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Geotechnical Engineering

Environmental Engineering

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Materials Testing

Building Science

Archaeological Studies

Geotechnical Investigation

Proposed Residential Development
3288 Greenbank Road - Ottawa

Prepared For

Caivan Communities

March 6, 2019

Report: PG2743-2

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Caivan Communities to conduct a geotechnical investigation for the proposed residential development to be located at 3288 Greenbank Road, in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objective of the investigation was to:

❏ determine the subsoil and groundwater conditions at this site by means of test holes.

❏ provide geotechnical recommendations for the 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 our findings and includes geotechnical recommendations pertaining to the design and construction of the proposed development as understood at the time of this report.

Investigating the presence or potential presence of contamination on the proposed development was not part of the scope of work. Therefore, the present report does not address environmental issues.

2.0 Proposed Development

It is understood that the proposed development consists of townhouse style housing blocks and multi-storey apartment buildings. Local roadways, car parking and landscaped areas are further anticipated for the proposed development.

3.0 Method of Investigation

3.1 Field Investigation

The field program for our investigation was carried out in February 2019 and October 2012. As part of our investigations, eleven (11) boreholes and 8 test pits were completed across the subject site extending to a maximum 10 m depth. The test hole location was placed in a manner to provide general coverage of the subject site taking into account existing test holes completed by others. The test hole locations are illustrated on Drawing PG2743-4 - Test Hole Location Plan presented in Appendix 2.

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

Sampling and In Situ Testing

Soil samples were collected from the borehole using a 50 mm diameter split-spoon (SS) sampler, using 73 mm diameter thin walled (TW) Shelby tubes in conjunction with a piston sampler, or from the auger flights. All soil samples were visually inspected and initially classified on site. The split-spoon samples were placed in sealed plastic bags and the Shelby tubes were sealed at both ends on site. All samples were transported to the our laboratory for examination and classification. The depths at which the split-spoon, Shelby tube and auger samples were recovered from the test holes are shown as SS, TW and AU, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

The Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are recorded as “N” values on the Soil Profile and Test Data sheets. The “N” value is the number of blows required to drive the split-spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

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

The overburden thickness was evaluated by a dynamic cone penetration testing (DCPT) at BH 6, BH 8 and BH 10. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at the tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

The subsurface conditions observed at the test hole locations 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

Flexible standpipes were installed in the boreholes to monitor the groundwater level subsequent to the completion of the sampling program. The groundwater observations are noted on the Soil Profile and Test Data sheets presented in Appendix 1.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of the report. They will then be discarded unless we are otherwise directed.

3.2 Field Survey

The test holes were located in the field by JD Barnes. It is understood that the elevations are referenced to a geodetic datum. The ground surface elevation and location of the test holes are presented on Drawing PG2743-4 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the field investigation were examined in our laboratory to review field notes and soil samples.

Seven (7) Shelby tube samples were submitted for unidimensional consolidation and one (1) sample submitted for Atterberg limit testing from our test holes completed during our investigation. Eight (8) additional soil samples were submitted for atterberg limit testing as part of our current investigation.

The results of the consolidation testing are presented on the Consolidation Test sheets presented in Appendix 1 and are further discussed in Sections 4 and 5.

4.0 Observations

4.1 Surface Conditions

Currently, the subject site consists of agricultural lands and associated farmhouse and outbuildings. The majority of the ground surface across the subject site is relatively flat and slopes gradually downwards to the south.

4.2 Subsurface Profile

Generally, the soil conditions encountered at the test hole locations consist of a cultivated topsoil/organic layer followed by a stiff, brown silty clay deposit overlying a glacial till layer. Practical refusal to augering or DCPT was encountered at BH 1, BH 6, BH 8 and BH 10 at depths varying between 8.2 and 14.8 m. It should be noted that BH 2 was terminated due to damage of drilling augers on dense till material at a 5.3 m depth. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Based on available geological mapping, the bedrock in this area mostly consists of interbedded limestone and dolomite of the Gull River formation with an overburden drift thickness of 5 to 15 m depth.

4.3 Groundwater

Groundwater levels (GWL) were measured in the piezometers installed in the boreholes and results are summarized in Table 1. It should be noted that surface water can become perched within a backfilled borehole, which can lead to higher than normal groundwater level readings. The long-term groundwater level can also be estimated based on moisture levels and colour of the recovered soil samples. Based on these observations, the long-term groundwater table is expected between 1.5 to 2.5 m below original ground surface. 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 Surface Elevation (m)	Groundwater Level (m)	Groundwater Elevation (m)	Recording Date
BH 1	92.89	1.30	91.59	November 7, 2012
BH 2	92.37	1.08	91.29	November 7, 2012
BH 3	92.66	0.55	92.11	November 7, 2012
BH 4	92.81	1.76	91.05	November 7, 2012
BH 5	92.06	-	92.06	November 7, 2012
BH 6	92.19	1.08	91.11	November 7, 2012
BH 7	92.38	2.71	89.67	November 7, 2012
BH 8	92.88	1.35	91.53	November 7, 2012
BH 9	92.64	3.32	89.32	November 7, 2012
BH 10	92.40	1.63	90.77	November 7, 2012
BH 11	92.19	1.08	91.11	November 7, 2012

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is adequate for the proposed residential development. However, due to the presence of the sensitive silty clay layer, the proposed development will be subjected to grade raise restrictions.

Our permissible grade raise recommendations are discussed in Subsection 5.3 and the recommended permissible grade raise areas for housing are presented in Drawing PG2743-2 - Permissible Grade Raise Areas - Housing in Appendix 2. Also, the recommended permissible grade raise areas for apartment buildings are presented in Drawing PG2743-3 - Permissible Grade Raise Areas - Apartment Buildings in Appendix 2. If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill and/or other measures should be investigated to reduce the risks of unacceptable long-term post construction total and differential settlements.

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

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and deleterious fill, such as those containing organic materials, should be stripped from under any buildings, paved areas, pipe bedding and other settlement sensitive structures.

Fill Placement

Fill used for grading beneath the building areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. Granular material should be tested and approved prior to delivery to the site. The fill should be placed in lifts of 300 mm thick or less and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the building areas should be compacted to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD).

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

5.3 Foundation Design

Bearing Resistance Values

Strip footings, up to 2.5 m wide, and pad footings, up to 5 m wide, placed on an undisturbed, stiff silty clay bearing surface can be designed using a bearing resistance value at SLS of **100 kPa** and a factored bearing resistance value at ULS of **200 kPa**. Footings designed using the bearing resistance value at SLS given above will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively.

The bearing resistance values are provided on the assumption that the footings will be placed on undisturbed soil bearing surfaces. 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.

Lateral Support

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

Settlement/Grade Raise

Consideration must be given to potential settlements which could occur due to the presence of the silty clay deposit and the combined loads from the proposed footings, any groundwater lowering effects, and grade raise fill. The foundation loads to be considered for the settlement case are the continuously applied loads which consist of the unfactored dead loads and the portion of the unfactored live load that is considered to be continuously applied. For dwellings, a minimum value of 50% of the live load is recommended by Paterson.

Generally, the potential long term settlement is evaluated based on the compressibility characteristics of the silty clay. These characteristics are estimated in the laboratory by conducting unidimensional consolidation tests on undisturbed soil samples collected using Shelby tubes in conjunction with a piston sampler. Seven (7) site specific consolidation tests were conducted. The results of the consolidation tests are presented in Table 2 and in Appendix 1.

The value for p'_c is the preconsolidation pressure and p'_o is the effective overburden pressure of the test samples. The difference between these values is the available preconsolidation. The increase in stress on the soil due to the cumulative effects of the fill surcharge, the footing pressures, the slab loadings and the lowering of the groundwater should not exceed the available preconsolidation if unacceptable settlements are to be avoided.

The values for C_{cr} and C_c are the recompression and compression indices, respectively. These soil parameters are a measure of the compressibility due to stress increases below and above the preconsolidation pressures. The higher values for the C_c, as compared to the C_{cr}, illustrate the increased settlement potential above, as compared to below, the preconsolidation pressure.

Table 2 - Summary of Consolidation Test Results

Borehole	Sample	Elevation	p'_c	p'_o	C_{cr}	C_c	Q
BH 3	TW 4	88.45	104	50	0.021	2.253	A
BH 4	TW 4	88.53	103	55	0.019	2.146	A
BH 6	TW 3	87.16	119	63	0.022	1.064	A
BH 7	TW 3	87.35	113	68	0.016	1.683	A
BH 8	TW 3	87.78	111	62	0.015	2.000	A
BH 11	TW 1	88.41	119	58	0.014	1.253	A

* - Q - Quality assessment of sample - G: Good A: Acceptable P: Likely disturbed

The values of p'_c, p'_o, C_{cr} and C_c are determined using standard engineering testing procedures and are estimates only. Natural variations within the soil deposit will affect the results. The p'_o parameter is directly influenced by the groundwater level. Groundwater levels were measured during the site investigation. Groundwater levels vary seasonally which has an impact on the available preconsolidation. Lowering the groundwater level increases the p'_o and therefore reduces the available preconsolidation. Unacceptable settlements could be induced by a significant lowering of the groundwater level. The p'_o values for the consolidation tests during the investigation are based on the long term groundwater level being at 0.5 m below the existing groundwater table. The groundwater level is based on the colour and undrained shear strength profile of the silty clay.

The total and differential settlements will be dependent on characteristics of the proposed buildings. For design purposes, the total and differential settlements are estimated to be 25 and 20 mm, respectively. A post-development groundwater lowering of 0.5 m was assumed.

The potential post construction total and differential settlements are dependent on the position of the long term groundwater level when building are situated over deposits of compressible silty clay. Efforts can be made to reduce the impacts of the proposed development on the long term groundwater level by placing clay dykes in the service trenches, reducing the sizes of paved areas, leaving green spaces to allow for groundwater recharge or limiting planting of trees to areas away from the buildings. However, it is not economically possible to control the groundwater level.

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

Based on the consolidation testing results and subsurface profile encountered at the borehole locations, a permissible grade raise restriction was calculated for loadings associated with housing and for loadings associated with a 4 storey apartment building with an underground parking level. The recommended permissible grade raise areas for housing and apartment buildings are defined in Drawing PG2743-2 - Permissible Grade Raise Areas - Housing and Drawing PG2743-3 - Permissible Grade Raise Areas - Apartment Buildings in Appendix 2.

If higher grade raises and/or higher loading conditions are required, post construction settlements can be reduced by several methods. The following options can be considered and are further discussed in Subsection 5.4:

☐ preloading and surcharging
☐ lightweight fill (LWF)

Bearing resistance values for footing designs should be determined on a per lot basis at the time of construction.

5.4 Foundation Options

Based on the above discussion, several options could be considered for the foundation support of the proposed buildings:

Scenario A

Where the grade raise is close to, but below, the maximum permissible grade raise, consideration should be given to using more reinforcement in the design of the foundation (footings and walls) to reduce the risks of cracking in the concrete foundation. The use of control joints within the brick work between the garage and basement area should also be considered.

Scenario B

Where the grade raise cannot be accommodated with soil fill, the following options could be used alone or in combination.

Option 1 - Use of Lightweight Fill

Lightweight fill (LWF) can be used, consisting of EPS (expanded polystyrene) Type 19 or 22 blocks or other light weight materials which allow for raising the grade without adding a significant load to the underlying soils. However, these materials are expensive and, in the case of the EPS, are more difficult to use under the groundwater level, as they are buoyant, and must be protected against potential hydrocarbon spills. Use lightweight fill within the interior of the garage and porch areas to reduce the fill-related loads.

As an alternative to lightweight fill in the interior of the garage and porch, a structural slab can be designed to create a void beneath the floor slab and therefore reduce fill-related loads. Additional information can be provided once the design of the buildings is known.

Option 2 - Preloading or Surcharging

It is possible to preload or surcharge the proposed site in localized areas provided sufficient time is available to achieve the desired settlements based on theoretical values from the settlement analysis. If this option is considered, a monitoring program using settlement plates and electronic piezometers will have to be implemented. This program will determine the amount of settlement in the preloaded or surcharged areas. Obviously, preloading to proposed finished grades will allow for consolidation of the underlying clays over a longer time period. Surcharging the site with additional fill above the proposed finished grade will add additional load to the underlying clays accelerating the consolidation process and allowing for accelerated settlements. Once the desired settlements are achieved, the site can be unloaded and the fill can be used elsewhere on site.

With both the preloading and surcharging methods, the loading period can be reduced by installing vertical wick drains or sand drains in the silty clay layer to promote the movement of groundwater towards the ground surface. However, vertical drains are expensive for this type of residential project.

Underground Utilities

The underground services may be subjected to unacceptable total or differential settlements. In particular, the joints at the interface building/soil may be subjected to excessive stress if the differential settlements between the building and the services are excessive. This should be considered in the design of the underground services.

Once the required grade raises are established, the above options could be further discussed along with further recommendations on specific requirements.

5.5 Design for Earthquakes

A seismic site response **Class D** is applicable for foundations designed for the subject site according to the OBC 2012. A higher site class, such as Class C, may be applicable for foundations constructed within the east portion of the subject site. However, the higher site class should be confirmed by a site specific shear wave velocity test. The soils underlying the site are not susceptible to liquefaction.

5.6 Basement Slab

With the removal of all topsoil and deleterious fill, containing organic matter, within the footprints of the proposed buildings, undisturbed native soil surface will be considered acceptable subgrade on which to commence backfilling for floor slab construction. Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-slab fill consist of 19 mm clear crushed stone.

5.7 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of car parking areas and access lanes/local residential streets. These guidelines should be reviewed once the details of the development are known.

Table 4 - Recommended Pavement Structure - Car 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 5 - Recommended Pavement Structure - Local Residential Roadways

Thickness (mm)	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Binder Course -** 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	

Table 6 - Recommended Pavement Structure - Roadways with Bus Traffic

Thickness mm	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Upper Binder Course** - Superpave 19.0 Asphaltic Concrete
50	**Lower Binder Course** - Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
600	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - Either in situ soil or OPSS Granular B Type II material placed over in situ soil

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 I or II material. Weak subgrade conditions may be experienced over service trench fill materials. This may require the use of a geotextile, thicker subbase or other measures that can be recommended at the time of construction as part of the field observation program.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the material's SPMDD using suitable vibratory equipment.

Pavement Structure Drainage

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

Due to the low permeability of the subgrade materials consideration should be given to installing subdrains during the pavement construction as per City of Ottawa standards. The subdrain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

A perimeter foundation drainage system is recommended for proposed structures. The system should consist of a 100 to 150 mm diameter, geotextile-wrapped, perforated, corrugated, plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining, non frost susceptible granular materials. The site materials will be frost susceptible and, as such, are not recommended for re-use as backfill unless a composite drainage system (such as system Platon or Miradrain G100N) connected to a drainage system is provided.

6.2 Protection Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum 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 excavation for the current phase of the proposed development will be mostly through sandy silt and/or clayey silt/silty clay. Above the groundwater level, for excavations to depths of approximately 3 m, the excavation side slopes should be stable in the short term at 1H:1V. Flatter slopes could be required for deeper excavations or for excavation below the groundwater level. Where such side slopes are not permissible or practical, temporary shoring should be used. The subsoil at this site is considered to be mainly a Type 2 or 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

The slope cross-sections recommended above are for temporary slopes. 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.

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 City of Ottawa.

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. Where the bedding is located within the firm grey silty clay, the thickness of the bedding material should be increased to a minimum of 300 mm. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD. The bedding material should extent at least to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at least 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 its SPMDD.

Generally, it should be possible to re-use the moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Wet silty clay materials will be difficult to re-use, as the high water contents make compacting impractical 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 material’s SPMDD.

To reduce long-term lowering of the groundwater level at this site, clay seals should be provided in the service trenches. The seals should be at least 1.5 m long (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 and compactable brown silty clay placed in maximum 225 mm thick loose layers 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 no more than 60 m intervals in the service trenches.

6.5 Groundwater Control

Due to the relatively impervious nature of the silty clay materials, it is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. A perched groundwater condition may be encountered within the silty sand/sandy silt 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 3 to 4 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.

6.6 Winter Construction

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

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

The trench excavations should be constructed in a manner that will 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 work takes place. 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.

6.7 Landscaping Considerations

Tree Planting Restrictions

In accordance with the City of Ottawa Tree Planting in Sensitive Marine Clay Soils (2017 Guidelines), Paterson completed a soils review of the site to determine applicable tree planting setbacks. Atterberg limits testing was completed for recovered silty clay samples at selected locations throughout the subject site. A shrinkage limit test and sieve analysis testing was also completed on selected soil samples. The shrinkage limit testing indicates a shrinkage limit of 21% with a shrinkage ratio of 1.78. The results of our atterberg limit and sieve testing are presented in Appendix 1.

During our field investigation, it was noted that the silty clay deposit across the site consists of a brown, stiff to very stiff silty clay, which is not considered to be a sensitive marine clay soil. Therefore, the Tree Planting Guidelines not required to be followed for the subject site. **Based on our review of the silty clay deposit, a tree planting setback limit of 4.5 m for small (mature tree height up to 7.5m) and medium size trees (mature tree height 7.5 m to 14 m) is recommended across the subject site provided that the following conditions are met.**

☐ The underside of footing (USF) is 2.1 m or greater below the lowest finished grade must be satisfied for footings within 10 m from the tree, as measured from the centre of the tree trunk and verified by means of the Grading Plan as indicated procedural changes below.

☐ A small tree must be provided with a minimum of 25 m^3 of available soil volume while a medium tree must be provided with a minimum of 30 m^3 of available soil volume, as determined by the Landscape Architect. The developer is to ensure that the soil is generally un-compacted when backfilling in street tree planting locations.

❏ The tree species must be small (mature tree height up to 7.5 m) to medium size (mature tree height 7.5 m to 14 m) as confirmed by the Landscape Architect. The foundation walls are to be reinforced at least nominally (minimum of two upper and two lower 15M bars in the foundation wall).

❏ Grading surround the tree must promote drainage to the tree root zone (in such a manner as not to be detrimental to the tree), as noted on the subdivision Grading Plan.

Swimming Pools

The in-situ soils are considered to be acceptable for swimming pools. Above ground swimming pools must be placed at least 4 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer`s requirements.

Aboveground Hot Tubs

If consideration is given to construction of an aboveground hot tub, a geotechnical consultant should be retained by the homeowner to review the site conditions. Additional grading around the hot tub should not exceed permissible grade raises. Otherwise, hot tub construction is considered routine, and can be constructed in accordance with the manufacturer’s specifications.

Installation of Decks or Additions

If consideration is given to construction of a deck or addition, a geotechnical consultant should be retained by the homeowner to review the site conditions. Additional grading around proposed deck or addition should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

7.0 Recommendations

It is recommended that the following be completed once the master plan and site development are determined:

- ☐ Review detailed grading plan(s) from a geotechnical perspective.
- ☐ Observation of all bearing surfaces prior to the placement of concrete.
- ☐ 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 placing backfilling materials.
- ☐ Field density tests to ensure that the specified level of compaction has been 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 Paterson's recommendations could be issued upon request, following the completion of a satisfactory material testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations made in this report are in accordance with Paterson's present understanding of the project. Paterson requests permission to review the grading plan once available. Paterson's recommendations should be reviewed when the drawings and specifications are complete.

The client should be aware that any information pertaining to soils and the test hole log are furnished as a matter of general information only. Test hole descriptions or logs are not to be interpreted as descriptive of conditions at locations other than those of the test holes.

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 to be notified immediately in order to permit reassessment of the recommendations.

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

March 12, 2019

LICENSED PROFESSIONAL ENGINEER
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PROVINCE OF ONTARIO

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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEET

SYMBOLS AND TERMS

RECORDS OF BOREHOLE BY OTHERS

CONSOLIDATION TEST RESULTS

ATTERBERG LIMITS' TESTING RESULTS

GRAIN SIZE DISTRIBUTION RESULTS

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 850X Power Auger

DATE October 15, 2012

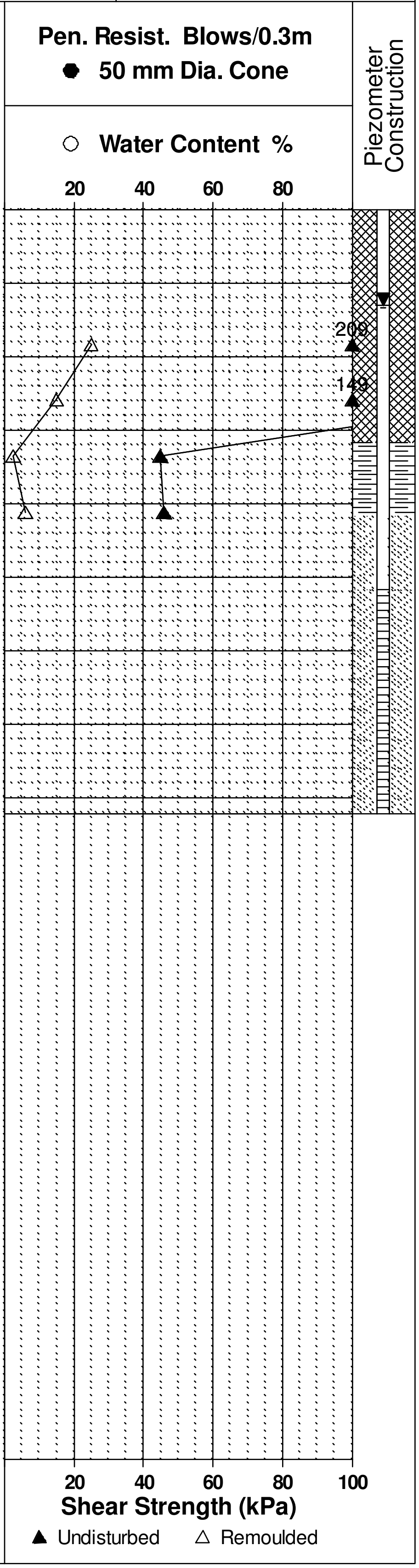
FILE NO. PG2743

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT
GROUND SURFACE	
TOPSOIL — 0.30	▇
Hard to very stiff, brown **SILTY CLAY** - firm by 2.8m depth — 4.34	▨
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders — 8.21	^^^
End of Borehole Practical refusal to augering at 8.21m depth (GWL @ 1.30m-Nov. 7, 2012)	

SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
AU	1		
AU	2		
SS	3	100	10
SS	4	100	4
SS	5	12	2
SS	6	17	2
SS	7	100	3
SS	8	73	50+

DEPTH (m)	ELEV. (m)
0	92.89
1	91.89
2	90.89
3	89.89
4	88.89
5	87.89
6	86.89
7	85.89
8	84.89



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

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FILE NO. **PG2743**

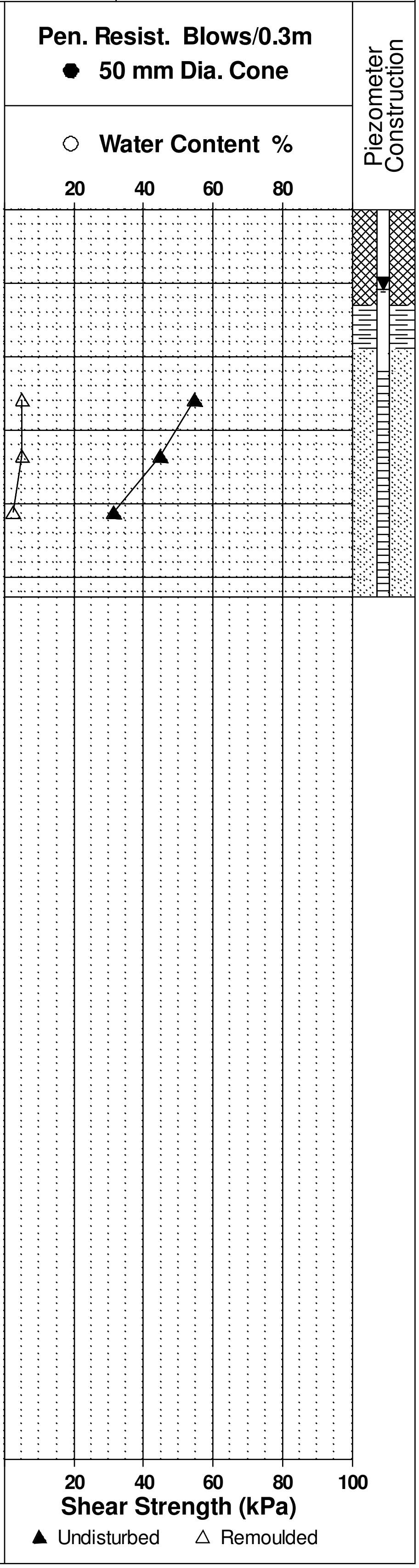
REMARKS

HOLE NO. **BH 2**

BORINGS BY CME 850X Power Auger

DATE October 16, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.37
TOPSOIL 0.30		AU	1				
		AU	2				
		SS	3	100	10	1	91.37
Very stiff to stiff, brown **SILTY CLAY**		SS	4	100	5	2	90.37
- firm by 2.8m depth						3	89.37
4.34						4	88.37
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders		SS	5	38	50+		
5.26						5	87.37
End of Borehole							
(GWL @ 1.08m-Nov. 7, 2012)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. **PG2743**

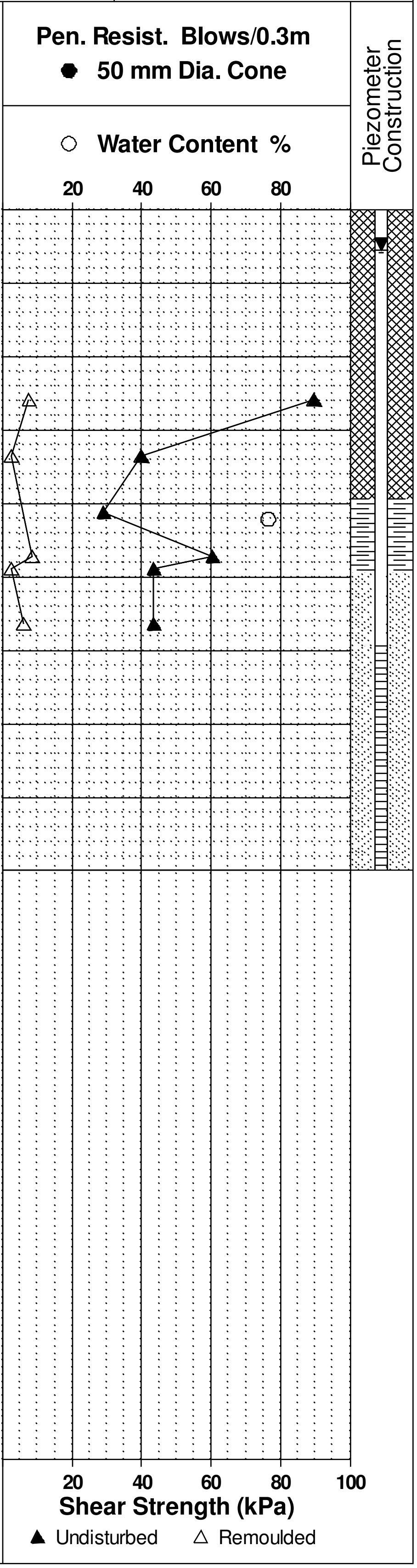
REMARKS

HOLE NO. **BH 3**

BORINGS BY CME 850X Power Auger

DATE October 16, 2012

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	92.66
TOPSOIL 0.25	AU	1				
	SS	2	100	10	1	91.66
	SS	3	100	4		
Very stiff to stiff, brown **SILTY CLAY**					2	90.66
- firm and grey by 2.8m depth					3	89.66
	TW	4	100		4	88.66
					5	87.66
5.87					6	86.66
	SS	5	0	4		
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders	SS	6	0	6	7	85.66
	SS	7	83	8	8	84.66
8.99	SS	8	67	38		
End of Borehole						
(GWL @ 0.55m-Nov. 7, 2012)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by J.D. Barnes Limited.

FILE NO. PG2743

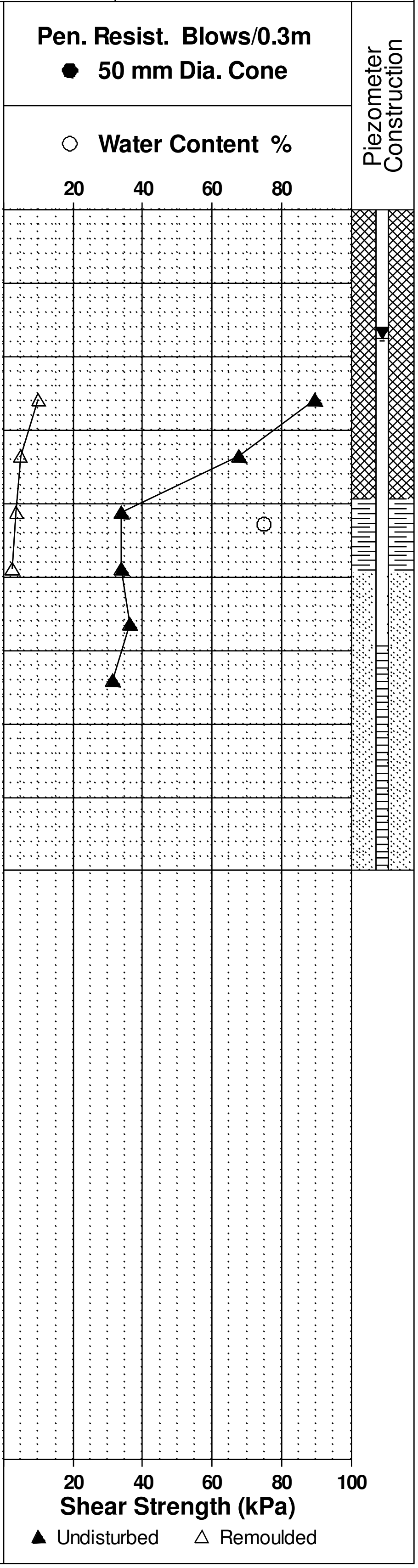
REMARKS

HOLE NO. BH 4

BORINGS BY CME 850X Power Auger

DATE October 16, 2012

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	92.81
TOPSOIL 0.30	AU	1				
	SS	2	100	12	1	91.81
	SS	3	100	4	2	90.81
Very stiff to stiff, brown **SILTY CLAY**					3	89.81
- firm and grey by 3.6m depth	TW	4			4	88.81
					5	87.81
					6	86.81
7.54	TW	5	83		7	85.81
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders	SS	6	83	7	8	84.81
8.99	SS	7	67	12		
End of Borehole						
(GWL @ 1.76m-Nov. 7, 2012)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

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REMARKS

BORINGS BY CME 850X Power Auger

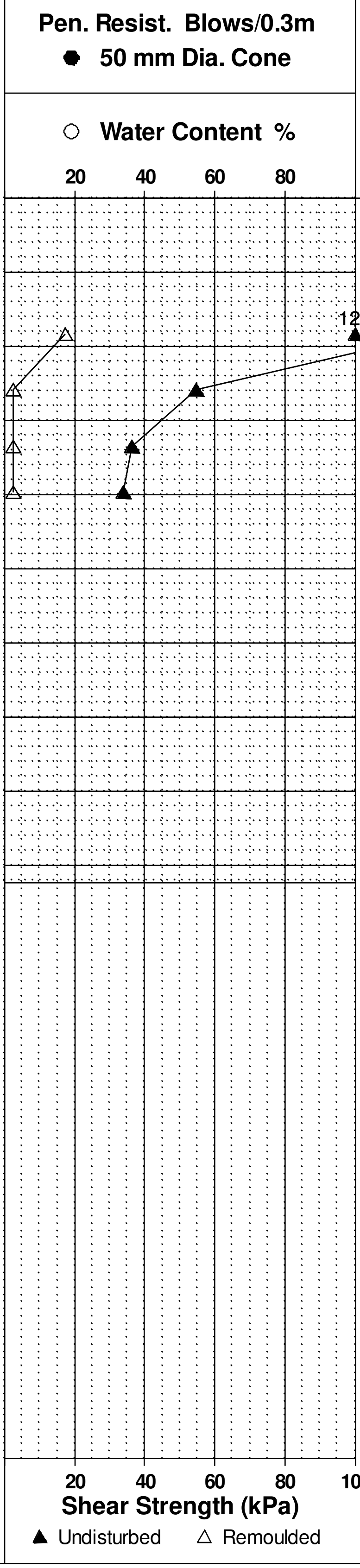
DATE October 16, 2012

FILE NO. PG2743

HOLE NO. BH 5

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.28	AU	1		
Very stiff to stiff, brown **SILTY CLAY**	SS	2		12
- firm and grey by 2.8m depth	TW	3	100	
4.27	TW	4	46	
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders	SS	5	50	8
	SS	6	50	3
	SS	7	50	15
7.16				
Loose, grey **SAND**	SS	8	42	9
9.24				
End of Borehole				

DEPTH (m)	ELEV. (m)
0	92.06
1	91.06
2	90.06
3	89.06
4	88.06
5	87.06
6	86.06
7	85.06
8	84.06
9	83.06



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by J.D. Barnes Limited.

FILE NO. **PG2743**

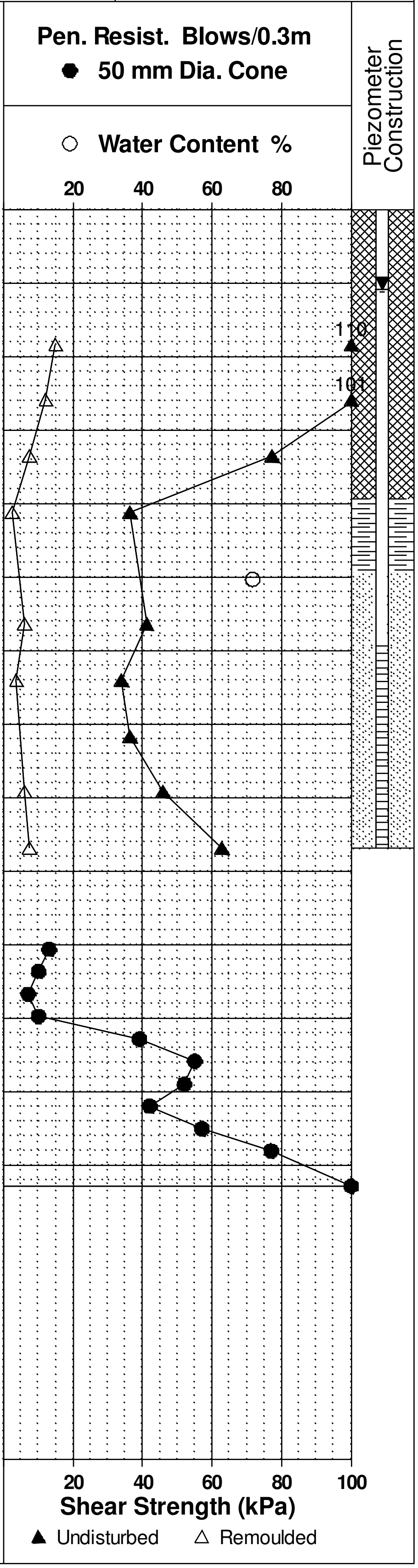
REMARKS

HOLE NO. **BH 6**

BORINGS BY CME 850X Power Auger

DATE October 17, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.19
TOPSOIL 0.33		AU	1				
		SS	2	100	9	1	91.19
						2	90.19
Very stiff to stiff, brown **SILTY CLAY**							
						3	89.19
- firm and grey 3.6m depth							
						4	88.19
		TW	3	100		5	87.19
						6	86.19
						7	85.19
						8	84.19
8.69							
Dynamic Cone Penetration Test commenced at 8.69m depth. Cone pushed to 10.0m depth.						9	83.19
						10	82.19
						11	81.19
						12	80.19
						13	79.19
13.28							
End of Borehole Practical cone refusal at 13.28m depth (GWL @ 1.08m-Nov. 7, 2012)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - 3288 Greenbank Rd.
Ottawa, Ontario

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REMARKS

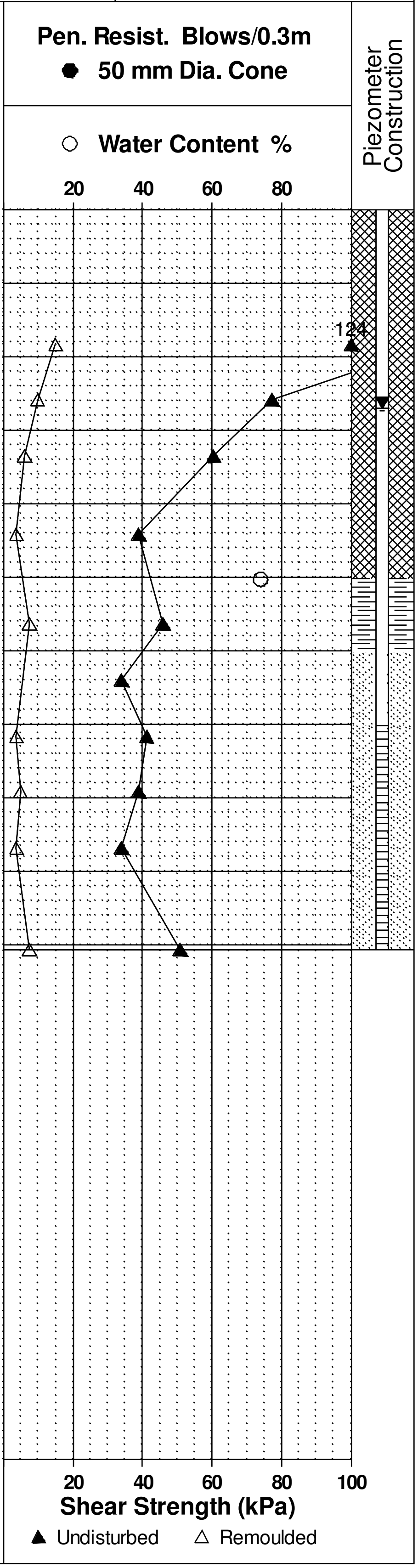
BORINGS BY CME 850X Power Auger

DATE October 17, 2012

FILE NO. PG2743

HOLE NO. BH 7

SOIL DESCRIPTION	STRATA PLOT	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.38
TOPSOIL 0.30		AU	1				
		SS	2	100	8	1	91.38
						2	90.38
Very stiff to stiff, brown **SILTY CLAY**						3	89.38
- firm and grey by 3.6m depth						4	88.38
		TW	3	83		5	87.38
						6	86.38
						7	85.38
						8	84.38
						9	83.38
		TW	4	100			
10.06						10	82.38
End of Borehole							
(GWL @ 2.71m-Nov. 7, 2012)							



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SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

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FILE NO. **PG2743**

REMARKS

HOLE NO. **BH 8**

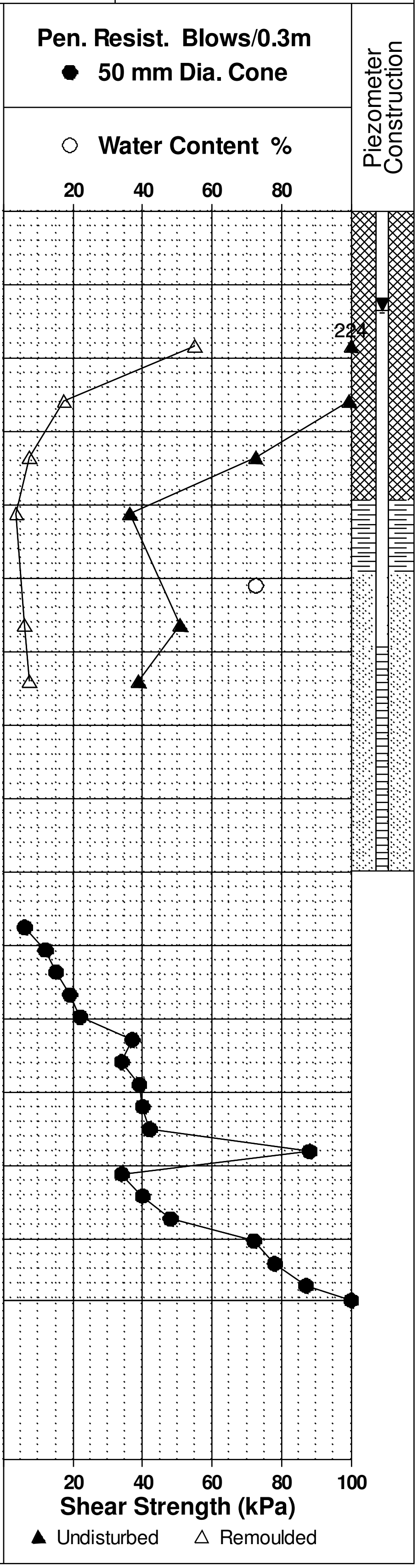
BORINGS BY CME 850X Power Auger **DATE** October 17, 2012

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	92.88
TOPSOIL 0.30	AU	1				
	SS	2	100	10	1	91.88
					2	90.88
Hard to stiff, brown **SILTY CLAY**					3	89.88
- firm and grey by 3.6m depth					4	88.88
	TW	3	100		5	87.88
					6	86.88
7.16	TW	4	58		7	85.88
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders	SS	5	42	8	8	84.88
9.00	SS	6	33	6	9	83.88
Dynamic Cone Penetration Test commenced at 9.00m depth.					10	82.88
					11	81.88
					12	80.88
					13	79.88
					14	78.88
14.83						

End of Borehole

Practical refusal to augering at 14.83m depth.

(GWL @ 1.35m-Nov. 7, 2012)



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SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

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FILE NO. **PG2743**

REMARKS

HOLE NO. **BH 9**

BORINGS BY CME 850X Power Auger

DATE October 18, 2012

SOIL DESCRIPTION

GROUND SURFACE

TOPSOIL 0.30

Very stiff to stiff, brown **SILTY CLAY**

- firm and grey by 2.8m depth

- stiff and grey-brown by 5.1m depth

6.63

GLACIAL TILL: Grey silty clay with sand, gravel, cobbles, boulders

8.23

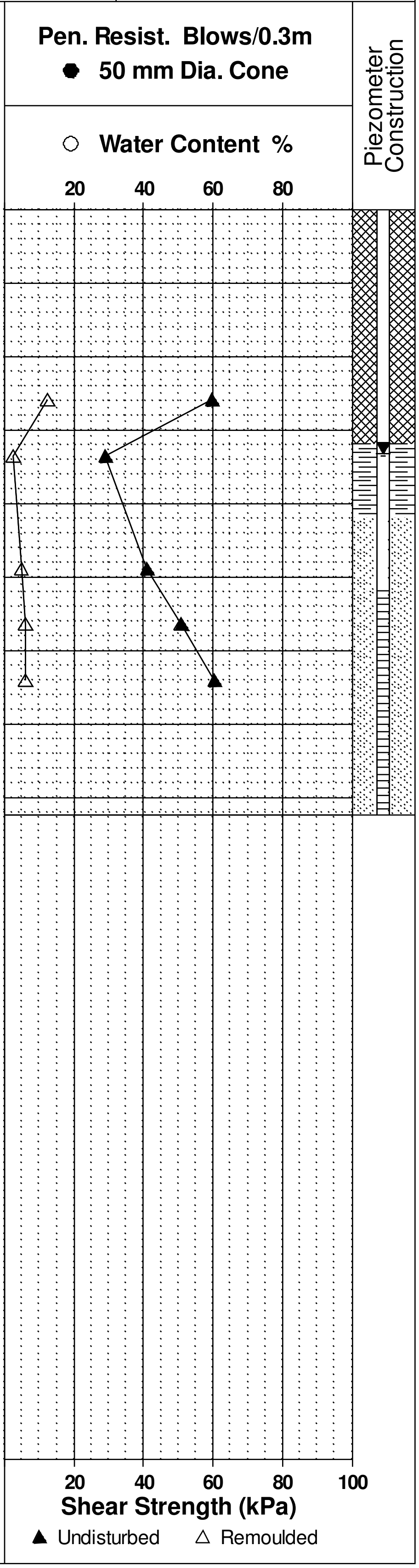
End of Borehole

(GWL @ 3.32m-Nov. 7, 2012)

SAMPLE

TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	13
SS	3	100	7
TW	4		
TW	5	100	
SS	6	42	50
SS	7	8	14

DEPTH (m)	ELEV. (m)
0	92.64
1	91.64
2	90.64
3	89.64
4	88.64
5	87.64
6	86.64
7	85.64
8	84.64



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. **PG2743**

REMARKS

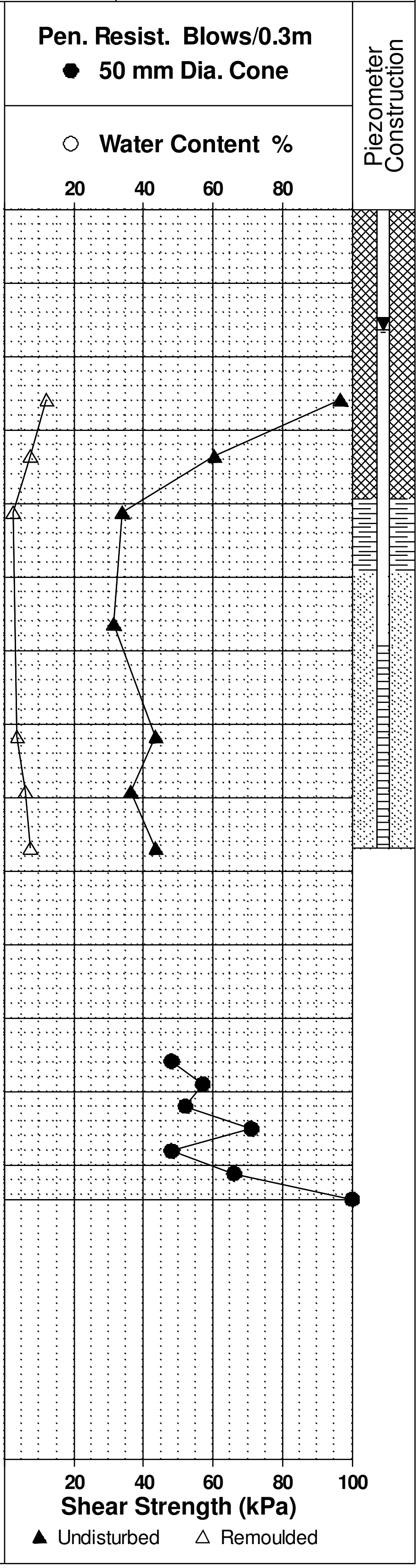
HOLE NO. **BH10**

BORINGS BY CME 850X Power Auger

DATE October 18, 2012

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.30	AU	1		
Stiff, brown **SILTY CLAY**	SS	2	100	7
- firm and grey-brown by 3.6m depth	SS	3	100	3
	TW	4	100	
8.69	TW	5	100	
Dynamic Cone Penetration Test commenced at 8.69m depth. Cone pushed to 11.5m depth.				
13.46				
End of Borehole Practical cone refusal at 13.46m depth. (GWL @ 1.63m-Nov. 7, 2012)				

DEPTH (m)	ELEV. (m)
0	92.40
1	91.40
2	90.40
3	89.40
4	88.40
5	87.40
6	86.40
7	85.40
8	84.40
9	83.40
10	82.40
11	81.40
12	80.40
13	79.40



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SOIL PROFILE AND TEST DATA

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FILE NO. **PG2743**

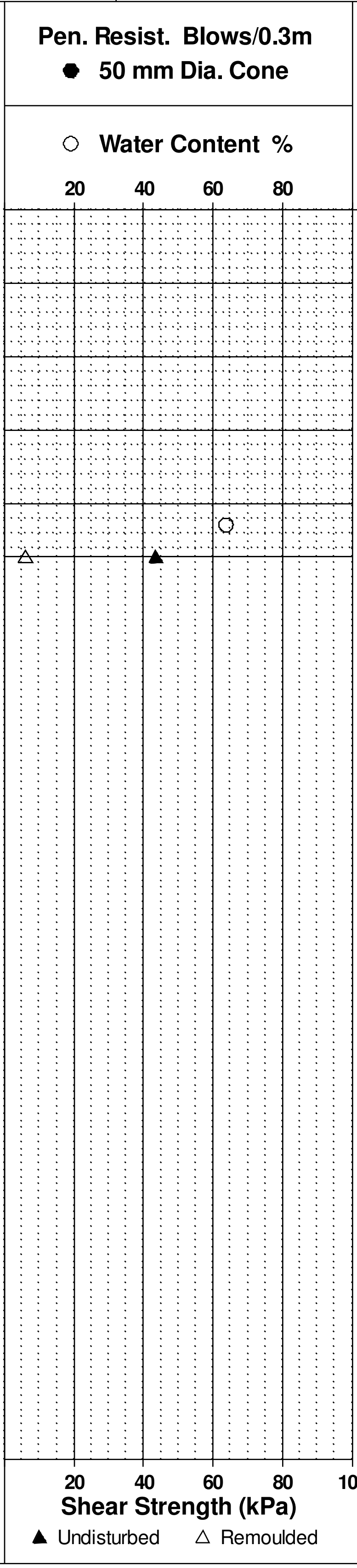
REMARKS

HOLE NO. **BH11**

BORINGS BY CME 850X Power Auger

DATE October 18, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.70
TOPSOIL 0.30						1	91.70
Firm, grey **SILTY CLAY**						2	90.70
						3	89.70
4.72		TW	1	100		4	88.70
End of Borehole							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
2388 Greenbank Road
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

REMARKS

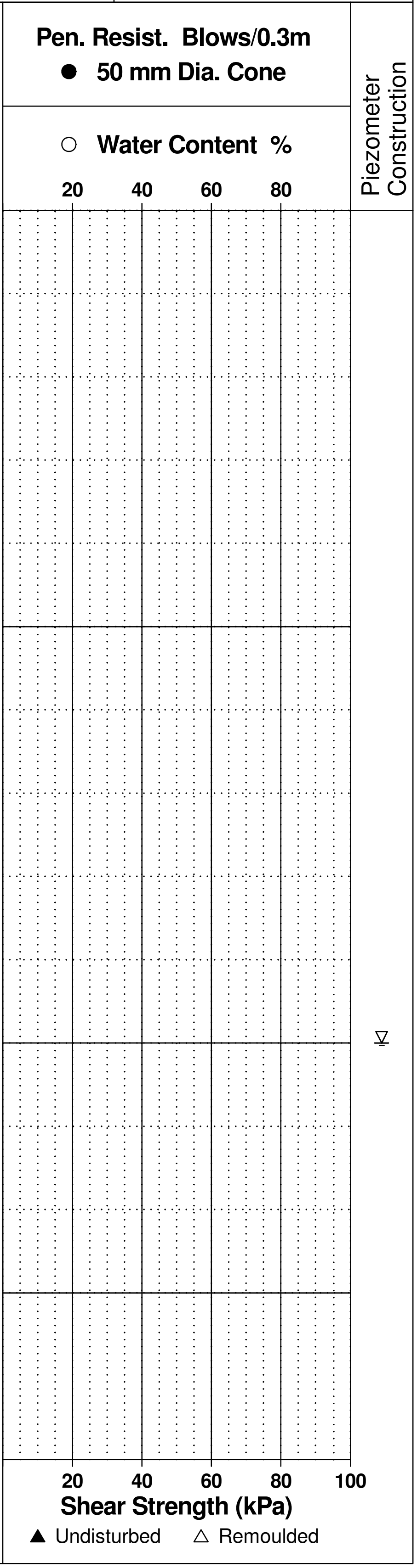
BORINGS BY Excavator

DATE February 19, 2019

FILE NO. PG2743

HOLE NO. TP 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.85
TOPSOIL 0.20							
Brown **SILTY SAND** with clay 0.40							
Stiff, brown **CLAYEY SILT**						1	92.85
		G	1				
1.80							
GLACIAL TILL: Brown clayey silt with sand, gravel, cobbles and boulders		G	2			2	91.85
		G	3				
2.60							
End of Test Pit (GWL @ 2.0m depth based on field observations)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
2388 Greenbank Road
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

FILE NO. PG2743

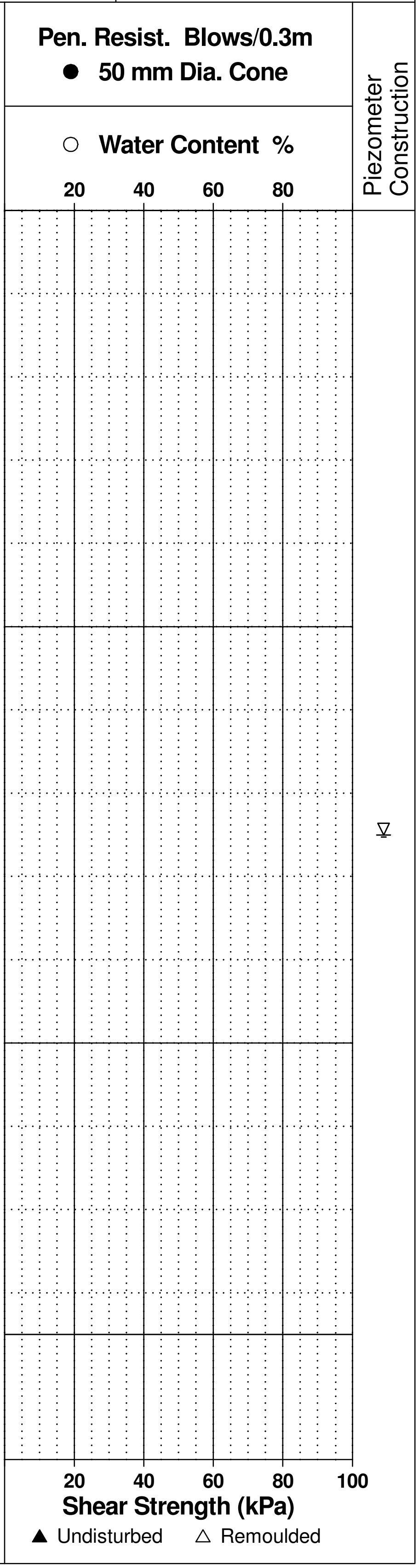
REMARKS

HOLE NO. TP 2

BORINGS BY Excavator

DATE February 19, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.72
TOPSOIL — 0.25	■						
Very stiff to stiff, brown **SILTY CLAY** - grey by 1.0m depth	▨	G	1				
						1	91.72
		G	2				
						2	90.72
		G	3				
— 2.70		G	4				
End of Test Pit (Groundwater infiltration at 1.5m depth)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
2388 Greenbank Road
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

FILE NO. PG2743

REMARKS

HOLE NO. TP 3

BORINGS BY Excavator

DATE February 19, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	92.90		
TOPSOIL									
0.30									
		G	1						
Very stiff to stiff, brown **SILTY CLAY**									
- grey by 1.0m depth						1	91.90		
		G	2						
									▽
						2	90.90		
		G	3						
2.50		G	4						
End of Test Pit (Groundwater infiltration at 1.8m depth)								20 40 60 80 100 **Shear Strength (kPa)** ▲ Undisturbed △ Remoulded	

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REMARKS

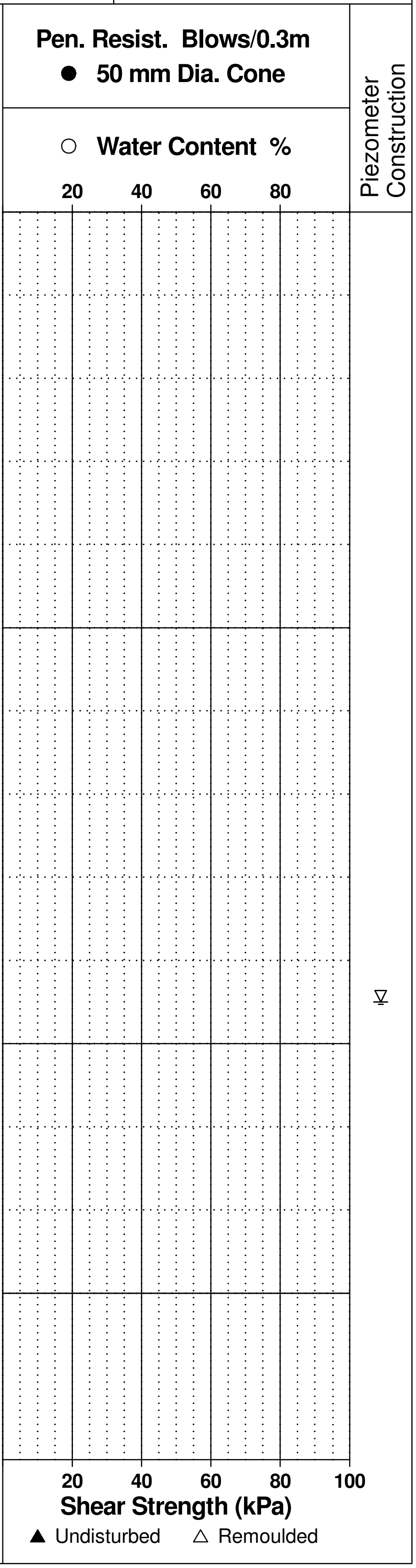
BORINGS BY Excavator

DATE February 19, 2019

FILE NO. PG2743

HOLE NO. TP 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.95
TOPSOIL — 0.25	■						
Very stiff, brown **CLAYEY SILT/SILTY CLAY** — 1.00	▨					1	91.95
Very stiff, brown **SILTY CLAY**	▨	G	1				
	▨					2	90.95
	▨	G	2				
— 2.60	▨	G	3				
End of Test Pit (Groundwater infiltration at 1.9m depth)							



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DATUM Ground surface elevations provided by J.D. Barnes Limited.

FILE NO. PG2743

REMARKS

HOLE NO. TP 5

BORINGS BY Excavator

DATE February 19, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	92.40		
TOPSOIL 0.30	■								
	▨					1	91.40		
Stiff, brown **SILTY CLAY**	▨	G	1						
	▨								∇
	▨					2	90.40		
	▨	G	2						
2.60	▨	G	3						
End of Test Pit (Groundwater infiltration at 1.7m depth)									

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

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REMARKS

BORINGS BY Excavator

DATE February 19, 2019

FILE NO. PG2743

HOLE NO. TP 6

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.48
TOPSOIL — 0.20	■						
Very stiff, brown **SILTY CLAY** with sand — 1.40	▨	G	1			1	91.48
Stiff, grey-brown **SILTY CLAY** - grey by 1.7m depth — 2.60	▨	G G G	2 3 4			2	90.48
End of Test Pit (Groundwater infiltration at 1.8m depth)							

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

○ **Water Content %**

20 40 60 80

Piezometer Construction

∇ (about 1.8 m depth)

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

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FILE NO. **PG2743**

REMARKS

HOLE NO. **TP 7**

BORINGS BY Excavator

DATE February 19, 2019

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE 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	92.63		
TOPSOIL 0.40	■								
Very stiff, brown **SILTY CLAY** with sand 1.00	▨	G	1						
						1	91.63		
Stiff, brown **SILTY CLAY**	▨	G	2						
						2	90.63		
2.40	▨	G	3						
End of Test Pit (Groundwater infiltration at 1.5m depth)									▽

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
2388 Greenbank Road
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

REMARKS

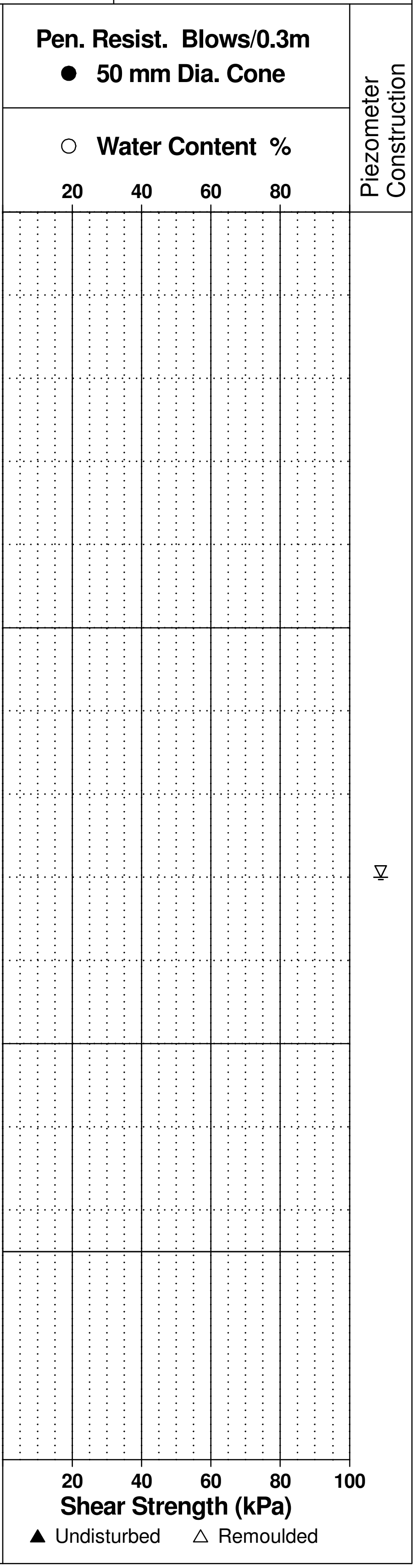
BORINGS BY Excavator

DATE February 19, 2019

FILE NO. PG2743

HOLE NO. TP 8

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.20
TOPSOIL 0.30	■						
Very stiff, brown **SILTY CLAY** with sand 1.10	▨					1	92.20
Very stiff, brown **SILTY CLAY**	▨	G	1				
	▨	G	2			2	91.20
2.60	▨	G	3				
End of Test Pit (Groundwater infiltration at 1.6m depth)							



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 x 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)

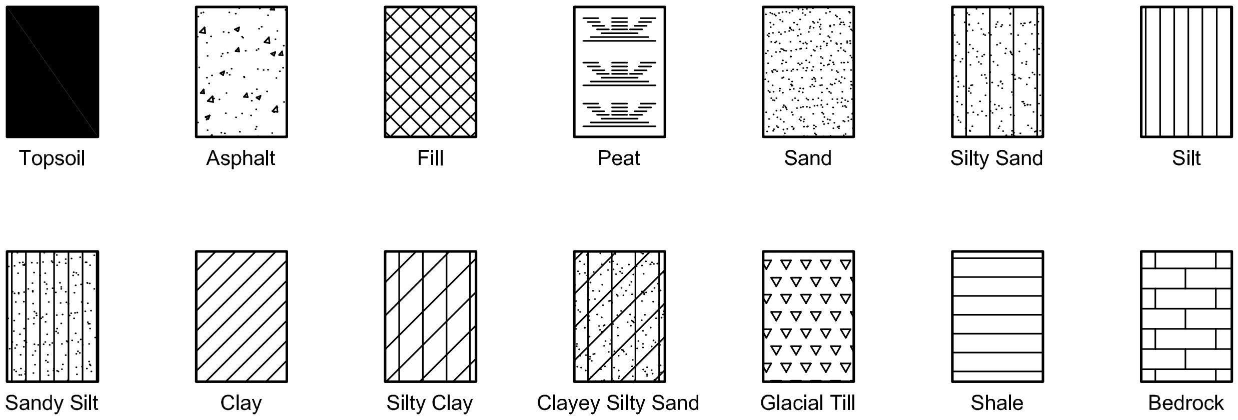
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

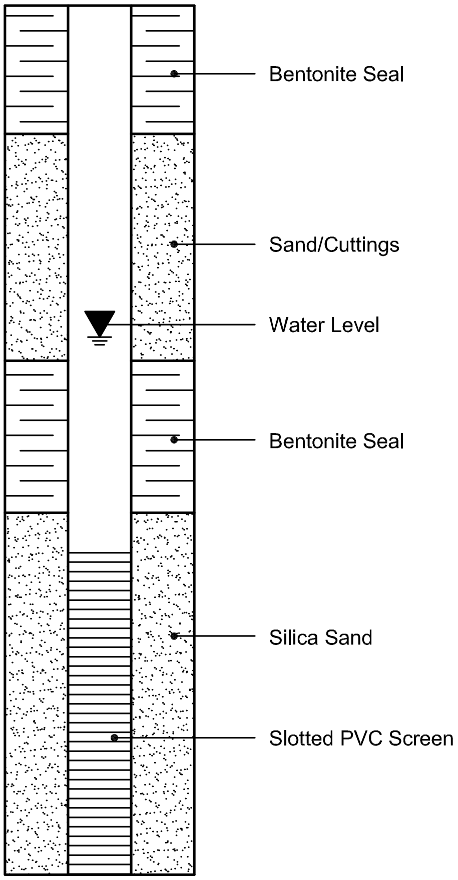
SYMBOLS AND TERMS (continued)

STRATA PLOT

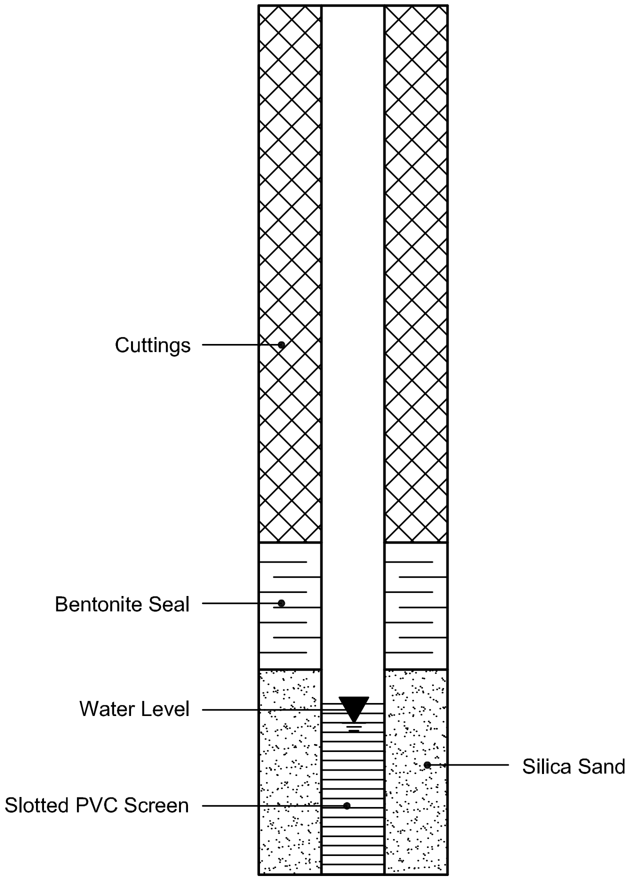


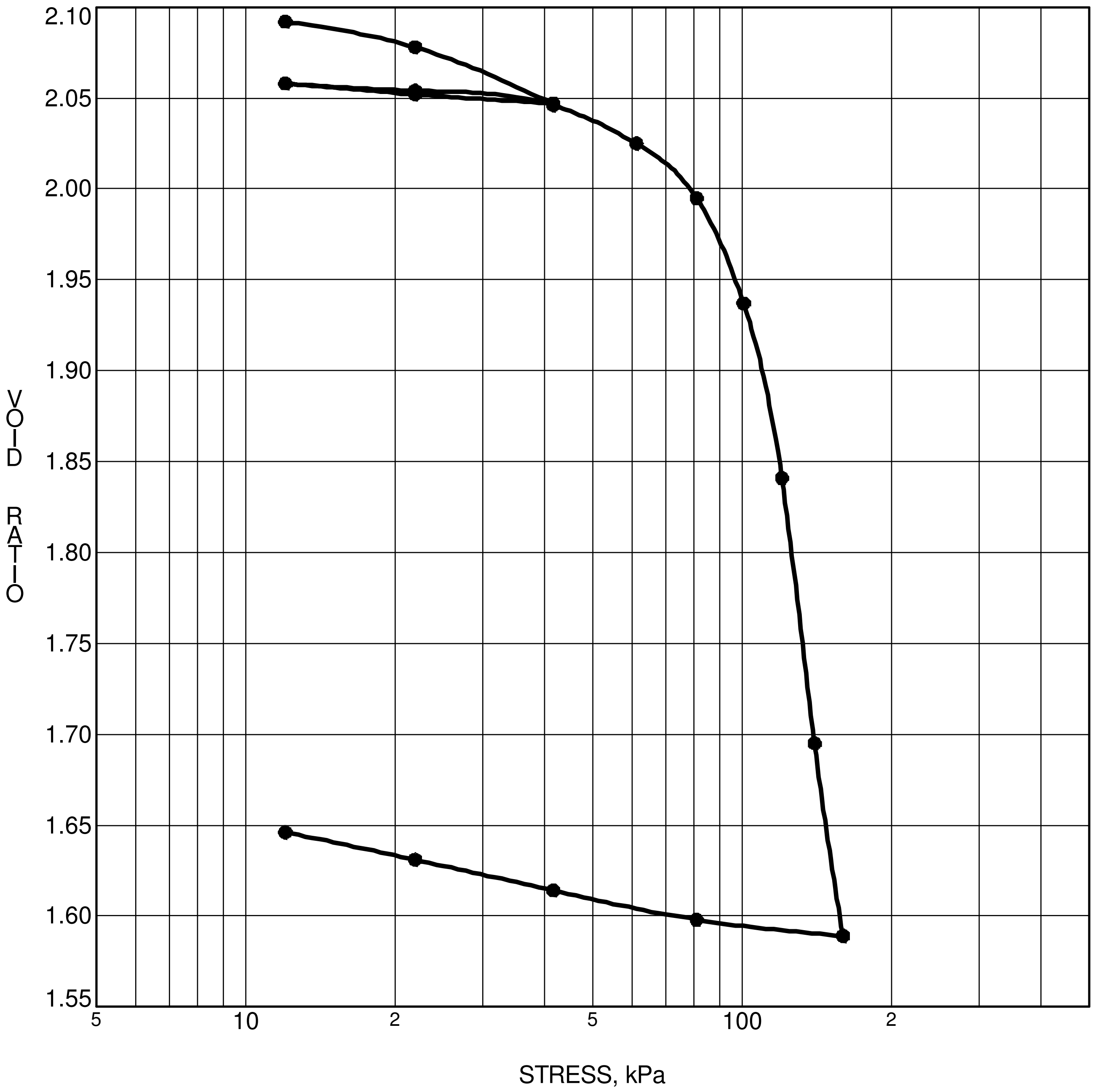
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





CONSOLIDATION TEST DATA SUMMARY

Borehole No.	**BH 3**	p'o	**50** kPa	Ccr	**0.021**
Sample No.	**TW 4**	p'c	**104** kPa	Cc	**2.253**
Sample Depth	**4.21** m	OC Ratio	**2.1**	Wo	**76.5** %
Sample Elev.	**88.45** m	Void Ratio	**2.103**	Unit Wt.	**15.8** kN/m 3

CLIENT **Mattamy Homes**

PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**

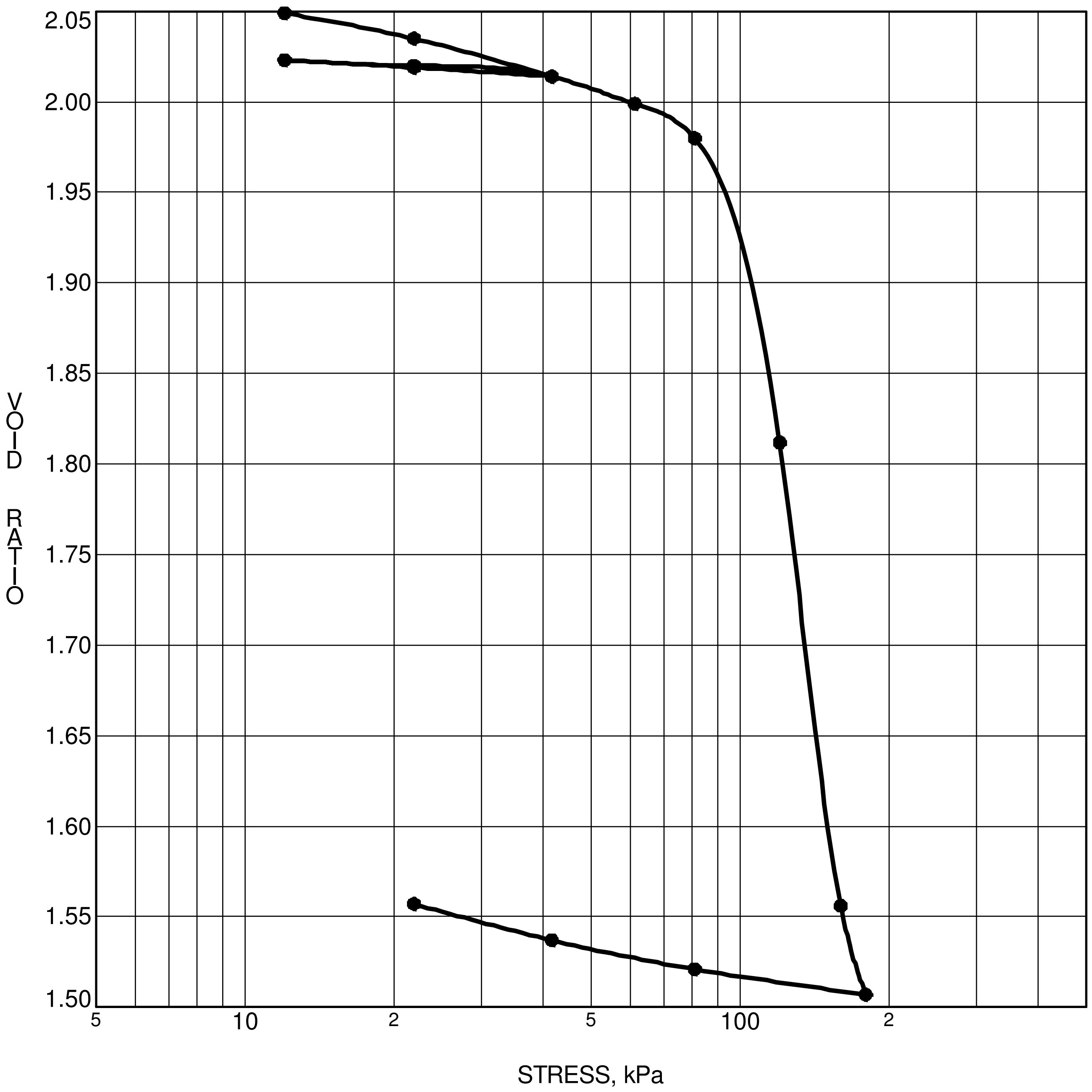
FILE NO. **PG2743**

DATE **26/10/2012**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 4**	p'_o	**55** kPa	Ccr	**0.019**
Sample No.	**TW 4**	p'_c	**103** kPa	Cc	**2.146**
Sample Depth	**4.28** m	OC Ratio	**1.9**	Wo	**74.9** %
Sample Elev.	**88.53** m	Void Ratio	**2.061**	Unit Wt.	**15.8** kN/m^3

CLIENT **Mattamy Homes**

FILE NO. **PG2743**

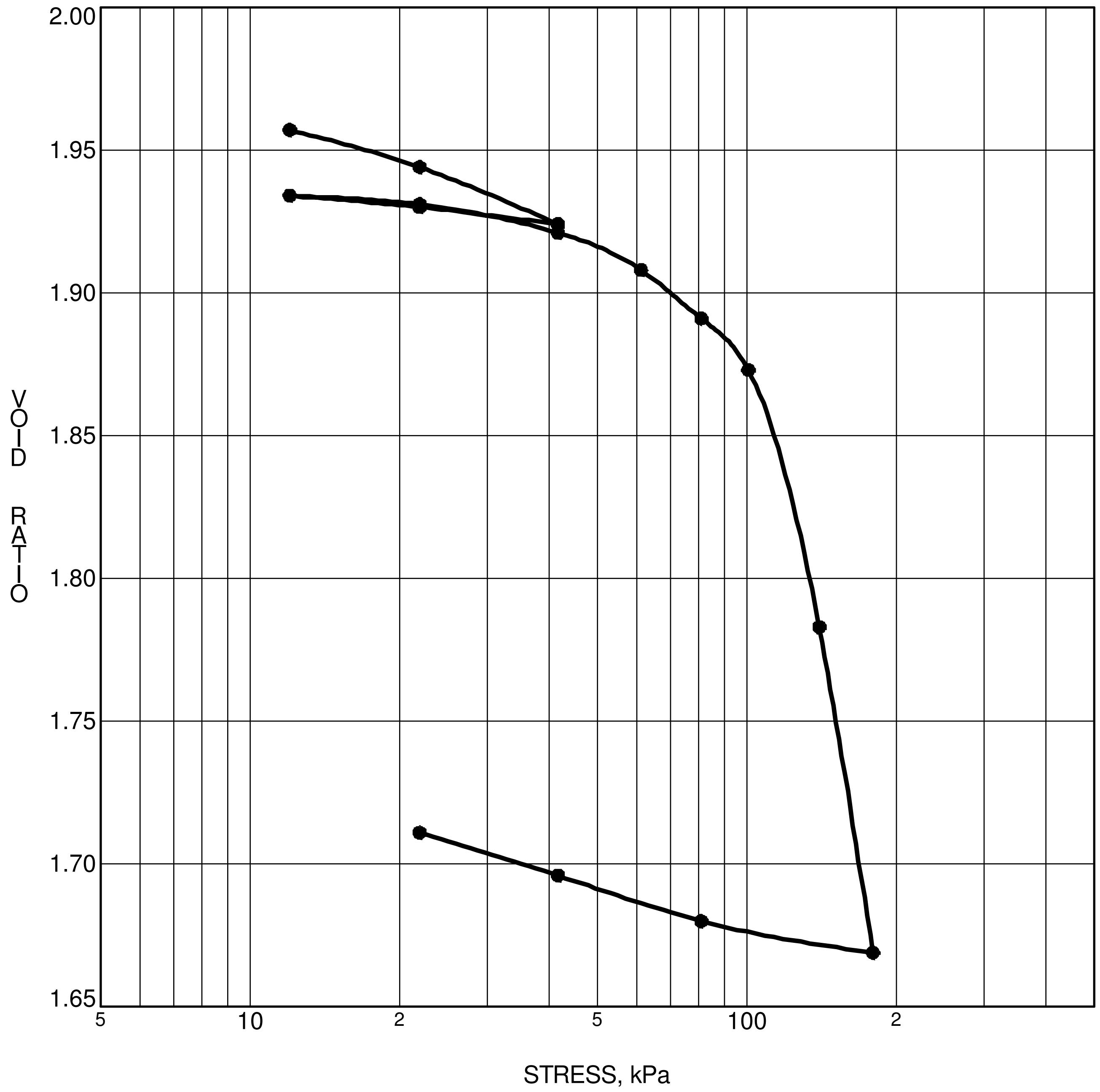
PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**

DATE **22/10/2012**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 6**	p'_o	**63** kPa	Ccr	**0.022**
Sample No.	**TW 3**	p'_c	**119** kPa	Cc	**1.064**
Sample Depth	**5.03** m	OC Ratio	**1.9**	Wo	**71.7** %
Sample Elev.	**87.16** m	Void Ratio	**1.971**	Unit Wt.	**16.0** kN/m ^{3}

CLIENT **Mattamy Homes**

FILE NO. **PG2743**

PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**

DATE **22/12/2012**

patersongroup **Consulting Engineers**

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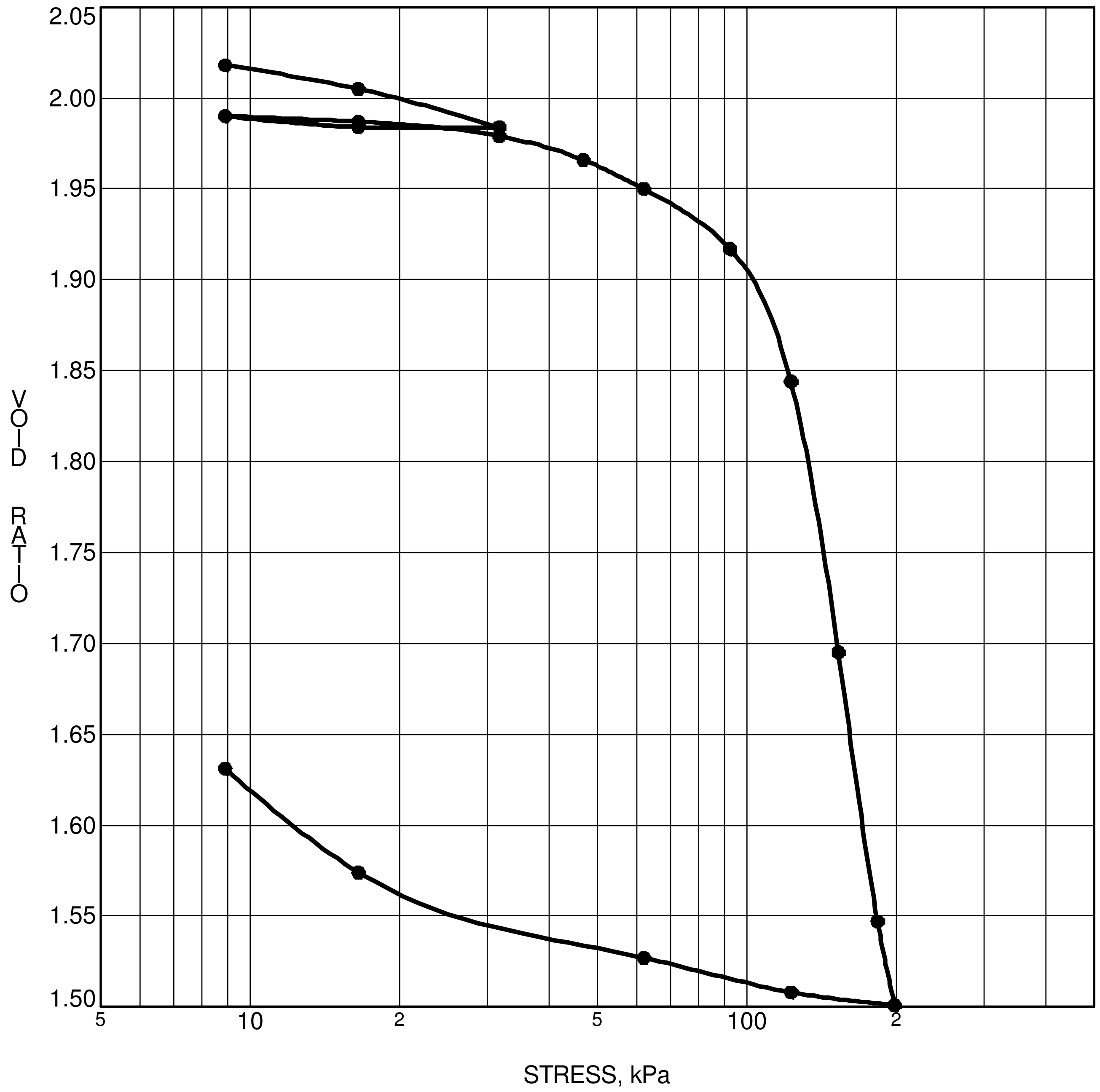
CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY								
Borehole No.	BH 7		p'o	68	kPa	Ccr	0.016	
Sample No.	TW 3		p'c	113	kPa	Cc	1.683	
Sample Depth	5.03	m	OC Ratio	1.7		Wo	74.0	%
Sample Elev.	87.35	m	Void Ratio	2.034		Unit Wt.	15.8	kN/m 3

CLIENT **Mattamy Homes** FILE NO. **PG2743**

PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.** DATE **29/10/2012**

patersongroup **Consulting Engineers**

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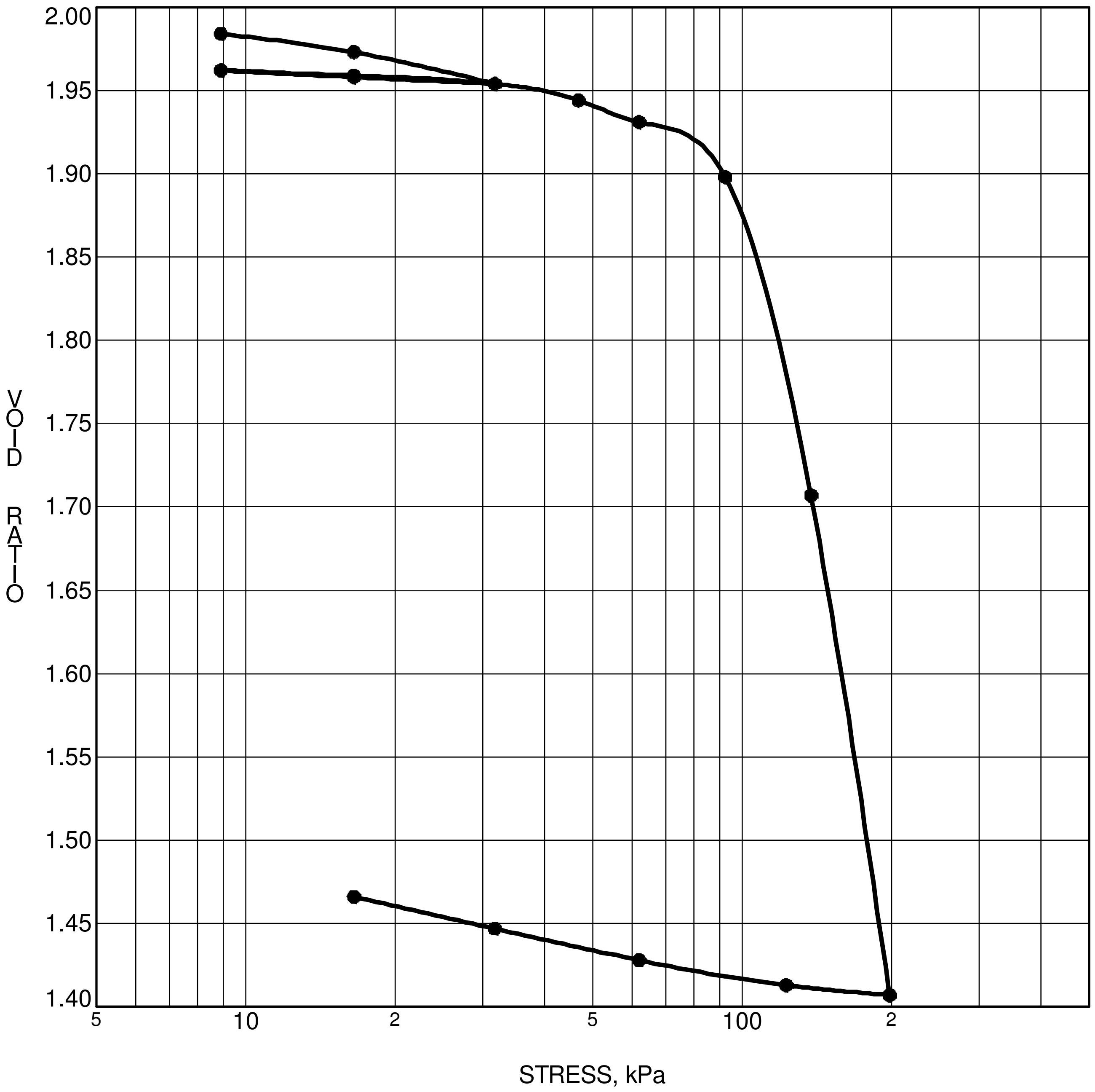
CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY

Borehole No.	**BH 8**		p'_o	**62**	kPa	Ccr	**0.015**	
Sample No.	**TW 3**		p'_c	**111**	kPa	Cc	**2.000**	
Sample Depth	**5.10**	m	OC Ratio	**1.8**		Wo	**72.6**	%
Sample Elev.	**87.78**	m	Void Ratio	**1.996**		Unit Wt.	**15.9**	kN/m^3

CLIENT **Mattamy Homes**
PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**

FILE NO. **PG2743**
DATE **22/10/2012**

patersongroup **Consulting Engineers**
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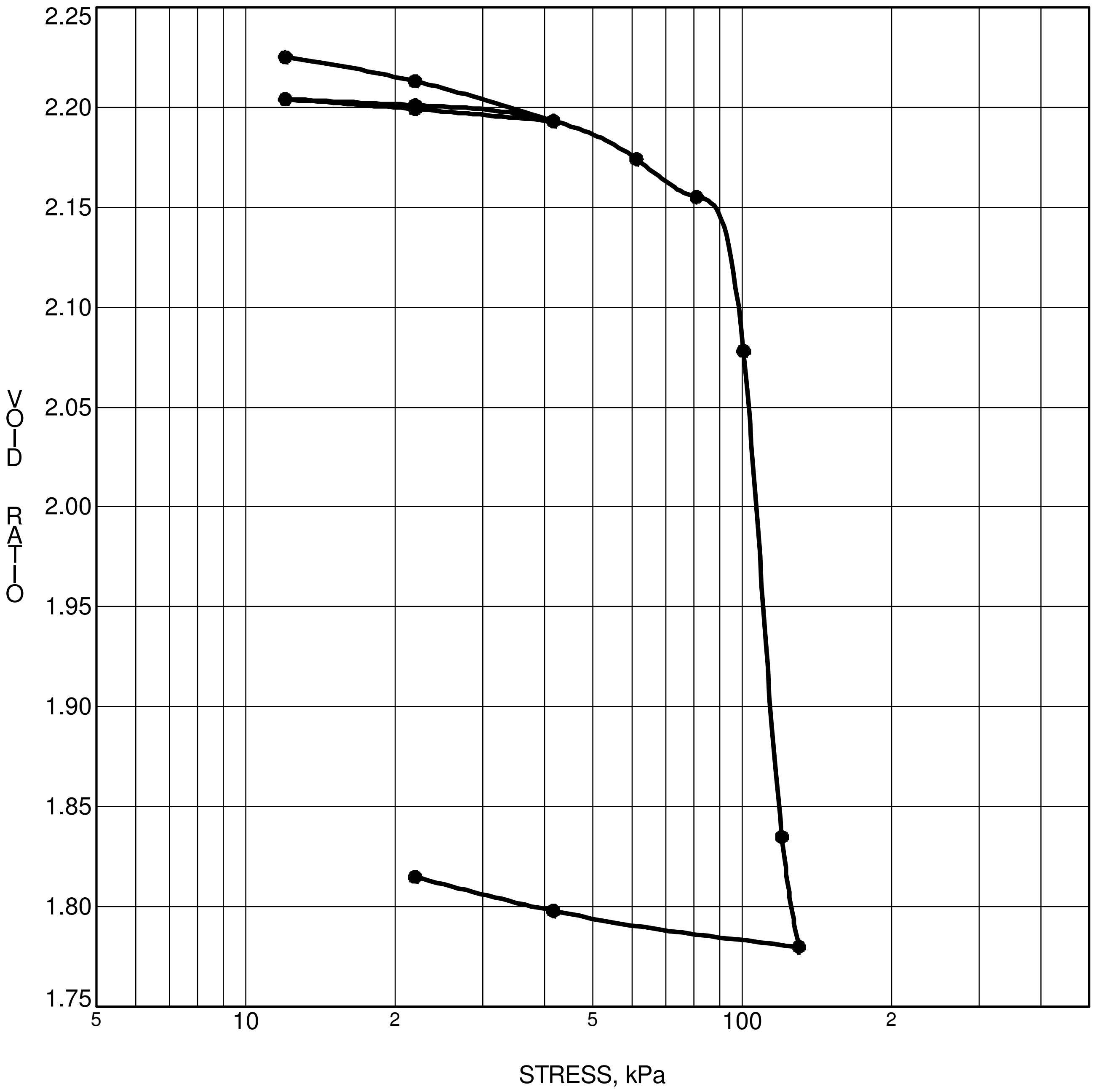
CONSOLIDATION TEST

