

# Geotechnical Investigation Proposed OC Transpo Electrical Bus Garage 1500 St. Laurent Boulevard Ottawa, Ontario

# **Client:**

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# **Executive Summary**

# Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed electrical bus garage to be located at the OC Transpo facility at 1500 St. Laurent Boulevard, Ottawa, Ontario (Figure 1). The geotechnical investigation was undertaken in two (2) phases with the original investigation conducted in 2022 and the additional investigation conducted in 2024. Terms and conditions of the two (2) phases of this assignment were outlined in EXP's two (2) proposals dated June 21,2022 and March 11,2024 and are under EXP's standing offer agreements (SOAs) with the City of Ottawa SOA 30820-02500-S01 Category 5A and 5B (2022) and SOA 24423 24423-92500-S01 Category 5A and 5B (2024). Authorization to proceed with this work was provided by City of Ottawa Purchase Order Numbers: 0045102541 dated October 4,2022 and 0045108222 dated April 25,2024.

The geotechnical investigation for the proposed electrical bus garage was undertaken in conjunction with the geotechnical investigation for the proposed hydro substation to be located at the OC Transpo facility. The proposed garage will be located in the northwest portion of the facility and the proposed hydro substation will be located north of the proposed garage. The boreholes completed for the geotechnical investigation for the proposed OC Transpo electrical bus garage include Borehole Nos. 22-01 to 22-09, 22-16, 22-17, 24-01 to 24-07, 24-09 and 24-12. The boreholes completed for the hydro substation include Borehole Nos. 22-10 to 22-15, 24-10 and 24-11. This geotechnical report discusses the results for the proposed electrical bus garage. The results of the geotechnical investigation for the proposed hydro substation are provided in a separate geotechnical report.

EXP completed a Phase One Environmental Site Assessment (ESA) of the site for the proposed development and the results of the ESA are provided in a separate report dated May 15,2023 (EXP Project Number: OTT-22007382-A0). EXP also completed a Phase Two of the site for the proposed development and the results are presented in a separate report dated December 8, 2022 (EXP Project No. OTT-22007382-A0). As part of the current assignment, EXP updated the Phase Two ESA of the site for the proposed development and the results are provided in a separate report.

# **Proposed Development**

The proposed electrical bus garage will be located in the northwest portion of the OC Transpo facility at 1500 St. Laurent Boulevard in Ottawa. Currently, the site is occupied by an outdoor paved parking lot for buses. Based on available design information including the schematic architectural drawing, Sheet No. AS101, dated March 28,2024 (Project No. 60716350), the proposed building will have an approximate footprint of 8800 square metres and will be a single-storey industrial type slab-on-grade building with no basement. The design elevation of the floor slab will be at Elevation 69.90 m. Factored axial loads for perimeter columns will be approximately 1000 kN and approximately 1600 kN for central columns. Some of the columns at braced bays may have net uplift loads of approximately 200 kN. The proposed garage building will be serviced by new municipal services. The exterior ground surface around the building will have concrete aprons, paved access roads and parking lots and landscaped areas. A retaining wall will be located east of the new garage building.

#### **Fieldwork Program**

The fieldwork for this geotechnical investigation was undertaken in two (2) phases and consists of a total of twenty (20) boreholes. The first phase was undertaken on September 19,20 and November 17,2022 and consists of eleven (11) boreholes (Borehole Nos. 22-01 to 22-09, 22-16 and 22-17) advanced to auger refusal and termination depths ranging from 2.4 m to 8.7 m below existing grade. The second phase was undertaken from May 3 to 10,2024 and consists of nine (9) boreholes (Borehole Nos. 24—01 to 24-07, 24-09 and 24-12) advanced to casing refusal and termination depths of 5.2 m to 8.8 m below existing grade. Borehole No. 24-08 was not drilled due to conflict with existing underground services.



A seismic shear wave velocity soundings survey consisting of one (1) survey line was conducted at the site on May 15,2024 by Geophysics GPR International Inc. (GPR).

#### **Subsurface Conditions**

The borehole information indicates the subsurface conditions at the site for the proposed garage building and retaining wall consist of fill, buried topsoil and organic layers that extend to depths of 1.1 m to 3.0 m (Elevation 68.8 m to Elevation 67.0 m) underlain by loose to very dense shaley glacial till followed by shale bedrock contacted at 2.8 m to 4.6 m depths (Elevation 66.9 m to Elevation 65.2 m). The groundwater level ranges from 0.9 m to 2.2 m depths (Elevation 69.0 m to Elevation 67.9 m).

# **Geotechnical Engineering Comments and Recommendations**

The seismic shear wave velocity soundings survey report dated May 31,2024 and prepared by GPR is shown in Appendix A. The GPR report indicates the seismic shear wave velocities (Vs) of the subsurface soils are greater than 200 m/s. Therefore, based on the results of the seismic shear wave velocity soundings survey and the results of the additional boreholes drilled as part of the additional geotechnical investigation, the subsurface soils are considered not to be liquefiable during a seismic event.

For the underside of footings and grade beams founded 3.0 m or less from the bedrock surface, the site class for seismic response may be taken as **Class A**. If the underside of footings and grade beams are greater than 3.0 m from the bedrock surface, the site class for seismic response is **Class C**.

A review of the available design information and borehole data indicates that the proposed garage building may be supported by strip and spread footings designed to bear on an engineered fill pad constructed on top of the native shaley glacial till. Alternatively, the proposed garage building may be supported by caissons socketed into the sound shale bedrock. Piles designed in end bearing and driven to practical refusal into the shale bedrock are not considered practical due to the shallow depth of the bedrock. For the two (2) foundation options, the ground floor of the proposed garage building may be designed as a slab-on-grade founded on an engineered fill pad constructed on the shaley glacial till. The proposed retaining wall may be supported by a strip footing founded on the engineered fill pad that is constructed on top of the native shaley glacial till. The existing fill and buried topsoil/organic soil are not suitable to support foundations and the ground floor slab-on-grade of the proposed garage building and to support the foundations of the proposed retaining wall.

The excavation for the construction of the engineered fill pad to support the footings and the floor slab-on-grade of the proposed garage building and retaining wall is anticipated to extend below the groundwater level into the shaley glacial till that contains loose zones. The loose zones of the shaley glacial till below the groundwater level are susceptible to instability of the base of the excavation in the form of piping or heave. To minimize 'base-heave' type failure of the excavation base, it is necessary to lower the groundwater table at the site to below the final excavation level prior to the start of the excavation. This may be achieved by installing deep sumps, pumping with high-capacity pumps and pumping on a continuous basis (such as twenty-four (24) hours a day, seven (7) days a week). The groundwater level should be lowered and maintained to at least 1.0 m below the bottom of the excavation until the placement and compaction of the engineered fill pad has been completed to the design subgrade level. Standpipes should also be installed to monitor the groundwater level during initial groundwater lowering and during construction. A specialized dewatering contractor should be consulted to determine the most appropriate dewatering method for the site conditions to allow for the construction of the engineered fill pad to be undertaken in relatively dry conditions.

The ground floor of the proposed garage building may be designed and constructed as a slab-on-grade placed on a 200 mm thick 19 mm sized clear stone bed placed on a minimum 300 mm thick engineered fill pad set on the approved shaley glacial till. The clear stone will minimize the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the clear stone layer may be replaced with a 200 mm thick bed of OPSS Granular A overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

The proposed garage building will require perimeter and underfloor drainage systems.



All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation. Within zones of seepage, the excavation side slopes are expected to slough and eventually stabilize at 2H:1V to 3H:1V from the bottom of the excavation. For excavations above the groundwater level or properly dewatered (refer to paragraph below), the installation of the municipal underground services may be undertaken within the confines of a prefabricated support system (trench box) designed and installed in accordance with OHSA.

If side slopes cannot be achieved due to space restrictions on site such as the proximity of open cut excavations to the property limits, existing infrastructure or to foundations of adjacent existing building(s), the new building construction would have to be undertaken within the confines of an engineered support system (shoring system).

It is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed building and retaining wall and in the underground service trenches will need to be imported and should preferably conform to the material specifications indicated in the attached geotechnical report.

The above and other related considerations are discussed in greater detail in the main body of the attached geotechnical report.



# 1. Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed electrical bus garage to be located at the OC Transpo facility at 1500 St. Laurent Boulevard, Ottawa, Ontario (Figure 1). The geotechnical investigation was undertaken in two (2) phases with the original investigation conducted in 2022 and the additional investigation conducted in 2024. Terms and conditions of the two (2) phases of this assignment were outlined in EXP's two (2) proposals dated June 21,2022 and March 11,2024 and are under EXP's standing offer agreements (SOAs) with the City of Ottawa SOA 30820-02500-S01 Category 5A and 5B (2022) and SOA 24423 24423-92500-S01 Category 5A and 5B (2024). Authorization to proceed with this work was provided by City of Ottawa Purchase Order Numbers: 0045102541 dated October 4,2022 and 0045108222 dated April 25,2024.

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EXP completed a Phase One Environmental Site Assessment (ESA) of the site for the proposed development and the results of the ESA are provided in a separate report dated May 15,2023 (EXP Project Number: OTT-22007382-A0). EXP also completed a Phase Two of the site for the proposed development and the results are presented in a separate report dated December 8, 2022 (EXP Project No. OTT-22007382-A0). As part of the current assignment, EXP updated the Phase Two ESA of the site for the proposed development and the results are provided in a separate report.

The proposed electrical bus garage will be located in the northwest portion of the OC Transpo facility at 1500 St. Laurent Boulevard in Ottawa. Currently, the site is occupied by an outdoor paved parking lot for buses. Based on available design information including the schematic architectural drawing, Sheet No. AS101, dated March 28,2024 (Project No. 60716350), the proposed building will have an approximate footprint of 8800 square metres and will be a single-storey industrial type slab-on-grade building with no basement. The design elevation of the floor slab will be at Elevation 69.90 m. Factored axial loads for perimeter columns will be approximately 1000 kN and approximately 1600 kN for central columns. Some of the columns at braced bays may have net uplift loads of approximately 200 kN. The proposed garage building will be serviced by new municipal services. The exterior ground surface around the building will be occupied by concrete aprons, paved access roads and parking lots and landscaped areas. A retaining wall will be located east of the new garage building.

The geotechnical investigation was undertaken to:

- a) Establish the subsurface soil and groundwater conditions at twenty (20) boreholes located on the site,
- Classify the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code

   (as amended January 1,2022) and assess the potential for liquefaction of the subsurface soils during a seismic event,
- c) Comment on grade-raise restrictions and provide site grading requirements,
- Make recommendations regarding the most suitable type of foundations, founding depth and bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements of the recommended foundation type,



- e) Provide comment regarding slab-on-grade construction and the requirement for perimeter and underfloor drainage systems,
- f) Comment on excavation conditions and de-watering requirements during construction,
- g) Provide pipe bedding requirements for underground services,
- h) Discuss backfilling requirements and suitability of on-site soils for backfilling purposes,
- Recommend pavement structure thicknesses for concrete aprons and paved access roads and parking lots,
- j) Comment on the corrosion potential of subsurface soils buried concrete and steel structures/members;
   and
- k) Provide comment on tree planting restrictions.

The comments and recommendations given in this report are based on the assumption that the above-described design concepts will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations, or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.



# 2. Site Description

The site of the proposed garage will be located at the OC Transpo facility at 1500 St. Laurent Boulevard in the northwest portion of the facility, west of the existing north garage building. The site of the retaining wall will be located east of the proposed garage. The site is currently occupied by an outdoor paved parking lot for buses. The overall site is relatively flat with borehole ground surface elevations ranging from Elevation 70.36 m to Elevation 69.28 m.



# 3. Site Geology

# 3.1 Surficial Geology Map

The surficial geology map (Map 1506A – Surficial Geology, Ontario-Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1982) indicates that beneath any fill, the site is underlain by glacial till.

# 3.2 Bedrock Geology Map

The bedrock geology map (Map 1508A – Generalized Bedrock Geology, Ottawa-Hull, Ontario and Quebec, Geological Survey of Canada, printed by the Surveys and Mapping Branch, 1979) indicates the site is underlain by shale bedrock of the Billings formation.



# 4. Procedure

#### 4.1 Boreholes

#### 4.1.1 Fieldwork

The fieldwork for this geotechnical investigation was undertaken in two (2) phases and consists of a total of twenty (20) boreholes. The first phase was undertaken on September 19,20 and November 17,2022 and consists of eleven (11) boreholes (Borehole Nos. 22-01 to 22-09, 22-16 and 22-17) advanced to auger refusal and termination depths ranging from 2.4 m to 8.7 m below existing grade. The second phase was undertaken from May 3 to 10,2024 and consists of nine (9) boreholes (Borehole Nos. 24-01 to 24-07, 24-09 and 24-12) advanced to casing refusal and termination depths of 5.2 m to 8.8 m below existing grade. Borehole No. 24-08 was not drilled due to conflict with existing underground services. The borehole fieldwork was supervised on a full-time basis by EXP.

It is noted that Borehole Nos. 22-10 to 22-15, 24-10 and 24-11 were undertaken for the proposed hydro substation to be located north of the proposed garage building and are included in a separate geotechnical engineering report. The locations of the proposed garage building and hydro substation are shown in Figure 2.

The locations and geodetic elevations of the boreholes for the proposed garage and retaining wall were established on site by EXP and are shown on the borehole location plan, Figure 3.

The boreholes were drilled using a CME-55 and CME-75 truck-mounted drill rigs equipped with continuous flight hollow-stem auger equipment and rock coring capabilities. Below the augered depth of 1.5 m, the 2024 boreholes (Borehole Nos. 24-01 to 24-07, 24-09 and 24-12) were advanced to casing refusal depths using casing and washboring technique and maintaining a head (column) of water in the casing. Grab (GS) and auger (AS) samples were taken in the upper level of the boreholes. Standard penetration tests (SPTs) were performed in all the boreholes on a continuous basis to 0.75 m depth interval and the soil samples (SS) retrieved by the split-spoon sampler. The bedrock was cored in selected boreholes using the N-size core barrel and conventional rock coring techniques. A field record of wash water return, colour of wash water and any sudden drops of the core barrel were kept during rock coring operations.

The subsurface soil conditions in each borehole were logged and each soil sample placed in labelled plastic bags. Similarly, the rock cores were visually examined, placed in core boxes, identified, and logged.

Monitoring wells ranging in diameter from nineteen (19 mm) to thirty-two (32 mm) to fifty (50 mm) were installed in selected boreholes for long-term monitoring of the groundwater level and for groundwater sampling as part of the Phase Two ESA. The monitoring wells were installed in accordance with EXP standard practice, and the installation configuration is documented on the respective borehole log. The boreholes were backfilled upon completion of drilling and installation of the monitoring wells.

# 4.1.2 Laboratory Testing Program

On completion of the borehole fieldwork, the soil samples and rock cores were transported to the EXP laboratory in Ottawa where they were examined by a geotechnical engineer and borehole logs prepared. The main constituents of the soils are classified in accordance with the Unified Soil Classification System (USCS) using the soil group name and symbol and by the modified Burmister soil classification method for the classification of the minor constituents of the soil using adjectives and modifiers such as trace and some (2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM)).

The rock cores were visually examined by the geotechnical engineer and logged in accordance with Section 3.2 of the 2006 Canadian Foundation Engineering Manual (CFEM) Fourth Edition. Photographs were taken of the bedrock cores.



The laboratory testing program for the soil samples and rock core sections is summarized in Table I.

Table I: Summary of Laboratory Testing Program					
Type of Test	Number of Tests Completed				
Soil S	amples				
Moisture Content Determination	116				
Grain Size Analysis	14				
Atterberg Limit Determination	6				
Corrosion Analysis (pH, sulphate, chloride and resistivity)	11				
Bedrock C	ore Sections				
Unit Weight Determination	21				
Unconfined Compressive Strength Test	21				
Corrosion Analysis (pH, sulphate, chloride and resistivity)	3				

# 4.2 Seismic Shear Wave Velocity Soundings Survey

A seismic shear wave velocity soundings survey consisting of one (1) survey line was conducted at the site on May 15,2024 by Geophysics GPR International Inc. (GPR). The purpose of the seismic shear wave survey was to determine the seismic shear wave velocity of the site and based on the shear wave velocity provide the site classification for seismic response and to assist in determining if the subsurface soils are liquefiable during a seismic event. The survey line is located within the footprint of the proposed garage building. The location of the survey line is shown on the Borehole Location Plan, Figure 3. The seismic shear wave survey was undertaken using the multi-channel analysis of surface waves (MASW), spatial auto correlation (SPAC) and seismic refraction methods. The seismic shear wave velocity soundings survey report dated May 31,2024 and prepared by GPR is shown in Appendix A.



# 5. Subsurface Conditions and Groundwater Levels

A detailed description of the subsurface conditions encountered in the boreholes is given on the attached Borehole Logs, Figures 4 to 23.

The borehole logs and related information depict subsurface conditions only at the specific locations and at the times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions. Reference should be made to the EXP Phase One and Two Environmental Site Assessments (ESAs) for potential environmental concerns with respect to the subsurface conditions at the site.

It should be noted that the soil and bedrock boundaries indicated on the borehole logs are inferred from observations during drilling operations. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Descriptions" preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following subsurface soil and bedrock conditions with depth and groundwater level measurements.

# 5.1 Topsoil

Borehole No. 24-12 is located in a landscaped area and a 75 mm thick surficial topsoil layer was encountered in the borehole.

#### 5.2 Pavement Structure

With the exception of Borehole No. 22-17, the remaining boreholes are located in a paved area where the pavement structure consists of 65 mm to 180 mm thick asphaltic concrete underlain by 300 mm to 620 mm thick (locally 1100 mm thick in Borehole No. 22-16) granular fill (base). The granular fill (base) consists of gravel, sand and silt of varying percentages. Based on the standard penetration test (SPT) N-values of 22 to 61 the granular fill (base) is in a compact to very dense state. Moisture contents of the granular fill (base) range from 1 percent to 3 percent.

Borehole No. 22-17 is located in a gravel surface area where the granular fill (base) extends to an 0.8 m depth (Elevation 69.2 m). The granular fill (base) consists of a sand and gravel that is in a dense state, based on the SPT N-value of 30. The moisture content of the granular fill (base) is 5 percent.

Results from the grain-size analysis conducted on one (1) sample of the granular fill (base) are summarized in Table II. The grain-size distribution curve is shown in Figure 24.

Table II: Summary of Results from Grain-Size Analysis – Granular Fill (Base)							
Borehole No.	Depth		Grain-Siz				
(BH): Sample No. (SS)	(m)	Gravel	Sand	Silt	Clay	Soil Classification	
BH 24-02 – AS1	0.1-0.6	54	33	13	0	Gravel (GM) – Sandy, Some Silt	

Based on a review of the results of the grain-size analysis, the granular fill (base) may be classified as a gravel (GM) that is sandy with some silt.



# 5.3 Buried Topsoil Layer

A 50 mm thick buried topsoil layer was contacted beneath the pavement structure at a 1.2 m depth (Elevation 68.4 m) in Borehole No. 22-16.

#### 5.4 Fill

Fill was contacted beneath the pavement structure, surficial topsoil layer and buried topsoil layer in all boreholes except Borehole Nos. 22-02, 22-03, 22-05 and 22-08. The fill extends to depths of 1.1 m to 3.0 m below existing grade (Elevation 68.8 m to Elevation 67.0 m). The fill consists of gravel, sand silt and clay of varying percentages. In some boreholes, the fill also contains asphalt and wood fragments, organics (rootlets), blast-shattered rock type fragments and possible cobbles and boulders. Based on the SPT N-values of 4 to 35, the fill is in a loose to dense state. The moisture content of the fill is 5 percent to 15 percent.

Results from the grain-size analysis and Atterberg limit determination conducted on four (4) samples of the fill are summarized in Table III. The grain-size distribution curves are shown in Figures 25 to 28.

Tabl	Table III: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination – Fill Samples									
Borehole		Grain-Size Analysis (%) and Atterberg Limits (%)								
No. (BH): Sample No. (SS)	Depth (m)	Gravel	Sand	Silt	Clay	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
BH/MW 22-01: SS3	1.5- 2.1	17	42	28	13	10	-	-	-	Silty Sand (SM) – Some Gravel and Clay
BH 22-06: SS2	0.8- 1.4	16	46	25	13	8	18	13	5	Clayey Sand (SC) – Low Plasticity, Some Gravel, Silty
BH 24-03: SS3	1.5- 2.1	21	43	25	11	8	17	9	8	Clayey Sand (SC) – Low Plasticity, Gravelly, Silty
BH/MW 24-07: SS2	0.8- 1.4	8	47	32	13	10	25	13	12	Clayey Sand (SC) – Low Plasticity, Silty, Trace Gravel

Based on a review of the results of the grain-size analysis and Atterberg limits, the fill may be classified as a silty sand (SM) with some gravel and clay to a clayey sand (SC) of low plasticity, that is gravelly to trace gravel and silty.

# 5.5 Buried Organic Soil

An approximate 900 mm thick buried organic soil was encountered below the fill in Borehole No. 24-09 at a 1.4 m depth (Elevation 67.9 m) and extends to a 2.3 m depth (Elevation 67.0 m). The organic soil consists of a mixture of silty sand and organic soil (with rootlets). Based on the SPT N-value of 7, the organic soil is in a loose state. The moisture content of the organic soil is 12 percent.

# 5.6 Shaley Glacial Till

The pavement structure, fill and buried organic soil (Borehole No. 24-09) in all of the boreholes are underlain by shaley glacial till contacted at 0.5 m to 3.0 m depths (Elevation 69.8 m to Elevation 67.0 m). The shaley glacial till extends to depths of 2.7 m to 4.6 m (Elevation 67.5 m to Elevation 65.4 m). The shaley glacial till contains varying percentages of gravel, sand, silt and clay. The shaley glacial till also contains shale fragments and possible cobbles and boulders. Based on the SPT N-values of 5 to 115, the shaley glacial till is in a loose to very dense state. In some boreholes, the SPT N-value is high for low sampler penetration, such as 50 for 125 mm of sampler penetration. This



may be a result of the sampler making contact with a possible cobble, boulder or concentrated zone or seams of shale fragments within the shaley glacial till. The natural moisture content of the shaley glacial till ranges from 3 percent to 14 percent.

The results from the grain-size analysis and Atterberg limit determination conducted on nine (9) samples of the shaley glacial till are summarized in Table IV. The grain-size distribution curve is shown in Figures 29 to 37.

Table IV: S	Table IV: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination – Glacial Till Samples									
Borehole	Danah	Grain-Size Analysis (%) and Atterberg Limits (%)								
No. (BH): Sample No. (SS)	Depth (m)	Gravel	Sand	Silt	Clay	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
BH/MW 22-02-2: SS4	2.3- 2.9	27	38	23	12	8	-	-	-	Silty Sand (SM) – Gravelly, Some Clay
BH/MW 22-02: SS6	3.8- 4.2	16	52	26	6	6	-	-	-	Silty Sand (SM) – Some Gravel, Trace Clay
BH/MW 22-03: SS4	2.3- 2.9	31	48	15	6	4	-	-	-	Silty Sand (SM) – Gravelly, Trace Clay
BH 22-04: SS4	2.3- 2.9	14	44	30	12	10	-	-	-	Silty Sand (SM) – Some Gravel and Clay
BH 22-05: SS6	3.8- 4.2	15	50	30	5	8	-	-	-	Silty Sand (SM) – Some Gravel, Trace Clay
BH/MW 22-08: SS4	2.3- 2.9	15	46	26	13	6	-	-	-	Silty Sand (SM) – Some Gravel and Clay
BH/MW 24-05: SS4	2.3- 2.9	17	47	26	10		16	8	8	Clayey Sand (SC) – Low Plasticity, some gravel, silty
BH 24-06: SS3	1.5- 2.1	15	47	28	10	9	19	10	9	Clayey Sand (SC) – Low Plasticity, Some Gravel, Silty
BH 24-12: SS5	3.0- 3.6	26	39	25	10	10	19	11	8	Clayey Sand (SC) – Low Plasticity, Gravelly, Silty

Based on a review of the test results of the grain-size analysis and Atterberg limits, the glacial till may be classified as a silty sand (SM) that is gravelly to some gravel with trace to some clay to a clayey sand (SC) of low plasticity that is gravelly to some gravel, with trace to some clay. The shaley glacial till contains shale fragments and may contain possible cobbles and boulders.

# 5.7 Sand

Locally, in Borehole No. 22-04, the shaley glacial till is underlain by a sand contacted at a 3.8 m depth (Elevation 66.1 m).



# 5.8 Inferred and Actual Bedrock

Auger and casing refusal was met on inferred cobbles, boulders or bedrock in Borehole Nos. 22-01, 22-03 to 22-06, 22-08, 22-16, 22-17 and 24-12 at 2.4 to 5.2 m depths (Elevation 67.4 m to Elevation 65.6 m). Bedrock was contacted in the remaining boreholes at 2.8 m to 4.6 m (Elevation 66.9 m to Elevation 65.2 m). It was necessary to core through cobbles and boulders within the glacial till in order to reach the bedrock in Borehole Nos. 24-01, 24-07 and in 24-09. A summary of the auger refusal and bedrock depths (elevations) are shown in Table V.



Table V: Summary of Inferred and Actual Bedrock Depths (Elevations)							
Borehole (BH)/Monitoring Well (MW) No.	Ground Surface Elevation (m)	Auger Depth (Elevation) on Inferred Bedrock (m)	Bedrock Depth (Elevation) (m)				
BH/MW 22-01	70.09	4.0 (66.1)	-				
BH/MW 22-02	70.01	-	4.2 (65.8)				
BH/MW 22-03	69.72	3.6 (66.1)	-				
BH 22-04	69.87	4.1 (65.8)	-				
BH 22-05	70.25	4.2 (66.1)	-				
BH 22-06	69.80	2.4 (67.4)	-				
BH 22-07	69.72	-	4.1 (65.6)				
BH/MW 22-08	70.32	4.4 (65.9)	-				
BH 22-09	69.69	-	2.8 (66.9)				
BH/MW 22-16	69.60	3.7 (65.9)	-				
BH 22-17	69.99	4.4 (65.6)	-				
BH/MW 24-01	70.15	-	3.4 (66.8)				
BH 24-02	70.28	-	4.5 (65.8) – weathered bedrock 4.8 (65.5) – intact bedrock				
BH 24-03	70.19	-	4.6 (65.6)				
BH 24-04	69.83	-	4.0 (65.8)				
BH/MW 24-05	69.80	-	3.7 (66.1)				
BH 24-06	70.26	-	4.3 (66.0)				
BH/MW 24-07	70.36	-	4.5 (65.9)				
BH 24-09	69.28	-	4.1 (65.2)				
BH 24-12	70.78	5.2 (65.6)	-				

The bedrock is black shale of the Billings formation. A review of the borehole logs indicates that in Borehole No. 24-02, a 300 mm thick weathered zone of the bedrock was contacted at a 4.5 m depth (Elevation 65.8 m). The total core recovery ranges from 77 percent to 100 percent. The rock quality designation (RQD) ranges from 37 percent to 100 percent indicating the quality of the bedrock is poor to excellent. Photographs of the bedrock cores are shown in Appendix B.

