Geotechnical Investigation

Proposed Church

3555 Borrisokane Road
Ottawa, Ontario

Prepared for Ottawa Korean Community Church

Report PG6842-2 dated November 3, 2023

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Ottawa Korean Community Church to prepare a geotechnical investigation report for the proposed church to be located at 3555 Borrisokane Road, Ottawa, Ontario (refer to Figure 1 - Key Plan presented in Appendix 1).

The objective of the geotechnical investigation was to:

- determine the subsoil and groundwater conditions at the site by means of boreholes.
- provide geotechnical recommendations for the design of the proposed church including construction considerations which may affect its design.

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

2.0 Proposed Development

The subject site is currently undeveloped and consists of a formerly agricultural land which has been used for stockpiling backfill material during construction of neighbouring subdivisions. Based on the available conceptual drawings, it is anticipated that the proposed development will consist of a slab-on-grade type of construction building with associated at-grade parking areas, and sidewalk areas. It is further anticipated that the proposed development will be municipally serviced.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

Historical boreholes were completed by Paterson within the subject site, as part of the geotechnical investigation pertaining to a previous residential development plan within the subject area. The field programs for the original geotechnical investigations for the residential subdivision were carried out from 2003 through 2012. A total of five (5) boreholes are found to be located within the subject site of the proposed church. The five boreholes were advanced to a maximum depth of 15.2 m below the existing ground surface. The test hole locations are presented on Drawing PG6504-1 - Test Hole Location Plan included in Appendix 2.

The borehole was completed using a low clearance drill rig operated by a two-person crew. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer from the geotechnical division. The drilling procedure consisted of drilling to the required depths at the selected locations, sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split spoon (SS) sampler, or using 73 mm diameter thin walled (TW) Shelby tubes in conjunction with a piston sampler. The split-spoon and grab samples were placed in sealed plastic bags and the Shelby tubes were sealed at both ends on site. All samples were transported to our laboratory for further examination and classification. The depths at which the split-spoon, grab and Shelby tube samples were recovered from the boreholes are shown as SS, G 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 carried out in cohesive soils using a field vane apparatus.

Overburden thickness was also evaluated during the course of the investigation by completing a dynamic cone penetration test (DCPT) at BH10-05 and BH 1. 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.

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

Groundwater

Flexible polyethylene standpipes were installed in all boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. The groundwater observations are discussed in subsection 4.3 and presented in the Soil Profile and Test Data Sheets in Appendix 1

3.2 Field Survey

The test hole locations along with ground surface elevations were determined in the field by J.D. Barnes Limited, ASL, and Paterson. It is understood that the ground surface elevations at the borehole locations are referenced to a geodetic datum. The location of the test holes is presented on Drawing PG6842-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. A total of one (1) sample was submitted for Atterberg Limits testing, and two (2) Shelby tube samples were submitted for unidimensional consolidation testing. The results are presented in Subsection 4.2 and enclosed in Appendix 1.

3.4 Analytical Testing

Three (3) soil samples from nearby boreholes were submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures by others.

The samples were submitted to determine the concentration of sulphate and chloride, the resistivity, and the pH of the samples. The results are presented in Appendix 1 and discussed further in Subsection 6.7

4.0 Observations

4.1 Surface Conditions

The subject site is currently undeveloped and covered with vegetation. Based on aerial images, it is understood that the site consists of a formerly agricultural land which has been used for stockpiling backfill material during construction of neighbouring residential subdivisions. It is further understood that the original vegetation cover and shrubs have been stripped off from the subject site Furthermore, several piles of fill material and tree roots were hauled into and out of the site over the past ten years. However, the majority of the fill piles have been removed from most of the site by 2021, with the exception of a remaining fill pile which was kept within the northwest portion of the site. In addition, a 1m deep ravine with slow water flow was observed to be located along the southern portion of the subject site, and within the footprint of the proposed building.

The subject site is bordered by Flagstaff Drive followed by a future residential development to the north, a recently constructed shallow water channel followed by a future residential development to the east, a treed undeveloped property to the south, and by Borrisokane Road followed by an agricultural land to the west.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile observed at the test hole locations at the time of the historical geotechnical investigation consists of topsoil/fill underlain by silty sand to silty clay, followed by a deep deposit of firm grey silty clay overlying glacial till. However, following the past construction works within the neighbouring region, fill material of varying thicknesses might be anticipated at some locations within the subject site.

Practical refusal to the DCPT was encountered at depth of about 18.57m and 17.53 in boreholes BH 10-05 and BH 1, respectively.

Bedrock

Based on available geological mapping, the site is located in an area where the bedrock consists of Dolomite of the Oxford Formation, with an overburden drift thickness of 15 to 25m.

Atterberg Limit Tests

One selected silty clay sample was submitted for Atterberg Limit testing. The test results indicate that low plasticity silty clays are anticipated at the subject site. The results are summarized in Table 1 and presented in Appendix 1.

Table 1 - Summary of Atterberg Limits Test Results

Test Hole	Sample No.	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
BH 10-05	TW5	37	19	18

4.3 Groundwater

Groundwater levels were measured in the installed piezometers during the geotechnical investigation. The groundwater level readings are presented in the Soil Profile and Test Data sheets in Appendix:

It is important to note that groundwater level readings could be influenced by surface water infiltrating the backfilled borehole. Long-term groundwater levels can also be estimated based on recovered soils samples moisture levels and recovered soil sample coloring and consistency. Based on the existing groundwater information and our knowledge of the groundwater within the area, the long-term groundwater level is estimated to be at **2** to **4 m** depth below the existing grade.

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 Geotechnical Assessment

The subject site is considered suitable for the proposed church. It is expected that the proposed church will be founded using conventional shallow footings placed over an undisturbed, compact silty sand or firm to stiff silty clay bearing surface.

For structures founded on the undisturbed silty sand formation, and where the encountered silty sand bearing surface is observed to be in a loose state of compactness, proof rolling using a suitable sized roller shall be completed.

Due to the presence of the sensitive silty clay deposit, the site will be subjected to grade raise restrictions. If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill and/or other measures should be investigated to reduce the risks of unacceptable long-term post construction total and differential settlements.

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

5.1 Site Grading and Preparation

Stripping Depth

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

Fill Placement

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

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids.

If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. 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.

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

Ravine Backfilling Recommendations

Based on our review of the topographic survey information presented on the grading plans and on our field observations, an existing ravine is currently located along the southern property boundary, and within the footprint of the proposed building. The approximate geodetic elevation of the bottom of the ravine is 91.55 to 91.66m. Based on our review of the grading plans, it is understood that the finish floor elevation for the proposed building will be at a geodetic elevation of 93.05m. The USF of the proposed building is not known however, it is anticipated to be at approximate geodetic elevation of 91.55m. Therefore, several footings will be located at the bottom of the ravine. In this case, the ravine will be required to be drained, cleaned of debris (as detailed in proceeding sections) and the ground surface raised to support the proposed building foundation structure.

The following backfilling program is recommended for development within the ravine areas. Our backfilling recommendations take into consideration the subsoils profile within the ravine area and proposed finished grading at the proposed building. The ravine should be drained before the backfilling procedure begins and the backfilling operation should be completed under dry weather conditions (specifically for the clay placement portion of the program) and above freezing temperatures.

- ❑ The ravine side slopes should be stepped to provide a 1.5H:1V profile with maximum 500 mm high steps. All existing topsoil, sediment and fill associated with the ravine should be removed.

