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Geotechnical Investigation

Proposed Multi-Storey Buildings
Wateridge Block 19
Codd's Road
Ottawa, Ontario

Prepared For

Mattamy Homes

May 28, 2018

Report: PG4064-2R

Paterson Group Inc.
Consulting Engineers
154 Colonnade Road South
Ottawa (Nepean), Ontario
Canada K2E 7J5

Tel: (613) 226-7381
Fax: (613) 226-6344
www.patersongroup.ca

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Mattamy Homes to conduct a geotechnical investigation for the proposed Wateridge Block 19 development site (subject site) to be located on Codd's Road in the City of Ottawa (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objective of the geotechnical investigation was to:

- ❑ Determine the subsoil and groundwater conditions at this site by means of test holes.

- ❑ 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. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are understood at the time of writing this report.

The relevant test hole logs and laboratory testing results from previous geotechnical investigation reports prepared by DST Consulting Engineers, entitled Report No. IN-SO-026755 dated November 16, 2016 and Report No. OE-OT-015358 dated November 2015, are presented in Appendix 1.

2.0 Proposed Development

Based on the available drawings, it is understood that the proposed development will consist of four mixed-use buildings with 6 to 7 storeys (designated as Buildings A through D) and an amenity building with 2 storeys (designated as Building F). An underground parking level will also extend under the entirety of the site (designated as Building E). At finished grade, the proposed buildings will be surrounded by associated roadways, walkways, and landscaped areas.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

A previous geotechnical investigation was completed for the Wateridge Village development which included a total of 4 test pits and 4 boreholes completed in Block 19 on March 6 and 8, 2017, respectively. The test pits and boreholes were advanced to maximum depths of 1.5 and 6.7 m, respectively. The test hole locations were distributed in a manner to provide general coverage of the subject site taking into consideration underground utilities and site features. The locations of the test holes are shown on Drawing PG4064-1 - Test Hole Location Plan included in Appendix 2.

The test pits were completed using a track-mounted excavator and the boreholes were advanced using a track-mounted drill rig. All fieldwork was conducted under the full-time supervision of our personnel under the direction of a senior engineer from our geotechnical department. The excavating procedures consisted of advancing each test hole to the required depths at the selected locations and sampling the overburden.

In addition, field investigation programs were completed by others at the site in August 2015 and 2016 which included a total of 6 boreholes and 1 test pit completed within, or in the vicinity of, Block 19. The boreholes and test pit were completed to maximum depths of 10 m and 2.7 m, respectively. The test hole logs prepared by others are provided in Appendix 1.

The subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are logged on the Soil Profile and Test Data sheets presented in Appendix 1 of this report.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using two different techniques, namely, sampled directly from the auger flights (AU) or collected using a 50 mm diameter split-spoon (SS) sampler. All samples were visually inspected and initially classified on site. The auger and split-spoon samples were placed in sealed plastic bags, and rock cores were placed in cardboard boxes. All samples were transported to our laboratory for further examination and classification. The depths at which the auger, split spoon and rock core samples were recovered from the boreholes are shown as AU, SS and RC, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

A Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split spoon samples. The SPT results are recorded as "N" values on the Soil Profile and Test Data sheets. The "N" value is the number of blows required to drive the split spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm. This testing was done in general accordance with ASTM D1586-11 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

Undrained shear strength testing was conducted in cohesive soils using a field vane apparatus.

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

Groundwater

A 51 mm diameter PVC groundwater monitoring well was installed within borehole BH 14-17 to permit monitoring of the groundwater level subsequent to the completion of the sampling program.

Monitoring Well Installation

Typical monitoring well construction details are described below:

- 1.5 m of slotted 51 mm diameter PVC screen at the base of the aforementioned borehole.
- 51 mm diameter PVC riser pipe from the top of the screen to the ground surface.
- No.3 silica sand backfill within annular space around screen.
- A minimum of 300 mm thick bentonite hole plug directly above PVC slotted screen.
- Clean backfill from top of bentonite plug to the ground surface.

The remainder of the boreholes completed during the geotechnical investigation were instrumented with flexible standpipes to monitor the groundwater level subsequent to the completion of the sampling program. The groundwater levels were recorded in the open test pits upon completion of the sampling program.

3.2 Field Survey

The boreholes completed during the current investigation were selected by Paterson and located in the field and surveyed by J. D. Barnes Limited. The test pits were selected, located and surveyed in the field by Paterson personnel. The ground surface elevations at the test pit locations were referenced to the ground surface elevations at nearby borehole locations previously surveyed by J. D. Barnes Limited. The locations and ground surface elevation at each test hole location are presented on Drawing PG4064-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the subject site were visually examined in our laboratory to review the results of the field logging.

A total of 5 soil samples were submitted for grain size distribution analysis from the vicinity of Block 19 during the previous geotechnical investigation completed for the adjacent roadways by DST Consulting Engineers. The Grain Size Distribution sheets are provided in Appendix 1.

Furthermore, Atterberg Limits testing was also conducted which included 2 representative soil samples within the adjacent roadways during the previous geotechnical investigation completed by DST Consulting Engineers. The Atterberg Limits testing sheets are provided in Appendix 1.

3.4 Analytical Testing

A total of 4 representative soil samples from the Wateridge Village development site were submitted by others during the previous geotechnical investigation for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The samples were submitted at that time to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample within the adjacent roadways. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

Block 19 was among the sites acquired by the Department of National Defence in the 1890s and used as a military base known as Canadian Forces Base (CFB) Rockcliffe until the early 2010s. The majority of the subject section of the site was occupied by Private Married Quarters (PMQ's), outbuildings and common areas which were municipally serviced and linked by private asphalt covered roadways. By 2013, all structures within the subject section of the site were demolished while leaving the bulk of the asphalt covered roadways and municipal services intact.

The location of the former structures are illustrated on the 1991 aerial photograph provided on Drawing PG4064-2 - Aerial Photograph - 1991 in Appendix 2.

Currently, Block 19 is vacant and is being utilized as a contractor staging area. The subject site is bordered by the Hemlock Road to the north, Barielle-Snow Street then Block 21 to the east, Mikinak Road to the south, and Codd's Road to the west. The site is generally at grade with neighbouring properties and appears to be at grade with the proposed roadways which are currently under construction.

4.2 Subsurface Profile

The subsurface profile at the borehole and test pit locations in Block 19 consists of fill material which generally extends to approximate depths of 0.3 to 1.5 m below the existing ground surface. The fill material was observed to vary from crushed stone to silty clay, with occasional brick, coal, slag, and other debris. A hard to stiff, brown to grey silty clay deposit was encountered underlying the fill, extending to depths ranging from 1.5 m at the northwest end of the site to approximately 7 m at the southeast end of the site. A glacial till deposit was encountered underlying the silty clay, extending to depths ranging from approximately 2 m at the northwest end of the site to approximately 8 m at the southeast end of the of the site. The glacial till deposit was generally observed to consist of a compact to dense, brown silty clay with sand, gravel, cobbles, and boulders.

Practical refusal to augering was generally encountered at depths ranging between approximately 2 to 7.9 m below existing ground surface. Bedrock consisting of fair to excellent quality grey limestone and black shale was cored at boreholes BH 15-15 and BH 15-18 beginning at depths of 2.1 to 6.8 m below the existing ground surface.

Based on available geological mapping, the bedrock in this area consists of interbedded limestone and dolomite of the Gull River formation with an overburden drift thickness of 2 to 10 m.

4.3 Groundwater

Groundwater level readings were recorded on March 20, 2017, at the borehole locations. The groundwater level readings are presented in Table 1 below. Long-term groundwater level can also be estimated based on the observed colour, moisture levels and consistency of the recovered soil samples. Based on these observations, the long-term groundwater level is expected between 2 to 3 m depth. It should be noted that groundwater levels are subject to seasonal fluctuations, therefore, the groundwater levels could vary at the time of construction.

Table 1 - Summary of Groundwater Level Readings

Borehole Number	Ground Elevation (m)	Groundwater Levels (m)		Recording Date
		Depth	Elevation	
BH 12-17	87.46	damaged	-	March 20, 2017
BH 13-17	87.61	damaged	-	March 20, 2017
* BH 14-17	87.77	2.72	85.05	March 20, 2017
BH 15-17	87.81	damaged	-	March 20, 2017

Note:
* - Denotes borehole instrumented with a 51 mm diameter monitoring well.
- The ground surface elevations at each borehole location were provided by J. D. Barnes Limited.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed development. It is expected that the proposed buildings will generally be founded on conventional footings bearing on the undisturbed, hard to stiff silty clay, compact to dense glacial till, and/or clean, surface sounded bedrock. If the building loads exceed the bearing resistance values provided for conventional spread footing foundations, consideration can be given to a raft foundation. Due to the presence of a the silty clay deposit encountered at the site, a permissible grade raise restriction is required for the subject site.

It is expected that some bedrock removal may be required within the northern portion of the subject site to allow for construction of the below-grade parking level.

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

5.2 Site Grading and Preparation

Stripping Depth

Topsoil, asphalt and fill, containing deleterious or organic materials, should be stripped from under any building, paved areas, pipe bedding and other settlement sensitive structures. Under paved areas, existing construction remnants, such as foundation walls, pipe ducts, etc., should be excavated to a minimum depth of 1 m below final grade.

Bedrock Removal

Bedrock removal can be accomplished by hoe ramming where only a small quantity of bedrock needs to be removed. Sound bedrock may be removed by line drilling and controlled blasting and/or hoe ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings, and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in the proximity of the blasting operations should be carried out prior to commencing site activities. The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries or claims related to the blasting operations.

As a general guideline, peak particle velocities (measured at the structures) should not exceed 25 mm/s during the blasting program to reduce the risks of damage to the existing surrounding structures. The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

Excavation side slopes in sound bedrock can be carried out using near vertical sidewalls. A minimum 1 m horizontal ledge should be left between the bottom of the overburden excavation and the top of the bedrock surface to provide an area to allow for potential sloughing. The 1 m horizontal ledge set back can be eliminated with a shoring program which has drilled piles extending below the proposed founding elevation.

Vibration Considerations

Construction operations could cause vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels as much as possible should be incorporated in the construction operations to maintain a cooperative environment with the residents.

Two parameters determine the recommended vibration limit, the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As a guideline, the peak particle velocity should be less than 15 mm/s between frequencies of 4 to 12 Hz, and 50 mm/s above a frequency of 40 Hz (interpolate between 12 and 40 Hz). These guidelines are for current construction standards. These guidelines are above perceptible human level and, in some cases, could be very disturbing to some people. A pre-construction survey is recommended to minimize the risks of claims during or following the construction of the proposed building.

Fill Placement

Fill used for grading purposes beneath the proposed buildings 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 in thickness and compacted using suitable compaction equipment for the specified lift thickness. Fill placed beneath the building areas should be compacted to at least 98% of its 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 be compacted at minimum 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 their respective 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 membrane.

