Geotechnical Engineering

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Geotechnical Investigation

Proposed Multi-Storey Buildings
Norberry Crescent
Ottawa, Ontario

Prepared For

Greatwise Developments

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Report PG4834-1

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1.0 Introduction

Paterson Group (Paterson) was commissioned by Greatwise Developments to conduct a geotechnical investigation for the proposed multi-storey residential development to be located at Norberry Crescent in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the current investigation were to:

❏ Determine the subsurface conditions by means of boreholes.

❏ Provide geotechnical recommendations pertaining to 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. The report contains Paterson's findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

2.0 Proposed Development

Based on the available drawings, it is our understanding that the proposed development will consist of three, four (4) storey residential slab-on-grade buildings along with associated at-grade parking areas, access lanes, and landscaped areas. It is anticipated that the proposed development will be municipally serviced.

3.0 Method of Investigation

3.1 Field Investigation

The field program for the current investigation was completed on February 25 and 26, 2019. At that time, nine (9) boreholes were advanced to a maximum depth of 6.8 m below existing grade. The borehole locations were distributed in a manner to provide general coverage of the proposed development taking into consideration existing site features. The locations of the boreholes are shown on Drawing PG4834-1 - Test Hole Location Plan included in Appendix 2.

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

Sampling and In-situ Testing

Soil samples were recovered with a 50 mm diameter split-spoon sample or from the auger flights. The split-spoon and auger samples were classified on site and placed in sealed plastic bags. All samples were transported to Paterson's laboratory. The depths at which the split-spoon and auger samples were recovered from the boreholes are presented 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.

Overburden thickness was also evaluated during the course of the investigation by dynamic cone penetration testing (DCPT) at BH 4. 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 increment.

Undrained shear strength tests were conducted in cohesive soils with a field vane apparatus.

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

Groundwater

Flexible polyethylene standpipes were installed in a number of boreholes to permit monitoring of the groundwater levels subsequent to the completion of the current sampling program. The groundwater observations are discussed in Subsection 4.3 and presented in the Soil Profile and Test Data Sheets in Appendix 1.

3.2 Field Survey

The boreholes completed during the field investigation were selected in the field and surveyed by Paterson personnel. The ground surface elevations at the borehole locations were referenced to a temporary benchmark (TBM), consisting of a catch basin cover located within the eastern parking area adjacent to 840 Springland Drive. An arbitrary elevation of 100.00 m was assigned to the TBM. The locations of the boreholes and the ground surface elevation at each borehole location are presented on Drawing PG4834-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

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

3.4 Analytical Testing

One (1) soil sample was submitted for analytical testing to assess the potential for exposed ferrous metals and the sulphate potential against subsurface concrete structures. The results are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

The subject site is presently occupied by four existing multi-storey residential buildings, a parking structure with one level of above-grade parking situated between the existing building at 660 Norberry Crescent and Norberry Crescent, a central slab-on-grade recreational building, accompanying access lanes and at-grade parking.

The ground surface across the subject site is relatively flat and at grade with Norberry Crescent and Springland Drive. The majority of the site is surfaced with asphalt parking areas and grass/tree covered landscaped areas. The subject site is bordered by Norberry Crescent along the south and east, and Springland Drive along the north and west borders.

4.2 Subsurface Profile

Overburden

The subsurface profile at the borehole locations consists of asphaltic concrete followed by a silty sand with gravel fill overlying a hard to stiff silty clay crust and a grey, very stiff to firm silty clay deposit. Glacial till was encountered below the above noted layers consisting of dense to compact silty clay with sand to sandy silt with clay, gravel, cobbles and boulders.

Practical refusal to augering on inferred bedrock was encountered in BH 2 to BH 5 and BH 8 at depths ranging between 5.3 to 7.0 m. Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets provided in Appendix 1.

Bedrock

Based on available geological mapping, the subject site is located in an area where the bedrock consists of limestone of the Bobcaygeon Formation. The overburden drift thickness is anticipated to be between 5 to 10 m in depth.

Atterberg Limit Testing

A total of 4 atterberg limit tests, as well as associated moisture content tests, were completed on the recovered silty clay samples at selected locations throughout the subject site. The results of the Atterberg limits tests are presented in Table 1 and on the Atterberg Limits Results sheet in Appendix 1. The tested silty clay samples classify as inorganic clay of low plasticity (CL), inorganic clay of high plasticity (CH) and inorganic clay and silt of low plasticity (CL-ML) in accordance with the Unified Soil Classification System.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)	Classification
BH 1	1.5	44	18.0	26	18.2	CL
BH 2	0.75	26	15	11	14.9	CL
BH 4	2.3	53	18	35	18.1	CH
BH 5	0.75	22	15	6	15.2	CL-ML

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

Shrinkage Testing

The results of the shrinkage limit test indicate a shrinkage limit of 18% and a shrinkage ratio of 1.92.

4.3 Groundwater

Groundwater levels were measured in the piezometers at the borehole locations on March 5, 2019. The measured groundwater level (GWL) readings are presented in Table 2 below.

Table 2 - Groundwater Measurements at Monitoring Well Locations

Test Hole Location	Ground Surface Elevation (m)	GW Level Reading (m)	GW Level Elev. (m)
BH 1	100.13	2.04	98.09
BH 2	99.99	1.31	98.68
BH 3	100.05	BLOCKED	n/a
BH 4	99.56	3.33	96.23
BH 5	100.30	BLOCKED	n/a
BH 6	100.20	1.15	99.05
BH 7	100.12	1.69	98.43
BH 8	100.64	1.75	98.89
BH 9	100.87	1.30	99.57

It should be noted that groundwater measurements can be influenced by surface water infiltrating the backfilled boreholes and moisture perched within the silty clay deposit. The long-term groundwater table can also be estimated based on consistency, moisture levels and colour of the recovered soil samples. Based on our field observations and experience with the local area, it is expected that the long-term groundwater level will be at a depth ranging between 2.5 to 3.5 m below existing grade. It should be noted that the groundwater level is subject to seasonal fluctuations. Therefore, groundwater could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed development. The proposed multi-storey buildings are anticipated to be founded on shallow footings placed on an undisturbed hard to stiff brown to grey silty clay, glacial till, or engineered fill placed over an undisturbed bearing medium.