- ❑ A workable, stiff brown silty clay (moisture contents varying between 20 to 40%) should be placed in maximum 300 mm loose lifts under dry conditions and in above freezing temperatures to in-fill the ditch. Every lift should be adequately compacted using a sheepsfoot roller and approved by Paterson personnel during placement.

- ❑ For Building areas, a woven geotextile liner such as Terrafix 200W or equivalent should be placed directly above the compacted silty clay backfill material. A minimum 300 mm thick layer of suitable granular backfill such as OPSS Granular A should be placed directly below USF for the proposed building. The engineered granular fill layer should be placed in maximum 300 mm thick loose lifts and compacted to a minimum 98% of the material's SPMDD using suitable compaction equipment and approved by Paterson at the time of placement. This may result in surface water pooling within the granular pad located below the finished floor slabs which may increase humidity. Therefore, it is recommended that a damp-proofing membrane be placed below the floor slabs to reduce the anticipated humidity.

- ❑ Where granular fill is required below only a portion of the proposed building footprint, the remainder of the building footprint should be sub-excavated an approximately uniform thickness below underside of footing as the other side of the building. The sub-excavation should extend at least 1 m beyond the building perimeter. A woven geotextile liner, such as Terrafix 200W (or equivalent other approved by Paterson) should be placed across the base of the sub-excavated area. A biaxial geogrid liner, such as Terrafix TBX1500 (or equivalent other approved by Paterson), should be placed over the geotextile liner and extend at least 1 m beyond the building footprint. The sub-excavated area should be backfilled with granular fill, consisting of a Granular B Type II or Granular A crushed stone placed in maximum 300 mm loose lifts and compacted to 98% of its SPMDD. These layers should wrap across the top of the granular layer and extend a minimum of 1 m into the building footprint and past the interior perimeter footing face.

- For right of way (ROW) areas, up to a maximum of 1 m of engineered fill, such as OPSS Granular A or Granular B crushed stone and/or well-graded blast rock, up to 150 mm in particle size, may be used to in-fill the ravine up to the spring line elevation of the proposed services, where applicable. The engineered fill should be placed in maximum 300 mm loose lifts under dry conditions, compacted to a minimum 98% of the material's SPMDD using suitable compaction equipment and approved by Paterson at the time of backfilling.

- Where more than 1 m of in-filling is required, a workable brown silty clay, free of organics and deleterious fill is to be placed from the bottom of the ditch up to approximately 1 m below the invert elevation of the proposed services. The silty clay is to be placed in maximum 400 mm thick loose lifts and compacted to a minimum 98% of the material's SPMDD using a sheepsfoot roller making several passes, under dry conditions and above freezing temperatures and approved by Paterson personnel.

- Inspections During Construction: Periodic inspections during the backfilling operation should be completed by Paterson personnel to confirm the above noted recommendations are adhered to.

Proof Rolling

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. Any loose or disturbed areas within the subgrade level, below the proposed footings is recommended to be proof-rolled under dry conditions and above freezing temperatures by an adequately sized roller making several passes to achieve optimum compaction levels. The compaction program should be reviewed and approved by the geotechnical consultant. In poor performing areas, consideration may be given to removing the poor performing soil and replace with an approved engineered fill such as OPSS Granular A or Granular B Type II compacted to a minimum 98% of the material's SPMDD.

5.2 Foundation Design

Bearing Resistance Values (Conventional Shallow Foundation)

Footings placed on an undisturbed, soil bearing surface can be designed using the following bearing resistance values provided in Table 2 below.

Table 2 - Bearing Resistance Values		
Bearing Surface	**Bearing Resistance Values (kPa)**	
	SLS	**ULS**
Compact Silty Sand	75	120
Firm Silty Clay	60	100
Stiff Silty Clay	100	150
Note: Strip and pad footings, up to 3 m wide, can be designed using the bearing resistance values provided for an undisturbed, silty clay bearing surface.		

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

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 prior to the placement of concrete for footings.

Footings bearing on an undisturbed soil bearing surface and designed using the bearing resistance values provided herein, will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively.

Where the silty sand bearing surface is found to be in a loose state of compactness, the area should be proof-rolled using a suitably sized vibratory compactor completing several passes, and approved by the geotechnical consultant prior to placing 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 stiff to firm 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 Recommendations

Based on the undrained shear strength values of the silty clay deposit encountered within the vicinity of the subject site, the **permissible grade raise of 1.0 m** is recommended for finished grading within 6 m of the proposed building footprint. A **permissible grade raise of 1.5 m** can be used only for the grading of parking areas, access roads, and landscaping areas. The final grading plans for the development should be reviewed by Paterson.

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. Provided sufficient time is available to induce the required settlements, consideration could be given to surcharging the subject site.

5.3 Design for Earthquakes

The site class for seismic site response can be taken as **Class E** for foundations constructed at the subject site. The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 Ontario Building Code for a full discussion of the earthquake design requirements.

5.4 Slab-on-Grade Construction

With the removal of all topsoil and deleterious fill, containing significant amounts of organic matter, within the footprints of the proposed building, undisturbed existing material, reviewed and approved by Paterson, will be considered acceptable subgrade on which to commence backfilling for floor slab construction.

The upper 200 mm of sub-slab fill should consist of an OPSS Granular A crushed stone. All backfill material within the footprint of the proposed buildings should be placed in a maximum 300 mm thick loose lifts and compacted to at least 98% of its SPMDD. 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.

5.5 Pavement Structure

The pavement structures presented in the following tables could be used for the design of parking areas and access lanes.

Table 3 - Recommended Pavement Structure – Parking Areas

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

Table 4 - Recommended Pavement Structure – Access Lanes

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

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

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 98% 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.

For areas where silty clay is encountered at subgrade level, it is recommended that subdrains be installed during the pavement construction as per City of Ottawa standards. The subdrain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

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.

Foundation Backfilling

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

Concrete Sidewalks and Walkways

Backfill material below sidewalks and walkway subgrade areas throughout the subject site, including along the building, should be provided with a minimum 300 mm thick layer of OPSS Granular A or OPSS Granular B Type II crushed stone. This material should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 98% of the materials SPMDD. The subgrade for walkway structures against the building should be shaped to promote drainage towards the buildings perimeter drainage system.

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 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 soil and fill 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 excavation to be undertaken by open-cut methods (i.e., unsupported excavations).

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

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe, should consist of OPSS Granular A or Granular B Type II with a maximum size of 25 mm. The bedding layer should be increased to a minimum thickness of 300 mm where the subgrade consists of grey silty clay.

The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to 99% of the material's standard Proctor maximum dry density.

It should generally be possible to re-use the upper portion of the dry to moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Any stones greater than 200 mm in their longest dimension should be removed from these materials prior to placement.

The backfill material within the frost zone (about 1.5 m below finished grade) should match the soils exposed at the trench walls to reduce potential differential frost heaving. The backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD.

Clay Seals

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, sub-bedding 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

It is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations. For deeper excavations in the sandy formation, higher infiltration rates may be encountered.

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.

A temporary Ministry of the Environment, Conservation and Parks (MECP) 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 MECP.

6.6 Winter Construction

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

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

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

6.7 Corrosion Potential and Sulphate

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

6.8 Landscaping Considerations

Tree Planting Restrictions

In accordance with the City of Ottawa Tree Planting in Sensitive Marine Clay Soils (2017 Guidelines), Paterson completed a soils review of the site to determine applicable tree planting setbacks. Atterberg limits testing was completed for recovered silty clay samples at selected locations throughout the subject site. The result of our testing is presented in Table 1 in Subsection 4.2 and in Appendix 1. Based on the results of our review, the encountered clays at the subject site are classified as low/medium sensitivity clay soils as per City Guidelines at the subjected site. Based on our Atterberg Limits test results, the plasticity index limit generally does not exceed 40%.