A summary of the unit weight and unconfined compressive strength of the bedrock are shown in Table VI.



Table VI: Summary of Unit V	eight and Uncon	fined Compressiv	ve Strength – Bedrock Cores
Borehole (BH)/Monitoring Well (MW)No.: Run No.	Depth (m)	Unit Weight (kN/m³)	Unconfined Compressive Strength (MPa)
BH/MW 22-02: Run 1Run3	4.8-4.9	25.9	28.8
BH/MW 22-02: Run 3	8.5-8.7	25.9	40.3
BH 22-07: Run 1	4.9-5.0	25.8	38.3
BH 22-07: Run 3	7.5-7.6	26.0	40.0
BH 22-09: Run 3	6.1-6.2	25.9	39.6
BH/MW 24-01: Run 1	3.7-3.9	26.5	36.6
BH/MW 24-01: Run 3	6.8-6.9	26.7	44.4
BH 24-02: Run 1	5.2-5.3	26.4	41.8
BH 24-02: Run 3	8.2-8.3	26.9	39.7
BH 24-03: Run 3	5.5-5.8	25.9	66.6
BH 24-03: Run 4	7.4-7.5	26.1	40.2
BH 24-04: Run 1	4.6-4.8	25.9	33.2
BH 24-04: Run 2	6.6-7.0	25.8	35.6
BH 24-05: Run 2	4.6-4.7	26.8	45.9
BH 24-05: Run 3	6.8-6.9	26.6	43.0
BH 24-06: Run 2	5.6-5.8	26.6	36.5
BH 24-06: Run 3	8.3-8.5	26.3	31.0
BH/MW 24-07: Run 2	4.7-4.9	26.2	49.2
BH/MW 24-07: Run 3	6.4-6.6	26.9	38.5
BH 24-09: Run 2	4.1-4.2	26.6	44.5
BH 24-09: Run 3	6.5-6.7	26.6	41.3

A review of the test results in Table VI indicates the strength of the rock may be classified as medium strong (R3) in accordance with the Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006. Locally, Run 3 (5.5 m to 5.8 m) in Borehole No. 24-03 is classified as strong (R4).

# 5.9 Groundwater Level Measurements

A summary of the groundwater level measurements taken in the boreholes equipped with monitoring wells on May 29 and 30,2024 and November 14 and 24,2022 is shown in Table VII.



Table VII: Summary of Groundwater Level Measurements							
Borehole (BH)/Monitoring Well (MW) No.	Ground Surface Elevation (m)	Groundwater Depth Below Ground Surface (Elevation), (m					
DLL/MANA/ 22 04	70.09	May 29,2024 (~1.5 years))	1.7 (68.4)				
BH/MW 22-01	70.09	November 14,2022 (55 days)	2.2 (67.9)				
DIT/MM/ 22 02	70.01	May 29,2024 (~1.5 years)	1.1 (68.9)				
BH/MW 22-02		November 14,2022 (56 days)	1.7 (68.3)				
BH/MW 22-03	69.72	May 29,2024 (~1.5 years)	0.9 (68.8)				
BH/1VIVV 22-U3		November 14,2022 (56 days)	1.4 (686.3)				
BH/MW 22-08	70.32	May 29, 2024 (~1.5 years)	2.0 (68.3)				
BH/MW 22-16	69.60	May 30,2024 (~1.5 years)	1.1 (68.5)				
ВП/IVIVV 22-10 09.00	09.60	November 24,2022 (7 days)	1.4 (68.2)				
BH/MW 24-01	70.15	May 30,2024 (104 days)	1.2 (69.0)				
BH/MW 24-05	69.80	May 30, 2024 (20 days)	1.5 (68.3)				
BH/MW 24-07	70.36	May 30,2024 (23 days)	2.1 (68.3)				

Based on a review of the measurements, the groundwater level ranges from 0.9 m to 2.2 m (Elevation 69.0 m to Elevation 67.9 m).

The groundwater levels were determined in the boreholes at the time and under the condition stated in this report. Note that fluctuations in the level of groundwater may occur due to a seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.



# 6. Site Classification for Seismic Site Response and Liquefaction Potential of Soils

# 6.1 Liquefaction Potential of Soils

The seismic shear wave velocity soundings survey report dated May 31,2024 and prepared by GPR is shown in Appendix A. The GPR report indicates the seismic shear wave velocities (Vs) of the subsurface soils are greater than 200 m/s. Therefore, based on the results of the seismic shear wave velocity soundings survey and the results of the additional boreholes drilled as part of the additional geotechnical investigation, the subsurface soils are considered not to be liquefiable during a seismic event.

# 6.2 Site Classification for Seismic Site Response

For the underside of footings and grade beams founded 3.0 m or less from the bedrock surface, the site class for seismic response may be taken as **Class A**. If the underside of footings and grade beams are greater than 3.0 m from the bedrock surface, the site class for seismic response is **Class C**.



# 7. Grade Raise Restrictions

The borehole information indicates that compressible clays do not exist at the site. Therefore, from a geotechnical perspective, there is no restriction to raising the grades at the site.



# 8. Site Grading

The borehole information indicates the subsurface conditions at the site for the proposed garage building and retaining wall consist of fill, surficial and buried topsoil and organic layers that extend to depths of 1.1 m to 3.0 m (Elevation 68.8 m to Elevation 67.0 m) underlain by loose to very dense shaley glacial till followed by shale bedrock contacted at 2.8 m to 4.6 m depths (Elevation 66.9 m to Elevation 65.2 m). The groundwater level ranges from 0.9 m to 2.2 m depths (Elevation 69.0 m to Elevation 67.9 m).

Site grading within the **proposed garage building and retaining wall footprints** should consist of the excavation and removal of the existing fill, buried topsoil/organic layers and organic stained soils down to the shaley glacial till. Underground service locate information indicates that municipal services such as storm sewers and associated catchbasins and manholes exist within the footprint of the proposed garage building. The existing underground services will need to be relocated to the outside the proposed garage building and retaining wall footprints. The existing fill inside and outside the service trenches will also need to be excavated and removed down to the shaley glacial till. Within existing service trenches, the fill may be deeper than indicated on the borehole logs.

For engineered fill pad areas that will support the foundations and slab-on-grade of the proposed garage building and foundation for the proposed retaining wall, the native shaley glacial till subgrade should be examined by a geotechnician. Any loose/soft areas identified during the subgrade examination should be excavated, removed and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II material compacted to 100 percent standard Proctor maximum dry density (SPMDD). Once the subgrade has been approved, the grades may be raised to the design underside footing and/or floor slab elevation by an engineered fill pad constructed in accordance with Section 9.1.1 of this report.

The excavation for the construction of the engineered fill pad is anticipated to extend below the groundwater level into the shaley glacial till which contains loose zones. The loose zones of the shaley glacial till below the groundwater level are susceptible to instability of the base of the excavation in the form of piping or heave. To minimize 'baseheave' type failure of the excavation base, it is necessary to lower the groundwater table at the site to below the final excavation level prior to the start of the excavation. This may be achieved by installing deep sumps, pumping with high-capacity pumps and pumping on a continuous basis (such as twenty-four (24) hours a day, seven (7) days a week). The groundwater level should be lowered and maintained to at least 1.0 m below the bottom of the excavation until the placement and compaction of the engineered fill pad has been completed to the design subgrade level. Standpipes should also be installed to monitor the groundwater level during initial groundwater lowering and during construction. A specialized dewatering contractor should be consulted to determine the most appropriate dewatering method for the site conditions to allow for the construction of the engineered fill pad to be undertaken in relatively dry conditions.

Site grading outside the proposed garage building and retaining wall in areas within the **proposed concrete apron**, **parking lots and access road areas** should consist of the removal of existing pavement structure, surficial topsoil and organic stained soils. The subgrade should be proofrolled in the presence of a geotechnician. Any loose/soft areas identified during the proofrolling process should be excavated, removed, and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II or OPSS Select Subgrade Material (SSM) compacted to 95 percent standard Proctor maximum dry density (SPMDD). Once the subgrade has been approved, the grades may be raised to the design subgrade level of the pavement structure by approved on site material and/or OPSS Select Subgrade Material (SSM) compacted to 95 percent SPMDD.

In place density tests should be performed on each lift of placed material to ensure that it has been compacted to the project specifications.



# 9. Foundation Considerations

The borehole information indicates the subsurface conditions at the site for the proposed garage building and retaining wall consist of fill, buried topsoil and organic layers that extend to depths of 1.1 m to 3.0 m (Elevation 68.8 m to Elevation 67.0 m) underlain by loose to very dense shaley glacial till followed by shale bedrock contacted at 2.8 m to 4.6 m depths (Elevation 66.9 m to Elevation 65.2 m). The groundwater level ranges from 0.9 m to 2.2 m depths (Elevation 69.0 m to Elevation 67.9 m).

# 9.1 Proposed Garage Building

Based on available design information including the schematic architectural drawing, Sheet No. AS101, dated March 28,2024 (Project No. 60716350), the proposed building will have an approximate footprint of 8800 square metres and will be a single-storey industrial type slab-on-grade building with no basement. The design elevation of the floor slab will be at Elevation 69.90 m. Factored axial loads for perimeter columns will be approximately 1000 kN and approximately 1600 kN for central columns. Some of the columns at braced bays may have net uplift loads of approximately 200 kN. A retaining wall will be located east of the new garage building.

The site for the proposed garage building is relatively flat with borehole ground surface elevations ranging from Elevation 70.36 m to Elevation 69.28 m. A design floor slab elevation of Elevation 69.90 m will result in fill areas of up to approximately 0.6 m and cut areas to approximately 0.5 m within the garage building footprint.

A review of the available design information and borehole data indicates that the proposed building may be supported by strip and spread footings designed to bear on an engineered fill pad constructed on top of the native shaley glacial till. Alternatively, the proposed garage building may be supported by caissons socketed into the sound shale bedrock. Piles designed in end bearing and driven to practical refusal into the shale bedrock is not considered practical due to the shallow depth of the bedrock. For the two (2) foundation options, the ground floor of the proposed garage building may be designed as a slab-on-grade founded on an engineered fill pad constructed on the shaley glacial till. The existing fill and buried topsoil/organic soil are not suitable to support foundations and the ground floor slab-on-grade of the proposed garage building and to support the foundations of the proposed retaining wall.

As previously discussed, the excavation for the construction of the engineered fill pad is anticipated to extend below the groundwater level into the shaley glacial till that contains loose zones. The loose zones of the shaley glacial till below the groundwater level are susceptible to instability of the base of the excavation in the form of piping or heave. To minimize 'base-heave' type failure of the excavation base, it is necessary to lower the groundwater table at the site to below the final excavation level prior to the start of the excavation. This may be achieved by installing deep sumps, pumping with high-capacity pumps and pumping on a continuous basis (such as twenty-four (24) hours a day, seven (7) days a week). The groundwater level should be lowered and maintained to at least 1.0 m below the bottom of the excavation until the placement and compaction of the engineered fill pad has been completed to the design subgrade level. Standpipes should also be installed to monitor the groundwater level during initial groundwater lowering and during construction. A specialized dewatering contractor should be consulted to determine the most appropriate dewatering method for the site conditions to allow for the construction of the engineered fill pad to be undertaken in relatively dry conditions.

The two (2) foundation options of footings and caissons are discussed in the following sections of this report.

# 9.1.1 Footings

The proposed garage building may be supported by strip and spread footings founded on a minimum 300 mm thick engineered fill pad set on the shaley glacial till and constructed in accordance with the procedure below. It is anticipated that the footing will be founded to a maximum depth of 1.5 m below the finished floor. Footings founded to a maximum 1.5 m depth below finished floor on the properly constructed engineered fill pad may be designed for a bearing pressure at serviceability limit state (SLS) of 200 kPa and factored geotechnical resistance at ultimate



limit state (ULS) of 300 kPa. The factored geotechnical resistance at ULS value includes a geotechnical resistance factor of 0.50.

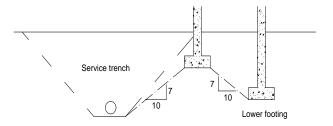
The total and differential settlements of footings designed in accordance with the recommendations of this report and with careful attention to construction detail are expected to be less than 25 mm and 19 mm respectively.

The preparation of the site for engineered fill pad construction requires all fill, surficial and buried topsoil/organic soil be excavated and removed down to the shaley glacial till. The excavation should extend a sufficient distance beyond the limits of the footprint of the proposed building to accommodate a 1.0 m wide bench of engineered fill around the perimeter of the building, which is thereafter sloped at an inclination of 1H:1V down to the approved shaley glacial till. The exposed shaley glacial till subgrade should be proofrolled and examined by a geotechnical engineer. Any loose/soft areas identified during proofrolling operations should be excavated and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II compacted to 100 percent standard Proctor maximum dry density (SPMDD).

Following approval of the subgrade for the engineered fill pad, the excavation may be backfilled with the engineered fill consisting of free draining Ontario Provincial Standard Specification (OPSS) Granular B Type II material placed in 300 mm thick lifts and each lift compacted to 100 percent of the SPMDD under the footings and floor slab area. The engineered fill should be placed under the full-time supervision of a geotechnician working under the direction of a geotechnical engineer. In-place density tests should be undertaken on each lift of the engineered fill to ensure that it is properly compacted prior to placement of the subsequent lift.

Reference is made to previous comments dealing with dewatering of the excavation for the construction of the engineered fill pad.

Footings founded in soils at different elevations should be located such that the higher footings are set below a line drawn up at 10 horizontal to 7 vertical (10H:7V) from the near edge of the lower footing, as shown below. This concept should also be applied to service excavation, etc. to ensure that undermining is not a problem.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

All footing beds should be examined by a geotechnical engineer to ensure that the founding soil is capable of supporting the bearing pressure at SLS and that the footing beds have been properly prepared.

It should be noted that the exposed shaley glacial till subgrade surface is susceptible to disturbance due to movement of workers and construction traffic and the prevailing weather conditions during construction. To prevent disturbance to the soil subgrade, the approved shaley glacial till subgrade should be covered with a layer of engineered fill within the same day of approval.

A minimum of 1.5 m of earth cover should be provided to the exterior foundations founded on soil of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity and to 2.4 m if snow will be removed from the vicinity of the structure. When earth cover is less than the minimum required, an equivalent thermal combination of earth cover and rigid insulation board or rigid insulation board alone should be provided. EXP can provide developmental comments in this regard, if required.



# 9.1.1.1 Resistance to Uplift Forces

# 9.1.1.1.1 Weight of Footing

Footings may resist uplift forces by the submerged or effective weight of the footing. Alternatively, rock anchors may be used to resist uplift forces.

#### 9.1.1.1.2 Rock Anchors

Post-tensioned rock anchors installed in the bedrock may be required as part of the footing design to resist uplift forces.

Pre-stressed anchors may fail in one or more of the following manners:

- a) Failure of the grout/tendon bond,
- b) Failure of the steel tendon or top anchorage,
- c) Failure of the rock/grout bond; or
- d) Pull-out failure of the cone-shaped rock mass.

Failure modes a) and b) require review by the structural engineer. Geotechnical related failure modes c) and d) for vertical grouted anchors are discussed below:

# Failure of the rock/grout bond:

- The factored ultimate limit state (ULS) bond stress between the sound shale bedrock and the grout may be taken as 600 kPa and includes a resistance factor of 0.3. The unconfined compressive strength of the grout is assumed to be 35 MPa.
- Weathered zones such as in the upper 300 mm of the shale bedrock in Borehole No. 24-02 should not be included in the bond length. The depth and presence of the weathered and highly fractured zones of the bedrock may vary at locations away from the boreholes. For design purposes, the sound bedrock may be assumed to commence at 1.0 m below the bedrock surface.
- The minimum bonded length should be 3.0 m.

#### Pull-out failure of the cone-shaped rock mass:

- The pull-out failure of the embedment cone-shaped rock mass is defined by a 60 or 90-degree cone in the bedrock with the apex located at the midpoint of the bonded length of the anchor. For the shale bedrock, the apex angle of the rock failure cone should be taken as 60 degrees.
- The unbonded length may be taken as equal to the height of the theoretical rock cone minus half of the bonded length.
- The factored uplift resistance of the anchor should be determined by the submerged weight of the coneshaped rock mass around the anchor. The submerged weight of the rock cone mass should not be less than the ultimate capacity of the anchor. The submerged unit weight of the shale bedrock equal to 16.5 kN/m<sup>3</sup> should be used in the calculations.
- Where the embedment rock cones for a group of anchors overlap with each other, the combined embedment cones for the group of anchors should be used to determine the anchor group resistance to the rock mass pull-out failure.

The installation method of the rock anchors should take into consideration the presence of cobbles and boulders and shale fragments within the soils.

# **Corrosion Protection of the Anchors:**



• Corrosion protection of the anchors should be in accordance with the Ontario Provincial Standard Specification (OPSS) 942.

#### Testing of Rock Anchors:

Pre-production or design performance tests of permanent rock anchors should be in accordance with the Ontario Provincial Standard Specification (OPSS) 942. Pre-production performance tests should be conducted on selected rock anchors. Proof load tests should be conducted on all anchors and should be in accordance with OPSS 942.

# 9.1.2 Drilled Shafts (Caissons)

The proposed building may be supported by drilled shafts (caissons) socketed into the sound shale bedrock below the any weathered zones of the bedrock. Based on the borehole information, shale bedrock was contacted at 2.8 m to 4.6 m depths (Elevation 66.9 m to Elevation 65.2 m). For design purposes, the sound bedrock may be assumed to commence at 1.0 m below the bedrock surface.

The axial geotechnical resistance is based on the caisson designed to carry the load based on sidewall (shaft) resistance between the concrete and the sound shale bedrock for the socketed length of the caisson in the sound bedrock and neglecting end bearing capacity. The caissons may be designed for a factored sidewall resistance at ULS of 800 kPa and includes a geotechnical resistance factor of 0.4. Compressive strength of concrete should be 35 MPa. The socket length into the sound bedrock should be at least 3 times the diameter of the caisson and the caissons should be spaced at a minimum of three (3) caisson diameters (centre-to-centre). Uplift forces may be resisted by the submerged weight of the caisson or by rock anchors.

The sidewall resistance of the bedrock at SLS required to produce 25 mm of settlement will be much larger than the recommended value for factored sidewall resistance at ULS. Therefore, the factored geotechnical resistance at ULS will govern the design.

The installation of the caissons should take into consideration the presence of cobbles and boulders and shale fragments within the soils. Installation of the caissons will require the use of at least one liner to minimize soil loss. The liner should be driven to the shale bedrock. It may be necessary to loosen the overburden material by augering through to the shale bedrock. The liner may then be advanced through the soil slurry to the bedrock. It is noted that the caissons will likely require dewatering operations since the groundwater level at the site is high above the bedrock surface. If the caissons cannot be dewatered, concrete may have to be placed by 'tremie' technique. During the withdrawal of the liner, a positive head of concrete would have to be maintained in the liner with respect to the exterior hydrostatic pressure.

It is imperative that the sidewalls of the portion of the caisson socketed into the sound bedrock be cleaned of any soil smearing, to ensure the concrete is in contact with clean bedrock.

All caissons must be inspected by a geotechnician under the supervision of a geotechnical engineer to confirm the factored geotechnical resistance value at ULS of the founding rock and to ensure that the caissons have been prepared satisfactorily and properly cleaned.

The concrete grade beams and pile caps for heated structures should be protected from frost action by providing the beams and caps with 1.5 m of earth cover. For non-heated structures, the pile caps and beams should be provided with 2.4 m of earth cover in areas where the snow will be removed and 2.1 m of earth cover where the snow will not be removed. Alternatively, frost protection may be provided by rigid insulation board or a combination of rigid insulation board and earth cover.

# 9.2 Retaining Wall

It is our understanding that a retaining wall will be constructed in the vicinity of Borehole No. 24-12. Details regarding the design of the retaining wall were not available at the time of this geotechnical investigation. The borehole information indicates the subsurface conditions consist of fill to a 3.0 m depth (Elevation 67.9 m) underlain by loose



to compact shaley glacial till. The existing fill is not considered suitable to support the foundation for the retaining wall. Therefore, consideration may be given to supporting the retaining wall by a strip footing founded at a 2.4 m depth below existing grade, for frost protection, on an engineered fill pad constructed on the shaley glacial till and designed for a bearing pressure at SLS of 100 kPa and factored geotechnical resistance at ULS of 150 kPa. If higher SLS and factored ULS values are required, the strip footing for the retaining wall may be founded higher up to a maximum depth of 1.5 m below existing grade and designed for an SLS value of 200 kPa and factored ULS value of 300 kPa. For the footing founded at a 1.5 m depth below existing grade, the footing will need to be protected from frost action by a combination of soil cover and rigid insulation board. EXP can provide additional comments regarding frost protection for the footing, if required. Reference is made to section 9.1.1 of this report for the procedure to construct the engineered fill pad.

Reference is made to previous comments dealing with dewatering of the excavation for the construction of the engineered fill pad.

# 9.2.1 Sliding Resistance

The factored coefficient of friction at ULS between the concrete of the footing and engineered fill is estimated at 0.46 and includes a geotechnical resistance factor of 0.8.

# 9.3 Additional Comment for Foundations

The recommended bearing pressure at SLS and factored geotechnical resistances at ULS have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily ongoing as new information of underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes, when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.



# 10. Floor Slab and Drainage Requirements

# 10.1 Floor Slab and Drainage Requirements

The ground floor of the proposed garage building may be designed and constructed as a slab-on-grade placed on a 200 mm thick well-packed 19 mm sized clear stone bed placed on a minimum 300 mm thick engineered fill pad set on the approved shaley glacial till. The engineered fill pad should be constructed in accordance with section 9.1.1. of this report. The clear stone will minimize the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the clear stone layer may be replaced with a 200 mm thick bed of OPSS Granular A compacted to 100 percent SPMDD overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

Reference is made to previous comments dealing with dewatering of the excavation for the construction of the engineered fill pad.

The proposed garage building will require perimeter and underfloor drainage systems.

The perimeter drainage system may consist of 100 mm diameter perforated pipe set on the footings and surrounded with

150 mm thick 19 mm sized clear stone that is fully wrapped or covered with an approved porous geotextile membrane, such as Terrafix 270R or equivalent. The underfloor drainage system may consist of 100 mm diameter perforated pipe or equivalent placed in parallel rows at 5 m to 6 m centres and at least 300 mm below the underside of the floor slab. The drains should be set on a 100 mm thick bed of 19 mm sized clear stone and covered on top and sides with 100 mm thick clear stone that is fully wrapped or covered with an approved porous geotextile membrane, such as Terrafix 270R or equivalent.

The perimeter and underfloor drainage systems should be connected to separate sumps equipped with backup (redundant) pumps and generators in case of mechanical failure and/or power outage, so that at least one system would be operational should the other fail.

The floor slab should be set at a minimum of 150 mm higher than the final exterior grade surrounding the garage building.

The final exterior grade surrounding the garage building should be sloped away from the building to prevent ponding of surface water close to the exterior walls of the building.

# 10.2 Vertical Modulus of Subgrade Reaction

For the slab-on-grade founded on the granular material consisting of 200 mm thick well-packed clear stone or OPSS Granular A layer over a minimum 300 mm thick engineered fill pad (OPSS Granular B Type II) compacted to 100 percent SPMDD, the vertical modulus of subgrade reaction is estimated to be 50 MPa/m.



# 11. Lateral Earth Pressure Against Retaining Wall

# 11.1 Lateral Earth Pressure against Retaining Wall

The retaining wall will be subjected to lateral static as well as lateral seismic (dynamic) earth forces during a seismic event. The seismic lateral earth pressure coefficients given below have been derived based on the peak horizontal ground acceleration (PGA) of 0.32g for the site determined from the 2020 National Building Code of Canada Seismic Hazard Tool.

The retaining wall should be backfilled with free draining material, such as Ontario Provincial Standard Specification (OPSS) Granular B Type II compacted to 95 percent SPMDD and equipped with a permanent drainage system to prevent the buildup of hydrostatic pressure behind the wall. The expressions below assume the walls are backfilled with free-draining material and equipped with a drainage system.

Seismic loading will result in an increase in the active lateral earth pressure on the wall. The total active <u>pressure</u> distribution can be separated into a static component and a seismic (dynamic) component and may be determined as follows (Mononobe and Matsuo, 1929):

$$\sigma_{AE}(z) = K_A \gamma z + (K_{AE} - K_A) \gamma (H - z) + q$$

Where  $\sigma_{AE}(z)$  = the total combined active earth pressure (static and seismic) at depth z, (kPa).

z = depth below the top of the retaining wall at back of wall (m)

K<sub>A</sub> = static lateral active earth pressure coefficient

KAE = seismic lateral active earth pressure coefficient

 $\gamma$  = unit weight of the backfill soil (kN/m<sup>3</sup>)

H = total height of the wall (m)

q = surcharge such as traffic and compaction pressure, where applicable (kPa)

For the total active earth pressure, the seismic (dynamic) pressure distribution is an inverted triangle with maximum pressure at the top of the wall and a minimum at the bottom of the wall. Therefore, the resultant of the static and seismic (dynamic) pressures on the retaining wall is assumed to be applied at depths ranging between 0.67z from the top of the backfill behind the wall and 0.67 (H-z) from the bottom of the wall, respectively.

The total passive <u>pressure</u> in front of the wall can similarly be separated into static and seismic (dynamic) components as follows:

$$\sigma_{PE}(z) = K_{p}\gamma z + (K_{PE} - K_{p})\gamma(z) + q$$

Where  $\sigma_{PF}(z)$  = the total combined passive earth pressure (dynamic and static) a depth z, (kPa)

z = depth below the ground surface in front of the wall (m)

 $K_p$  = static lateral passive earth pressure coefficient

K<sub>PE</sub> = seismic lateral passive earth pressure coefficient

 $\gamma$  = unit weight of the backfill soil (kN/m<sup>3</sup>)

q = surcharge such as traffic and compaction pressure, where applicable (kPa)



The seismic passive pressure acts in the opposite direction to the static passive pressure thereby reducing the available passive pressure. The resultant force of the static and dynamic components of the passive pressure acts at 0.67z from the top of final grade in front of the retaining wall.

