Geotechnical Engineering

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Geotechnical Investigation

Proposed Multi-Storey Building
3368 Carling Avenue
Ottawa, Ontario

Prepared For

Cardel Homes

January 6, 2016

Report: PG3682-1

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1.0 Introduction

Paterson Group (Paterson) was commissioned by Cardel Homes to complete a geotechnical study for the proposed multi-storey building to be located at 3368 Carling Avenue, in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2).

The objectives of the geotechnical investigation were:

- ☐ to review existing borehole logs and available information;
- ☐ to 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 the original findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope for this present investigation. Therefore, the present report does not address environmental issues.

2.0 Proposed Project

The proposed project will consist of a three to four storey building with one level of underground parking and will occupy the majority of the subject site.

3.0 Background Information

Four (4) boreholes were completed by SPL Consultants Limited in August 2014 within the subject site. Four boreholes were completed to provide general coverage of the proposed development. The boreholes were advanced to a maximum depth of 18 m and a groundwater monitoring well was installed at all of the borehole locations, except BH 14-2. The test hole locations are presented on Drawing PG3682-1 - Test Hole Location Plan included in Appendix 2. Diamond core drilling was completed at one location to confirm the depth to bedrock and bedrock quality.

The subsurface profiles are presented on the Log of Borehole sheets presented in Appendix 1.

3.1 Surface Conditions

The subject site is located at 3368 Carling Avenue, which is located at the southeast corner of the intersection of Carling Avenue and Bedale Drive in the City of Ottawa. The site was formerly occupied by a single storey commercial building with a single basement level. The single storey building was surrounded by an at grade, paved parking area. The subject site is approximately 1.5 m above the adjacent roadways and slopes from the building downward to the property boundaries. The subject site is surrounded by residential development to the east, west and south and green space to the north.

3.2 Subsurface Profile

Generally, the soil profile encountered at the borehole locations consists of a pavement structure and non-specified fill overlying a native silty clay layer which extends to 10.7 to 12.2 m below existing ground surface. The non-specified fill material consists of silty clay mixed with trace crushed stone and is approximately 1.2 to 1.5 m thick. The native silty clay layer consists of a stiff to very stiff crust extending to a 5 to 6 m depth followed by a 6.0 to 8.5 m thick unweathered silty clay, which is of a firm to very stiff consistency. The unweathered silty clay is underlain by very loose to loose silty sand till, which is approximately 2.7 to 5.1 m thickness and extends to bedrock. A limestone bedrock was encountered at a depth of 14.8 to 15.8 m.

Bedrock

Weathered limestone bedrock was encountered at depths ranging between 14.8 to 15.8 m below the existing ground surface. Bedrock was cored at BH14-2. Based on the recovered cores, the rock quality designation (RQD) values were calculated for the rock core and the bedrock quality was assessed based on the results. Generally, the bedrock is good to excellent quality.

Practical refusal to DCPT was encountered at BH 14-3 at 15.8 m depth. Additionally, practical refusal to augering was encountered at BH 14-1 and BH 14-4, at 14.9 m and 12.8 m, respectively.

Based on available geological mapping, dolomite bedrock of the Oxford Formation is present in this area with an overburden thickness ranging between 10 to 15 m.

Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

3.3 Groundwater

Monitoring wells were installed at BH14-1, BH14-3 and BH14-4. Groundwater levels were obtained 7 days after the drilling program in the groundwater monitoring wells. The groundwater levels varied between 3.2 to 4.5 m below ground surface. Groundwater levels are subject to seasonal fluctuations and therefore, groundwater levels could be higher at the time of construction.

4.0 Discussion

4.1 Geotechnical Assessment

The subject site is satisfactory for the proposed development from a geotechnical perspective. It is anticipated that the proposed building will be constructed over conventional shallow footings.

Due to the presence of a silty clay deposit, a permissible grade raise restriction is required for the subject site.

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

4.2 Site Grading and Preparation

Stripping Depth

Topsoil, deleterious fill and soils containing significant amounts of organics, should be stripped from under any buildings and other settlement sensitive structures. Precautions should be taken to ensure that all bearing surfaces and subgrade soils remain undisturbed during site preparation activities.

Fill Placement

Fill placed for grading beneath the proposed building, 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. The fill should be placed in maximum 300 mm thick lifts and be compacted to a minimum of 98% of the standard proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be placed as general landscaping fill where ground surface settlement is of minor concern. The backfill should be spread in thin lifts and at a minimum compacted by the tracks of the spreading equipment to minimize voids. If the backfill is to be placed to increase the subgrade level for paved areas, the material should be compacted in thin lifts to a minimum density of 95% of the respective 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.

Protective Mud Slab

It is anticipated that the excavation bottom will be over a silty clay subgrade which will require protection from disturbance due to worker traffic. Consideration should be given to placing a 50 to 75 mm thick lean concrete mud slab over the undisturbed clay surface once exposed. The lean concrete should consist of a minimum 17 MPa compressive strength concrete.

4.3 Foundation Design

Shallow Footing Foundation

Strip footings, up to 3 m wide, and pad footings, up to 6 m wide, founded on an undisturbed, stiff silty clay bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **175 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **275 kPa**. A geotechnical resistance factor of 0.5 was applied to the reported bearing resistance value at ULS.

A permissible grade raise restriction of 1.5 m above existing ground surface is recommended for the subject site.

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

The bearing resistance value given for footings at SLS will be subjected to potential post-construction total and differential settlements of 25 and 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 an engineered fill, stiff silty clay above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

4.4 Design for Earthquakes

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

4.5 Basement Slab

All organic containing and/or deleterious materials, as well as, disturbed soils should be removed from beneath the floor slab prior to placement of concrete. The basement area for the proposed building will be mostly parking and the recommended pavement structure noted in Subsection 4.8 will be applicable. However, if a concrete floor slab will be constructed for storage purposes, the upper 200 mm of sub-slab fill is recommended to consist of 19 mm clear crushed stone. All backfill material placed within the proposed building footprint should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 98% of the SPMDD.

All soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill or concrete. OPSS Granular A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

4.6 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and dry unit weight of 20 kN/m^3.

If undrained conditions are anticipated, the applicable effective unit weight of the retained soil can be taken as 13 kN/m^3, where applicable. A hydrostatic pressure should be added to the total static earth pressure when calculating the effective unit weight. The total earth pressure (P_{AE}) includes both the static earth pressure component (P_o) and the seismic component (ΔP_{AE}).

Lateral Earth Pressures

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

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

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

Actual earth pressures could be higher than the “at-rest” case if care is not exercised during the compaction of the backfill materials to maintain a minimum separation of 0.3 m from the walls with the compaction equipment.