Due to the presence of a sensitive silty clay layer at the site, the proposed development will be subjected to grade raise restrictions. Permissible grade raise recommendations are discussed in Subsection 5.3.

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 under the proposed building, paved areas, pipe bedding and other settlement sensitive structures.

Consideration could be given to leaving the existing fill free of significant amounts of deleterious fill and other construction remnants under the proposed buildings floor slabs outside the lateral support of the proposed footings. However, it is recommended that the existing fill for the slab-on-grade be approved by the geotechnical consultant at the time of construction. It is recommended that the existing fill be proof-rolled using an adequate compaction equipment making several passes. Any poor performance areas should be sub-excavated and replaced with OPSS Granular A crushed stone or Granular B Type II and compacted to 98% of the material's SPMDD.

Fill Placement

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

Non-specified existing fill along with site-excavated soil can be placed as general landscaping fill where surface settlement is a minor concern. The backfill materials should be spread in thin lifts and at a minimum compacted by the tracks of the spreading equipment to minimize voids. If the non-specified backfill is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of the material's SPMDD. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

5.3 Foundation Design

Shallow Foundation

Footings placed on an undisturbed, hard to stiff brown silty clay bearing surface or compact glacial till 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 **250 kPa**. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance value at ULS. Footings founded on engineered fill placed on undisturbed bearing medium can be designed using the above noted bearing resistance values.

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.

Settlement

Footings designed using the bearing resistance value at SLS provided herein 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 be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to the in-situ bearing medium soils above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil.

Permissible Grade Raise

Based on the existing borehole coverage and results of the undrained shear strength testing completed within the underlying cohesive soils, a permissible grade raise restriction of **1.0 m** is provided for design purposes for the subject site.

5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class C** for the foundations considered at this site. The soils underlying the subject site are not susceptible to liquefaction. Refer to the latest revision of the Ontario Building Code for a full discussion of the earthquake design requirements.

5.5 Slab-on-Grade Construction

With the removal of topsoil and deleterious fill, such as those containing organic materials, within the footprint of the proposed building, the native soil or approved fill is 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 A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab.

It is recommended that the upper 200 mm of sub-floor fill consist of Granular A crushed stone. All backfill materials within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

5.6 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of car only parking areas, access lanes and heavy truck parking.

Table 3 - Recommended Flexible Pavement Structure - 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, OPSS Granular B Type II material placed over in situ soil or fill	

Table 4 - Recommended Flexible 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
300	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill 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 100% of the material's SPMDD.

Pavement Structure Drainage

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

Due to the impervious nature of the subgrade materials consideration should be provided to installing subdrains during the pavement construction. The subdrains should extend in four orthogonal directions and longitudinally when placed along a curb. The clear crushed stone surrounding the drainage lines or the pipe, should be wrapped with suitable filter cloth. The subdrain inverts should be shaped to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

A perimeter foundation drainage system is optional for the proposed structures. However, it is still recommended that a perimeter foundation system be used where structures susceptible to frost heave such as sidewalks, are proposed within the perimeter of the proposed building. The system should consist of a 100 to 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 19 mm clear stone, placed at the footing level around the exterior perimeter of the structure. The clear stone or the pipe itself should be wrapped in a non-woven geotextile. 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 are not recommended for re-use as backfill against the foundation walls unless used in conjunction with a composite drainage system (such as Delta Drain 6000 or equivalent). Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for this purpose.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effects of frost action. A minimum of 1.5 m of soil cover alone, or a combination of soil cover and foundation insulation, should be provided. More details regarding foundation insulation can be provided, if requested.

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

The side slopes of excavations in the soil and fill overburden materials should either be excavated at acceptable slopes or should be 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 excavated at 1H:1V or shallower. Below the groundwater lever, flatter slopes, such as 3H:1V, could be required due to the presence of loose silty and/or sandy silt. The subsurface soils are considered to be a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects. The side slopes of excavations in bedrock can be cut quasi-vertically (i.e. 1H:10V).

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

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

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.

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

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

6.5 Groundwater Control

It is anticipated that groundwater infilitration into the excavations should be 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 Environment, Conservation and Parks (MECP) permit to take water (PTTW) may be required if more than 400,000 L/day are 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.

For typical ground or surface water volumes being pumped during the construction phase, typically 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 MECP review of the PTTW application.

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.

6.7 Corrosion Potential and Sulphate

The results on analytical testing show that the sulphate content is less than 0.1%. The results are indicative that Type 10 Portland Cement (Type GU) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity in indicative of a moderate to very aggressive corrosive environment.

6.8 Landscaping Considerations

Tree Planting Restrictions

In accordance with the City of Ottawa Tree Planting in Sensitive Marine Clay Soils (2017 Guidelines), Paterson completed a soils review of the site to determine applicable tree planting setbacks. Atterberg limits testing was completed for recovered silty clay samples at selected locations within the north portion of the subject site. Sieve analysis testing was also completed on selected soil samples. The above noted soil samples were recovered from elevations below the anticipated design underside of footing elevation and 3.5 m depth below anticipated finished grade. The results of our testing are presented in Subsection 4.2 and in Appendix 1.

Area 1 - Glacial Till (Building B)

No tree planting restrictions are required for the subject area (Building B) due to the absence of a silty clay deposit within the future location of the proposed residential building (southwest portion of the site).

Area 2 - Low to Medium Sensitivity Area (Buildings A and C)

A low to medium sensitivity clay soil was encountered across the remainder of the subject site. Based on our Atterberg Limits test results, the modified plasticity limit does not exceed 40% in all the boreholes locations where silty clay was encountered. The following tree planting setbacks are recommended for the low to medium sensitivity area. Large trees (mature height over 14 m) can be planted within these areas provided a tree to foundation setback equal to the full mature height of the tree can be provided (e.g. in a park or other green space). Tree planting setback limits may be reduced to 4.5 m for small (mature tree height up to 7.5m) and medium size trees (mature tree height 7.5 m to 14 m) provided that the conditions noted below are met.

7.0 Recommendations

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

- ❑ Review of the grading plan from a geotechnical perspective.
- ❑ Observation of all bearing surfaces prior to the placement of concrete.
- ❑ Sampling and testing of the concrete and fill materials used.
- ❑ Periodic observation of the condition of unsupported excavation side slope 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 that these works have been conducted in general accordance with our recommendations could be issued, upon request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

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

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

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

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Greatwise Developments 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.

