Geotechnical Investigation Report - 30 Sophia Street West, Barrie, Ontario

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Prepared for:
Solid General Contractors

Cambium Reference: 14909-001

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1.0 Introduction

Cambium Inc. (Cambium) was retained by Innovative Planning Solutions (IPS) on behalf of Solid General Contactors (the Client) to complete a geotechnical investigation in support of a proposed residential development located at 30 Sophia Street West in Barrie, Ontario (Site).

The geotechnical investigation was required to confirm subsurface conditions at the Site to provide geotechnical design parameters as input into the design and construction of the proposed development.

This report presents the methodology and findings of the geotechnical investigation to determine subsurface conditions at the Site. Based on the results of this investigation, the report provides recommendations pertaining to the proposed development including soil bearing capacity, foundation design options, seismic site classification, excavations, and dewatering, backfill and compaction, frost depth, drainage, and pavement design.

As part of the scope of work, Cambium was also retained to complete a hydrogeological assessment, which has been provided under a separate cover.

1.1.1 Site Description

The property is situated at the northeast corner of the intersection of Sophia Street West and Mary Street, covering an area of approximately 60 m x 40 m. The parcel is bordered to the north and east by residentially developed properties, to the south by Sophie Street West and to the west by Mary Street.

The Site is currently partially developed with an existing two-storey structure, which has a square footprint area of approximately 20 m x 20 m, and the remainder of the property consists of both paved and grassed areas. The ground elevation at the Site is relatively constant at around 234 m above sea level (mASL), with the exception of an open ditch bisecting the eastern grassed portion of the Site (maximum depth of roughly 2 m), which leads into a 1.3 m-diameter culvert running below the existing structure and other portions of the Site towards the west. A Site location plan is appended as Figure 1 of this report.

1.1.2 Project Description

It is understood that the proposed development involves the demolition of the existing building and construction of a multi-storey apartment building including one level of underground parking. At the time of writing, Cambium is aware of two alternatives being considered for the proposed development. One consists of a four-storey apartment building with a footprint size of 40 m x 18 m, with one level of underground parking as well as surface parking along the north and east property lines. The apartment building is located in the southwest corner of the Site and has a setback of approximately 3 m from the southern and western property lines.

The second, alternative concept consists of an eight-storey apartment building with a footprint of roughly 55 m x 30 m, with one level of underground parking extending approximately 1.5 m below the existing grade. The building line for the first two above-ground storeys is immediately adjacent to the western property line and will be set back approximately 3 m from the southern and eastern property lines (landscape buffers). The perimeter of the other above-ground storeys (level 3 to 8) will be offset between 2 m and 5 m inward from the building lines of the lower two storeys (“tower”). A driveway area is proposed in the remaining undeveloped area between the northern building line and the northern property line, presumably with access to underground parking.

2.0 Methodology

2.1 Borehole Investigation

A borehole investigation was conducted on March 23, 2022, to assess the subsurface conditions at the Site. A total of four boreholes, numbered BH/MW101-22, through BH/MW103-22, and BH104-22, were advanced across the Site. All the boreholes were terminated at a depth of 6.7 m below ground surface (mbgs).

GPS coordinates and elevations of each borehole were obtained using a Topcon real-time kinematic (RTK) unit. The elevations were referenced to the top of the concrete monument at the southwest corner of the property, having an elevation of 233.68 mASL, as per the topographic survey of the Site, provided by the Client and dated March 14, 2022. The borehole UTMs and elevations are provided on the borehole logs in Appendix A. Borehole locations are shown on Figure 2.

Drilling and sampling was completed using a track-mounted drill rig, under the full-time supervision of a Cambium Geotechnical Analyst. The boreholes were advanced to the pre-determined depths by means of continuous flight hollow 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 (SS) sampler 305 mm into the soil using a 63.5 kg drop hammer falling 750 mm, as per ASTM D1586 procedures. Soil samples were collected at 0.75 m intervals from 0 to 3 m and at 1.5 m intervals after 3 m. The encountered soil units 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.

Three of the boreholes, BH/MW101-22, BH/MW102-22, and BH/MW103-22 were outfitted with monitoring wells to determine the static groundwater elevation at the Site.

Borehole logs are provided in Appendix A. Site soil and groundwater conditions are described, and geotechnical recommendations are discussed in the following sections of this report.

2.2 Physical Laboratory Testing

Physical laboratory testing, including four grain size analyses (LS-702, 705) was completed on selected soil samples to confirm textural classification and to assess geotechnical parameters. Natural moisture content testing (LS-701) was completed on all retrieved soil samples. Results of the grain size testing are presented in Appendix B and are discussed in Section 3.0.

3.0 Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes are presented on the attached Borehole Logs in Appendix A. The stratigraphic boundaries indicated on the logs are inferred from non-continuous samples and observations of drilling resistance and typically represent a transition from one soil type to another, sometime gradually. The boundaries should not be interpreted to represent exact planes of geologic change. The subsurface conditions have been confirmed in a series of widely spaced boreholes and will vary between and beyond the borehole locations.

It is understood that the proposed apartment building will have one storey of underground parking.

The subsurface conditions at the site generally consist of paved asphalt or surficial topsoil overlying a sand fill material in the upper 1.5 m. Underlying the fill, native soils consist of sand to silty sand with varying amounts of gravel and clay, and sand and silt deposits with some gravel. A summary of the encountered subsurface conditions is provided in the following sections.

3.1 Topsoil and Asphalt

A 305 mm thick surficial layer of topsoil was encountered in boreholes BH/MW101-22 and BH104-22. Assessment of organic matter content or other topsoil quality tests were beyond the scope of this study.

Borehole BH/MW102-22 was augered through a paved surface with an asphalt thickness of 25 mm.

3.2 Fill

Underlying the topsoil and asphalt described in Section 3.1, and at surface in borehole BH/MW103-22, a layer of fill was encountered in all the boreholes within the Site. The surficial fill layer in borehole BH/MW103-22 consisted of a grey silty clay with trace gravel and extended to a depth of 0.6 mbgs.

The remaining fill encountered below the topsoil/asphalt layer consisted of a reddish-brown or brown to black sand layer with varying amounts of gravel. This same sand layer was encountered beneath the silty clay in borehole BH/MW103-22. Overall, the fill layer extended to approximate depths ranging between 0.9 mbgs and 1.5 mbgs. SPT N–values measured in the sand fill material ranges from 0 (weight of hammer) to 6, indicative of a very loose to loose relative density, and an SPT N-value of 14 was measured in the silty clay fill, indicative of a stiff consistency. The moisture content in this layer ranged from 10% to 23% based on laboratory testing.

3.3 Inferred Glacial Till

Underlying the fill material in all boreholes, soils presumed to be native were encountered consisting of mixtures of sand and silt (generally sand-dominant, with variable silt content) with varying amounts of gravel and clay. Given the grain size analysis results presented below and the relative densities of the encountered material, this layer was inferred to be glacial till material.

The inferred glacial till extended to the borehole termination depth of 6.7 mbgs at all locations. SPT N-values measured in this layer generally ranged from 14 to over 50 blows, indicative of a compact to very dense relative density. Exceptions were recorded in boreholes BH/MW101-22 and BH/MW102-22 at a depth of 1.0 mbgs and 1.5 mbgs respectively, where SPT N-values of 6 to 8 were measured, indicative of a loose relative density.

However, the sand and silt mixtures transitioned to a very dense relative density at a depth of ±2.3 mbgs in all boreholes, with a very dense relative density observed to the termination depth of each borehole. The sand and silt mixtures were grey in colour with moisture generally increasing with depth from moist to saturated, with natural moisture contents ranging from 8% to 19% based on laboratory testing.

Particle size distribution testing was completed on four samples obtained from the sand and silt (inferred glacial till) formation. A summary of the results can be found in Table 1.

Table 1 Particle Size Distribution – Inferred Glacial Till

Borehole	Depth (mbgs)	Description	% Gravel	% Sand	% Silt	% Clay	% Moisture Content
BH/MW101-22, SS3	1.5 – 2.1	Sand and Silt, some Gravel, trace Clay	10	44	39	7	15.5
BH/MW102-22, SS5	3.0 – 3.7	Sand, some Silt, trace Clay, trace Gravel	2	71	18	9	16.0
BH/MW103-22, SS4	2.3 – 2.9	Silty Sand, some Clay, trace Gravel	3	63	22	12	9.5
BH104-22, SS3	1.5 – 2.1	Sand, some Silt, some Clay, trace Gravel	5	66	19	10	9.2

3.4 Bedrock

Bedrock was not confirmed within the investigation depths, and all boreholes were terminated in native soils at the pre-determined depth of 6.7 mbgs. The elevation of each borehole and the respective termination depths are provided in Table 2.

Table 2 Borehole Termination Depth and Elevations

Borehole	Borehole Elevation (mASL)	Borehole Termination Depth (mbgs)	Borehole Termination Elevation (mASL)
BH/MW101-22	234.15	6.7	227.45
BH/MW102-22	233.90	6.7	227.20
BH/MW103-22	234.11	6.7	227.41
BH104-22	234.01	6.7	227.31

3.5 Groundwater

Wet to saturated soils (based on visual observations during drilling works) were encountered in all of the boreholes at the time of the investigation. Wet/saturated soils were first encountered in boreholes BH/MW101-22, BH/MW102-22, and BH/MW103-22 at depths between 1.5 mbgs and 3.0 mbgs, and at a depth of 4.7 mbgs in borehole BH104-22.