The lateral earth pressure parameters are summarized in Table VIII.

Table VIII: Lateral Earth Pressure Parameters						
Soil Type:	OPSS Granular B Type II					
Unit Weight of Soil (γ); kN/m³	22					
Angle of Internal Friction (φ'); degrees	30°					
Coefficient of Static Active Lateral Earth Pressure Coefficient, KA	0.33					
Coefficient of Static Passive Lateral Earth Pressure Coefficient, KP	3.00					
Coefficient of Seismic Active Lateral Earth Pressure, KAE	0.44					
Coefficient of Seismic Passive Lateral Earth Pressure, K <sub>PE</sub>	2.70					

For the calculation of the active and passive seismic lateral earth pressure coefficients, the seismic coefficient in the horizontal direction,  $k_h$ , was taken as 0.5 times the PGA value of 0.32g. The calculated active and passive seismic lateral earth pressure coefficients assume the seismic coefficient in the vertical direction,  $k_v$ , is zero. If vertical acceleration is taken into consideration, the computed active and passive seismic lateral earth pressure coefficient values would be somewhat different.

The  $K_{AE}$  and  $K_{PE}$  value calculations assume the front and back faces of the wall are vertical, there is no friction between the wall and the backfill soil (in front of and behind the wall) and the ground surface of the backfill (in front of and behind the wall) is level or flat and the ground surface of the backfill behind the wall is at the same level as the top of the retaining wall

# 11.2 Factor of Safety Against Global Instability

For retaining walls greater than 1.0 m in height, a global stability analysis will be required to determine the factor of safety against global instability, as per the City of Ottawa document titled, *Slope Stability Guidelines for Development Applications in the City of Ottawa (2012)*.



# 12. Excavation and De-Watering Requirements

# 12.1 Excess Soil Management

Ontario Regulation 406/19 specifies protocols that are required for the management and disposal of excess soils. As set forth in the regulation, specific analytical testing protocols need to be implemented and followed based on the volume of soil to be managed and the requirements of the receiving site. The testing protocols are specific as to whether the soils are stockpiled or in situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19.

Reference is also made to the updated Phase Two ESA completed by EXP as part of this assignment.

# 12.2 Excavation

Excavations for the construction of the proposed garage building and retaining wall and installation of the underground services are anticipated to extend to depths ranging from approximately 3.0 m to 4.0 m below existing grade and are expected to be within the fill and shaley glacial till for the proposed building and retaining wall and may possibly extend to shallow depths below the surface of the shale bedrock for site servicing. Excavations will extend below the groundwater level.

# 12.2.1 Soil Excavation

The excavations within the soils may be undertaken by conventional heavy equipment capable of removing possible debris, cobbles and boulders within the fill and cobbles and boulders within the shaley glacial till.

Open cut excavations within the soils above the groundwater level are anticipated to be relatively straight forward.

All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation. Within zones of seepage, the excavation side slopes are expected to slough and eventually stabilize at 2H:1V to 3H:1V from the bottom of the excavation. For excavations above the groundwater level or properly dewatered (refer to paragraph below), the installation of the municipal underground services may be undertaken within the confines of a prefabricated support system (trench box) designed and installed in accordance with OHSA.

The open cut excavations for this project are anticipated to extend below the groundwater level into the shaley glacial till which contains loose zones. The loose zones of the shaley glacial till below the groundwater level are susceptible to instability of the base of the excavation in the form of piping or heave. To minimize 'base-heave' type failure of the excavation base, it is necessary to lower the groundwater table at the site to below the final excavation level prior to the start of the excavation. This may be achieved by installing deep sumps, pumping with high-capacity pumps and pumping on a continuous basis (such as twenty-four (24) hours a day, seven (7) days a week). The groundwater level should be lowered and maintained to at least 1.0 m below the bottom of the excavation until the placement and compaction of the engineered fill pad has been completed to the design subgrade level. Standpipes should also be installed to monitor the groundwater level during initial groundwater lowering and during construction. A specialized dewatering contractor should be consulted to determine the most appropriate dewatering method for the site conditions to allow for the construction to be undertaken in relatively dry conditions.

If side slopes cannot be achieved due to space restrictions on site such as the proximity of open cut excavations to the property limits, existing infrastructure or to foundations of adjacent existing building(s), the new building construction would have to be undertaken within the confines of an engineered support system (shoring system).



The need for a shoring system, the most appropriate type of shoring system and the design and installation of the shoring system should be determined by the contractors bidding on this project. The design of the shoring system should be undertaken by a professional engineer experienced in shoring design and the installation of the shoring system should be undertaken by a contractor experienced in the installation of shoring systems. The shoring system should be designed and installed in accordance with latest edition of Ontario Regulation 213/91 under the OHSA and the 2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM). The shoring system should be monitored on a periodic basis for lateral and vertical movements.

# 12.2.2 Bedrock Excavation

It is anticipated that excavations may extend to shallow depths below the bedrock surface. The side walls of the excavation that extend into the weathered zone of the bedrock should be cut back at 1H:1V from the bottom of this zone. Excavation of the competent sound bedrock is anticipated to be at a minimum. If excavations extend into the competent sound bedrock, excavation side slopes may be cut back with near vertical sides subject to examination by a geotechnical engineer.

The upper level of the bedrock may be excavated using a hoe ram for removal of very small quantities of the bedrock; however, this process is expected to be slow. The excavation of the sound shale bedrock will likely require line drilling and blasting method. Should blasting not be permitted, the excavation of the bedrock would have to be undertaken by line drilling and excavation. Specialized contractors bidding on this project should decide on their own the most preferred rock removal method; hoe ramming or line drilling and blasting.

The vibration limits for blasting should be monitored and in accordance with City of Ottawa Special Provisions (SP No. 1201).

#### 12.2.3 Additional Comments

It is recommended that a pre-construction condition survey of adjacent building(s) and infrastructure located within the zone of influence of construction be undertaken prior to any earth (soil) and rock excavation work as well as vibration monitoring during excavation, blasting and construction operations. Prior to the commencement of blasting, a detailed blast methodology should be submitted by the Contractor.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

# 12.3 De-Watering Requirements

Seepage of the surface and subsurface water into the excavations is anticipated. However, it should be possible remove groundwater entering into excavation by pumping from sumps. In areas of high infiltration or in areas where more permeable soil layers may exist, a higher seepage rate should be anticipated and will require high-capacity pumps to keep the excavation dry (may need to operate 24 hours a day, seven (7) days a week).

As discussed above, to minimize base type failure of excavations that extend below the groundwater level and into the shaley glacial till, it is recommended that the groundwater level should be lowered by at least 1.0 m below the bottom of the excavation prior to the start of excavation. This may be achieved by installing deep sumps and pumping with high-capacity pumps. A specialized dewatering contractor should be consulted to determine the most appropriate dewatering method for the site conditions to allow for the construction to be undertaken in relatively dry conditions.

For construction dewatering, an Environmental Activity and Sector Registry (EASR) approval may be obtained for water takings greater than 50 m<sup>3</sup> and less than 400 m<sup>3</sup> per day. If more than 400 m<sup>3</sup> per day of groundwater are generated for dewatering purposes, then a Category 3 Permit to Take Water (PTTW) must be obtained from the Ministry of the Environment, Conservation and Parks (MECP). A Category 3 PTTW would require a complete



hydrogeological assessment and would take at least 90 days for the MECP to process once the application is submitted.

Although this investigation has estimated the groundwater levels at the time of the fieldwork, and commented on dewatering and general construction problems, conditions may be present which are difficult to establish from standard boring and excavating techniques and which may affect the type and nature of dewatering procedures used by the contractor in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile, thin layers of soil with large or small permeabilities compared with the soil mass, etc. Only carefully controlled tests using pumped wells and observation wells will yield the quantitative data on groundwater volumes and pressures that are necessary to adequately engineer construction dewatering systems.

# 12.4 Short and Long-Term Effects of Dewatering on Existing Structures

Based on a review of the subsurface conditions at the site, short-term dewatering of the site during construction and long-term lowering of the groundwater by perimeter and underfloor drainage systems are not anticipated to negatively impact adjacent foundations and infrastructure.



# 13. Pipe Bedding Requirements

It is anticipated that the subgrade for the proposed underground services will consist of existing fill and shaley glacial till.

The pipe bedding including material specifications, thickness of cover material and compaction requirements should conform to City of Ottawa specifications, drawings and special provisions. The bedding and cover material should be compacted to a minimum of 95 percent standard Proctor maximum dry density (SPMDD).

The bedding thickness may be increased in areas where the subgrade is subject to disturbance. If this is the case, trench base stabilization techniques, such as the removal of loose material, placement of sub-bedding, consisting of OPSS Granular B Type II completely wrapped in a non-woven geotextile, may be used.

To minimize the potential for bending stresses within the pipe, a transition zone treatment should be provided in areas where the pipe subgrade changes from soil to bedrock and vice versa. In areas where the surface of the bedrock slopes at a steeper gradient than 3H:1V, the bedrock should be excavated and additional bedding material placed to create a 3H:1V transition zone.

For paved surfaces that will be located over service trenches, it is recommended that the trench backfill material within the 1.8 m frost zone, should match the existing material exposed along the trench walls to minimize differential frost heaving of the subgrade. The trench backfill should be placed in 300 mm thick lifts and each lift should be compacted to 95 percent SPMDD. Alternatively, frost tapers may be used.

The underground services should be installed in short open trench sections that are excavated and backfilled the same day.



# 14. Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The materials to be excavated from the site will comprise of topsoil, buried organic soil, fill and shaley glacial till and possibly shale bedrock. From a geotechnical perspective, the excavated topsoil, buried organic soil, fill and shale bedrock are not considered suitable for reuse as backfill material in the interior or exterior of the garage building and retaining wall and should be discarded. These soils (free of debris) may be used for general grading purposes in landscaped areas. Portions of the excavated granular fill (base) and shaley glacial till (free of cobbles and boulders) above the groundwater level may be re-used as fill in locations away from the proposed building and retaining wall as backfill in service trenches and subgrade fill in paved and landscaped areas, subject to further geotechnical examination and testing during construction. These soils are subject to moisture absorption due to precipitation and must be protected at all times from the elements. Subject to additional examination and testing during construction, portions of the shaley glacial till (free of cobbles and boulders) below the groundwater level, may be re-used as fill in locations away from the proposed building and retaining wall as backfill in service trenches and subgrade fill in paved and landscaped areas, but will likely require air-drying to reduce the moisture content to compact the materials to the specified degree of compaction. Air-drying may be problematic (difficult) since it is weather dependent, may take time and that the soils are subject to moisture absorption from precipitation and must be protected at all times from the elements.

Therefore, it is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed building, retaining wall and in the underground service trenches will need to be imported and should preferably conform to the following specifications:

- Engineered fill under footings and the floor slab for the proposed garage building and backfill against the retaining wall OPSS Granular B Type II placed in 300 mm thick lifts and each lift compacted to 100 percent SPMDD under footings and floor slab and 95 percent SPMDD for the backfill against the retaining wall.
- Backfill material for footing trenches and against foundation walls located outside the proposed garage building – OPSS Granular B Type II placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD,
- Trench backfill and subgrade fill should consist of OPSS Granular B Type I or OPSS Select Subgrade Material (SSM) placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD; and
- Landscaped areas Clean fill that is free of organics and deleterious material, cobbles and boulders and is placed in 300 mm thick lifts with each lift compacted to 92 percent of the SPMDD.



# 15. Pavement Structures for Concrete Aprons, Access Roads and Parking Lots

Subgrade for the proposed concrete aprons and paved parking lots and access roads are anticipated to comprise of existing fill, OPSS Granular B Type II material or select subgrade material (SSM) used to raise the grades to the design subgrade level.

# 15.1 Rigid Pavement Structure - Concrete Apron

Rigid pavement structure thicknesses for the new concrete aprons were computed and are shown on Table IX. The pavement structure is based upon an estimate of the subgrade soil properties determined from visual examination, textural classification of the soil samples and functional design life of 15 to 18 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table IX: Rigid Pavement Structure – Concrete Aprons					
Pavement Layer	Compaction Requirements	Computed Pavement Structure – Light Duty Traffic (Cars) and Heavy Duty Traffic (Buses, Emergency Vehicles and Trucks)			
Reinforced Concrete	-	200 mm			
OPSS 1010 Granular A Base (crushed limestone)	100% SPMDD	150 mm			
OPSS 1010 Granular B Sub-base, Type II  100% SPMDD 600 mm					
Note: SPMDD denotes Standard Proctor Maximum Dry Density, ASTM-D698-12e2.					

The concrete for the rigid pavement structure should be designed by a structural engineer. The concrete should be reinforced and equipped with expansion and control joints. The concrete should also have a compressive strength of 32 MPa and air content ranging from 5 percent to 8 percent.

Additional comments on the construction of the new concrete aprons are as follows:

- 1. As part of the subgrade preparation, the proposed concrete apron area should be stripped of the existing pavement structure and fill and any other unsuitable material. Portions of the existing fill may remain as part of the subgrade, subject to further examination during construction.
- 2. The subgrade should be properly shaped, crowned, proofrolled and the exposed subgrade examined by a geotechnical technician. Any soft or spongy subgrade areas detected should be excavated and replaced with OPSS Granular B Type II material compacted to 95 percent SPMDD.
- 3. Fill required to raise the grades to the design subgrade elevation should consist of to OPSS Granular B Type II compacted to 95 percent SPMDD.
- 4. The need for adequate drainage of surface and subsurface water for the concrete aprons cannot be over emphasized. The drainage system should comprise of sub-drains as well as a trench drain at the low point of the concrete aprons that will direct water away from the aprons to a suitable outlet.
- 5. The granular materials used for pavement structure should conform to OPSS 1010 for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD.



## 15.2 Flexible Pavement Structures – Access Roads and Parking Lots

Pavement structure thicknesses required for the new paved access roads and parking lots set on the anticipated approved subgrade materials were computed and are shown in Table X. The pavement structures assume a functional design life of 15 to 18 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table X: Flexible Pavement Structures – Parking Lots and Access Roads							
		Computed	Pavement Structure				
Pavement Layer	Compaction Requirements	Light Duty Traffic (Cars Only)	Heavy Duty Traffic (Buses, Emergency Vehicles and Trucks)				
Asphaltic Concrete	92 percent-97 percent MRD	65 mm HL3/SP12.5 mm/ Cat. B (PG 58-34)	60 mm HL3/SP12.5 Cat. D (PG 64-34) 90 mm HL8/SP 19 Cat. D (PG 64-34)				
OPSS 1010 Granular A Base	100% percent SPMDD	150 mm	150 mm				
OPSS 1010 Granular B Type II Sub-base	100% percent SPMDD	450 mm	600 mm				

### Notes:

- 1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698-12e2.
- 2. MRD denotes Maximum Relative Density, ASTM D2041.
- 3. The upper 300 mm of the subgrade fill must be compacted to 98 percent SPMDD.
- The approved subgrade should be covered with a woven geotextile prior to placement of granular sub-base of the pavement structure.

The foregoing design assumes that construction is carried out during dry periods and that the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather and heaving or rolling of the subgrade is experienced, additional thickness of granular material may be required in addition to the woven geotextile indicated in Table X.

Additional comments for the construction of the access roads and parking lots are as follows:

- 1. As part of the subgrade preparation, the proposed parking areas and the internal access roads should be stripped of existing pavement structure, surficial topsoil and any other unsuitable material. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory roller in the full-time presence by a geotechnician. Any soft or spongy subgrade areas detected should be sub excavated and properly replaced with suitable approved material or approval OPSS Granular B Type II placed in 300 mm lift and each lift compacted to 95 percent SPMDD (ASTM D698-12e2).
- 2. The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The need for adequate drainage cannot be over-emphasized. Subdrains should be installed on both sides of the access road(s). Subdrains must be installed in the proposed parking area and on both sides of the roadways at low points and should be continuous between catchbasins to intercept excess surface and subsurface moisture and to prevent subgrade softening. This will ensure no water collects in the granular course, which could result in pavement failure during the spring thaw.
- 3. To minimize the problems of differential movement between the pavement and catchbasins/manhole due to frost action, the backfill around the structures should consist of free-draining granular preferably conforming to OPSS Granular B Type II material. Weep holes should be provided in the catchbasins/manholes to facilitate drainage of any water that may accumulate in the granular fill.



- 4. The most severe loading conditions on light-duty pavement areas and the subgrade may occur during construction. Consequently, special provisions such as restricted lanes, half-loads during paving, temporary construction roadways, etc., may be required, especially if construction is carried out during unfavorable weather.
- 5. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum cross fall of 2 percent) to provide effective surface drainage towards catchbasins. Surface water should not be allowed to pond adjacent to the outside edges of paved areas.
- 6. Relatively weaker subgrade may develop over service trenches at subgrade level. These areas may require the use of thicker/coarser sub-base material and the use of a geotextile at the subgrade level. If this is the case, it is recommended that additional 150 mm of granular sub-base Granular B Type II should be provided in these areas in addition to the use of a geotextile at the subgrade level.
- 7. The granular materials used for pavement construction should conform to OPSS 1010 for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD (ASTM D698). The asphaltic concrete and its placement should meet OPSS requirements. It should be compacted to 92 to 97 percent of the maximum relative density in accordance with ASTM D2041.

The asphaltic concrete used, and its placement should meet OPSS 1150 or 1151 requirements. It should be compacted from 92 percent to 97 percent of the MRD (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313.

## 15.3 Additional Comments

Prior to construction, it is recommended that EXP be retained to review the final pavement structure design and drainage plans for the rigid (concrete aprons) and flexible pavement structures (paved areas) to ensure they are consistent with the recommendations of this report.



## 16. Corrosion Potential

Chemical tests limited to pH, sulphate, chloride and resistivity were undertaken on eleven (11) soil samples and three (3) sections of the bedrock cores. A summary of the results is shown in Table XI. The laboratory certificate of analysis is shown in Appendix C.

Table XI: Corrosion Test Results on Soil Samples and Rock Core Sections										
Borehole – Sample/Run No.	Depth (m)	Soil/Bedrock Type	рН	Sulphate (%)	Chloride (%)	Resistivity (ohm-cm)				
Soil Samples										
BH/MW 22-01: SS2	0.8-1.4	Fill	7.84	0.0281	0.0933	362				
BH/MW 22-03: SS3	1.5-2.1	Shaley Glacial Till	7.65	0.0819	0.1320	207				
BH 22-05: SS5	3.0-3.6	Shaley Glacial Till	7.54	0.0515	0.0422	599				
BH 22-07: SS5	3.0-3.6	Shaley Glacial Till	7.55	0.0863	0.1140	265				
BH 22-09: SS3	1.5-2.1	Shaley Glacial Till	7.84	0.0116	0.0518	621				
BH 24-02: SS6	3.8-4.4	Shaley Glacial Till	6.83	0.0353	0.1250	400				
BH 24-04: SS4	2.3-2.9	Shaley Glacial Till	8.38	0.0639	0.2570	167				
BH/MW 24-05: SS3	1.5-2.1	Shaley Glacial Till	8.62	0.0829	0.2350	240				
BH/MW 24-07: SS6	3.8-4.2	Shaley Glacial Till	8.52	0.0527	0.0905	645				
BH 24-09: SS4	2.3-2.9	Shaley Glacial Till	2.9 Shaley Glacial Till	7.80	0.0419	0.0810	415			
BH 24-12: SS6	3.8-4.4	Shaley Glacial Till	7.30	0.0429	0.0642	800				
		Bedro	ck Core Sectio	ns						
BH/MW 24-01: Run 1	3.4-3.5	Shale Bedrock	9.89	0.0055	0.0104	1960				
BH/MW 24-05: Run 2	4.2-4.3	Shale Bedrock	9.95	0.0047	0.0102	2670				
BH/MW 24-07: Run 1	4.2-4.3	Shale Bedrock	9.29	0.0033	0.0087	3370				

The test results indicate the soils and shale bedrock have a negligible sulphate attack on subsurface concrete. The concrete should be designed in accordance with CSA A.23.1-19.

The results from the resistivity tests indicate that the fill and shaley glacial till are very corrosive to moderately corrosive and the shale bedrock is corrosive to mildly corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be taken to protect the buried bare steel from corrosion.



# 17. Tree Planting Restrictions

Since sensitive marine clays are not present at the site, there are no restrictions to tree planting with respect to the City of Ottawa 2005 Clay Soils Policy and 2017 Tree Planting in Sensitive Marine Clay Soils Guidelines.



## 18. General Comments

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for the design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report is not intended to reflect on environmental aspects of the soils and groundwater. Reference should be made to the EXP Phase One and Two Environmental Site Assessments (ESAs) for the environmental aspects of the soils and groundwater.

We trust that the information contained in this report will be satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Sincerely,

Susan M. Potyondy, P.Eng. Senior Geotechnical Engineer Earth & Environment S.M. POTYONDY 37232568

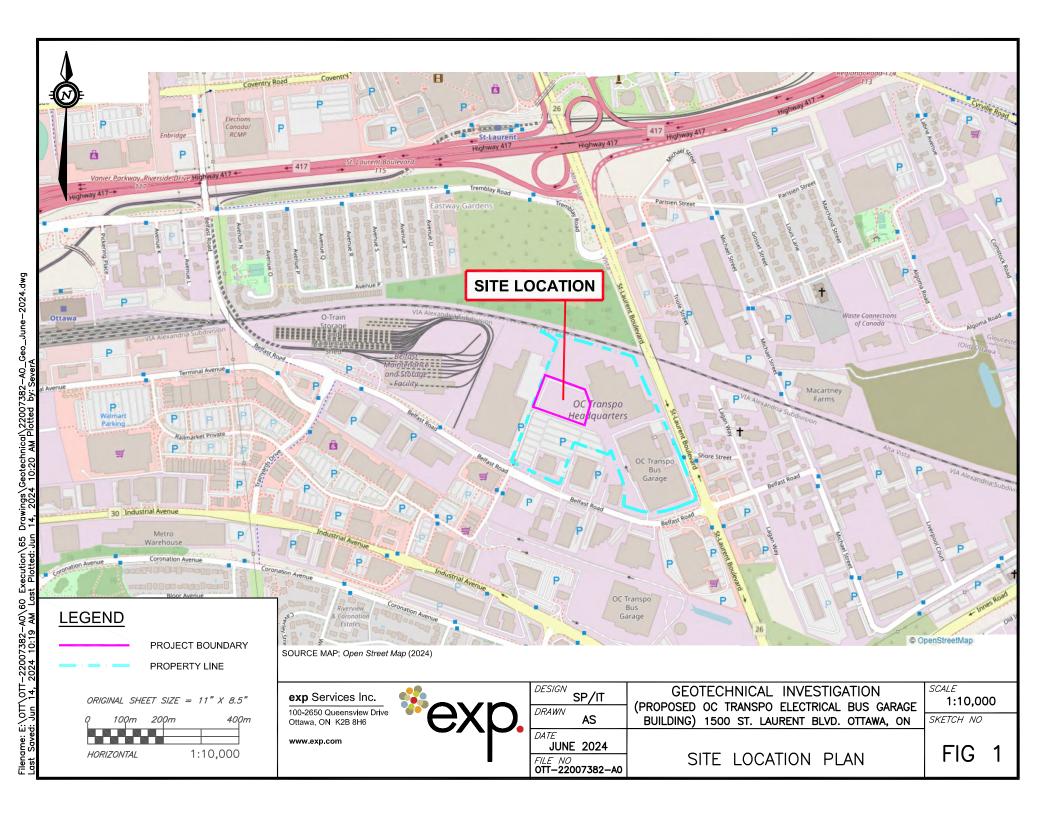
Ismail M. Taki, M.Eng., P.Eng. Senior Manager, Eastern Region Earth & Environment

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# **Figures**





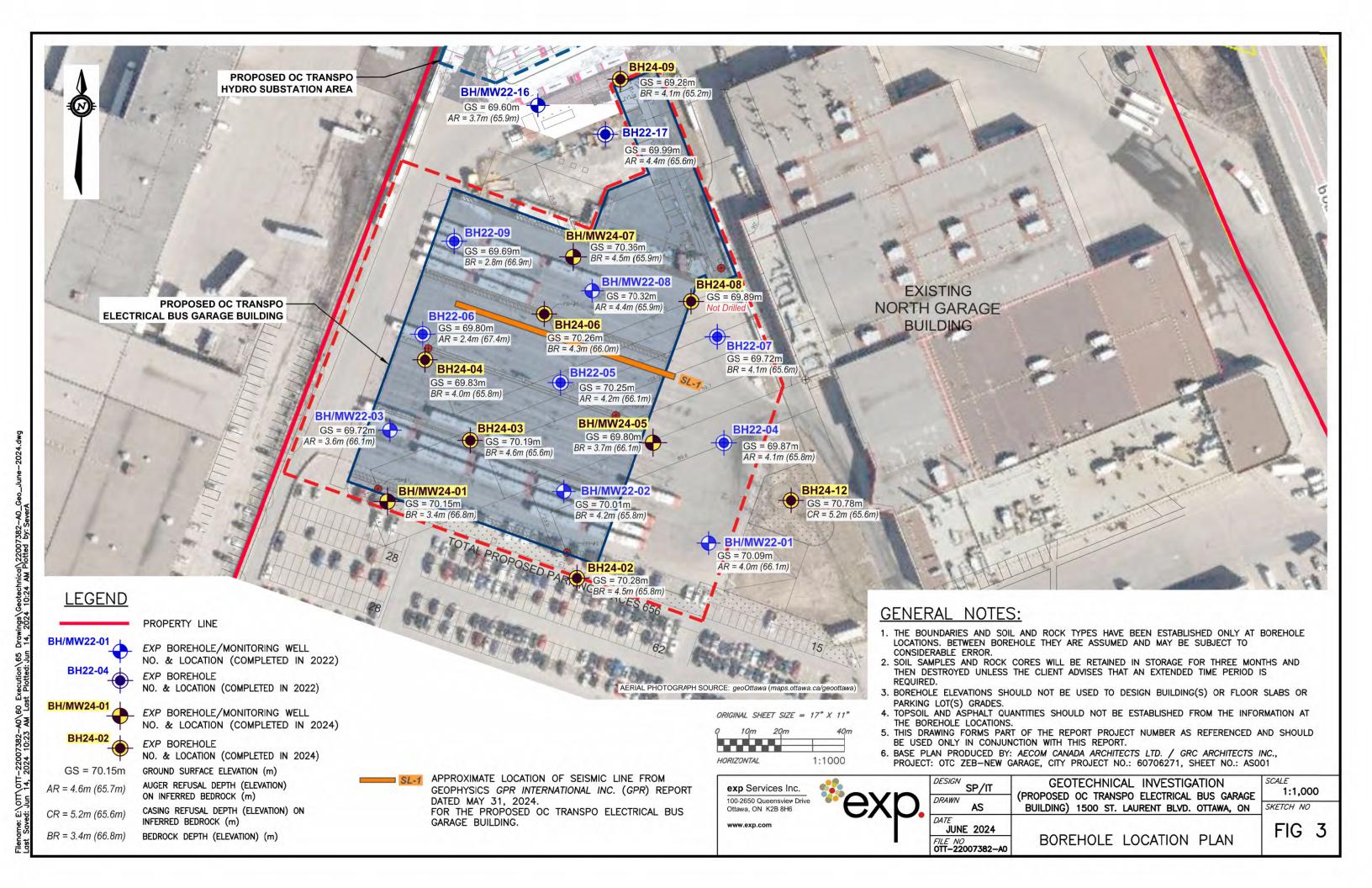
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HYDRO SUB-STATION AREA



## Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by exp Services Inc. also follow the same system. Different classification systems may be used by others one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

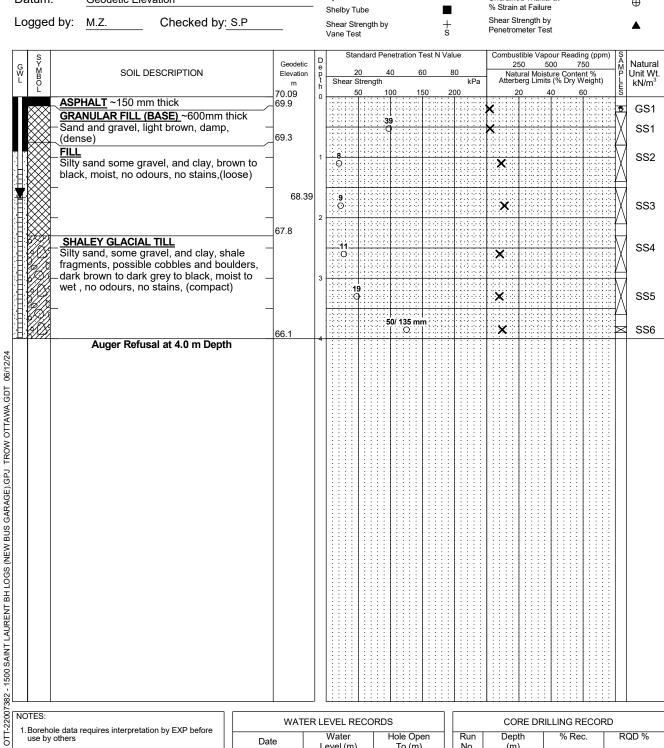


UNIFIED SOIL CLASSIFICATION

- 2. Fill, Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only; and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites, unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.
- 3. Till. The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.



	Log of E	3ore	9	hole <u>MW</u>	<b>22-0</b>	1	0	Y
Project No:	OTT-22007382-A0						C	$\sim$
Project:	Proposed OC Transpo Electrical Bus G	arage				Figure No4		
Location:	1500 St. Laurent Blvd., Ottawa, Ontario					Page. <u>1</u> of <u>1</u>		
Date Drilled:	'Sept 20, 2022			Split Spoon Sample		Combustible Vapour Reading		
Drill Type:	CME-55 Truck Mounted Drill Rig			Auger Sample SPT (N) Value	<b>I</b>	Natural Moisture Content Atterberg Limits		<b>X</b> →
Datum:	Geodetic Elevation			Dynamic Cone Test —	<del>_</del>	Undrained Triaxial at % Strain at Failure	•	Φ
Logged by:	M.Z. Checked by: S.P			Shelby Tube Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test		•
S Y M B C	SOIL DESCRIPTION	Geodetic Elevation m	D e p t b	Standard Penetration Test  20 40 60  Shear Strength	t N Value 80 kPa	Combustible Vapour Reading (ppr 250 500 750 Natural Moisture Content % Atterberg Limits (% Dry Weight)	n) S A M P L	Natura Unit W



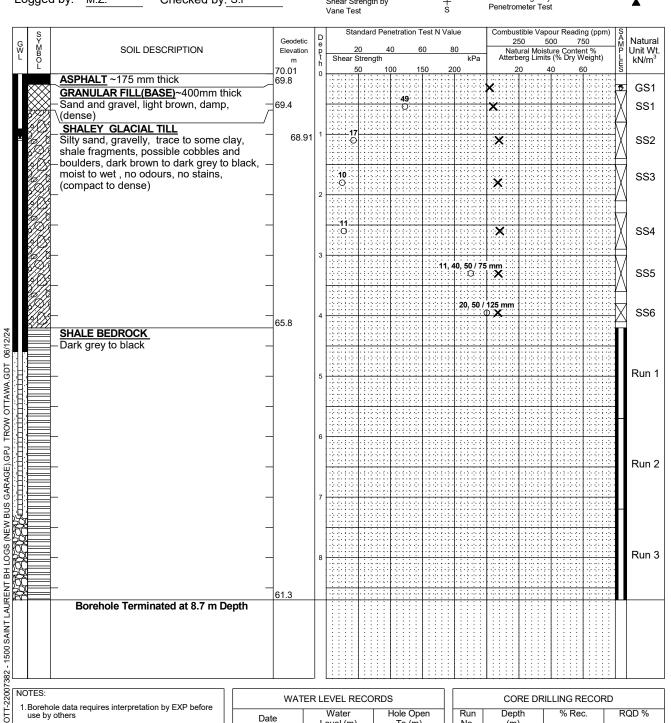
- Borehole data requires interpretation by EXP before use by others
- 2.50 mm monitoring well installed upon completion of drilling.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5. Log to be read with EXP Report OTT-22007382-A0

	WATER LEVEL RECORDS							
	Date	Water Level (m)	Hole Open To (m)					
	Upon Completion		10 (111)					
1"	lovember 14, 202	2 2.2						
	'May 29, 2024	1.7						

CORE DRILLING RECORD						
Run	Depth	% Rec.	RQD %			
No.	(m)					

# Log of Borehole MW22-02

	<b>209 0. 20.</b>		,	<i>y</i> <b>=</b> (5)	
Project No:	OTT-22007382-A0				CA
Project:	Proposed OC Transpo Electrical Bus Garage			Figure No5	
Location:	1500 St. Laurent Blvd., Ottawa, Ontario			Page. <u>1</u> of <u>1</u>	_
Date Drilled:	'Sept 19, 2022	Split Spoon Sample	$\boxtimes$	Combustible Vapour Reading	
Orill Type:	CME-55 Truck Mounted Drill Rig	Auger Sample SPT (N) Value	<b>■</b>	Natural Moisture Content Atterberg Limits	<b>×</b> ⊢—⊙
Datum:	Geodetic Elevation	Dynamic Cone Test —— Shelby Tube	_	Undrained Triaxial at % Strain at Failure	$\oplus$
_ogged by:	M.Z. Checked by: S.P	Shear Strength by	<del>-</del>	Shear Strength by	•



LOG OF

- Borehole data requires interpretation by EXP before use by others
- 2.19 mm standpipe installed upon completion of drilling.
- $3. \mbox{{\it Field}}$  work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

	WATER LEVEL RECORDS						
	Date	Water Level (m)	Hole Open To (m)				
			3.4				
'n	November 14, 202	2 1.7					
	'May 29, 2024	1.1					

CORE DRILLING RECORD								
Run No.	Depth (m)	% Rec.	RQD %					
1	4.2 - 5.7	98	60					
2	5.7 - 7.2	99	99					
3	7.2 - 8.7	98	98					

Project No:	Log of E	3ore	)	hol	e _	MV	<b>V2</b> 2						e	xp
Project:	Proposed OC Transpo Electrical Bus G	arage						F	Figure N		6			
Location:	1500 St. Laurent Blvd., Ottawa, Ontario	)						_	Pag	ge	1_ of _			
Date Drilled: '	Sept 19, 2022			Split Spoo	on Samn	le	$\boxtimes$		Combust	ible Vand	our Readir	na		П
	CME-55 Truck Mounted Drill Rig			Auger Sa	mple				Natural N	Noisture (		.g L		×
Datum: 0	Geodetic Elevation			Dynamic	Cone Te	st			Undraine	d Triaxia		ľ		Ф
Logged by: N	M.Z. Checked by: S.P	_		Shelby Tu Shear Str Vane Tes	ength by	,	+ s		% Strain Shear St Penetron	rength by	/			<b>A</b>
G Y M B O L	SOIL DESCRIPTION	Geodetic Elevation m	D e p t h	1	0 Strength	40 (		ue 80 kPa	25	ural Moist erg Limits	our Readir 00 75 ure Conte s (% Dry W	50 nt % /eight)	SAMPLES	Natural Unit Wt. kN/m³
	ALT ~175 mm thick	69.72 69.5	0				30 2		×				<u>.</u>	GS1
	IULAR FILL (BASE) ~500mm thick and gravel, light brown, damp, —	69.0		33.13.	<b>3€</b>				×				X	SS1
SHALEY GLACIAL TILL Silty sand, gravelly, trace clay, possible cobbles and boulders, dark brown to dark grey to black, moist, no odours, no stains, ( loose to dense)	68.82	1	<b>9</b> O					×					SS2	
		2	10 O			10 0 0 0		×				X	SS3	
	-	_		-2 (-1 -2 -		48 ①			×					SS4
	_		3			50 / 135 m	m: :::::::::::::::::::::::::::::::::::		×				:/\ ::\	SS5
	Auger Refusal at 3.6 m Depth	66.1												

LOG OF BOREHOLE OTT-22007382 - 1500 SAINT LAURENT BH LOGS (NEW BUS GARAGE).GPJ TROW OTTAWA.GDT 06/12/24

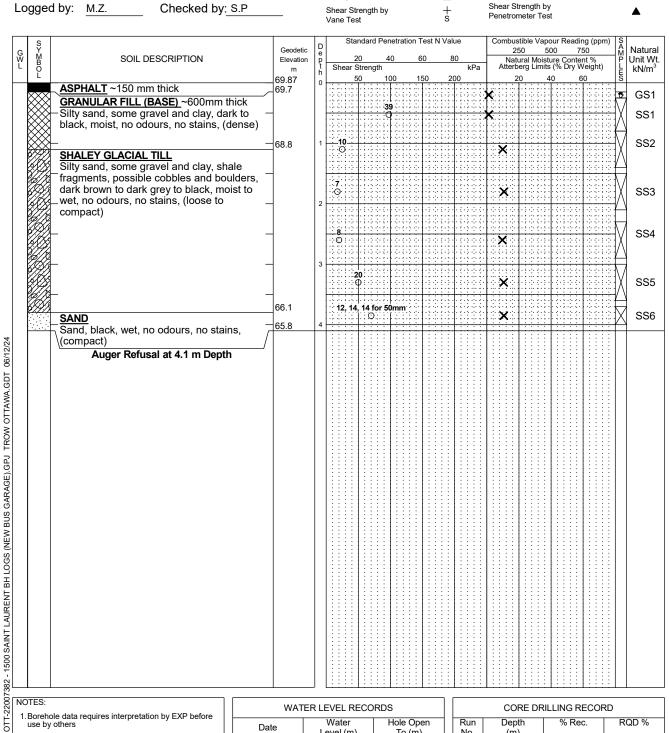
- Borehole data requires interpretation by EXP before use by others
- 2.50 mm monitoring well installed upon completion of drilling.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

	WATER LEVEL RECORDS								
	Date	Water Level (m)	Hole Open To (m)						
	Upon Completion	dry	no cave						
1"	lovember 14, 202	2 1.4							
	'May 29, 2024	0.9							

CORE DRILLING RECORD							
Run No.	Depth	% Rec.	RQD %				
INO.	(111)						

## DU2204

	Log of Bore	ehole BH2	22-0	4	eyr	7
Project No:	OTT-22007382-A0				CAL	_
Project:	Proposed OC Transpo Electrical Bus Garage			Figure No7_ Page. 1 of 1		
Location:	1500 St. Laurent Blvd., Ottawa, Ontario			rage. <u>1</u> 01 <u>1</u>	_	
Date Drilled:	'Sept 20, 2022	Split Spoon Sample	$\boxtimes$	Combustible Vapour Reading		
Orill Type:	CME-55 Truck Mounted Drill Rig	Auger Sample SPT (N) Value	<b>Ⅲ</b> ○	Natural Moisture Content Atterberg Limits	× ⊷	
Datum:	Geodetic Elevation	Dynamic Cone Test — Shelby Tube	_	Undrained Triaxial at % Strain at Failure	$\oplus$	
_ogged by:	M.Z. Checked by: S.P	Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test	<b>A</b>	
		Standard Penetration Test	N Value	Combustible Vapour Reading (pr	pm) S	$\neg$



LOG OF 1

- Borehole data requires interpretation by EXP before use by others
- 2. Borehole backfilled upon completion.
- $3. \mbox{{\it Field}}$  work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

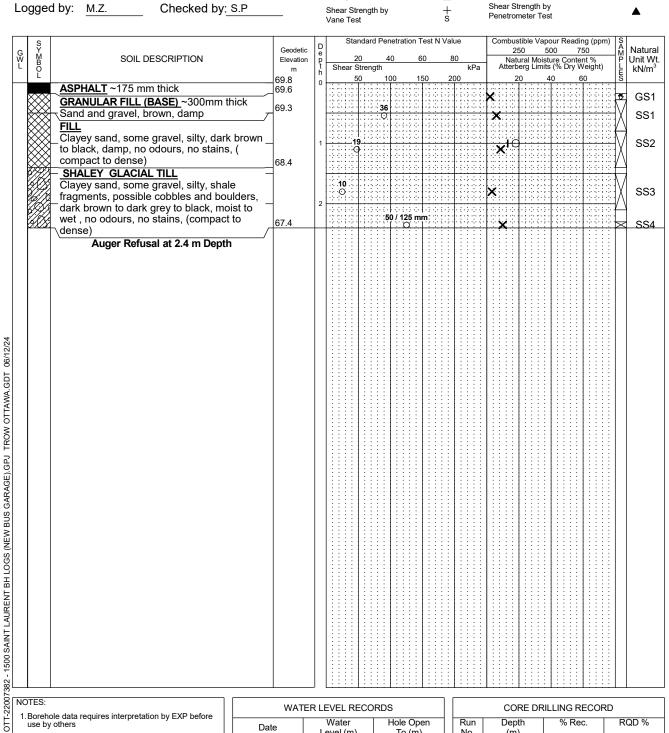
WATER LEVEL RECORDS							
Date	Water Level (m)	Hole Open To (m)					
Upon Completion	2.1	3.0					

CORE DRILLING RECORD						
Run No.	Depth	% Rec.	RQD %			
INO.	(111)					

# Log of Borehole BH22-05

	OTT-22007382-A0												Fig	- jure l	No.			8			_	′′
Project:	Proposed OC Transpo Electrical Bus G	Sarage										_	3				1		- 1			
ocation:	1500 St. Laurent Blvd., Ottawa, Ontario	)										_			5							
ate Drilled:	'Sept 19, 2022		-		t Spo			e						ombus					ing			
rill Type:	CME-55 Truck Mounted Drill Rig			_	er Sa (N)									latural .tterber			Cont	ent		ŀ		× ⊸
atum:	Geodetic Elevation			-	amic Iby Ti		e Te	st			_			Indrain 6 Strair								$\oplus$
ogged by:	M.Z. Checked by: S.P			She	ar Sti e Tes	reng	th by				+ s			hear S enetro								•
S Y M B O O	SOIL DESCRIPTION	Geodetic Elevation m	D e p t h		2 near S	20 Stren	gth	10	6		80	) kPa	$\bot$	Na Atterl	tural berg	Moist Limit	00 ture ( s (%	7 Conte Dry V	'50 ent % Veig	5	SAMPLIES	Nat Unit
	HALT ~150 mm thick	70.25 70.1	0			50 	1	00	15	50	20	0	×		20	::::	40 		60			G
	NULAR FILL (BASE) ~300mm thick and gravel, brown, damp (dense)	69.8						5	0				_ x	<b>.</b>	1:::						$\frac{1}{2}$	s
	EY GLACIAL TILL sand, some gravel, trace clay, shale					22															$\left\langle \cdot \right\rangle$	
fragm	nents, possible cobbles and boulders, brown to dark grey to black, moist to		1			Ó								×							<u> </u>	s
	no odours, no stains, (compact to very-	-		333	11	(+ i + ) (+ i + ) (+ i + )	- (- (- (- (- (- (- (- (- (- (- (- (- (-		3 (1) 3 (1) 3 (1)	-2-0-1	::::	· ( · ) · ( ·			1::::	1- (1-) 1- (1-) 1- (1-)		100		(+1+0 (+1+0 (+1+0	7	
	-		2	10.0	0		4. i.		.; .; . .; .; .					×						(		S
					17																	S
	_									-3-0-				×					12.	( · 1 · i	<u> </u>	٦
	-		3		14		:::::								1:::						1	
	-			100	O		::::::::::::::::::::::::::::::::::::::							×			#					S
	_		1						53 O					<b>V</b>								s
	Auger Refusal at 4.2 m Depth	66.1	4				<del></del>		<del>0.</del>					×							1	3
	•																					
OTES:	equires interpretation by EXP before	WATER	R L	EVE	LR	ECC	RD	s			 ] [			CC	RE	DRII	LLIN	IG R	EC	ORD		
use by others	Da		L	Wa eve	l (m)				(m)	en	] [	Run No.		Dep (m			9	6 Re	C.		R	QD
3. Field work super	lled upon completion.  Tyised by an EXP representative.  Typon Col  Tyised by an EXP representative.  Typon Col  Typon Co	mpletion		dr	у			2	2.7													

	Log of B	sore	е	noie RH	<b>ZZ-(</b>	Jb 🔭		X
Project No:	OTT-22007382-A0						_	^
Project:	Proposed OC Transpo Electrical Bus Gar	age				Figure No. 9		
Location:	1500 St. Laurent Blvd., Ottawa, Ontario					Page. <u>1</u> of <u>1</u>		
Date Drilled:	'Sept 19, 2022			Split Spoon Sample		Combustible Vapour Reading		
Orill Type:	CME-55 Truck Mounted Drill Rig			Auger Sample		Natural Moisture Content		×
Datum:	Geodetic Elevation			SPT (N) Value  Dynamic Cone Test  Shelby Tube	<u> </u>	Atterberg Limits Undrained Triaxial at % Strain at Failure		<b>⊕</b>
_ogged by:	M.Z. Checked by: S.P	-		Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test		•
S G W M		Geodetic	De	Standard Penetration Te		Combustible Vapour Reading (ppm) 250 500 750	S A M	Natura



LOG OF BOREHOLE

- Borehole data requires interpretation by EXP before use by others
- 2. Borehole backfilled upon completion.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

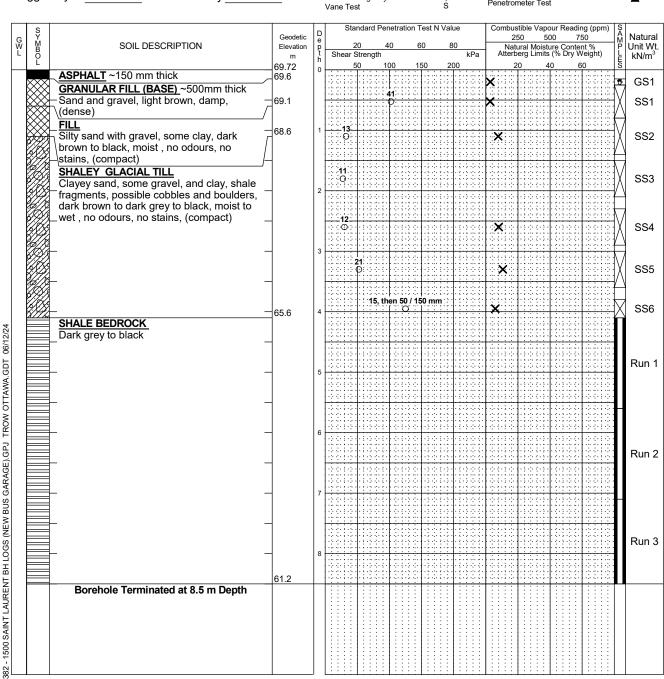
WAT	WATER LEVEL RECORDS								
Date	Water Level (m)	Hole Open To (m)							
Upon Completion	dry	no cave							

	CORE DRILLING RECORD						
Run	Depth	% Rec.	RQD %				
No.	(m)						

....

# Log of Borehole BH22-07

Project No: OTT-22007382-A0 Figure No. Project: Proposed OC Transpo Electrical Bus Garage Page. 1 of 1 Location: 1500 St. Laurent Blvd., Ottawa, Ontario Date Drilled: 'Sept 20, 2022 Split Spoon Sample  $\boxtimes$ Combustible Vapour Reading X Auger Sample Natural Moisture Content Drill Type: CME-55 Truck Mounted Drill Rig SPT (N) Value 0 0 Atterberg Limits Dynamic Cone Test Datum: Undrained Triaxial at Geodetic Elevation  $\oplus$ % Strain at Failure Shelby Tube Checked by: S.P Shear Strength by Logged by: M.Z. Shear Strength by Penetrometer Test



### NOTES:

- Borehole data requires interpretation by EXP before use by others
- use by officis
- $2. \\ Borehole\ backfilled\ upon\ completion.$
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

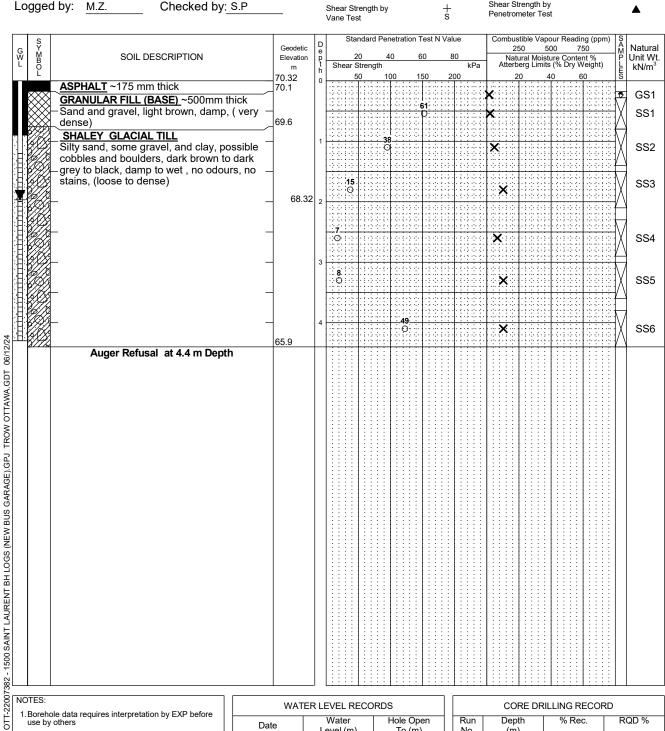
3. Field work supervised by an EXP representative.

Date Water Level (m)	11 1 0
	Hole Open To (m)
	3.5

	CORE DRILLING RECORD						
Run	Depth	% Rec.	RQD %				
No.	(m)						
1	4.1 - 5.6	85	55				
2	5.6 - 7.1	99	86				
3	7.1 - 8.5	98	77				

# Log of Borehole MW22-08

	Log of Doro	11010 11111		<u>,                                    </u>	$\leftarrow x$
Project No:	OTT-22007382-A0			Figure No. 11	CA
Project:	Proposed OC Transpo Electrical Bus Garage				
Location:	1500 St. Laurent Blvd., Ottawa, Ontario			Page. <u>1</u> of <u>1</u>	_
Date Drilled:	'Sept 20, 2022	Split Spoon Sample		Combustible Vapour Reading	
Drill Type:	CME-55 Truck Mounted Drill Rig	Auger Sample SPT (N) Value	<b>Ⅲ</b> ○	Natural Moisture Content Atterberg Limits	<b>×</b> ⊢—⊙
Datum:	Geodetic Elevation	Dynamic Cone Test  Shelby Tube	_	Undrained Triaxial at % Strain at Failure	$\oplus$
Logged by:	M.Z. Checked by: S.P	Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test	<b>A</b>



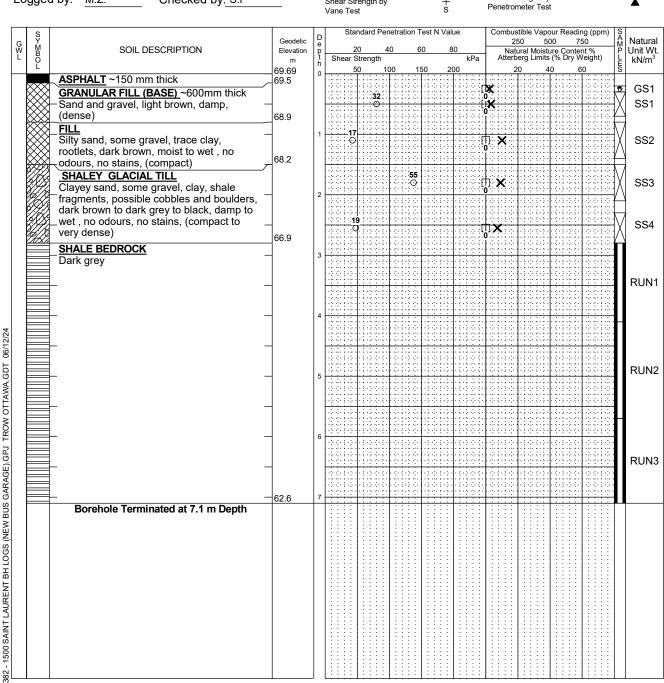
- Borehole data requires interpretation by EXP before use by others
- 2.50 mm monitoring well installed upon completion of drilling.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5. Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS								
Date	Water Level (m)	Hole Open To (m)						
Upon Completion	dry	no cave						
'May 29, 2024	2.0							

CORE DRILLING RECORD						
Run No.	Depth (m)	% Rec.	RQD %			
	<u>,,</u>					

# Log of Borehole BH22-09

Project No: OTT-22007382-A0 Figure No. Project: Proposed OC Transpo Electrical Bus Garage Page. 1 of 1 Location: 1500 St. Laurent Blvd., Ottawa, Ontario Date Drilled: 'Sept 20, 2022 Split Spoon Sample  $\boxtimes$ Combustible Vapour Reading X Auger Sample Natural Moisture Content Drill Type: CME-55 Truck Mounted Drill Rig SPT (N) Value 0 0 Atterberg Limits Dynamic Cone Test Datum: Undrained Triaxial at Geodetic Elevation  $\oplus$ % Strain at Failure Shelby Tube Checked by: S.P Shear Strength by Logged by: M.Z. Shear Strength by



### NOTES:

- Borehole data requires interpretation by EXP before use by others
- 2. Borehole backfilled upon completion.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS							
Date	Water Level (m)	Hole Open To (m)					
Upon Completion	dry	2.4					

CORE DRILLING RECORD						
Run No.	Depth (m)	% Rec.	RQD %			
1	2.8 - 4.1	98	68			
2	4.1 - 5.7	99	82			
3	5.7 - 7.1	100	79			

# Log of Borehole MW22-16

Project No:	Log of E	3ore	9	hole	<u> </u>	<u> MV</u>	<u>V2</u> 2		<b>6</b> Figure N	lo.	13		е	xp
Project:	Proposed OC Transpo Electrical Bus G	arage						'	-	_	1 of	_		
Location:	1500 St. Laurent Blvd., Ottawa, Ontario	)						_	Га	ye	01			
Date Drilled:	Nov. 17, 2022			Split Spoon S	ample				Combus	tible Vap	our Read	ing		
Drill Type:	CME-55 Truck Mounted Drill Rig			Auger Sample SPT (N) Valu					Natural I	Moisture	Content	ı	ļ	<b>X</b> ⊕
Datum:	Geodetic Elevation			Dynamic Con					Undraine	ed Triaxia at Failur		•		<b>⊕</b>
Logged by:	M.Z. Checked by: S.P			Shelby Tube Shear Streng Vane Test	th by		+ s		Shear St	trength by	y			<b>A</b>
S Y M B O L	SOIL DESCRIPTION	Geodetic Elevation m	D e p t h	Standar 20 Shear Stren 50	40		0 8	lue 30 kPa 00	2: Nat	50 5 ural Moist	ture Conte s (% Dry \	750 ent %	SAMPLES	Natural Unit Wt. kN/m³
TOP  TOP  FILL Silty including grey  SHA Silty poss to grey	HALT ~180 mm thick  INULAR FILL (BASE) ~1100mm thick sand and gravel, light brown, damp, dours, no stains, ( compact to dense)  SOIL~50mm thick sand, trace clay, with topsoil, isions( black with rootlets), greenish , moist, no odours, no stains, (loose)  LEY GLACIAL TILL sand, some gravel, shale fragments, sible cobbles and boulders, dark brown ey to black, moist, no odours, no is, (compact to dense)  Auger Refusal at 3.7 m Depth	68.4 68.5 68.4 67.3	3 3	220 	35.0	46			X  15 					SS1 SS2 SS3 SS4 SS5
use by others	requires interpretation by EXP before  Date the properties of the	te 24, 2022		EVEL RECO Water evel (m) 1.4 1.1		ole Ope To (m)	en	Run No.	CO Dep (m	th	LLING F % Re			QD %

LOG OF BOREHOLE OTT-22007382 - 1500 SAINT LAURENT BH LOGS (HYDRO SUBSTATION) GPJ TROW OTTAWA,GDT 08/1/2/24

4. See Notes on Sample Descriptions

5.Log to be read with EXP Report OTT-22007382-A0

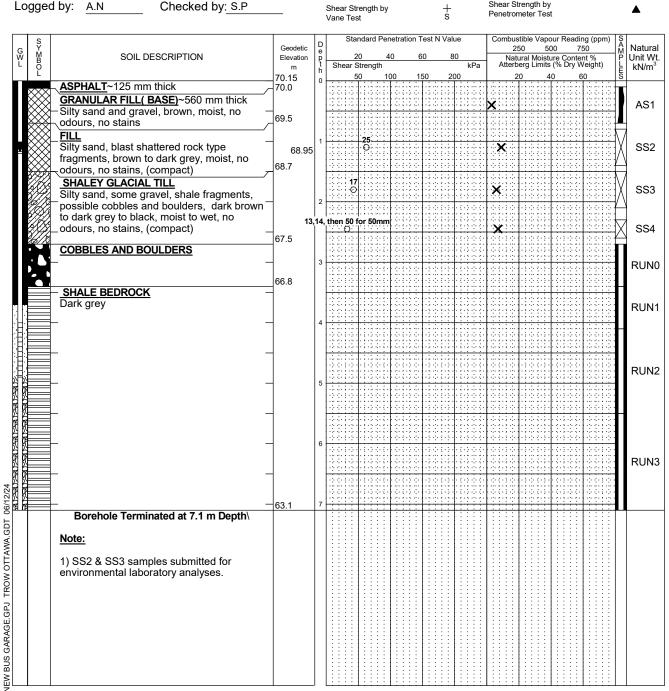
Droject No:		of Bo	re	ho	le	_	Bŀ	122	<u>2-1</u>	<u>7</u>				e	X
Project No:	OTT-22007382-A0	ool Puo Carago							ı	Figure N	۱o	14			
Project: Location:	Proposed OC Transpo Electric									Pag	ge	of	_1_		
	1500 St. Laurent Blvd., Ottawa	a, Ontano													
	'Nov. 17, 2022		_	Split Spo Auger Sa		mple		⊠ II				pour Readi Content	ing		□ <b>X</b>
Drill Type:	CME-55 Truck Mounted Drill R	Rig	_	SPT (N)	Value	T		0	-	Atterber					<b>→</b>
Datum:	Geodetic Elevation		_	Dynamic Shelby T		rest			I	Undraine % Strain	at Failu	ire			$\oplus$
Logged by:	M.Z. Checked by:	S.P		Shear St Vane Tes	st			+ s		Shear S Penetro	meter Te	est			<b>^</b>
GWL SYMBO	SOIL DESCRIPTION	Geodetic Elevation m		Shear S	20 Strengt	40 th	(		80 kPa	2 Nat Atterb	50 cural Moi perg Lim	pour Readi 500 7 sture Conte its (% Dry V	50	∐ÂI	Natural Unit Wt. kN/m³
Sanc	NULAR FILL~790mm thick I and gravel, light brown, moist, irs, no stains, (dense)	no69.99	0	5	30 O	100	) 1	50 2	200	TX 10	20	40 (	60		SS1
FILL Silty	sand, some gravel, trace clay, o		1	10						<b>N</b>					SS2
	n to black, moist to wet, no odo s, (loose to compact)	urs, no		4						10				M	SS3
			2	5				1-2-0-0-0 1-2-0-0-0 1-2-0-0-0 1-2-0-0-0		10			+2 (+1 +   +2 (+1 +   +2 (+1 +   +2 (+1 +	-//	333
SHA	ILEY GLACIAL TILL	67.0	3	Ŏ: ::						↑ ×			-5 (-1)		SS4
Silty poss to gre	sand, gravel, some shale fragn ible cobbles and boulders, darl ey to black, moist, no odours, no	k brown —		11 O						∏ <b>×</b>				$\bigvee$	SS5
stain	s, (compact)	65.6	4	12 						∏ X 10					SS6
<i>8747</i>	Auger Refusal at 4.4 m Depth														
NOTES:	in a suite of interpretation in EVD I. C	WATE	ER L	EVEL RI	ECOF	RDS				СО	RE DR	ILLING R	ECOR		
use by others	requires interpretation by EXP before	Date	L	Water evel (m)	)		ole Op To (m)		Run No.	Dep (m		% Re	C.	R	QD %
	illed upon completion. ervised by an EXP representative.														
4. See Notes on S	Sample Descriptions														

LOG OF BOREHOLE OTT-22007382 - 1500 SAINT LAURENT BH LOGS (HYDRO SUBSTATION).GPJ TROW OTTAWA.GDT 06/12/24

5.Log to be read with EXP Report OTT-22007382-A0

# Log of Borehole MW24-01

Project No:	OTT-22007382-A0	<u> </u>		Figure No. 15	C	^
Project:	Proposed OC Transpo Electrical Bus Garage			Page. 1 of 1		
_ocation:	1500 St. Laurent Blvd, Ottawa, Ontario			rage. <u>1</u> 01 <u>1</u>	-	
Date Drilled:	'May 10, 2024	Split Spoon Sample		Combustible Vapour Reading		
Orill Type:	CME 75 Track-Mounted Drill Rig	Auger Sample SPT (N) Value	<b>Ⅲ</b> ○	Natural Moisture Content Atterberg Limits	<u> </u>	× →
Datum:	Geodetic Elevation	Dynamic Cone Test Shelby Tube	_	Undrained Triaxial at % Strain at Failure		$\oplus$
odded by:	A N Chacked by: S P	Observation by	Ŧ	Shear Strength by		



### NOTES:

BH LOGS-I

LOG OF

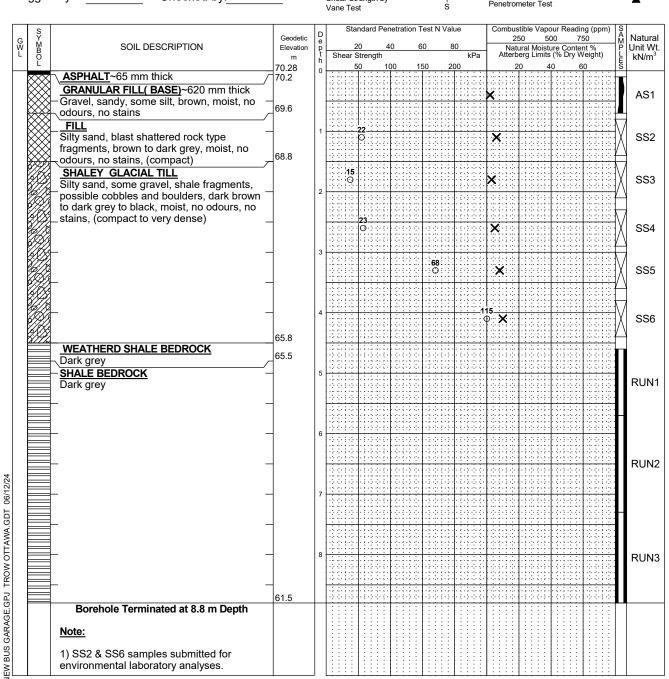
- Borehole data requires interpretation by EXP before use by others
- 2.A 32 mm diameter monitoring well installed as shown.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS						
Date	Water Level (m)	Hole Open To (m)				
'May 30, 2024	1.2					

CORE DRILLING RECORD						
Run No.	Depth (m)	% Rec.	RQD %			
1	3.4 - 4.1	100	67			
2	4.1 - 5.5	100	85			
3	5.5 - 7.1	100	100			

# Log of Borehole BH24-02

Project No:	OTT-22007382-A0			16	CA
Project:	Proposed OC Transpo Electrical Bus Garage			Figure No16	
Location:	1500 St. Laurent Blvd, Ottawa, Ontario			Page. <u>1</u> of <u>1</u>	-
Date Drilled:	'May 8, 2024	Split Spoon Sample	$\boxtimes$	Combustible Vapour Reading	
Drill Type:	CME 75 Track-Mounted Drill Rig	Auger Sample		Natural Moisture Content	×
	ONE TO TRUCK MOUNTOU DIM TRIS	SPT (N) Value	0	Atterberg Limits	$\longrightarrow$
Datum:	Geodetic Elevation	Dynamic Cone Test —	_	Undrained Triaxial at % Strain at Failure	$\oplus$
Logged by:	A.N Checked by: S.P	Shelby Tube Shear Strength by	+	Shear Strength by	<b>A</b>



### NOTES:

BH LOGS-

LOG OF

Borehole data requires interpretation by EXP before use by others

2. Borehole backfilled upon completion of drilling.

3. Field work supervised by an EXP representative.

4. See Notes on Sample Descriptions

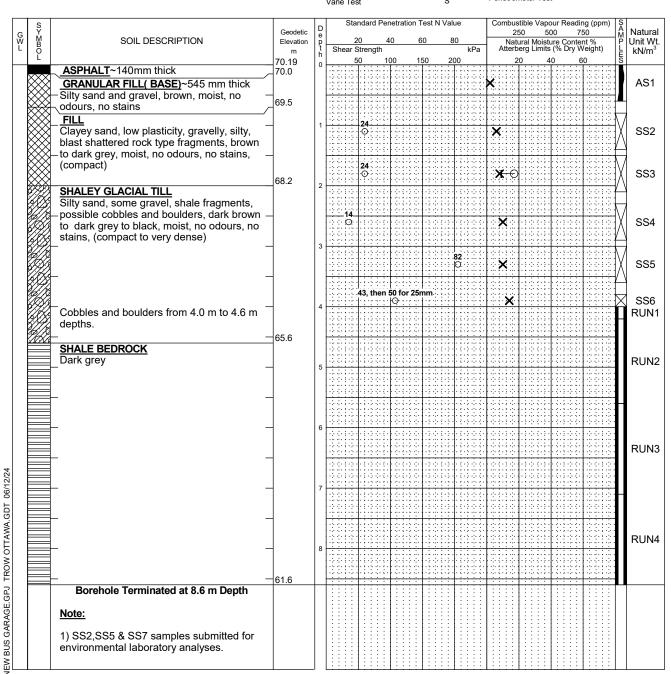
5. Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS							
Date	Water Level (m)	Hole Open To (m)					

CORE DRILLING RECORD							
Run No.	Depth (m)	% Rec.	RQD %				
1	4.6 - 5.7	97	72				
2	5.7 - 7.3	90	83				
3	7.3 - 8.8	100	67				

# Log of Borehole BH24-03

Project No:	OTT-22007382-A0	<u> </u>		Figure No. 17	CV
Project:	Proposed OC Transpo Electrical Bus Garage				
Location:	1500 St. Laurent Blvd, Ottawa, Ontario			Page. <u>1</u> of <u>1</u>	-
Date Drilled:	May 3, 2024	Split Spoon Sample	$\boxtimes$	Combustible Vapour Reading	
Drill Type:	CME 75 Track-Mounted Drill Rig	Auger Sample SPT (N) Value	<b>Ⅲ</b> ○	Natural Moisture Content Atterberg Limits	<b>×</b> ⊢—⊙
Datum:	Geodetic Elevation	Dynamic Cone Test —— Shelby Tube	_	Undrained Triaxial at % Strain at Failure	$\oplus$
Logged by:	A.N Checked by: S.P	Shear Strength by	+	Shear Strength by	<b>A</b>



BH LOGS-I

LOG OF

Borehole data requires interpretation by EXP before use by others

2. Borehole backfilled upon completion of drilling.

3. Field work supervised by an EXP representative.

4. See Notes on Sample Descriptions

5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS							
Date	Water Level (m)	Hole Open To (m)					

CORE DRILLING RECORD						
Run	Depth	% Rec.	RQD %			
No.	(m)					
1	4 - 4.2	0	0			
2	4.2 - 5.6	100	37			
3	5.6 - 7.1	100	88			
4	7.1 - 8.6	100	100			

Project No:	Log of OTT-22007382-A0	Bor	е	hol	e _	Bŀ	124	-04	<u>4</u>			10.	$\epsilon$	X
Project:	Proposed OC Transpo Electrical Bus G	Sarage						F	igure N		18			
Location:	1500 St. Laurent Blvd, Ottawa, Ontario							_	Paç	ge	1_ of .	_1_		
Date Drilled	: 'May 3, 2024			Split Spoor	n Sample	ż		_	Combus	tible Vand	our Readir	na		
Drill Type:	CME 75 Track-Mounted Drill Rig		-	Auger San	nple				Natural N	Moisture (		.9		×
Datum:	Geodetic Elevation		-	SPT (N) Va		t				ed Triaxia				<del>-</del> О
Logged by:	A.N Checked by: S.P		_	Shelby Tub Shear Stre Vane Test	ngth by		+ s		Shear St	at Failure rength by neter Tes	,			<b>▲</b>
G M M B O	SOIL DESCRIPTION	Geodetic Elevation m	D e p t h		4			0 kPa	2	50 5	our Readir 00 7: ure Conter 6 (% Dry W	50	n) SA N P L	1.81/3
₩ GR	PHALT~130mm thick ANULAR FILL( BASE)~555 mm thick	69.83 -69.7	0	50	10	0 15	50 20	00	<b>X</b>	0 4	0 6	0	S	AS1
no s FILL Silty rock moi: com  SHL Silty cob grey (cor	d and gravel, brown, moist, no odour, tains  sand, some gravel, blast shattered type fragments, brown to dark grey, st, no odours, no stains, (loose to pact)  ALEY GLACIAL TILL sand, some gravel, clayey, possible obles and boulders, dark brown to dark to black, moist, no odour, no stains, npact to dense)  ALE BEDROCK K grey	69.1 67.6 65.8	3 4	11O	26 ⊙ ⊙ 24 ⊕	50 for 2€ ⊙	imm		× × ×					SS2 SS3 SS4 SS5 SS6
	- - -	-62.7	6											RUN2
1) S	3orehole Terminated at 7.1 m Depth  2: S2 & SS5 samples submitted for ronmental laboratory analyses.													

LOG OF BOREHOLE BH LOGS-NEW BUS GARAGE.GPJ TROW OTTAWA.GDT 06/12/24

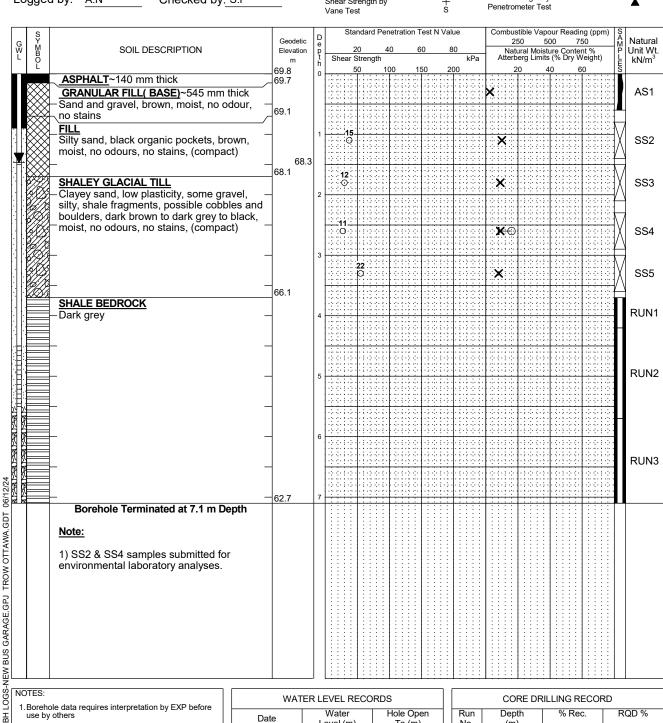
- Borehole data requires interpretation by EXP before use by others
- 2. Borehole backfilled upon completion of drilling.
- $3. \mbox{{\it Field}}$  work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS						
Date	Water Level (m)	Hole Open To (m)				

CORE DRILLING RECORD					
Run No.	Depth (m)	% Rec.	RQD %		
1	4 - 5.5	100	75		
2	5.5 - 7.1	100	77		

# Log of Borehole <u>MW24-05</u>

Project No: OTT-22007382-A0 Figure No. Project: Proposed OC Transpo Electrical Bus Garage Page. 1 of 1 Location: 1500 St. Laurent Blvd, Ottawa, Ontario Date Drilled: 'May 8, 2024 Split Spoon Sample  $\boxtimes$ Combustible Vapour Reading X Auger Sample Natural Moisture Content Drill Type: CME 75 Track-Mounted Drill Rig SPT (N) Value 0 0 Atterberg Limits Dynamic Cone Test Datum: Undrained Triaxial at Geodetic Elevation  $\oplus$ % Strain at Failure Shelby Tube Checked by: S.P Shear Strength by Logged by: A.N Shear Strength by



LOG OF

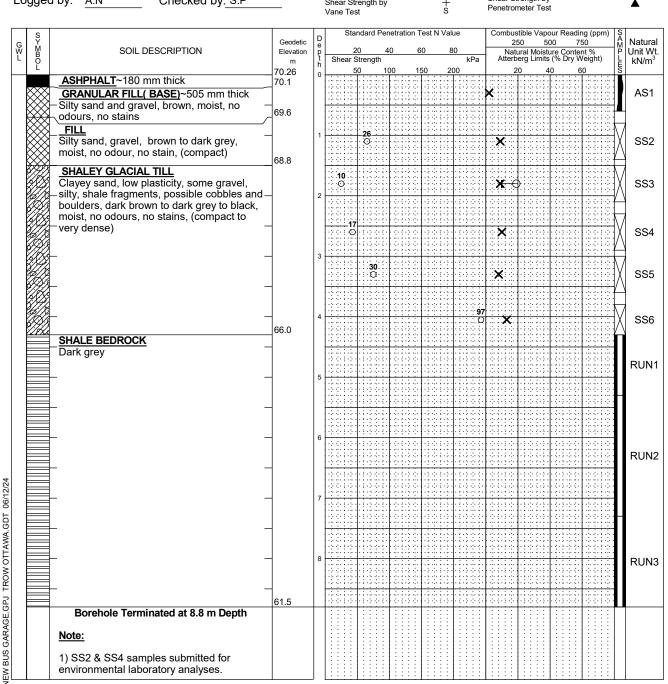
- Borehole data requires interpretation by EXP before use by others
- 2.A 50 mm diameter monitoring well installed as shown.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS						
Date	Water Level (m)	Hole Open To (m)				
'May 30, 2024	1.5					

CORE DRILLING RECORD					
Run No.	Depth (m)	% Rec.	RQD %		
1	3.7 - 4.2	95	84		
2	4.2 - 5.7	88	80		
3	5.7 - 7.1	100	94		

# Log of Borehole BH24-06

	<b></b>			V (70)	
Project No:	OTT-22007382-A0			Figure No. 20	CA
Project:	Proposed OC Transpo Electrical Bus Garage				
Location:	1500 St. Laurent Blvd, Ottawa, Ontario			Page1_ of _1_	
Date Drilled:	'May 7, 2024	Split Spoon Sample	$\boxtimes$	Combustible Vapour Reading	
Orill Type:	CME 75 Track-Mounted Drill Rig	Auger Sample SPT (N) Value	<b>■</b>	Natural Moisture Content Atterberg Limits	<b>×</b> ⊢—⊙
Datum:	Geodetic Elevation	Dynamic Cone Test  Shelby Tube	_	Undrained Triaxial at % Strain at Failure	$\oplus$
_ogged by:	A.N Checked by: S.P	Shear Strength by	<del>-</del> + s	Shear Strength by Penetrometer Test	•



### NOTES

BH LOGS-I

LOG OF

Borehole data requires interpretation by EXP before use by others

2. Borehole backfilled upon completion of drilling.

3. Field work supervised by an EXP representative.

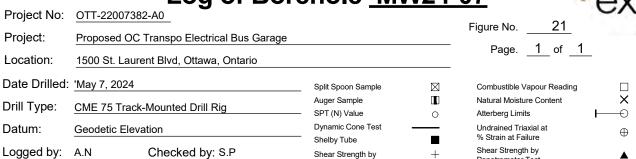
4. See Notes on Sample Descriptions

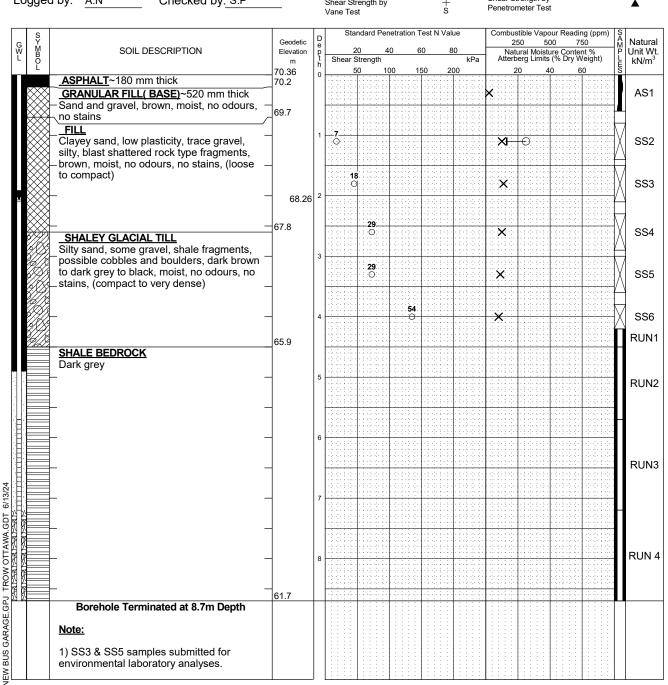
5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS						
Date	Water Level (m)	Hole Open To (m)				

CORE DRILLING RECORD					
Run No.	Depth (m)	% Rec.	RQD %		
1	4.3 - 5.3	84	41		
2	5.3 - 7.3	100	97		
3	7.3 - 8.8	100	91		

# Log of Borehole <u>MW24-07</u>





### NOTES:

BH LOGS-

LOG OF

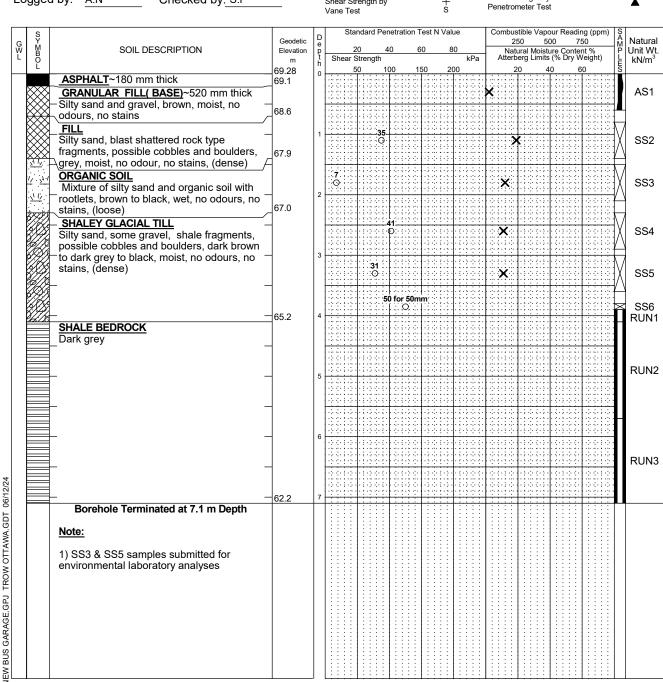
- Borehole data requires interpretation by EXP before use by others
- 2.A 50 mm diameter monitoring well installed as shown.
- 3. Field work supervised by an EXP representative.
- 4. See Notes on Sample Descriptions
- 5.Log to be read with EXP Report OTT-22007382-A0

WATER LEVEL RECORDS					
Date	Water Level (m)	Hole Open To (m)			
'May 30, 2024	2.1				

CORE DRILLING RECORD						
Run	Depth	% Rec.	RQD %			
No.	(m)					
1	4.2 - 4.5	77	0			
2	4.5 - 5.7	100	57			
3	5.7 - 7.2	95	95			
4	7.2 - 8.7	100	92			

# Log of Borehole BH24-09

Project No: OTT-22007382-A0 Figure No. Project: Proposed OC Transpo Electrical Bus Garage Page. 1 of 1 Location: 1500 St. Laurent Blvd, Ottawa, Ontario Date Drilled: 'May 9, 2024 Split Spoon Sample  $\boxtimes$ Combustible Vapour Reading X Auger Sample Natural Moisture Content Drill Type: CME 55 Track-Mounted Drill Rig SPT (N) Value 0 0 Atterberg Limits Dynamic Cone Test Datum: Undrained Triaxial at Geodetic Elevation  $\oplus$ % Strain at Failure Shelby Tube Shear Strength by Logged by: A.N Checked by: S.P. Shear Strength by



BH LOGS-

LOG OF

Borehole data requires interpretation by EXP before use by others

2. Borehole backfilled upon completion of drilling.

3. Field work supervised by an EXP representative.

4. See Notes on Sample Descriptions

5.Log to be read with EXP Report OTT-22007382-A0

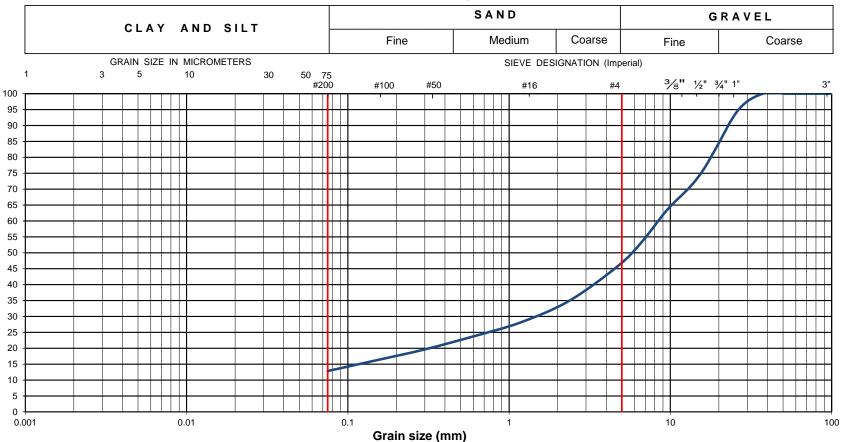
WATER LEVEL RECORDS						
Date	Water Level (m)	Hole Open To (m)				

CORE DRILLING RECORD					
Run	Depth	% Rec.	RQD %		
No.	(m)				
1	3.9 - 4.1	100	0		
2	4.1 - 5.7	100	75		
3	5.7 - 7.1	100	67		

oject:	Proposed OC Transpo Electric	al Bus Garage						Figure No <u>23</u> Page. 1 of 1									
cation:	1500 St. Laurent Blvd, Ottawa	, Ontario								_	1 ago1_01 _1_						
ite Drilled:	'May 10, 2024		Split Spoon Sample						Combustible Vapour Reading								
ill Type:	CME 55 Track-Mounted Drill R	ig	Auger Sample SPT (N) Value						<b>■</b>		Natural I Atterberg		Content		<u> </u>	X ⊸	
ıtum:	Geodetic Elevation		_	Dynamic Shelby T			t	_	_		Undraine % Strain					$\oplus$	
gged by:	A.N Checked by:	S.P		Shear St Vane Te	treng				+ s		Shear Son Penetron					•	
S Y M B O -	SOIL DESCRIPTION	Geodeti Elevatio m		Shear	20 Stren	4 ngth		60	80	kPa	2 Nat Atterb	50 ural Moi perg Lim	pour Rea 500 sture Con its (% Dry	750 ntent % ( Weight)	M	Natura Unit W kN/m <sup>3</sup>	
—— KXXX	SOIL~75 mm thick	70.78 70.7	0		50 20:	10	00 1	50	200	) 		20	40	60	S		
FILL Silty sand, some gravel, blast shatt	_ sand, some gravel, blast shatte	ered -			Φ::						×					AS1	
XXX fragn	type fragments, rootlets, asphal nents,possible cobbles and bou n, moist, no odour, no stain, (loo	lders,	1	8							X					SS2	
comp											<b></b>				1	332	
		7			<b>22</b>							×			$\setminus$	SS3	
<b>XX</b> -		$\dashv$	2	!		2 ( 1 ( 1 ( ) ) 2 ( 1 ( ) ) 3 ( 1 ( ) )				1:2:0:0:0:					<del>                                      </del>		
<b>—</b>		-		1	8						×					SS4	
NA PUA	LY GLACIAL TILL	67.8	3												<u> </u>		
Claye	ey sand, low plasticity, gravelly,			. <b>5</b>							<b>X</b> (	<b>}</b>				SS5	
bould	e fragments, possible cobbles and ders, moist, no odours, no stains of the compact.)														· / /		
(IOUS	e to compact)	-	4	<b>5</b> ⊙						1.2.2.2.2.	X					SS6	
		_													<u>::: /</u>		
			5		<b>24</b> ①	3 (* 1 · 1 · 1 · 1 · 1 · 1 · 1 · 1 · 1 · 1										SS7	
<i>68</i> 88	Casing Refusal at 5.2 m Depti	65.6 1		1.3.3.3.3											:: / \ : :		
Note	<u>:</u>																
	63 & SS7 samples submitted for	-															
envir	onmental laboratory analyses.																
TES: Borehole data r	equires interpretation by EXP before	WAT	ER L	EVEL R	ECC								RILLING				
use by others		Date	ı	Water _evel (m	)	H	Hole Op To (m			Run No.	Dep (m		% Rec.		R	QD %	
use by others Borehole backfi	lled upon completion of drilling.	Date	L		)	ŀ							% R	Rec.	R	QI	

# Grain-Size Distribution Curve Method of Test For Sieve Analysis of Aggregate ASTM C-136

100-2650 Queensview Drive Ottawa, ON K2B 8H6

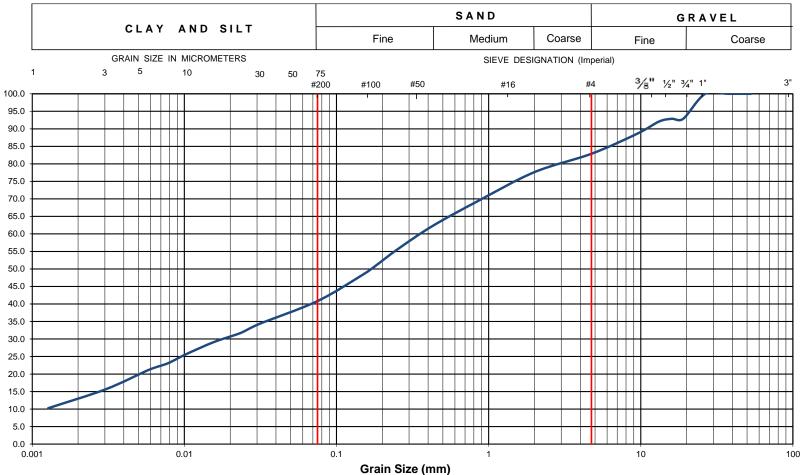


EXP Project No.:	OTT-22007382-A0	Project Name :							
Client :	City of Ottawa	Project Location	roject Location: 1500 St. Laurent Blvd., Ottawa, ON						
Date Sampled :	May 7, 2024	Borehole No:		BH24-02	Sample	Depth (m) :	0.1-0.6		
Sample Composition :		Gravel (%)	54	Sand (%)	33	Silt & Clay (%)	13	Figure :	24
Sample Description :									



# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6

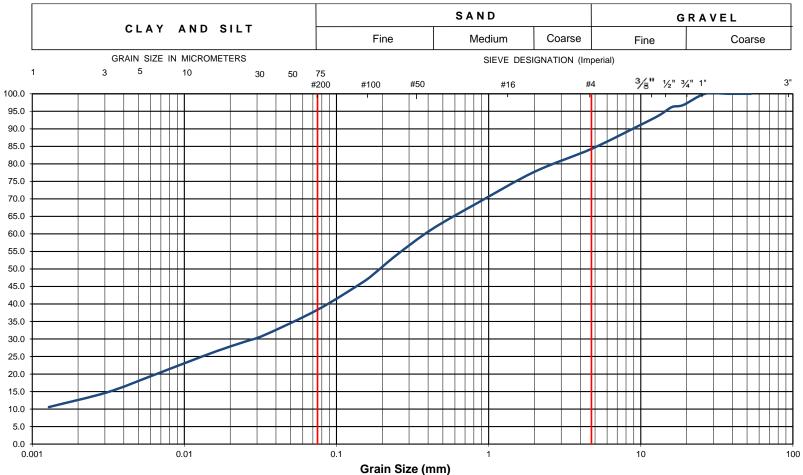


EXP Project No.:	OTT-22007382-A0	Project Name :	Project Name : Proposed OC Transpo Electrical Bus Garage										
Client :	City of Ottawa	Project Location	Project Location : 1500 St. Laurent Blvd., Ottawa, ON										
Date Sampled :	September 20, 2022	Borehole No:		22-01	Sample No.: SS3				Depth (m):	1.5-2.1			
Sample Description :		% Silt and Clay	41	% Sand	42	% Gravel		17	Figure :	25			
Sample Description : FILL: Silty Sand (SM) - Some Gravel and Clay									rigule :	25			



# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6

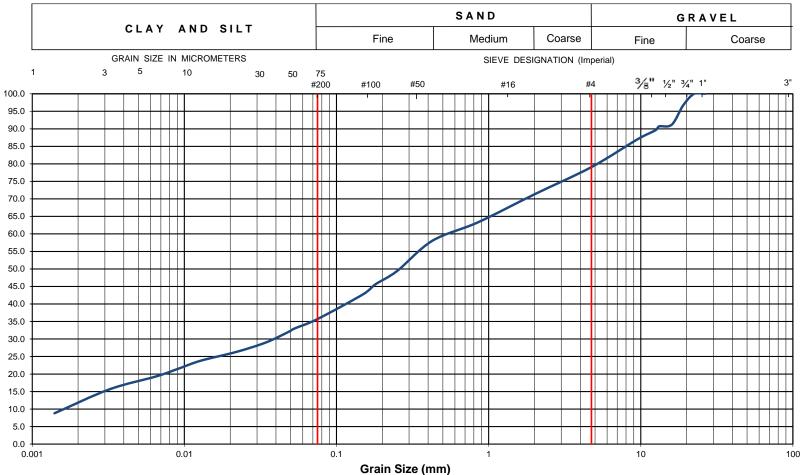


EXP Project No.:	OTT-22007382-A0	Project Name :	Project Name : Proposed OC Transpo Electrical Bus Garage									
Client :	City of Ottawa	Project Location	ject Location: 1500 St. Laurent Blvd., Ottawa, ON									
Date Sampled :	September 19, 2022	Borehole No:		22-06	Sample No.: SS2				Depth (m):	0.8-1.4		
Sample Description :		% Silt and Clay	38	% Sand	46	% Gravel		16	Figure :	26		
Sample Description : FILL: Clayey Sand (SC) - Low Plasticity, Some Gravel, Silty									rigure .	20		



# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6

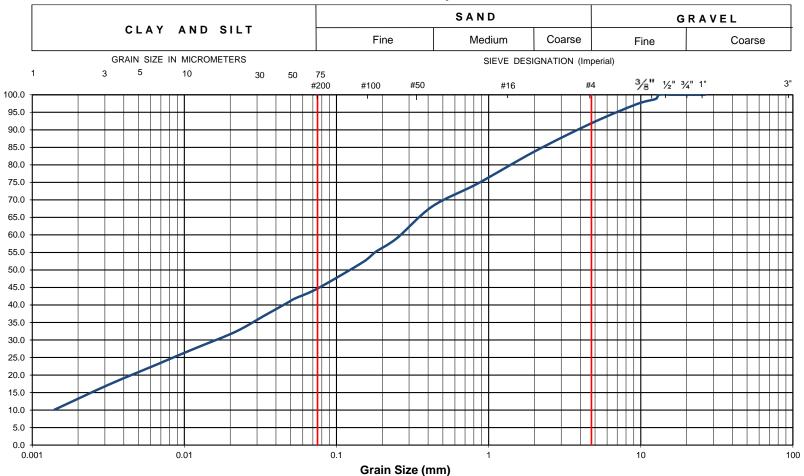


EXP Project No.:	OTT-22007382-A0	Project Name : Proposed OC Transpo Electrical Bus Garage								
Client :	City of Ottawa	Project Location	roject Location: 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	May 3, 2024	Borehole No:		24-03	Sample No.: SS3				Depth (m) :	1.5-2.1
Sample Description :		% Silt and Clay	36	% Sand	43	% Gravel		21	Figure :	27
Sample Description : FILL: Clayey Sand (SC) - Low Plasticity, Gravelly, Silty									rigure .	21

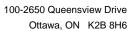


# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6

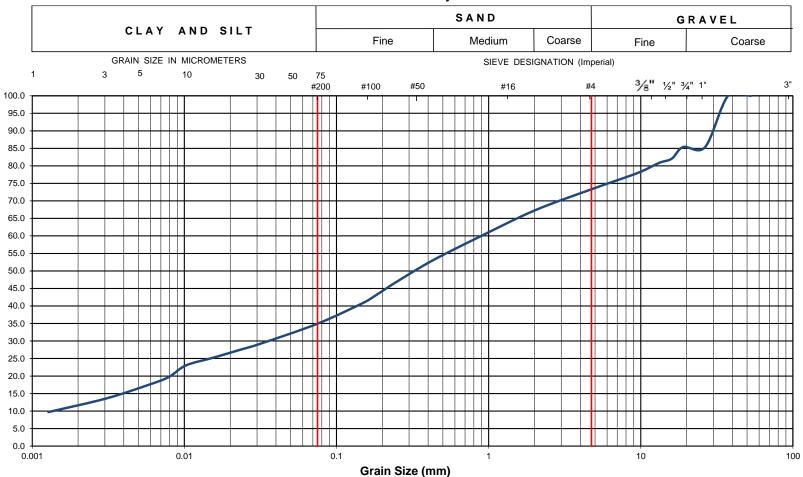


EXP Project No.:	OTT-22007382-A0	Project Name :	Project Name : Proposed OC Transpo Electrical Bus Garage									
Client :	City of Ottawa	Project Location	:	1500 St. Laurent Blvd., Ottawa, ON								
Date Sampled :	May 7, 2024	Borehole No:		24-07	Sam	ple No.:		Depth (m) :	0.8 - 1.4			
Sample Description :		% Silt and Clay	45	% Sand	47	% Gravel		8	Figure :	28		
Sample Description : FILL: Clayey Sand (SC) - Low Plasticity, Silty, Trace Gravel										20		





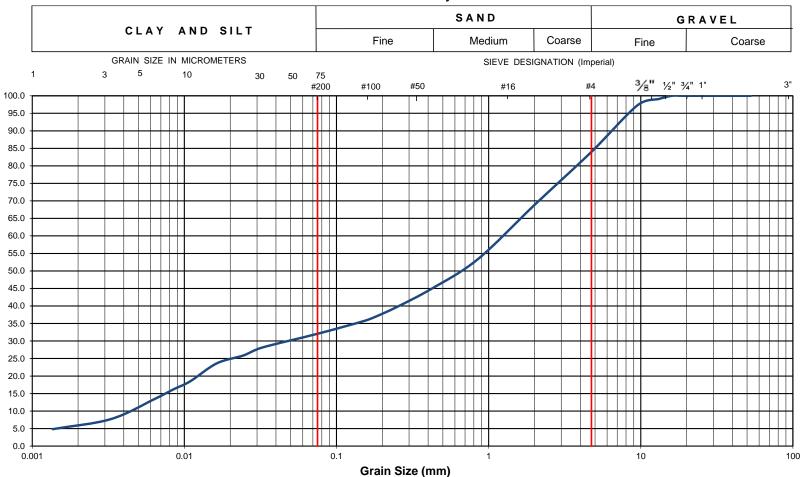
# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422



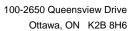
EXP Project No.:	OTT-22007382-A0	Project Name : Proposed OC Transpo Electrical Bus Garage								
Client :	City of Ottawa	Project Location	oject Location : 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	September 19, 2022	Borehole No:		22-02	Sample No.: SS4				Depth (m) :	2.3-2.9
Sample Description :		% Silt and Clay	35	% Sand	38	% Gravel		27	Figure :	29
Sample Description :	GLACIAL TILL: Silty Sand (SM) - Gravelly, Some Clay									29



# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

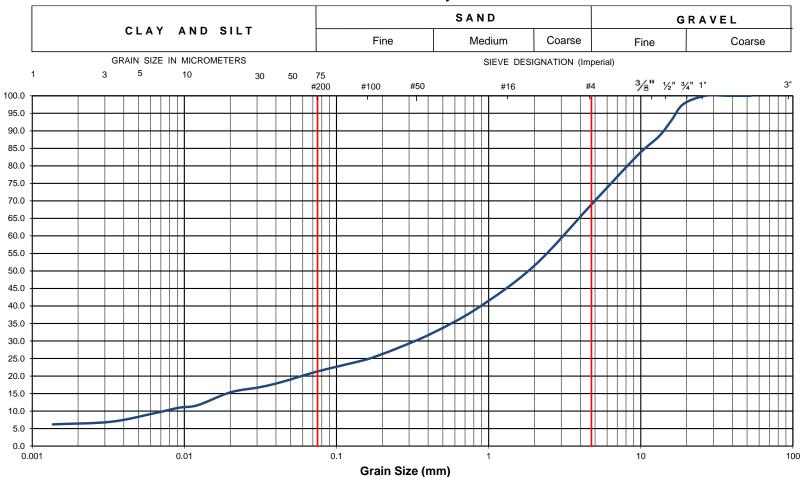


EXP Project No.:	OTT-22007382-A0	Project Name :	roject Name : Proposed OC Transpo Electrical Bus Garage							
Client :	City of Ottawa	Project Location	Project Location: 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	September 19, 2022	Borehole No:		22-02	Sample No.: SS6 De			Depth (m):	3.8-4.2	
Sample Description :		% Silt and Clay	32	% Sand	52	% Gravel		16	Figure :	30
Sample Description : GLACIAL TILL: Silty Sand (SM) - Some Gravel, Trace Clay							rigure .	30		





# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

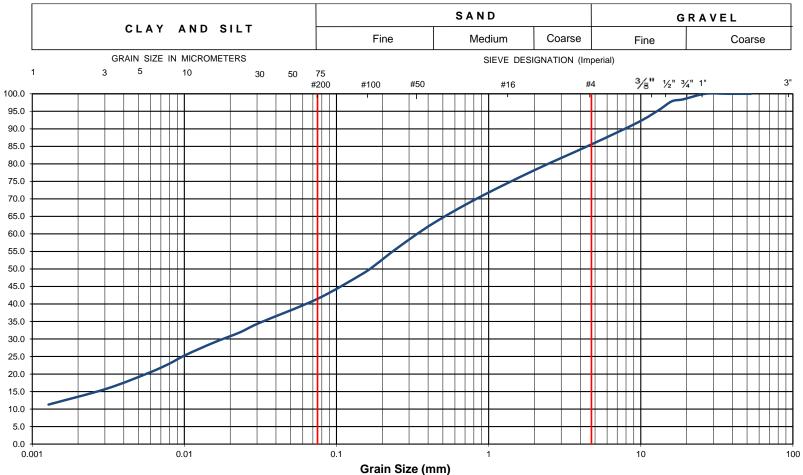


EXP Project No.:	OTT-22007382-A0	Project Name: Proposed OC Transpo Electrical Bus Gar					rage			
Client :	City of Ottawa	Project Location: 1500 St. Laurent Blvd., Ottawa, ON								
Date Sampled :	September 19, 2022	Borehole No:		22-03 Sample No.: SS4 D				Depth (m):	2.3-2.9	
Sample Description :		% Silt and Clay	21	% Sand	48	% Gravel		31	Figure :	31
Sample Description : GLACIAL TILL: Silty Sand (SM) - Gravelly, Trace Clay							rigure .	31		

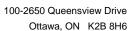


# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6

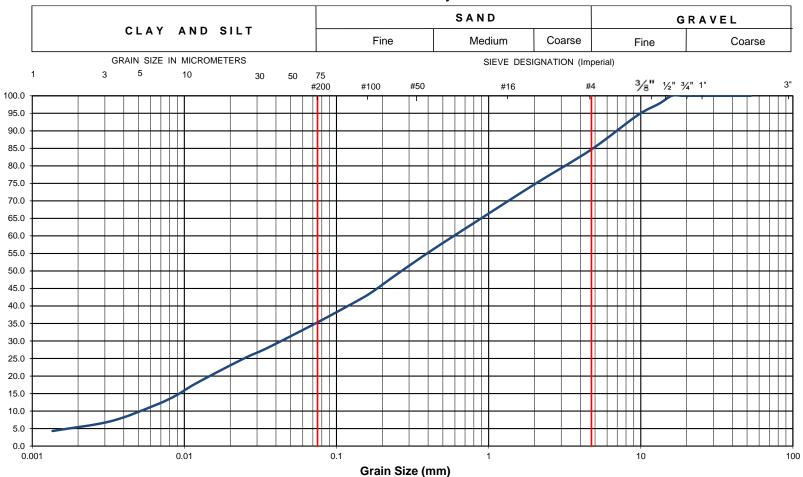


EXP Project No.:	OTT-22007382-A0	Project Name :		Proposed OC T	Proposed OC Transpo Electrical Bus Garage					
Client :	City of Ottawa	Project Location: 1500 St. Laurent Blvd., Ottawa, ON								
Date Sampled :	September 20, 2022	Borehole No:		22-04 Sample No.: SS4 Dep				Depth (m):	2.3-2.9	
Sample Description :		% Silt and Clay	42	% Sand	44	% Gravel		14	Figure :	32
Sample Description : GLACIAL TILL: Silty Sand (SM) - Some Gravel and Clay							rigure .	32		

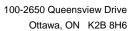




# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

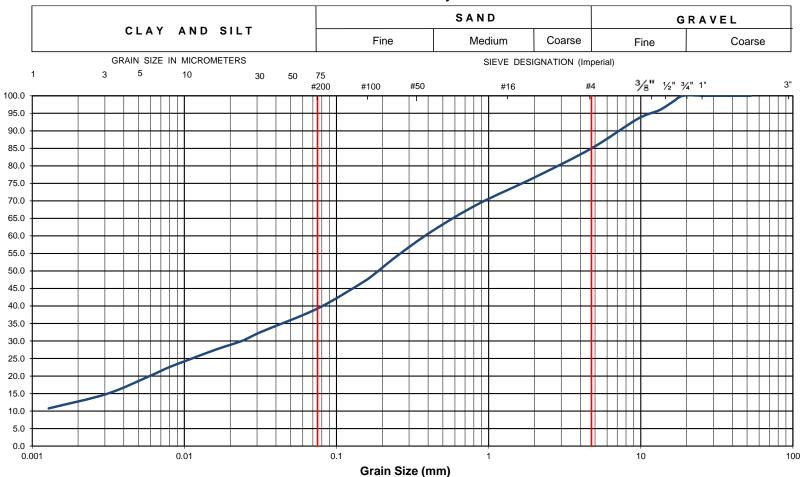


EXP Project No.:	OTT-22007382-A0	Project Name :	Project Name : Proposed OC Transpo Electrical Bus Garage							
Client :	City of Ottawa	Project Location	Project Location: 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	September 19, 2022	Borehole No:		22-05	Sample No.: SS6			S6	Depth (m):	3.8-4.2
Sample Description :		% Silt and Clay	35	% Sand	50	% Gravel		15	Figure :	33
Sample Description : GLACIAL TILL: Silty Sand (SM) - Some Gravel, Trace Clay							rigure .	33		

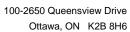




# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

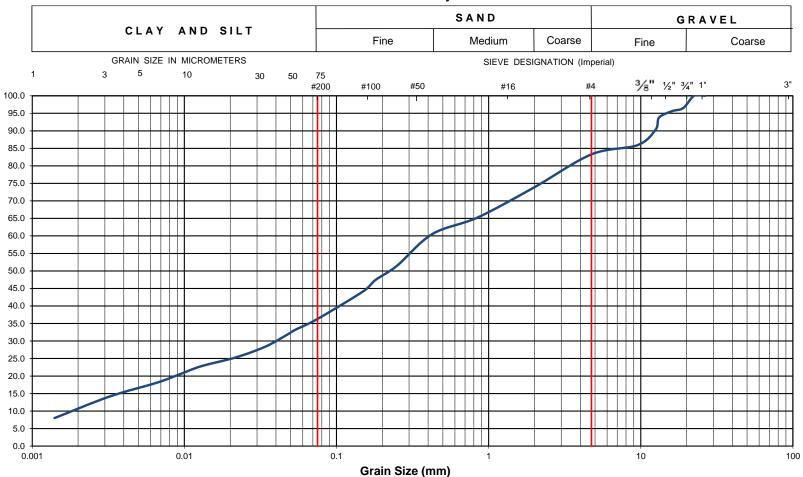


EXP Project No.:	OTT-22007382-A0	Project Name :		Proposed OC Transpo Electrical Bus Garage						
Client :	City of Ottawa	Project Location	Project Location: 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	September 20, 2022	Borehole No:		22-08	22-08 Sample No.: SS4 I				Depth (m):	2.3-2.9
Sample Description :		% Silt and Clay	39	% Sand	46	% Gravel		15	Figure :	34
Sample Description : GLACIAL TILL: Silty Sand (SM) - Some Gravel and Clay								rigure .	34	

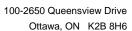




# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

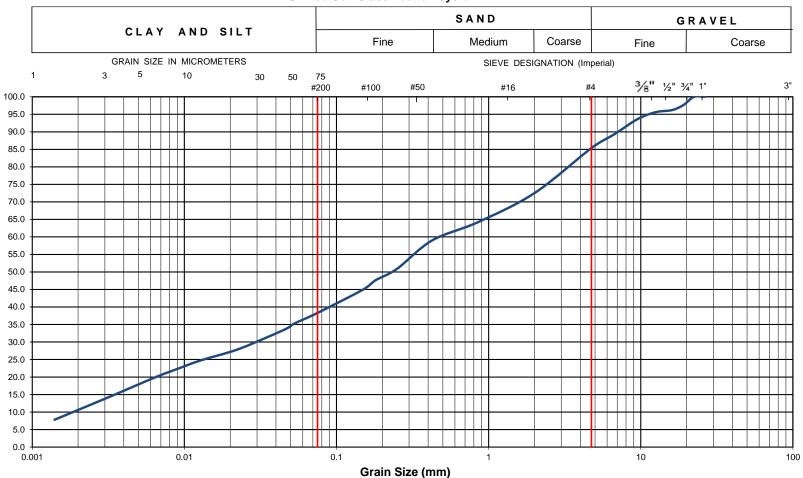


EXP Project No.:	OTT-22007382-A0	Project Name :		Proposed OC Transpo Electrical Bus Garage						
Client :	City of Ottawa	Project Location	ı:	1500 St. Lauren	t Blvd., (	Ottawa, ON				
Date Sampled :	May 8, 2024	Borehole No:		24-05	Sam	ple No.:	SS	64	Depth (m) :	2.3 - 2.9
Sample Description :		% Silt and Clay	36	% Sand	47	% Gravel		17	Figure :	35
Sample Description : GLACIAL TILL: Clayey Sand (SC) - Low Plasticity, Some Gravel, Silty						rigule .	33			





# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

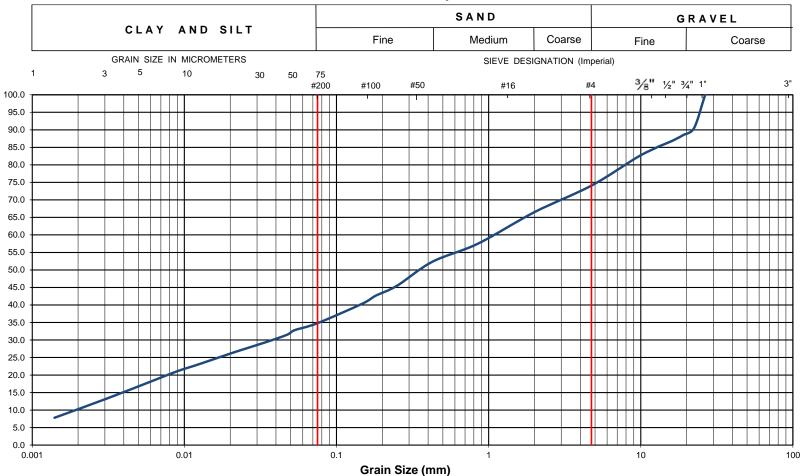


EXP Project No.:	OTT-22007382-A0	Project Name :		Proposed OC T	ranspo I	Electrical Bus	s Ga	rage		
Client :	City of Ottawa	Project Location	oject Location: 1500 St. Laurent Blvd., Ottawa, ON							
Date Sampled :	May 7, 2024	Borehole No:		24-06	Sample No.: SS3 Dept				Depth (m):	1.5-2.1
Sample Description :		% Silt and Clay	38	% Sand 47 % Gravel 15				Figure :	36	
Sample Description : Glacial Till: Clayey Sand (SC) - Low Plasticity, Some Gravel, Silty								rigure .	30	



# Grain-Size Distribution Curve Method of Test For Particle Size Analysis of Soil ASTM C-136/ASTM D422

100-2650 Queensview Drive Ottawa, ON K2B 8H6



EXP Project No.:	OTT-22007382-A0	Project Name :		Proposed OC To	ranspo l				
Client :	City of Ottawa	Project Location	ı:	1500 St. Lauren	t Blvd.,	Ottawa, ON			
Date Sampled :	May 8, 2024	Borehole No:		24-12	Sam	ple No.:	SS5	Depth (m):	3.0-3.6
Sample Description :		% Silt and Clay	35	% Sand	39	% Gravel	26	Figure :	37
Sample Description : GLACIAL TILL: Clayey Sand (SC) - Low Plasticity. Gravelly, Silty						Figure :	31		

Geotechnical Investigation – Proposed OC Transpo Electrical Bus Garage 1500 St. Laurent Boulevard, Ottawa, ON OTT-22007382-A0 November 26, 2024

Appendix A – Seismic Shear Wave Velocity Soundings Survey Report by GPR





May 31<sup>st</sup>, 2024

Transmitted by email: ismail.taki@exp.com

Our ref: GPR24-05486-b

Mr. Ismail Taki, M.Eng., P.Eng. Senior Manager, Earth & Environment, Eastern Region **exp** Services inc. 100 - 2650 Queensview Drive Ottawa ON K2B 8H6

Subject: **Shear Wave Velocity Soundings for the Site Classes Determination** 1500 St. Laurent Boulevard, Ottawa (ON)

[Project: OTT-22007382-B0]

Dear Mr. Taki,

Geophysics GPR International inc. has been mandated by **exp** Services inc. to carry out seismic surveys at the OC Transpo Bus Garage Parking, located at 1500 St. Laurent Boulevard, in Ottawa (ON). The geophysical investigation used the Multi-channel Analysis of Surface Waves (MASW), the Spatial AutoCorrelation (SPAC), and the seismic refraction method. From the subsequent results, the seismic shear wave velocity values were calculated for the soils and the rock, to determine two Site Classes.

The surveys were conducted on May 15<sup>th</sup>, 2024, by Mrs. Karyne Faguy, B.Sc. geophysics and Mr. Charles Trottier, M.Sc. physics. Figure 1 shows the regional location of the site and Figure 2 illustrates the locations of the seismic spreads. Both figures are presented in the Appendix.

The following paragraphs briefly describe the survey design, the principles of the testing methods, and the results presented in table and graph.

#### **MASW Principle**

The Multi-channel Analysis of Surface Waves (MASW) and the SPatial AutoCorrelation (SPAC or MAM for Microtremors Array Method) are seismic methods used to evaluate the shear wave velocities of subsurface materials through the analysis of the dispersion properties of the Rayleigh surface wave. The MASW is considered an "active" method, as the seismic signal is induced at known location and time in the geophones' spread axis. Conversely, the SPAC is considered a "passive" method, using the low frequency "signals" produced far away. The method can also be used with "active" seismic source records. The SPAC method generally allows deeper V<sub>S</sub> soundings. Its dispersion curve can then be merged with the one of higher frequency from the MASW to calculate a more complete inversion. The dispersion properties are expressed as a change of velocities with respect to frequencies. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. The inversion of the Rayleigh wave dispersion curve yields a shear wave (V<sub>S</sub>) velocity depth profile (sounding).

Figure 3 schematically outlines the basic operating procedure for the MASW method. Figure 4 illustrates an example of one of the MASW/SPAC records, a corresponding spectrogram analysis and resulting 1D  $V_S$  model.

#### INTERPRETATION

The main processing sequence involved data inspection and edition when required; spectral analysis (from MASW and SPAC); picking the fundamental mode; and 1D inversion of the MASW and SPAC shot records using the SeisImagerSW™ software. The data inversions used a nonlinear least squares algorithm.

In theory, all the shot records for a given seismic spread should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation, local surface seismic velocities variations, and/or dipping of overburden layers or rock. In general, the precision of the calculated seismic shear wave velocities (V<sub>S</sub>) is around 15% or better.

More detailed descriptions of these methods are presented in *Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock,* Hunter, J.A., Crow, H.L., et al., Geological Surveys of Canada, General Information Product 110, 2015.



#### **SURVEY DESIGN**

The seismic spreads were laid out west of the building (Figure 2). The seismic line SL-1 was located South, and SL-2 was located North. For SL-1, the geophone spacing was 3.0 metres for the main spread, using 24 geophones, and it was 2.5 metres for SL-2. Two shorter seismic spreads, with geophone spacing of 0.5 and 1.0 metre, were dedicated to the near surface materials. The seismic records were produced with a seismograph Terraloc MK6 (from ABEM Instrument), and the geophones were 4.5 Hz.

The seismic records counted 4096 data, sampled at 1000  $\mu$ s for the MASW surveys, and at 50  $\mu$ s for the seismic refraction. The records included a pre-trigged portion of 10 ms. An 8 kg sledgehammer was used as the energy source, with impacts being recorded off both ends of the seismic spreads. A stacking procedure was also used to improve the Signal / Noise ratio for the seismic records.

The shear wave depth sounding can be considered as the average of the bulk area within the geophone spread, especially for its central half-length.

#### **RESULTS**

The MASW calculated V<sub>S</sub> results are illustrated at Figure 5.

The  $\overline{V}_{830}$  value results from the harmonic mean of the shear wave velocities, from the surface to 30 metres deep. It is calculated by dividing the total depth of interest (30 metres) by the sum of the time spent in each velocity layer from the surface down to 30 metres, as:

$$\bar{V}_{S30} = \frac{\sum_{i=1}^{N} H_i}{\sum_{i=1}^{N} H_i / V_i} \mid \sum_{i=1}^{N} H_i = 30 \text{ m}$$

(N: number of layers;  $H_i$ : thickness of layer "i";  $V_i$ :  $V_S$  of layer "i")

Thus, the  $\overline{V}_{830}$  value represents the seismic shear wave velocity of an equivalent homogeneous single layer response, between the surface and 30 metres deep.

The calculated  $\overline{V}_{S30}$  values of the actual sites are 1171.6 m/s (Table 1) for the South part and 1094.1 m/s (Table 3) for the North part, both corresponding to the Site Class "B". However, the Site Classes A and B are not to be used if there is 3 metres or more of soils between the rock and the bottom of the foundation. In the case there would be 2.6 metres or less of soils at the South location (table 2), and 1.7 metres or less of soils at the North one (Table 4), the  $\overline{V}_{S30}$ \* values would be greater than 1500 m/s, corresponding to the Site Class "A".



Mr. Ismail Taki, M.Eng., P.Eng. May 31<sup>st</sup>, 2024

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#### **CONCLUSION**

Geophysical surveys were carried out to identify two Site Classes at the OC Transpo Bus Garage Parking, located at 1500 St. Laurent Boulevard, in Ottawa (ON). The seismic surveys used the MASW and the SPAC analysis, and the seismic refraction to calculate the  $\overline{V}_{S30}$  values. Their calculations are presented at Table 1 and Table 3.

The  $\overline{V}_{S30}$  values of the actual sites are 1172 and 1094 m/s, for the South and the North parts respectively. Both values are corresponding to the Site Class "B" (760  $<\overline{V}_{S30} \le 1500$  m/s), as determined through the MASW and SPAC methods, Table 4.1.8.4.-A of the NBC (2015), and the Building Code, O. Reg. 332/12. It must be noted that the Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated materials between the rock surface and the bottom of spread footing or mat foundation.

In the case there would be 2.6 metres or less of soils at the South location, and 1.7 metres or less of soils at the North one, the  $\overline{V}_{S30}$ \* values would be greater than 1500 m/s, corresponding to the Site Class "A".

It must also be noted that other geotechnical information gleaned on site; including the presence of liquefiable soils, very soft clays, high moisture content etc. (cf. Table 4.1.8.4.-A of the NBC 2015) can supersede the Site classification provided in this report based on the  $\overline{V}_{S30}$  value.

The  $V_S$  values calculated are representative of the in situ materials and are not corrected for the total and effective stresses.

Hoping the whole to your satisfaction, we remain yours truly,

Jean-Luc Arsenault, M.A.Sc., P.Eng. Senior Project Manager



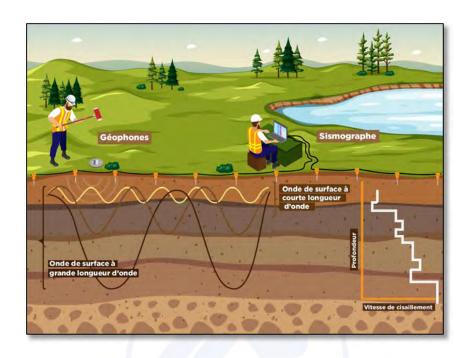


Figure 1: Regional location of the Site (Source : OpenStreetMap®)



Figure 2: Location of the seismic spreads (source: Google Earth™)





**Figure 3: MASW Operating Principle** 

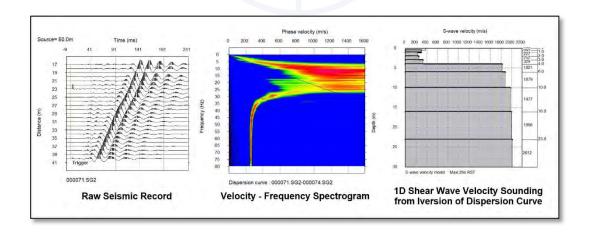


Figure 4: Example of a MASW/SPAC record, Phase Velocity - Frequency curve of the Rayleigh wave and resulting 1D Shear Wave Velocity Model



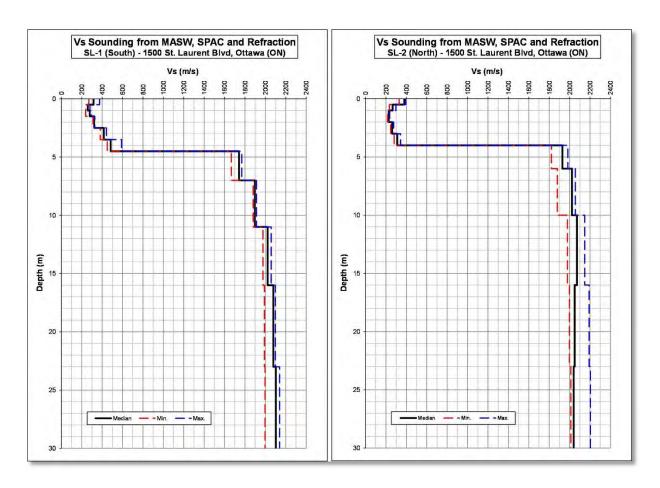


Figure 5: MASW Shear-Wave Velocity Soundings



 $\frac{\text{TABLE 1}}{\text{SL-1 (South)}} \cdot \bar{V}_{\text{S30}} \,\, \text{Calculation for the Site Class (actual site)}$ 

Donth		Vs		Thickness	Cumulative	Delay for	Cumulative	Vs at given
Depth	Min.	Median	Max.	THICKHESS	Thickness	med. Vs	Delay	Depth
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	269.5	315.9	374.8		Grade	Level (May 15	5 <sup>th</sup> , 2024)	
0.5	238.4	259.4	280.3	0.50	0.50	0.001583	0.001583	315.9
1.0	238.3	278.0	294.0	0.50	1.00	0.001928	0.003510	284.9
1.5	310.3	321.3	327.0	0.50	1.50	0.001798	0.005309	282.6
2.5	382.1	416.5	441.8	1.00	2.50	0.003113	0.008421	296.9
3.5	450.2	483.3	590.3	1.00	3.50	0.002401	0.010822	323.4
4.5	1665.9	1741.6	1768.9	1.00	4.50	0.002069	0.012891	349.1
7.0	1880.4	1897.0	1912.0	2.50	7.00	0.001435	0.014326	488.6
11.0	1975.7	2021.6	2056.7	4.00	11.00	0.002109	0.016435	669.3
16.0	1990.7	2077.9	2097.2	5.00	16.00	0.002473	0.018908	846.2
23.0	1996.5	2102.5	2139.3	7.00	23.00	0.003369	0.022277	1032.5
30				7.00	30.00	0.003329	0.025606	1171.6

Vs30 (m/s)	1171.6
Class	B <sup>(1)</sup>

(1) The Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated material between the rock surface and the bottom of the spread footing or the mat foundation.

 ${\color{red}{\bf TABLE~2}}$  SL-1 (South) -  ${\color{blue}{\bar{V}_{\rm S30}}}$  \* Calculation for the Limit of the Site Class A

Depth		Vs		Thickness	Cumulative	Delay for	Cumulative	Vs at given
Deptil	Min.	Median	Max.	THICKHESS	Thickness	med. Vs	Delay	Depth
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	269.5	315.9	374.8					
0.5	238.4	259.4	280.3					
1.0	238.3	278.0	294.0		Limit for the Sit	te Class A (2.6	6 metres of soil	s)
1.5	310.3	321.3	327.0					
1.9	310.3	321.3	327.0					
2.5	382.1	416.5	441.8	0.60	0.60	0.001868	0.001868	321.3
3.5	450.2	483.3	590.3	1.00	1.60	0.002401	0.004268	374.8
4.5	1665.9	1741.6	1768.9	1.00	2.60	0.002069	0.006337	410.3
7.0	1880.4	1897.0	1912.0	2.50	5.10	0.001435	0.007773	656.1
11.0	1975.7	2021.6	2056.7	4.00	9.10	0.002109	0.009881	920.9
16.0	1990.7	2077.9	2097.2	5.00	14.10	0.002473	0.012355	1141.3
23.0	1996.5	2102.5	2139.3	7.00	21.10	0.003369	0.015723	1341.9
31.9				8.90	30.00	0.004233	0.019957	1503.3

Vs30 *	1503.3
Class	Α



Donth	Depth Vs		Thickness	Cumulative	Delay for	Cumulative	Vs at given	
Deptil	Min.	Median	Max.	HIICKHESS	Thickness	med. Vs	Delay	Depth
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	329.5	378.5	394.5		Grade Level (May 15th, 2024)			
0.5	233.7	265.4	297.4	0.50	0.50	0.001321	0.001321	378.5
1.0	215.3	227.3	236.3	0.50	1.00	0.001884	0.003205	312.0
2.0	246.4	260.6	275.0	1.00	2.00	0.004399	0.007604	263.0
3.0	280.3	310.3	342.5	1.00	3.00	0.003838	0.011442	262.2
4.0	1821.3	1929.8	1982.3	1.00	4.00	0.003222	0.014664	272.8
6.0	1879.0	2023.1	2055.8	2.00	6.00	0.001036	0.015700	382.2
10.0	1977.9	2072.0	2147.5	4.00	10.00	0.001977	0.017677	565.7
16.0	1998.4	2049.1	2190.9	6.00	16.00	0.002896	0.020573	777.7
23.0	2012.4	2039.9	2203.7	7.00	23.00	0.003416	0.023989	958.8
30				7.00	30.00	0.003432	0.027421	1094.1

Vs30 (m/s)	1094.1
Class	B <sup>(1)</sup>

(1) The Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated material between the rock surface and the bottom of the spread footing or the mat foundation.

Depth		Vs		Thickness	Cumulative	Delay for	Cumulative	Vs at given		
Deptili	Min.	Median	Max.	HIICKHESS	Thickness	med. Vs	Delay	Depth		
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)		
0	329.5	378.5	394.5							
0.5	233.7	265.4	297.4	297.4						
1.0	215.3	227.3	236.3		Limit for the Sit	te Class A (1.	7 metres of soil	s)		
2.0	246.4	260.6	275.0		, , , , , , , , , , , , , , , , , , ,					
2.3	246.4	260.6	275.0							
3.0	280.3	310.3	342.5	0.70	0.70	0.002686	0.002686	260.6		
4.0	1821.3	1929.8	1982.3	1.00	1.70	0.003222	0.005909	287.7		
6.0	1879.0	2023.1	2055.8	2.00	3.70	0.001036	0.006945	532.8		
10.0	1977.9	2072.0	2147.5	4.00	7.70	0.001977	0.008922	863.0		
16.0	1998.4	2049.1	2190.9	6.00	13.70	0.002896	0.011818	1159.2		
23.0	2012.4	2039.9	2203.7	7.00	20.70	0.003416	0.015234	1358.8		
32.3				9.30	30.00	0.004559	0.019793	1515.7		

Vs30 *	1515.7
Class	Α



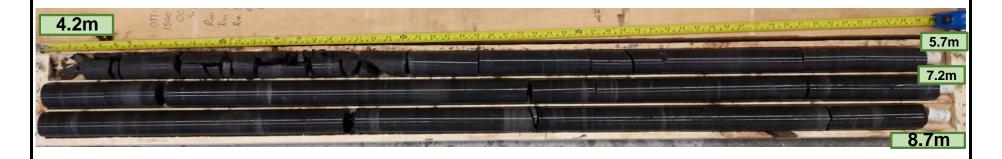
Geotechnical Investigation – Proposed OC Transpo Electrical Bus Garage 1500 St. Laurent Boulevard, Ottawa, ON OTT-22007382-A0 November 26, 2024

**Appendix B – Bedrock Core Photographs** 





#### WET BEDROCK CORES





# EXP Services Inc. www.exp.com

borehole no.				project no.
BH/MW 22-02	Run 1: 4.2m - 5.7m Run 2: 5.7m - 7.2m Run 3: 7.2m - 8.7m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored			Rock Core Photographs	FIG. B-1
Sep 21, 2022			ntoon oolo i netograpiio	

## DRY BEDROCK CORES



## **WET BEDROCK CORES**





# EXP Services Inc. www.exp.com

borehole no.				project no.
BH 22-07	Run 1: 4.1m - 5.6m Run 2: 5.6m - 7.1m Run 3: 7.1m - 8.5m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored Sep 21, 2022			Rock Core Photographs	FIG. B-2

# 2.8m 2.8m 4.1m 7.1m

#### WET BEDROCK CORES



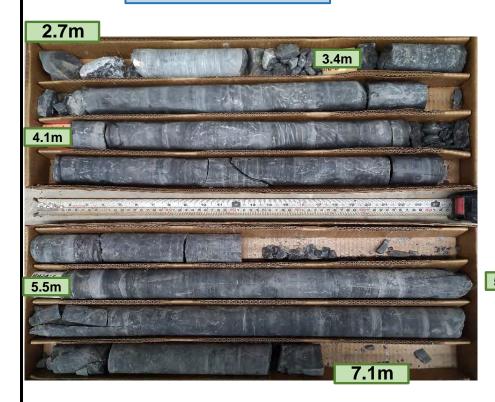


# EXP Services Inc. www.exp.com

borehole no.				project no.
BH 22-09	Run 1: 2.8m - 4.1m Run 2: 4.1m - 5.7m Run 3: 5.7m - 7.1m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored Sep 21, 2022			Rock Core Photographs	FIG. B-3

## DRY BEDROCK CORES

## WET BEDROCK CORES

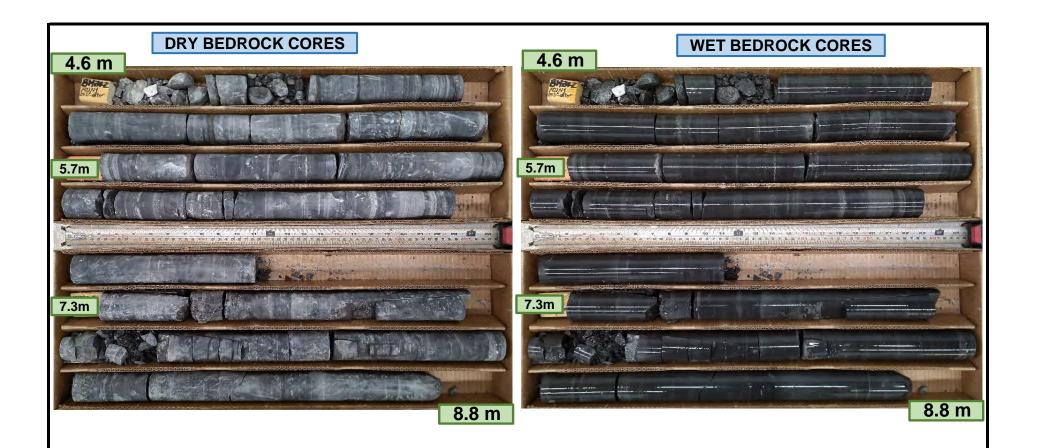






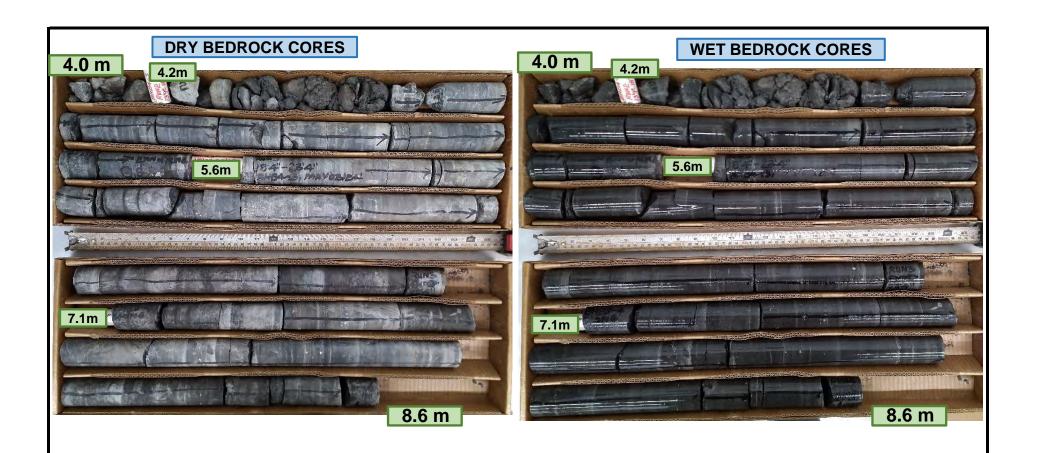
# EXP Services Inc. www.exp.com

borehole no.				project no.
BH/MW 24-01	Run 0: 2.7m - 3.4m Run 1: 3.4m - 4.1m Run 2: 4.1m - 5.5m Run 3: 5.5m - 7.1m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 10, 2024	end of borehole		Rock Core Photographs	FIG. B-4



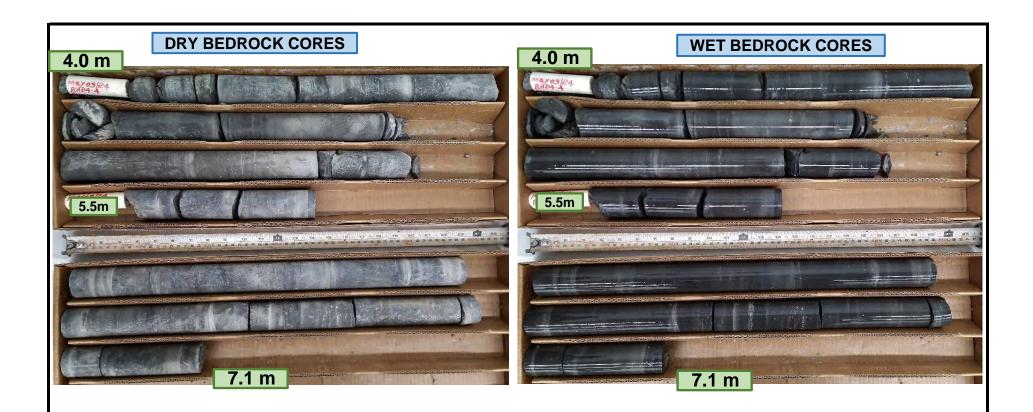


borehole no.				project no.
BH24-02	Run 1: 4.6m - 5.7m Run 2: 5.7m - 7.3m Run 3: 7.3m - 8.8m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 08, 2024	end of borehole		Rock Core Photographs	FIG. B-5