Drew Petahtegoose, EIT

Faisal Abou-Seido, P.Eng.

Report Distribution:

- ❏ Greatwise Developments (4 copies)
- ❏ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

ATTERBERG LIMIT TESTING RESULTS

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

REMARKS

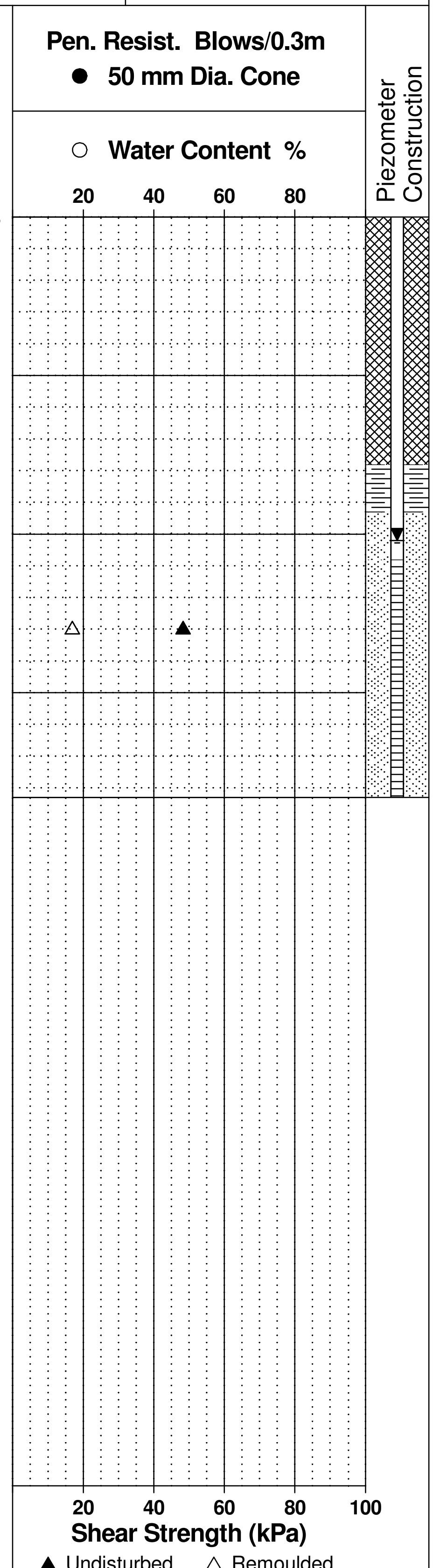
BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 1

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.13
Asphaltic concrete	0.08	AU	1				
FILL: Brown silty sand with gravel	1.37	SS	2	56	50+	1	99.13
Stiff, brown **SILTY CLAY** - firm and grey by 2.1m depth	3.05	SS	2	88	5	2	98.13
GLACIAL TILL: Loose, grey silty sand with clay and gravel	3.66	SS	3	54	8	3	97.13
End of Borehole (GWL @ 2.04m - March 5, 2019)							



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the

REMARKS TBM.

BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 2

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.99
Asphaltic concrete	0.08						
FILL: Brown silty sand with gravel	0.76	AU	1				
Compact, brown **SANDY SILT,** trace clay	1.37	SS	2		11	1	98.99
Very stiff, brown **SILTY CLAY** - grey by 2.1m depth	3.05					2	97.99
						3	96.99
GLACIAL TILL: Loose, grey silt with clay, gravel, cobbles and boulders		SS	3	67	3	4	95.99
		SS	4	79	6	5	94.99
	5.46	SS	5		50+		
End of Borehole							

Practical refusal to augering at 5.46m depth

(GWL @ 1.31m - March 5, 2019)

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

○ Water Content %

Shear strength values (undisturbed): 121 (approx. 1.7m), 112 (approx. 2.4m), 121 (approx. 3.2m)

Shear Strength (kPa): 20 40 60 80 100

▲ 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 Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the
REMARKS TBM.
BORINGS BY CME 55 Power Auger **DATE** February 25, 2019

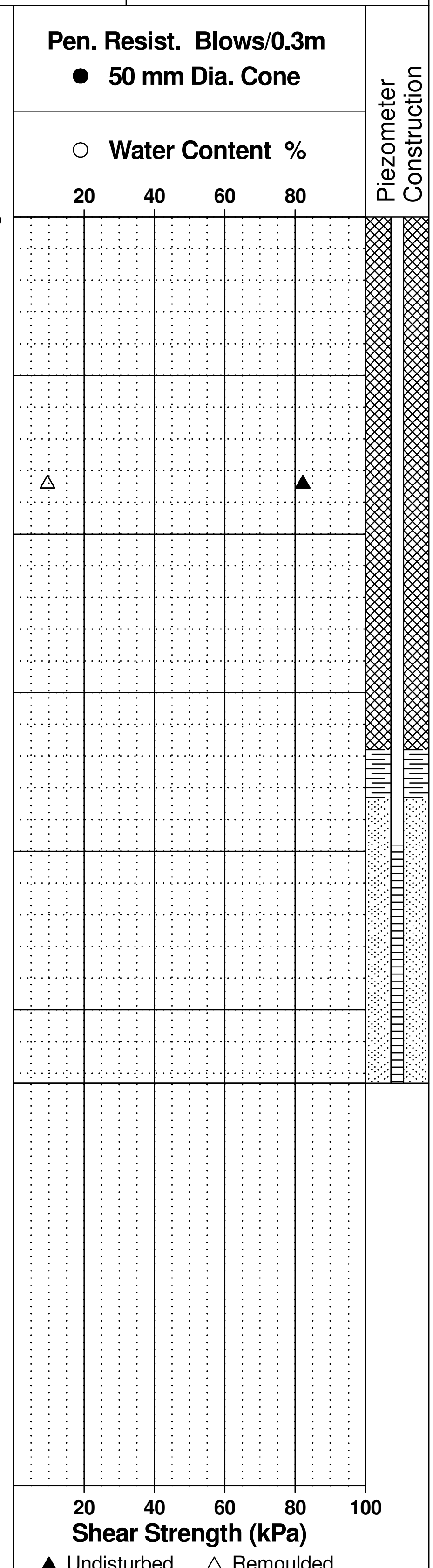
FILE NO. PG4834
HOLE NO. BH 3

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.05
Asphaltic concrete	0.08						
FILL: Brown silty sand with gravel and crushed stone	0.60	AU	1				
Stiff, brown **SILTY CLAY**	1.98	SS	2	75	11	1	99.05
GLACIAL TILL: Loose to compact, grey sandy silt with gravel, cobbles and boulders	5.46					2	98.05
		SS	3	54	13	3	97.05
		SS	4	33	8	4	96.05
		SS	5	46	11	5	95.05
		SS	6	0	50+		
		SS	7	100	50+		

End of Borehole

Practical refusal to augering at 5.46m depth

(Piezometer blocked at 0.50m depth - March 5, 2019)



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the

REMARKS TBM.

BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 4

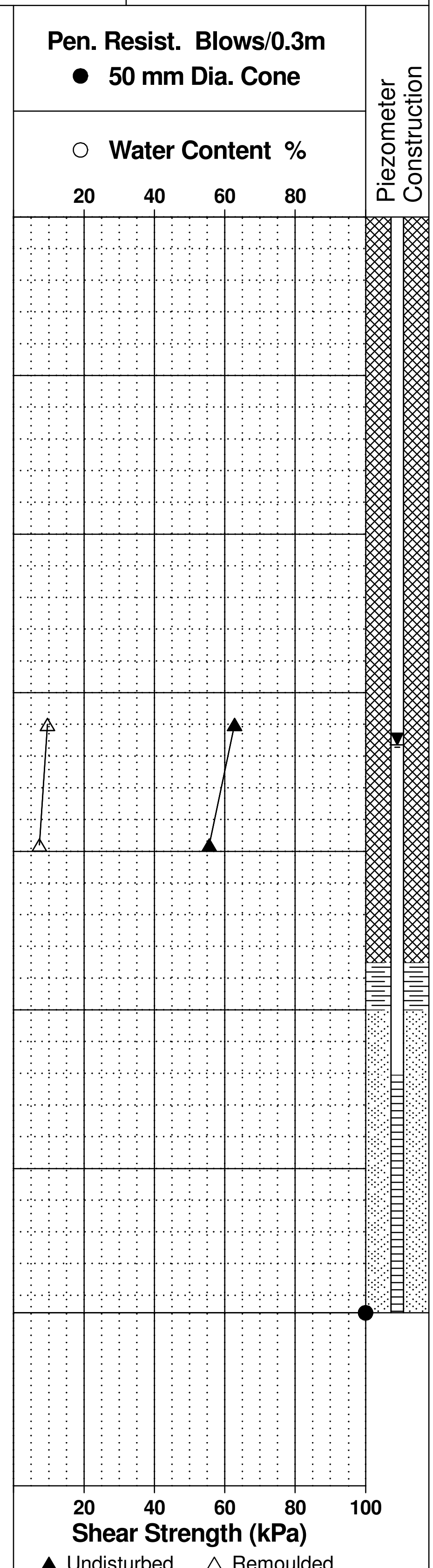
SOIL DESCRIPTION	Layer bottom (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.05				
Concrete	0.15	AU	1		
FILL: Brown silty sand with gravel	1.52	SS	2	72	50+
Compact to loose, brown **SILTY SAND,** with gravel, trace clay	2.44	SS	3		11
Stiff, grey **SILTY CLAY**	4.47	SS	4	71	4
GLACIAL TILL: Very loose, grey clayey silt with sand and gravel	6.70	SS	5		3
		SS	6		P
		SS	7		3
Dynamic Cone Penetration Test commenced at 6.70m depth.	6.91				

End of Borehole

Practical DCPT refusal at 6.91m depth

(GWL @ 3.33m - March 5, 2019)

DEPTH (m)	ELEV. (m)
0	99.56
1	98.56
2	97.56
3	96.56
4	95.56
5	94.56
6	93.56



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the

REMARKS TBM.

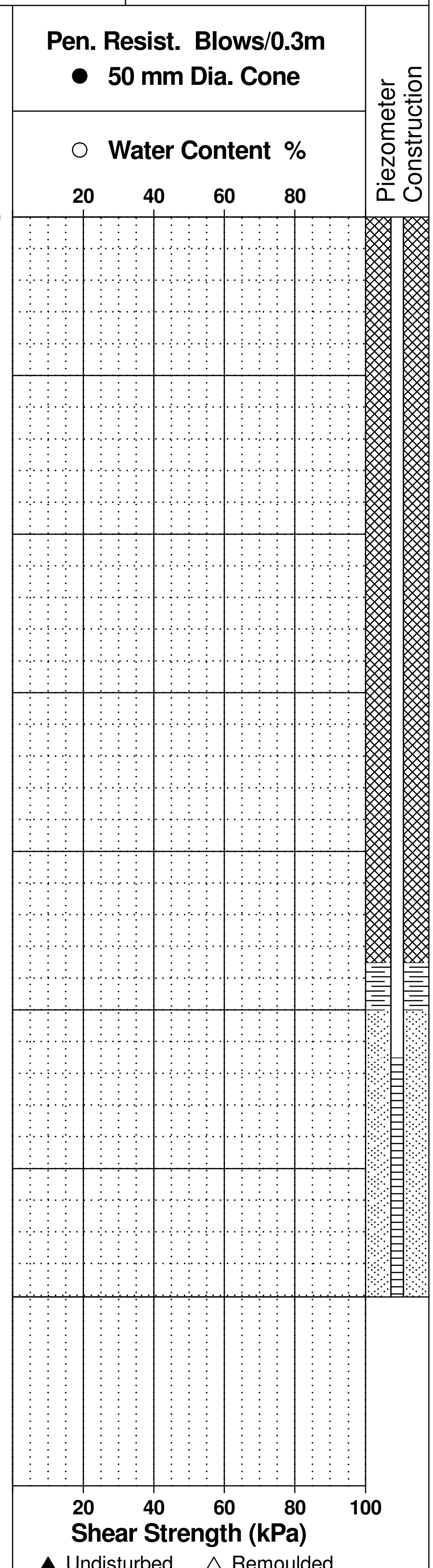
BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 5

