GEOTECHNICAL ENGINEERING REPORT

338 Mapleview Drive East (Loon Lands), Barrie, Ontario

PREPARED FOR:
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ATTENTION:
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Grounded Engineering Inc.
File No. 20-295 (Rev 1)
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1 Introduction

Loon Avenue Lands OP Inc. has retained Grounded Engineering Inc. ("Grounded") to provide geotechnical engineering design advice for their proposed development known as "Loon Lands" at 338 Mapleview Drive East, in Barrie, Ontario. The subject lands are located in a wooded area north of Mapleview Drive East, east of Huronia Road, and south of the dwellings on Loon Avenue. The subject lands comprise what will be referred to as the *Development Limit* and the *Conservation Lands*. The Development Limit is the portion that is being developed within the Subject Lands outside of the future Environmental Protection Zone. The Conservation Lands are both the Edge Management Zone and the Wetland Buffer within the Development Limit of the Subject Lands.

Revision 1 of this report (current version) has been completed with new concept and grading plans received in February 2022. Comments from Loon Avenue Lands OP Inc. and Counterpoint Engineering Inc. have also been addressed in this version of the geotechnical report.

The proposed project ("the community") includes constructing thirteen new townhome blocks consisting of the following:

- Existing site grades of the Development Limit slopes from northwest to southeast. Existing ground elevations range from Elev. 245.5± m on the west side of the Development Limit to Elev. 242.6± m on the east side. Grade cuts and raises are proposed. Retaining walls will be required in four areas.
- Blocks 1 through 13, each consisting of a collection of 3 to 4-storey townhomes with one underground level (basements and walkouts are proposed). Block details, including the assumed lowest Basement Finished Floor Elevation (BFFE), are summarized in the table below.
- Associated surface parking, private roads and site services are proposed.
- General ground floor Finished Floor Elevations (FFEs) were provided by Counterpoint Engineering Inc. per Block.
- Lowest underground BFFEs were assumed at 2.75m below the provided ground floor FFEs, as advised by Counterpoint Engineering Inc.

Table 1.1 – Assumed Development Details

Block	Unit Type	Number of Units	Ground Floor FFE (masl)	Assumed Lowest BFFE (masl)
1	Back-to-back Townhomes with Basement	Twelve (12)	247.2	244.5
2	Back-to-back Townhomes with Basement	Sixteen (16)	247.0	244.3
3	Back-to-back Townhomes with Basement	Sixteen (16)	246.8	244.0
4	Back-to-back Townhomes with Basement	Eight (8)	246.5	243.8

Block	Unit Type	Number of Units	Ground Floor FFE (masl)	Assumed Lowest BFFE (masl)
5	Townhomes with walkouts	Eight (8)	246.3	243.5
6	Townhomes with walkouts	Eight (8)	246.3	243.5
7	Townhome with walkouts	Ten (10)	246.3	243.5
8	Townhomes with walkouts	Three (3)	246.3	243.5
9	Townhomes with walkouts	Seven (7)	246.3	243.5
10	Townhomes with walkouts	Two (2)	246.5	243.8
11	Townhomes with walkouts	Five (5)	246.8	244.0
12	Townhomes with walkouts	Three (3)	247.0	244.3
13	Townhomes with walkouts	Seven (3)	247.2	244.5

Grounded has been provided with the following to assist in our geotechnical scope of work:

- We Merchandise Space Inc. – Forrest Group Inc., “Conceptual Site Plan, Proposed Townhome Community: 338 Mapleview Dr E, Barrie”; Project No 3079, Drawing No A1, dated February 1, 2022 (Issued for Coordination).
- Counterpoint Engineering, “Conceptual Grading Plan, 338 Mapleview Dr E: Proposed Townhome Community: Barrie, Ontario”; Project No 21076, Figure 6, dated October 2021 (lowest BFFE assumptions confirmed February 3, 2022).
- Rudy Mark Surveying Ltd., “Topographic Survey Plan of Part of the South Half Lot 11 Concession 12, City of Barrie”; File No 14529, dated 2021.

Grounded’s most recent subsurface investigation of the Development Limit to date includes five (5) boreholes (Boreholes 101 to 105) which were advanced from March 29th to June 2nd, 2021.

Based on the borehole findings, preliminary geotechnical engineering advice for the proposed development is provided for foundations, seismic site classification, earth pressure design, slab on grade design, basement drainage, and pavement design. Construction considerations including excavation, groundwater control, and geostructural engineering design advice are also provided.

This preliminary geotechnical engineering report is appropriate for due diligence and planning purposes only. Additional boreholes, wells, and a detailed geotechnical engineering report will be required for detailed design.

2 Ground Conditions

The borehole results are detailed on the attached borehole logs. Our assessment of the relevant stratigraphic units is intended to highlight the strata as they relate to geotechnical engineering. The ground conditions reported here will vary between and beyond the borehole locations. The stratigraphic boundary lines shown on the borehole logs are assessed from non-continuous samples supplemented by drilling observations. These stratigraphic boundary lines represent transitions between soil types and should be regarded as approximate and gradual. They are not exact points of stratigraphic change. The boreholes were surveyed for horizontal coordinates and geodetic elevations with a Trimble R10 Receiver connected to the Global Navigation Satellite System and the Can-Net Virtual Reference Station Network.

Surficial material thicknesses (e.g., topsoil) reported here are observed in individual borehole locations through the top of the open borehole. Thicknesses may vary between and beyond the boreholes.

2.1 Soil Stratigraphy

The following soil stratigraphy summary is based on the borehole results and the geotechnical laboratory testing. A cross-section showing stratigraphy and engineering units is appended.

2.1.1 Topsoil and Upper Sands

At existing grade, all of the boreholes observed 100 to 300 mm of topsoil.

Boreholes 101, 102, and 105 observed native sands underlying the topsoil. The native sands extended to depths of 0.8 to 1.5 m below grade (Elev. 243.8 to 242.6 ±m).

The sands contain a variable amount of silt (ranging from some silt to silty), and trace amounts of gravel, organics, and rootlets. The sands generally range in colour from dark brown to orangey-brown, and wet. The Standard Penetration Test (SPT) results (N-Values) measured in the sand ranges from 4 to 6 blows per 300 mm of penetration (“bpf”), indicating a loose relative density.

2.1.2 Glacial Till and Silty Clay

Underlying the topsoil and surficial sands, the boreholes observed highly variable undisturbed native soils, consisting of both cohesive and cohesionless glacial till deposits as well as silty clay, and occasional sands and gravels in the lower portion of Borehole 102.

The glacial till has a variable matrix of cohesive clayey silt to cohesionless sandy silt and silty sand, with trace amounts of gravel. This unit was encountered at 0.8 to 1.5 m below grade (Elev. 243.8 to 242.6 ±m) and extends down to 9.1 to 9.8 m below grade (Elev. 235.7 to 233.1 ±m). Boreholes 101 and 103 to 105 reach target depths within the glacial till unit. The till is generally brown to grey, and moist to wet. SPT N-values measured in this unit range from 5 to 42 bpf (on average stiff to very stiff or compact, and occasionally firm/loose).

Borehole 102 observed a cohesionless, coarse sand and gravel at a depth of 9.1 m below grade (Elev. 234.0 ±m). Trace rock fragments were observed (cobbles are inferred). The coarse sand and gravel unit was grey, wet, and dense.

Weaker cohesive soils (potentially compressible) were observed near ground surface in Boreholes 101 and 104. The blow counts in these zones range from 5 to 11 bpf (firm to stiff). These weaker zones vary in depth and thickness but are generally above 5 m depth and 1 to 3 m thick.

2.2 Groundwater

The groundwater observations are shown on the Borehole Logs and are summarized as follows.

Table 2.1 – Summary of Groundwater Observations

Borehole No.	Screen Interval (mbgs)	Strata Screened	Water Level in Well, Depth/Elev. (mbgs / masl)			
			Highest Level	Date	Most Recent Level	Date
101	6.1 - 9.1	Glacial Till	1.2 / 244.1	Dec 29, 2021	1.4 / 243.9	Jan 28, 2022
102	6.1 - 9.1	Glacial Till	0.1 / 243.0	Jul 25, 2021	0.2 / 242.9	Nov 11, 2021
103	5.5 - 8.5	Glacial Till	0.8 / 243.1	Dec 29, 2021	1.1 / 242.8	Jan 28, 2022
104	6.1 - 9.1	Glacial Till	0.1 / 242.8	Dec 29, 2021	0.4 / 242.5	Jan 28, 2022
105	6.1 - 9.1	Glacial Till	0.3 / 243.1	Dec 29, 2021	0.6 / 242.8	Jan 28, 2022

The design groundwater table is based on the highest stabilized groundwater reading recorded to date in each monitoring well. The design groundwater table ranges from Elev. 244.1 to 242.8 ±m. This translates to about 0.1 to 1.2 ±m below existing ground surface across the Development Limit. The groundwater table has been observed at 0.1 ±m below existing ground surface elevation as noted in Boreholes 102 and 104 on July 25, 2021, and December 29, 2021, respectively.

Within the anticipated zones of excavation for the proposed blocks, the surficial sands and cohesionless tills (higher permeability soils) will produce free flowing water when penetrated below the prevailing groundwater table.

Grounded has prepared a hydrogeological report for this site (File No. 20-295).

2.3 Corrosivity and Sulphate Attack

Three (3) soil samples were submitted for corrosivity testing parameters (pH, Resistivity, Electrical Conductivity, Redox Potential, Sulphate, Sulphide and Chloride). The Certificate of Analyses is appended. The soil samples were analysed for soluble sulphate concentration and compared to the Canadian Standard CAN3/CSA A23.1-M94 Table 3, *Additional Requirements for Concrete Subjected to Sulphate Attack*. The results are summarized as follows:

Table 2.2 – Corrosivity Results (1 of 2)

Parameter	BH 103 SS 5	BH 104 SS 2	BH 105 SS 3
Soluble Sulphate (SO_4) in soil sample	45 µg/g < 0.1 %	4.4 µg/g < 0.1 %	20 µg/g < 0.1 %
Class of Exposure	**Negligible**	**Negligible**	**Negligible**

Corrosivity parameters are also used for assessing soil corrosivity applicable to cast iron alloys, according to the 10-point soil evaluation procedure described in the American Water Work Association (AWWA) C-105 standard. The results are summarized as follows:

Table 2.3 – Corrosivity Results (2 of 2)

Parameter	AWWA C-105 Standard – Assigned Points					
	BH 103 SS 5		BH 104 SS 2		BH 105 SS 3	
	Result	Points	Result	Points	Result	Points
Resistivity (ohm.cm)	7200	0	6100	0	7100	0
pH	8.07	0	7.66	0	7.74	0
Redox Potential (mV)	184	0	286	0	252	0
Sulfides (%)	<0.04	2	<0.04	2	<0.04	2
Moisture (%)	14	2	23	2	21	2
Corrosion protection recommended?	No		No		No	
Resistivity less than 2000 ohm.cm?	No		No		No	

The analytical results only provide an indication of the potential for corrosion. All three samples scored less than 10 points and corrosion protective measures are therefore not recommended for cast iron alloys. A more recent study by the AWWA has suggested that soil with a resistivity of less than about 2000 ohm.cm should be considered aggressive. All three samples had resistivity measurements exceeding 2000 ohm.cm.

2.4 Frost Heave Susceptibility of Soils

A soil's susceptibility to frost heave is related to the percentage of silt and very fine sand in the soil, as frost heave impacts fine-grained soils with low cohesion and high capillarity. The site soils are classified for susceptibility to frost heave according to their grain size distributions on this basis. Geotechnical laboratory results for this site are appended. Per the Second Edition of the Pavement Design and Rehabilitation Manual by the Ministry of Transportation in Ontario, the following table summarizes the relationship between grain size and frost heave susceptibility:

Table 2.4 – Relationship Between Grain Size and Frost Susceptibility (MTO)

Grain Size Percentage between 5 and 75 µm	Susceptibility to Frost Heaving
0 to 40%	Low
40 to 55%	Moderate
55 to 100%	High

Per the grain size data measured and visual identification of the site soils, frost heave susceptibility is summarized accordingly:

Table 2.5 – Summary of Estimated Frost Heave Susceptibility

Stratum	Grain Size Percentage between 5 and 75 µm	Estimated Susceptibility to Frost Heaving
Surficial Sands	Est. 5 to 25%	Low
Glacial Tills	Est. 10 to 35%	Low

3 Geotechnical Engineering Recommendations

Based on the factual data summarized above, preliminary geotechnical engineering recommendations are provided. These preliminary recommendations are for due diligence purposes only. They must be supplemented and confirmed by additional boreholes, wells, and a detailed geotechnical engineering report at the detailed design stage.

This report assumes that the design features relevant to the geotechnical analyses will be in accordance with applicable codes, standards, and guidelines of practice. If there are any changes to the site development features, or there is any additional information relevant to the interpretations made of the subsurface information with respect to the geotechnical analyses or other recommendations, then Grounded should be retained to review the implications of these changes with respect to the contents of this report.

The proposed project ("the community") includes constructing thirteen (13) new 3 to 4-storey townhome blocks with one underground level (basements and walkouts are proposed). Ground floor elevations have been provided to us. Assuming each basement is set at a depth of 2.75 m below the ground floor FFEs, the lowest BFFEs range from Elev. 244.5 to 243.5 ±m as indicated in the table above.

Due to the underlying weaker (potentially compressible) cohesive soils present in the native soils (directly observed in BH105, and other nearby sites), net site grade raises/fills greater than 0.5 to 1 m will cause long term consolidation settlement, which could take months to years depending on the amount of upfill.

Based on these considerations, we recommend Blocks 1 to 13 to be supported by conventional spread footings on native soils.

3.1 Site Grading

Existing grade will be altered across the Development Limit per the conceptual site grading plan provided by Counterpoint Engineering. Grade raises are summarized below.

Table 3.1 – Summary of Net Site Grade Raises

Block	Relevant Borehole	Borehole Elevations (masl)	Assumed Lowest BFFE (masl)	Proposed Net Grade Change Below Buildings (mbgs)	Proposed Founding Elevation (masl)	Founding Subgrade
1	BH101	245.3	244.5	-0.9	243.0	Native Soil
2	BH101	245.3	244.3	-1.1	242.8	Native Soil
3	BH103	243.9	244.0	+0.1	242.5	Native Soil
4	BH102	243.1	243.8	+0.7	242.3	Native Soil
5	BH102	243.1	243.5	+0.4	242.0	Native Soil
6	BH104	242.6	243.5	+0.6	242.0	Native Soil
7	BH105	243.4	243.5	+0.1	242.0	Native Soil
8	BH105	243.4	243.5	+0.1	242.0	Native Soil
9	BH105	243.4	243.5	+0.1	242.0	Native Soil
10	BH103	243.9	243.8	-0.2	242.3	Native Soil
11	BH103	243.9	244.0	+0.1	242.5	Native Soil
12	BH101	245.3	244.3	-1.1	242.8	Native Soil
13	BH101	245.3	244.5	-0.9	243.0	Native Soil

Due to the underlying weaker (potentially compressible) cohesive soils present below the Development Limit, net site grade raises/fills greater than 0.5 to 1 m may cause long term consolidation settlement, which could take months to years depending on the amount of upfill. Based on the preliminary conceptual grading plan provided, there are no net grade raises/fills for proposed buildings greater than 0.5 m presently proposed.

If the grading plan changes such that grade raises exceed 0.5 to 1 m, mitigation measures may include a) letting the fill sit for 6-9 months in advance (with a min. 0.3 m winter cap included), b) preloading above pregrade elevation to speed up consolidation settlement, or c) ground improvement. Preload heights depend on the amount of time available for consolidation to happen. Regardless, construction will not be possible until monitoring indicates that settlement is finished.

For building areas for Blocks 1 to 13, it is expected that the overall grading will generally consist of cuts and foundations will bear on native soils. The current concept does not require foundations bearing on engineered fill.

For pavement areas, moderate grade raises are anticipated. Grade raises for these elements may comprise compacted common earth fill.

Compacted fill does not need full-time inspection and testing, although it does need periodic geotechnical engineering testing and inspections for quality control. The frequency of periodic inspections can vary from once a day to once every 3 days and is to be confirmed after the construction schedule is available for review. Compacted fill can be made on an existing earth fill subgrade if it is proof rolled under our inspection and approved by us prior to fill placement. Engineered fill requires an approved subgrade of native soils.

Compacted fill shall comprise earth fill that is inorganic, clean, and geotechnically suitable soil sourced from the site or imported. Although not required, it is recommended that all areas of grade raise be placed as engineered fill to ensure full-time quality control of the placed fill, and to anticipate future structures constructed within the pavement area. An engineered fill earthworks specification is appended for reference purposes.

Across the fill areas, the topsoil and other deleterious materials must be removed. The proposed subgrade must be proof rolled and must be inspected by Grounded to identify any voids, organics, or soft, wet, or weak zones. Any identified areas must be sub-excavated to a competent subgrade (approved existing clean non-organic earth fill, or native soil). Prior to the arrival of imported soil materials, they must be test per the requirements of O. Reg 406/19 and approved by the Environmental QP for the site.

All fill must be placed in loose lifts of 150 mm and compacted to a minimum of 98% SPMDD at a moisture content within 2% of optimum. Engineered fill must be placed under the full-time supervision of a Geotechnical Engineer, who shall perform frequent in situ density measurements to ensure the uniformity and adequacy of the compaction effort.

Soil that is used as engineered or common earth fill must have a moisture content within 2% of optimum and be free of deleterious materials, cobbles/boulders greater than 150 mm in diameter, topsoil, and other organics. Representative soil samples must be collected from the proposed fill material and tested using the Standard Proctor Maximum Dry Density (SPMDD) method to determine the optimum moisture content and maximum dry density prior to placement and compaction as common or engineered fill.

The existing topsoil is not geotechnically suitable and must be removed from settlement sensitive areas (structures, engineered fill, pavements, etc.) or used in landscaped areas. Within 2 m of the existing grade moisture content measurements made on the native soil samples ranges from 6 to 70% (on average, 20%). These native soils occasionally contain trace organics. Most of the undisturbed native soils at the site are not suitable for immediate re-use on site and will require further sorting/blending to remove excess organics, moisture, and other deleterious materials.

Common earth fill or engineered fill may not be readily compacted in small volumes, such as trenches or in areas adjacent to foundations or catch basins. For areas of limited extent, compactable aggregate-source backfills like Granular B (OPSS.MUNI 1010) are recommended for post-construction grade integrity. All new fill shall be compacted to a minimum of 98% SPMDD.