Based on our review, the following tree planting setbacks are recommended for footings supported on the low to medium sensitivity area. Large trees (mature height over 14 m) can be planted within this area 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). The tree planting setback limits may be reduced to 4.5 m for small (mature tree height up to 7.5 m) 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 center of the tree trunk and verified by means of the Grading Plan.
- ❑ A small tree must be provided with a minimum of 25 m^3 of available soils 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 surrounds the tree must promote drainage to the tree root zone. This should be confirmed by the landscape architect and civil engineer.

7.0 Recommendations

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

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

All excess soils, with the exception of engineered crushed stone fill, generated by construction activities that will be transported on-site or off-site should be handled as per *Ontario Regulation 406/19: On-Site and Excess Soil Management.*

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

8.0 Statement of Limitations

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

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

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

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Ottawa Korean Community Church 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
Nov. 3, 2023
M. SALEH
100507739
PROVINCE OF ONTARIO

Ghada Ali, EIT

Maha K. Saleh, M.A.Sc., P.Eng.

Report Distribution:

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❑ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ATTERBERG LIMIT TESTING RESULTS

UNIDIMENSIONAL CONSOLIDATION TEST RESULTS

ANALYTICAL TESTING RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half-Moon Bay West - Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

REMARKS

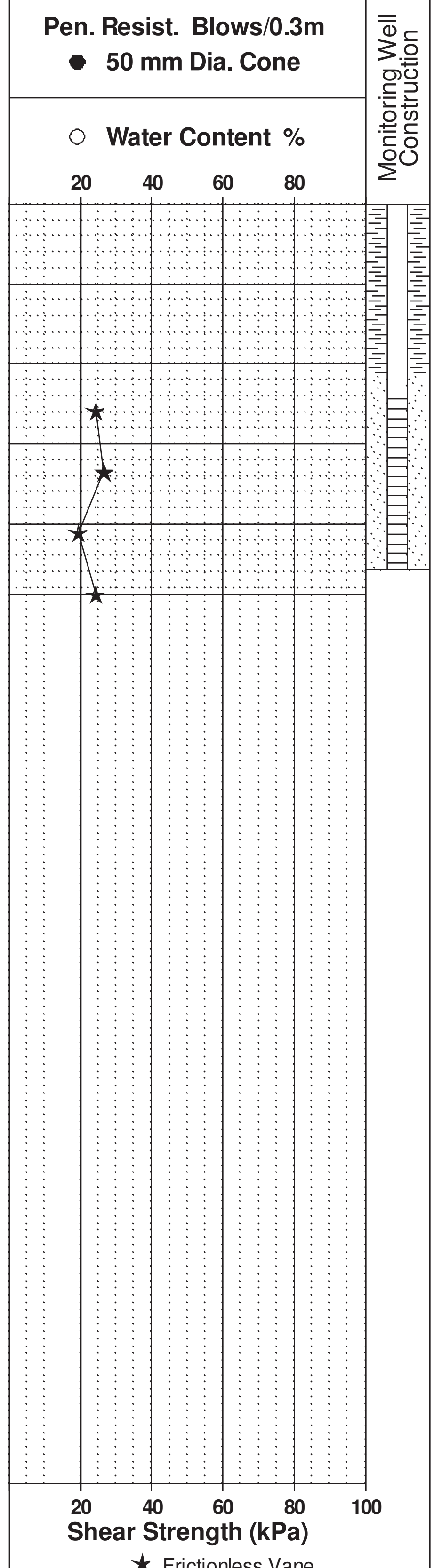
BORINGS BY CME 55 Power Auger

DATE March 5, 2012

FILE NO. PG2246

HOLE NO. BH13-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.94
PEAT 0.30							
Very loose, brown **SILTY SAND** with clay 1.52		SS	1	12	3	1	90.94
Soft, grey **SILTY CLAY**		SS	2	50	1	2	89.94
						3	88.94
4.88						4	87.94
End of Borehole							



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half-Moon Bay West - Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

FILE NO. PG2246

REMARKS

HOLE NO. BH14-12

BORINGS BY CME 55 Power Auger **DATE** March 5, 2012

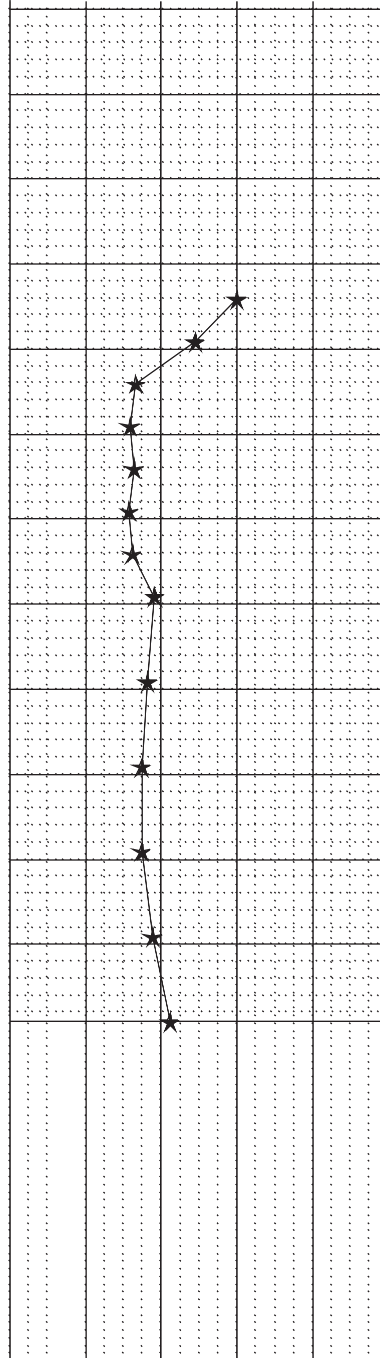
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.62
FILL: Brown silty sand with gravel and cobbles		SS	1			1	92.62
1.83						2	91.62
Stiff, brown **SILTY CLAY** with sand		SS	2		4	3	90.62
3.90						4	89.62
Firm, grey **SILTY CLAY**						5	88.62
						6	87.62
						7	86.62
						8	85.62
						9	84.62
						10	83.62
						11	82.62
11.91							
End of Borehole							

