REPORT

Geotechnical Investigation

Proposed Residential Buildings
30 Cleary Avenue, Ottawa, ON

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out at the Site of two proposed residential buildings to be located at 30 Cleary Avenue, Ottawa, Ontario.

The purpose of this geotechnical investigation was to assess the general subsurface conditions at the site by means of a limited number of boreholes. Based on an interpretation of the factual information obtained, a general description of the subsurface conditions is presented. These interpreted subsurface conditions and available project details were used to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could influence design decisions.

An environmental Site Assessment was completed at the same time as the present geotechnical investigation. The results of this assessment are provided in a separate report.

The reader is referred to the "*Important Information and Limitations of This Report*" which follows the text but forms an integral part of this document.

2.0 DESCRIPTION OF PROJECT AND SITE

The site of the proposed development is located at 30 Cleary Avenue, Ottawa, Ontario. The approximate location of the site is shown on the Key Map inset on the attached Site Plan (Figure 1).

The proposed Site has not been previously developed but is currently surrounded by a number of structures:

- The proposed development area measures approximately 100 m by 20 m in plan view and is currently covered by various landscaping and surface parking areas.
- The proposed residential buildings will be located in the northwest corner of the larger overall site, to the north of the existing river Parkway Children's Centre and southwest of the existing First Unitarian Congregation Church. The proposed building footprints are shown on the Site plan, Figure 1
- The proposed buildings will include a proposed high-rise residential building up to 16 stories, and a mid-rise residential building up to 6 stories.
- The proposed buildings will have one common level of underground parking of about 70 parking spaces, which will extend outside and between the footprints of the two buildings.
- Details of the exact floor elevations were not available at the time of preparation of this report. It is, however, assumed that there would be no significant regrading of the site to accommodate the development.

2.1 Available subsurface Information

Previous subsurface investigations at or near the site were carried out by Golder Associates Ltd, and McRostie & Associates Ltd. The locations of those previous boreholes are shown on the attached Site Plan (Figure 1). The following reports were reviewed in the assessment of site conditions for this study, which include the investigations for the existing development:

1) Report to Charlesfort Developments by Golder Associated Ltd. titled "Phase II Environmental Site Assessment and Remedial Action Plan 761 and 763 Richmond Road, Ottawa, Ontario" dated August 2007 (Report No. 04-1120-806-1).

2) Report to Unitarian Church by McRostie & Associates Ltd. titled “Preliminary Report on Subsurface Investigation for Unitarian Church, Leafloor Avenue, Ottawa, Ontario” dated May 19, 1964 (Report No. SF-763).

3) Report to Craig & Kohler, Architects and Robert Halsall and Associates, Structural Engineers titled “Report on Foundation Investigation for Proposed Unitarian Church, Leafloor Avenue, Ottawa, Ontario” dated October 22, 1965 (Report No. SF-917).

Based on the available information, the subsurface conditions are anticipated to consist of surficial fill material over native sand, underlain by glacial till. The bedrock surface was found to vary from about 0.4 to 3.3 m below the existing ground surface in the previous investigations in the general area.

Published bedrock geology mapping indicates that the site is underlain by limestone with shale interbeds of the Gull River Formation.

3.0 PROCEDURE

The field work for the current geotechnical and environmental assessment was carried out between August 24 and September 29, 2023. During that time, a total of ten boreholes (numbered 23-01 to 23-07, 2307A to 23-09) were advanced at the approximate locations shown in the site plan in Figure 1.

The boreholes were advanced with a truck-mounted hollow stem auger drill rig supplied and operated by George Downing Estate Drilling Ltd. of Grenville, Quebec.

Standard Penetration Tests (SPTs) were carried out within the overburden at various intervals of depth in general conformance with ASTM D 1586. Soil samples were recovered using split-spoon sampling equipment.

Seven boreholes were advanced to refusal on the bedrock surface at depths ranging from 0.8 to 2.4 m. Upon encountering refusal, boreholes 23-01,23-05 and 23-07A were advanced into the bedrock using rotary diamond drilling techniques while retrieving NQ sized core up to a depth of approximately 9.9 m.

Monitoring wells were sealed into three boreholes to allow for subsequent measurements of stabilized groundwater levels. The monitoring wells consisted of 32 mm inside diameter rigid PVC pipe with 3 m long slotted screen sections, installed within silica sand backfill, and sealed by a section of bentonite hole plug. Measurement of groundwater levels was completed on September 05and October 12, 2023.

The fieldwork was supervised by WSP staff who logged the boreholes, directed the in-situ testing, and collected the soil samples retrieved in the boreholes. The samples obtained during the fieldwork were brought to WSP’s laboratory for further examination and laboratory testing.

The laboratory testing included determination of natural water content and grain size distribution on selected soil samples. Two samples of soil were submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

The borehole locations were marked in the field and surveyed by WSP. The position and ground surface elevation at the borehole location were determined using a Trimble R8 GPS survey unit. The Geodetic reference system used for the survey is the North American Datum of 1983 (NAD83). The borehole coordinates are based on the Universal Transverse Mercator (UTM Zone 09) coordinate system. The elevations are referenced to the Geodetic datum (CGVD28).

4.0 SUBSURFACE STRATIGRAPHY

4.1 General

The soil descriptions provided in this report are based on accepted standard methods of classification and identification routinely used in current geotechnical state of practice. The method of soil classification used by WSP is attached in Appendix A.

The subsurface soil and groundwater conditions encountered in the borehole and the results of in situ and laboratory testing from the current investigation are given on the Record of Borehole sheets presented in Appendix A. The Record of Borehole sheets from the previous investigation at the site are provided for reference in Appendix B. The results of geotechnical laboratory testing from the current investigation are also presented in Appendix C. The results of basic soil and water chemical testing are included in Appendix D and rock core photographs are provided in Appendix E.

The borehole locations from the current and previous investigations are shown on Figure 1.

In general, the subsurface stratigraphy encountered within the footprint of the proposed structures consists of surficial fill layer, underlain by native sand and silt deposit, over Glacial Till overlying limestone with thin shale interbeds.

4.2 Pavement Structure

A layer of asphaltic concrete, ranging from 30 to 130 mm thick, was encountered at BH23-01 to BH23-04, BH23-06 and BH23-09 (which were drilled in existing parking areas) during the current investigation.

4.3 Surficial Fill Materials

A thin layer of fill material was present underlying the asphaltic concrete. Within the footprint of the new development, the fill extended to depths of up to 0.86 m below the original ground surface.

The fill layer is brown to grey in colour, with measured SPT “N” values ranging from 6 to 71 blows per 0.3 m of penetration, indicating a loose to very dense state of packing.

The results of natural moisture content testing carried out on eight samples of the fill layer gave values ranging between 1 and 4 percent. The results of grain size distribution testing carried out on two samples of the fill are presented in appendix C.

As the proposed building footprint currently contains a below grade level, it is anticipated that the above noted materials will be entirely removed during construction of the proposed buildings.

4.4 Glacial Till

A deposit of glacial till was encountered beneath the fill in all boreholes. The glacial till was fully penetrated and proven to depths of 1.8 m below ground surface in all boreholes except borehole 23-07 in which the glacial till was proven to 2.4m. In general, the glacial till consists of a heterogeneous mixture of cobbles, boulders, clay and gravel in a matrix of silty sand.

Standard penetration tests carried out within this layer gave ‘N’ values ranging from 8 to 42 blows per 0.3 m of penetration, indicating a compact to dense state of packing.

The higher SPT N values may be due to the presence of cobbles and boulders and may not reflect the state of packing of the soil matrix.

The results of natural moisture content testing carried out on nine samples of the glacial till layer gave values ranging between 5 and 27 percent. The results of grain size distribution testing carried out on two samples of the till are presented in appendix C.

4.5 Bedrock / Auger Refusal

Refusal to augering within the footprint of the proposed structures was encountered in all boreholes during the current investigation at depths ranging from 0.9 to 2.4 m below the existing ground surface (0.9 m to 1.9 m in the area in which the proposed buildings will be located). The bedrock was cored in two of the current boreholes to a maximum depth of 8 m below the existing ground surface. The bedrock consists of grey limestone with shale interbeds. The following table summarizes the ground surface, bedrock or auger refusal depths and elevations, and core lengths as encountered at the borehole locations within (or near to) the footprint of the proposed buildings:

Borehole/ Test Pit Number	Ground Surface Elevation (m)	Depth to Bedrock Surface or Auger Refusal (m)	Core Length (m)	Bedrock or Auger Refusal Elevation (m)
23-01 (WSP,2023)	59.91	0.86	7.04	59.05
23-02 (WSP,2023)	60.22	1.47	-	58.75
23-03 (WSP,2023)	60.59	1.83	-	58.76
23-04 (WSP,2023)	61.15	1.37	-	59.78
23-05 (WSP,2023)	62.13	1.93	6.04	60.20
23-06 (WSP,2023)	61.97	1.50	-	60.47
23-07 (WSP,2023)	63.37	2.44	-	60.93
23-07A (WSP, 2023)	63.37	4.47	5.47	53.43
23-08 (WSP,2023)	61.73	1.30	-	60.43
23-09 (WSP,2023)	59.68	1.87	-	57.81
No. 1 (Mcrostie,1964)	-	0.48	1.52	-
No. 2 (Mcrostie,1964)	-	3.53	1.55	-
No. 3 (Mcrostie,1964)	-	2.34	1.52	-
No. 4 (Mcrostie,1965)	59.80	2.43	1.70	57.36
No. 5 (Mcrostie,1965)	58.30	0.79	1.52	57.51
No. 6 (Mcrostie,1965)	58.79	0.60	2.92	58.18
No. 7 (Mcrostie,1965)	58.82	2.80	2.65	56.02

Rock Quality Designation (RQD) values measured in the boreholes ranges from 46 to 97%, indicating a poor to excellent quality rock.

Photographs of the recovered bedrock cores and results of the UCS testing are presented in Appendix E.

4.6 Groundwater conditions

Monitoring wells were sealed into borehole 23-05, 23-07 and 23-07A during the current investigation. The following table summarizes the available measured groundwater level.

Table 1: Summary of Groundwater Level

Borehole Number	Depth of Groundwater Level from ground surface (m)	Measurement Date
23-05 (shallow)	(dry)	September 5, 2023
23-05 (Deep)	3.38	September 5, 2023
23-07	(dry)	September 5, 2023
23-07A	3.59	October 12, 2023

Groundwater levels are expected to fluctuate seasonally and over shorter periods of time. Higher groundwater levels are expected during wet periods of the year, such as spring after the snowmelt or during periods of heavy rain.

5.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the proposed expansion based on our interpretation of the borehole information and project requirements. Reference should be made to the “Important Information and Limitations of This Report”, which follows the text but forms part of this document.

The information in this portion of the report is provided for planning and design purposes for the guidance of the design engineers and architects. The recommendations provided herein are consistent with the Ontario Building Code of 2012 (OBC 2012). Where comments are made on construction, they are provided only to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the factual information for construction, and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities, costs, sequencing and the like.

5.2 Site Grading

It is understood that the proposed development will maintain approximately the existing grades, as it will be tied in to the existing site development. Based on the conditions encountered, there would not be any meaningful restrictions on localized minor grade changes which may be required.

5.3 Frost Susceptibility

The fill and glacial till encountered at this site is considered to be frost susceptible. Foundations should be provided with a minimum of 1.8 m of earth for frost protection purposes. The bedrock at the site is not typically considered to be frost susceptible (provided it does not contain extensive seams of soil, which can be present in the upper portion of the bedrock).

Structures which are founded on bedrock at a depth of less than 1.8 m could be designed with reduced soil cover, however, the quality of the bedrock at the specific location would need to be confirmed during construction. This is typically done by drilling a small diameter (50 mm) hole below the proposed foundation subgrade to observe the rock quality within the frost depth.

As an alternative to frost cover, insulation may also be considered. Appropriate insulation details would need to be developed during detailed design based on the specific structure, depth, location, etc.

5.4 Seismic Considerations

The OBC 2012 contains seismic analysis methodology. The Seismic Site Class value, as defined in section 4.8.4 of the OBC 2012, depends on the average shear wave velocity of the upper 30 m of the soil and/or rock below founding level. The OBC permits the Site class to be specified based solely on the stratigraphy and in situ testing data (i.e., shear strengths and standard penetration test results), rather than from direct measurements of the shear wave velocity.

Based on the results of the sub-surface investigation, the site can be considered to be a Site Class C for design purposes.

The towers will include a below-grade level and will therefore be founded on bedrock. The seismic site class for bedrock sites is typically Site Class A or B. The building code, however, does not allow Site Class A or B to be used without a site-specific measurement of shear wave velocities. It is recommended that shear wave velocity measurements be undertaken at the site to allow for an improved site class (as this will have a significant impact on the building design).

5.5 Foundation Design

As discussed previously, the subsurface conditions at this site consist of fill overlying by glacial till. It is understood that the proposed buildings will have one underground parking level.

The bedrock surface was found to be approximately 1 to 2 m below the existing ground surface (i.e., elevations ranging from 59.9 to 62.1 m). With a single level of underground parking, the new building foundations are expected to be founded within limestone bedrock.

It is expected the towers could be supported on pad, strip or raft foundations placed on the bedrock at the base of the basement excavation. Foundations supported directly on the bedrock may be designed using a factored Ultimate Limit States bearing resistance of 6 MPa. Provided the bedrock surface is properly cleaned of soil and loose rock at the time of construction, the settlement of footings sized using this factored bearing resistance would be expected to be less than the 25 mm which is typically accepted and therefore Serviceability Limit States (SLS) typically do not govern the design of shallow foundations on rock.