Frost susceptible soils within 1.5 m of finished grades in unheated areas (e.g., pavements) could potentially cause pavements to heave or crack next to other structures (e.g., curbs, catch basins, etc.). The degree of heaving is unknown. If frost susceptibility is to be considered in design (to be determined by the Owner based on their own pavement performance criteria), all soil placed within 1.5 m of finished grades must be classified to have a low susceptibility to frost heaving, as defined in Section 2.4 above.

3.2 Foundation Design Parameters

The topsoil, any earth fill soils, and stiff/loose native soils are considered unsuitable for the support of the proposed building foundations.

Where foundations are exposed to typical outdoor temperatures, 1.5 m of earth cover (or equivalent insulation) is required for frost protection in Barrie.

It is possible for townhome structures at this site to be made as conventional drained structures provided that the underside of the subfloor drainage layer (nominally 0.3 m below lowest BFFE) is at least 0.5 m above the groundwater table in each location (i.e., lowest BFFE is 0.8 m above the groundwater table in each location). The current site grading plan indicates Blocks 3 and 11 can be constructed with drained foundations, whereas all other proposed structures be made with fully waterproofed basements. The analysis below is based on very limited borehole information at this preliminary design stage and must be updated with additional boreholes during detailed design.

Table 3.2 – Summary of Basement Structures per Block

Block	Assumed Lowest BFFE (masl)	0.8m Below Lowest BFFE (masl)	Design Groundwater Table (masl)	Recommended Basement Structure
1	244.5	243.7	244.1	Waterproofed
2	244.3	243.5	244.1	Waterproofed
3	*244.0*	*243.2*	*243.1*	*Drained Foundations*
4	243.8	243.0	243.0	Waterproofed
5	243.5	242.7	243.0	Waterproofed
6	243.5	242.7	242.8	Waterproofed
7	243.5	242.7	243.1	Waterproofed
8	243.5	242.7	243.1	Waterproofed

Block	Assumed Lowest BFFE (masl)	0.8m Below Lowest BFFE (masl)	Design Groundwater Table (masl)	Recommended Basement Structure
9	243.5	242.7	243.0	Waterproofed
10	243.8	243.0	243.0	Waterproofed
11	*244.0*	*243.2*	*243.0*	*Drained Foundations*
12	244.3	243.5	244.1	Waterproofed
13	244.5	243.7	244.1	Waterproofed

3.2.1 Spread Footings

The proposed structures for Block 1 to 13 with lowest BFFEs ranging from Elev. 244.5 to 243.5 ±m, may be supported on conventional, lightly-loaded spread footing foundations bearing on native soils. The native, undisturbed (dewatered) very stiff/compact glacial tills are considered suitable to support the proposed building foundations.

Conventional spread footings made to bear on these undisturbed (dewatered) native soils may be designed using the maximum factored geotechnical resistance at ultimate limit state (ULS) of 175 kPa. The net geotechnical reaction at serviceability limit state (SLS) is 100 kPa, for an estimated total settlement of 25 mm.

Table 3.3 – Foundation Elevations: Blocks 1 to 13

Block	Assumed Lowest BFFE (masl)	Relevant Borehole	Proposed Founding Elevation (masl)	Design Groundwater Table (masl)
1	244.5	101	243.0	244.1
2	244.3	101	242.8	244.1
3	244.0	103	242.5	243.1
4	243.8	102	242.3	243.0
5	243.5	102	242.0	243.0
6	243.5	104	242.0	242.8
7	243.5	105	242.0	243.1
8	243.5	105	242.0	243.1
9	243.5	105	242.0	243.0
10	243.8	103	242.3	243.0
11	244.0	103	242.5	243.0
12	244.3	101	242.8	244.1
13	244.5	101	243.0	244.1

If higher capacities are required, the proposed structures may be supported on helical piles, extending through the weaker (compressible) cohesive soils, and made to bear on the stronger, lower sand glacial till.

Excavations for typical footings will be about 1.1 to 2.8 ±m below existing ground surface. Therefore,

- Foundation excavations will extend below the stabilized groundwater table;
- Foundation excavations will penetrate native cohesionless sand till, which will produce free-flowing water when penetrated below the groundwater table.

It will therefore be necessary to positively dewater foundation excavations extending below Block 1 to 13. These excavations must be dewatered to a minimum 1.2 m below proposed excavation elevation prior to excavation, to preserve the in-situ integrity of the native soils. If the subsurface is not dewatered prior to excavation, the native soils will become disturbed by the ingress of groundwater and the above recommendations for bearing capacity will not be valid.

3.2.2 Raft Foundation

Should the below-grade structure be designed as a fully waterproofed structure with no permanent dewatering, a raft foundation will be required to carry structural loads, with waterproofed foundation walls designed to withstand hydrostatic forces (lateral and uplift).

Rafts would be founded on undisturbed (dewatered) very stiff/compact native soils. A 15x50 m raft is considered for the following preliminary discussion.

The preliminary raft design parameters are provided assuming a *uniform load* at the base of the raft. In reality, raft loads are non-uniform; they will be highest around the core and will decrease away from the core. Consequently, detailed raft design is an iterative process between the structural and geotechnical engineers. The preliminary parameters below are provided as the initial step in determining raft feasibility (a structural task).

Utilizing preliminary soil stiffness parameters, analysis of a *uniformly* loaded raft foundation shows that for 25 mm of total settlement, the total uniform SLS bearing pressure is 50 kPa. Each additional increase of 50 kPa (which is now virgin loading) generates an additional 25 mm of settlement. Thus, a total (gross) *uniform* geotechnical reaction at SLS of 100 kPa will generate 50 mm of settlement.

On the basis of our preliminary stiffness parameters and the assumption of *uniform* raft loading, the preliminary modulus of subgrade reaction appropriate for raft design at this site is about 1,800 kPa/m.

The loads on these rafts will not be uniform. Experience at similar sites indicates that loads will be concentrated at the foundation walls and will approximate strip footing behaviour. In this case, the spread footing SLS capacity of 75 kPa for 25 mm of settlement can be used for preliminary design purposes.

These settlement parameters are based on assumed Young's Moduli (virgin and unload-reload) for each of the load-bearing strata and can likely be improved by in situ testing of the Young's Modulus within the critical portions of the zone of influence of the raft, in future boreholes.

Settlement parameters can likewise be improved by modelling the real non-uniform loading at the base of the raft.

Detailed raft design is an iterative process between the structural and geotechnical engineers. Once a draft structural design is completed by the structural engineer, the resulting non-uniform raft pressure distribution is provided to us (typically as a contour plot). Grounded will then use finite element modelling to determine the real settlement more accurately at each point under the raft. The detailed settlement distribution and MSRs under the raft are then sent back to the structural engineer, and the structural design is modified as necessary.

The maximum factored geotechnical resistance of a 15x50 m raft foundation at ULS is 800 kPa for design purposes.

Should raft slab design be considered beyond this conceptual level, recommendations and discussion pertaining to differential settlement must be provided by Grounded.

It will be necessary to positively dewater the Development Limit to a minimum 1.2 m below proposed founding elevation prior to excavation to preserve the in situ integrity of the native soils. If the subsurface is not dewatered prior to excavation, the native soils will become disturbed by the ingress of groundwater and the above recommendations for bearing capacity will not be valid. The Development Limit should not be excavated without positive dewatering in place, to preserve the native soils in their undisturbed state.

During construction, the subgrade at founding elevation should be cut neat, inspected, and immediately protected by a minimum 200 mm thick mud slab (comprising lean concrete) to provide a working surface. The subsurface must not be proof-rolled as this activity would further weaken these soils. The raft slab is then constructed on top of the mud slab. Prior to pouring the mud mat and foundation, the foundation subgrade must be cleaned of all deleterious materials such as softened, disturbed, or caved materials, or standing water. If construction proceeds during freezing weather conditions, adequate temporary frost protection for the raft foundation base and concrete must be provided.

As the raft slab is to be fully waterproofed, the structure must be designed to resist uplift and lateral hydrostatic pressure on foundation walls. During construction, it will be necessary to consider the potential uplift pressure on the underside of a raft foundation due to hydrostatic forces. Positive dewatering operations during construction must begin prior to excavation and must continue until such time as the structural dead load exceeds the potential uplift forces (with suitable partial factors (LRFD) included in this assessment). A design groundwater elevation corresponding to the nearest well is to be used.

Differential settlement is related to real non-uniform raft load distribution and must be assessed as part of the detailed design process.

3.2.3 Helical Piles

Spread footings are suitable for supporting the proposed structures within the Development Limit of the subject site. Helical pile recommendations are provided as an option if it is deemed advantageous by the design team.

Helical piles can be used to support either a drained or fully waterproofed structure.

If higher capacities are required, helical piles may be designed to carry the proposed building loads for Blocks 1 to 13. Helical piles can be installed using small equipment, with minimal ground disturbance and minimal excess soil cuttings. Contractors specializing in helical pile design and installation can provide detailed information on installation methodology, detailed design, product quality, and certification. EBS Geostructural is one local specialist contractor that provides design-build services for Chance helical piles.

At this site, helical piles can be installed through the underlying weaker (potentially compressible) cohesive soils and made to bear on the stronger, lower glacial till (additional boreholes will be required to fully investigate this unit), in order to obtain adequate resistance to support the proposed building loads for Blocks 1 to 13. Following helical pile installation, a pile cap or grade beam is constructed to transfer the building loads onto the underlying competent soils through the helical piles. The design earth cover (or equivalent insulation) for frost protection of grade beams exposed to ambient environmental temperatures is 1.5 metres for this location.

Helical pile detailed design will ultimately depend upon the loading considerations and the ground conditions. The project geotechnical information should be provided to a specialist design/build contractor to assess the feasibility of this foundation system and to determine probable helical pile refusal/installation depths.

The actual installation depth of each helical pile is determined on site during installation based on depth and torque measurements made during installation, and the load support requirements. The load carrying capacity of each helical pile is confirmed by the helical pile contractor based on the torque measurements and a full-scale performance test of a prototype/production pile. Occasionally, field torque measurements indicate that helical piles must be advanced deeper than originally designed. Provision must be made in helical pile contracts to allocate and quantify risks associated with any extra time and materials utilized to achieve the required field torque readings.

The presence of debris/obstructions or larger sized cobbles or boulders in native soil (such as cobbles inferred observed in Borehole 102 at Elev. 234.0 ±m) could impede helical pile installation. Refer to the borehole logs for detailed subsurface information. Provision must be made in helical pile contracts to allocate risks associated with the time spent and equipment utilized to remove or work around such obstructions when encountered.

3.2.4 General Foundation Recommendations

Footings stepped from one elevation to another should be offset at a slope not steeper than 7 vertical to 10 horizontal.

The founding subgrade must be cleaned of all unacceptable materials and approved by Grounded prior to pouring concrete for the footings. Such unacceptable materials may include disturbed or caved soils, ponded water, or similar as indicated by Grounded during founding subgrade inspection. During the winter, adequate temporary frost protection for the footing bases and concrete must be provided if construction proceeds during freezing weather conditions.

Soils at the base of the foundation excavation shall not exceed a maximum particle size of 75 mm. Backfill shall not exceed a maximum particle size of 75 mm in foundation excavations exceeding 1 m in depth. If cobbles and boulders exceeding this maximum particle size are encountered, they will be deemed unsuitable and must be subexcavated and replaced with suitable material.

3.3 Earthquake Design Parameters

The Ontario Building Code (2012) stipulates the methodology for earthquake design analysis, as set out in Subsection 4.1.8.7. 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 4.1.8.4A of the Ontario Building Code (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 from the rational analysis of undrained shear strength (s_u) or penetration resistance (N-values) according to the OBC and National Building Code of Canada.

Based on the stratigraphy within the Development Limit, the site designation for seismic site class is **Class D**, per Table 4.1.8.4.A of the Ontario Building Code (2012). Tables 4.1.8.4.B and 4.1.8.4.C. of the same code provide the applicable acceleration- and velocity-based site coefficients.

We have estimated the site designation based on quantitative analysis of penetration resistance (N-values) with assumed N-values for the soil stratigraphy beyond the investigation depth. If an improved seismic site class provides economic benefit to the project, consideration should be given to conducting a site-specific Multichannel Analysis of Surface Waves (MASW, to determine the average shear wave velocity in the top 30 meters of the site stratigraphy. MASW testing may result in an improved seismic site designation (to a Class C) which may help reduce the cost implication for the structure.

3.4 Earth Pressure Design Parameters

At this site, the design parameters for structures subject to unbalanced earth pressures such as basement walls and retaining walls are shown in the table below. Grounded should be retained to provide global slope stability review of any retaining walls higher than 1.2 m of grade separation.

Table 3.4 – Unbalanced Earth Pressure Design Parameters

Stratigraphic Unit	γ	φ	K_a	K_o	K_p
Compact Granular Fill Granular 'B' (OPSS.MUNI 1010)	21	32	0.31	0.47	3.26
Existing Earth Fill	19	29	0.35	0.52	2.88
Cohesionless Tills, Sands	21	30	0.33	0.50	3.00
Stiff Clays	22	28	0.36	0.53	2.77

γ = soil bulk unit weight (kN/m^3)
φ = internal friction angle (degrees)
K_a = active earth pressure coefficient (Rankine, dimensionless)
K_o = at-rest earth pressure coefficient (Rankine, dimensionless)
K_p = passive earth pressure coefficient (Rankine, dimensionless)

These earth pressure parameters assume that grade is horizontal behind the retaining structure. If retained grade is inclined, these parameters do not apply and must be re-evaluated.

The following equation can be used to calculate the unbalanced earth pressure imposed on walls:

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

P = horizontal pressure (kPa) at depth h
h = the depth at which P is calculated (m)
K = earth pressure coefficient
h_w = height of groundwater (m) above depth h
γ = soil bulk unit weight (kN/m^3)
γ' = submerged soil unit weight (γ - 9.8 kN/m^3)
q = total surcharge load (kPa)

The possible effects of frost on retaining earth structures must be considered. In frost-susceptible soils, pressures induced by freezing pore water are basically irresistible. Insulation typically addresses this issue. Alternatively, non-frost-susceptible backfill may be specified.

Foundation resistance to sliding is proportional to the friction between the soil subgrade and the base of the footing. The factored geotechnical resistance to friction (**R_f**) at ULS provided in the following equation:

$$R_f = \Phi N \tan\varphi$$

R_f = frictional resistance (kN)
Φ = reduction factor per Canadian Foundation Engineering Manual (CFEM) Ed. 4 (0.8)
N = normal load at base of footing (kN)
φ = internal friction angle (see table above)

3.5 Slab on Grade Design Parameters

All lowest BFFEs are within native soils. Therefore, a conventional basement slab on grade would be made on native undisturbed (dewatered) glacial till, sand, or clay. In its present state, the native soils are not competent for the support of a slab on grade. The native soils should be compacted in place, proof-rolled and inspected under the supervision of Grounded for obvious exposed loose or disturbed areas, or for areas containing excessive deleterious materials or moisture. Unacceptable material (as determined by Grounded) must be subexcavated and replaced with Granular B (OPSS 1010) and compacted to a minimum of 98% SPMDD.

The modulus of subgrade reaction appropriate for design of a conventional slab on grade resting on compacted native soils is 12,000 kPa/m. This does not apply for raft foundation design.

3.6 Long-Term Groundwater and Seepage Control

To limit seepage to the extent practicable, exterior grades adjacent to foundation walls should be sloped at a minimum 2 percent gradient away from the wall for 1.2 m minimum.

For waterproofed basements, the full height of the basement walls should be waterproofed (no drainage) and designed to withstand horizontal hydrostatic pressure below the highest groundwater table observed in the nearest wells. Perimeter and subfloor drainage is to be specifically excluded.

It is possible for townhome structures at this site to be made as conventional drained structures provided that the underside of the subfloor drainage layer (nominally 0.3 m below BFFE) is at least 0.5 m above the groundwater table in each location (i.e., lowest BFFE is 0.8 m above the groundwater table in each location). The current site grading plan indicates Blocks 3 and 11 can be constructed with drained foundations, whereas all other proposed structures be made with fully waterproofed basements. This analysis is based on very limited borehole information at this preliminary design stage and must be updated with additional boreholes during detailed design.

For a conventional drained basement approach, perimeter and subfloor drainage systems are required for the underground structures (such as basements or walkouts). Subfloor drainage collects and removes the seepage that infiltrates under the floor. Perimeter drainage collects and removes seepage that infiltrates at the foundation walls. The exterior faces of foundation walls should be provided with a layer of waterproofing to protect interior finishes.

Subfloor drainage pipes (min. 100mm diameter) are to be spaced at an average 6 m (measured on-centres). If subdrain elevation conflicts with top of footing elevation, footings should be lowered, as necessary.

The walls of the substructure are to be fully drained to eliminate hydrostatic pressure. In an open cut excavation, basement wall drainage is installed directly against the basement wall from the open cut side. Perimeter foundation drains made in this application comprise perforated pipe (minimum 100 mm diameter) surrounded by a granular filter of OPSS.MUNI HL-8 Coarse

Aggregate providing a minimum 300 mm of cover over the drain pipe. Typical basement drainage details are appended.

The perimeter and subfloor drainage systems are critical structural elements since they eliminate hydrostatic pressure from acting on the basement walls and floor slab. The drainage system should be connected directly to the municipal storm system if possible, or else positively discharged to grade away from the structures. Flow must not be directed into the drainage layers.

The subfloor drainage system is a critical structural element since it keeps water pressure from acting on the floor slab. There will be hydrostatic pressure on the permanent wall structures. As such, the sumps ensure the performance of this system and must have a duplexed pump arrangement for 100% pumping redundancy and these pumps must be on emergency power. The size of the sump must be designed to accommodate the anticipated water seepage.

The short-term and long-term dewatering requirements are provided in Grounded's Hydrogeological Report (File No. 20-295).

If any water is to be discharged to the storm or sanitary sewers, the City of Barrie will require Discharge Agreements to be in place. It should be noted that securing a permit to take water on a permanent basis may not be supported by regulatory agencies.

3.7 Site Servicing

All services must have at least 1.5 metres of earth cover or equivalent insulation for frost protection.

3.7.1 Bedding

The soil subgrade encountered within utility trenches on site may consist of either earth fill or native soil. If earth fill is encountered, the subgrade must be compacted in place to a minimum 98% SPMDD. The trench base must be inspected for obvious loose, wet, or disturbed material. Any unsuitable material must be subexcavated and replaced with imported fill compacted to 98% SPMDD. If trenches extend into the high permeability cohesive till below the groundwater table, the groundwater table must be lowered to 1.2 m below the lowest excavation elevation prior to excavation. Bedding material must consist of well graded granular fill such as Granular A (OPSS.MUNI 1010). Clear stone is specifically prohibited at this site. The bedding material must be compacted to a minimum 95% SPMDD.

