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Geotechnical Investigation

Proposed Residential Development
Legault Lands
Trim Road - Ottawa

Prepared For

Novatech Engineering Consultants

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Report: PG4278-1

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Novatech Engineering Consultants to conduct a geotechnical investigation for the proposed Legault Lands residential development located adjacent to Trim 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 boreholes and relevant test holes completed as part of the previous geotechnical investigation.

☐ provide geotechnical recommendations for the design of the proposed development based on the results of the boreholes and other soil information available. These recommendations include permissible grade raises, long term settlements and other 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 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 current phase of the proposed development will consist of townhouses, residential dwellings with attached garages, associated driveways, local roadways and landscaping areas.

It is further understood that the proposed development will be serviced by future municipal water, sanitary and storm services.

3.0 Method of Investigation

3.1 Field Investigation

The field program for the current investigations was carried out on November 22 to 24, 2017, January 8, 2018 and February 5 to 7, 2018. At that time, a total of twenty one (21) boreholes were placed in a manner to provide general coverage of the subject site taking into consideration site features, underground utilities and existing test holes completed during the previous investigations. The location of the test holes are presented on Drawing PG4278-1 - Test Hole Location Plan included in Appendix 2.

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

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon sampler, 73 mm diameter thin walled 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 auger and 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 auger, split-spoon and Shelby tube samples were recovered from the test holes are shown as AU, SS and TW, 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 thickness of the sensitive silty clay deposit was evaluated by dynamic cone penetration testing (DCPT) completed at BH 1-17, BH 4-17 and BH 7-17. 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. Our findings are presented in the Soil Profile and Test Data sheets in Appendix 1.

Groundwater Monitoring

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

3.2 Field Survey

The test hole locations and ground surface elevations at the test hole locations completed during the current investigation were provided by Novatech Engineering Consultants Ltd. It is understood that the ground surface elevations are referenced to a geodetic datum.

The test hole locations and ground surface elevations at the test hole locations are presented on Drawing PG4278-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

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

A total of two (2) Shelby tube samples collected from the boreholes during the current investigation were submitted for unidimensional consolidation testing. The results of the consolidation testing are presented on the Unidimensional Consolidation Test Results in Appendix 1 and are further discussed in Sections 4 and 5.

A total of two (2) representative soil samples were submitted for Atterberg limit testing during the current investigation. The results of the Atterberg testing are presented on the Atterberg Limit Test Results sheet presented in Appendix 1 and are further discussed in Sections 4 and 5.

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

3.4 Analytical Testing

One soil sample was submitted to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was analyzed to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample. The results are discussed in Subsection 6.7 and shown in Appendix 1.

4.0 Observations

4.1 Surface Conditions

Currently, the subject site is former agricultural land. The subject site consists of an approximately 45 hectare property which is bordered by Trim Road to the east and residential and school properties to the north, west and south. Portobello Boulevard and Provence Avenue trisect the site in the north-south direction. The ground surface across the site is relatively level and consists mainly of agricultural fields, however an approximate 5 hectare forested area with visible bedrock outcroppings is located in the central portion of the site. A few residential houses are also located in the northeast, southeast and southwest corners of the subject site.

4.2 Subsurface Profile

Generally, the soil conditions encountered at the test hole locations consists of a thin layer of topsoil/organic layer followed by a sensitive silty clay deposit. A layer of compact silty sand was encountered under the topsoil and above the silty clay in some locations. Two boreholes (BH 3-17 and BH 3B-17) encountered a glacial till deposit below the topsoil. The glacial till was observed to consist of a compact to very dense, silty clay with some sand, gravel, cobbles and trace boulders.

Practical refusal to augering/DCPT was encountered at 3.3 and 18.2 m below existing ground surface at BH 3B-17 and BH 1-17, respectively. DCPT testing was completed at BH 4-17 and BH 7-17 to 30.5 m below existing ground surface, with no refusal encountered.

Based on available geological information, the local bedrock consists of interbedded limestone and shale of the Lindsay River formation with an anticipated overburden thickness of 15 to 50 m in general, excepting the central portion of the site where the drift thickness is 1 to 2 m.

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.

Silty Clay

Grey silty clay was encountered at all test holes completed during current investigation with the exceptions of BH 3-17 and BH 3B-17. The silty clay extended to the maximum depth of sampling at each test hole location. In situ shear vane field testing carried out in the grey silty clay yielded undrained shear strength values ranging between 19 and 58 kPa. These values are indicative of a soft to stiff consistency.

A total of two (2) silty clay samples collected at this site during the current investigation were subjected to unidimensional consolidation testing. The results of the testing are presented in Appendix 1 and are discussed in Subsection 5.3.

The consolidation test results indicate that the silty clay is overconsolidated with overconsolidation ratios (OCR) for the tested samples varying between 1.0 and 1.2. The OCR is the ratio of the preconsolidation pressure to the effective pressure at the sample depth. This is further discussed in Subsection 5.3.

Two (2) silty clay samples were submitted for Atterberg Limits testing during the current investigation. The tested materials are classified as inorganic clays of high plasticity (CH). The results are summarized in Table 1 and presented on the Atterberg Limits results sheet in Appendix 1.

Table 1 - Summary of Atterberg Limits Tests

Sample	Liquid Limit %	Plastic Limit %	Plasticity Index %	Classification
BH 8-17 TW4	71	23	49	CH
BH 9-17 TW4	73	21	52	CH

4.3 Groundwater

Groundwater level readings were recorded at boreholes BH1-17 to BH7-17 on December 1, 2017 and at boreholes BH8-17 and BH9-17 on January 18, 2018. The groundwater level readings are presented in the Soil Profile and Test Data sheets in Appendix 1. Based on the field observations, experience with the local area, moisture levels and colouring of the recovered soil samples, the water level is expected at depths between 3 to 5 m below existing grade. The groundwater level readings are summarized in Table 2 below.

Table 2 - Summary of Groundwater Level Readings

Borehole Number	Ground Elevation (m)	Groundwater Levels (m)		Recording Date
		Depth	Elevation	
BH 1-17	89.42	1.10	88.32	December 1, 2017
BH 2-17	89.38	2.82	86.56	December 1, 2017
BH 3-17	90.20	Dry	-	December 1, 2017
BH 4-17	88.15	2.88	85.27	December 1, 2017
BH 5-17	88.74	3.39	85.35	December 1, 2017
BH 6-17	88.22	3.67	91.89	December 1, 2017
BH 7-17	88.44	3.65	84.79	December 1, 2017
BH 8-17	88.35	2.47	85.88	January 18, 2018
BH 9-17	88.70	6.48	82.22	January 18, 2018

It is important to note that the groundwater level readings could be influenced by surface water infiltrating the backfilled borehole due to seasonal changes, which can lead to water perching inside the boreholes resulting in higher water levels than noted during the investigation. It should also be noted that groundwater levels are subject to seasonal fluctuations and therefore groundwater levels could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

It is anticipated that the proposed buildings will be supported by shallow footings placed over stiff to firm silty clay or glacial till bearing surface. Due to the presence of the sensitive silty clay layer, the proposed development 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 PG4278-2-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 a settlement test fill pile program is anticipated to be completed to better assess the permissible grade raise restrictions for the subject site. The program will consist of a series of settlement test fill piles placed throughout the subject site. Settlement plates will be placed within the test fill piles to monitor settlement over a minimum 12 month period. A review of the permissible grade raise restrictions will be completed, which considers the settlement test fill monitoring program results.

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 proposed 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 fill should be placed in maximum 300 mm thick lifts 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 where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If excavated brown silty clay, free of organics and deleterious materials, is to be used to build up the subgrade level for areas to be paved, it is recommended that the material be placed under dry conditions and in above freezing temperatures, compacted in thin lifts using suitable compaction equipment for the lift thickness by making several passes and approved by the geotechnical consultant. 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.

Protection of Subgrade and Bearing Surfaces

It is expected that site grading and preparation will consist of stripping of the soils containing significant amounts of organic materials. The contractor should take appropriate precautions to avoid disturbing the subgrade and bearing surfaces from construction and worker traffic. Disturbance of the subgrade may result in requiring sub-excavation of the disturbed material and the placement of additional fill.

5.3 Foundation Design

Bearing Resistance Values

Strip footings, up to 2 m wide, and pad footings, up to 6 m wide, placed on an undisturbed, stiff silty clay bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **100 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **150 kPa**. Strip footings, up to 2 m wide, and pad footings, up to 4 m wide, placed on an undisturbed, firm silty clay bearing surface can be designed using a bearing resistance value at SLS of **60 kPa** and a factored bearing resistance value at ULS of **90 kPa**. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance values at ULS.

Footings placed on an undisturbed, compact to very dense glacial till bearing surface or clean, surface sounded bedrock can be designed using a bearing resistance value at SLS of **150 kPa** and a factored bearing resistance value at ULS of **225 kPa**, incorporating a geotechnical resistance factor of 0.5.

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

Our permissible grade raise recommendations for the proposed residential development are presented in Drawing PG4278-2 - Permissible Grade Raise Plan in Appendix 2.

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 as part of the current investigation. The results of the consolidation tests from our investigation is presented in Table 3 and in Appendix 1.

Table 3 - Summary of Consolidation Test Results

Borehole No.	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c	Q (*)
BH 8-17	TW4	4.14	49.6	48.1	0.055	4.900	A
BH 9-17	TW4	4.90	70.4	57.3	0.036	2.330	A

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

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.

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 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 1 m was assumed.

The potential post construction total and differential settlements are dependent on the position of the long term groundwater level when buildings 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 undrained shear strength values at the borehole locations, we have determined our permissible grade raise recommendations for the current phase of the proposed development. Our permissible grade raise recommendations for housing are presented in Drawing PG4278-2 - 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.

Underground Utilities

The underground services may be subjected to unacceptable total or differential settlements. In particular, the joints at the building/soil interface 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.

5.4 Design for Earthquakes

Shear wave velocity testing was completed for the subject site to accurately determine the applicable seismic site classification for the proposed development in accordance with Table 4.1.8.4.A of the Ontario Building Code (OBC) 2012. The shear wave velocity testing was completed by Paterson personnel. The results of the shear wave velocity test are attached to the present report.

Field Program

The seismic array testing location was placed across the site in an approximate east-west direction as presented on Drawing PG4278-1 - Test Hole Location Plan. Paterson field personnel placed 24 horizontal 4.5 Hz geophones mounted to the surface by means of two 75 mm ground spikes attached to the geophone land case. The geophones were spaced at 3 m intervals and connected by a geophone spread cable to a Geode 24 Channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-Beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated 4 to 8 times at each shot location to improve signal to noise ratio. The shot locations are also completed in forward and reverse directions (i.e. striking both sides of the I-Beam seated parallel to the geophone array). The shot locations were located 30, 4.5 and 3 m away from the first and last geophones, and at the centre of the seismic array.

Data Processing and Interpretation

Interpretation for the shear wave velocity results were completed by Paterson personnel. Shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity, Vs_{30}, of the upper 30 m profile, immediately below the building foundations. The layer intercept times, velocities from different layers and critical distances are interpreted from the shear wave records to compute the bedrock depth at each location. Through interpretation, the overburden thickness is approximately 50 m at the testing location.

Based on the test results, the average overburden seismic shear wave velocity is 144.1 m/s. Therefore, the site class for seismic site response can be taken as **Class E** for the majority of foundations considered at this site. However, the site class for seismic site response can be taken as **Class C** for the foundations located to the west of Provence Avenue. The soils underlying the proposed foundations are not susceptible to liquefaction. Reference should be made to the latest revision of the OBC 2012 for a full discussion of the earthquake design requirements.

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 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.

5.6 Pavement Structure

Car only parking areas, local and collector roadways are anticipated at this site. The proposed pavement structures are shown in Tables 4, 5 and 6.

Table 4 - 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 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
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 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

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type II material. Weak subgrade conditions may be experienced over service trench fill materials, which will require the use of a woven geotextile liner, such as Terratrack 200 or equivalent.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the material's SPMDD using suitable vibratory equipment. Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

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 and all subdrains should be provided with a positive outlet to the storm sewer.

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 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 or sump pit.

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 Delta Drain 6000) connected to a drainage system is provided.

Based on our groundwater level observations, a sub-floor drain system for the proposed buildings with basements is recommended. It is recommended that a geosock wrapped, 150 mm diameter perforated corrugated plastic pipe be placed below the floor slab across the building footprint. A sleeve through the footing should be provided to connect the sub-floor drain to the perimeter foundation drainage system. It is further recommended that the perimeter drainage system have a positive outlet to the storm sewer.

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

Excavations will be mostly through brown to grey 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.

Based on observations at the test hole locations at the time of the field program and review of the recovered soil samples, 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 excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter.

The 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. A minimum of 4 to 6 m setback should be considered from the excavation face depending on the excavation depth and soil consistency.

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 Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa.

The pipe bedding for sewer and water pipes placed on a relatively dry, undisturbed subgrade surface 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 extend 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 material 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 at this site, clay seals should be provided within the service trenches excavated through the silty clay deposit. 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 excavated through the silty clay deposit.

6.5 Groundwater Control

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.

Infiltration levels are anticipated to be low through the excavation face, depending on the local groundwater table. The groundwater infiltration will be controllable with open sumps and pumps.

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

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

6.6 Winter Construction

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

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 Corrosion Potential and Sulphate

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

6.8 Landscaping Considerations

Tree Planting Setbacks

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. Sieve analysis testing was also completed on selected soil samples. The abovenoted test results were completed between design underside of footing elevation and a 3.5 m depth below finished grade. The results of our testing are presented in Table 1 in Subsection 4.2 and in Appendix 1.

A medium to high sensitivity clay soil was encountered between design underside of footing elevations and 3.5 m below finished grade as per City Guidelines. Based on our Atterberg Limits test results, the modified plasticity limit generally exceeds 40%. The following tree planting setbacks are recommended for these high sensitivity areas. Large trees (mature height over 14 m) can be planted within these provided a tree to foundation setback equal to the full mature height of the tree can be provided (e.g. in a park or other green space). Tree planting setback limits is 7.5 m for small (mature tree height up to 7.5m) and medium size trees (mature tree height 7.5 m to 14 m) 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 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.

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.

A geotechnical investigation of this nature 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 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.

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 Novatech Engineering Consultants 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.

LICENSED PROFESSIONAL ENGINEER
July 5-2018
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Nathan F. S. Christie, P.Eng.

David J. Gilbert, P.Eng.

Report Distribution:

☐ Novatech Engineering Consultants (3 copies)
☐ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

UNIDIMENSIONAL CONSOLIDATION TEST RESULTS

ATTERBERG LIMIT TEST RESULTS

ANALYTICAL TESTING RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

REMARKS

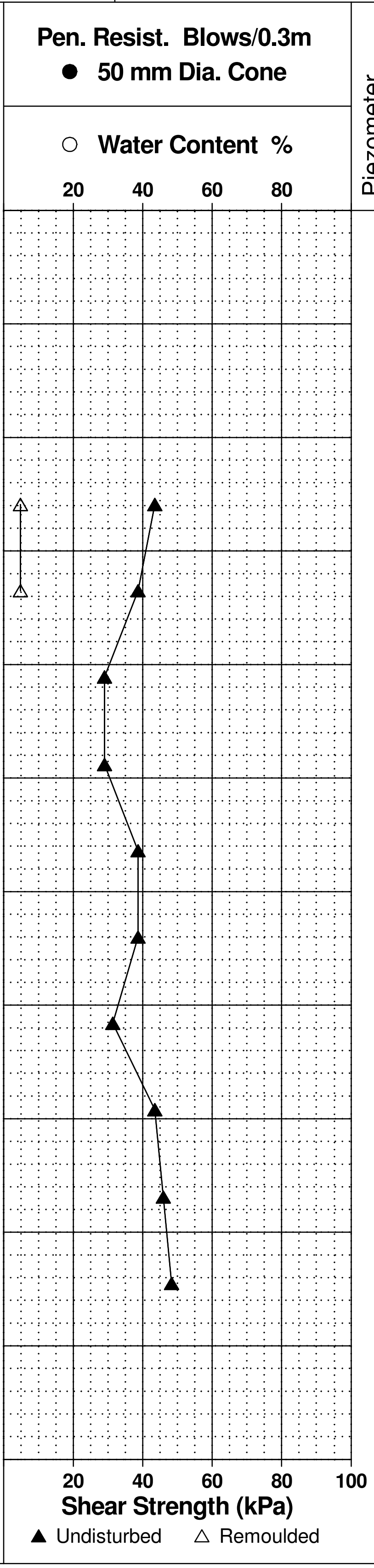
BORINGS BY CME 55 Power Auger

DATE November 22, 2017

FILE NO. PG4278

HOLE NO. BH 1-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	89.42	
TOPSOIL 0.30		AU	1					
Brown **SILTY CLAY,** trace sand		SS	2	75	9	1	88.42	▼
		SS	3	83	3	2	87.42	
- grey by 3.0m depth						3	86.42	
						4	85.42	
						5	84.42	
						6	83.42	
						7	82.42	
						8	81.42	
9.45						9	80.42	
Dynamic Cone Penetration Test commenced at 9.45m depth, pushed to 17.0m depth.						10	79.42	
						11	78.42	



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

REMARKS

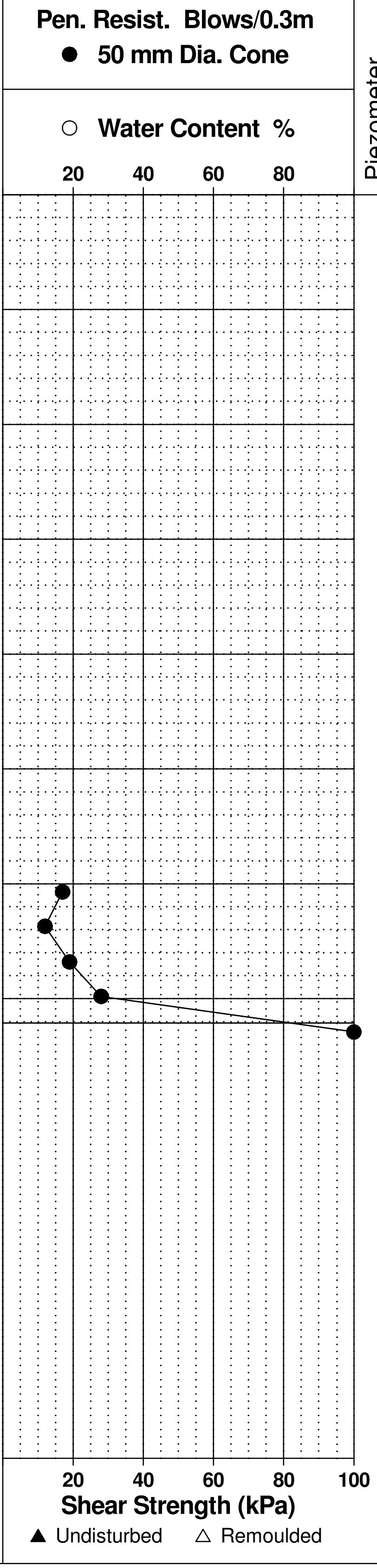
BORINGS BY CME 55 Power Auger

DATE November 22, 2017

FILE NO. PG4278

HOLE NO. BH 1-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			
GROUND SURFACE						11	78.42	
						12	77.42	
						13	76.42	
						14	75.42	
						15	74.42	
						16	73.42	
						17	72.42	
						18	71.42	
18.21 End of Borehole Practical DCPT refusal at 18.21 m depth (GWL @ 1.10m - Dec. 1, 2017)								



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

FILE NO. **PG4278**

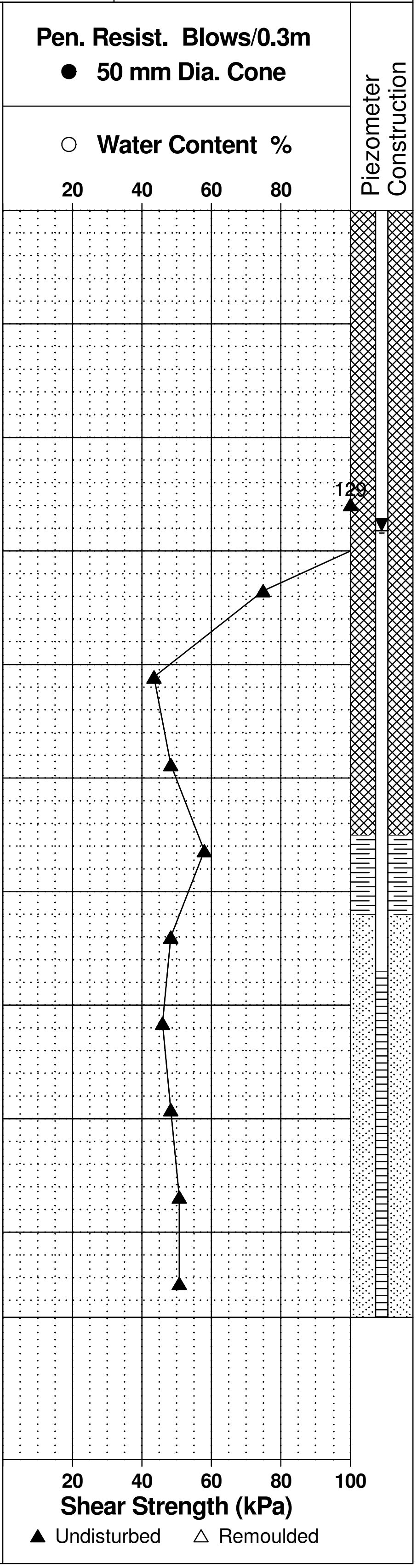
REMARKS

HOLE NO. **BH 2-17**

BORINGS BY CME 55 Power Auger

DATE November 23, 2017

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	89.38
TOPSOIL 0.35	AU	1				
	SS	2	100	9	1	88.38
Brown **SILTY CLAY,** trace sand	SS	3	100	6	2	87.38
					3	86.38
- grey by 3.8m depth					4	85.38
					5	84.38
					6	83.38
					7	82.38
					8	81.38
					9	80.38
9.75	SS	4	100	P		
End of Borehole (GWL @ 2.82m - Dec. 1, 2017)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

FILE NO. PG4278

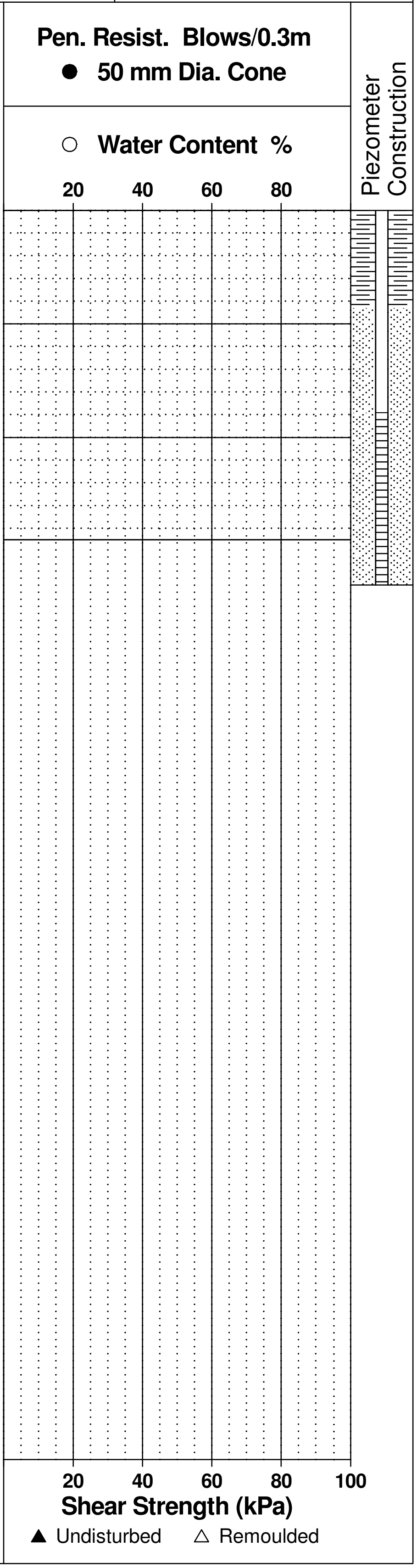
REMARKS

HOLE NO. BH 3-17

BORINGS BY CME 55 Power Auger

DATE November 22, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	90.20
TOPSOIL 0.35		AU	1				
GLACIAL TILL: Brown silty clay, some sand, trace gravel and cobbles		SS	2	25	21	1	89.20
		SS	3	33	9	2	88.20
2.90		SS	4	50	25		
End of Borehole (BH dry - Dec. 1, 2017)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

REMARKS

BORINGS BY CME 55 Power Auger

DATE November 22, 2017

FILE NO. PG4278

HOLE NO. BH 3B-17

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	90.20
TOPSOIL (to 0.35)	AU	1				
GLACIAL TILL: Brown silty clay, some sand, gravel and cobble, trace boulders (0.35 to 3.30)	SS	2	71	+50	1	89.20
	SS	3	42	25	2	88.20
	SS	4	38	16		
	SS	5	40	+50	3	87.20
End of Borehole Practical refusal to augering at 3.30m depth						

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

FILE NO. PG4278

REMARKS

HOLE NO. BH 4-17

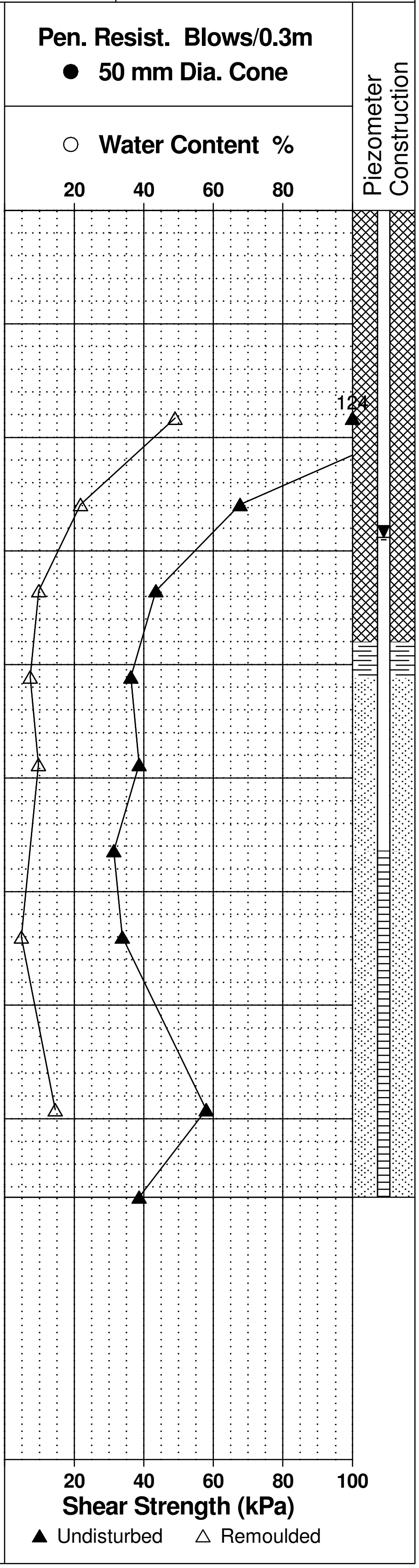
BORINGS BY CME 55 Power Auger

DATE November 24, 2017

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.15
TOPSOIL 0.30	AU	1				
Brown **SILTY CLAY,** trace sand	SS	2	75	5	1	87.15
	SS	3	83	P	2	86.15
					3	85.15
- grey by 3.8m depth					4	84.15
					5	83.15
					6	82.15
					7	81.15
8.69					8	80.15

Dynamic Cone Penetration Test commenced at 8.69m depth, pushed to 30.5m depth. Borehole terminated.

(GWL @ 2.88m - Dec. 1, 2017)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

FILE NO. PG4278

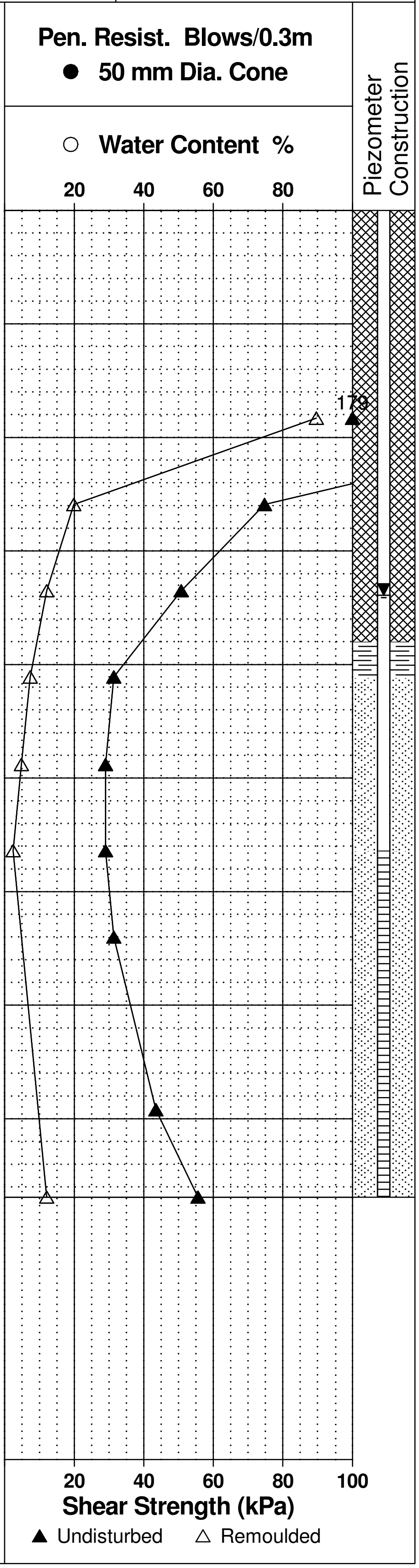
REMARKS

HOLE NO. BH 5-17

BORINGS BY CME 55 Power Auger

DATE November 22, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.30		AU				0	88.74
Brown **SILTY CLAY,** trace sand		SS		83	5	1	87.74
		SS		83	P	2	86.74
						3	85.74
- grey by 3.8m depth						4	84.74
						5	83.74
						6	82.74
						7	81.74
						8	80.74
8.69							
End of Borehole							
(GWL @ 3.39m - Dec. 1, 2107)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

FILE NO. PG4278

REMARKS

HOLE NO. BH 6-17

BORINGS BY CME 55 Power Auger

DATE November 23, 2017

SOIL DESCRIPTION

GROUND SURFACE

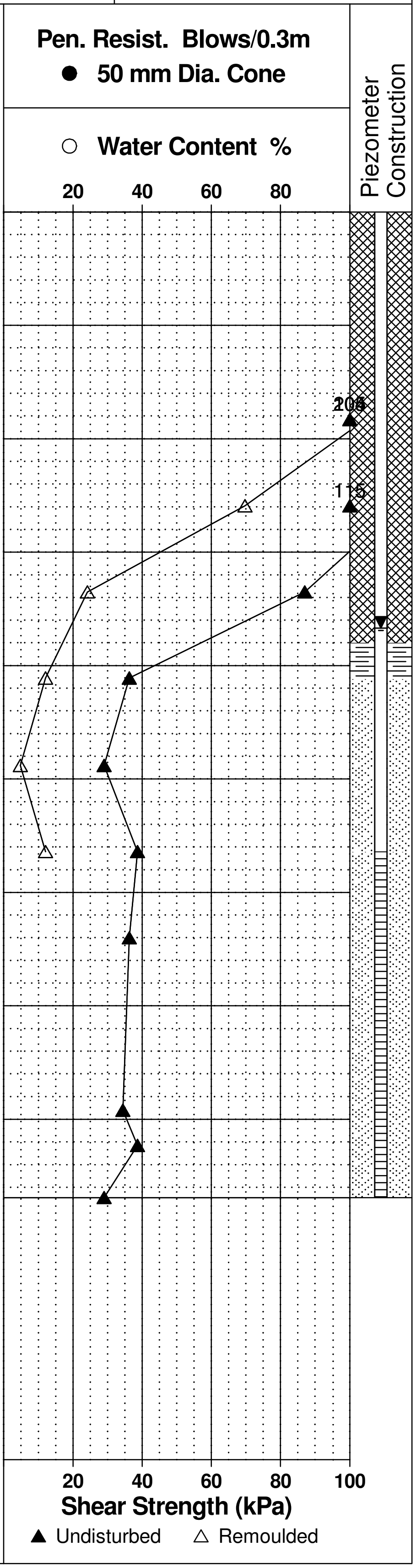
Soil description	Depth (m)
TOPSOIL	0.40
Brown **SILTY CLAY,** trace sand - grey by 4.6m depth	8.69

End of Borehole

(GWL @ 3.67m - Dec. 1, 2017)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	75	5

DEPTH (m)	ELEV. (m)
0	88.22
1	87.22
2	86.22
3	85.22
4	84.22
5	83.22
6	82.22
7	81.22
8	80.22



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE November 23, 2017

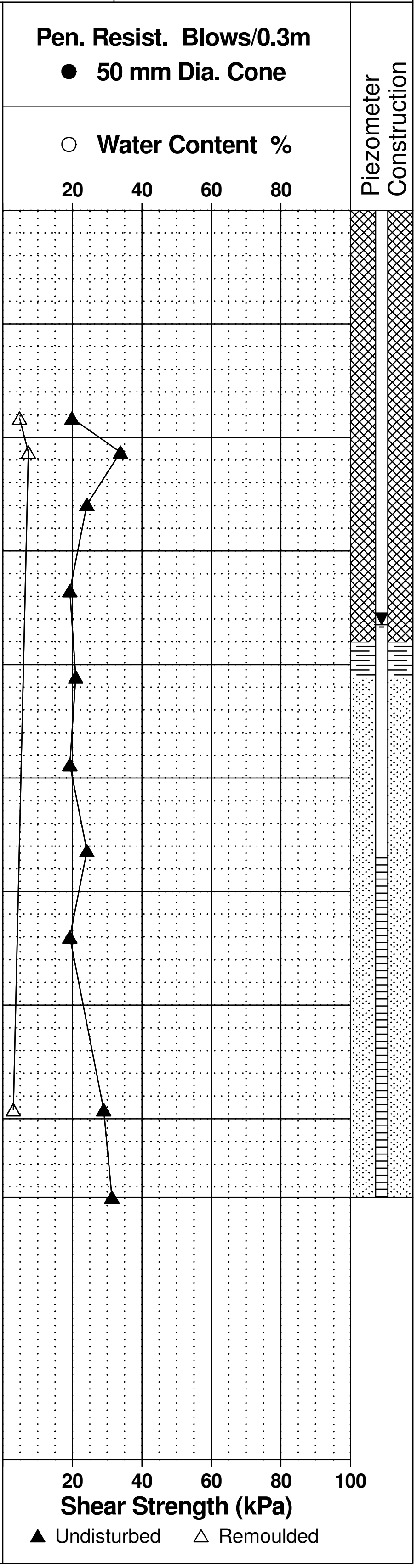
FILE NO. PG4278

HOLE NO. BH 7-17

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.44
TOPSOIL 0.35						
Brown **SILTY SAND,** some clay 1.07	SS	1	75	6	1	87.44
Brown **SILTY CLAY,** trace sand					2	86.44
- grey by 3.1m depth					3	85.44
					4	84.44
					5	83.44
					6	82.44
					7	81.44
8.69					8	80.44

Dynamic Cone Penetration Test commenced at 8.69 m depth, pushed to 30.5m depth. Borehole terminated.

(GWL @ 3.65m - Dec. 1, 2017)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

REMARKS

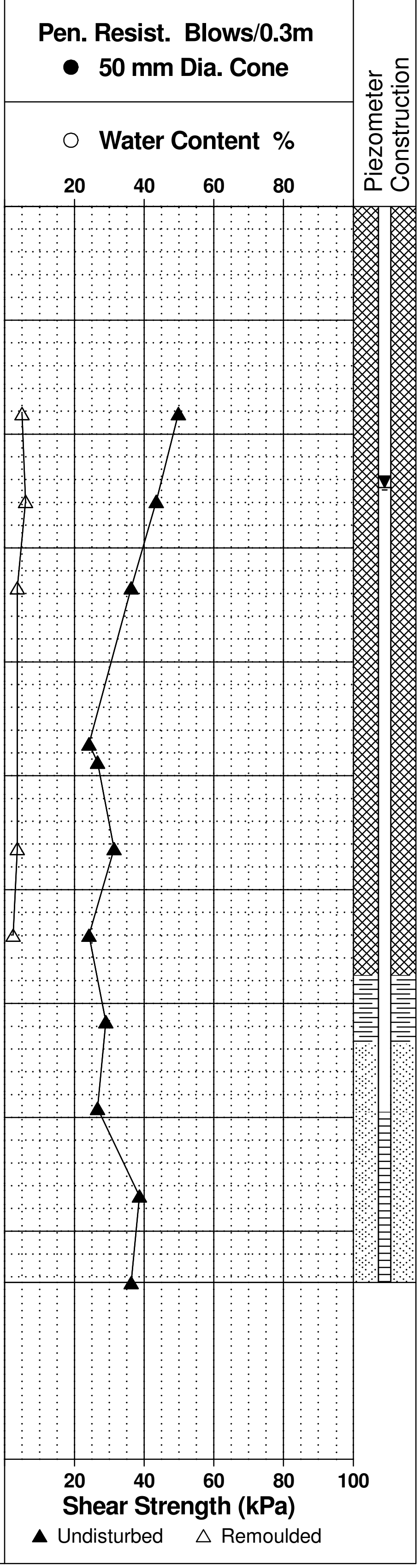
BORINGS BY CME 55 Power Auger

DATE January 8, 2018

FILE NO. PG4278

HOLE NO. BH 8-17

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.35
TOPSOIL 0.23	AU	1				
	SS	2	100	3	1	87.35
	SS	3	100	P	2	86.35
Stiff to firm, brown **SILTY CLAY,** some to trace sand					3	85.35
- soft to firm and grey by 3.6m depth	TW	4	92		4	84.35
					5	83.35
					6	82.35
					7	81.35
					8	80.35
					9	79.35
9.45						
End of Borehole (GWL @ 2.47m - Jan. 18, 2018)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic as provided by Novatech Engineering

REMARKS

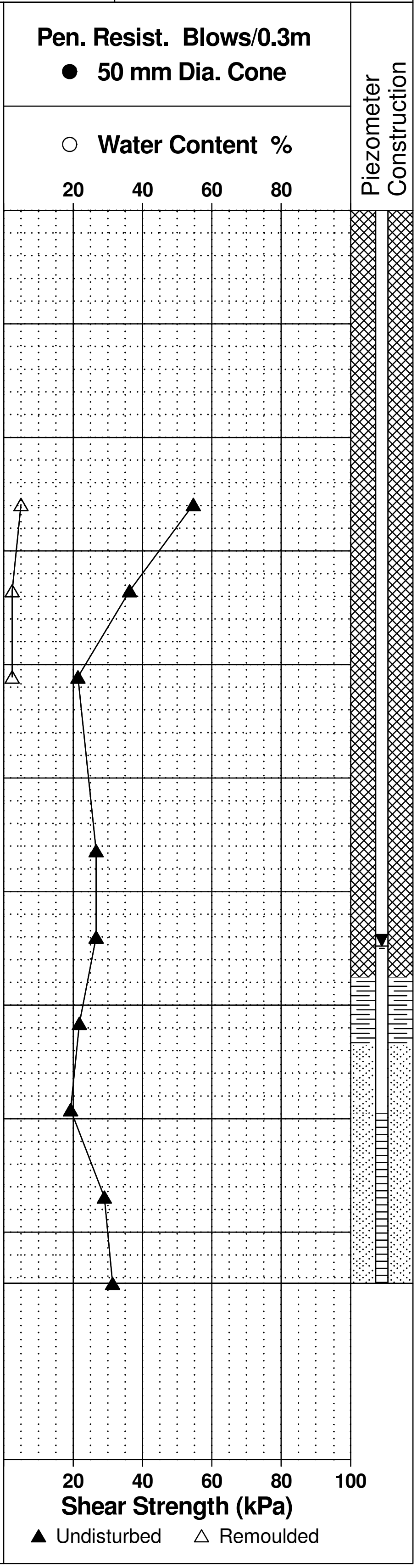
BORINGS BY CME 55 Power Auger

DATE January 8, 2018

FILE NO. PG4278

HOLE NO. BH 9-17

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.70
TOPSOIL 0.28	AU	1				
	SS	2	67	9	1	87.70
	SS	3	100	6	2	86.70
Stiff to firm, brown **SILTY CLAY,** trace sand					3	85.70
- soft to firm and grey by 3.6m depth					4	84.70
	TW	4	92		5	83.70
					6	82.70
					7	81.70
					8	80.70
					9	79.70
9.45 End of Borehole						
(GWL @ 6.48m - Jan. 18, 2018)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

FILE NO. **PG4278**

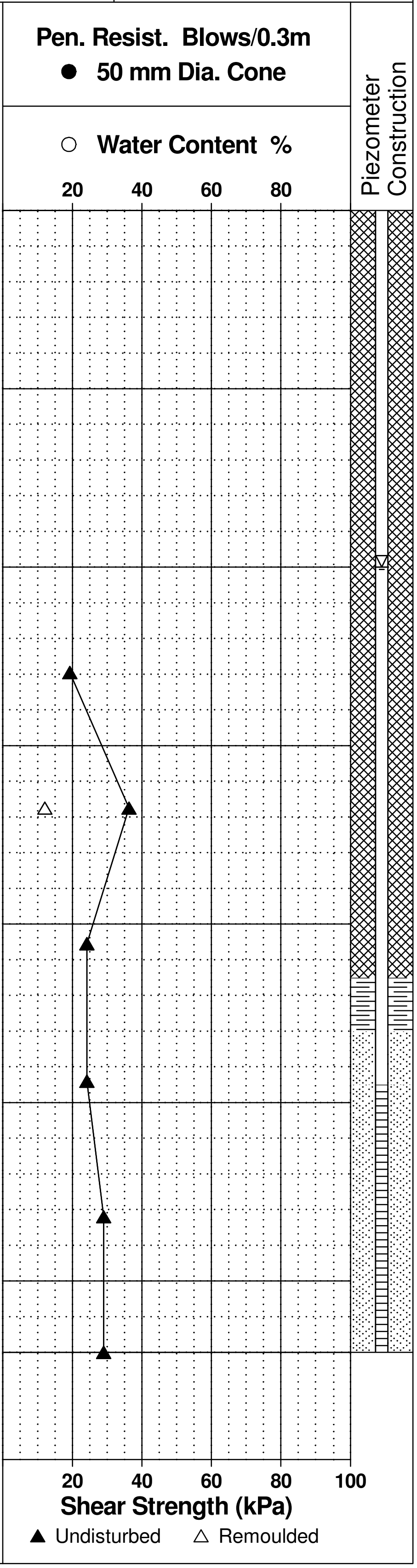
REMARKS

HOLE NO. **BH 1-18**

BORINGS BY CME 55 Power Auger

DATE February 5, 2018

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.44
TOPSOIL 0.28		AU	1				
Compact, brown **SILTY SAND,** trace clay 1.45		SS	2	42	12	1	87.44
Soft to firm, brown **SILTY CLAY,** some sand - grey by 3.0m depth 6.40		SS	3	75	1	2	86.44
						3	85.44
						4	84.44
						5	83.44
						6	82.44
End of Borehole (GWL @ 2.0m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

FILE NO. PG4278

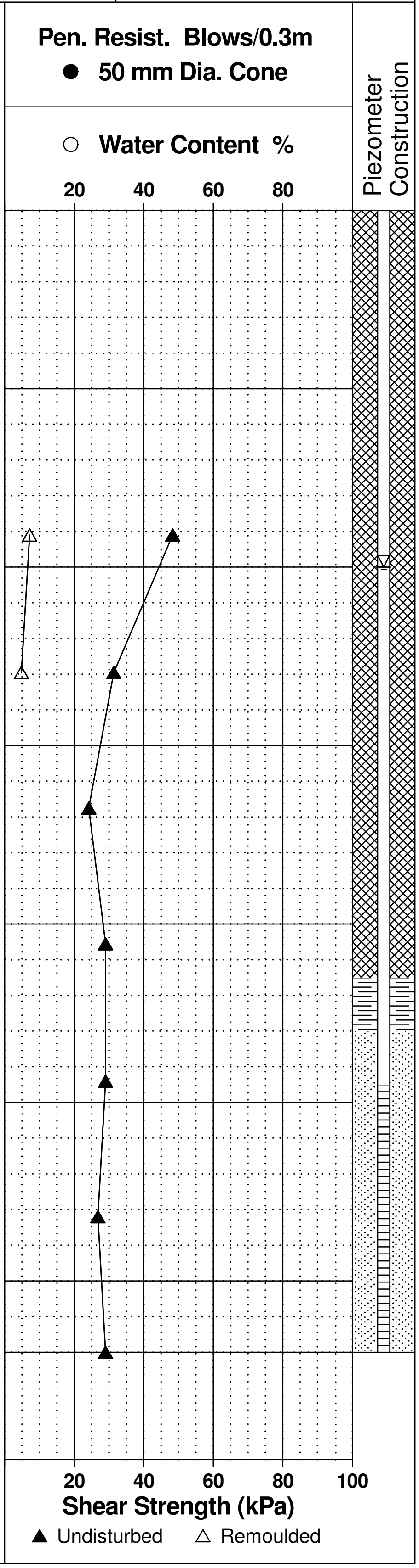
REMARKS

HOLE NO. BH 2-18

BORINGS BY CME 55 Power Auger

DATE February 5, 2018

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.34
TOPSOIL 0.30	AU	1				
Compact, brown **SILTY SAND,** trace clay 1.45	SS	2	58	12	1	87.34
Firm, brown **SILTY CLAY,** trace sand - grey by 3.0m depth	SS	3	100	P	2	86.34
					3	85.34
					4	84.34
					5	83.34
6.40					6	82.34
End of Borehole (GWL @ 2.0m depth based on field observations)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

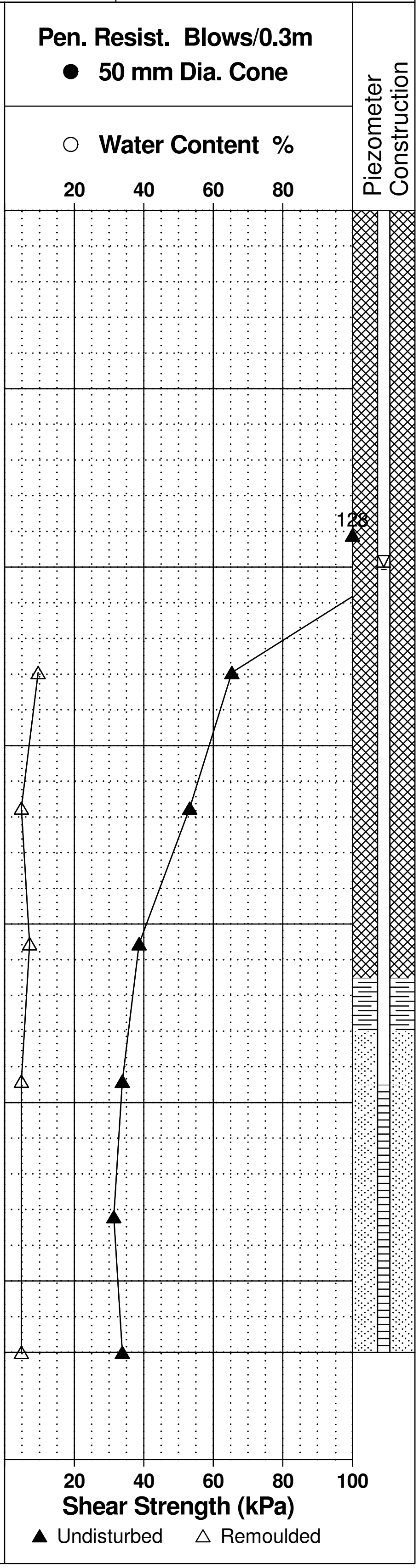
BORINGS BY CME 55 Power Auger

DATE February 5, 2018

FILE NO. PG4278

HOLE NO. BH 3-18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.36
TOPSOIL 0.30		AU	1				
		SS	2	67	7	1	87.36
		SS	3	100	P	2	86.36
Very stiff to stiff, brown **SILTY CLAY,** trace sand						3	85.36
- firm and grey by 3.8m depth						4	84.36
						5	83.36
6.40						6	82.36
End of Borehole (GWL @ 2.0m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

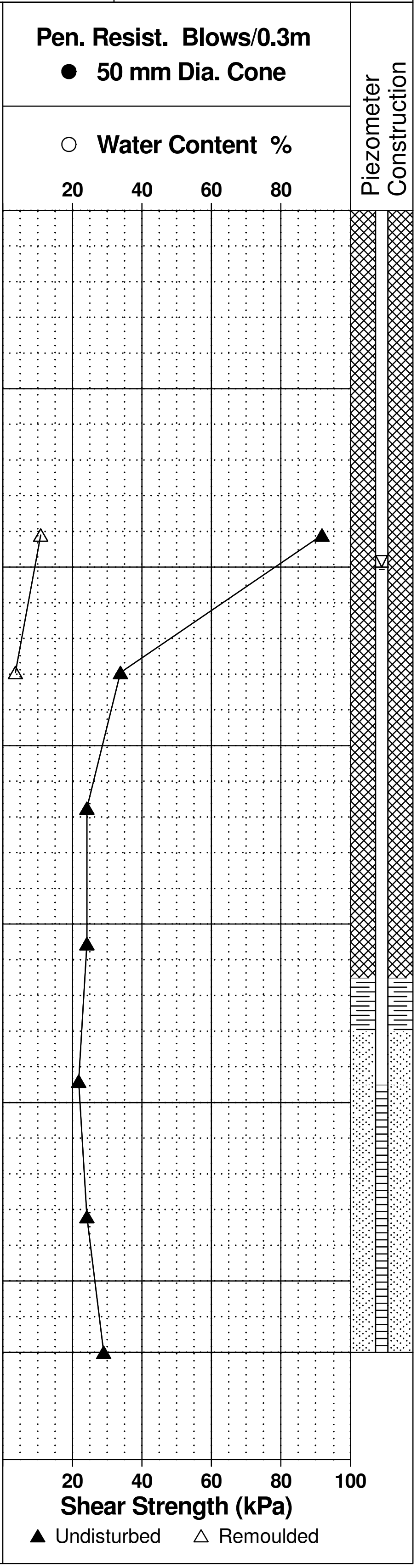
BORINGS BY CME 55 Power Auger

DATE February 5, 2018

FILE NO. PG4278

HOLE NO. BH 4-18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.44
TOPSOIL 0.28		AU	1				
Stiff to firm, brown **SILTY CLAY,** trace sand - soft to firm and grey by 3.0m depth		SS	2	92	5	1	87.44
		SS	3	100	P	2	86.44
						3	85.44
						4	84.44
						5	83.44
6.40						6	82.44
End of Borehole (GWL @ 2.0m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 6, 2018

FILE NO. PG4278

HOLE NO. BH 5-18

SOIL DESCRIPTION

GROUND SURFACE

TOPSOIL 0.25

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

- firm to soft and grey by 3.0m depth

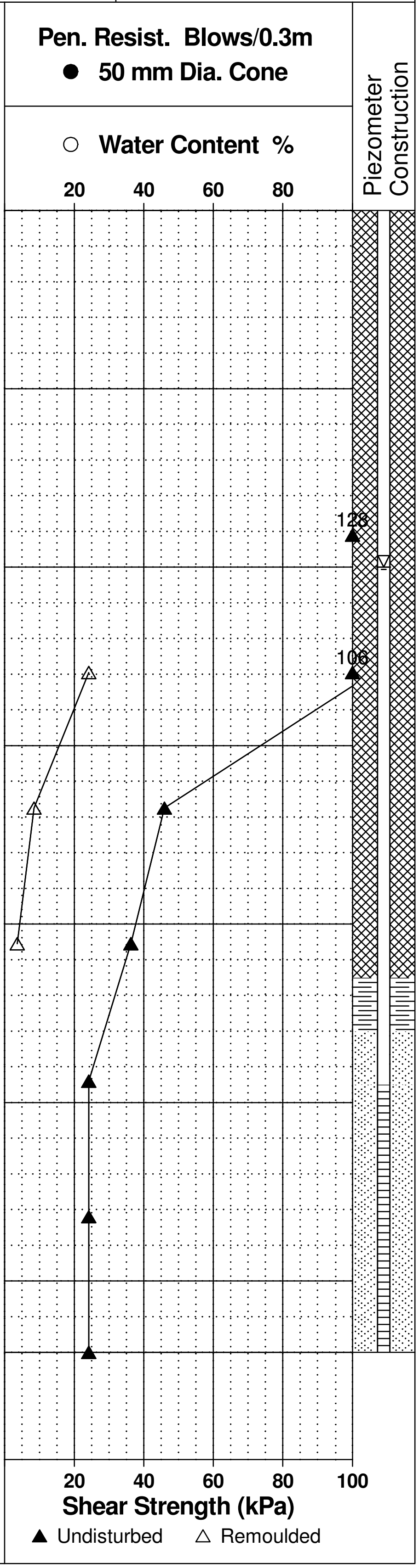
6.40

End of Borehole

(GWL @ 2.0m depth based on field observations)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	71	9
SS	3	88	P

DEPTH (m)	ELEV. (m)
0	88.58
1	87.58
2	86.58
3	85.58
4	84.58
5	83.58
6	82.58



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

FILE NO. PG4278

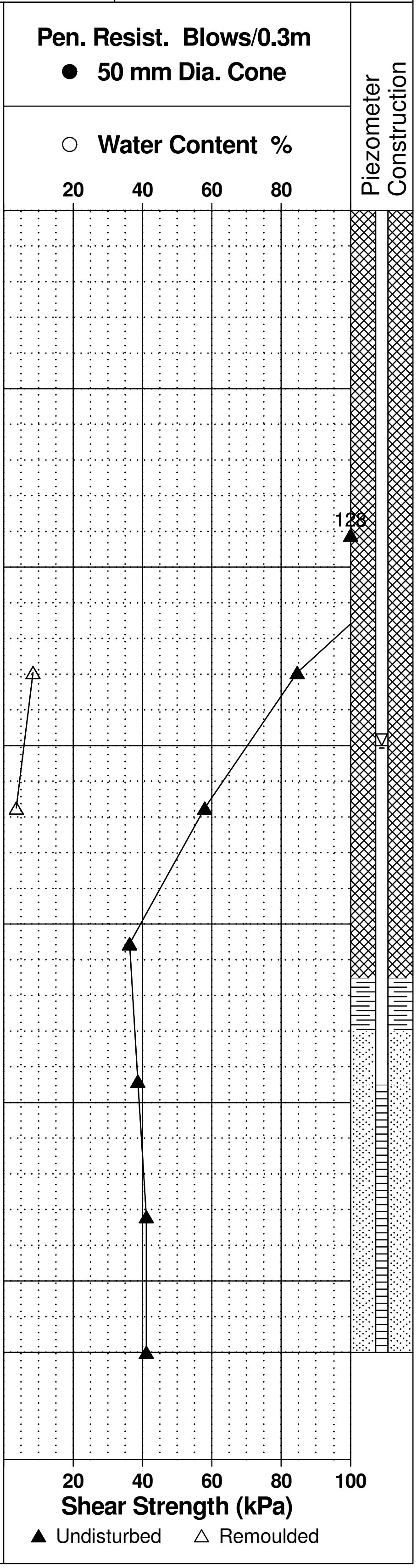
REMARKS

HOLE NO. BH 6-18

BORINGS BY CME 55 Power Auger

DATE February 6, 2018

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.30		AU	1			0	88.98
		SS	2	83	6	1	87.98
		SS	3	100	P	2	86.98
Very stiff to stiff, brown **SILTY CLAY,** trace sand - stiff to firm and grey by 3.0m depth						3	85.98
						4	84.98
						5	83.98
						6	82.98
6.40 End of Borehole (GWL @ 3.0m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

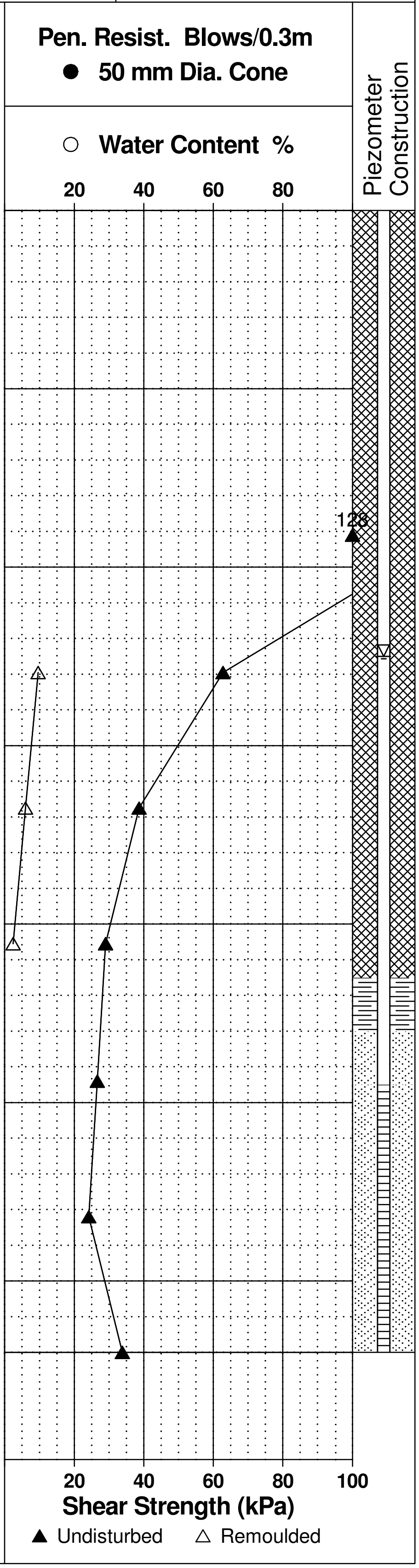
BORINGS BY CME 55 Power Auger

DATE February 6, 2018

FILE NO. PG4278

HOLE NO. BH 7-18

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.84
TOPSOIL 0.28	AU	1				
	SS	2	83	6	1	87.84
	SS	3	100	P	2	86.84
Very stiff to stiff, brown **SILTY CLAY,** trace sand - firm and grey by 3.0m depth					3	85.84
					4	84.84
					5	83.84
					6	82.84
6.40 End of Borehole (GWL @ 2.5m depth based on field observations)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

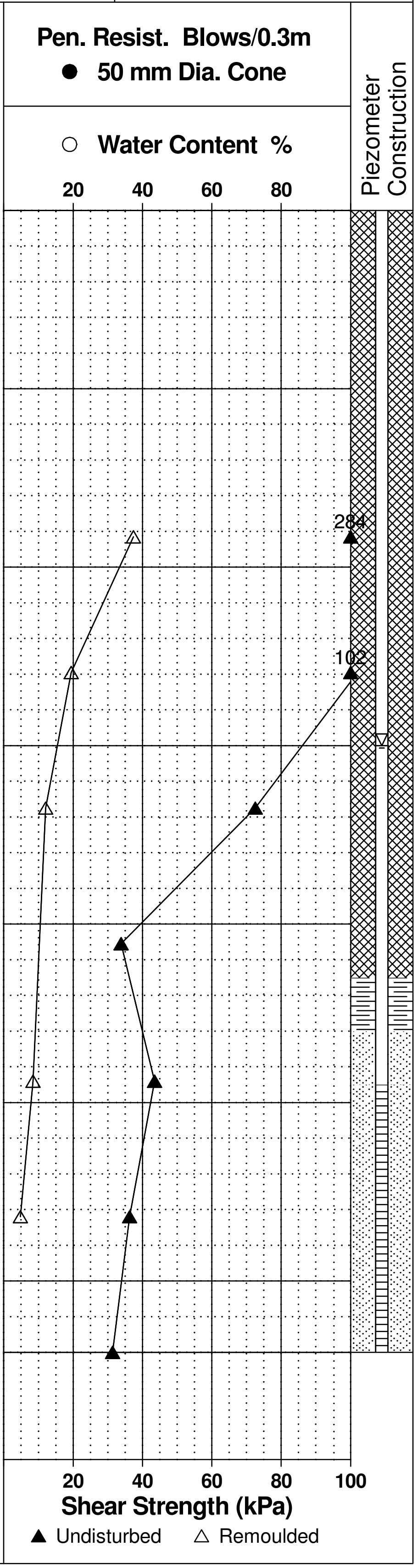
BORINGS BY CME 55 Power Auger

DATE February 6, 2018

FILE NO. PG4278

HOLE NO. BH 8-18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.94
TOPSOIL 0.33		AU	1				
		SS	2	67	8	1	87.94
						2	86.94
Hard to stiff, brown **SILTY CLAY,** trace sand							
						3	85.94
- firm and grey by 3.8m depth						4	84.94
						5	83.94
						6	82.94
6.40 End of Borehole							
(GWL @ 3.0m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
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DATUM Geodetic, as provided by Novatech Engineering

REMARKS

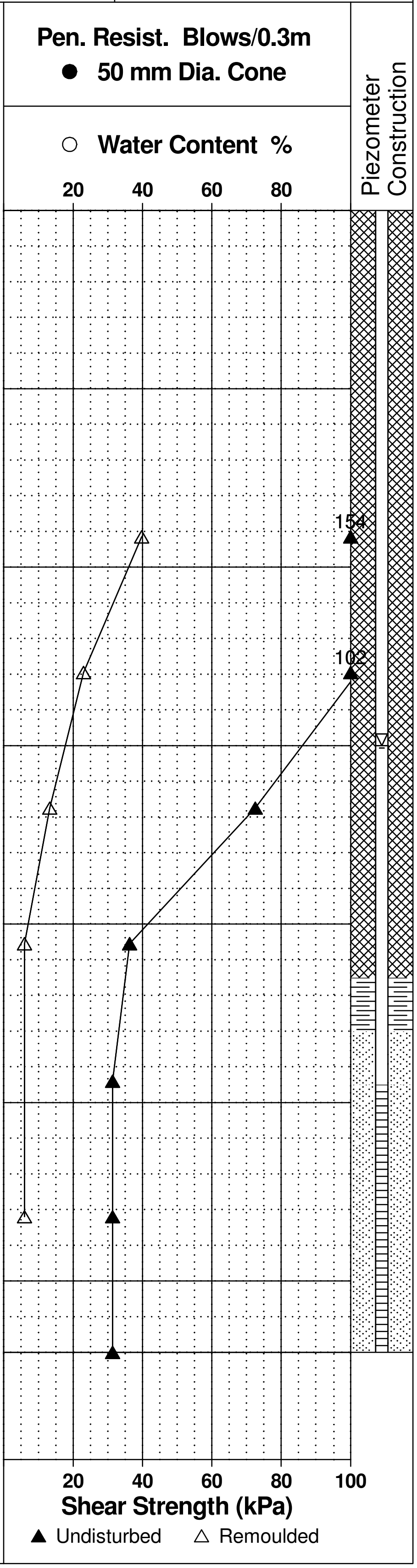
BORINGS BY CME 55 Power Auger

DATE February 7, 2018

FILE NO. PG4278

HOLE NO. BH 9-18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.53
TOPSOIL 0.36		AU	1				
		SS	2	58	6	1	87.53
						2	86.53
Very stiff to stiff, brown **SILTY CLAY,** trace sand						3	85.53
- firm and grey by 3.8m depth						4	84.53
						5	83.53
						6	82.53
6.40 End of Borehole (GWL @ 3.0m depth based on field observations)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

REMARKS

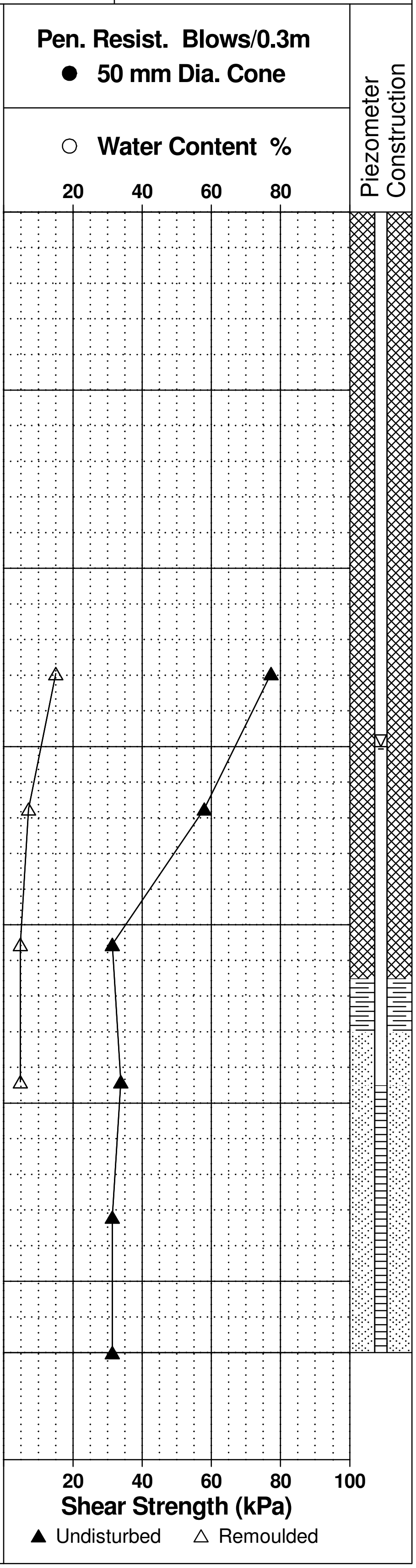
BORINGS BY CME 55 Power Auger

DATE February 7, 2018

FILE NO. PG4278

HOLE NO. BH10-18

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.58
TOPSOIL 0.56	AU	1				
	SS	2	42	10	1	87.58
	SS	3	46	4	2	86.58
Stiff to firm, brown **SILTY CLAY,** some sand - grey by 3.0m depth					3	85.58
					4	84.58
					5	83.58
6.40					6	82.58
End of Borehole (GWL @ 3.0m depth based on field observations)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

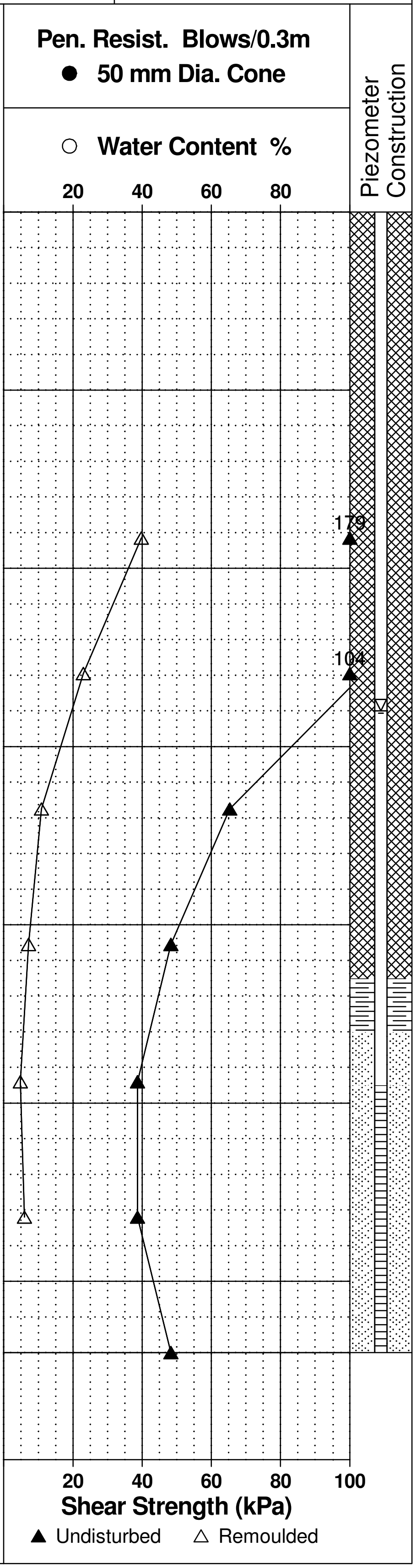
FILE NO. **PG4278**

REMARKS

HOLE NO. **BH11-18**

BORINGS BY CME 55 Power Auger **DATE** February 7, 2018

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.17
TOPSOIL 0.28		AU	1				
		SS	2	54	7	1	88.17
						2	87.17
Very stiff to stiff, brown **SILTY CLAY,** trace sand						3	86.17
- firm and grey by 3.8m depth						4	85.17
						5	84.17
6.40						6	83.17
End of Borehole (GWL @ 2.8m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Development - Trim Road - Legault Lands
Ottawa, Ontario

DATUM Geodetic, as provided by Novatech Engineering

FILE NO. PG4278

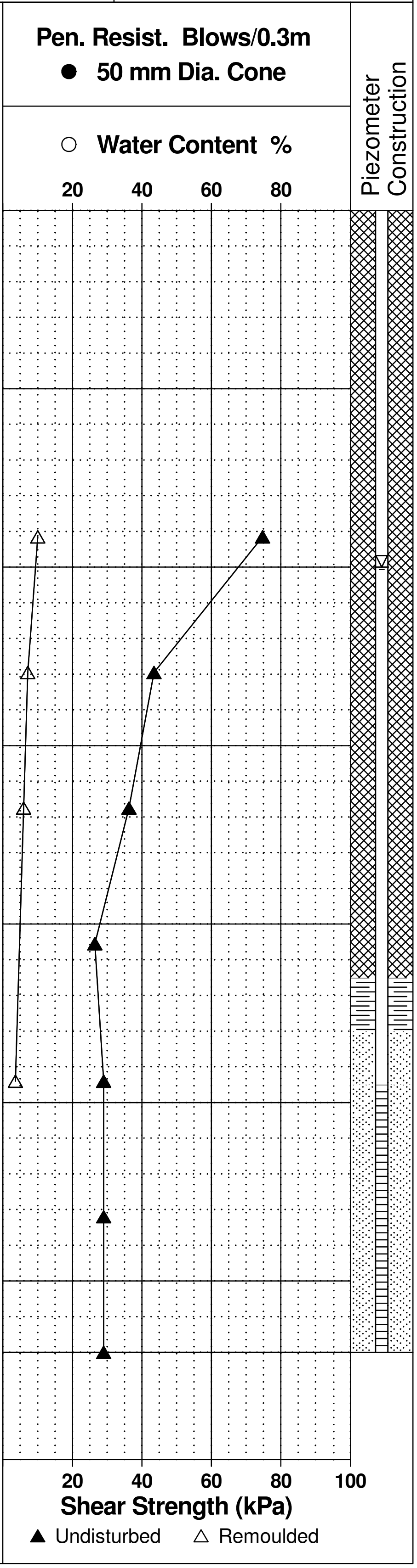
REMARKS

HOLE NO. BH12-18

BORINGS BY CME 55 Power Auger

DATE February 7, 2018

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.70
TOPSOIL 0.25		AU	1				
		SS	2	67	7	1	87.70
						2	86.70
Stiff to firm, brown **SILTY CLAY,** some sand - grey by 3.0m depth						3	85.70
						4	84.70
						5	83.70
						6	82.70
6.40							
End of Borehole (GWL @ 2.0m depth based on field observations)							



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)

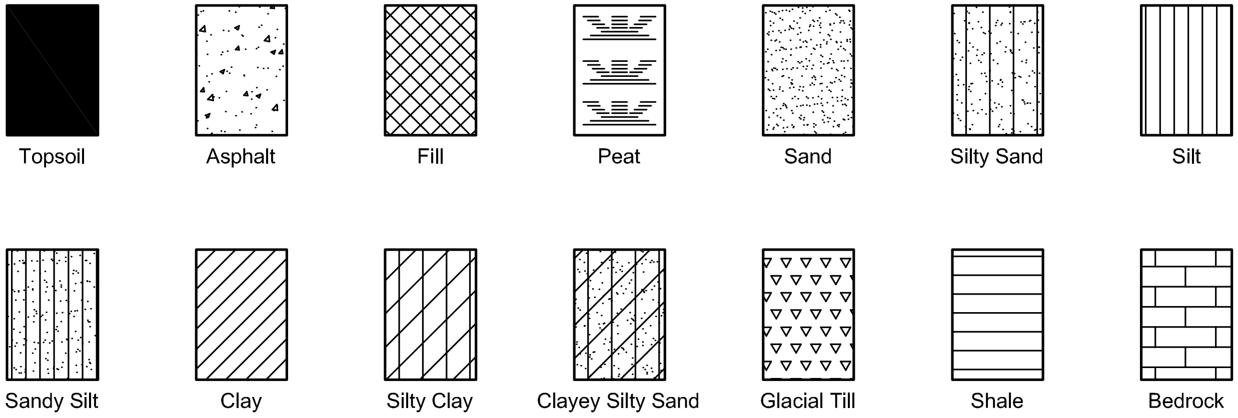
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

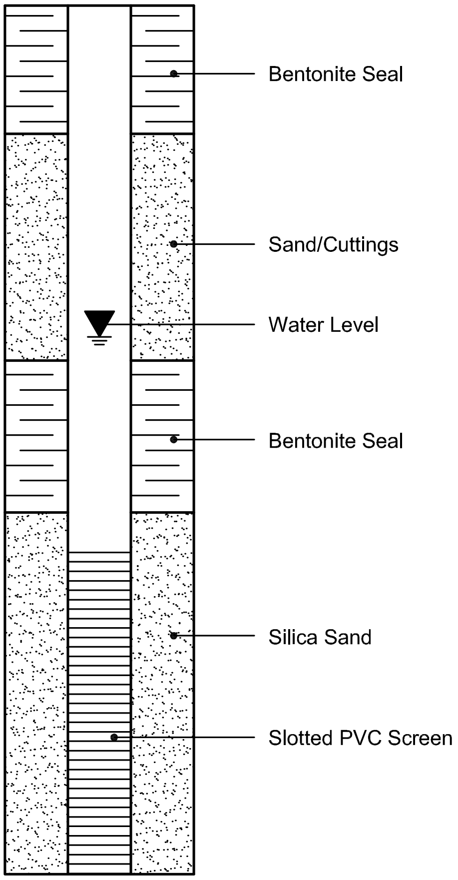
SYMBOLS AND TERMS (continued)

STRATA PLOT

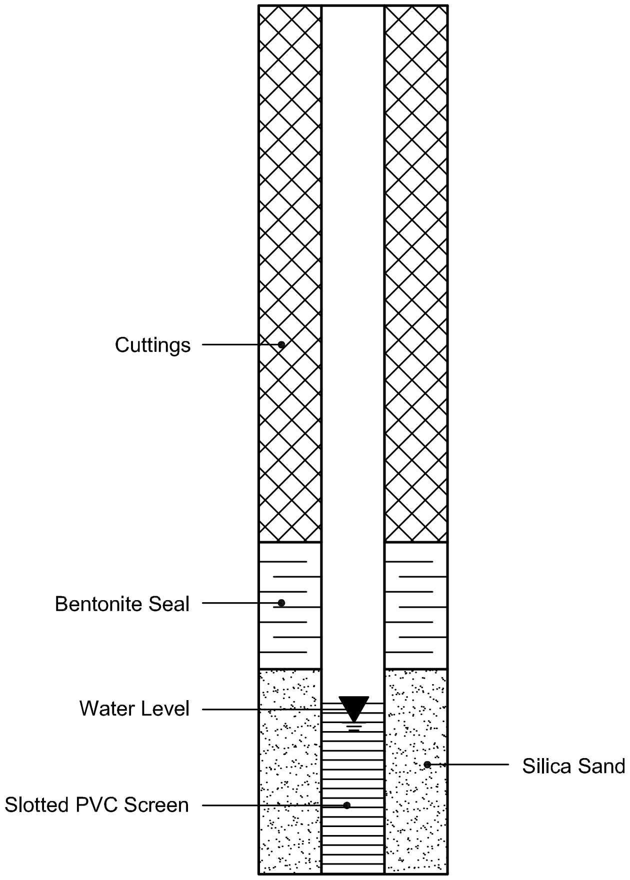


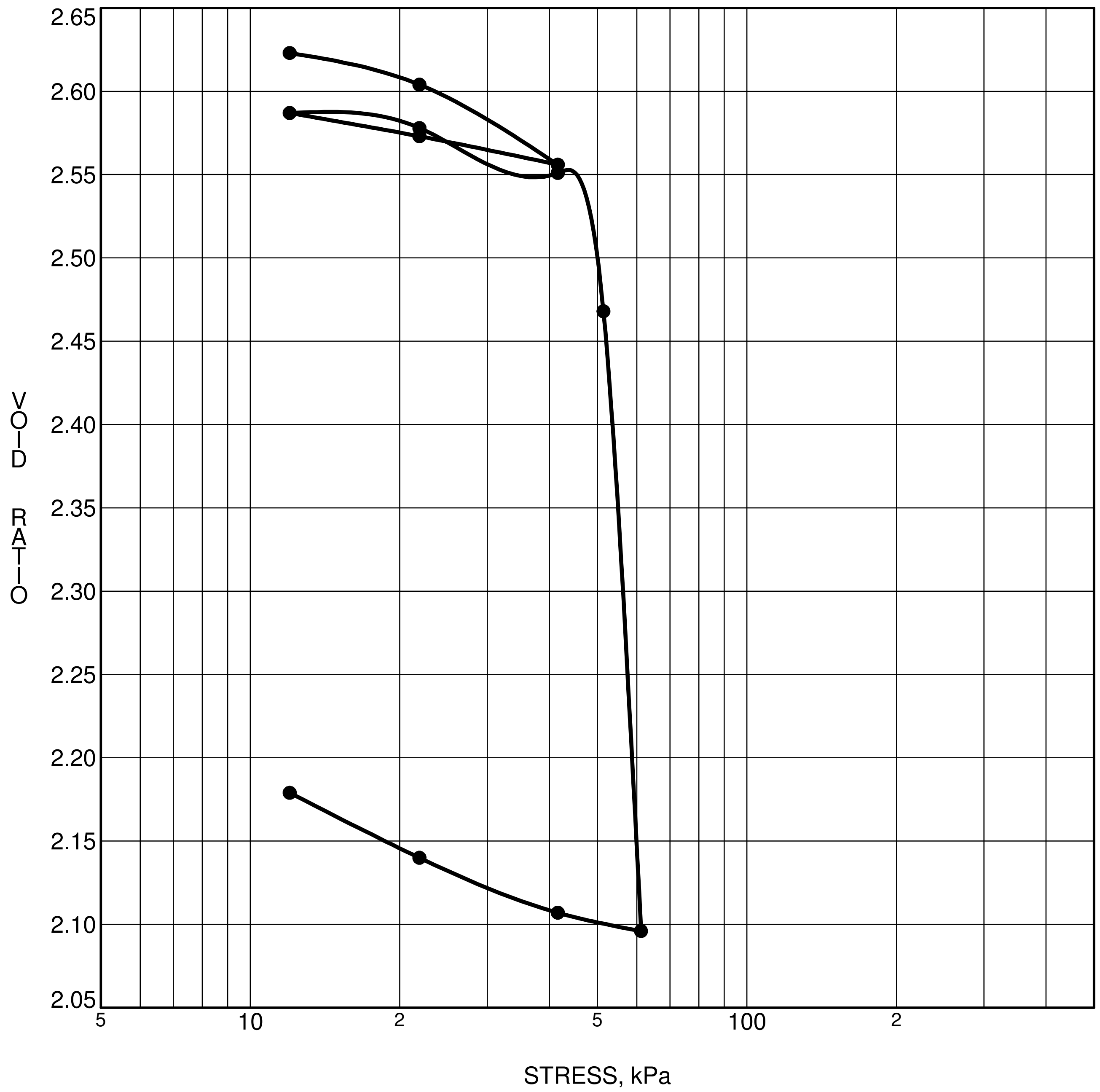
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 8-17**	p'o	**48** kPa	Ccr	**0.055**
Sample No.	**TW 4**	p'c	**50** kPa	Cc	**4.900**
Sample Depth	**4.14** m	OC Ratio	**1.0**	Wo	**96.3** %
Sample Elev.	**84.21** m	Void Ratio	**2.648**	Unit Wt.	**14.5** kN/m ^{3}

CLIENT **Novatech Engineering Consultants Ltd.**

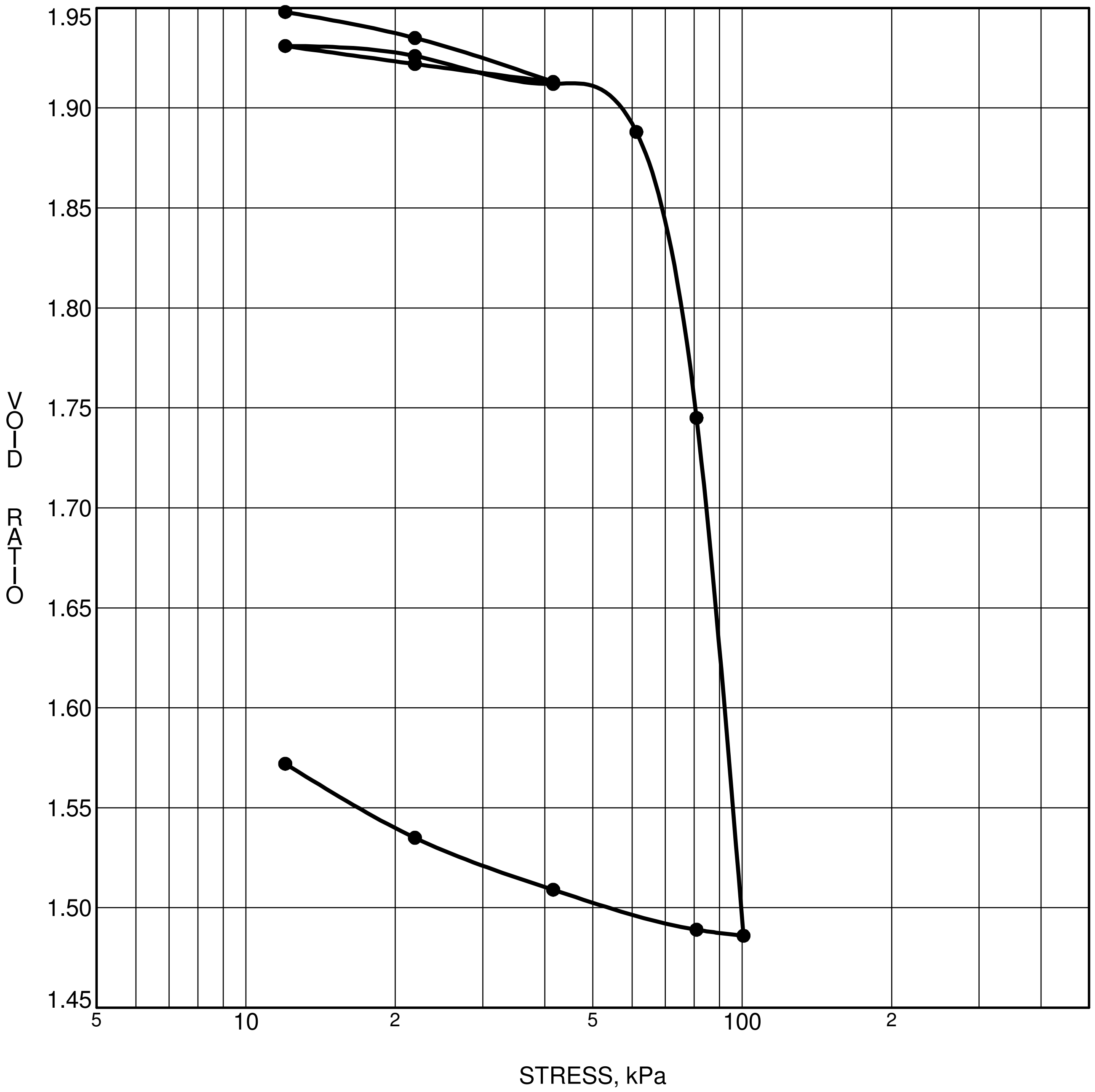
FILE NO. **PG4278**

PROJECT **Geotechnical Investigation - Proposed Development - Trim Road - Legault Lands**