Foundations should be entirely supported on rock. If the existing rock surface is below the planned footing level at the time of construction (for example where a previous excavation was present), mass concrete should be placed to bring the surface up to the planned underside of footing. Mass concrete, if used, should extend beyond the edge of the footing a distance equal to the depth of the mass concrete. Alternatively the foundation could be lowered to the as-found rock surface.

5.6 Earthworks

5.6.1 Excavations and Site Servicing

It is understood that the excavation for the proposed building towers will extend one storey below the existing ground surface. Deeper excavations may be required for the site services; however, the design invert levels are not yet known. The upper portion of the excavations (in soil) will be through fill material and glacial till.

No unusual problems are anticipated with excavating in the soil using conventional hydraulic excavating equipment. Cobbles and boulders should be expected in the glacial till. Fill material is, by nature, heterogeneous and obstructions may be encountered within the fill material.

In general, it is anticipated that open-cut methods will be feasible for excavations in soil. Where space is restricted, steel trench boxes, possibly in conjunction with steel plates and/or unsupported slopes at the surface, or a shoring system may be required to accommodate excavations.

The soils were found to be above the groundwater table and would generally be classified as a Type 3 soil in accordance with the Occupational Health and Safety Act (OHSA) of Ontario. As such, these excavations may be made with side slopes at 1 horizontal to 1 vertical (1H:1V).

5.6.2 Bedrock Excavation

Localized or shallow bedrock excavation can typically be completed by mechanical methods (such as hoe ramming). More extensive bedrock removal is more economically carried out by controlled blasting. Both methods should employ line drilling around the perimeter to define the extent of excavation and prevent overbreak.

If blasting is considered, blast induced damage to the bedrock must be avoided in the vicinity of existing structures (including buried structures such as the utilities), otherwise additional rock reinforcement could be required. At the final rock line, the bedrock should be line drilled at a close spacing in advance of blasting so that a clean bedrock face can be formed. It is considered that 75 mm diameter holes at a spacing of 200 mm or less would be appropriate for this purpose, though this is dependant on the blasting program and will need to be confirmed as part of the overall blast design.

Based on the quality of the bedrock encountered in the boreholes, it is expected that existing near vertical bedrock walls can likely be maintained for the construction period provided that any loose pieces of the bedrock are scaled off the faces for worker safety. Where the localized new excavations extend deeper than 1.5 m into the bedrock, the near vertical walls should be reviewed by a geotechnical engineer for any sign of unstable pillars or slabs that should be removed or stabilized. Stabilization options could consist of rock anchors, mesh, shotcrete, sloping the side slopes or a combination thereof. The appropriate stabilization methodology, if required, will depend on the actual site conditions during construction, and further guidance can be provided at that time.

5.6.3 Vibration Monitoring

Due to the close proximity of the existing surrounding structures to the proposed development, construction vibration, (particularly when blasting, breaking rock, driving piles or carrying out other similar vibration intensive works) should be controlled to limit the peak particle velocities at all adjacent structures or services such that vibration induced damage will be avoided.

A pre-construction survey is recommended to be carried out on all nearby structures and services. Any area of concerns should be identified during the pre-construction survey and should be monitored for movements during construction.

If blasting is required, the contractor should be required to submit a complete and detailed blasting design, as well as a monitoring plan prepared by a blasting/vibration specialist before starting blasting. This should be reviewed and accepted in relation to the requirements of the blasting specifications. The contractor should be limited to only small, controlled blastss. Peak vibration limits dependent on the following frequencies to the nearest structures and services are suggested.

The following frequency dependent peak vibration limits at the nearest structures and services are typical, but it is suggested they be confirmed by the structural engineer for the particular structure.

Frequency Range (Hz)	Vibration Limits (mm/s)
< 10	5
10 to 40	5 to 50 (sliding scale)
> 40	50

These limits should be practical and achievable on this project. Blasting typically generates vibrations greater than 40 Hz at near distances.

These limits are based on reducing the risk of structural damage to normal structures, in normal condition. These vibration limits may need to be adjusted if, for example, there is vibration-sensitive equipment in any of the receptors, the nearby structures are of unusual construction, or are fragile or in poor condition (for example older, heritage structures).

It is recommended that the monitoring of ground vibration intensities (peak ground vibrations and accelerations) from the construction activities (e.g., blasting) be carried out both in the ground adjacent to the closest structures and within or at the structures themselves. Where practical, blasting should be commenced furthest from most critical receptors to allow monitoring of the ground response and (if required) adjustment of the blasting program.

5.7 Groundwater Control

It is understood that one level of underground garage parking is being considered, which will be located within the footprint of buildings. The parking garage is assumed to extend about 3.0 m below the existing ground surface (i.e., base elevation of 58.5 m). Accordingly, excavation to this depth will be through surficial fill and sand, into the underlying bedrock in areas outside the footprint of the proposed buildings footprint.

Groundwater was encountered within the boreholes advanced at this site at about 3.4 m below ground surface. If major excavations are kept above this level no significant groundwater inflows would be expected during the excavations for the underground parking garage. Relatively minor groundwater flow is likely in localized excavations for footings, utilities, etc. which may extend below the groundwater level. It should be possible to handle inflows into the excavations by pumping from well filtered sumps established in the floor of the excavations, provided suitably sized and multiple pumps are used.

According to O.Reg. 63/16 and O.Reg. 387/04, if the volume of water to be pumped from excavations for the purpose of construction dewatering is greater than 50,000 L/day and less than 400,000 L/day, the water taking will need to be registered as a prescribed activity in the Environmental Activity and Sector Registry (EASR) and has several requirements including the completion of a “Water Taking Plan”. Alternatively, a Permit to Take Water

(PTTW) is required from the Ministry of the Environment Conservation and Parks (MECP) if a volume of water greater than 400,000 L/day is to be pumped from an excavation.

Based on the soil and groundwater conditions as well as possible size of the excavations, neither of these permits will likely be required during construction of the project. This assumption should be reviewed during detailed design based on the actual proposed excavations.

5.8 Basement Drainage

The backfill and drainage requirements for basement walls, as well as the lateral earth pressures will depend on the exact details of the existing excavation and the new underground structure.

The following sections assume that water-tight construction will not be required. If it is determined that water-tight construction is needed, additional design guidelines will be required.

5.8.1 Open Cut Excavations

The soils at this site are potentially frost susceptible and should not be used as foundation backfill. To avoid problems with frost adhesion and heaving as well as to provide drainage, these foundation elements should be backfilled, within the design frost penetration depth below finished grade, with non-frost susceptible sand or sand and gravel conforming to the requirements for Ontario Provincial Standard Specification (OPSS) Granular B Type I, Granular B Type II, or Granular A.

To avoid ground settlements around the basement walls which could affect site grading and drainage, all of the backfill materials should be placed in 0.3 m thick lifts and compacted to at least 95% of the material's SPMDD.

The basement wall backfill should be drained by means of a perforated pipe subdrain in a surround of 19 mm clear stone, fully wrapped in a geotextile, which leads by positive drainage to a storm sewer or to a sump from which the water is pumped.

5.9 Basement Floor /Raft Slab

It is possible that the basement floor will be above the groundwater level measured at the site (3.4 m below existing grade in September 2023). It is, however, likely that a single floor of underground parking will result in a basement that is relatively close to the groundwater table. In addition, it is likely that over the life of the building the site will experience higher groundwater levels than were recorded during the field investigation. It is recommended that floor drains be installed below the basement level as a precautionary measure. The floor drains can consist of perforated pipe drains as discussed above. For preliminary design the drains can be assumed to be at approximately 6 m spacing.

5.10 Lateral Earth Pressures for Design

The magnitude of the lateral earth pressures will depend on the backfill materials and backfill conditions adjacent to the foundation walls. If the backfill materials for open cut excavations consist of compacted granular and the walls are considered rigid (i.e., no lateral displacement), then the lateral earth pressures may be taken as:

$$s_h(z) = K_o\,(gz + q)$$

Where: $s_h(z)$ = Lateral earth pressure on the wall at depth z, kPa;
K_o = At-rest earth pressure coefficient for rigid walls, see table below;
K_a = Active earth pressure coefficient, see table below;
g = Unit weight of retained soil, use 21 kN/m^3;
z = Depth below top of wall, metres; and,
q = Uniform surcharge at ground surface to account for traffic and equipment (not less than 15 kPa), plus any surcharge due to adjacent foundation loads.

The following values in the table below provide preliminary guidelines for the lateral earth pressures for static (i.e., not earthquake) loading conditions for planning purposes. These lateral earth pressure coefficients assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes, new lateral earth pressures will need to be calculated (or the soil above the wall treated as a surcharge).

Table 2: Lateral Earth Pressure Coefficient for Unrestrained Shoring

Strata	Soil Unit Weight ρ (kN/m^3)	Effective Angle of Friction, f' (◦)	Coefficients of static lateral earth pressure		
			Active coefficient, K_a	Passive Coefficient, K_p	At rest, K_o
Existing Granular or Native Sand	23	32	0.30	3.25	0.47
Granular A	21	35	0.27	3.69	0.43
Granular B Type II	22	35	0.27	3.69	0.43

These lateral earth pressures would increase under seismic loading conditions. The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e., an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) for design may be determined as follows:

$$s_h(z) = K_o\,\gamma\,z + (K_{AE} – K_a)\,\gamma\,(H\text{-}z)$$

Where: $s_h(d)$ = Lateral earth pressure at depth z, kilopascals;
K_{AE} = Seismic earth pressure coefficient, see table below, and;
H = Total height of the wall, metres.

Table 3: Seismic Active Coefficients (KAE)

Material	Seismic Active Pressure Coefficients, K_{AE}		
	Existing Granular Fill or Native Sand	Granular A	Granular B Type II
Yielding wall	0.39	0.35	0.35
Non-Yielding wall	0.50	0.45	0.45

It should be noted that all of the lateral earth pressure equations are given in an unfactored format and will need to be factored for ULS design purposes.

If the wall allows lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as:

- Rotation of approximately 0.002 about the base of a vertical wall (where the rotation is calculated as the horizontal displacement divided by the height of the wall);
- Horizontal translation of 0.001 times the height of the wall; or,
- A combination of both.

If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at-rest earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.

5.11 Pavement Design

It is understood new parking lots and access roadway will be constructed as part of the development. The following provides guidelines for the construction of access roads and parking areas for light traffic (ie. Cars) and heavy traffic (trucks).

5.11.1 Subgrade Preparation

In preparation for pavement construction, all topsoil, unsuitable fill, disturbed, or otherwise deleterious materials (i.e., those materials containing organic material) should be removed from the pavement areas. Some of the existing fill could remain provided that it is free of organic matter, and that the subgrade be subjected to a proof roll with a loaded tandem truck to reveal weak or soft areas prior to the construction of the new pavement structure. Soft or weak areas should be removed and repaired with acceptable earth borrow or OPSS Select Subgrade Material (SSM).

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow (OPSS.MUNI 206/212), Select Subgrade Material (OPSS.MUNI 1010) or additional granular base if grade changes are minor. These materials should be placed in maximum 300 mm thick lifts and should be compacted to at least 98% of the materials SPMDD using suitable compaction equipment.

The surface of the subgrade or fill should be crowned or sloped to promote drainage of the roadway granular structure. Perforated pipe subdrains should be provided along the low sides of the roadway along the entire length. The subdrains should be installed in accordance with OPSS.MUNI 405. The subdrains should be connected to the catch basins such that the pavement structure will be positively drained and will intercept flows within the subbase.

Below the pavement structure, frost compatibility must be maintained across any new service trenches. Due to the variability of the soils within the project limits, the subsoil should be inspected by qualified geotechnical personnel to make sure that there is no potential for differential frost heaving. Frost tapers from the bottom of granular subbase to 1.8 m depth should be constructed at 10H:1V and should be provided where necessary.

The pavement recommendations have been split up into two categories of light duty and heavy-duty pavements. It has been assumed the light duty areas will consist of parking areas and lighter vehicles (i.e., no truck or bus traffic), and the heavy-duty pavements will consist of occasional truck traffic. The pavement in each area should be constructed as follows:

Material		Thickness of Pavement Elements (mm)	
		Light Duty	Heavy Duty
Asphaltic Concrete OPSS.MUNI 1151	Superpave 12.5 mm	40	50
	Superpave 19.0 mm	50	70
Granular Material OPSS.MUNI 1010	Granular A Base	150	150
	Granular B, Type II Subbase	400	500

The above pavement design is based on the assumption that the pavement subgrade has been acceptably prepared (i.e., where the bottom of the excavation has been adequately compacted to the required density and the subgrade surface is not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase.

Additionally, a Class II woven geotextile conforming to OPSS 1860 should be provided under pavement areas to prevent pumping of the subgrade into the Granular B Type II subbase.

5.12 Corrosion and Cement Type

Two soil samples from boreholes 23-03 and 23-05 were submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures.

The results of the current investigation also indicate a low potential for corrosion of buried ferrous elements, which should be considered in the design of substructures, buried ferrous elements.

The results of this testing are provided in Appendix D and summarized below.

Borehole Number	Sample Number	Depth Intervals (m)	Chlorides (%)	Sulphates (%)	pH	Resistivity (Ohm-cm)
23-03	2	0.76 – 1.37	0.005	0.01	8.07	3448
23-05	3	1.52 – 2.13	0.006	0.01	8.76	4348

6.0 IMPACT ON ADJACENTS DEVELOPMENTS

Possible impacts on adjacent developments could result from:

- Ground movement around the perimeter of new excavations.
- Ground settlements due to the planned temporary and permanent groundwater level lowering.

A preconstruction survey of all structures located within close proximity to this site should be carried out prior to commencement of the excavation.