3.7.2 Backfill

Excavated earth fill and native soils on site will constitute adequate backfill material if the soil meets the backfill specifications:

- Any deleterious material in the earth fill is removed prior to reuse as backfill.
- The moisture content is within 2% of optimum, or moisture conditioned to within 2% of optimum.
- The backfill must be compacted to a minimum 98% SPMDD.

3.7.3 Trench Plugs

Trench plugs are installed when the invert of the trench is below the groundwater table, to prevent the groundwater from preferentially flowing through the granular bedding and backfill material, creating a local drawdown of the groundwater table. Where local drawdown is not tolerated, trench plugs can be installed in the granular bedding and backfill material. Trench plugs may be constructed as clay plugs or cut off collars around the pipe barrel.

Clay plugs should be installed every 50 m along the full length of the trench, where the trench invert is below the groundwater table. Clay plugs must be a minimum of 1 m thick along the length of the trench and will completely replace any bedding or backfill material around the pipe barrel. Material used for clay plugs must have greater than 15% of the particles finer than 2 microns and a coefficient of permeability of less than 10^{-8} m/s. The material must be compacted to 95% SPMDD. Unshrinkable fill is also a suitable clay plug material. A representative sample of clay plug material must be submitted prior to construction and during construction for permeability and particle size testing to confirm the material is adequate and in compliance with the above material specifications.

If cut off collars are used instead of clay plugs, the cut off collar must not be placed within 1 m of a pipe joint to ensure adequate compaction. The soils around the cut off collar must be compacted to 95% SPMDD. A watertight connection is required between the collar and the pipe wall.

4 Pavement Design Advice

The following design pertains to asphaltic concrete pavements (‘pavement’) where the pavement will rest on a soil subgrade. The following Ontario Provincial Standards Specifications (OPSS) apply to the pavement construction and material requirements:

- OPSS 310 - Hot Mix Asphalt
- OPSS 501 - Compacting
- OPSS 1010 - Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
- OPSS 1101 - Performance Graded Asphalt Cement
- OPSS 1150 - Hot Mix Asphalt

The pavement construction and material should also follow the relevant city specifications, as applicable.

4.1 Pavement Subgrade Preparation

Topsoil and existing wet or organic rich earth fill soils are considered unsuitable for the pavement subgrade. These materials must be stripped down to acceptable subgrade prior to pavement construction. Existing earth fill, if cleared of organic rich or wet soils, and native subgrade will provide adequate subgrade for the support of the pavement. The subgrade must be proof-rolled and inspected under the supervision of Grounded for obvious loose or disturbed soils or where there is deleterious materials or moisture. These areas can either be recompacted in place and retested or replaced with Granular B in lifts 150 mm thick or less and compacted to a minimum of 98% SPMDD. The subgrade for all pavement structures shall be frost tapered at a 3H to 1V slope to match with existing pavement structures, to reduce differential settlements due to frost heave.

4.2 Pavement Design

The following **basic pavement design** will last for 8 to 10 years before significant maintenance is required, depending on the traffic volume.

Table 4.1 – Basic Pavement Design Specifications

Basic Pavement Structure	Compaction Requirement	Car Parking Minimum Component Thickness
Asphalt Top Lift HL-3 (OPSS 1150), and PG 58-28 (OPSS 1101)	OPSS 310	40 mm
Asphalt Base Course HL-8 (OPSS 1150), and PG 58-28 (OPSS 1101)	OPSS 310	70 mm
Granular Base Course 19 mm diameter crusher run limestone or Granular A (OPSS 1010)	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm
Granular Subbase Course 50 mm diameter crusher run limestone or Granular B Type II (OPSS 1010)	98% Standard Proctor Maximum Dry Density (ASTM-D698)	400 mm
Total Thickness		**660 mm**

The following **performance pavement design** will last approximately twice as long before significant maintenance is required. The performance pavement design considers that the top layer of asphalt will be damaged over time, and therefore, will contribute less to the structural strength of the asphalt.

Table 4.2 – Performance Pavement Design Specifications

Performance Pavement Structure	Compaction Requirement	Car Parking Minimum Component Thickness
Asphalt Top Lift HL-3 (OPSS.MUNI 1150), and PG 58-28 (OPSS.MUNI 1101)	OPSS.MUNI 310	40 mm
Asphalt Base Course HL-8 (OPSS.MUNI 1150), and PG 58-28 (OPSS.MUNI 1101)	OPSS.MUNI 310	100 mm
Granular Base Course 19 mm diameter crusher run limestone or Granular A (OPSS.MUNI 1010)	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm
Granular Subbase Course 50 mm diameter crusher run limestone or Granular B Type II (OPSS.MUNI 1010)	98% Standard Proctor Maximum Dry Density (ASTM-D698)	500 mm
Total Thickness		**790 mm**

The existing soils have a low to moderate susceptibility to frost heave, and pavement on these materials must be designed accordingly.

4.3 Pavement Drainage

Adequate drainage of the pavement subgrade is required. Prior to paving, the subgrade should be free of any depressions and sloped at a minimum grade of 2% to provide positive drainage. Perforated plastic subdrains (100 mm diameter) should be designed to collect subgrade water and positively outlet it at the catch basins. Typical pavement drainage details are appended.

Controlling surface water is important in keeping pavements in good maintenance. Grading adjacent pavement areas must be designed so that water is not allowed to pond adjacent to the outside edges of the pavement or curb.

5 Considerations for Construction

5.1 Excavations

Excavations must be carried out in accordance with the *Occupational Health and Safety Act – Regulation 213/91 – Construction Projects (Part III - Excavations, Section 222 through 242).* These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety. For practical purposes, with the zones of excavation:

- Earth fill is a Type 3 soil;
- The native soils are Type 4 soils, or Type 3 soils if dewatered.

In accordance with the regulation's requirements, the soil must be suitably sloped and/or braced where workers must enter a trench or excavation deeper than 1.2 m. Safe excavation slopes (of no more than 3 m in height) by soil type are stipulated as follows:

Table 5.1 – Soil Types and Associated Safe Excavation Slopes

Soil Type	Base of Slope	Steepest Slope Inclination
1	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
2	within 1.2 metres of bottom of trench	1 horizontal to 1 vertical
3	from bottom of trench	1 horizontal to 1 vertical
4	from bottom of trench	3 horizontal to 1 vertical

Minimum support system requirements for steeper excavations are stipulated in Sections 235 through 238 and 241 of the Act and Regulations and include provisions for timbering, shoring and moveable trench boxes.

Larger obstructions (e.g., buried concrete debris, other obstructions) not directly observed in the boreholes are likely present in the earth fill. Similarly, larger inclusions (e.g., cobbles and boulders) may be encountered in the native soils. The size and distribution of these obstructions cannot be predicted with boreholes, as the split spoon sampler is not large enough to capture particles of this size. Provision must be made in excavation contracts to allocate risks associated with the time spent and equipment utilized to remove or penetrate such obstructions when encountered.

5.2 Short-Term Groundwater Control

Additional groundwater considerations are provided in Grounded's Hydrogeological Report (File No. 20-295).

The design groundwater table ranges from Elev. 244.1 to 242.8 ±m across the Development Limit. Within the anticipated zones of excavation for the proposed blocks, the surficial sands (higher permeability soils) will produce free-flowing water when penetrated below the prevailing groundwater table, whereas the cohesive glacial till (lower permeability soil) will typically preclude the free flow of water when wet.

Bulk and localized excavations in Blocks 1 to 13 will extend below the stabilized groundwater table into permeable cohesionless till, which will yield free-flowing water and requires positive dewatering prior to excavation.

Positive dewatering to lower the groundwater table will be required to facilitate construction as well as to maintain the integrity of the subgrade for foundation and slab-on-grade support. The water level must be kept at least 1.2 m below the lowest excavation elevation during construction. Failure to dewater prior to excavation will result in unrecoverable disturbance of the subgrade, which will render advice provided for undisturbed subgrade conditions inapplicable.

Dewatering will take some time to accomplish prior to the start of excavation.

It is recommended that a professional dewatering contractor be consulted to review the subsurface conditions and to design a site-specific dewatering system. It is the dewatering contractor's responsibility to assess the factual data and to provide recommendations on dewatering system requirements.

5.3 Site Work

To better protect wet undisturbed subgrade, excavations exposing wet soils must be cut neat, inspected, and then immediately protected with a skim coat of concrete (i.e., a mud mat). Wet sands are susceptible to degradation and disturbance due to even mild site work, frost, weather, or a combination thereof.

The effects of work on site can greatly impact soil integrity. Care must be taken to prevent this damage. Site work carried out during periods of inclement weather may result in the subgrade becoming disturbed unless a granular working mat is placed to preserve the subgrade soils in their undisturbed condition. Subgrade preparation activities should not be conducted in wet weather and the project must be scheduled accordingly.

If site work causes disturbance to the subgrade, removal of the disturbed soils and the use of granular fill material for site restoration or underfloor fill will be required at additional cost to the project.

It is construction activity itself that often imparts the most severe loading conditions on the subgrade. Special provisions such as end dumping and forward spreading of earth and aggregate fills, restricted construction lanes, and half-loads during placement of the granular base and other work may be required, especially if construction is carried out during unfavourable weather.

Adequate temporary frost protection for the founding subgrade must be provided if construction proceeds in freezing weather conditions. The subgrade at this site is susceptible to frost damage. Depending on the project context, consideration should be given to frost effects (heaving, softening, etc.) on exposed subgrade surfaces.

5.4 Engineering Review

By issuing this preliminary report, Grounded Engineering has assumed the role of Geotechnical Engineer of Record for this site. Grounded should be retained to review the structural engineering drawings prior to issue or construction to ensure that the recommendations in this report have been appropriately implemented.

All foundation installations must be reviewed in the field by Grounded, the Geotechnical Engineer of Record, as they are constructed. The on-site review of the condition of the founding subgrade as the foundations are constructed is as much a part of the geotechnical engineering design function as the design itself; it is also required by Section 4.2.2.2 of the Ontario Building Code. If Grounded is not retained to carry out foundation engineering field review during construction, then Grounded accepts no responsibility for the performance or non-performance of the foundations, even if they are constructed in general conformance with the engineering design advice contained in this report.

House foundations designed under Part 9 of the Building Code are approved by local building inspectors. Prior to placing concrete for foundations of dwellings, the foundation areas must be cleaned of all deleterious materials such as topsoil, fill, and softened, disturbed, or caved materials, as well as any standing water.

The long-term performance of a slab on grade is highly dependent upon the subgrade support and drainage conditions. Strict procedures must be maintained during construction to maintain the integrity of the subgrade to the extent possible. The design advice in this report is based on an assessment of the subgrade support capabilities as indicated by the boreholes. These conditions may vary across the Development Limit depending on the final design grades and therefore, the preparation of the subgrade and the compaction of all fill should be monitored by Grounded at the time of construction to confirm material quality, thickness, and to ensure adequate compaction.

A visual pre-construction survey of adjacent lands and buildings is recommended to be completed prior to the start of any construction. This documents the baseline condition and can prevent unwarranted damage claims. Any shoring system, regardless of the execution and design, has the potential for movement. Small changes in stress or soil volume can cause cracking in adjacent buildings.

6 Limitations and Restrictions

Grounded should be retained to review the structural engineering drawings prior to issue or construction to ensure that the recommendations in this report have been appropriately implemented.

This preliminary geotechnical engineering feasibility study is intended for due diligence purposes only. At detailed design, site-specific boreholes, groundwater monitoring wells, and updated detailed geotechnical engineering advice are required. Once completed, the future detailed geotechnical engineering report by Grounded Engineering would then supersede this preliminary report.

6.1 Investigation Procedures

The geotechnical engineering analysis and advice provided are based on the factual borehole information observed and recorded by Grounded. The investigation methodology and engineering analysis methods used to carry out this scope of work are consistent with conventional standard practice by Grounded as well as other geotechnical consultants, working under similar conditions and constraints (time, financial and physical).

Borehole drilling services were provided to Grounded by a specialist professional contractor. The drilling was observed and recorded by Grounded's field supervisor on a full-time basis. Drilling was conducted using conventional drilling rigs equipped with conventional augers. As drilling proceeded, groundwater observations were made in the boreholes. Based on examination of recovered borehole samples, our field supervisor made a record of borehole and drilling observations. The field samples were secured in air-tight clean jars and bags and taken to the Grounded soil laboratory where they were each logged and reviewed by the geotechnical engineering team and the senior reviewer.

The Split-Barrel Method technique (ASTM D1586) was used to obtain the soils samples. The sampling was conducted at conventional intervals. As such, stratigraphic interpolation between samples is required and stratigraphic boundary lines do not represent exact depths of geological change. They should be taken as gradual transition zones between soil or rock types.

A carefully conducted, fully comprehensive investigation and sampling scope of work carried out under the most stringent level of oversight may still fail to detect certain ground conditions. As such, users of this report must be aware of the risks inherent in using engineered field investigations to observe and record subsurface conditions. As a necessary requirement of working with discrete test locations, Grounded has assumed that the conditions between test locations are the same as the test locations themselves, for the purposes of providing geotechnical engineering advice.

It is not possible to design a field investigation with enough test locations that would provide complete subsurface information, nor is it possible to provide geotechnical engineering advice that completely identifies or quantifies every element that could affect construction, scheduling, or tendering. Contractors undertaking work based on this report (in whole or in part) must make their own determination of how they may be affected by the subsurface conditions, based on their own analysis of the factual information provided and based on their own means and methods. Contractors using this report must be aware of the risks implicit in using factual information at discrete test locations to infer subsurface conditions across the site and are directed to conduct their own investigations as needed.

6.2 Site and Scope Changes

This report provides preliminary geotechnical engineering advice intended for use by the owner and their retained design team for due diligence only. These preliminary interpretations, design parameters, advice, and discussion on construction considerations are not complete. A detailed site-specific geotechnical investigation must be conducted by Grounded during detailed design to confirm and update the preliminary recommendations provided here.

6.3 Report Use

The authorized users of this report are Loon Avenue Lands OP Inc. and their design team, for whom this report has been prepared. Grounded Engineering Inc. maintains the copyright and ownership of this document. Reproduction of this report in any format or medium requires explicit prior authorization from Grounded Engineering Inc.

The local municipal/regional governing bodies may also make use of and rely upon this report, subject to the limitations as stated.

7 Closure

If the design team has any questions regarding the discussion and advice provided, please do not hesitate to have them contact our office. We trust that this report meets your requirements at present.

For and on behalf of our team,

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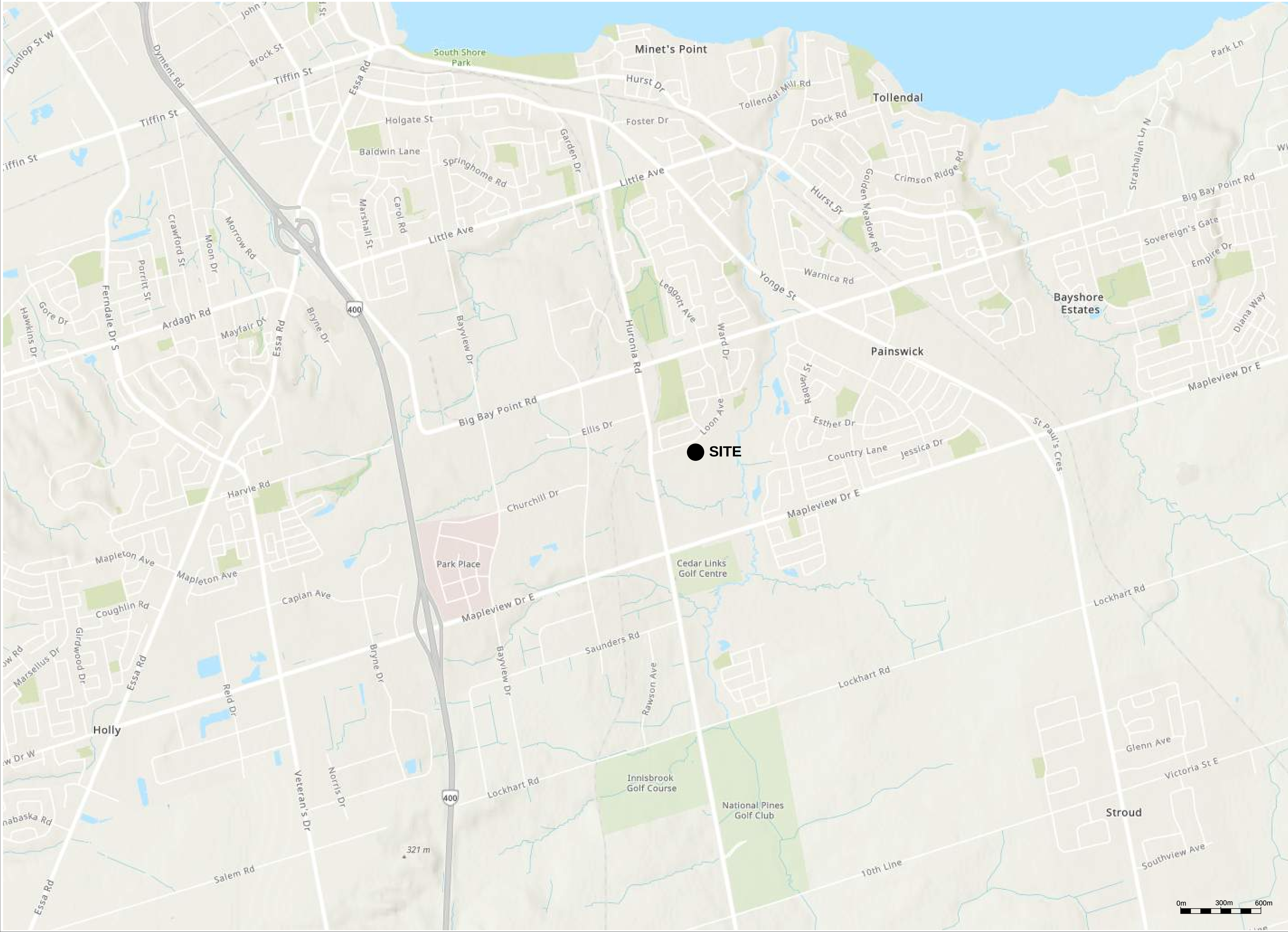
FIGURES



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LEGEND

● APPROXIMATE SITE LOCATION

Note

Reference

ArcGIS Map 2021

Project

338 MAPLEVIEW DR E BARRIE, ON

Figure Title

SITE LOCATION PLAN (Regional Map)

