Geotechnical Investigation Report

Proposed WWTS Upgrades – 100 County Rd 64, Brighton

December 18, 2024

Prepared for:
J L Richards & Associates Limited

Cambium Reference: 19712-001

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1.0 Introduction

Cambium Inc. (Cambium) was retained by the J L Richards & Associates Ltd. (The Client) on behalf of the Municipality of Brighton, to complete a geotechnical investigation for the proposed improvements of the Wastewater Treatment System (WWTS) located at 100 County Road 64, in Brighton, Ontario. The location of the Site is shown on the attached Figure 1.

The geotechnical investigation was conducted in accordance with Cambium's proposal 19712-P Rev1, dated February 20, 2024.

The purpose of the field work and testing was to obtain information on the general subsurface soil and groundwater conditions at the site by means of a limited number of boreholes and laboratory tests. Based on an interpretation of the data available for this site, this report provides engineering comments, recommendations, and parameters for the geotechnical design aspects of the project, including selected construction considerations which could influence design decisions.

In addition to the proposed upgrades, the Client has requested preliminary recommendations and commentary regarding the relocation of a section of Arena Creek located north of the WWTS. The creek drains directly into Presqu-ile Bay of Lake Ontario. The fieldwork for the investigation of the relocation of the creek was completed concurrently with the fieldwork for the proposed upgrades. The results of the investigation for the creek relocation are provided under a separate report cover.

It should be noted that this report addresses only the geotechnical (physical) aspects of the subsurface conditions at the site. The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources, are beyond the terms of reference for our assignment and are not addressed herein.

This report provides the results of the geotechnical exploration and testing and should be read in conjunction with the *"Standard Limitations"* in Section 8.0 which forms an integral part of this document. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report. The data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location, or elevation, or if the project is not initiated within eighteen months of the date of the report, Cambium should be given an opportunity to confirm the recommendations in this report.

1.1 Reviewed Documents

The following project documents were received and reviewed during the drafting of this report:

[1] "Request for Proposal – Geotechnical and Hydrogeological" – Prepared by J.L. Richards, dated January 19, 2024, JLR No. 32296-001.

[2] "Brighton Wastewater Treatment System Municipal Class Environmental Assessment – Phase 2 Report – Final" – Prepared by J.L. Richards, dated August 2018, JLR No. 27271.

[3] "Class EA Addendum Report – Municipality of Brighton Wastewater Treatment System Class EA Addendum" – Prepared by J.L. Richards, dated December 22, 2022, JLR No. 31795-000.

[4] "Geotechnical Investigation Report – Harbour Street New Sewage Forcemain", Prepared by Cambium Inc., Dated 2021-06-25, Project No. 11897-001.

[5] "A-045163-TOPO_V3-WB", Topographic survey provided as CAD file via email by the Client, Dated 2024-01-24.

[6] "Brighton Wastewater Treatment System Upgrades", Drawings No. GA1, GA2, HP002, S200, S202, S300, S301, S302, S400, S401, S402, S500, S501, S503, S600, S601, S603, S800, and S802, Prepared by J.L. Richards in May 2024, not dated.

1.2 Standards and Guidelines

Applicable standards, guidelines and other normative documents utilized in preparing geotechnical engineering recommendations for this report are provided below.

[7] Canadian Foundation Engineering Manual – 5th Edition; Canadian Geotechnical Society; 2023.

2.0 Background

2.1 Site Description

The property is a 68-acre parcel of land with access off County Road 64 with the civic address of 100 County Road 64, Lot 33 and 34, Concession B, Municipality of Brighton, County of Northumberland, Ontario. The site is occupied by the current WWTS consisting of two lagoons: one large triangular shaped lagoon located on the southern side of the property, and one smaller rectangular lagoon located north of the larger lagoon. The property is occupied by multiple sea-can storage units and one single storey structure. Additionally, there is a decommissioned drying bed located west of the rectangular lagoon. The bed is an open-air concrete structure with a concrete floor slab. A gravel surfaced road provides access to the site, including the area of the proposed construction. There is a small, forested grove located within the site area as well.

Publicly available geology maps the area as being covered in glaciolacustrine sand deposits. Localized areas of alluvial cohesive deposits may be encountered as well. The underlying bedrock is mapped as limestone of the Lindsay Formation.

Cambium completed a previous geotechnical investigation at this property just south of the proposed site in 2021 [4]. Based on the results of nearby borehole data this investigation, the subsurface conditions in this area are anticipated to consist of a deposit of brown sandy silty gravel extending from the surface to 2.6 metres below ground surface (mbgs). The borehole was terminated at 2.6 mbgs due to practical refusal on presumed bedrock.

2.1 Project Description

Based on site plans and building sections provided by the Client [6], it is understood that the proposed development will consist of the following:

- Sewage pumping station with the underside of the foundations set at about 77 metres above sea level (mASL);
- Headworks building with the underside of foundations set at 82.4 mASL;

- Two aeration tanks with underside of slab set at 78.3 mASL;
- Two clarifier tanks with underside of slab set at 78.3 mASL;
- A maintenance and electrical tunnel will be constructed between the aeration and clarifier tanks set at the same elevation (78.3 mASL);
- A sludge hopper located west of the clarifier tanks, with the underside of the slab set at 76.8 mASL;
- A UV building with the underside of the foundations stepped from 80.1 mASL to 78.3 mASL;
- Structural process building with underside of slab set at 78.3 mASL;
- An administrative building with underside of foundations set at 82.5 mASL;
- New underground service lines, and;
- A new access roadway.

For reference, the proposed exterior grades adjacent to the structures are set ay 84 mASL.

3.0 Methodology

3.1 Borehole Investigation

Cambium completed the field investigation work at the site on February 20 to 23 and 27 to 28, 2024, to assess the subsurface conditions. A total of 20 boreholes were advanced across the site. Fifteen of the boreholes were advanced within the area of the proposed upgrades, subject of this investigation report, numbered BH101-24 through BH115-24. The other five boreholes (numbers BH116-24 through BH120-24) were advanced as part of the investigation for the proposed relocation of the creek and will be described in a separate report. The boreholes were advanced from depths ranging from approximately 1.5 to 9.2 mbgs. The approximate locations of the boreholes advanced are shown on the attached Figure 2.

Drilling and sampling were completed using a track mounted drill rig operating under the supervision of a Cambium geotechnical analyst. The boreholes were advanced to the sampling depths by means of continuous flight solid stem augers with 50 mm O.D. split spoon samplers. Standard Penetration Test (SPT) results (N-values) were recorded for the sampled intervals as the number of blows required to drive a split spoon sampler 305 mm into the soil, using a 63.5 kg drop hammer falling 750 mm, as per ASTM D1586 procedures. The SPT N-values were used in this report to estimate the relative density of the non-cohesive soil.

Practical refusal was encountered at several borehole locations. Details on practical refusal depths and locations are provided in Section 4.5. Following refusal, rock coring was completed at 3 of the locations to prove bedrock.

The encountered soil unit descriptions were logged in the field using visual and tactile methods, and samples were placed in labelled plastic bags for transport, future reference, laboratory testing, and storage. Open boreholes were checked for groundwater and general stability prior to backfilling. The boreholes were backfilled in accordance with O.Reg. 903, as amended. Four borehole locations were outfitted with groundwater monitoring wells, including nested wells screened at shallower elevations.

Records of the Borehole Logs are provided in Appendix A and Rock Core Logs are provided in Appendix B. Photographs of the rock cores are provided in Appendix C.

The spatial locations and elevations of the boreholes were surveyed by Cambium personnel. The elevations are referenced to the benchmark provided by the Client noted on the topographic survey [5]: the manhole on a concrete pad located on the property. An elevation of 82.95 mASL was indicated for the benchmark.

Locations of the individual boreholes are summarized in Table 1 below.

Table 1 Borehole Locations (UTM 18 T)

Borehole	Northing (m)	Easting (m)	Surface Elevation (mASL)
BH101-24	4879279	281792	85.1
BH102-24	4879300	281792	84.7
BH103-24	4879292	281781	84.5
BH104-24	4879292	281761	84.5
BH105-24	4879311	281766	85.3
BH106-24	4879316	281786	85.2
BH107-24	4879301	281704	84.8
BH108-24	4879277	281716	84.3
BH109-24	4879266	281696	83.9
BH110-24	4879259	281716	83.7
BH111-24	4879323	281711	84.9
BH112-24	4879342	281748	85.2
BH113-24	4879300	281813	84.7
BH114-24	4879269	281819	81.9
BH115-24	4879249	281784	82.1

3.2 Laboratory Testing

Laboratory soil testing included four Particle Size Distribution Analyses (LS 702), Natural Moisture Content Analyses (LS 701) on all samples, and Atterberg Limits testing (LS-703/704) on three samples. Results are presented in Appendix D and are summarized on the borehole logs and described in the subsequent sections of this report.

3.3 Multi-channel Analysis of Surface Waves

As part of this investigation, Multi-channel Analysis of Surface Waves (MASW) survey was completed on the site to evaluate the shear wave velocities of the subsurface materials and determine the seismic site class. The survey was completed on February 16, 2024, by Frontwave Geophysics Inc. A total of twenty-four geophones in 1 m spacing were placed in a single line across the site to acquire shear wave velocities and complete the testing. A report summarizing the testing was provided by Frontwave Geophysics Inc. and included as Appendix E in this report.

4.0 Subsurface Conditions

The subsurface soil, rock, and groundwater conditions encountered in the boreholes are presented on the attached Borehole Logs and Rock Core Logs. It is noted that the conditions indicated on the logs are for specific locations only and can vary between and beyond each location. The soil and rock boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change. In addition, the descriptions provided on the borehole logs are inferred from a variety of factors, including visual observations of the soil samples retrieved, laboratory testing, measurements prior to and after drilling, and the drilling process itself (drilling speed, shaking/grinding of the augers, etc.).

4.1 Topsoil

Topsoil was encountered from the surface of 9 borehole locations. Topsoil thickness ranges from 50 to 300 mm.

Assessments of organic matter content or other topsoil quality tests were beyond the scope of this study.

4.2 Asphaltic Concrete

Asphaltic concrete was encountered from the surface of BH110-24. The asphaltic concrete has been significantly broken up and appears very old. The thickness of the asphaltic concrete at this location measures 75 mm. Asphaltic concrete debris was also noted within the upper portions of the fill material encountered from the surface of BH115-24.

4.3 Fill Material

Fill material was encountered underlying surficial topsoil and asphaltic concrete or from the surface at all borehole locations.

The fill material varies in composition between borehole locations and with depth but is generally non cohesive across the site composed of silty sand and/or sandy silt with trace to some gravel and/or trace clay. The material is slightly plastic or cohesive at some locations, such as in BH106-24, BH107-24, BH109-24, and BH112-24. Additionally, fill material composed predominantly of sand and gravel was noted at the surface of some borehole locations such as in BH102-24, BH108-24, and BH111-24 through BH114-24. Organics and wood debris was also noted up to 2.0 and 2.5 mbgs in BH106-24 and BH112-24, respectively, indicative of possible buried topsoil. Asphaltic concrete was noted within the fill material in BH115-24. Further details on the composition of the fill material are provided on the respective borehole logs.

The fill material thickness where fully penetrated ranged from 0.7 to 3.1 m. BH111-24 and BH113-24 terminated within the fill material at 1.5 mbgs.

SPT N values measured in the fill material range from 5 to 53, indicative of the loose to very dense relative density. Where the fill material is cohesive, the N values indicate that the material is a firm consistency.

Laboratory particle size distribution analysis was completed on one sample of the fill material encountered within the existing roadway and the results are summarized in Table 2.

Table 2 Particle Size Distribution Results – Fill Material

Sample Location	Depth (mbgs)	Soil	% Gravel	% Sand	% Silt and Clay
BH108-24 SS1B	0.2 to 0.6	Silty gravelly sand	31	41	28

The results are compared to Ontario Provincial Standard Specifications (OPSS.MUNI) 1010 gradation envelopes of Granular A and Granular B Type I for reference on the results diagram in Appendix D.

4.4 Glacial Till

Native deposits of glacial till were encountered underlying the fill material at all borehole locations with the exception of BH111-24 and BH113-24 where the boreholes were terminated within the fill material.

Glacial till is a heterogeneous mixture of all grain sizes due to the nature of deposition. At this location the glacial till is generally composed of silty sand, gravelly to some gravel, with trace to some clay. Cobbles and boulders were also observed within the material. The upper portions of the glacial till deposit are cohesive in nature in boreholes BH101-24, BH104-24, BH106-24, BH112-24, and BH114-24. The deposit transitions to non-cohesive material at depths ranging from 2.4 to 4.6 mbgs at these locations.

The glacial till was encountered at depths ranging from 0.8 to 3.1 mbgs. Boreholes BH102-24, BH109-24, BH110-24, BH114-24, and BH115-24 terminated at depths ranging from 3.1 to 5.0 mbgs within the glacial till due to reaching target investigation depths. The remaining boreholes terminated due to practical refusal. Refusal does not necessarily indicate bedrock as refusal can also occur on cobbles or boulders within the glacial till. Refusal was also encountered in BH101-24, BH106-24, and BH107-24; however, rock coring was initiated following refusal to prove and qualify the bedrock.

Rock coring advanced in BH101-24 and BH106-24 encountered very dense glacial till in the upper core recovery, measuring a thickness of 0.7 and 2.1 m, respectively.

Based on the results from BH101-24, BH106-24, and BH107-24, where bedrock was cored and proven, the glacial till is estimated to have a thickness measuring 4.0 to 4.7 m.

SPT N values measured in the glacial till range from 9 to over 50. Lower N values are consistent with cohesive deposits, therefore based on the N values, the glacial till has a relative density of compact to very dense for the cohesionless deposits, and firm to stiff for the upper cohesive deposits.

Laboratory particle size distribution analysis was completed on three samples of the glacial till and the results are summarized in Table 3.

Table 3 Particle Size Distribution Results – Glacial Till

Sample Location	Depth (mbgs)	Soil	% Gravel	% Sand	% Silt	% Clay
BH101-24 SS4B	2.5 to 2.9	Silty gravelly sand, trace clay	24	36	32	8
BH101-24 SS6	4.6 to 5.0	Silty sand, some gravel, some clay	15	44	29	12
BH104-24 SS5	3.0 to 3.5	Gravelly silty sand, trace clay	31	36	27	6

Atterberg Limits Testing was also completed on the above samples of the glacial till to confirm the material's plasticity. The results of the testing are summarized in Table 4 below.

Table 4 Atterberg Limits Tests

Sample Location	Depth (mbgs)	Liquid Limit %	Plastic Limit %	Plasticity Index %	Natural Moisture Content %
BH101-24 SS4B	2.5 to 2.9	16.9	12.0	4.9	42.3
BH101-24 SS6	4.6 to 5.0	15.5	12.3	3.3	9.6
BH104-24 SS5	3.0 to 3.5	15.7	10.9	4.7	61.8

Based on the results of the Atterberg Limit tests, the upper portions of the glacial till can be considered cohesive silt that transition to a non-cohesive material with depth.

4.5 Bedrock/Practical Refusal

Practical refusal was encountered at 5 borehole locations (BH103-24 through BH105-24, BH108-24, and BH112-24). As noted in the previous section, refusal may occur on cobbles and/or boulders, or due to very dense glacial till, and as such, refusal depths may not indicate the top of the bedrock. BH101-24, BH106-24, and BH107-24 were cored in order to prove bedrock. BH101-24 and BH106-24 encountered very dense glacial till in the rock core runs extending deeper than the refusal depths. These very dense glacial till deposits extended 0.7 to 2.1 m deeper than the depth to refusal.

The depths and elevations to refusal and to the top of the bedrock surface are summarized in the Table 5 below.

Table 5 Depths/Elevation to Refusal or Top of Bedrock

Borehole Location	Depth/Elevation (mbgs/mASL.)
BH103-24	5.5/79.1
BH104-24	6.3/78.2
BH105-24	4.9/80.4
BH108-24	6.1/78.2
BH112-24	7.0/78.2
Cored and Proven Bedrock Depths	
BH101-24	6.5/78.6
BH106-24	7.8/77.5
BH107-24	5.0/79.8

The bedrock beneath the site is of the Lindsay Formation, which is a deposit comprised predominantly of limestone bedrock of the Ordovician age. The limestone may contain thin layers of shale which are typically significant weaker in strength than the limestone, however no significantly thick layers of shale were noted.

There is typically a weathered zone at the contact between the top of the bedrock and the overlying overburden material. The subsurface conditions transition from glacial till to the bedrock and a zone of very dense glacial till was encountered in BH101-24 and BH106-24. Therefore, it should be anticipated that the upper portions of the limestone bedrock will be significantly weathered as the material transitions from deposition to sound bedrock.

Rock Quality Designation (RQD) refers to the total length of those pieces of sound core which are 100 mm or greater in length in the core run, expressed as a percentage of the total length of that core run. Sound pieces of rock are those pieces separated by natural fractures or bedding. The RQD from the bedrock at this site ranged from 0 % to 78 %, indicative of a variable very poor to good quality. It should be noted that Run 2 of BH107-24 encountered a heavily fractured, almost rubblized zone. Omitting the core samples from this run, the RQD varies from 35 % to 78 %.

One sample of the limestone bedrock taken at about 5.7 mbgs was submitted for testing of unconfined compressive strength. The results are provided in Appendix D. The bedrock provided an unconfined compressive strength (UCS) of 129 MPa, indicative that the material is very strong.

4.6 Groundwater

Stabilized groundwater measurements were taken from the groundwater monitoring wells prior to fieldwork being completed on each well as part of the hydrogeological investigation. provides the measured stabilized groundwater levels.

Table 6 Summary of Groundwater Level Measurements

Borehole	Screened Subsurface Stratum	Depth of Well (mbgs)	Groundwater Level (mbgs) / Elevation (mASL)
			March 5th, 2024
BH101-24	Limestone Bedrock	8.1	2.9/82.2
BH101-24	Glacial Till	5.1	3.7/81.4
BH106-24	Limestone Bedrock	7.5	3.3/81.9
BH106-24	Glacial Till	5.5	2.3/82.9
BH107-24	Limestone Bedrock	8.9	3.3/81.5
BH107-24	Glacial Till	5.2	3.4/81.4
BH112-24	Glacial Till	6.8	2.3/82.9
BH112-24	Glacial Till	4.6	2.3/82.9

Based on the above, groundwater was observed within the overburden and bedrock at a depth of around 82 mASL ±1m.

Observations were also made in each borehole for groundwater levels and borehole sidewall integrity (caving) immediately following drilling. Comments on these observations can be found on the attached borehole logs.

Seasonal fluctuations and precipitation events may cause significant changes to the depth of the groundwater table over time.

4.7 Chemical Analysis

4.7.1 Corrosivity Analysis

One soil sample from BH106-24 was submitted to CALA certified SGS Laboratories for chemical corrosivity analysis. The laboratory results are presented in the Appendix F. The samples were analysed for chloride, sulphate, pH, electrical conductivity, resistivity, redox potential, and sulphide concentrations. The submitted sample, SS5 from BH106-24 was taken from a depth of 3.1 m to 3.4 mbgs.

To determine the potential for corrosion, the laboratory results were compared to the ANSI/AWWA corrosivity rating system, as shown on the following table. Based on the total points scored, the soil is determined to be virtually not corrosive.

Table 7 Corrosivity Results

Parameter	**BH102-13**	
	Test Results	**ANSI/AWWA Point Rating**
Resistivity (Ω·cm)	5,030	0
pH	8.34	0
Redox Potential (mV)	212	0
Sulphide	Negligeable	0
Moisture Content	9.4%	1
Total Points		**1**

Please note that there may be other overriding factors in the assessment of corrosion potential, such as the nature of effluent conveyed, the application of de-icing salts on any access roads and subsequent leaching into the subsoils and stray currents.

The laboratory test results also indicate that the soluble sulphates concentration of the tested samples is approximately 68 ppm. Based on this concentration, there is a negligible potential for sulphate attack on concrete. Accordingly, normal Type 10 Portland cement can be used in concrete.

5.0 Geotechnical Design Considerations

The following discussion and recommendations are based on factual data from this investigation and are intended to assist designers. These recommendations are for planning and design purposes only.

This report assumes that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards, and guidelines of practice. Recommendations should not be construed as providing instructions to contractors, who should form their own opinions about site conditions. It is possible that subsurface conditions beyond the borehole locations may vary from those observed. If significant variations are found before or during construction, or if there are significant changes to site development features, Cambium should be retained to review the implications of these changes with respect to the contents of this report.

5.1 Project Understanding & Assumptions

The purpose of the investigation is to summarize the obtained factual data of the site conditions at the time of study to provide geotechnical input into future development of the site. It is noted that at the time of preparing, the pre-30%% design drawings [6] had been completed and provided for review. Based on the iteration, the following is proposed for the improvements to the site:

- Sewage pumping station with the underside of the foundations set at about 77 mASL;
- Headworks building with the underside of foundations set at 82.4 mASL;
- Two aeration tanks with underside of slab set at 78.3 mASL;
- Two clarifier tanks with underside of slab set at 78.3 mASL;
- A maintenance and electrical tunnel will be constructed between the aeration and clarifier tanks set at the same elevation (78.3 mASL);
- A sludge hopper located west of the clarifier tanks, with the underside of the slab set at 76.8 mASL;

- A UV building with the underside of the foundations stepped from 80.1 mASL to 78.3 mASL;
- Structural process building with underside of slab set at 78.3 mASL;
- An administrative building with underside of foundations set at 82.5 mASL;
- New underground service lines, and;
- A new access roadway.

Exterior grades adjacent to the proposed improvements are planned to be set at 84 mASL.

5.2 Frost Penetration

Based on climate data and the Ontario Provincial Standard Drawing (OPSD) 3090.101, the typical frost penetration depth is estimated at 1.4 mbgs for both heated and unheated structures. Foundations and underground utilities connected to the structure should be founded below the frost penetration depths or be adequately insulated.

5.3 Overburden Excavations

All excavations must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA). The existing fill materials and glacial tills may be classified as Type 3 soils above the groundwater table in accordance with OHSA. Below the groundwater, the overburden soils may be classified as Type 4 soils.

Type 3 soils may be excavated with side slopes no steeper than 1H:1V.

Type 4 soils may be excavated with side slopes no steeper than 3H:1V.

Excavation side slopes should be protected from exposure to precipitation and associated ground surface runoff and should be inspected regularly for signs of instability. If localized instability is noted during excavation or if wet conditions are encountered, the side slopes should be flattened as required to maintain safe working conditions or the excavation sidewalls must be fully supported (shored). General discussion on shoring is provided in Section 5.4.

Large sized particles (cobbles and boulders) should be anticipated from within the glacial till deposits. The size and distribution of particles of this size cannot be predicted with boreholes as the sampler size is insufficient to secure samples of this particle size. It is therefore recommended that provisions are made in contracts for the additional time and materials required for removal of such obstructions within the material.

5.4 Bedrock Excavation and General Shoring Commentary

Based on the results of the investigation, bedrock excavation will likely only be a requirement for the proposed pump station founded at about 77 mASL and the lower portions of the aeration and clarifier tanks.

Excavations extending into the bedrock will extend through the limestone formation. The limestone bedrock encountered within the anticipated excavation depths at these locations are heavily fractured. Additionally, some areas of the site encountered very dense glacial till following auger refusal, and therefore anticipated bedrock depths may be within very dense glacial till. The excavation work could therefore be completed using conventional rock excavation techniques such as hoe ramming and/or line drilling.

Excavations into the rock can be completed using near vertical sidewalls, provided that the rock faces are scaled and maintained to preclude spalling of the rock face, in combination with appropriate excavation practices to support the overburden: either open excavations or shored. Line drilling should be utilized with closer spacing along the perimeter of the excavation to maintain the excavation footprint and reduce overbreaking.

Design of any shoring systems must be completed by an experienced geostructural contractor. Cambium can provide a list of potential design consultants that can provide such services. It is recommended that a successful bidder submit a shoring system design which includes anticipated lateral earth pressures design details, movement tolerances, and a monitoring plan for review prior to construction.