Monitoring wells were installed in boreholes BH/MW101-22, BH/MW102-22, and BH/MW103-22 to measure the static water level at the Site and for hydrogeological purposes. The groundwater levels were measured in the monitoring wells between March 25, 2022 and October 19, 2022. These observations are summarized in Table 3.

Table 3 Groundwater Depths and Elevations

Borehole		BH/MW101-22	BH/MW102-22	BH/MW103-22
Ground Surface Elevation (mASL)		234.15	233.90	234.11
March 25, 2022	Depth to Groundwater (mbgs)	**1.40**	**2.50**	5.32
	Groundwater Elevation (mASL)	**232.75**	**231.40**	228.79
March 31, 2022	Depth to Groundwater (mbgs)	1.44	**2.50**	3.22
	Groundwater Elevation (mASL)	232.71	**231.40**	230.89
April 29, 2022	Depth to Groundwater (mbgs)	1.52	2.58	**0.85**
	Groundwater Elevation (mASL)	232.63	231.32	**233.26**
May 2, 2022	Depth to Groundwater (mbgs)	1.60	2.62	1.00
	Groundwater Elevation (mASL)	232.55	231.28	233.11
June 28, 2022	Depth to Groundwater (mbgs)	1.79	2.73	1.23
	Groundwater Elevation (mASL)	232.36	231.17	232.87
July 14, 2022	Depth to Groundwater (mbgs)	1.93	2.85	1.34
	Groundwater Elevation (mASL)	232.22	231.05	232.77
September 20, 2022	Depth to Groundwater (mbgs)	1.89	2.84	1.31
	Groundwater Elevation (mASL)	232.26	231.04	232.80
October 19, 2022	Depth to Groundwater (mbgs)	1.85	2.86	1.22
	Groundwater Elevation (mASL)	232.30	231.04	232.89

***Bold** text denotes high groundwater measurements recorded during monitoring events.*

Based on the above monitoring well observations, the groundwater table at the Site stabilizes between approximately 1 mbgs and 2.9 mbgs, corresponding to elevations ranging from 231.0 mASL to 233.3 mASL (based on groundwater elevations observed during April/May 2022).

These depths would match the approximate depths that wet to saturated soils were first encountered during the drilling investigation. Soils at these depths were also grey in colour, indicating a prolonged exposure to groundwater, providing reducing, anoxic conditions.

The moisture content of the soils generally ranged from 8% to 23%. It should be noted that soil moisture and groundwater levels at the Site may fluctuate seasonally and in response to climatic events.

4.0 Geotechnical Considerations

The following discussion and recommendations are based on the factual data obtained from this investigation and are intended for use by the owner and designers. Contractors bidding or providing services on this project should review the factual data and determine their own conclusions regarding the construction methods and scheduling. It is possible that subsurface conditions beyond the borehole locations may vary from those observed. If significant variations are found before or during construction, Cambium should be contacted so that we can reassess our findings, if necessary.

This report assumes that the design features relevant to the geotechnical analysis will be completed in accordance with applicable codes, standards, and guidelines of practice. If there are changes to the site development features, or there are any significant variations in the subsurface conditions that are found before or during construction, Cambium should be retained to review the implications of these changes with respect to the contents of this report.

4.1 Site Preparation

Any existing fill, organic material and other disturbed material encountered should be excavated and removed beneath any areas of the Site to be developed; additionally, this material should be excavated and removed to a minimum distance of 3 m around the building footprint. Any topsoil and materials with significant quantities of organics and deleterious materials (i.e., construction debris, etc.) are not appropriate for use as fill below buildings or grading and parked areas.

The exposed subgrade should be proof-rolled and inspected by a qualified geotechnical engineer prior to placement of granular fill or foundations. Any loose/soft soils identified at the time of proof-rolling that are unable to uniformly be compacted should be sub-excavated and removed. The excavations created through the removal of these materials should be backfilled with approved engineered fill consistent with the recommendations provided below.

The near surface sand soils can become unstable if they are wet or saturated. Such conditions are common in the spring and late fall.

Under these conditions, temporary use of granular fill, and possible reinforcing geotextiles, may be required to prevent severe rutting on construction access routes.

All slopes and embankments, and any drainage runoff areas must be protected from surficial erosion by means of erosion mats, sodding, deep rooted vegetation, or other stabilizing features.

4.2 Excavations

Based on information provided to Cambium by the Client, the proposed apartment building is to contain one level of underground parking, and thus excavations are assumed to extend to a depth of approximately 3.0 mbgs.

Depending on which of the two concept alternatives are selected, the building line locations of the proposed structure vary and range from being adjacent to the property lines to being set back a minimum of 3 m from the property lines.

Wherever the proposed building line is situated adjacent to a property line, it will be necessary to use shoring to support the excavation. Based on the encountered soil materials and groundwater conditions, this can be done using an impermeable system such as interlocking sheet piling, although given the very dense soils it may be necessary to utilize additional methods such as pre-drilling to allow driving of the sheet piles to the required embedment depths. Alternatively, soldier piles and lagging may be used to support the excavation, however these would need to be combined with appropriate dewatering methods to reduce the groundwater level outside the excavation perimeter.

All shoring methods require detailed engineering design by a qualified engineer according to relevant standards and guidelines. Specialty geotechnical contractors can often be retained to design shoring systems, which may be proprietary in nature.

Shoring will also be necessary in areas where the maximum slope angles given below (based on OHSA) cannot be realized due to the setback of the proposed structure from the property lines. In general, a minimum distance of 0.5 m (workspace allowance) should be maintained between the base of the excavation slope and the outer building line of the proposed structure.

For example, for an excavation slope at a maximum inclination of 1H:1V to an excavation depth of 3.0 m, a minimum distance of 3.5 m would be required between the outer building line and the property line to accommodate the excavation.

For excavations along the southern and western property lines (i.e., with an excavation slope crest adjacent to the roadway, slope stability should be considered using geotechnical principles, to verify the factor of safety of the temporary slope.

Provided that the available space is sufficient and slope stability requirements considering any adjacent traffic loads, etc., are satisfied, temporary excavations being conducted at the Site must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA), Ontario Regulation 213/91 (as amended). For practical purposes, the soils at the site above the water table can be considered to be Type 3 soils, as such excavation side slopes should be no steeper than 1H:1V. Unsupported excavations below the groundwater table are not recommended without advance dewatering. Since there is one proposed underground parking level, excavations could extend to 3.0 mbgs or deeper.

The anticipated groundwater levels at the Site are approximately 1.0 mbgs to 2.6 mbgs. Therefore, advanced dewatering using a well-point system will most likely be required. Once dewatered, the native soils may also be classified as Type 3 soils and may be excavated with side slopes no steeper than 1H:1V. If dewatering is deemed not necessary, soils below the water table should be treated as Type 4 soils and therefore excavation side slopes should be increased to 3H:1V in these areas.

Excavation side slopes should be protected during construction from precipitation, runoff, or snow/ice melt to ensure stability. If visible instability occurs, it may be necessary to flatten the excavation slopes accordingly.

4.3 Groundwater Control and Dewatering

Groundwater (free water) was observed at depths of 1.0 mbgs to 2.9 mbgs in the three monitoring wells (BH/MW101-22, BH/MW102-22, and BH/MW103-22) installed at the Site. These depths correspond to elevations of 231.0 mASL to 233.3 mASL.

This is consistent with observations of the soil during drilling, which were generally observed to be grey in colour and/or wet to saturated below 1.5 mbgs.

Anticipating that the excavations for the underground parking level will be below the groundwater table and subgrade soils consist mainly of sand, significant groundwater seepage is anticipated and advanced dewatering using a well-point dewatering system is recommended. Registration on the Environmental Activity and Sector Registry (EASR) and a Permit to Take Water (PTTW) will be required from the Ministry of the Environment, Conservation and Parks (MOECP) as pumping rates are expected to exceed 50,000 L/day.

It is recommended that the Client measure the static groundwater levels at the Site during different seasons to determine the driest time of year for construction. Cambium is able to provide this service, using the existing monitoring wells on site, and can provide a quote to the Client, if required.

It should be noted that the groundwater table is influenced by seasonal fluctuations and major precipitation events.

4.4 Frost Penetration

Based on climate data and design charts, the maximum frost penetration depth below the surface at the site is estimated at 1.5 mbgs.

Exterior footings for the proposed structures should be situated at or below this depth for frost penetration or should be appropriately protected.

It is assumed that any pavement structure thickness will be less than 1.5 m; therefore, grading and drainage are important for good pavement performance and life expectancy.

Any services should be located below this depth or be appropriately insulated.

4.5 Foundation Design

Design and construction recommendations for potential foundation systems are outlined below.

4.5.1 Shallow Strip/Spread Foundations

If the site is prepared as outlined above, the structures can be supported on standard strip and spread footings placed with at least 1.5 m of earth cover for frost protection, prepared as outlined in Section 4.1 and founded on native soils. It is understood that the proposed apartment building is planned with one level of underground parking. The structure with one level of underground parking can also be supported on standard strip and spread footings placed at least 3.0 m below existing grades in the generally very dense native sand material.

The recommended Serviceability Limit States (SLS) and Ultimate Limit State (ULS) bearing capacities at the borehole locations are summarized in Table 4. The quality of the subgrade should be inspected by Cambium during construction, prior to constructing the footings to confirm bearing capacity estimates. Settlement potential at the above-noted SLS loadings is less than 25 mm and differential settlement should be less than 10 mm.

