Geotechnical Engineering

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Hydrogeological Assessment

Proposed Residential Development
23, 33 and 39 Deerfox Drive
Ottawa, Ontario

Prepared For

Glenview Properties Inc.

May 29, 2018

Report PG4436-2

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1.0 INTRODUCTION

Paterson Group (Paterson) was commissioned by Glenview Properties Inc. to prepare a hydrogeological assessment for the proposed residential development to be located at 23, 33 and 39 Deerfox Drive in Ottawa, Ontario (refer to Figure 1 - Key Plan within Appendix 1).

Subsurface information was obtained from the geotechnical investigation carried out to determine the subsoil and groundwater conditions at the site by means of test holes.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains the investigation findings and includes hydrogeological assessments pertaining to the proposed program as understood at the time of writing this report.

1.1 Proposed Project

Design details are not currently available, however, it is expected that the proposed development will consist of residential housing with associated driveways and local roadways. It is also anticipated that the subject site will be municipally serviced.

2.0 SITE CONDITIONS

Physical Setting

The subject site is located on the south side of Deerfox Drive and currently occupied by three residential dwellings with associated driveways and surrounding landscaped areas. The lots at 23 and 33 Deerfox Drive are generally heavily treed, whereas the lot at 39 Deerfox Drive is mostly open lawn with a few trees. The ground surface generally slopes down from northeast to southwest across the north portion of the site with elevations ranging from 99.20 to 97.3 m above sea level (asl). Retaining walls approximately 2 and 3 m high were noted at the south and west property boundaries, respectively. The site is bordered by existing residential properties to the east, south and west, and Deerfox Drive to the north. There were no named water bodies known to exist on the subject site.

According to available mapping, the subject site is located in the Ottawa Valley Clay Plains physiographic region.

2.1 Geology

Surficial Geology

The field program for the geotechnical investigation was carried out on February 12, 2018. During that time, a total of three (3) boreholes were advanced to a maximum depth of 8.1 m below existing ground surface. The borehole locations were determined in the field by Paterson in a manner to provide general coverage of the proposed development taking into consideration existing site features and underground services. The borehole locations are presented in Drawing PG4436-1 - Test Hole Location Plan included in Appendix 2.

Overburden soils identified during the geotechnical field investigation were generally consistent with available mapping for the area. Soils typically consisted of topsoil overlying a native, compact to very dense glacial till deposit. The fine soil matrix of the glacial till deposit was noted to consist of a brown to grey silty sand with some clay and gravel to silty clay with some sand and gravel. A very stiff to stiff brown silty clay deposit was encountered overlying the glacial till deposit at BH2 to a depth of approximately 4.7 m. Practical refusal to DCPT was encountered at a depth of 8.1 m below ground surface at BH 2.

Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets included in Appendix 2.

Bedrock

Based on available geological mapping, the subject site is located in an area where bedrock consists of interbedded sandstone and dolomite of the March Formation, and is expected at depths between 10 to 15 m.

Karst Features

The term "karst" refers to a geologic formation characterized by the dissolution of carbonate bedrock, such as limestone or dolostone. In order for karstification to occur, precipitation must be allowed to infiltrate the top of the bedrock to dissolutionally enlarge previously existing joints and bedding planes. Based on available geological mapping and the given depth of surficial soils overlying the bedrock that are non-conductive to groundwater infiltration, it is highly unlikely that karstification is occurring.

2.2 Hydrogeology

Existing Aquifer Systems

Aquifer systems may be defined as geological media, either overburden soils or fractured bedrock, which permit the movement of groundwater under hydraulic gradients. Although groundwater has been observed within the overburden soils at the subject site, the composition of materials does not allow for the development of significant water supply wells. Water supply wells in the vicinity are instead likely found in bedrock aquifers.

Bedrock aquifer mapping, provided by Natural Resources Canada Urban Geology of the National Capital Region mapping, was reviewed as part of this assessment. Using this tool, the March and Oxford Formation aquifer systems were identified as the water supply aquifer systems in the vicinity of the study area with all domestic wells extending into the bedrock aquifer.

Groundwater Levels

Groundwater was observed in the piezometers installed in the overburden at the borehole locations. Based on a review of water well records, groundwater is also present in the bedrock at depth.

