

Geotechnical Investigation

Proposed Multi-Storey Building

1184, 1188, and 1196 Cummings Avenue
Ottawa, Ontario

Prepared for TCU Development

Report PG6604-1 dated March 27, 2023

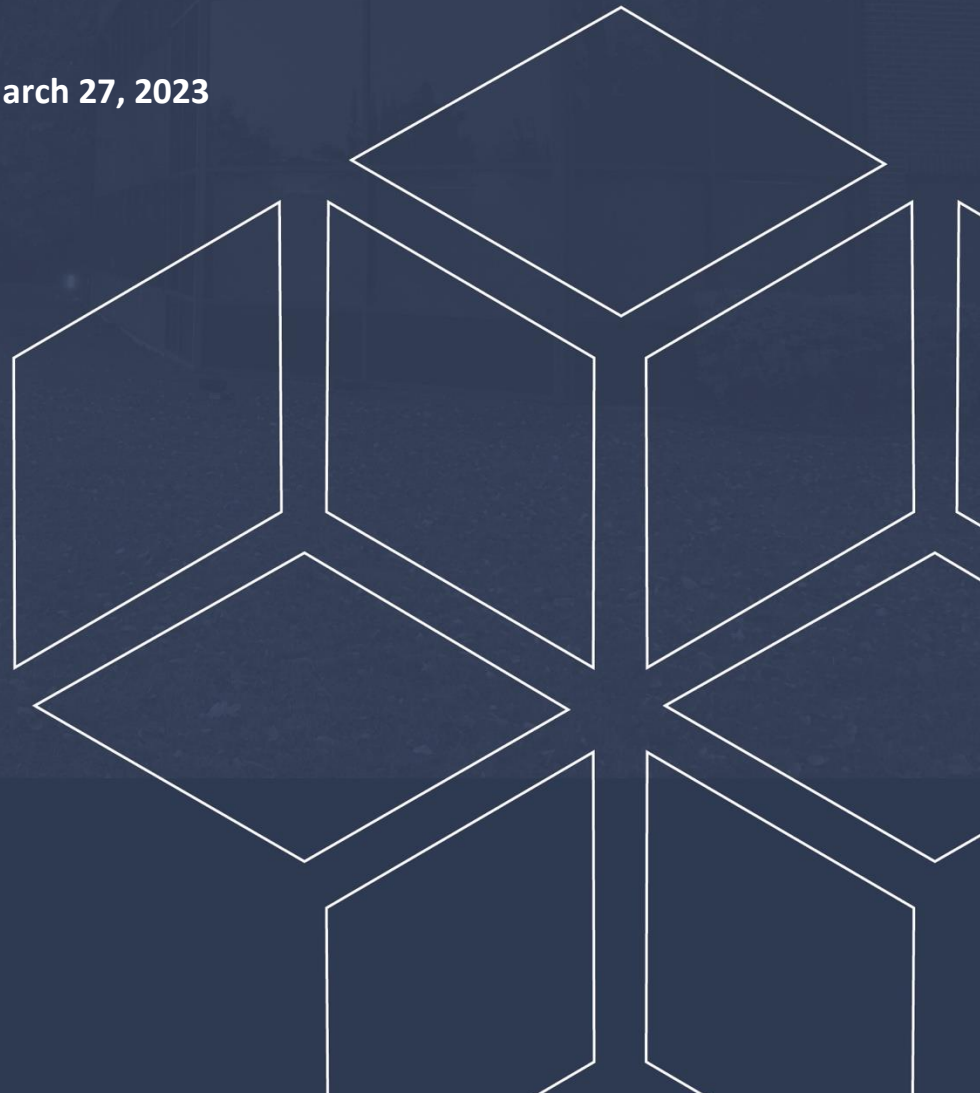


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1.0 Introduction

Paterson Group (Paterson) was commissioned by TCU Development to prepare a geotechnical investigation report for the proposed multi-storey building to be located at 1184, 1188, and 1196 Cummings Avenue, Ottawa, Ontario (refer to Figure 1 - Key Plan presented in Appendix 2 of this report).

The objective of the geotechnical investigation was to:

- determine the subsoil and groundwater conditions at the site by means of test holes
- provide geotechnical recommendations for the design of the proposed development 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

Based on the available conceptual drawings, it is understood that the proposed multi-storey building will consist of six floors and one underground parking structure occupying the majority of the site area. Access lanes, at-grade parking and landscaped areas are also anticipated as part of the development. It is further understood that the proposed residential building will be municipally serviced.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the current investigation was carried out on March 9 and March 10, 2023 and consisted of advancing a total of four (4) boreholes to a maximum depth of 7.6 m below existing grade. A previous investigation was also carried out by Paterson on February 14, 2023. At that time, a total of thirteen (13) test pits were excavated to a maximum depth of 2.1 m below existing grade. The test holes were placed in a manner to provide general coverage of the subject site taking into consideration site features and underground utilities. Historical investigations were also completed by others at the subject site in 2021. The test hole locations for the current and previous investigations are presented on Drawing PG6604-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were completed using a track mounted drill rig operated by a two-person crew. The test pits were completed using a hydraulic shovel at the selected locations across the site. 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 and excavation procedure consisted of augering to the required depth at the selected locations, sampling and testing the overburden, and coring in bedrock.

Sampling and In Situ Testing

The soil samples were recovered from the auger flights and using a 50 mm diameter split-spoon sampler. The samples were initially classified on site, placed in sealed plastic bags and transported to our laboratory. The depths at which the auger, split-spoon and grab samples were recovered from the test holes are shown as AU, SS, and G respectively, on the Soil Profile and Test Data sheets 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.

Rock samples were recovered from BH1-23, BH 2-23, BH 3-23, and BH 4-23 using a core barrel and diamond drilling techniques. The bedrock samples were classified on site, placed in hard cardboard core boxes and transported to Paterson's laboratory. The depths at which rock core samples were recovered from the boreholes are presented as RC on the Soil Profile and Test Data sheets in Appendix 1.

The recovery value and a Rock Quality Designation (RQD) value were calculated for each drilled section of bedrock and are presented on the borehole logs. The recovery value is the length of the bedrock sample recovered over the length of the drilled section. The RQD value is the total length of intact rock pieces longer than 100 mm over the length of the core run. The values indicate the bedrock quality.

The subsurface conditions observed in the test holes 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

A groundwater monitoring well was installed in borehole BH 2-23 to monitor the groundwater level subsequent of the sampling program. Also, flexible polyethylene standpipes were installed in boreholes BH 1-23, BH 3-23, and BH 4-23. The groundwater observations are discussed in subsection 4.3 and presented in the Soil Profile and Test Data Sheets in Appendix 1.

Monitoring Well Installation

Typical monitoring well construction details are described below:

- 3.0 m of slotted 51 mm diameter PVC screen at the base of the boreholes.
- 51 mm diameter PVC riser pipe from the top of the screen to the ground surface.
- No. 3 silica sand backfill within annular space around screen.
- 300 mm thick bentonite hole plug directly above PVC slotted screen.
- Clean backfill from top of bentonite plug to the ground surface.

Refer to the Soil Profile and Test Data sheets in Appendix 1 for specific well construction details.

Sample Storage

All samples will be stored in the laboratory for a period of one (1) month after issuance of this report. They will then be discarded unless we are otherwise directed.

3.2 Field Survey

The test hole locations were selected by Paterson to provide general coverage of the subject site. The test hole locations and ground surface elevation at each test hole location were surveyed by Paterson using a high precision GPS and referenced to a geodetic datum. The location of the test holes is presented on Drawing PG6604-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Review

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging.

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 by others. The sample was 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 consists of three residential properties, each occupied by a single-family dwelling and associated asphalt/gravel-covered driveways and backyards. Several mature trees were observed in the grass-covered backyards. In addition, the properties were observed to have a fence. The ground surface across the site is generally flat and approximately at grade with the neighbouring roads and properties.