Any shoring system(s) chosen to support the excavation must consider the soil and bedrock stratigraphy, groundwater conditions, groundwater management, and possible movement associated with construction of the respective shoring system(s).

It should be noted that the site is underlain by very dense glacial till that may be confused for bedrock due to the density of the material. The contact between the underside of the glacial till and the top of sound bedrock should be verified at the time of installation.

The type of shoring system will be chosen by the shoring designer.

5.5 Dewatering and Groundwater Management

The measured groundwater levels appear to be consistent across the site at about 82 mASL ±1m.

Cambium is completing a hydrogeological investigation concurrently with the geotechnical investigation. The report for the hydrogeological investigation will provide information on the anticipated dewatering requirements for the proposed excavation work. Monitoring wells drilled as part of the investigation will remain on site to be used by future contractors as needed.

Due to the measured piezometric level and the proposed depth of the structures, any excavation should not extend below groundwater levels prior to depressurizing. For all construction to be founded on overburden soils, groundwater levels must be maintained at least 1.0 m below the lowest excavation elevation during construction, If the excavation progresses into the glacial till below the groundwater table without depressurization, the cohesionless soils will becomes disturbed be the ingress of water from the sides and base of the excavation and the recommendations for bearing capacities of the native soils will not be valid. The installation of a skim coat of lean mix concrete (mud-slab) in combination with active pumping may be used to preserve subgrade integrity and provide a trafficable surface.

Cambium should review the dewatering plan prior to start of excavation work, to determine if the proposed plan will be sufficient to prevent any disturbance to supporting stratum.

Flows from pumps during excavation and construction may require a Permit to Take Water (PTTW). Further discussion regarding the anticipated groundwater pumping is provided in our hydrogeological report.

5.6 Foundation Design

5.6.1 Bearing Capacities

Foundations for the proposed structures, continuous perimeter strip footings and/or spread foundations will be founded at different elevations depending on the proposed building. Foundations for all structures should be founded directly on native undisturbed deposits. Foundations made to bear directly on the dense to very dense glacial till can be sized using a net geotechnical reaction at **SLS** of **400 kPa** and factored geotechnical resistance at ULS of **600 kPa**. Settlement potential at these loading conditions should be less than 25 mm and differential settlement should be less than 20 mm.

Foundations made to bear directly on the underlying bedrock composed of limestone may be designed for an allowable bearing capacity of **1 MPa** at ultimate limit state (**ULS**). Plate load testing was not completed on the underlying bedrock. Considering bedrock is non-yielding the load required for 25 mm of compression would exceed the capacity of the founding element. Therefore, the geotechnical reaction at SLS should be assumed 0.6 times the factored geotechnical resistance at ULS (**600 kPa**) for design purposes.

Where required, where the proposed founding levels are above the level of the top of native undisturbed soils, or where subexcavation is required, footings can be made to bear directly on a pad of Engineered Fill such as that conforming to OPSS.MUNI 1010 Granular B Type II. Any engineered fill placed below proposed foundations should consist of 100% crushed rock, such as crusher run limestone (CRL) and should be placed directly on undisturbed native glacial till or directly on sound bedrock. The imported engineered fill should be placed in maximum 200 mm thick lifts to at least 99 % of the standard proctor maximum dry density (SPMDD) value. To allow for adequate spread of the loading below and beyond the footings, the engineered fill should extend a horizontal distance of at least 300 mm beyond the edge of the footings and then down and away from the edges at an angle of 1H:1V, or flatter. Excavations should be sized to accommodate fill placement. Foundations made on top of adequately compacted engineered fill should be sized using a net reaction at **SLS** of **150 kPa** and factored geotechnical resistance at **ULS** of **225 kPa**. Settlement potential at these loading conditions should be less than 25 mm and differential settlement should be less than 20 mm.

Table 8 below provides the depth and elevation of the native soils/bedrock that provide the above-described allowable bearing capacities. Foundations should be constructed within the elevations provided below, per location, as required.

Table 8 Depth to Undisturbed Dense Glacial Till/Possible Bedrock

Borehole	Proposed Structure (Anticipated Founding Elevation)	Founding Material[1]	Depth (mbgs)	Elevation (mASL)
BH101-24	Process Building (78.3 mASL)	Glacial Till	4.6	80.5
		Bedrock	6.5	78.6
BH102-24	Aeration Tank #1 (78.3 mASL)	Glacial Till	4.6	80.1
		Bedrock	5.0	79.6
BH103-24	Clarifier Tank #1 (78.3 mASL)	Glacial Till	4.6	79.9
		Bedrock	5.5	79.1
BH104-24	Clarifier Tank #3 (78.3 mASL)	Glacial Till	4.6	79.3
		Bedrock	6.3	77.6
BH105-24	Headworks Building/Aeration Tank #1 (82.4 mASL/78.3 mASL)	Glacial Till	3.1	82.3
		Bedrock	4.9	80.4
BH106-24	Aeration Tank #2 (78.3mASL)	Glacial Till	5.7	79.5
		Bedrock	7.8	77.5
BH107-24	Sewage Pumping Station (77 mASL)	Glacial Till	2.3	82.5
		Bedrock	5.0	79.8
BH108-24	Admin building (82.5 mASL)	Glacial Till	0.8	83.5
BH109-24	Admin Building (82.5 mASL)	Glacial Till	1.5	82.5
BH110-24	Admin Building (82.5 mASL)	Glacial Till	0.8	83.0
BH112-24	-	Glacial Till	4.6	80.6
		Bedrock	7.0	78.2

Notes:

1. Bedrock was cored and proven exclusively in boreholes BH101-24, BH106-24, and BH107-24. The results of the rock coring indicate that very dense glacial till may be encountered at the presumed bedrock depths at other borehole locations where practical refusal was encountered. The depths and elevations provided for bedrock at other locations should therefore be considered approximate and additional subexcavation may be required.

5.6.2 Foundation Transitions Between Different Subgrade Materials

To reduce cracking in the footings, foundation walls, and concrete slab on grades where footings change between different subgrade materials, suitable transition zones should be created and the footings adequately reinforced.

It is understood that the Headworks Building and UV Building will have higher founding elevations along the west sides of the structures at 82.4 mASL and 80.1 mASL, respectively, and that the east sides of the buildings will be supported at the same elevations as the adjacent clarifier and aeration tanks (78.3 mASL). In order to reduce differential settlement it is recommended that the foundations are extended to be supported on the underlying very dense glacial till. Based on our subsurface information, this would be set at an elevation of about 79.5 mASL for the UV Building, and an elevation of about 80.5 mASL for the Headworks Building. It is further recommended that the foundations along the east side founded on the glacial till be designed with reduced bearing capacity, for reduced settlements of 12.5 mm. These foundations placed on the dense to very dense glacial till can be sized using a net geotechnical reaction at **SLS** of **200 kPa** and factored geotechnical resistance at ULS of **300 kPa.**

Alternatively, if shallow foundations cannot be extended, consideration could be given to the use of helical piles or micropiles. These deep foundation systems are typically proprietary, designed and installed by a specialized contractor / supplier. A specialized pile contractor should be contacted to provide a design build fee proposal for the work. To verify that the piles are installed in accordance with design assumptions, monitoring of the pile installations by an experienced inspector is recommended.

5.6.3 Stepped Footings

Footings stepped from one level to another must be at a slope not exceeding 10H:7V from the outside edges of each foundation.

5.6.4 Uplift Forces

It is recommended that, for design purposes, the groundwater level is assumed to be at least 1.5 m higher than the recorded groundwater elevations at this site (82 mASL), to compute buoyant uplift forces on the buildings and tanks.

Rock anchors could be used to prevent buoyant uplift of the building. Anchors should be suitably sized and consider the following possible modes of failure:

- Anchor tendon failure;
- Pull out along the tendon/grout contact;
- Pull out along the grout/bedrock contact;
- Rock cone failure; or,
- Corrosion of the anchor.

Anchors made into the bedrock may be designed using a ULS working adhesion of 500 kPa. The unconfined compressive strength of the grout used should be at least 30 times the design working adhesion. The installation of the anchors should be tested to at least 133 % of the design load. Embedment depth of the rock anchors will depend on required loads however a minimum of 2.1 m is recommended for this site. Minimal distance between 2 anchors should be at least 4 times the diameter of the anchor hole to negate group effects. Two adjacent rock anchors will have to be tested simultaneously to observe group effect conditions.

It is not anticipated that basal heaving of the sound bedrock subgrade will be a factor during construction. It is recommended that this is verified following excavation to ensure no movement occurs following pressure relief of the overburden.

5.7 Earthquake Design

The NBCC (2020) stipulates the methodology for earthquake design analysis, as set out in Subsection 4.1.8. The determination of the type of analysis is predicated on the importance of the structure, the spectral response acceleration, and the site classification.

The parameters for determination of Site Classification for Seismic Site Response are set out in Table 4.1.8.4 of the NBCC (2020) The classification is based on the determination of the average shear wave velocity in the top 30 m of the site stratigraphy underlying the foundation base, where shear wave velocity (V_s) measurements have been taken. Alternatively, the classification can be estimated based on rational analysis of undrained shear strength in cohesive deposits (s_u) or penetration resistance (N-values).

$$\upsilon_{s-avg} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{\upsilon_{si}}} \qquad S_{u-avg} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{s_{ui}}} \qquad N_{avg} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

Shear wave velocity **Undrained shear strength** **SPT N-values**

An MASW survey was completed at this site to measure the average V_s of the upper 30 m of the site stratigraphy. The results of this survey indicate an average V_s of 994 m/s for the equivalent single layer response between the surface and 30 m in depth. The foundations for the proposed buildings will range in depth from at grade structures to buildings founded on the underlying limestone bedrock. Therefore, the designation of the seismic analysis can also vary depending on founding depths. For structures with greater than 3 m of overburden soils between the base of the foundations and the top of the bedrock, these structures may be designed as Site Class C, as per Table 4.1.8.4 of the National Building Code of Canada. For any structures with less than 3 m of overburden, the seismic Site Class B may be applied for design.

It is understood that the pump station, processing building, and tanks will likely be founded on the underlying bedrock due to the required founding elevation. For structures founded directly on the limestone bedrock, provided that the bedrock is sound bedrock, and inspected and approved by a geotechnical engineer, a Site Class A may be applied in design.

5.8 Backfill, Compaction and Lateral Pressures

The lateral earth pressure resulting from the weight of the retained earth and other surrounding surcharge loads need be considered in both the designs of structures. The guidelines below are provided to assist with the designs.

Table 9 Lateral Earth Pressure Coefficients

Material	γ	φ	K_a	K_o	K_p
Existing Earth Fill	20	29	0.35	0.52	2.88
Granular Backfill	21	32	0.31	0.47	3.25

Where:

γ = bulk unit weight of soil (kN/m^3)

φ = internal angle of friction (degrees)

K_a = Rankine active earth pressure coefficient (dimensionless)

K_o = Rankine at-rest earth pressure coefficient (dimensionless)

K_p = Rankine passive earth pressure coefficient (dimensionless)

All backfill against the structures should consist of free draining non-frost susceptible engineered fill such as that composed of OPSS.MUNI Granular B Type I or II. The existing fill material may be reusable as backfill in combination with bond break in the upper 1.4 m, provided the material is sorted, stockpiled, tested and approved by geotechnical personnel. Organics were noted within the fill material at varying depths and should not be used as backfill against the structure.

Typically, backfill should be placed in maximum 200 mm thick lifts and should be compacted to a minimum of 95% of SPMDD under landscaped areas and 98% of SPMDD under hardscaped areas. Light, walk behind compaction equipment should be used in proximity to foundation walls.

The above earth pressure parameters pertain to a horizontal grade condition behind a retaining structure. Values of earth pressure parameters for an inclined retained grade condition will vary.

Walls subject to unbalanced earth pressures must be designed to resist a pressure that can be calculated based on the following equation:

$$P = K[\gamma(h - h_w) + \gamma' h_w + q] + \gamma_w h_w$$

Where: P = the horizontal pressure at depth, h (m)

K = the earth pressure coefficient

h_w = the depth below the ground water level (m)

γ = the bulk unit weight of soil, (kN/m^3)

γ' = the submerged unit weight of the exterior soil, (γ_{sat} - 10 kN/m^3)

q = the complete surcharge loading (kPa)

If the proposed structures are made as waterproof buildings, the maximum exterior groundwater pressures should be used in design of the foundation walls.

The empirical approach for the design of subsurface walls below bedrock level is to use a uniform pressure distribution consistent with the maximum earth pressure calculated for the lowest level of the soil profile plus the groundwater pressure based on depth. This approach is likely conservative considering the composition of the bedrock.

An additional surcharge load of 10 kPa should be incorporated in design to account for compaction induced forces on walls.

5.8.1 Dynamic Earth Pressure Coefficients for Seismic Forces

The corresponding coefficients to be used in the design of retaining walls subject to dynamic forces from a seismic event are tabulated as follows in Table 10.

Table 10 Seismic Earth Pressure Coefficients

Material	K_{ae}	K_{pe}
Earth Backfill	0.49	2.46

According to the National Building Code of Canada, the PGA at the site location is measured at 0.177 for measured average shear wave velocity of the site at founding level. The dynamic earth pressure coefficients were calculated using the method suggested by Mononobe and Okabe. The following assumptions were made for the value provided above:

- The horizontal seismic coefficient, kh, of 0.116 (taken conservatively as the PGA);
- The vertical seismic coefficient, kv, of 0;
- The angle of inclination of the wall at 90 degrees;
- The grade against the wall has an angle of 0 degrees, and;
- The friction between the wall surface and the backfill has not been included.

5.9 Floor Slabs

The deflections and the resulting forces and bending moments in the slab to be used in its structural design could be determined by structural analysis using a modulus of subgrade reaction, K_v, for the subgrade. However, the modulus of subgrade reaction is not a fundamental soil property, and its value depends, in part, on the size and shape of the slab. For the analysis of the contact stress distribution beneath a slab, its value would depend on the size of the areas over which increased/concentrated contact stresses are anticipated; the size of these areas is in turn related to the value the modulus of subgrade reaction. Accordingly, the analysis of the slab should involve an iterative analysis between the determination of the contact stress distribution by the structural engineer and the geotechnical determination of the modulus of subgrade reaction value, until these two are consistent with each other.

All organic material and disturbed materials must be removed prior to constructing the slab on grade. These materials do not constitute an adequate subgrade for support of a slab on grade. The subgrade for the slab must be cut-neat, proof rolled, and inspected by Cambium, prior to the placement of an aggregate base. The subgrade should be proof rolled using a static smooth drum roller. If any soft or weak subgrade areas are identified, or if there are areas containing excessive amounts of deleterious/organic material or moisture, they must be locally sub-excavated and backfilled with approved clean earth fill or engineered fill such as OPSS Granular B (Type I or II) and compacted to a minimum 98% of SPMDD.

5.9.1 Floor Slabs Below Grade

The floor slabs for the buildings proposed below grade will be founded on the underlying very dense glacial till. These materials constitute adequate subgrade for the support of floor slabs. The modulus of subgrade reaction appropriate for the design is provided below:

- Very dense glacial till 60,000 kPa/m.

It is not anticipated that the deeper structures will require ongoing drainage, as this will likely not be feasible due to the depth of the prevailing groundwater table and the proximity to the adjacent lagoons. It is assumed that these structures will be constructed as a waterproof structures. If ongoing drainage is to be included as part of design, additional recommendations can be provided.

5.9.2 Slab on Grade

The floor slab should be supported on compacted engineered fill such as material meeting OPSS 1010 Granular A or B Type II.

For initial analyses, the moduli of subgrade reaction appropriate for slab on grade design on the soils at the site are as follows:

- Engineered Fill: 28,000 kPa/m

It is necessary that the slab be provided with a capillary moisture barrier and drainage layer. This is made by placing the slab on a minimum 200 mm layer of 19 mm diameter crushed clear stone and nominally compacted by vibration to a dense state. A geotextile separator (Terrafix 270R or equivalent) is recommended between the granular material/clearstone and the native subgrade soils.

Perimeter drainage is not considered necessary for slab on grade structures, provided that the finished floor elevations is set at least 300 mm higher than surrounding grades.

5.10 Buried Services

5.10.1 Excavation and Dewatering

Excavations for proposed site services should adhere to the recommendations provided in Sections 4.1 and 4.2.

5.10.2 Bedding

Based on the result of the investigation, the underlying undisturbed native glacial till will provide adequate support for buried services on conventional well graded granular base material.

Granular bedding material should consist of a conventional Class ‘B’ bedding, such as OPSS.MUNI 1010 Granular A. The use of 19 mm clear stone (OPSS.MUNI 1004) as bedding is also acceptable for services, provided that the bedding is wrapped in suitable geotextile filter (Terrafix 360R or equivalent). The bedding materials should be compacted to a minimum 95% of SPMDD. Clear stone bedding material should be nominally compacted to a dense state.

5.10.3 Trench Backfill

In general, excavated soils encountered on site may be re-used as backfill, provided the moisture content of these materials is within 2% of optimum to ensure adequate compaction, the trenches are wide enough to accommodate large compaction equipment, and the soil is free of any organic material. Soils with elevated moisture could be put aside to dry, tilled to reduce the moisture content so that they can be effectively compacted, or could be mixed with dryer material. Alternatively, materials of higher moisture content could be wasted and replaced with imported material which can be readily compacted.

The backfill should consist of clean earth fill and should be placed in lifts of 150 mm thickness or less and compacted to a minimum 95% of SPMDD (in settlement sensitive areas) and 90% of SPMDD (in non-settlement sensitive areas) at a water content within 2% of optimum. Existing earth fill and native soils will be difficult to place and compact successfully in narrow trench excavations, where large compaction equipment could not operate. For narrow trench excavations, it is recommended that free draining granular material, such as OPSS.MUNI 1010 Granular B Type I or II be used in order to allow for adequate compaction using walk behind vibratory equipment.

The placement and inspection of any earth fill as backfill must be conducted under the full-time observation of Cambium.

5.11 Pavement Design Consideration

5.11.1 Subgrade Preparation

The performance of the pavement is dependent upon proper subgrade preparation. The existing fill material may remain, depending on the condition of the material. All topsoil and organic materials are to be removed from the subgrade. The subgrade should be proof rolled and inspected by Cambium personnel. Any areas where rutting or appreciable deflection is noted should be sub-excavated and replaced with suitable earth fill. The earth fill may be taken from other parts of the site for reuse. The fill should be compacted to at least 98% of SPMDD.

The most severe loading conditions on pavement subgrades may occur during construction, and subgrades may become disturbed due to construction operations. Therefore, the recommended pavement structure provided may not be adequate due to the presence of localized disturbed areas and it may be necessary to increase the thickness of the Granular B Type II subbase and/or incorporate a woven geotextile separator between the subgrade surface and the granular base. The requirement for an increase in the pavement structure and/or incorporating geotextile will be evaluated by Cambium personnel during proof roll inspections.

5.11.2 Flexible Pavement Structure

The pavement structure recommended in Table 11 below assumes that traffic flow for the proposed access roadway will be limited to periodic commercial vehicles and that the subgrades will be prepared as described above. More detailed information on the anticipated traffic volumes should be provided and the following pavement structure reviewed.

Table 11 Recommended Minimum Pavement Structure

Pavement Layer	Thickness and Material
Surface Course Asphalt	40 mm HL3 or HL4
Binder Course Asphalt	60 mm HL8
Granular Base	150 mm OPSS 1010 Granular A
Granular Subbase	350 mm OPSS 1010 Granular B

Material and thickness substitutions must be approved by the Design Engineer. The thickness of the subbase layer could also be increased at the discretion of the Engineer, to accommodate site conditions at the time of construction, including soft or weak subgrade soil replacement.

Compaction of the subgrade should be verified by the Engineer prior to placing the granular fill. Granular layers should be placed in no more than 300 mm thick lifts and compacted to at least 98% of SPMDD (ASTM D698) standard. The granular materials specified should conform to OPSS standards, as confirmed by appropriate materials testing.

5.11.3 Pavement Drainage

The design of a storm water management system is beyond the scope of this investigation, however it is recommended that the subgrade, subbase, base, and asphalt surfaces should be shaped and crowned to promote drainage of the pavement structure.

6.0 Limitations and Use of Report

This geotechnical engineering report intended for planning and design purposes only. This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by engineering practitioners. The discussion and recommendations that have been presented are based on factual data obtained from this investigation.

6.1 Design Review and Inspections

Cambium should be contacted to review and approve design drawings, prior to tendering or commencing construction, to ensure that all pertinent geotechnical-related factors have been addressed. It is important that onsite geotechnical supervision be provided at this site for excavation and backfill procedures, deleterious soil removal, subgrade inspections and compaction testing.

6.2 Changes in Site and Project Scope

Subsurface conditions can be altered by the passage of sufficient time, natural occurrences, and human intervention. In particular, consideration should be given to contractual responsibilities as they relate to control of groundwater seepage, disturbance of soils, and frost protection.

The design parameters provided, and the engineering advice offered in this report are intended for use by the owner and its retained design consultants. If there are changes to the project scope and development features, these interpretations made of the subsurface information, for geotechnical design parameters, advice, and comments relating to constructability issues and quality control may not be complete for the project. Cambium should be retained to conduct further review to interpret the implications of such changes with respect to this report.

7.0 Closing

Please note that this work program and report are governed by the attached Qualifications and Limitations. If you have questions or comments regarding this document, please do not hesitate to contact the undersigned at (705) 742-7900.

Respectfully submitted,

Cambium Inc.

DS

LICENSED PROFESSIONAL ENGINEER
B. VIJAYABASKARAN
100216716
PROVINCE OF ONTARIO

2024-12-18

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8.0 Standard Limitations

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Site Assessments

A site assessment is created using data and information collected during the investigation of a site and based on conditions encountered at the time and particular locations at which fieldwork is conducted. The information, sample results and data collected represent the conditions only at the specific times at which and at those specific locations from which the information, samples and data were obtained and the information, sample results and data may vary at other locations and times. To the extent that Cambium's work or report considers any locations or times other than those from which information, sample results and data was specifically received, the work or report is based on a reasonable extrapolation from such information, sample results and data but the actual conditions encountered may vary from those extrapolations.

Only conditions at the site and locations chosen for study by the client are evaluated; no adjacent or other properties are evaluated unless specifically requested by the client. Any physical or other aspects of the site chosen for study by the client, or any other matter not specifically addressed in a report prepared by Cambium, are beyond the scope of the work performed by Cambium and such matters have not been investigated or addressed.