Groundwater levels in the overburden at the subject site were observed to vary from 1.7 to 3.6 m bgs at the time of the geotechnical field investigation. It should be noted that groundwater levels may have been influenced by surface water infiltrating the backfilled boreholes. Subsequent groundwater level readings within the piezometers can be influenced by perched water in the backfill material within the borehole. Groundwater levels are also influenced by seasonal variations in temperature and precipitation. As such, long-term groundwater levels are also estimated based on other factors such as colour and consistency of the recovered soil samples. Based on these observations, the long-term groundwater level at the subject site is expected to range from approximately 5 to 6 m bgs.

Hydraulic Gradients

Vertical hydraulic gradients were not measured at the subject site as the previous studies completed did not warrant the installation of monitoring well nests.

With respect to horizontal hydraulic gradients, due to the nature of the water levels obtained from field work conducted at the site (piezometers), the absolute direction of horizontal hydraulic gradients was not determined. However, using the available data, it was possible to approximate the horizontal hydraulic gradients in the overburden material given that the horizontal hydraulic gradient between any 2 points is the slope of the hydraulic head between those points:

$$i=(h_2-h_1)/L$$

Where: i=horizontal hydraulic gradient
h=water level (m asl)
L=horizontal distance between test hole locations

Using the above noted formula, the horizontal hydraulic gradient has been calculated to be approximately 0.031 in an easterly orientation. Shallow groundwater flow in the vicinity of the subject site is expected to reflect local topography. Regional groundwater flow is considered to be in an easterly direction, towards the Rideau River.

Hydraulic Conductivity

The hydraulic conductivity values were conservatively estimated based upon previous experience at similar sites in the area, information obtained from the results of the geotechnical field program and typical published values for similar stratigraphy. The values are interpreted to be in the order of 1×10^{-6} to 1×10^{-10} m/sec for glacial till, 1×10^{-7} to 1×10^{-9} m/sec for brown silty clay, and 1×10^{-9} to 1×10^{-12} m/sec for grey silty clay.

Groundwater Recharge and Discharge

In general, groundwater will follow the path of least resistance from areas of higher hydraulic head to areas of lower hydraulic head. While upward and downward hydraulic gradients may be indicative of discharge and recharge respectively, other factors must be considered.

Based on the hydraulic conductivity estimates obtained from previous studies and published literature, the glacial till overburden is generally considered to act as a confining layer. It is our interpretation that groundwater will generally flow laterally through the glacial till material, as opposed to vertically upwards through overburden soils with lower hydraulic conductivity such as the silty clay. As such, the volume of recharge occurring within the site boundaries is expected to be minimal.

With regards to discharge zones, neither the topographical or geological conditions are suitable for discharge to be occurring at the subject site.

3.0 POTENTIAL IMPACTS

3.1 Adverse Effects on Adjacent Structures

The overburden in the area generally consists of topsoil and/or fill material overlying a very dense to compact glacial till deposit. The fine soil matrix of the glacial till deposit is comprised of a brown to grey silty sand to silty clay with varying amounts of gravel, cobbles and boulders. Discontinuous silty clay deposits have been identified overlying the glacial till deposit in the study area. The potential dewatering volumes due to groundwater infiltration into the excavation footprints are anticipated to be low to moderate. It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of the excavation. Additionally, given the nature of the development (low lying residential housing and associated servicing), the duration of any excavation on site is expected to be short term in duration. As such, any effects related to ground surface settlement due to the water taking activities during construction are expected to be negligible.

3.2 Adverse Effects on Neighbouring Water Wells

A search of the Ontario Water Well Records online mapping database and the Groundwater Information Network (GIN) indicates there are 10 domestic wells and 3 decommissioned wells within 500 m of the site as depicted on Drawing PG4436-2 - MOECC Water Well Location Plan included in Appendix 1. Additionally, the water supply wells noted to potentially remain in use generally extended to the bedrock aquifer, well beyond the maximum depth of any excavation that may take place as part of the proposed development. Construction activities at the site are therefore not expected to cause any interference to the water supply of surrounding properties or other negative impacts.

