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GEOTECHNICAL REPORT

Proposed Commercial Development
441 Huronia Road
Barrie, Ontario

Prepared For: Dr. Behrooz Azizi
Type of Document: Final Report
Reference Number: 19-1243A
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1 Introduction

Central Earth Engineering Inc. (CEE) was retained by Dr. Behrooz Azizi to complete a geotechnical investigation and report for the proposed commercial development located at 441 Huronia Road, in Barrie, Ontario. A site location plan is provided as Figure 1. The existing property is approximately 0.5 hectares in size and triangular. The property is currently a vacant field and is bounded by Huronia Road to the west, an existing commercial plaza to the north and a railway to the southeast. The site is relatively flat with grades ranging from about Elev. 261 to 262 metres. CEE is completing a hydrogeological study for the site under a separate cover.

CEE was provided with the following drawing set in preparation of this report:

- *"Huronia Road Development, 441 Huronia Road, Barrie, Ontario",* by Gerrits Engineering Limited.

This drawing set indicates a 2-storey office building with no underground levels will be constructed in the northwest corner of the site, and the remaining parts of the property will be parking and driving areas. It is understood that the drawing set is preliminary and is subject to change (e.g. the building location may change, the number of storeys may be reduced, etc.). No grading plans were provided to CEE but significant grade changes are not expected. It is expected that the site will be municipally serviced.

The purpose of the geotechnical investigation was to assess the subsurface soil conditions at the site by advancing four (4) exploratory boreholes and to provide geotechnical engineering recommendations in support of the proposed commercial development. The borehole locations are shown on Figure 2. This report summarizes the borehole findings, provides design recommendations for foundations, slabs on grade, earth pressures, seismic site classification and pavements, and provides considerations for constructability such as soil excavation, compaction, and temporary groundwater control.

2 Procedures and Methodology

Prior to the commencement of drilling activities, the locations of underground utilities including natural gas, electrical, telephone, water, etc. were marked out by public and private utility locating companies. The fieldwork for the drilling program was carried out on December 12th, 2019. A total of four boreholes (Boreholes 1 to 4) were advanced on site by Drilltech Drilling using a track-mounted drill rig, continuous flight solid stem augers and standard soil sampling equipment.

All samples were collected as per ASTM D1586 to assess the strength characteristics of the substrate. The boreholes were advanced to depths of 6.5 to 9.6 metres below existing grade. The horizontal locations were laid out in the field by CEE prior to the drilling operations. Ground surface elevations of the boreholes were measured using laser level survey equipment in reference to a geodetic benchmark (Cosine Station #00119713848) with a known geodetic elevation of 261.316 metres in reference to datum CGVD2013. GPS measurements measured with a handheld GPS unit and referenced to the NAD 83. Monitoring wells were installed in Boreholes 1, 2, and 4 to facilitate long-term measurements of groundwater levels.

The CEE field staff examined and classified characteristics of the soils encountered in the boreholes, including the presence of fill materials, made groundwater observations during and upon completion of the drilling, recorded observations of borehole construction, and processed the recovered samples. Soil sampling was conducted at

regular intervals for the full depth of the borehole. The boreholes were backfilled upon completion. All recovered soil samples were logged in the field, carefully packaged and transported to the laboratory for more detailed examination and classification. In the laboratory, the samples were classified as to their visual and textural characteristics and geotechnical laboratory testing was carried out with the results included in Appendix B. Stabilized groundwater levels were measured in the three installed monitoring wells on December 20th, 2019.

3 Subsurface Conditions

3.1 General Overview

The detailed soil profiles encountered in the boreholes are indicated on the attached borehole logs in Appendix A. The borehole locations are shown on Figure 2 and geotechnical laboratory test results are included as Appendix B. It should be noted that the conditions indicated on the borehole logs are for specific locations only and can vary between and beyond the borehole locations. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones and should not be interpreted as exact planes of geological change.

In addition, the descriptions provided in the borehole logs are inferred from a variety of factors, including: visual observations of the soil samples retrieved, laboratory testing, measurements prior to and after drilling, and the drilling process itself (speed of drilling, shaking/grinding of the augers, etc.). The passage of time also may result in changes in conditions interpreted to exist at locations where sampling was conducted.

3.2 Stratigraphy

3.2.1 Topsoil and Earth Fill

Borehole 1 encountered 100 mm of topsoil at the ground surface, and Borehole 4 encountered a surficial zone of earth fill that was mixed with topsoil.

Underlying the topsoil in Borehole 1 and at the ground surface in Boreholes 2 to 4, a surficial zone of earth fill was encountered that consisted of silt and sand to silty sand with trace clay and trace gravel. The earth fill extended to depths of 1.5 to 2.3 metres below grade (Elev. 259.6 to 260.6 metres) and was brown and moist. The full depth of earth fill in Borehole 4 was mixed with topsoil and was dark brown. The Standard Penetration Test (SPT) results ("N" Values) measured in the earth fill ranged from 5 to 18 blows per 300 mm of penetration, indicating a loose to compact relative density.

3.2.2 Glacial Till

Underlying the earth fill, Borehole 2 encountered a glacial till deposit with a cohesive matrix consisting of clayey and sandy silt with trace gravel and trace organics. The clayey silt glacial till was encountered at a depth of 1.5 metres below grade (Elev. 260.6 metres) and extended to a depth of 3.1 metres (Elev. 259.1 metres). The clayey silt glacial till was dark brown and moist, and the measured Standard Penetration Test (SPT) results ("N" Values) were 3 and 9, indicating a soft to stiff consistency. The disturbed soil samples collected from the split spoon sampler were also tested using a pocket penetrometer to obtain a general sense of the undrained shear strength

of the deposit. The pocket penetrometer testing indicated that the undrained shear strength ranged from approximately 150 to 225 kPa.

Underlying the earth fill in Boreholes 1, 3, and 4, and underlying the clayey silt glacial till in Borehole 2, a glacial till deposit was encountered with a cohesionless matrix consisting of silty sand with trace to some clay and trace gravel. The silty sand glacial till was encountered at depths of 1.5 to 3.1 metres below grade (Elev. 260.5 to 259.1 metres) and extended beyond the vertical depth of investigation at 6.5 to 9.6 metres below grade (Elev. 255.3 to 251.8 metres). The silty sand glacial till was brown and moist, and the measured SPT "N" Values ranged from 11 to greater than 100 blows per 300 mm of penetration, indicating a compact to very dense (but generally very dense) relative density.

3.3 Ground Water

Unstabilized ground water level measurements and cave measurements were taken upon completion of drilling of each borehole. These measurements provide a rough estimate of the possible excavation and temporary ground water control constructability considerations that may arise. The boreholes remained open and dry. 50 mm diameter PVC monitoring wells were installed in Boreholes 1, 2, and 4 to facilitate the measurement of stabilized groundwater levels. The results are shown on the borehole logs in Appendix A and are summarized in the table below.