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

○ Water Content %

20 40 60 80

Monitoring Well Construction



20 40 60 80 100
Shear Strength (kPa)
★ Frictionless Vane

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

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

REMARKS

BORINGS BY CME 75 Power Auger

DATE 10 January 2007

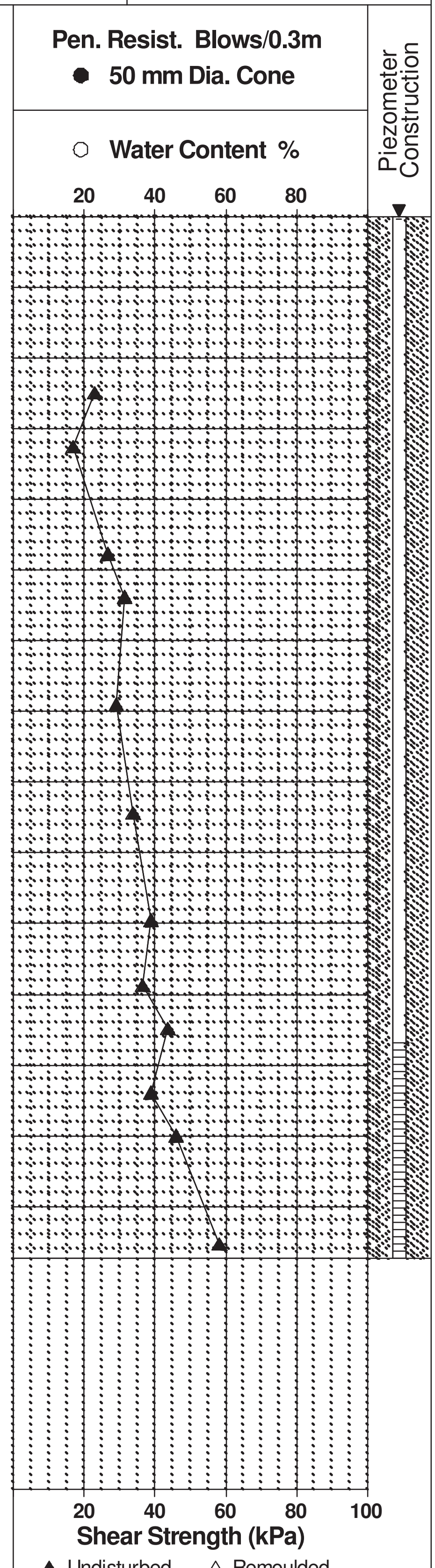
FILE NO. PG0177

HOLE NO. BH22-06

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.95
TOPSOIL 0.28							
Firm to soft, brown **SILTY CLAY** with sand		SS	1	75	5	1	90.95
		SS	2	0	4	2	89.95
- grey by 2.0m depth						3	88.95
- firm by 4.0m depth		TW	3	100		4	87.95
						5	86.95
		SS	4	100	1	6	85.95
						7	84.95
		TW	5	100		8	83.95
		SS	6		1	9	82.95
						10	81.95
						11	80.95
						12	79.95
						13	78.95
- stiff by 14.0m depth 14.73		SS	7	100	1	14	77.95

End of Borehole

(GWL @ 400mm above ground surface - Feb. 5/07)



patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

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

FILE NO. PG0177

REMARKS

HOLE NO. BH10-05

BORINGS BY CME 55 Power Auger

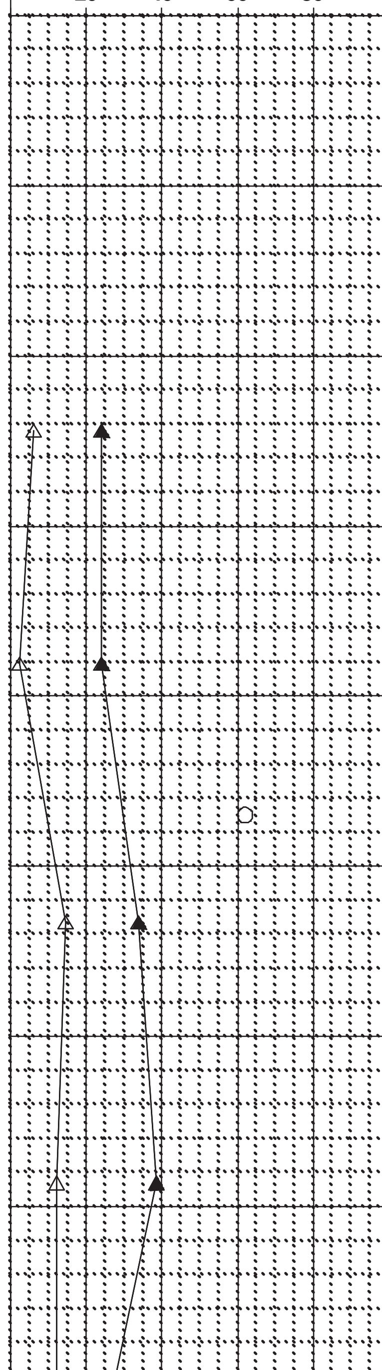
DATE 28 June 2005

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.66
TOPSOIL 0.27							
Compact, brown **SANDY SILT**, trace clay 0.70		AU	1				
Stiff to firm, brown **SILTY CLAY**, some fine sand		SS	2	25	4	1	90.66
		SS	3	67	1	2	89.66
- firm and grey by 2.0m depth							
						3	88.66
		SS	4	100	1	4	87.66
		TW	5	98		5	86.66
						6	85.66
		SS	6	100	1	7	84.66
		SS	7	100	1	8	83.66

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

○ Water Content %

20 40 60 80



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

Piezometer Construction

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

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

REMARKS

BORINGS BY CME 55 Power Auger **DATE** 28 June 2005

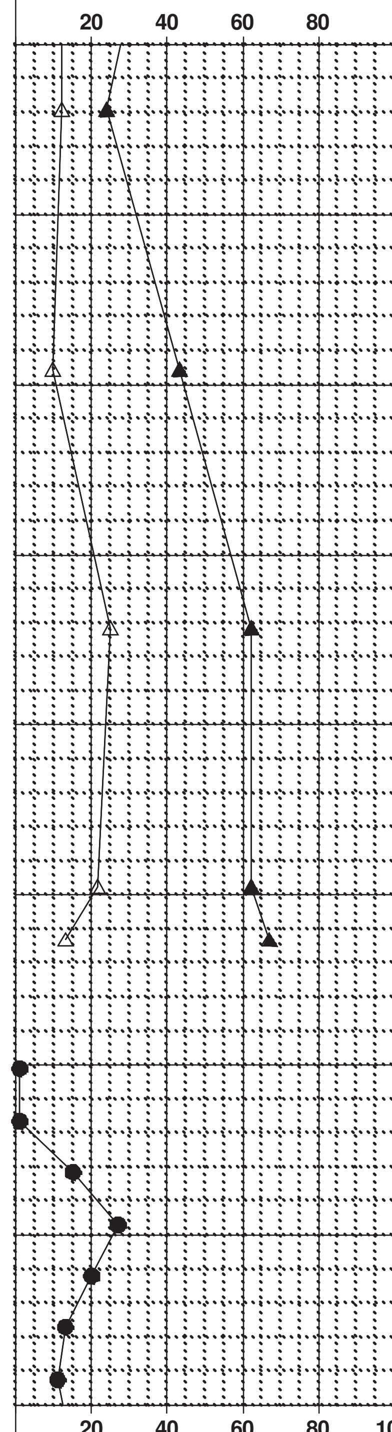
FILE NO. PG0177

HOLE NO. BH10-05

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						8	83.66
						9	82.66
Firm, grey **SILTY CLAY**		SS	8	100	1		
						10	81.66
- stiff by 10.7m depth		SS	9	100	1	11	80.66
						12	79.66
		SS	10	100	1		
13.41						13	78.66
Dynamic Cone Penetration Test commenced @ 13.41m depth							
Inferred **SILTY CLAY**						14	77.66
14.50							
Inferred **GLACIAL TILL**						15	76.66
						16	75.66