A series of calculations were carried out on theoretical radii of influence for a typical servicing trench excavation of 9 m deep and withdrawing water from the upper 5.5 to 7.5 m of the saturated zone. These calculations were completed based on Sichardt (1992) using the equation:

$$R = r_e + 3000 * \Delta h (k^{0.5})$$

- R = radius of influence (m)
- r_e = equivalent radius of excavation (m)
- Δh = thickness of drawdown within the aquifer (m)
- k = hydraulic conductivity (m/sec)

For the purposes of completing the calculations, the following assumptions were made:

- r_e = 9.55 m
- k = 1 x 10^{-6} m/sec, based upon our experience in the area and published values.
- Δh = 5.5 to 7.5 m, to review potential minimum/maximum variable conditions.

Using the above equation and assumptions, a radius of influence of approximately 16.5 to 22.50 m will develop as a steady state condition, extending from the edge of the excavation, in the area of the subject site.

Given the hydrogeological characteristics of the subject site, the theoretical radii of influence for the potential excavations related to the development and the depth of the water supply wells within 500 m, a long-term groundwater monitoring program is not required to be implemented based on our review.

In the interest of public perception, consideration may be given to undertaking a baseline subdivision sampling program. The premise of the program is to obtain groundwater quality information from the water supply wells in the vicinity of the proposed development prior to the project commencing. This ensures that all parties involved (developer, homeowner and City of Ottawa) are protected should a concern arise during or after construction.

3.3 Groundwater

A search of the MOECC Brownfields Environmental Site Registry was conducted as part of the assessment of the site, neighbouring properties and the general area of the site. Using a search radius of 1 km provided no recorded Brownfield sites in that area. No concerns were identified in the review of the MOECC Brownfields database.

It is anticipated that the material on site will be disposed of or re-used as per the MOECC policy, *Management of Excess Soil - A Guide for Best Management Practices* dated January, 2014.

The groundwater that is pumped from site excavations must be managed in an appropriate manner. The contractor will be required to implement a water management program to dispose of the pumped water.

4.0 STATEMENT OF LIMITATIONS

The recommendations provided in this report are in accordance with our present understanding of the project.

A hydrogeological review of this nature is a limited sampling of a site. The recommendations are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around the test locations. Should any conditions at the site be encountered which differ from those at the test locations, we request notification 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 Glenview Properties Inc. or their agent(s) is not authorized without review by Paterson Group for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Nicholas Zulinski, P.Geo., géo.

David J. Gilbert, P.Eng.