North

TRUE
PROJECT

Date

FEBRUARY 2022

Scale

AS INDICATED

Job No

20-295

Figure No

FIGURE 1A

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LEGEND

SUBJECT LANDS

PROPOSED DEVELOPMENT LIMIT

Note

Reference

ArcGIS Map 2021

Project

338 MAPLEVIEW DR E BARRIE, ON

Figure Title

SUBJECT LANDS AND DEVELOPMENT LIMIT

North

TRUE

Date

FEBRUARY 2022

Scale

AS INDICATED

Job No

20-295

Figure No

FIGURE 1B

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LEGEND

PROPOSED DEVELOPMENT LIMIT

GROUNDED BOREHOLE / MONITORING WELL

CROSS SECTION A-A'

GUELPH PERMEAMETER TESTS COMPLETED BY GROUNDED

Note

Reference

Google Earth Satellite Image 2021

Project

338 MAPLEVIEW DR E BARRIE, ON

Figure Title

BOREHOLE LOCATION PLAN - EXISTING CONDITION

North

TRUE

Date

FEBRUARY 2022

Scale

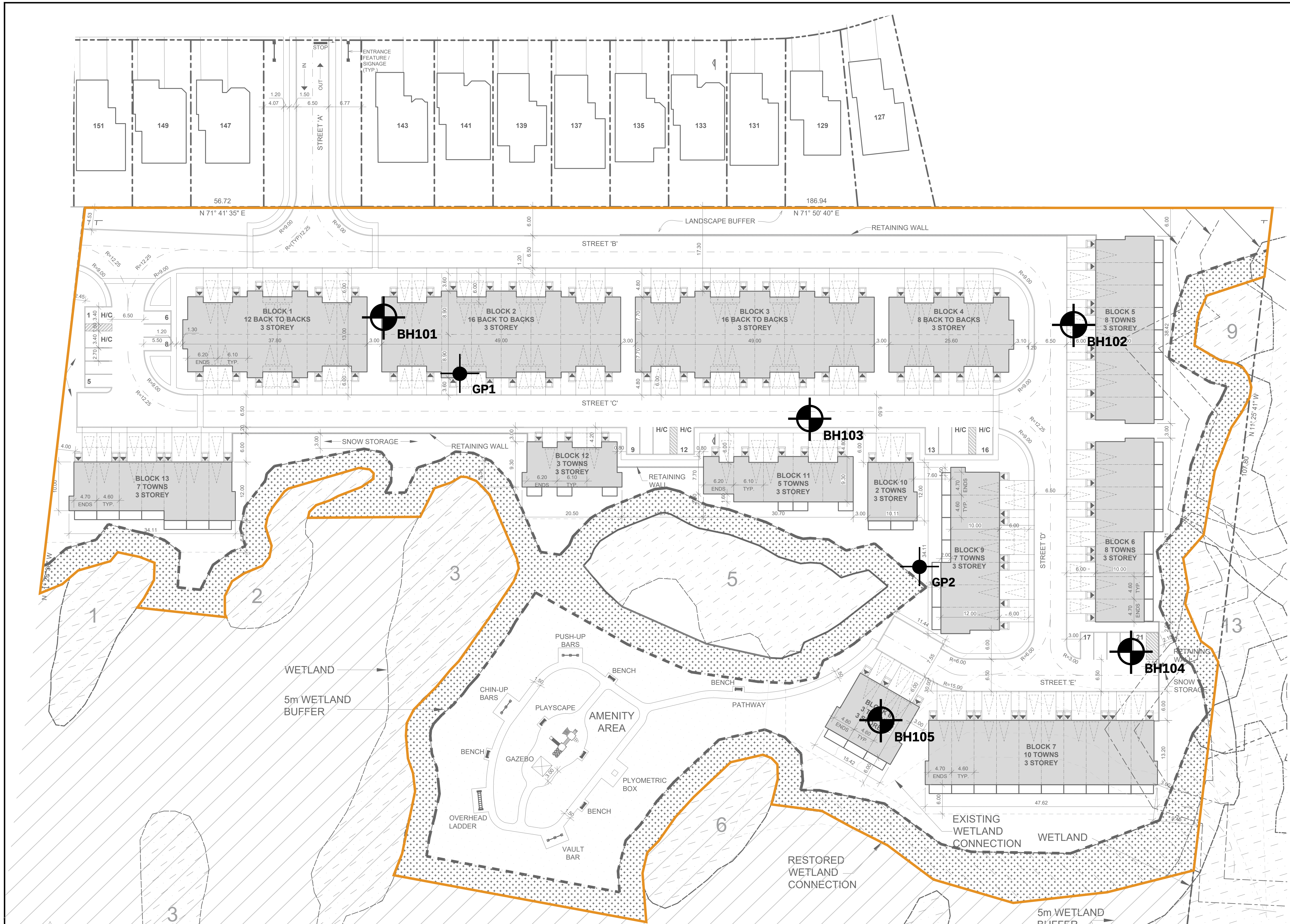
AS INDICATED

Job No

20-295

Figure No

FIGURE 2



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LEGEND

- PROPOSED DEVELOPED AREA
- GROUNDED BOREHOLE / MONITORING WELL
- CROSS SECTION A-A'
- GUELPH PERMEAMETER TESTS COMPLETED BY GROUNDED

Note

Reference

Concept Grading Plan, 338 Mapleview Dr E, Project No: 21076, Figure 6, Counterpoint Engineering Inc, September 2021

Project

338 MAPLEVIEW DR E
BARRIE, ON

Figure Title

BOREHOLE LOCATION PLAN - PROPOSED CONDITIONS

North

TRUE

Date

FEBRUARY 2022

Scale

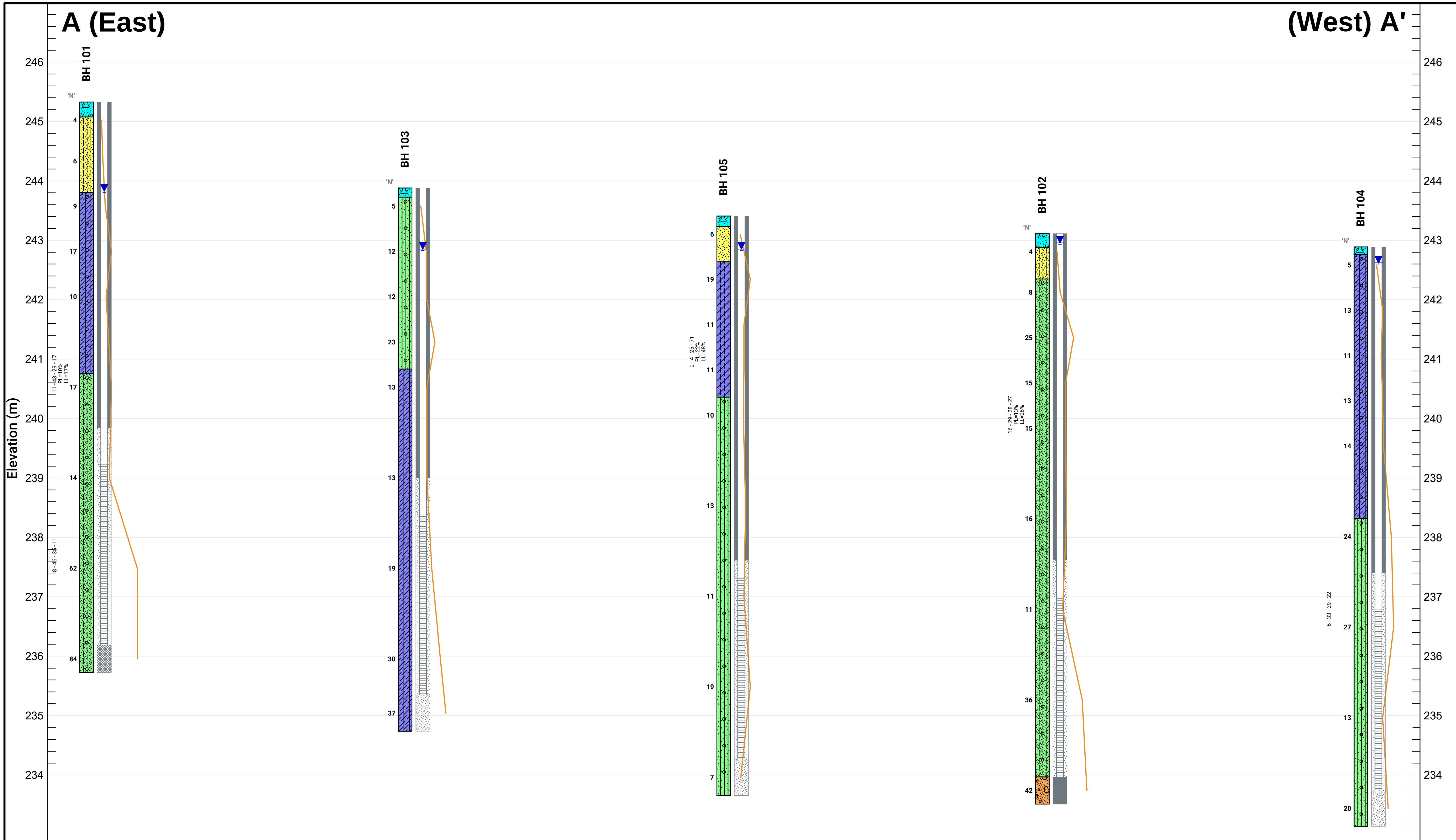
0m 15m 30m

Job No

20-295

Figure No

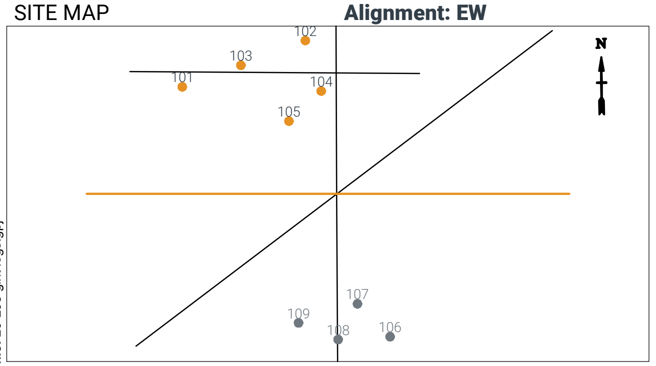
FIGURE 3



Boreholes Equally Spaced

SITE MAP

Alignment: EW



file: 20-295 gint logs.gpj

LITHOLOGY GRAPHIC LEGEND

- Topsoil
- Sand and Gravel
- Silty Clay
- Silty Sand
- Sandy Silt Till
- Clayey Silt Till
- Clayey Silt
- Silty Sand Till
- Sand

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LEGEND

- FILL
- GRAVELS (gravel to gravelly sand)
- SILT TO SAND (not till)
- COHESIONLESS TILLS
- COHESIVE SOILS (clayey silt to clay, incl. tills)
- DISTURBED/REWORKED SOILS

- water level, unstabilized
- water level, stabilized

Project

Figure Title
SUBSURFACE CROSS-SECTION
EW

Date
FEBRUARY 2022

Scale
AS INDICATED

Job No
20-295

Figure No
FIGURE 4

APPENDIX A

BOREHOLE LOG TERMINOLOGY

GROUNDED ENGINEERING

SAMPLING/TESTING METHODS

SS: split spoon sample

AS: auger sample

GS: grab sample

FV: shear vane

DP: direct push

PMT: pressuremeter test

ST: shelby tube

CORE: soil coring

RUN: rock coring

SYMBOLS & ABBREVIATIONS

MC: moisture content

LL: liquid limit

PL: plastic limit

PI: plasticity index

γ: soil unit weight (bulk)

G_s: specific gravity

S_u: undrained shear strength

▽ unstabilized water level

▼ 1st water level measurement

▼ 2nd water level measurement most recent

▼ water level measurement

ENVIRONMENTAL SAMPLES

M&I: metals and inorganic parameters

PAH: polycyclic aromatic hydrocarbon

PCB: polychlorinated biphenyl

VOC: volatile organic compound

PHC: petroleum hydrocarbon

BTEX: benzene, toluene, ethylbenzene and xylene

PPM: parts per million

FIELD MOISTURE (based on tactile inspection)

DRY: no observable pore water

MOIST: inferred pore water, not observable (i.e. grey, cool, etc.)

WET: visible pore water

COHESIONLESS

Relative Density	N-Value
Very Loose	<4
Loose	4 - 10
Compact	10 - 30
Dense	30 - 50
Very Dense	>50

COHESIVE

Consistency	N-Value	Su (kPa)
Very Soft	<2	<12
Soft	2 - 4	12 - 25
Firm	4 - 8	25 - 50
Stiff	8 - 15	50 - 100
Very Stiff	15 - 30	100 - 200
Hard	>30	>200

COMPOSITION

Term	% by weight
trace silt	<10
some silt	10 - 20
silt***y***	20 - 35
sand ***and*** silt	>35

ASTM STANDARDS

ASTM D1586 Standard Penetration Test (SPT)
Driving a 51 mm O.D. split-barrel sampler ("split spoon") into soil with a 63.5 kg weight free falling 760 mm. The blows required to drive the split spoon 300 mm ("bpf") after an initial penetration of 150 mm is referred to as the N-Value.

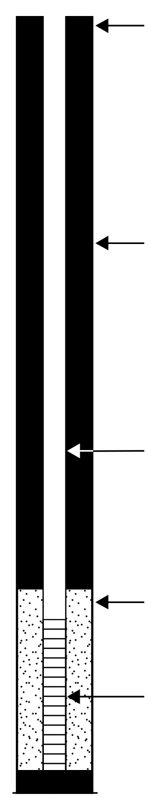
ASTM D3441 Cone Penetration Test (CPT)
Pushing an internal still rod with a outer hollow rod ("sleeve") tipped with a cone with an apex angle of 60° and a cross-sectional area of 1000 mm² into soil. The resistance is measured in the sleeve and at the tip to determine the skin friction and the tip resistance.

ASTM D2573 Field Vane Test (FVT)
Pushing a four blade vane into soil and rotating it from the surface to determine the torque required to shear a cylindrical surface with the vane. The torque is converted to the shear strength of the soil using a limit equilibrium analysis.

ASTM D1587 Shelby Tubes (ST)
Pushing a thin-walled metal tube into the in-situ soil at the bottom of a borehole, removing the tube and sealing the ends to prevent soil movement or changes in moisture content for the purposes of extracting a relatively undisturbed sample.

ASTM D4719 Pressuremeter Test (PMT)
Place an inflatable cylindrical probe into a pre-drilled hole and expanding it while measuring the change in volume and pressure in the probe. It is inflated under either equal pressure increments or equal volume increments. This provides the stress-strain response of the soil.

WELL LEGEND



GROUNDED ENGINEERING

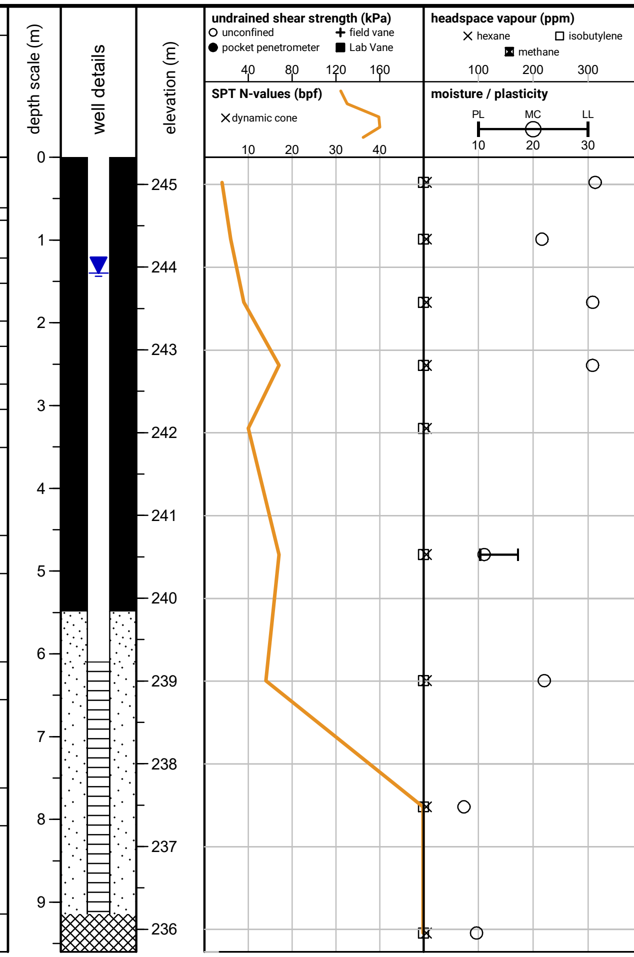
Date Started : Mar 29, 2021
Position : E: 606771, N: 4911332 (UTM 17T)
Elev. Datum : Geodetic

BOREHOLE LOG 101

File No. : 20-295 **Project** : Loon Lands, Barrie, ON **Client** : Loon Avenue Lands OP Inc.

drill method : *Big Beaver* — solid stem augers OD=150 mm

elev depth (m)	description	number	type	SPT N-value
245.3	**GROUND SURFACE**			
	250mm **TOPSOIL**	1	SS	4
	SILTY SAND, some clay, trace gravel, trace rootlets, loose, dark brown, moist ...at 0.8 m, orange-brown, trace clay	2	SS	6
243.8 1.5	**CLAYEY SILT**, trace sand, trace gravel, stiff to very stiff, brown, moist (GLACIAL TILL)	3	SS	9
		4	SS	17
	...at 3.0 m, grey	5	SS	10
240.7 4.6	**SILTY SAND**, some clay, some gravel, compact, grey, moist (GLACIAL TILL)	6	SS	17
		7	SS	14
	...at 7.6 m, sand and silt, some clay, trace gravel, very dense	8	SS	62
235.7 9.6	...at 9.1 m, some gravel	9	SS	84



lab data and comments — grain size distribution (%) (MIT)

Sample	GR	SA	SI	CL
6	11	43	29	17
8	8	46	35	11

9.1m: Maximum drill depth reached, equipment limitations

END OF BOREHOLE

Unstabilized water level measured at 0.2 m below ground surface upon completion of drilling.