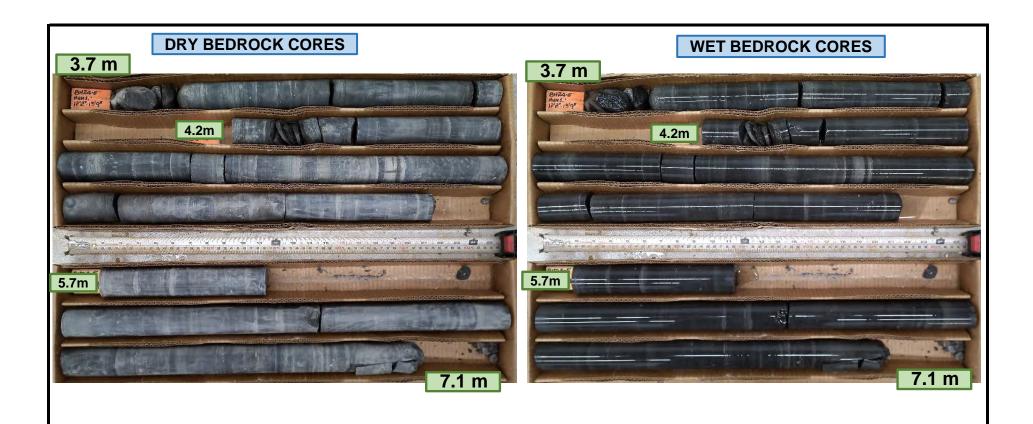


borehole no.				project no.
BH 24-03	Run 1: 4.0m - 4.2m Run 2: 4.2m - 5.6m Run 3: 5.6m - 7.1m Run 4: 7.1m - 8.6m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
May 03, 2024	end of borehole		Rock Core Photographs	FIG. B-6





borehole no.				project no.
BH24-04	Run 1: 4.0m - 5.5m Run 2: 5.5m - 7.1m end of borehole	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 03, 2024	Cha di Balchaic		Rock Core Photographs	FIG. B-7





borehole no.				project no.
BH/MW 24-05	Run 1: 3.7m - 4.2m Run 2: 4.2m - 5.7m Run 3: 5.7m - 7.1m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored	end of borehole			
May 08, 2024			Rock Core Photographs	FIG. B-8





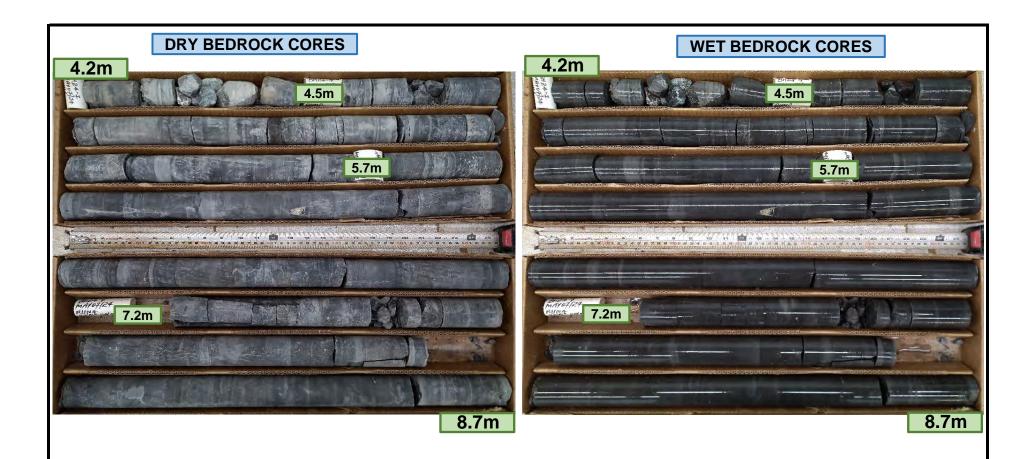
8.8 m

8.8 m



# EXP Services Inc. www.exp.com

borehole no.				project no.
BH 24-06	Run 1: 4.3m - 5.3m Run 2: 5.3m - 7.3m Run 3: 7.3m - 8.8m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 07, 2024	end of borehole		Rock Core Photographs	FIG. B-9





borehole no.				project no.
BH/MW 24-07	Run 1: 4.2m - 4.5m Run 2: 4.5m - 5.7m Run 3: 5.7m - 7.2m Run 4: 7.2m - 8.7m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 07, 2024	end of borehole		Rock Core Photographs	FIG. B-10

## DRY BEDROCK CORES

## WET BEDROCK CORES





7.1 m

# EXP Services Inc. www.exp.com

borehole no.				project no.
BH24-09	Run 1: 3.9m - 4.1m Run 2: 4.1m - 5.7m Run 3: 5.7m - 7.1m	project	Proposed OC Transpo Electrical Bus Garage - 1500 St. Laurent Blvd., Ottawa, ON	OTT-22007382-A0
date cored May 09, 2024	end of borehole		Rock Core Photographs	FIG. B-11

Geotechnical Investigation – Proposed OC Transpo Electrical Bus Garage 1500 St. Laurent Boulevard, Ottawa, ON OTT-22007382-A0 November 26, 2024

**Appendix C – Laboratory Certificate of Analysis Report by AGAT** 





5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC

2650 QUEENSVIEW DRIVE, UNIT 100

OTTAWA, ON K2B8H6

(613) 688-1899

ATTENTION TO: SURINDER AGGARWAL

PROJECT: OTT-22007382-AO

AGAT WORK ORDER: 22Z962626

SOIL ANALYSIS REVIEWED BY: Jacky Zhu, Spectroscopy Technician

DATE REPORTED: Nov 03, 2022

PAGES (INCLUDING COVER): 6 VERSION\*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

- 1
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#### Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may
  incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may
  be exempt, please contact your Client Project Manager for details.
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- The test results reported herewith relate only to the samples as received by the laboratory.
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  contained in this document.
- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.

AGAT Laboratories (V1)

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Certificate of Analysis

AGAT WORK ORDER: 22Z962626 PROJECT: OTT-22007382-AO 5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC

SAMPLING SITE:

Sulphate (10:1)

10:1 (DI water Extr.)

ATTENTION TO: SURINDER AGGARWAL SAMPLED BY:

				Д	nion Sca	an in Soil					
DATE RECEIVED: 2022-10-27								DA	TE REPOR	TED: 2022-11-03	
				BH 1 SS 2 2.				BH 5 SS 5		BH 7 SS 5	
		SAMPLE DESCR	IPTION:	5'-4.5'		BH 3 SS 3 5'-7'		10'-12'		10'-12'	
		SAMPLI	E TYPE:	Soil		Soil		Soil		Soil	
		DATE SA	MPLED:	2022-10-20		2022-10-19		2022-10-19		2022-10-20	
Parameter	Unit	G/S	RDL	4467358	RDL	4467360	RDL	4467361	RDL	4467362	
Chloride (10:1)	mg/kg		40	933	100	1320	20	422	40	1140	
Sulphate (10:1)	mg/kg		40	281	100	819	20	515	40	863	
10:1 (DI water Extr.)			N/A	Υ	N/A	Υ	N/A	Υ	N/A	Υ	
						BH 11 SS 4 7.		BH 13 SS 4 7.		BH 13 SS 6	
		SAMPLE DESCR	IPTION:	BH 9 SS 3 5'-7'		5'-9.5'		5'-9.5'		12.5'-14.5'	
		SAMPLI	E TYPE:	Soil		Soil		Soil		Soil	
		DATE SA	MPLED:	2022-10-20		2022-10-21		2022-10-22		2022-10-22	
Parameter	Unit	G/S	RDL	4467363	RDL	4467364	RDL	4467365	RDL	4467366	
Chloride (10:1)	mg/kg		20	518	40	1660	20	237	40	1630	

N/A

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

4467358-4467366 Results are based on a dry weight.

Dilution required, RDL has been increased accordingly.

mg/kg

20

116

Analysis performed at AGAT Toronto (unless marked by \*)

CHARTERED S CHEMIST OF

67

Υ

N/A

Certified By:

20

N/A

111

576



# Certificate of Analysis

AGAT WORK ORDER: 22Z962626 PROJECT: OTT-22007382-AO

5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC

SAMPLING SITE:

ATTENTION TO: SURINDER AGGARWAL

SAMPLED BY:

31 1 tog: 100(01.1)	(Conj	

					,	J / 1	` '		
DATE RECEIVED: 2022-10-27									DATE REPORTED: 2022-11-03
				BH 1 SS 2 2.		BH 5 SS 5	BH 7 SS 5		
	S	SAMPLE DES	CRIPTION:	5'-4.5'	BH 3 SS 3 5'-7'	10'-12'	10'-12'	BH 9 SS 3 5'-7'	
		SAM	PLE TYPE:	Soil	Soil	Soil	Soil	Soil	
		DATE	SAMPLED:	2022-10-20	2022-10-19	2022-10-19	2022-10-20	2022-10-20	
Parameter	Unit	G/S	RDL	4467358	4467360	4467361	4467362	4467363	
Resistivity (2:1) (Calculated)	ohm.cm		1	362	207	599	265	621	
pH, 2:1 CaCl2 Extraction	pH Units		NA	7.84	7.65	7.54	7.55	7.84	

O Reg. 153(511) - Resistivity pH (Soil)

RDL - Reported Detection Limit; G / S - Guideline / Standard Comments:

4467358-4467366 EC was determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract obtained from 2:1 leaching procedure (2 parts extraction fluid:1 part wet soil).

Analysis performed at AGAT Toronto (unless marked by \*)

Certified By:



5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

# **Quality Assurance**

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 22Z962626

PROJECT: OTT-22007382-AO

ATTENTION TO: SURINDER AGGARWAL

SAMPLING SITE: SAMPLED BY:

Soil Analysis															
RPT Date: Nov 03, 2022			DUPLICATE				REFEREN	NCE MA	TERIAL	METHOD	BLANK	SPIKE	MAT	RIX SPI	KE
PARAMETER	Batch Sa	Sample	Dup #1	Dup #2	RPD	Method Blank	Measured		otable nits	Recovery	Lin	ptable nits	Recovery	Lin	ptable nits
		ld	- '	.,			Value	Lower	Upper	,	Lower	Upper	, , ,	Lower	Upper

O. Reg. 153(511) - Resistivity, pH (Soil)

pH, 2:1 CaCl2 Extraction 4467360 4467360 7.65 7.55 1.3% NA 101% 80% 120%

Comments: NA signifies Not Applicable.

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Anion Scan in Soil

Chloride (10:1) 4474463 10 10 NA < 10 97% 80% 120% 95% 90% 110% 96% 80% 120% Sulphate (10:1) 4474463 15 80% 120% 93% 90% 110% 96% 80% 120%

Comments: NA signifies Not Applicable.

Duplicate NA: results are under 5X the RDL and will not be calculated.

CHARTERED SOME NANDONG 2PU CHEMIST

Certified By:



5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

# **Method Summary**

CLIENT NAME: EXP SERVICES INC AGAT WORK ORDER: 22Z962626

PROJECT: OTT-22007382-AO ATTENTION TO: SURINDER AGGARWAL

SAMPLING SITE: SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (10:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (10:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
10:1 (DI water Extr.)		McKeague 4.12	N/A
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	EC METER
pH, 2:1 CaCl2 Extraction	INOR-93-6075	modified from EPA 9045D, MCKEAGUE 3.11 E3137	PC TITRATE



5835 Coopers Avenue Mississauga, Ontario 147 1Y2 Ph: 905 712.5100 Fax: 905.712.5122 webearth.ogatloba.com

Labo	ratory	Use	Only
			_

Work Order #	227962626
Work Order #	227102626

Cooler Quantity:	NA-NO ILEIDOCIU
Arrival Temperatures: 71.1	71.2 21.2
L-T 3.	3   3.8   3.2

	200	2.8	0.7
Custody Seal Intact:	□Yes	□No	□N/A
Notes: Page	dice-		

Chain of Custody Record	If this is a Dr	inking Water s	ample, plea	se use Drink	king Water Chaln	of Custody Form (pot	table water	consume	ed by hu	nans)		_	AIIIV	ai ieli	nperatu	- 7	5	1.3	1	3.8	13.	
Report Information:  Company: FXP				Reg (Please	Sulatory Req	uirements:							Cust		Pal Inta		□Y			□No		]N/A
	ggrwal			Re	gulation 153/04	Excess Soils	R406		ver Use			1			-		1.6					
Contact: Surinder Address: 7650 Queensu:	ow Dr 9	Suite 10	ත		,			□s	anitary	Sto	m	- 11	Turn	aroı	und	ime	(TA	Γ) Re	iup	ed:		
OHAWG ON	K25	3 8HC			Indicate One	Table Indicate C	ne	_	Region	_		- 11	Regu	ılar 1	ГАТ		<b>57</b> ( 5	5 to 7 f	3usine	ss Days	5	
Phone: 613-688-1899	Fax:				Res/Park Agriculture	Regulation 5	58	Prov	v. Wateı	Quality		- 11	Rush	TAT	(Rush Su							
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2. Email:					Fine				Indicate (	ne		-		OR	Date F	Require	ed (Ru	ısh Sur	rcharg	es May	Apply):	
Project Information:				ls	this submissi	on for a	R	eport	Guide	line o	n											
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	gx												-			analys	sis, p	lease (	conta	et your	AGAT CP	M
AGAT Quote #:	PO:			Sam	ple Matrix Le	adond	8	0.	Reg 153				O. Reg	O. Re	g 406							N.
Please note: If quotation number is not	provided, client will be	billed full price for a	analysis	B	Biota	genu	.×.			8			CLP.	등	age							tion (
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Address:				SD	Sediment		ered	anics	rVI, CI	required			S Lar	7 P	arac als, E				2 3	3		o sno
Email:				sw	Surface Water		Field Filtered - Metals, Hg, CrVI, DOC	norg	CrVI				posal	ils SF etals	ess Soils Characterization Package ICPMS Metals, BTEX, F1-F4	NAR.		S.144.10S				azard
					1		- Fi	\\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\	ls -    Cr	ze F.		-	II Dis	ss Soils : $\square$ Meta	S So	EC/S	11	4	0 -	ct		ially H
Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix		nments/ Instructions	Y/N	Metals & Inorganics	Metals - □ CrVI, □ Hg, □ HWSB	Anelyze I	PCBs	700	Landfill Disposal Characterization TCLP: TCLP: ☐M& ☐VOCS ☐ABNS ☐ B(a)P☐P	Excess SPLP:	Excess PH, ICPI	Salt - EC/SAR	Hd			Electro		Potentially
BH 1 562 7.51-4.51	Syl 20/22	AM PM	-												V.		~	1	1	1		
BH 3 553 51.71	5119	AM PM			1			-									1		1			4
BH 5 55 10'-121	5119	AM PM																				
RH 7 555 10'-12'	5.120	AM PM		/				es:		-					No.							
BH 9 563 51-71	5/20	AM PM					-	14							4					100		
BH 11 554 7.5'-9.51	Sed 21	AM PM					176	00		()(4)		- 7			90.					1 - 1		44
RH 12 &4 7.51-9.51	5,1 27	AM PM			) <sub>i</sub> = =		100	W.							SEL .		1	1	1			
BH 13 es6 12.5'-14.5'	5 1 22	AM PM						1,513		14					115		1	V	1			M
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		AM PM																				
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	AM PM				
	AM PM				
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bampies Helinguisnoa uji il-vint ivame ano sligni:	Date	Samples Received by (Print Name and Sign)	Date	Time	N°: <b>T</b> 133519



5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC 2650 QUEENSVIEW DRIVE, UNIT 100 OTTAWA, ON K2B8H6

(613) 688-1899

**ATTENTION TO: Matthew Zammit** 

PROJECT: OTT-22007382

AGAT WORK ORDER: 24Z154646
SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganic Team Lead

DATE REPORTED: Jun 03, 2024

PAGES (INCLUDING COVER): 6 VERSION\*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*Notes	

#### Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may
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  contained in this document.
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- For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.

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**Certificate of Analysis** 

**AGAT WORK ORDER: 24Z154646** 

PROJECT: OTT-22007382

**ATTENTION TO: Matthew Zammit** 

**SAMPLED BY:EXP** 

5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

# CLIENT NAME: EXP SERVICES INC

pH (2:1)

Resistivity (2:1) (Calculated)

SAMPLING SITE:1500 St Laurent, Ottawa, ON

#### (Soil) Inorganic Chemistry

				<b>\</b>	,	,					
DATE RECEIVED: 2024-05-27									DATE REPORT	ED: 2024-06-03	
		SAMPLE DES	CDIDTION	BH24-2 SS6 12.5'-14.5'	BH24-4 SS4 7.5'-9.5'	BH24-5 SS3 5'-7'	BH24-7 SS6 12.5'-14.5'	BH24-12 SS6 12.5'-14.5'	BH24-9 SS4 7.5'-9.5'	BH24-11 SS5 10'-12'	BH24-1 Run1 11'2-11'6
		SAM	PLE TYPE: SAMPLED:	Soil 2024-05-08	Soil 2024-05-03	Soil 2024-05-08	Soil 2024-05-07	Soil 2024-05-10	Soil 2024-05-09	Soil 2024-05-09	Soil 2024-05-10
Parameter	Unit	G/S	RDL	5888898	5888900	5888901	5888902	5888903	5888904	5888905	5888906
Chloride (2:1)	μg/g		2	1250	2570	2350	905	642	810	1370	104
Sulphate (2:1)	μg/g		2	353	639	829	527	429	419	422	55
pH (2:1)	pH Units		NA	6.83	8.38	8.62	8.52	7.30	7.80	7.63	9.89
Resistivity (2:1) (Calculated)	ohm.cm		1	400	167	240	645	800	415	337	1960
				BH24-5 Run2	BH24-7 Run1	BH24-10 Run2	BH24-11 Run1				
		SAMPLE DES	CRIPTION:	3'8-14'3	13'10-14'2	18'4-18'8	15'1-15'7				
		SAM	PLE TYPE:	Soil	Soil	Soil	Soil				
		DATE	SAMPLED:	2024-05-07	2024-05-07	2024-05-09	2024-05-09				
Parameter	Unit	G/S	RDL	5888907	5888908	5888909	5888910				
Chloride (2:1)	μg/g		2	102	87	81	16				
Sulphate (2:1)	μg/g		2	47	33	29	20				

9.29

3370

9.84

4220

9.23

6060

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

pH Units

ohm.cm

**588898-5888910** pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter. Analysis performed at AGAT Toronto (unless marked by \*)

9.95

2670

Certified By:





5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

# **Quality Assurance**

**CLIENT NAME: EXP SERVICES INC** 

PROJECT: OTT-22007382

AGAT WORK ORDER: 24Z154646 **ATTENTION TO: Matthew Zammit** 

**SAMPLED BY:EXP** 

SAMPLING SITE:1500 St Laurent, Ottawa, ON

				Soi	l Ana	alysis	5								
RPT Date: Jun 03, 2024			E	UPLICAT	E		REFEREN	ICE MA	TERIAL	METHOD	BLANK	SPIKE	MAT	RIX SPI	KE
PARAMETER	Batch	Sample	Dup #1	Dup #2	RPD	Method Blank	Measured		ptable nits	Recovery	Lie	ptable nits	Recovery	1 1 1	ptable nits
. ,		ld	,				Value	Lower	Upper	,	Lower	Upper			Upper
(Soil) Inorganic Chemistry															
Chloride (2:1)	5888898	5888898	1250	1260	0.4%	< 2	96%	70%	130%	96%	80%	120%	NA	70%	130%
Sulphate (2:1)	5888898 5	5888898	353	348	1.5%	< 2	95%	70%	130%	104%	80%	120%	99%	70%	130%
pH (2:1)	5888898 5	5888898	6.83	6.83	0.0%	NA	97%	80%	120%						

Comments: NA signifies Not Applicable.

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Matrix spike NA: Spike level < native concentration. Matrix spike acceptance limits do not apply and are not calculated.

#### (Soil) Inorganic Chemistry

Chloride (2:1)	5888906 5888906	104	102	1.9%	< 2	97%	70%	130%	95%	80%	120%	90%	70%	130%
Sulphate (2:1)	5888906 5888906	55	56	1.8%	< 2	96%	70%	130%	100%	80%	120%	96%	70%	130%
pH (2:1)	5888906 5888906	9.89	9.73	1.6%	NA	101%	80%	120%						

Comments: NA signifies Not Applicable.

pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.







5835 COOPERS AVENUE MISSISSAUGA, ONTARIO CANADA L4Z 1Y2 TEL (905)712-5100 FAX (905)712-5122 http://www.agatlabs.com

# **Method Summary**

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 24Z154646

PROJECT: OTT-22007382

ATTENTION TO: Matthew Zammit

SAMPLING SITE:1500 St Laurent, Ottawa, ON SAMPLED BY:EXP

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

P3/2

**Laboratory Use Only** 

Work Order #: 242154646

# AGAT Laboratories

Have feedback? Scan here for a quick survey!



5835 Coopers Avenue Mississauga, Ontano 142 142 Ph: 905.712.5100 Fax: 905.712.5122

Report Information:		Regulatory Requirements:		Custody Seal Intact: Yes No No.
ontact: Hatthew Zamm: toddress: 2650 Queensurew Office Ontact:  hone: eports to be sent to: Email:  Dyan.d.g.usopAe @ex	exp.com	Regulation 153/04 Table	Sanitary Storm  Region  Prov. Water Quality Objectives (PWQ0)	Turnaround Time (TAT) Required:  Regular TAT
roject Information: roject:	ottawn, OD	Is this submission for a Record of Site Condition (RSC)?  Yes No	Report Guideline on Certificate of Analysis  Yes No	Please provide prior notification for rush TAT  * *TAT is exclusive of weekends and statutory holidays  For 'Same Day' analysis, please contact your AGAT CSR
GAT Quote #: Presse note: If quotation number is not providen, cleant will be	billed full price for analysis.	Legal Sample □	0. Reg 153	ation Package  ater Leach  O Syocs Doc  Tation TCL:  Glasp DPCts  Sulphide  Sulphide
nvolce information:  ompany: ontact: ddress: imail:	To Same: Yes 🔼 — No 🗌	Sample Matrix Legend GW Ground Water SD Sediment O Oil SW Surface Water P Paint R Rock/Shale S Soil	Metals & Inorganics Metals - Crvi, Chg, ChwSB BTEX, F1-F4 PHCs VOC PAHs	SPIP Rainwish Moisture
Sample Identification Date Sampled		Sample Comments/ Matrix Special Instructions	Metals Metals Woc Voc PAHs PCBs: A	Fegura Ph. N
BH24-2 SSG 12.5'-14.5' May 8	AM (			
BH 24.4 SSY 7.5'-9.5' Huy ?	AM N			
BH 24- \$5 553 5'-7 May 8	AM N			
ZH 24-7 556 17.5'-14.5 Man 7 3H 24-12 556 17.5'-14.5' Man 10	AM N			
	AM PM			
BH 24.9 554 7.5-9.5 Many 9 BH 24-11 555 10'-12' Many 9	AM PM			
BH 24-1 Pur 1 112-116	AM PM			
BH 24-5 Run 2 138-1413	AM PM			
BH 24-7 Dug 1 13:10-14:2	AM PM			
-BH 74-10 Run 2 18'4-18'3	AMI PM			100
ples Relinquished By (Print Name and Sign):	D <sub>il</sub> t <sub>in</sub> Time	Sample Received By (Print Name and Satric	Date	1 Time
pelas Halangumhad By (Print Hame and Signil:	Della di Time	Continue	05/2	212 Uma V ( 14 Page of

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Laboratory Use Only

Work Order #: 24715

# CGGT Laboratories

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Mississauga, Ontario 142 192
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webeatth adatable com

Contact: Address:  Phone: Reports to be sent to: 1. Email: 2. Email:  Project Information: Project: Site Location: Sampled By: AGAT Quote #: Please note: If quotation number a not provided, Involce Information: Company: Contact: Address: Email:  Sample Identification Dasam 1. Bill 24-11 Rull 15'1-15' 2 2. 3. 4.	D? 3 (S)			Soil To	ral Sample  nple Matrix L Ground Water Si	on (RSC)?  No  Regend  By Sediment  Surface Water	8 Cen	Prov. Object Other	Region  Water Quitives (PW radicate One studdelline of An seg 153	ality (QO)		Reg Rus	Days OR D *TAT is or 'Same Reg 406	weh Surchisiness siness ease pros exclus  Day' ar	quired (	5 to 2 Bu Days (Rush)	7 Business s Surchar otificationds and	rges May A	TAT holidays  GAT CSR  High Concentration (1/4/N)
Project: DTT-2201 Site Location: Sampled By: AGAT Quote #: Posse note: If quotation number as not provided,  Involce Information: Company: Contact: Address: Email:  Sample Identification Dassam 1. B# 24-11 Rull 15'1-15' 2 2. 3.	):, client will be i	e billed full price for		Legs Sam GW O P	if Site Condition Yes  Gal Sample  Inple Matrix L  Ground Water Oil  Si	egend  Sediment Sw Surface Water	Cer	Yes 0. R	eg 153	alysis		0. F	*TAT is or 'Same	Day' ar	nalysis	weeke	nds and	act your A	holidays  GAT CSR  High Concentration (IV/N)
AGAT Quote #: Popease note: If quotation number is not provided.  Involce Information:  Company: Contact: Address: Email:  Sample Identification  Da Sam L. B.H. 24-11 Run 1 15'1 - 15' 2.  3.	, client will be i			Sam GW O	nple Matrix L Ground Water SI	.egend iD Sediment iW Surface Water	1-Metals, Hg. CrVI, DOC		□HWSB			1	Rainwater Leach	3 8	and			3	- 語
1. Bl 24-11 Run 1 15'1-15' 2 2.					Soil	unció pugia	Field Filtered	& Inorganics	Metals - 🗆 CrVI, 🗆 Hg. I BTEX, F1-F4 PHCs		PCBs; Arodors 🗆	tion 406 Charact tals, BTEX, F1-F4	n 406 SPLP		IM& □ vocs □		phuls.	fro Pes:	Potentially Hazardous or
3.		Time Sampled	# of Containers	Sample Matrix		nments/ Instructions	Y/N	Metals	Metals - BTEX, F7	VOC	PCBs: A	Regulation pH, Metals,	EC, SAR Regulation	Landfill	Corrosi	-	i K	Elec	Potentia
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Geotechnical Investigation – Proposed OC Transpo Electrical Bus Garage 1500 St. Laurent Boulevard, Ottawa, ON OTT-22007382-A0 November 26, 2024

# **Legal Notification**

This report was prepared by EXP Services for the account of City of Ottawa.

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