5.3 Foundation Design

It is expected that the proposed buildings and exterior structures, if present, will generally be founded on conventional spread footing foundations founded on the bedrock, on concrete filled trenches extending to bedrock, the glacial till deposit and/or the very stiff silty clay deposit.

Conventional Spread Footings

Bearing resistance values are provided in Table 2, below, for footings placed on a bearing surface consisting of undisturbed, hard to stiff silty clay, glacial till, or clean, surface sounded bedrock. Footings supported on undisturbed, hard to stiff silty clay and compact to dense glacial till, designed using the bearing resistance values at SLS provided in Table 2, will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively. Footings placed on clean, surface sounded bedrock will be subjected to negligible settlements.

An undisturbed soil bearing surface consists of a surface from which all organic materials 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. A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

Table 2 - Bearing Resistance Values		
Bearing Surface	**Factored Bearing Resistance Values at ULS (kPa)**	**Bearing Resistance Values at SLS (kPa)**
Hard to Stiff Silty Clay	250	150
Glacial Till	400	250
Clean Surface Sounded Bedrock	3,000	1,500

Notes:
- ❏ ULS - Ultimate Limit States
- ❏ SLS - Serviceability Limit States
- ❏ A geotechnical resistance factor of 0.5 was applied to the provided bearing resistance values at ULS

For adjacent footings where one is bearing on bedrock and the other is bearing on soil, it is recommended to decrease the soil bearing resistance value by 25% for the footings placed on soil bearing media to reduce the potential long term total and differential settlements. Also, for a given footing supported on both soil and bedrock, it is recommended that the upper 0.5 m of the bedrock be removed for a minimum length of 2 m (on the bedrock side) and replaced with nominally compacted OPSS Granular A or Granular B Type II material. The width of the subexcavation should be at least the proposed footing width plus 0.5 m. Steel reinforcement, extending at least 3 m on both sides of the 2 m long transition, should be placed in the top part of the footings and foundation walls.

Permissible Grade Raise Recommendations

Permissible grade raise recommendations have been determined for the proposed development based on the undrained shear strength values observed within the silty clay deposit during our field investigation. Based on our findings, our preliminary permissible grade raise recommendations are presented in Drawing PG4064-3 - Permissible Grade Raise in Appendix 2.

To reduce potential long term liabilities, consideration should be given to provide means to reduce long term groundwater lowering (e.g. clay dykes, restriction on planting around the structures, etc). It should be noted that building on silty clay deposits increases the likelihood of building movements and, therefore, of cracking. The use of steel reinforcement in foundations placed at key structural locations will tend to reduce foundation cracking as compared to unreinforced foundations.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to the insitu soils above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil. In sound, unfractured bedrock, a 1H:6V slope may be used.

5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class C** for Block 19. Soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the Ontario Building Code (OBC) 2012 for a full discussion of the earthquake design requirements.

A higher seismic site class, **Class A**, is be available for foundations placed on the bedrock. However, this higher site class would have to be confirmed by site specific shear wave velocity testing.

5.5 Basement Slab

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

Any soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill. 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 200 mm of sub-floor fill consists of 19 mm clear crushed stone. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

5.6 Basement Wall

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

However, undrained conditions are anticipated (i.e. below the groundwater level). Therefore, the applicable effective (undrained) 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 using the effective unit weight.

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 will only be applicable for static analyses and should not be used 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 total seismic force (P_{AE}) includes both the earth force component (P_o) and the seismic component (ΔP_{AE}).

The seismic earth force (ΔP_{AE}) can be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ 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 0.32 g according to OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

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

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

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

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

5.7 Pavement Design

Car only parking areas, access lanes and local roadways are anticipated within the subject blocks. The proposed pavement structures are shown in Tables 3 and 4.

Table 3 - Recommended Pavement Structure - Car Only Parking Areas

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

Table 4 - Recommended Pavement Structure - Access Lanes and Local Roadways

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. The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the material's SPMDD using suitable compaction equipment.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

It is recommended that a perimeter foundation drainage system be provided for the proposed buildings. The system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the underground parking structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Sub-Slab Drainage

It is anticipated that sub-slab drainage will be required to control water infiltration. For preliminary design purposes, we recommend that 150 mm perforated pipes be placed at 6 to 9 m centres underlying the basement slab. The spacing of the sub-slab drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

Foundation Backfill

Backfill against the exterior sides of the foundation walls should consist of free-draining, non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a drainage geocomposite, such as Miradrain G100N or Delta Drain 6000, connected to the perimeter foundation drainage system. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose. A waterproofing system should be provided to the elevator pits (pit bottom and walls).

6.2 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 in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for other exterior unheated footings.

6.3 Excavation Side Slopes

The side slopes of excavations in the overburden materials should be either 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).

Unsupported Side Slopes

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 subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

In bedrock, almost vertical side slopes can be used provided that all loose rock and blocks with unfavourable weak planes are removed or stabilized.

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.

Temporary Shoring

The design and approval of the temporary shoring system will be the responsibility of the shoring contractor and the shoring designer who is a licensed professional engineer and is hired by the shoring contractor. It is the responsibility of the shoring contractor to ensure that the temporary shoring system is in compliance with safety requirements, designed to avoid any damage to adjacent structures and include dewatering control measures. In the event that subsurface conditions differ from the approved design during the actual installation, it is the responsibility of the shoring contractor to commission the required experts to re-assess the design and implement the required changes. Furthermore, the design of the temporary shoring system should take into consideration a full hydrostatic condition which can occur during significant precipitation events.

The temporary shoring system could consist of a soldier pile and lagging system or steel sheet piles. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be included to the earth pressures described below. This system could be cantilevered, anchored or braced. The shoring system is recommended to be adequately supported to resist toe failure, if required, by means of extending the piles into the bedrock through pre-augered holes, if a soldier pile and lagging system is the preferred method.

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

Table 5 - Soil Parameters for Shoring System Design

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

The active earth pressure should be calculated where wall movements are permissible while the at-rest pressure should be calculated if no movement is permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

The 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.

6.4 Pipe Bedding and Backfill

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

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe, should consist of OPSS Granular A or Granular B Type II with a maximum size of 25 mm. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to 95% of the material's standard Proctor maximum dry density.

It should generally be possible to re-use the site materials above the cover material if the operations are carried out in dry weather conditions.

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) and above the cover material should match the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material standard Proctor maximum dry density.

6.5 Groundwater Control

Due to the relatively impervious nature of the overlying silty clay at the site, it is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. Where excavations are extended within the glacial till and/or bedrock surface below the long term groundwater level, the groundwater infiltration is anticipated to be moderate to high. Generally, pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations.

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

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

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.

6.6 Winter Construction

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

The subsoil 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. Additional information could be provided, if required.

6.7 Corrosion Potential and Sulphate

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

7.0 Recommendations

It is a requirement for the foundation design data provided herein to be applicable that the following material testing and observation program be performed by the geotechnical consultant.

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

A report confirming that these works have been conducted in general accordance with our recommendations could be issued upon the completion of a satisfactory inspection program by the geotechnical consultant.

8.0 Statement of Limitations

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

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

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

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

Paterson Group Inc.

Scott S. Dennis, P.E.

Carlos P. Da Silva, P.Eng., ing. QP_{ESA}

Report Distribution:

- ❏ Mattamy Homes (3 copies)
- ❏ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

TEST DATA SHEETS BY OTHERS

GRAIN SIZE DISTRIBUTION ANALYSIS BY OTHERS

ATTERBERG LIMITS TESTING RESULTS BY OTHERS

ANALYTICAL TESTING RESULTS BY OTHERS

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 8, 2017

FILE NO. PG4064

HOLE NO. BH12-17

SOIL DESCRIPTION	Depth of strata change (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.46
Asphaltic concrete	0.08	AU	1				
FILL: Crushed stone with sand	0.28	AU	2				
Hard to very stiff, brown **SILTY CLAY**		SS	3	100	14	1	86.46
	2.13	SS	4	100	11	2	85.46
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders		SS	5	92	P	3	84.46
		SS	6	73	3		
	3.99	SS	7	67	50+		
End of Borehole							
Practical refusal to augering at 3.99m depth							

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 - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 8, 2017

FILE NO. PG4064

HOLE NO. BH13-17

SOIL DESCRIPTION	Layer depth (m)	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							0	87.61
TOPSOIL with organics	0.20		AU	1				
FILL: Brown silty clay, trace sand and gravel	0.60		AU	2				
Hard, brown **SILTY CLAY**			SS	3	100	12	1	86.61
			SS	4	100	12	2	85.61
	2.64		SS	5	100	12		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders			SS	6	58	49	3	84.61
- grey by 4.6m depth			SS	7	30	28	4	83.61
			SS	8	42	18	5	82.61
End of Borehole	5.49							

Practical refusal to augering at 5.49m depth

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 - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 55 Power Auger

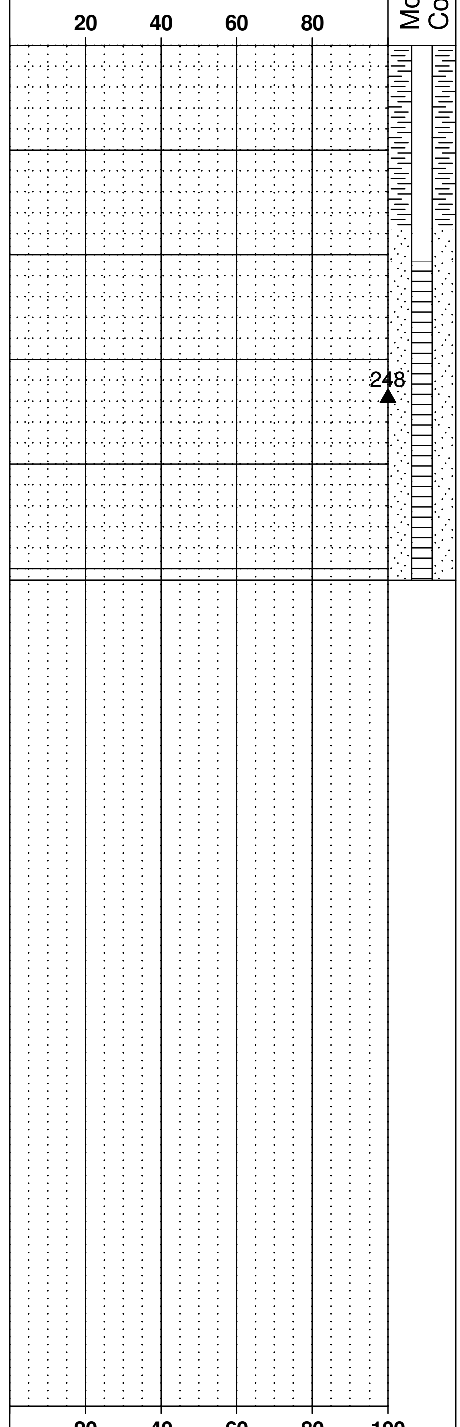
DATE March 8, 2017

FILE NO. PG4064

HOLE NO. BH14-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.77
TOPSOIL (0.10)		AU	1				
FILL: Brown silty sand with clay, trace gravel (0.66)		AU	2				
Hard to very stiff, brown **SILTY CLAY**		SS	3	100	12	1	86.77
		SS	4	100	12	2	85.77
		SS	5	100	9		
(3.63)		SS	6	100	7	3	84.77
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders		SS	7	50	19	4	83.77
- grey by 4.1m depth (5.11)		SS	8	7	50+	5	82.77
End of Borehole Practical refusal to augering at 5.11m depth							