Given the relatively shallow depth of additional bedrock excavation, underpinning or extensive shoring is not expected to be required for the proposed construction. The proposed excavation extents should, however be reviewed during detailed design to confirm this assumption. During construction the exposed bedrock should be inspected by qualified geotechnical personnel at the time of excavation, particularly in areas where excavations will be in close proximity to existing foundations.

7.0 ADDITIONAL CONSIDERATIONS

At the time of writing this report, only conceptual details related to the proposed building towers were available. WSP should review the final drawings and specifications for this project prior to tendering to confirm that the guidelines in this report have been adequately interpreted.

During construction, sufficient foundation inspections, subgrade inspections, in-situ density tests, materials testing, pile installation monitoring should be carried out to confirm that the conditions exposed are consistent with those encountered in the borehole, and to monitor conformance to the pertinent project specifications. Concrete testing should be carried out in a CCIL certified laboratory.

All bearing surfaces must be inspected by WSP prior to filling or concreting to ensure that strata having adequate bearing capacity have been reached and that the bearing surfaces have been properly prepared.

8.0 CLOSURE

WSP trust that this report provides sufficient geotechnical engineering information to facilitate the design of this project. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact this office.

Signature Page

WSP Canada Inc.

Arthur Kuitchoua Petke, P.Eng	Chris Hendry, P.Eng
Geotechnical Engineer	*Senior Geotechnical Engineer*

AKP/CH/al

https://wsponlinecan.sharepoint.com/sites/ca-ca00083769447/shared documents/06. deliverables/4_reports/1-geotechnical/final/ca0008376.9447-rev0-cleary development.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: WSP Canada Inc. (WSP) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to WSP by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. WSP cannot be responsible for use of this report, or portions thereof, unless WSP is requested to review and, if necessary, revise the report.

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The report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, communications between WSP and the Client, and to any other reports prepared by WSP for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. WSP can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Ground Water Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, WSP does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that WSP interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: WSP will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

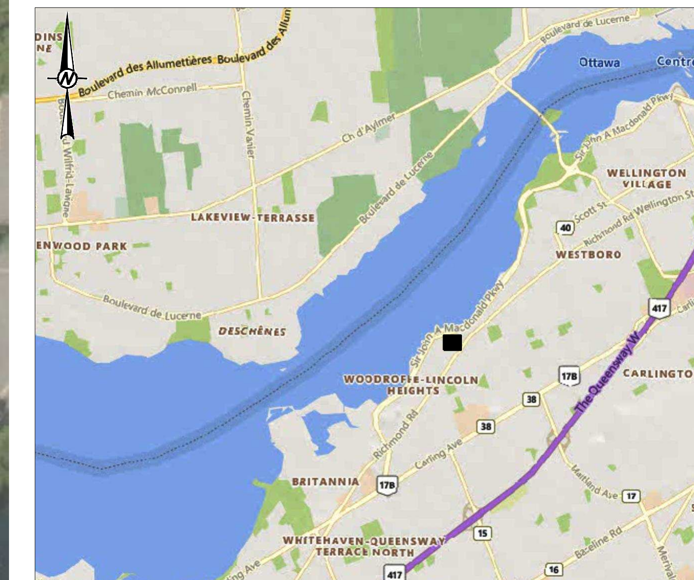
Follow-Up and Construction Services: All details of the design were not known at the time of submission of WSP's report. WSP should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of WSP's report.

During construction, WSP should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of WSP's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in WSP's report. Adequate field review, observation and testing during construction are necessary for WSP to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, WSP's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that WSP be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that WSP be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. WSP takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

KEY MAP



SCALE: 1:100,000

LEGEND

- APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
- APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION BY MCROSTIE & ASSOCIATES LTD., REPORT NO. SF-763 (1964)
- APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION BY MCROSTIE SETO GENEST & ASSOCIATES LTD., REPORT NO. SF-917 (1965)

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: UTM ZONE 18

0 12.5 25
1:750 METRES

CLIENT
THEIA PARTNERS

PROJECT
GEOTECHNICAL INVESTIGATION
TWO MULTI-USE RESIDENTIAL BUILDINGS
30 CLEARY AVENUE, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT

YYYY-MM-DD	2023-09-05
DESIGNED	----
PREPARED	NV
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
CA0008376.9447	0001	A	1

APPENDIX A

Record of Borehole Sheet (Current Investigation)

METHOD OF SOIL CLASSIFICATION

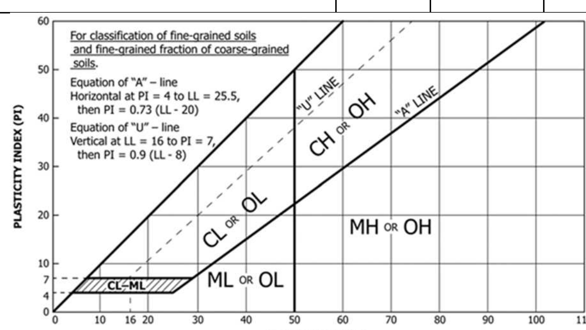
The WSP Canada Soil Classification[1] System is based on the Unified Soil Classification System (USCS) (after ASTM D2487)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content [6,9]	USCS Group Symbol [3,5,7]	Primary Group Name[2]
INORGANIC (Organic Content <30% by mass)	**COARSE-GRAINED SOILS** (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Clean Gravels with <5% fines [3] (by mass)	Well Graded	≥4 (and)	≥1 to ≤3	≤30%	GW	Well-graded GRAVEL [4,6]
				Poorly Graded	<4 (and/or)	<1 or >3		GP	Poorly graded GRAVEL [4,6]
			Gravels with >12% fines [3] (by mass)	Below A Line	n/a			GM	SILTY GRAVEL [4,6]
				Above A Line	n/a			GC	CLAYEY GRAVEL [4,5,6]
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Clean Sands with <5% fines [7] (by mass)	Well Graded	≥6 (and)	≥1 to ≤3		SW	Well-graded SAND [6,8]
				Poorly Graded	<6 (and/or)	<1 or >3		SP	Poorly graded SAND [6,8]
			Sands with >12% fines [7] (by mass)	Below A Line	n/a			SM	SILTY SAND [6,8]
				Above A Line	n/a			SC	CLAYEY SAND [5,6,8]

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators: Dilatancy	Dry Strength	Shine Test	Thread Diameter (mm)	Toughness (of 3 mm thread)	Organic Content [B,H]	USCS Group Symbol [A]	Primary Group Name [A]
INORGANIC (Organic Content <30% by mass)	**FINE-GRAINED SOILS** (≥50% by mass is smaller than 0.075 mm)	SILTS (Nonplastic or PI and LL plot **below A-Line** on Plasticity Chart below) [C]	Liquid Limit <50 [D]	Rapid	None to Low	Dull to None	3 to >6	Low/can't roll 3 mm	<15%	ML	SILT [H]
				None to Slow	Low to Medium	Dull to Slight	3 to 6	Low	15% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50 [D]	None to V.Slow	Low to Medium	Slight	3 to 6	Low to Medium	<15%	MH	ELASTIC SILT[H]
				None	Medium to High	Dull to Slight	1 to 3	Low to Medium	15% to <30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot **above A-Line** on Plasticity Chart below) [A]	Liquid Limit <50 [D]	None to Medium Slow	Medium to High	Slight to Shiny	1 to 3	Medium	<15%	CL	LEAN CLAY [A,E,F,G,H]
				None to V.Slow	Medium to High	Slight to Shiny	1 to 3	Medium	15% to <30%	OL	ORGANIC CLAY [E,F,G]
			Liquid Limit ≥50 [D]	None	High to V.High	Shiny	<1	High	<15%	CH	FAT CLAY [E,F,G,H]
				None	High	Shiny	<1 to 1	High	15% to <30%	OH	ORGANIC CLAY [E,F,G]
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures	Relatively lightweight, possibly spongy. Some water may squeeze from sample. Some shrinkage may occur on air drying. Sand fraction may be visible. Low to high dilatancy. Thread weak near plastic limit. Low to medium dry strength.						30% to <75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat	Lightweight, spongy. Much water squeezes from sample. Shrinks considerably on air drying (i.e., very high water content). Plant structure identiable to altered.						75% to 100%		PEAT

Coarse-Grained Soil Note(s):

1. Based on the material passing the 75 mm sieve.
2. If field sample contains or drilling observations indicate cobbles or boulders or both, add, "with cobbles" or "with cobbles and boulders". Include notes on the depth(s) encountered, and sizes if possible.
3. Gravels with 5% to 12% fines require dual symbols:
   (GW-GM) Well-graded GRAVEL with silt,
   (GW-GC) Well-graded GRAVEL with clay,
   (GP-GM) Poorly graded GRAVEL with silt,
   (GP-GC) Poorly graded GRAVEL with clay.
4. If soil contains ≥15% sand, add "with sand" to Group Name.
5. If fines classify as CL-ML, use dual symbol (GC-GM) or (SC-SM) for Group Symbol.
6. If the soil has an organic content (OC) 15%≤OC<30% the prefix "Organic" should be added before the Group Name. If the soil has an organic content 3%≤OC<15% add "with organic fines" to Group Name. If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
7. Sands with 5% to 12% fines require dual symbols:
   (SW-SM) Well-graded SAND with silt,
   (SW-SC) Well-graded SAND with clay,
   (SP-SM) Poorly graded SAND with silt,
   (SP-SC) Poorly graded SAND with clay.
8. If soil contains ≥15% gravel, add "with gravel" to Group Name.



Fine-Grained Soil Note(s):

A. If Atterberg limits plot above the A-line but in the 'hatched' area on the plasticity chart, soil is a (CL-ML) SILTY CLAY.
B. If the soil contains >0% to ≤3% organics, the descriptor "trace organics" may be added.
C. If fine-grained materials are nonplastic (i.e., a plastic limit (PL) cannot be measured), soil is a (ML) SILT.
D. If soil has a liquid limit (LL) >30% to <50%, the term 'medium plasticity' may be included in the description, but the Group Name/Symbol is not changed.
E. If soil contains 15% to <30% +No.200, add "with sand" or "with gravel".
F. If soil contains ≥30% +No.200 mainly sand, add "Sandy" to Group Name.
G. If soil contains ≥30% +No.200 mainly gravel, add "Gravelly" to Group Name.
H. If the soil has an organic content (OC) 3%≤OC<15% add "with organic fines" to Group Name.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

GRADATIONAL COMPONENT TERMS

% (by mass)	Term
≤ 5	Use "trace"
> 5 to ≤ 12	Use "few"
> 12 to <30	Use "little"
≥ 30 to <50	Use "some"
≥ 50	Use "mostly"

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)
An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); Nd:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven, pushed tube sampler, or geoprobe macro-core – note size
DS	Denison type sample
FS	Foil Sample
GS	Grab Sample
MC	Modified California Samples – note sample diameter and hammer weight
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split-spoon sampler (50 mm OD); larger sizes use MC
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in general accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in general accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
NP	nonplastic
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

RECORD OF BOREHOLE: BH23-01

PROJECT: CA0008376.9447
LOCATION: N 5025707.68; E 439473.01
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 24, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (100 200 300 400) / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ ND = Not Detected (100 200 300 400)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp —○W— Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		GROUND SURFACE		59.91							
0	Power Auger 204 mm Diam. (Hollow Stem)	ASPHALT		0.00 / 0.03							
		FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, loose			1	SS	9	⊕□ ND			
				59.05	2	SS	50/ 0.05				
1		Borehole continued on Record Drillhole BH23-01									
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

LOGGED: OB
CHECKED: AKP

PROJECT: CA0008376.9447

RECORD OF DRILLHOLE: BH23-01

LOCATION: N 5025707.68 ;E 439473.01

DRILLING DATE: August 24, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing

NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE % / SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION; Jr Ja Jcon)	WEATHERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Cont'd from Record of Borehole BH23-01		59.05										
1–7	Rotary Drill, NQ Core	Fresh, thinly to medium bedded, grey, fine to medium grained, faintly porous, strong LIMESTONE bedrock with slightly weathered to fresh, porous, fine grained, medium strong, black shale		0.86	1, 2, 3, 4, 5								BC, BC, BC, BC	UCS=198 MPa
8		END OF DRILLHOLE		52.01 7.90										

Note(s):

1. Borehole dry upon completion of drilling.

DEPTH SCALE

1 : 50

LOGGED: OB

CHECKED: AKP

RECORD OF BOREHOLE: BH23-02

PROJECT: CA0008376.9447
LOCATION: N 5025681.49; E 439478.54
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 25, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger, 204 mm Diam. (Hollow Stem)

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEADSPACE VAPOUR CONCENTRATIONS [PPM]	WATER CONTENT PERCENT
GROUND SURFACE	60.22					
ASPHALT	0.00 / 0.05					
FILL - (SP) gravelly SAND, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, compact,	59.46 / 0.76	1	SS	24	ND	
(SM) SILTY SAND, trace clay, trace gravel; grey to brown (GLACIAL TILL); non-cohesive, moist to wet, loose	58.75 / 1.47	2	SS	8		
END OF BOREHOLE Auger Refusal						

Note(s):

1. Borehole dry upon completion of drilling.

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE; STRATA PLOT; SAMPLES; HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (100, 200, 300, 400); HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ ND = Not Detected (100, 200, 300, 400); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (20, 40, 60, 80); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH SCALE
1 : 50

wsp

LOGGED: OB
CHECKED: AKP

RECORD OF BOREHOLE: BH23-03

PROJECT: CA0008376.9447
LOCATION: N 5025657.83; E 439481.27
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 25, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		GROUND SURFACE	60.59							
0	Power Auger, 204 mm Diam. (Hollow Stem)	ASPHALT	0.00 / 0.06							
		FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, compact	59.92 / 0.67	1	SS	16	ND	○		47 45 (8)
1		(SP) SAND, trace to some silt, fine grained; brown; moist to wet, loose	59.07 / 1.52	2	SS	7	ND			
		(SM/GP) SILTY SAND and GRAVEL; dark to brown, contains organic matters (GLACIAL TILL); moist, very dense	58.76 / 1.83	3	SS	50/0.25	ND; ⊕	○		
2		END OF BOREHOLE Auger Refusal Note(s): 1. Borehole dry upon completion of drilling.								