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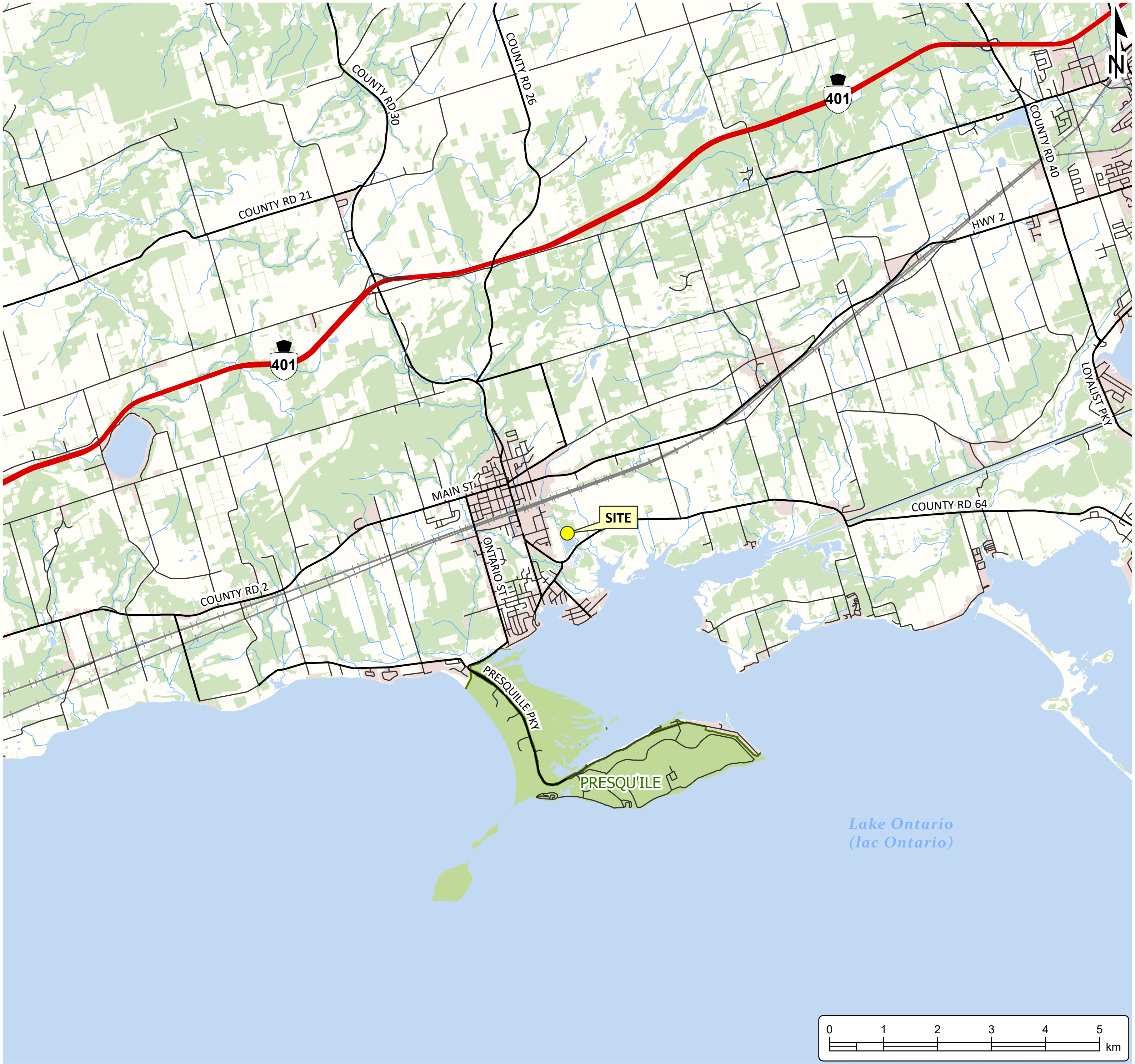
The client expressly agrees that Cambium employees shall have no personal liability to the client with respect to a claim, whether in contract, tort and/or other cause of action in law. Furthermore, the client agrees that it will bring no proceedings nor take any action in any court of law against Cambium employees in their personal capacity.

Appended Figures



GEOTECHNICAL INVESTIGATION

J L RICHARDS & ASSOCIATES LTD.
100 Concession Road 64
Brighton, Ontario

LEGEND

- Highway
- Major Road
- Minor Road
- Railway
- Watercourse
- Water Area
- First Nations Reserve
- Provincial Park
- Wooded Area
- Built Up Area

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SITE LOCATION PLAN

Project No.: 19712-001	Date: March 2024 Rev.:
Scale: 1:100,000	Projection: NAD 1983 UTM Zone 18N

Created by: DBB	Checked by: BVJ	Figure: 1

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GEOTECHNICAL INVESTIGATION

J L RICHARDS & ASSOCIATES LTD.
100 Concession Road 64
Brighton, Ontario

LEGEND

△ Benchmark
⊕ Borehole

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BOREHOLE LOCATION PLAN

Project No.: 19712-001
Date: March 2024
Rev.:
Scale: 1:1,500
Projection: NAD 1983 UTM Zone 18N
Created by: DBB
Checked by: BVJ
Figure: 2

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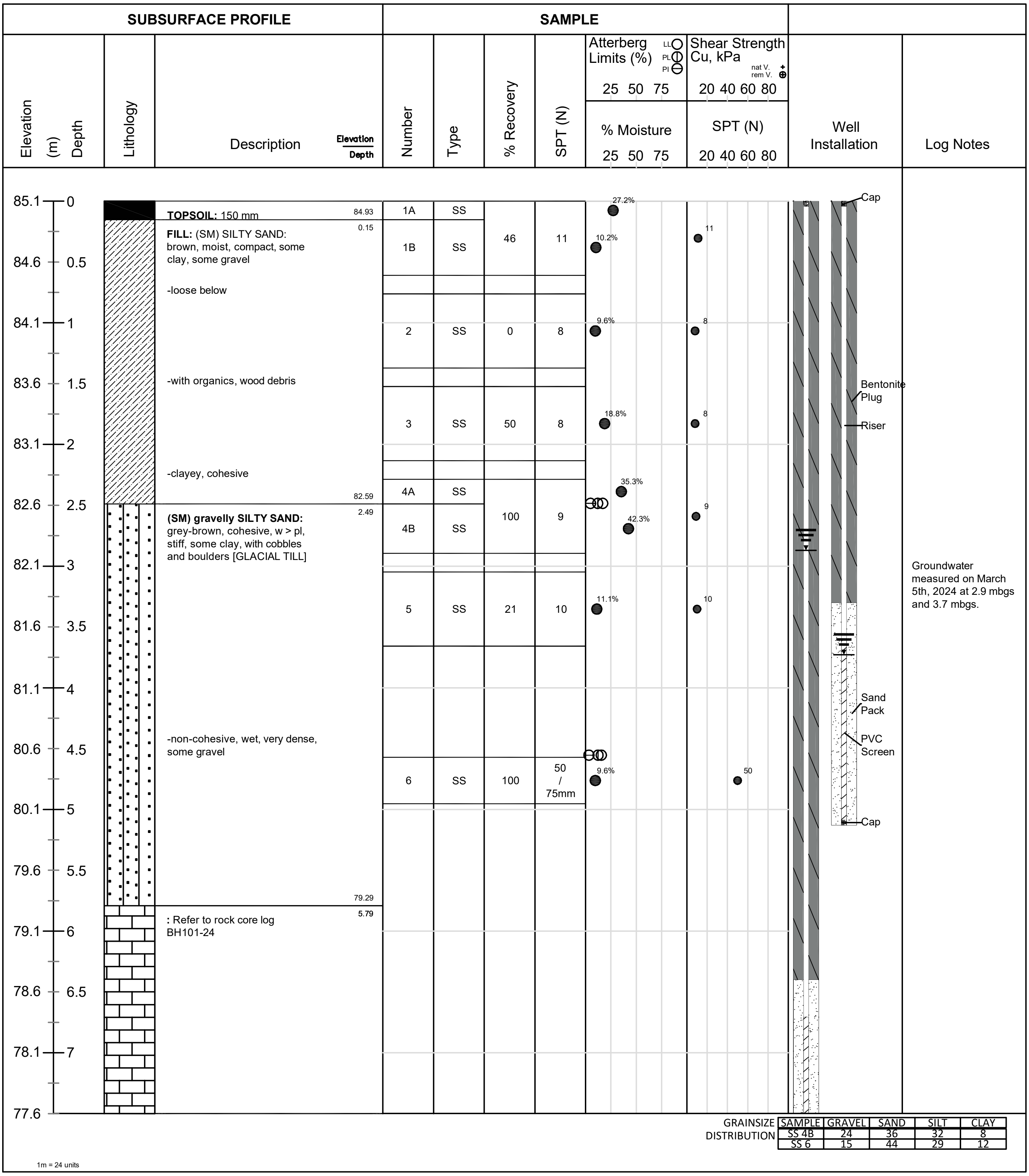
Appendix A

Borehole Logs

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 85.08 mASL
UTM: 18 T **N:** 4879279 **E:** 281792

Log of Borehole: BH101-24
Page: 1 of 2
Date Completed: February 20, 2024



Elevation / Depth	Description
84.93 0.15	**TOPSOIL:** 150 mm
	FILL: (SM) SILTY SAND: brown, moist, compact, some clay, some gravel -loose below -with organics, wood debris -clayey, cohesive
82.59 2.49	**(SM) gravelly SILTY SAND:** grey-brown, cohesive, w > pl, stiff, some clay, with cobbles and boulders [GLACIAL TILL] -non-cohesive, wet, very dense, some gravel
79.29 5.79	: Refer to rock core log BH101-24

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N)
1A	SS			27.2%	
1B	SS	46	11	10.2%	11
2	SS	0	8	9.6%	8
3	SS	50	8	18.8%	8
4A	SS			35.3%	
4B	SS	100	9	42.3%	9
5	SS	21	10	11.1%	10
6	SS	100	50 / 75mm	9.6%	50

Groundwater measured on March 5th, 2024 at 2.9 mbgs and 3.7 mbgs.

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 4B	24	36	32	8
SS 6	15	44	29	12

Logged By: RR **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

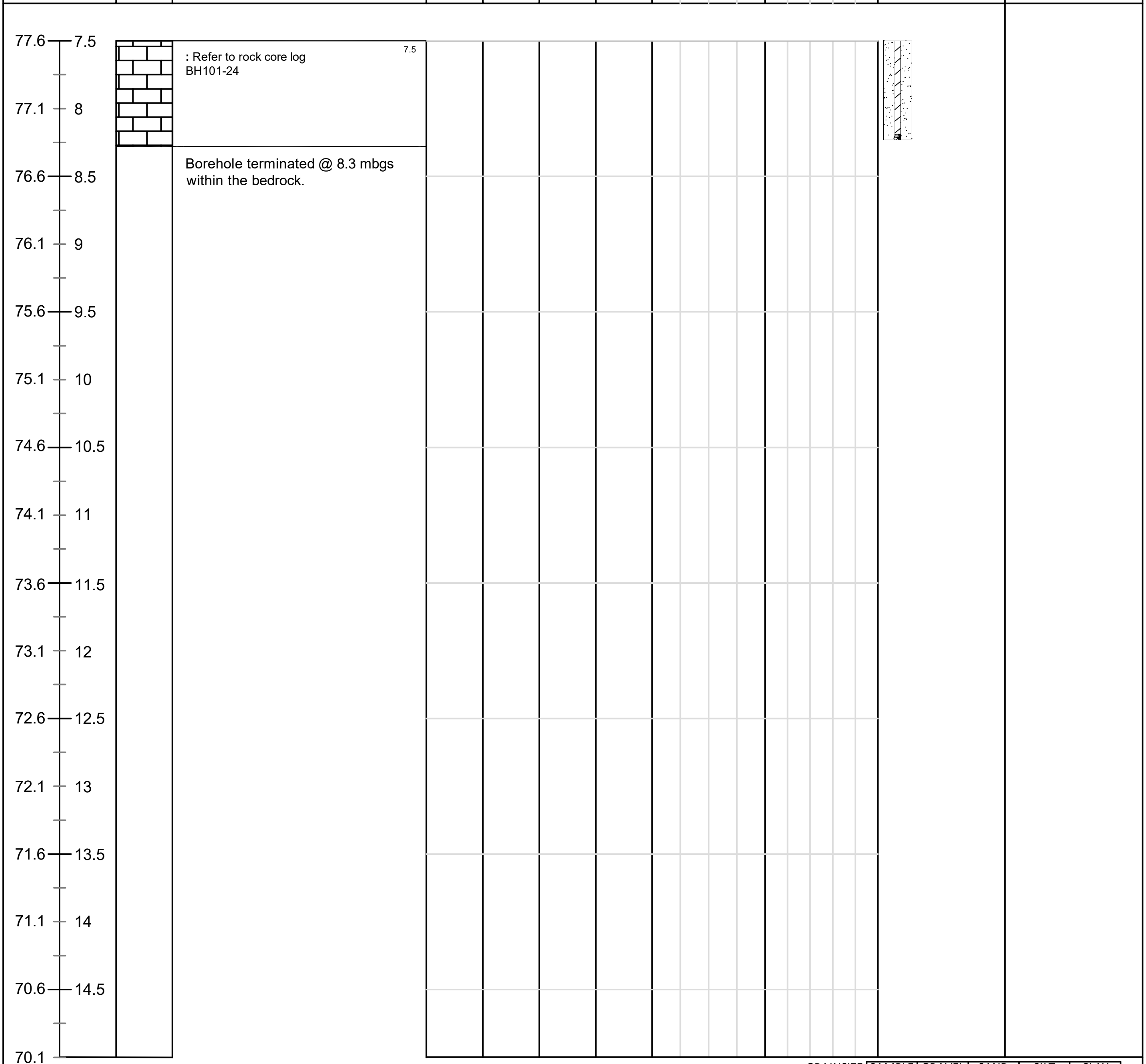
Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64,
Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 85.08 mASL
UTM: 18 T **N:** 4879279 **E:** 281792

Log of Borehole: BH101-24
Page: 2 of 2
Date Completed: February 20, 2024

SUBSURFACE PROFILE | **SAMPLE**

Elevation (m) Depth | Lithology | Description (Elevation / Depth) | Number | Type | % Recovery | SPT (N) | Atterberg Limits (%) LL PL PI 25 50 75 / % Moisture 25 50 75 | Shear Strength Cu, kPa nat V. rem V. 20 40 60 80 / SPT (N) 20 40 60 80 | Well Installation | Log Notes



: Refer to rock core log BH101-24

Borehole terminated @ 8.3 mbgs within the bedrock.

GRAINSIZE DISTRIBUTION

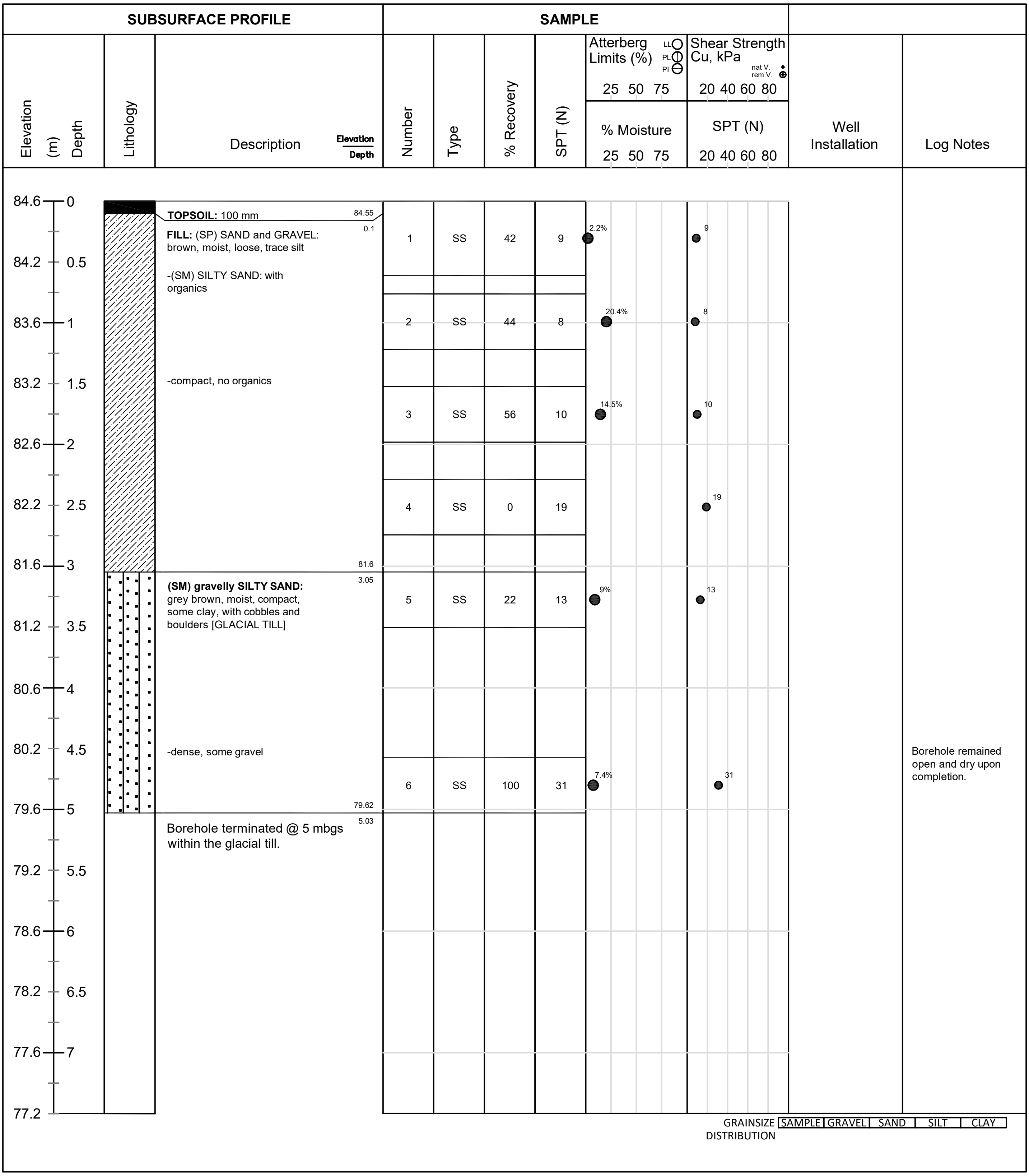
SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 4B	24	36	32	8
SS 6	15	44	29	12

1m = 24 units

Logged By: RR **Input By:** BV

CAMBIUM

Client:	J L Richards & Associates Limited	**Project Name:**	Brighton WWTS Upgrades	**Log of Borehole:**	BH102-24
Contractor:	Canadian Environmental Drilling	**Method:**	Track Mounted Solid Stem Auger	Page:	1 of 1
Project No.:	19712-001	**Elevation:**	84.65 mASL	**Date Completed:**	February 23, 2024
Location:	100 County Rd 64, Brighton ON	**UTM:**	18 T **N:** 4879300 **E:** 281792		



Description	Elevation / Depth
TOPSOIL: 100 mm	84.55 0.1
FILL: (SP) SAND and GRAVEL: brown, moist, loose, trace silt -(SM) SILTY SAND: with organics -compact, no organics	81.6 3.05
(SM) gravelly SILTY SAND: grey brown, moist, compact, some clay, with cobbles and boulders [GLACIAL TILL] -dense, some gravel	79.62 5.03
Borehole terminated @ 5 mbgs within the glacial till.	

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N)
1	SS	42	9	2.2%	9
2	SS	44	8	20.4%	8
3	SS	56	10	14.5%	10
4	SS	0	19		19
5	SS	22	13	9%	13
6	SS	100	31	7.4%	31

Well Installation

Log Notes

Borehole remained open and dry upon completion.

Logged By: SS **Input By:** BV

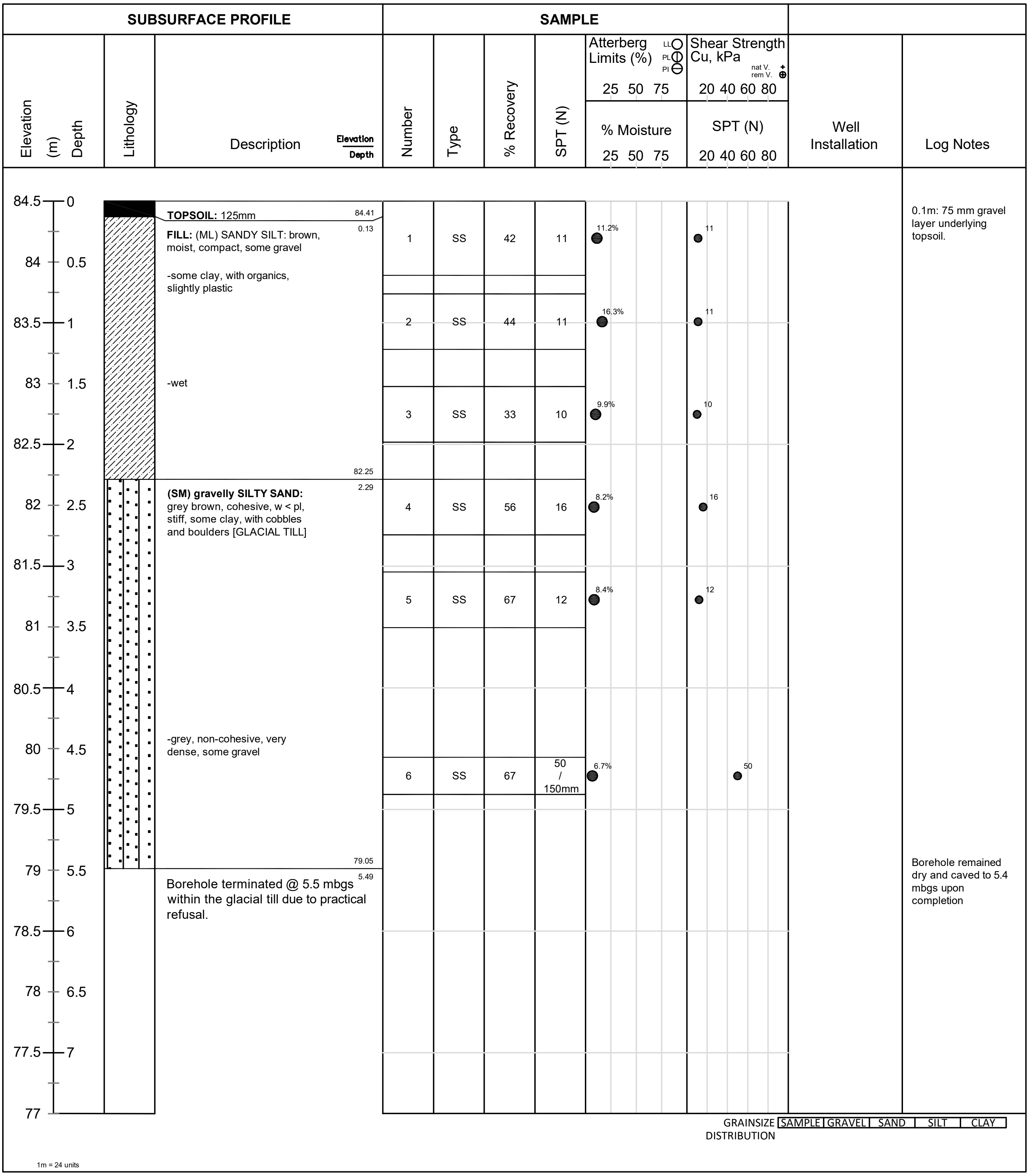
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.54 mASL
UTM: 18 T **N:** 4879292 **E:** 281781

Log of Borehole: BH103-24
Page: 1 of 1
Date Completed: February 23, 2024



TOPSOIL: 125mm — 84.41 / 0.13

FILL: (ML) SANDY SILT: brown, moist, compact, some gravel
-some clay, with organics, slightly plastic
-wet
— 82.25 / 2.29

(SM) gravelly SILTY SAND: grey brown, cohesive, w < pl, stiff, some clay, with cobbles and boulders [GLACIAL TILL]
-grey, non-cohesive, very dense, some gravel
— 79.05 / 5.49

Borehole terminated @ 5.5 mbgs within the glacial till due to practical refusal.

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N) plot
1	SS	42	11	11.2%	11
2	SS	44	11	16.3%	11
3	SS	33	10	9.9%	10
4	SS	56	16	8.2%	16
5	SS	67	12	8.4%	12
6	SS	67	50 / 150mm	6.7%	50

Log Notes:

0.1m: 75 mm gravel layer underlying topsoil.