Table 4 Bearing Capacities at Required Depths on Native Soils

Borehole	Depth (mbgs)	Elevation (mASL)	Maximum Geotechnical Reaction SLS (kPa)	Maximum Geotechnical Reaction ULS (kPa)
BH/MW101-22	1.5 – 2.3 Below 2.3	232.65 – 231.85 Below 231.85	130 225	195 300
BH/MW102-22	Below 2.3	Below 231.60	225	300
BH/MW103-22	1.5 – 2.3 Below 2.3	232.61 – 231.81 Below 231.81	130 225	195 300
BH104-22	Below 1.5	Below 232.51	225	300

If the footings are to be constructed on an engineered fill pad, per the recommendations in Section 4.7, the site grading drawings should be provided to Cambium for review, as the estimated design bearing capacities will need to be revised.

Fill was encountered in all boreholes and the depth was found to range between 0.9 to 1.5 mbgs. It is noted that due to the variation in thickness of the earth fill across the site, there may be other areas where the earth fill is deeper than 1.5 mbgs.

Foundations placed on approved engineered fill at a depth of at least 1.5 m below final grade, with a minimum thickness of 1 m between subgrade/base of foundation and subgrade of imported fill, may be designed using a bearing capacity of 150 kPa at SLS and 225 kPa ULS. Post-construction settlement will occur following the placement of engineered fill and is estimated to be in the order of 1% of the height of the placed fill. Generally, if granular soil is placed as engineered fill, the settlement will occur within ± 4 weeks. Foundations for structures should not be constructed until post-construction settlement has been completed.

To reduce cracking in the footings, foundation walls and concrete slab on grades, where footings are constructed on engineered fill or change between different subgrade materials, suitable transition zones should be created. Additionally, in this instance the footings and foundation walls should be suitably reinforced.

4.5.2 Deep Foundations

Should the allowable bearing capacities given above for shallow foundation options not be sufficient to support the actual loading from the proposed structure, deep foundation options may be necessary to support the structural loads while meeting bearing capacity/settlement requirements.

Caissons may be considered as a deep foundation option for this Site. Caissons must be designed according to relevant standards by a qualified geotechnical engineer. Should this option be pursued, Cambium can be contacted to provide preliminary design parameters (i.e., base resistance and sleeve friction values) for the encountered lithology.

4.5.3 Raft / Mat Foundations

A raft slab may also be considered to found the proposed structure. Raft slabs must be placed on competent soil, found at ± 231.6 mASL.

If the underside of the raft foundation is higher than 231.6 mASL, the slab must be placed on an engineered fill pad extending into competent soil and constructed according to the backfill and compaction recommendations provided below.

To make sure the building loads are distributed uniformly over the entire building footprint, a raft foundation would need to be designed with sufficient rigidity.

The design of raft foundations is generally governed by settlement considerations rather than bearing capacity since the design bearing pressure is generally less than the allowable bearing capacity. The thickness and reinforcement should be designed by the project structural engineer.

If the raft slab is founded on the very dense till soils at 231.6 mASL or lower, the raft foundation may be designed using a maximum bearing capacity of 225 kPa at SLS and 300 kPa at ULS on undisturbed native soils.

It is recommended to undertake a settlement analysis using actual loading and appropriate deformation parameters for the encountered soil stratigraphy. The results can be used to calibrate the concrete design of the raft (reinforcement requirements) using an iterative process to determine actual moduli of subgrade reaction as necessary.

The structural analysis of the raft 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. For initial analyses, the modulus of subgrade reaction may be assumed to be in the range of 20 MPa/m to 80 MPa/m. This range reflects both uncertainties of the size of the footing as well as variability in the properties of the subgrade soils and should be refined as actual loads and foundation dimensions become known.

Bearing capacity and modulus of subgrade reaction values should be verified following excavation to the slab underside elevation, by using plate load tests (or similar). It is noted that the values provided herein are for preliminary design purposes and that the actual values may vary.

Hydrostatic pressure acting on the foundation elements must be considered in the structural design of foundations/basement walls. For these purposes, it is recommended to assume a maximum water level of 233.8 mASL (corresponds to maximum water level observed during groundwater monitoring events of 233.3 mASL, with an additional allowance of 500 mm).

For watertight raft foundations, this elevation may be used to determine uplift loading.

4.6 Floor Slabs

To create a stable working surface, to distribute loadings, and for drainage purposes, an allowance should be made to provide at least 200 mm of OPSS.MUNI 1010 Granular A compacted to 98% of Standard Proctor Maximum Dry Density (SPMDD) beneath all floor slabs. It is recommended that all floor slabs are situated at least 500 mm above the seasonal high groundwater elevation.

Within any interior areas that may be exposed to freezing conditions for extended periods of time, the floor slab may be susceptible to frost heaving, depending on the composition of the subgrade. The subgrade underlying these areas should be adequately insulated to prevent frost penetration.

Any basement floor slabs should be underlain by a 300 mm thick layer of 19 mm diameter crushed clear stone wrapped in a geotextile (Terrafix 270R or equivalent) and hydraulically connected to perimeter subdrains as discussed below. The clear stone material should be nominally compacted to a dense state.

4.7 Backfill and Compaction

Excavated topsoil from the Site is not appropriate for use as fill below grading areas Excavated sand soils not containing significant quantities of cohesive soils (clay, silt) may be appropriate for use as fill below grading and parking areas, provided that the actual or adjusted moisture content at the time of construction is within a range that permits compaction to the required densities. Some moisture content adjustments may be required depending upon seasonal conditions. Geotechnical inspections and testing of engineered fill are required to confirm acceptable quality.

Foundation wall and any buried utility backfill material should consist of free-draining imported granular material. Backfill should be placed in maximum 300 mm thick lifts and should be compacted to a minimum of 98% of SPMDD. The backfill material in the upper 300 mm below the pavement subgrade elevation should be compacted to 100% of SPMDD in all areas.

All existing vegetation, topsoil, organic and non-organic fills, and any loose soils shall be removed down to a competent base. Backfill areas must be approved by a qualified geotechnical engineer prior to placement of any new fill, to ensure the suitability of subgrade conditions.

4.7.1 Engineered Fill

Where the existing fill is treated as an engineered fill to support structural elements such as foundations and/or floor slabs the following is recommended for the construction of engineered fill:

I. Remove any and all existing vegetation, surficial topsoil / organics, organic fills or fills and any loose/disturbed soils to a competent subgrade for a suitable envelope.

II. The area of the engineered fill should extend horizontally 1 m beyond the outside edge of the foundations then extend downward at an imaginary 1H:1V slope to the competent approved native soil. The exposed edges of the engineered fill should be sloped at a maximum of 3H:1V to avoid weakening of the engineered fill edges due to slope movement. If fill is required adjacent to sloped banks (i.e., slope steeper than 3H:1V), the fill shall be placed in stepped planes to avoid a plane weakness.

III. The subgrade or base of the engineered fill area must be approved by Cambium prior to placement of any new fill, to ensure that suitability of subgrade condition.

IV. Place approved OPSS 1010.MUNI SSM or Granular ‘B’ Type I material at a moisture content at or near optimum moisture in suitable maximum 200 mm thick lifts, compacted to 100% of SPMDD. If native soils from the site are not used as engineered fill, imported material for engineered fill should consist of clean, non-organic soils, free of chemical contamination or deleterious material. Any frost penetration into the fill material must be removed prior to placement of subsequent lifts of fill and reviewed by Cambium.

V. The engineered fill should be placed at least 600 mm above the elevation of the proposed underside of footing.

VI. Due to the potential negative effects of differential settlement between the engineered fill and the native soils, in any block where footings are to be placed partly on engineered fill and partly on native soils, reinforcing steel bars should be included and placed within the footings and the top of the foundation walls. All tie reinforcing steel bars should be included and placed within the top of the foundation walls. All tie reinforcing steel bars should have at least 600 mm of overlap. The actual steel reinforcement design should be confirmed / designed by the project structural engineer.

VII. Full time testing and inspection of the engineered fill will be required for it to be used as a founding material, as outlined in Section 4.2.2.2 of the Ontario Building Code.

4.8 Lateral Earth Pressures

Lateral earth pressure coefficients (K) are shown in Table 5. The coefficients provided assume that the surface of the granular backfill is horizontal against any proposed wall, and the wall is vertical and smooth.

Table 5 Unfactored Lateral Earth Pressure Coefficients

Soil	Bulk Unit Weight γ (kN/m³)	Internal Friction Angle Φ' (°)	Active earth pressure coefficient K_a (Rankine)	Passive earth pressure coefficient K_p (Rankine)	At-rest earth pressure coefficient K_o (Rankine)
Granular Backfill	20.5	33	0.29	3.39	0.46
Fill: Sand *loose*	19.5	28	0.36	2.77	0.53
Sand and Silt Mixtures (Glacial Till) *compact to dense*	20.5	30	0.33	3.00	0.50

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:

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

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/m3)

γ' = the submerged unit weight of the exterior soil, (γ - 9.8 kN/m3)

q = the complete surcharge loading (kPa)

The wall backfill must be drained effectively to eliminate hydrostatic pressures on the wall that would otherwise act in conjunction with the earth pressure. In this case, the above equation is simplified to:

$$\boldsymbol{P = K[\gamma h + q]}$$

The factored geotechnical resistance to sliding of foundation elements is developed by friction between the base of the footing and the soil.

This friction (**R**) depends on the normal load at the soil contact (**N**) and the frictional resistance of the soil (**tan φ**) expressed as $\boldsymbol{R_f = N\ tan\varphi}$, which is the unfactored resistance. The factored geotechnical resistance at ULS is $\boldsymbol{R_f = 0.8\ N\ tan\varphi}$.