Monitoring Well	Well Screen Location		Strata Screened	Depth / Elevation (m) of Groundwater Table	
	Depth (m)	Elevation (m)		Dec. 12th, 2019	Dec. 20th, 2019
1	7.6 to 9.1	254.4 to 252.9	Silty Sand Glacial Till	8.2* / 253.5	5.3 / 250.6
2	7.6 to 9.1	254.6 to 253.1		Dry	
4	7.6 to 9.1	253.6 to 252.1			

*Water level measured same day as drilling and may not represent a stabilized level.

Based on the above groundwater level measurements and moisture contents of the recovered soil samples, it is expected that the groundwater table is at or below a depth of 5.3 metres below grade. The wells installed in Boreholes 2 and 4 were dry. It is possible that the well installed in Borehole 1 captured a zone of perched water within the glacial till deposit rather than the prevailing groundwater table.

The silty sand glacial till deposit is cohesionless but contains more than 30% fines and will have a relatively lower permeability that typically precludes the free flow of water when wet. Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions.

Additional groundwater considerations and data is provided in the hydrogeological study being prepared by CEE under a separate cover.

4 Engineering Design Parameters & Analysis

It is currently proposed to construct a 2-storey office building with no underground levels in the northwest corner of the site, and the remaining parts of the property will be parking and driving areas. It is understood that the proposed development plan is preliminary and is subject to change (e.g. the building location may change, the

number of storeys may be reduced, etc.). No grading plans were provided to CEE but significant grade changes are not expected. It is expected that the site will be municipally serviced.

4.1 Foundation Design

The topsoil and earth fill encountered beneath the site are not suitable for the support of new foundations. The undisturbed glacial till deposits encountered at depths of 1.5 to 2.3 metres below existing grades (Elev. 260.6 to 259.6 metres) are suitable to support new foundations.

Foundations at this site may be constructed as conventional spread and strip footing foundations that extend down to bear on the undisturbed clayey silt to silty sand glacial till at Elev. 260.6 to 259.6 metres. The foundations can be designed using a geotechnical reaction at SLS of 150 kPa, for 25 mm or less of total settlement. The factored geotechnical resistance at ULS is 225 kPa.

It is important to note that these bearing capacities are applicable for foundations set onto undisturbed glacial till that was encountered at 1.5 to 2.3 metres below existing grades. If the grade is raised prior to foundation construction, the foundations must be extended through any new grade raise in addition to the required depth to reach the competent bearing elevation.

The minimum strip and spread footing widths to be used shall be dictated as per the Ontario Building Code, regardless of loading considerations. Footings stepped from one level to another must be at a slope not exceeding 7 vertical to 10 horizontal. This concept should also be applied to excavations for new foundations in relation to existing footings or underground services unless rigid shoring is provided. All footings exposed to ambient air temperature throughout the year must be provided with a minimum of 1.2 metres of earth cover or equivalent insulation for frost protection.

The foundation design parameters provided below are predicated on the assumption that the foundation subgrade surface is undisturbed, and that all deleterious, softened, disturbed, organic, and caved material is removed. The foundation excavation must be done in such a way that groundwater is controlled to prevent any disturbance to the foundation base. Temporary groundwater control is discussed in Section 5.2.

The foundation subgrade must be reviewed by a geotechnical engineer prior to concrete placement to ensure the below foundation design parameters are applicable, and to provide remedial recommendations if necessary. If the foundation excavation will be open for a prolonged period of time, the foundation subgrade should be protected with a skim coat of lean mix concrete (after inspection by the geotechnical engineer), to ensure that no deterioration will occur due to weather effects.

4.2 Seismic Site Classification

Section 4.1.8.4 of the Ontario Building Code provides values of the acceleration and velocity-based site coefficients (F_a and F_v) for various time periods, associated with specific Site Classes. These Site Classes are based on the energy-corrected Average Standard Penetration Resistance values and undrained shear strength within the upper 30 metres of soil underlying the grade beams or foundations of the proposed structure. As the boreholes were advanced less than this depth at the site, the site classification recommendation provided below assumes that the soil conditions are similar below the drilled depth.

Underneath the proposed foundations, the soil will consist of cohesive glacial till with an undrained shear strength of greater than 150 kPa, or a generally very dense cohesionless glacial till. Based on this, the Site Classification for this site is “C”.

4.3 Earth Pressures

Underground levels, basements, retaining walls, cantilevered shoring walls and shoring walls with a single level of earth anchors all must be designed to resist unbalanced lateral earth pressures imparted from the weight of adjacent soils. Lateral earth pressures are calculated using the following equation:

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

where, **P** = the horizontal pressure at depth, **h** (m)
K = the earth pressure coefficient (dimensionless)
h = depth below surface in metres
γ = the bulk unit weight of soil, (kN/m^3)
q = surcharge loading (kPa)

The above equation assumes that a drainage system is present which prevents the build up of any hydrostatic pressure behind the structure subjected to the unbalanced lateral earth pressures. If this is not the case, the equation must be revised to also incorporate the submerged unit weight of the soil multiplied by the earth pressure coefficient, in addition to the water pressure itself.

The values for use in the design of structures subjected to unbalanced lateral earth pressures at this site are as follows:

Soil Type	γ - Bulk Unit Weight (kN/m^3)	φ - Friction Angle (degrees)	Earth Pressure Coefficient (dimensionless)		
			K_a - Active	K_o – At-Rest	K_p - Passive
Granular ‘B’ (OPSS 1010)	21.0	32	0.31	0.47	3.25
Earth Fill	19.0	30	0.33	0.50	3.00
Clayey Silt Glacial Till	21.0	32	0.31	0.47	3.25
Silty Sand Glacial Till	21.0	36	0.26	0.41	3.85

The calculation of the earth pressure coefficients is based on Rankine theory, which provides a conservative estimate as no friction between the soil and the structure is accounted for. The earth pressure coefficients provided above are only applicable for flat ground surfaces beyond the structure and must be increased for sloping ground surfaces.

The earth pressure coefficients referenced within the above table are a function of the friction angle of the adjacent soil, and both the degree and direction of movement of the structure subjected to unbalanced lateral earth pressures. For structures that are restrained at the top (such as basement walls), the at-rest earth pressure coefficient will apply. For structures that allow for 0.1 to 1% of movement away from the soil, the full active earth

pressure coefficient will apply. For structures that allow for 1 to 10% of movement into the soil, the full passive earth pressure coefficient will apply. The percentage movement is based on the height of the structure.

Other types of structures such as shoring walls with multiple rows of tiebacks and soil nail walls are subject to different loading conditions and must be analyzed separately.

4.4 Slab on Grade Design

The topsoil and earth fill encountered in Borehole 4 (containing topsoil throughout) are not suitable for the support of a slab on grade. Proof-rolled and approved earth fill free of excessive organics and neatly cut and inspected glacial till deposits are suitable for the support of a lightly loaded unreinforced concrete slab on grade.