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



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Monitoring Well Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 8, 2017

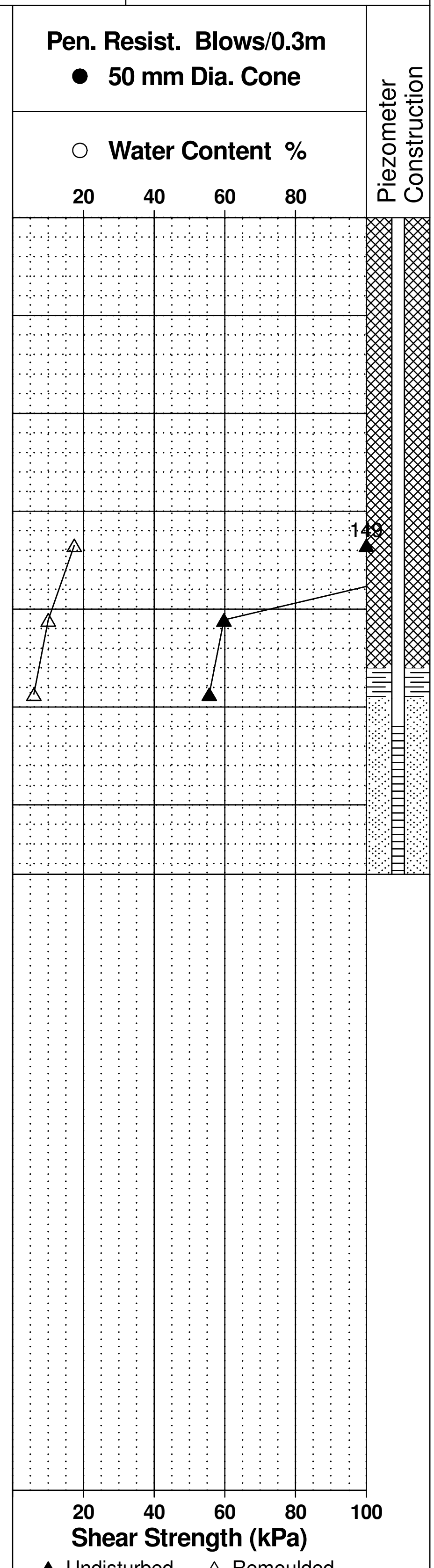
FILE NO. PG4064

HOLE NO. BH15-17

SOIL DESCRIPTION	Layer depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.81
25mm Asphaltic concrete over crushed stone and sand **FILL**	0.28	AU	1				
		AU	2				
Hard to stiff, brown **SILTY CLAY,** trace sand		SS	3	100	17	1	86.81
		SS	4	100	12	2	85.81
		SS	5	100	5	3	84.81
	4.57					4	83.81
Stiff, grey **SILTY CLAY**	5.18	SS	6	100	P	5	82.81
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders		SS	7	100	2	6	81.81
	6.71	SS	8	54	12		

End of Borehole

Practical refusal to augering at 6.71m depth



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY Hydraulic Excavator

DATE March 6, 2017

FILE NO. PG4064

HOLE NO. TP 1-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	87.50		
FILL: Brown silty clay, some sand, trace crushed stone and topsoil		G	1						
0.45									
Very stiff to stiff, brown **SILTY CLAY**		G	2						
		G	3						
0.95									
End of Test Pit (TP observed to be dry upon completion - March 6, 2017)									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY Hydraulic Excavator

DATE March 6, 2017

FILE NO. PG4064

HOLE NO. TP 2-17

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.09
FILL: Crushed stone	0.10						
FILL: Brown silty sand with crushed stone and gravel, trace clay, brick, glass, coal and slag	0.60	G	1				
TOPSOIL	0.80	G	2				
Very stiff to stiff, brown **SILTY CLAY**	1.00	G	3			1	87.09
End of Test Pit (TP observed to be dry upon completion - March 6, 2017)							

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 - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY Hydraulic Excavator

DATE March 6, 2017

FILE NO. PG4064

HOLE NO. TP 3-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	87.98		
FILL: Brown silty sand with clay, crushed stone, gravel, trace cobbles, boulders, metal wire, shingles, tile and brick (to 0.70)		G	1						
Very stiff to stiff, brown **SILTY CLAY** (0.70 to 1.50)		G	2			1	86.98		
End of Test Pit (1.50)									

(TP observed to be dry upon completion - March 6, 2017)

Pen. Resist. / Water Content % axis: 20, 40, 60, 80

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

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Blocks 15, 19, 22 & 24
335 St. Laurent Blvd., Ottawa, Ontario

DATUM Ground surface elevations referenced from the ground surface elevations of borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY Hydraulic Excavator

DATE March 6, 2017

FILE NO. PG4064

HOLE NO. TP 4-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	87.96		
FILL: Topsoil with brown silty clay, some sand and crushed stone, trace coal and slag (to 0.65)		G	1						
Very stiff to stiff, brown **SILTY CLAY** (to 1.30)		G	2			1	86.96		
End of Test Pit									
(TP observed to be dry upon completion - March 6, 2017)									

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

▲ Undisturbed △ Remoulded

LOG OF BOREHOLE BH15-15

DST REF. No.:**OE-OT-015358**
CLIENT: **Canada Lands Company (CLC)**
PROJECT: **Phase 1A Development - Site Servicing**
LOCATION:**Former CFB Rockliffe, Ottawa Ontario**
SURFACE ELEVATION: 87.76 N/A

Drilling Data
METHOD: **Hollow Stem Auger/ NQ Size Core Barrel**
DIAMETER: **200 mm**
DATE: **August 26, 2015**
COORDINATES: **5033477.421** m N, **450420.068** m E

MATERIAL DESCRIPTION	SAMPLE #	'N' VALUE
ASPHALT ~ 150 mm		
FILL - SAND - silty, brown, loose	SS1	5
CLAY - Silty, brown, stiff	SS2	13
TILL - Sand, silty, some gravel, grey, compact	SS3	50
LIMESTONE BEDROCK - Grey to dark grey RC1 - 0.78 m, TCR = 100%, SCR = 78%, RQD = 50%	RC1	
RC2 - 1.45 m, TCR = 98%, SCR = 98%, RQD = 88%	RC2	
RC3 - 1.60 m, TCR = 92%, SCR = 92%, RQD = 81%	RC4	
RC4 - 1.52 m, TCR = 97%, SCR = 95%, RQD = 89%	RC3	
RC5 - 0.59 m, TCR = 95%, SCR = 95%, RQD = 69%	RC5	
End of Borehole at 8.0 m.		

DEPTH (m): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0
ELEV. (m): 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77, 76

% MOISTURE: W_p W W_l 20 40 60 80
VANE (kPa) × 20 40 60 80
SPT (N) □ Blows/0.3m DCPT ◆ 20 40 60 80

REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
- 19 mm diameter standpipe piezometer installed as shown
- Groundwater level is 3.27 m (Elev. 84.5 m) on October 1, 2015

DST consulting engineers
DST Consulting Engineers Inc.
203 - 2150 THURSTON DRIVE
OTTAWA, ONTARIO, K1G 5T9
PH: (613)748-1415
FX: (613)748-1356
Email: ottawa@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

☰ Auger Sample	▮ Rock Core	■ Bentonite
▨ Split Spoon Sample	▩ Hiller Peat Sampler	░ Sand
▥ Bulk Sample	▯ 70mm Thin Wall Tube	▦ Slough

ENCLOSURE 16

LOG OF BOREHOLE BH15-18

DST REF. No.:**OE-OT-015358**
CLIENT: **Canada Lands Company (CLC)**
PROJECT: **Phase 1A Development - Site Servicing**
LOCATION:**Former CFB Rockliffe, Ottawa Ontario**
SURFACE ELEVATION: 87.18 N/A

Drilling Data
METHOD: **Hollow Stem Auger/ NQ Size Core Barrel**
DIAMETER: **200 mm**
DATE: **August 24, 2015**
COORDINATES: **5033318.423** m N, **450416.451** m E

DEPTH (m)	ELEV. (m)	Water Data	% MOISTURE (W_p, W, W_l) 20 40 60 80	MATERIAL DESCRIPTION	SAMPLE #	SAMPLE TYPE	'N' VALUE	VANE (kPa) ✕ / SPT (N) □ Blows/0.3m / DCPT ◆ 20 40 60 80	REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
	87			TOPSOIL~380 mm	SS1	Split Spoon	5		
				FILL - SAND AND GRAVEL - silty, brown, loose					
1.0	86			FILL - SILT AND SAND - trace gravel, rootlets, dark brown, loose	SS2	Split Spoon	7		
2.0	85			CLAY - Silty, brown, stiff	SS3	Split Spoon	15		
					SS4	Split Spoon	11		
3.0	84				SS5	Split Spoon	8		
4.0	83			CLAY - Silty, grey, very stiff to hard				Vane 200	
					SS6	Split Spoon	3		
								Vane 147	
5.0	82							Vane 129	
		▼			SS7	Split Spoon	1		
6.0	81							Vane 200	
				TILL- Sand, silty, some clay and gravel, grey, compact	SS8	Split Spoon	12		
7.0	80			LIMESTONE BEDROCK - Grey to dark RC1 - 0.46 m, TCR = 100%, SCR = 65%, RQD = 65%	RC1	Rock Core			
8.0	79			RC2 - 1.37 m, TCR = 91%, SCR = 52%, RQD = 50%	RC2	Rock Core			
9.0	78			SHALE BEDROCK - Black RC3 - 1.39 m, TCR = 84%, SCR = 71%, RQD = 71%	RC3	Rock Core			
10.0	77			End of Borehole at 10.0 m.					
11.0	76								

DST Consulting Engineers Inc.
203 - 2150 THURSTON DRIVE
OTTAWA, ONTARIO, K1G 5T9
PH: (613)748-1415
FX: (613)748-1356
Email: ottawa@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

Auger Sample, Split Spoon Sample, Bulk Sample, Rock Core, Hiller Peat Sampler, 70mm Thin Wall Tube, Bentonite, Sand, Slough

ENCLOSURE 19

LOG OF BOREHOLE BH15-19

DST REF. No.:**OE-OT-015358**
CLIENT: **Canada Lands Company (CLC)**
PROJECT: **Phase 1A Development - Site Servicing**
LOCATION:**Former CFB Rockliffe, Ottawa Ontario**
SURFACE ELEVATION: 88.25 N/A

Drilling Data
METHOD: **Hollow Stem Auger**
DIAMETER: **200 mm**
DATE: **August 24, 2015**
COORDINATES: **5033321.045** m N, **450560.448** m E

DEPTH (m)	ELEV. (m)	MATERIAL DESCRIPTION	SAMPLE #	'N' VALUE	REMARKS
0.0	88.25	TOPSOIL~125 mm			- 19 mm diameter standpipe piezometer installed as shown
		FILL - CLAY AND SILT - trace to some rootlets, brown to dark brown, stiff	SS1	9	
		CLAY - Silty, brown, very stiff to hard	SS2	16	
			SS3	11	
			SS4	8	
			SS5	4	- Groundwater level is 4.22 m (Elev. 84.0 m) on October 1, 2015
					Vane: 172
					Vane: 200
		CLAY - Silty, grey, stiff	SS6	0	
			SS7	0	
		TILL - Sand, silty, some clay and gravel, grey, loose	SS8	9	
7.9		End of Borehole at 7.9 m.			