4.9 Subdrainage

Given the groundwater conditions, perimeter subdrains consisting of geotextile wrapped perforated pipes set in a trench of clear stone are recommended around the building perimeter below the floor slab and beneath the foundation/basement floor slab. For basement foundations, geotextile wrapped perforated pipe subdrains set in a trench of clear stone and connected to a sump or other frost-free positive outlet are recommended around all footings and underneath the basement slabs.

It is noted that the slab and foundation walls should be waterproofed if the foundation is to extend below the inferred depth of the water table; otherwise, the foundation wall should be backfilled with suitable free-draining material, or equivalent, in accordance with the Ontario Building Code.

Basement floor slabs will also potentially be exposed to uplift forces from buoyancy and should be reinforced structural slabs designed to resist uplift.

4.10 Buried Utilities

Trench excavations must be completed per the requirements outlined above in Section 4.2.

If utilities are to extend deeper than the groundwater table, the work should be completed while the Site is dewatered with the well-point system. It is not recommended to excavate beyond the groundwater table without an advanced dewatering system in place.

The bedding and cover material for any services should consist of OPSS 1010-3 Granular A or B Type ll, placed in accordance with pertinent Ontario Provincial Standard Drawings (OPSD 802.013). The bedding and cover material shall be placed in maximum 200 mm thick lifts and should be compacted to a minimum of 98% of SPMDD.

The cover material shall be a minimum 300 mm over the top of pipe and compacted to a minimum of 95% of SPMDD, taking care not to damage the utility pipes during compaction. If groundwater is present during placement of bedding material for utilities, then 19 mm crushed clear stone shall be used in place of granular material to ensure adequate compaction under wet conditions.

4.11 Seismic Site Class

The Ontario Building Code (OBC) specifies that the structures should be designed to withstand forces due to earthquakes. For the purpose of earthquake design, geotechnical information shall be used to determine the “Site Class”. `The parameters for determination of Site Classification for Seismic Site Response are set out in Table 4.1.8.4A of the OBC (2012).

The classification is based on the determination of the average shear wave velocity in the top 30 metres of the site stratigraphy, where shear wave velocity (V_s) measurements have been taken. Alternatively, the classification is estimated based on rational analysis of undrained shear strength (S_u) or penetration resistances (N_{60} values).

Based on the explored soil properties and in accordance with Table 4.1.8.4.A, it is recommended that Site Class “D” be applied for structural design at the Site. Peak ground acceleration and spectral acceleration (period of 0.2 seconds) for the site are calculated to be 0.064g and 0.108g respectively using the 2015 National Building Code Seismic Hazard Calculation. A detailed report of the calculation and its results can be found in Appendix C.

Consideration could be given to carrying out shear wave velocity testing (Multichannel Analysis of Surface Waves, “MASW”) to evaluate whether an improved seismic site class can be obtained. Further details regarding shear wave velocity testing could be provided upon request.

4.12 Pavement Design

The performance of the pavement is dependent upon proper subgrade preparation. All topsoil and organic materials should be removed from the site and backfilled with approved engineered fill or native material, compacted to 100% of SPMDD. The subgrade should be proof rolled and inspected by a Geotechnical Engineer. Any areas where boulders, rutting, or appreciable deflection is noted should be sub excavated and replaced with suitable fill. The fill should be compacted to at least 100% of SPMDD.

In order to completely protect against damage due to frost heaving, excavations would have to be made to the maximum frost penetration depth and backfilled with free-draining granular material. In order to reduce costs an alternative pavement structure is proposed. It should be noted that while the designs presented will provide adequate support for the intended use, some minor frost heaving could persist, resulting in minor degradation and minimal annual maintenance.

The recommended pavement structure should meet the Ministry standards for parking and driving areas and should, as a minimum, consist of the pavement layers identified in Table 6. The light duty pavement structure is intended for private roads, parking areas, driveways which will not see frequent heavy traffic from trucks, buses, etc. while the heavy-duty pavement structure is appropriate for private roads, or parking/loading areas where heavy loads such as trucks, buses are anticipated or for designated fire routes.

Table 6 Recommended Minimum Pavement Structure

Pavement Layer	Light Duty	Heavy-Duty (Roads to be assumed by the City of Barrie)
Surface Course Asphalt	40 mm HL3 or HL4	40 mm HL3 or HL4
Binder Course Asphalt	50 mm HL8	70 mm HL8
Granular Base	150 mm OPSS 1010 Granular A	150 mm OPSS 1010 Granular A
Granular Subbase	300 mm OPSS 1010 Granular B	450 mm OPSS 1010 Granular B

Material and thickness substitutions must be approved by the Design Engineer.

The thickness of the subbase layer could be increased at the discretion of the Engineer, to accommodate site conditions at the time of construction, including soft or weak subgrade soil replacement. Asphalt materials should be rolled and compacted as per OPSS 310.

Compaction of the subgrade should be verified by the Engineer prior to placing the granular fill. Granular layers should be placed in 150 mm thick maximum loose lifts and compacted to at least 100% of SPMDD. The granular materials specified should conform to OPSS standards, as confirmed by appropriate materials testing.

The final asphalt surface should be sloped at a minimum of 2% to shed runoff. Abutting pavements should be saw cut to provide clean vertical joints with new pavement areas.

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 crown to promote drainage of the pavement structure.

5.0 Report Limitations

5.1 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.

5.2 Changes in Site and Project Scope

This geotechnical engineering report is intended for planning and design purposes only.

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.

6.0 Closing

We trust that the information contained in this report meets your current requirements. If you have questions or comments regarding this document, please do not hesitate to contact the undersigned at (705) 719-0700.

Respectfully submitted,

CAMBIUM INC.

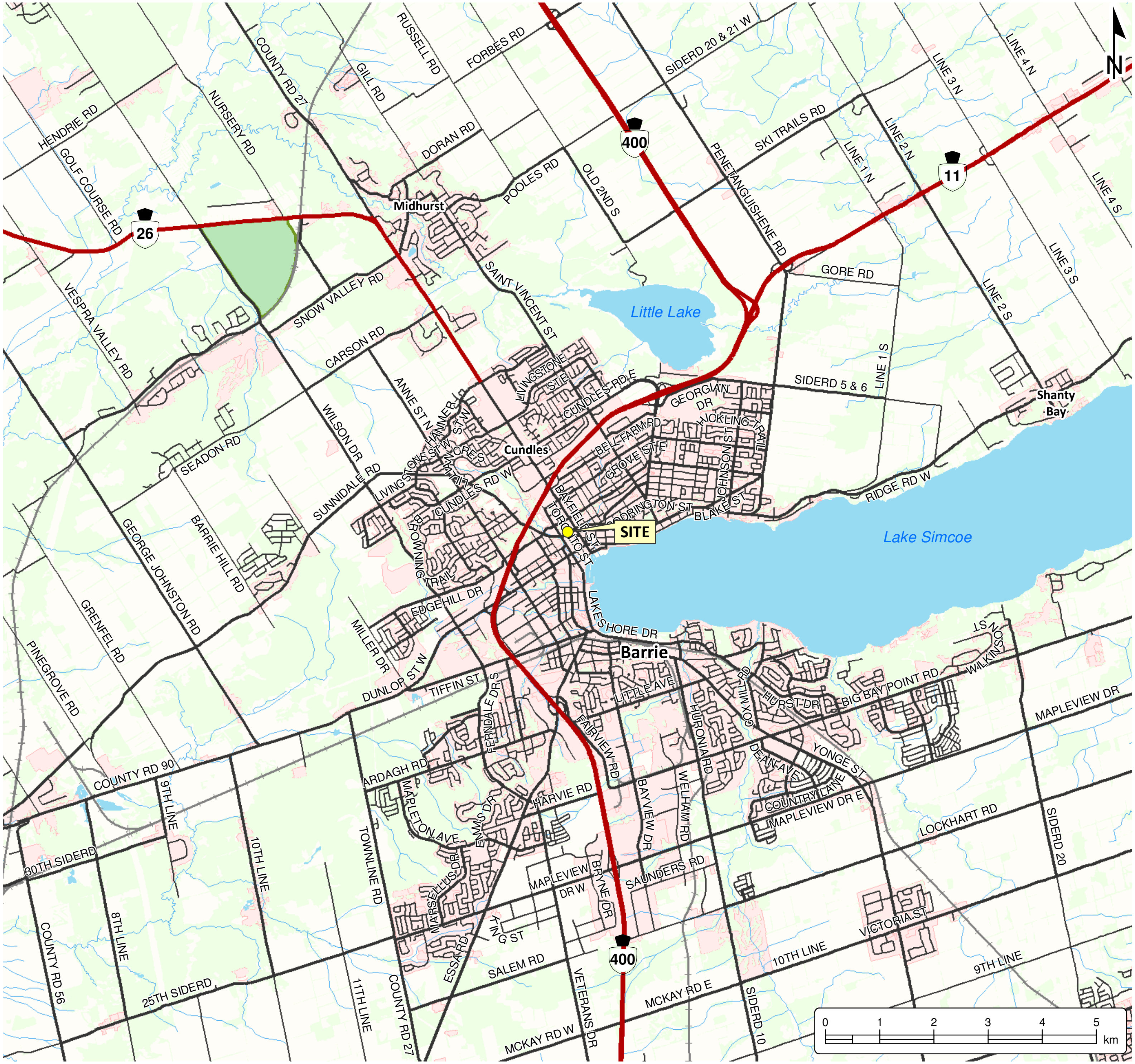
LICENSED PROFESSIONAL ENGINEER
R. L. GETHIN
100196175
December 20, 2022
PROVINCE OF ONTARIO

Juan Monroy, P.Eng.
Project Coordinator

Rob Gethin, P.Eng.
Group Manager - Geotechnical

RG/jdm/js

Appended Figures



GEOTECHNICAL INVESTIGATION

SOLID GENERAL CONTRACTORS
30 Sophia St. W.
Barrie, Ontario

LEGEND

- Highway
- Major Road
- Minor Road
- Railroad
- Watercourse
- Water Area
- Provincial Park
- Wooded Area
- Built Up Area

Notes:
- Base mapping features are © Queen's Printer of Ontario, 2019 (this does not constitute an endorsement by the Ministry of Natural Resources or the Ontario Government).
- Distances on this plan are in metres and can be converted to feet by dividing by 0.3048.
- Cambium Inc. makes every effort to ensure this map is free from errors but cannot be held responsible for any damages due to error or omissions. This map should not be used for navigation or legal purposes. It is intended for general reference use only.