Borehole remained dry and caved to 5.4 mbgs upon completion

Logged By: SS **Input By:** BV

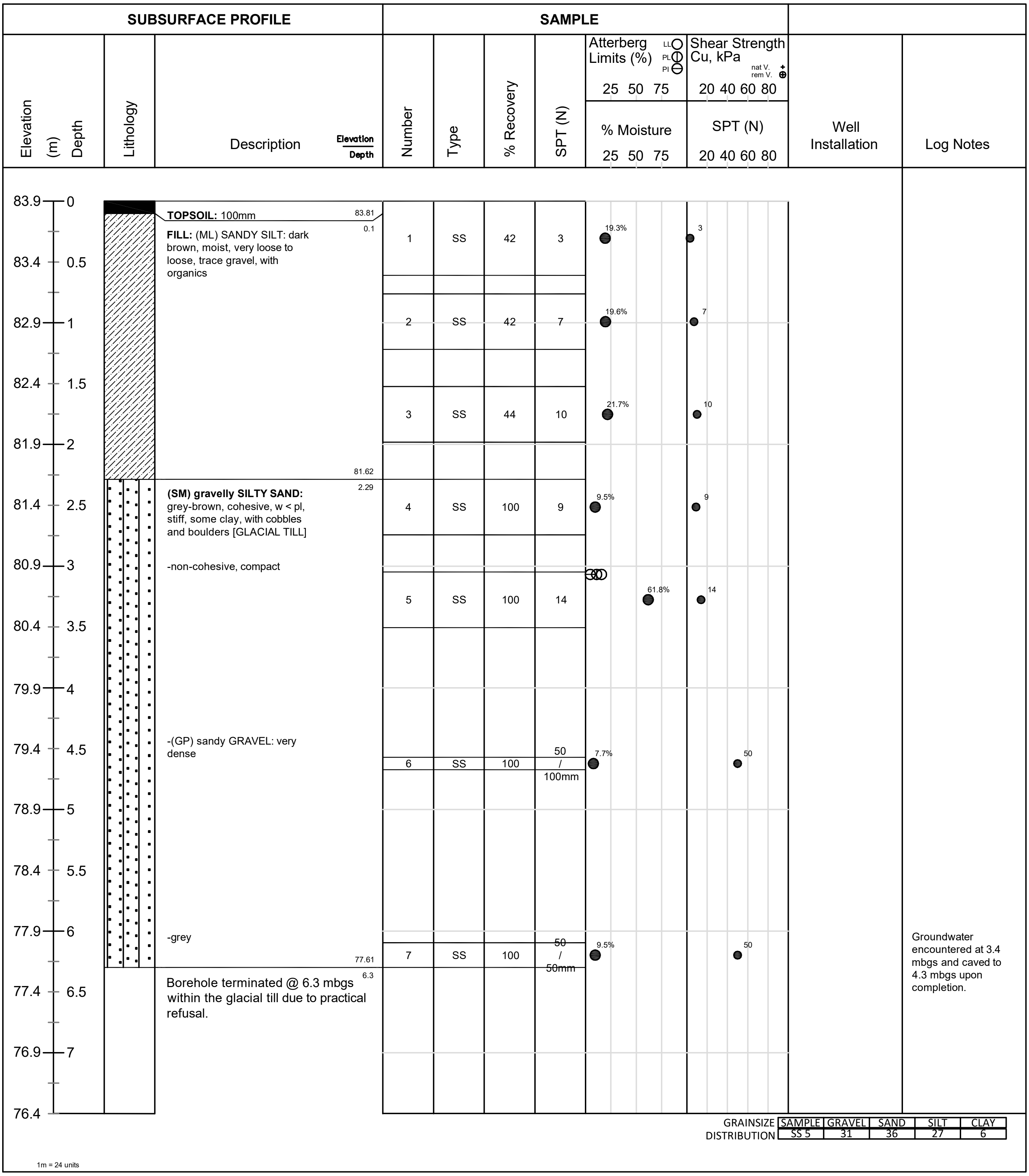
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 83.91 mASL
UTM: 18 T **N:** 4879292 **E:** 281761

Log of Borehole: BH104-24
Page: 1 of 1
Date Completed: February 23, 2024



Elevation / Depth	Description
83.81 0.1	**TOPSOIL:** 100mm
81.62 2.29	**FILL:** (ML) SANDY SILT: dark brown, moist, very loose to loose, trace gravel, with organics
	(SM) gravelly SILTY SAND: grey-brown, cohesive, w < pl, stiff, some clay, with cobbles and boulders [GLACIAL TILL] -non-cohesive, compact -(GP) sandy GRAVEL: very dense -grey
77.61 6.3	Borehole terminated @ 6.3 mbgs within the glacial till due to practical refusal.

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N)
1	SS	42	3	19.3%	3
2	SS	42	7	19.6%	7
3	SS	44	10	21.7%	10
4	SS	100	9	9.5%	9
5	SS	100	14	61.8%	14
6	SS	100	50 / 100mm	7.7%	50
7	SS	100	50 / 50mm	9.5%	50

Log Notes: Groundwater encountered at 3.4 mbgs and caved to 4.3 mbgs upon completion.

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS 5	31	36	27	6

Logged By: SS **Input By:** BV

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 85.3 mASL
UTM: 18 T **N:** 4879311 **E:** 281766

Log of Borehole: BH105-24
Page: 1 of 1
Date Completed: February 23, 2024

SUBSURFACE PROFILE

Elevation (m)	Depth
85.3	0
84.8	0.5
84.3	1
83.8	1.5
83.3	2
82.8	2.5
82.3	3
81.8	3.5
81.3	4
80.8	4.5
80.3	5
79.8	5.5
79.3	6
78.8	6.5
78.3	7
77.8	

Lithology	Description	Elevation Depth
■	**TOPSOIL:** 125 mm	85.17 0.13
▨	**FILL:** (SM) SILTY SAND: dark brown, moist, loose, some gravel, with organics -dark grey	82.25 3.05
⁘	**(SM) SILTY SAND:** grey brown, moist, dense, some gravel, trace clay, with cobbles and boulders [GLACIAL TILL] -very dense	80.42 4.88
	Borehole terminated @ 4.9 mbgs within the glacial till due to practical refusal.	

SAMPLE

Number	Type	% Recovery	SPT (N)	% Moisture (25 50 75)	SPT (N) (20 40 60 80)
1	SS	50	8	7.6%	8
2	SS	22	5	9.1%	5
3	SS	56	9	19.5%	9
4	SS	56	7	22%	7
5	SS	100	30	12.2%	30
6	SS	33	50 / 150mm	4.3%	50

Atterberg Limits (%) LL ○ PL ⊖ PI ⊖ 25 50 75

Shear Strength Cu, kPa nat V. ✦ rem V. ⊕ 20 40 60 80

Well Installation

Log Notes

Groundwater observed at 3.0 mbgs upon completion.

GRAINSIZE DISTRIBUTION | SAMPLE | GRAVEL | SAND | SILT | CLAY |

Logged By: SS **Input By:** BV

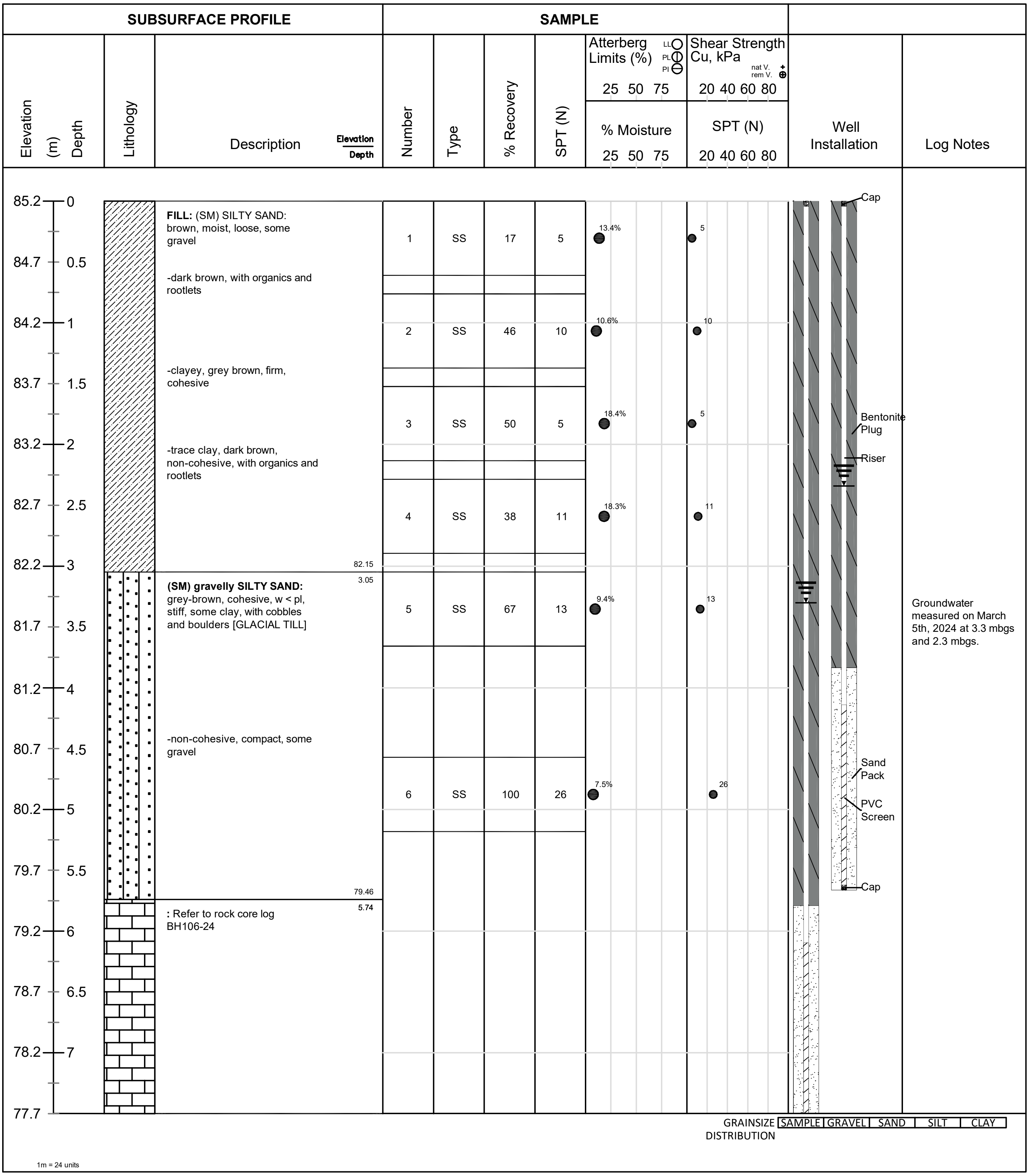
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 85.2 mASL
UTM: 18 T **N:** 4879316 **E:** 281786

Log of Borehole: BH106-24
Page: 1 of 2
Date Completed: February 20, 2024



FILL: (SM) SILTY SAND: brown, moist, loose, some gravel

-dark brown, with organics and rootlets

-clayey, grey brown, firm, cohesive

-trace clay, dark brown, non-cohesive, with organics and rootlets

82.15
3.05

(SM) gravelly SILTY SAND: grey-brown, cohesive, w < pl, stiff, some clay, with cobbles and boulders [GLACIAL TILL]

-non-cohesive, compact, some gravel

79.46
5.74

: Refer to rock core log BH106-24

Number	Type	% Recovery	SPT (N)	% Moisture
1	SS	17	5	13.4%
2	SS	46	10	10.6%
3	SS	50	5	18.4%
4	SS	38	11	18.3%
5	SS	67	13	9.4%
6	SS	100	26	7.5%

Groundwater measured on March 5th, 2024 at 3.3 mbgs and 2.3 mbgs.

Logged By: RR **Input By:** BV

CAMBIUM

Client: J L Richards & Associates Limited

Project Name: Brighton WWTS Upgrades

Log of Borehole: BH106-24

Contractor: Canadian Environmental Drilling

Method: Track Mounted Solid Stem Auger

Page: 2 of 2

Project No.: 19712-001

Elevation: 85.2 mASL

Date Completed: February 20, 2024

Location: 100 County Rd 64,
Brighton ON

UTM: 18 T **N:** 4879316 **E:** 281786

SUBSURFACE PROFILE			SAMPLE							
Elevation (m) Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL ○ PL ⦶ PI ⊖ 25 50 75 % Moisture 25 50 75	Shear Strength Cu, kPa nat V. + rem V. ⊕ 20 40 60 80 SPT (N) 20 40 60 80	Well Installation	Log Notes
77.7 — 7.5		: Refer to rock core log BH106-24 (7.5)								
77.2 — 8										
76.7 — 8.5										
76.2 — 9										
		Borehole terminated @ 9.3 mbgs within the bedrock.								
75.7 — 9.5										
75.2 — 10										
74.7 — 10.5										
74.2 — 11										
73.7 — 11.5										
73.2 — 12										
72.7 — 12.5										
72.2 — 13										
71.7 — 13.5										
71.2 — 14										
70.7 — 14.5										
70.2										

GRAINSIZE DISTRIBUTION | SAMPLE | GRAVEL | SAND | SILT | CLAY |

1m = 24 units

Logged By: RR **Input By:** BV

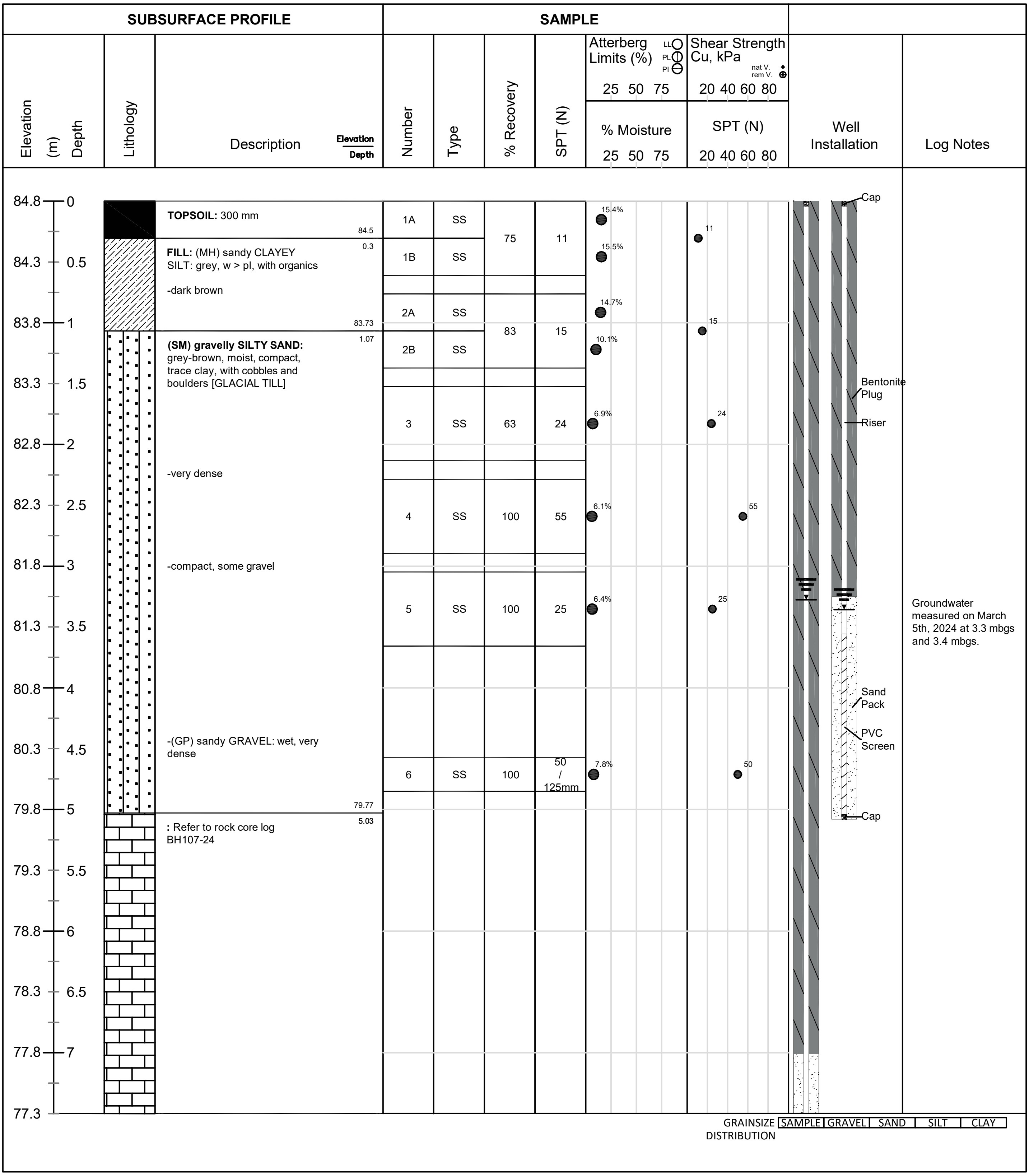
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.8 mASL
UTM: 18 T **N:** 4879301 **E:** 281704

Log of Borehole: BH107-24
Page: 1 of 2
Date Completed: February 21, 2024



Elevation (m)	Depth
84.8	0
84.3	0.5
83.8	1
83.3	1.5
82.8	2
82.3	2.5
81.8	3
81.3	3.5
80.8	4
80.3	4.5
79.8	5
79.3	5.5
78.8	6
78.3	6.5
77.8	7
77.3	

Description	Elevation Depth
TOPSOIL: 300 mm	84.5 0.3
FILL: (MH) sandy CLAYEY SILT: grey, w > pl, with organics -dark brown	83.73 1.07
(SM) gravelly SILTY SAND: grey-brown, moist, compact, trace clay, with cobbles and boulders [GLACIAL TILL] -very dense -compact, some gravel -(GP) sandy GRAVEL: wet, very dense	79.77 5.03
: Refer to rock core log BH107-24	

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N)
1A	SS	75	11	15.4%	11
1B	SS			15.5%	
2A	SS	83	15	14.7%	15
2B	SS			10.1%	
3	SS	63	24	6.9%	24
4	SS	100	55	6.1%	55
5	SS	100	25	6.4%	25
6	SS	100	50 / 125mm	7.8%	50

Groundwater measured on March 5th, 2024 at 3.3 mbgs and 3.4 mbgs.

Logged By: RR **Input By:** BV

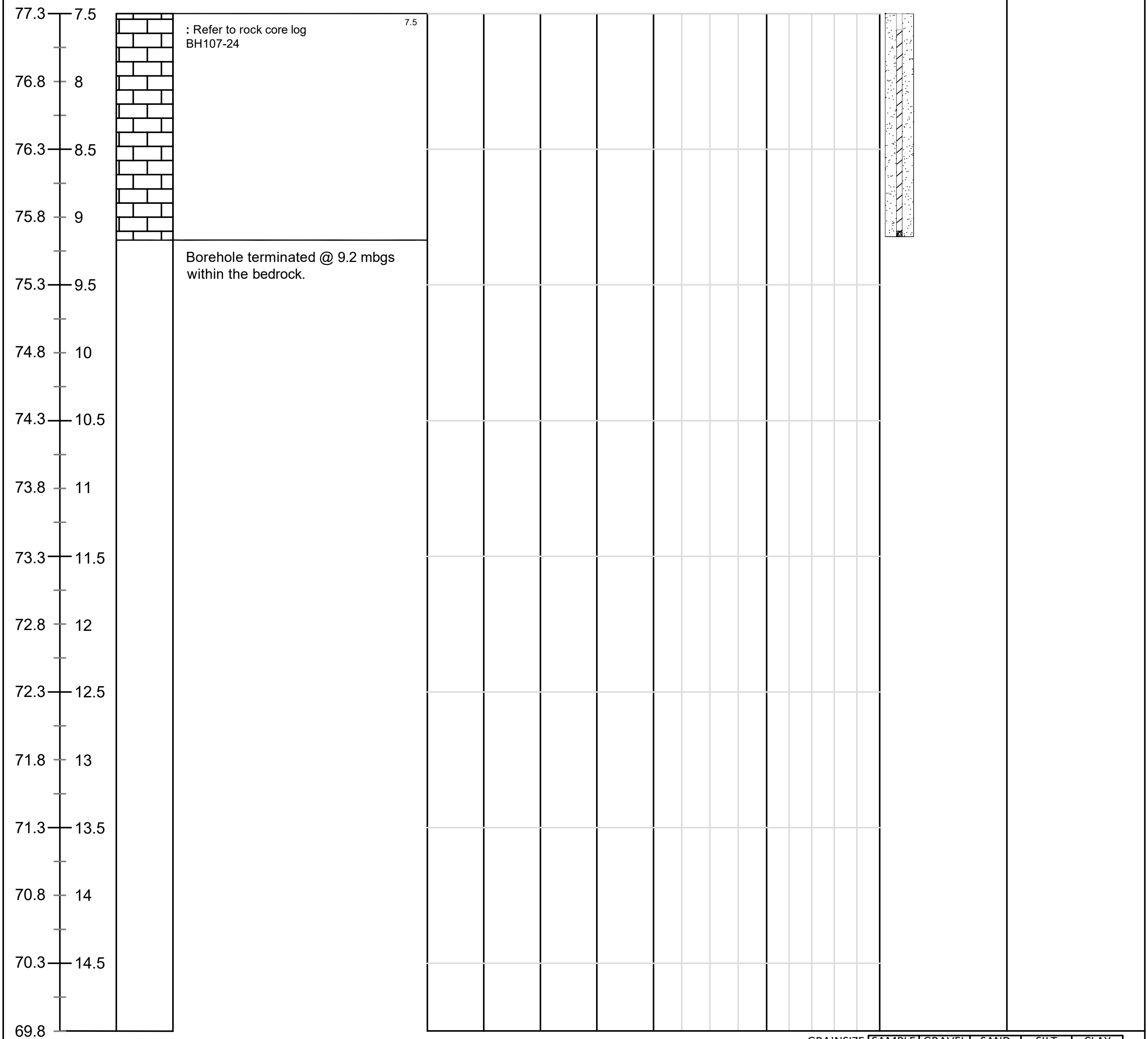
CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.8 mASL
UTM: 18 T **N:** 4879301 **E:** 281704

Log of Borehole: BH107-24
Page: 2 of 2
Date Completed: February 21, 2024

SUBSURFACE PROFILE			**SAMPLE**							
Elevation (m) Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL PL PI 25 50 75 / % Moisture 25 50 75	Shear Strength Cu, kPa nat V. rem V. 20 40 60 80 / SPT (N) 20 40 60 80	Well Installation	Log Notes
77.3 / 7.5		7.5 : Refer to rock core log BH107-24								
		Borehole terminated @ 9.2 mbgs within the bedrock.								



GRAINSIZE DISTRIBUTION | SAMPLE | GRAVEL | SAND | SILT | CLAY |

Logged By: RR **Input By:** BV

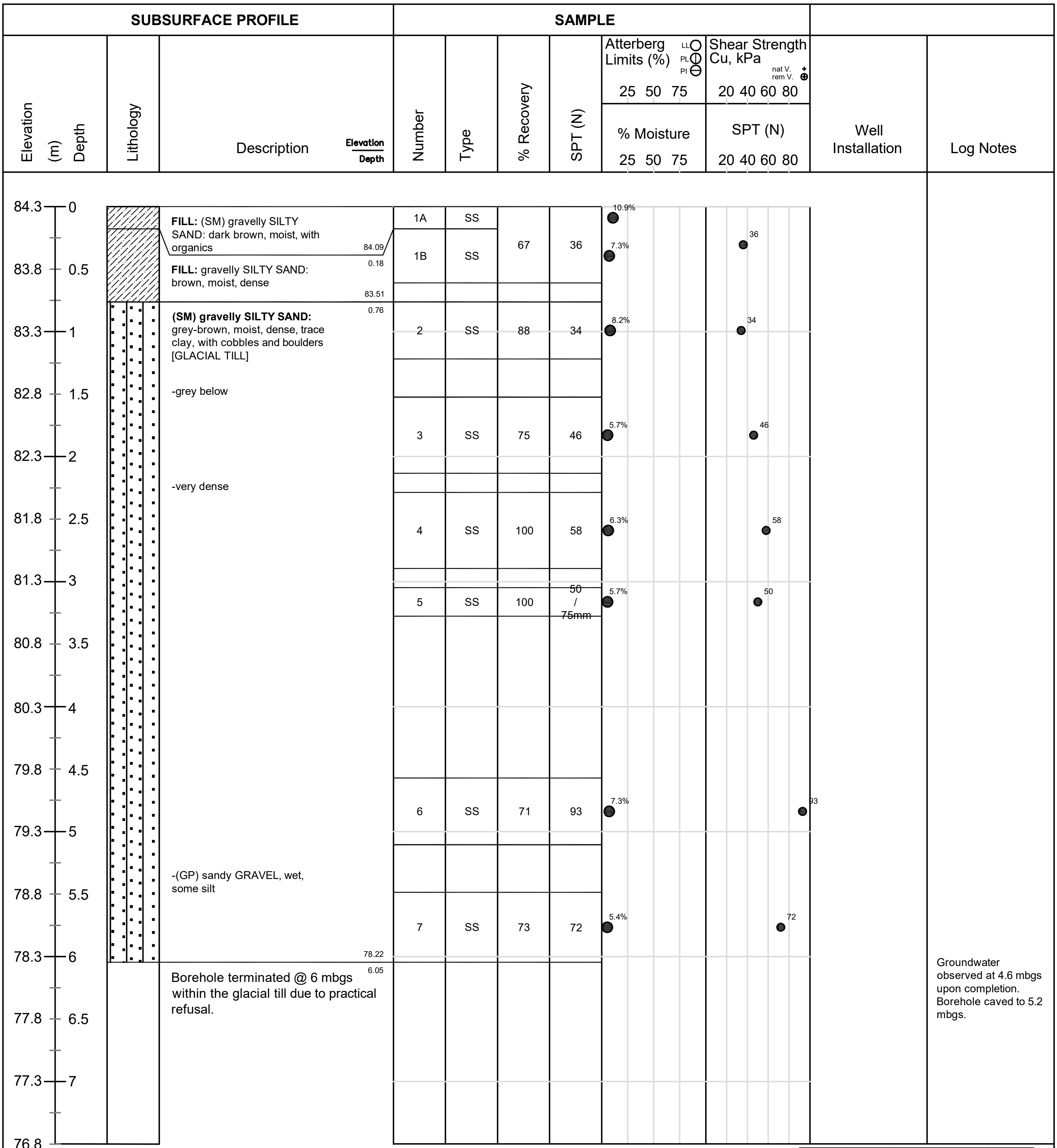
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.27 mASL
UTM: 18 T **N:** 4879277 **E:** 281716

Log of Borehole: BH108-24
Page: 1 of 1
Date Completed: February 22, 2024



Elevation / Depth	Description
84.09 / 0.18	**FILL:** (SM) gravelly SILTY SAND: dark brown, moist, with organics
83.51 / 0.76	**FILL:** gravelly SILTY SAND: brown, moist, dense
78.22 / 6.05	**(SM) gravelly SILTY SAND:** grey-brown, moist, dense, trace clay, with cobbles and boulders [GLACIAL TILL] -grey below -very dense -(GP) sandy GRAVEL, wet, some silt
	Borehole terminated @ 6 mbgs within the glacial till due to practical refusal.