Column headings: DEPTH (m); ELEV. (m); Water Data; % MOISTURE (W_p, W, W_l; 20 40 60 80); Symbol; MATERIAL DESCRIPTION; SAMPLE #; SAMPLE TYPE; 'N' VALUE; VANE (kPa) × 20 40 60 80; SPT (N) □ Blows/0.3m; DCPT ◆ 20 40 60 80; REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL

Depth scale: 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0
Elevation scale: 88, 87, 86, 85, 84, 83, 82, 81, 80, 79, 78, 77

BOREHOLE (STANDARD) - OTTAWA PROJECT.GPJ DST_MIN.GDT 11/6/15

DST consulting engineers
DST Consulting Engineers Inc.
203 - 2150 THURSTON DRIVE
OTTAWA, ONTARIO, K1G 5T9
PH: (613)748-1415
FX: (613)748-1356
Email: ottawa@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

Auger Sample	Rock Core	Bentonite
Split Spoon Sample	Hiller Peat Sampler	Sand
Bulk Sample	70mm Thin Wall Tube	Slough

ENCLOSURE 20

LOG OF BOREHOLE BH16-01

DST REF. No.: **IN-SO-026755**
CLIENT: **Canada Lands Company**
PROJECT: **Site Servicing Phase 1B**
LOCATION: **Wateridge Village, Ottawa, Ontario**
SURFACE ELEV.: **87.71 metres**

Drilling Data
METHOD: **Hollow Stem Auger**
DIAMETER: **200 mm**
DATE: **August 26, 2016**
COORDINATES: **5035157.53** m N, **372599.17** m E

DEPTH (m)	ELEV. (m)	Water Data	% MOISTURE (W_p W W_l) 20 40 60 80	Symbol	MATERIAL DESCRIPTION	SAMPLE #	SAMPLE TYPE	'N' VALUE	VANE (kPa) 20 40 60 80 / SPT (N) Blows/0.3m / DCPT 20 40 60 80	REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
					TOPSOIL - grass 180 mm thick					
					FILL - SAND AND GRAVEL - trace silt, asphalt fragments, brown, loose	SS1		4		
	87				CLAY - silty, brown, stiff					Standpipe piezometer 20 mm diameter installed as shown
1.0						SS2		10		
	86				CLAY - silty, grey, stiff to very stiff	SS3		11		
2.0										Groundwater level is 2.0 m (Elev. 85.71 m), on Sept. 8, 2016
	85					SS4		8		
3.0					TILL - sand, some clay and silt, trace of gravel, grey, loose	SS5		10		
4.0	84					SS6		8		9 70 (21)
	83				End of Borehole at 4.4 m Split Spoon Sampler and Auger Refusal on Inferred Bedrock					
5.0	82									
6.0	81									
7.0	80									

DST Consulting Engineers
Email: thunderbay@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

Auger Sample	Rock Core	Bentonite
Split Spoon Sample	Hiller Peat Sampler	Sand
Bulk Sample	70mm Thick Wall Tube	

LOG OF BOREHOLE BH16-02

DST REF. No.: **IN-SO-026755**
CLIENT: **Canada Lands Company**
PROJECT: **Site Servicing Phase 1B**
LOCATION: **Wateridge Village, Ottawa, Ontario**
SURFACE ELEV.: **88.05 metres**

Drilling Data
METHOD: **Hollow Stem Auger**
DIAMETER: **200 mm**
DATE: **August 26, 2016**
COORDINATES: **5035157.52** m N, **372671.86** m E

DEPTH (m)	ELEV. (m)	MATERIAL DESCRIPTION	SAMPLE #	SAMPLE TYPE	'N' VALUE (Blows/0.3m)	REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
0.0	88	ASPHALT - 250 mm thick				
		FILL - SAND AND GRAVEL - trace clay and silt, brown, compact	SS1	Split Spoon	28	37 57 (6)
1.0	87		SS2	Split Spoon	18	
		FILL - GRAVELLY SAND - trace clay and silt, brown, compact to dense	SS3	Split Spoon	10	22 65 (13)
2.0	86		SS4	Split Spoon	37	29 60 (11)
3.0	85		SS5	Split Spoon	16	
			SS6	Split Spoon	50+	
4.0	84	End of Borehole at 4.0 m Split Spoon Sampler and Auger Refusal on Inferred Bedrock				

Chart column headings: Water Data; % MOISTURE (W_p, W, W_l; 20 40 60 80); Symbol; VANE (kPa) ✖ 20 40 60 80; SPT (N) □ Blows/0.3m; DCPT ◆ 20 40 60 80

Depth scale: 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0 — Elevation scale: 88, 87, 86, 85, 84, 83, 82, 81

BOREHOLE (STANDARD) PHASE 1B BOREHOLES V1.3.GPJ DST_MIN.GDT 10-24-16

DST consulting engineers

DST Consulting Engineers
Email: thunderbay@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

Auger Sample; Split Spoon Sample; Bulk Sample; Rock Core; Hiller Peat Sampler; 70mm Thick Wall Tube; Bentonite; Sand

LOG OF BOREHOLE BH16-13

DST REF. No.: **IN-SO-026755**
CLIENT: **Canada Lands Company**
PROJECT: **Site Servicing Phase 1B**
LOCATION: **Wateridge Village, Ottawa, Ontario**
SURFACE ELEV.: **87.66 metres**

Drilling Data
METHOD: **Hollow Stem Auger**
DIAMETER: **200 mm**
DATE: **August 26, 2016**
COORDINATES: **5035075.11** m N, **372672.07** m E

DEPTH (m)	ELEV. (m)	MATERIAL DESCRIPTION	SAMPLE #	'N' VALUE	REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
		ASPHALT - 75 mm thick			
		TOPSOIL - 50 mm thick			
		FILL - SAND - gravelly, trace clay and silt, brown, compact	SS1	13	22 67 (11)
	87				
1.0		CLAY - Silty, brown, stiff to hard	SS2	8	
	86				
2.0			SS3	10	
	85				
3.0			SS4	2	
	84				
4.0			SS5	0	
		CLAY - Silty, grey, soft to stiff			
	83		SS6	0	
5.0					
	82		SS7	0	
6.0		TILL - Silty clay, grey, stiff	SS8	14	
	81	End of Borehole at 6.7 m			
7.0					
	80				

Column headings: Water Data; % MOISTURE (W_p, W, W_l; 20 40 60 80); Symbol; SAMPLE TYPE; VANE (kPa) ✖ 20 40 60 80; SPT (N) □ Blows/0.3m; DCPT ◆ 20 40 60 80

>>✖

DST consulting engineers

DST Consulting Engineers
Email: thunderbay@dstgroup.com
Web: www.dstgroup.com

SAMPLE TYPE LEGEND

Auger Sample, Split Spoon Sample, Bulk Sample, Rock Core, Hiller Peat Sampler, 70mm Thick Wall Tube, Bentonite, Sand

LOG OF TESTPIT TP13-10

DST REF. No.: **OE-OT-017184**
CLIENT: **Canada Lands Company (CLC)**
PROJECT: **Stormwater Management Plan**
LOCATION: **Former CFB Rockcliffe, Ottawa, Ontario**
SURFACE ELEV.: **87.76 metres**

Testpit Data
METHOD: **Excavator**
DATE: **9/4/2013**
COORDINATES: **5033403.6** m N, **450499.2** m E

DEPTH (m)	ELEV. (m)	Water Data	% MOISTURE (W_p, W, W_l; 20 40 60 80)	Symbol	MATERIAL DESCRIPTION	DEPTH(m)	SAMPLE TYPE	'N' VALUE	VANE (kPa) × 20 40 60 80 / CPT (kPa) ◆ 300 600 900 1200	REMARKS & GRAINSIZE DISTRIBUTION (%) GR SA SI CL
0.0–0.5					FILL - SAND & GRAVEL - some silt, trace clay and roots, brown					
0.5–0.7					FILL - SAND - some cobbles, light brown					
0.7–0.9	87				CLAY - Silty, some sand and gravel, brown, stiff					
0.9–2.7	86				CLAY - Silty, grey, stiff	1, 2				
2.7	85				End of Testpit at 2.7 m	3, 4				

Depth scale (m): 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.2, 4.4, 4.6, 4.8
Elevation scale (m): 87, 86, 85, 84, 83

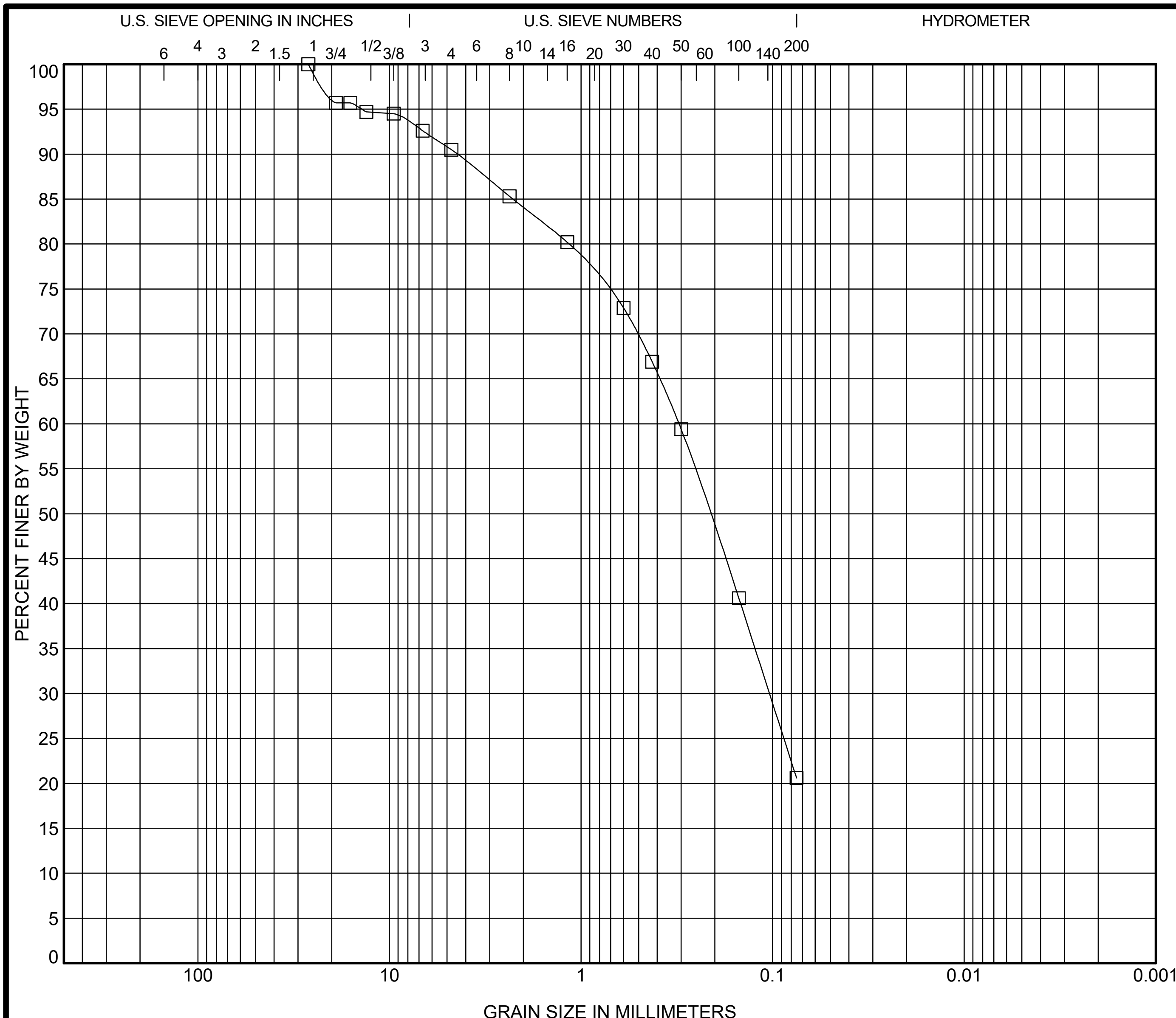
DST consulting engineers

*DST Consulting Engineers Inc.
203 - 2150 THURSTON DRIVE
OTTAWA, ONTARIO, K1G 5T9
PH: (613)748-1415
FX: (613)748-1356
Email: ottawa@dstgroup.com
Web: www.dstgroup.com*

SAMPLE TYPE LEGEND

Bulk Sample

ENCLOSURE 10



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification
□	**BH16-01, SS6, Depth: 3.8 - 4.4 m**
	Date started:
	Date completed:

CAN GRAIN SIZE SIEVE TEST BH-01(SS-6) V1.1.GPJ DST MIN.GDT 10-24-16

DST consulting engineers

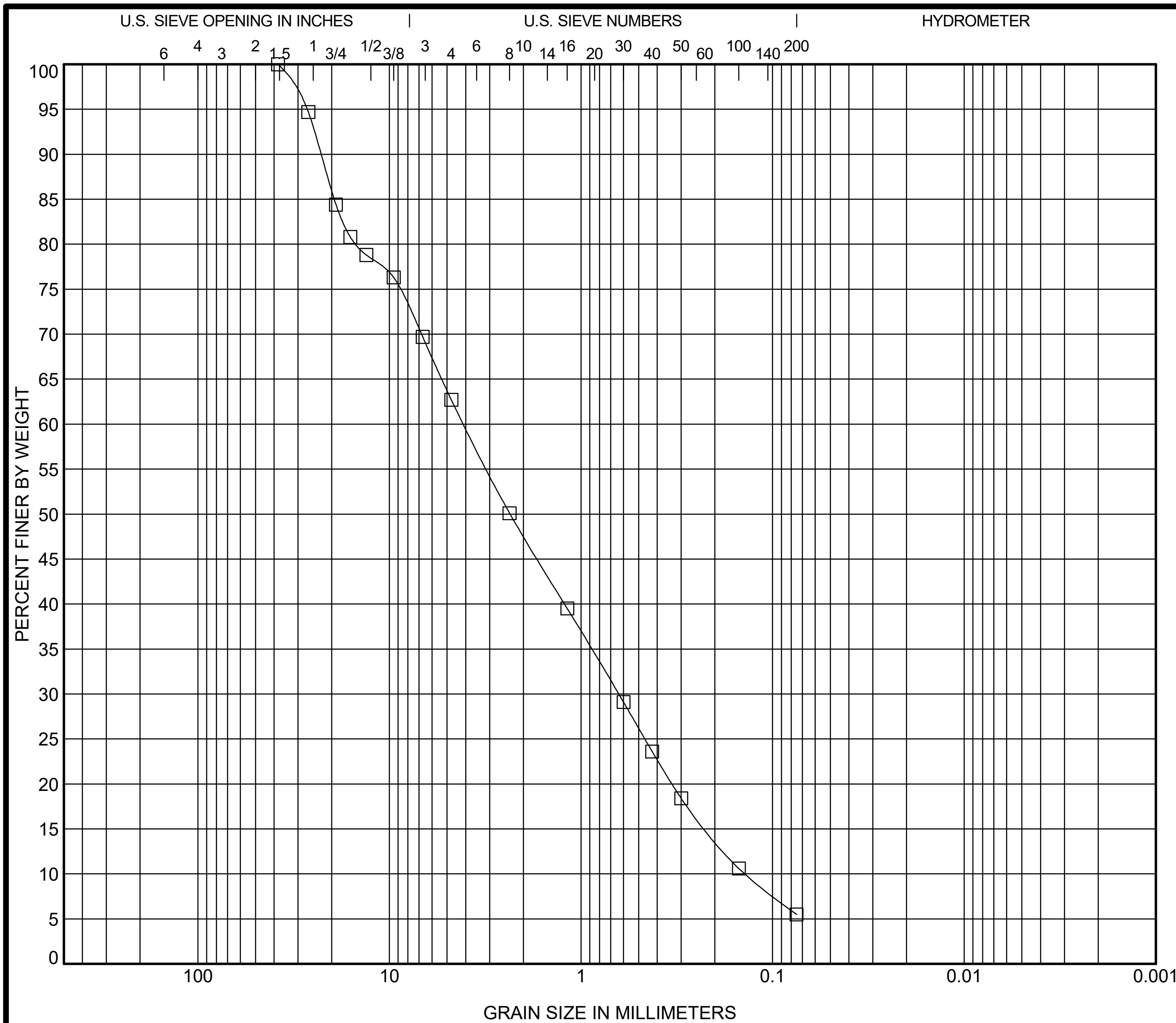
DST Consulting Engineers
2150 Thurston Drive
Ottawa, Ontario K1G 5T9
Telephone: (613) 748-1415
Fax: (613) 748-1356

GRAIN SIZE DISTRIBUTION CURVE

Project: Site Servicing Phase 1B

Location: Wateridge Village, Ottawa, Ontario

Project Number: IN-SO-026755



<table>
<tr><td rowspan="2">COBBLES</td><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td rowspan="2">SILT OR CLAY</td></tr>
<tr><td>coarse</td><td>fine</td><td>coarse</td><td>medium</td><td>fine</td></tr>
</table>

Specimen Identification	
☐	**BH16-02, SS-1, Depth: 0.1 - 0.7 m**
	Date started:
	Date completed:

CAN GRAIN SIZE SIEVE TEST BH-02(SS-1) V1.1.GPJ DST MIN.GDT 10-24-16

DST consulting engineers

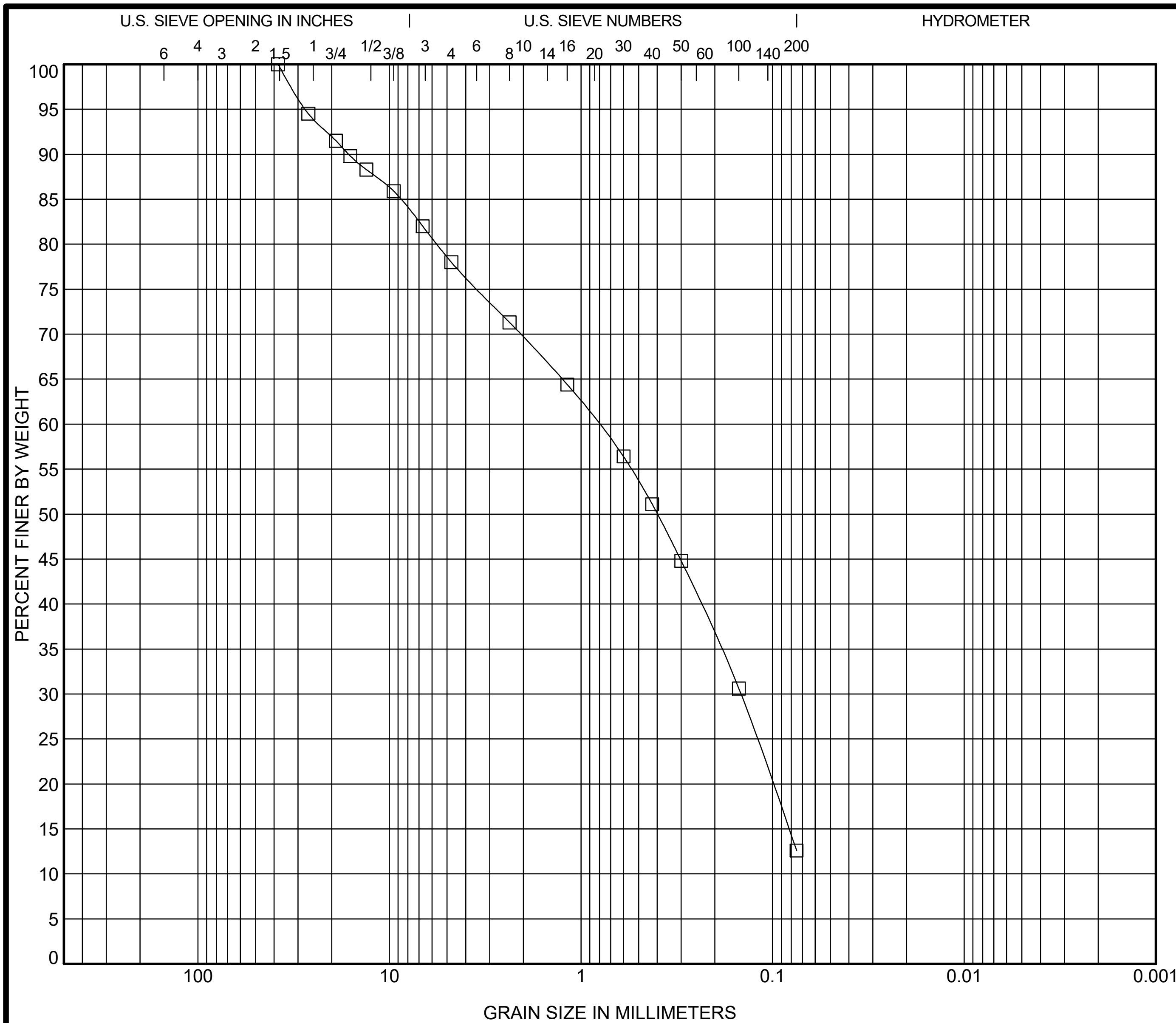
DST Consulting Engineers
2150 Thurston Drive
Ottawa, Ontario K1G 5T9
Telephone: (613) 748-1415
Fax: (613) 748-1356