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

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

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

FILE NO. PG0177

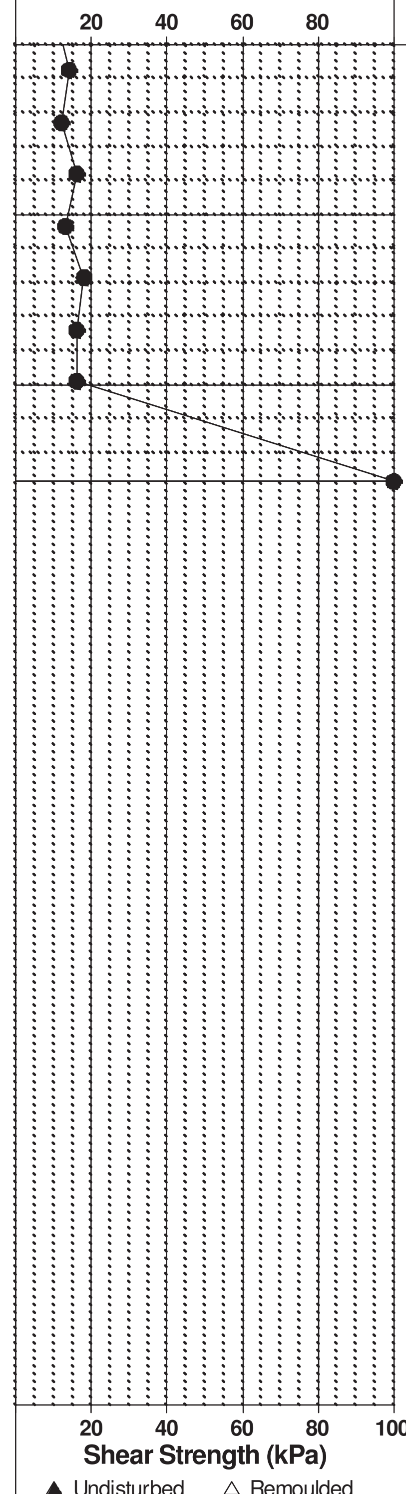
REMARKS

HOLE NO. BH10-05

BORINGS BY CME 55 Power Auger

DATE 28 June 2005

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						16	75.66		
						17	74.66		
Inferred **GLACIAL TILL**						18	73.66		
18.57									
End of Borehole DCPT refusal @ 18.57m depth									



patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Nepean South Lands, South of Jock River
Ottawa (Nepean), Ontario

DATUM

REMARKS

BORINGS BY CME 45 Power Auger

DATE 26 November 2003

FILE NO. G9132

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0			
Remoulded **SILTY CLAY** with organic matter (0.76)									
Firm, brown **SILTY CLAY**						1			▼
- soft and grey by 2.2m depth						2–3		○ ~43 (at ~2.8m)	
- firm by 5.6m depth						5–6			
- soil running up the augers upon removing auger plug starting @ 6.1m depth						6–7			
- soft by 7.0m depth						7–8			
- firm by 10.0m depth (15.24)						10–15			
Dynamic Cone Penetration Test commenced @ 15.24m depth						15–16			
Inferred **SILTY CLAY** (17.53)						17			
End of Borehole									
Cone refusal @ 17.53m depth									
(GWL @ 1.43m-Dec. 11/03)									

Shear Strength (kPa): 20 40 60 80 100

▲ 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 x D60)
Cu	-	Uniformity coefficient = D60 / D10

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

CONSOLIDATION TEST

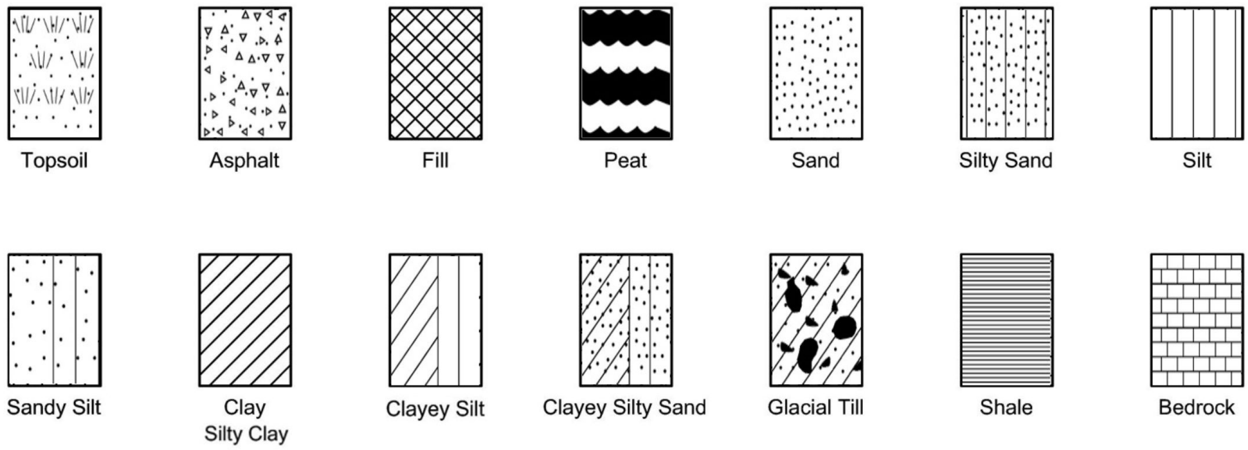
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

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

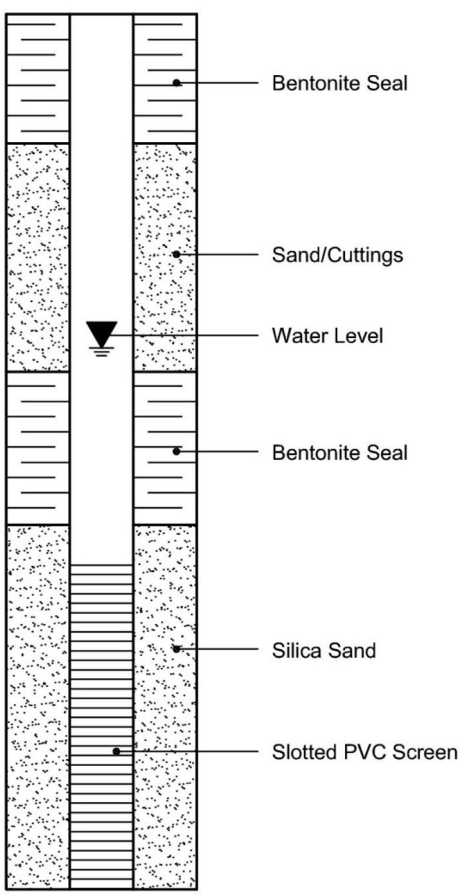
SYMBOLS AND TERMS (continued)