Number	Type	% Recovery	SPT (N)	% Moisture
1A	SS	67	36	10.9%
1B	SS			7.3%
2	SS	88	34	8.2%
3	SS	75	46	5.7%
4	SS	100	58	6.3%
5	SS	100	50 / 75mm	5.7%
6	SS	71	93	7.3%
7	SS	73	72	5.4%

Log Notes: Groundwater observed at 4.6 mbgs upon completion. Borehole caved to 5.2 mbgs.

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY
SS1B	31	41	28	

Logged By: FI **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Project Name: Brighton WWTS Upgrades
Log of Borehole: BH109-24
Contractor: Canadian Environmental Drilling
Method: Track Mounted Solid Stem Auger
Page: 1 of 1
Project No.: 19712-001
Elevation: 83.95 mASL
Date Completed: February 22, 2024
Location: 100 County Rd 64, Brighton ON
UTM: 18 T **N:** 4879266 **E:** 281696

SUBSURFACE PROFILE		SAMPLE							
Elevation (m) Depth	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N)	Well Installation	Log Notes
84 / 0	**FILL:** (SM) gravelly SILTY SAND: dark brown, wet, compact, some clay, with organics, slightly plastic	1A	SS			15.8%			
		1B	SS	67	21	19.0%	21		
	83.19 / 0.76								
	(SM) gravelly SILTY SAND: grey-brown, moist, dense, trace clay, with cobbles and boulders [GLACIAL TILL]	2	SS	63	14	5.8%	14		
	-dense	3	SS	83	37	6.4%	37		
	-wet, very dense, some gravel	4	SS	92	67	9.0%	67		
	80.9 / 3.05								
	Borehole terminated @ 3 mbgs within the glacial till.								Groundwater observed a 1.8 mbgs upon completion. Borehole caved to 2.3 mbgs.

Atterberg Limits (%) LL ○ PL ⦶ PI ⊖ 25 50 75
Shear Strength Cu, kPa nat V. + rem V. ⊕ 20 40 60 80
% Moisture 25 50 75
SPT (N) 20 40 60 80

Elevation (m) / Depth scale: 84 / 0, 83.4 / 0.5, 83 / 1, 82.4 / 1.5, 82 / 2, 81.4 / 2.5, 81 / 3, 80.4 / 3.5, 80 / 4, 79.4 / 4.5, 79 / 5, 78.4 / 5.5, 78 / 6, 77.4 / 6.5, 77 / 7, 76.4

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY

1m = 24 units

Logged By: FI **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

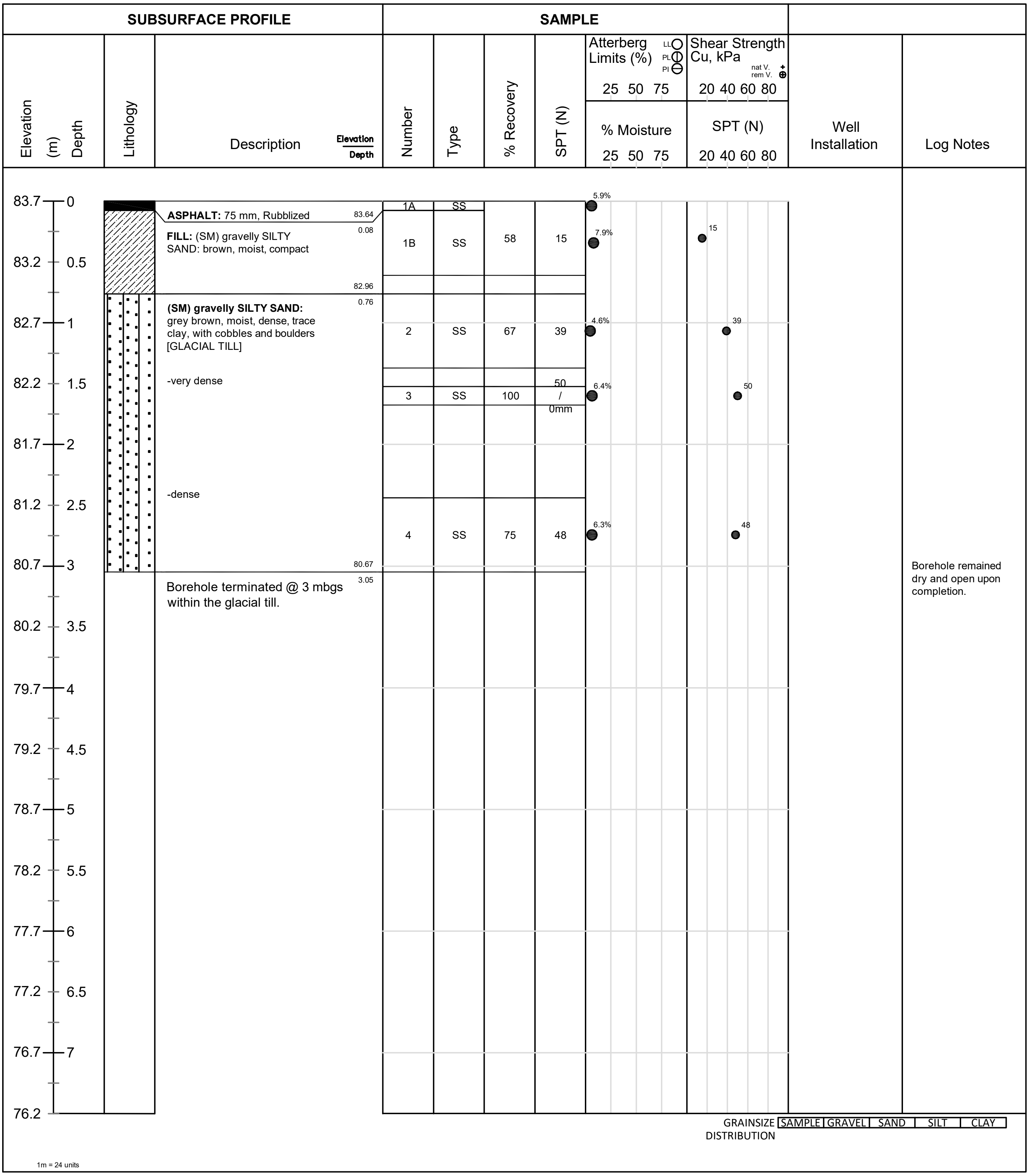
CAMBIUM

Client: J L Richards & Associates Limited
Project Name: Brighton WWTS Upgrades
Log of Borehole: BH110-24

Contractor: Canadian Environmental Drilling
Method: Track Mounted Solid Stem Auger
Page: 1 of 1

Project No.: 19712-001
Elevation: 83.72 mASL
Date Completed: February 22, 2024

Location: 100 County Rd 64, Brighton ON
UTM: 18 T **N:** 4879259 **E:** 281716



Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	% Moisture	Log Notes
ASPHALT: 75 mm, Rubblized	83.64 0.08	1A	SS			5.9%	
FILL: (SM) gravelly SILTY SAND: brown, moist, compact	82.96 0.76	1B	SS	58	15	7.9%	
(SM) gravelly SILTY SAND: grey brown, moist, dense, trace clay, with cobbles and boulders [GLACIAL TILL]		2	SS	67	39	4.6%	
-very dense		3	SS	100	50 / 0mm	6.4%	
-dense	80.67 3.05	4	SS	75	48	6.3%	
Borehole terminated @ 3 mbgs within the glacial till.							Borehole remained dry and open upon completion.

Logged By: FI **Input By:** BV

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.86 mASL
UTM: 18 T **N:** 4879323 **E:** 281711

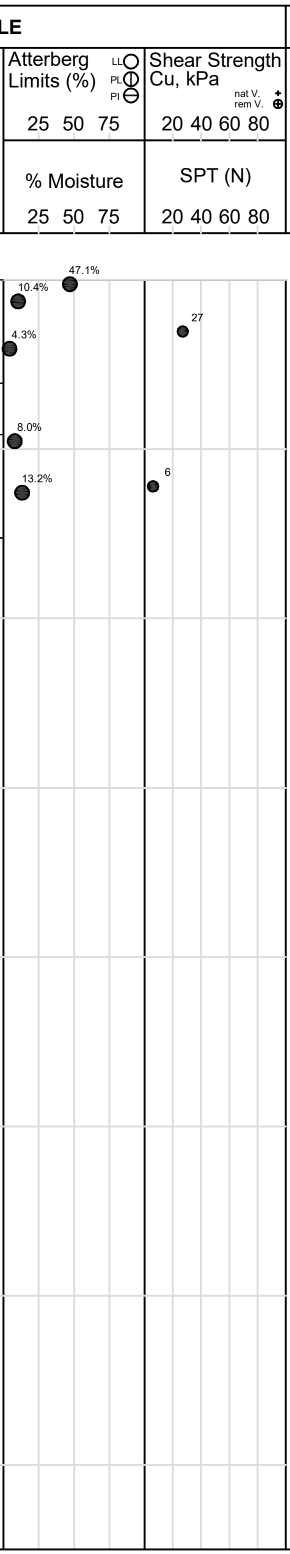
Log of Borehole: BH111-24
Page: 1 of 1
Date Completed: February 22, 2024

SUBSURFACE PROFILE

Elevation (m)	Depth	Description	Elevation / Depth
84.9	0	**TOPSOIL:** 50mm	84.81 0.05
		FILL: (SM) gravelly SILTY SAND: grey brown, moist, with cobbles	83.34 1.52
		Borehole terminated @ 1.5 mbgs within the fill material.	

SAMPLE

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N) plotted
1A	SS			47.1%	
1B	SS			10.4%	
1C	SS	75	27	4.3%	27
2A	SS			8.0%	
2B	SS	33	6	13.2%	6



Elevation (m)	Depth
84.9	0
84.4	0.5
83.9	1
83.4	1.5
82.9	2
82.4	2.5
81.9	3
81.4	3.5
80.9	4
80.4	4.5
79.9	5
79.4	5.5
78.9	6
78.4	6.5
77.9	7
77.4	

Lithology

Well Installation

Log Notes: Borehole remained dry and open upon completion.

GRAINSIZE DISTRIBUTION: SAMPLE | GRAVEL | SAND | SILT | CLAY

1m = 24 units

Logged By: FI **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 85.15 mASL
UTM: 18 T **N:** 4879342 **E:** 281748

Log of Borehole: BH112-24
Page: 1 of 1
Date Completed: February 22, 2024

SUBSURFACE PROFILE

Elevation (m)	Depth (m)	Description	Elevation / Depth
85.2	0	**TOPSOIL:** 125 mm	85.02 0.13
		FILL: (SM) gravelly SAND and SILT: grey brown, moist, compact, some clay, with wood debris	
		-clayey, w > pl, firm, cohesive	
83.6	1.5	-trace gravel, non-cohesive	
82.6	2.5	-dark brown, with organics and rootlets	82.1 3.05
		(SM) gravelly SILTY SAND: grey, cohesive, w < pl, firm, some clay, with cobbles and boulders [GLACIAL TILL]	
80.6	4.5	-non-cohesive, very dense	
79.2	6	-(GP) sandy GRAVEL: moist	78.19 6.96
		Borehole terminated @ 7 mbgs within the glacial till due to practical refusal.	

Elevation / Depth scale: 85.2 – 0; 84.6 – 0.5; 84.2 – 1; 83.6 – 1.5; 83.2 – 2; 82.6 – 2.5; 82.2 – 3; 81.6 – 3.5; 81.2 – 4; 80.6 – 4.5; 80.2 – 5; 79.6 – 5.5; 79.2 – 6; 78.6 – 6.5; 78.2 – 7; 77.6

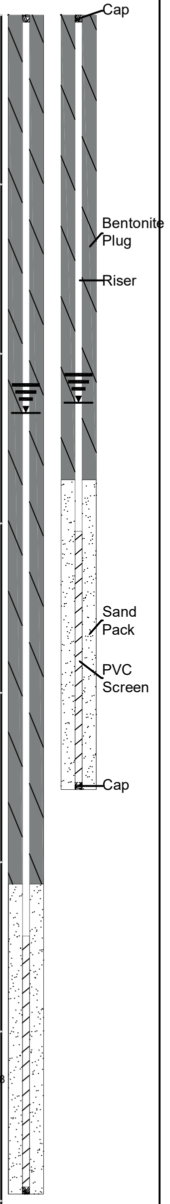
1m = 24 units

SAMPLE

Number	Type	% Recovery	SPT (N)	% Moisture
1A	SS			22.3%
1B	SS	58	12	6.6%
2	SS	42	5	12.6%
3	SS	63	8	13.4%
4A	SS	100	13	16.0%
4B	SS			32.4%
5	SS	17	5	9.7%
6	SS	75	67	7.8%
7	SS	67	88	5.2%

Atterberg Limits (%) LL ○ PL ⦶ PI ⊖ 25 50 75
Shear Strength Cu, kPa nat V. + rem V. ⊕ 20 40 60 80
% Moisture 25 50 75
SPT (N) 20 40 60 80

Well Installation



Log Notes

Groundwater measured on March 5th, 2024 at 2.4 mbgs and 2.3 mbgs.

Groundwater observed at 3.1 mbgs upon completion.

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY

Logged By: FI **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 84.69 mASL
UTM: 18 T **N:** 4879300 **E:** 281813

Log of Borehole: BH113-24
Page: 1 of 1
Date Completed: February 23, 2024

SUBSURFACE PROFILE				SAMPLE							
Elevation (m)	Depth	Lithology	Description (Elevation / Depth)	Number	Type	% Recovery	SPT (N)	Atterberg Limits (%) LL ○ PL ⦶ PI ⊖ / % Moisture 25 50 75	Shear Strength Cu, kPa nat V. + rem V. ⊕ / SPT (N) 20 40 60 80	Well Installation	Log Notes
84.7	0	▨	**FILL:** (SP) SAND and GRAVEL: grey, moist, compact	1	SS	100	11	5.3%	11		
84.2	0.5	▨	-very dense								
83.7	1	▨		2	SS	100	53	6.7%	53		
83.2	1.5		83.17 / 1.52 Borehole terminated @ 1.5 mbgs within the fill material.								Borehole remained dry and open upon completion.
82.7	2										
82.2	2.5										
81.7	3										
81.2	3.5										
80.7	4										
80.2	4.5										
79.7	5										
79.2	5.5										
78.7	6										
78.2	6.5										
77.7	7										
77.2											

GRAINSIZE DISTRIBUTION

SAMPLE	GRAVEL	SAND	SILT	CLAY

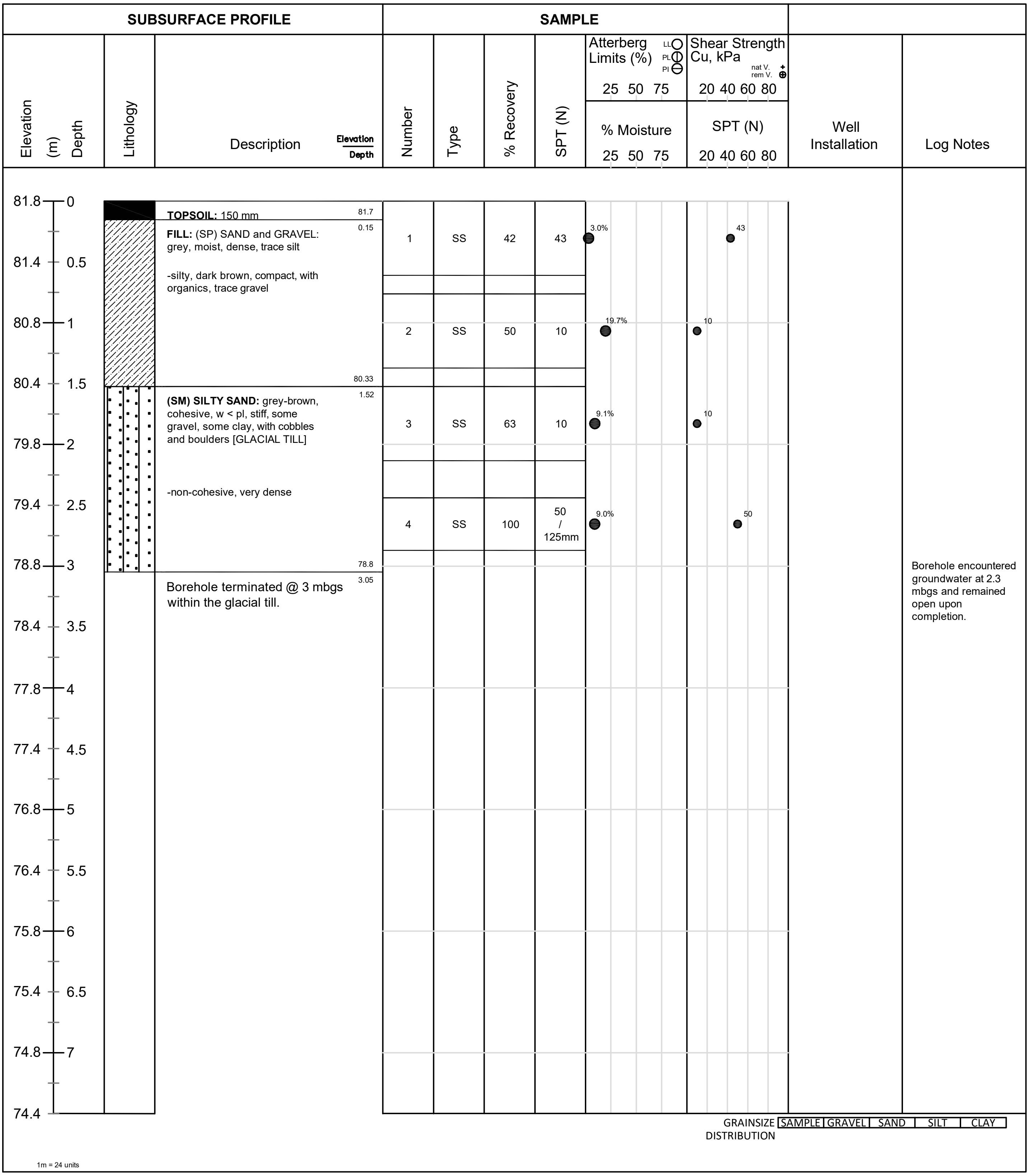
Logged By: SS **Input By:** BV

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Elevation: 81.85 mASL
UTM: 18 T **N:** 4879269 **E:** 281819

Log of Borehole: BH114-23
Page: 1 of 1
Date Completed: February 23, 2024



Description	Elevation / Depth
TOPSOIL: 150 mm	81.7 / 0.15
FILL: (SP) SAND and GRAVEL: grey, moist, dense, trace silt -silty, dark brown, compact, with organics, trace gravel	80.33 / 1.52
(SM) SILTY SAND: grey-brown, cohesive, w < pl, stiff, some gravel, some clay, with cobbles and boulders [GLACIAL TILL] -non-cohesive, very dense	78.8 / 3.05
Borehole terminated @ 3 mbgs within the glacial till.	

Number	Type	% Recovery	SPT (N)	% Moisture	SPT (N) plotted
1	SS	42	43	3.0%	43
2	SS	50	10	19.7%	10
3	SS	63	10	9.1%	10
4	SS	100	50 / 125mm	9.0%	50

Log Notes: Borehole encountered groundwater at 2.3 mbgs and remained open upon completion.

Logged By: SS **Input By:** BV

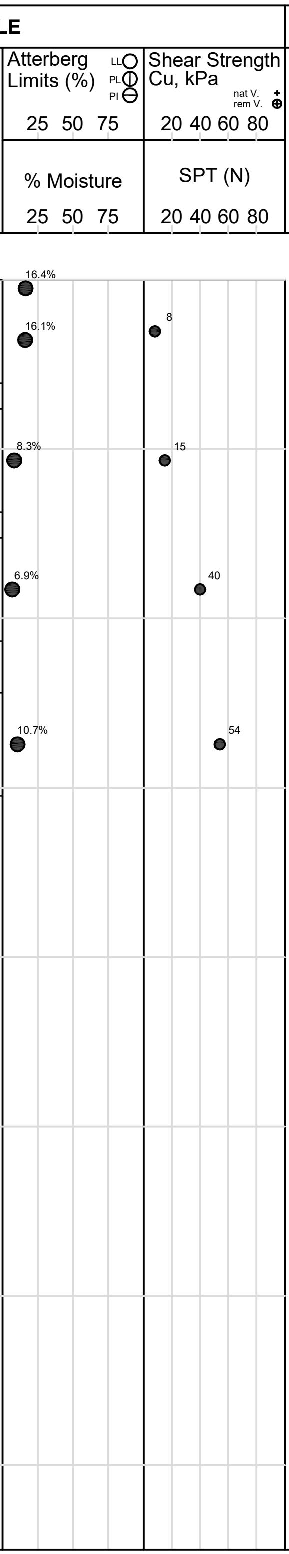
Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Project Name: Brighton WWTS Upgrades
Log of Borehole: BH115-24
Contractor: Canadian Environmental Drilling
Method: Track Mounted Solid Stem Auger
Page: 1 of 1
Project No.: 19712-001
Elevation: 82.1 mASL
Date Completed: February 22, 2024
Location: 100 County Rd 64, Brighton ON
UTM: 18 T **N:** 4879249 **E:** 281784

SUBSURFACE PROFILE | **SAMPLE**

Elevation (m)	Depth	Description	Elevation / Depth	Number	Type	% Recovery	SPT (N)	Log Notes
82.1	0	**FILL:** (SM) SILTY SAND: black, moist, loose, some gravel, with asphaltic concrete and organics		1A	SS			
				1B	SS	67	8	
81.6	0.5	-no asphaltic concrete						
81.1	1	**(SM) gravelly SILTY SAND:** brown, moist, dense, trace clay, with cobbles and boulders [GLACIAL TILL]	81.03 1.07	2	SS	54	15	
80.6	1.5			3	SS	79	40	
80.1	2							
79.6	2.5	-wet, very dense		4	SS	67	54	
79.1	3	Borehole terminated @ 3 mbgs within the glacial till.	79.05 3.05					Groundwater observed at 2.1 mbgs upon completed. Borehole remained open.
78.6	3.5							
78.1	4							
77.6	4.5							
77.1	5							
76.6	5.5							
76.1	6							
75.6	6.5							
75.1	7							
74.6								



Well Installation

GRAINSIZE DISTRIBUTION | SAMPLE | GRAVEL | SAND | SILT | CLAY

Logged By: FI
Input By: BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

Appendix B

Rock Core Logs

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Ground Elevation: 85.08 mASL
UTM: 18 T **N:** 4879279 **E:** 281792

Log of Borehole: BH101-24
Page: 1 of 1
Date Completed: February 20, 2024

SUBSURFACE PROFILE

Elevation (m) Depth	Lithology	Description	Elevation Depth	Core Run	UCS (MPa) 10 50 100 250	Natural Fractures	Lab Notes	Log Notes
79.3 5.8		**:** (SP) gravelly SAND: with cobbles and boulders [GLACIAL TILL]	78.58 6.5	Run 1 TCR = **100%** SCR = **20%** RQD = **0%**		20 20		
	▦	**Limestone:** [Lindsay Formation] grey, strong, fresh, slightly disintigrated, intensely to moderately fractured, poor RQD	76.8 8.28	Run 2 TCR = **100%** SCR = **93%** RQD = **48%** Run 3 TCR = **100%** SCR = **96%** RQD = **35%**		4 4 2 2 2 3		
		Rock core terminated @ 8.3m due to due to target depth achieved.						