APPENDIX 1

Figure 1 - Key Plan

Drawing PG4436-2 - MOECC Water Well Location Plan

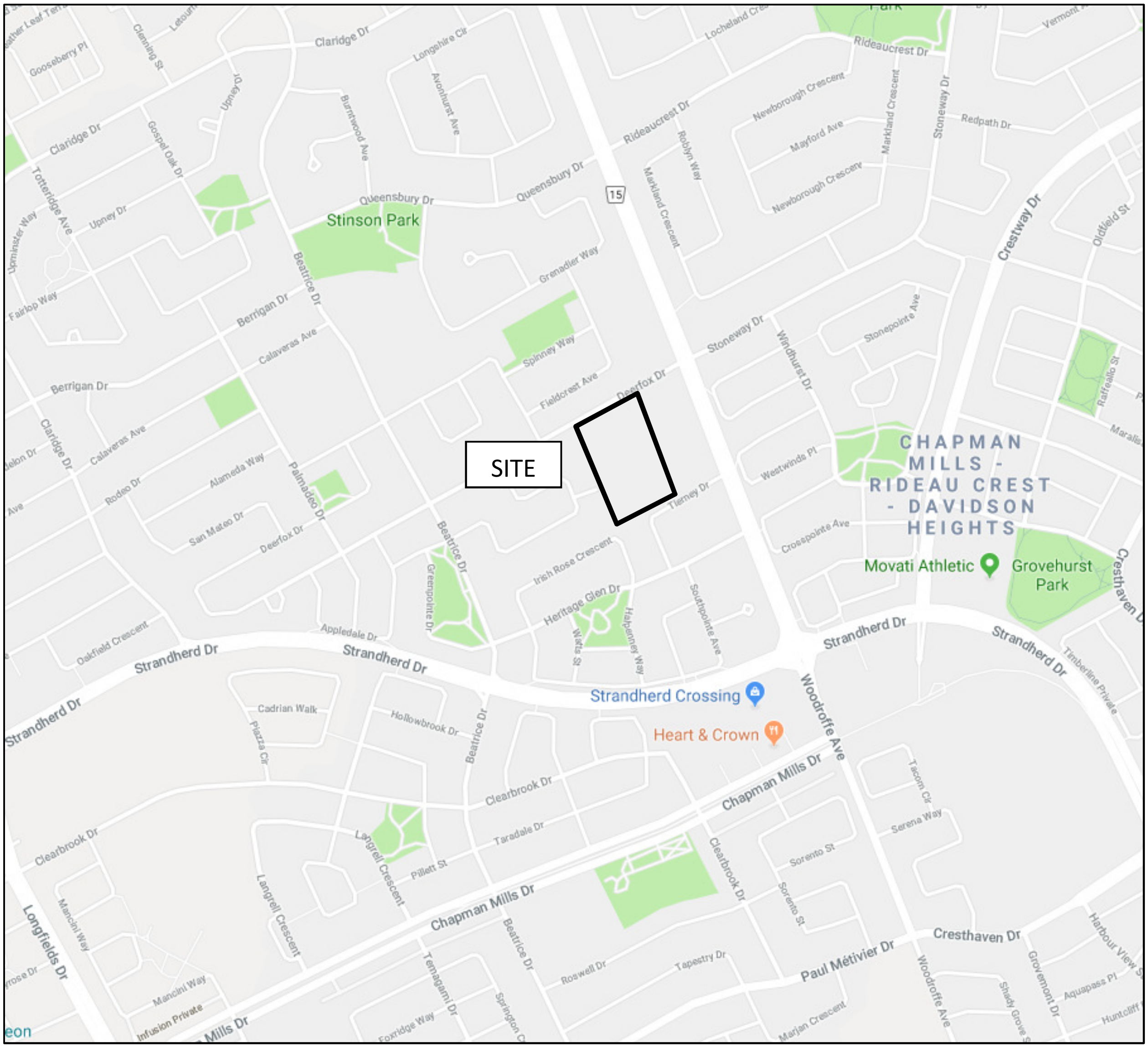

FIGURE 1

KEY PLAN

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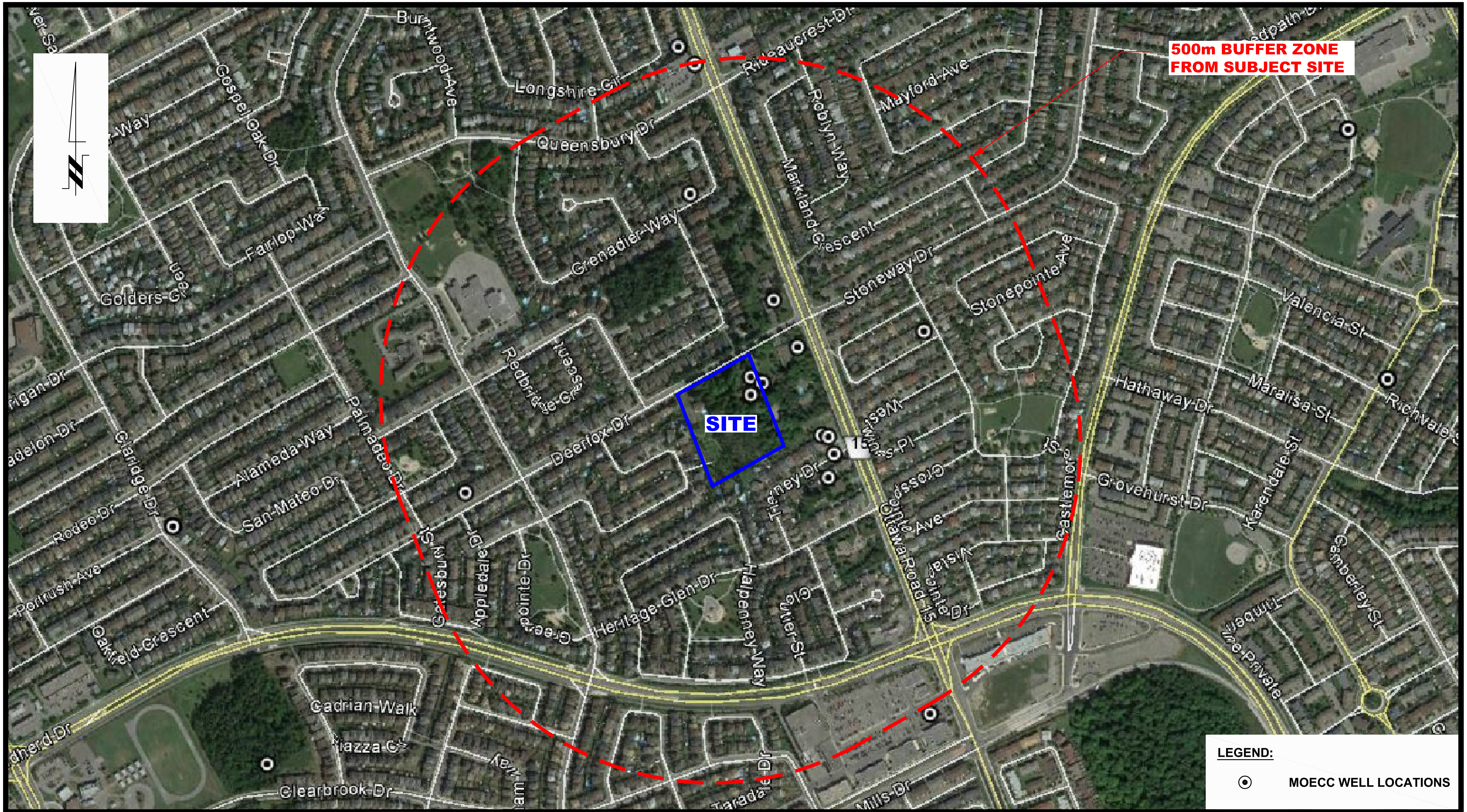

