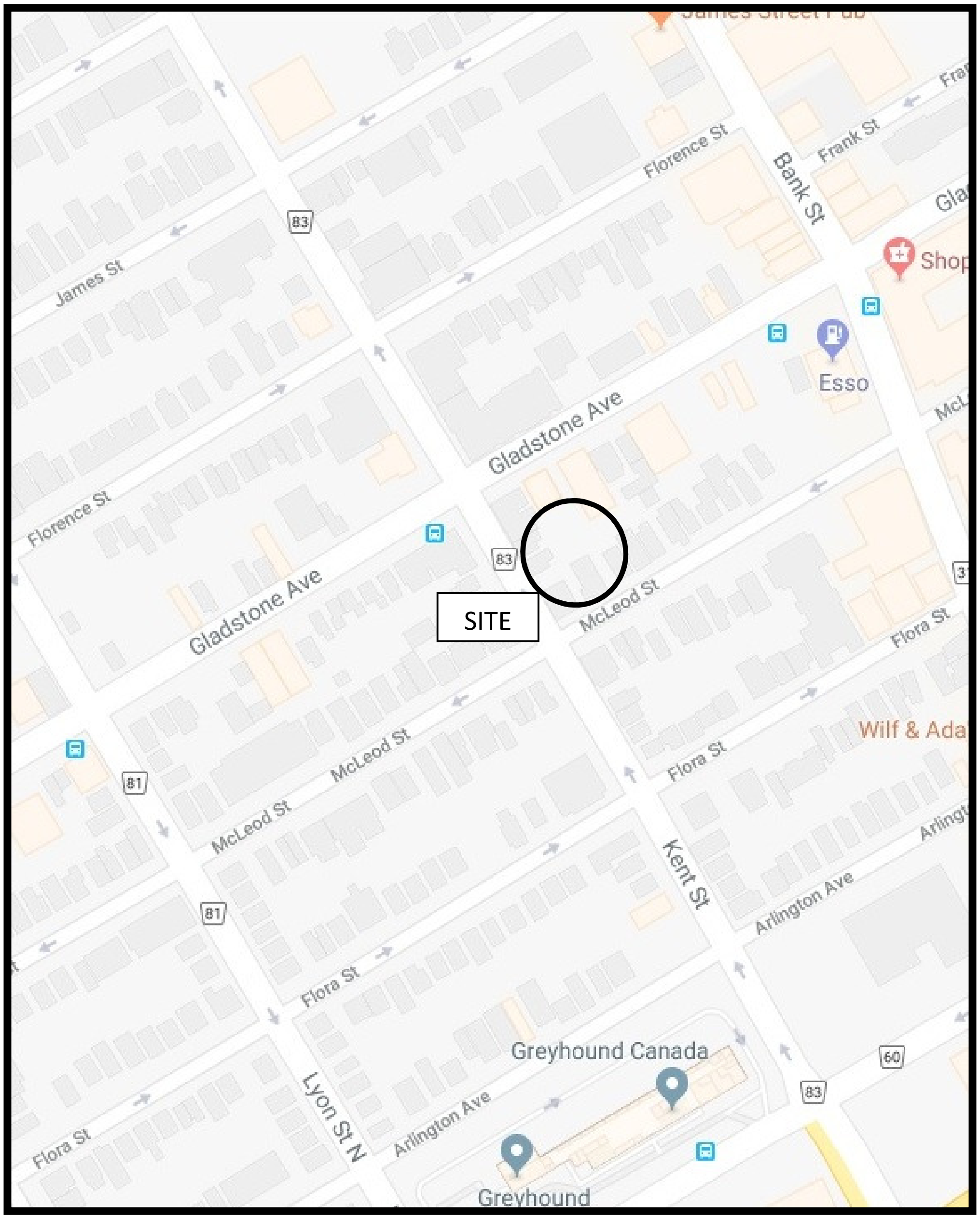
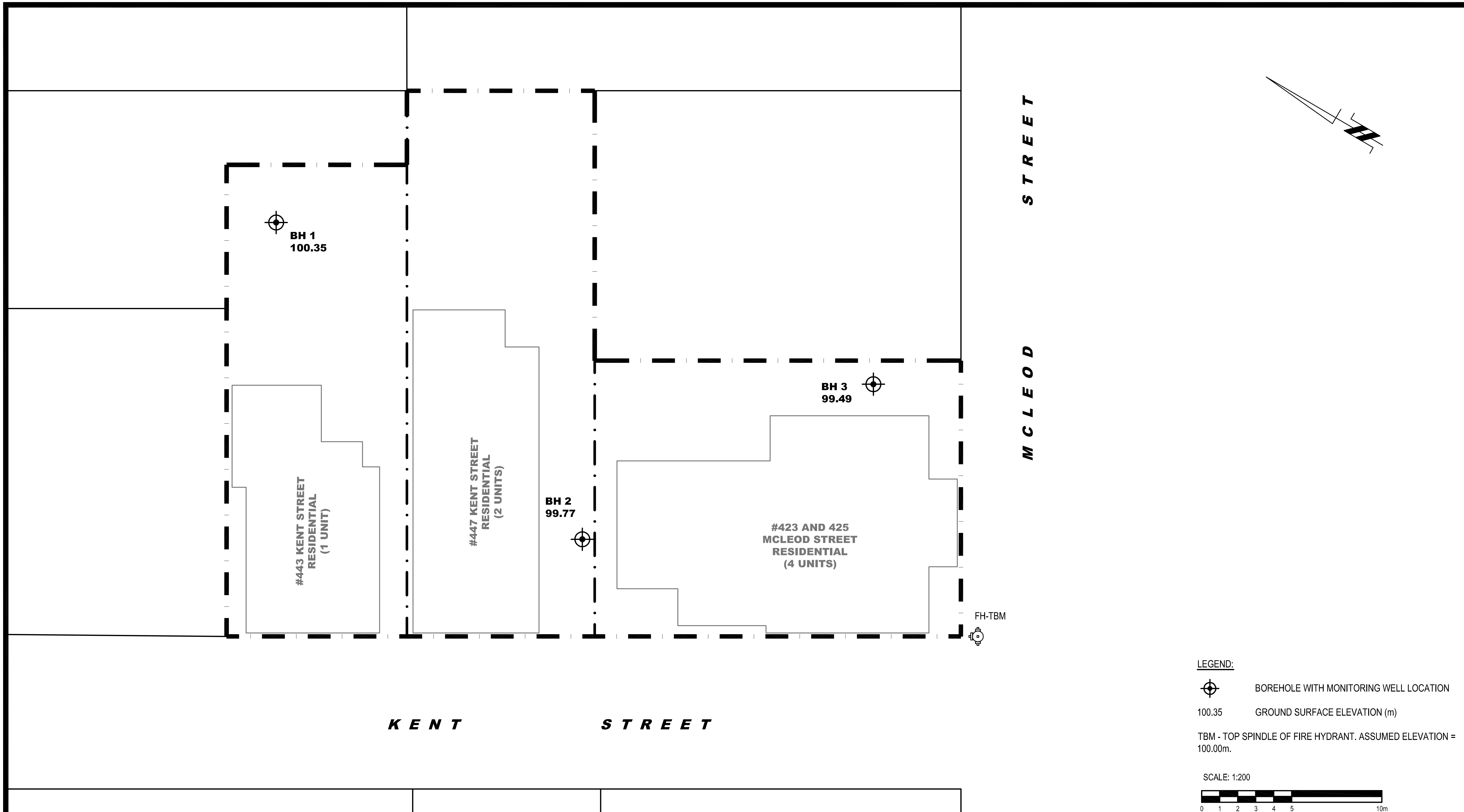


FIGURE 1

KEY PLAN

patersongroup



patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
0			

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GEOTECHNICAL INVESTIGATION
443 & 447 KENT STREET AND 423 & 425 MCLEOD STREET

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:200	Date: 03/2018
Drawn by: MPG	Report No.: PG4397-1
Checked by: MB	Dwg. No.: PG4397-1
Approved by: MSD	Revision No.: 0

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