DEPTH SCALE
1 : 50

LOGGED: OB
CHECKED: AKP

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RECORD OF BOREHOLE: BH23-04

PROJECT: CA0008376.9447
LOCATION: N 5025645.99; E 439508.24
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 25, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected)	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	61.15							
0	Power Auger, 204 mm Diam. (Hollow Stem)	ASPHALT	0.00							
		FILL - (GP) sandy GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, dense	0.08	1	SS	32	ND			
		(SM) SILTY SAND, trace clay, trace gravel; brown with black bedding (GLACIAL TILL); moist, very dense	60.39 / 0.76	2	SS	14				
		END OF BOREHOLE Auger Refusal Note(s): 1. Borehole dry upon completion of drilling.	59.78 / 1.37							

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}
WATER CONTENT PERCENT: Wp —○W— Wl; 20, 40, 60, 80
HEADSPACE scales: 100, 200, 300, 400
GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

DEPTH SCALE
1 : 50

wsp

LOGGED: OB
CHECKED: AKP

RECORD OF BOREHOLE: BH23-05

PROJECT: CA0008376.9447
LOCATION: N 5025611.77; E 439503.11
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 24, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		62.13							
0	Power Auger 204 mm Diam. (Hollow Stem)	FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, dense		0.00							Bentonite
		(SM) SILTY SAND, some gravel, trace clay; light brown (GLACIAL TILL); moist, compact		61.88 / 0.25	1	SS	42	□ ⊕ ND	○		Cuttings
1					2	SS	21	□ ⊕ ND			32 mm Diam. PVC #10 Slot Screen 'B'
		- rock fragments, ground-up, bedrock; weathered rock			3	SS	50/ 0.13	□ ⊕ ND			
2				60.20							
		Borehole continued on Record Drillhole BH23-05									

Scale values: Headspace 100, 200, 300, 400; Hydraulic conductivity 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}; Water content 20, 40, 60, 80. GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

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DEPTH SCALE
1 : 50

LOGGED: OB
CHECKED: AKP

LOCATION: N 5025611.77 ;E 439503.11

DRILLING DATE: August 24, 2023

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing

NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FEATURES	PIEZOMETER
		Cont'd from Record of Borehole BH23-05		60.20			
2–8	Rotary Drill, NQ Core	Fresh, thinly to medium bedded, grey, fine to medium grained, faintly porous, strong LIMESTONE bedrock with slightly weathered to fresh, porous, fine grained, medium strong, black shale		1.93	1, 2, 3, 4	BC/LC; BC	32 mm Diam. PVC #10 Slot Screen 'B'; Silica Sand; Bentonite; UCS=187 MPa; Silica Sand; 32 mm Diam. PVC #10 Slot Screen 'A'
8		END OF DRILLHOLE		54.16 7.97			

Other column headings: FLUSH RETURN; RECOVERY (TOTAL CORE %, SOLID CORE %: 80 60 40 20); R.Q.D. % (80 60 40 20); FRACT. INDEX PER (5 10 15 20); DISCONTINUITY DATA (DIP w.r.t. CORE AXIS: 0 30 60 90; TYPE AND SURFACE DESCRIPTION; Jr; Ja; Jcon); WEATH-ERING INDEX (W1 W2 W3 W4 W5 W6); Diametral Point Load Index (MPa) (2 4 6)

Depth scale: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Note(s):

1. Groundwater measured in Screen 'B' at 0.90 m depth upon completion of drilling.

2. Groundwater measured in Screen 'A' at 3.03 m depth upon completion of drilling.

RECORD OF BOREHOLE: BH23-06

PROJECT: CA0008376.9447
LOCATION: N 5025623.60; E 439532.36
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 25, 2023
DRILL RIG: CME 75

SHEET 1 OF 1
DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		GROUND SURFACE		61.98							
0	Power Auger 204 mm Diam. (Hollow Stem)	ASPHALT		0.00							
		FILL - (GP) sandy GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, dense		0.13	1	SS	65	ND	○		
1		(SM/GP) SILTY SAND and GRAVEL; grey to brown, cobbles and boulders, contains strong petroleum odor (GLACIAL TILL); moist, compact		61.17 / 0.81	2	SS	23		○		38 41 (21)
		- rock fragments			3	SS	50/0.20				
		END OF BOREHOLE Auger Refusal Note(s): 1. Borehole dry upon completion of drilling.		60.48 / 1.50							

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Headspace scale: 100, 200, 300, 400. Hydraulic conductivity scale: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}. Water content scale: 20, 40, 60, 80.

DEPTH SCALE
1 : 50

wsp

LOGGED: OB
CHECKED: AKP

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RECORD OF BOREHOLE: BH23-07

PROJECT: CA0008376.9447
LOCATION: N 5025623.43; E 439573.43
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING DATE: August 25, 2023
DRILL RIG: CME 75

DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	HEADSPACE VAPOUR CONCENTRATIONS [PPM]	WATER CONTENT PERCENT	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	63.38						
0	Power Auger, 204 mm Diam. (Hollow Stem)	FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular; non-cohesive, moist, loose	0.00	1A			ND		Cuttings
		(SM) - SILTY SAND, some clay, some gravel; grey to black, cobbles and boulders, contains organic matter (GLACIAL TILL); moist, compact	0.15	1B	SS	16	ND		Bentonite
1				2	SS	25	ND		Silica Sand
				3	SS	7	ND		32 mm Diam. PVC #10 Slot Screen
2		- fine grained SAND; moist to wet		4	SS	50/0.23	ND		
		END OF BOREHOLE Auger Refusal Note(s): 1. Borehole dry upon completion of drilling.	60.94 2.44						

Column header notes: HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕, ND = Not Detected (100, 200, 300, 400); HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □, ND = Not Detected (100, 200, 300, 400); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp — W — Wl (20, 40, 60, 80); ADDITIONAL LAB. TESTING; STRATA PLOT; SAMPLES; SOIL PROFILE; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH SCALE
1 : 50

wsp

LOGGED: OB
CHECKED: AKP

PROJECT: CA0008376.9447

LOCATION: N 5025621.99; E 439571.86

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH23-07A

BORING DATE: September 29, 2023

DRILL RIG: CME 75

SHEET 1 OF 1

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE - DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION; GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		GROUND SURFACE		63.38							
0		FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular; non-cohesive, moist, loose		0.00							Bentonite
		(SM) - SILTY SAND, some clay, some gravel; grey to black, cobbles and boulders, contains organic matter (GLACIAL TILL); moist, compact		0.15							
1											
2		- fine grained SAND; moist to wet									Cuttings
3											
											Oct. 12, 2023
4											Bentonite
		END OF BOREHOLE Auger Refusal		58.93							

END OF BOREHOLE
Auger Refusal

Note(s):

1. Borehole dry upon completion of drilling.

2. Groundwater level measured at a depth of 3.59 m on October 12, 2023.

Borehole continued on Record Drillhole BH23-07A

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

LOGGED: OB

CHECKED: AKP

RECORD OF DRILLHOLE: BH23-07A

PROJECT: CA0008376.9447

LOCATION: N 5025621.99 ;E 439571.86

INCLINATION: -90° AZIMUTH: ---

DATUM: Geodetic

DRILLING DATE:

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	Jcon	WEATHERING INDEX	Diametral Point Load Index (MPa)	FEATURES	PIEZOMETER
		Cont'd from Record of Borehole BH23-07A		58.91															
5		Fresh, thinly to medium bedded, grey, fine to medium grained, faintly porous, strong LIMESTONE bedrock with slightly weathered to fresh, porous, fine grained, black shale		4.47	1														Bentonite
6					2														Silica Sand
7																			
8					3														32 mm Diam. PVC #10 Slot Screen
9					4														
10		END OF DRILLHOLE		53.44 9.94															
11																			
12																			
13																			
14																			

DEPTH SCALE

1 : 50

LOGGED: OB

CHECKED: AKP

RECORD OF BOREHOLE: BH23-08

PROJECT: CA0008376.9447
LOCATION: N 5025623.80; E 439505.34
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm
BORING DATE: August 25, 2023
DRILL RIG: CME 75
SHEET 1 OF 1
DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] ⊕ / HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] □ (ND = Not Detected)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		GROUND SURFACE		61.74							
0	Power Auger 204 mm Diam. (Hollow Stem)	FILL - (GP) sandy GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, very dense		0.00	1	SS	71	□ ND; ⊕	○		37 41 (22)
				61.04							
1		(SM/GP) SILTY SAND and GRAVEL; dark to brown, contains organic matter, rootlets and rock fragments (GLACIAL TILL); moist, very dense		0.70	2	SS	42		○		
				60.44	3	SS	50/0.08				
		END OF BOREHOLE Auger Refusal Note(s): 1. Borehole dry upon completion of drilling.		1.30							

DEPTH SCALE
1 : 50

wsp

LOGGED: OB
CHECKED: AKP

PROJECT: CA0008376.9447

LOCATION: N 5025685.05; E 439517.69

RECORD OF BOREHOLE: BH23-09

SHEET 1 OF 1

BORING DATE: August 24, 2023

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DRILL RIG: CME 75

HAMMER TYPE: AUTOMATIC

BORING METHOD: Power Auger, 204 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected)	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	GROUND SURFACE	59.68					
0	ASPHALT	0.00					
	FILL - (SP/GP) SAND and GRAVEL, trace silt; brown to grey, angular (PAVEMENT STRUCTURE); non-cohesive, moist, compact	0.06	1A		13	ND	
			1B			ND	
	FILL - (SP) SAND, some silt; brown to grey, angular; non-cohesive, moist, loose	59.43 0.25	2		6	ND	
1	TOPSOIL - (SM/ML) SILTY SAND to sandy SILT; black, contains rootlets and organic matter; non-cohesive	58.38 1.30	3A			ND	
	(SP/GP) SAND and GRAVEL, some silt; brown to light brown, angular (GLACIAL TILL); non-cohesive, moist, dense	1.40	3B		36	ND	41 39 (20)
2	END OF BOREHOLE	57.81 1.87					

Note(s):

1. Borehole dry upon completion of drilling.

Column headings also include: HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] (ND = Not Detected) 100 200 300 400; HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp W Wl 20 40 60 80; ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION; STRATA PLOT.

DEPTH SCALE 1 : 50

wsp

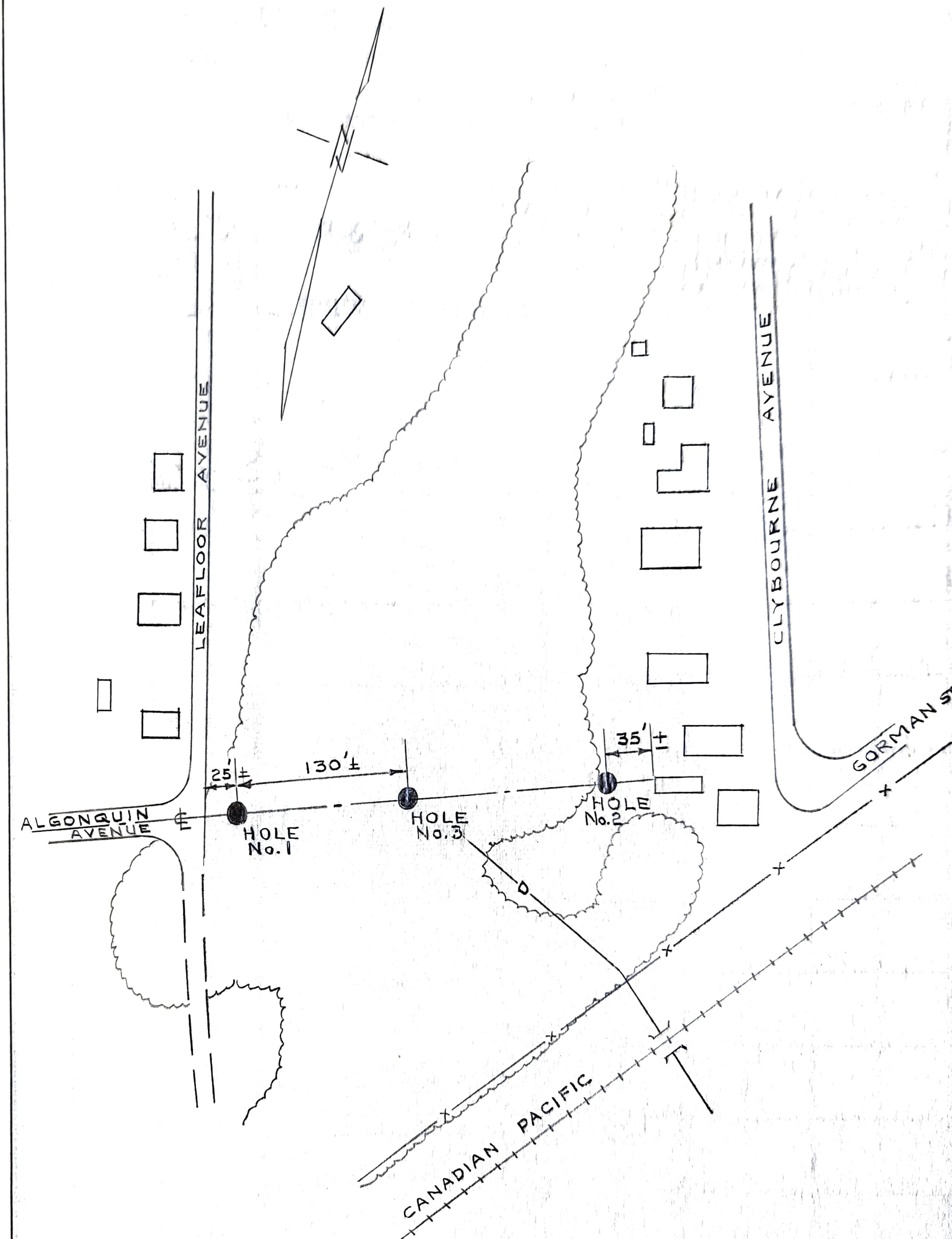
LOGGED: OB

CHECKED: AKP

APPENDIX B

Record of Borehole Sheet (Previous Investigation)