25 mm dia. monitoring well installed.
No. 10 screen

GROUNDWATER LEVELS

date	depth (m)	elevation (m)
Apr 1, 2021	1.4	243.9
Jun 7, 2021	2.0	243.3
Jul 25, 2021	1.5	243.8
Sep 10, 2021	1.9	243.4
Nov 11, 2021	1.5	243.8
Dec 29, 2021	1.2	244.1
Jan 28, 2022	1.4	243.9

file: 20-295 gint logs.gpj

 Tech : MC | **PM** : KM | **Rev** : MD

GROUNDED ENGINEERING

Date Started : Mar 30, 2021
Position : E: 606912, N: 4911385 (UTM 17T)
Elev. Datum : Geodetic

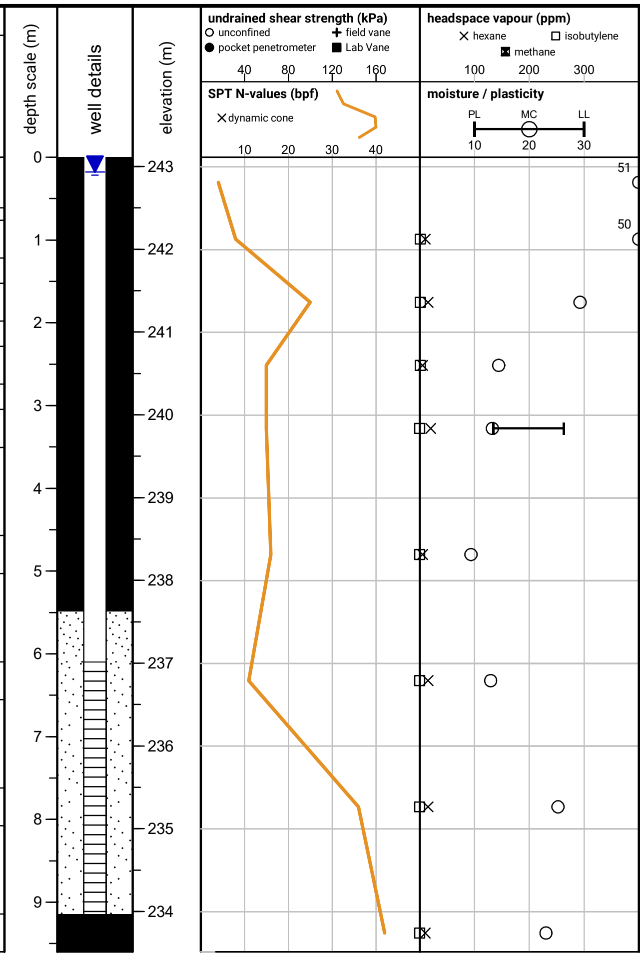
BOREHOLE LOG 102

File No. : 20-295 **Project** : Loon Lands, Barrie, ON **Client** : Loon Avenue Lands OP Inc.

drill method : *Big Beaver* — solid stem augers OD=150 mm

stratigraphy

elev / depth (m)	description	sample number	type	SPT N-value
243.1	**GROUND SURFACE**			
	230mm **TOPSOIL**	1	SS	4
242.3 / 0.8	**SILTY SAND**, some clay, trace gravel, trace rootlets, loose, brown, moist			
	SILTY SAND, clayey, trace gravel, loose to compact, brown, moist (GLACIAL TILL)	2	SS	8
		3	SS	25
	...at 2.3 m, grey	4	SS	15
	...at 3.0 m, some gravel, very stiff	5	SS	15
		6	SS	16
	...at 6.1 m, wet	7	SS	11
	...at 7.6 m, dense	8	SS	36
234.0 / 9.1	**COARSE SAND and GRAVEL**, trace silt, trace rock fragments, (cobbles inferred), very dense, grey, wet	9	SS	42
233.5 / 9.6				



lab data and comments

grain size distribution (%) (MIT)

depth (m)	GR	SA	SI	CL
3.0	16	29	28	27

9.1m: Maximum drill depth reached, equipment limitations

END OF BOREHOLE

Unstabilized water level measured at 0.2 m below ground surface upon completion of drilling.

25 mm dia. monitoring well installed.
No. 10 screen

GROUNDWATER LEVELS

date	depth (m)	elevation (m)
Apr 1, 2021	0.2	242.9
Jun 7, 2021	0.5	242.6
Jul 25, 2021	0.1	243.0
Sep 10, 2021	0.5	242.6
Nov 11, 2021	0.2	242.9

file: 20-295 gint logs.gpj

Tech : MC | **PM** : KM | **Rev** : MD

GROUNDED ENGINEERING

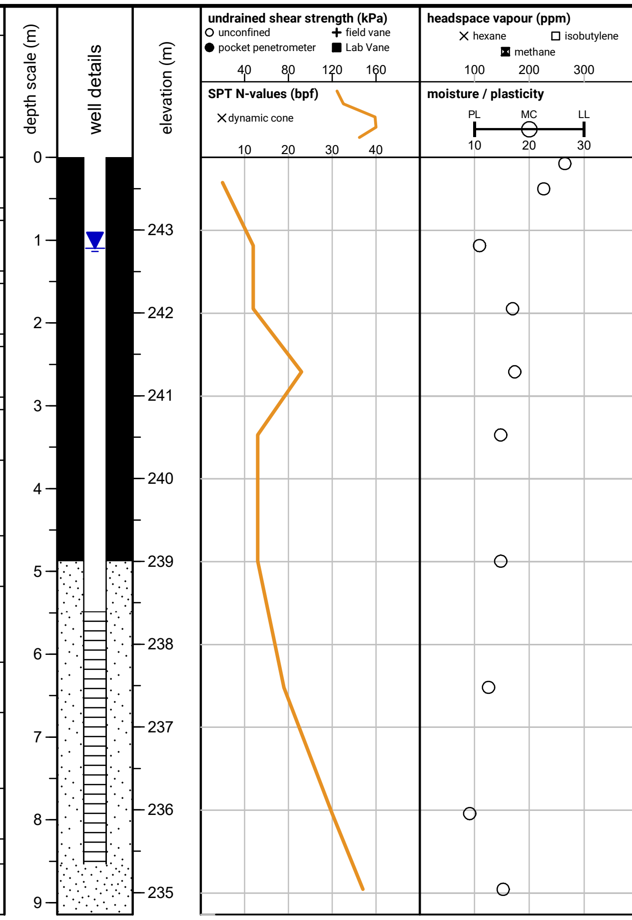
Date Started : Jun 2, 2021
Position : E: 606838, N: 4911357 (UTM 17T)
Elev. Datum : Geodetic

BOREHOLE LOG 103

File No. : 20-295 **Project** : Loon Lands, Barrie, ON **Client** : Loon Avenue Lands OP Inc.

drill method : *Big Beaver* — solid stem augers (skinny)

elev / depth (m)	description (stratigraphy)	number	type	SPT N-value
243.9	**GROUND SURFACE**			
	150mm **TOPSOIL**	1A		
	SANDY SILT, some clay, trace gravel, trace rootlets, loose to compact, brown and grey, moist (GLACIAL TILL)	1B	SS	5
		2	SS	12
	...at 1.5 m, grey	3	SS	12
		4	SS	23
240.9 / 3.0	**CLAYEY SILT**, trace sand, stiff, grey, moist	5	SS	13
		6	SS	13
	...at 6.1 m, some sand, very stiff	7	SS	19
	...at 7.6 m, hard, some gravel (glacial till inferred)	8	SS	30
		9	SS	37
234.8 / 9.1	**END OF BOREHOLE**			



lab data and comments — grain size distribution (%) (MIT) GR SA SI CL

SS2: BTEX, H-Ms, Metals, ORPs, PAHs, PCBs, PHCs, VOCs

SS4: BTEX, PHCs

8.5m: Auger grinding for 10 mins then refusal (boulder inferred)

Unstabilized water level measured at 2.4 m below ground surface upon completion of drilling.

50 mm dia. monitoring well installed.
No. 10 screen

GROUNDWATER LEVELS

date	depth (m)	elevation (m)
Jun 3, 2021	1.3	242.6
Jun 7, 2021	1.4	242.5
Jul 25, 2021	1.1	242.8
Sep 10, 2021	1.4	242.5
Nov 11, 2021	1.1	242.8
Dec 29, 2021	0.8	243.1
Jan 28, 2022	1.1	242.8

file: 20-295 gint logs.gpj

 Tech : DI | **PM** : KM | **Rev** : MD

GROUNDED ENGINEERING

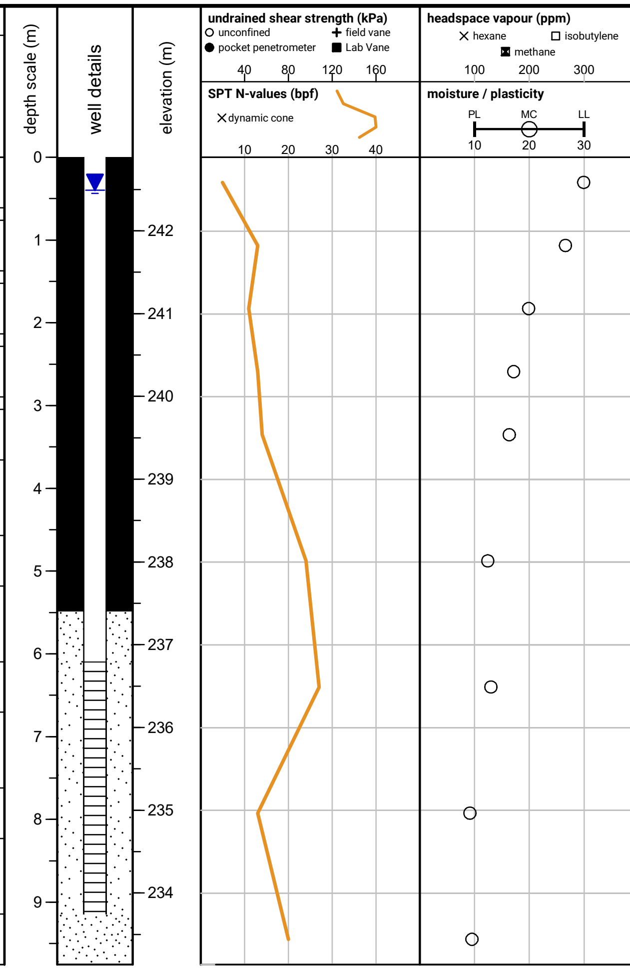
Date Started : May 31, 2021
Position : E: 606929, N: 4911327 (UTM 17T)
Elev. Datum : Geodetic

BOREHOLE LOG 104

File No. : 20-295 | **Project** : Loon Lands, Barrie, ON | **Client** : Loon Avenue Lands OP Inc.

drill method : *Big Beaver* — solid stem augers (skinny)

elev depth (m)	stratigraphy description	sample number	type	SPT N-value
242.9	**GROUND SURFACE**			
	125mm **TOPSOIL**	1	SS	5
	CLAYEY SILT, trace sand, trace gravel, firm to stiff, brown, wet (GLACIAL TILL)	2	SS	13
		3	SS	11
	...at 2.3 m, grey	4	SS	13
		5	SS	14
238.3 / 4.6	**SANDY SILT**, clayey, trace gravel, compact, grey, moist (GLACIAL TILL)	6	SS	24
		7	SS	27
	...at 7.6 m, wet	8	SS	13
		9	SS	20
233.1 / 9.8				



lab data and comments

grain size distribution (%) (MIT)

GR	SA	SI	CL
6	33	39	22

9.1m: Maximum drill depth reached, equipment limitations

END OF BOREHOLE

Unstabilized water level measured at 0.9 m below ground surface upon completion of drilling.

50 mm dia. monitoring well installed.
No. 10 screen

GROUNDWATER LEVELS

date	depth (m)	elevation (m)
Jun 3, 2021	1.3	241.6
Jun 7, 2021	1.1	241.8
Jul 25, 2021	0.4	242.5
Sep 10, 2021	0.6	242.3
Nov 11, 2021	0.3	242.6
Dec 29, 2021	0.1	242.8
Jan 28, 2022	0.4	242.5

file: 20-295 gint logs.gpj

Tech : DI | **PM** : KM | **Rev** : MD

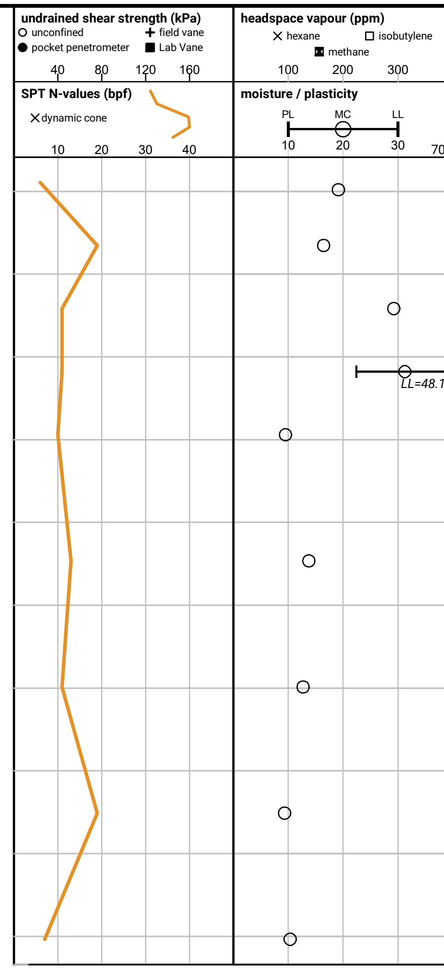
Date Started : Jun 1, 2021
Position : E: 606892, N: 4911293 (UTM 17T)
Elev. Datum : Geodetic

BOREHOLE LOG 105

File No. : 20-295 **Project** : Loon Lands, Barrie, ON **Client** : Loon Avenue Lands OP Inc.

drill method : Big Beaver — solid stem augers (skinny)

elev depth (m)	description (stratigraphy)	sample number	type	SPT N-value
243.4	**GROUND SURFACE**			
	175mm **TOPSOIL**	1A		
	SAND, some silt, trace clay, trace gravel, trace rootlets, loose, orange - brown, moist	1B	SS	6
242.6 / 0.8	**SILTY CLAY**, trace sand, stiff to very stiff, brown and grey, moist	2	SS	19
	...at 1.5 m, wet	3	SS	11
	...at 2.3 m, grey	4	SS	11
240.4 / 3.0	**SANDY SILT**, clayey, trace gravel, compact, grey, moist (GLACIAL TILL)	5	SS	10
		6	SS	13
		7	SS	11
		8	SS	19
	...at 9.1 m, loose, wet	9	SS	7
233.6 / 9.8	**END OF BOREHOLE**			



lab data and comments — grain size distribution (%) (MIT): GR 0, SA 4, SI 25, CL 71

9.1m: Maximum drill depth reached, equipment limitations

Unstabilized water level measured at 2.1 m below ground surface upon completion of drilling.

50 mm dia. monitoring well installed.
No. 10 screen

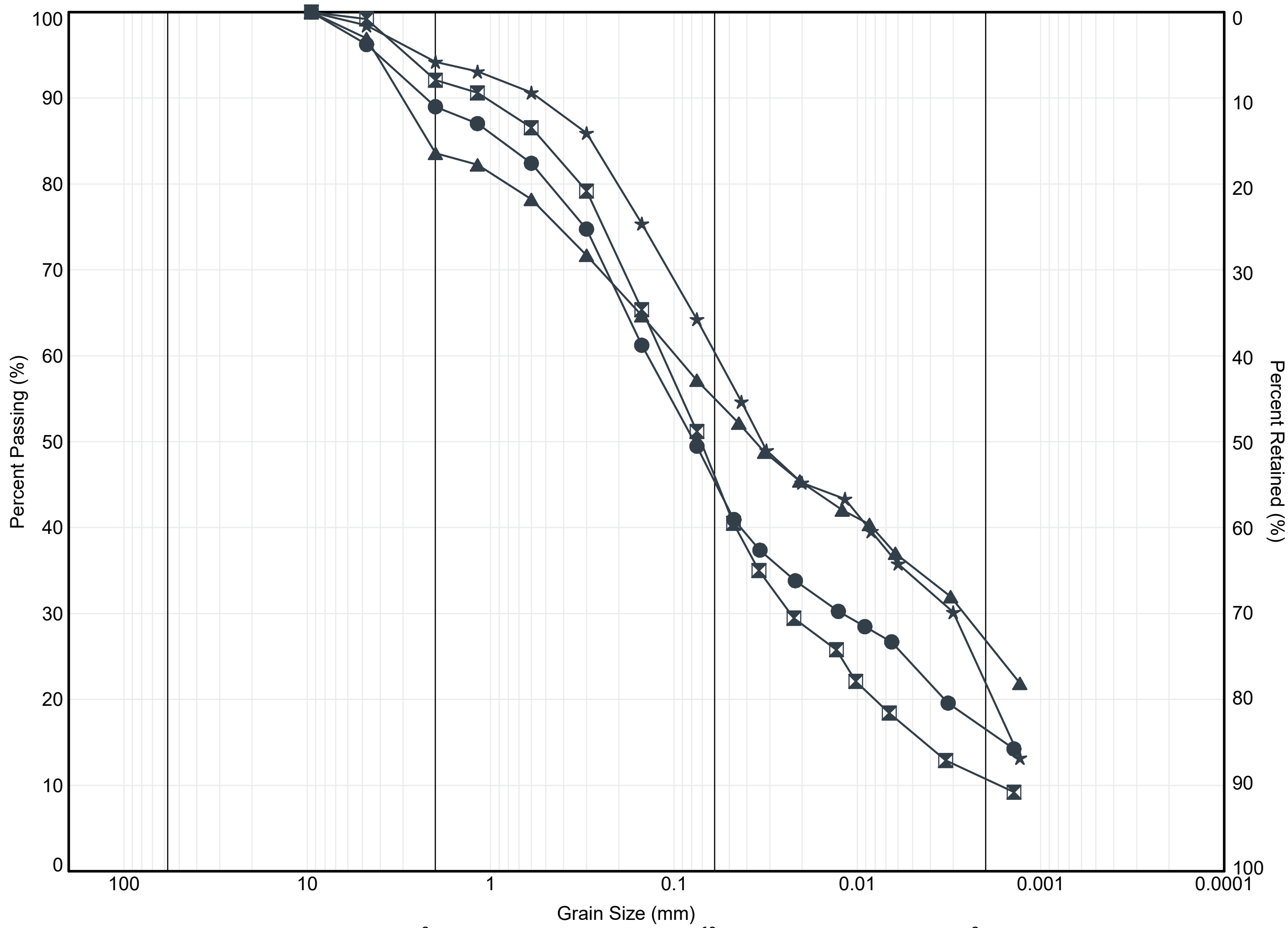
GROUNDWATER LEVELS

date	depth (m)	elevation (m)
Jun 3, 2021	2.9	240.5
Jun 7, 2021	1.7	241.7
Jul 25, 2021	0.7	242.7
Sep 10, 2021	0.9	242.5
Nov 11, 2021	0.6	242.8
Dec 29, 2021	0.3	243.1
Jan 28, 2022	0.6	242.8