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.30
Asphaltic concrete (0.08)							
FILL: Brown silty sand with gravel (1.07)		AU	1				
		SS	2	46	8	1	99.30
Very stiff to stiff, brown SILTY CLAY with sand - grey by 2.1m depth (3.35)		SS	3	67	10	2	98.30
		SS	4	50	10	3	97.30
		SS	5	67	10		
GLACIAL TILL: Loose to compact, grey sandy silt with gravel, cobbles and boulders (6.81)		SS	6	100	11	4	96.30
		SS	7	100	12	5	95.30
		SS	8	100	4	6	94.30
		SS	9	71	12		
End of Borehole Practical refusal to augering at 6.81m depth (Piezometer blocked - March 5, 2019)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

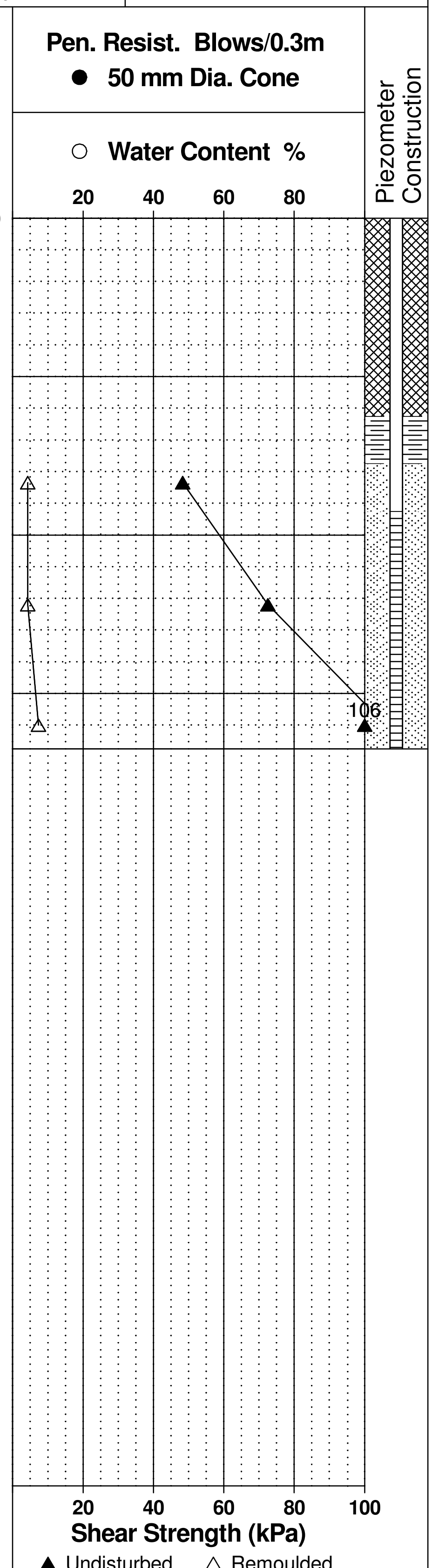
DATUM / **REMARKS** TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

FILE NO. PG4834

HOLE NO. BH 6

BORINGS BY CME 55 Power Auger **DATE** February 25, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.20
Asphaltic concrete (0.08)							
FILL: Brown silty sand with gravel (0.76)		AU	1				
Firm to stiff, brown **SILTY CLAY**		SS	2	62	11	1	99.20
- grey by 1.4m depth (3.35)						2	98.20
						3	97.20
End of Borehole							
(Piezometer blocked at 1.15m depth - March 5, 2019)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 7

SOIL DESCRIPTION	Depth to bottom (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.08				
FILL: Brown silty sand with gravel	1.37	AU	1		
		SS	2	67	58
Grey **SILTY CLAY**	1.88	SS	3	83	3
GLACIAL TILL: Loose, grey silty clay with sand, gravel, cobbles and boulders	3.66	SS	4	75	7
		SS	5	29	10
End of Borehole					
(GWL @ 1.69m - March 5, 2019)					

DEPTH (m)	ELEV. (m)
0	100.12
1	99.12
2	98.12
3	97.12

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the

REMARKS TBM.

BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 8

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.64
Asphaltic concrete	0.08						
FILL: Brown silty sand with gravel	1.37	AU	1				
		SS	2	50	50+	1	99.64
GLACIAL TILL: Loose to compact, brown silty clay with sand and gravel	6.70	SS	3	33	9	2	98.64
		SS	4	46	9		
		SS	5	75	8	3	97.64
		SS	6	50	11	4	96.64
		SS	7	33	5	5	95.64
		SS	8	29	13		
		SS	9	83	2	6	94.64
End of Borehole							
(GWL @ 1.75m - March 5, 2019)							

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

Piezometer Construction

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

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Multi-Storey Buildings - Norberry Crescent
Ottawa, Ontario

DATUM TBM - Top of catchbasin cover located within the eastern parking area, adjacent to 840 Springland Drive. An arbitrary elevation of 100.00m was assigned to the

REMARKS TBM.

BORINGS BY CME 55 Power Auger

DATE February 25, 2019

FILE NO. PG4834

HOLE NO. BH 9

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE 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						0	100.87		
Asphaltic concrete (0.08)									
FILL: Brown silty sand with gravel		AU	1						
		SS	2		50+	1	99.87		
(1.37)									
GLACIAL TILL: Loose, grey silty clay with sand and gravel		SS	3	38	10	2	98.87		
		SS	4	67	8				
		SS	5	33	7	3	97.87		
		SS	6	33	6	4	96.87		
		SS	7	50	7	5	95.87		
		SS	8	21	3	6	94.87		
		SS	9	50	7				
(6.70) End of Borehole									
(GWL @ 1.30m - March 5, 2019)									

Shear Strength (kPa) (20, 40, 60, 80, 100)

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

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

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

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

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

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

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

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

SYMBOLS AND TERMS (continued)

PLASTICITY LIMITS AND GRAIN SIZE DISTRIBUTION

WC%	-	Natural water content or water content of sample, %
LL	-	Liquid Limit, % (water content above which soil behaves as a liquid)
PL	-	Plastic Limit, % (water content above which soil behaves plastically)
PI	-	Plasticity Index, % (difference between LL and PL)
Dxx	-	Grain size at which xx% of the soil, by weight, is of finer grain sizes These grain size descriptions are not used below 0.075 mm grain size
D10	-	Grain size at which 10% of the soil is finer (effective grain size)
D60	-	Grain size at which 60% of the soil is finer
Cc	-	Concavity coefficient = $(D30)^2 / (D10 \times D60)$
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