STRATA PLOT

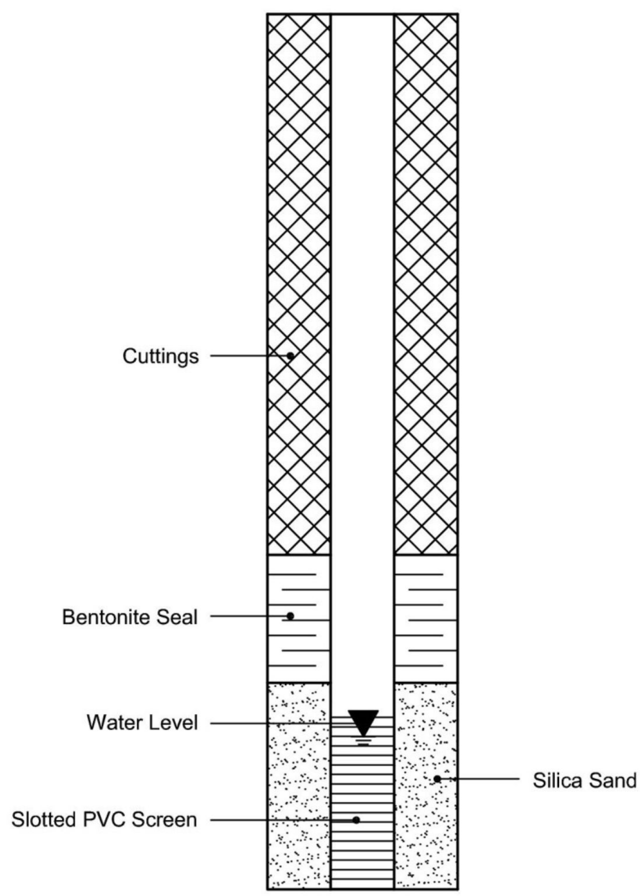


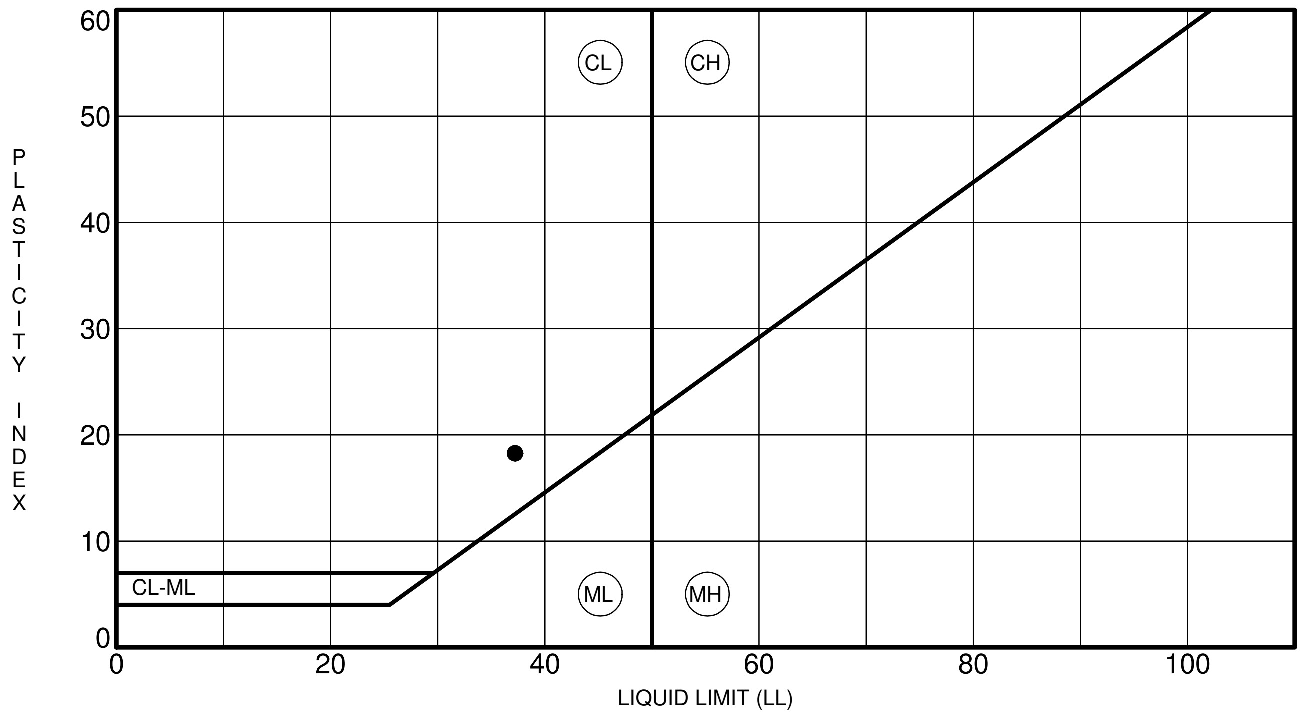
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





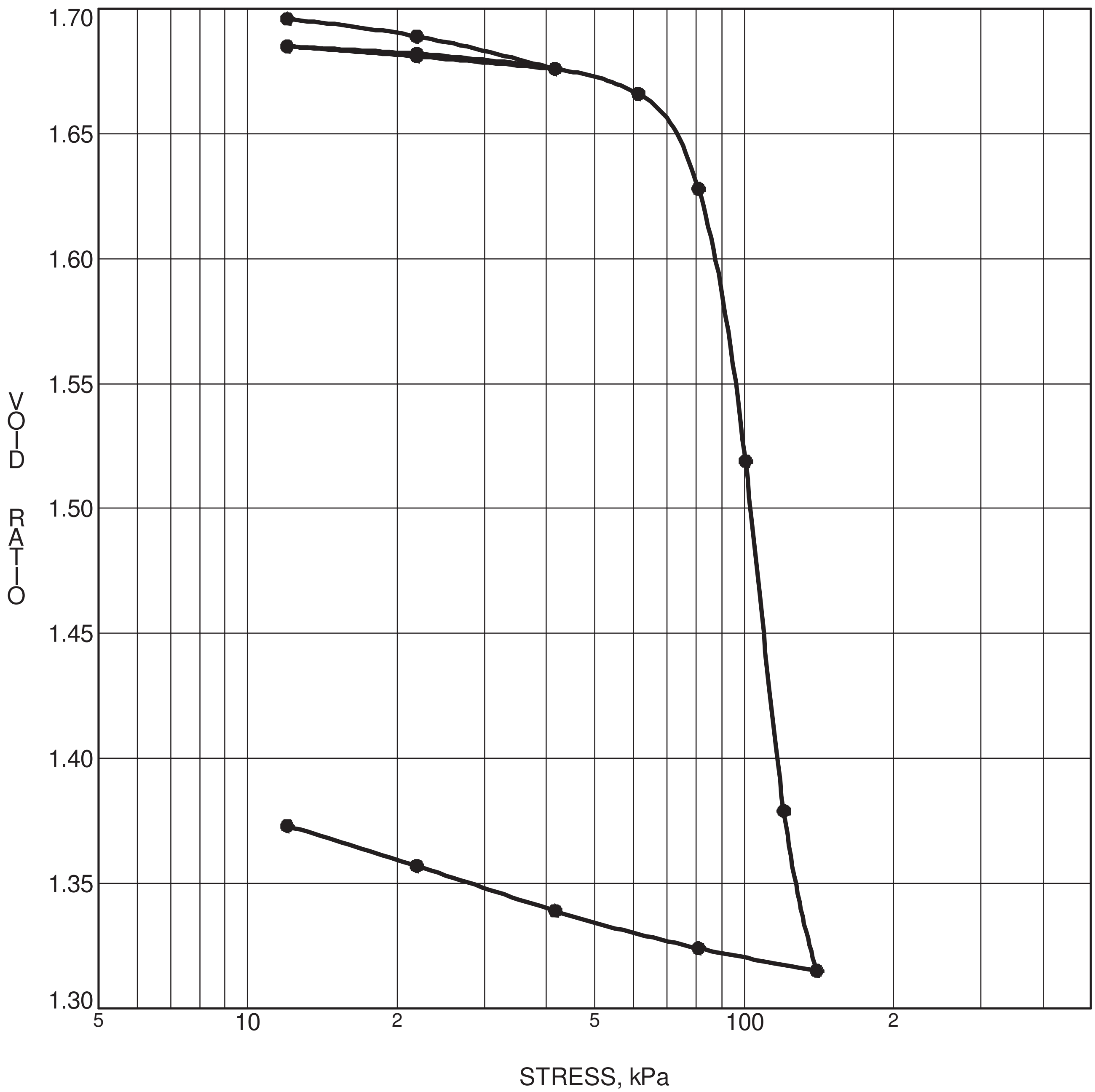
	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH10-05**	**TW 5**	**37**	**19**	**18**		**CL - Clays with low plasticity**