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NO.	REVISIONS	DATE	INITIAL
0			

GLENVIEW PROPERTIES INC.
HYDROGEOLOGICAL ASSESSMENT
PROP. RESIDENTIAL DEVELOPMENT - 23, 33 & 39 DEERFOX DRIVE
OTTAWA, ONTARIO

Title:
MOECC WATER WELL LOCATION PLAN

Scale: 1:5000	Date: 05/2018
Drawn by: RCG	Report No.: PG4436-2
Checked by: NZ	Dwg. No.: **PG4436-2**
Approved by: DJG	Revision No.: 0

APPENDIX 2

Soil Profile and Test Data Sheets

Symbols and Terms

Drawing PG4436-1 - Test Hole Location Plan

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Deerfox Drive
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located in front of 39 Deerfox Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

REMARKS

BORINGS BY CME-55 Low Clearance Drill **DATE** February 12, 2018

FILE NO. PG4436

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.20
TOPSOIL 0.41							
GLACIAL TILL: Compact, brown silty sand, some clay, gravel, cobbles and boulders		SS	1	83	15	1	98.20
		SS	2	75	29	2	97.20
		SS	3	75	13	3	96.20
		SS	4	50	27	4	95.20
		SS	5	92	14		
		SS	6	75	20	5	94.20
		SS	7	67	22	6	93.20
- grey by 6.1m depth 6.70		SS	8		9		
End of Borehole							
(GWL @ 1.66m - Feb. 26, 2018)							

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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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Deerfox Drive
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located in front of 39 Deerfox Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