FORM 8-11-2



McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS

BOREHOLE LOCATIONS
LEAFLOOR AVE. NEAR
OTTAWA RIVER PARKWAY

SCALE 1" = 100'	PLATE 1

FORM S-10-4

McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

LEAFLOOR NEAR OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) ____ DATE MAY 12, 1964

REMARKS ____

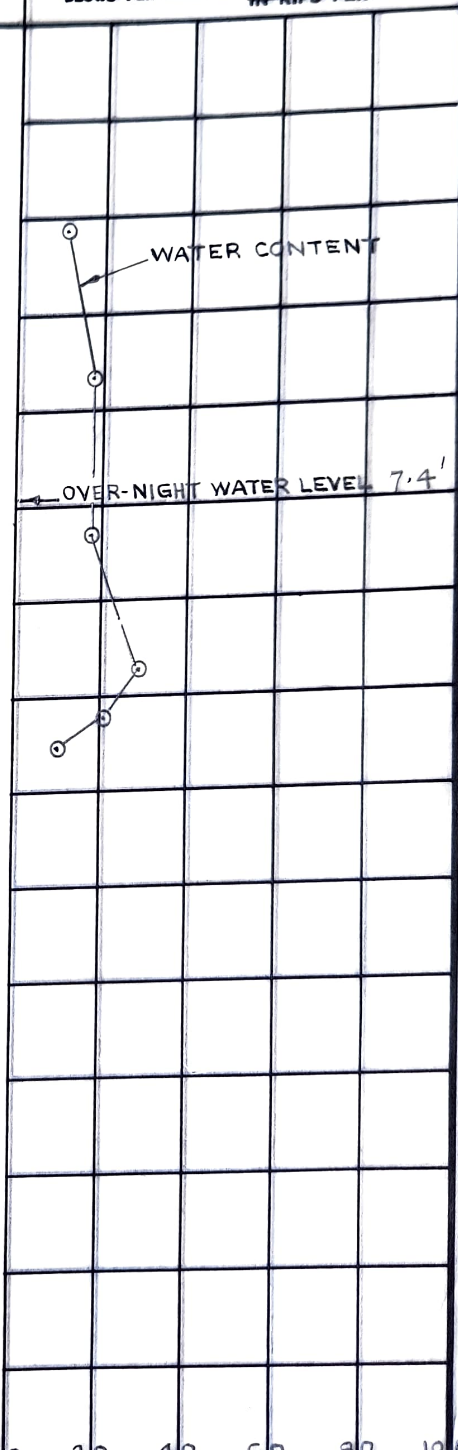
HOLE NO. 2

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT.²	SMALL SCALE PENETROMETER KIPS/FT.²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL (GROUND SURFACE)	DEPTH IN FEET	ELEVATION
					0'	
				TOPSOIL		
					1'	
		9 / 8 for 6"	2-1	LOOSE FINE SAND WITH SOME VERY FINE SAND A LITTLE MEDIUM SAND & A TRACE OF GRAVEL		
					3.5'	
		26	2-2	MEDIUM DENSE FINE SAND WITH SOME VERY FINE SAND A LITTLE MEDIUM SAND & A TRACE OF GRAVEL		
					7.5'	
		25	2-3	MEDIUM DENSE FINE SAND WITH SOME MEDIUM SAND		
					10'	
		16	2.4A	MEDIUM DENSE VERY FINE SAND WITH SOME SILT		
					10.5'	
			2.4B	MEDIUM DENSE SILT WITH A 1/4" SILTY CLAY LAYER		
					11'	
		19 for 6"	2.4C	DENSE TILL		
					11.6'	
				ROCK CORE RECOVERY 98%		
					16.7'	
				BOTTOM OF HOLE		

PROBING OR VANE TEST

........LB. HAMMER ....INCH DROP | NO CASING ....INCH DIA. ROD

~~BLOWS PER FOOT OR~~ ~~SHEAR STRENGTH IN KIPS PER FT.²~~



% WATER CONTENT
NATURAL ⊙
LIQUID LIMIT ⊡
PLASTIC LIMIT △

PLATE 3

R - REMOULDED

McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

LEAFLOOR NEAR
OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) ______ DATE MAY 11, 1964

HOLE No. 1

REMARKS ______

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT.^{2}	SMALL SCALE PENETROMETER KIPS/FT.^{2}	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL (GROUND SURFACE)	DEPTH IN FEET	ELEVATION	PROBING OR VANE TEST (……LB. HAMMER ……INCH DROP; NO CASING ……INCH DIA. ROD; ~~BLOWS PER FOOT OR SHEAR STRENGTH IN KIPS PER FT.^{2}~~)
					0'		
				ORGANIC TOPSOIL	1·6'		
	1/2" DROP			ROCK CORE RECOVERY 95%	6·6'		
				BOTTOM OF HOLE			

R - REMOULDED

% WATER CONTENT
NATURAL ○
LIQUID LIMIT □
PLASTIC LIMIT △

PLATE 2

FORM S-10-4

McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

LEAFLOOR NEAR OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) ________ DATE MAY 12, 1964

HOLE No. 3

REMARKS ________

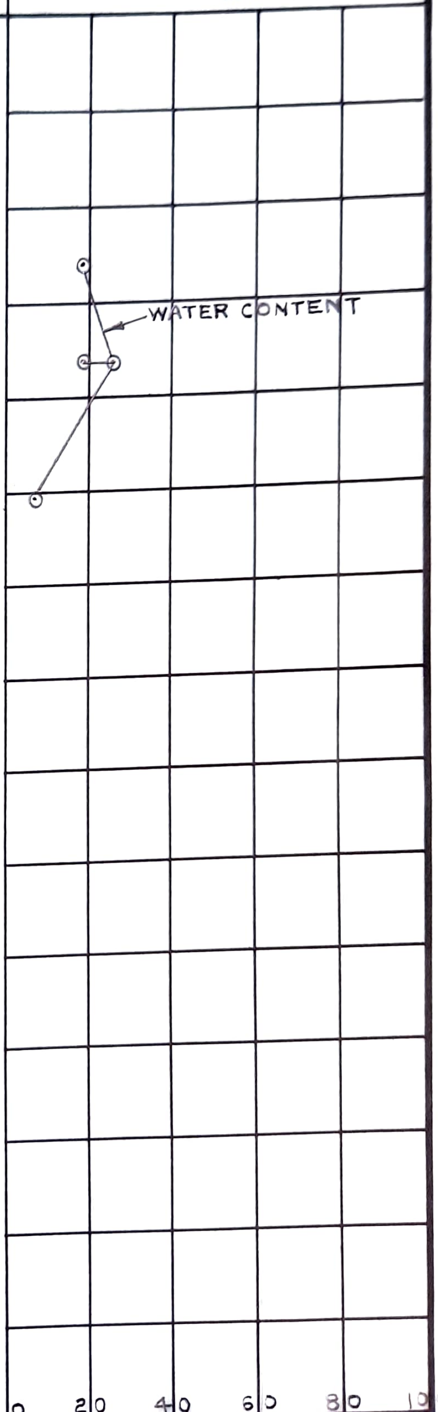
UNCONFINED COMPRESSIVE STRENGTH KIPS/FT.²	SMALL SCALE PENETROMETER KIPS/FT.²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL (GROUND SURFACE)	DEPTH IN FEET	ELEVATION
					0'	
				FILL SAWDUST & WOOD WITH A LITTLE SILT		
			3.1A			
		4	3.1B		3.8'	
				LOOSE FINE SAND WITH A LITTLE MEDIUM SAND	5'	
		6		LOOSE CLAYEY SILT WITH A LITTLE VERY FINE SAND A TRACE OF GRAVEL & A 1/2" LAYER OF FINE SAND	6'	
		9 for 6"	3.2	MEDIUM DENSE CLAYEY SILT WITH A LITTLE VERY FINE SAND & A TRACE OF GRAVEL & A 1/2" LAYER OF FINE SAND	7.5'	
		19 for 3"	3.3	DENSE TILL	7.7'	
				ROCK CORE RECOVERY 87%	12.7'	
				BOTTOM OF HOLE		