CLIENT	**Mattamy Homes**
PROJECT	**Geotechnical Investigation - Proposed Residential Development-Half Moon Bay**
FILE NO.	**PG0177**
DATE	**28 Jun 05**

patersongroup **Consulting Engineers**

9 Auriga Drive, Ottawa, Ontario K2E 7T9

ATTERBERG LIMITS' RESULTS



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH10-05**	p'$_o$	**48.2** kPa	Ccr	**0.017**
Sample No.	**TW 5**	p'$_c$	**82** kPa	Cc	**1.460**
Sample Depth	**4.70** m	OC Ratio	**1.7**	Wo	**62.0** %
Sample Elev.	**86.96** m	Void Ratio	**1.71**	Unit Wt.	**16.1** kN/m^3

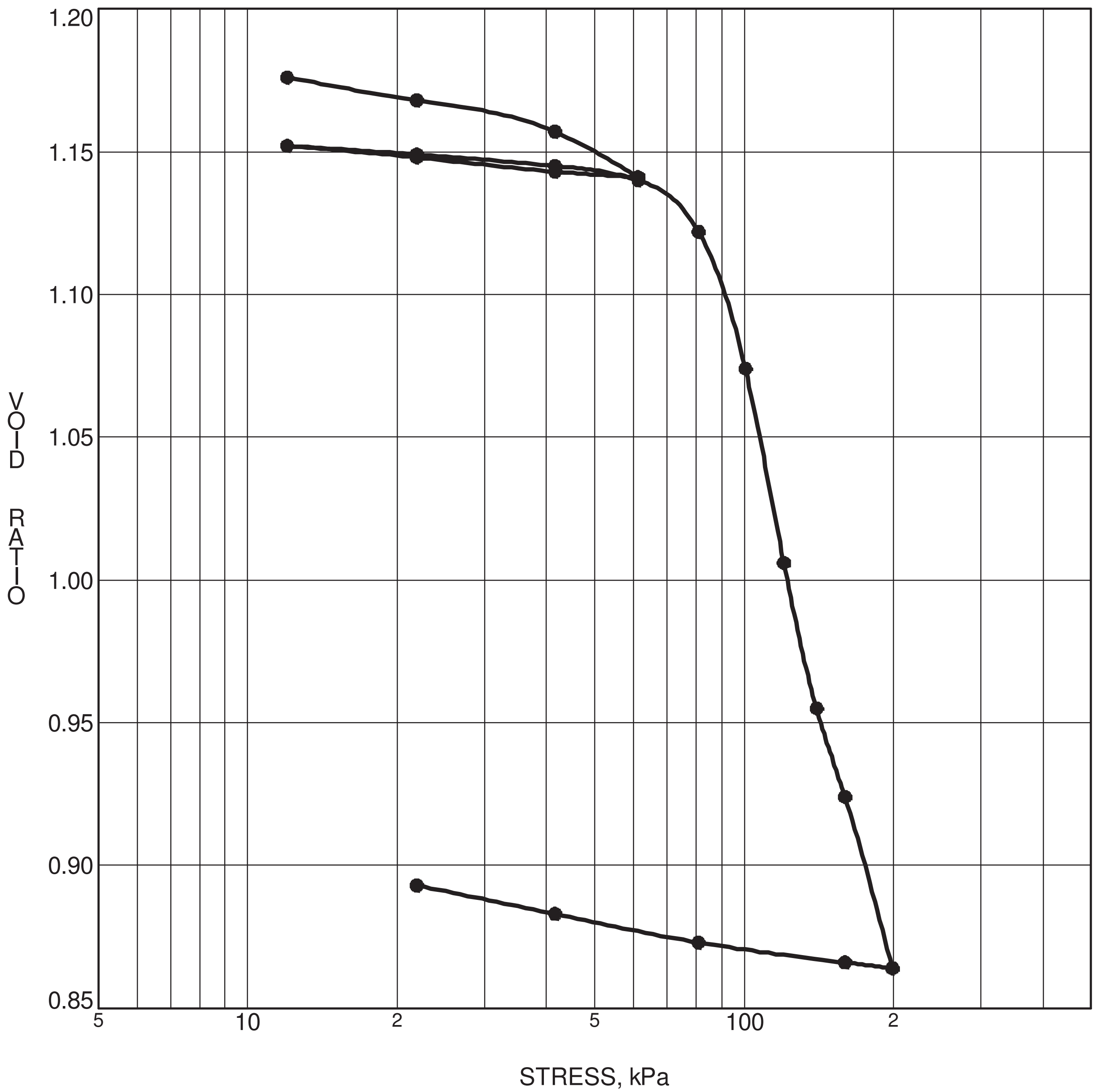
Note: Overburden stress calculated from original ground surface (91.76m)

CLIENT	**Mattamy Homes**	FILE NO.	**PG0177**
PROJECT	**Geotechnical Investigation - Proposed Residential Development-Half Moon Bay**	DATE	**07/15/2005**

patersongroup **Consulting Engineers**

28 Concouse Gate, Unit 1, Ottawa, Ontario K2E 7T7

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 1**	p'_o	**36.2** kPa	Ccr	**0.018**
Sample No.	**TW 4**	p'_c	**82** kPa	Cc	**0.702**
Sample Depth	**2.80** m	OC Ratio	**2.3**	Wo	**43.0** %
Sample Elev.	m	Void Ratio	**1.18**	Unit Wt.	**17.7** kN/m^3

Note: Overburden stress calculated from original ground surface (92.20m)

CLIENT **Brickland Timberlay**

FILE NO. **G9132**

PROJECT **Preliminary Geotechnical Investigation - Nepean South Lands, South of Jock River**

DATE **12/06/2003**

patersongroup **Consulting Engineers**

28 Concouse Gate, Unit 1, Ottawa, Ontario K2E 7T7

CONSOLIDATION TEST

PARACEL
LABORATORIES LTD.

Order #: 1112209

Certificate of Analysis

Report Date: 23-Mar-2011

Client: **Paterson Group Consulting Engineers**

Order Date:17-Mar-2011

Client PO: 10293

Project Description: PG2246

	Client ID:	BH 15-10 SS2	BH 9-10 SS4	BH 23-10 SS5	-
	Sample Date:	17-Mar-11	17-Mar-11	17-Mar-11	-
	Sample ID:	1112209-01	1112209-02	1112209-03	-
	MDL/Units	Soil	Soil	Soil	-
Physical Characteristics					
% Solids	0.1 % by Wt.	80.3	81.0	77.9	-
General Inorganics					
pH	0.05 pH Units	7.44	7.52	7.47	-
Resistivity	0.10 Ohm.m	54.1	46.3	10.7	-
Anions					
Chloride	5 ug/g dry	13	16	7	-
Sulphate	5 ug/g dry	55	134	548	-