file: 20-295 gint logs.gpj

 Tech : DI | **PM** : KM | **Rev** : MD

APPENDIX B



MIT SYSTEM	COBBLES	GRAVEL			SAND			SILT	CLAY
		COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE		

MIT SYSTEM

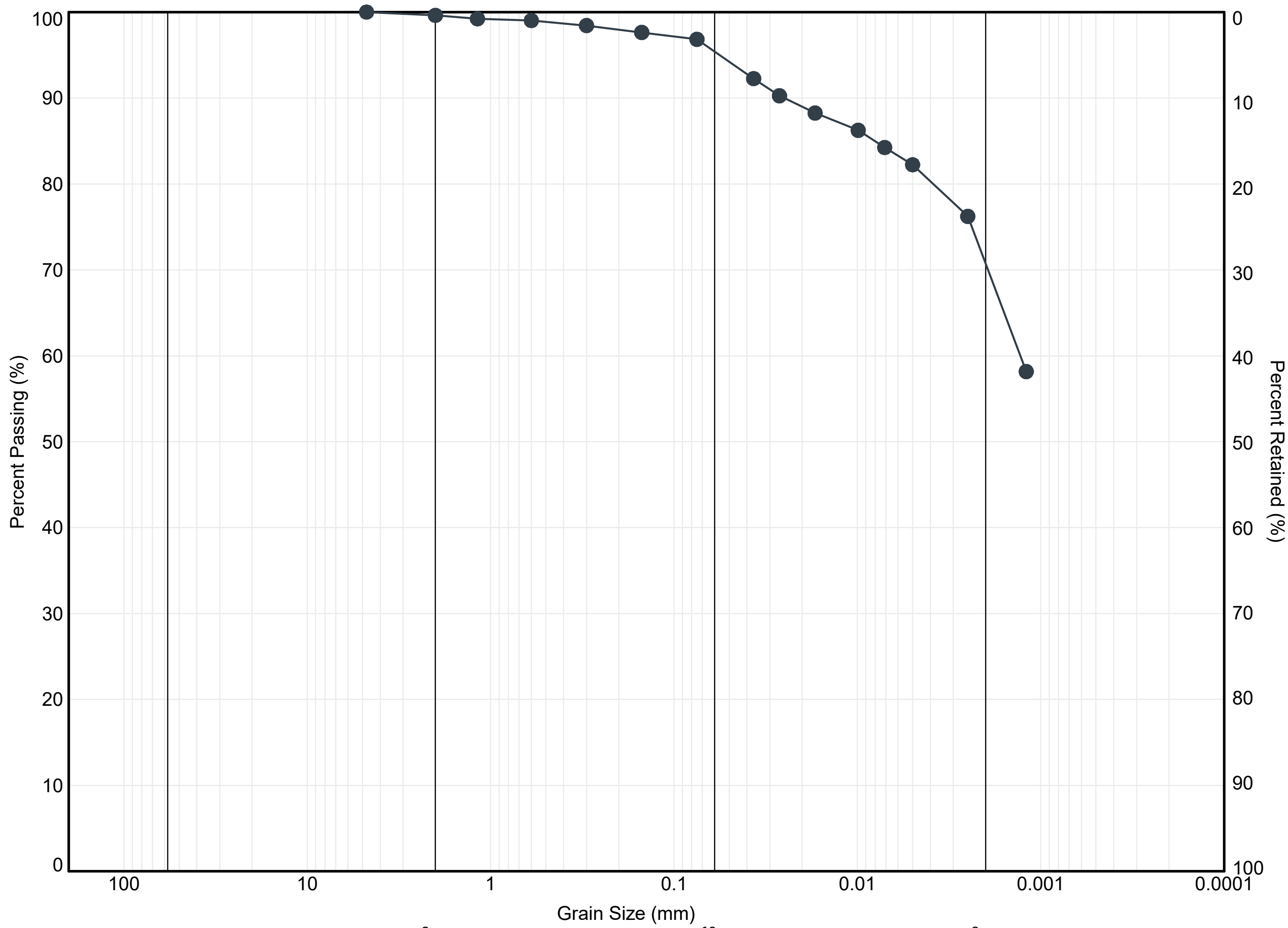
	Borehole	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
●	**101**	SS6	4.8	240.5	11	43	29	17
⊠	**101**	SS8	7.8	237.5	8	46	35	11
▲	**102**	SS5	3.3	239.8	16	29	28	27
★	**104**	SS7	6.4	236.5	6	33	39	22

GROUNDED ENGINEERING

Title: **GRAIN SIZE DISTRIBUTION**

File No.: **20-295**

file: 20-295 gint logs.gpj



MIT SYSTEM	COBBLES	GRAVEL			SAND			SILT	CLAY
		COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE		

MIT SYSTEM

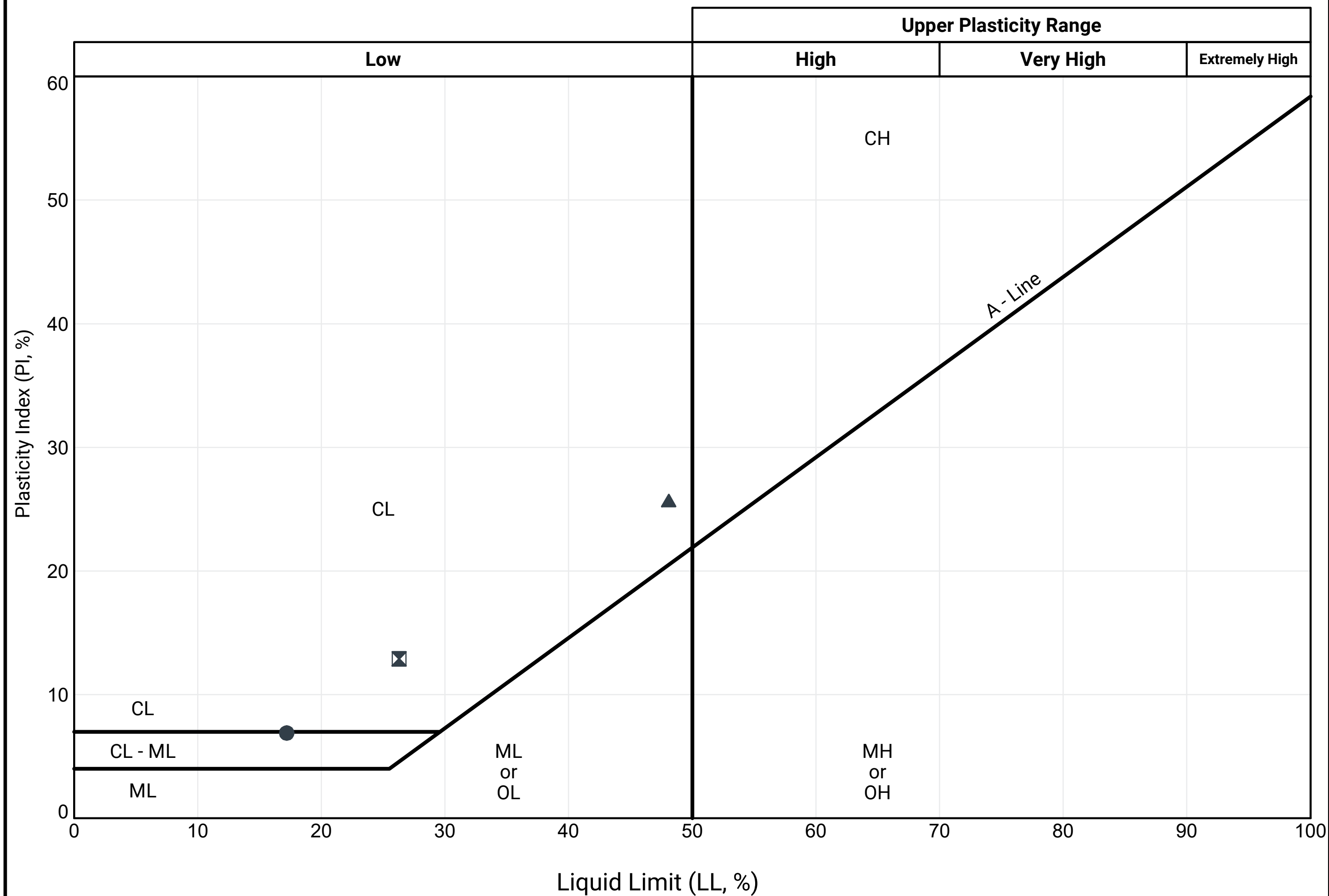
	Borehole	Sample	Depth (m)	Elev. (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
●	**105**	SS4	2.6	240.8	0	4	25	71

GROUNDED ENGINEERING

Title: **GRAIN SIZE DISTRIBUTION**

File No.: **20-295**

file: 20-295 gint logs.gpj



	Borehole	Sample	Depth (m)	Elev. (m)	LL (%)	PL (%)	PI (%)
●	**101**	SS6	4.8	240.5	17	10	7
⊠	**102**	SS5	3.3	239.8	26	13	13
▲	**105**	SS4	2.6	240.8	48	22	26

GROUNDED ENGINEERING

Title: **ATTERBERG LIMITS CHART**

File No.: **20-295**

APPENDIX C

Your Project #: 20-295
Site Location: LOON LANDS, BARRIE
Your C.O.C. #: 813865-01-02, 813865-01-01

Attention: Katrina Morgenroth

Grounded Engineering Inc.
12 Banigan Drive
Toronto, ON
CANADA M4H 1E9

Report Date: 2021/06/15
Report #: R6677091
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1F3569
Received: 2021/06/04, 18:08

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	3	2021/06/10	2021/06/10	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	3	2021/06/10	2021/06/10	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 3)	3	N/A	2021/06/11	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	3	N/A	2021/06/12	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	3	2021/06/10	2021/06/10	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2021/06/05	2021/06/10	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	3	2021/06/10	2021/06/10	CAM SOP-00464	EPA 375.4 m
Redox Potential (2, 4)	3	N/A	N/A		

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Bureau Veritas Calgary via Mississauga
(2) This test was performed by Sub from Campo to Env. Testing Canada (Eurofins)
(3) Offsite analysis requires that subcontracted moisture be reported.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

Your Project #: 20-295
Site Location: LOON LANDS, BARRIE
Your C.O.C. #: 813865-01-02, 813865-01-01

Attention: Katrina Morgenroth

Grounded Engineering Inc.
12 Banigan Drive
Toronto, ON
CANADA M4H 1E9

Report Date: 2021/06/15
Report #: R6677091
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1F3569
Received: 2021/06/04, 18:08

(4) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode.

Encryption Key

Marijane Cruz
Senior Project Manager
15 Jun 2021 16:43:51

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Marijane Cruz, Senior Project Manager
Email: Marijane.Cruz@bureauveritas.com
Phone# (905)817-5756
==
BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

BV Labs Job #: C1F3569
Report Date: 2021/06/15

Grounded Engineering Inc.
Client Project #: 20-295
Site Location: LOON LANDS, BARRIE
Sampler Initials: KM

SOIL CORROSIVITY PACKAGE (SOIL)

BV Labs ID		PTI346	PTI347			PTI347			PTI348		
Sampling Date		2021/06/04 08:00	2021/06/04 08:00			2021/06/04 08:00			2021/06/04 08:00		
COC Number		813865-01-01	813865-01-01			813865-01-01			813865-01-01		
	UNITS	**BH103 SS5**	**BH104 SS2**	**RDL**	**QC Batch**	**BH104 SS2 Lab-Dup**	**RDL**	**QC Batch**	**BH105 SS3**	**RDL**	**QC Batch**
Calculated Parameters											
Resistivity	ohm-cm	7200	6100		7391559				7100		7391559
Inorganics											
Soluble (20:1) Chloride (Cl-)	ug/g	20	<20	20	7400010	22	20	7400010	34	20	7400010
Conductivity	umho/cm	139	163	2	7400062				142	2	7400062
Available (CaCl2) pH	pH	8.07	7.66		7399987				7.74		7399987
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	20	7400014				<20	20	7400014
Sulphide	mg/kg	2.6	2.5	0.5	7408480				2.6	0.5	7408480
Physical Testing											
Moisture-Subcontracted	%	14	23	0.30	7406216				21	0.30	7406216

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

BV Labs Job #: C1F3569
Report Date: 2021/06/15

Grounded Engineering Inc.
Client Project #: 20-295
Site Location: LOON LANDS, BARRIE
Sampler Initials: KM

TEST SUMMARY

BV Labs ID: PTI346
Sample ID: BH103 SS5
Matrix: Soil

Collected: 2021/06/04
Shipped:
Received: 2021/06/04

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7400010	2021/06/10	2021/06/10	Alina Dobreanu
Conductivity	AT	7400062	2021/06/10	2021/06/10	Khushbu Vijay kumar Patel
Moisture (Subcontracted)	BAL	7406216	N/A	2021/06/11	Parveer Singh
Sulphide in Soil	SPEC	7408480	N/A	2021/06/12	Bailey Morrison
pH CaCl2 EXTRACT	AT	7399987	2021/06/10	2021/06/10	Neil Dassanayake
Resistivity of Soil		7391559	2021/06/10	2021/06/10	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7400014	2021/06/10	2021/06/10	Avneet Kour Sudan
Redox Potential	COND	7408892	2021/06/15		Marijane Cruz

BV Labs ID: PTI347
Sample ID: BH104 SS2
Matrix: Soil

Collected: 2021/06/04
Shipped:
Received: 2021/06/04

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7400010	2021/06/10	2021/06/10	Alina Dobreanu
Conductivity	AT	7400062	2021/06/10	2021/06/10	Khushbu Vijay kumar Patel
Moisture (Subcontracted)	BAL	7406216	N/A	2021/06/11	Parveer Singh
Sulphide in Soil	SPEC	7408480	N/A	2021/06/12	Bailey Morrison
pH CaCl2 EXTRACT	AT	7399987	2021/06/10	2021/06/10	Neil Dassanayake
Resistivity of Soil		7391559	2021/06/10	2021/06/10	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7400014	2021/06/10	2021/06/10	Avneet Kour Sudan
Redox Potential	COND	7408892	2021/06/15		Marijane Cruz

BV Labs ID: PTI347 Dup
Sample ID: BH104 SS2
Matrix: Soil

Collected: 2021/06/04
Shipped:
Received: 2021/06/04

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7400010	2021/06/10	2021/06/10	Alina Dobreanu

BV Labs ID: PTI348
Sample ID: BH105 SS3
Matrix: Soil

Collected: 2021/06/04
Shipped:
Received: 2021/06/04

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7400010	2021/06/10	2021/06/10	Alina Dobreanu
Conductivity	AT	7400062	2021/06/10	2021/06/10	Khushbu Vijay kumar Patel
Moisture (Subcontracted)	BAL	7406216	N/A	2021/06/11	Parveer Singh
Sulphide in Soil	SPEC	7408480	N/A	2021/06/12	Bailey Morrison
pH CaCl2 EXTRACT	AT	7399987	2021/06/10	2021/06/10	Neil Dassanayake
Resistivity of Soil		7391559	2021/06/10	2021/06/10	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7400014	2021/06/10	2021/06/10	Avneet Kour Sudan
Redox Potential	COND	7408892	2021/06/15		Marijane Cruz

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

Microbiology testing is conducted at 6660 Campobello Rd. Chemistry testing is conducted at 6740 Campobello Rd.

GENERAL COMMENTS

Results relate only to the items tested.

Bureau Veritas Laboratories 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.bvlabs.com

BV Labs Job #: C1F3569
Report Date: 2021/06/15

QUALITY ASSURANCE REPORT

Grounded Engineering Inc.
Client Project #: 20-295
Site Location: LOON LANDS, BARRIE
Sampler Initials: KM

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7399987	Available (CaCl2) pH	2021/06/10			100	97 - 103			0.22	N/A
7400010	Soluble (20:1) Chloride (Cl-)	2021/06/10	111	70 - 130	105	70 - 130	<20	ug/g	11	35
7400014	Soluble (20:1) Sulphate (SO4)	2021/06/10	NC	70 - 130	108	70 - 130	<20	ug/g	13	35
7400062	Conductivity	2021/06/10			99	90 - 110	<2	umho/cm	0.20	10
7406216	Moisture-Subcontracted	2021/06/11					<0.30	%	5.2	20
7408480	Sulphide	2021/06/12	77	75 - 125	84	75 - 125	<0.5	mg/kg	NC	30

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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BV Labs Job #: C1F3569
Report Date: 2021/06/15

Grounded Engineering Inc.
Client Project #: 20-295
Site Location: LOON LANDS, BARRIE
Sampler Initials: KM

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Anastassia Hamanov, Scientific Specialist

Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Marijane Cruz, Senior Project Manager

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Bureau Veritas Laboratories
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CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:	REPORT TO:	PROJECT INFORMATION:	Laboratory Use Only:
Company Name: #36876 Grounded Engineering Inc.	Company Name:	Quotation #: C04975	BV Labs Job #: / Bottle Order #: 813865
Attention: ~~James Rybicki~~ Katrina Morgenroth	Attention: ~~James Rybicki~~ Katrina Morgenroth	P.O. #:	
Address: 12 Banigan Drive	Address:	Project: 20-295	COC #: C#813865-01-02 / Project Manager: Marijane Cruz
Toronto ON M4H 1E9		Project Name: Loon Lands, Barrie	
Tel: Fax:	Tel: Fax:	Site #:	
Email: kmorgenroth@groundedeng.ca	Email: kmorgenroth@groundedeng.ca	Sampled By: KM	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE BV LABS DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): Table 1, Table 2, Table 3, Table ___; Res/Park, Ind/Comm, Agri/Other, Medium/Fine, Coarse, For RSC

Other Regulations: CCME, Reg 558, MISA, PWQO, Other ___; Sanitary Sewer Bylaw, Storm Sewer Bylaw, Municipality ___, Reg 406 Table ___

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ___

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required: Please provide advance notice for rush projects

Regular (Standard) TAT: (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission) Date Required: ___ Time Required: ___ Rush Confirmation Number: ___ (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	O.Reg 153 PAHs	O.Reg 153 PCBs (Water)	O.Reg 153 VOCs by HS & F1-F4	Toronto Sanitary&Storm Sewer (100-2016)	Corrosivity Suite						# of Bottles	Comments
1		BH 103 SS5	2021-06-04	8AM	Soil						X						2	
2		BH 104 SS2	2021-06-04	8AM	"						X						2	
3		BH 105 SS3	2021-06-04	8AM	"						X						2	
4																		
5																		
6																		
7																		
8																		
9																		
10																		

04-Jun-21 18:08
Marijane Cruz
C1F3569
AF2 ENV-1212

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Laboratory Use Only: Temperature (°C) on Recei	Custody Seal	Yes	No
Katrina Morgenroth	21/06/04	8AM	NAVNEETA SAVAN	21/06/04	18:08			18/20/23 — ON ICE PACKS	Present / Intact		✓

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT WWW.BVLABS.COM/RESOURCES/CHAIN-OF-CUSTODY-FORMS.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO BV LABS

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Certificate of Analysis

Environment Testing

Client:	Bureau Veritas Canada (2019) Inc 6740 Campobello Road Mississauga, ON L5N 2L8	Report Number:	1955065
		Date Submitted:	2021-06-09
		Date Reported:	2021-06-15
		Project:	C1F3569
Attention:	Ms. Marijane Cruz	COC #:	874806
PO#:			
Invoice to:	Bureau Veritas Canada (2019) Inc		

Dear Marijane Cruz:

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

Report Comments:

Addrine
Thomas
2021.06.15
11:48:30 -04'00'

APPROVAL: ______________________________
Addrine Thomas, Inorganics Supervisor

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

Eurofins Environment Testing Canada Inc. (Ottawa, Ontario) is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on the scope of accreditation. The scope is available at: http://www.cala.ca/scopes/2602.pdf.