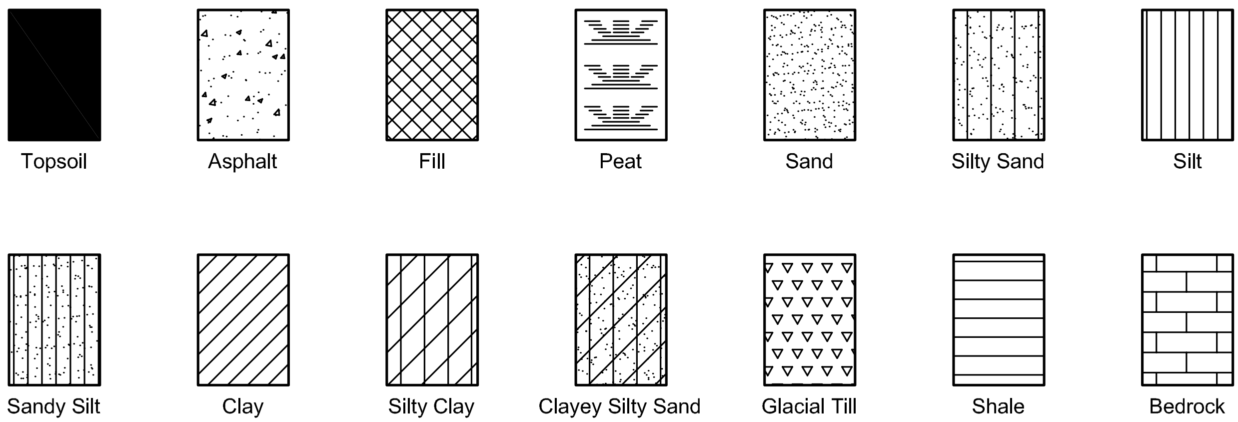
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void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

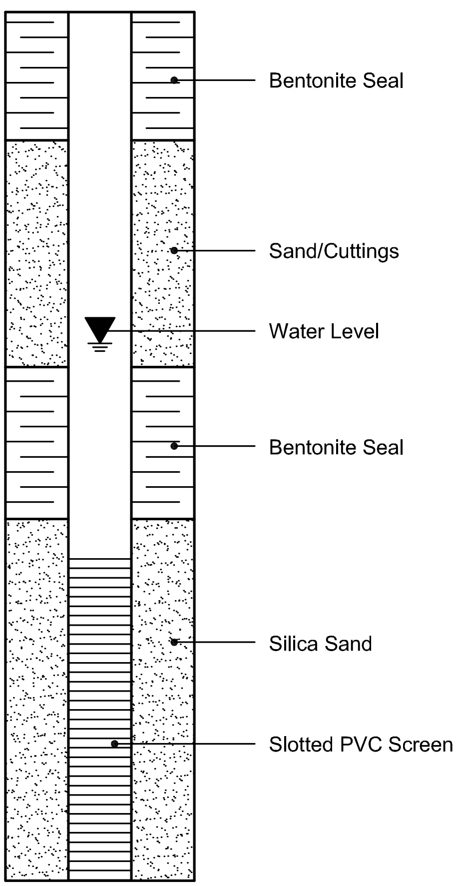
SYMBOLS AND TERMS (continued)

STRATA PLOT

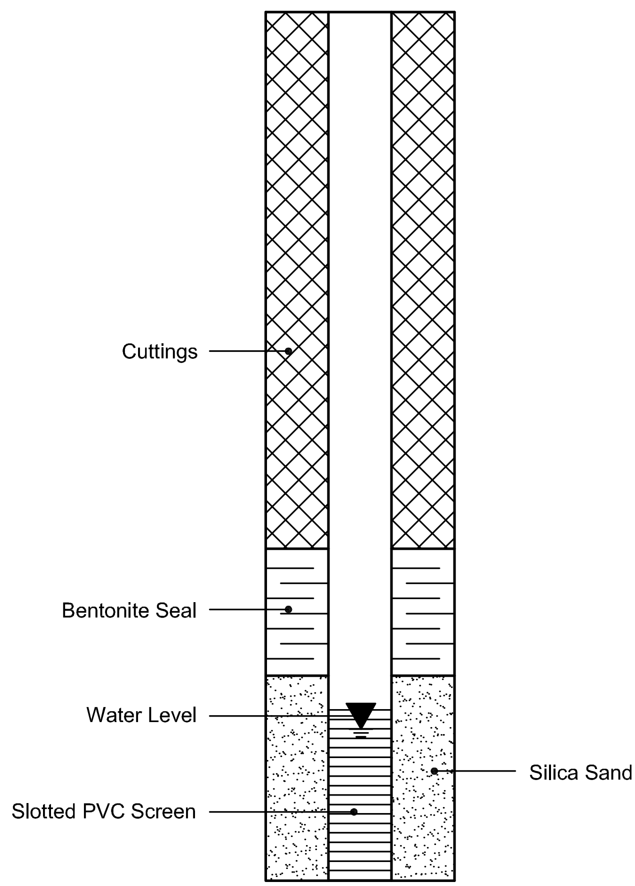


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: Paterson Group Consulting Engineers

