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July 2, 2015
File: PG3465-LET.01

Mr. Luca Diaconescu
34 Glencairn Avenue
Ottawa, Ontario
K1S 1N6

Subject: **Geotechnical Investigation**
Proposed Residential Building
559 Riverdale Avenue - Ottawa

Dear Sir,

Further to your request and authorization, Paterson Group (Paterson) conducted a geotechnical investigation for the proposed residential building to be located at the aforementioned site.

The proposed project is understood to consist of a three (3) storey building with one level underground parking and the associated landscaped areas. The project will also require the demolition of the existing building.

The following letter report presents our geotechnical recommendations pertaining to the design and construction of the proposed structure as they are understood at the time of writing this report.

1.0 Method of Investigation

Field Program

The field program for the current investigation took place on April 8 and April 24, 2015 and consisted of drilling three (3) boreholes to a maximum depth of 3.1 m with the use of a Geoprobe track drill, and drilling one (1) borehole to a maximum depth of 6 m with the use of a truck mounted drill rig, respectively. The location of the test holes are shown on Drawing PG3465-1 - Test Hole Location Plan attached to the present report.

The boreholes were placed in a manner to provide general coverage of the proposed building taking into consideration underground utilities and site features. 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.

2.0 Observations

Surface Conditions

The subject site is currently occupied by a residential building within the central portion of the subject site. The ground surface consists of a grassed area within the backyard of the existing building and asphaltic material within the front and the garage ramp area. The ground surface was noted to be relatively flat and at grade with Riverdale Avenue.

Subsurface Profile

The subsurface profile encountered at the borehole locations consists of topsoil or asphalt over a loose to very dense fill, consisting of silty sand with gravel, cobbles and boulders. A thin layer of silty clay mixed with sand, gravel and boulders was noted at a depth of 3.6 m. A very dense silty sand with gravel, cobbles, boulders, and trace clay was encountered below the above noted layers. Specific details at the test hole locations are presented in the Soil Profile and Test Data sheets attached to the present report.

Based on the available geological mapping, the subject site is located in an area where bedrock consists of shale of the Billings formation or interbedded limestone and shale of the Verulam formation. The overburden drift thickness is between 5 to 10 m depth in the area of the subject site.

Groundwater

A 32 mm diameter groundwater monitoring well was installed at BH 1A to monitor the groundwater level subsequent to the completion of the sampling program. In addition, two (2) flexible pipe piezometers were installed at BH 2 and BH 3.

Groundwater level readings were taken at the borehole locations on May 1, 2015. Our groundwater measurements are presented in the Soil Profile and Test Data sheets. It is important to note that groundwater level readings could be influenced by surface water infiltrating the backfilled borehole, which can lead to higher water levels than noted during the investigation. The long-term groundwater level can also be estimated based on moisture levels and colour of the recovered soil samples. Based on these observations at the borehole locations, the long-term groundwater level is expected at a 3 to 4 m depth.

3.0 Geotechnical Assessment

Geotechnical Assessment

From a geotechnical perspective, the subject site is satisfactory for the proposed residential building. The proposed building is expected to be founded over conventional shallow footings placed directly over very dense silty sand with gravel and cobbles.

It is recommended that footings for the proposed building be placed over an undisturbed, very dense silty sand with gravel and cobbles and/or existing fill bearing surface. Engineered fill may be required where existing fill is located below the proposed footing level. Consideration could be given to leaving the existing fill, free of significant amounts of deleterious materials, below the proposed building floor slab outside the lateral support zone of the proposed footing. However, it is recommended that the existing fill be approved by the geotechnical consultant at the time of construction once the subgrade is exposed. The approved existing fill material should be proof-rolled using suitable compaction equipment under dry conditions and above freezing temperatures and approved by Paterson personnel. Areas deemed poor performing should be removed and replaced with engineered fill.

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

Site Grading and Preparation

Asphalt, topsoil and deleterious fill, such as those containing organic materials and construction debris, should be stripped from under any buildings, paved areas and other settlement sensitive structures. Existing foundation walls and other construction debris should be entirely removed from within the building perimeter.

Fill used for grading beneath the proposed structure, unless otherwise specified, should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill should be tested and approved prior to delivery to the site. It 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 structure should be compacted to at least 98% of the standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of the SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless used in conjunction with a composite drainage system.

Foundation Design

Footings placed on an undisturbed, very dense silty sand with gravel and cobbles 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 above noted bearing resistance value at ULS.

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

The bearing resistance values 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 be provided with adequate lateral support with respect to excavations and different foundation levels. Above the groundwater level, adequate lateral support is provided to the very dense silty sand layer with gravel and cobbles or engineered fill 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.