PROBING OR VANE TEST

........LB. HAMMER ....INCH DROP

NO CASING ....INCH DIA. ROD

BLOWS PER FOOT OR SHEAR STRENGTH IN KIPS PER FT.²

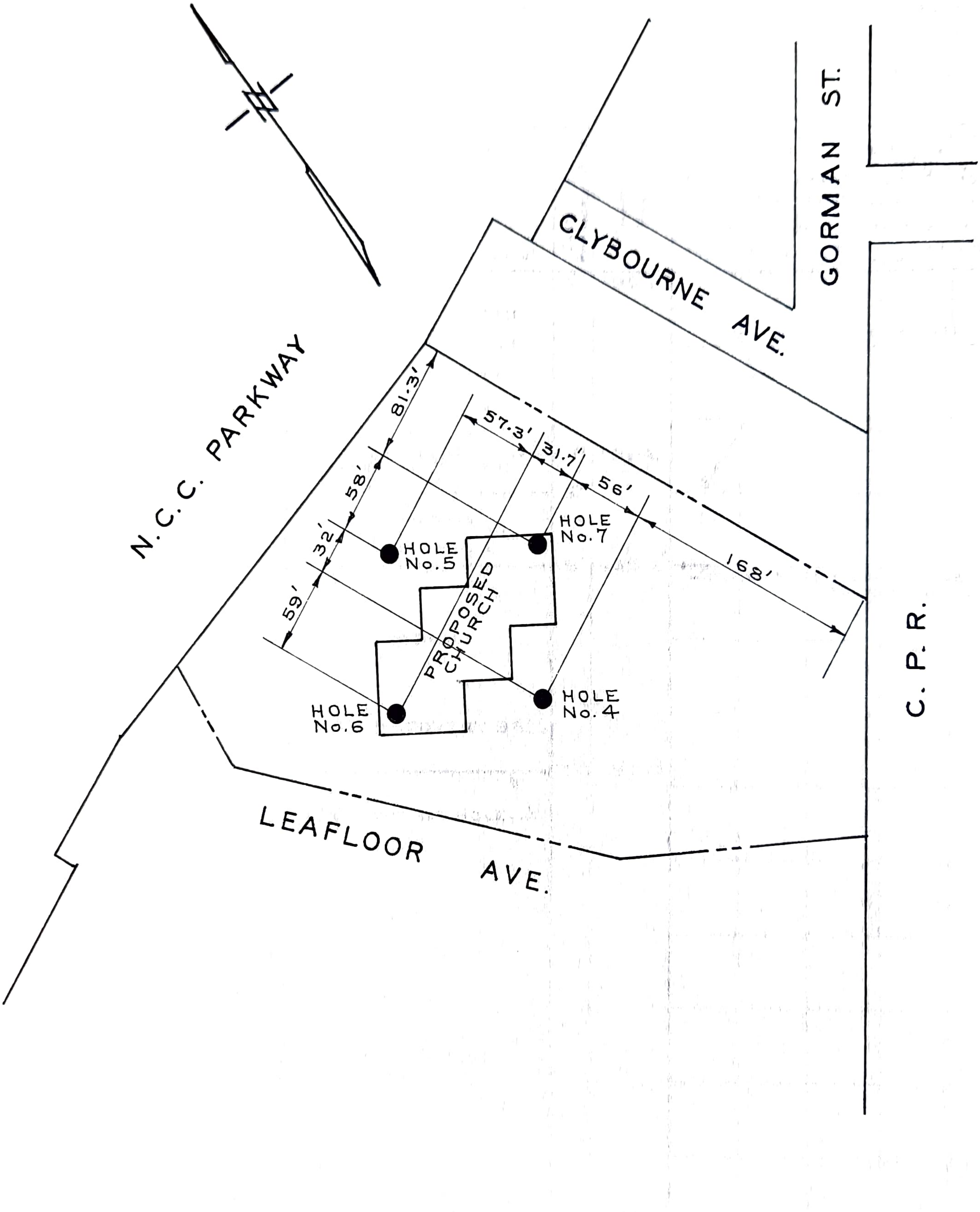


% WATER CONTENT
NATURAL ⊙
LIQUID LIMIT □
PLASTIC LIMIT △

PLATE 4

R - REMOULDED

LOWE-MARTIN CO.—AB1965



McROSTIE SETO GENEST

& ASSOCIATES LTD. - CONSULTING ENGINEERS

& ASSOCIÉS LTÉE - INGÉNIEURS CONSEILS

BOREHOLE LOCATIONS - POSITIONS DES FORAGES

LEAFLOOR NEAR
OTTAWA RIVER PARKWAY

SCALE ÉCHELLE	1" = 100'	PLATE PLAQUE	1

McROSTIE SETO GENEST
& ASSOCIATES LTD. & ASSOCIÉS LTÉE
CONSULTING ENGINEERS – INGÉNIEURS CONSEILS
OTTAWA CANADA

SOIL PROFILE & TEST SUMMARIES
PROFIL SOUTERRAIN ET RÉSUMÉ DES ESSAIS

LEAFLOOR NEAR
OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) / NIVEAU DU SOL (PROFONDEUR ZÉRO) 196.2′

DATE SEPT. 30, 1965

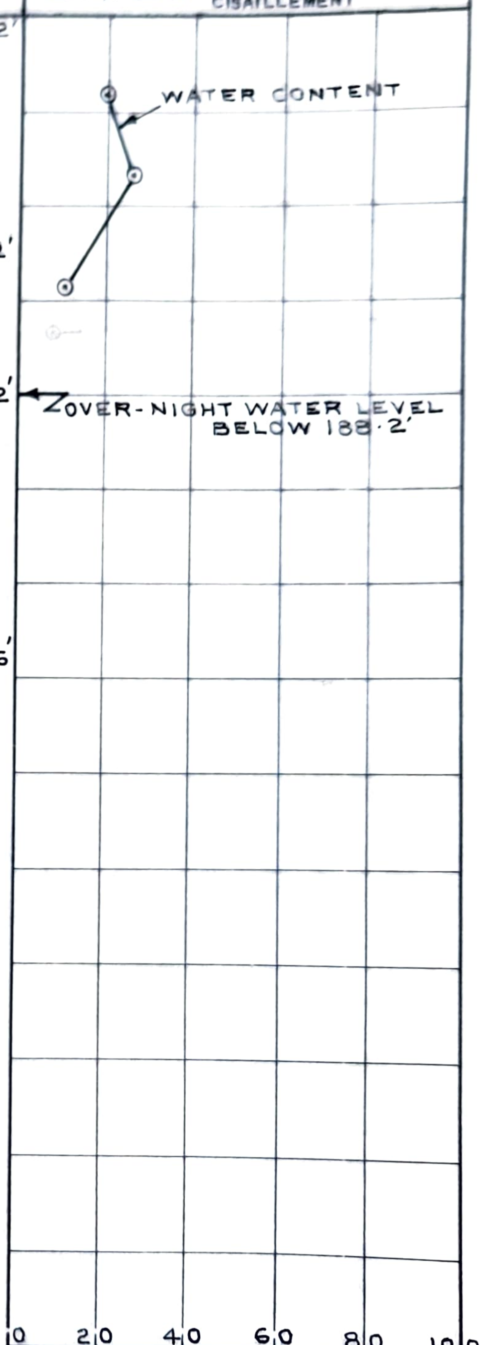
HOLE / FORAGE No. 4

NOTES JOB B.M. EL. 193.34 GEODETIC – TOP OF CONCRETE BASE FOR CORNER POST OF N.C.C. FENCE AT N.E. CORNER OF PROPERTY.

Compressive Strength K.S.F. / Résistance à la Compression K/Pd.2	Small Scale Penetrometer K.S.F. / Petit Pénétromètre K/Pd.2	Essai-Standard Penetration Blows/ft.-Coups/pd	Sample No. / Echantillon	DESCRIPTION OF SOIL / DU SOL (Ground Surface – Niveau du Sol)	Depth in Feet / Profondeur - Pied	Elevation / Niveau
				FILL	0′	196.2′
		18	4-1	VERY FINE SAND WITH SOME SILT A LITTLE CLAY & A TRACE OF WOOD & GRAVEL		
		9 6″ FOR 6	4-2			
		18 29″ FOR 6	4-3	MEDIUM DENSE SILTY TILL	5′	191.2′
		25″ FOR 6		DENSE SILTY TILL	6′	
				ROCK / CORE RECOVERY 98%	8′	188.2′
				BOTTOM OF HOLE	13.6	182.6′

OVER-NIGHT WATER LEVEL BELOW 188.2′

PROBING OR VANE TEST / SONDAGE OU ESSAI AU MOULINET
MARTEAU----HAMMER / CHUTE LIBRE---DROP
NO CASING / SANS TUBAGE
BARRE-----DIA. ROD
BLOWS/FOOT OR SHEAR STRENGTH K.S.F. / COUPS/PIED OU RÉSISTANCE AU CISAILLEMENT K/PD.2



WATER CONTENT % / TENEUR EN EAU
NATURAL / NATURELLE ⊙
LIQUID LIMIT / LIMITE DE LIQUIDITÉ ⊡
PLASTIC LIMIT / LIMITE DE PLASTICITÉ Δ

PLATE / PLAQUE No. 2

R = REMOULDED-REMANIÉ
CR = CORE RECOVERY / CAROTTE RÉCUPÉRÉE

McROSTIE SETO GENEST

& ASSOCIATES LTD. & ASSOCIÉS LTÉE

CONSULTING ENGINEERS – INGÉNIEURS CONSEILS

OTTAWA CANADA

SOIL PROFILE & TEST SUMMARIES

PROFIL SOUTERRAIN ET RÉSUMÉ DES ESSAIS

LEAFLOOR NEAR OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) / NIVEAU DU SOL (PROFONDEUR ZÉRO): 191·3'

DATE: OCT. 2, 1965

HOLE / FORAGE No. 5

NOTES: SEE PLATE No. 2

Compressive Strength K.S.F. / Résistance à la Compression K/Pd.2	Small Scale Penetrometer K.S.F. / Petit Pénétromètre K/Pd.2	Essai - Standard Penetration Blows/ft.-Coups/pd	Sample No. / Echantillon	DESCRIPTION OF SOIL / DU SOL (Ground Surface – Niveau du Sol)	Depth in Feet / Profondeur - Pied	Elevation / Niveau
					0'	191·3'
				TOPSOIL & BOULDERS		
					1·2'	
		6" FOR 6	5-1	MEDIUM DENSE SANDY TILL		
					1·8'	
		16" FOR 6		DENSE SANDY TILL		
					2·6'	188·7'
				ROCK CORE RECOVERY 100%		
					4·4'	186·9'
				ROCK CORE RECOVERY INDEFINITE BUT MORE THAN 71%		
					7·6'	183·7'
				BOTTOM OF HOLE		

PROBING OR VANE TEST / SONDAGE OU ESSAI AU MOULINET

MARTEAU----HAMMER / CHUTE LIBRE---DROP / NO CASING / SANS TUBAGE / BARRE-----DIA. ROD

BLOWS/FOOT OR SHEAR STRENGTH K.S.F. / COUPS/PIED OU RÉSISTANCE AU CISAILLEMENT, K/PD.2

⊙ ← WATER CONTENT

0 20 40 60 80 100

WATER CONTENT % TENEUR EN EAU

NATURAL / NATURELLE ⊙

LIQUID LIMIT / LIMITE DE LIQUIDITÉ ⊡

PLASTIC LIMIT / LIMITE DE PLASTICITÉ △

R = REMOULDED - REMANIÉ

CR = CORE RECOVERY / CAROTTE RÉCUPÉRÉE

PLATE / PLAQUE No. 3

McROSTIE SETO GENEST
& ASSOCIATES LTD. & ASSOCIÉS LTÉE
CONSULTING ENGINEERS – INGÉNIEURS CONSEILS
OTTAWA CANADA

SOIL PROFILE & TEST SUMMARIES
PROFIL SOUTERRAIN ET RÉSUMÉ DES ESSAIS

LEAFLOOR NEAR
OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) / NIVEAU DU SOL (PROFONDEUR ZÉRO): 192.9'
DATE: OCT. 2, 1965
HOLE / FORAGE No. 6
NOTES: SEE PLATE No. 2

Compressive Strength K.S.F. / Résistance à la Compression K/Pd.2	Small Scale Penetrometer K.S.F. / Petit Pénétromètre K/Pd.2	Essai-Standard Penetration Blows/ft.-Coups/pd.	Sample No. / Echantillon	DESCRIPTION OF SOIL / DU SOL (Ground Surface – Niveau du Sol)	Depth in Feet / Profondeur-Pied	Elevation / Niveau
					0'	192.9'
				TOPSOIL		
					1'	
		4	6-1	LOOSE SILT		
					2'	190.9'
				WEATHERED OR FRACTURED ROCK CORE RECOVERY 70%		
					6.9'	186.0'
				ROCK CORE RECOVERY 93%		
					9.4'	183.5'
				ROCK CORE RECOVERY 88%		
					11.6'	181.3'
				BOTTOM OF HOLE		

PROBING OR VANE TEST / SONDAGE OU ESSAI AU MOULINET
MARTEAU----HAMMER / CHUTE LIBRE---DROP
NO CASING / SANS TUBAGE / BARRE-----DIA. ROD
BLOWS/FOOT OR SHEAR STRENGTH K.S.F. / COUPS/PIED OU RÉSISTANCE AU CISAILLEMENT K/PD.2

WATER CONTENT
OVER-NIGHT WATER LEVEL BELOW 190.9'

0 20 40 60 80 100

WATER CONTENT % / TENEUR EN EAU
NATURAL / NATURELLE ⊙
LIQUID LIMIT / LIMITE DE LIQUIDITÉ ⊡
PLASTIC LIMIT / LIMITE DE PLASTICITÉ △

R = REMOULDED - REMANIÉ
CR = CORE RECOVERY / CAROTTE RÉCUPÉRÉE

PLATE / PLAQUE No. 4

McROSTIE SETO GENEST

& ASSOCIATES LTD. & ASSOCIÉS LTÉE

CONSULTING ENGINEERS – INGÉNIEURS CONSEILS

OTTAWA CANADA

SOIL PROFILE & TEST SUMMARIES

PROFIL SOUTERRAIN ET RÉSUMÉ DES ESSAIS

LEAFLOOR NEAR OTTAWA RIVER PARKWAY

ELEVATION OF GROUND SURFACE (ZERO DEPTH) / NIVEAU DU SOL (PROFONDEUR ZÉRO): 193·0′

DATE: OCT. 4, 1965

HOLE / FORAGE & PIT No. 7

NOTES: SEE PLATE No. 2

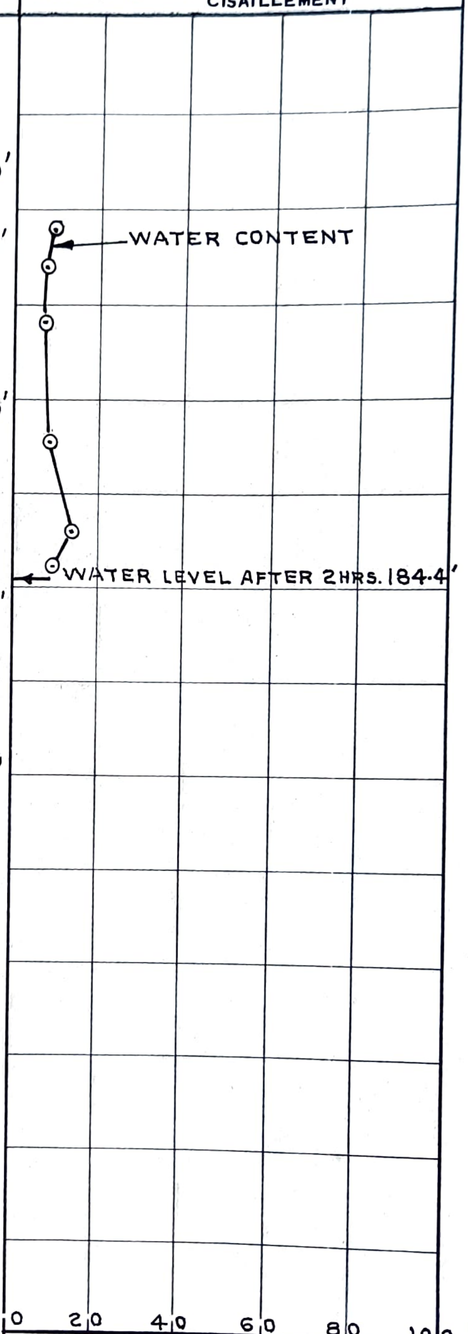
Compressive Strength K.S.F. / Résistance à la Compression K/Pd.2	Small Scale Penetrometer K.S.F. / Petit Pénétromètre K/Pd.2	Essai-Standard Penetration Blows/ft.-Coups/pd.	Sample No. / Echantillon	DESCRIPTION OF SOIL / DU SOL (Ground Surface – Niveau du Sol)	Depth in Feet / Profondeur-Pied	Elevation / Niveau
				TOPSOIL	0′	193·0′
			7-1A	SILTY VERY FINE SAND	0·5	
		15	7-1B	DENSE MEDIUM & FINE SAND WITH A TRACE OF GRAVEL	1·5′	191·5′
		18	7-2			
		41	7-3	DENSE SANDY TILL	5·0′	188·0′
		54	7-4	DENSE WELL GRADED SAND WITH A LITTLE GRAVEL	8′	
				ROCK CORE RECOVERY 76%	9·2′	183·8′
				ROCK CORE RECOVERY 90%	12·8′	180·2′
				BOTTOM OF HOLE	17·9′	175·1′