The site is bordered to the north by Weldon Drive, to the east by Cummings Avenue, to the west by residential properties, and to the south by a gas/service station.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile observed at the test hole locations consists of a topsoil and fill, underlain by a layer of silty sand to sandy silty with gravel and cobbles, overlying bedrock. The fill was observed to consist of a mixture of brown silty sand with gravel and crushed stone, trace clay, some shale and cobbles. The silty sand/sandy silt formation was observed to be compact to dense.

Practical refusal to excavation/augering was encountered at all test holes at depths ranging between approximately 0.8 and 2.5m below the existing ground surface.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Bedrock

Bedrock was cored at BH 1-23, BH 2-23, BH 3-23 and BH 4-23, beginning at approximate depths of 1.83 to 2.54 m, and extending down to the final depth of the test holes. The bedrock was observed to consist of black shale of the Billings formation. Based on the RQDs of the recovered rock core, the bedrock can be classified as very poor to fair in quality at the top, generally increasing in quality with depth.

4.3 Groundwater

Groundwater levels were measured in the installed monitoring well and piezometers during the current investigation. The groundwater readings obtained from the current field program are summarised in Table 1 below and are also presented on the Soil Profile and Test Data sheets in Appendix 1.

Table 1 – Summary of Groundwater Levels				
Test Hole	Ground Surface Elevation (m)	Measured Groundwater Level		Date Recorded
		Depth (m)	Elevation (m)	
BH 1-23	71.36	2.80	68.56	March 21, 2023
BH 2-23	71.39	2.59	68.80	March 21, 2023
BH 3-23	70.66	2.07	68.59	March 21, 2023
BH 4-23	71.73	2.87	68.86	March 21, 2023

Note: The ground surface elevation at each borehole location was surveyed using a high precision GPS and referenced to a geodetic datum.

Based on the observed groundwater level measurements and our knowledge of the groundwater conditions within the area, the long-term groundwater level is estimated to be at **2 to 3 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 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered suitable for the proposed multi-storey building. It is recommended that the proposed six-floor building, and one underground parking structure be founded using conventional shallow footings placed on clean, surface sounded bedrock.

Depending on the final founding depth, bedrock removal may be required within the subject site to complete the underground parking level. Bedrock removal can be accomplished by hoe ramming where only a small quantity of the bedrock needs to be removed. Sound bedrock may be removed by line drilling and controlled blasting and/or hoe ramming. The blasting operations should be planned and conducted under the guidance of a professional engineer with experience in blasting operations.

Due to the expansive nature of the shale bedrock encountered at the subject site, precautions should be taken during construction to reduce the risks associated with heaving of the shale bedrock. The bedrock surface should be protected from excessive dewatering and exposure to ambient air. Therefore, a 50mm thick concrete mud slab consisting of a minimum of 15 MPA lean concrete, should be placed on the exposed bedrock surface within 48-hour period of being exposed. The excavated side slopes of the bedrock surface should be sprayed with bituminous emulsion to seal bedrock from exposure to air and dewatering.

Removal of concrete elements is likely to be encountered due to the demolition of the existing structures on site. In addition, tree roots may also be encountered at the west and east ends of the site, and these shall be removed as well.

Temporary shoring will be required where excavation is to be completed in close proximity to existing properties and roads.

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

5.2 Site Grading and Preparation

Stripping Depth

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

Due to the relatively shallow depth of the bedrock surface and the anticipated founding level for the proposed building, all existing overburden material should be excavated from within the proposed building footprint.

Existing foundation walls, and other construction debris should be entirely removed from within proposed building perimeters. Under paved areas, existing construction remnants such as foundation walls should be excavated to a minimum of 1 m below final grade.

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.

Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless used in conjunction with a geocomposite drainage membrane, such as Miradrain G100N or Delta Drain 6000.

Bedrock Removal

Bedrock removal could be carried out by hoe-ramming where only small quantities of bedrock need to be removed. Sound bedrock may be removed by line drilling and controlled blasting and/or hoe ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in proximity of the blasting operations should be completed prior to commencing site activities.

The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries/claims related to the blasting operations. As a general guideline, peak particle velocities of 25 mm/sec (measured at the structures) should not be exceeded during the blasting program to reduce the risks of damage to the existing structures.

The blasting operations should be planned and carried out under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

Vibration Considerations

Construction operations are the cause of vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels as much as possible should be incorporated in the construction operations to maintain, as much as possible, a cooperative environment with the residents.

The following construction equipment could be the source of vibrations: hoe ram, compactor, dozer, crane, truck traffic, etc. Vibrations, whether caused by blasting operations or by construction operations, could be the source of detrimental vibrations on the nearby buildings and structures. Therefore, all vibrations are recommended to be limited.

Two parameters are used to determine the permissible vibrations, namely, the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As outlined by City of Ottawa S.P. No: F-1201, vibrations limits should be limited to 20 mm/s for frequencies below or equal to 40 Hz and 50 mm/s for frequencies greater than 40 Hz. Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, a pre-construction survey is recommended be completed to minimize the risks of claims during or following the construction of the proposed building.

Should blasting be utilized a pre-blast survey must be completed for the surrounding area per City of Ottawa S.P. No: F-1201 and blast notices must be distributed 15 business days prior to the commencement of blasting work.

5.3 Foundation Design

Bearing Resistance Values (Conventional Shallow Footings)

Footings placed on a clean, surface sounded bedrock surface can be designed using a bearing resistance value at ultimate limit states (ULS) of **1,000 kPa**, incorporating a geotechnical resistance factor of 0.5.

A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

Settlement

Footings bearing on an acceptable bedrock bearing surface and designed using the bearing resistance values provided herein will be subjected to negligible potential post-construction total and differential settlements.

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 sound bedrock bearing medium when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:6V passes only through sound bedrock. Slopes of 1H:1V or shallower can be used for fractured bedrock.

5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class C** for foundations constructed at the subject site, according to Table 4.1.8.4.A of the 2012 Ontario Building Code (OBC 2012). Footings supporting on sound bedrock 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.

5.5 Basement Slab

For the proposed building, all overburden soil will be removed from the building footprint, leaving the bedrock as the founding medium for the basement floor slab. The basement area for the proposed building will be mostly parking and the recommended pavement structure noted in Subsection 5.7 will be applicable. However, if storage or other uses of the lower level where a concrete floor slab will be constructed, the upper 200 mm of sub-slab fill is recommended to consist of 19 mm clear crushed stone.

Any soft areas in the basement slab subgrade should be removed and backfilled with appropriate backfill material prior to placing any fill. OPSS Granular A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab.

All backfill material within the footprint of the proposed building(s) should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

Furthermore, a subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the subfloor fill under the lower basement floor (discussed further in Subsection 6.1). A modulus of subgrade reaction of **100 MPa/m** should be utilized for the design of the basement floor.

5.6 Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the subject structure. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and a drained unit weight of 20 kN/m³.

However, undrained conditions are anticipated (i.e. below the groundwater level). Therefore, the applicable effective (undrained) unit weight of the retained soil can be taken as 13 kN/m³, where applicable. A hydrostatic pressure should be added to the total static earth pressure when using the effective unit weight.

Lateral Earth Pressures

The static horizontal earth pressure (p_o) can be calculated using a triangular earth pressure distribution equal to $K_o \cdot \gamma \cdot H$ where:

K_o = at-rest earth pressure coefficient of the applicable retained soil (0.5)

γ = unit weight of fill of the applicable retained soil (kN/m³)

H = height of the wall (m)

An additional pressure having a magnitude equal to $K_o \cdot q$ and acting on the entire height of the wall should be added to the above diagram for any surcharge loading, q (kPa), that may be placed at ground surface adjacent to the wall. The surcharge pressure will only be applicable for static analyses and should not be used in conjunction with the seismic loading case.

Actual earth pressures could be higher than the “at-rest” case if care is not exercised during the compaction of the backfill materials to maintain a minimum separation of 0.3 m from the walls with the compaction equipment.

Seismic Earth Pressures

The total seismic force (P_{AE}) includes both the earth force component (P_o) and the seismic component (ΔP_{AE}). The seismic earth force (ΔP_{AE}) can be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ where:

$$a_c = (1.45 - a_{max}/g)a_{max}$$

γ = unit weight of fill of the applicable retained soil (kN/m³)

H = height of the wall (m)

g = gravity, 9.81 m/s²

The peak ground acceleration, (a_{max}), for the site area is 0.32 g according to OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

The earth force component (P_o) under seismic conditions can be calculated using $P_o = 0.5 K_o \gamma H^2$, where $K_o = 0.5$ for the soil conditions noted above.