Seismic Earth Pressures

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

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

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

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

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

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

4.7 Pavement Structure

Asphalt pavement is not anticipated to be required at the subject site. However, should a flexible pavement be considered for the project, the recommended flexible pavement structures shown in Tables 1 and 2 would be applicable.

Table 1 - Recommended Flexible Pavement Structure - Car Only Parking Areas

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

Table 2 - Recommended Flexible Pavement Structure - Access Ramp

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

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.

Pavement Structure Drainage

The pavement structure performance is dependent on the moisture condition at the contact zone between the subgrade material and granular base. Failure to provide adequate drainage under conditions of heavy wheel loading could result in the subgrade fines pumped into the stone subbase voids, thereby reducing the load bearing capacity.

Due to the impervious nature of the subgrade materials consideration should be provided to installing sub-drains 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 approximately 300 mm below subgrade level and placed in accordance with City of Ottawa specifications. The subgrade surface should be shaped to promote water flow to the drainage lines.

5.0 Design and Construction Precautions

5.1 Foundation Drainage and Backfill

A perimeter drainage system is recommended for the proposed building. The system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the foundation 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. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for placement as backfill against the foundation walls, unless placed in conjunction with a composite drainage system, such as Miradrain G100N or Delta Drain 6000. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for backfill material.

5.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum of 1.5 m thick soil cover (or equivalent) should be provided.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for exterior unheated footings, such as exterior columns, piers, etc.

5.3 Excavation Side Slopes

Temporary Side Slopes

Excavation side slopes constructed in fill materials should excavated to acceptable slopes or retained by shoring systems from the beginning of the excavation until the structure is backfilled. Since the building will occupy the majority of the subject site, a temporary shoring system is anticipated for construction.

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or shallower. A shallower slope is required for excavations below groundwater level. The subsurface soils are considered to be a Type 2 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.

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 exposed for extended periods of time.

Temporary Shoring

Temporary shoring may be required for the overburden soil to complete the required excavations where insufficient room is available for open cut methods. The shoring requirements should be designed by a structural engineer, specializing in shoring design. The shoring will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations, roadways and underground services.

The design and implementation of the temporary systems will be the responsibility of the excavation contractor. The geotechnical information provided below is to assist the contractor in completing a safe shoring system. The shoring designer should take into account the impact of a significant precipitation event and designate design measures to ensure that a precipitation event will not negatively impact the shoring system or soils supported by the system. Any changes during construction to the approved shoring design should be reported immediately to the owner's consultants prior to implementation.

The temporary system could consist of soldier pile and lagging system or interlocking steel sheet piling. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be included to the earth pressures described below. The shoring system could be cantilevered, anchored or braced. Generally, the shoring systems is provided with tie-back rock anchors to ensure the stability. The shoring system is recommended to be adequately supported to resist toe failure and inspected to ensure that the sheet piles extend well below the excavation base. If consideration is given to utilizing a raker style support for the shoring system, the structural engineer should ensure that the design selected minimizes lateral movements to tolerable levels.

The earth pressures acting on the shoring system may be calculated with the following parameters.

Table 3 - Soil Parameters

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

The active earth pressure should be calculated where wall movements are permissible, while the at-rest pressure should be calculated if movement is not permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

A hydrostatic groundwater pressure should be included to the earth pressure distribution wherever the effective unit weight are calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil/bedrock should be calculated full weight, with no hydrostatic groundwater pressure component. For design purposes, the minimum factor of safety of 1.5 should be calculated.

5.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications and Standard Detail Drawings from the City of Ottawa.

Excavation to approximately 4 m depth or shallower, below the existing grade, should be within the silty clay crust material. If deeper excavations are expected, the services will be excavated through the unweathered grey silty clay.

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of the SPMDD. The bedding material should extend at a minimum to the spring line of the pipe. The placement of clear stone is not recommended for bedding or cover as the finer particles of the native and backfill may migrate into the clear stone voids, thereby reducing the pipe support.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at a minimum of 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of the SPMDD.

Generally,the brown silty clay should be possible to place above the cover material if the excavation and backfilling operations are completed in dry weather conditions. Wet silty clay materials will be difficult for placement, as the high water content are impractical for the desired compaction without an extensive drying period.

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

To reduce long-term lowering of the groundwater level, clay seals should be provided in the service trenches, where the services are located below the local groundwater table. The seals should be a minimum of 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. The seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry impervious material placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at a maximum of 60 m intervals in the service trenches.

5.5 Groundwater Control

Due to the relatively impervious nature of the silty clay materials, groundwater infiltration into the excavations should be low and controllable by open sumps. A perched groundwater condition may be encountered within the silty sand deposit which may produce significant temporary groundwater infiltration levels. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations.

A temporary MOE permit to take water (PTTW) will be required for this project if more than 50,000 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 MOE.

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.

5.6 Winter Construction

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

In the event that construction is completed during below zero temperatures, the founding stratum and excavation side slopes should be protected from freezing temperatures by the installation of straw, propane heaters, tarpaulins or other suitable means. The excavation base 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 constructed in a manner that should avoid the introduction of frozen materials into the trenches. As well, pavement construction is difficult during winter. The subgrade consists of frost susceptible soils which will experience total and differential frost heaving as the construction is completed. In addition, the introduction of frost, snow or ice into the pavement materials, which is difficult to avoid, could adversely affect the performance of the pavement structure. Additional information could be provided, if required.

5.7 Corrosion Potential and Sulphate

The analytical test results indicate that the sulphate content is less than 0.1%. This result is indicative that Type 10 Portland cement (normal cement) would be appropriate. The results of the chloride content, pH and resistivity indicate the presence of a aggressive environment for exposed ferrous metals.

6.0 Recommendations

The following material testing and observation program should be performed by a geotechnical consultant and is required for the foundation design data provided herein to be applicable:

❏ Review of the proposed structure(s) and adjacent structures 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 and follow-up field density tests to determine the level of compaction achieved.

❏ Sampling and testing of the bituminous concrete including mix design reviews.

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

7.0 Statement of Limitations

The recommendations made in this report are for review and design purposes. Paterson requests permission to review the 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.

A geotechnical investigation is a limited sampling of a site. 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 Cardel Homes and their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Joe Forsyth, P.Eng.