The subgrade for the slab on grade must be assessed by the geotechnical engineer, prior to the placement of an aggregate base. If any soft or weak subgrade areas are identified, or if there are areas containing excessive amounts of moisture or deleterious/organic material, they must be locally sub-excavated and backfilled with approved clean earth fill or imported granular material and compacted to a minimum of 98% SPMDD. The modulus of subgrade reaction appropriate for design of a slab on grade on approved earth fill is 25,000 kPa/m, and the modulus of subgrade reaction appropriate for design of a slab on undisturbed glacial till is 50,000 kPa/m.

All building floor slabs must be provided with a capillary moisture barrier and drainage layer. This is made by placing the concrete slab on a minimum 200 mm layer of 19 mm clear stone (OPSS.MUNI 1004) compacted by vibration to a dense state. The upper 50 mm of clear stone can be replaced with 19 mm crusher run limestone for a working surface.

The proposed commercial building has no basement levels or other below-grade space. Perimeter and under-slab drainage at the foundation level is not required, provided that the underside of concrete slab is at least 200 mm above the prevailing grade of the site and the surrounding surfaces slope away from the building at a gradient of at least 2% to promote surface water run-off and to reduce groundwater infiltration adjacent to foundations. To minimize infiltration of surface water, the upper 150 mm of backfill could comprise relatively impervious compacted soil material.

4.5 Site Servicing

4.5.1 Bedding

The type of material and depth of granular bedding below the pipe will, to some extent, depend on the method of construction used by the contractor. Pipe bedding for flexible pipes should follow the requirements in Ontario Provincial Standard Drawing 802.010 or 802.013 or applicable municipal standards. Pipe bedding for rigid pipes should follow the requirements in Ontario Provincial Standard Drawings 802.030 to 802.033 or applicable municipal standards.

A subgrade consisting of earth fill or glacial till will provide adequate support for pipes with the bedding requirements as laid out in the above referenced OPS drawings. Where disturbance of the trench base has occurred from groundwater seepage, construction traffic, etc., the disturbed soils should be sub-excavated and replaced with suitably compacted granular fill. If weak zones are encountered, additional bedding materials and differing construction practices may be required and should be determined during construction.

Regardless of whether flexible or rigid pipes are implemented, granular bedding and cover material should consist of a well graded, free draining material, such as Granular 'A' (OPSS.MUNI 1010). All granular bedding must be compacted to a minimum of 95% SPMDD. Clear stone or high-performance bedding is permitted at this site provided it is fully wrapped in a non-woven filter fabric.

4.5.2 Backfill

Excavated native soils and earth fill may be used as backfill in trenches provided the moisture content is within 2% of optimum. The backfill should be compacted to a minimum of 95% SPMDD. Below pavement areas, the backfill should be compacted to 98% SPMDD. In confined areas the layer thickness will have to be reduced to utilize smaller compaction equipment efficiently or by using granular material instead of locally sourced fill. Any backfill that is frozen, contains a high percentage of organic material (topsoil, peat, etc.) or moisture, or has otherwise unsuitable deleterious inclusion should not be used as backfill. The maximum cobble or boulder size should not exceed half of the loose lift thickness (i.e. all particles with a diameter greater than 100 mm should be removed).

Where trenches are within the traveled portions of a roadway, backfill within the frost penetration depth of 1.2 metres should consist of native, non-organic, excavated material consistent with the soils surrounding the trench. If this technique is not undertaken, then frequently problems arise with yearly differential frost heave movements between the trench backfill and the adjacent native soil. This would occur, for example, if imported granular fill was used to backfill the trenches instead of glacial till which is more susceptible to frost effects. Alternatively, if different soil is used as the backfill due to issues with achieving compaction, a frost taper of 5H:1V can be implemented to help mitigate the potential for differential settlement and frost heave.

4.6 Pavement Design

4.6.1 Subgrade Preparation

New parking and driving areas will be constructed as part of the proposed commercial development. It is expected that subgrade soils below a pavement structure at the site will consist of earth fill. The earth fill will be an adequate subgrade for the support of a pavement structure, provided the subgrade is proof-rolled and approved by a geotechnical engineer at the time of construction and does not contain excessive amounts of organics, moisture or deleterious materials. The earth fill encountered in Borehole 4 (containing topsoil throughout) may not be a suitable subgrade for the pavement structure and will have to be assessed on site to determine if it must be sub-excavated and replaced with approved earth fill. The pavement subgrade should be compacted to a minimum of 98% SPMDD. It is anticipated that the subgrade bearing modulus will be 25,000 kPa/m.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures must be maintained to ensure that uniform subgrade moisture and density conditions are achieved as much as possible when fill is placed, and the natural subgrade is not disturbed or weakened after it is exposed.

4.6.2 Drainage

Control of surface water is an important factor in achieving a good pavement life. The need for adequate subgrade drainage cannot be over-emphasized. The subgrade must be free of depressions and sloped (at a minimum grade

of 3 percent) to provide effective drainage toward subgrade drains. Grading adjacent to pavement areas should be designed to ensure that water is not allowed to pond adjacent to the outside edges of the pavement.

Continuous pavement subdrains should be provided along the edges of the parking area and drained into respective catchbasins to facilitate drainage of the subgrade and the granular materials. The subdrain invert should be maintained at least 0.3 metres below subgrade level. To minimize the problems of differential movement between the pavement and catchbasins/manholes due to frost action, the backfill around the structures should consist of free-draining granulars. Typical pavement drainage details are included in Appendix C.

4.6.3 Pavement Structure

The industry pavement design methods are based on a design life of 15 to 20 years for typical weather conditions depending on actual traffic volumes. The following pavement thickness designs are provided on the above noted considerations and subgrade basis.

Pavement Layer	Compaction Requirements	Minimum Component Thickness	
		Light Duty	Heavy Duty
Surface Course Asphaltic Concrete: HL3 (OPSS 1150) with PG 58-28 Asphalt Cement (OPSS.MUNI 1101)	OPSS 310	40 mm	40 mm
Binder Course Asphaltic Concrete: HL8 (OPSS 1150) with PG 58-28 Asphalt Cement (OPSS.MUNI 1101)		50 mm	80 mm
Base Course: Granular A (OPSS.MUNI 1010)	100% Standard Proctor Maximum Dry Density (ASTM-D698)	150 mm	150 mm
Subbase Course: Granular B Type I or II (OPSS.MUNI 1010)		300 mm	450 mm

The granular materials should be placed in lifts 200 mm thick or less and must be compacted to a minimum of 100% SPMDD for both granular base and granular subbase. Asphalt materials should be rolled and compacted as per OPSS 310. The granular and asphalt pavement materials and their placement should conform to OPSS 310, 501, 1010 and 1150.