Design for Earthquakes

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

Basement Slab

With the removal of all topsoil and fill, containing deleterious or organic materials and/or construction debris, the native soil or existing granular fill approved by the geotechnical consultant at the time of construction will be considered to be an acceptable subgrade surface on which to commence backfilling for slab on grade construction. Any soft areas should be removed and backfilled with appropriate backfill material. OPSS 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 150 to 200 mm of sub-floor fill consist of 19 mm clear 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.

Pavement Structure

Car only parking areas are anticipated at this site. The proposed pavement structure is presented in Table 1.

Table 1 - Recommended Pavement Structure - Car Only Parking

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 in situ soil, fill or OPSS Granular B Type 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 SPMDD using suitable compaction equipment.

Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed structure. The system should consist of a 100 mm to 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 10 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.

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for this purpose. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls unless a composite drainage system, such as System Platon or Miradrain, connected to a perimeter drainage system is provided.

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 should be provided in this regard.

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

Excavation Side Slopes

The side slopes of excavations in the soil and fill overburden materials should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods (i.e. unsupported excavations).

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 at this site is considered to be mainly 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 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.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by “cut and cover” methods and excavations will not be left open for extended periods of time.

Groundwater Control

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

A temporary MOE permit to take water (PTTW) may be required for this project if more than 50,000 L/day is 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 MOE.

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

Winter Construction

Precautions must be taken if winter construction is considered for this project. The subsurface soil conditions at this site consist of frost susceptible materials. In the presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

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

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

4.0 Recommendations

It is a requirement for the design data provided herein to be applicable that an acceptable materials testing and observation program, including the aspects shown below, be performed by the geotechnical consultant.

- ❑ Review detailed grading plan(s) 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 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.

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

5.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. Our recommendations should be reviewed when the project drawings and specifications are complete.

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 that we be notified immediately in order to permit reassessment of our recommendations.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Mr. Luca Diaconescu, or their agents, without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Faisal I. Abou-Seido, P.Eng.

David J. Gilbert, P.Eng.

Attachments

- ❏ Soil Profile and Test Data sheet
- ❏ Figure 1 - Key Plan
- ❏ PG3465-1 - Test Hole Location Plan

Report Distribution

- ❏ Mr. Luca Diaconescu (3 Copies)
- ❏ Paterson Group (1 Copy)

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
559 Riverdale Avenue
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on west side of Riverdale Avenue, across 565 Riverdale Avenue. Geodetic elevation = 59.79m.

REMARKS

BORINGS BY Geoprobe

DATE April 24, 2015

FILE NO. PG3465

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	59.57
TOPSOIL 0.10							
FILL: Brown silty sand with gravel - some boulders by 1.5m depth		SS	1	50	2		
		SS	2	21	19	1	58.57
		SS	3	29	31		
		SS	4	93	50+	2	57.57
2.50		SS	5	50	50+		
End of Borehole Practical refusal to augering at 2.5m depth						3	56.57
						4	55.57
						5	54.57
						6	53.57

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
559 Riverdale Avenue
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on west side of Riverdale Avenue, across 565 Riverdale Avenue. Geodetic elevation = 59.79m.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 24, 2015

FILE NO. PG3465

HOLE NO. BH 1A

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	59.57
Overburden						1	58.57
						2	57.57
3.05						3	56.57
Very dense, brown **SILTY SAND,** some gravel, cobbles and boulders		SS	1	58	50+		
		SS	2	33	50+		
		SS	3	67	50+		
5.18							
Compact, brown **SILTY SAND**		SS	4	58	10		
6.10							
End of Borehole							
(GWL @ 3.35m-May 1, 2015)							

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

○ Water Content %

20 40 60 80

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

Piezometer Construction

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
559 Riverdale Avenue
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on west side of Riverdale Avenue, across 565 Riverdale Avenue. Geodetic elevation = 59.79m.

REMARKS

BORINGS BY Geoprobe

DATE April 8, 2015

FILE NO. PG3465

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	59.15
Asphaltic concrete (0.05)							
FILL: Brown sand with gravel, some cobbles and boulders		SS	1	25	7		
		SS	2	67	22	1	58.15
		SS	3	67	50+		
(2.13)		SS	4	80	50+	2	57.15
End of Borehole							
Practical refusal to augering at 2.13m depth							
(BH dry - May 1, 2015)							

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

○ Water Content %

20 40 60 80

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
559 Riverdale Avenue
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located on west side of Riverdale Avenue, across 565 Riverdale Avenue. Geodetic elevation = 59.79m.