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LICENSED PROFESSIONAL ENGINEER
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APPENDIX 1

BOREHOLE LOGS BY OTHERS

ANALYTICAL TESTING RESULTS

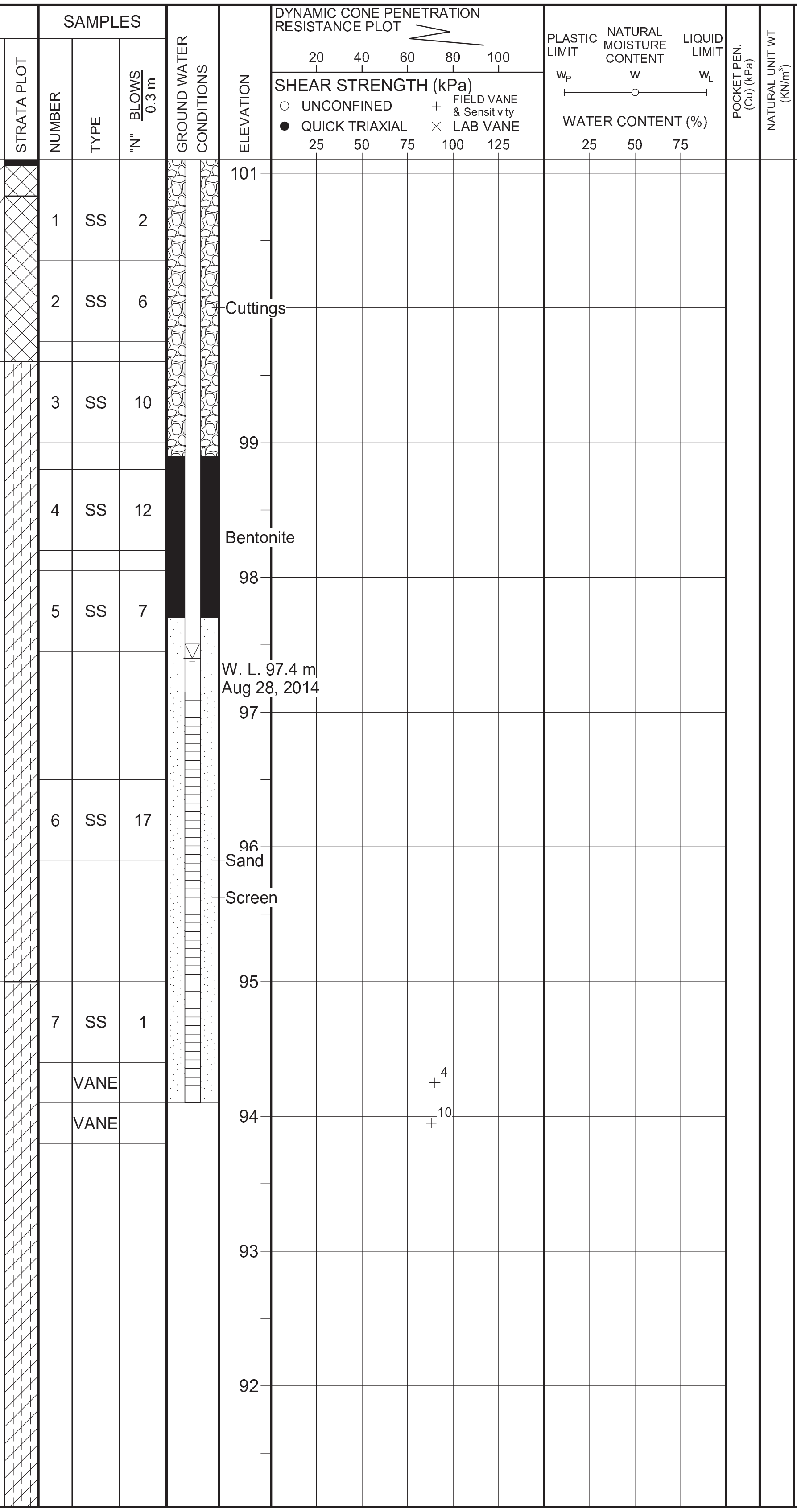
LOG OF BOREHOLE BH14-1

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/21/2014

REF. NO.: 10000823
ENCL NO.:

SOIL PROFILE		SAMPLES			REMARKS AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	GR SA SI CL
101.1					
100.9 0.0	**ASPHALT** 40 mm				
100.8 0.3	**CRUSHED SAND AND GRAVEL** brown, moist (Granular Base)				
	SILTY CLAY trace gravel, dark brown, moist, firm (FILL)	1	SS	2	
		2	SS	6	
99.6 1.5	**SILTY CLAY** grey brown, moist, stiff to very stiff (Weathered Crust)	3	SS	10	
		4	SS	12	
		5	SS	7	
	- silty sand seam	6	SS	17	
95.0 6.1	**SILTY CLAY** with silty sand seams, grey, wet, stiff to very stiff	7	SS	1	-Hollow stem augered to 6.1 m then advanced casing to 14.9 m
			VANE		
			VANE		



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH14-1

PROJECT: Cardel Homes - 3368 Carling Avenue	**DRILLING DATA**
CLIENT: Cardel Homes	Method: Hollow Stem Auger Drilling
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON	Diameter: 203
DATUM: local	Date: Aug/21/2014
BH LOCATION: See Location Plan	

REF. NO.: 10000823
ENCL NO.:

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE: 25 50 75 100 125
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (KN/m^3)
REMARKS AND GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION
	SILTY CLAY with silty sand seams, grey, wet, stiff to very stiff(Continued)						91
			8	SS	1		90
			9A 9B	SS SS	1		
88.9 12.2	**SILTY SAND** trace clay, grey, wet, very loose to loose		10	SS	1		89
			11	SS	8		88
			12	SS	2		87
			13	SS	5		
86.2 14.9	**End of Borehole**						

Notes:
1 - Borehole was advanced with hollow stem augers to 6.1 m depth then advanced with casing to 14.9 m depth. Casing filled with water prior to SPT sampling below 10.7 m depth.
2 - Borehole terminated at 14.9 m below surface on casing refusal.
3 - Water level on completion of sampling at a depth of 2.5 m below surface.
4 - 50 mm dia. monitoring well installed in adjacent auger hole
5 - Date Water Level
Aug 28, 2014 3.7 m