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

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

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

Certificate of Analysis

Client:	Bureau Veritas Canada (2019) Inc 6740 Campobello Road Mississauga, ON L5N 2L8	Report Number:	1955065
		Date Submitted:	2021-06-09
		Date Reported:	2021-06-15
		Project:	C1F3569
Attention:	Ms. Marijane Cruz	COC #:	874806
PO#:			
Invoice to:	Bureau Veritas Canada (2019) Inc		

Group	Analyte	MRL	Units	Guideline	1562027	1562028	1562029
				Lab I.D.	1562027	1562028	1562029
				Sample Matrix	Soil	Soil	Soil
				Sample Type			
				Sampling Date	2021-06-04	2021-06-04	2021-06-04
				Sample I.D.	PTI346-BH103 SS5	PTI347-BH104 SS2	PTI348-BH105 SS3
Redox Potential	REDOX Potential		mV		183.6	286	252

Guideline = *** = Guideline Exceedence**

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

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

Certificate of Analysis

eurofins Environment Testing

Client:	Bureau Veritas Canada (2019) Inc 6740 Campobello Road Mississauga, ON L5N 2L8	Report Number:	1955065
Attention:	Ms. Marijane Cruz	Date Submitted:	2021-06-09
PO#:		Date Reported:	2021-06-15
Invoice to:	Bureau Veritas Canada (2019) Inc	Project:	C1F3569
		COC #:	874806

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 402569 **Analysis/Extraction Date** 2021-06-14 **Analyst** MW **Method** C SM2580B			
REDOX Potential	252 mV	100	

Guideline = *** = Guideline Exceedence**

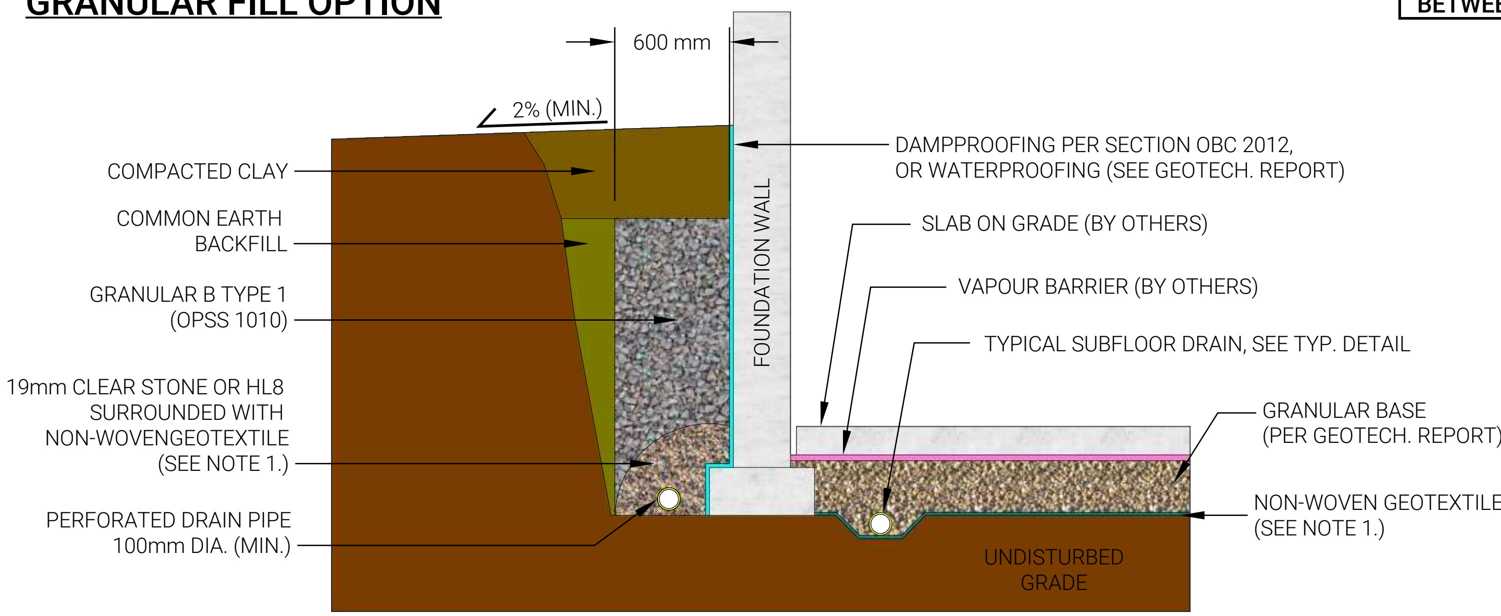
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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

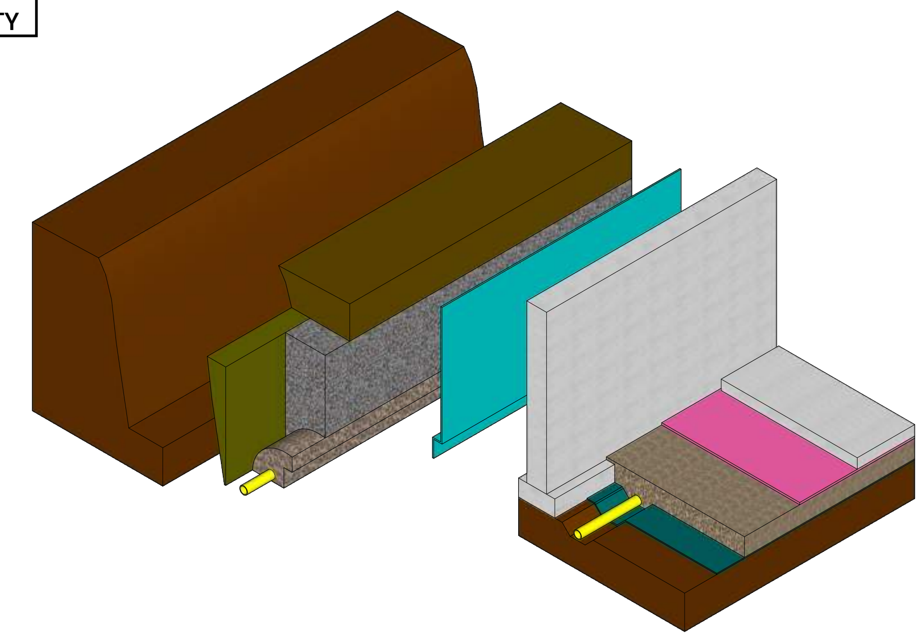
APPENDIX D

OBJECTS ARE COLOR-CODED BETWEEN TWO VIEWS FOR CLARITY

GRANULAR FILL OPTION

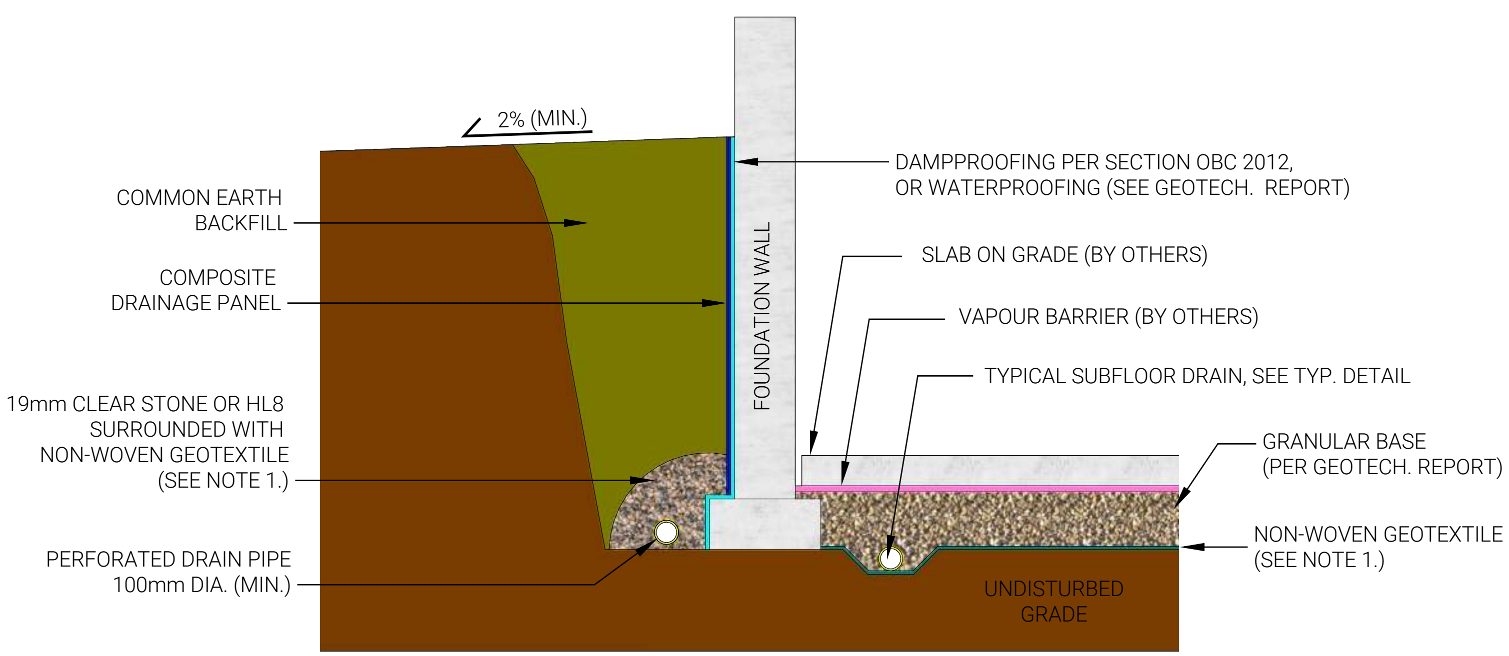


SECTIONAL VIEW

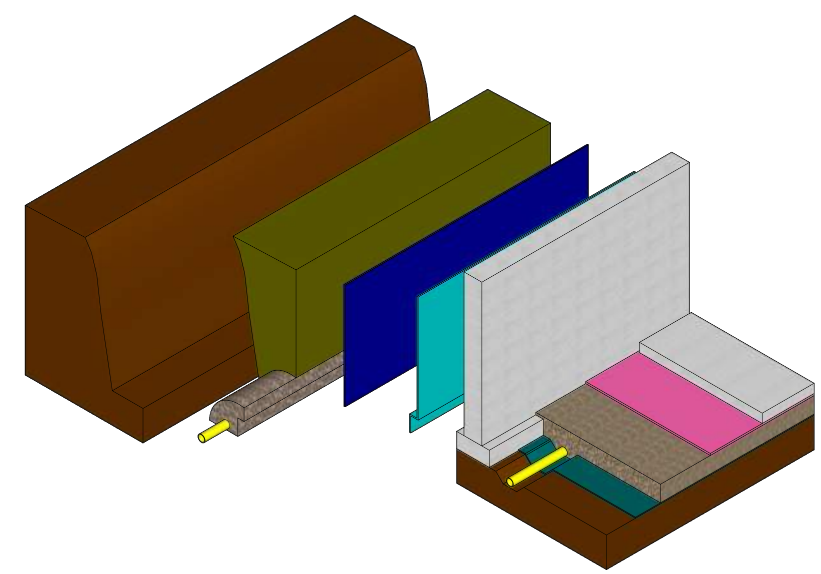


ISOMETRIC VIEW

GEO-COMPOSITE DRAINAGE PANEL OPTION



SECTIONAL VIEW



ISOMETRIC VIEW

NOTES

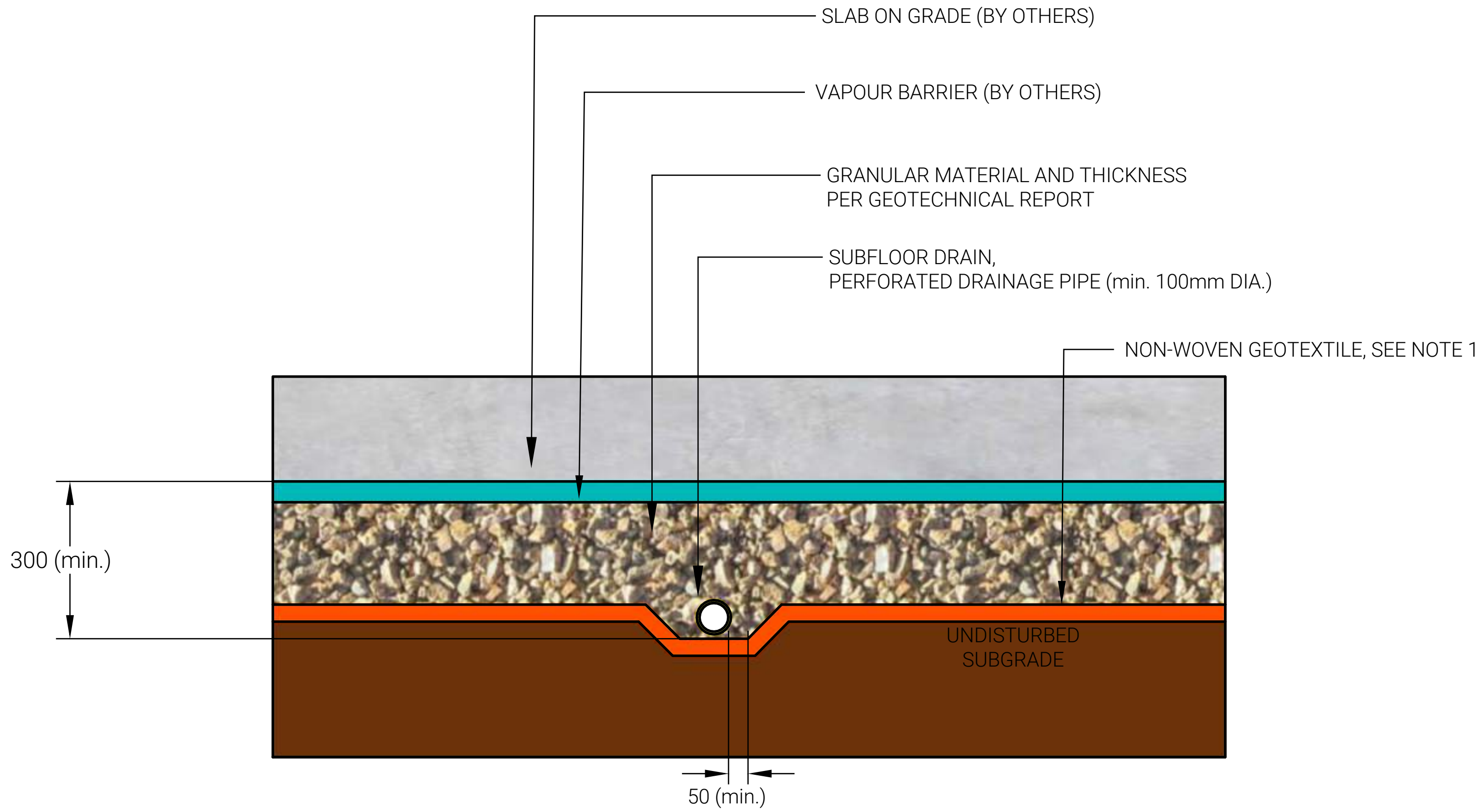
1. A NON-WOVEN GEOTEXTILE WITH AN APPARENT OPENING SIZE OF < 0.250mm AND A TEAR RESISTANCE OF > 200 N.

GROUNDED ENGINEERING

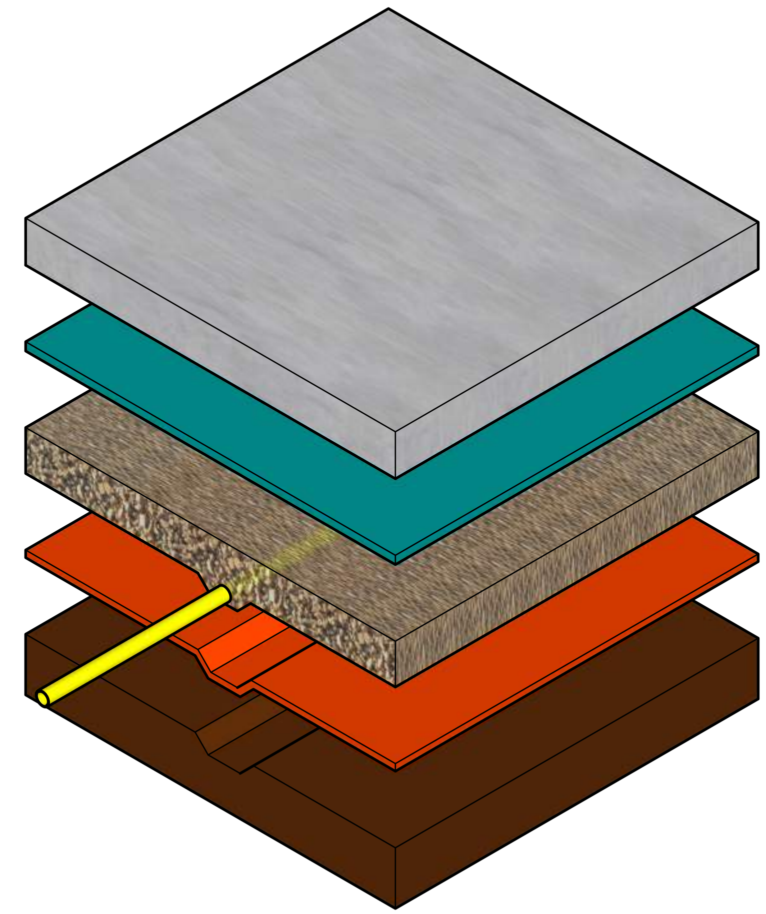
Title

BASEMENT DRAINAGE TYPICAL DETAIL

OBJECTS ARE COLOR-CODED
BETWEEN TWO VIEWS FOR CLARITY



SECTIONAL VIEW



ISOMETRIC VIEW

NOTES

1. WHEN THE SUBGRADE CONSISTS OF COHESIONLESS SOIL, IT MUST BE SEPARATED FROM THE SUBFLOOR DRAINAGE LAYER USING A NON-WOVEN GEOTEXTILE (WITH AN APPARENT OPENING SIZE OF < 0.250mm AND A TEAR RESISTANCE OF > 200 N).