REMARKS

BORINGS BY Geoprobe

DATE April 8, 2015

FILE NO. PG3465

HOLE NO. BH 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	59.01
TOPSOIL 0.10							
FILL: Dark brown sand, some gravel and boulders		SS	1	46	3		
		SS	2	50	30	1	58.01
		SS	3	67	50+		
		SS	4	83	50+	2	57.01
2.87		SS	5	100	50+		
End of Borehole Practical refusal to augering at 2.87m depth (BH dry - May 1, 2015)							

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

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

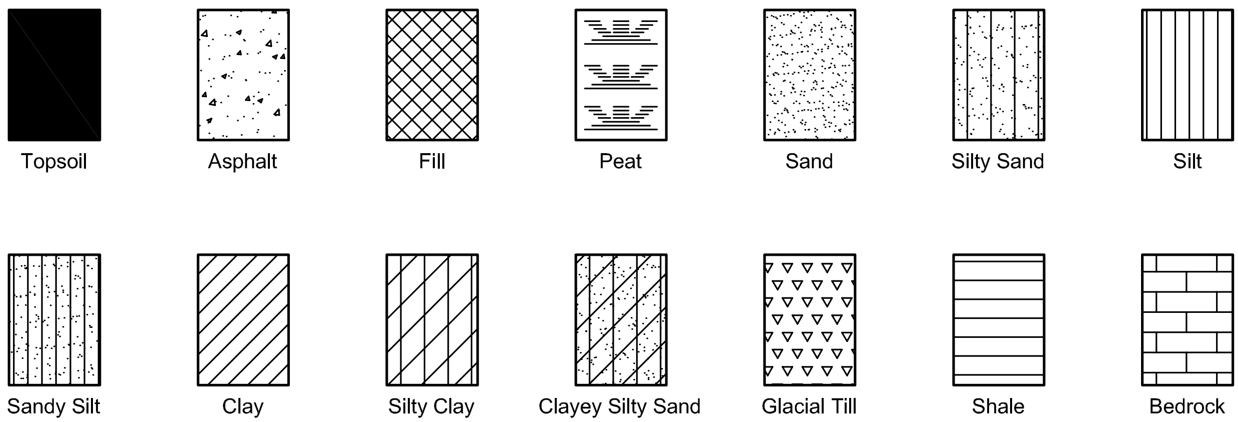
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void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

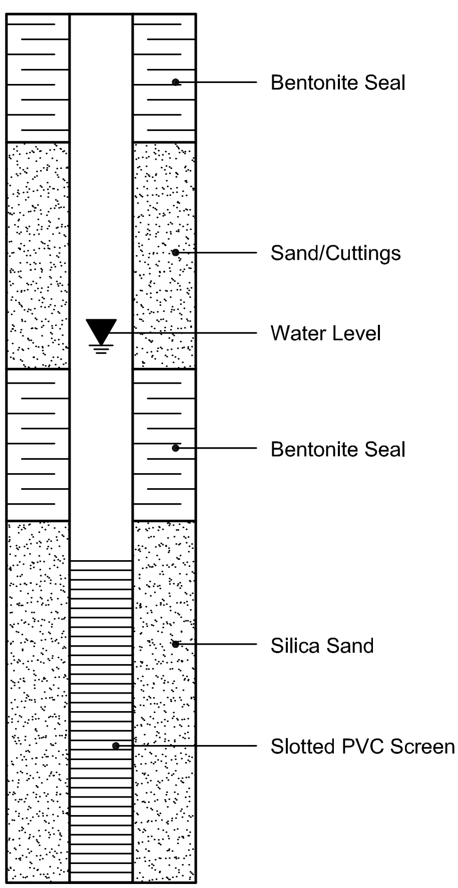
SYMBOLS AND TERMS (continued)