If the pavement construction occurs in wet, winter or inclement weather, it may be necessary to provide additional subgrade support for heavy construction traffic by increasing the thickness of the granular subbase, base or both. Further, traffic areas for construction equipment may experience unstable subgrade conditions. These areas may be stabilized utilizing additional thickness of granular materials.

It should be noted that in addition to adherence of the above pavement design recommendations, a close control on the pavement construction process will also be required in order to obtain the desired pavement life. Therefore,

it is recommended that regular inspection and testing should be conducted during the pavement construction to confirm material quality, thickness, and to ensure adequate compaction.

5 Constructability Considerations

5.1 Excavations and Temporary Groundwater Control

Excavations must be carried out in accordance with the Occupational Health and Safety Act, Ontario Regulation 213/91 (as amended), Construction Projects, Part III - Excavations, Section 222 through 242.

Where workers must enter a trench or excavation the soil must be suitably sloped and/or braced in accordance with the OHSA. These regulations designate four (4) broad classifications of soils to stipulate appropriate measures for excavation safety. The regulation stipulates safe slopes of excavation as follows based on the soils encountered at this site:

- *Type 3 Soils – All soils on site:* Trench sidewalls to be constructed no steeper than 1 horizontal to 1 vertical from the base of the excavation.

Minimum support system requirements for steeper excavations are stipulated in Sections 235 through 238 and 241 of the OHSA and include provisions for timbering, shoring and moveable trench boxes. In order to reduce the potential for instability of the trench excavations, materials excavated from the service trenches and/or other fill materials or heavy equipment should not be placed near the crest of the trench excavations.

As excavations are expected to be above the prevailing ground water table, there should be limited groundwater control issues present. During times of high precipitation, some water may collect at the base of the excavation. Local sumps placed at the base of the excavation can typically control groundwater seepage in this scenario.

It is important to note that soils encountered in the construction excavations may vary significantly across the site. Our preliminary soil classifications are based solely on the materials encountered in widely spaced boreholes advanced on site. The contractor should verify that similar conditions exist throughout the proposed area of excavation. If different subsurface conditions are encountered at the time of construction, we recommend that CEE be contacted immediately to evaluate the conditions encountered.

5.2 Compaction Specifications

Standard Proctor Maximum Dry Density (SPMDD) is the level to which a soil or aggregate is compacted. To achieve the specified SPMDD as indicated in this report, all soils or aggregates must be placed in lift thicknesses no greater than 200 mm. If this is not the case, only the upper portion of the lift will be adequately compacted, and the lower portion of the lift has a high probability of not meeting compaction specifications. In addition, industry standard equipment used to determine the degree of compaction consists of nuclear densometers. These devices have an inherent limitation in that they cannot test beyond 300 mm in depth, and so the degree of compaction beyond this depth cannot be quantitatively determined.

Along with lift thickness, ensuring that the soil or aggregate is within 2% of its optimum moisture content ensures that the specified compaction can be reached. If the soil or aggregate is too dry/wet, it is either very difficult or

impossible to reach the specified compaction. This is especially true for when higher compaction specifications such as 98% and 100% SPMDD are required.

Based on our review of the soil types encountered in the boreholes with associated moisture contents, the soils at this site are considered as follows:

- Half of in-situ soil: At or near optimum moisture content.
- One quarter of in-situ soil: Above optimum moisture content.
- One quarter of in-situ soil: Below optimum moisture content.

The zones with higher moisture content will require moisture conditioning prior to re-use in areas that require compaction. Moisture could be reduced by tilling the soil, spreading the soil out, or blending it with drier material. Soil that is dry of optimum could be blended with wetter soil or have water added prior to re-use. It must be also noted that the above percentages can change based on the time of year in which construction occurs, as the prevailing weather can have a significant effect on the moisture content of stockpiled and in-situ soil.

In addition to the above compaction specifications, in any areas where compacted fill will be placed over the exposed native soil subgrade, any loose, soft, wet or unstable areas should be sub-excavated, and backfilled with clean earth fill of Granular 'B' (OPSS.MUNI 1010) compacted to a minimum of 98% SPMDD. This recommendation applies to site servicing, slab on grade and pavement subgrades.

5.3 Quality Verification Services

On-site quality verification services are an integral part of the geotechnical design function, and for foundations and retaining walls, are required under the Ontario Building Code. Quality verification services are used to confirm that construction is being conducted in general conformance with the requirements as outlined in the drawings, reports and specifications prepared for the proposed development.

Central Earth Engineering can provide all the on-site quality verification services outlined below:

- The subgrade for shallow commercial building foundations must be field reviewed by the geotechnical engineer as required in the OBC.
- Installation of retaining structures over 1.0 metres high and related backfilling operations must be field reviewed on a continuous basis by the geotechnical engineer as required in the OBC.
- Part-time monitoring of the subgrade support capabilities (i.e. proof-roll), material quality, lift thickness, moisture content, degree of compaction, etc. is recommended for the following areas to ensure the recommendations within this report are followed and they perform adequately in the long-term:
    - Slabs on grade;
    - Pavement structure (granulars and asphalt); and
    - Bedding/backfilling of site servicing.
- Testing of the concrete (compressive strength, slump, air content, etc.) and testing of the asphalt (asphalt content and gradation) are recommended to ensure that the quality of the materials being brought to site meet the requirements of the project.

5.4 Site Work

The soils found at this site may become weakened when subjected to traffic, particularly when wet. If there is site work carried out during periods of wet weather, then it can be expected that the subgrade will be disturbed unless an adequate granular working surface is provided to protect the integrity of the subgrade soils from construction traffic. Subgrade preparation works cannot be adequately accomplished during wet weather and the project must be scheduled accordingly. The disturbance caused by the traffic can result in the removal of disturbed soil and use of granular fill material for site restoration or underfloor fill that is not intrinsic to the project requirements.

The most severe loading conditions on the subgrade may occur during construction. Consequently, special provisions such as end dumping and forward spreading of earth and aggregate fills, restricted construction lanes, and half-loads during paving and other work may be required, especially if construction is carried out during unfavourable weather.

If construction proceeds during freezing weather conditions, adequate temporary frost protection for the founding subgrade and concrete must be provided. The soil at this site is susceptible to frost damage. Consideration must be given to frost effects, such as heave or softening, on exposed soil surfaces in the context of this particular project development.

6 Limitations and Conclusion

6.1 Limitations

The recommendations and comments provided are necessarily on-going as new information of underground conditions becomes available. More specific information with respect to the conditions between samples, or the lateral and vertical extent of materials may become apparent during excavation operations. The interpretation of the borehole information must, therefore, be validated during excavation operations. Consequently, conditions not observed during this investigation may become apparent. Should this occur, CEE should be contacted to assess the situation and additional testing and reporting may be required.