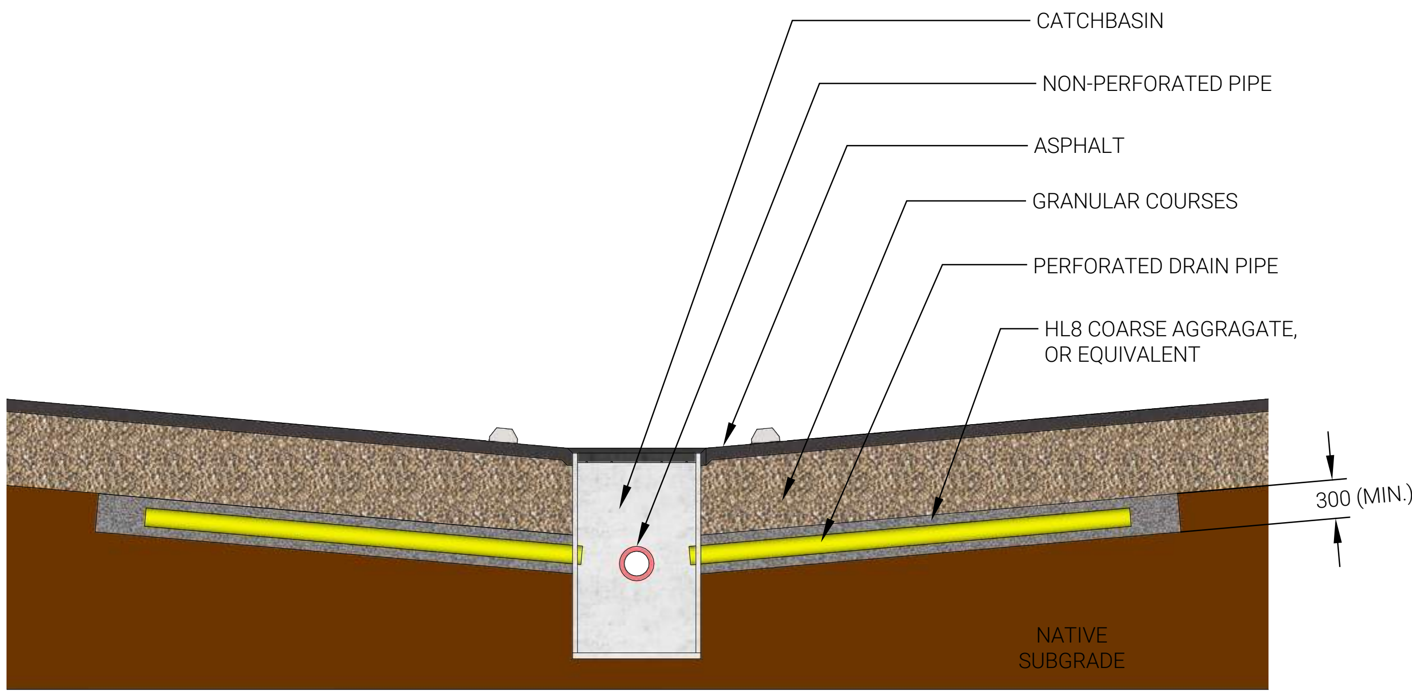
2. TYPICAL SCHEMATIC ONLY. MUST BE READ IN CONJUNCTION WITH GEOTECHNICAL REPORT.

GROUNDED ENGINEERING

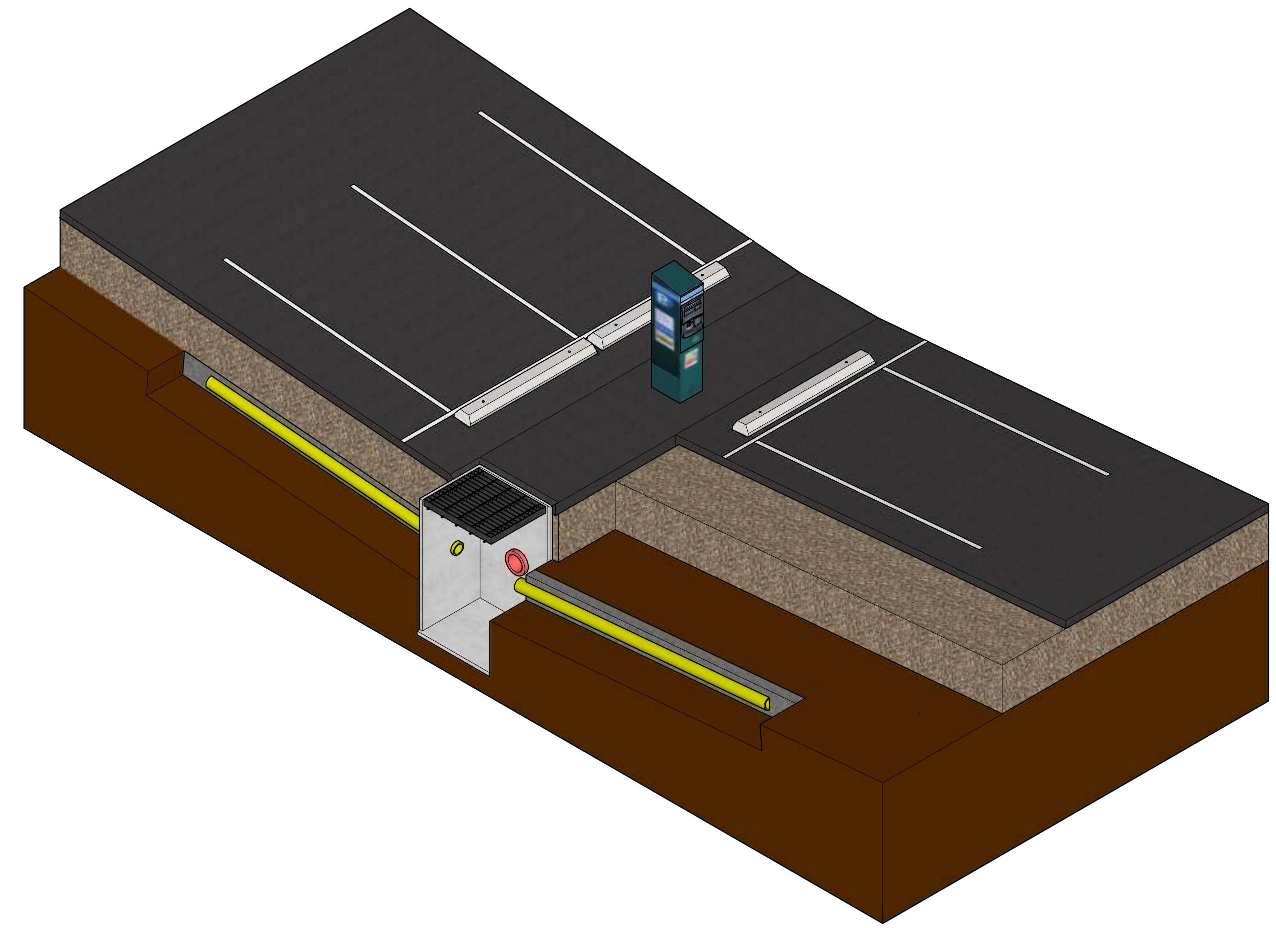
Title

BASEMENT SUBDRAIN TYPICAL DETAIL

OBJECTS ARE COLOR-CODED
BETWEEN TWO VIEWS FOR CLARITY



SECTIONAL VIEW



ISOMETRIC

GROUNDED ENGINEERING

Title

LONGITUDINAL SUBDRAIN CONNECTION TO CATCHBASIN

APPENDIX E

1 GENERAL

These specifications are suitable for use as a technical specification only, relating to the engineering aspects as discussed in Grounded's corresponding geotechnical report for the site. If this technical specification is to be used as a tender document, the geotechnical report and this technical specification must be read in conjunction with the relevant supporting tender documents, prepared by others.

This specification must be read in conjunction with Grounded's geotechnical report for the site. Wherever there is conflicting advice, Grounded's geotechnical report for the site governs.

1.1 Description

Engineered Fill refers to earthworks (earth fill) designed and constructed with engineering inspection and testing to support foundations at SLS loads for a design net geotechnical reaction.

Site preparation for Engineered Fill operations must only be conducted under the full time inspection and testing of a Third Party Testing Agency (Testing Engineer), with review by the Geotechnical Engineer, in order to ensure adequate compaction and fill quality.

Poured concrete foundation walls must be provided with nominal reinforcing steel to provide stiffening of the foundation walls and to protect against excessive crack formation within the foundation walls.

The Engineered Fill to be constructed is shown on the Design Drawings prepared by the Design Civil Engineer and as described by these specifications. The work included in this section includes the following:

1. Topsoil stripping from the ground surface below all Engineered Fill areas,
2. Test pit excavating into the subgrade to a) investigate subgrade suitability for the support of Engineered Fill and b) observe and document any prior existing fill materials,
3. Proof-rolling of the subgrade below all Engineered Fill areas, to detect the presence and extent of unstable ground conditions,
4. Excavating and removing unstable/unacceptable subgrade materials, or the implementation of other approved subgrade stabilization measures (as required) prior to the placement of Engineered Fill,
5. Surveying of ground elevations prior to placing Engineered Fill,
6. Supply, placement, and compaction of approved clean earth as specified herein, with full time inspection and testing,
7. Surveying of ground elevations on completion of Engineered Fill placement,
8. Providing and maintaining survey layout of the Engineered Fill areas, and monitoring of ground elevations throughout the construction of Engineered Fill.

1.2 The Project Parties

1. The term Contractor shall refer to the individual or firm who will be carrying out the earthworks related to preparation and construction of Engineered Fill.
2. The term Testing Engineer shall refer to the individual or firm who will be carrying out the full time inspection and testing of the earthworks related to preparation and construction of Engineered Fill.

3. The term Geotechnical Engineer shall refer to Grounded Engineering.

4. The term Design Civil Engineer shall refer to the individual or firm who will be carrying out the Site Grading Design (pre-grading), the determination of Design Foundation Grades for the structures on the site, and the choice of lots and site areas to receive Engineered Fill.

2 MATERIALS

2.1 Definitions

1. Topsoil is the layer of naturally organic soil typically found at the ground surface and commonly in the range of about 100 to 300 mm thick.

2. Earth Fill is soil material which has been placed by humans and has not been deposited by nature over a long period of time.

3. Subgrade Soil is the "in situ" (in place) native soil beneath any earth fill and/or topsoil layer(s).

4. Disturbed Soil is soil material which was originally deposited naturally but has since been disturbed or reworked in place, usually by agriculture activities. Disturbed Soil may or may not be suitable Subgrade Soil; see our Geotechnical Report.

5. Weathered Soil is soil material which is naturally deposited but weathered in place due to its exposure to the elements. Weathered Soil may or may not be suitable Subgrade Soil; see our Geotechnical Report.

6. Engineered Fill soils must consist of clean earth materials, not excessively wet, free of organics and topsoil, free of deleterious materials such as building rubble, wood, plant materials. It is placed in thin lifts of no more than 150 mm in thickness. Cohesionless soils such as sand or gravel are the easiest to place and compact.

7. All values stated in metric units shall be considered as accurate.

3 ENGINEERED FILL DESIGN

3.1 Design Foundation Pressure

1. Engineered Fill can be expected to experience post-construction settlement on the order of 1 percent of the depth of the Engineered Fill. The time (after initial placement) over which this settlement typically occurs depends on the composition of the Engineered Fill as follows:

   a) sand or gravel soil; several days
   b) silt soil; several weeks
   c) clay or clayey soil; several months.

   The placement of Engineered Fill might also result in post-construction settlement of the natural soil.

   The timing of foundation construction must consider the post-construction settlement of the Engineered Fill and the foundation soil.

2. Unless otherwise stated, the Engineered Fill is to be placed over the entire lot area or site area.

3. Engineered Fill is to extend up to at least 1 m above the highest level of required foundation support. Typically, this can be within 1 m of the design final grades. Additional common fill can be placed over the Engineered Fill to provide protection against environmental factors such as wind, frost, precipitation, and the like.

4. An allowable design foundation pressure (net geotechnical reaction at SLS for 25 mm of settlement) of 150 kPa is typically recommended for the Engineered Fill, unless it consists of glaciolacustrine silt and clay in which case a lower design foundation pressure will need to be determined on a site specific basis. Foundations shall have minimum widths of 0.8 m for continuous strip footings, and minimum dimensions of 1 m for column footings.

5. At the foundation level, sufficient Engineered Fill shall be constructed to ensure that it extends at least 1.0 m laterally beyond the edge of any foundations, and that it extends outward within an area defined by a 1 to 1 line downward from the edge of any Engineered Fill.

6. Foundations placed on the Engineered Fill must be provided with nominal reinforcing steel for stiffening of basement foundation walls and for protection against excessive minor cracking. The reinforcing steel must consist of 2-15M bars continuous at the top of the foundation wall, and 2-15M bars continuous at the bottom of the foundation walls.

7. At the time of foundation construction, foundation excavations must be reviewed by the Geotechnical Engineer to confirm suitable bearing capacity of the Engineered Fill. The Geotechnical Engineer must inspect the foundation subgrade immediately after excavation, and must inspect the foundation subgrade immediately prior to placement of concrete for footings. The Geotechnical Engineer must also inspect the placement of reinforcing steel in the foundation walls. Written approval must be obtained from the Geotechnical Engineer prior to,

   a) placement of footing concrete, and
   b) placement of foundation wall concrete.

4 CONSTRUCTION

4.1 Survey Layout

1. The survey layout shall be carried out and maintained throughout the construction of Engineered Fill activities. A suitable layout stake shall be placed at the corners of the start and finish of every block or work area to receive Engineered Fill.

2. At least two temporary survey elevation benchmarks shall be provided for every work area to receive Engineered Fill, to assist in monitoring the level of the Engineered Fill as it is constructed. Benchmark positions may need to be reviewed by Grounded if consolidation settlement is expected to influence their elevations.

3. The ground elevations of the subgrade approved for receiving Engineered Fill shall be surveyed and recorded on a regular grid pattern. Engineered Fill shall not be placed on any work area without the written approval of the Testing Engineer.

4. The ground elevations of the Engineered Fill on each work area shall be surveyed and recorded on a regular grid pattern at the end of each day during the placement of Engineered Fill.

5. On completion of Engineered Fill construction, the final ground elevations shall be surveyed and recorded on a regular grid pattern.

4.2 Topsoil Stripping

1. The Geotechnical Engineer must observe the stripping of topsoil from the areas proposed for Engineered Fill, from start to finish.

2. Topsoil must be stripped from the entire building site area. The Geotechnical Engineer must photograph the work areas which have been suitably stripped.

4.3 Test Holes Into Subgrade

1. After topsoil has been stripped, the exposed subgrade must be investigated for the presence of old buried fill or deleterious material, which may be unsuitable (as determined by the Testing Engineer or the Geotechnical Engineer) for the support of Engineered Fill.

2. Exploratory test pits must be dug using a small backhoe, on a suitable pattern, to observe an appropriate representation of the entire site area.

3. The Testing Engineer or Geotechnical Engineer must observe the digging and backfilling of the test pits; must log the test pit stratigraphy; must obtain soil samples at maximum depth intervals of 0.3m; and must photograph each dug test pit.

4. If the test pits discover any old buried fill or deleterious materials, it must be excavated and removed from the Engineering Fill area down to undisturbed, stable native soil.

5. All test pits must be properly backfilled and compacted in thin lifts (max. 150mm thickness) to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD), at the optimum water content plus or minus 2 percent. The Testing Engineer or Geotechnical Engineer must observe the backfilling and compaction of the test pits.

4.4 Subgrade Proof-rolling

1. Prior to placing any Engineered Fill, the exposed subgrade must be proofrolled under the observation of the Testing Engineer.

2. If unstable subgrade conditions are encountered, the unstable subgrade must be sub-excavated. If wet site conditions exist during filling, stabilization with granular materials may be required.

4.5 Engineered Fill Placement

1. Engineered fill must not be placed without the approval of the Testing Engineer. Prior to placing any Engineered Fill, the topsoil must be stripped, the subgrade must be investigated for old buried fill or deleterious material, the subgrade must be proof-rolled, and the subgrade elevations must be surveyed.

2. Prior to the placement of Engineered Fill, the source or borrow area for the Engineered Fill must be evaluated for its suitability both geotechnically and environmentally. Samples of the proposed fill material must be obtained and tested by the Testing Engineer. The samples must be tested in a geotechnical laboratory for Standard Proctor Maximum Dry Density. Samples must also be tested per the requirements of Ontario Regulation 406/19, prior to approval of the material for use as Engineered Fill. The results of the lab testing must be approved by the Geotechnical Engineer and the results of the environmental testing must be approved by the site Qualified Person, prior to import.

3. The Engineered Fill must be placed in maximum loose lift thicknesses of 150 mm. Each lift of Engineered Fill must be compacted with a heavy roller, to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD), at the optimum water content plus or minus 2 percent.

4. Field density tests must be taken by the Testing Engineer, on each lift of Engineered Fill, on each lot area. Any Engineered Fill which is tested and found to not meet the specifications, shall be either removed or, reworked and retested.

5. Engineered fill must not be placed during the period of the year when cold weather occurs, i.e. when there are freezing ambient temperatures during the daytime and overnight.

4.6 Certification

1. The Testing Engineer shall provide written summaries of the compaction and lab testing to the Geotechnical Engineer on a frequency of not less than every two weeks.

2. Upon Completion of the Engineered Fill placement the Testing Engineer will provide certification to the Geotechnical Engineer of General Compliance with this specification.

3. Upon receipt of the certification from the Testing Engineer, the Geotechnical Engineer will provide the owner with a Certificate of Engineered Fill