SPL SOIL LOG-OTTAWA 10000823 - 3368 CARLING AVENUE.GPJ SPL.GDT 17/9/14

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

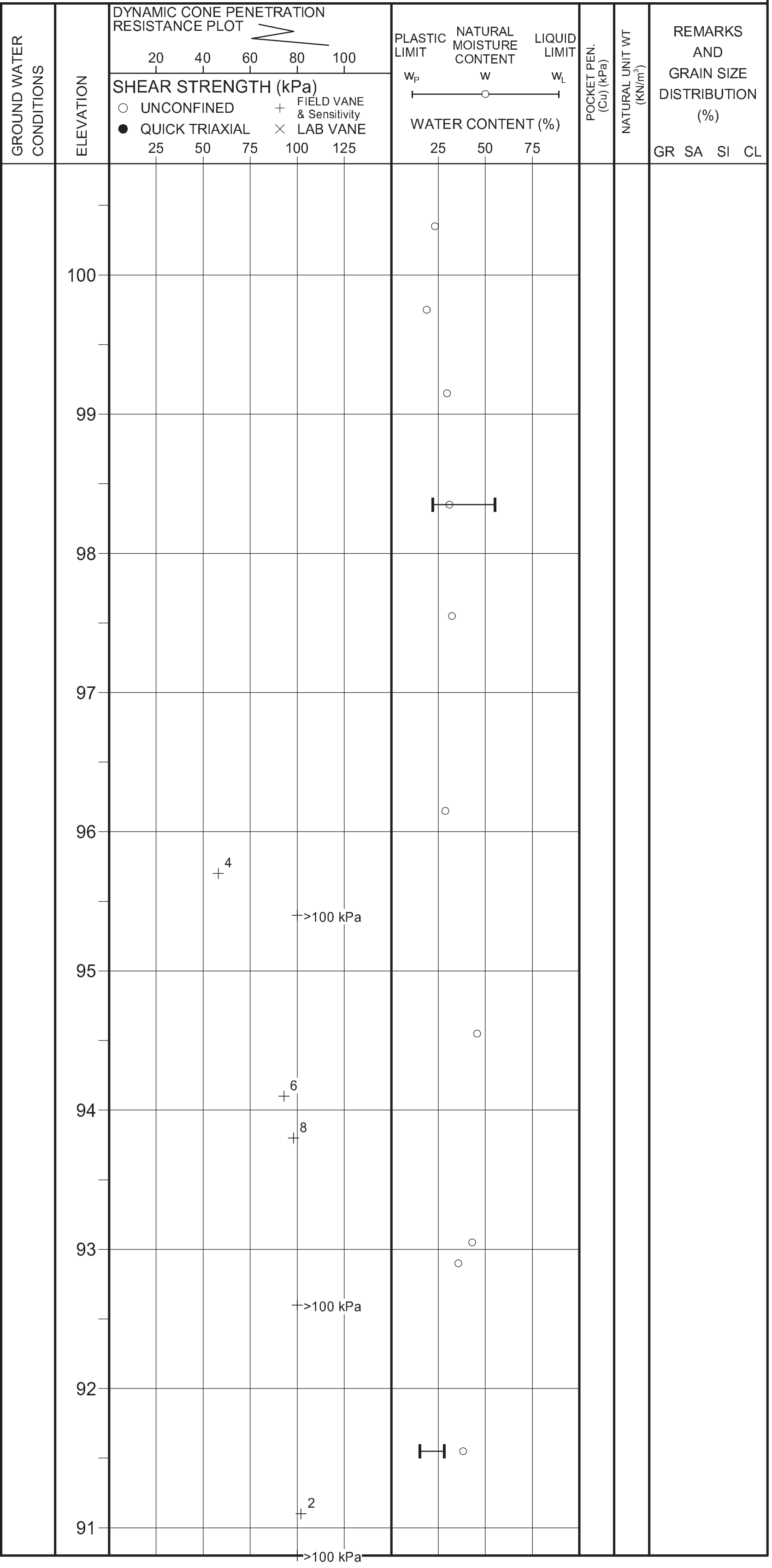
LOG OF BOREHOLE BH14-2

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/19/2014

REF. NO.: 10000823
ENCL NO.:

SOIL PROFILE		SAMPLES		
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m
100.8				
100.7 0.1	**ASPHALT** 100 mm			
100.6 0.2	**CRUSHED SAND AND GRAVEL** brown, moist (Granular Base)			
	SILTY CLAY trace to some gravel, trace roots, brown, moist, firm (FILL)	1	SS	6
		2	SS	7
99.5 1.4	**SILTY CLAY** grey brown to brown, moist, stiff to very stiff (Weathered Crust)	3	SS	13
		4	SS	11
		5	SS	6
96.5 4.4	**SILTY CLAY** with silty sand seams, grey brown to grey, moist, stiff to very stiff	6	SS	2
			VANE	
			VANE	
	- grey below 6.0 m	7	SS	WH
			VANE	
			VANE	
		8A 8B	SS SS	1
			VANE	
		9	SS	WH
			VANE	



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

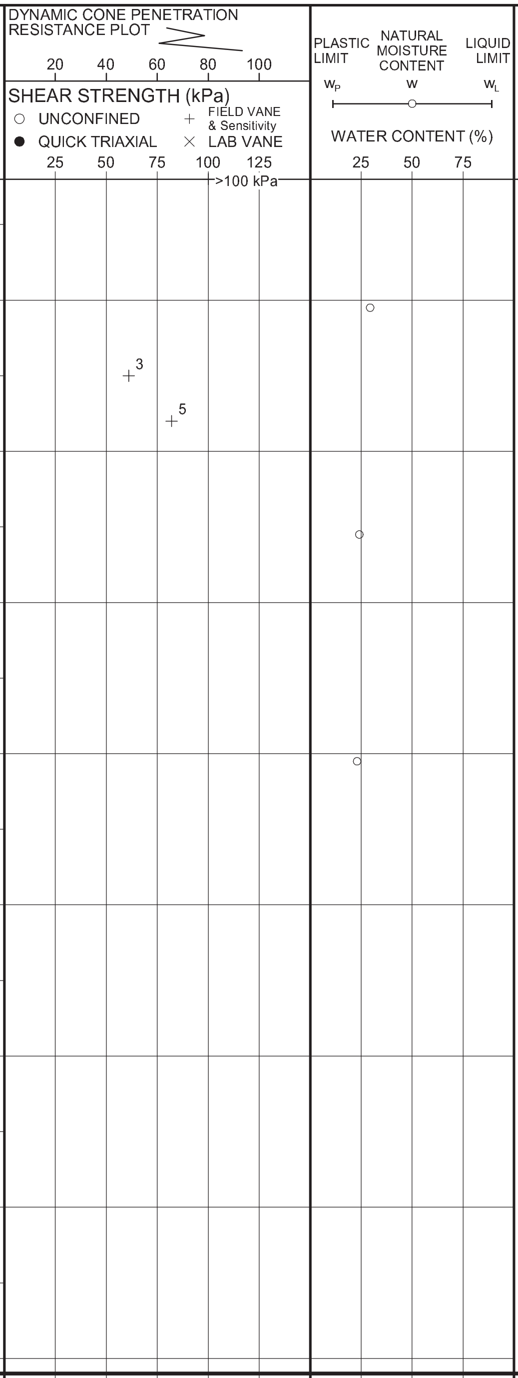
LOG OF BOREHOLE BH14-2

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/19/2014

REF. NO.: 10000823
ENCL NO.:

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	ELEVATION	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY with silty sand seams, grey brown to grey, moist, stiff to very stiff(Continued)		VANE					
		10	SS	WH	90			
			VANE					
			VANE		89			
88.8 12.1	**SILTY SAND** trace clay, grey, wet, very loose	11	SS	WR	88			
		12	SS	2	87		21.1	0 73 24 3 - approx. 0.3 m of heave inside hollow stem auger when center plug removed
86.0 14.8	**LIMESTONE** fresh, grey, thin to medium bedded with some shale seams, moderately to widely spaced discontinuities - TCR: 100% - SCR: 99% - RQD: 99%	1	CORE		86 85			
	- TCR: 97% - SCR: 92% - RQD: 85%	2	CORE		84 83			
82.9 17.9	**End of Borehole** Notes: 1 - Switched from augering to NQ rock coring at a depth of 14.8 m below surface after encountering auger refusal. 2 - Water level after augering was at a depth of 6.9 m below surface. 3 - Water level after completion of borehole was at a depth of 7.0 m below surface							



GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

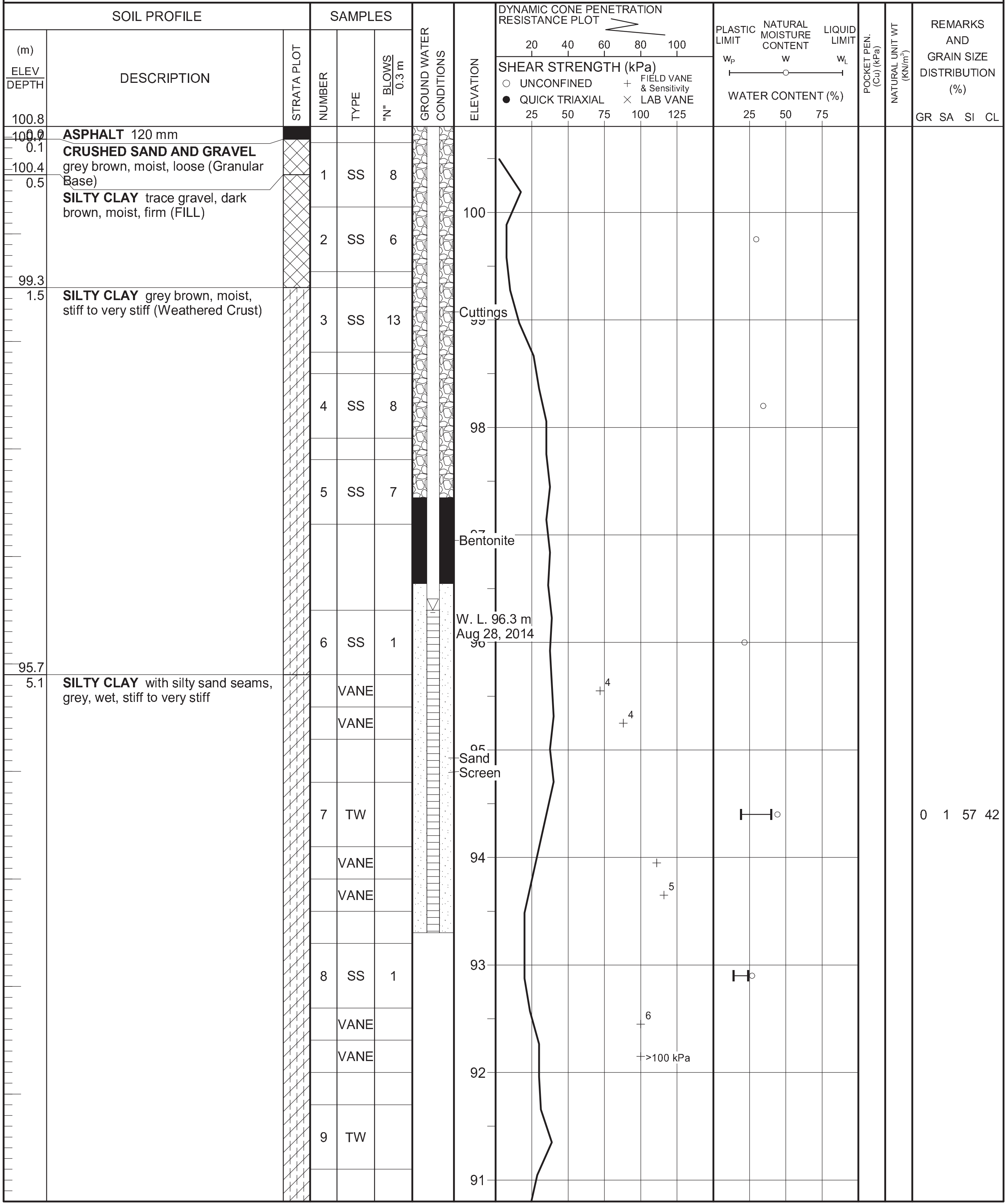
GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH14-3

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/20/2014

REF. NO.: 10000823
ENCL NO.:



SOIL PROFILE

ELEV (m) DEPTH	DESCRIPTION
100.8	
100.7 0.1	**ASPHALT** 120 mm
	CRUSHED SAND AND GRAVEL grey brown, moist, loose (Granular Base)
100.4 0.5	**SILTY CLAY** trace gravel, dark brown, moist, firm (FILL)
99.3 1.5	**SILTY CLAY** grey brown, moist, stiff to very stiff (Weathered Crust)
95.7 5.1	**SILTY CLAY** with silty sand seams, grey, wet, stiff to very stiff

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	8	
2	SS	6	
3	SS	13	
4	SS	8	
5	SS	7	
6	SS	1	
	VANE		
	VANE		
7	TW		0 1 57 42
	VANE		
	VANE		
8	SS	1	
	VANE		
	VANE		
9	TW		