CEE should be retained for a general review of the final design drawings and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, CEE will assume no responsibility for interpretation of the recommendations in the report.

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

This report was prepared by CEE for the account of Dr. Behrooz Azizi. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Central Earth Engineering Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

6.2 Conclusion

It is recognized that municipal/regional governing bodies, in their capacity as the planning and building authority under Provincial statues, will make use of and rely upon this report, cognizant of the limitations thereof, both as are expressed and implied.

We trust this report is complete within our terms of reference, and the information presented is sufficient for your present purposes. If you have any questions, or when we may be of further assistance, please do not hesitate to contact our office.

Yours Truly,

Central Earth Engineering Inc.

Alexander Winkelmann, P.Eng.
President, Geotechnical Engineer

Russell Wiginton, P.Eng.
Geotechnical Engineer

Figures –

SITE LOCATION PLAN

BOREHOLE LOCATION PLAN

Central Earth ENGINEERING

Geotechnical Engineering and Construction
Materials Testing & Inspection

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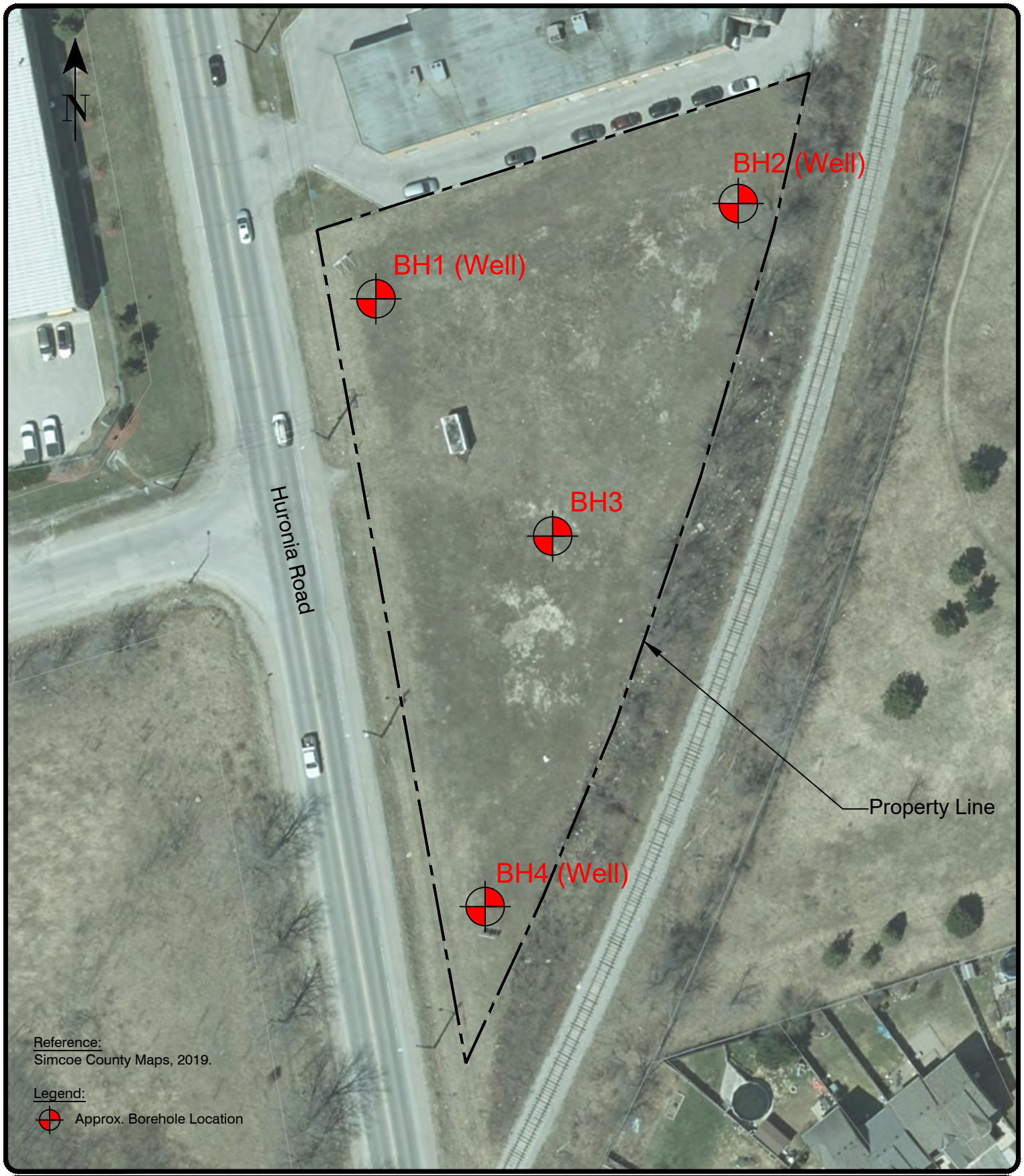
Project:	441 Huronia Road, Barrie, Ontario				
Title:	SITE LOCATION PLAN				
Approved by:	A.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	R.W.	Scale:	N.T.S.	Figure No.:	1



Reference:
Simcoe County Maps, 2019.

Legend:
Approx. Borehole Location

Central Earth ENGINEERING
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Materials Testing & Inspection
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Project:	441 Huronia Road, Barrie, Ontario				
Title:	BOREHOLE LOCATION PLAN				
Approved by:	A.W.	Date:	January 2020	Project No.:	19-1243A
Drawn by:	R.W.	Scale:	1:750	Figure No.:	2

Appendix A –

BOREHOLE LOGS

RECORD OF BOREHOLE No. 1

Project Number: **19-1243A**
Project Client: **Mr. Behrooz Azizi**
Project Name: **441 Huronia Road**
Project Location: **Barrie, Ontario**
Drilling Location: **NW Corner of Lot**

Drilling Method: **Solid Stem Augers** Drilling Machine: **Track Mount**
Logged By: **RD** Northing: **4911659** Date Started: **2019-12-12**
Reviewed By: **AW** Easting: **606473** Date Completed: **2019-12-12**

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)				
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	Shear Strength Testing (kPa): Other Test, Pocket Penetrometer, Field Vane (Intact), Field Vane (Remolded); Penetration Testing: SPT, DCPT	Combustible Organic Vapour (ppm), Combustible Organic Vapour (%LEL), Total Organic Vapour (ppm); Atterberg Limits: PL, LL, Water Content (%)	Instrumentation Installation		GR	SA	SI	CL
	Geodetic 262.04m														
	FILL: Silty Sand, Trace Gravel, Loose to Compact, Brown, Moist	SS	1	58	5	0	262	5	9		Topsoil = 100mm				
		SS	2	89	13			13	8						
	1.5 260.5								7						
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Dense, Brown, Moist	SS	3	100	32	2	260	32							
	- - - Very Dense - - -	SS	4	100	76			76	8						
		SS	5	100	79			79	7						
						4	258								
		SS	6	100	71			71	9						
						6	256								
		SS	7	100	56			56	9			8	57	26	9
		SS	8	100	100+			100+	7						
						8	254								
	9.6 252.5	SS	9	53	100+			100+	9						
	End of Borehole @ 9.6m														