The total earth force (P_{AE}) is considered to act at a height, h (m), from the base of the wall, where:

$$h = \{P_o \cdot (H/3) + \Delta P_{AE} \cdot (0.6 \cdot H)\} / P_{AE}$$

The earth forces calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per OBC 2012.

5.7 Pavement Design

For design purposes, the rigid pavement structure presented in Table 4 could be used for the design of the lower level of the parking garage:

Table 3 - Recommended Rigid Pavement Structure – Underground Parking	
Thickness (mm)	Material Description
125	Rigid Concrete Pavement - 32 MPa concrete with air entrainment
300	BASE - OPSS Granular A Crushed Stone
SUBGRADE - Either fill, OPSS Granular B Type II material placed over in situ soil, fill or rock.	

The flexible pavement structure presented in Tables 5 and 6 could be used for the design of the pavement structure for car only parking, access lanes, and heavy truck parking areas.

Table 4 - Recommended Pavement Structure – Car Only 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 in situ soils, fill approved by the geotechnical consultant or OPSS Granular B Type I or II material placed over in situ soil.	

Table 5 - Recommended Pavement Structure – Access Lanes and Heavy Truck Parking Areas	
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, fill approved by the geotechnical consultant 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.

Where the subgrade is observed to be in a loose state of compactness, proof rolling should be completed, under dry conditions and above freezing temperatures, using suitably sized equipment to achieve desired levels of compactness.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Foundation Drainage

Based on the preliminary information provided, it is expected that a portion of the proposed building foundation walls will be located below the long-term groundwater table. To limit long-term groundwater lowering, it is recommended that a groundwater infiltration control system be designed for the proposed building. Also, a perimeter foundation drainage system will be required as a secondary system to account for any groundwater which breaches the primary ground infiltration control system. 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 sump pump pit or storm sewer.

The groundwater infiltration control system should extend at least 1 m above the long-term groundwater level and the following is suggested for preliminary design purposes:

- Place a suitable waterproofing membrane against the temporary shoring surface, such as a bentomat liner system or equivalent. The membrane liner should extend down to footing level. The membrane liner should also extend horizontally a minimum of 600 mm below the footing at underside of footing level.
- Place a composite drainage layer, such as Delta Drain 6000 or equivalent, over the membrane, as a secondary system. The composite drainage layer should extend from finished grade to underside of footing level.
- Pour the foundation wall against the composite drainage system.

It is recommended that the composite drainage system (such as Delta Drain 6000 or equivalent) extend down to the footing level. It is recommended that 150 mm diameter sleeves at 3-6 m centres be cast in the footing or at the foundation wall/footing interface to allow the infiltration of water to flow to the interior perimeter drainage pipe. The perimeter drainage pipe and underfloor drainage system should direct water to sump pit(s) within the lower basement area.

It is important to note that the building's sump pit and elevator pit be considered for waterproofing in a similar fashion. A detail can be provided by Paterson once the design drawings are available for the elevator and sump pits.

Foundation Backfilling – Double Side Pour Areas

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.

Underfloor Drainage

Underfloor drainage is recommended to control water infiltration for the proposed structure. For preliminary design purposes, we recommend that 150 mm diameter perforated PVC pipes be placed below the floor slab at 3 to 6m center spacings. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

Adverse Effects of Dewatering on Adjacent Properties

Based on the subsurface conditions and on the anticipated excavation depth, any minor dewatering will be considered temporary and limited to the local area of the proposed building during the construction period. Therefore, adverse effects to the surrounding buildings or properties are not expected with respect to any groundwater lowering.

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.

It has been our experience that insufficient soil cover is typically provided to footings located in areas where minimal soil cover is available, such as entrance ramps to underground parking garages. Paterson requests permission to review design drawings prior to construction to ensure proper frost protection is provided.

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 insufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods (i.e. unsupported excavations) and temporary shoring will likely be required.

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.

Temporary Shoring

Temporary shoring will be required to support the overburden soils. The design and implementation of these temporary systems will be the responsibility of the excavation contractor or the shoring contractor and their design team. Inspections and approval of the temporary system will also be the responsibility of the designer.

Geotechnical information provided below is to assist the designer in completing a suitable and safe shoring system. The designer should take into account the potential for a fully saturated condition following a significant precipitation event. Any changes to the approved shoring design system should be reported immediately to the owner's representative prior to implementation.

For design purposes, the temporary system may consist of soldier pile and lagging system or interlocking steel sheet piling. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be added to the earth pressures described below. These systems can be cantilevered, anchored or braced. The earth pressures acting on the shoring system may be calculated using the following parameters.

Table 7 - Soil Parameters for Shoring System Design

Parameters	Values
Active Earth Pressure Coefficient (K_a)	0.33
Passive Earth Pressure Coefficient (K_p)	3
At-Rest Earth Pressure Coefficient (K_o)	0.5
Unit Weight (γ), kN/m ³	20
Submerged Unit Weight (γ), kN/m ³	13

The active earth pressure should be calculated where wall movements are permissible while the at-rest pressure should be calculated if no movement is permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

The hydrostatic groundwater pressure should be included to the earth pressure distribution wherever the effective unit weights are calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil should be calculated full weight, with no hydrostatic groundwater pressure component.

For design purposes, the minimum factor of safety of 1.5 should be calculated.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications & Standard Detail Drawings of the OPSD.

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 95% 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) sandy silt 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 1.8 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 300 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD.

6.5 Groundwater Control

Groundwater Control for Building Construction

Based on our observations, it is anticipated that groundwater infiltration into the excavations should be moderate and controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations above the groundwater level.

If excavation below the groundwater level will be completed, consideration may need to be given to undertaking a dewatering program taking place outside the excavation footprints. The system would require the use of deep wells or well points to temporarily lower the local groundwater table below the depth of future excavations. 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.

Permit to Take Water

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. 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.

Impacts to Neighbouring Properties

It is understood that one level of underground parking is planned for the proposed building. Any groundwater encountered along the building's perimeter or under-slab drainage system will be directed to the proposed building's cistern/sump pit. Provided the proposed groundwater infiltration control system is properly implemented and approved by the geotechnical consultant at the time of construction, long-term groundwater lowering is anticipated to be negligible for the area. Therefore, no adverse effects to neighbouring properties are expected.

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.

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 GU (General Use) 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 moderate to very aggressive corrosive environment.

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 of the grading and site servicing plans from a geotechnical perspective.
- Review of the proposed excavation activities
- Once structural and architectural drawings are available, it is recommended that Paterson provide a damp-proofing, waterproofing and drainage plan for the subject building.
- Periodic inspections of the damp-proofing of the foundation walls and waterproofing of the mechanical pits 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 generated by construction activities 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 TCU Development 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.



Zubaida Al-Moselly, P.Eng.