GROUND WATER CONDITIONS

Cuttings
Bentonite
W. L. 96.3 m
Aug 28, 2014
Sand
Screen

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

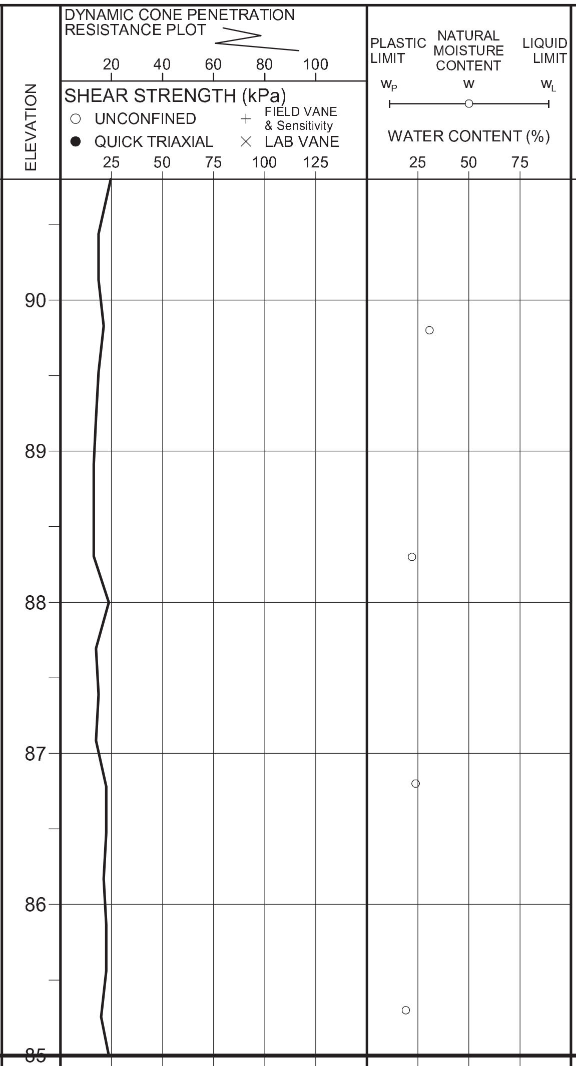
LOG OF BOREHOLE BH14-3

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/20/2014

REF. NO.: 10000823
ENCL NO.:

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (KN/m³)	GR	SA	SI	CL
	SILTY CLAY with silty sand seams, grey, wet, stiff to very stiff(Continued)										
90.1 10.7	**SILTY SAND** trace clay, grey, wet, very loose to loose	10	SS	1							
	- some silt	11	SS	7			20.5	0	87	12	1
		12	SS	3							
		13	SS	5				0	70	24	6
85.0 15.8	**End of Borehole**										



Notes:
1 - Borehole terminated at 15.8 m below surface on auger refusal.
2 - Water level after completion of borehole was at a depth of 8.2 m below surface.
3 - 50 mm dia. monitoring well advanced in adjacent auger hole
4 - Date Water Level
Aug 28, 2014 4.5 m

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

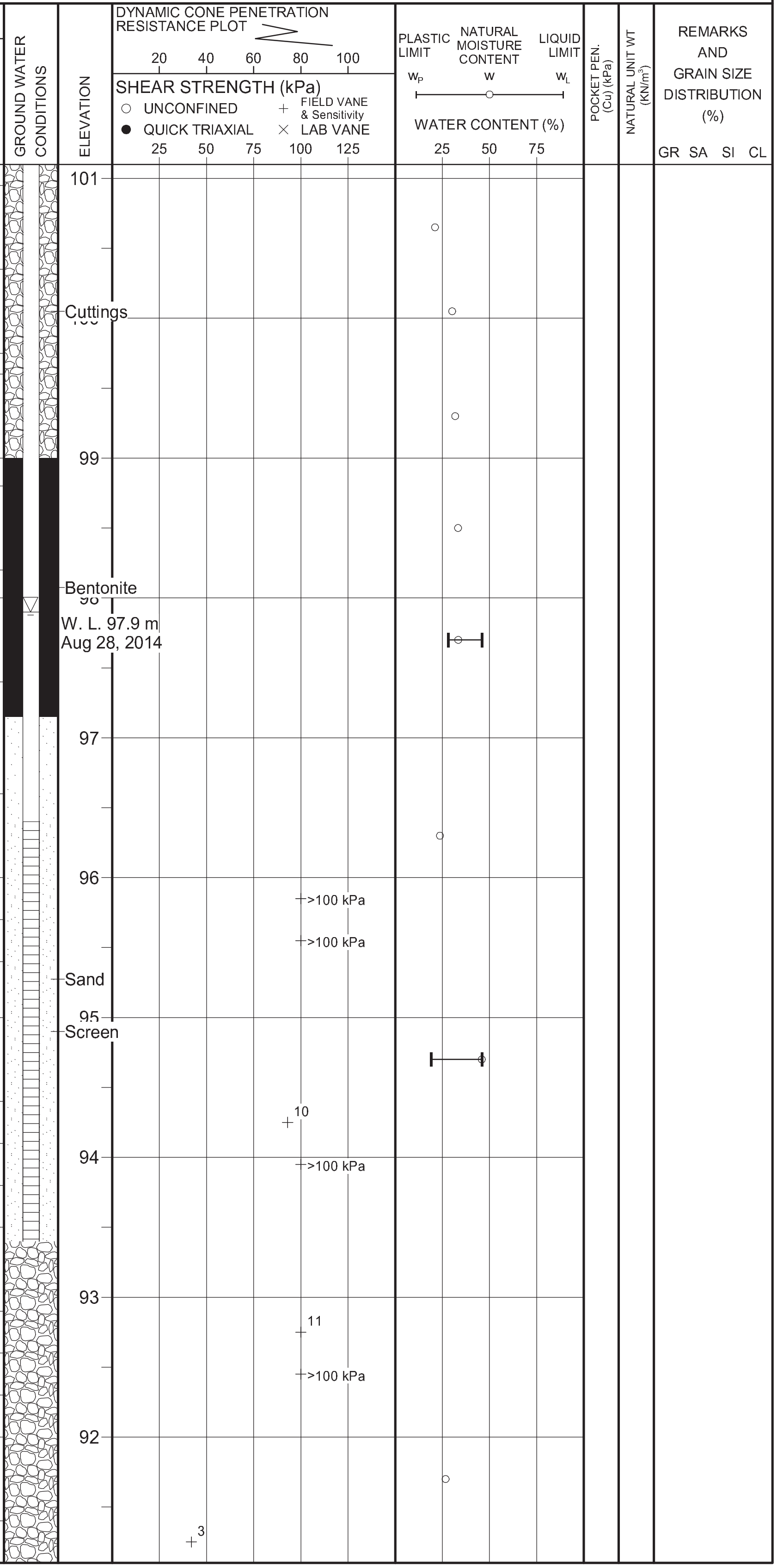
LOG OF BOREHOLE BH14-4

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/20/2014

REF. NO.: 10000823
ENCL NO.:

SOIL PROFILE		SAMPLES		
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m
101.1				
101.0 0.0	**ASPHALT** 120 mm			
0.1	**CRUSHED SAND AND GRAVEL** some silt, brown, moist (Granular Base)	1	SS	4
100.3 0.9	**SILTY CLAY** brown grey, moist, firm to stiff (FILL)	2	SS	8
99.7 1.4	**SILTY CLAY** brown, moist, stiff to very stiff (Weathered Crust)	3	SS	11
		4	SS	11
		5	SS	6
		6	SS	2
			VANE	
			VANE	
95.0 6.1	**SILTY CLAY** with silty sand seams, grey, wet, stiff to very stiff	7	SS	1
			VANE	
			VANE	
		8	TW	
			VANE	
			VANE	
		9	SS	2
	- firm at 9.8 m		VANE	



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GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▽

GRAPH NOTES
$+^3, \times^3$: Numbers refer to Sensitivity
$\bigcirc^{\varepsilon=3\%}$ Strain at Failure

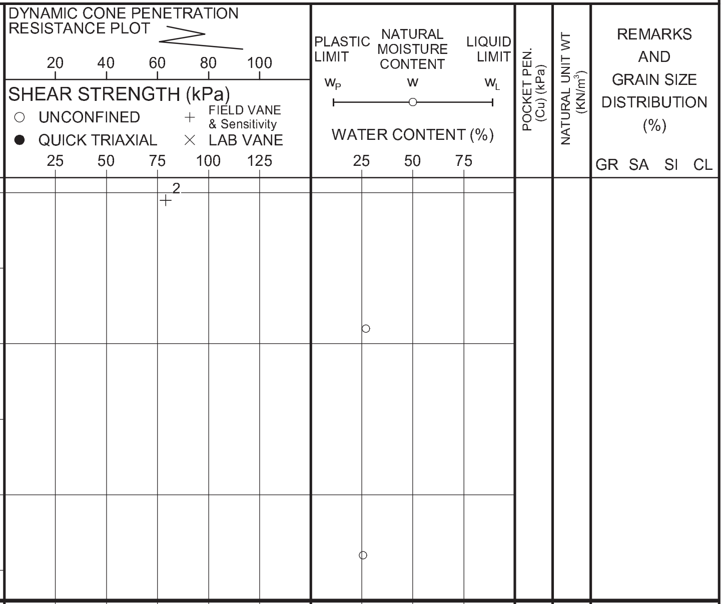
LOG OF BOREHOLE BH14-4

PROJECT: Cardel Homes - 3368 Carling Avenue
CLIENT: Cardel Homes
PROJECT LOCATION: 3368 Carling Avenue, Ottawa, ON
DATUM: local
BH LOCATION: See Location Plan

DRILLING DATA
Method: Hollow Stem Auger Drilling
Diameter: 203
Date: Aug/20/2014

REF. NO.: 10000823
ENCL NO.:

(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION
	SILTY CLAY with silty sand seams, grey, wet, stiff to very stiff(Continued)			VANE			91 Cave
90.4 10.7	**SILTY SAND** trace clay, grey, wet, very loose		10	SS	1		90
							89
88.3 12.8			11	SS	WH		



End of Borehole
Notes:
1 - Borehole terminated at 12.8 m below surface.
2 - Water level upon completion of borehole was at a depth of 8.2 m below surface
3 - Date Water Level
Aug 28, 2014 3.2 m

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: SPL Consultants Ltd.
146 Colonnade Rd., Unit 17
Ottawa, ON
K2E 7Y1
Attention: Ms. Wendy McLaughlin
PO#:
Invoice to: SPL Consultants Ltd.

Report Number: 1418214
Date Submitted: 2014-08-27
Date Reported: 2014-08-29
Project: 10000823
COC #: 172975

				Lab I.D.	1129070	1129071	1129072
				Sample Matrix	Soil	Soil	Soil
				Sample Type			
				Sampling Date	2014-08-19	2014-08-19	2014-08-19
				Sample I.D.	BH 14-2 SS7	BH 14-3 SS3	BH 14-3 SS11
Group	**Analyte**	**MRL**	**Units**	**Guideline**			
Agri. - Soil	pH	2.0			8.8	8.1	8.9
General Chemistry	Cl	0.002	%		0.024	0.017	<0.002
	Electrical Conductivity	0.05	mS/cm		0.66	0.72	0.07
	Resistivity	1	ohm-cm		1520	1410	14300
	SO4	0.01	%		0.03	0.02	<0.01

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG3682-1 - TEST HOLE LOCATION PLAN