Elevation	Depth
79.3	5.8
78.8	6.3
78.3	6.8
77.8	7.3
77.3	7.8
76.8	8.3
76.3	8.8
75.8	9.3
75.3	9.8
74.8	10.3
74.3	10.8
73.8	11.3
73.3	11.8
72.8	12.3
72.3	

1m = 26 units

Logged By: RR **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

CAMBIUM

Client: J L Richards & Associates Limited
Contractor: Canadian Environmental Drilling
Project No.: 19712-001
Location: 100 County Rd 64, Brighton ON

Project Name: Brighton WWTS Upgrades
Method: Track Mounted Solid Stem Auger
Ground Elevation: 85.2 mASL
UTM: 18 T **N:** 4879316 **E:** 281786

Log of Borehole: BH106-24
Page: 1 of 1
Date Completed: February 20, 2024

SUBSURFACE PROFILE

Elevation (m)	Depth
79.5	5.7
79	6.2
78.5	6.7
78	7.2
77.5	7.7
77	8.2
76.5	8.7
76	9.2
75.5	9.7
75	10.2
74.5	10.7
74	11.2
73.5	11.7
73	12.2
72.5	

Description	Elevation / Depth	Core Run	UCS (MPa) 10 50 100 250	Natural Fractures	Lab Notes	Log Notes
: (SP) sandy GRAVEL: with cobbles and boulders [GLACIAL TILL]	77.45	Run 1 TCR = **0%** SCR = **0%** RQD = **0%**		20		
		Run 2 TCR = **0%** SCR = **0%** RQD = **0%**		20		
		Run 3 TCR = **0%** SCR = **0%** RQD = **0%**		20 20 20 20		
Limestone: [Lindsay Formation] grey, strong, fresh, competent, moderately fractured, fair RQD	7.75 75.98	Run 4 TCR = **95%** SCR = **95%** RQD = **65%**		2 3 1 1 3		
Rock core terminated @ 9.2m due to due to target depth achieved.	9.22					

1m = 26 units

Logged By: RR **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

Client: J L Richards & Associates Limited
Project Name: Brighton WWTS Upgrades
Log of Borehole: BH107-24
Contractor: Canadian Environmental Drilling
Method: Track Mounted Solid Stem Auger
Page: 1 of 1
Project No.: 19712-001
Ground Elevation: 84.8 mASL
Date Completed: February 21, 2024
Location: 100 County Rd 64, Brighton ON
UTM: 18 T **N:** 4879301 **E:** 281704

SUBSURFACE PROFILE

Elevation (m)	Depth	Lithology	Description (Elevation / Depth)	Core Run	UCS (MPa) 10 50 100 250	Natural Fractures	Lab Notes	Log Notes
79.8	5		**Limestone:** [Lindsay Formation], grey, strong, fresh, slightly decomposed to competent, intensely fractured, poor to very poor RQD	Run 1 TCR = **100%** SCR = **58%** RQD = **50%**		20 1		
79.3	5.5			Run 2 TCR = **50%** SCR = **44%** RQD = **0%**		20 4		
78.8	6			Run 3 TCR = **90%** SCR = **79%** RQD = **35%**		5		
78.3	6.5					4 3		
77.8	7					20 3		
77.3	7.5		-slightly fractured, good RQD	Run 4 TCR = **100%** SCR = **100%** RQD = **78%**		3		
76.8	8					2 0		
76.3	8.5					1 7		
75.8	9		**75.63 / 9.17** Rock core terminated @ 9.2m due to due to target depth achieved.					
75.3	9.5							
74.8	10							
74.3	10.5							
73.8	11							
73.3	11.5							
72.8								

Logged By: RR **Input By:** BV

Peterborough, Barrie, Oshawa, Kingston, Ottawa

Appendix C

Rock Core Photographs

Photo 1: Rock Core Run 1- 3, BH101-24, 5.8 to 8.3 mbgs

Photo 2: Rock Core Run 1-4, BH106-24, 5.7 to 9.3 mbgs

Photo 3: Rock Core Run 1-4, BH107-24, 5.0 to 9.2 mbgs

Appendix D

Physical Laboratory Testing Results

Grain Size Distribution Chart

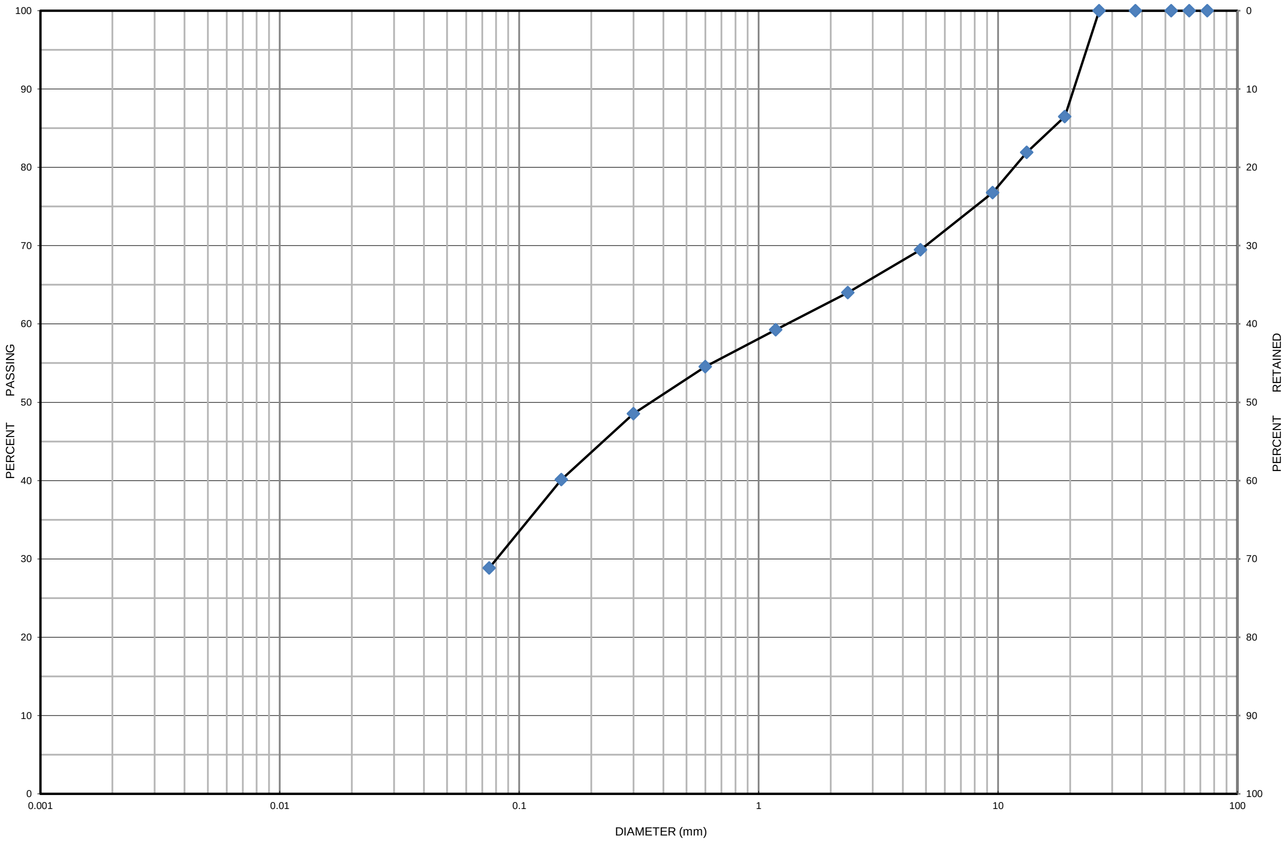
Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*

Project Name: *Brighton WWTS Upgrades*

Sample Date: *January 12, 2024* **Sampled By:** *Rory Ryan - Cambium Inc.*

Location: *BH 108-24 SS 1B* **Depth:** *0.2 m to 0.6 m* **Lab Sample No:** *S-24-0423*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 108-24	SS 1B	0.2 m to 0.6 m	31	41	28		7.3

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Silty Gravelly Sand	SM	1.400	0.080	-	-	-

Additional information available upon request

Issued By:

(Senior Project Manager)

Date Issued: *March 25, 2024*

CAMBIUM

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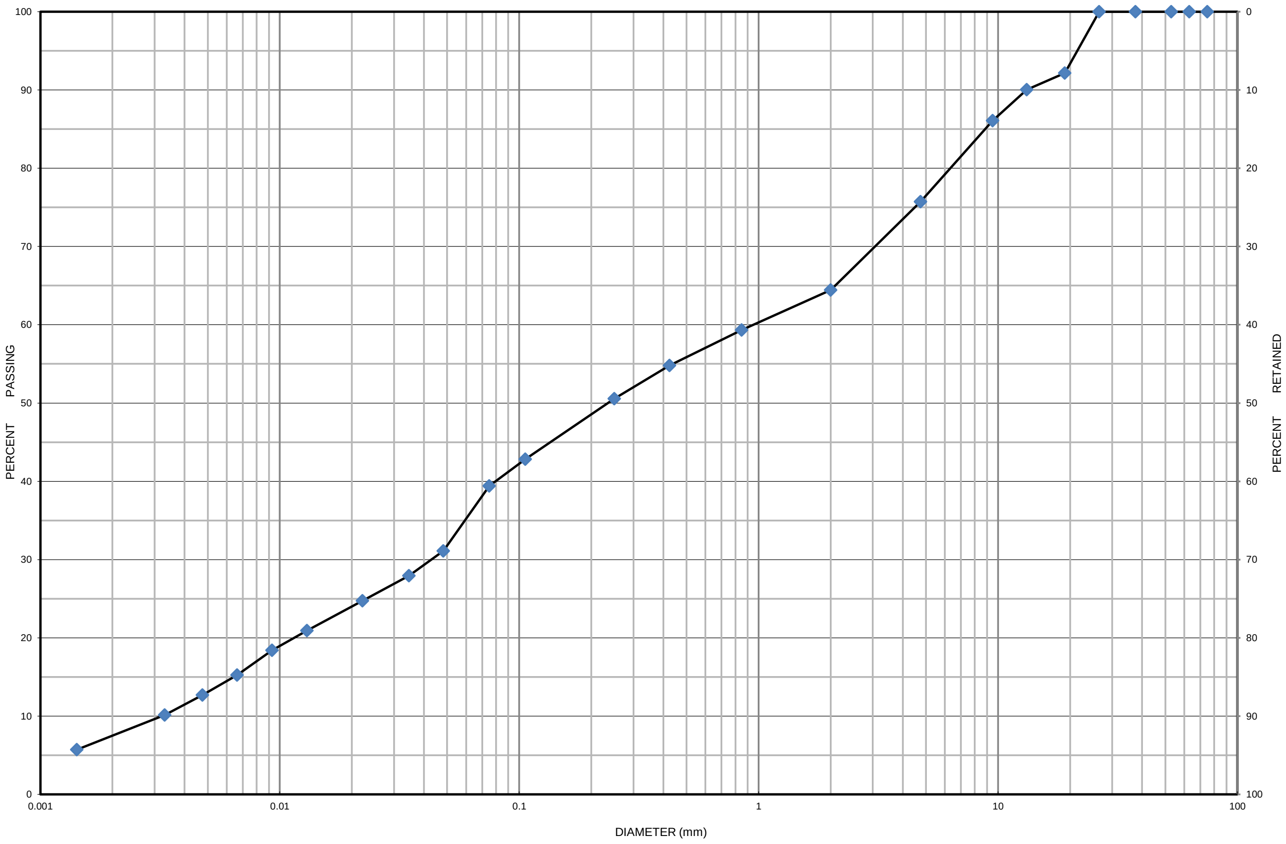
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Grain Size Distribution Chart

Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*
Project Name: *Brighton WWTS Upgrades*
Sample Date: *January 12, 2024* **Sampled By:** *Rory Ryan - Cambium Inc.*
Location: *BH 101-24 SS 4B* **Depth:** *2.5 m to 2.9 m* **Lab Sample No:** *S-24-0421*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 101-24	SS 4B	2.5 m to 2.9 m	24	36	32	8	42.3

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Silty Gravelly Sand trace Clay	SM	0.9500	0.0440	0.0032	296.88	0.64

Additional information available upon request

Issued By: (Senior Project Manager) *Date Issued:* *March 25, 2024*

Docusign Envelope ID: 58F851AC-B8A9-4BA6-BEE3-9890C72C7F86

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For specific tests as listed on www.ccil.com

Grain Size Distribution Chart

Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*

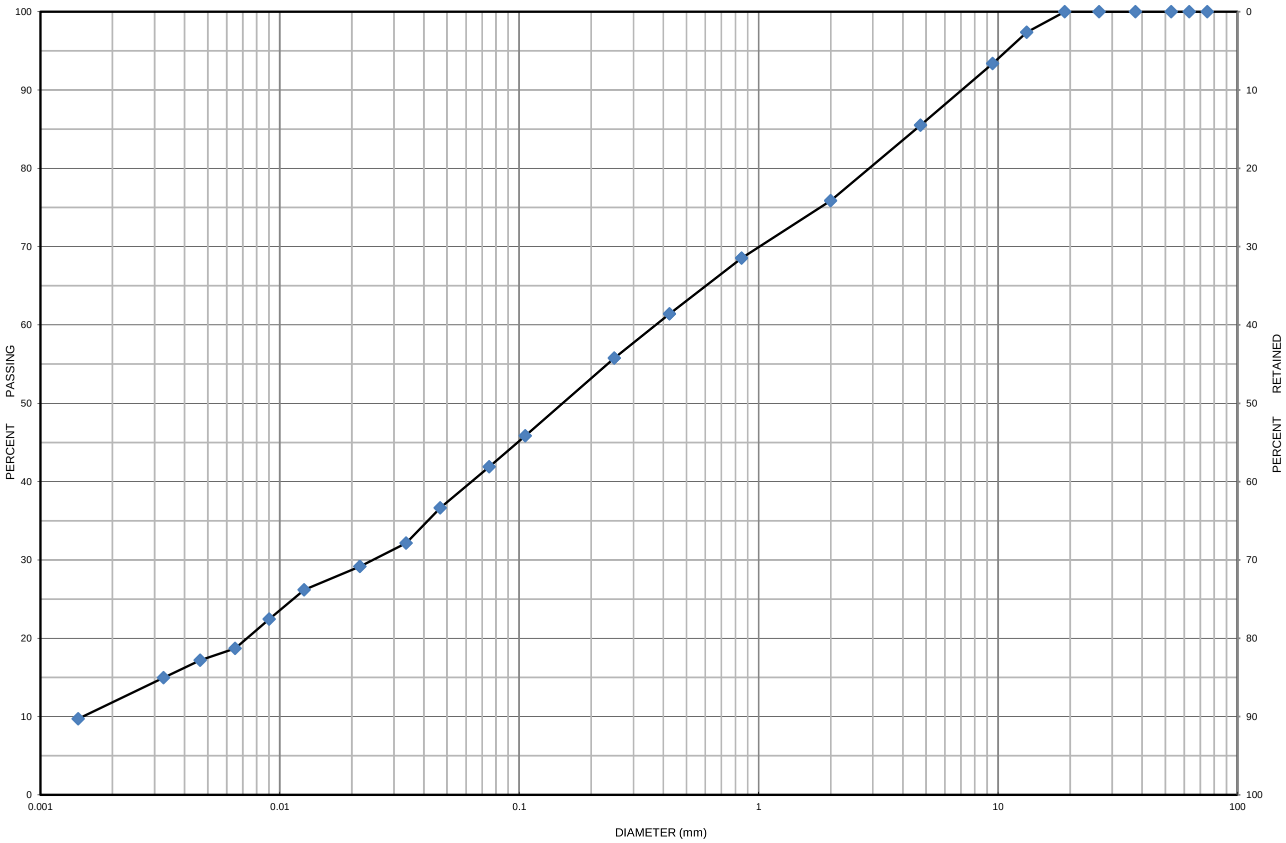
Project Name: *Brighton WWTS Upgrades*

Sample Date: *January 12, 2024* **Sampled By:** *Rory Ryan - Cambium Inc.*

Location: *BH 101-24 SS 6* **Depth:** *4.6 m to 5 m* **Lab Sample No:** *S-24-0422*

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM

CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 101-24	SS 6	4.6 m to 5 m	15	44	29	12	9.6

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Silty Sand some Gravel some Clay	SM	0.3700	0.0240	0.0016	231.25	0.97

Additional information available upon request

Issued By: (Senior Project Manager) *Date Issued:* *March 25, 2024*

Cambium Inc. (Laboratory)
866.217.7900 | cambium-inc.com
194 Sophia St. | Peterborough | ON | K9H 1E5

Grain Size Distribution Chart

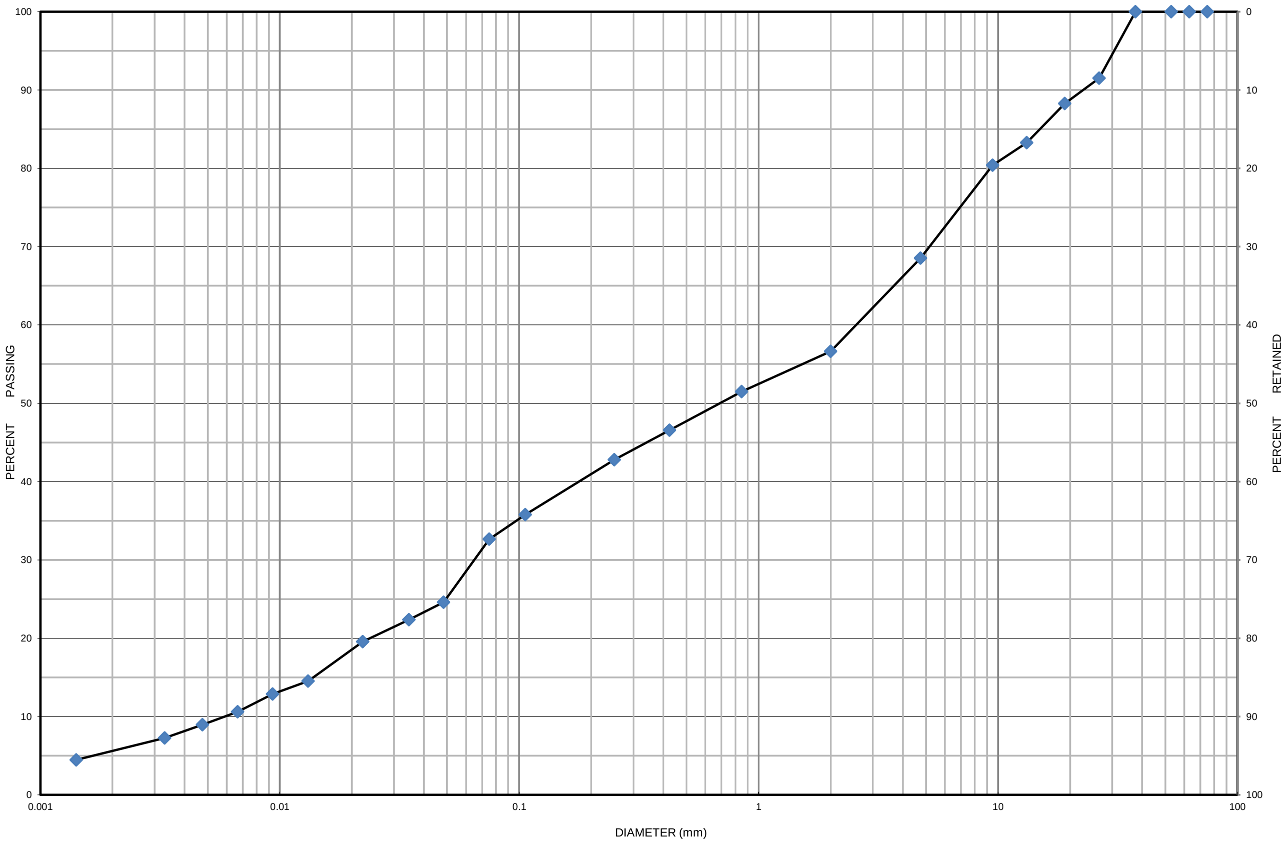
Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*

Project Name: *Brighton WWTS Upgrades*

Sample Date: *January 12, 2024* **Sampled By:** *Rory Ryan - Cambium Inc.*

Location: *BH 104-24 SS 5* **Depth:** *3 m to 3.5 m* **Lab Sample No:** *S-24-0424*

UNIFIED SOIL CLASSIFICATION SYSTEM					
CLAY & SILT (<0.075 mm)	SAND (<4.75 mm to 0.075 mm)			GRAVEL (>4.75 mm)	
	FINE	MEDIUM	COARSE	FINE	COARSE



MIT SOIL CLASSIFICATION SYSTEM								
CLAY	SILT	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	BOULDERS
		SAND			GRAVEL			

Borehole No.	Sample No.	Depth	Gravel	Sand	Silt	Clay	Moisture
BH 104-24	SS 5	3 m to 3.5 m	31	36	27	6	61.8

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Gravelly Silty Sand trace Clay	SM	2.6000	0.0650	0.0059	440.68	0.28

Additional information available upon request

Issued By: *Date Issued:* *March 25, 2024*

(Senior Project Manager)

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194 Sophia St. | Peterborough | ON | K9H 1E5