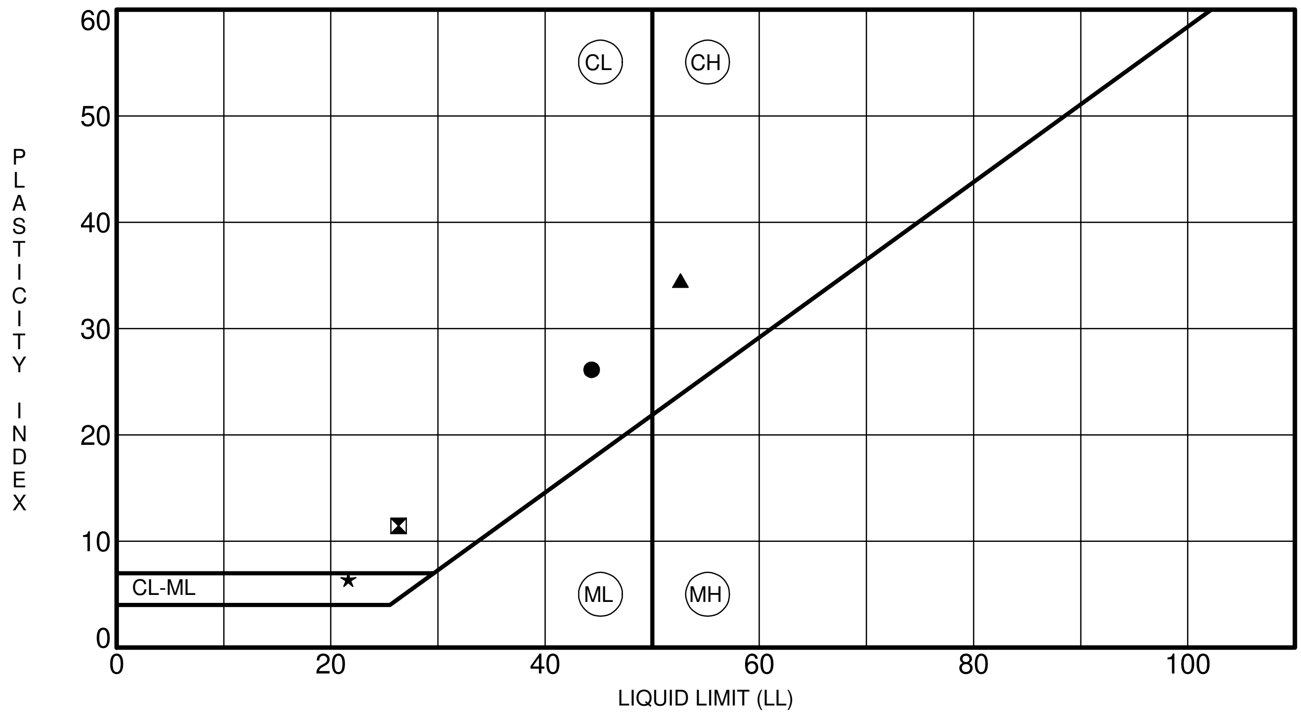
Client PO: 26036

Report Date: 01-Mar-2019

Order Date: 26-Feb-2019

Project Description: PG4834

	Client ID:	BH1 SS3	-	-	-
	Sample Date:	02/25/2019 13:00	-	-	-
	Sample ID:	1909218-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	76.0	-	-	-
General Inorganics					
pH	0.05 pH Units	7.70	-	-	-
Resistivity	0.10 Ohm.m	26.3	-	-	-
Anions					
Chloride	5 ug/g dry	83	-	-	-
Sulphate	5 ug/g dry	86	-	-	-



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 1**	**SS 3**	**44**	**18**	**26**		**CL - Inorganic clays of low plasticity**
⧗	**BH 2**	**SS 2**	**26**	**15**	**11**		**CL - Inorganic clays of low plasticity**
▲	**BH 4**	**SS 4**	**53**	**18**	**35**		**CH - Inorganic clays of high plasticity**
★	**BH 5**	**SS 2**	**22**	**15**	**6**		**CL-ML - Inorganic clay & silt with low plasticity**

CLIENT **Greatwise Developments**

FILE NO. **PG4834**

PROJECT **Geotechnical Investigation - Proposed Multi-Storey Buildings - Norberry Crescent**

DATE **25 Feb 19**

patersongroup **Consulting Engineers**

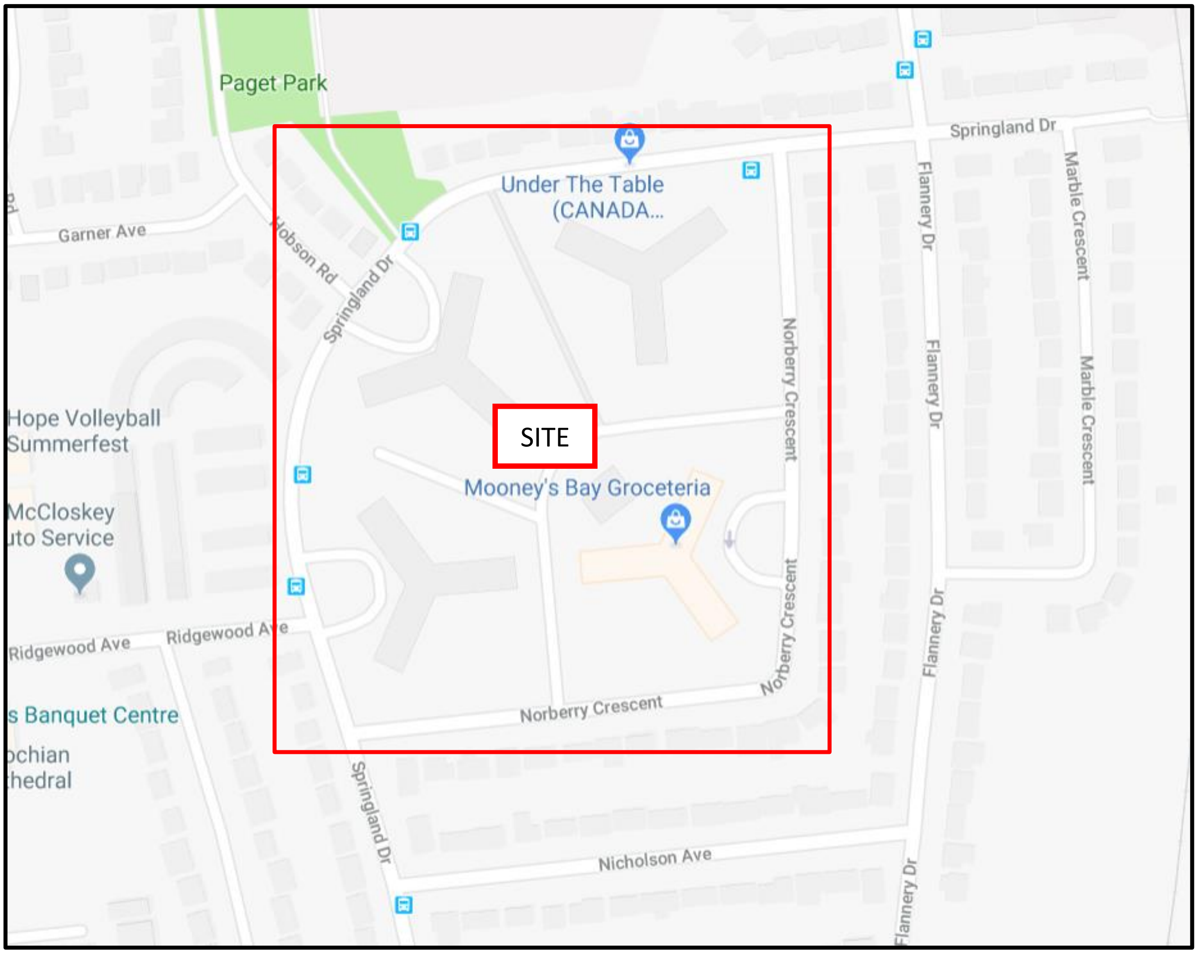
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS

APPENDIX 2

FIGURE 1 - KEY PLAN

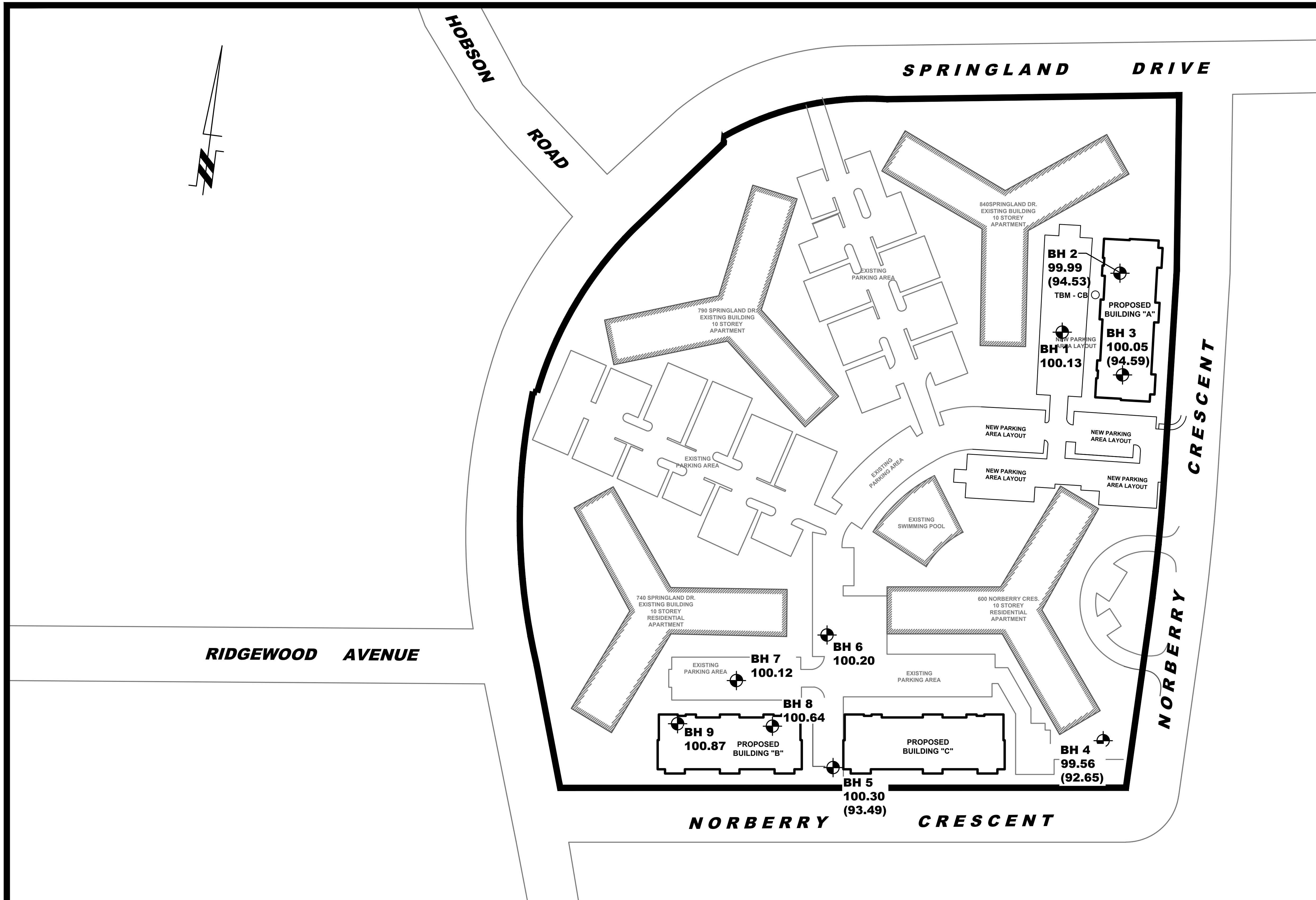
DRAWING PG4834-1 - TEST HOLE LOCATION PLAN



<u>FIGURE 1</u>

KEY PLAN

patersongroup



LEGEND:

⌖	BOREHOLE LOCATION
100.05	GROUND SURFACE ELEVATION (m)
(94.59)	PRACTICAL REFUSAL TO DCPT / AUGERING ELEVATION (m)

TBM - TOP OF CATCH BASIN COVER LOCATED WITHIN THE EASTERN PARKING AREA, ADJACENT TO 840 SPRINGLAND DRIVE. AN ARBITRARY ELEVATION OF 100.00m WAS ASSIGNED TO THE TBM

SCALE: 1:1500

0 25 50 75 100m

p:\autocad drawings\geotechnical\pg48xx\pg4834\pg4834-1 thlp.dwg

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NO.	REVISIONS	DATE	INITIAL

GREATWISE DEVELOPMENTS

GEOTECHNICAL INVESTIGATION
PROP. MULTI-STOREY BUILDINGS - NORBERRY CRESCENT

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1500	Date: 03/2019
Drawn by: MPG	Report No.: PG4834-1
Checked by: NC	**PG4834-1**
Approved by: DJG	Revision No.: