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Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Archaeological Services

Geotechnical Investigation

Proposed Residential Development
879 River Road
Ottawa, Ontario

Prepared For

Richcraft Group of Companies

March 2, 2018

Report PG4402-1

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 Richcraft Group of Companies to conduct a geotechnical investigation for the subject site located at 879 River Road, in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the current investigation were to:

- ❏ determine the subsoil and groundwater conditions at this site by means of boreholes.

- ❏ to provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

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

2.0 Proposed Project

Based on available design plans, it is understood that the proposed development will consist of residential dwellings with associated roadways and landscaped areas. Installation of municipal services is also anticipated as part of the proposed project.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the geotechnical investigation was carried out on January 11, 2018. A total of six (6) boreholes were advanced to a maximum depth of 6.7 m. The borehole locations were distributed in a manner to provide general coverage of the subject site. The approximate locations of the boreholes are shown on Drawing PG4402-1 - 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. All fieldwork was conducted under the full-time supervision of our personnel under the direction of a senior engineer from our geotechnical department. The drilling procedure consisted of advancing each test hole to the required depths at the selected locations and sampling the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler or from the auger flights. The depths at which the auger and split spoon samples were recovered from the test holes are shown as AU and SS, respectively, on the Soil Profile and Test Data sheets in Appendix 1.

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

Undrained shear strength testing was carried out at regular depth intervals in cohesive soils using a vane apparatus.

All soil samples were classified on site, placed in sealed plastic bags and were transported to our laboratory for visual inspection.

The thickness of the overburden was evaluated during the course of the investigation by a dynamic cone penetration test (DCPT) at BH 3. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at its 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.

Subsurface conditions observed in the test holes were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

Flexible polyethylene standpipes were installed in all boreholes except BH 6 to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

Sample Storage

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.

3.2 Field Survey

The borehole locations were selected in the field by Paterson personnel to provide general coverage of the subject site taking into consideration existing site features. The borehole locations are presented on Drawing PG4402-1 - Test Hole Location Plan in Appendix 2. The ground surface elevations at the borehole locations were interpolated based on a recently completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

3.3 Laboratory Testing

The soil samples recovered from the subject site were visually examined in our laboratory to review the results of the field logging. Two atterberg limit tests were completed on selected soil samples. The results are presented in Table 1 under Subsection 4.2.

3.4 Analytical Testing

One (1) 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 sample was submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample. The results are presented in Appendix 1 and are discussed further in Subsection 6.6.

4.0 Observations

4.1 Surface Conditions

The majority of the subject site consists of agricultural fields. Two residential buildings occupy the northwest corner while a heavily treed area occupies the northeast portion of the subject site. The ground surface slopes gradually from east to west with an existing ravine with a maximum depth of 3 m running across the subject site. The site is bordered to the north by a forested area, to the east by agricultural properties, to the south by agricultural and residential properties and to the west by River Road.

It should be noted that the above mentioned ravine runs across the south portion of the subject site mainly from east to west. The ravine branches from the south central portion to the northeast corner. The ravine ranges in depth from 1 to 3 m based on available topographic survey completed for the subject site.

4.2 Subsurface Profile

Overburden

Generally, the soil profile at the borehole locations consists of topsoil/agricultural soils underlain by silty sand followed by a very stiff to stiff silty clay deposit. A grey, stiff to firm silty clay deposit was encountered below the silty clay crust. Practical refusal to DCPT was encountered at a depth of 14 m below existing grade at BH 3. Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

The results of the atterberg limit testing on select silty clay samples are presented in Table 1 below:

Table 1 - Summary of Atterberg Limits Tests

Samples	Depth (m)	Initial Moisture Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %
BH2 SS3	1.5 - 2.1	50.0	84	38	46
BH1 SS4	2.3 - 2.9	34.0	63	22	41

Bedrock

Based on available geological mapping, the subject site is located in an area where the bedrock consists of dolomite of the Oxford formation with an overburden thickness between 10 and 15 m.

4.3 Groundwater

Groundwater levels were measured in the standpipes installed in the boreholes on January 22, 2018. The observed groundwater levels are summarized in Table 2.

Table 2 - Summary of Groundwater Level Readings

Test Hole Number	Groundwater Depth (m)	Recording Date
BH 1	1.32	January 22, 2018
BH 2	0.40	January 22, 2018
BH 3	2.98	January 22, 2018
BH 4	0.96	January 22, 2018
BH 5	2.06	January 22, 2018

It should be noted that the groundwater levels could be influenced by surface water infiltrating the backfilled boreholes. It is important to note that groundwater readings at the piezometers can be influenced by water perched within the borehole backfill material. Long-term groundwater levels can also be estimated based on the observed colour and consistency of the recovered soil samples. Based on these observations, the long-term groundwater table can be expected at approximately 3.5 to 4.5 m below ground surface. The recorded groundwater levels are noted on the applicable Soil Profile and Test Data sheet presented in Appendix 1.

It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed development. It is expected that the proposed buildings will be founded over conventional shallow footings placed on an undisturbed, very stiff to stiff silty clay bearing surface.

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

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

5.2 Site Preparation

Stripping Depth

Topsoil, and any deleterious fill, such as those containing organic materials, should be stripped from under any buildings and other settlement sensitive structures. Care should be taken not to disturb adequate bearing soils below the founding level during site preparation activities.

Existing fill, free of deleterious materials, should be reviewed by the geotechnical consultant at the time of construction to confirm if the existing fill can remain in place or be re-used as select subgrade fill or to in-fill existing ditches. For areas where the existing fill is to remain in place, it is recommended that the existing fill, free of deleterious materials, should be proof-rolled by a vibratory roller making several passes and any poor performing areas should be removed.

Fill Placement

Fill used for grading beneath the building areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II 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 buildings should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If excavated stiff brown silty clay, free of organics and deleterious materials, is to be used to build up the subgrade level for areas to be paved, the silty clay, under dry conditions, should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

In-filling the existing ditches should be completed in a stepped fashion within the lateral support of the proposed buildings. The fill should consist of clean imported granular fill, such as OPSS Granular A or Granular B Type II material. The steps should have a minimum horizontal length of 1.5 m and minimum vertical height of 0.5 m and should be compacted using suitable compaction equipment to a minimum 98% of the material's SPMDD.

5.3 Foundation Design

Shallow Foundation

Strip footings, up to 3 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 **150 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **225 kPa**. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance value at ULS.

Footings placed on engineered fill bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **150 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **225 kPa.**

Footings designed using the above noted bearing resistance value at SLS given above will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively.

An undisturbed soil bearing surface consists of a surface 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 a stiff silty clay 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.

Permissible Grade Raise

A permissible grade raise restriction of **2 m** is recommended above existing grade for the proposed buildings where footings are to be placed over a stiff silty clay bearing surface. It should be noted that where existing ditches are to be in-filled, the permissible grade raise recommended for these areas is **1.5 m** above existing grade in adjacent table land. If greater 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.

5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class D** for the foundations considered at this site. A higher seismic site class, such as Class C, may be applicable for the subject site. However, the higher seismic site class would have to be confirmed by a site-specific seismic shear wave velocity test. The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the Ontario Building Code (OBC) 2012 for a full discussion of the earthquake design requirements.

5.5 Basement Slab/Slab on Grade Construction

With the removal of all topsoil and fill, containing deleterious or organic materials, the native soil or existing granular fill approved by the geotechnical consultant at the time of excavation will be considered to be an acceptable subgrade surface on which to commence backfilling for basement floor slab or slab on grade construction. Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab.

It is recommended that the upper 200 mm of sub-floor fill for basement slab construction consist of 19 mm clear crushed stone. It is also recommended that the upper 300 mm sub-floor fill below slab on grade construction consist of OPSS Granular A crushed stone. All backfill materials within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

5.6 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of car only parking areas and local roadways.

Table 3 - Recommended Pavement Structure - Car Only Parking Areas/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 in situ soils or OPSS Granular B Type I or II material placed over in situ soil	

Table 4 - Recommended Pavement Structure - Local Roadways

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

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

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on keeping 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 its load carrying capacity.

Where silty clay is anticipated at subgrade level, consideration should be given to installing subdrains during the pavement construction. The subdrain inverts should be approximately 300 mm below subgrade level and run longitudinal along the curblines. 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

It is recommended that a perimeter foundation drainage system 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 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a composite drainage system, such as Delta Drain 6000 or an approved equivalent. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose.

6.2 Protection of Footings Against Frost Action

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

Exterior unheated footings, such as those for isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the structure proper and require additional protection, such as soil cover of 2.1 m or a combination of soil cover and foundation insulation.

6.3 Excavation Side Slopes

The side slopes of excavations in the overburden materials should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavations to be undertaken by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below groundwater level. The subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

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

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by “cut and cover” methods and excavations will not be left open for extended periods of time.

6.4 Pipe Bedding and Backfill

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

At least 150 mm of OPSS Granular A should be used for bedding for sewer and water pipes when placed on soil subgrade. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe should consist of OPSS Granular A (concrete or PSM PVC pipes) or sand (concrete pipe). The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 95% of the material’s SPMDD.

Generally, it should be possible to re-use the moist, not wet, silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. The wet silty clay should be given a sufficient drying period to decrease its moisture content to an acceptable level to make compaction possible prior to being re-used.

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

To reduce long-term lowering of the groundwater level at this site, clay seals should be provided in the service trenches. The seals should be at least 1.5 m long 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 material's SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 60 m intervals in the service trenches.

6.5 Groundwater Control

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.

It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of the excavations.

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

For typical ground or surface water volumes being pumped during the construction phase, typically 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 must be taken if winter construction is considered for this project. The subsoil conditions at this site consist of frost susceptible materials. In the presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

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

Trench excavations and pavement construction are also difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be taken if such activities are to be carried out during freezing conditions.

6.7 Corrosion Potential and Sulphate

The results of analytical testing show that the sulphate content is less than 0.1%. These results are indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The results of the chloride content, pH and resistivity indicate the presence of a non-aggressive to slightly aggressive environment for exposed ferrous metals at this site.

6.8 Landscaping Considerations

Tree Planting Restrictions

The proposed development is located in an area of medium sensitive silty clay deposits for tree planting. Based on the results of the atterberg tests completed under Subsection 4.2, the plasticity index was found to be between 41 and 46%. Therefore, it is recommended that trees placed within 7.5 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 7.5 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. Above ground swimming pools must be placed at least 4 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer`s requirements.

6.9 Slope Stability Analysis

A slope stability analysis was completed for the slope along the south and southeast portion of the subject site. Two sections considered the worst case scenarios were analyzed as part of this study. The location of section A and B are presented on Drawing PG4402-1 - Test Hole Location Plan in Appendix 2.

Slope Stability Analysis

The analysis of the stability of the slope was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favoring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain the risks of failure are acceptable. A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures.

The cross-sections were analyzed taking into account a groundwater level at ground surface. Subsoil conditions at the cross-sections were inferred based on the findings at nearby borehole locations and general knowledge of the area's geology.

Static Analysis

The results for the existing slope conditions at Section A and B are shown in Figure 2A and 3A, respectively, in Appendix 2. The factor of safety was found to be greater than 1.5 for both sections when analyzed under static conditions.

Seismic Loading Analysis

An analysis considering seismic loading was also completed. A horizontal seismic acceleration, K_h, of 0.16G was considered for the analyzed sections. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The results of the analyses including seismic loading are shown in Figure 2B and 3B for the slope sections. The results indicate that the factor of safety for Section A and B are greater than 1.1. Based on these results, the slopes are considered to be stable under seismic loading.

7.0 Recommendations

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

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

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

8.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review the grading plan once available and our recommendations when the drawings and specifications are complete.

A geotechnical investigation of this nature is a limited sampling of a site. The recommendations are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around the test locations. The extent of the limited area depends on the soil, bedrock and groundwater conditions, as well the history of the site reflecting natural, construction, and other activities. Should any conditions at the site be encountered which differ from those at the test locations, we request notification immediately in order to permit reassessment of our recommendations.

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

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
Mar. 2, 2018
F. I. ABOU-SEIDO
100156744
PROVINCE OF ONTARIO

Faisal I. Abou-Seido, P.Eng.

David J. Gilbert, P.Eng.

Report Distribution:

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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

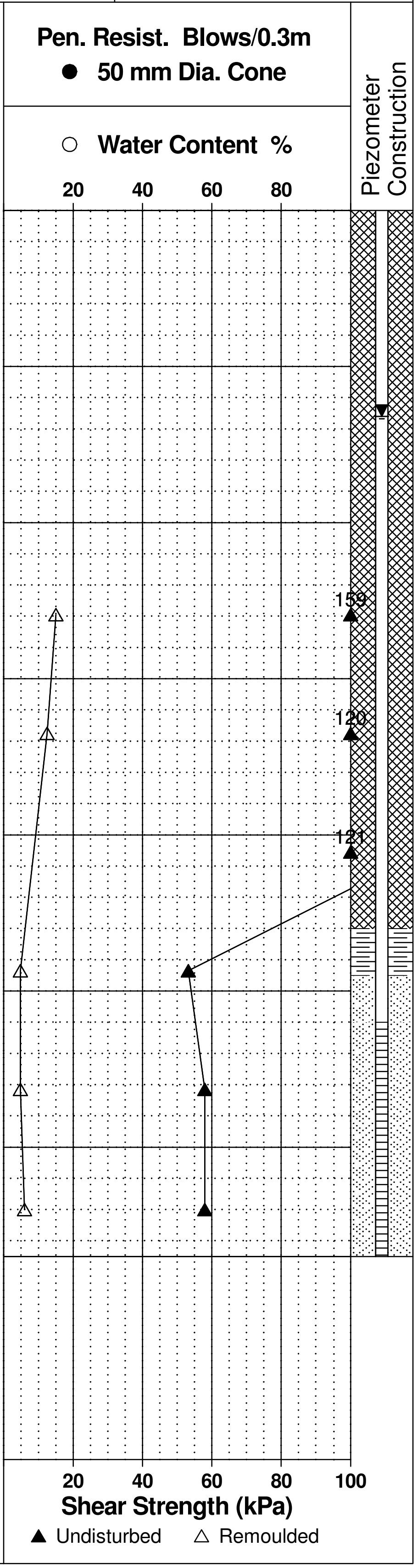
BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	90.00
FILL: Brown silty sand, some topsoil, trace gravel 0.28		AU	1				
Loose, brown **SILTY SAND**		SS	2	50	7	1	89.00
1.68		SS	3	100	3	2	88.00
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	4	100	P		
		SS	5	100	P	3	87.00
- grey by 3.8m depth		SS	6	100	P	4	86.00
		SS	7	100	P	5	85.00
		SS	8	100	P	6	84.00
6.70		SS	9	100	P		
End of Borehole (GWL @ 1.32m - Jan. 22, 2018)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

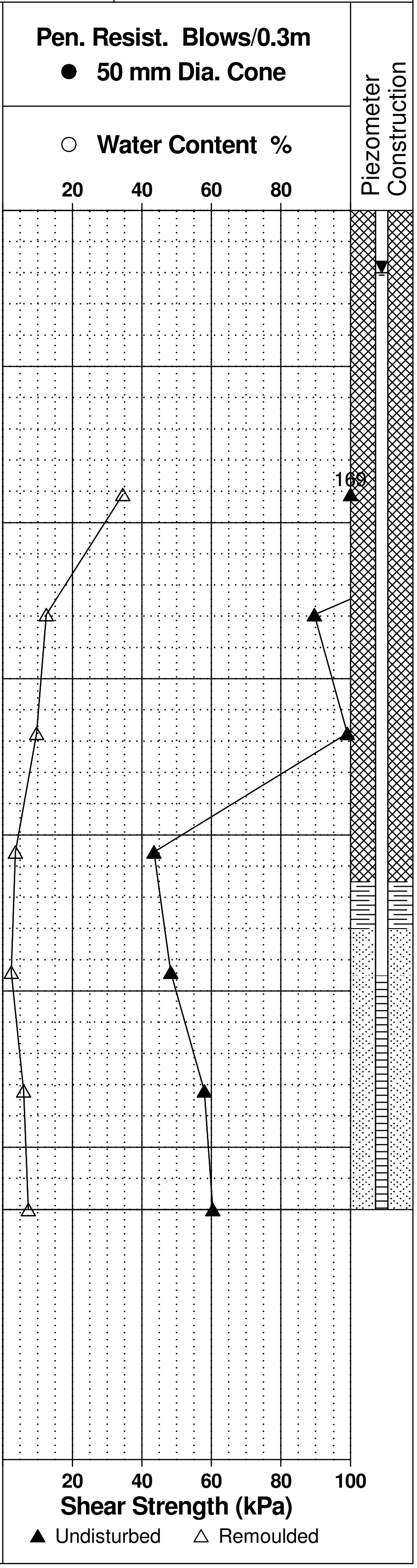
BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	90.10
TOPSOIL 0.40		AU	1				
Very stiff to stiff, brown **SILTY CLAY,** trace sand		SS	2	67	3	1	89.10
		SS	3	75	P	2	88.10
- firm to stiff and grey by 3.8m depth						3	87.10
						4	86.10
						5	85.10
6.40						6	84.10
End of Borehole (GWL @ 0.40m - Jan. 22, 2018)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
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DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 3

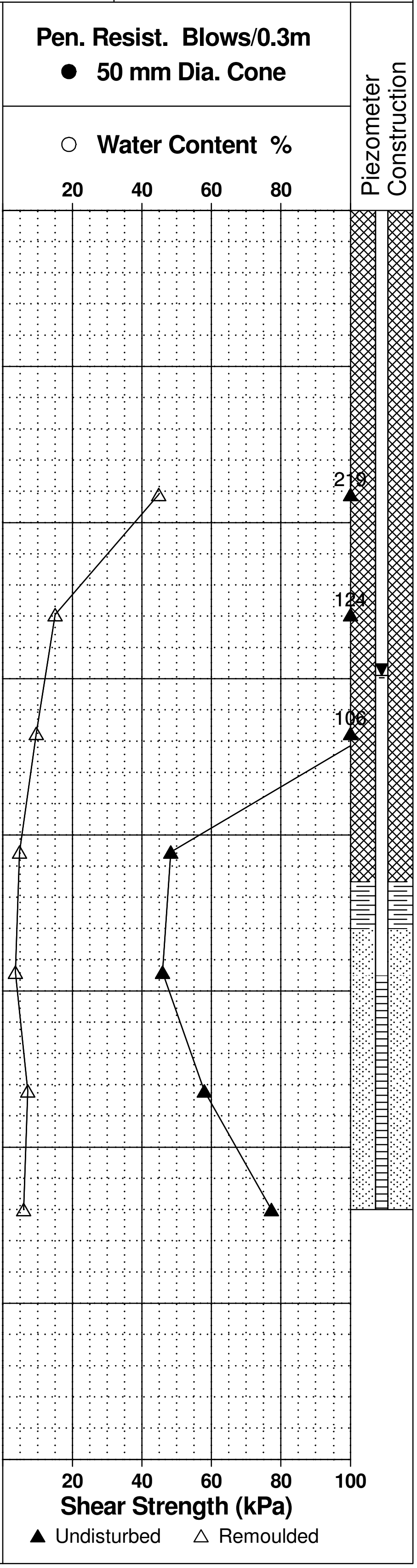
SOIL DESCRIPTION

GROUND SURFACE

Soil Description	Depth to base (m)
TOPSOIL	0.33
Loose, brown **SILTY SAND**	0.91
Very stiff to stiff, brown **SILTY CLAY,** trace sand - firm to stiff and grey by 3.8m depth	6.40
Dynamic Cone Penetration Test commenced at 6.40m depth. Cone pushed to 12.5m depth.	

TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	62	5
SS	3	100	P

DEPTH (m)	ELEV. (m)
0	90.00
1	89.00
2	88.00
3	87.00
4	86.00
5	85.00
6	84.00
7	83.00
8	82.00



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

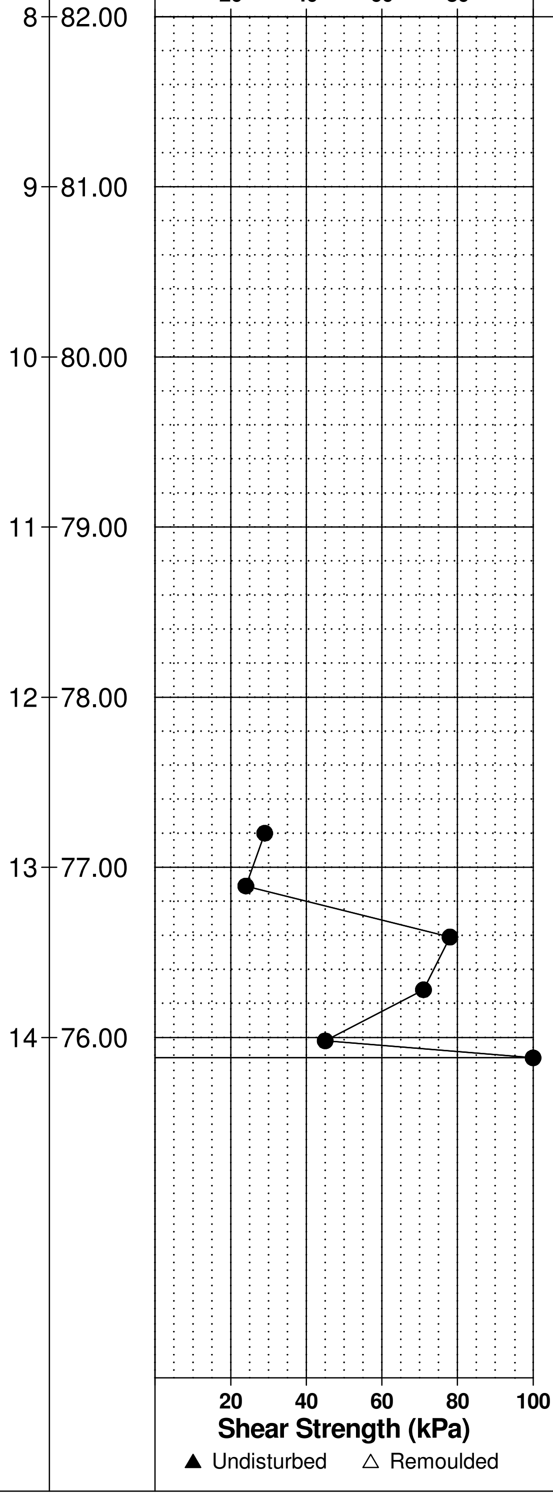
BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			20 40 60 80	
14.12 End of Borehole Practical DCPT refusal at 14.12m depth. (GWL @ 2.98m - Jan. 22, 2018)									



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

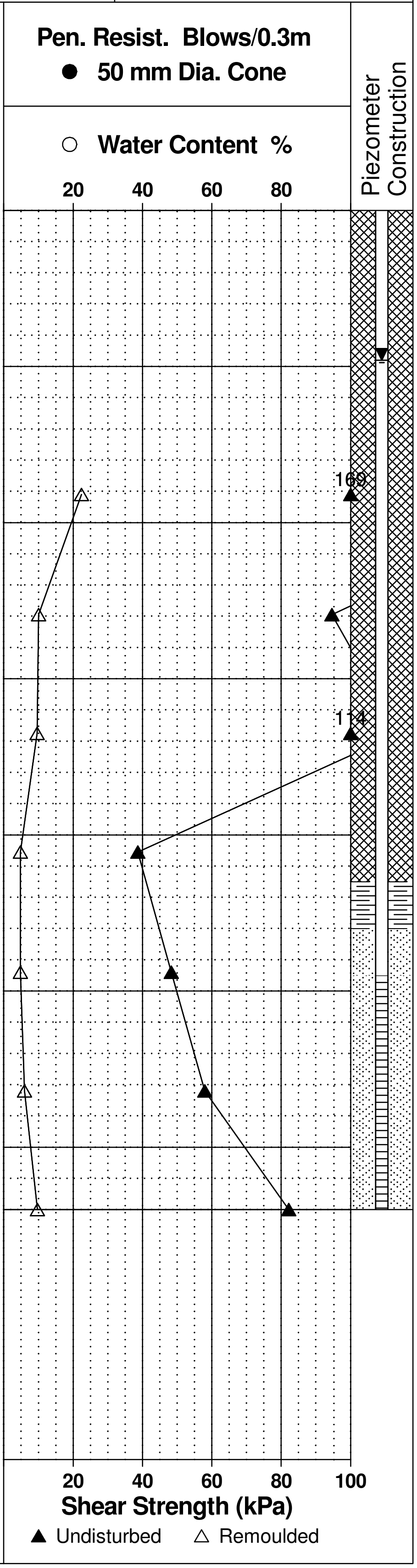
BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.80
TOPSOIL 0.28		AU	1				
Very stiff to stiff, brown **SILTY CLAY,** trace sand		SS	2	58	3	1	88.80
		SS	3	100	P	2	87.80
						3	86.80
- firm to stiff and grey by 3.8m depth						4	85.80
						5	84.80
6.40						6	83.80
End of Borehole							
(GWL @ 0.96m - Jan. 22, 2018)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

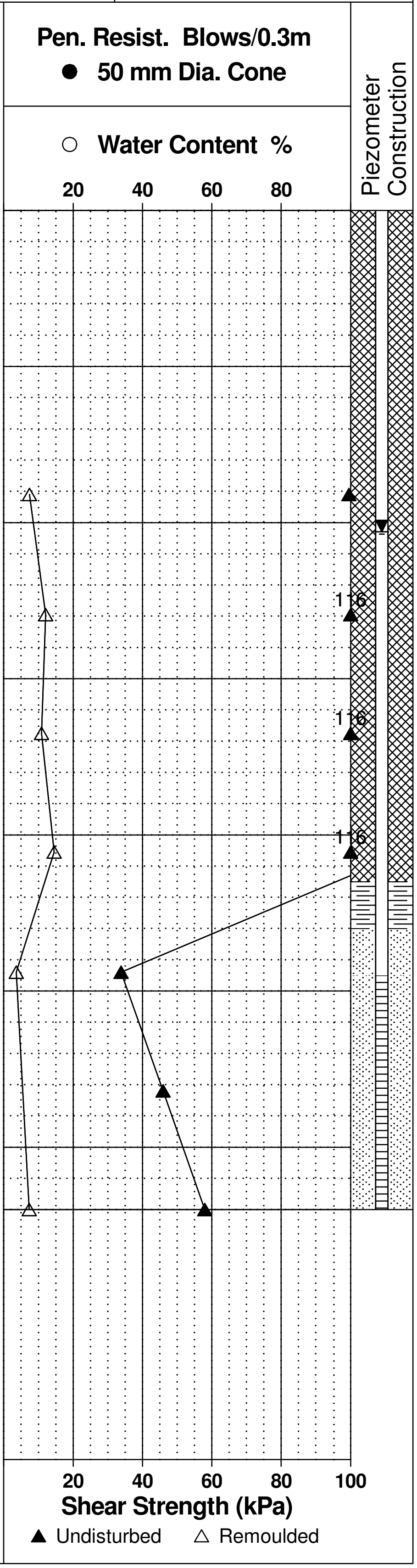
BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. **PG4402**

HOLE NO. **BH 5**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.50
TOPSOIL 0.43	■	AU	1				
	▨	SS	2	58	5	1	87.50
	▨	SS	3	67	P	2	86.50
Very stiff to stiff, brown **SILTY CLAY,** trace sand	▨					3	85.50
	▨					4	84.50
- firm to stiff and grey by 4.6m depth	▨					5	83.50
	▨					6	82.50
6.40							
End of Borehole (GWL @ 2.06m - Jan. 22, 2018)							



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
879 River Road
Ottawa, Ontario

DATUM Ground surface elevations at test hole locations interpolated from recent completed topographic survey by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 11, 2018

FILE NO. PG4402

HOLE NO. BH 6

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	90.10		
FILL: Brown silty sand, trace gravel, cobbles, topsoil and a piece of brick 0.69		AU	1						
Loose, brown **SILTY SAND,** some clay 1.52		AU	2			1	89.10		
End of Borehole (BH dry upon completion)									

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

SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	**ROCK QUALITY**
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu - Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

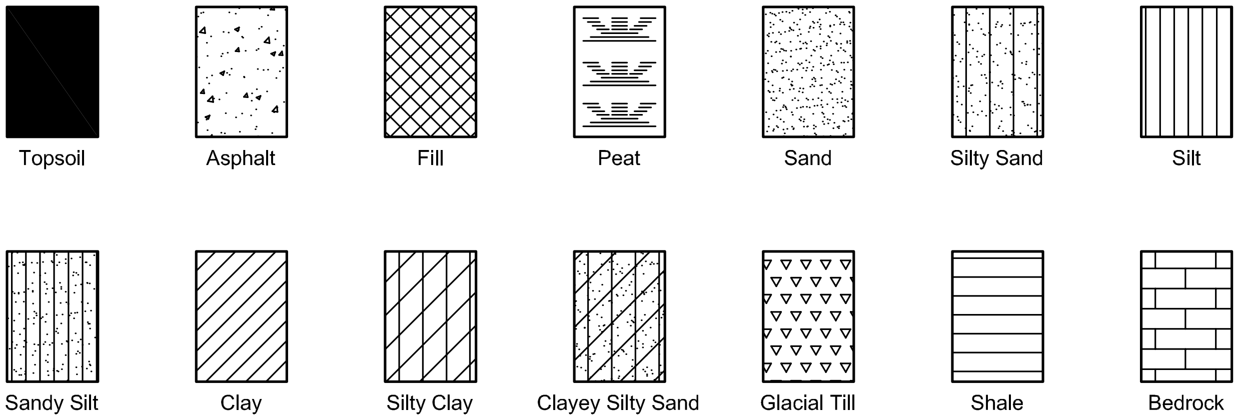
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

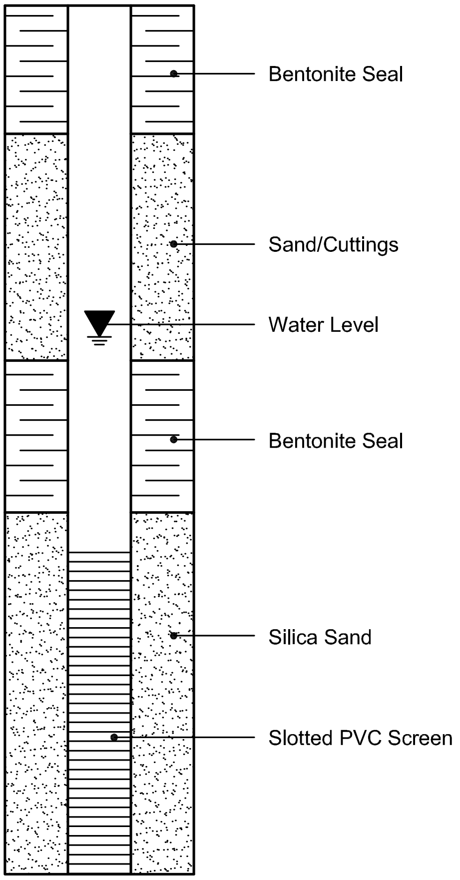
SYMBOLS AND TERMS (continued)

STRATA PLOT

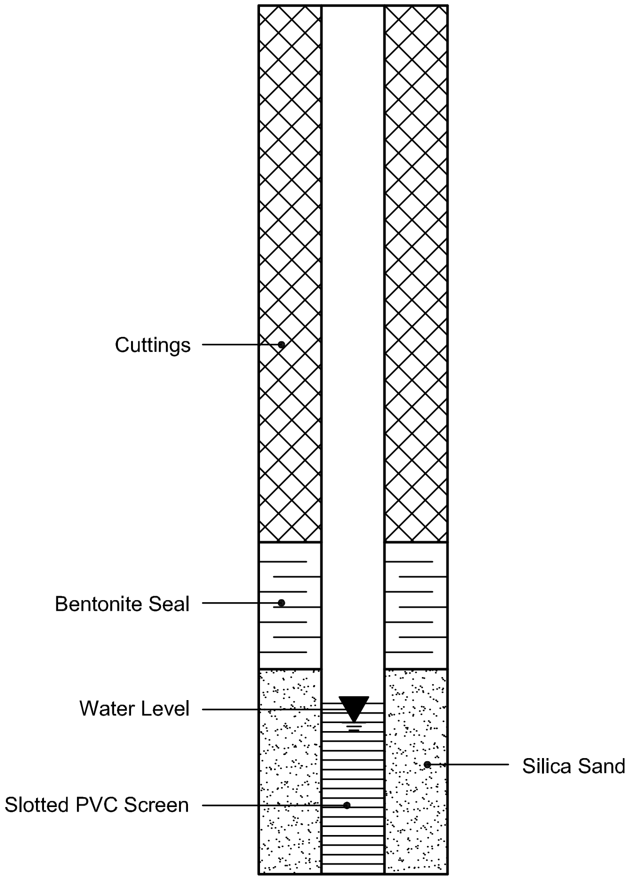


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 23197

Report Date: 17-Jan-2018

Order Date: 12-Jan-2018

Project Description: PE4402

Client ID:		BH3-18 SS3	-	-	-
Sample Date:		11-Jan-18	-	-	-
Sample ID:		1802490-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	68.1	-	-	-
General Inorganics					
pH	0.05 pH Units	7.23	-	-	-
Resistivity	0.10 Ohm.m	175	-	-	-
Anions					
Chloride	5 ug/g dry	7	-	-	-
Sulphate	5 ug/g dry	8	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURE 2A - 3B - SLOPE STABILITY SECTIONS

DRAWING PG4402-1 - TEST HOLE LOCATION PLAN

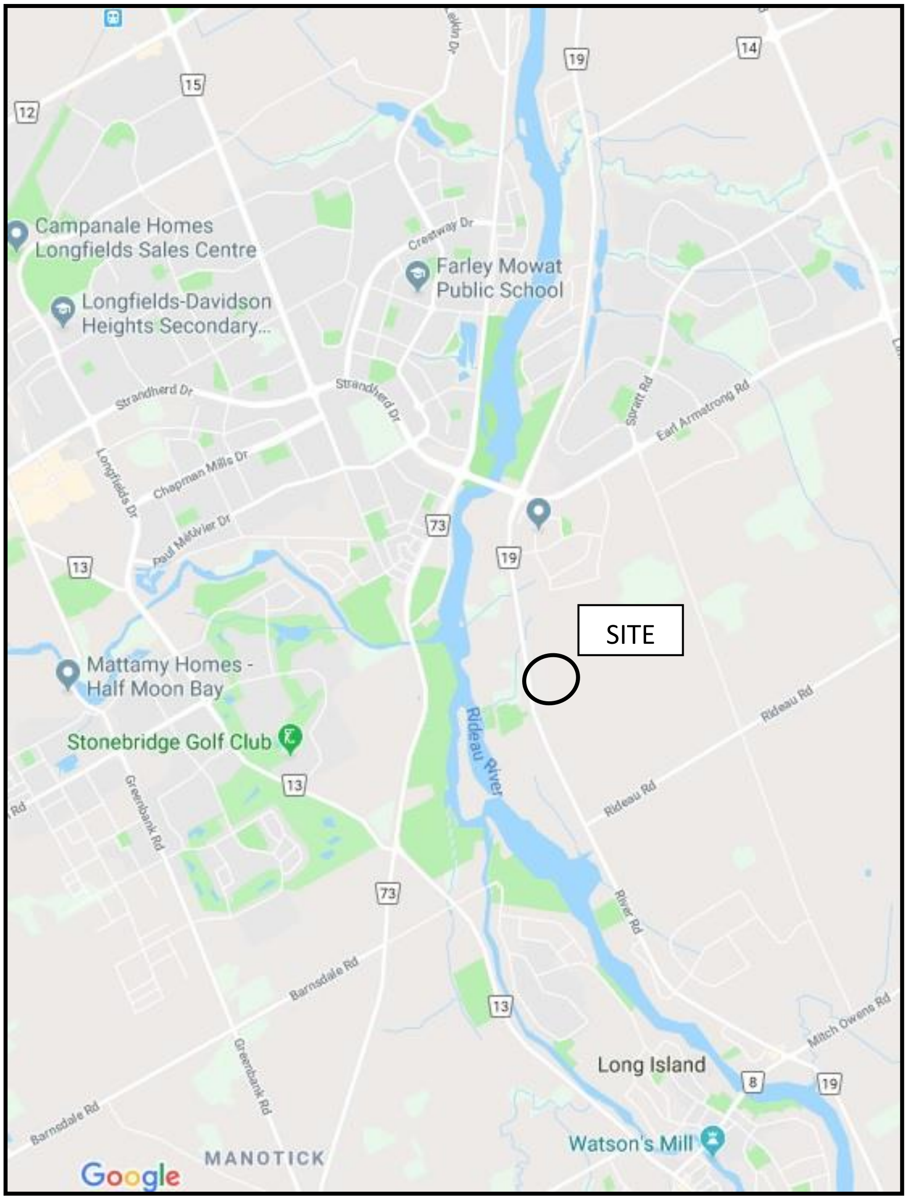


FIGURE 1

KEY PLAN

patersongroup

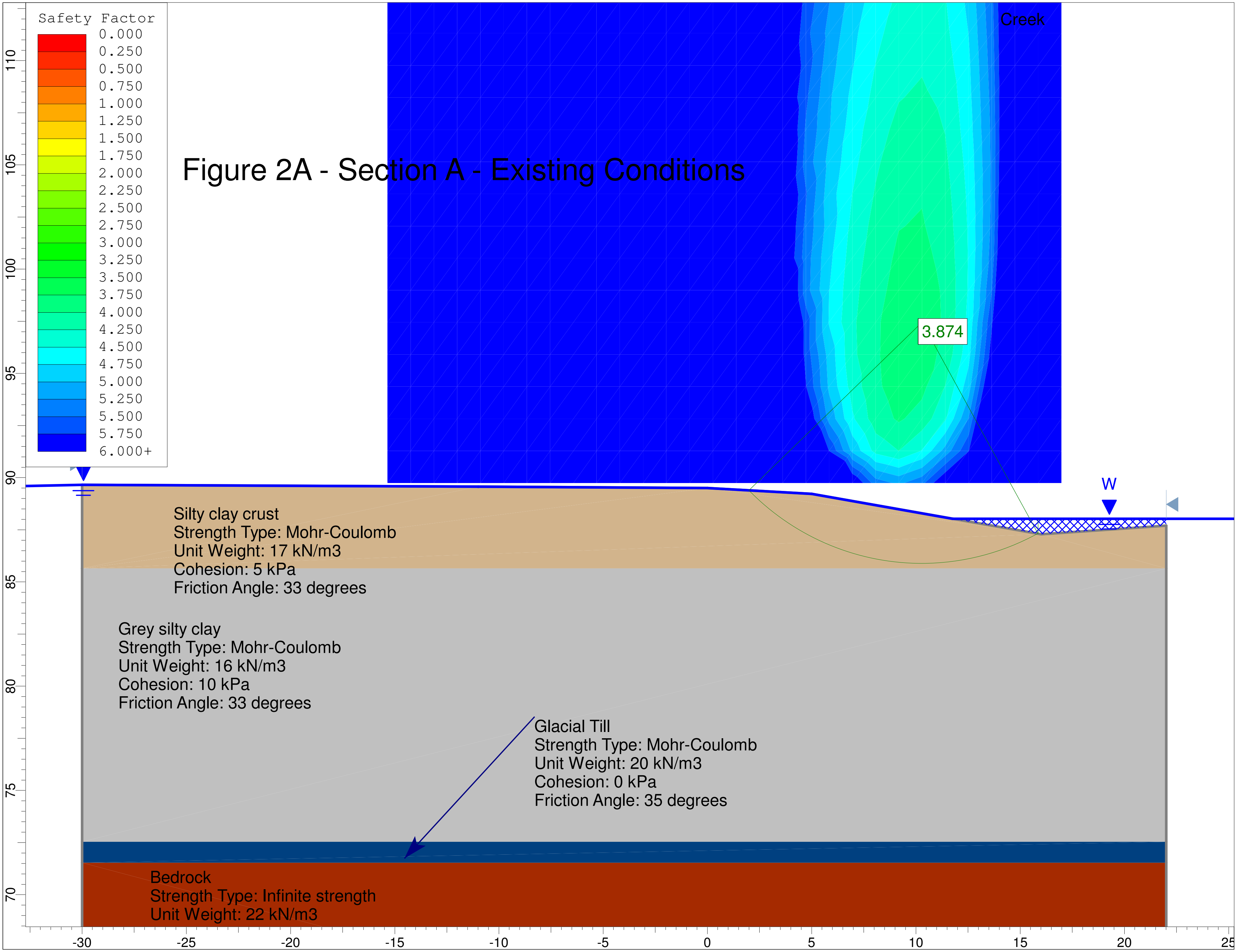


Figure 2A - Section A - Existing Conditions

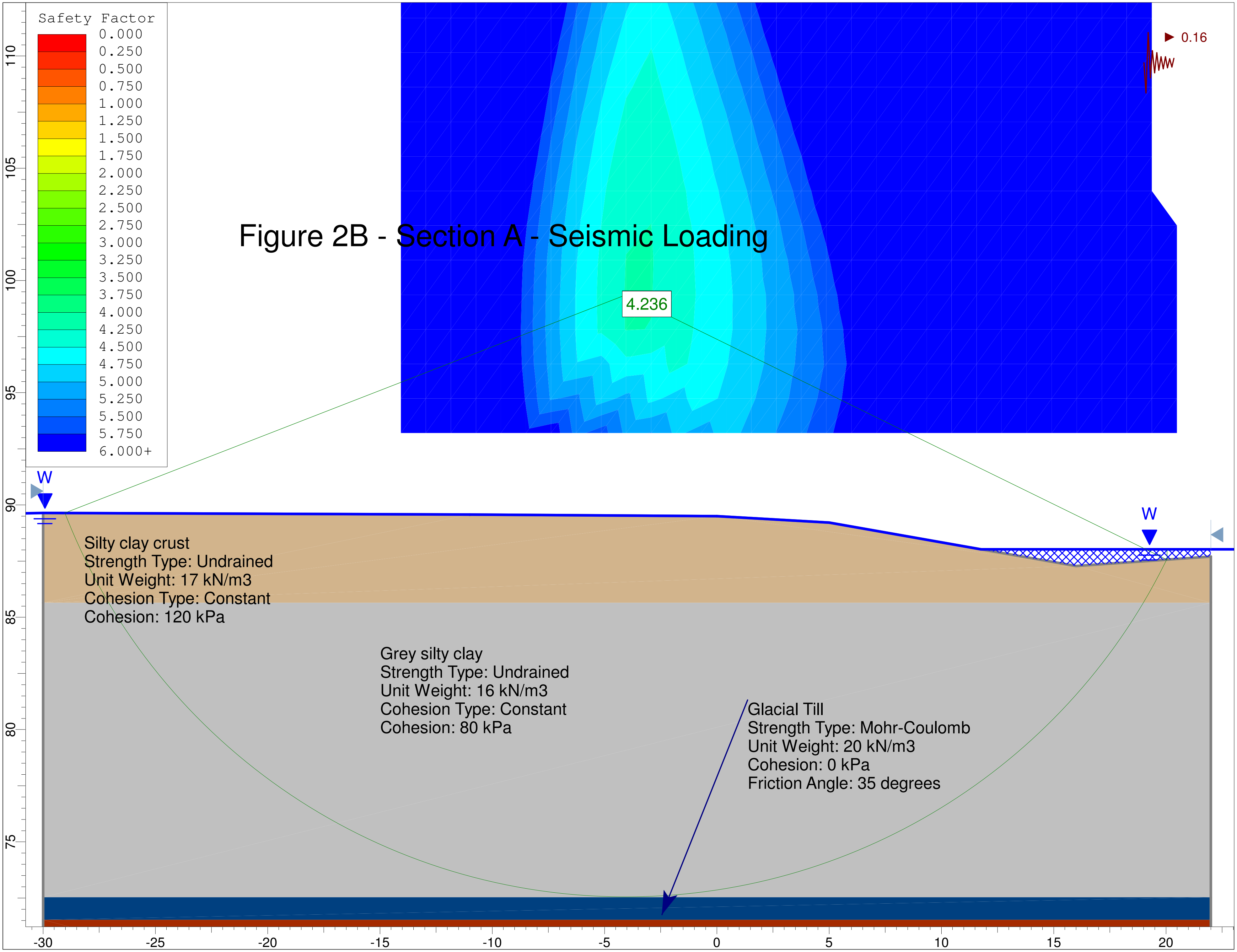


Figure 2B - Section A - Seismic Loading

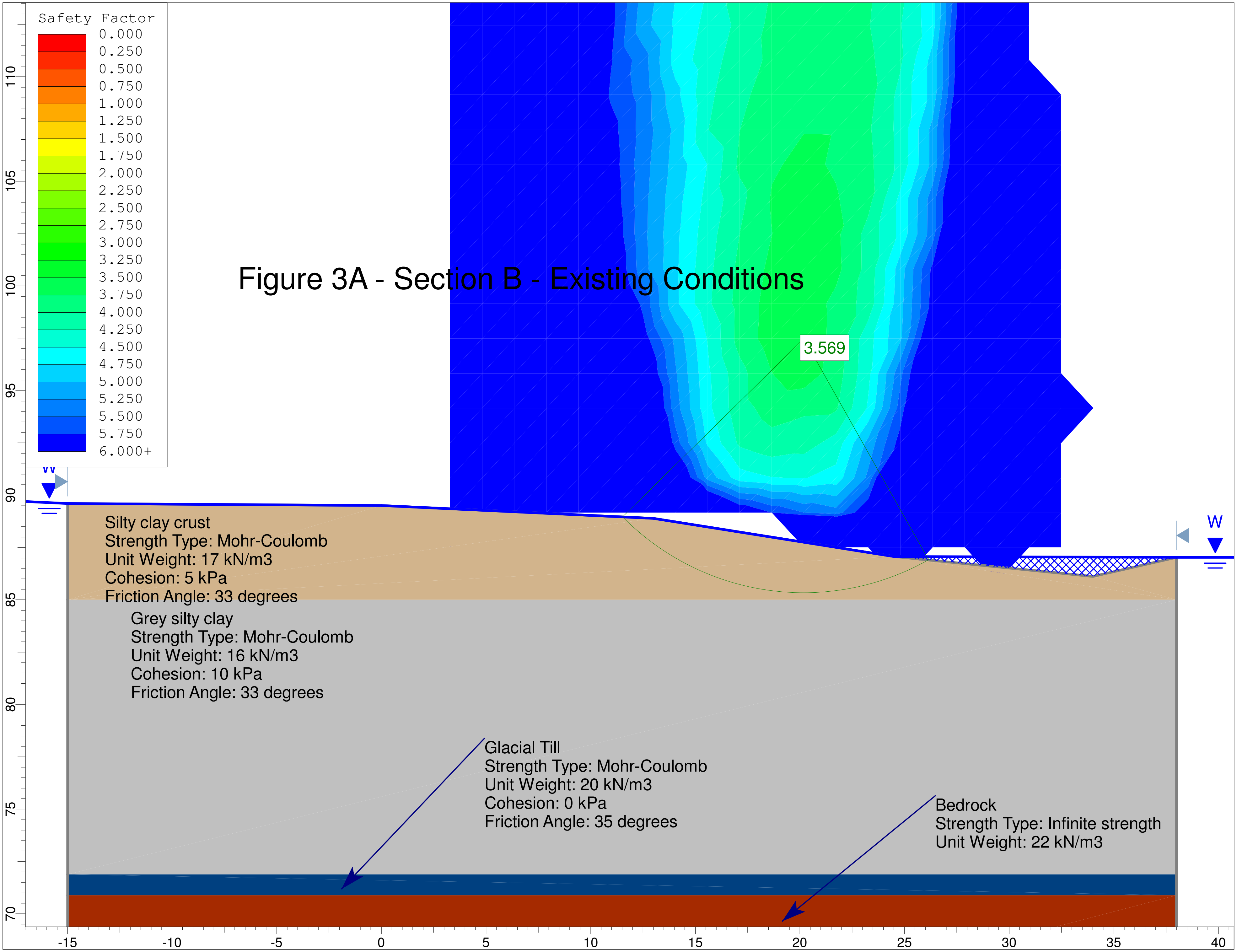


Figure 3A - Section B - Existing Conditions

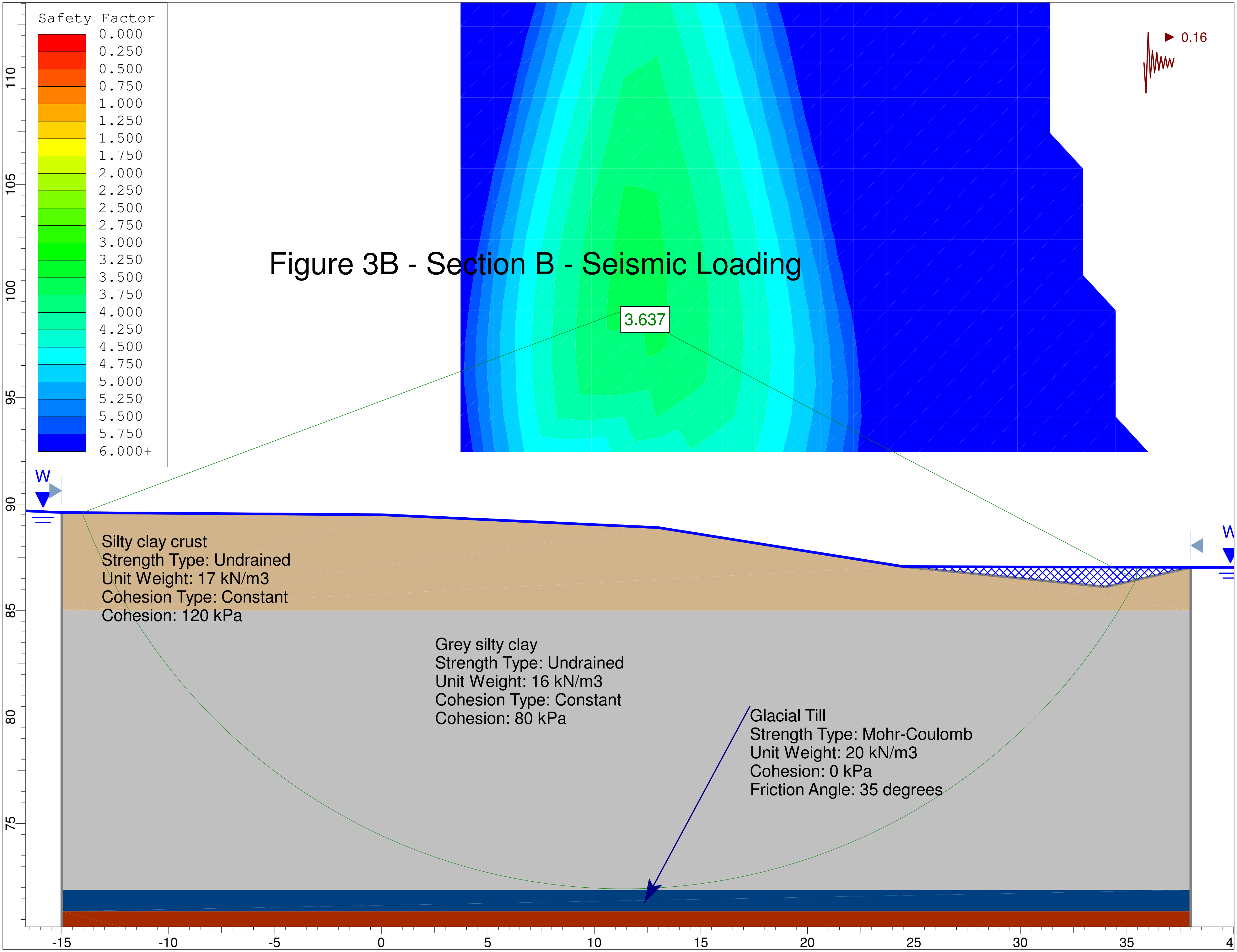
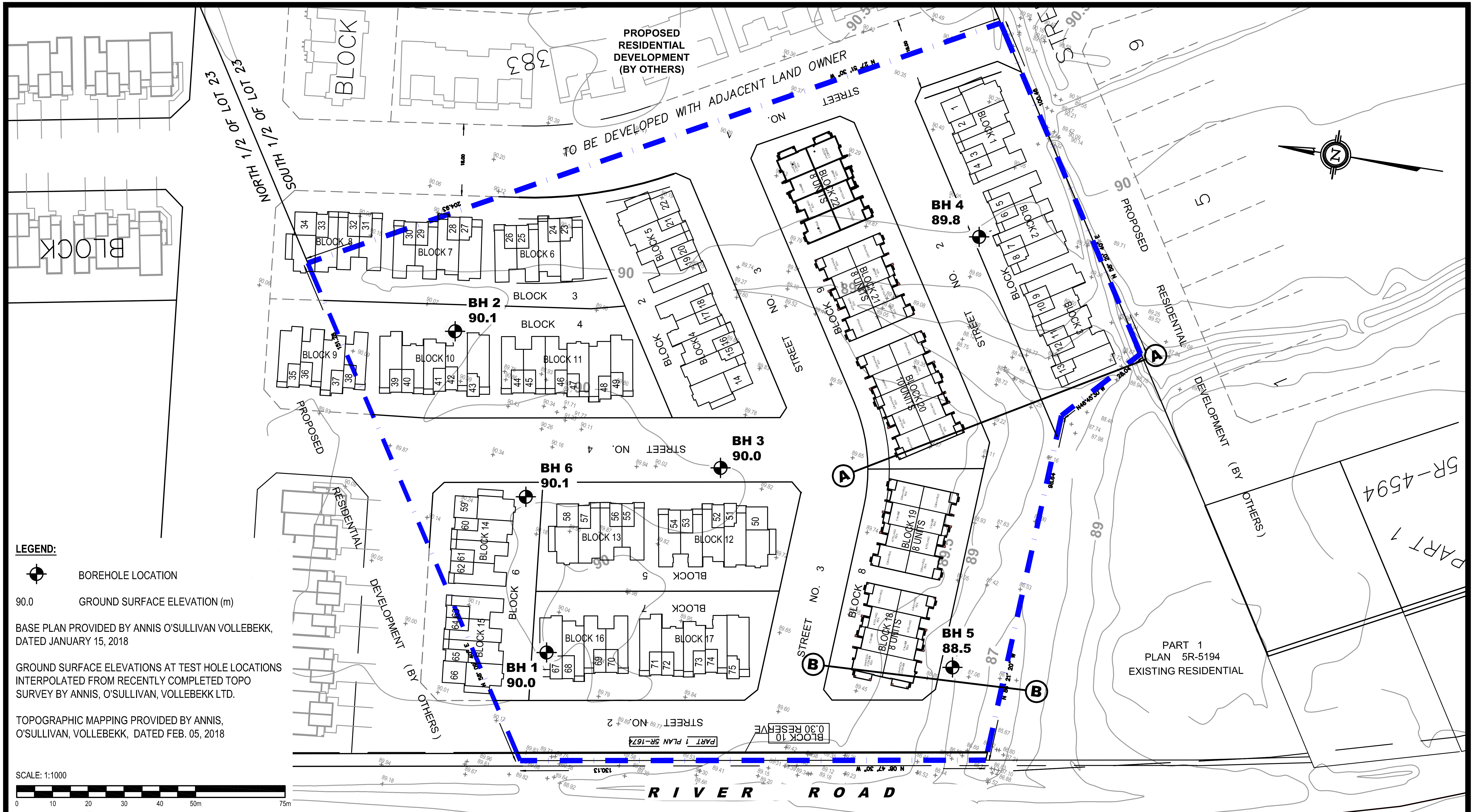


Figure 3B - Section B - Seismic Loading



LEGEND:

⊕	BOREHOLE LOCATION
90.0	GROUND SURFACE ELEVATION (m)

BASE PLAN PROVIDED BY ANNIS O'SULLIVAN VOLLEBEKK, DATED JANUARY 15, 2018

GROUND SURFACE ELEVATIONS AT TEST HOLE LOCATIONS INTERPOLATED FROM RECENTLY COMPLETED TOPO SURVEY BY ANNIS, O'SULLIVAN, VOLLEBEKK LTD.

TOPOGRAPHIC MAPPING PROVIDED BY ANNIS, O'SULLIVAN, VOLLEBEKK, DATED FEB. 05, 2018

SCALE: 1:1000

0 10 20 30 40 50m 75m

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

RICHCRAFT GROUP OF COMPANIES

GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVELOPMENT
879 RIVER ROAD

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1000
Date: 01/2018
Drawn by: RCG
Report No.: PG4402-1
Checked by: FA
Dwg. No.: PG4402-1
Approved by: FA
Revision No.: 0

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