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

Report Distribution:

- TCU Development (email copy)
- Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

TEST HOLE LOGS BY OTHERS

DATUM Geodetic

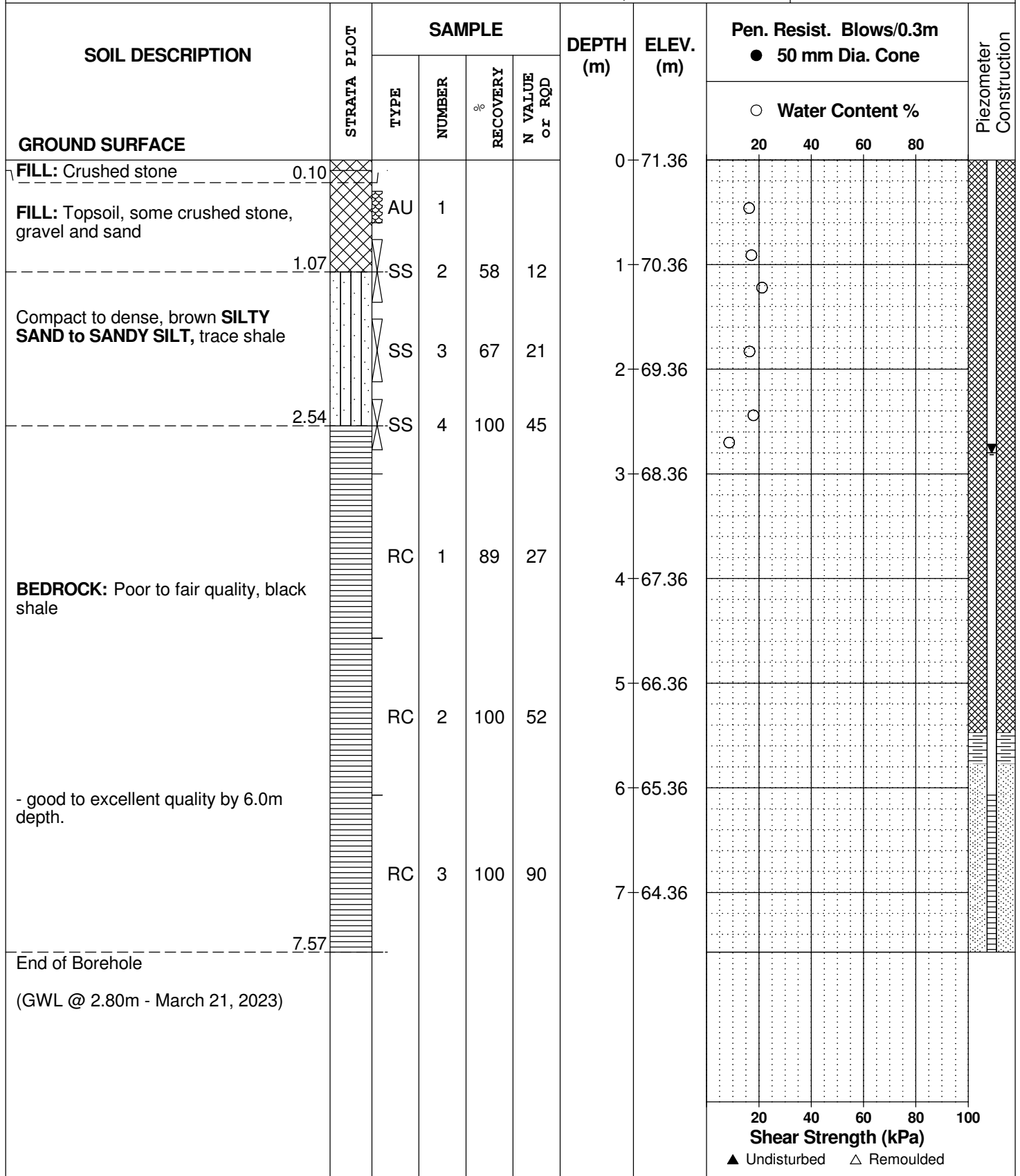
REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE March 9, 2023

FILE NO.
PG6604

HOLE NO.
BH 1-23



DATUM Geodetic

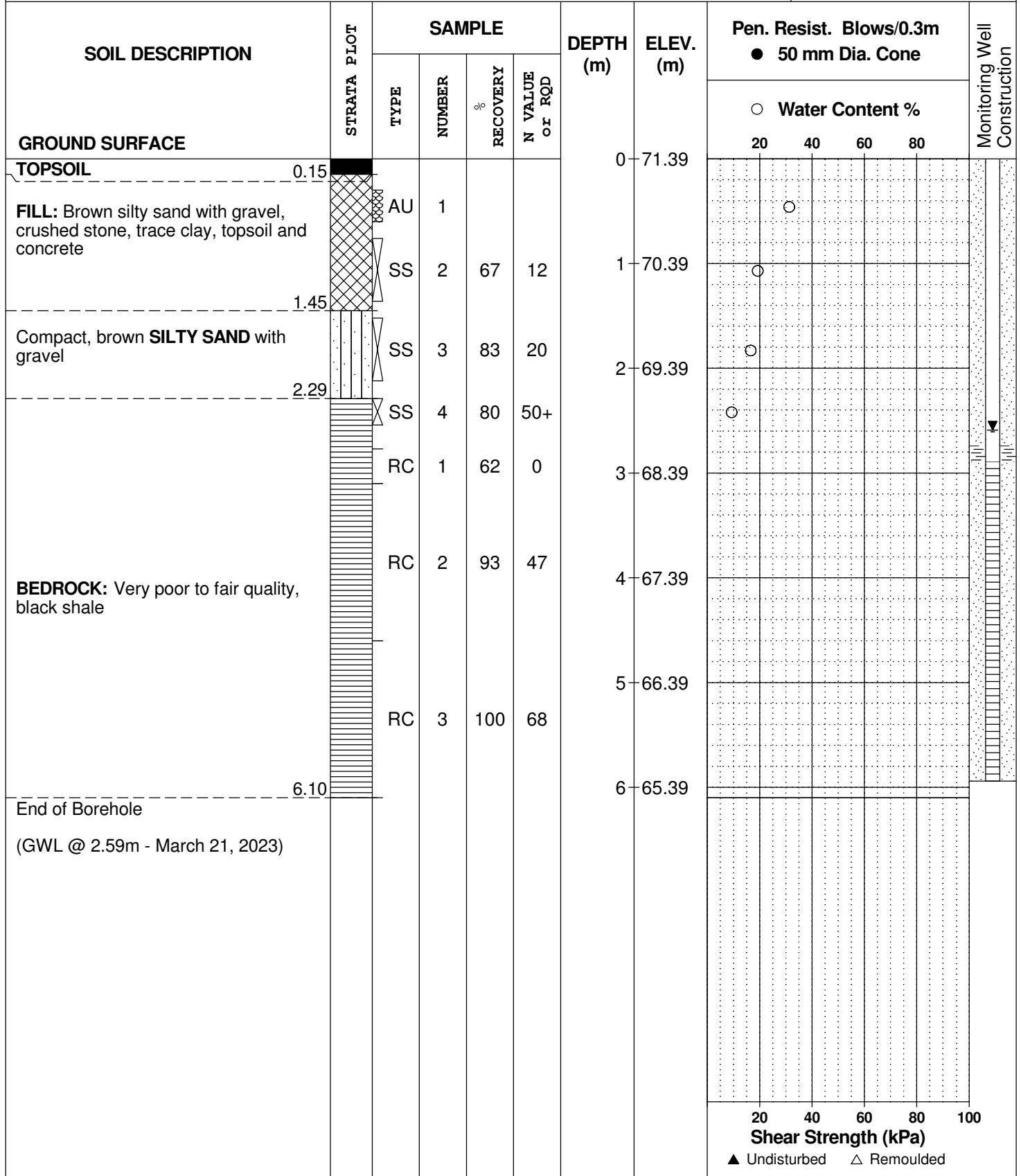
REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE March 9, 2023