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194 Sophia Street
Peterborough, Ontario, K9H 1E5
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SITE LOCATION MAP

Project No.: 14909-001	Date: April 2022 Rev.:
Scale: 1:100,000	Projection: NAD 1983 UTM Zone 17N

Created by: ACS	Checked by: RG	Figure: 1

O:\GIS\MXDs\14900-14999\14909-001 Solid General Contractors - GEO - 30 Sophia St. W, Barrie\2022-04-22 FIG 1 - Site Location Map.mxd

GEOTECHNICAL INVESTIGATION
SOLID GENERAL CONTRACTORS
30 Sophia St. W.
Barrie, Ontario

LEGEND

Borehole
Monitoring Well

Notes:
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BOREHOLE LOCATION PLAN

Project No.: 14909-001	Date: April 2022 Rev.:
Scale: 1:500	Projection: NAD 1983 UTM Zone 17N

Created by: ACS	Checked by: RG	Figure: 2

O:\GIS\MXDs\14900-14999\14909-001 Solid General Contractors - GEO - 30 Sophia St. W, Barrie\2022-04-22 FIG 2 - Borehole Location Plan.mxd

Appendix A

Borehole Logs

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Oshawa
Kingston
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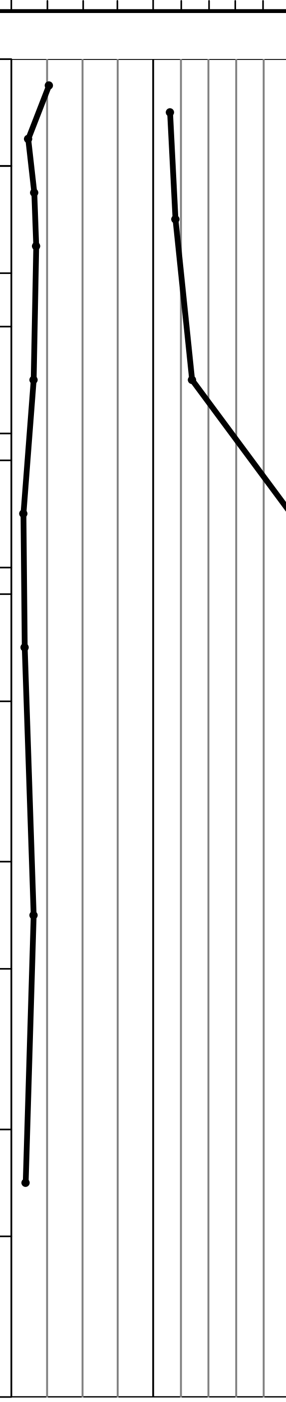
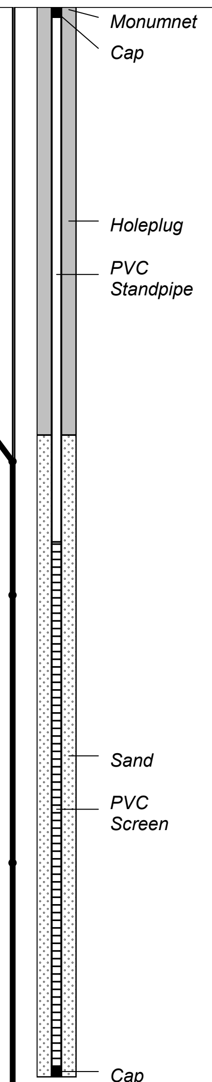
Log of Borehole: BH/MW101-22

Client: Solid General Contractors
Project Name: 30 Sophia Street West, Barrie, ON
Project No.: 14909-001
Contractor: Walker Drilling
Method: Solid Stem Augers
Date Completed: March 23, 2022
Location: 30 Sophia Street West , Barrie, ON
UTM: 17T, 4916167 m N, 603959 m E
Elevation: 234.15 mASL

Depth (m)	Description	Number	Type	% Recovery	SPT (N) / DCPT	Remarks
0	TOPSOIL: (305 mm thick)	1A	SS	40	6	Top of Pipe (TOP) elevation: 235.16 mASL. Groundwater measured at 1.6 mbgs (232.55 mASL) on May 2, 2022
	SAND: Brown sand, trace gravel, loose, dry, [FILL]	1B				
		2A	SS	70	8	
1	SAND AND SILT: Grey sand and silt, some gravel, trace clay, loose, moist	2B				
	-compact, wet	3	SS	80	14	GSA SS3: 10% Gravel 44% Sand 39% Silt 7% Clay
2	-very dense, saturated	4	SS	80	50/ 250 mm	
3		5	SS	60	50/ 150 mm	
5	-orange	6	SS	70	50/ 175 mm	
6		7	SS	60	50/ 150 mm	
7	Borehole terminated at 6.7 mbgs due to target depth achieved.					





Logged By: J. Schweighofer **Input By:** Waleed El-Taweel

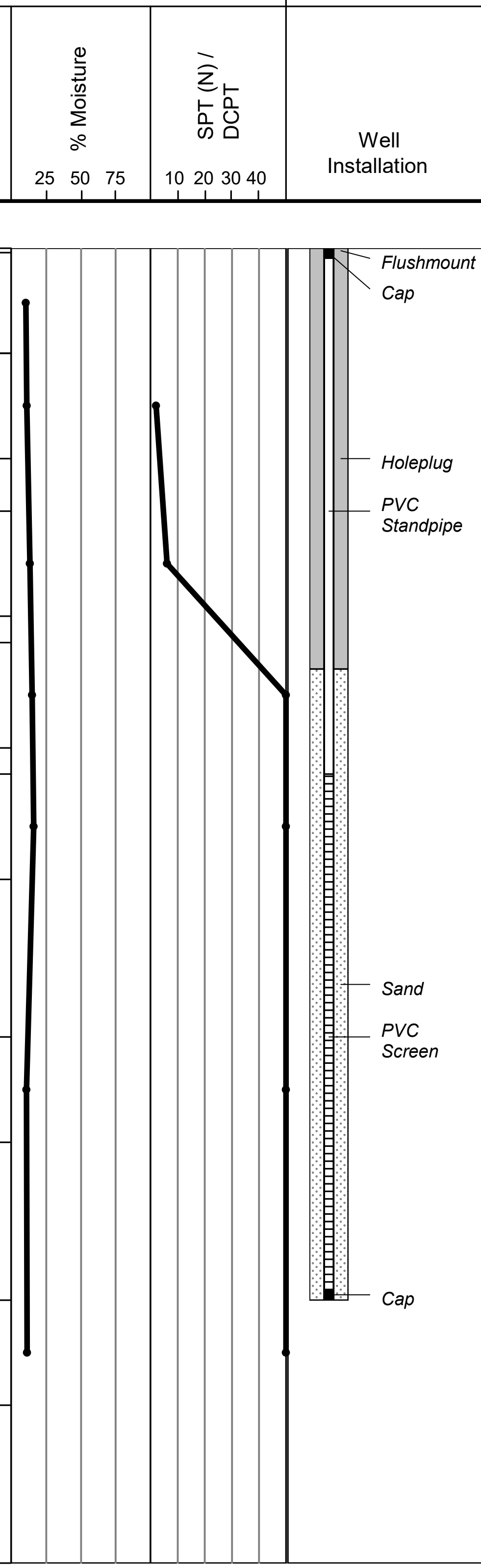
Peterborough
Barrie
Oshawa
Kingston
T: 866-217-7900
www.cambium-inc.com

Log of Borehole: BH/MW102-22

Client:	Solid General Contractors	**Project Name:**	30 Sophia Street West, Barrie, ON	**Project No.:**	14909-001
Contractor:	Walker Drilling	**Method:**	Solid Stem Augers	**Date Completed:**	March 23, 2022
Location:	30 Sophia Street West , Barrie, ON	**UTM:**	17T, 4916161 m N, 603970 m E	**Elevation:**	233.90 mASL

SUBSURFACE PROFILE / SAMPLE

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N) / DCPT	Remarks
	0	ASPHALT: (25 mm thick)					Top of Pipe (TOP) elevation: 233.74 mASL. Groundwater measured at 2.6 mbgs (231.28 mASL) on May 2, 2022
		SAND: Redish brown sand, some gravel, loose, moist, [FILL]	1A	GS	-	-	
233	1	SAND: Brown to black sand, some gravel, very loose, moist, [FILL]	2	SS	70	2	
232	2	SAND: Orange sand, some silt, trace gravel, loose, moist	3	SS	60	6	
231	3	SILTY SAND: Grey silty sand, very dense, moist	4	SS	60	50/ 175 mm	
230	4	SAND: Grey sand, some silt, trace gravel, trace clay, very dense, wet	5	SS	70	50/ 150 mm	GSA SS5: 2% Gravel 71% Sand 18% Silt 9% Clay
229	5		6	SS	100	50/ 200 mm	
228	6		7	SS	80	50/ 115 mm	
227	7	Borehole terminated in at 6.7 mbgs due to target depth achieved.					