PROBING OR VANE TEST / SONDAGE OU ESSAI AU MOULINET

MARTEAU----HAMMER / CHUTE LIBRE---DROP

NO CASING / SANS TUBAGE / BARRE-----DIA. ROD

BLOWS/FOOT OR SHEAR STRENGTH K.S.F. / COUPS/PIED OU RÉSISTANCE AU CISAILLEMENT K/PD.2



WATER CONTENT % / TENEUR EN EAU

NATURAL / NATURELLE ⊙

LIQUID LIMIT / LIMITE DE LIQUIDITÉ ⊡

PLASTIC LIMIT / LIMITE DE PLASTICITÉ △

R = REMOULDED-REMANIÉ

CR = CORE RECOVERY / CAROTTE RÉCUPÉRÉE

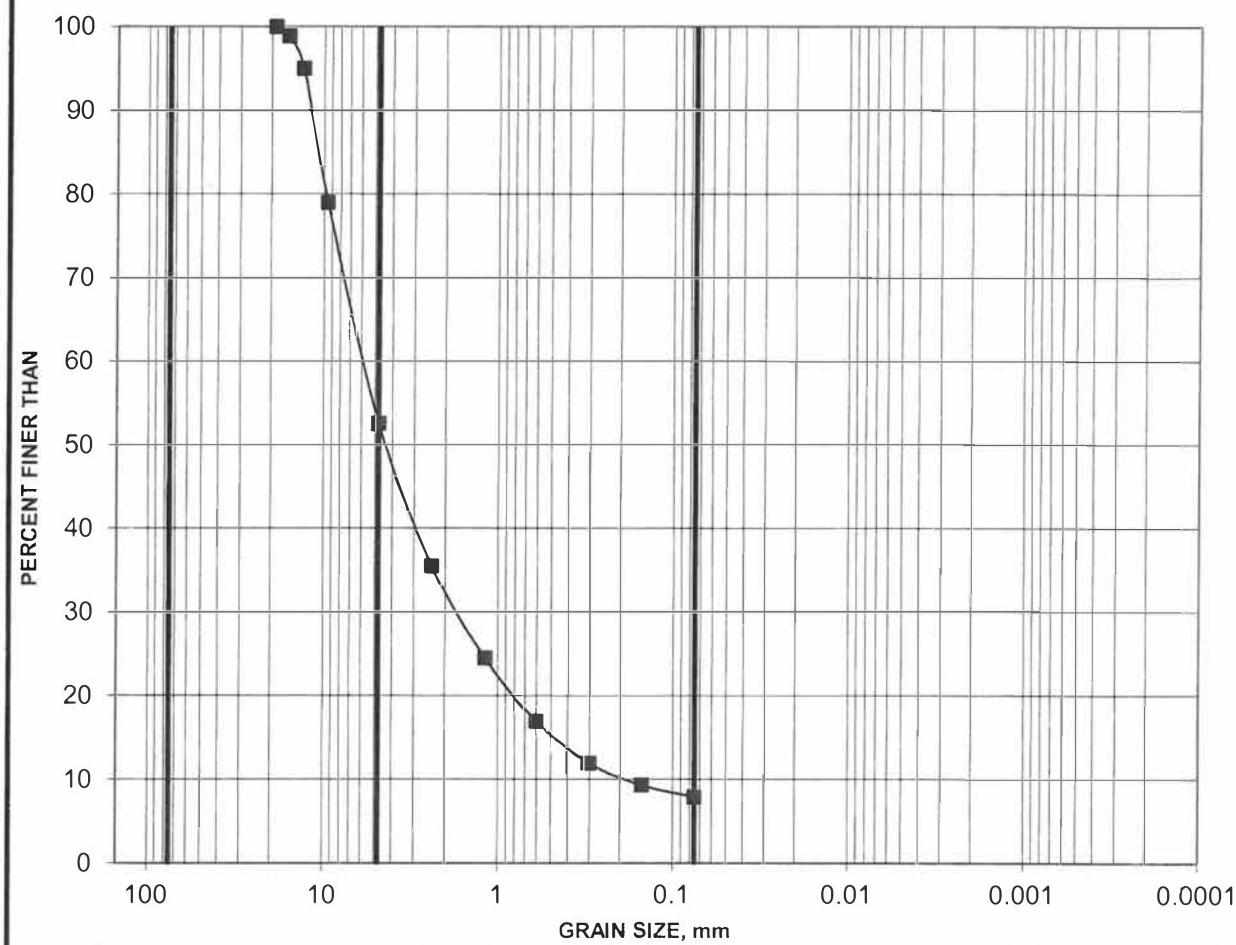
PLATE / PLAQUE No. 5

APPENDIX C

Laboratory Results

GRAIN SIZE DISTRIBUTION	FIGURE

SAND AND GRAVEL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
23-03	1	0.00-0.61	47	45	8	

wsp

Project: CA0008376.9447

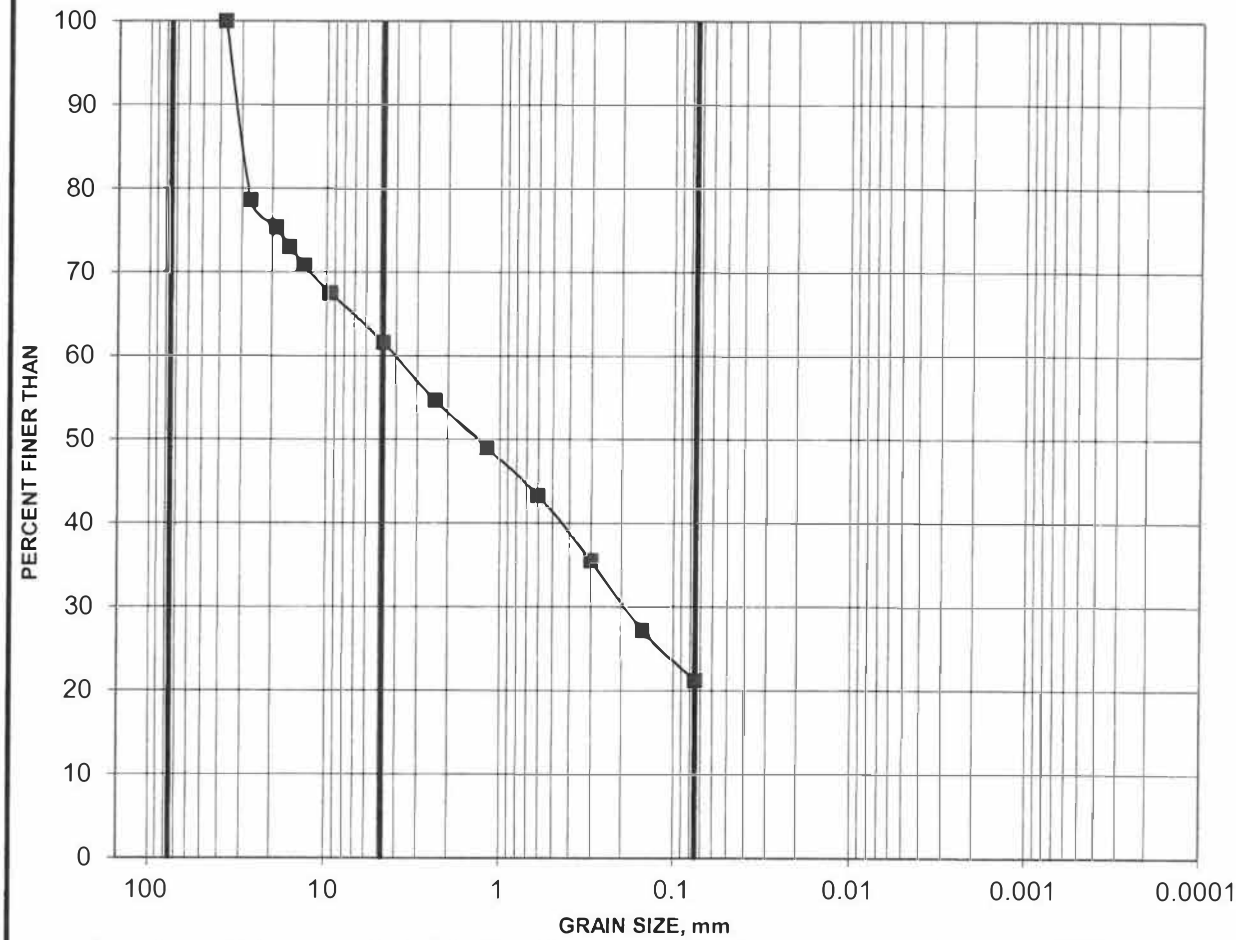
Created by: MI

Checked by: CW

GRAIN SIZE DISTRIBUTION

FIGURE

SILTY SAND AND GRAVEL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
23-06	2	0.69-1.30	38	41	21	

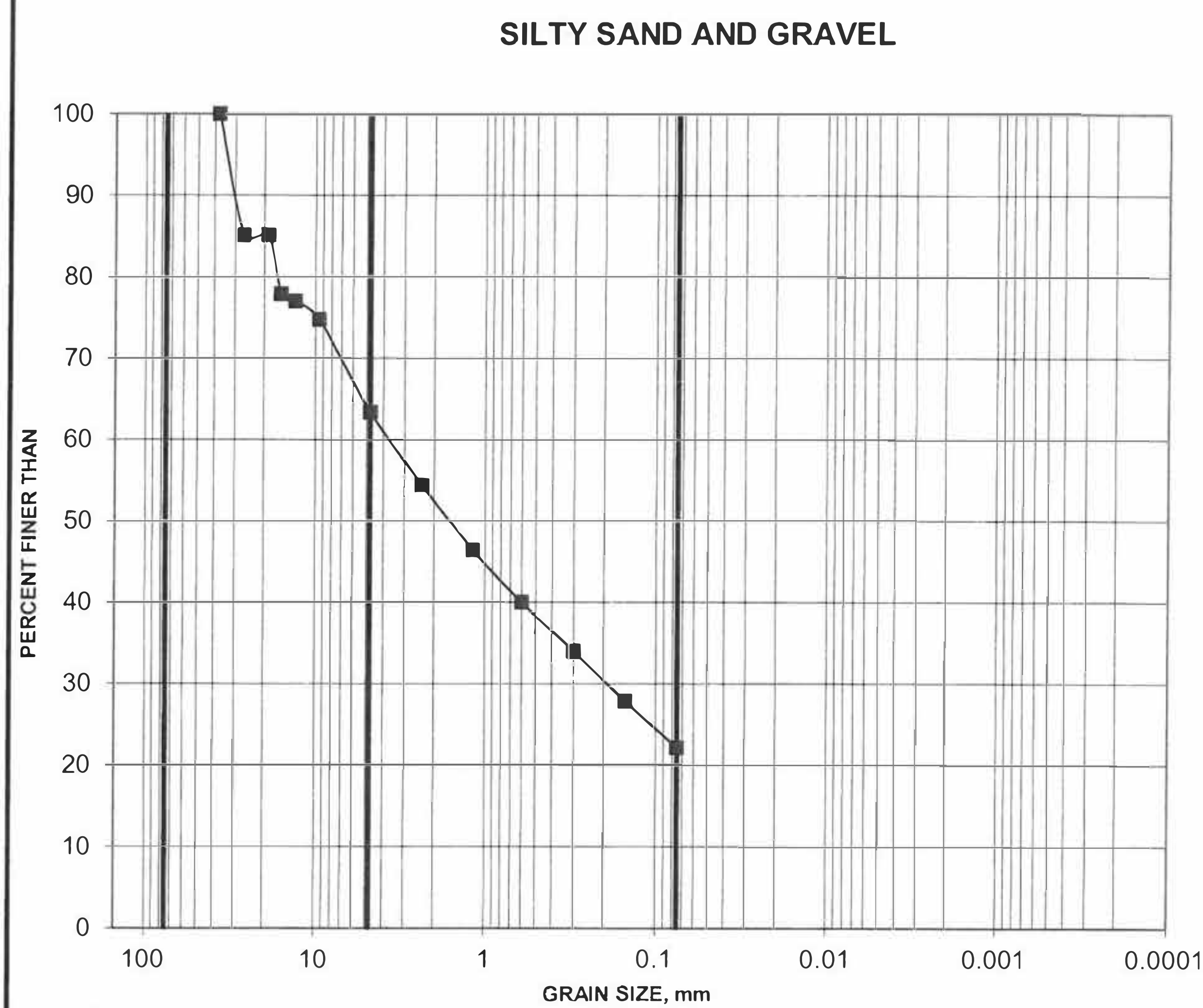
wsp

Project: CA0008376.9447

Created by: MI

Checked by: CW

GRAIN SIZE DISTRIBUTION	FIGURE



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)	Constituents (%) Gravel	Sand	Silt	Clay
23-08	2	0.61-1.22	37	41	22	