FILE NO.
PG6604

HOLE NO.
BH 2-23



DATUM Geodetic

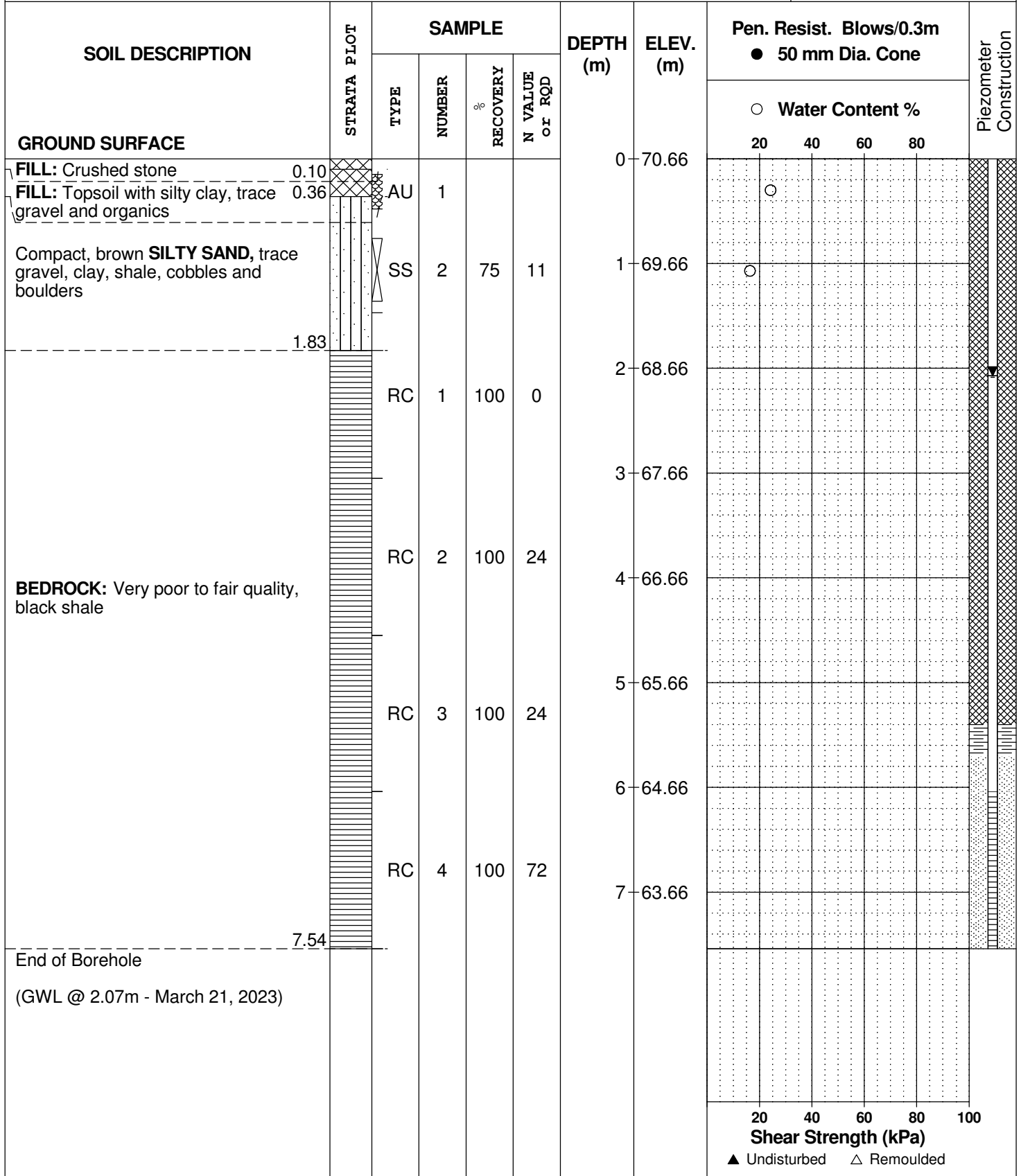
REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE March 9, 2023

FILE NO.
PG6604

HOLE NO.
BH 3-23



DATUM Geodetic

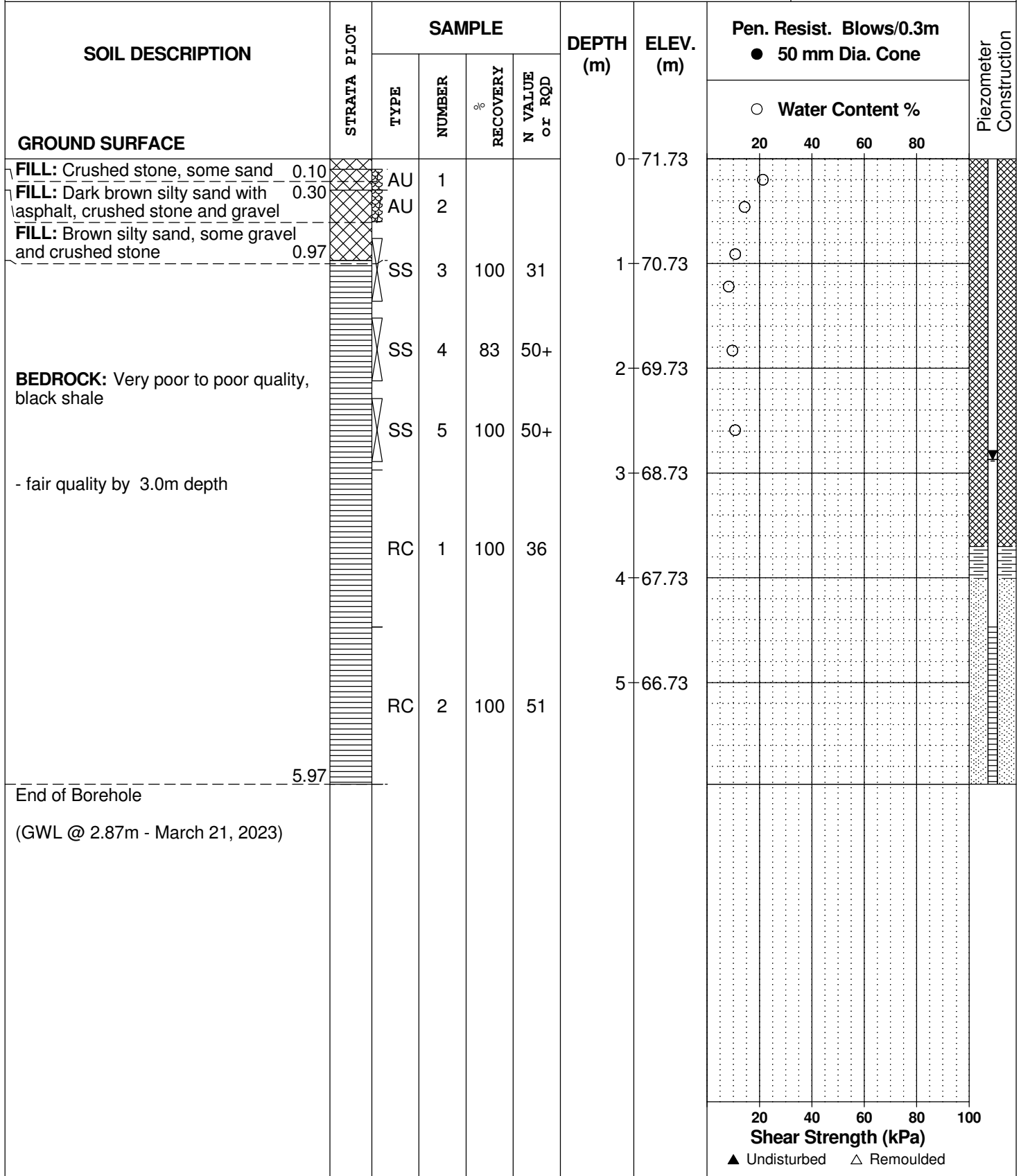
REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE March 10, 2023

FILE NO.
PG6604

HOLE NO.
BH 4-23



DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 1-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	G	1			0	71.44					
FILL: Brown silty sand with gravel, trace organics	0.40											
FILL: Brown silty sand with gravel	0.80	G	2									
Brown SANDY SILT with gravel, occasional cobbles	1.60	G	3			1	70.44					
End of Test Pit		G	4									
TP terminated on bedrock surface at 1.60m depth. (TP dry upon completion)												

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 2-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
TOPSOIL	0.10					0	71.44					
FILL: Brown silty sand with gravel, trace organics	0.50	G	1									
FILL: Brown silty sand, trace clay, gravel and concrete blocks	0.80	G	2									
Brown SILTY SAND with gravel, some clay		G	3			1	70.44					
		G	4									
End of Test Pit	2.00					2	69.44					
TP terminated on bedrock surface at 2.00m depth. (TP dry upon completion)												
								20	40	60	80	100
								Shear Strength (kPa)				
								▲ Undisturbed △ Remoulded				