Form: L6V.2 - Grad.Hydo

CAMBIUM

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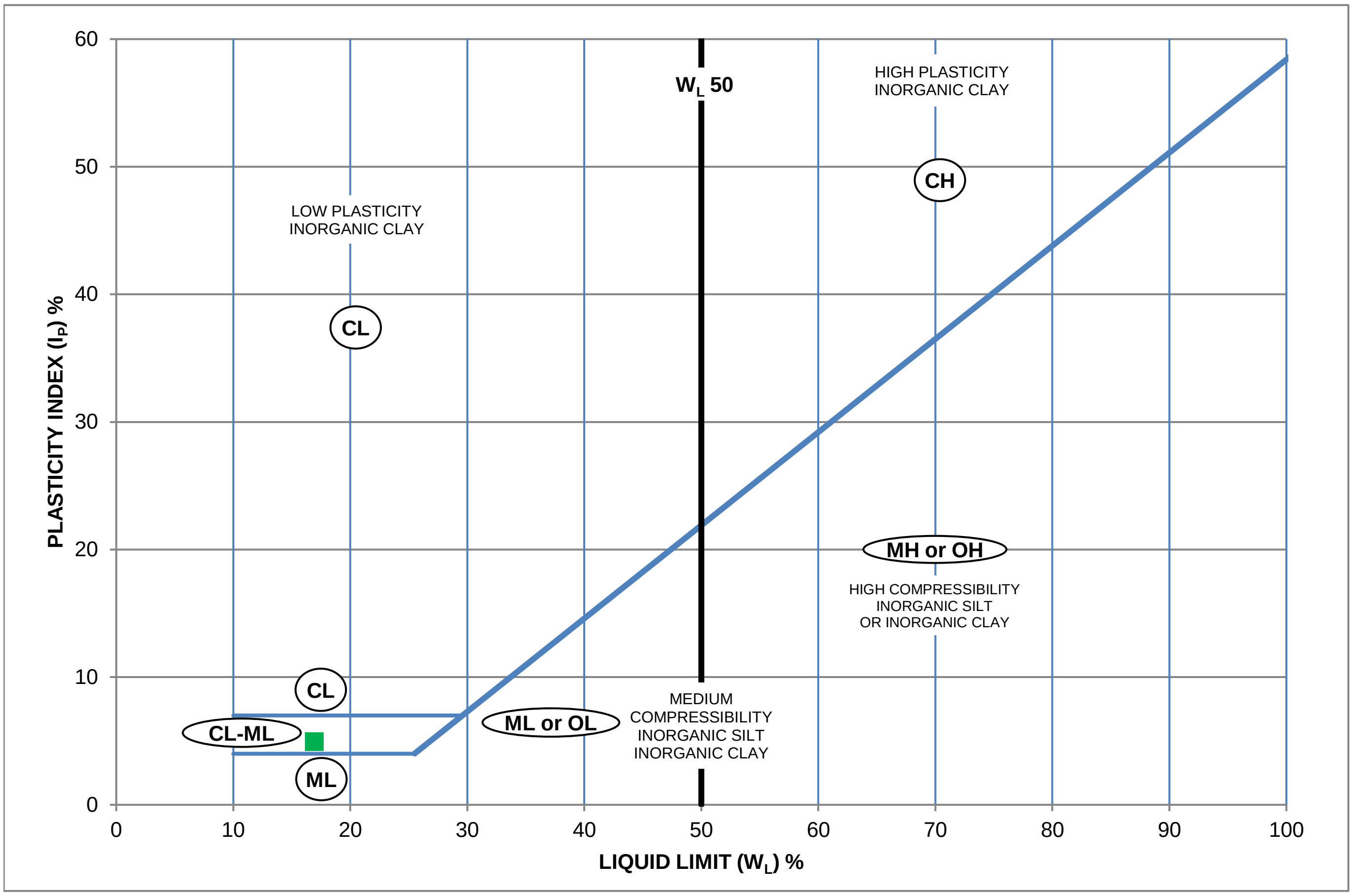
Plasticity Chart

Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*
Project Name: *Brighton WWTS Upgrades*
Sampled By: *Rory Ryan - Cambium Inc.* **Sample Date:** *January 12, 2024*

Hole No.: *BH 101-24 SS 4B* **Depth:** *2.5 m to 2.9 m* **Lab Sample No:** *S-24-0421*

Low Plasticity	High Plasticity



Symbol	Borehole	Sample	Depth	Description
🟩	BH 101-24	SS 4B	2.5 m to 2.9 m	CL-ML

Liquid Limit (%)	Plastic Limit	Plasticity Index (%)
16.9	***12.0***	***4.9***

Additional information available upon request

Issued By: ____________________ *Date Issued:* *March 25, 2024*

(Senior Project Manager)

Cambium Inc. (Laboratory)
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194 Sophia St. | Peterborough | ON | K9H 1E5

Form: L1.V1 - Att.Lmt

CAMBIUM

CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

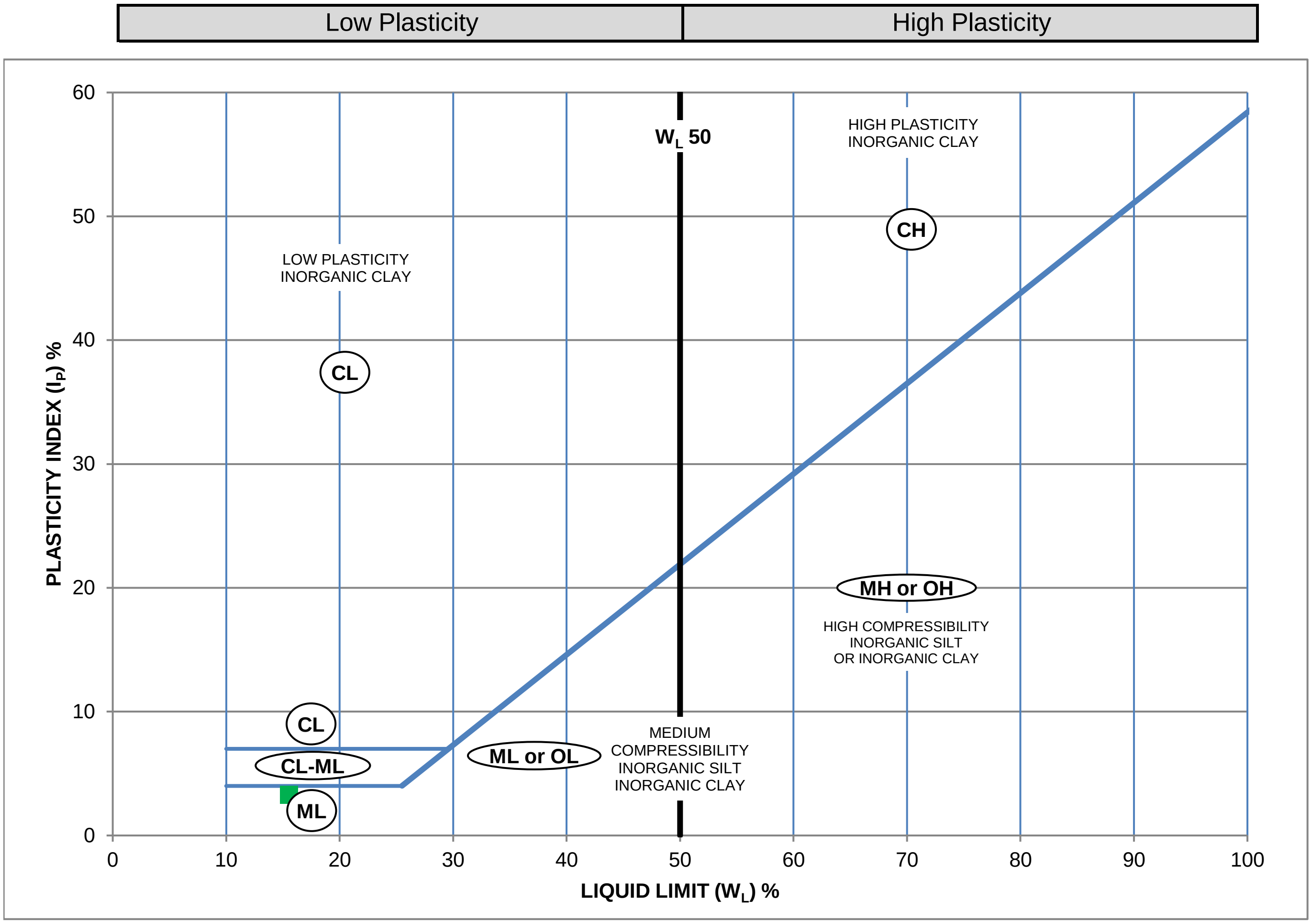
Plasticity Chart

Project Number: *19712-001* **Client:** *J L Richards & Associates Limited*

Project Name: *Brighton WWTS Upgrades*

Sampled By: *Rory Ryan - Cambium Inc.* **Sample Date:** *January 12, 2024*

Hole No.: *BH 101-24 SS 6* **Depth:** *4.6 m to 5 m* **Lab Sample No:** *S-24-0422*



Symbol	Borehole	Sample	Depth	Description
🟩	BH 101-24	SS 6	4.6 m to 5 m	ML

Liquid Limit (%)	Plastic Limit	Plasticity Index (%)
15.5	***12.3***	***3.3***

Additional information available upon request

Issued By: ____________________ *Date Issued:* *March 25, 2024*

(Senior Project Manager)

Plasticity Chart

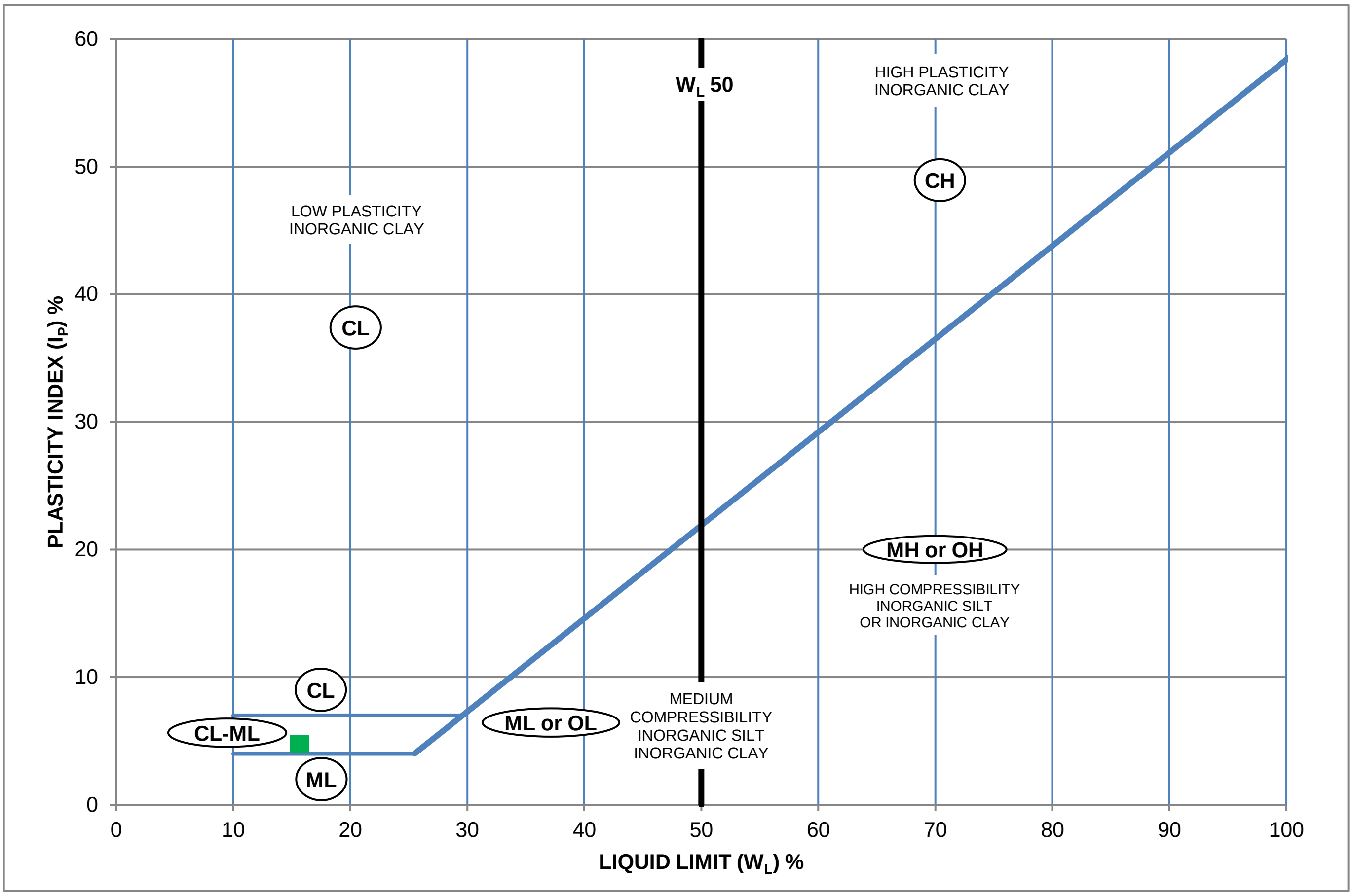
Project Number: *19712-001*　　**Client:** *J L Richards & Associates Limited*

Project Name: *Brighton WWTS Upgrades*

Sampled By: *Rory Ryan - Cambium Inc.*　　**Sample Date:** *January 12, 2024*

Hole No.: *BH 104-24　SS 5*　　**Depth:** *3 m to 3.5 m*　　**Lab Sample No:** *S-24-0424*

Low Plasticity	High Plasticity



Symbol	Borehole	Sample	Depth	Description
🟩	BH 104-24	SS 5	3 m to 3.5 m	CL-ML

Liquid Limit (%)	Plastic Limit	Plasticity Index (%)
15.7	***10.9***	***4.7***

Additional information available upon request

Issued By: ______________________　　*Date Issued:* *March 25, 2024*

(Senior Project Manager)

Concrete Core Compressive Strength Report

Project Number: *19712-001* **Client:** *J L Richards*

Project Name: *Brighton WWTS Upgrades*

Contractor: -

Location on Structure: *Top of Rock Core Run 4*

Date Cored: *2024-01-12*

Date Received: -

Concrete Supplier: -

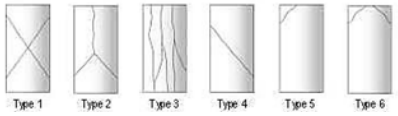
Cylinders Cored By: -

Conditioning Type: *Dry*

Remarks:
BH106-24
18'10"

Spec. 28 Day: *MPa*

Type of Fracture:



Lab Core Number	Client Core ID	Tested On	Diameter (mm)	Weight (kg)	L/D Ratio	L/D Correction Factor	Density (kg/m^3)	Load (kN)	Type of Fracture	Compressive Strength (MPa)	Corrected Compressive Strength (MPa)
9820A		*2024-03-14*	*61.0*	*0.86*	*1.8*	*0.984*	*2690*	*382.5*	*1*	*130.9*	*128.8*

Issued By: Stuart Baird **(Senior Project Manager)** ***Date Issued:*** ***March 14, 2024***

Appendix E

MASW Testing

Frontwave Geophysics Ltd.

FRONTWAVE
GEOPHYSICS

SHEAR WAVE VELOCITY TESTING FOR SEISMIC SITE CLASSIFICATION

BRIGHTON WWTS
100 COUNTY ROAD 64, BRIGHTON, ONTARIO

Submitted to:

Cambium Inc.
31 Hyperion Court, Suite 102
Kingston, Ontario K7K 7G3

Attention:

Mr. Blasco Vijayabaskaran, P.Eng. Email: Blasco.Vijayabaskaran@cambium-inc.com

File No. F-24171

February 21, 2024

Frontwave Geophysics Inc.
Brampton, ON
(647) 514-4724
www.frontwave.ca

TABLE OF CONTENTS

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1 INTRODUCTION

Frontwave Geophysics Inc. was retained by Cambium Inc. to carry out a geophysical investigation for the proposed development at the Brighton Wastewater Treatment System property located at 100 County Road 64 in Brighton, Ontario.

The objective of the survey was to determine site class for seismic site response based on the average shear wave velocity value measured over the upper 30 m (V_S30). The multi-channel analysis of surface waves (MASW) and seismic refraction methods were employed for this investigation. The MASW aimed to obtain shear wave velocity depth profiles in the overburden; the purpose of the seismic refraction survey was to obtain shear wave velocity values for the top of bedrock.

The fieldwork was conducted on February 16, 2024. The location of the seismic survey line is shown in Figure 1.

This report describes the basic principles of the seismic refraction and MASW methods, survey design, interpretation method, and presents the results of the investigation in the chart and table format.

2 INVESTIGATION METHODOLOGY

2.1 Multichannel Analysis of Surface Waves (MASW)

Overview

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method widely applied to produce shear wave velocity (V_S) profiles. It is based on the dispersive nature of Rayleigh or Love surface waves in layered media. Surface waves with longer wavelengths propagate deeper in the subsurface, hence, their phase velocity is more influenced by the elastic properties of deeper layers. The velocity of surface waves depends mainly on the shear wave velocity of the medium. The distribution of surface waves phase velocities as a function of wavelength (or frequency) can be visualized as a dispersion curve. The inverse problem is then solved by modelling the experimental data with a theoretical dispersion curve; the model parameters are typically limited to layer thickness and shear wave velocity with an assumption of horizontally layered strata. As a result of the inversion, a shear wave velocity depth profile is obtained. Figure 2 illustrates the overall procedure of the MASW method.

Survey Design

The acquisition layout consisted of 24 receivers in a linear array (spread), connected with two 12-channel cables to P.A.S.I. Gea-24 seismograph. 4.5 Hz natural frequency vertical geophones were used for this survey. The measurements were conducted with a spread length of 23 m (1 m spacing between geophones).

An 8-kg sledgehammer was used as an energy source. Shots were executed at five locations per spread: one shot in the middle of the spread, two shots close to the ends of the spread, and two shots with an offset of 12 m from the ends of the spread. The record length was set to 1500 ms with a 0.05 ms sampling interval.

Legend

🟨 Location of 23 m, 24-geophone MASW spread

🟥 Location of 69 m, 24-geophone seismic refraction spread

Image: Google Earth 2023

Date: 2024-02-21

File No: F-24171

FRONTWAVE GEOPHYSICS

Title: Survey location plan

Location: 100 County Rd 64,
Brighton, ON

Figure:
1

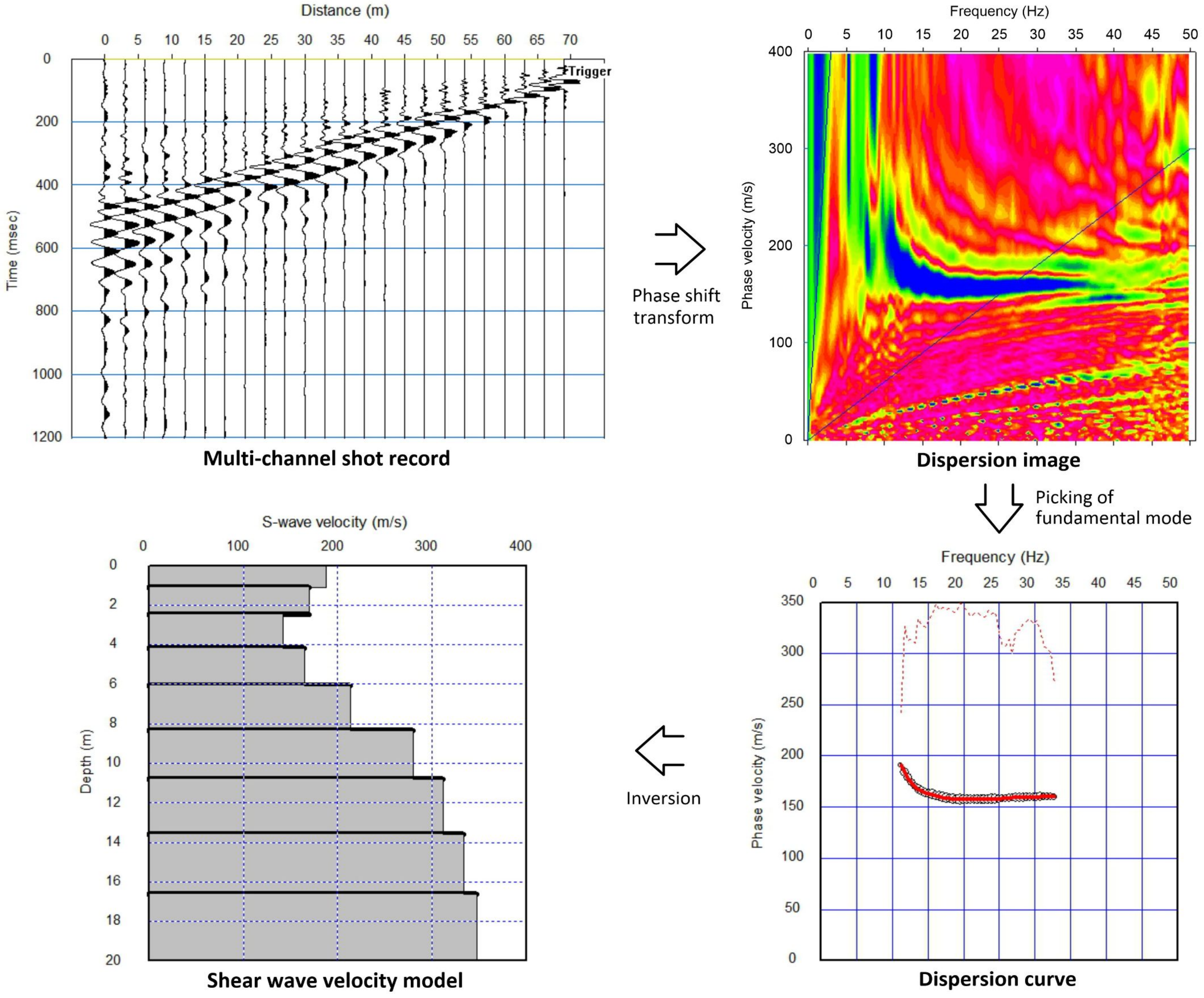


Figure 2 *The procedure of MASW data processing using the SeisImager SW software package.*

Interpretation

A dispersion curve is obtained from each field record by converting the shot gather into a dispersion image and then identifying and picking the fundamental mode. A shear wave velocity profile is obtained through inversion of the dispersion curve by modelling the subsurface as a horizontally layered medium with the model parameters limited to the number of layers, their thickness and shear-wave velocity.

ZondST2D software package was used for processing, picking and inversion of the MASW data.

Accuracy of the results

The accuracy of MASW generally depends on the complexity of the subsurface and specific site conditions (noise levels, topography, etc.). Lateral velocity variations and steeper bedrock topography increase the dispersion uncertainty. The presence of high-velocity contrast layers such as bedrock will require the use of a-priory information to optimize model parameters for more accurate results. Hence, if the a-priory information is not available (e.g. when the data are overly noisy to carry out refraction analysis), the accuracy decreases.

At bedrock sites and sites with very shallow overburden overlying bedrock, the MASW method performs poorly. Very strong velocity contrast between layers at shallow depths often results in a superposition of fundamental and higher Rayleigh wave modes which, when superimposed, cannot be distinguished. At sites where the thickness of the overburden is sufficient to obtain a coherent dispersion, the inversion would significantly underestimate the S-wave velocity within the rock. For this reason, it is preferred to supplement the MASW with shear wave refraction data which provide accurate shear wave velocity values for bedrock.

2.2 Seismic Refraction

Overview

The seismic refraction method is based on the measurement of arrival times of seismic waves refracted at interfaces between geological layers. The method is used to obtain velocity depth models and to map interfaces between layers with significant velocity contrast such as water table and bedrock surface. Compressional (P) wave or shear (S) wave refracted arrivals can be recorded using vertically or horizontally oriented sensors and sources, respectively. Figure 3 is a schematic of a simplified seismic model showing the basic principle of the refraction method.

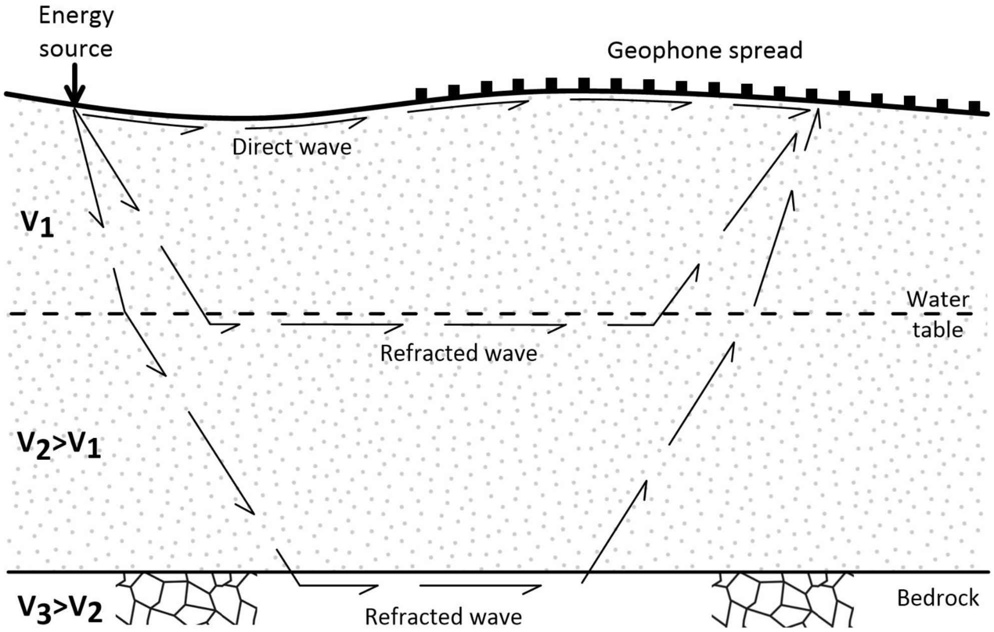


Figure 3 *Seismic model showing the basic principle of refraction method.*

Survey Design

The acquisition layout consisted of 24 receivers in a linear array (spread), connected with two 12-channel cables to P.A.S.I. Gea-24 seismograph. 10 Hz natural frequency horizontal geophones were used for this survey. The measurements were conducted with a spread length of 69 m (3 m spacing between geophones).