REMARKS

BORINGS BY CME-55 Low Clearance Drill

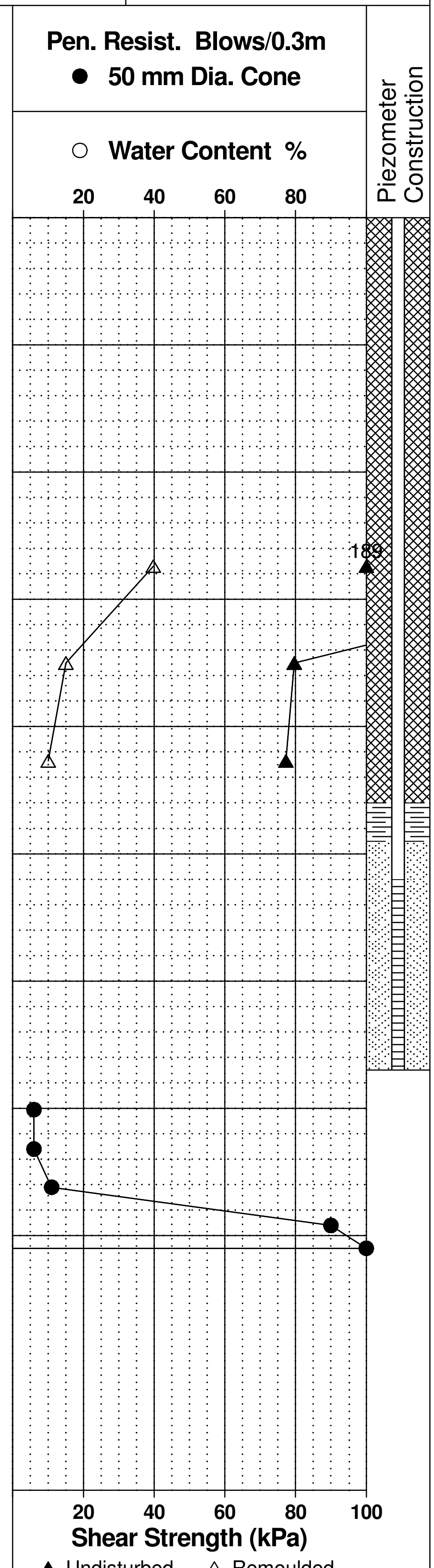
DATE February 12, 2018

FILE NO. PG4436

HOLE NO. BH 2

SOIL DESCRIPTION	Depth of boundary (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.15				
Very stiff to stiff, brown **SILTY CLAY,** trace sand		SS	1	100	11
		SS	2	100	6
		G	3		
- grey by 4.0m depth		G	4		
	4.72				
GLACIAL TILL: Grey silty clay with sand and gravel		SS	5	67	7
		SS	6	92	5
		SS	7	100	3
	6.70				
Dynamic Cone Penetration Test commenced at 6.70m depth. Inferred **GLACIAL TILL**					
	8.10				
End of Borehole					
Practical DCPT refusal at 8.10m depth					
(BH dry - Feb. 26, 2018)					

DEPTH (m)	ELEV. (m)
0	97.26
1	96.26
2	95.26
3	94.26
4	93.26
5	92.26
6	91.26
7	90.26
8	89.26



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Deerfox Drive
Ottawa, Ontario

DATUM TBM - Top spindle of fire hydrant located in front of 39 Deerfox Drive. An arbitrary elevation of 100.00m was assigned to the TBM.

REMARKS

BORINGS BY CME-55 Low Clearance Drill **DATE** February 12, 2018

FILE NO. PG4436

HOLE NO. BH 3

SOIL DESCRIPTION	Depth to base (m)	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.58
TOPSOIL	0.23						
FILL: Sand	0.36						
FILL: Dark grey silty sand with clay and gravel	1.22	SS	1	58	7	1	97.58
TOPSOIL	1.30						
Grey **SILTY CLAY,** some sand	2.03	SS	2	83	6	2	96.58
GLACIAL TILL: Very dense to compact, brown silty sand with gravel, cobbles and boulders, some clay - grey by 3.0m depth	6.70	SS	3	100	50+	3	95.58
		SS	4	67	29	4	94.58
		SS	5	67	26	5	93.58
		SS	6	92	27	6	92.58
		SS	7	50	15		
		SS	8	75	17		

End of Borehole

(GWL @ 3.59m - Feb. 26, 2018)