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 3-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %					
GROUND SURFACE								20	40	60	80		
FILL: Crushed stone	0.10					0	71.52						
FILL: Brown silty sand, some shale and gravel	0.50	G	1										
FILL: Brown silty sand, some cobbles, trace brick and shale	1.00	G	2										
Brown SILTY SAND, trace clay and gravel, occasional cobbles	1.70	G	3			1	70.52						
G			4										
End of Test Pit													
TP terminated on bedrock surface at 1.70m depth.													
								20	40	60	80	100	
								Shear Strength (kPa)					
								▲ Undisturbed △ Remoulded					

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 4-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	G	1			0	70.97					
FILL: Brown silty sand, trace gravel	0.30											
Brown SILTY SAND with gravel, occasional cobbles		G	2									
		G	3			1	69.97					
	1.60											
End of Test Pit												
TP terminated on bedrock surface at 1.60m depth. (TP dry upon completion)												
								20	40	60	80	100
								Shear Strength (kPa)				
								▲ Undisturbed △ Remoulded				

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 5-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	X				0	70.87					
Brown SILTY SAND , some clay, trace organics (possible topsoil)	0.40	G	1									
Brown SANDY SILT with gravel	0.70	G	2									
Brown SILTY SAND with gravel and cobbles	1.70	G	3			1	69.87					
End of Test Pit TP terminated on bedrock surface at 1.70m depth. (TP dry upon completion)												

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 6-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10					0	70.74					
TOPSOIL	0.50	G	1									
Brown SILTY SAND with gravel		G	2									
		G	3			1	69.74					
Brown SILTY SAND with shale fragments	1.50	G	4									
End of Test Pit	1.70											
TP terminated on bedrock surface at 1.70m depth.												

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 7-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	G	1			0	70.86					
FILL: Brown silty sand, trace silt and organics	0.50											
Brown SILTY SAND with gravel, occasional cobbles		G	2									
		G	3			1	69.86					
		G	4			2	68.86					
End of Test Pit	2.10											
TP terminated on bedrock surface at 2.10m depth. (TP dry upon completion)												
								20	40	60	80	100
								Shear Strength (kPa)				
								▲ Undisturbed △ Remoulded				

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 8-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	G	1		0	71.40						
FILL: Brown silty sand, some cobbles, trace shale and organics	0.40											
Brown SILTY SAND with gravel	0.80	G	2									
End of Test Pit												
TP terminated on bedrock surface at 0.80m depth. (TP dry upon completion)												

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP 9-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction
		TYPE	NUMBER	RECOVERY	N VALUE or RQD			○ Water Content %				
GROUND SURFACE								20	40	60	80	
FILL: Crushed stone	0.10	G	1		0	71.42						
FILL: Brown silty sand, some cobbles, trace shale, organics and brick	0.50											
Brown SILTY SAND with gravel	1.00	G	2									
Brown SILTY SAND with gravel, cobbles and shale fragments	1.30	G	3		1	70.42						
End of Test Pit												
TP terminated on bedrock surface at 1.30m depth. (TP dry upon completion)												

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP10-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY	N VALUE or RQD			○ Water Content %					
GROUND SURFACE								20	40	60	80		
FILL: Crushed stone	0.10					0	70.76						
FILL: Brown silty sand, some clay and organics	0.30	G	1										
FILL: Brown silty sand with cobbles, trace shale		G	2										
	1.00					1	69.76						
Brown SILTY SAND with gravel		G	3										
	1.50	G	4										
End of Test Pit													
TP terminated on bedrock surface at 1.50m depth. (TP dry upon completion)													

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

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP12-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %					
GROUND SURFACE								20	40	60	80		
TOPSOIL	0.10				0	71.08							
Brown SILTY SAND with gravel, trace shale fragments		G	1										
		G	2										
		G	3			1	70.08						
Brown SILTY SAND with gravel and cobbles	1.50	G	4										
End of Test Pit	1.80												
TP terminated on bedrock surface at 1.80m depth. (TP dry upon completion)													
								20	40	60	80	100	
								Shear Strength (kPa)					
								▲ Undisturbed △ Remoulded					

DATUM Geodetic

REMARKS

BORINGS BY Excavator

DATE February 14, 2023

FILE NO.
PG6604

HOLE NO.
TP13-23

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone				Piezometer Construction	
		TYPE	NUMBER	RECOVERY %	N VALUE or RQD			○ Water Content %					
GROUND SURFACE								20	40	60	80		
TOPSOIL						0	71.10						
FILL: Brown silty sand with cobbles, trace shale		G	1										
		G	2										
Brown SILTY SAND with gravel and cobbles		G	3										
		G	4										
		G	5										
End of Test Pit						2	69.10						
TP terminated on bedrock surface at 2.10m depth. (TP 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)
D _{xx}	-	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
D ₁₀	-	Grain size at which 10% of the soil is finer (effective grain size)
D ₆₀	-	Grain size at which 60% of the soil is finer
C _c	-	Concavity coefficient = $(D_{30})^2 / (D_{10} \times D_{60})$
C _u	-	Uniformity coefficient = D_{60} / D_{10}

C_c and C_u are used to assess the grading of sands and gravels:

Well-graded gravels have: $1 < C_c < 3$ and $C_u > 4$

Well-graded sands have: $1 < C_c < 3$ and $C_u > 6$

Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.

C_c and C_u 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
C _{cr}	-	Recompression index (in effect at pressures below p' _c)
C _c	-	Compression index (in effect at pressures above p' _c)
OC Ratio		Overconsolidation ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
W _o	-	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.
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SYMBOLS AND TERMS (continued)

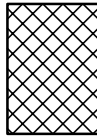
STRATA PLOT



Topsoil



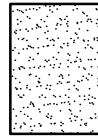
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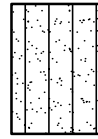
Fill



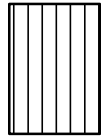
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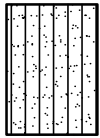
Sand



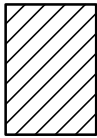
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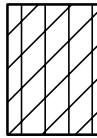
Silt