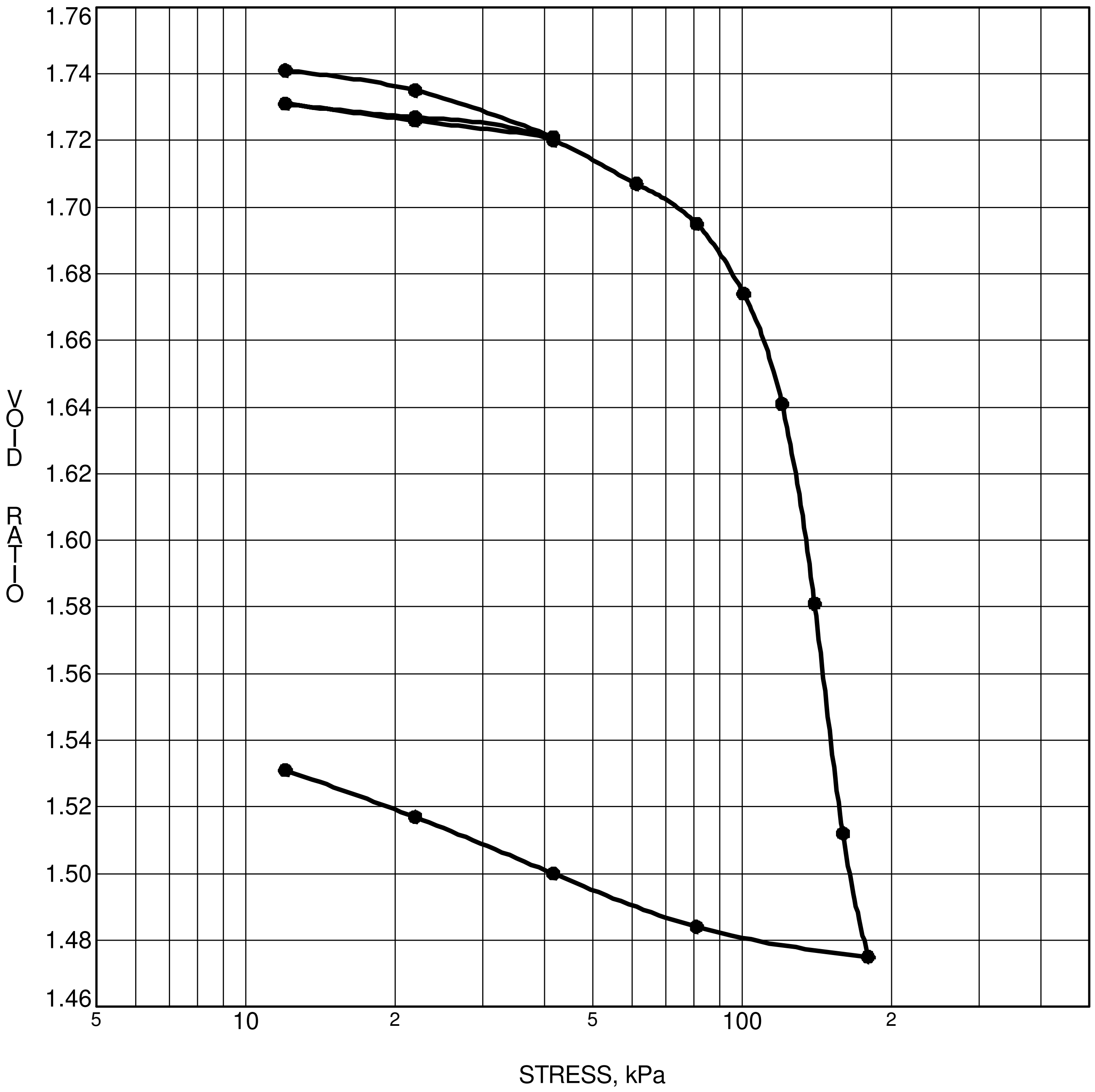


CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 9**	p'$_o$	**54** kPa	Ccr	**0.022**
Sample No.	**TW 5**	p'$_c$	**97** kPa	Cc	**3.224**
Sample Depth	**4.32** m	OC Ratio	**1.8**	Wo	**81.4** %
Sample Elev.	**88.32** m	Void Ratio	**2.237**	Unit Wt.	**15.5** kN/m^3

CLIENT **Mattamy Homes**
FILE NO. **PG2743**
PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**
DATE **12/11/2012**

patersongroup **Consulting Engineers**
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



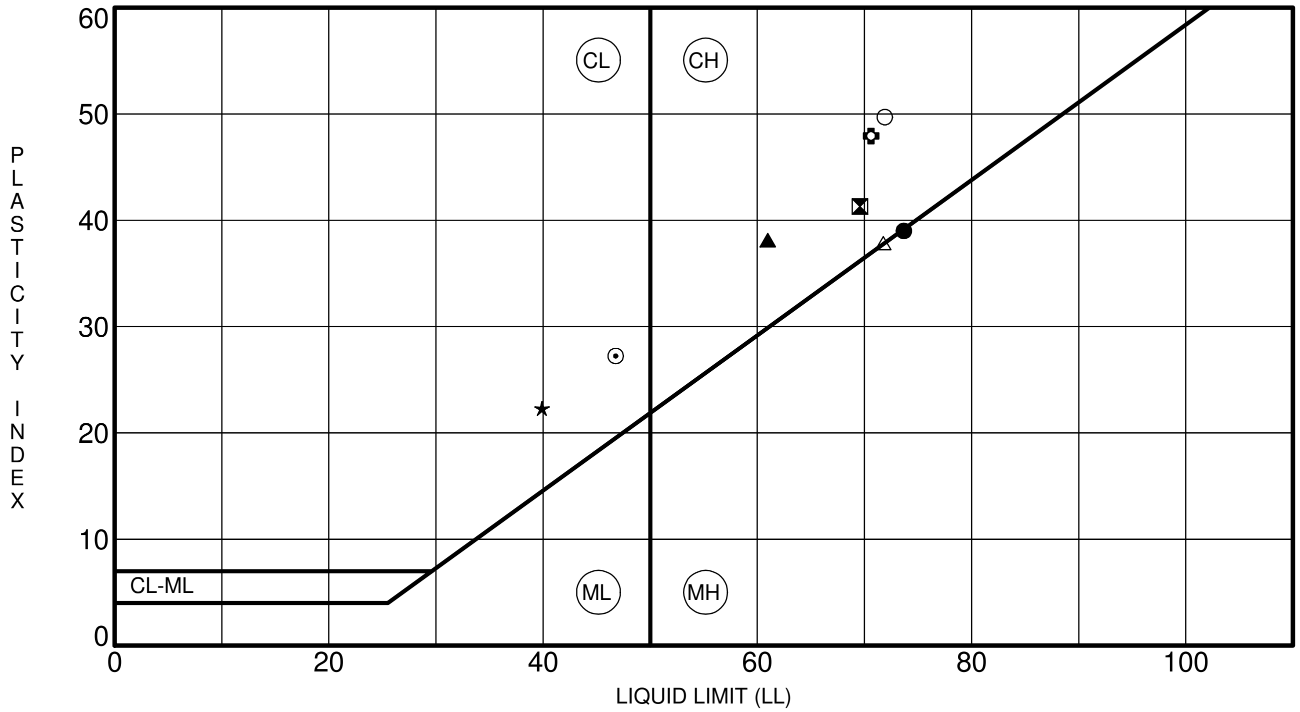
CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH11**	p'$_o$	**58** kPa	Ccr	**0.014**
Sample No.	**TW 1**	p'$_c$	**119** kPa	Cc	**1.253**
Sample Depth	**4.29** m	OC Ratio	**2.1**	Wo	**63.7** %
Sample Elev.	**88.41** m	Void Ratio	**1.753**	Unit Wt.	**16.4** kN/m ^{3}

CLIENT	**Mattamy Homes**	FILE NO.	**PG2743**
PROJECT	**Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**	DATE	**29/10/2012**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



Specimen Identification			LL	PL	PI	Fines	Classification
●	**TP 1**	**G 1**	**74**	**35**	**39**		**CH - Inorganic clays of high plasticity**
⧗	**TP 2**	**G 3**	**70**	**28**	**41**		**CH - Inorganic clays of high plasticity**
▲	**TP 3**	**G 3**	**61**	**23**	**38**		**CH - Inorganic clays of high plasticity**
★	**TP 4**	**G 2**	**40**	**18**	**22**		**CL - Inorganic clays of low plasticity**
⊙	**TP 5**	**G 2**	**47**	**20**	**27**		**CL - Inorganic clays of low plasticity**
✿	**TP 6**	**G 3**	**71**	**23**	**48**		**CH - Inorganic clays of high plasticity**
○	**TP 7**	**G 3**	**72**	**22**	**50**		**CH - Inorganic clays of high plasticity**
△	**TP 8**	**G 2**	**72**	**34**	**38**		**CH - Inorganic clays of high plasticity**

CLIENT **Caivan Communities**

PROJECT **Geotechnical Investigation - 2388 Greenbank Road**

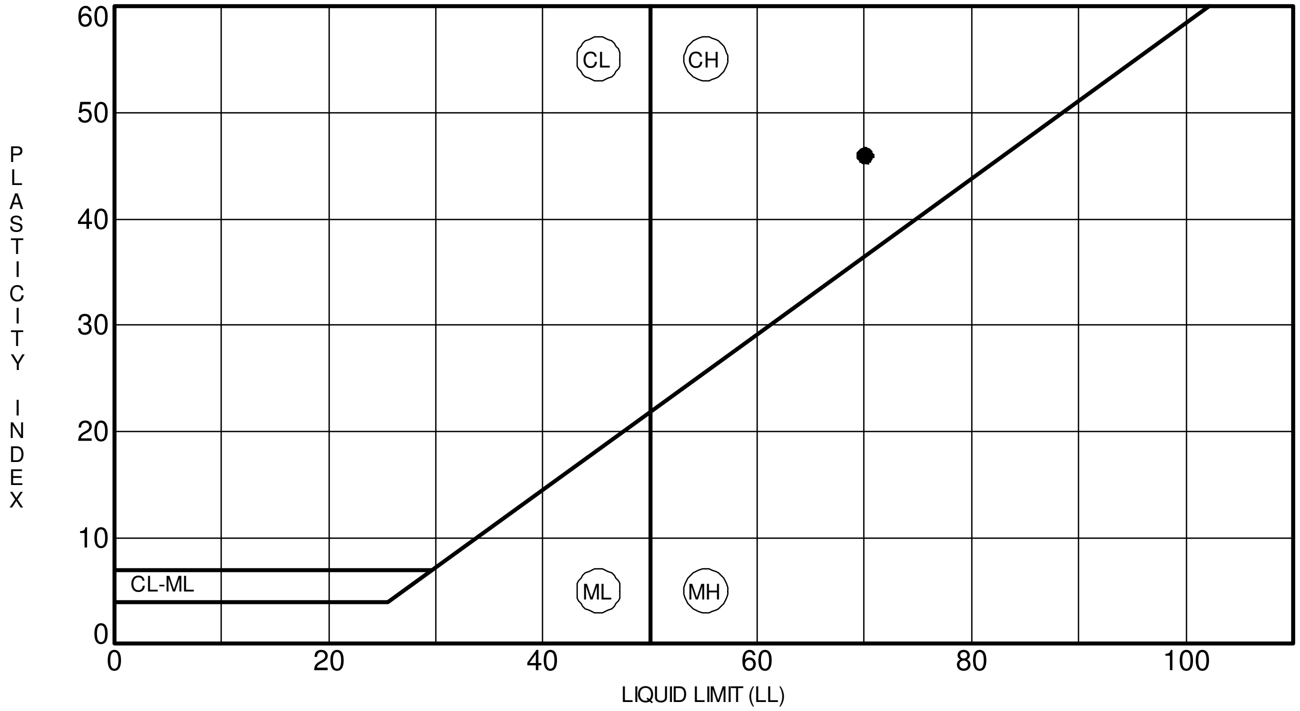
FILE NO. **PG2743**

DATE **19 Feb 19**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 6**	**TW 3**	**70**	**24**	**46**		**Inorganic clay of high plasticity**

CLIENT **Mattamy Homes**

FILE NO. **PG2743**

PROJECT **Geotechnical Investigation - Prop. Residential Development - 3288 Greenbank Rd.**

DATE **17 Oct 12**

patersongroup **Consulting Engineers**

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ATTERBERG LIMITS' RESULTS

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG2743-2 - PERMISSIBLE GRADE RAISE AREAS - HOUSING

DRAWING PG2743-3 - PERMISSIBLE GRADE RAISE AREAS - APARTMENT BLDG.