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

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

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

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

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

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

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

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

CONSOLIDATION TEST

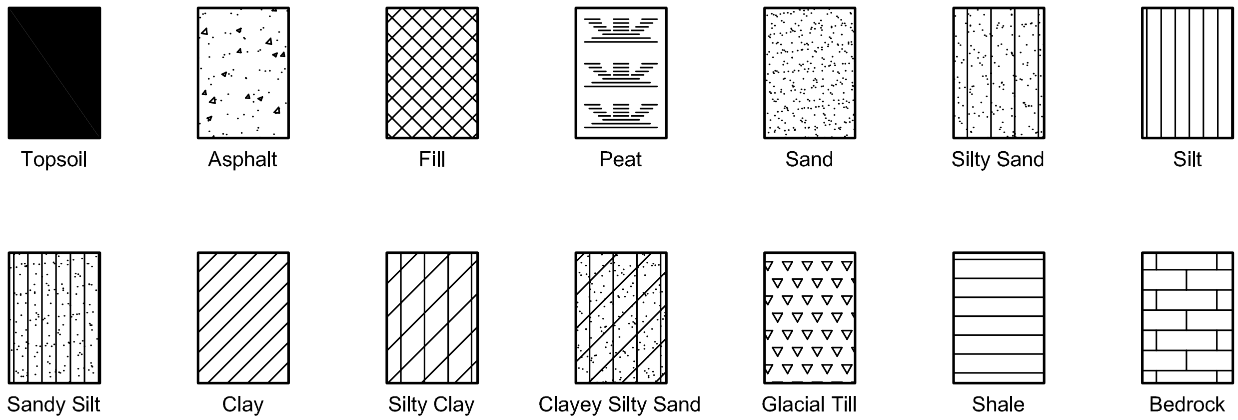
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

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

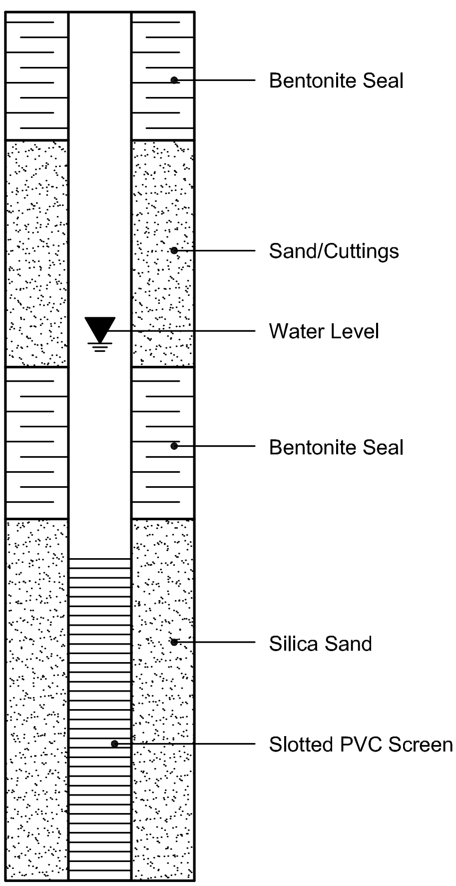
SYMBOLS AND TERMS (continued)