Logged By: J. Schweighofer **Input By:** Waleed El-Taweel

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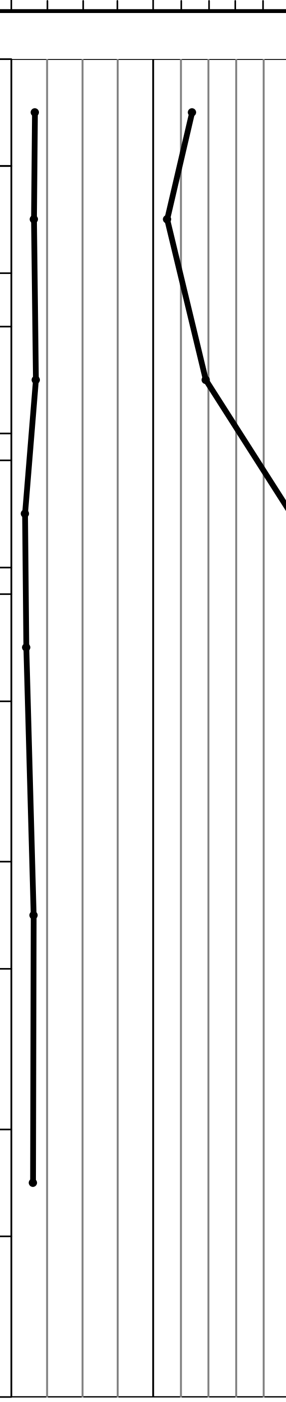
Log of Borehole: BH/MW103-22

Client:	Solid General Contractors	**Project Name:**	30 Sophia Street West, Barrie, ON	**Project No.:**	14909-001
Contractor:	Walker Drilling	**Method:**	Solid Stem Augers	**Date Completed:**	March 23, 2022
Location:	30 Sophia Street West , Barrie, ON	**UTM:**	17T, 4916196 m N, 603981 m E	**Elevation:**	234.11 mASL

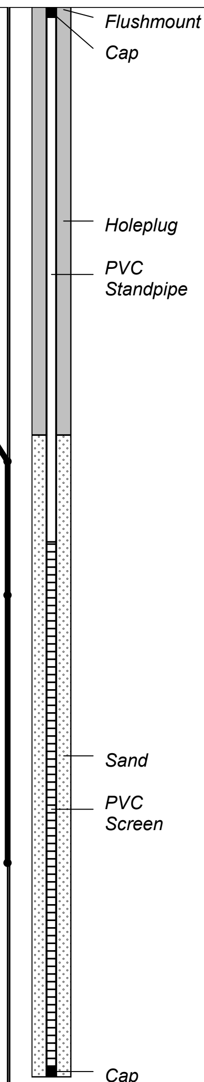
SUBSURFACE PROFILE / SAMPLE

Elevation (m)	Depth	Description	Number	Type	% Recovery	SPT (N) / DCPT	Remarks
234	0	SILTY CLAY: Grey silty clay, trace gravel, stiff, moist, [FILL]	1	SS	5	14	Top of Pipe (TOP) elevation: 234.05 mASL. Groundwater measured at 0.9 mbgs (233.11 mASL) on May 2, 2022
233	1	SAND: Black sand, some gravel, loose, moist, [FILL]	2	SS	5	5	
232	2	SILTY SAND: Grey silty sand, some gravel, some clay, compact, saturated	3	SS	90	19	
		-very dense	4	SS	100	50/ 150 mm	GSA SS4: 3% Gravel 63% Sand 22% Silt 12% Clay
231	3	SAND: Grey sand, some gravel, some silt, very dense, saturated	5	SS	90	50/ 150 mm	
230	4						
229	5	SILTY SAND: Grey silty sand, some gravel, very dense, saturated	6	SS	100	50/ 75 mm	
228	6		7	GS	-	-	
227	7	Borehole terminated at 6.7 mbgs due to target depth achieved.					

% Moisture: 25 50 75 — SPT (N) / DCPT: 10 20 30 40



Well Installation



Logged By: N. Heikoop **Input By:** Waleed El-Taweel

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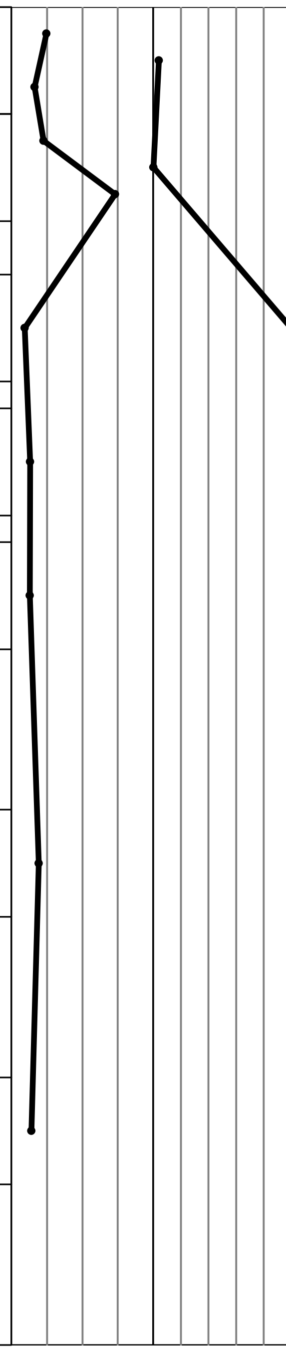
Log of Borehole: BH104-22

Client: Solid General Contractors
Project Name: 30 Sophia Street West, Barrie, ON
Project No.: 14909-001
Contractor: Walker Drilling
Method: Solid Stem Augers
Date Completed: March 23, 2022
Location: 30 Sophia Street West , Barrie, ON
UTM: 17T, 4916202 m N, 603997 m E
Elevation: 234.01 mASL

SUBSURFACE PROFILE			SAMPLE							
Elevation (m) Depth	Lithology	Description	Number	Type	% Recovery	SPT (N) / DCPT	% Moisture (25 50 75)	SPT (N) / DCPT (10 20 30 40)	Well Installation	Remarks
234 / 0		TOPSOIL: (305 mm thick)	1A	SS	20	2				
		SAND: Black sand, some gravel, very loose, moist, [FILL]	1B							
		-brown	2A	SS	40	0				
233 / 1		-black	2B							
232 / 2		SAND: Grey sand, some silt, some clay, trace gravel, very dense, moist	3	SS	90	50				GSA SS3: 5% Gravel 66% Sand 19% Silt 10% Clay
			4	SS	60	50/ 160 mm				
231 / 3		SILTY SAND: Grey silty sand, some gravel, very dense, moist	5	SS	70	50/ 140 mm				
230 / 4										
229 / 5		-wet	6	SS	100	50/ 150 mm				
228 / 6		-trace gravel	7	SS	100	50/ 75 mm				
227 / 7		Borehole terminated at 6.7 mbgs due to target depth achieved.								