DATE **13/01/2018**

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

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 9-17**	p'_o	**57** kPa	Ccr	**0.036**
Sample No.	**TW 4**	p'_c	**70** kPa	Cc	**2.330**
Sample Depth	**4.90** m	OC Ratio	**1.2**	Wo	**71.4** %
Sample Elev.	**83.80** m	Void Ratio	**1.962**	Unit Wt.	**15.6** kN/m ^{3}

CLIENT **Novatech Engineering Consultants Ltd.**
PROJECT **Geotechnical Investigation - Proposed Development - Trim Road - Legault Lands**
FILE NO. **PG4278**
DATE **15/01/2018**

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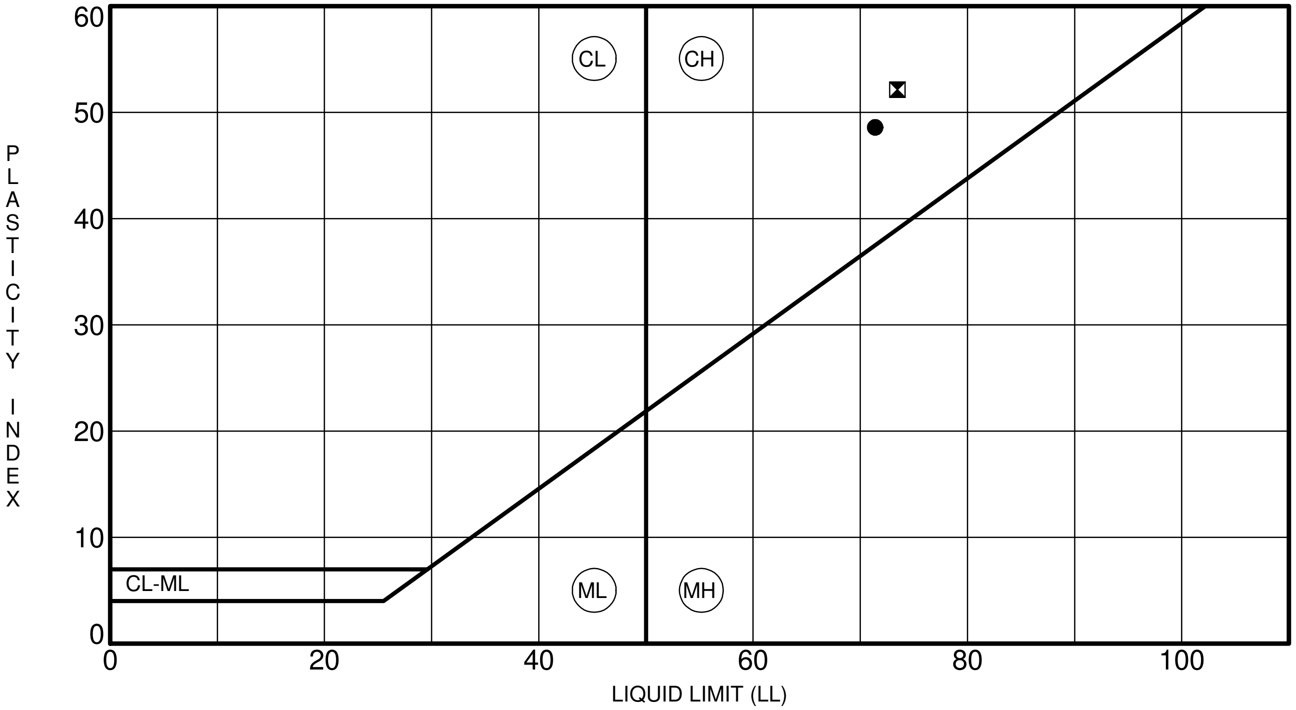
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 8-17**	**TW 4**	**71**	**23**	**49**		**CH - Inorganic clays of high plasticity**
⧗	**BH 9-17**	**TW 4**	**73**	**21**	**52**		**CH - Inorganic clays of high plasticity**

CLIENT **Novatech Engineering Consultants Ltd.**

FILE NO. **PG4278**

PROJECT **Geotechnical Investigation - Proposed Development - Trim Road - Legault Lands**

DATE **8 Jan 18**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS

Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 23193

Report Date: 30-Nov-2017

Order Date: 27-Nov-2017

Project Description: PG4278

	Client ID:	BH4-17 SS3	-	-	-
	Sample Date:	24-Nov-17	-	-	-
	Sample ID:	1748095-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	70.7	-	-	-
General Inorganics					
pH	0.05 pH Units	7.80	-	-	-
Resistivity	0.10 Ohm.m	30.3	-	-	-
Anions					
Chloride	5 ug/g dry	13	-	-	-
Sulphate	5 ug/g dry	115	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES

DRAWING PG4278-1 - TEST HOLE LOCATION PLAN

DRAWING PG4278-2 - PERMISSIBLE GRADE RAISE PLAN

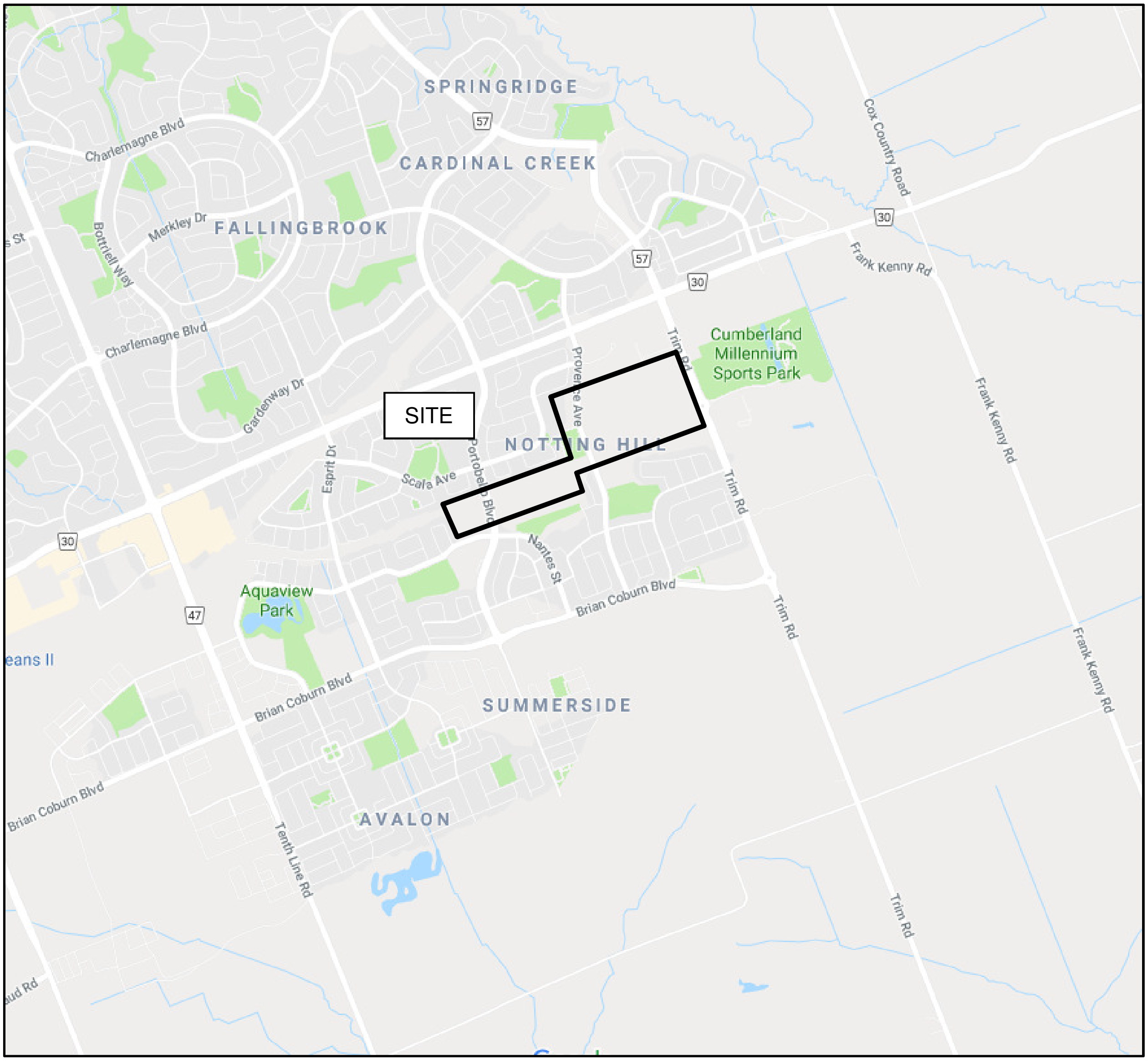


FIGURE 1

KEY PLAN

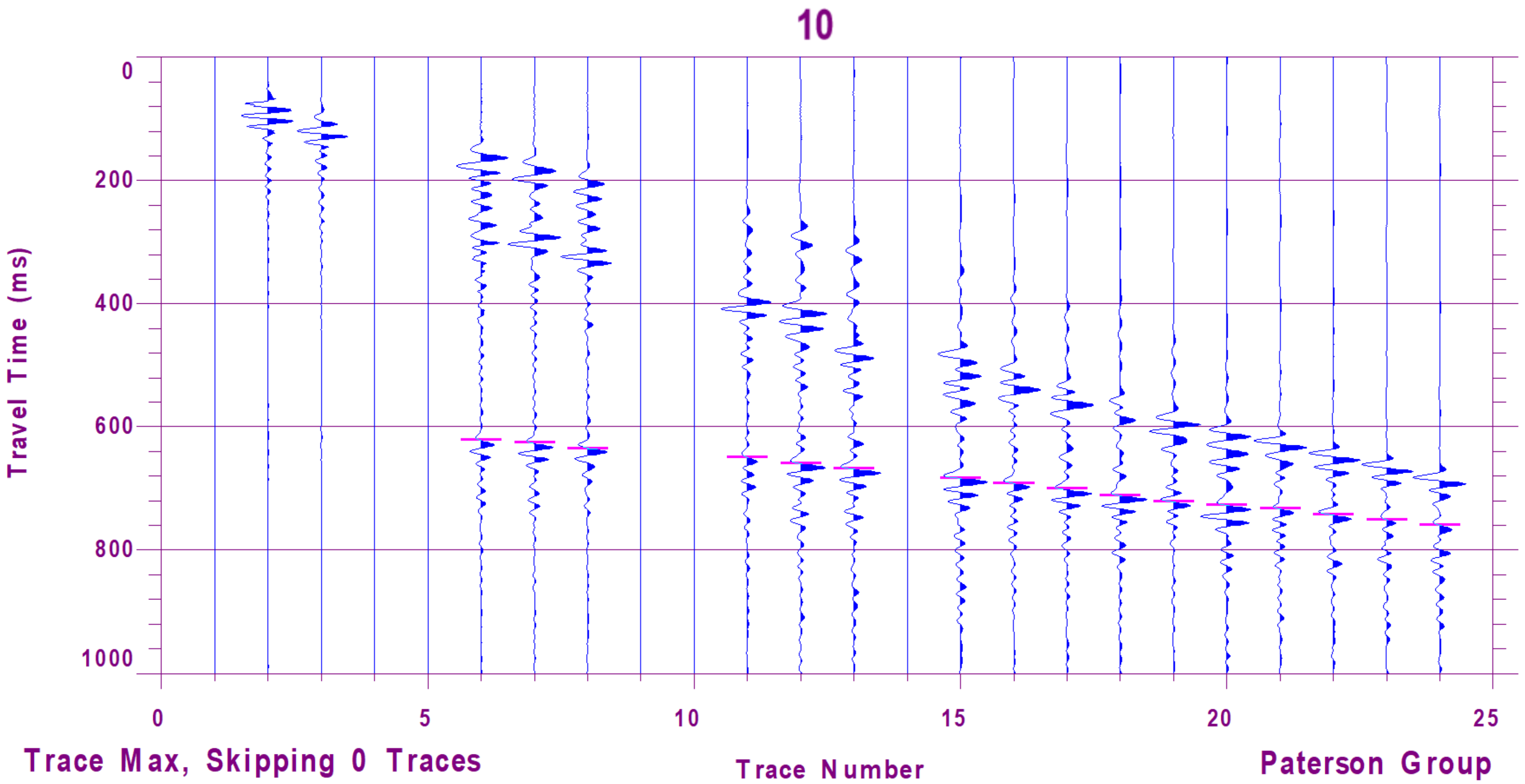


Figure 2 – Shear Wave Velocity Profile at Shot Location -3.0 m

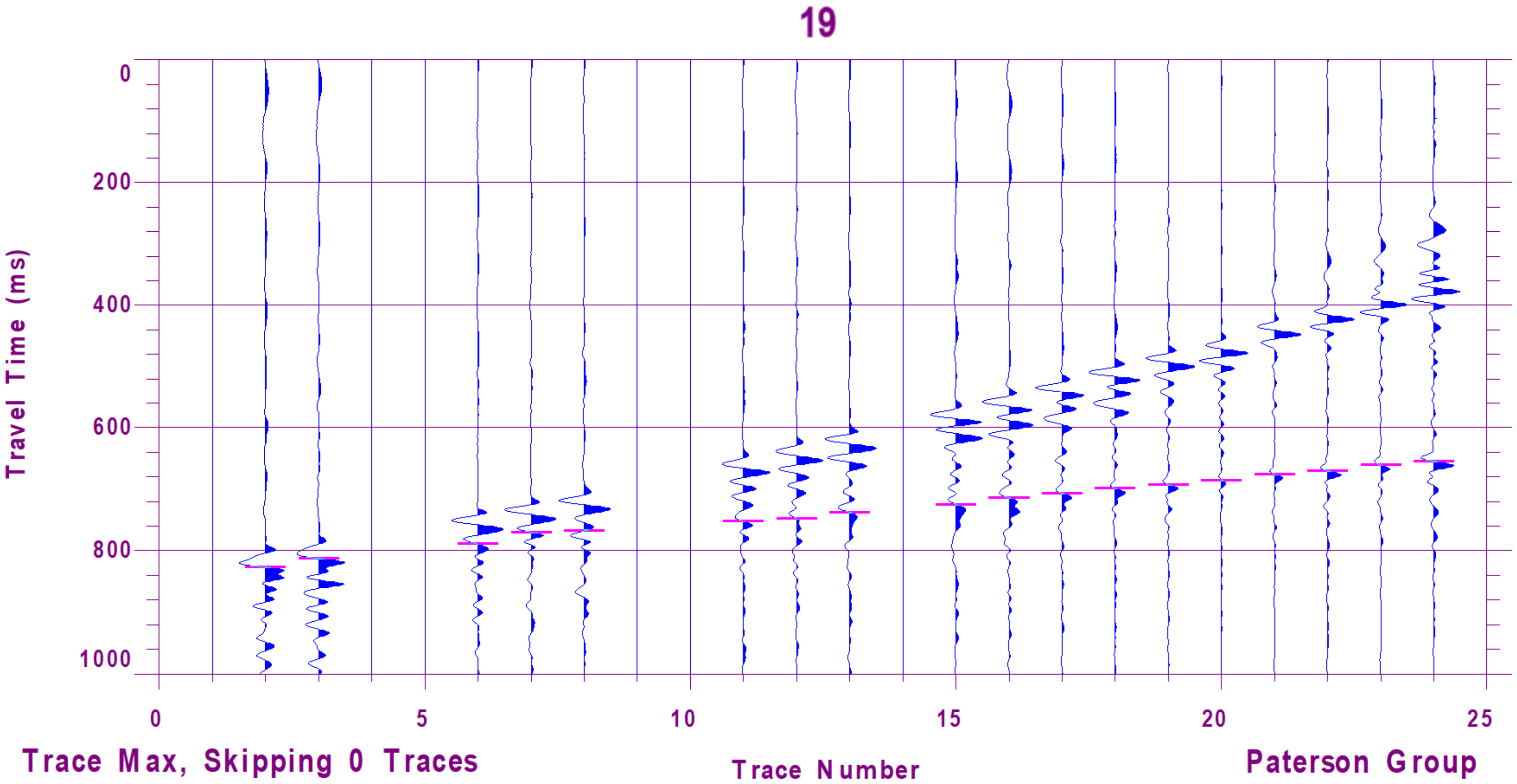


Figure 3 – Shear Wave Velocity Profile at Shot Location 99 m

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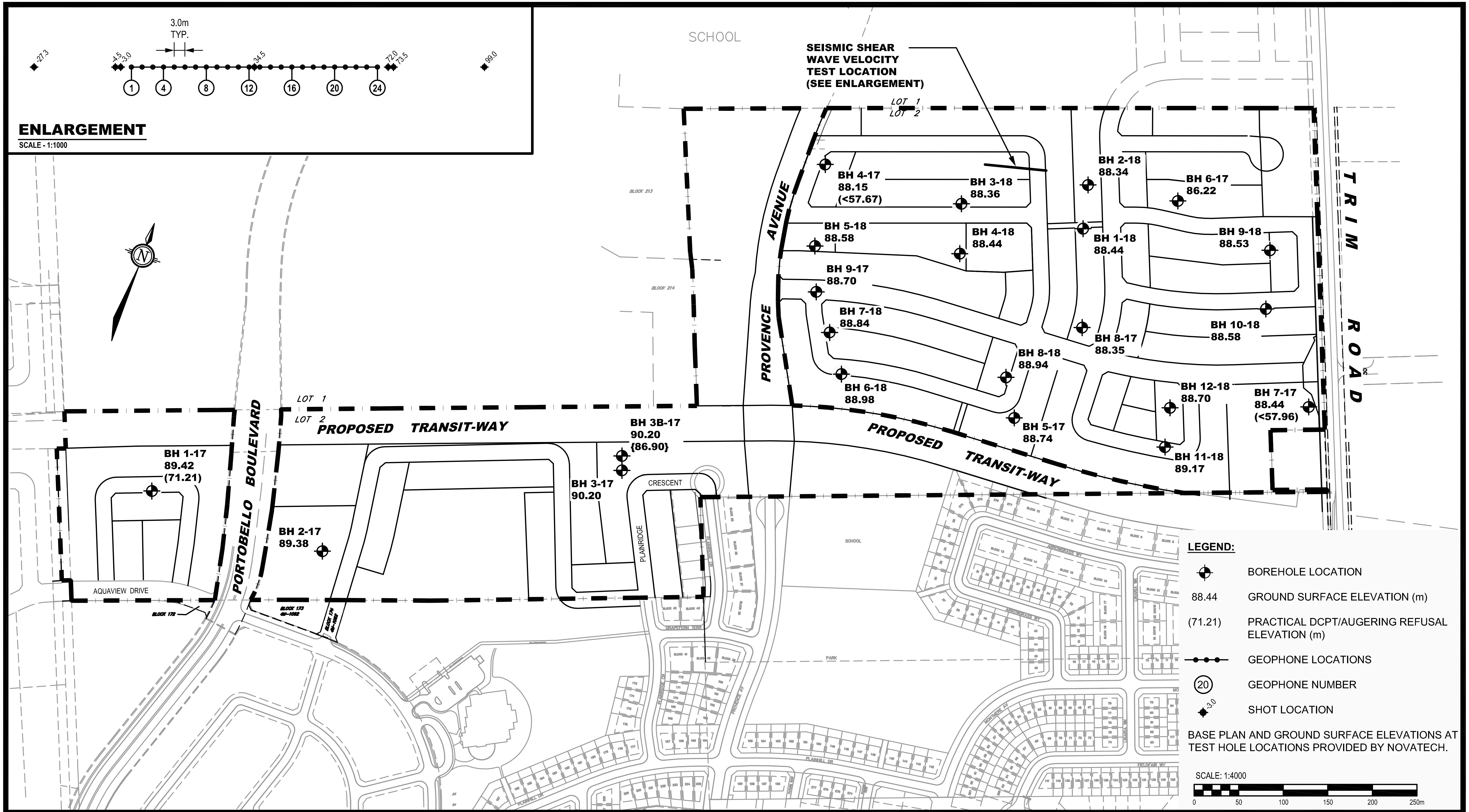

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NO.	REVISIONS	DATE	INITIAL
2	BOREHOLES BH 1-18 TO BH 12-18 AND SEISMIC ARRAY SURVEY ADDED	20/03/2018	SD
1	BOREHOLES BH 8-17 AND BH 9-17 ADDED	17/01/2018	SD

NOVATECH ENGINEERING

GEOTECHNICAL INVESTIGATION
TRIM ROAD - LEGAULT LANDS

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:4000	Date: 12/2017
Drawn by: RCG	Report No.: PG4278-1
Checked by: SD	Dwg. No.: PG4278-1
Approved by: DJG	Revision No.: 2

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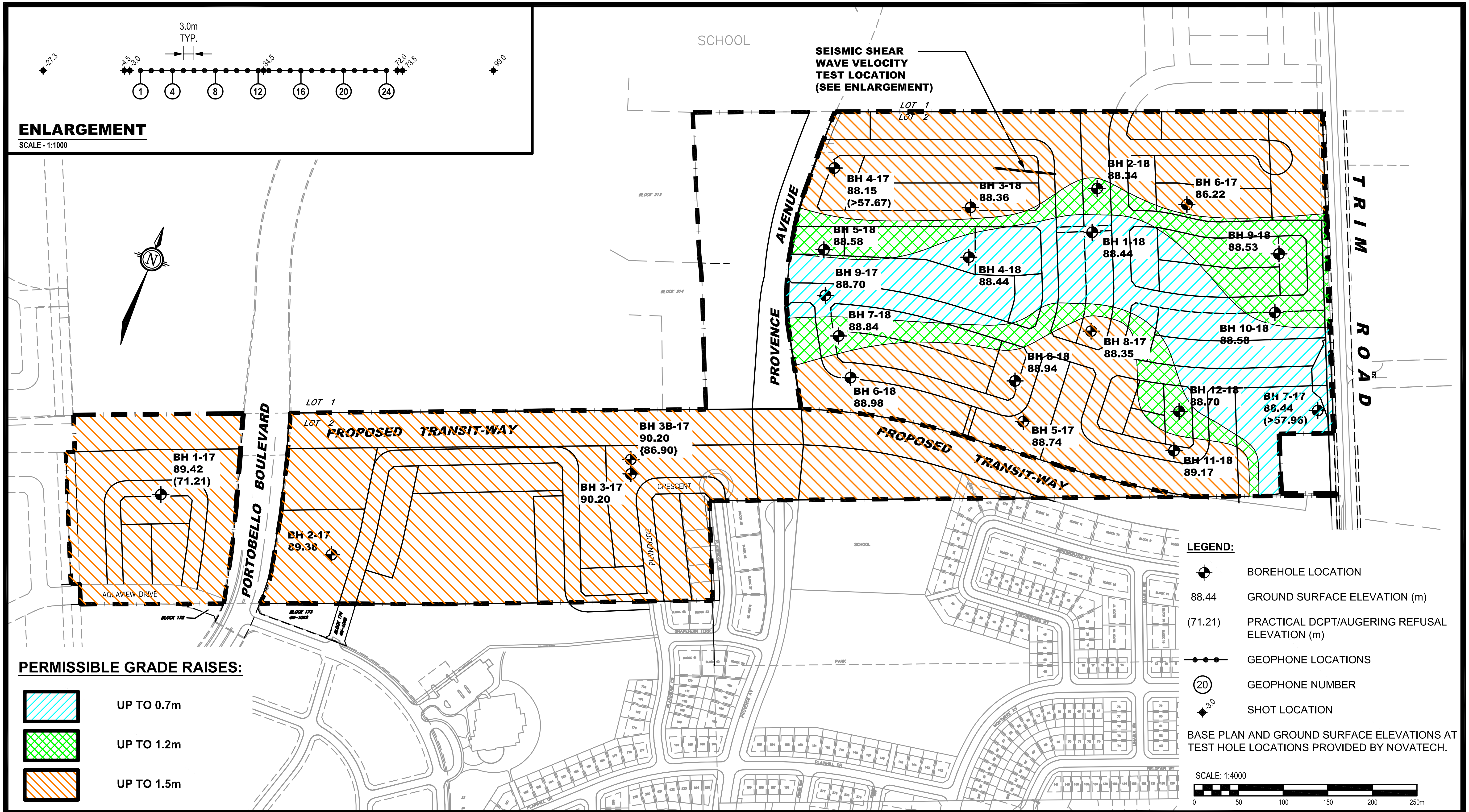

PERMISSIBLE GRADE RAISES:

▨	UP TO 0.7m
▩	UP TO 1.2m
▨	UP TO 1.5m

LEGEND:

⊕	BOREHOLE LOCATION
88.44	GROUND SURFACE ELEVATION (m)
(71.21)	PRACTICAL DCPT/AUGERING REFUSAL ELEVATION (m)
•–•–•	GEOPHONE LOCATIONS
⑳	GEOPHONE NUMBER
◆ 3.0	SHOT LOCATION

BASE PLAN AND GROUND SURFACE ELEVATIONS AT TEST HOLE LOCATIONS PROVIDED BY NOVATECH.

SCALE: 1:4000

0 50 100 150 200 250m

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154 Colonnade Road South
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NO.	REVISIONS	DATE	INITIAL
2	BOREHOLES BH 1-18 TO BH 12-18 AND SEISMIC ARRAY SURVEY ADDED	26/02/2018	SD
1	BOREHOLES BH 8-17 AND BH 9-17 ADDED	17/01/2018	SD

NOVATECH ENGINEERING

GEOTECHNICAL INVESTIGATION
TRIM ROAD - LEGAULT LANDS

OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE PLAN

Scale: 1:4000
Date: 12/2017
Drawn by: RCG
Report No.: PG4278-1
Checked by: SD
Dwg. No.: PG4278-2
Approved by: DJG
Revision No.: 2

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