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Geotechnical Investigation

Proposed Residential Development
Richardson Ridge - Phase 4
Terry Fox Drive - Ottawa

Prepared For

Regional Group of Companies

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Report: PG3695-1

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 Regional Group of Companies to conduct a geotechnical investigation for Phase 4 of the proposed residential development Richardson Ridge to be located along Terry Fox Drive, in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objective of the current investigation was to:

☐ determine the subsurface conditions by means of test pits, hand augers, boreholes and review of existing information.

☐ provide geotechnical recommendations for the design of the proposed building including construction considerations which may affect its design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. The report contains the geotechnical findings and includes recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work of this present investigation.

2.0 Proposed Project

It is understood that the proposed development will consist of residential single home and townhouse units with a basement level. Asphalt roadways, driveways and landscaped areas will occupy the remainder of the subject site. It is further understood that the subject site will be serviced by municipal water and sewer.

3.0 Method of Investigation

3.1 Field Investigation

The field program was conducted on December 7, 14 and 15, 2015. On December 7, 2015, the ground surface across the site was reviewed by Paterson personnel along with a surveyor from Annis, O'Sullivan Vollebekk to confirm the presence of bedrock outcrops. Where observed, bedrock outcrop elevations were surveyed, the survey results are presented in Drawing PG3695-1 - Test Hole Location Plan in Appendix 2. On December 14, 2015, test pits were completed within the west portion of the subject site to identify the presence of a silty clay deposit. On December 15, 2015, three (3) boreholes were completed within the portion of the site where the silty clay deposit was noted to be deepest. The test hole locations were determined in the field by Paterson personnel with consideration to site features and underground services. All test hole locations were surveyed by Annis O'Sullivan Vollebekk Ltd and are referenced to a geodetic datum. The test hole locations are presented in Drawing PG3695-1 - Test Hole Location Plan presented in Appendix 2.

The test pits were completed using a rubber-tired backhoe. The boreholes were drilled using a track-mounted auger drill rig operated by a two person crew. All fieldwork was conducted under the full-time supervision of personnel from Paterson's geotechnical division under the direction of a senior engineer. The testing procedure consisted of excavating or augering to the required depths and sampling the overburden.

Sampling and In Situ Testing

Soil samples were collected from the side walls of the test pits or from boreholes using a 50 mm diameter split-spoon (SS) sample or the auger flights. All soil samples were visually inspected and initially classified on site. The grab, split-spoon and auger samples were placed in sealed plastic bags. All samples were transported to the laboratory for further examination and classification. The depths at which the grab, split-spoon and auger samples were recovered from the test holes are presented as G, SS 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 as 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. This testing was done in general accordance with ASTM D2573-08 - Standard Test Method for Field Vane Shear Test in Cohesive Soil.

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.

Flexible standpipes were installed in all the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

All samples will be stored in the laboratory for a period of one month after issuance of this report and be discarded unless otherwise directed.

3.2 Field Survey

The test hole locations and ground surface elevations were surveyed by Annis O'Sullivan Vollebekk Ltd. The locations and ground surface elevations for each test hole location are presented on Drawing PG3695-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from our field investigation were examined in our laboratory. The subsurface soils were classified in general accordance with ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Two (2) Shelby tube samples were submitted for unidimensional consolidation and one (1) sample was selected for Atterberg limit testing from the boreholes completed for our investigation. The results of the consolidation and Atterberg testing are presented on the Unidimensional Consolidation Test Results and Atterberg Limits sheets presented in Appendix 1 and are further discussed in Sections 4 and 5.

3.4 Analytical Testing

One soil sample was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

Currently, the ground surface across the subject site consists of grassed and treed areas. Bedrock outcrops were noted throughout the central and east portions of the subject site. The ground surface across the central portion of the site undulates significantly and slopes downward within the west portion of the site.

4.2 Subsurface Profile

Generally, the subsurface profile encountered at the test hole locations consists of topsoil over a silty clay deposit and glacial till and/or bedrock. Based on undrained shear strength values, the silty clay varied between a firm to very stiff consistency. Refer 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 subject site is located in an area where the bedrock consists of either diorite, gabbro or paragneiss. The overburden drift thickness is estimated to be 0 to 5 m depth.

4.3 Groundwater

On January 6, 2015, groundwater levels were measured in piezometers installed at the borehole locations. The measured groundwater levels are presented on the Soil Profile and Test Data sheets in Appendix 1. The long-term groundwater level can also be estimated based on field observations of the recovered soil samples, such as moisture levels, colouring and consistency. Based on these observations, the long-term groundwater level can be expected between 3 to 6 m depth. Groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

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 within the west portion of the current phase, areas of the site will be subjected to grade raise restrictions.

Permissible grade raise recommendations are discussed in Subsection 5.3 and recommended permissible grade raise areas are presented in Drawing PG3695-2 - Permissible Grade Raise Plan 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. It should be noted that our permissible grade raise restrictions will be waived if a settlement surcharge program is designed by Paterson and given sufficient time to be successfully completed.

It should be further noted that bedrock outcrops and shallow bedrock were observed across the central and east portions of Phase 4. It is understood that a bedrock blasting program is to be completed within these areas. As part of the blasting program, crushing of the blasted material is to be completed to enable reuse of the material on site. Construction recommendations for use of the crushed material and footing placement over blasted areas are provided in the following subsections.

It should be noted that the existing slopes within the site are considered stable and no setbacks are required from a slope stability perspective. Bedrock was noted to be encountered at shallow depths in the areas where slopes are present, which provides a high factor of safety for slope stability (ie.- greater than 1.5) under static and seismic conditions.

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 placed 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. The backfill material should be tested and approved prior to delivery to the site. The fill should be placed in maximum 300 mm thick lifts and compacted to 98% of the standard Proctor maximum dry density (SPMDD).

Where over-blasting has occurred below proposed underside of footing level, it is suitable for a site crushed rock material, consisting of 150 mm minus material which is adequately compacted to be placed below underside of footing. Where required for grading purposes, the 150 mm minus material should be topped with a Granular B Type II or Granular A crushed stone material.

If site excavated blast rock is to be used as fill to build up the bearing medium, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 400 mm placed in maximum 600 mm loose lifts and compacted by an adequately sized bulldozer making several passes and approved by the geotechnical consultant at the time of placement. Any blast rock greater than 400 mm in diameter should be segregated and hoe rammed into acceptable fragments. The site excavated blast rock fill with maximum particle size of 400 mm should be capped with a minimum of 300 mm of of Granular B Type II or Granular A crushed stone material and 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 placed as general landscaping fill where settlement of the ground surface is of minor concern. The existing fill materials should be spread in thin lifts and at a minimum compacted by the tracks of the spreading equipment to minimize voids. If the material is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of the SPMDD. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

Fill used for grading beneath the base and subbase layers of paved areas should consist, unless otherwise specified, of clean imported granular fill, such as OPSS Granular B Type II or select subgrade material. This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the paved areas should be compacted to at least 95% of its SPMDD.

If excavated rock is to be used as fill to build up the subgrade for roadways, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 300 mm. Where the fill is open-graded, a blinding layer of finer granular fill or a geotextile may be required to prevent adjacent finer materials from migrating into the voids, with associated loss of ground and settlements.

5.3 Foundation Design

Bearing Resistance Values

Footings for the proposed buildings can be designed using the bearing resistance values presented in Table 1. It should be noted that where foundations are placed over engineered fill over bedrock or directly over bedrock, Part 9 of the current OBC 2012 standard should be used for design purposes. Also, where foundations are placed over a silty clay deposit, Part 4 of the current OBC 2012 standard should be used for design purposes. The area requiring permissible grade raise restrictions outlined in Drawing PG3695-2 - Permissible Grade Raise Areas in Appendix 2 should be used to delineate the houses where silty clay is anticipated below footing level.

Table 1 - Bearing Resistance Values

Bearing Surface	Bearing Resistance Value at SLS (kPa)	Factored Bearing Resistance Value at ULS (kPa)
Firm Silty Clay	60	125
Stiff Silty Clay	100	150
Clean, Bedrock	500	1,000
Engineered Fill	150	250

Note: Strip footings, up to 2 m wide, and pad footings, up to 4 m wide, placed over a silty clay bearing surface can be designed using the abovenoted bearing resistance values.

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.

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.

A geotechnical resistance factor of 0.5 was applied to the reported bearing resistance values at ULS.

Where a building is founded partly on bedrock and partly 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, at the soil/bedrock and bedrock/soil transitions, 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.

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

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to an engineered fill, firm to stiff silty clay above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

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. Two (2) site specific consolidation tests were conducted. The results of the consolidation tests from our testing 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 sample. 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	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c	Q
BH 2	TW 5	4.17	62	55	0.014	0.482	G
BH 2A	TW 1	3.33	53.8	49	0.008	0.385	P

* - 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 carried out for the present investigation are based on the long term groundwater level observed at each borehole location. The long-term 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 undrained shear strength values and consolidation testing results, permissible grade raise areas have been defined for Phase 4 of the proposed development. The recommended permissible grade raise areas are presented in Drawing PG3695-2 - Permissible Grade Raise Plan in Appendix 2.

Based on the above discussion, several options could be considered to accommodate proposed grade raises with respect to our permissible grade raise recommendations, such as, the use of lightweight fill, which allow for raising the grade without adding a significant load to the underlying soils. Alternatively, it is possible to preload or surcharge the subject site in localized areas provided sufficient time is available to achieve the desired settlements. It should be noted that a settlement surcharge program is currently under consideration for lots/blocks within the south portion of the site where a significant proposed grade raise is required.

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.

Preloading and Surcharging Alternative

Provided sufficient time is available to induce the required settlements, consideration could be given to preloading and surcharging the subject site where sensitive silty clay is encountered below underside of footing. For preliminary design purposes, it is suggested that the site be preloaded to finished grade and surcharged with an additional 1.5 to 2.5 m of fill. Settlement plates to monitor long term settlement should be installed at selected locations. Once the desired settlements have taken place, the surcharged portion can be removed and the site is considered acceptable for development.

5.4 Design for Earthquakes

It should be noted that where foundations are placed over glacial till or bedrock, Part 9 of the current OBC 2012 standard should be used for design purposes. Also, where foundations are placed over a silty clay deposit, Part 4 of the current OBC 2012 standard should be used for design purposes. The area requiring permissible grade raise restrictions outlined in Drawing PG3695-2 - Permissible Grade Raise Areas in Appendix 2 should be used to delineate the houses where silty clay is anticipated below footing level.

The site class for seismic site response can be taken as **Class E** for footings placed over the sensitive silty clay deposit within the west portion of the site (where a permissible grade raise of 2.5 m or less is delineated in Drawing PG3695-2). A seismic site **Class D** is recommended for the remainder of the area where footings will be founded over a silty clay deposit. Reference should be made to the latest version of the Ontario Building Code (2012) for a full discussion of the earthquake design requirements. The soils underlying the subject site are not susceptible to liquefaction.

5.5 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 or approved granular fill 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.

It is recommended that a minimum 300 mm thick layer (native soil plus crushed stone layer) be present between the floor slabs and the bedrock surface to reduce the risks of bending stresses in the concrete slab. The bending stress could lead to cracking of the concrete slabs. This requirement could be waived if the bedrock surface is relatively flat within the footprint of the building. This recommendation does not refer to potential concrete shrinkage cracking which should be controlled in the usual manner.

5.6 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of driveways and local residential streets. It should be noted that for residential driveways and car only parking areas, an Ontario Traffic Category A is applicable. For local roadways or roadways with bus traffic, an Ontario Traffic Category B should be used for design purposes.

Table 3 - Recommended Pavement Structure - Driveways

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 - 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
450	**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 5 - 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. It is recommended that a compaction level between 91% and 96.5% be provided for Superpave 19.0. A compaction level between 92% to 97.5% be provided for Superpave 12.5.

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 (where silty clay is encountered at subgrade level) consideration should be given to installing subdrains during the pavement construction as per City of Ottawa standards. The sub-drain 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 to be provided for the proposed structures. The system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 19 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 greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for placement as backfill against the foundation walls unless used in conjunction with a composite drainage system, such as Delta Drain 6000 or Miradrain G100N. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be placed for this purpose.

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.

For footings founded directly on sound bedrock where insufficient soil cover is available, the suggested soil cover is not required.

6.3 Excavation Side Slopes

The subsurface soil are considered to be mainly a Type 2 and Type 3 soils according to the Occupational Health and Safety Act and Regulations for Construction Projects. The excavation side slopes should be stable in the short term at 1H:1V. Shallower slopes should be provided for deeper excavations or for excavation below the groundwater level. Where such side slopes are not permissible or practical, temporary shoring should be installed.

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 maintain safe working distance from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

A trench box is recommended to be installed at all times to protect personnel working in trenches with steep or vertical sides. The services are expected be installed by “cut and cover” methods and excavations should not remain open for extended periods of time.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with City of Ottawa standards and specifications.

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material over a stiff silty clay subgrade. However, the bedding thickness should be increased to 300 mm for areas over a bedrock or grey, firm silty clay subgrade. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of the SPMDD. The bedding material should extend at a minimum to the spring line of the pipe.

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

Generally, the dry brown silty clay could be place above the cover material if the excavation and backfilling operations are completed in dry weather conditions. The wet silty clay materials could be difficult to place and compact, due to the high water content.

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 consist of the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD.

To reduce long-term lowering of the groundwater level, clay seals should be provided in the service trenches. The seals should be a minimum of 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. Generally, 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, roadway intersections and at a maximum distance of every 50 m in the service trenches.

6.5 Groundwater Control

Due to the relatively impervious nature of the silty clay materials, groundwater infiltration into the excavations should be low and controllable by open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations.

A temporary MOE permit to take water (PTTW) will be required for this project if more than 50,000 L/day are to be pumped during the construction phase. At least 4 to 5 months should be allowed for completion of the application and issuance of the permit by the MOE.

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

6.6 Winter Construction

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

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

The trench excavations should be constructed to avoid the introduction of frozen materials, snow or ice 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 during construction. Also, 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.

6.7 Landscaping Considerations

Tree Planting Restrictions

The proposed residential dwellings are located in a moderate sensitivity area with respect to tree plantings over a silty clay deposit. It is recommended that trees placed within 4.5 m of the foundation wall consist of low water demanding trees with shallow roots systems that extend less than 1.5 m below ground surface. Trees placed greater than 4.5 m from the foundation wall may consist of typical street trees, which are typically moderate water demand species with roots extending to a maximum 2 m depth.

It is well documented in the literature, and is our experience, that fast-growing trees located near buildings founded on cohesive soils that shrink on drying can result in long-term differential settlements of the structures. Tree varieties that have the most pronounced effect on foundations are seen to consist of poplars, willows and some maples (i.e. Manitoba Maples) and, as such, they should not be considered in the landscaping design.

Swimming Pools

The in-situ soils are considered to be acceptable for swimming pools. In areas where sensitive silty clay is observed, above ground swimming pools must be placed at least 5 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

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

Additional grading around proposed deck or addition should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

6.8 Corrosion Potential and Sulphate

The analytical test results are presented in Table 6 along with industry standards for the applicable threshold values. The results are indicative that Type 10 Portland cement (Type GU) is acceptable.

Table 6 - Corrosion Potential

Parameter	Laboratory Results	Threshold	Commentary
	TP 6 G3 PG1845		
Chloride	24 µg/g	Chloride content less than 400 mg/g	Negligible concern
pH	7.58	pH value less than 5.0	Neutral Soil
Resistivity	35.6 ohm.m	Resistivity greater than 1,500 ohm.cm	Slightly to Moderately Agressive
Sulphate	47 µg/g	Sulphate value greater than 1 mg/g	Negligible Concern

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 for review and design purposes. Paterson requests permission to review the recommendations when the drawings and specifications are completed.

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

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

A geotechnical investigation is a limited sampling of a site. The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Regional Group of Companies and their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
April 5, 2016
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Stephanie A. Boisvenue, P.Eng. David J. Gilbert, P.Eng.

Report Distribution:

☐ Regional Group of Companies (3 copies)
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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

UNIDIMENSIONAL CONSOLIDATION TESTING SHEETS

ATTERBERG LIMITS' TESTING RESULTS

ANALYTICAL TEST RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

BORINGS BY CME 75 Power Auger

DATE December 15, 2015

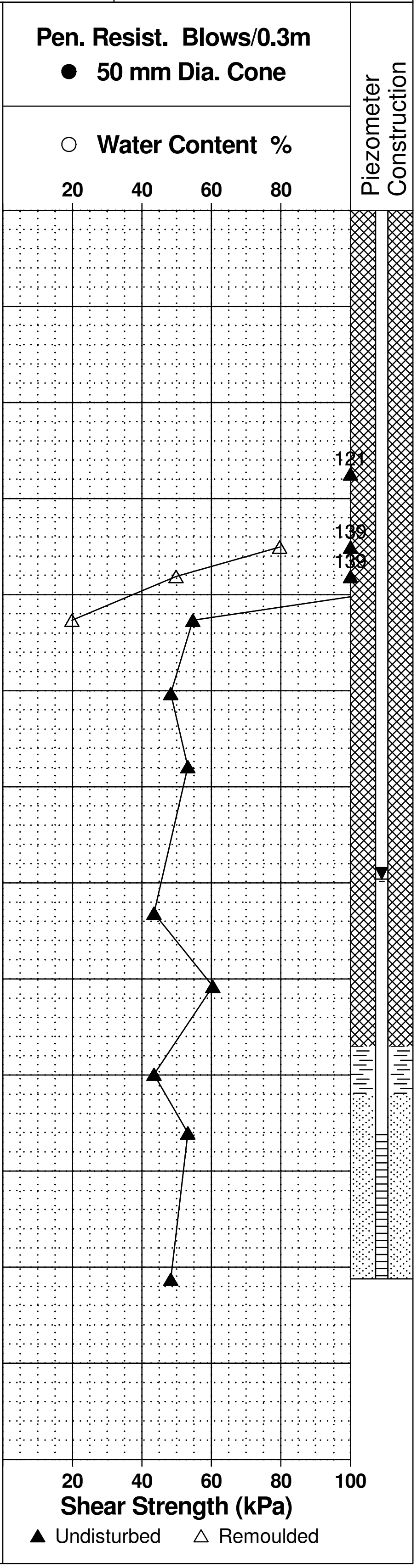
FILE NO. PG3695

HOLE NO. BH 1

SOIL DESCRIPTION	Depth to (m)
GROUND SURFACE	
TOPSOIL	0.30
Very stiff to stiff, brown **SILTY CLAY** -firm and grey by 5.9m depth	11.12
Dynamic Cone Penetration Test commenced at 11.12m depth. Cone pushed to 20.6m depth.	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	3
SS	3	100	3

DEPTH (m)	ELEV. (m)
0	94.69
1	93.69
2	92.69
3	91.69
4	90.69
5	89.69
6	88.69
7	87.69
8	86.69
9	85.69
10	84.69
11	83.69
12	82.69
13	81.69



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. BH 1

BORINGS BY CME 75 Power Auger

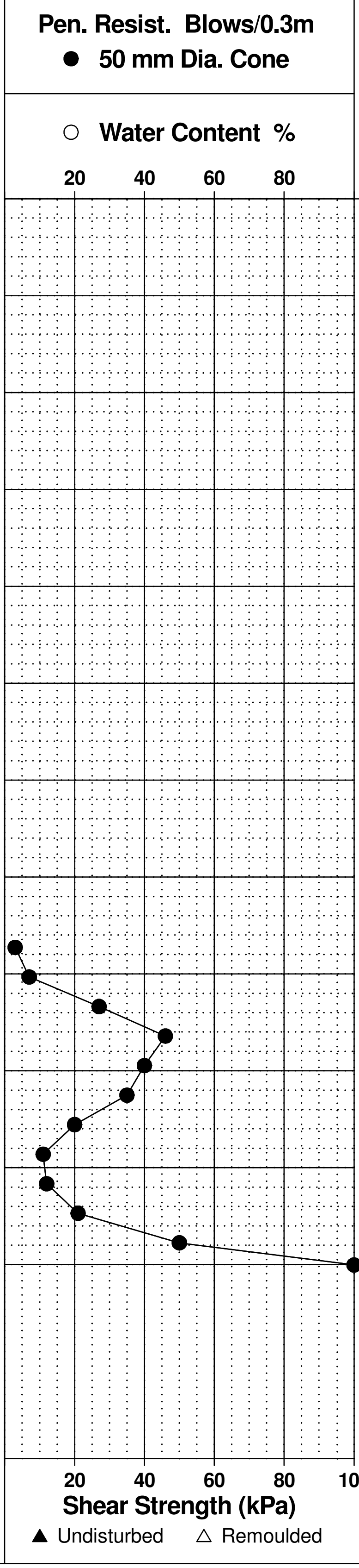
DATE December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						13	81.69
						14	80.69
						15	79.69
						16	78.69
						17	77.69
						18	76.69
						19	75.69
						20	74.69
						21	73.69
						22	72.69
						23	71.69
24.00						24	70.69

End of Borehole

Practical DCPT refusal at 24.00m depth

(GWL @ 6.96m-Jan. 6, 2016)



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

REMARKS

HOLE NO. **BH 2**

BORINGS BY CME 75 Power Auger

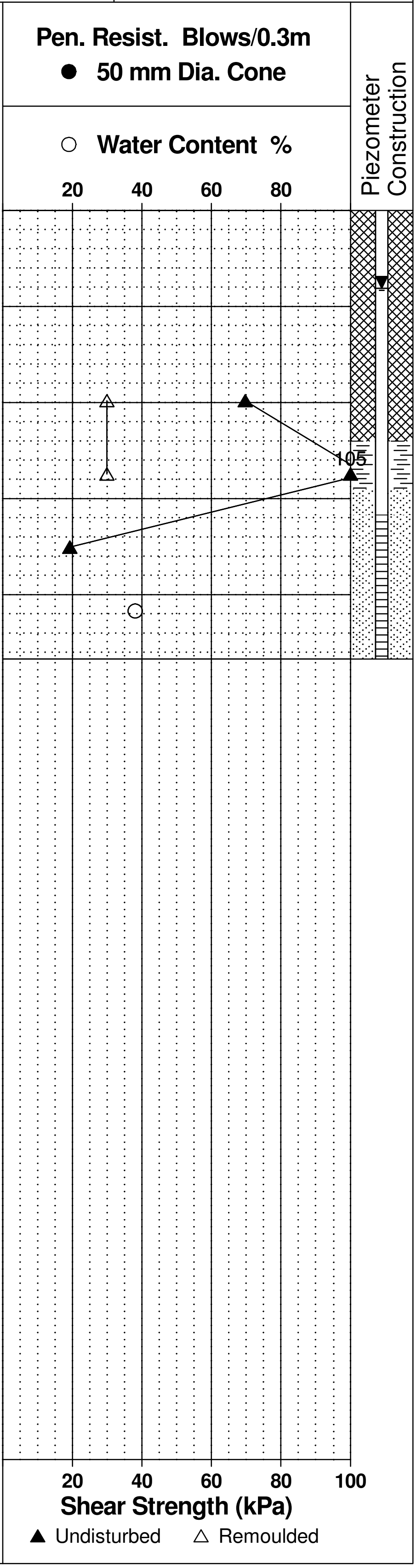
DATE December 15, 2015

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	93.53
TOPSOIL 0.30						
	SS	1	100	6	1	92.53
Stiff to firm brown **SILTY CLAY**, some sand					2	91.53
					3	90.53
- soft to firm and grey by 3.7m depth					4	89.53
	TW	2	75			
4.67	SS	3	100	50+		

End of Borehole

Practical refusal to augering at 4.67m depth

(GWL @ 0.81m-Jan. 6, 2016)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

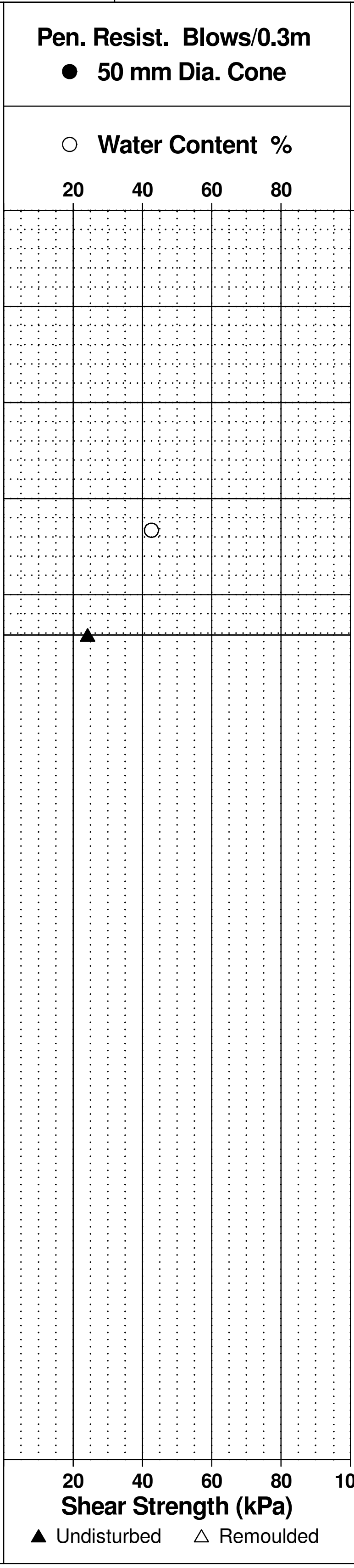
FILE NO. PG3695

REMARKS

HOLE NO. BH 2A

BORINGS BY CME 75 Power Auger **DATE** December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.53
Inferred **SILTY CLAY**	▨					1	92.53
	▨					2	91.53
3.05	▨						
Firm, brown **SILTY CLAY**	▨	TW	1			3	90.53
	▨					4	89.53
4.42							
End of Borehole							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

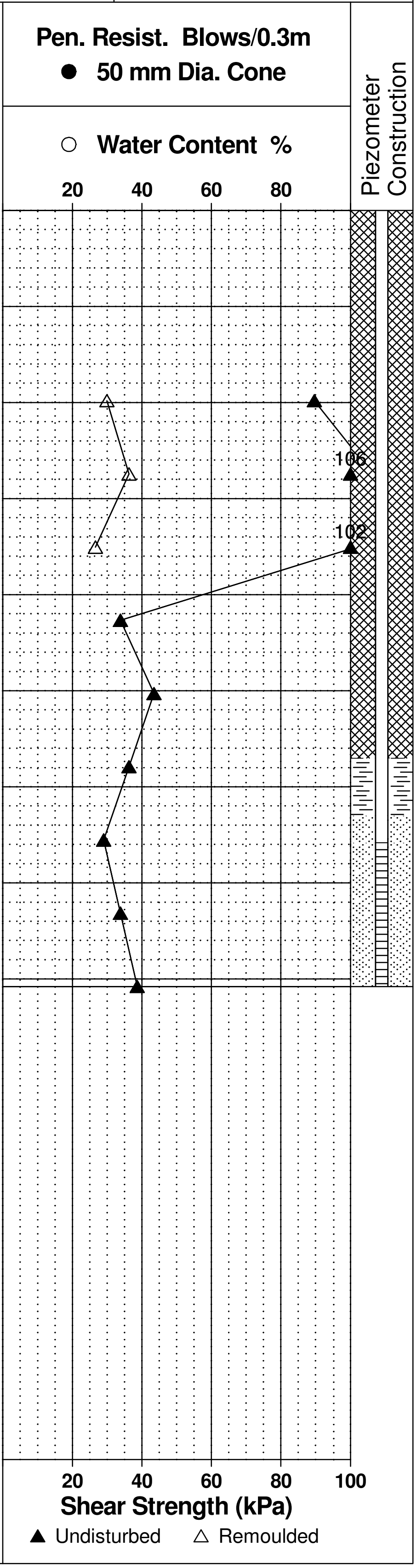
REMARKS

HOLE NO. **BH 3**

BORINGS BY CME 75 Power Auger

DATE December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.30						0	93.90
		SS	1	100	5	1	92.90
						2	91.90
Stiff to firm, brown **SILTY CLAY**						3	90.90
- grey by 4.2m depth						4	89.90
						5	88.90
						6	87.90
						7	86.90
8.08						8	85.90
End of Borehole (Piezometer blocked-Jan. 6, 2016)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

REMARKS

HOLE NO. **HA 1**

BORINGS BY Hand Auger

DATE December 7, 2015

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	99.56		
TOPSOIL 0.10	■								
Brown, **SILTY CLAY** 1.10	▨					1	98.56		
End of Auger Hole Practical refusal to hand augering at 1.10m depth									

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. HA 2

BORINGS BY Hand Auger

DATE December 7, 2015

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	99.57		
TOPSOIL 0.40	■								
End of Auger Hole Practical refusal to hand augering at 0.40m depth									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

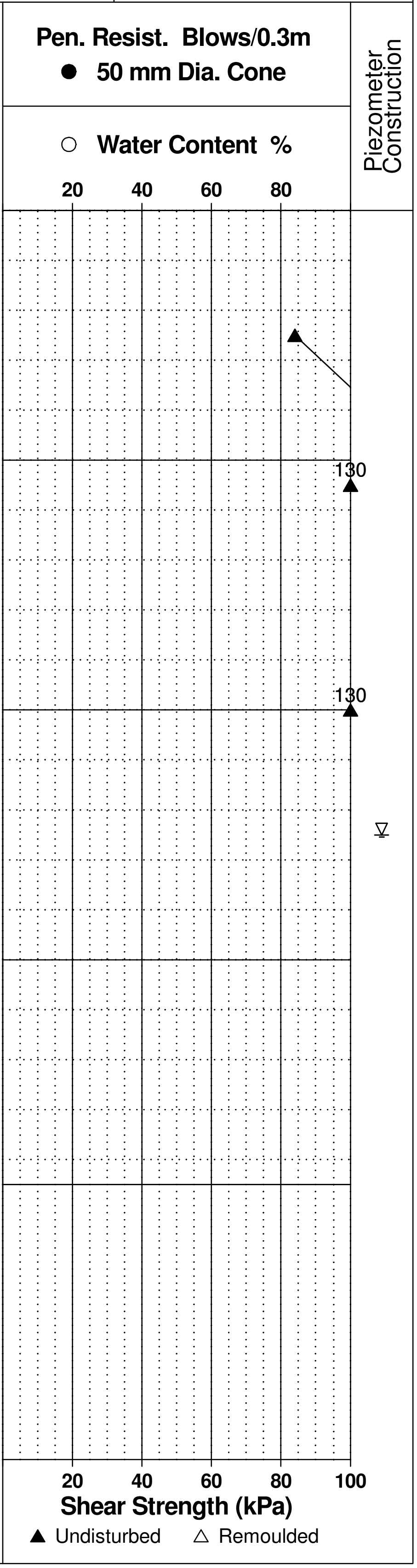
REMARKS

HOLE NO. TP 1

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.61
TOPSOIL 0.12		G	1				
		G	2			1	98.61
Very stiff, brown **SILTY CLAY**						2	97.61
		G	3				
		G	4			3	96.61
3.70 **GLACIAL TILL:** Grey silty sand with clay 3.90		G	5				
End of Test Pit (Open hole GWL @ 2.5m depth)							



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SOIL PROFILE AND TEST DATA

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FILE NO. PG3695

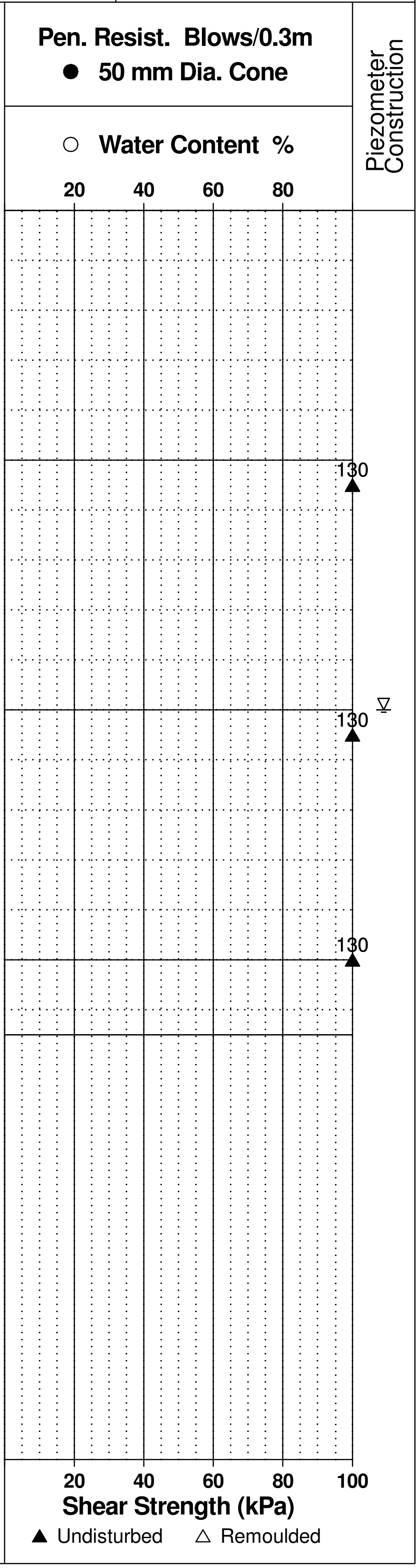
REMARKS

HOLE NO. TP 2

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	97.82
TOPSOIL 0.15							
Very stiff, brown SILTY CLAY						1	96.82
		G	1				
						2	95.82
		G	2				
						3	94.82
3.30							
End of Test Pit (Open hole GWL @ 2.0m depth)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

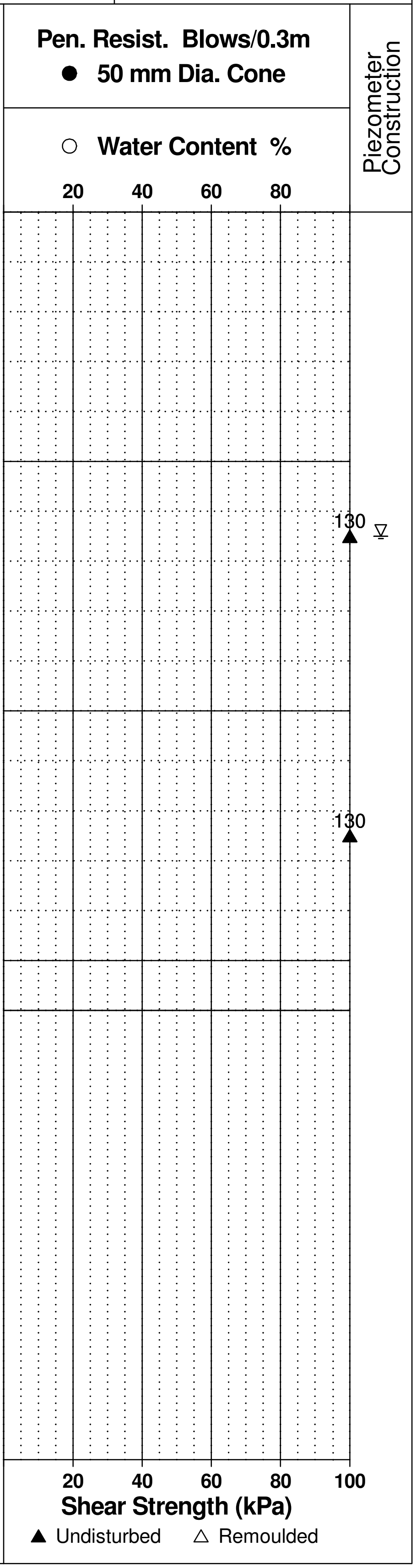
REMARKS

HOLE NO. TP 3

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.46
TOPSOIL							
0.25							
						1	94.46
		G	1				
Very stiff, brown **SILTY CLAY**							
						2	93.46
		G	2				
						3	92.46
3.20							
End of Test Pit (Open hole GWL @ 1.3m depth)							



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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

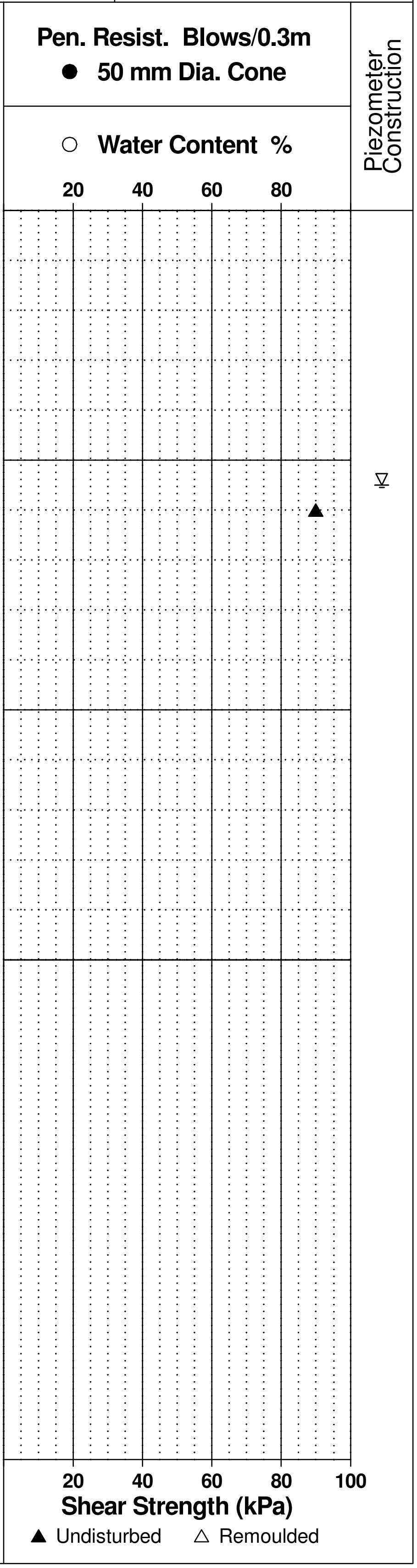
REMARKS

HOLE NO. TP 4

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.26
TOPSOIL 0.25	■	G	1				
Very stiff, brown **SILTY CLAY** 1.70	▨	G	2			1	94.26
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 3.00	^^^	G G	3 4			2 3	93.26 92.26
End of Test Pit (Open hole GWL @ 1.1m depth)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 5

BORINGS BY Backhoe

DATE December 14, 2015

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	97.28		
TOPSOIL 0.10	■								
BEDROCK: weathered bedrock with silty sand 0.90	▤	G	1						
End of Test Pit TP terminated on bedrock surface @ 0.90m depth (TP dry upon completion)									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

BORINGS BY Backhoe

DATE December 14, 2015

FILE NO. PG3695

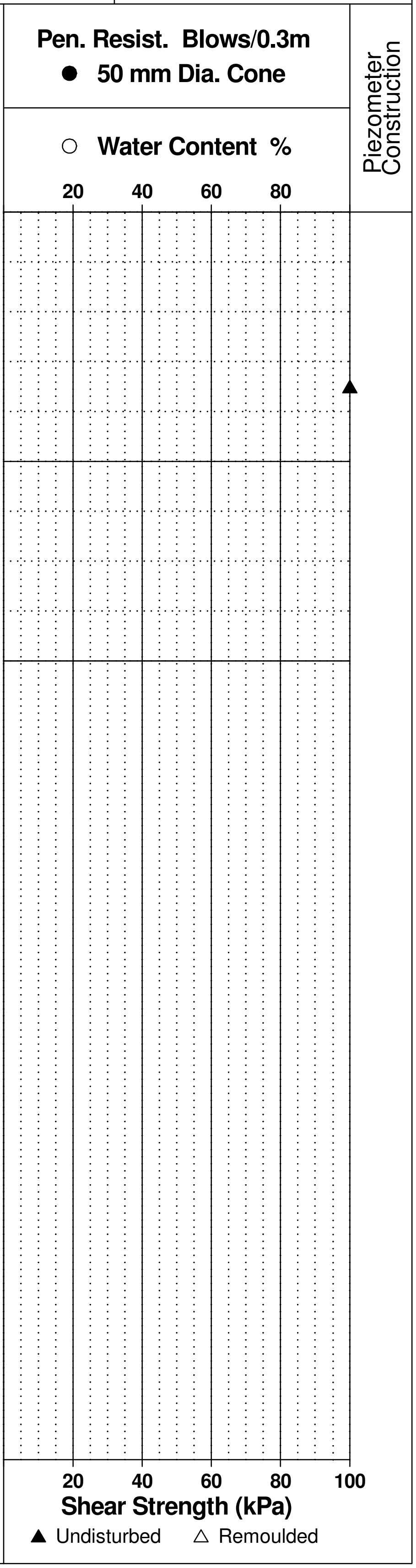
HOLE NO. TP 6

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	99.03
TOPSOIL 0.30	■	G	1				
Very stiff, brown **SILTY CLAY** 1.10	▨	G	2			1	98.03
BEDROCK 1.75	▤						

End of Test Pit

TP terminated on bedrock surface at 1.1m depth on north portion and at 1.75m depth on south portion.

(TP dry upon completion)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

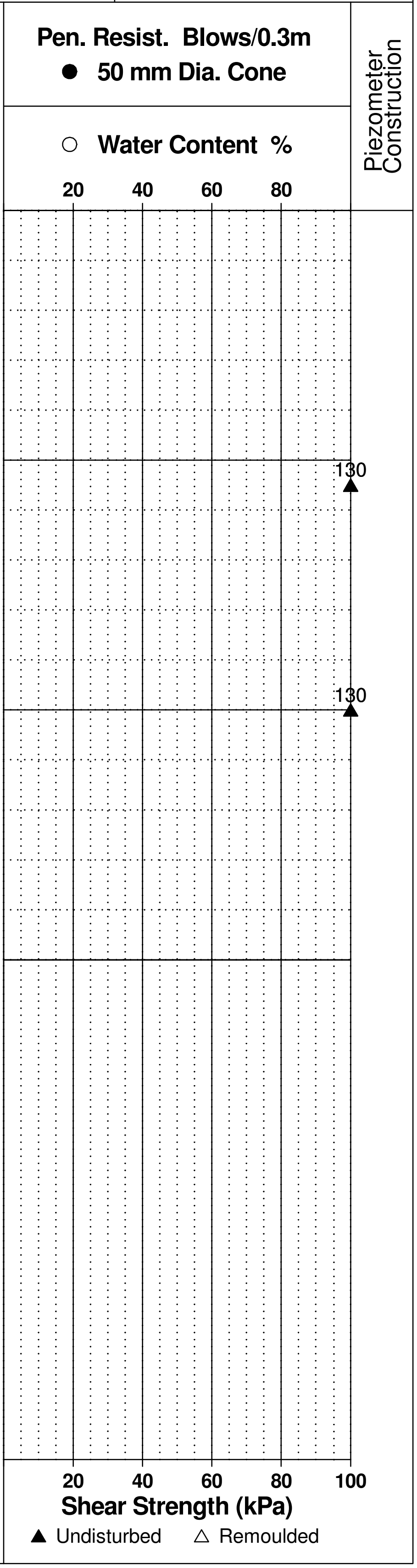
REMARKS

BORINGS BY Backhoe

DATE December 14, 2015

HOLE NO. TP 7

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.33
TOPSOIL 0.20							
Very stiff, brown **SILTY CLAY**		G	1			1	99.33
		G	2			2	98.33
3.00						3	97.33
End of Test Pit (TP dry upon completion)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

REMARKS

HOLE NO. **TP 8**

BORINGS BY Backhoe

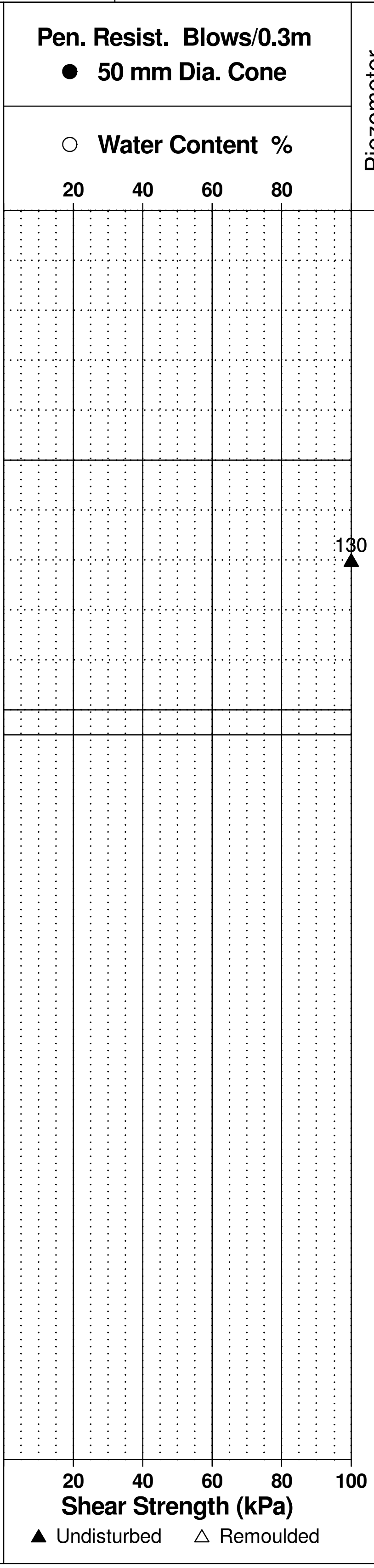
DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	96.77
TOPSOIL 0.30	■	G	1				
Very stiff, brown **SILTY CLAY** 1.80	▨	G	2			1	95.77
BEDROCK 2.10	▤					2	94.77

End of Test Pit

Practical refusal to excavation at 1.80m depth in northern portion of test pit and 2.10m depth in the southern portion.

(TP dry upon completion)



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

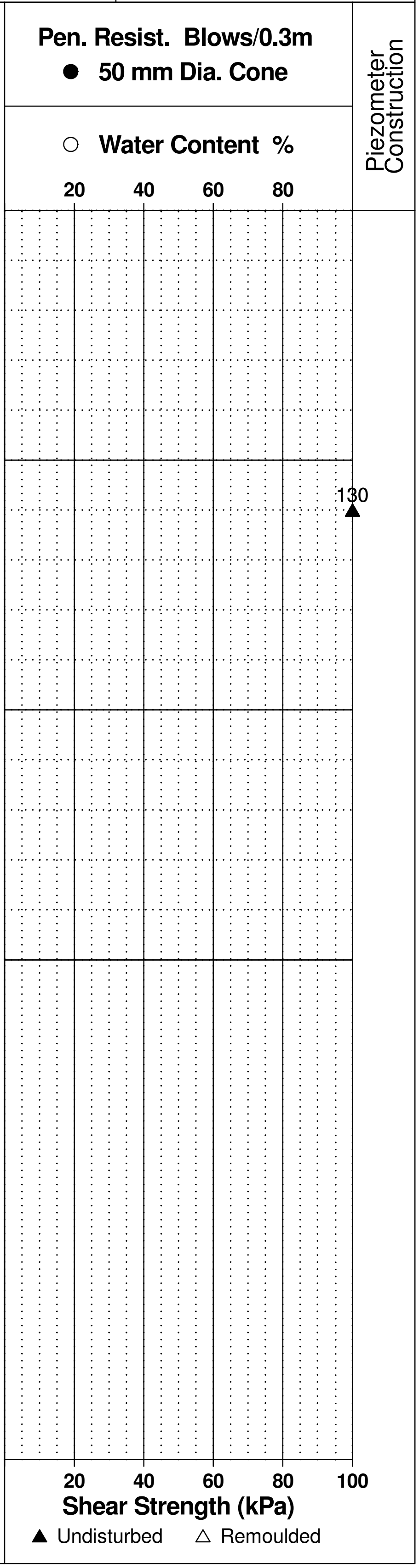
HOLE NO. TP 9

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
TOPSOIL 0.20	■				
Very stiff, brown **SILTY CLAY** 1.70	▨	G	1		
Very stiff, brown **SILTY CLAY** with sea shells, trace sand 3.00	▨	G	2		
End of Test Pit (TP dry upon completion)					

DEPTH (m)	ELEV. (m)
0	97.19
1	96.19
2	95.19
3	94.19



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

REMARKS

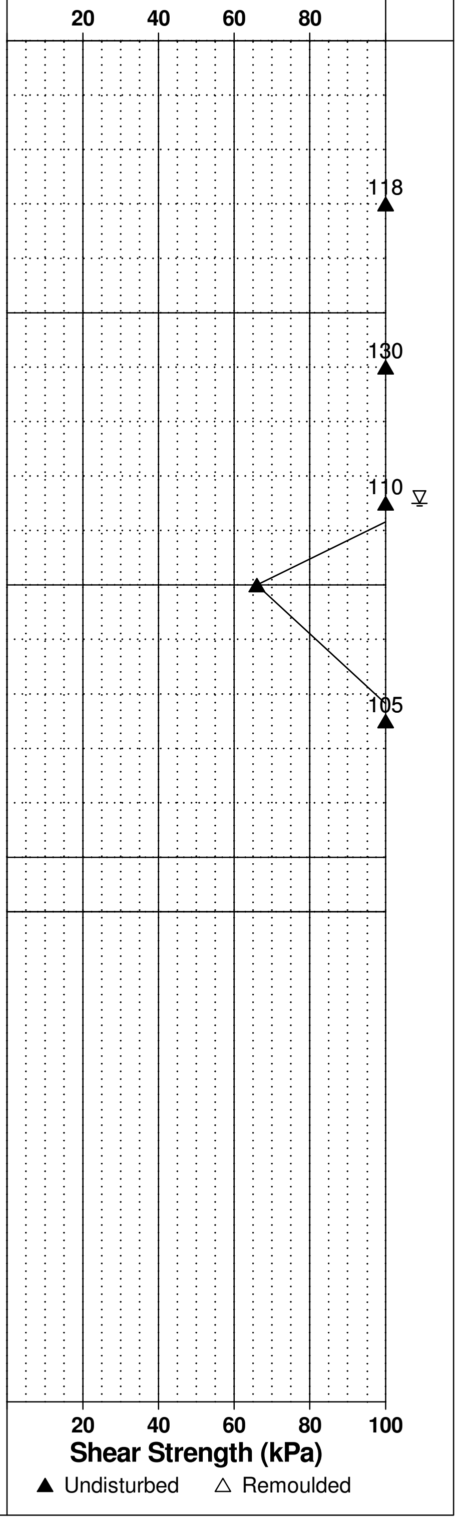
HOLE NO. **TP10**

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	93.54	
TOPSOIL 0.25								
Very stiff, brown **SILTY CLAY**		G	1			1	92.54	
		G	2			2	91.54	
3.20		G	3			3	90.54	
End of Test Pit (Open hole GWL @ 1.7m depth)								

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



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

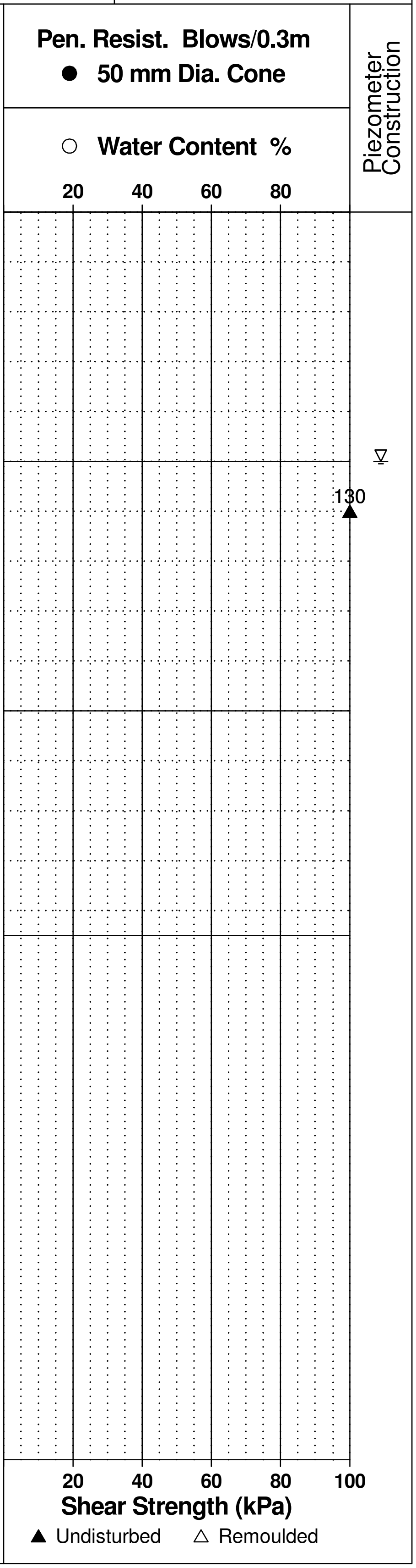
REMARKS

HOLE NO. TP11

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.90
TOPSOIL 0.15							
Very stiff, brown **SILTY CLAY** 1.30		G	1			1	92.90
Brown **SILTY SAND** with gravel and cobbles		G	2			2	91.90
2.90		G	3				
End of Test Pit (Open hole GWL @ 1m depth)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

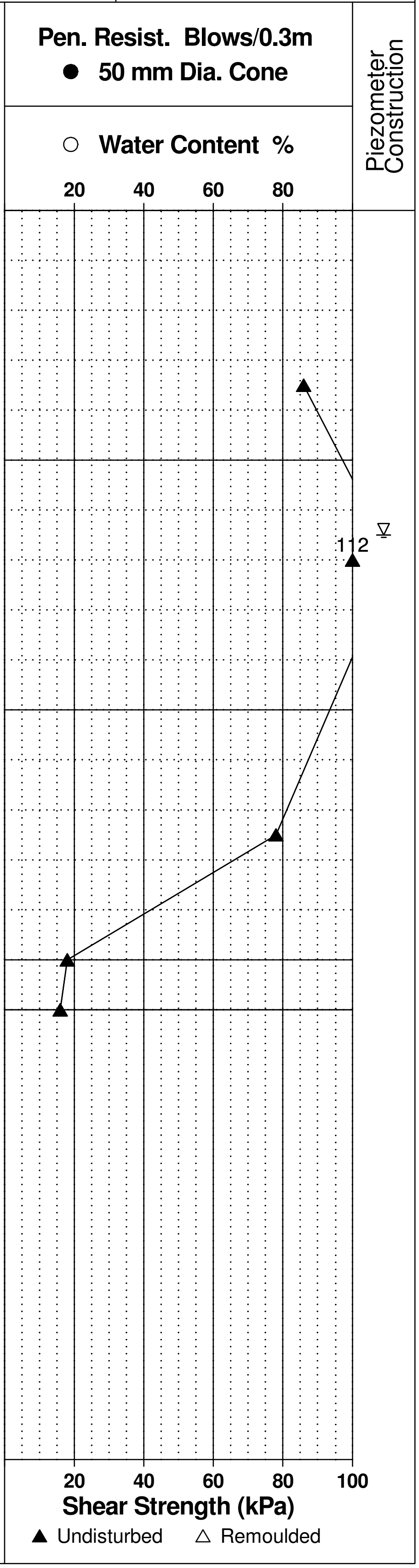
REMARKS

HOLE NO. **TP12**

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.29
TOPSOIL 0.35	■	G	1				
	▨					1	92.29
Very stiff to stiff, brown **SILTY CLAY**	▨	G	2				
	▨					2	91.29
- stiff to firm and grey by 2.4m depth	▨	G	3				
	▨					3	90.29
3.20 End of Test Pit (Open hole GWL @ 1.3m 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 = $(D30)^2 / (D10 \times D60)$
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)

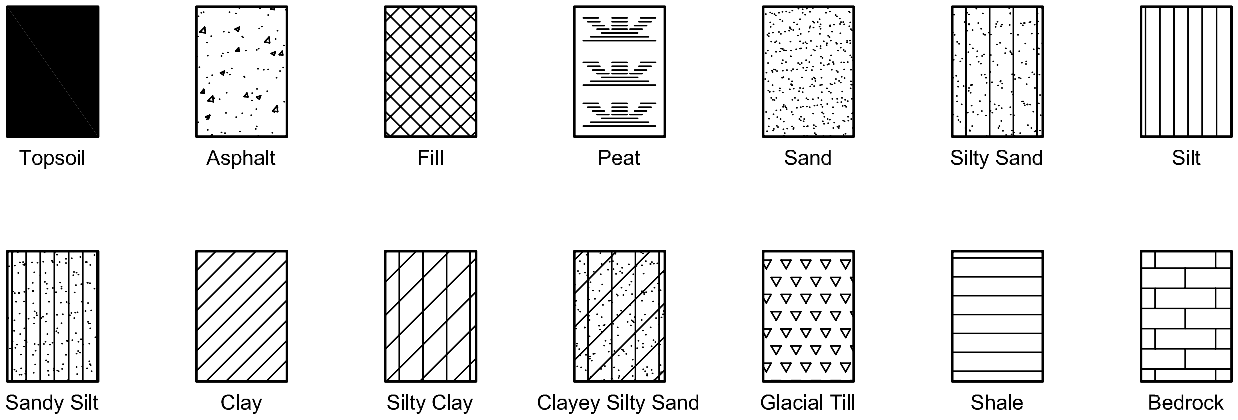
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

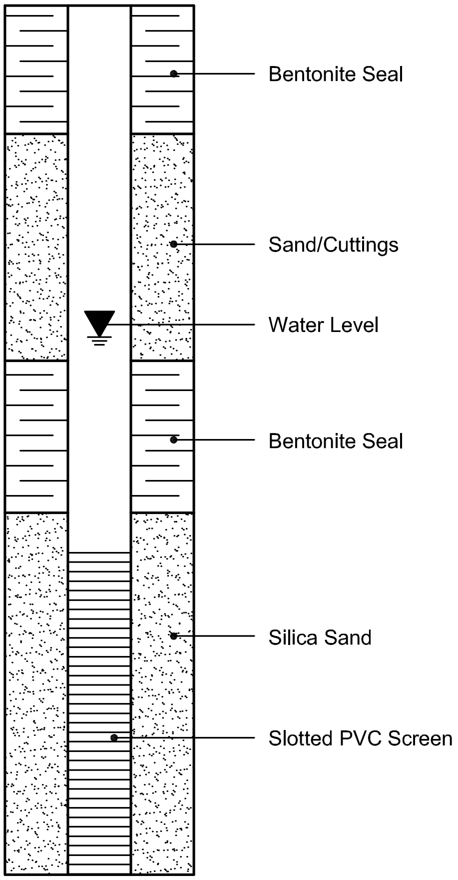
SYMBOLS AND TERMS (continued)

STRATA PLOT

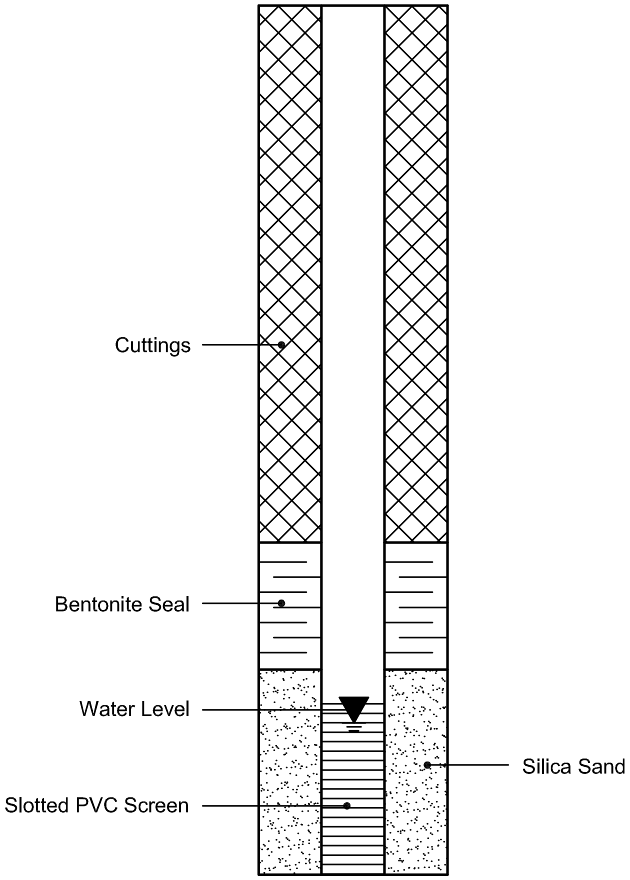


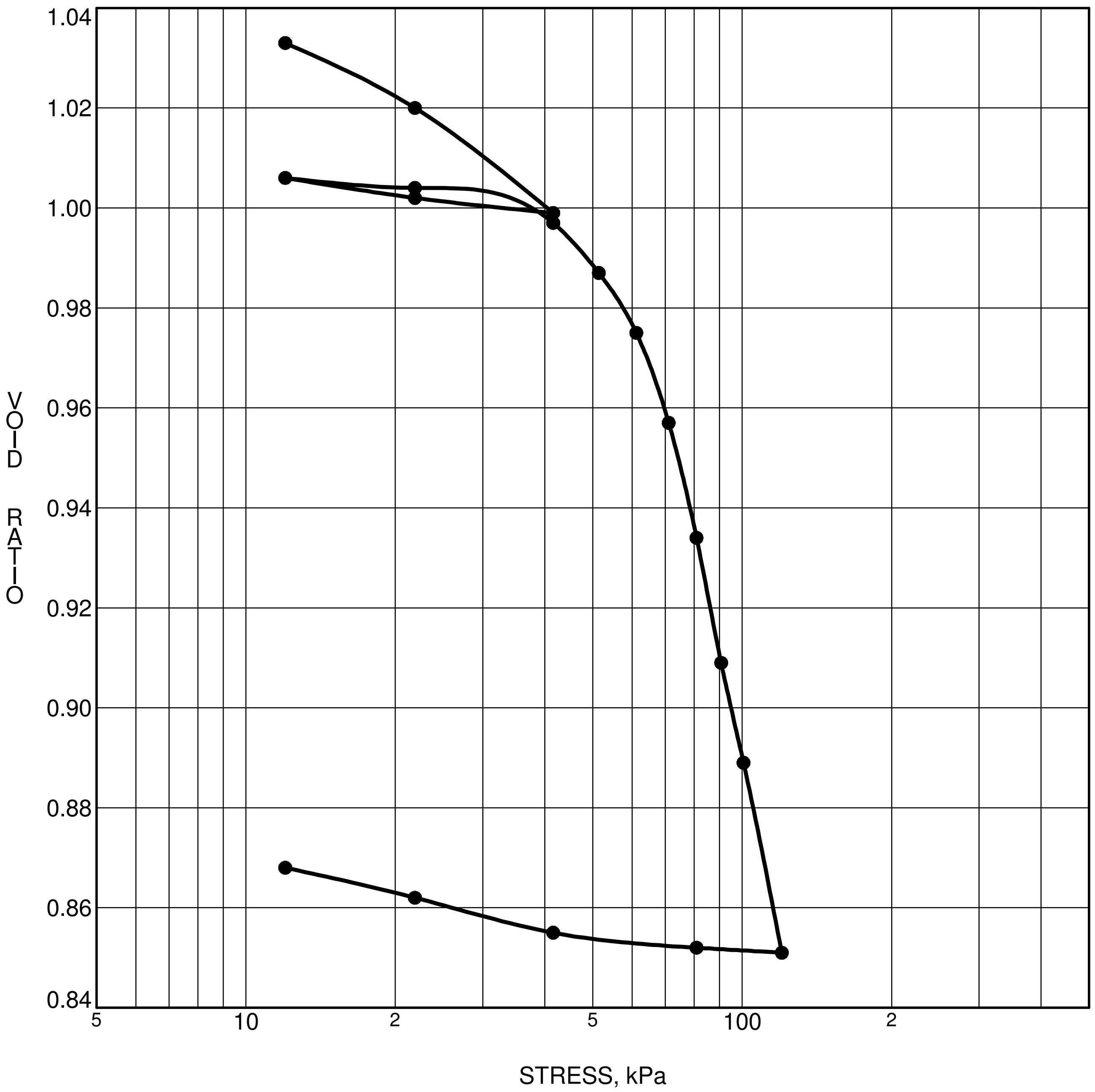
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 2**	p'o	**55** kPa	Ccr	**0.014**
Sample No.	**TW 5**	p'c	**62** kPa	Cc	**0.482**
Sample Depth	**4.17** m	OC Ratio	**1.1**	Wo	**38.1** %
Sample Elev.	**89.36** m	Void Ratio	**0.868**	Unit Wt.	**18.2** kN/m ^{3}

CLIENT **Regional Group of Companies**

FILE NO. **PG3695**

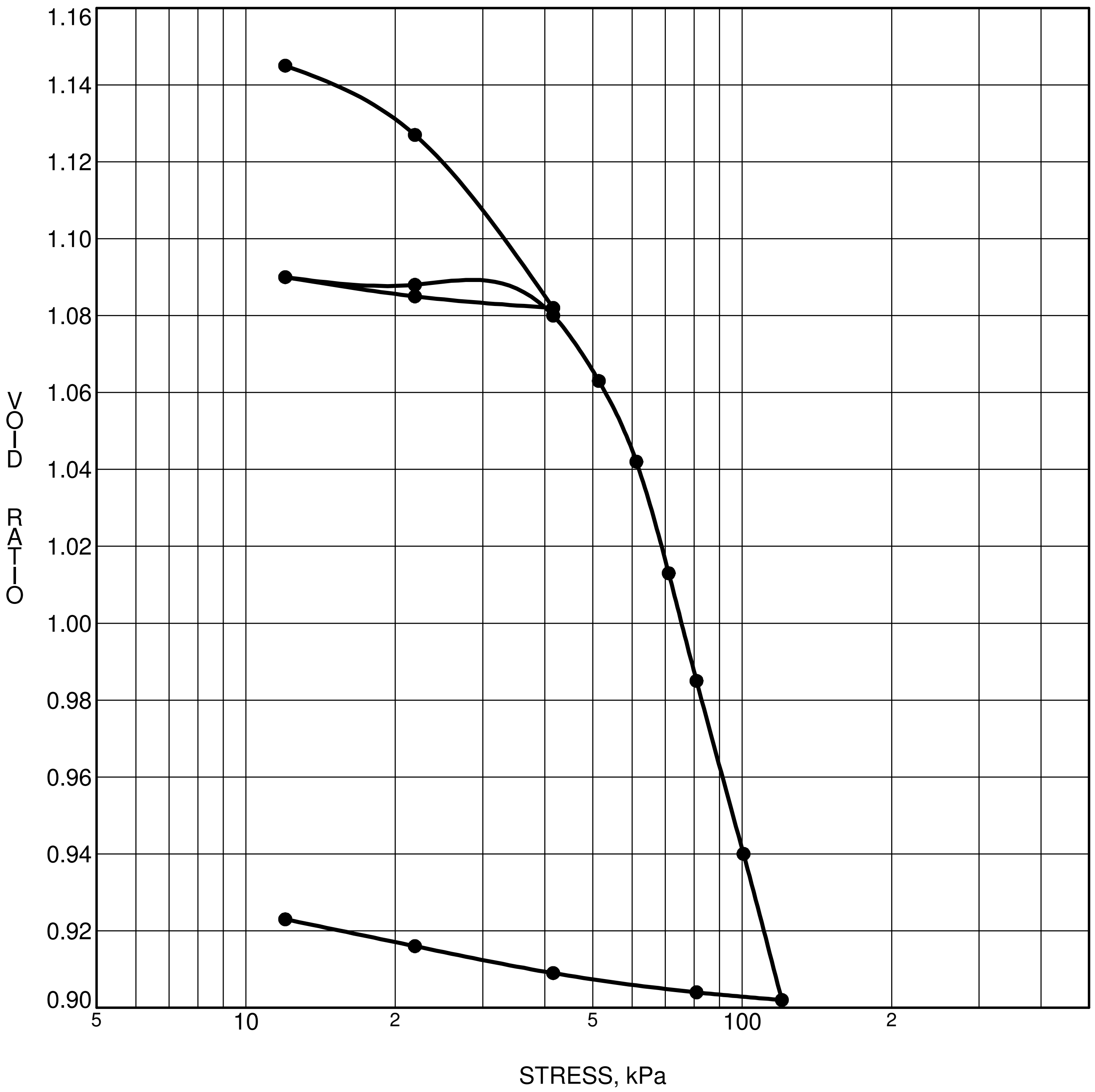
PROJECT **Geotechnical Investigation - Prop. Residential Development - Terry Fox Drive**

DATE **January 5, 2016**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY

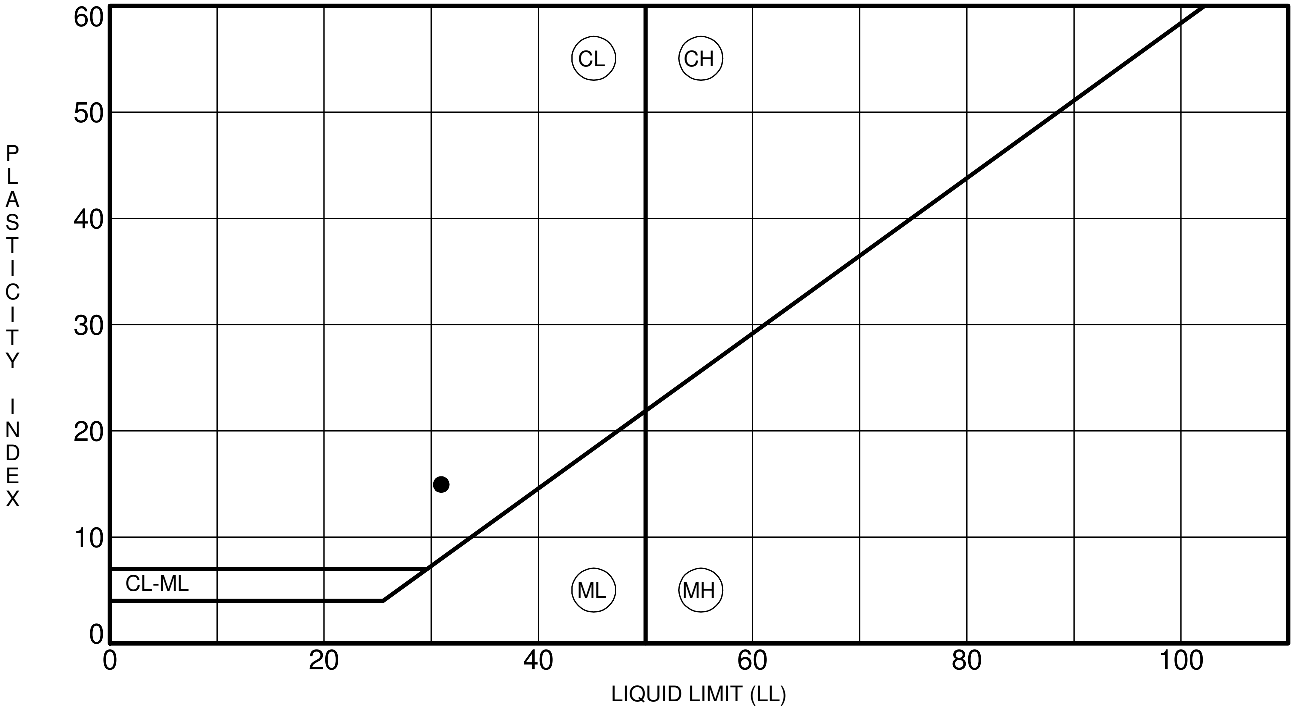
Borehole No.	**BH 2A**	p'o	**49** kPa	Ccr	**0.008**
Sample No.	**TW 1**	p'c	**53.8** kPa	Cc	**0.385**
Sample Depth	**3.33** m	OC Ratio	**1.1**	Wo	**42.6** %
Sample Elev.	**90.20** m	Void Ratio	**0.923**	Unit Wt.	**17.7** kN/m ^{3}

CLIENT **Regional Group of Companies**
PROJECT **Geotechnical Investigation - Prop. Residential**
Development - Terry Fox Drive

FILE NO. **PG3695**
DATE **January 8, 2016**

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

CONSOLIDATION TEST



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 2**	**TW 5**	**31**	**16**	**15**		**CL - Inorganic clays of low plasticity**

CLIENT **Regional Group of Companies**

FILE NO. **PG3695**

PROJECT **Geotechnical Investigation - Prop. Residential Development - Terry Fox Drive**

DATE **15 Dec 15**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS

Certificate of Analysis

Report Date: 05-Aug-2009
Order Date:28-Jul-2009

Client: **Paterson Group Consulting Engineers**
Client PO: 7904
Project Description: PG1845

	Client ID:	TP6 G3	-	-	-
	Sample Date:	27-Jul-09	-	-	-
	Sample ID:	0931126-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	69.9	-	-	-
General Inorganics					
pH	0.05 pH Units	7.58	-	-	-
Resistivity	0.10 Ohm.m	35.6	-	-	-
Anions					
Chloride	5 ug/g dry	24	-	-	-
Sulphate	5 ug/g dry	47	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG3695-1 - TEST HOLE LOCATION PLAN

DRAWING PG3695-2 - PERMISSIBLE GRADE RAISE PLAN

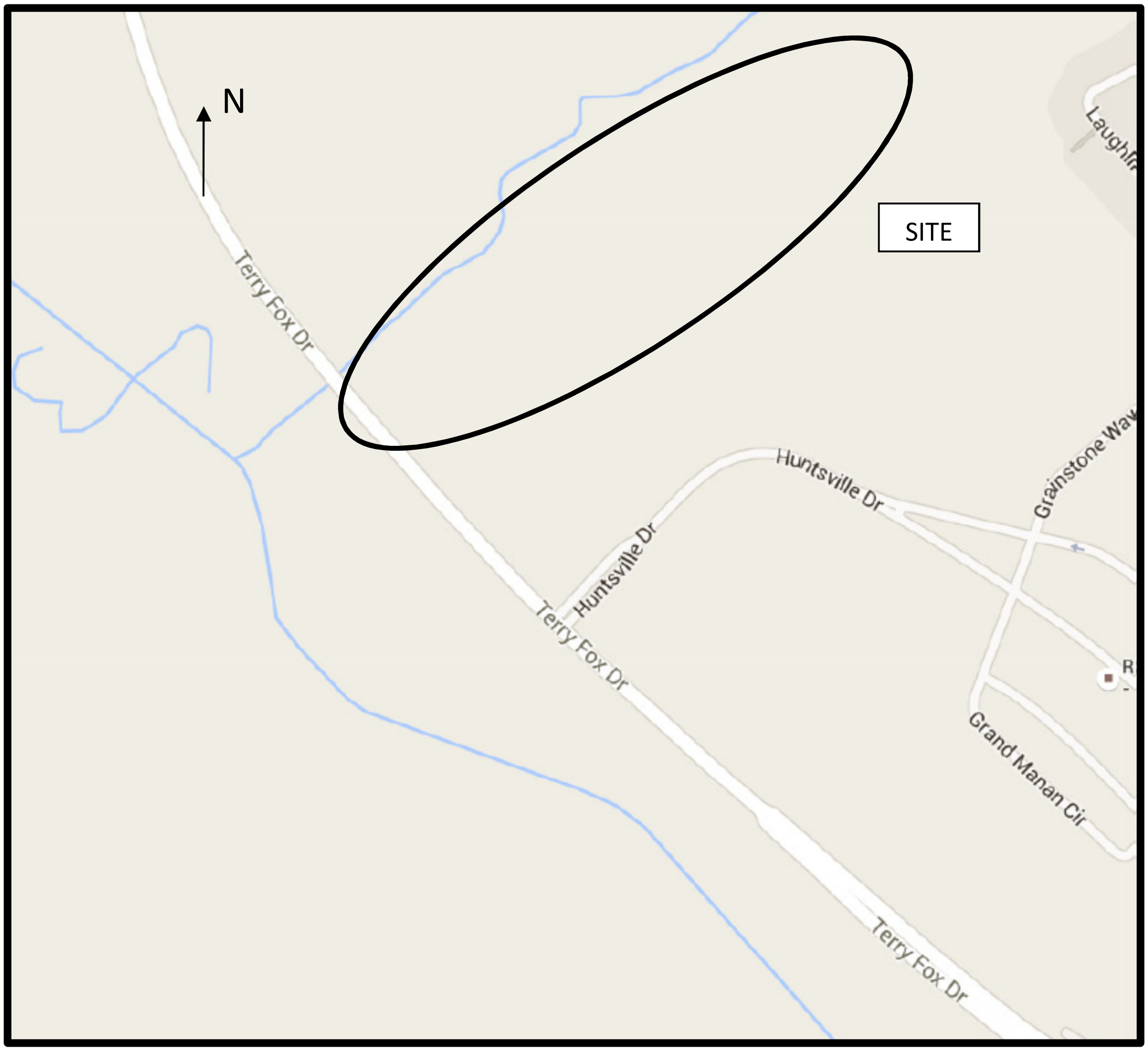


FIGURE 1

KEY PLAN

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL

REGIONAL GROUP

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT - RICHARDSON RIDGE PHASE 4
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Stamp:

Scale: 1:1000
Drawn by: MPG
Checked by: SB
Approved by: DJG
Date: 01/2016

Report No.: PG3695-1
Drawing No.: PG3695-1
Revision No.: 0

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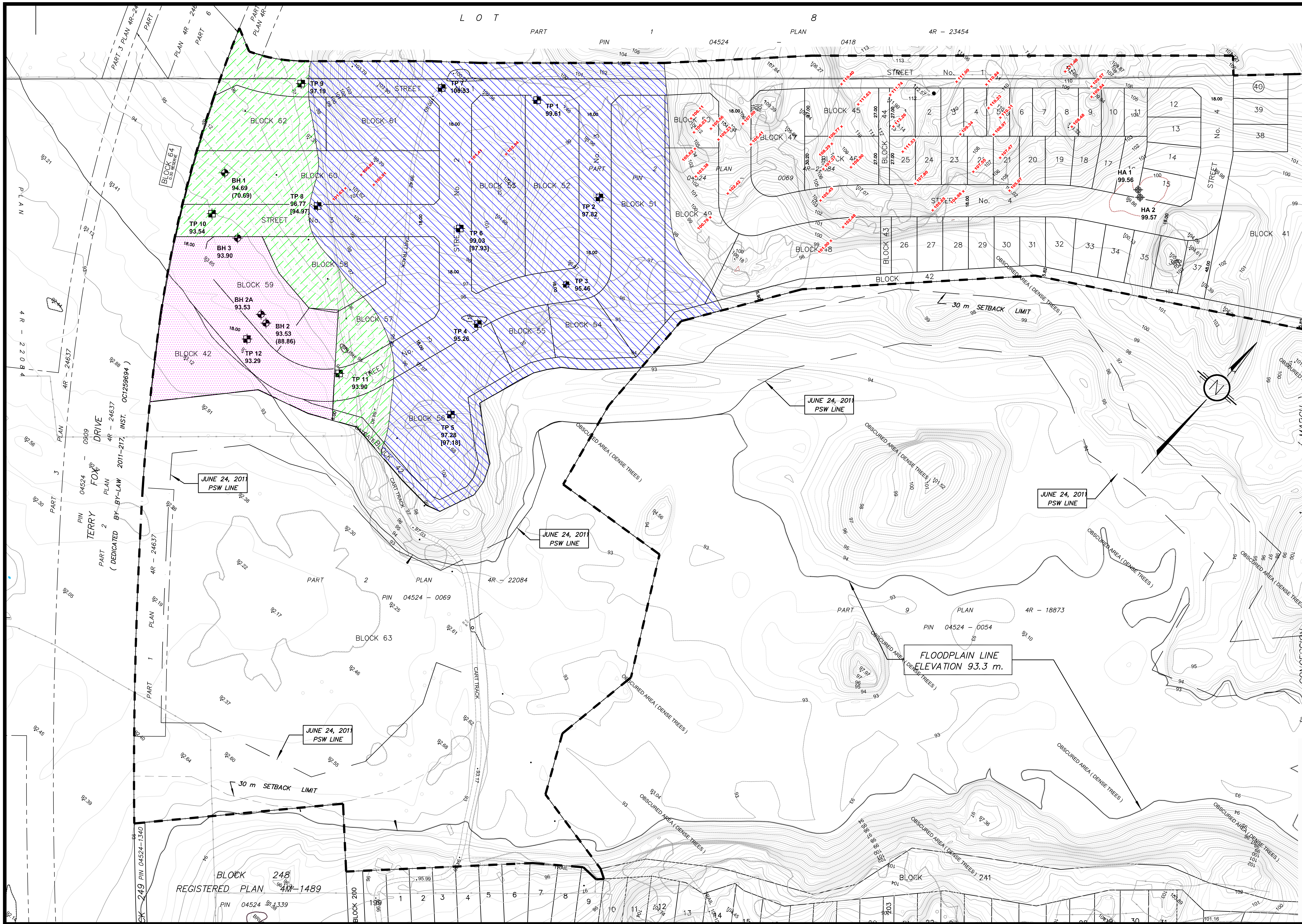

PERMISSIBLE GRADE RAISES:

▨	**UP TO 1.0m**
▨	**UP TO 2.5m**
▨	**UP TO 3.5m**

NOTE: PERMISSIBLE GRADE RAISE RESTRICTIONS NOT REQUIRED FOR AREAS WHERE A SETTLEMENT SURCHARGE PROGRAM HAS BEEN SUCCESSFULLY COMPLETED OR WHERE BUILDING FOOTINGS ARE FOUNDED OVER THE BEDROCK SURFACE.

LEGEND:

⊕	BOREHOLE LOCATION
⊞	TEST PIT LOCATION
⊕	HAND AUGER LOCATION
99.03	GROUND SURFACE ELEVATION (m)
[97.93]	BEDROCK SURFACE ELEVATION (m)
(70.69)	PRACTICAL REFUSAL TO AUGERING / DCPT ELEVATION (m)
x 102.94	BEDROCK OUTCROP SURFACE ELEVATION (m)

TEST HOLE LOCATIONS, GROUND SURFACE ELEVATIONS AND BEDROCK OUTCROP LOCATIONS PROVIDED BY ANNIS, O'SULLIVAN, VOLLEBEKK LTD.

SCALE: 1:1000

0 10 20 30 40 50m 75m

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

NO.	REVISIONS	DATE	INITIAL
0			

REGIONAL GROUP

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT - RICHARDSON RIDGE PHASE 4
OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE PLAN

Stamp:

Scale: 1:1000
Drawn by: MPG
Checked by: SB
Approved by: DJG
Date: 01/2016

Report No.: **PG3695-1**
Drawing No.: **PG3695-2**
Revision No.: **0**

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