GRAIN SIZE DISTRIBUTION CURVE

Project: Site Servicing Phase 1B

Location: Wateridge Village, Ottawa, Ontario

Project Number: IN-SO-026755



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification
☐	**BH16-02, SS-3, Depth: 1.5 - 2.1 m**
	Date started:
	Date completed:

CAN GRAIN SIZE SIEVE TEST BH-02(SS-3) V1.1.GPJ DST MIN.GDT 10-24-16

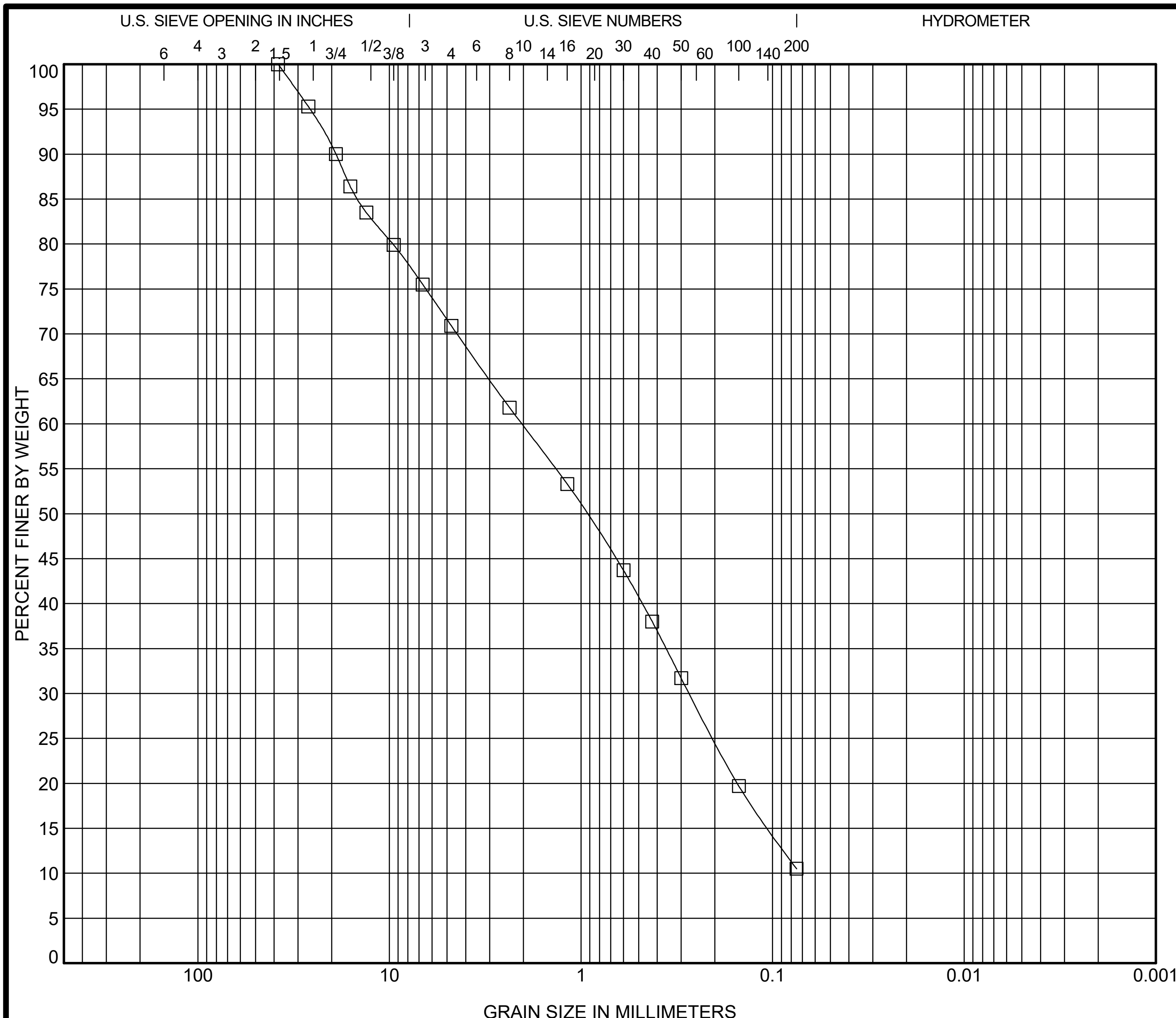
DST Consulting Engineers
2150 Thurston Drive
Ottawa, Ontario K1G 5T9
Telephone: (613) 748-1415
Fax: (613) 748-1356

GRAIN SIZE DISTRIBUTION CURVE

Project: Site Servicing Phase 1B

Location: Wateridge Village, Ottawa, Ontario

Project Number: IN-SO-026755



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	
☐	**BH16-02, SS-4, Depth: 2.3 - 2.9 m**
	Date started:
	Date completed:

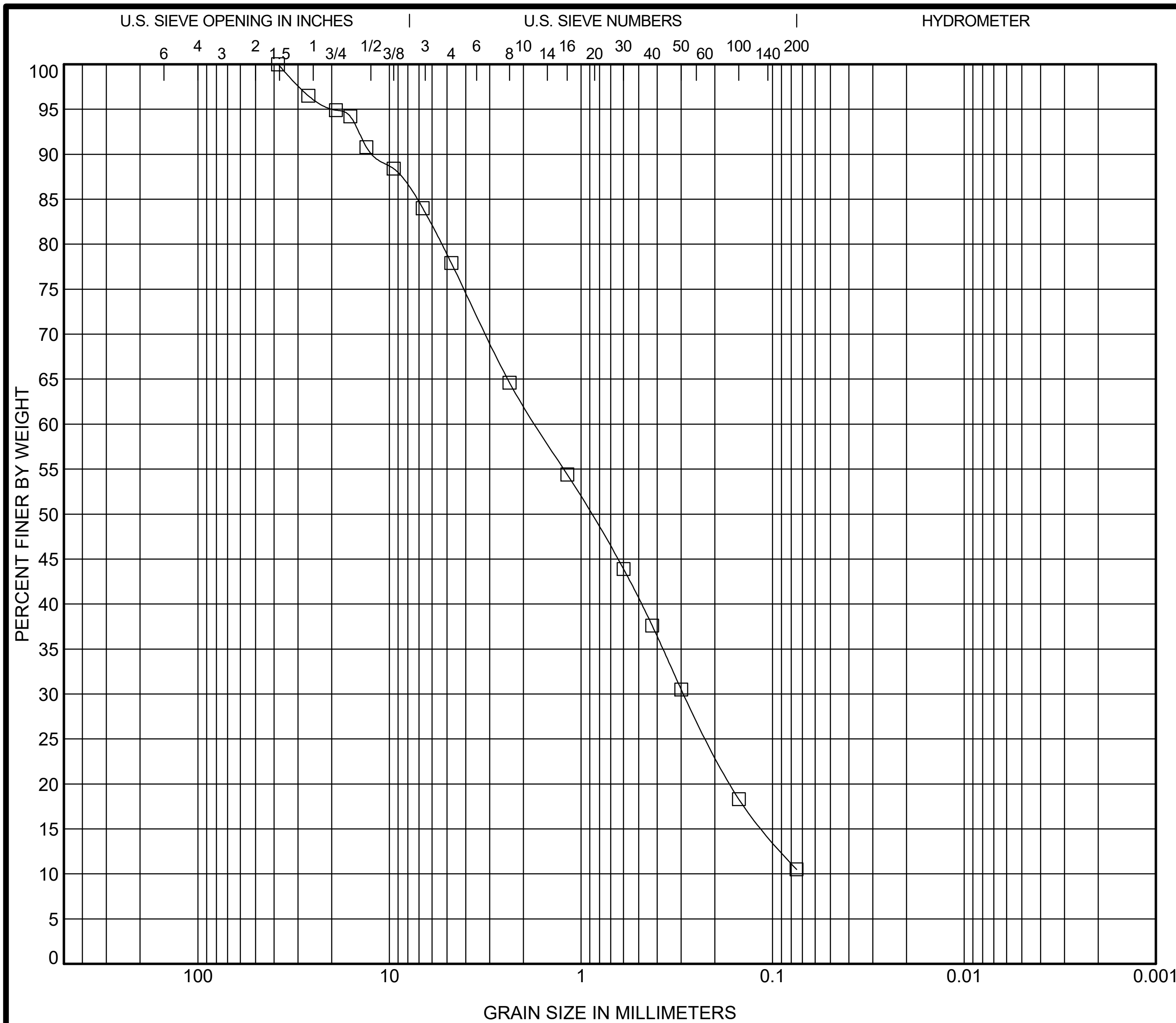
DST Consulting Engineers
2150 Thurston Drive
Ottawa, Ontario K1G 5T9
Telephone: (613) 748-1415
Fax: (613) 748-1356

GRAIN SIZE DISTRIBUTION CURVE

Project: Site Servicing Phase 1B

Location: Wateridge Village, Ottawa, Ontario

Project Number: IN-SO-026755



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification
□	**BH16-13, SS-1, Depth: 0.1 - 0.7 m**
	Date started:
	Date completed:

CAN GRAIN SIZE SIEVE TEST BH-13(SS-1) V1.1.GPJ DST MIN.GDT 10-24-16

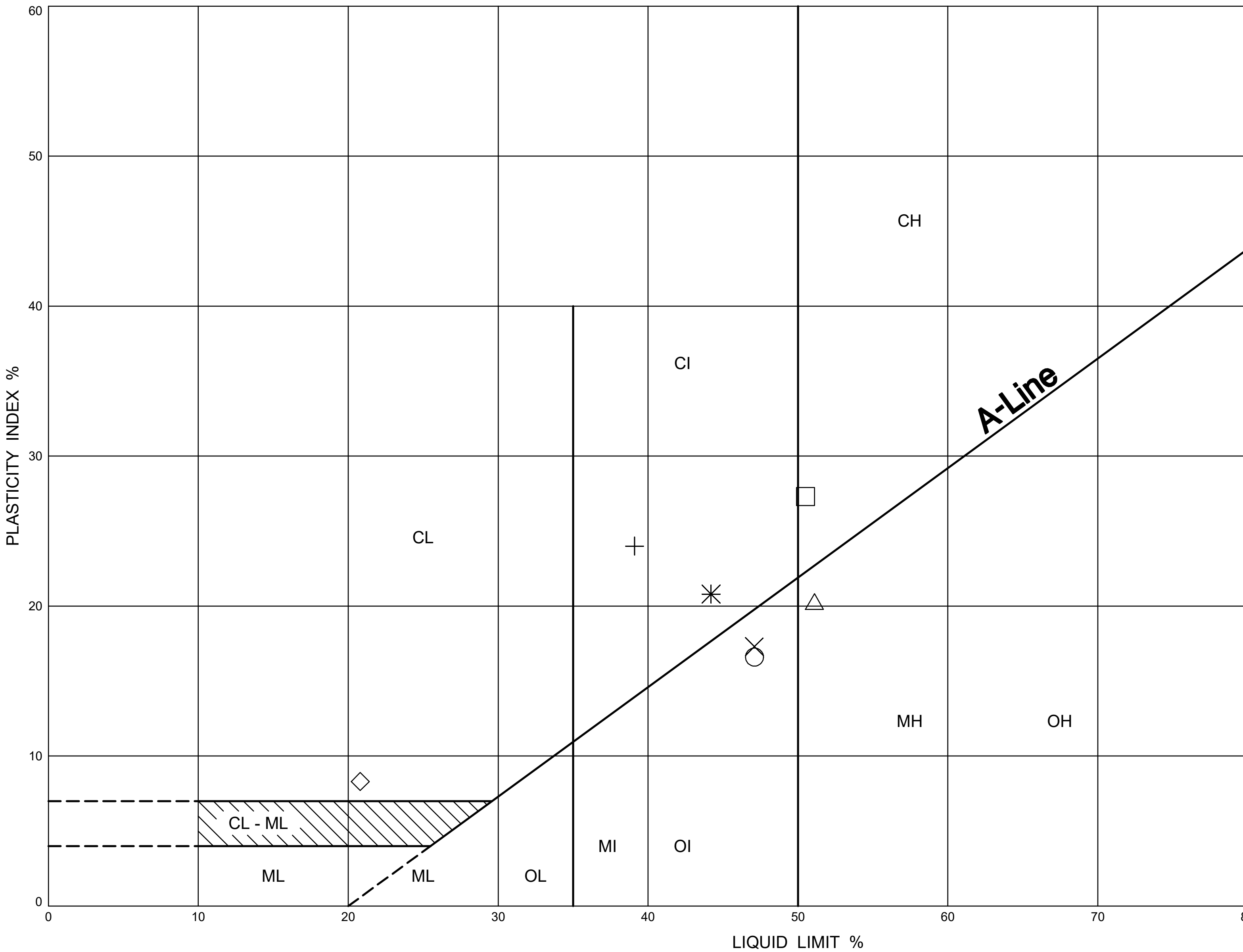
DST Consulting Engineers
2150 Thurston Drive
Ottawa, Ontario K1G 5T9
Telephone: (613) 748-1415
Fax: (613) 748-1356

GRAIN SIZE DISTRIBUTION CURVE

Project: Site Servicing Phase 1B

Location: Wateridge Village, Ottawa, Ontario

Project Number: IN-SO-026755



LEGEND		
BH	DEPTH	SYMBOL
BH16-01-SS3	1.5 - 2.1 m	□
BH16-04-SS3	1.5 - 2.1 m	✳
BH16-11-SS3	1.5 - 2.1 m	×
BH16-13-SS5	3.8 - 4.4 m	+
BH16-18-SS5	3.0 - 3.6 m	◇
BH16-19-SS3	1.5 - 2.1 m	△
BH16-22-SS6	3.8 - 4.4 m	○

ONTARIO MOT PLASTICITY CHART PHASE 1B ATTERBERG GRAPHS V1.1.GPJ DST_MIN.GDT 10-24-16

DST consulting engineers

PLASTICITY CHART

DST Ref. No.: **IN-SO-026755**

Client: **Canada Lands Company**

Project: **Site Servicing Phase 1B**

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

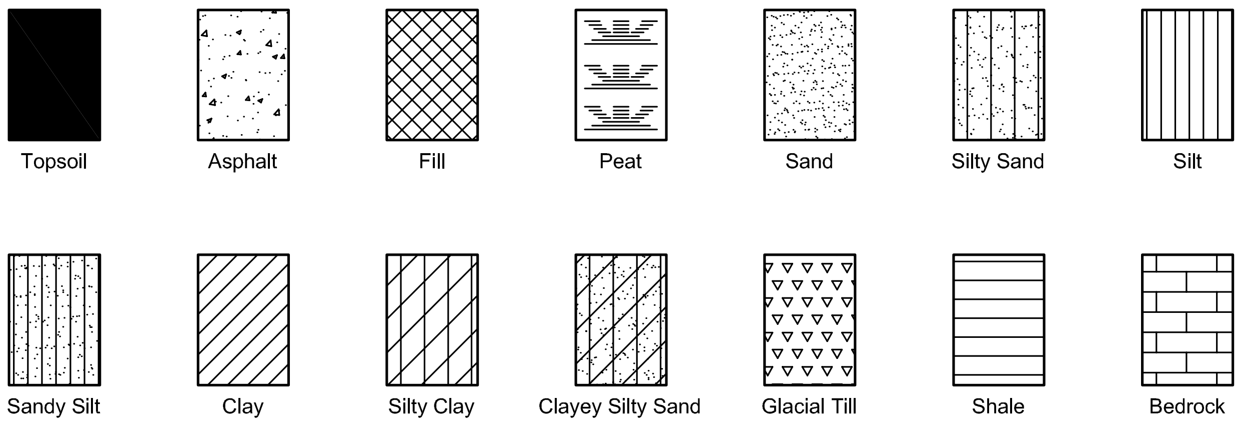
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void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

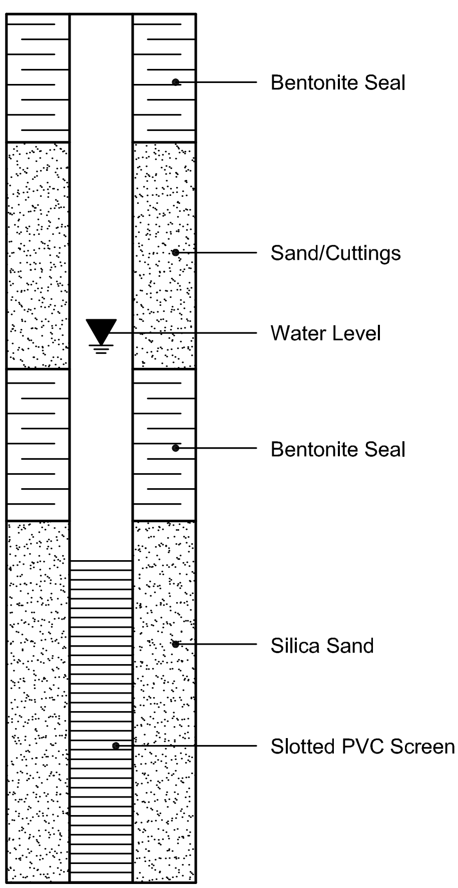
SYMBOLS AND TERMS (continued)

STRATA PLOT

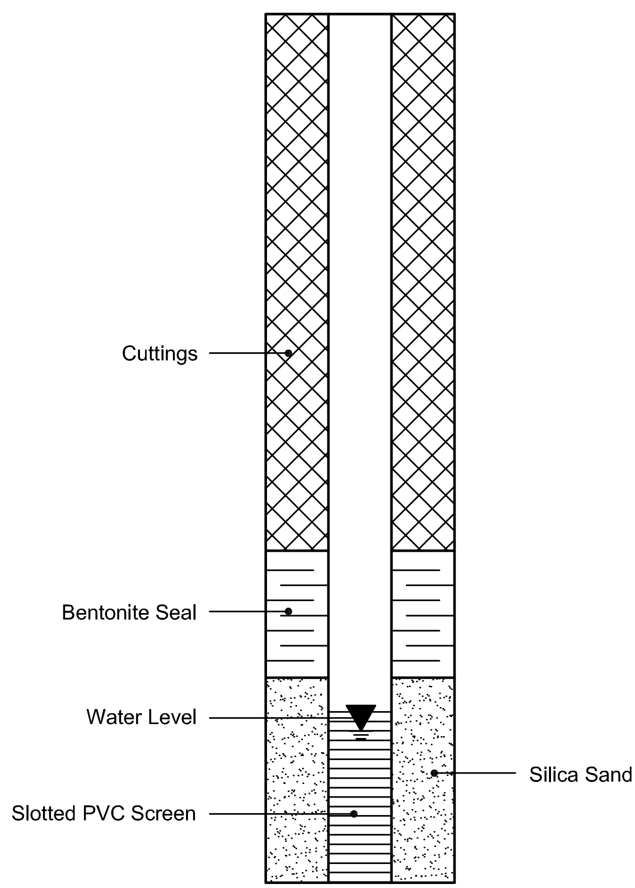


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: DST Consulting Engineers Inc. (Ottawa)

Client PO:

Report Date: 16-Sep-2016

Order Date: 15-Sep-2016

Project Description: IN SO 026755

	Client ID:	BH-17 (SS-8)	BH-14 (SS-7)	BH-13 (SS-6)	BH-6 (SS-6)
	Sample Date:	02-Sep-16	02-Sep-16	02-Sep-16	02-Sep-16
	Sample ID:	1638309-01	1638309-02	1638309-03	1638309-04
	MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics					
% Solids	0.1 % by Wt.	54.6	60.7	62.4	84.8
General Inorganics					
pH	0.05 pH Units	8.37	8.19	8.06	7.89
Resistivity	0.10 Ohm.m	11.9	29.8	11.3	34.7
Anions					
Chloride	5 ug/g dry	156	10	411	9
Sulphate	5 ug/g dry	146	186	170	254

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG4064-1 - TEST HOLE LOCATION PLAN

DRAWING PG4064-2 - AERIAL PHOTOGRAPH - 1991

DRAWING PG4064-3 - PERMISSIBLE GRADE RAISE AREAS

FIGURE 1

KEY PLAN

LEGEND:

BOREHOLE LOCATION

BOREHOLE WITH MONITORING WELL LOCATION

TEST PIT LOCATION

TEST PIT BY OTHERS (DST,2013)

BOREHOLE LOCATION (DST, 2016)

BOREHOLE LOCATION (DST, 2015)

BOREHOLE WITH MONITORING WELL (DST, 2013)

BOREHOLE WITH MONITORING WELL (DST, 2004)

SANITARY SEWER (CITY OF OTTAWA ARC VIEW)

92.27 GROUND SURFACE ELEVATION (m)

(90.52) PRACTICAL REFUSAL TO AUGERING/DCPT ELEVATION (m)