Sandy Silt



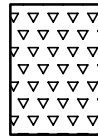
Clay



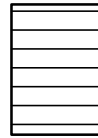
Silty Clay



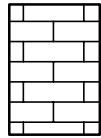
Clayey Silty Sand



Glacial Till



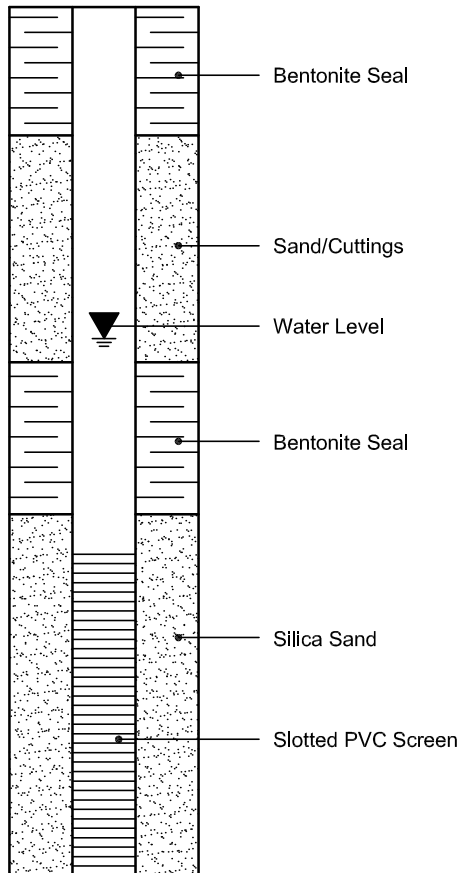
Shale



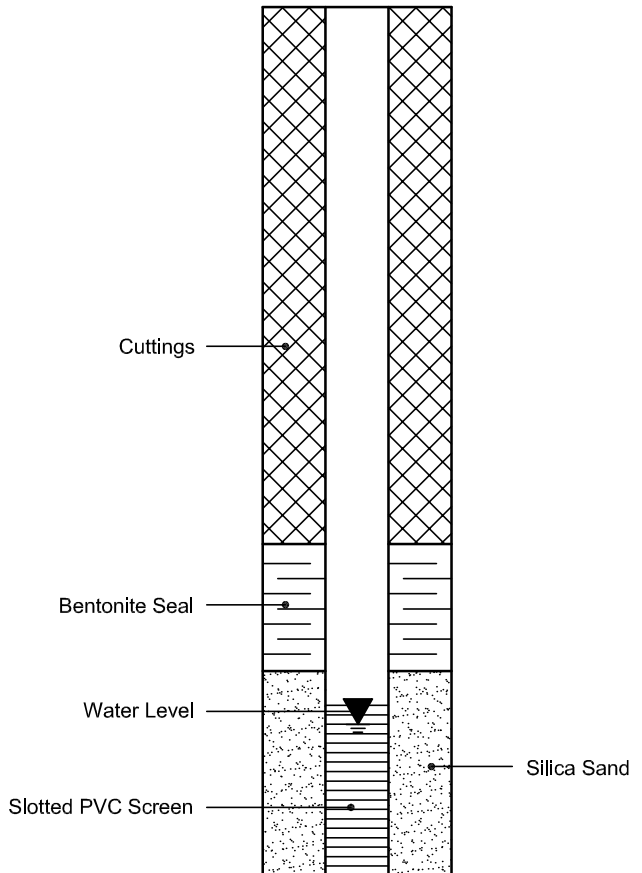
Bedrock

MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Report Date: 16-Mar-2023

Client: Paterson Group Consulting Engineers

Order Date: 10-Mar-2023

Client PO: 56998

Project Description: PG6604

Client ID:	BH1-23-SS4	-	-	-
Sample Date:	09-Mar-23 09:00	-	-	-
Sample ID:	2310483-01	-	-	-
MDL/Units	Soil	-	-	-

Physical Characteristics

% Solids	0.1 % by Wt.	86.3	-	-	-
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General Inorganics

pH	0.05 pH Units	7.85	-	-	-
Resistivity	0.1 Ohm.m	29.9	-	-	-

Anions

Chloride	10 ug/g dry	80	-	-	-
Sulphate	10 ug/g dry	68	-	-	-



Log of Borehole: BH1

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE									
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	Shear Strength kPa	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	98.63	No Monitoring Well Installed 									
		Fill Brown sand and gravel, trace silt, trace organics, frozen	98.17		SS	1	80	8	20				
1		Brown sand, trace silt, trace shale bedrock, compact, damp			SS	2	80	13	40				
		Shale Bedrock Blackish brown highly weathered shale bedrock	97.11		SS	3	100	>50	60				
2		End of Borehole	96.50										
3		Borehole terminated at approximately 2.13 mbgs due to auger refusal on weathered shale bedrock. No groundwater was encountered at drilling completion.											

Contractor: Strata Drilling Group

Grade Elevation: 98.63 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1



Log of Borehole: BH2

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE								
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	98.66	No Monitoring Well Installed 								
		Fill Brown sand and gravel, trace silt, frozen	98.51									
		Glacial Till Brown silty sand and gravel, compact, damp			SS	1	100	15				
		Brown sand, trace gravel, trace silt, compact, damp	97.90									
1		Brown sand, trace gravel, trace silt, compact, damp			SS	2	100	19				
		Trace weathered shale bedrock	97.14									
2		Trace weathered shale bedrock			SS	3	100	38				
		End of Borehole	96.53									
		Borehole terminated at approximately 2.13 mbgs due to auger refusal on weathered shale bedrock. No groundwater was encountered at drilling completion.										
3												

Contractor: Strata Drilling Group

Grade Elevation: 98.66 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1



Log of Borehole: BH3

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE										
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	SPT N-values	Shear Strength kPa	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	98.81	No Monitoring Well Installed 										
		Fill Brown sand and gravel, trace silt, frozen	98.61		SS	1	100	7	■	▲				
		Glacial Till Brown silty sand and gravel, loose, damp												
1		Brown sand, trace gravel, trace silt, loose, damp	98.05		SS	2	100	9	■	▲				
		Trace weathered shale bedrock	97.29		SS	3	80	13	■	▲				
2		Shale Bedrock Blackish brown highly weathered shale bedrock, wet	96.52											
		End of Borehole	96.07											
3		Borehole terminated at approximately 2.74 mbgs due to auger refusal on weathered shale bedrock. Groundwater measured at approximately 2.30 mbgs, at drilling completion.												
4														

Contractor: Strata Drilling Group

Grade Elevation: 98.81 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1



Log of Borehole: BH4

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE										
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	SPT N-values	Shear Strength kPa	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	99.43	No Monitoring Well Installed 										
		Fill Brown silty sand, trace gravel, trace clay, frozen	99.23											
		Glacial Till Brown sand and silt some clay, trace gravel, damp, compact			SS	1	100	22				Hyd.	18.1	
		Shale Bedrock Blackish brown highly weathered shale bedrock	98.67											
1														
					SS	2	100	40						
					SS	3	100	>50						
2		End of Borehole	97.45											
		Borehole terminated at approximately 1.98 mbgs due to auger refusal on weathered shale bedrock. No groundwater was encountered at drilling completion.												
3														

Contractor: Strata Drilling Group

Grade Elevation: 99.43 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1



Log of Borehole: BH5

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE								
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	99.44	No Monitoring Well Installed								
		Asphalt ~ 40 mm										
		Fill Brown sand and gravel, trace silt, frozen	98.68		SS	1	100	47				
1		Glacial Till Brown silty sand and gravel, loose, damp			SS	2	100	5				
		Very dense, moist	97.92		SS	3	30	>50				
2		Shale Bedrock Blackish brown highly weathered shale bedrock, wet	97.15		SS	4	100	58				
3		End of Borehole	96.39									
4		Borehole terminated at approximately 3.05 mbgs due to auger refusal on weathered shale bedrock. Groundwater measured at approximately 2.30 mbgs, at drilling completion.										

Contractor: Strata Drilling Group

Grade Elevation: 99.44 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1



Log of Borehole: BH6

Project #: 286278

Logged By: WT

Project: Geotechnical Investigation

Client: Siacku Limited

Location: 1188 and 1196 Cummings Avenue, Ottawa, Ontario

Drill Date: January 28, 2021

Project Manager: WT

SUBSURFACE PROFILE				SAMPLE										
Depth (m)	Symbol	Description	Elevation (m)	Monitoring Well Details	Sample Type	Sampler #	Recovery (%)	SPT N-values	SPT N-values	Shear Strength kPa	Lab Analysis	Moisture (%)	Plasticity Index	
0		Ground Surface	99.27	No Monitoring Well Installed										
		Organics ~ 100 mm	99.17											
		Glacial Till Brown silty sand, some gravel, some clay, frozen			SS	1	80	10						
1		Compact, damp	98.51											
					SS	2	90	10				Hyd.	17.8	
2		Brown sand, trace silt, trace gravel, damp	97.44											
			96.98											
		Shale Bedrock Blackish brown highly weathered shale bedrock	96.83		SS	4	30	>50						
		End of Borehole												
3		Borehole terminated at approximately 2.44 mbgs due to auger refusal on weathered shale bedrock. No groundwater was encountered at drilling completion.												