STRATA PLOT

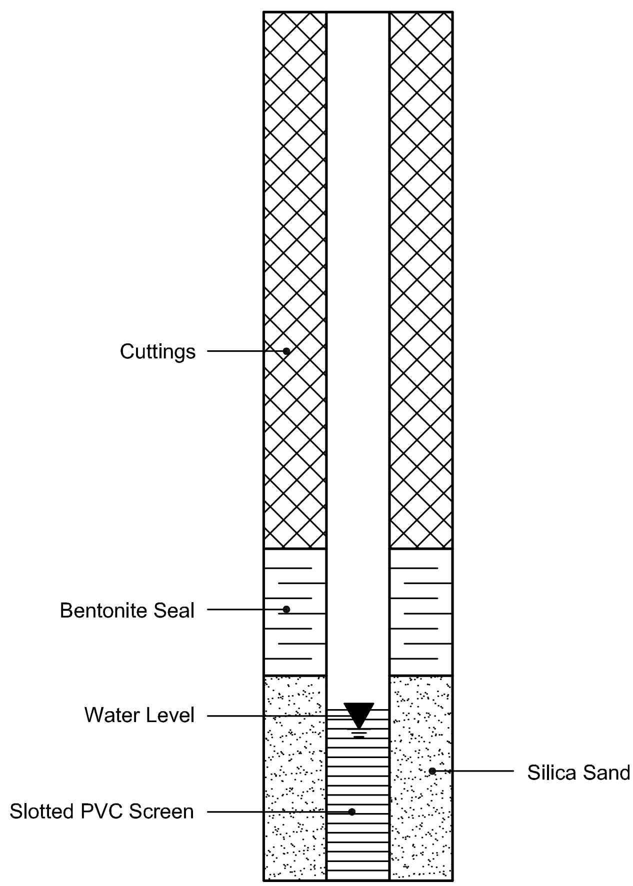


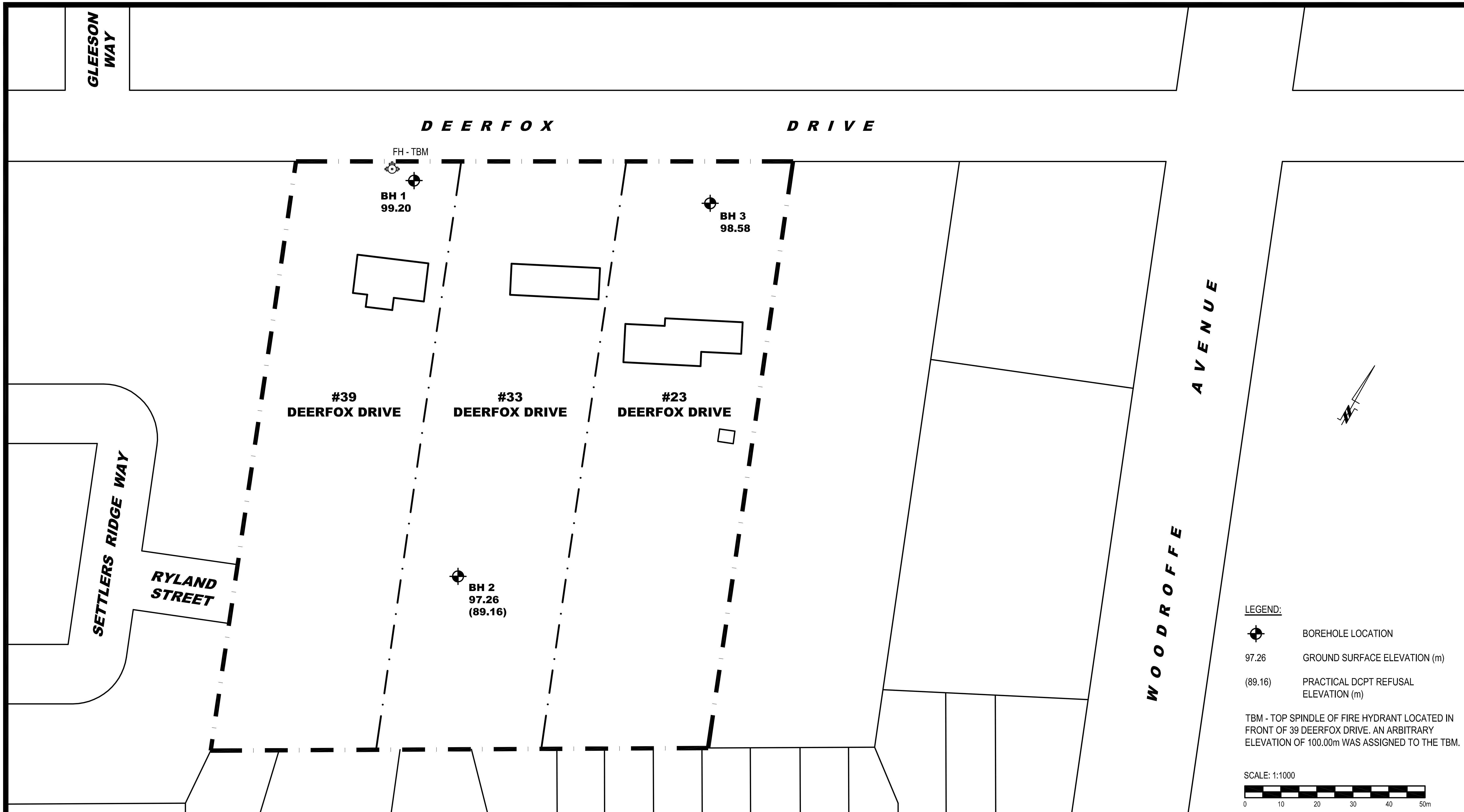
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





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GLENVIEW PROPERTIES INC.

GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - 23, 33 & 39 DEERFOX DRIVE

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale:	1:1000	Date:	03/2018
Drawn by:	MPG	Report No.:	PG4436-1
Checked by:	NC	Dwg. No.:	PG4436-1
Approved by:	DJG	Revision No.:	0

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