An 8-kg sledgehammer was used as an energy source. Shots were executed at four locations per spread: two shots at the ends of the spread and two shots with an offset of 15 m from the ends of the spread. Preferential S-wave energy was generated by horizontally striking a metal bar in a direction perpendicular to the survey line. Shots in two opposite directions were recorded at each shot location to record S-wave arrivals of opposite polarity. The record length was set to 500 ms with a 0.1 ms sampling interval.

Interpretation

The reciprocal (plus-minus) method was used for the interpretation of the seismic refraction data. The method assumes the subsurface as a series of discrete layers (refractors) with simple velocity distributions. It allows calculating the depth and velocity of a continuous undulating refractor, providing the target layer is of sufficient thickness and the dip angles are moderate.

ZondST2D software package was used for processing of the refraction data. The processing involved stacking of shot records obtained with opposite source directions, identification and picking of S-wave first arrivals.

Accuracy of the results

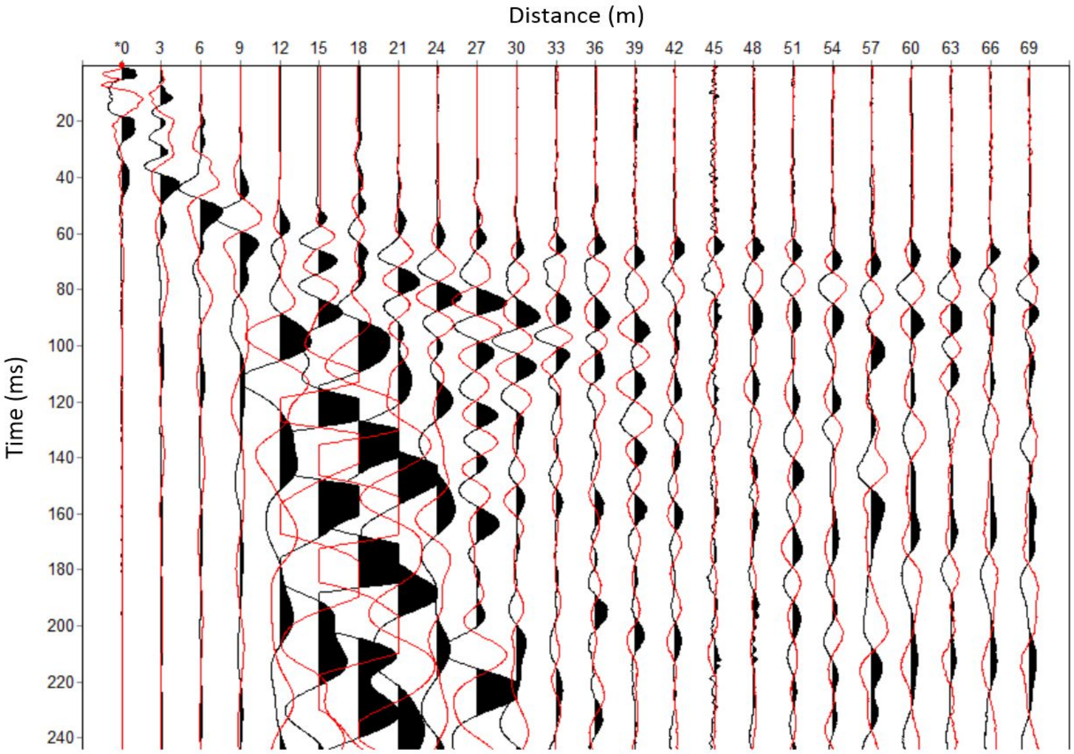
The accuracy of bedrock velocity determination at this site was estimated to be within 10%.

3 RESULTS

The quality of seismic shot records was very good; first arrivals of refracted waves and MASW dispersion curves were well defined. Example S-wave refraction shot records and an MASW dispersion image obtained at this site are presented in Figure 4.

Refraction analysis was performed on both P-wave (MASW) and S-wave (refraction) data sets collected at the site. The results of the interpretation are presented in Figure 5 in the form of a bedrock profile. The discrepancy between the bedrock depths determined from the P-wave and S-wave data probably indicates the presence of a layer of slightly weathered rock. The S-wave data collected using a longer spread provided the depth and velocity for competent rock; the measured P-wave velocity was also lower than could be expected assuming a suitable Poisson ratio for carbonate rock (0.3).

The interpreted depth to competent bedrock ranged approximately from 3 to 5 m below the ground surface. The shear wave velocity in the bedrock measured using the refraction method was 2887 ± 10% m/s.



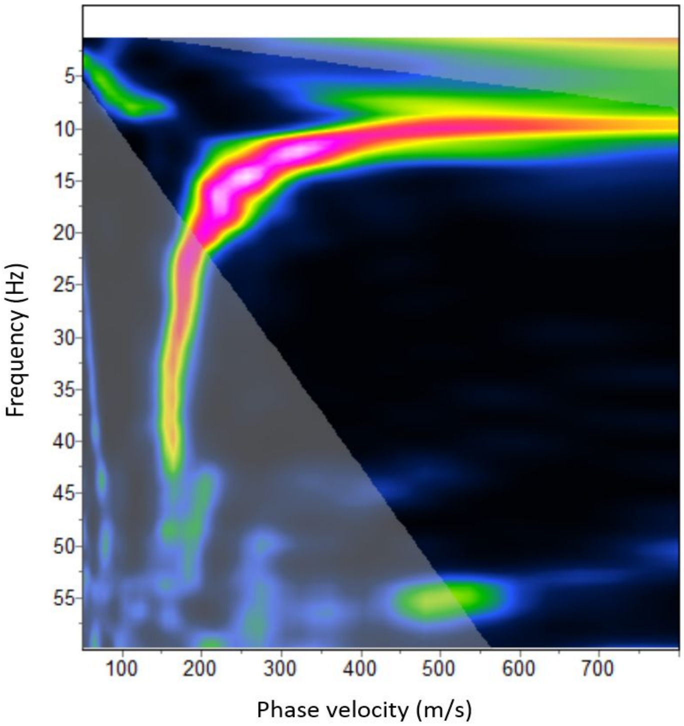


Figure 4 *Data examples displaying a stacked S-wave refraction shot record (top) and MASW dispersion image (bottom).*

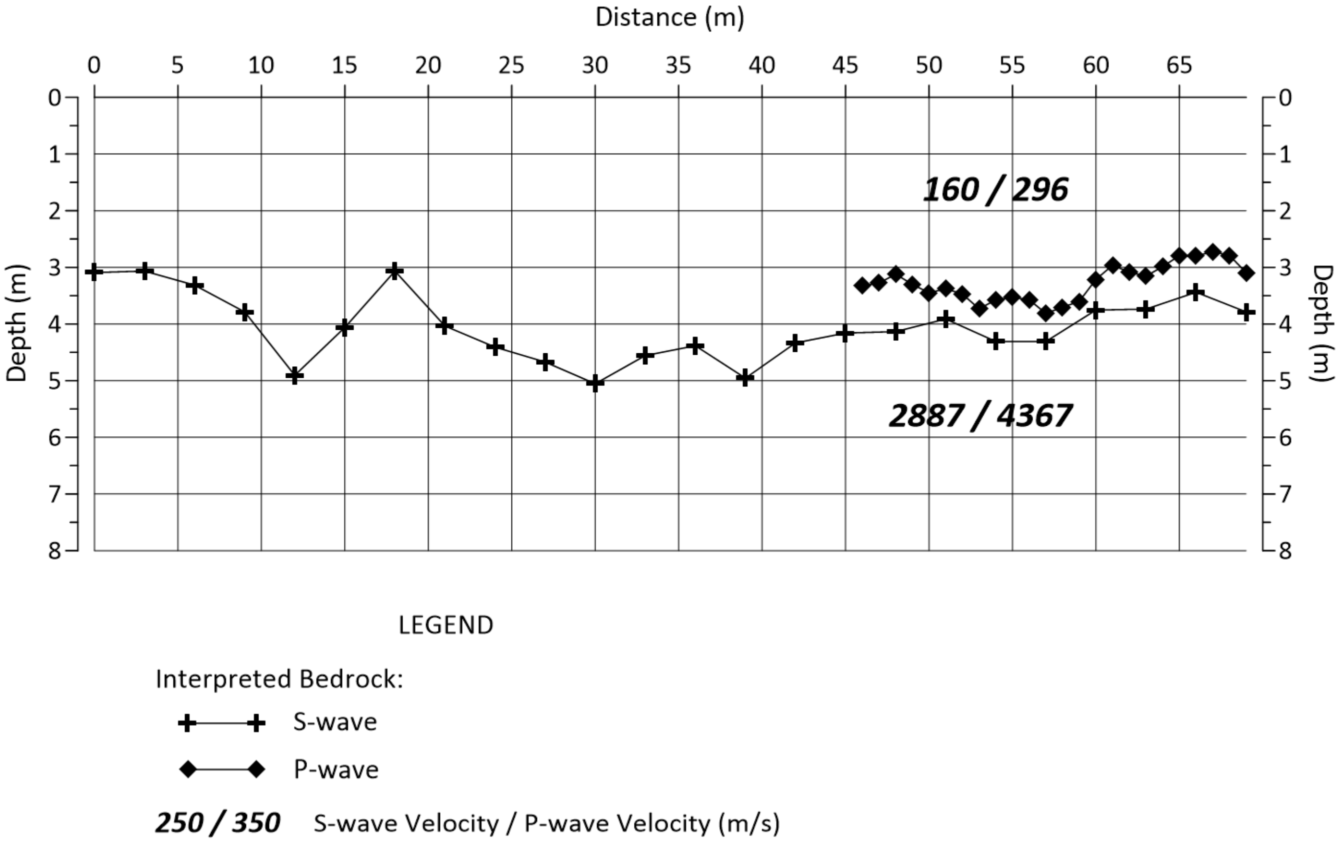


Figure 5 *Interpreted bedrock profile.*

Refraction data were used for parameterization of the initial MASW inversion models. The measured shear wave velocity for the bedrock is representative of the top of the rock. According to Commentary J (Paragraph 96) of the National Building Code of Canada 2015 (NBC), the measured value may be extrapolated if the rock conditions are known to be continuous to a depth of 30 m.

The resulting shear wave velocity depth profile is presented in Figure 6. The average S-wave velocity is plotted in the chart as a solid line. The dashed lines represent the upper and lower bound S-wave velocity profiles.

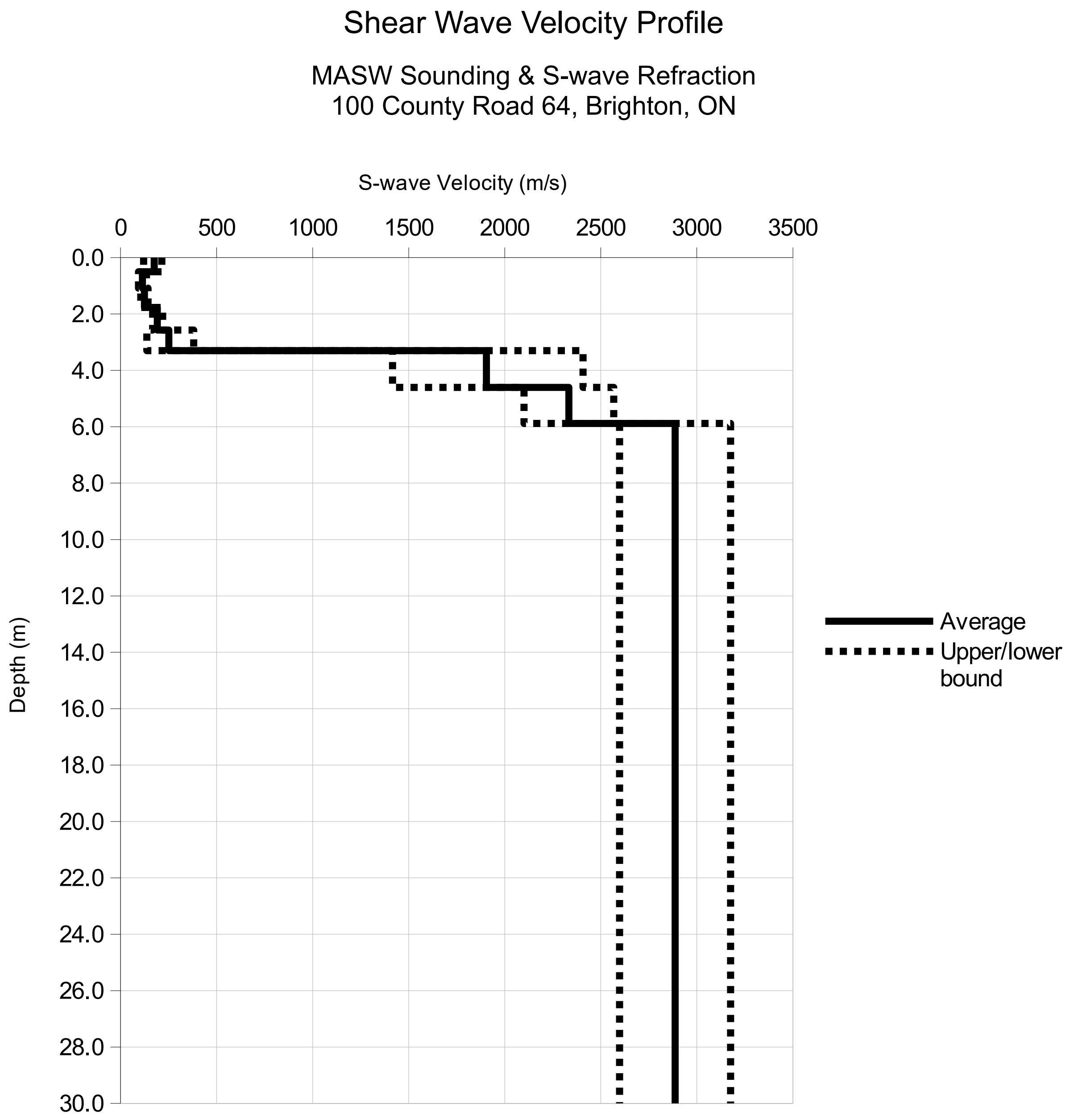


Figure 6 *Shear wave velocity profile from MASW sounding and S-wave refraction.*

The tabulated shear wave velocity model is presented in Table 1.

Table 1 *Shear wave velocities from MASW sounding and S-wave refraction.*

Depth Interval (m)		S-wave Velocity (m/s)
From	**To**	
0.0	0.5	175
0.5	1.1	114
1.1	1.8	124
1.8	2.6	191
2.6	3.3	251
3.3	4.6	1905
4.6	5.9	2334
5.9	30.0	2887

The average shear wave velocity within the upper 30 meters (V_S30) is defined as the travel-time weighted average velocity from surface to a depth of 30 m and calculated using the following formula:

$$V_S30 = 30 / \Sigma\, (d/V_S),$$

where d is the thickness of any layer and V_S is the layer S-wave velocity. In other words, V_S30 is calculated as 30 m divided by the sum of the S-wave travel times for each layer within the topmost 30 m.

The calculated V_S30 values are presented in Table 2.

Table 2 *V_S30 values from MASW sounding and S-wave refraction.*

Depth Range (m)	Minimum V_S30 (m/s)	Average V_S30 (m/s)	Maximum V_S30 (m/s)	NBC 2015 Seismic Site Class
0 to 30	793	**994**	1169	**B**

The V_S30 values obtained from the S-wave sounding varied from 793 m/s to 1169 m/s with an average of 994 m/s.

Based on the Site Classification for Seismic Site Response (Table 4.1.8.4.-A) of the National Building Code of Canada 2015 (NBC), the calculated V_S30 value falls in the Site Class B range ($760 < V_S30 \leq 1500$ m/s).

According to the requirements of Table 4.1.8.4.-A of NBC 2015, site classes A and B are not to be used if there is more than 3 m of soil between the rock surface and the bottom of the spread footing, pile cap or mat foundation of the building. If there is more than 3 m of soil between the building foundation and bedrock surface, **the investigated site must be assigned Site Class C**.

4 CLOSURE

Shear wave velocity testing involving the MASW and seismic refraction methodologies was carried out for the proposed development at the Brighton Wastewater Treatment System property located at 100 County Road 64 in Brighton, Ontario.

The average shear wave velocity (V_S30) value calculated from in situ shear wave velocity measurements falls in the Site Class B range. The depth to the top of bedrock at this site is estimated to be between 3 and 5 m. Taking into consideration the presence of more than 3 m of overburden at this site, **the applicable Site Class is C**.

Site Class B can be used if there is less than 3 m of soil between the rock surface and the bottom of the foundation of the building.

The shear wave velocity measured in the bedrock may be used as a V_S30 value for foundations constructed on competent bedrock. In this case, based on the Table 4.1.8.4.-A, Site Class A (V_S30 > 1500 m/s) can be applied.

We hope you find this report satisfactory. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Frontwave Geophysics Inc.

Ilia Gusakov, P.Geo.
Geophysicist
(647) 514-4724
ilia.gusakov@frontwave.ca

PROFESSIONAL GEOSCIENTIST
ILIA GUSAKOV
PRACTISING MEMBER
3161
ONTARIO

Appendix F

Laboratory Certificate of Analysis

FINAL REPORT

CA40048-APR24 R1

19712-001, Brighton

Prepared for

Cambium Inc.

FINAL REPORT

CA40048-APR24 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Cambium Inc.	Project Specialist	Maarit Wolfe, Hon.B.Sc
		Laboratory	SGS Canada Inc.
Address	31 Hyperion Court, Suite 102 Kingston, ON K7K 7G3, Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Blasco Vijayayabaskaran	Telephone	705-652-2000
Telephone	613-929-1507	Facsimile	705-652-6365
Facsimile	705-742-7901	Email	Maarit.Wolfe@sgs.com
Email	blasco.vijayabaskaran@cambium-inc.com; ESdat_CA+Cambiu	SGS Reference	CA40048-APR24
Project	19712-001, Brighton	Received	04/08/2024
Order Number		Approved	04/10/2024
Samples	Soil (1)	Report Number	CA40048-APR24 R1
		Date Reported	04/10/2024

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number: n/a

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Maarit Wolfe, Hon.B.Sc

FINAL REPORT

TABLE OF CONTENTS

FINAL REPORT

Client: Cambium Inc.
Project: 19712-001, Brighton
Project Manager: Blasco Vijayayabaskaran
Samplers: Tim Paget

MATRIX: SOIL

Sample Number 5
Sample Name BH106-24 10-12
Sample Matrix Soil
Sample Date 20/02/2024

Parameter	Units	RL		Result
Corrosivity Index				
Corrosivity Index	none	1		1
Soil Redox Potential	mV	no		212
Sulphide (Na2CO3)	%	0.01		< 0.01
pH	pH Units	0.05		8.34
Resistivity (calculated)	ohms.cm	-9999		5030
General Chemistry				
Conductivity	uS/cm	2		199
Metals and Inorganics				
Moisture Content	%	0.1		10.2
Sulphate	µg/g	0.4		68
Other (ORP)				
Chloride	µg/g	0.4		5.2

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0204-APR24	µg/g	0.4	<0.4	0	35	101	80	120	102	75	125
Sulphate	DIO0204-APR24	µg/g	0.4	<0.4	1	35	97	80	120	104	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0029-APR24	%	0.01	< 0.01								

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0207-APR24	uS/cm	2	< 2	0	20	98	90	110	NA		

FINAL REPORT

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0207-APR24	pH Units	0.05	NA	1		101			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Results relate only to the sample tested.
Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.
"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.
Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety

Request for Laboratory Services and CHAIN OF CUSTODY

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Sean berner

Received By (signature):

Received Date: 4 / 8 / 24 (mm/dd/yy)

Received Time: 15 : 37 (hr : min)

Custody Seal Present: Yes ☑ No ☐

Custody Seal Intact: Yes ☑ No ☐

Cooling Agent Present: Yes ☑ No ☐

Type: Ice

Temperature Upon Receipt (°C) 9°, ___, ___

LAB LIMS #: CA-40048-Apr24

REPORT INFORMATION

Company: Cambium

Contact: Blasco Vijayabaskaran

Address: 625 Fortune Crescent, Unit 1
Kingston ON K7P 2T3 Canada

Phone: 613.929.1507

Fax:

Email: blasco.vijayabaskaran@cambium-inc.com

INVOICE INFORMATION

☑ (same as Report Information)

Company:

Contact:

Address:

Phone:

Email:

Quotation #:

P.O. #:

Project #: 19712-001

Site Location/ID: Brighton

TURNAROUND TIME (TAT) REQUIRED

☐ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☑ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: April 10, 2024

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:

☐ Table 1 ☐ Res/Park Soil Texture:

☐ Table 2 ☐ Ind/Com ☐ Coarse

☐ Table 3 ☐ Agri/Other ☐ Medium/Fine

☐ Table ____

Other Regulations:

☐ Reg 347/558 (3 Day min TAT)

☐ PWQO ☐ MMER

☐ CCME ☐ Other:

☐ MISA

Sewer By-Law:

☐ Sanitary

☐ Storm

Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	M & I				SVOC		PCB	PHC		VOC		Pest	Other (please specify)							TCLP	COMMENTS:
						Field Filtered (Y/N)	Metals & Inorganics incl CrVI, CN, Hg pH, (B(HWS), EC, SAR–soil) (Cl, Na-water)	Full Metals Suite ICP metals plus B(HWS-soil only) Hg, CrVI	ICP Metals only Sb,As,Ba,Be,B,Cd,Cr,Co,Cu,Pb,Mo,Ni, Se,Ag,Tl,U,V,Zn	PAHs only	SVOCs all incl PAHs, ABNs, CPs	PCBs Total ☐ Aroclor ☐	F1-F4 + BTEX	F1-F4 only no BTEX	VOCs all incl BTEX	BTEX only	Pesticides Organochlorine or specify other	Corrosivity	Resistivity	Redox Potential	Chloride	Sulphate and Sulphide Content	Sewer Use: Specify pkg:	Water Characterization Pkg General ☐ Extended ☐	Specify TCLP tests ☐M&I ☐VOC ☐PCB ☐B(a)P ☐ABN ☐Ignit.	
1	BH106-24 10'-12'	Feb 20/2024	15:00	2	Soil													✓	✓	✓	✓	✓				
2																										
3																										
4																										
5																										
6																										
7																										
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12																										

Observations/Comments/Special Instructions

Sampled By (NAME): Tim Paget	**Signature:** Tim Paget Digitally signed by Tim Paget DN: cn=Tim Paget, o=Cambium, ou=Geotechnical, email=tim.paget@cambium-inc.com, c=CA Date: 2024.04.08 10:24:16 -04'00'	Date: 04 / 08 / 2024	(mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Tim Paget	**Signature:** Tim Paget Digitally signed by Tim Paget DN: cn=Tim Paget, o=Cambium, ou=Geotechnical, email=tim.paget@cambium-inc.com, c=CA Date: 2024.04.08 10:25:12 -04'00'	Date: 04 / 08 / 2024	(mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.3
Date of Issue: 13 Nov, 2019

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. {2} Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). {3} Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.