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Groundwater depth encountered on completion of drilling: **Dry**
Cave depth after auger removal: **Open**
Groundwater depth observed on **2019-12-12** at a depth of: **8.2m**
Observed on **2019-12-20** at a depth of: **5.3m**

Scale: **1 :100**

RECORD OF BOREHOLE No. 2

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Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911674**	Date Started: **2019-12-12**	
Drilling Location:	**NE Corner of Lot**	Reviewed By: **AW**	Easting: **606525**	Date Completed: **2019-12-12**	

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Geodetic 262.16m											
	FILL: Silty Sand, Trace Gravel, Loose, Brown, Moist	SS	1	67	6	0	262		No topsoil present			
		SS	2	83	6							
	1.5 260.6											
	CLAYEY SILT GLACIAL TILL, Sandy, Trace Gravel, Trace Organics, Soft, Dark Brown, Moist	SS	3	50	3	2	260					
	- - - Stiff - - -	SS	4	100	9							
	3.1 259.1											
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Compact, Brown, Moist	SS	5	67	11				1	66	21	12
	- - - Dense - - -	SS	6	100	37	4	258					
	- - - Very Dense - - -	SS	7	100	59	6	256					
		SS	8	100	56	8	254					
	9.6 252.6	SS	9	100	100+							
	End of Borehole @ 9.6m											

FIELD TESTING
Shear Strength Testing (kPa)
× Other Test
+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)
40 80 120 160
Penetration Testing
○ SPT ● DCPT
10 20 30 40

LAB TESTING
△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
✳ Total Organic Vapour (ppm)
100 200 300 400
Atterberg Limits
PL ○ Water Content (%) LL
10 20 30 40

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Groundwater depth encountered on completion of drilling: **Dry**
Cave depth after auger removal: **Open**
Groundwater depth observed on **2019-12-12** at a depth of: **Dry**
Observed on **2019-12-20** at a depth of: **Dry**

Scale: **1 :100**

RECORD OF BOREHOLE No. 3

Central Earth ENGINEERING

Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911625**	Date Started: **2019-12-12**	
Drilling Location:	**Centre of Lot**	Reviewed By: **AW**	Easting: **606499**	Date Completed: **2019-12-12**	

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)	FIELD TESTING (Shear Strength Testing (kPa); Penetration Testing: SPT / DCPT)	LAB TESTING (Combustible Organic Vapour (ppm); Combustible Organic Vapour (%LEL); Total Organic Vapour (ppm); Atterberg Limits; Water Content (%))	Instrumentation Installation	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Geodetic 261.87m													
	FILL: Silty Sand, Trace Clay, Trace Gravel, Compact, Brown, Moist	SS	1	100	16	0		16	8		No topsoil present			
		SS	2	78	18			18	6					
	- - - Loose, Moist to Wet - - -	SS	3	78	5	2	260	5	12		11	65	20	4
	2.3 259.6													
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Dense, Brown, Moist	SS	4	100	45			45	8					
	- - - Very Dense - - -	SS	5	100	53	4	258	53 →	7					
		SS	6	100	100+			100+ →	7					
		SS	7	100	100+	6	256	100+ →	6					
	6.5 255.3													
	End of Borehole @ 6.6m													

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

RECORD OF BOREHOLE No. 4

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Project Number:	**19-1243A**				
Project Client:	**Mr. Behrooz Azizi**				
Project Name:	**441 Huronia Road**	Drilling Method: **Solid Stem Augers**		Drilling Machine: **Track Mount**	
Project Location:	**Barrie, Ontario**	Logged By: **RD**	Northing: **4911572**	Date Started: **2019-12-12**	
Drilling Location:	**Southern Corner of Lot**	Reviewed By: **AW**	Easting: **606491**	Date Completed: **2019-12-12**	

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	DEPTH (m)	ELEVATION (m)
	Geodetic 261.20m						
	FILL: Silt & Sand, Trace Organics, Loose, Dark Brown, Moist (Topsoil)	SS	1	83	8	0	
	- - - Compact - - -	SS	2	100	15		260
	1.5 259.7						
	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Compact, Brown, Moist	SS	3	72	20	2	
	- - - Dense - - -	SS	4	100	47		
		SS	5	100	48		258
						4	
	- - - Very Dense - - -	SS	6	100	58		256
		SS	7	100	69	6	
							254
		SS	8	100	57	8	
	9.4 251.8	SS	9	100	100+		252
	End of Borehole @ 9.4m						

FIELD TESTING

Shear Strength Testing (kPa)

× Other Test
\+ Pocket Penetrometer
▲ Field Vane (Intact)
△ Field Vane (Remolded)

40 80 120 160

Penetration Testing

○ SPT ● DCPT

10 20 30 40

LAB TESTING

△ Combustible Organic Vapour (ppm)
▲ Combustible Organic Vapour (%LEL)
✳ Total Organic Vapour (ppm)

100 200 300 400

Atterberg Limits

PL ○ Water Content (%) LL

10 20 30 40

Instrumentation Installation

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
4	60	27	9

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Groundwater depth encountered on completion of drilling: **Dry**