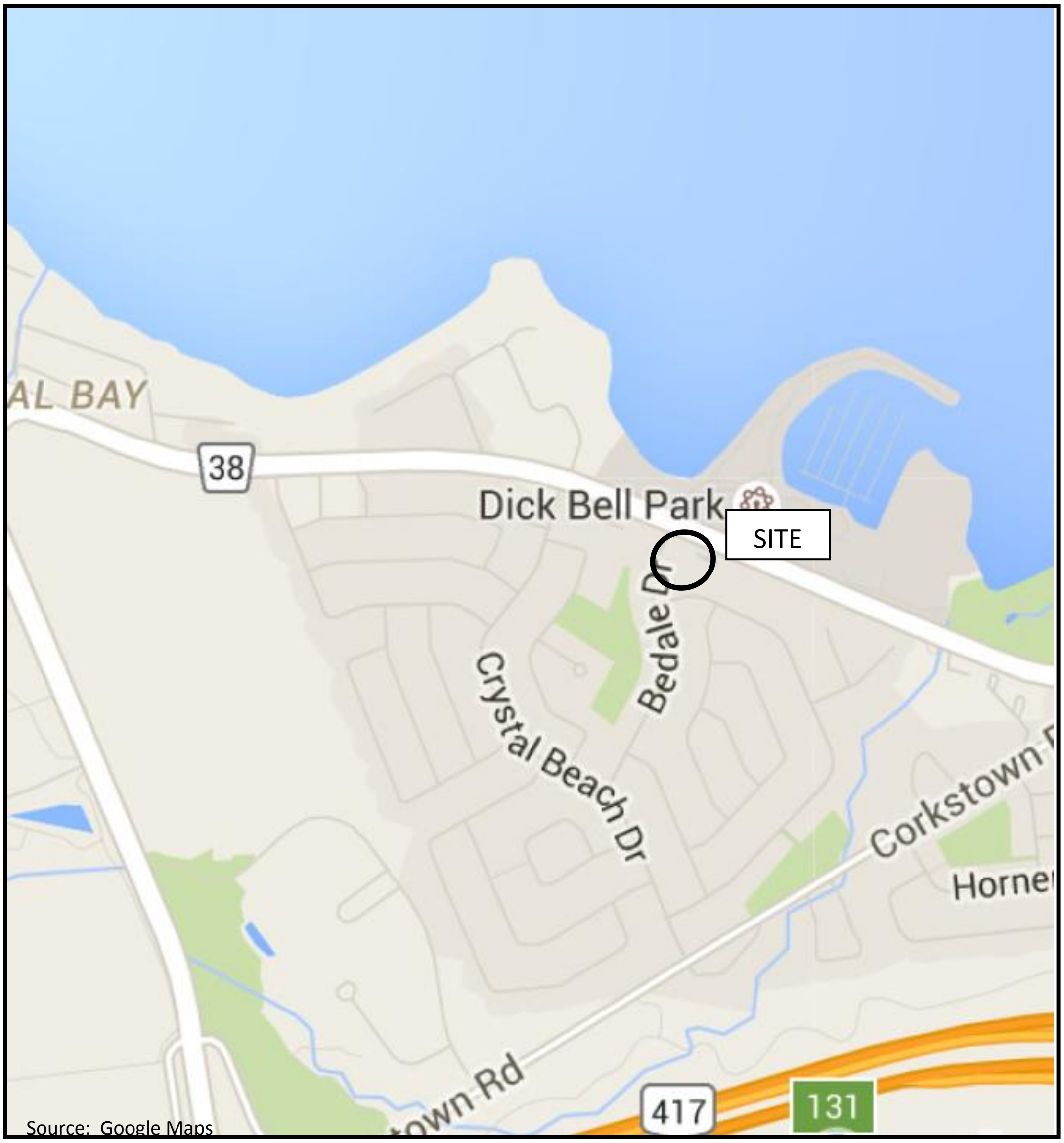
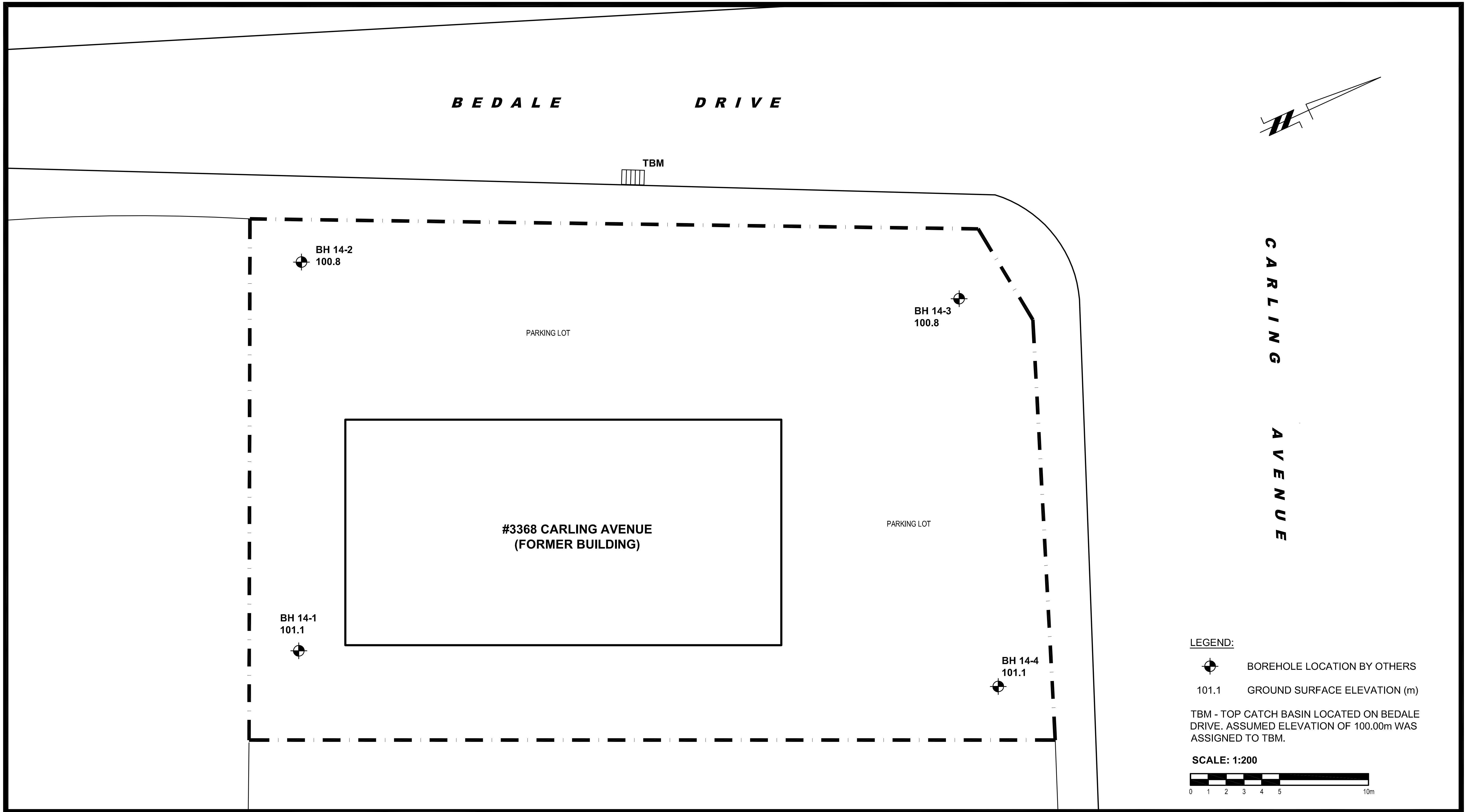


FIGURE 1

KEY PLAN



LEGEND:

⌖	BOREHOLE LOCATION BY OTHERS
101.1	GROUND SURFACE ELEVATION (m)

TBM - TOP CATCH BASIN LOCATED ON BEDALE DRIVE. ASSUMED ELEVATION OF 100.00m WAS ASSIGNED TO TBM.

SCALE: 1:200

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL

CARDEL HOMES

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL BUILDING - 3368 CARLING AVENUE

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:200
Drawn by: CPB
Checked by: JF
Approved by: DG
Date: 12/2015
Report No.: PG3682
Dwg. No.: PG3682-1
Revision No.: 0

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