Logged By: N. Heikoop
Input By: Waleed El-Taweel

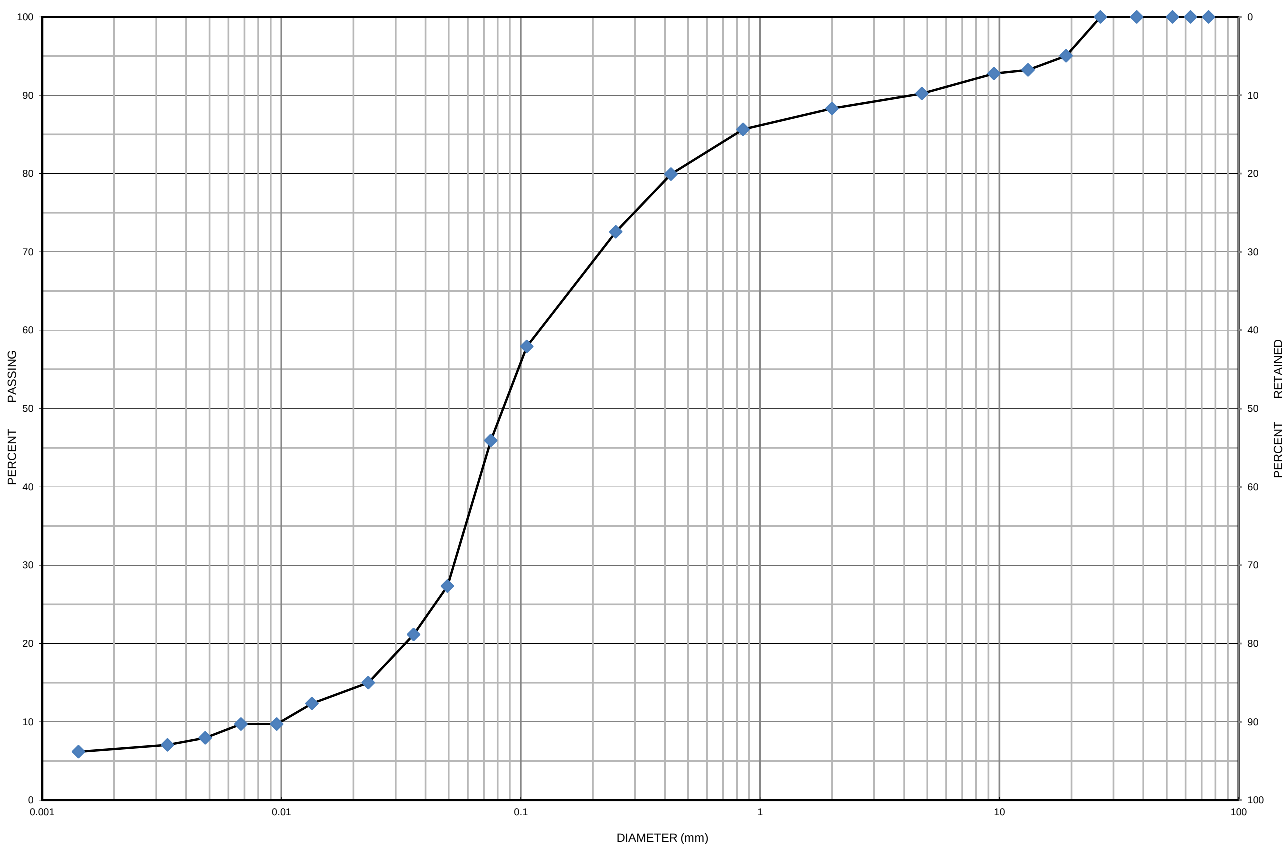
Appendix B

Physical Laboratory Testing Results

Grain Size Distribution Chart

Project Number:	*14909-001*	**Client:**	*Solid General Contractos*		
Project Name:	*30 Sophia Street, Barrie*				
Sample Date:	*March 23, 2022*	**Sampled By:**	*Nicole Heikoop - Cambium Inc.*		
Location:	*BH 101-22 SS 3*	**Depth:**	*1.5 m to 2.1 m*	**Lab Sample No:**	*S-22-0437*

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 101-22	SS 3	1.5 m to 2.1 m	10	44	39	7	15.5

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Sand and Silt some Gravel trace Clay	SM	0.130	0.053	0.010	13.00	2.16

Additional information available upon request

Issued By: (Senior Project Manager)

Date Issued: *April 3, 2022*

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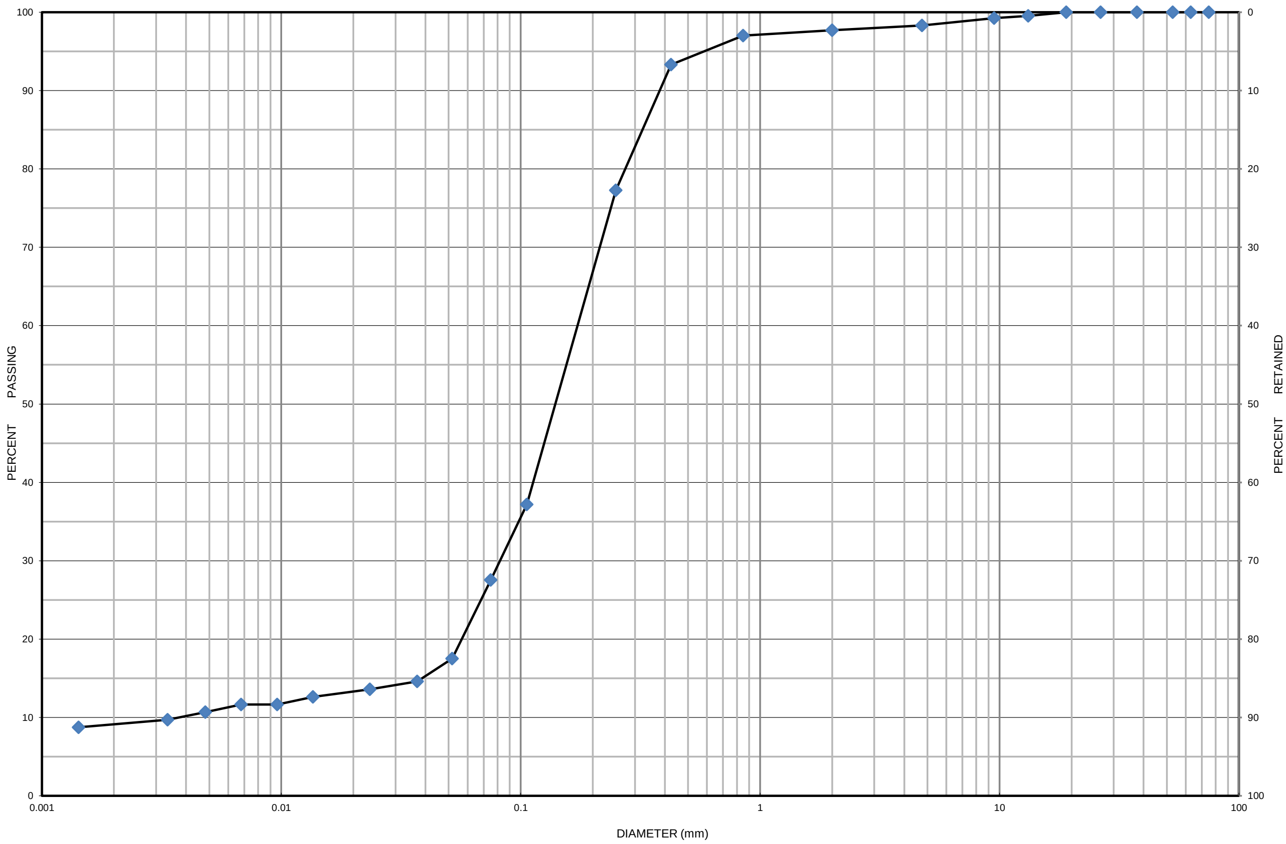
Form: L6V.2 - Grad.Hydo

Grain Size Distribution Chart

Project Number:	*14909-001*	**Client:**	*Solid General Contractos*		
Project Name:	*30 Sophia Street, Barrie*				
Sample Date:	*March 24, 2022*	**Sampled By:**	*Nicole Heikoop - Cambium Inc.*		
Location:	*BH 102-22 SS 5*	**Depth:**	*3 m to 3.7 m*	**Lab Sample No:**	*S-22-0438*

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 102-22	SS 5	3 m to 3.7 m	2	71	18	9	16.0

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Sand some Silt trace Clay trace Gravel	SM	0.1750	0.0820	0.0039	44.87	9.85

Additional information available upon request

Issued By: (Senior Project Manager)   *Date Issued:* *April 3, 2022*

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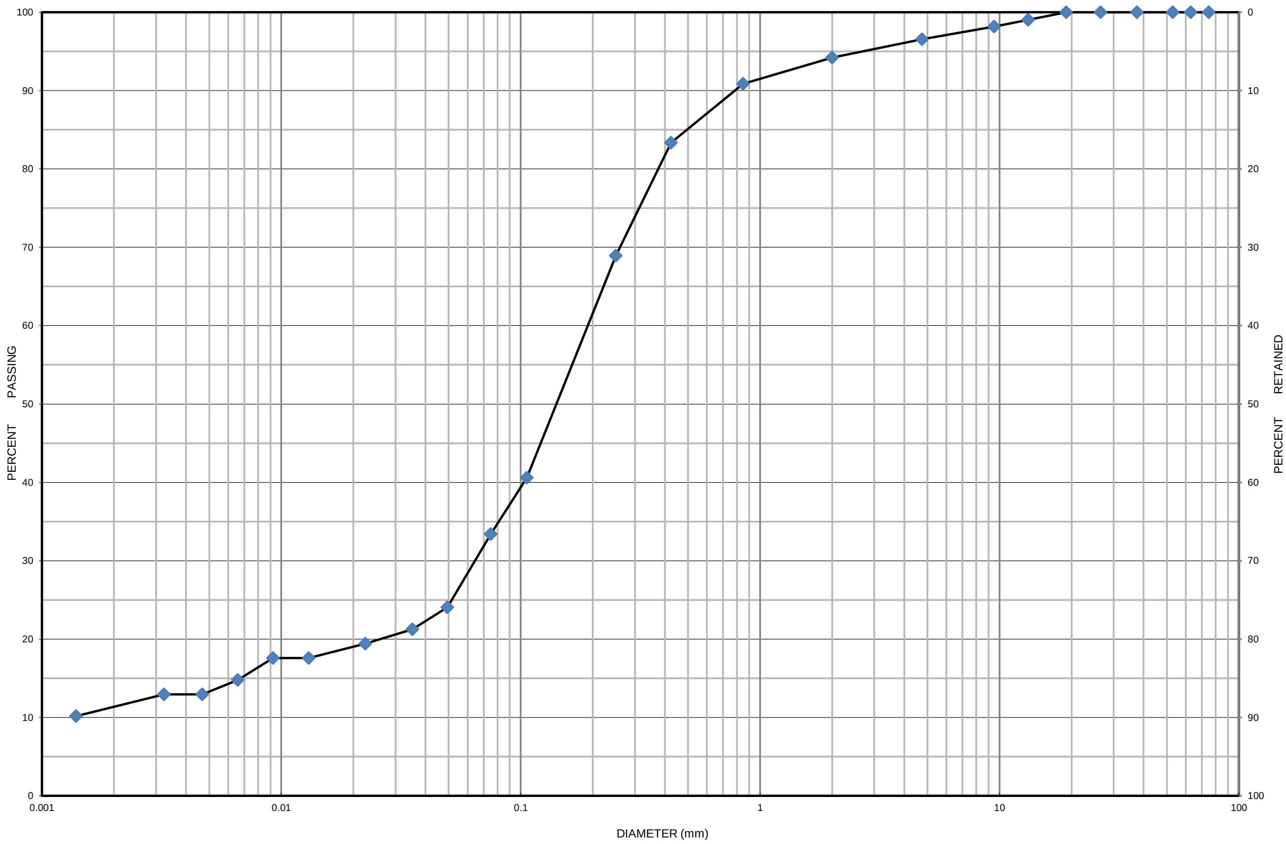
CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Grain Size Distribution Chart