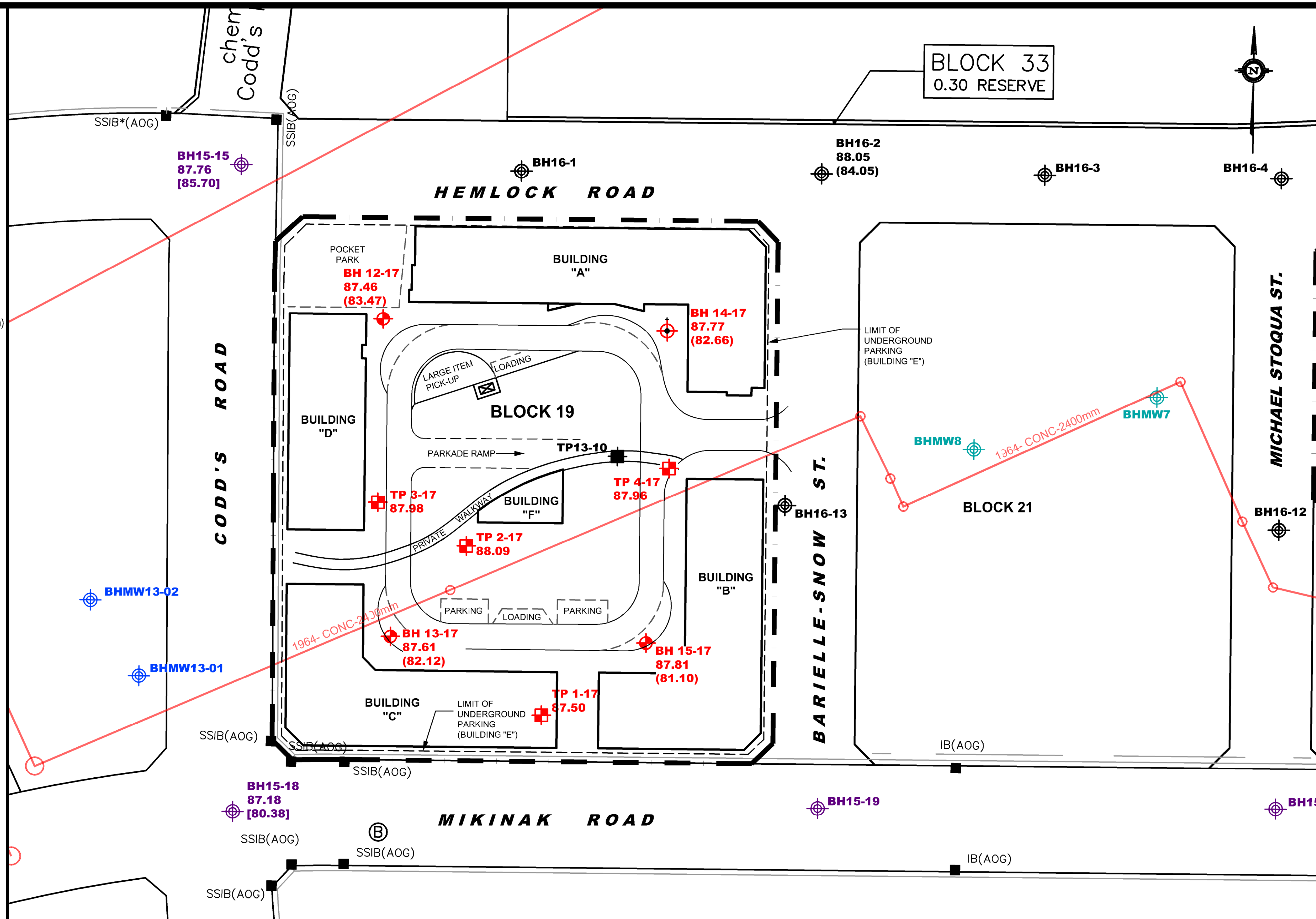
[85.70] BEDROCK SURFACE ELEVATION (m)

SURVEY PLAN PROVIDED BY ANNIS, O'SULLIVAN & VOLLEBEKK LTD.
JOB NO.14710-14 CLC Pt Lts 21-23 C1 OF GL Ph 1B SUB D13

GROUND SURFACE ELEVATIONS AT THE TEST PIT LOCATIONS REFERENCED FROM THE GROUND SURFACE ELEVATIONS OF NEARBY BOREHOLE LOCATIONS PROVIDED BY J.D. BARNES LIMITED.

SCALE: 1:1000

0 10 20 30 40 50m 75m



paterson group
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES
GEOTECHNICAL INVESTIGATION
WATERIDGE BLOCK 19 - CODD'S ROAD

OTTAWA, ONTARIO

Title: **TEST HOLE LOCATION PLAN**

Scale:	1:1000	Date:	01/2018
Drawn by:	RCG	Report No.:	PG4064-2
Checked by:	SD	Dwg. No.:	PG4064-1
Approved by:	CDS	Revision No.:	0

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LEGEND:

SURVEY PLAN PROVIDED BY ANNIS, O'SULLIVAN & VOLLEBEKK LTD. JOB NO.14710-14 CLC Pt Lts 21-23 C1 OF GL Ph 1B SUB D13

AERIAL PHOTOGRAPH OBTAINED FROM geoOTTAWA (1991)

SCALE: 1:1000

0 10 20 30 40 50m 75m

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION
WATERIDGE BLOCK 19 - CODD'S ROAD

OTTAWA, ONTARIO

Title: **AERIAL PHOTOGRAPH (1991)**

Scale: 1:1000	Date: 01/2018
Drawn by: RCG	Report No.: PG4064-2
Checked by: SD	Dwg. No.: PG4064-2
Approved by: CDS	Revision No.: 0

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LEGEND:

- BOREHOLE LOCATION
- BOREHOLE WITH MONITORING WELL LOCATION
- TEST PIT LOCATION
- TEST PIT BY OTHERS (DST,2013)
- BOREHOLE LOCATION (DST, 2016)
- BOREHOLE LOCATION (DST, 2015)
- BOREHOLE WITH MONITORING WELL (DST, 2013)
- BOREHOLE WITH MONITORING WELL (DST, 2004)

92.27 GROUND SURFACE ELEVATION (m)

(90.52) PRACTICAL REFUSAL TO AUGERING/DCPT ELEV. (m)

[85.70] BEDROCK SURFACE ELEVATION (m)

SANITARY SEWER (CITY OF OTTAWA ARC VIEW)

SURVEY PLAN PROVIDED BY ANNIS, O'SULLIVAN & VOLLEBEKK LTD.
JOB NO.14710-14 CLC Pt Lts 21-23 C1 OF GL Ph 1B SUB D13

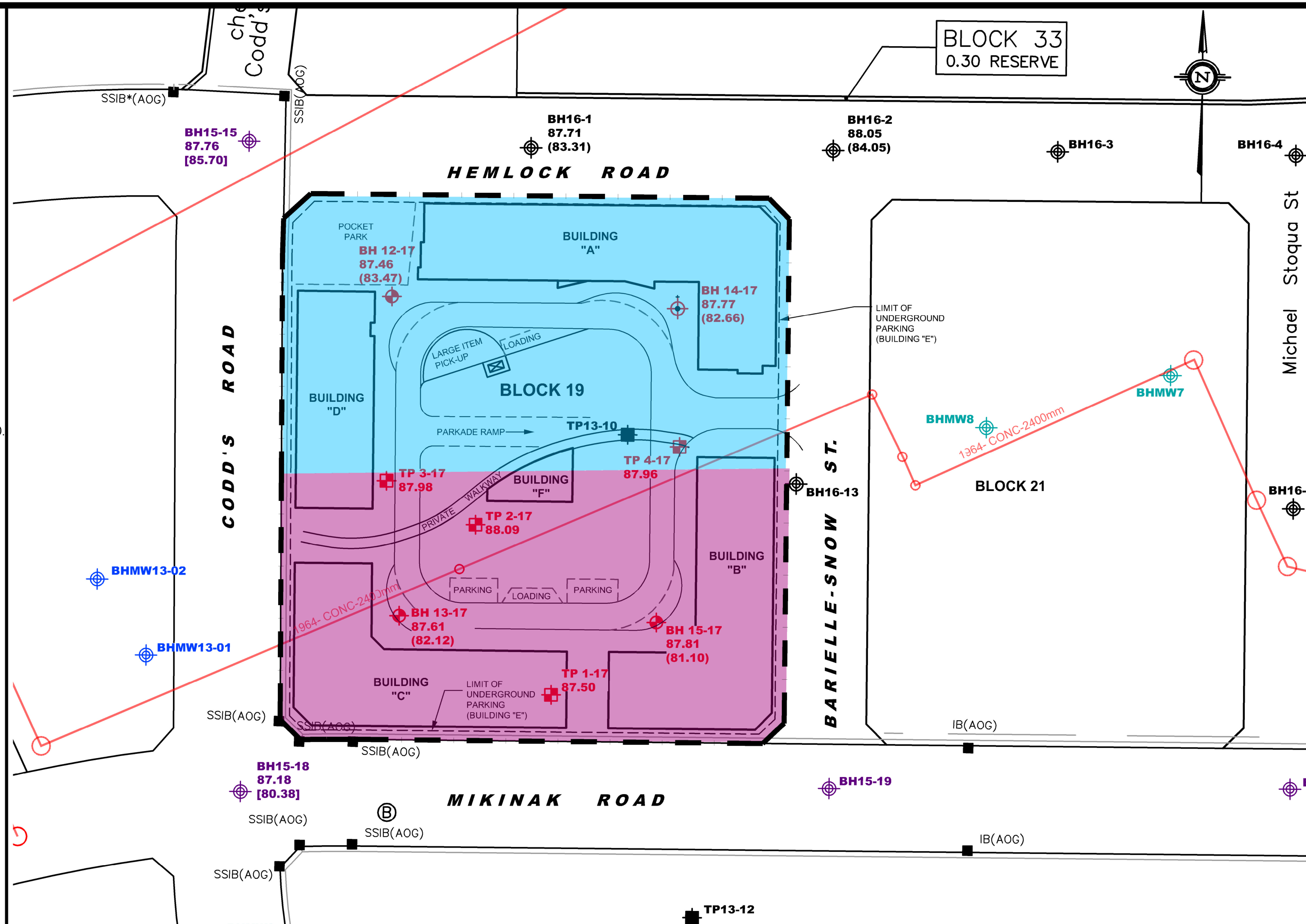
GROUND SURFACE ELEVATIONS AT TEST PIT LOCATIONS REFERENCED FROM THE GROUND SURFACE ELEVATIONS OF NEARBY BOREHOLE LOCATIONS PROVIDED BY J.D. BARNES LIMITED.

AREAS WHERE GRADE RAISES UP TO 1.5m IS PERMITTED

AREAS WHERE GRADE RAISE UP TO 2.0m IS PERMITTED

SCALE: 1:1000

0 10 20 30 40 50m 75m



patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION
WATERIDGE BLOCK 19 - CODD'S ROAD

OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE

Scale:	1:1000	Date:	01/2018
Drawn by:	RCG	Report No.:	PG4064-2
Checked by:	SD	Dwg. No.:	PG4064-3
Approved by:	DJG	Revision No.:	0

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