APPENDIX 2

FIGURE 1 – KEY PLAN

DRAWING PG6842-1 – TEST HOLE LOCATION PLAN

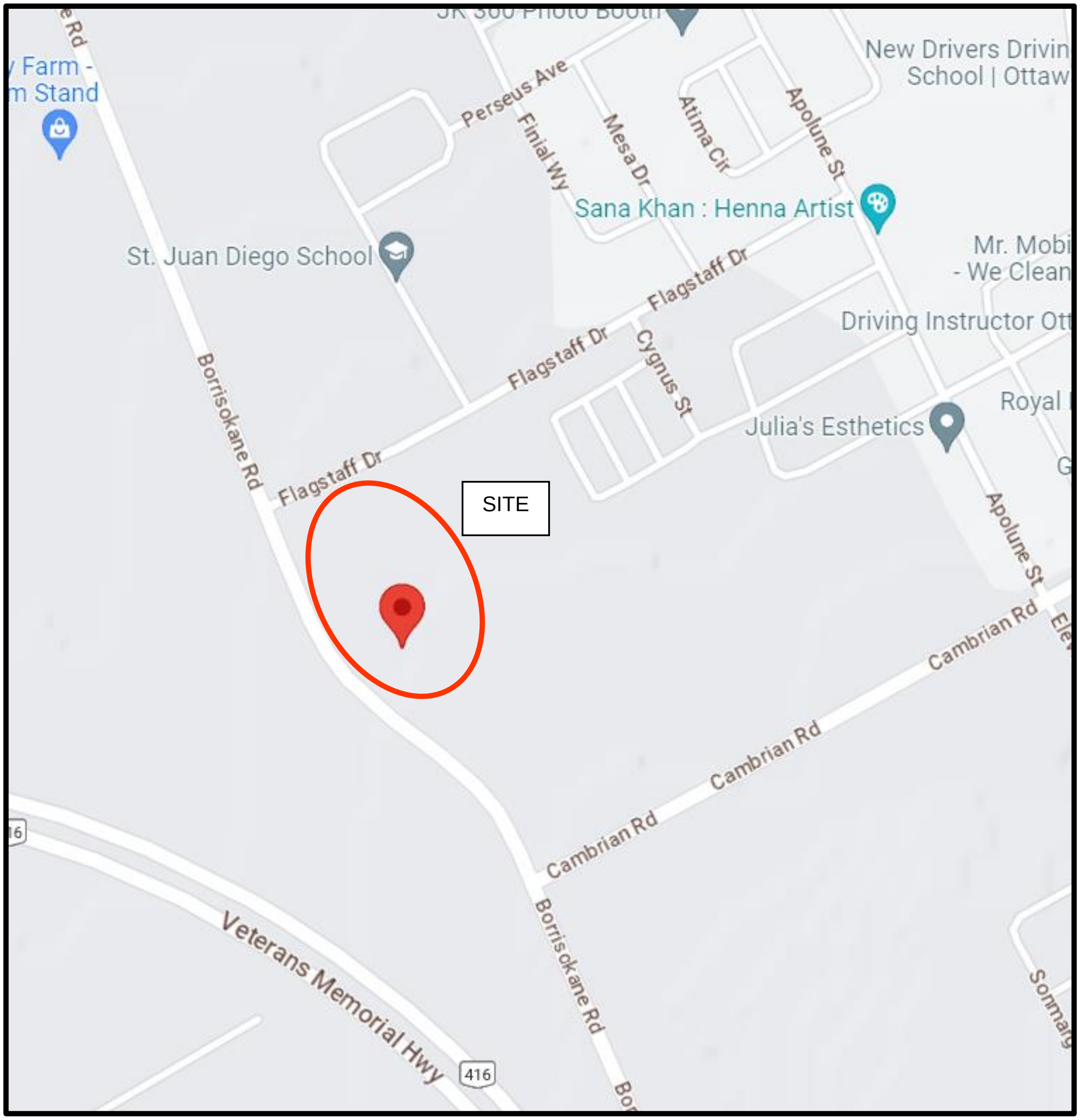
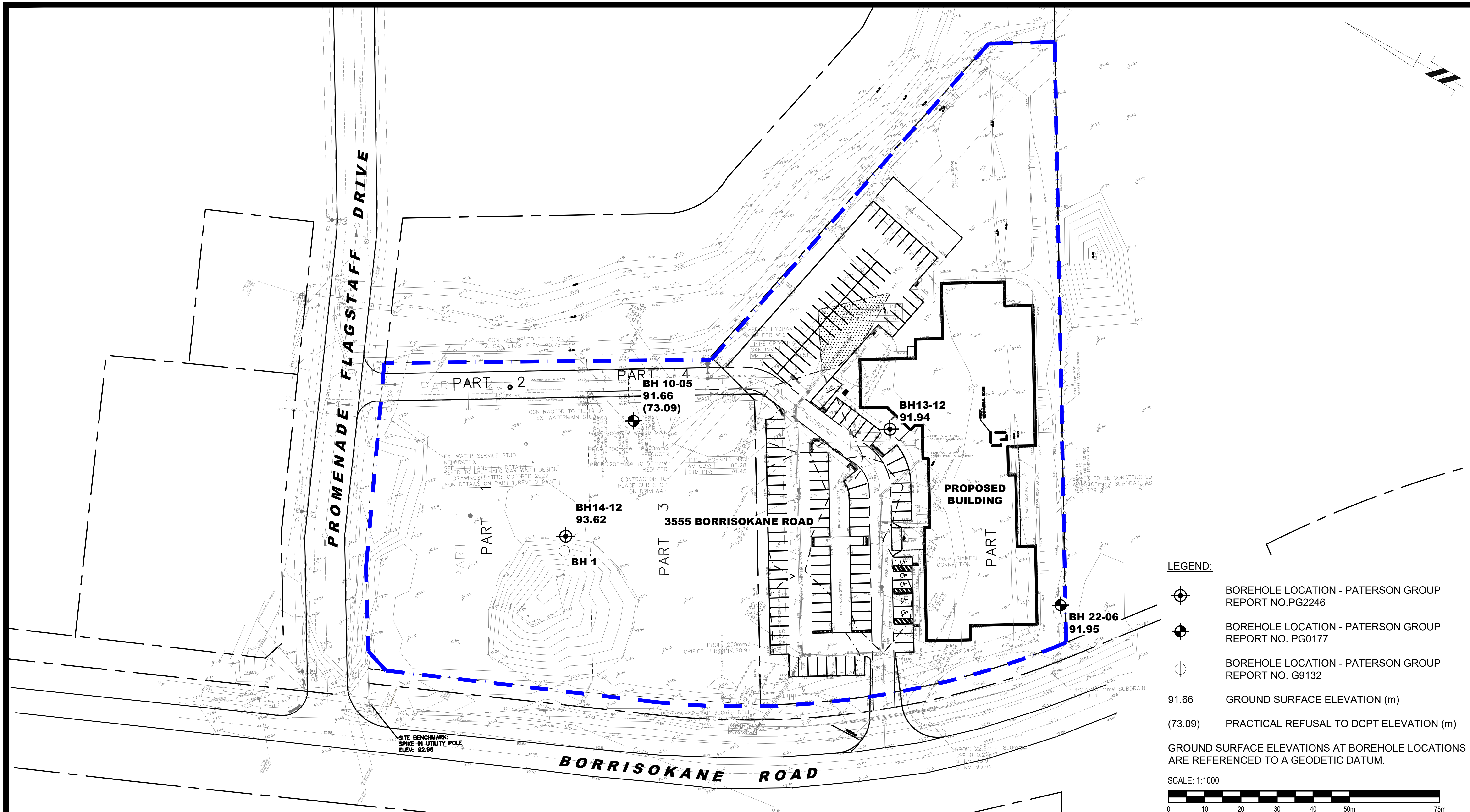


FIGURE 1

KEY PLAN

PATERSON GROUP



PATERSON GROUP

9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

NO.	REVISIONS	DATE	INITIAL

OTTAWA KOREAN COMMUNITY CHURCH
GEOTECHNICAL INVESTIGATION
PROPOSED CHURCH
3555 BORRISOKANE ROAD

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1000	Date: 11/2023
Drawn by: GK	Report No.: PG6842-2
Checked by: GA	Dwg. No.: PG6842-1
Approved by: MAS	Revision No.:

p:\autocad drawings\geotechnical\pg68xx\pg6842\pg6842-1 test hole location plan.dwg

11x17