Project Number:	*14909-001*	**Client:**	*Solid General Contractos*
Project Name:	*30 Sophia Street, Barrie*		
Sample Date:	*March 24, 2022*	**Sampled By:**	*Nicole Heikoop - Cambium Inc.*
Location:	*BH 103-22 SS 4*	**Depth:**	*2.3 m to 2.9 m*
Lab Sample No:	*S-22-0439*		

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 103-22	SS 4	2.3 m to 2.9 m	3	63	22	12	9.5

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Silty Sand some Clay trace Gravel	SM	0.195	0.064	-	-	-

Additional information available upon request

Issued By: (Senior Project Manager)

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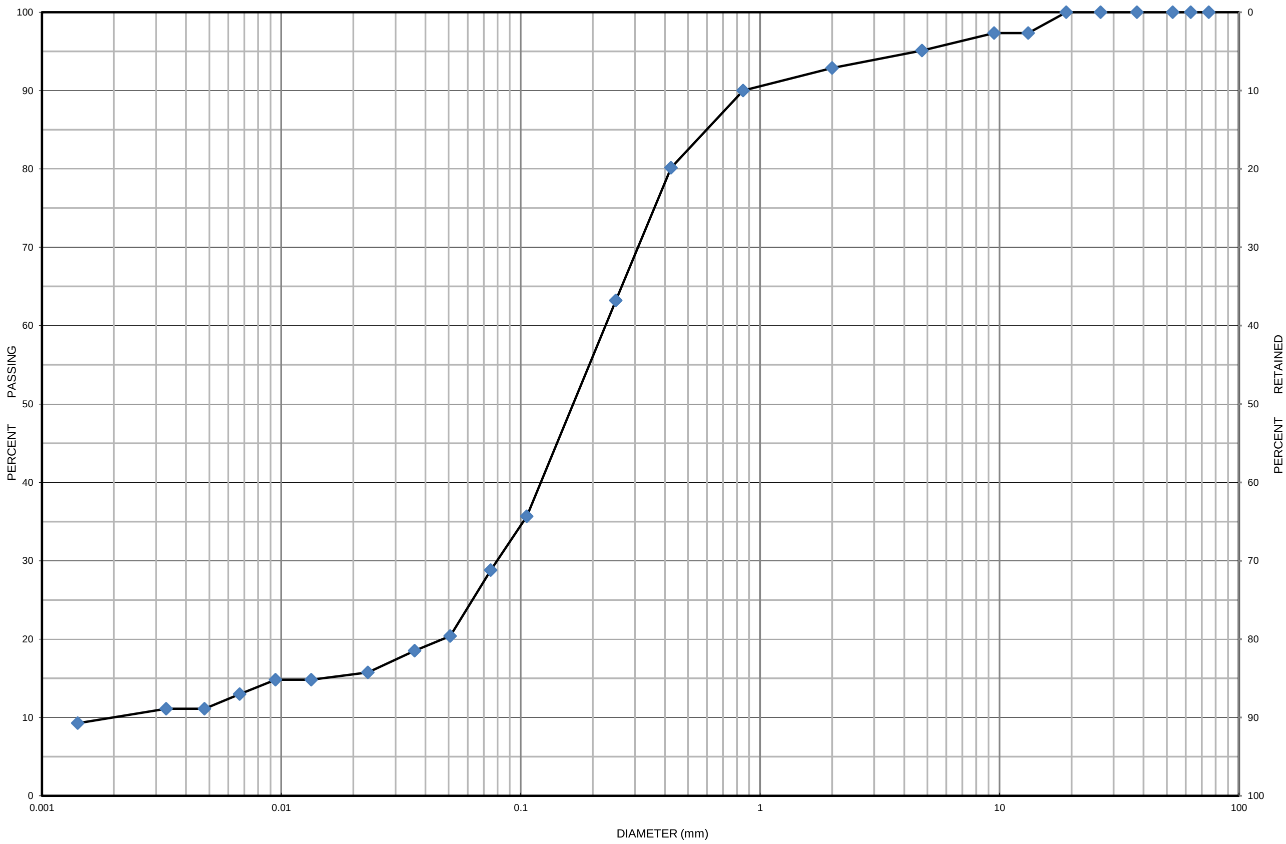
Form: L6V.2 - Grad.Hydo

Grain Size Distribution Chart

Project Number:	*14909-001*	**Client:**	*Solid General Contractos*
Project Name:	*30 Sophia Street, Barrie*		
Sample Date:	*March 23, 2022*	**Sampled By:**	*Nicole Heikoop - Cambium Inc.*
Location:	*BH 104-22 SS 3*	**Depth:**	*1.5 m to 2.1 m*
Lab Sample No:	*S-22-0440*		

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 104-22	SS 3	1.5 m to 2.1 m	5	66	19	10	9.2

Description	Classification	D_{60}	D_{30}	D_{10}	C_u	C_c
Sand some Silt some Clay trace Gravel	SM	0.230	0.080	0.002	115.00	13.91

Additional information available upon request

Issued By: (Senior Project Manager) *Date Issued:* *April 3, 2022*

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Moisture Content

Project Number: 14909-001
Project Name: 30 Sophia Street, Barrie
Client: Solid General Contractors
Date Taken: 2022-03-23

Lab Number: S-22-0436
Date Tested: 2022-03-25
Tested By: A. Heffernan

Borehole Number	Sample Number	Sample Depth (m)	Water Weight (g)	Water Content (%)	Additional Observations
101	1A	0.00-0.30	16.9	26.3	NR,1
101	1B	0.30-0.61	22.7	11.7	NR
101	2A	0.61-0.91	48.6	16.1	NR
101	2B	0.91-1.22	47.4	17.3	
101	3	1.52-2.13	109.5	15.5	NR
101	4	2.13-2.90	26.6	8.3	
101	5	3.05-3.66	27.6	9.3	
101	6	4.57-5.18	40.3	15.5	
101	7	6.10-6.71	27.3	9.9	
102	1	0.00-0.61	20.4	10.3	
102	2	0.61-1.22	22.3	11.0	
102	3	1.52-2.13	28.3	13.3	
102	4	2.29-2.90	41.5	14.8	
102	5	3.05-3.66	127.9	16.0	NR
102	6	4.57-5.18	31.1	10.8	
102	7	6.10-7.62	45.1	11.2	
103	1	0.00-0.61	5.0	16.4	NR
103	2	0.91-1.22	8.8	15.7	NR
103	3	1.52-2.13	47.6	17.1	
103	4	2.29-2.90	67.5	9.5	NR
103	5	3.05-3.66	42.6	10.4	
103	6	4.57-5.18	54.5	15.5	
103	7	6.10-6.71	14.1	15.1	NR
104	1A	0.00-0.61	31.7	24.7	NR,1
104	1B	0.30-0.61	30.1	16.3	NR
104	2A	0.61-0.91	47.6	22.6	NR
104	2B	0.91-1.22	65.2	73.1	NR

1 – Contains organics
2 – Contains rubble
3 – Hydrocarbon Odour
4 – Unknown Chemical Odour
5 – Saturated – free water visible
6 – Very moist – near optimum moisture content
7 – Moist – below optimum moisture
8 – Dry – dry texture – powdery
9 – Very small – caution may not be representative
10 – Hold sample for gradation analysis

Moisture Content

Project Number: 14909-001
Project Name: 30 Sophia Street, Barrie
Client: Solid General Contractors
Date Taken: 2022-03-23

Lab Number: S-22-0436
Date Tested: 2022-03-25
Tested By: A. Heffernan

Borehole Number	Sample Number	Sample Depth (m)	Water Weight (g)	Water Content (%)	Additional Observations
104	3	1.52-2.13	50.9	9.2	NR
104	4	2.29-2.90	43.0	13.1	
104	5	3.05-3.66	42.3	12.8	
104	6	4.57-5.18	59.0	19.1	
104	7	6.10-6.71	47.2	14.0	

1 – Contains organics
2 – Contains rubble
3 – Hydrocarbon Odour
4 – Unknown Chemical Odour
5 – Saturated – free water visible
6 – Very moist – near optimum moisture content
7 – Moist – below optimum moisture
8 – Dry – dry texture – powdery
9 – Very small – caution may not be representative
10 – Hold sample for gradation analysis

Appendix C
2015 National Building Code Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

INFORMATION: **Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 44.391N 79.694W **User File Reference:** 30 Sophia St. W., Barrie 2022-07-22 20:56 UT

Requested by: Cambium Inc.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.080	0.050	0.032	0.011
Sa (0.1)	0.111	0.071	0.047	0.017
Sa (0.2)	0.108	0.072	0.049	0.019
Sa (0.3)	0.093	0.062	0.043	0.017
Sa (0.5)	0.077	0.052	0.036	0.013
Sa (1.0)	0.047	0.031	0.021	0.006
Sa (2.0)	0.025	0.016	0.010	0.003
Sa (5.0)	0.006	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.064	0.041	0.027	0.009
PGV (m/s)	0.064	0.040	0.026	0.008

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information