DRAWING PG2743-4 - TEST HOLE LOCATION PLAN

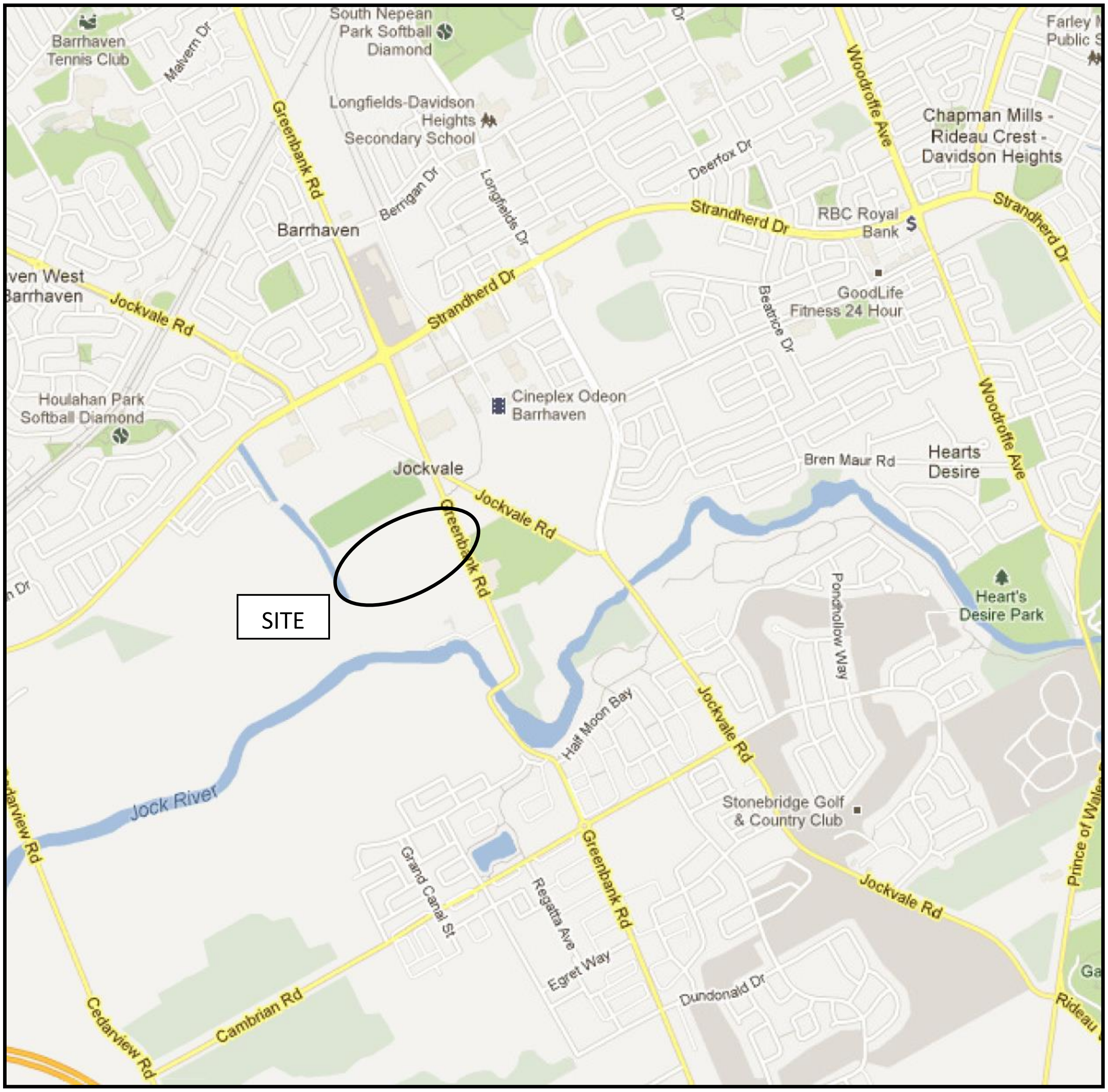
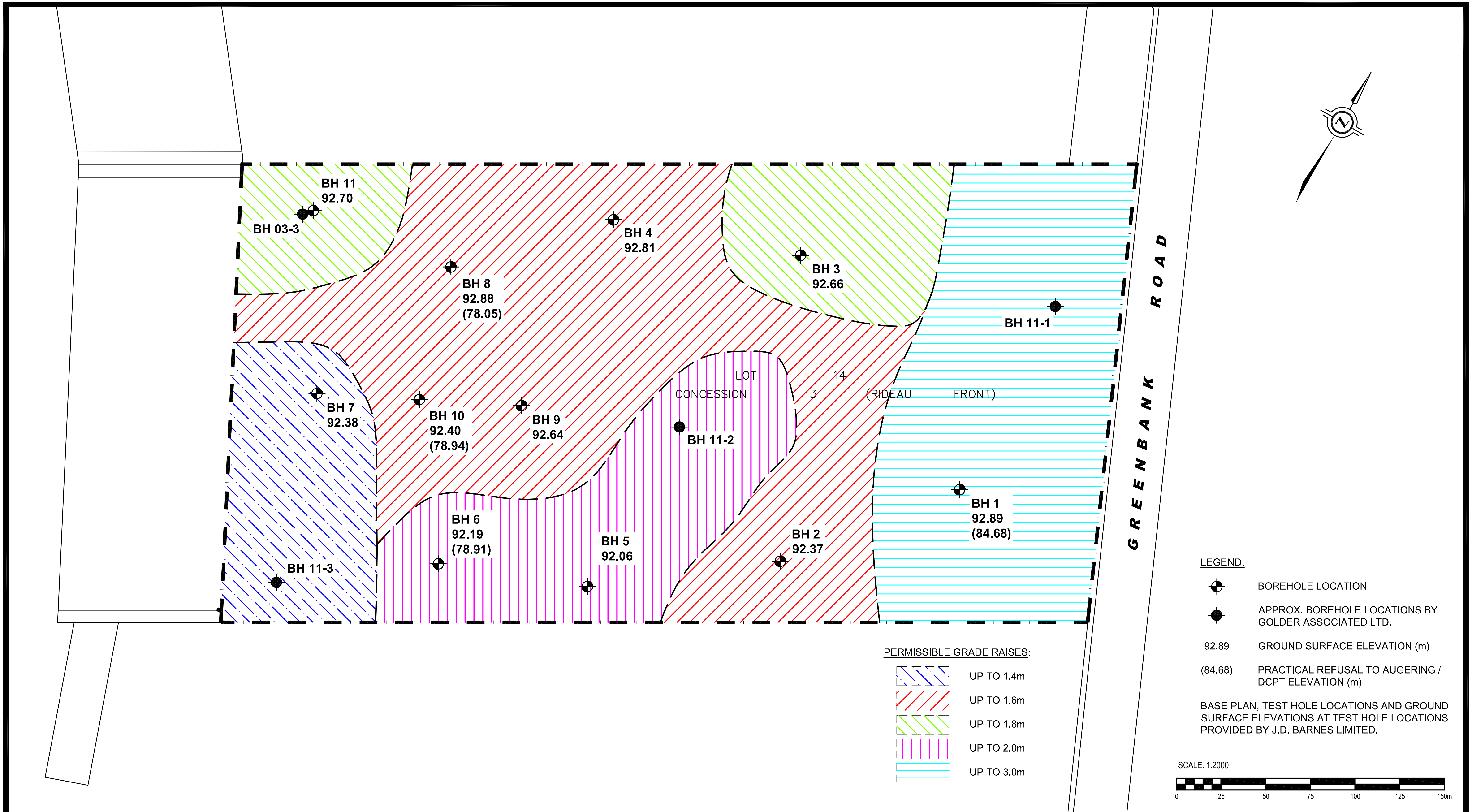


FIGURE 1

KEY PLAN



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154 Colonnade Road South
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NO.	REVISIONS	DATE	INITIAL

CAIVAN COMMUNITIES

GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - 2388 GREENBANK ROAD
OTTAWA, ONTARIO

Title:
PERMISSIBLE GRADE RAISE PLAN - HOUSING

Scale: 1:2000	Date: 11/2012
Drawn by: MPG	Report No.: PG2743-1
Checked by: DJG	**PG2743-2**
Approved by: DJG	Revision No.:

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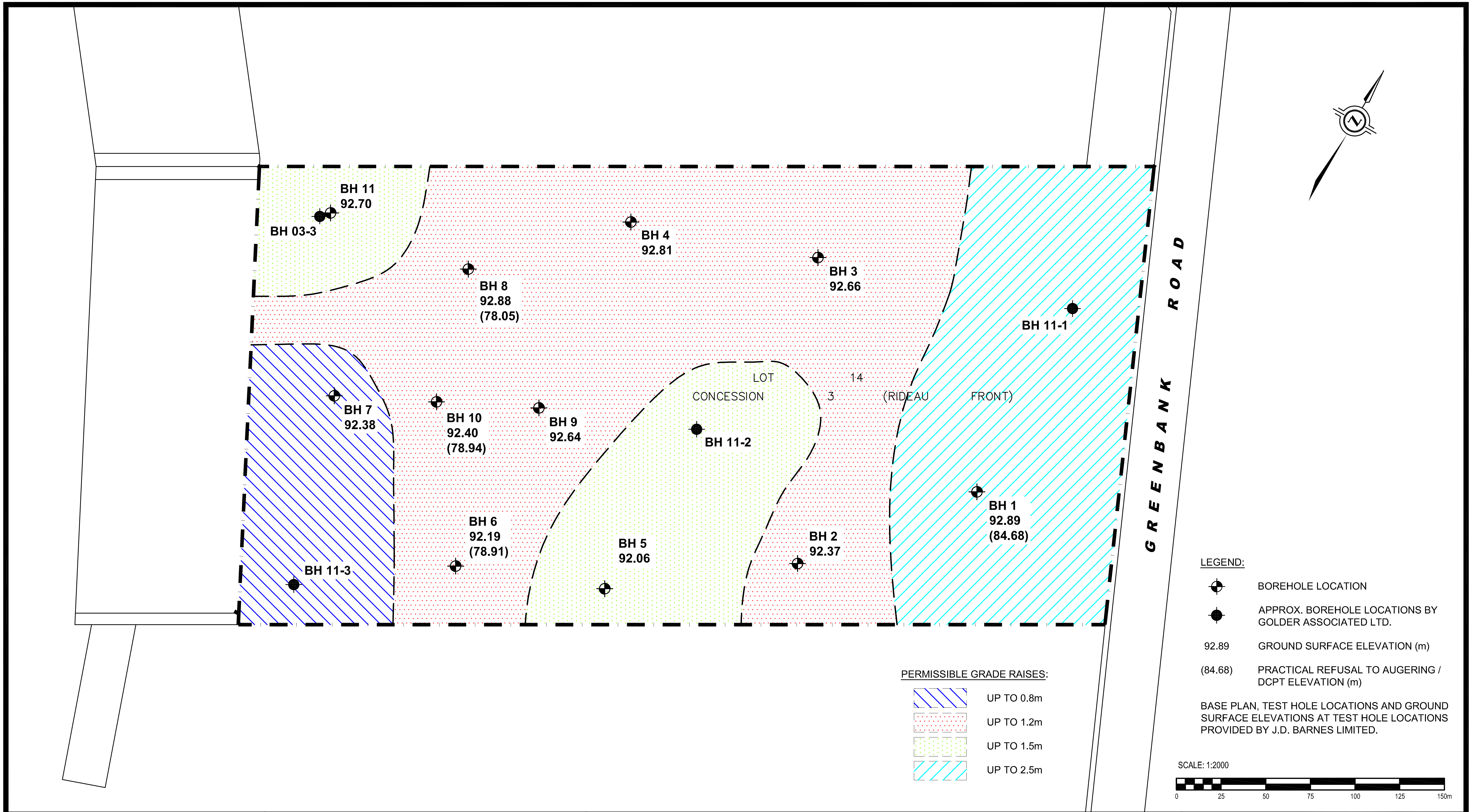

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154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

CAIVAN COMMUNITIES
GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - 2388 GREENBANK ROAD
OTTAWA, ONTARIO

Title:
PERMISSIBLE GRADE RAISE PLAN - APARTMENT BLDG.

Scale: 1:2000
Date: 11/2012
Drawn by: MPG
Report No.: PG2743-1
Checked by: DJG
Approved by: DJG
PG2743-3
Revision No.:

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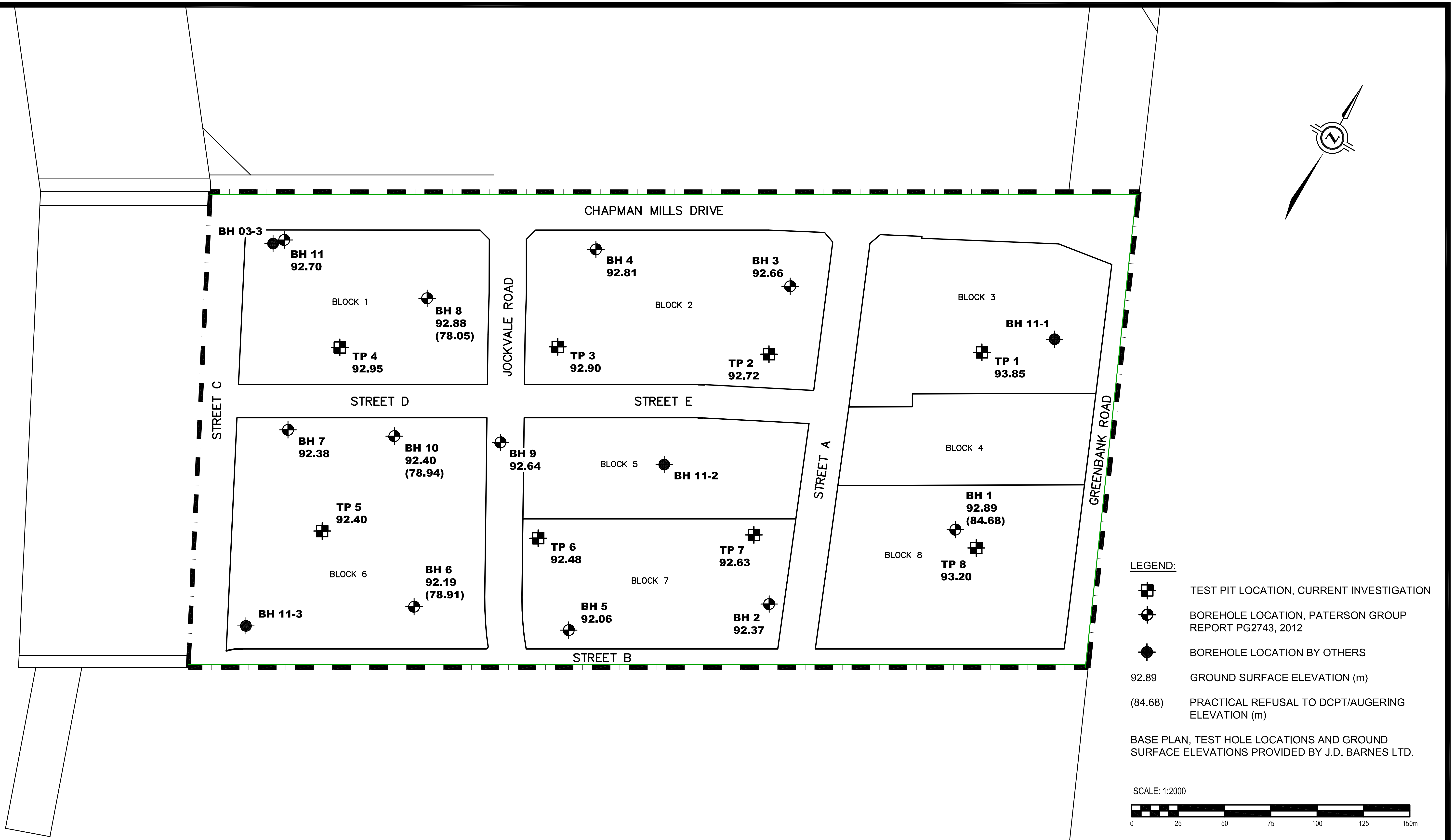

LEGEND:

⊞	TEST PIT LOCATION, CURRENT INVESTIGATION
⊕	BOREHOLE LOCATION, PATERSON GROUP REPORT PG2743, 2012
●	BOREHOLE LOCATION BY OTHERS
92.89	GROUND SURFACE ELEVATION (m)
(84.68)	PRACTICAL REFUSAL TO DCPT/AUGERING ELEVATION (m)

BASE PLAN, TEST HOLE LOCATIONS AND GROUND SURFACE ELEVATIONS PROVIDED BY J.D. BARNES LTD.

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

NO.	REVISIONS	DATE	INITIAL

CAIVAN COMMUNITIES
GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - 2388 GREENBANK ROAD
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:2000
Date: 03/2019
Drawn by: MPG
Report No.: PG2743
Checked by: JV
Approved by: DJG

PG2743-4

Revision No.:

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