STRATA PLOT

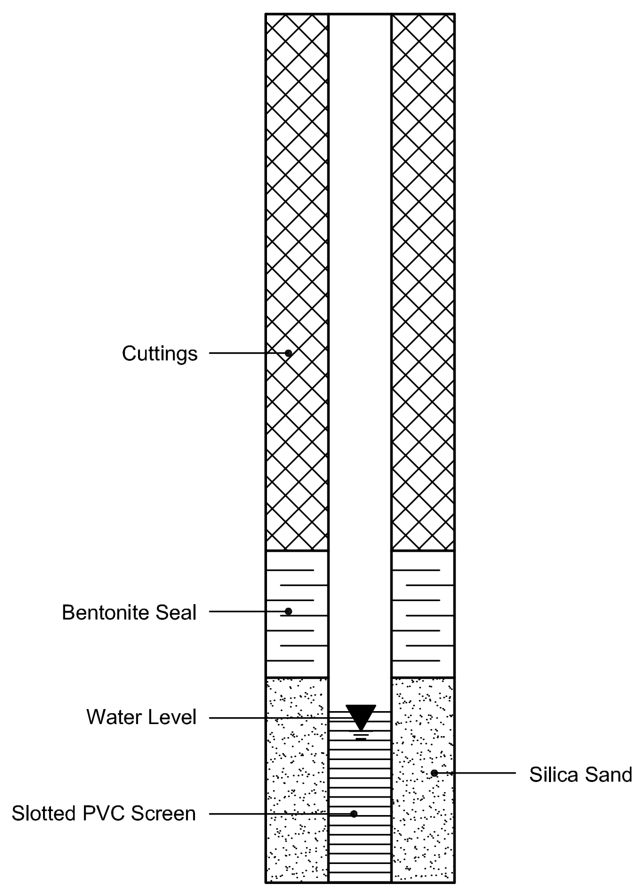


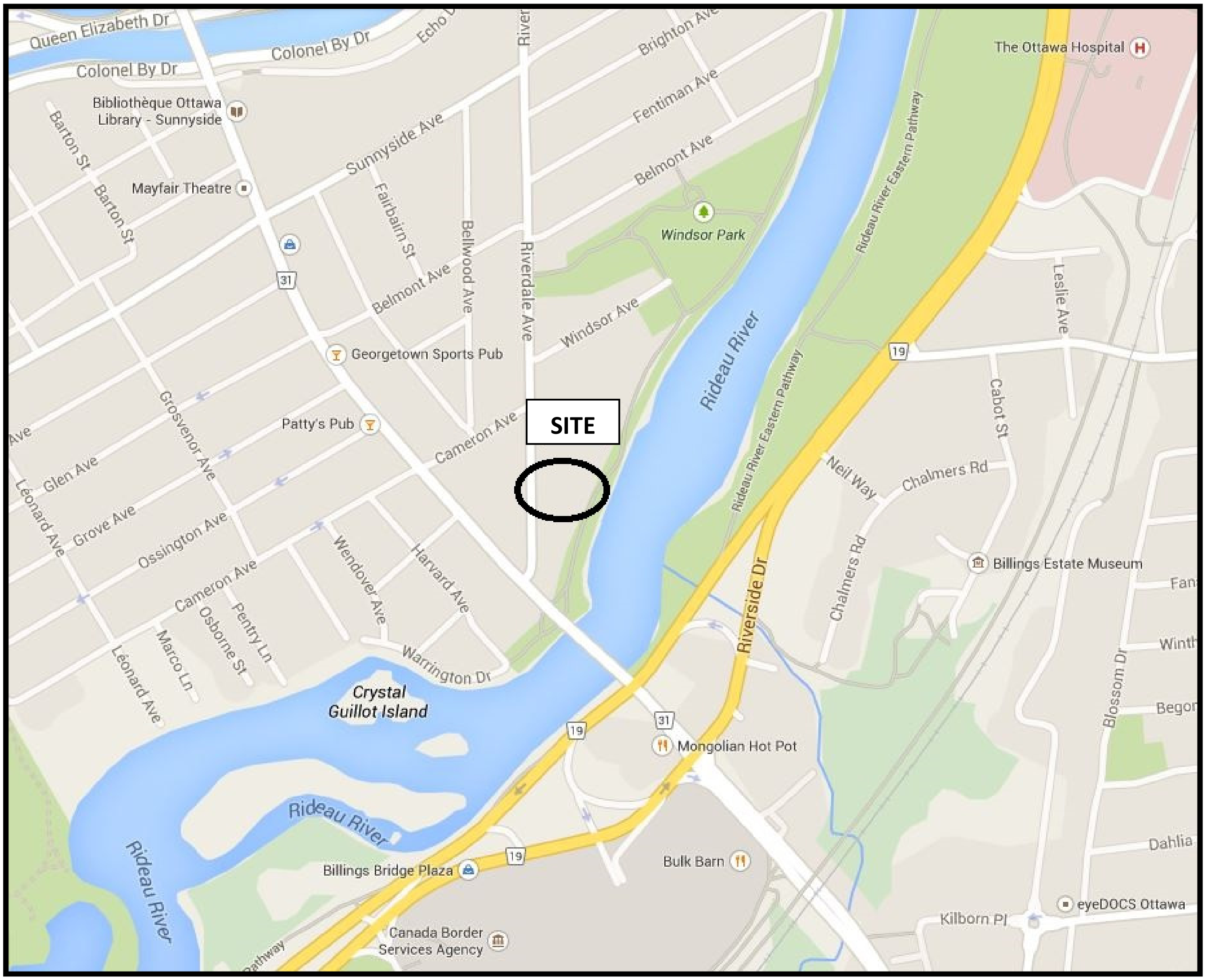
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION

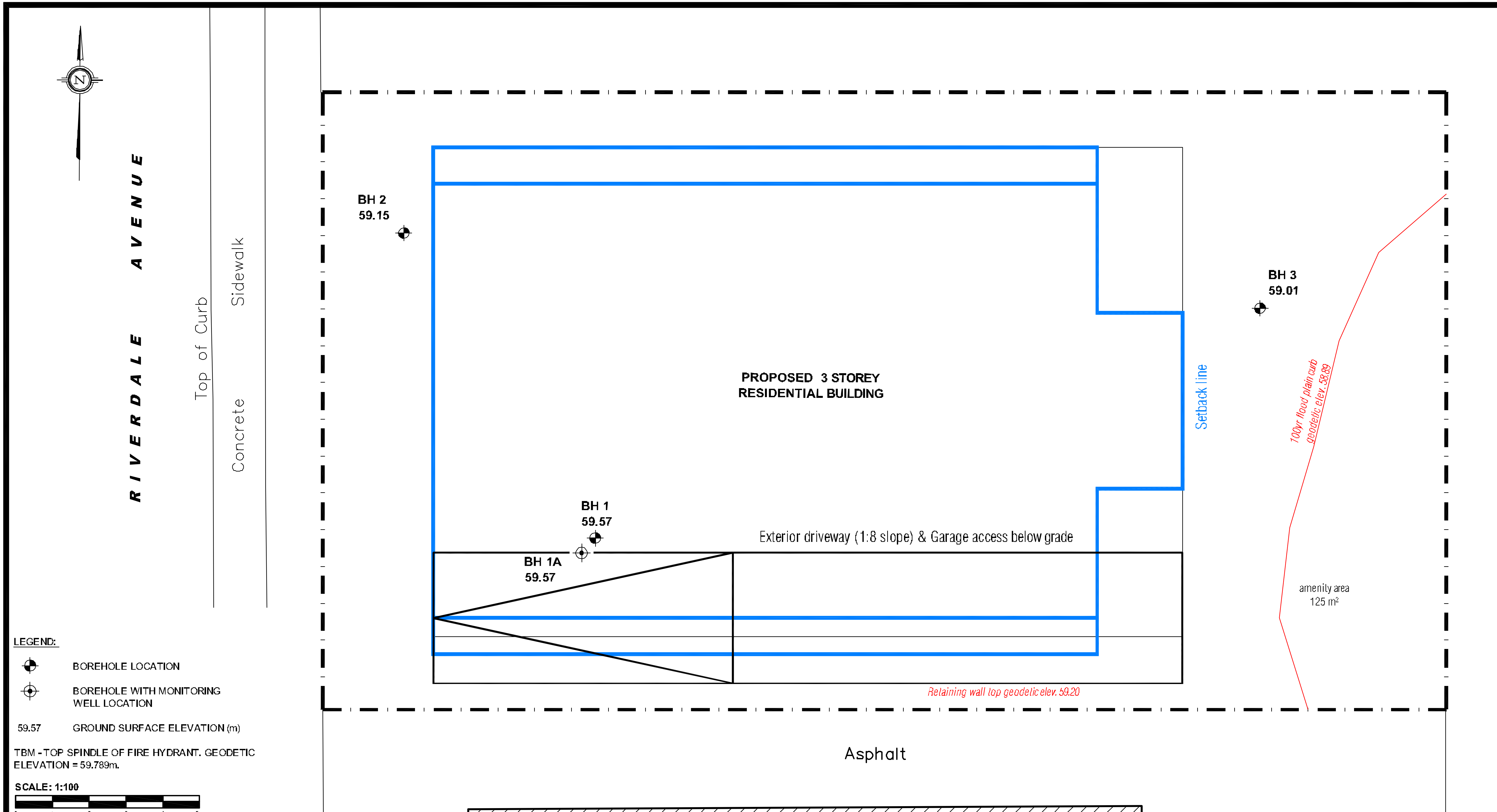




Source: Google Maps

FIGURE 1

KEY PLAN



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NO.	REVISIONS	DATE	INITIAL

MR. LUCA DIACONESCU

GEOTECHNICAL INVESTIGATION
559 RIVERDALE AVENUE

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:100	Date: 05/2015
Drawn by: CPB	Report No.: PG3465-1
Checked by: FA	Drawing No.:
Approved by: DJG	PG3465-1

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