Cave depth after auger removal: **Open**

Groundwater depth observed on **2019-12-12** at a depth of: **Dry**

Observed on **2019-12-20** at a depth of: **Dry**

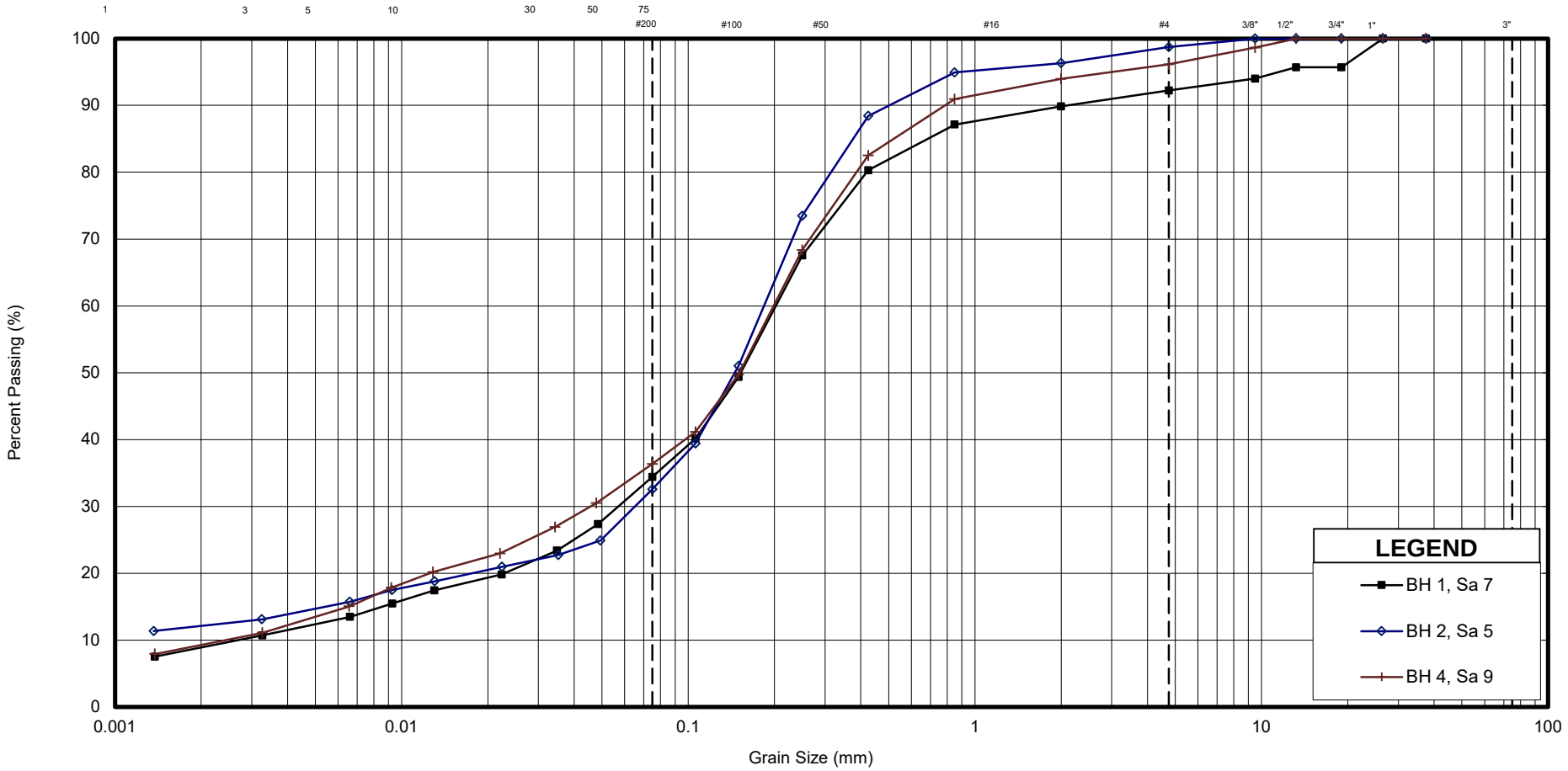
Scale: **1 :100**

Appendix B –

GEOTECHNICAL LABORATORY DATA

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 1, Sa 7	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	8	57	26	9	0.003	0.057	0.202	75	6.0
BH 2, Sa 5	SILTY SAND GLACIAL TILL, Some Clay, Trace Gravel	1	66	21	12	0.001	0.065	0.184	184	23
BH 4, Sa 9	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	4	60	27	9	0.002	0.046	0.20	82	4.3

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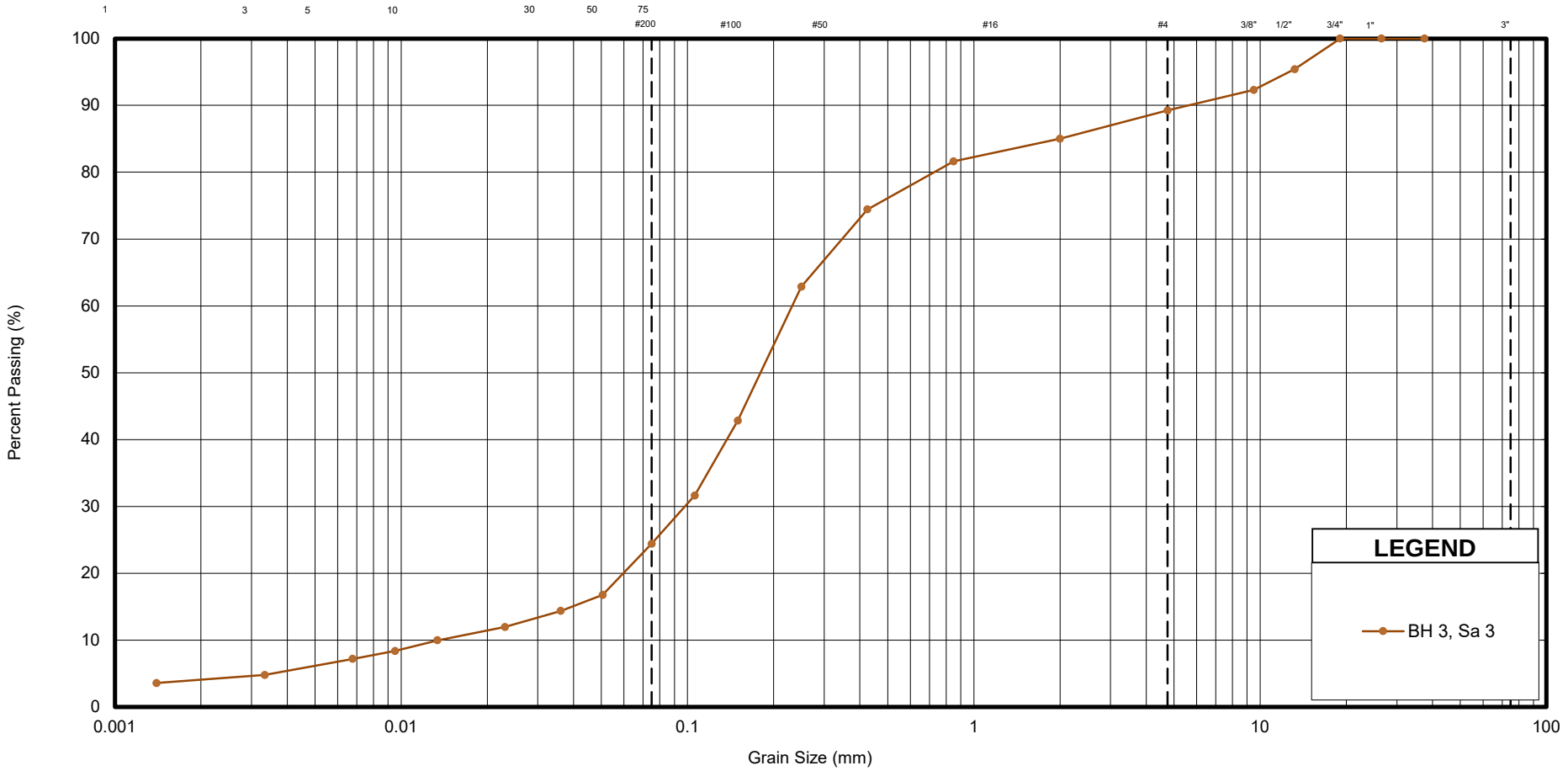
GRAIN SIZE DISTRIBUTION