Contractor: Strata Drilling Group

Grade Elevation: 99.27 m

Drilling Method: Hollow Stem Auger / Split Spoon

Top of Casing Elevation: N/A

Well Casing Size: N/A

Sheet 1 of 1

APPENDIX 2

FIGURE 1 – KEY PLAN

DRAWING PG6604-1 – TEST HOLE LOCATION PLAN

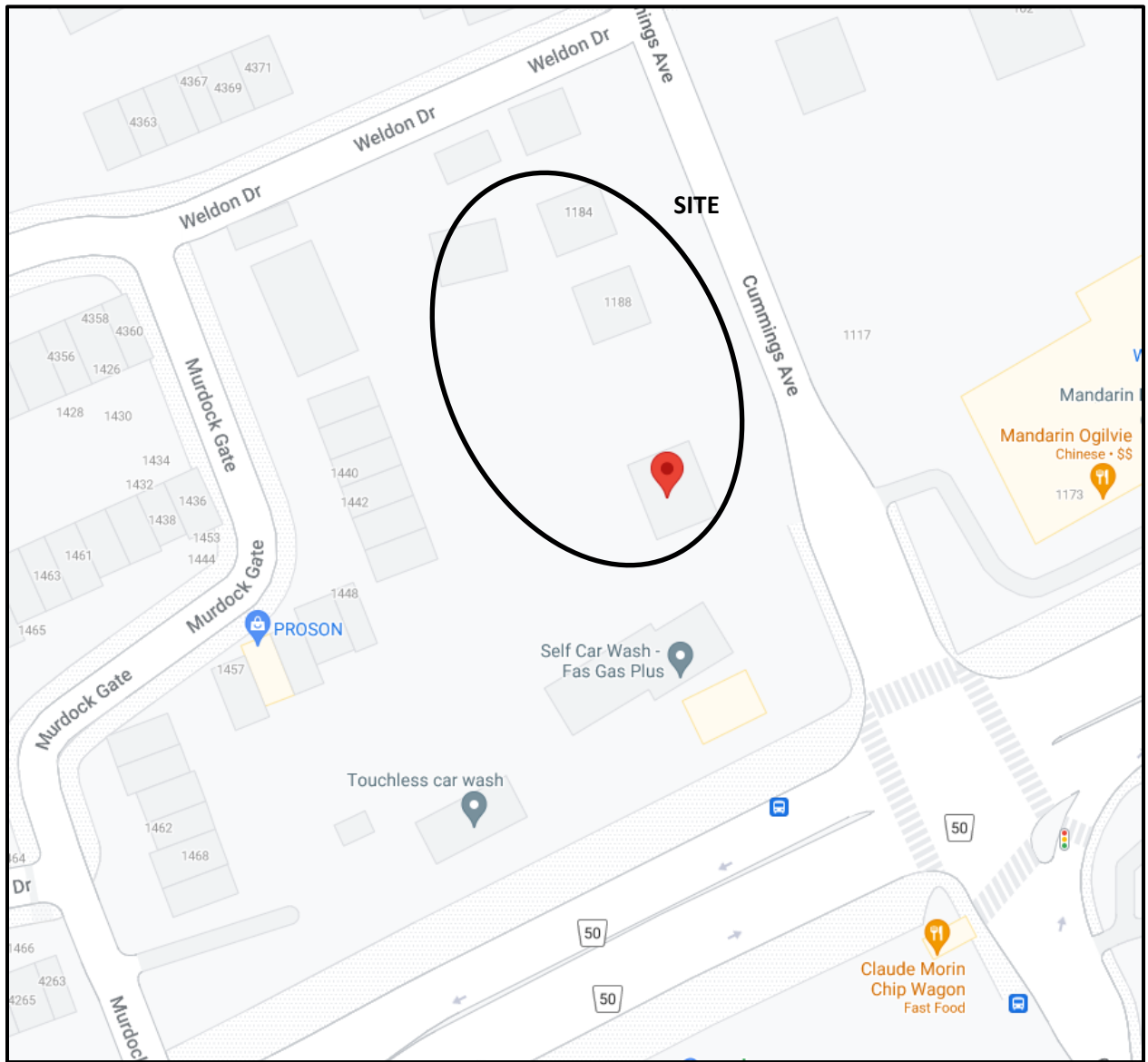
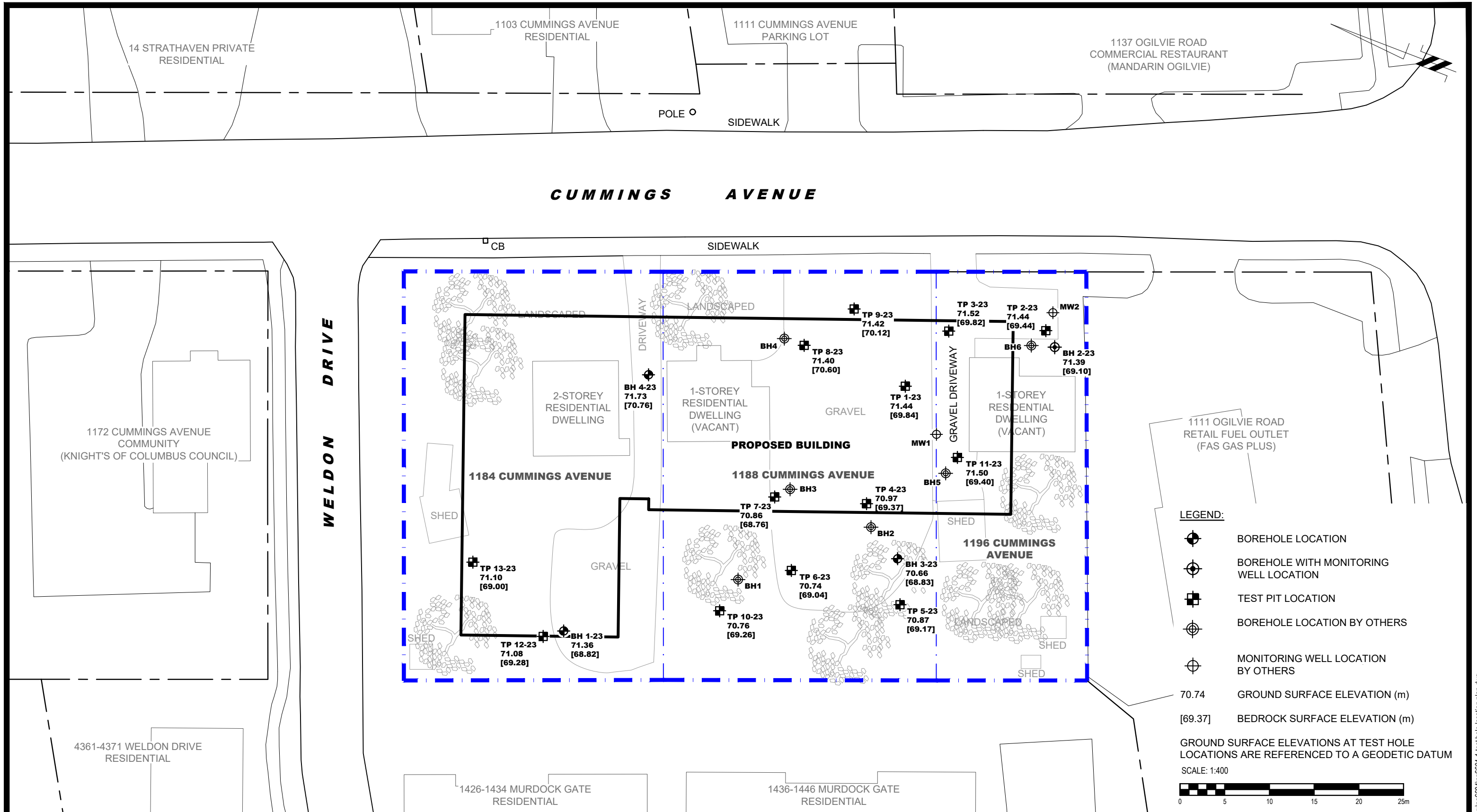


FIGURE 1

KEY PLAN



LEGEND:

- BOREHOLE LOCATION
- BOREHOLE WITH MONITORING WELL LOCATION
- TEST PIT LOCATION
- BOREHOLE LOCATION BY OTHERS
- MONITORING WELL LOCATION BY OTHERS
- 70.74 GROUND SURFACE ELEVATION (m)
- [69.37] BEDROCK SURFACE ELEVATION (m)

GROUND SURFACE ELEVATIONS AT TEST HOLE LOCATIONS ARE REFERENCED TO A GEODETIC DATUM

SCALE: 1:400

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

NO.	REVISIONS	DATE	INITIAL

TCU DEVELOPMENT
GEOTECHNICAL INVESTIGATION
PROPOSED MULTI-STOREY BUILDING
1184, 1186 AND 1196 CUMMINGS AVENUE

TEST HOLE LOCATION PLAN

OTTAWA, ONTARIO

Scale:	1:400	Date:	03/2023
Drawn by:	YA	Report No.:	PG6604-1
Checked by:	ZA	Dwg. No.:	PG6604-1
Approved by:	MAS	Revision No.:	