Project: CA0008376.9447

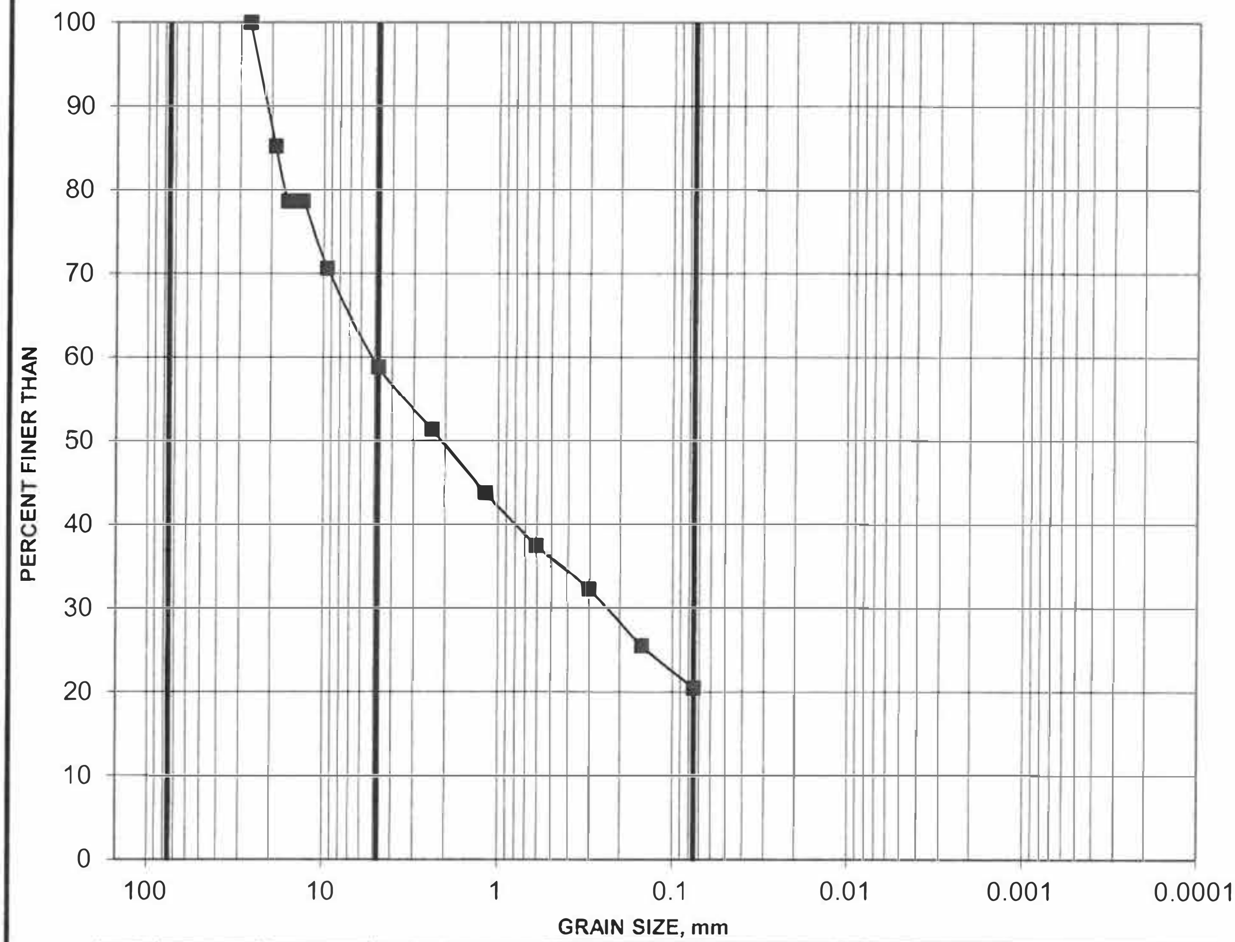
wsp

Created by: MI

Checked by: Cw

GRAIN SIZE DISTRIBUTION	FIGURE

SILTY SAND AND GRAVEL



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
—■—	23-09	3B	1.42-1.80	41	39	20	

Project: CA0008376.9447

wsp

Created by:	MI
Checked by:	[signature]

APPENDIX D

Basic Chemical Testing

Certificate of Analysis

Client:	WSP Canada Inc (Ottawa) 1931 Robertson Road Ottawa, Ontario K2H 5B7	Report Number:	3001153
		Date Submitted:	2023-09-08
		Date Reported:	2023-09-18
		Project:	CA0008376.9447
Attention:	Mr. Arthur Kuitchoua Petke	COC #:	910485
PO#:			
Invoice to:	WSP Canada Inc.		

Dear Arthur Kuitchoua Petke:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

Revised report to fix the ids as per clients request

APPROVAL: ______________________________

Rebecca Koshy, Project Manager

All analysis is completed at Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) unless otherwise indicated.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: https://directory.cala.ca/.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is licensed by the Ontario Ministry of the Environment, Conservation, and Parks (MECP) for specific tests in drinking water (license #2318). A copy of the license is available upon request.

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by the Ontario Ministry of Agriculture, Food, and Rural Affairs for specific tests in agricultural soils.

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required. Unless otherwise stated, measurement uncertainty is not taken into account when determining guideline or regulatory exceedances.

Certificate of Analysis

eurofins | Environment Testing

Client:	WSP Canada Inc (Ottawa) 1931 Robertson Road Ottawa, Ontario K2H 5B7	Report Number:	3001153
Attention:	Mr. Arthur Kuitchoua Petke	Date Submitted:	2023-09-08
PO#:		Date Reported:	2023-09-18
Invoice to:	WSP Canada Inc.	Project:	CA0008376.9447
		COC #:	910485

Group	Analyte	MRL	Units	Guideline	1702367	1702368
				Lab I.D.	1702367	1702368
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2023-08-24	2023-08-24
				Sample I.D.	23-03 SA2	23-05 SA3
Anions	Cl	0.002	%		0.005	0.006
	SO4	0.01	%		0.01	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.29	0.23
	pH	2.00			8.07	8.76
	Resistivity	1	ohm-cm		3448	4348

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

eurofins | Environment Testing

Client: WSP Canada Inc (Ottawa)
1931 Robertson Road
Ottawa, Ontario
K2H 5B7
Attention: Mr. Arthur Kuitchoua Petke
PO#:
Invoice to: WSP Canada Inc.

Report Number: 3001153
Date Submitted: 2023-09-08
Date Reported: 2023-09-18
Project: CA0008376.9447
COC #: 910485

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 448741 **Analysis/Extraction Date** 2023-09-13 **Analyst** IP **Method** Cond-Soil			
Electrical Conductivity	<0.05 mS/cm	99	90-110
pH	6.38	99	90-110
Resistivity			
Run No 448900 **Analysis/Extraction Date** 2023-09-15 **Analyst** IP **Method** AG SOIL			
SO4	<0.01 %	94	70-130
Run No 448924 **Analysis/Extraction Date** 2023-09-15 **Analyst** AsA **Method** C CSA A23.2-4B			
Chloride	<0.002 %	106	90-110

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

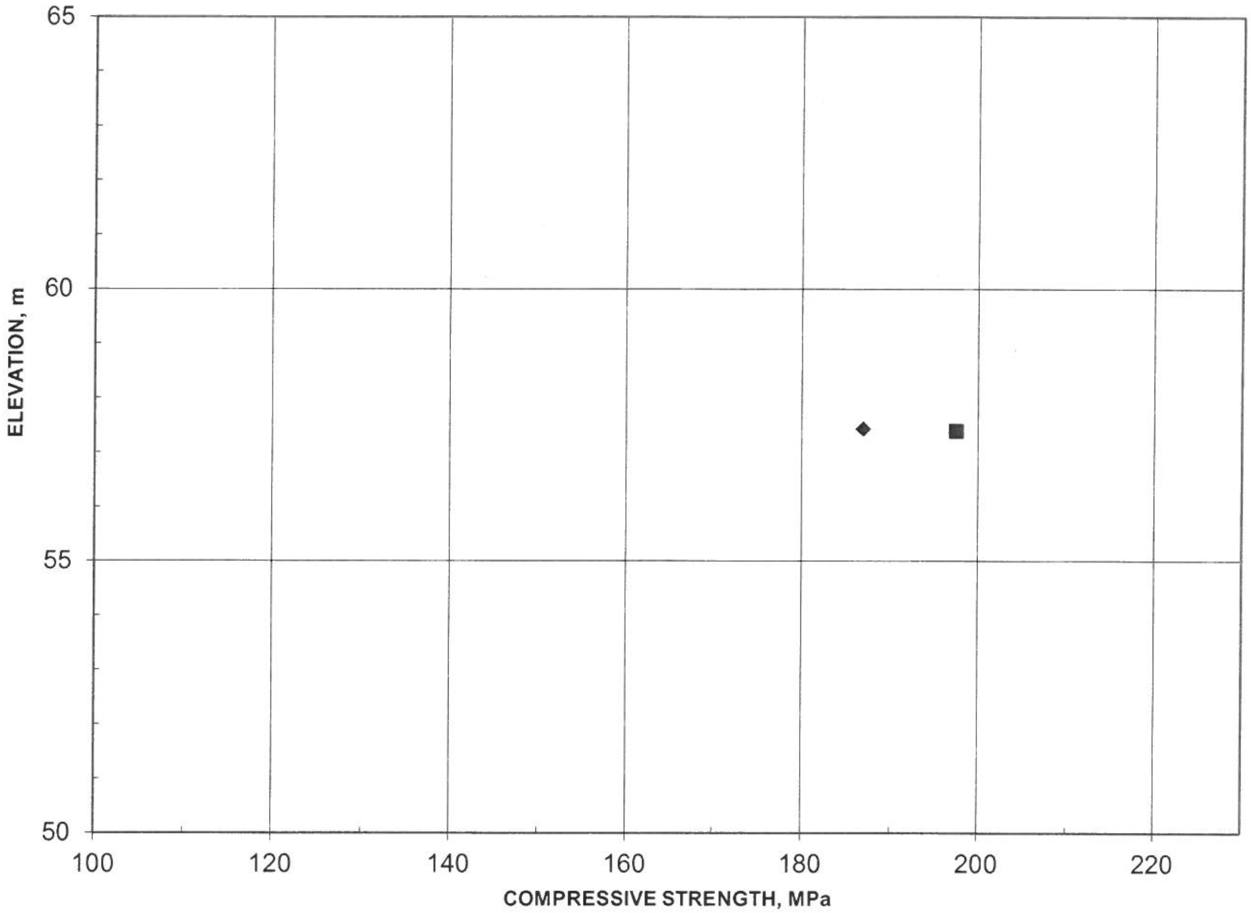
MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX E

Rock Photos and Results of USC Testing

ASTM D7012 - Method C
UNIAXIAL UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE
SUMMARY OF LABORATORY TEST RESULTS

FIGURE



	Borehole	Depth (m)	L/D	Bulk Density (kg/m^3)	Lithology	UCS (MPa)	Failure Type
■	BH23-1 RC1	2.5	2.1	2619	Limestone	198	1
◆	BH23-5 RC1	4.7	2.4	2595	Limestone	187	1

Notes:

Failure Types

1. Well formed cones on both ends
2. Well formed cones on one end, vertical cracks through cap
3. Columnar vertical craking through both ends
4. Diagonal fracture with no cracking through ends
5. Side fractures at top or bottom
6. Side fractures at both sides of top or bottom

Remarks

- Cores tested in vertical direction.
- Cores tested in air-dry condition.
- Time to failure > 2 and < 15 minutes.

wsp

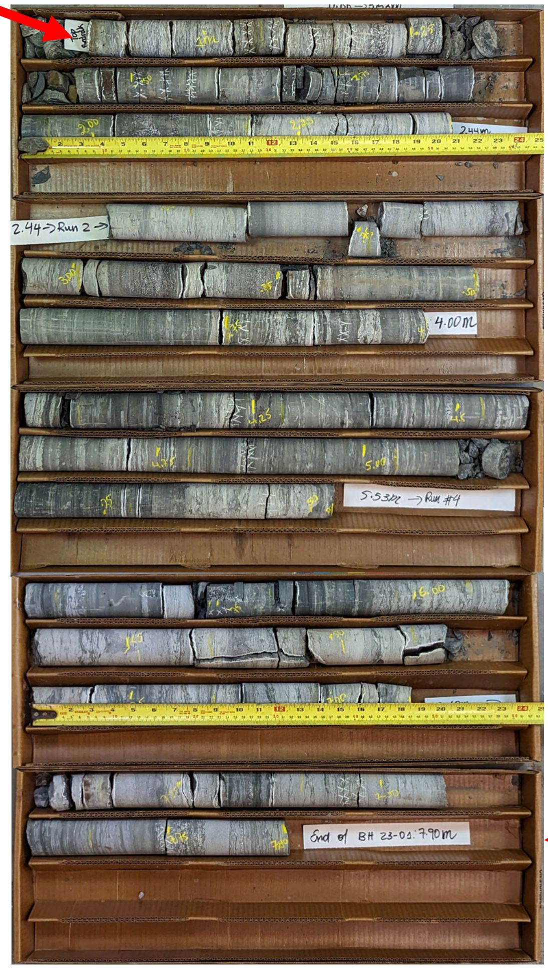
Project: CA0008376.9447

Created by: MI
Checked by: CW

https://wsponlinecan.sharepoint.com/Sites/Global-OttawaLab/Shared Documents/Active/CA0008376.9447/

BH 23-01 (Dry)
Core Box 1 to 5 of 5

Top of Bedrock 0.86 mbgs



EOH: 7.90 mbgs

Geotechnical Investigation

Cleary Development
CA0008376.9447
Ottawa, Ontario

Project No.	CA0008376.9447
Drawn:	PAK
Date:	2023-08-29
Checked:	AKP
Review:	CH

Figure D1

BH 23-01 (Wet)

Core Box 1 to 5 of 5

Top of Bedrock 0.86 mbgs

EOH: 7.90 mbgs

Geotechnical Investigation

Cleary Development

CA0008376.9447

Ottawa, Ontario

Project No.	CA0008376.9447
Drawn:	PAK
Date:	2023-08-29
Checked:	AKP
Review:	CH

Figure D2

BH 23-05 (Dry)
Core Box 1 to 4 of 4

Top of Bedrock 1.93 m

EOH: 7.97 mbgs

Geotechnical Investigation **Cleary Development** **CA0008376.9447** **Ottawa, Ontario**	

Project No.	CA0008376.9447
Drawn:	PAK
Date:	2023-08-29
Checked:	AKP
Review:	CH

Figure D3

BH 23-05 (wet)
Core Box 1 to 4 of 4

Top of Bedrock 1.93m

EOH: 7.97 mbgs

Geotechnical Investigation

Cleary Development
CA0008376.9447
Ottawa, Ontario

Project No.	CA0008376.9447
Drawn:	PAK
Date:	2023-08-29
Checked:	AKP
Review:	CH

Figure D4

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