SILTY SAND GLACIAL TILL

FIGURE No.	B1
REF. No.	19-1243A
DATE	January 2020

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 3, Sa 3	EARTH FILL: Silty Sand, Some Gravel, Trace Clay	11	65	20	4	0.013	0.098	0.23	17.2	3.1

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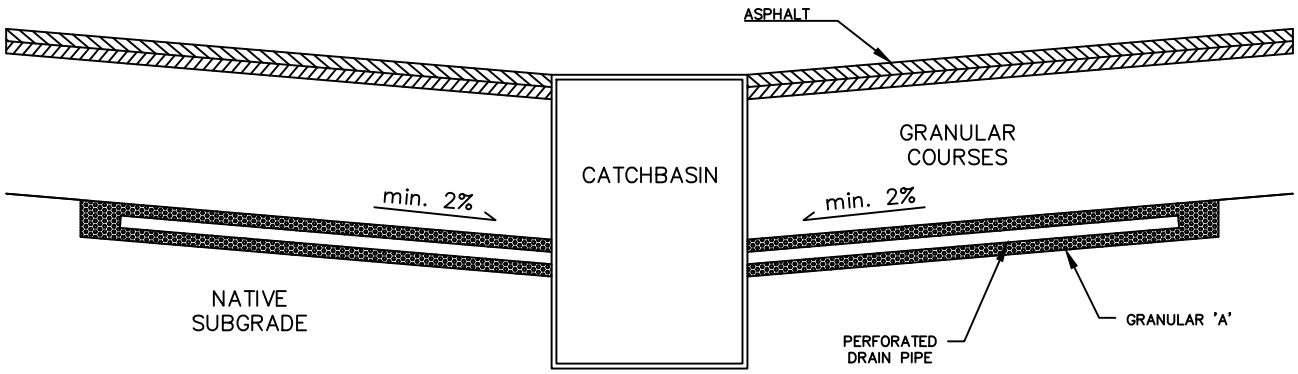
GRAIN SIZE DISTRIBUTION

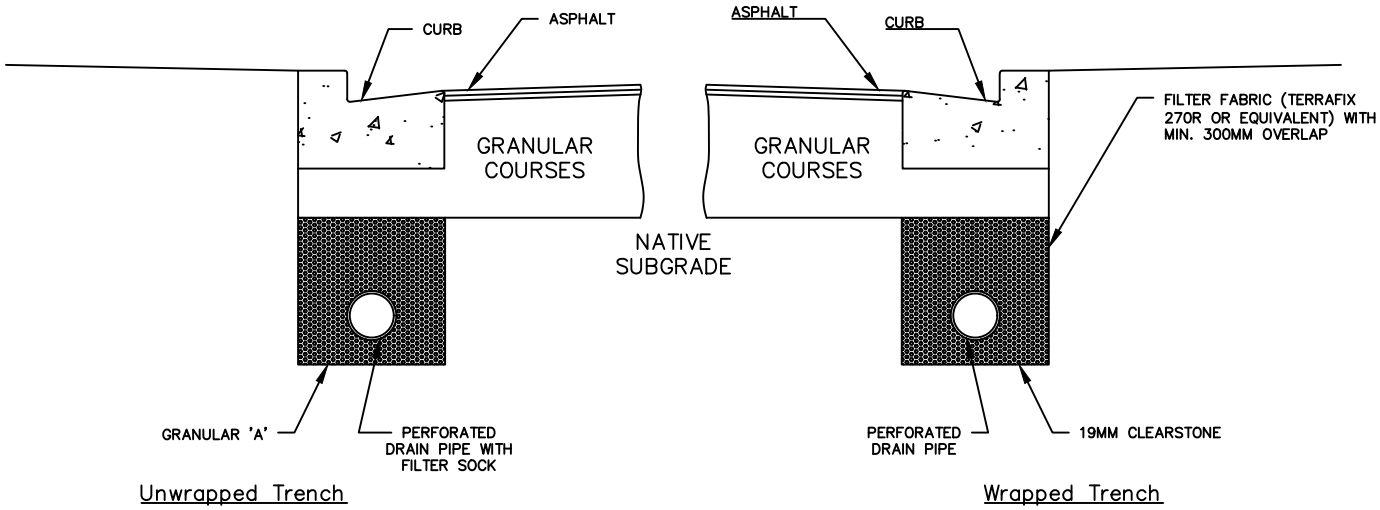
EARTH FILL

FIGURE No.	B2
REF. No.	19-1243A
DATE	January 2020

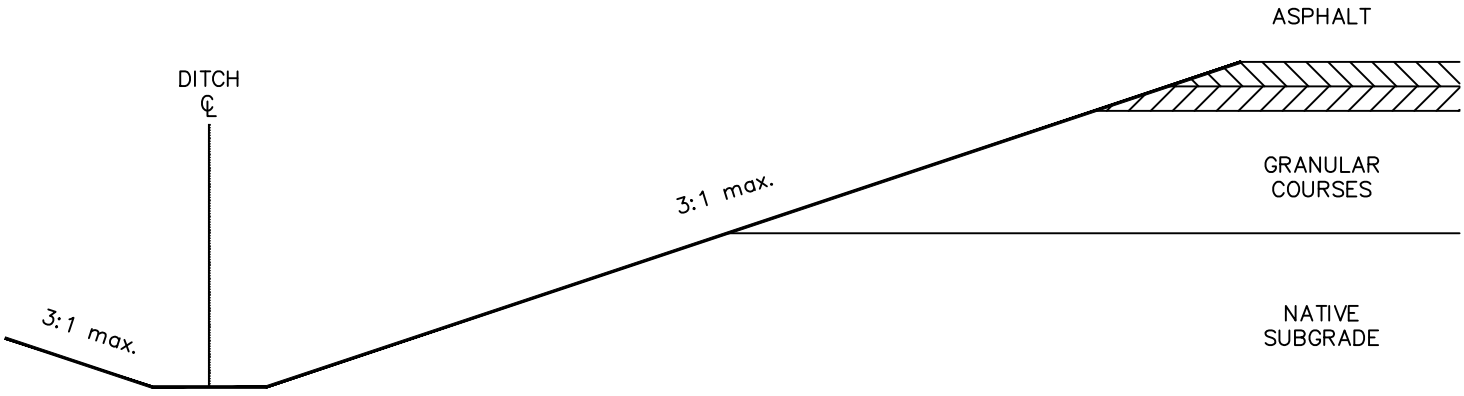
Appendix C –

TYPICAL DETAILS





Urban Cross Sections



Rural Cross Section

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PAVEMENT DRAINAGE ALTERNATIVES TYPICAL DETAILS