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GEOTECHNICAL REPORT

Proposed Residential Multi-Storey Building
520 & 526 Big Bay Point Road
Barrie, Ontario

Prepared For: Morriello Construction Ltd.
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1 Introduction

Central Earth Engineering Inc. (CEE) was retained by Morriello Construction Ltd. to complete a subsurface investigation and geotechnical report for a proposed residential development to be located at 520 & 526 Big Bay Point Road, in Barrie, Ontario. A site location plan is provided as Figure 1.

The site to be developed is rectangular in shape and measures approximately 65 metres wide (east to west) and 55 metres long (north to south) with a total site area of approximately 3500 square metres. The site is bounded by Big Bay Point Road to the south, residential properties to the east and west, and Warnica Public School to the north. The properties currently contain two single family residential dwellings with detached garages. CEE was provided with the following Surveyor's Real Property Report for 520 Big Bay Point Road:: *"Part of Lot 13, Concession 13, Geographic Township of Innisfil, City of Barrie, County of Simcoe*", File No. 13928, dated October 28, 2019, by Rudy Mak Surveying Ltd. Based on the on this drawing, there is approximately 2 metres of topographic relief across the site which slopes from near Elev. 253.5 metres in the north down to near Elev. 251.5 metres in the south.

CEE was provided with the following conceptual plan for review: "*6-Storey, 28 Apartment Unit Building, 520 Big Bay Point Rd, Barrie, ON, L4N 3Z5*", Project No. 194095, Drawing No. A100, Drawing: *Site Plan*, dated Feb. 4, 2020, by ISM Architects Inc. Based on the above site plan drawing, it is proposed to demolish the existing buildings and construct a new 6-storey residential apartment building with a footprint of approximately 900 m^2 and surrounding on-grade parking areas. It is unknown if the proposed building will have a basement level. It is understood that this concept plan is preliminary and subject to change. The development is expected to be municipally serviced. The footprint of the proposed apartment building will overlap with the footprint of the existing residential dwellings at the site (to be demolished).

The purpose of the current geotechnical investigation was to assess the subsurface soil conditions at the site by advancing three (3) exploratory boreholes, each with a monitoring well, to provide geotechnical engineering recommendations in support of the proposed development. This report summarizes the borehole findings, provides design recommendations for foundations, slabs-on-grade, seismic site classification, earth pressures, pavements, basement drainage and site servicing, as well as considerations for constructability such as soil excavation, soil 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 November 9th, 2020. A total of three boreholes (Boreholes 1 to 3) were advanced on site using a track-mounted drill rig. To advance the boreholes, hollow stem augers and standard soil sampling equipment was utilized. All samples were collected as per ASTM D1586 to assess the strength characteristics of the substrate.

The boreholes were advanced to a depth of 6.6 metres below existing grade (Elev. 246.3 to 245.2 metres). 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 survey equipment in reference to a geodetic benchmark (top of the fire hydrant spindle located in front of 526 Big Bay Point Road) taken from the above noted Surveyor's Real Property Report by Rudy Mak Surveying Ltd. GPS coordinates were measured with a handheld GPS unit and referenced to the NAD 83 geodetic datum, UTM Zone 17T.

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. A total of three (3) monitoring wells were installed on site (one per borehole) to facilitate the measurement of stabilized groundwater levels. Monitoring well construction is shown on the borehole logs in Appendix A.

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 the geotechnical laboratory results are included in 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

Boreholes 1 to 3 encountered a topsoil layer at the ground surface that ranged from 75 to 300 mm thick.

A zone of earth fill was encountered in the boreholes underlying the topsoil layer. The earth fill consisted of silty sand to sandy silt, with trace to some clay, trace to some gravel, and trace organics / rootlets. The earth fill extended to a depths ranging from 0.8 to 1.5 metres below grade (Elev. 252.1 to 250.2 metres). The earth fill was generally brown to dark brown and moist. The Standard Penetration Test (SPT) results ("N" Values) measured in the earth fill ranged from 6 to 14 blows per 300 mm of penetration, indicating a loose to compact (but typically loose) relative density.

Underlying the earth fill, the boreholes encountered a native glacial till deposit with a cohesionless matrix consisting of silty sand with trace to some gravel and trace clay. Cobbles and boulders may be embedded within the deposit. The upper 0.8 metres of the glacial till deposit in Borehole 1 was weathered/disturbed and loose, which is often caused by frost effects, or may consist of reworked native glacial till (i.e. earth fill). The brown and moist glacial till was encountered at a depth ranging from 0.8 to 1.5 metres below grade (Elev. 252.1 to 250.2 metres), extended to a depth of 6.1 metres below grade (Elev. 245.7 metres) in Borehole 1, and extended beyond the vertical depth of investigation in Boreholes 2 and 3 at 6.6 metres below grade (Elev. 246.3 to 246.0 metres). The SPT “N” Values measured in the glacial till ranged from 13 to 71 blows per 300 mm of penetration, indicating a compact to very dense relative density. The glacial till was generally compact to a depth of approximately 3 metres below grade and it was dense to very dense below a depth of 3 metres.

A 0.8-metre-thick layer of brown and damp silty sand was interbedded within the glacial till deposit in Borehole 2. The silty sand was encountered at a depth of 2.3 metres below grade (Elev. 250.6 metres). An SPT “N” Value of 24 blows was measured within the silty sand layer.

The glacial till in Borehole 1 was underlain by a deposit of gravelly sand with some silt. The brown and wet gravelly sand was encountered at a depth of 6.1 metres below grade (Elev. 245.7 metres) and extended beyond the vertical depth of investigation at 6.6 metres below grade (Elev. 245.2 metres). The measured SPT “N” Value was 59, indicating a very dense relative density.

3.3 Groundwater

Unstabilized groundwater 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 groundwater control constructability considerations that may arise. All three boreholes remained dry and open upon completion of drilling.

Each borehole was instrumented with a 50 mm diameter PVC monitoring well with a 1.5-metre-long screen 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
	Depth (m)	Local Elevation (m)		November 24, 2020
1	4.6 to 6.1	247.2 to 245.7	Silty Sand Glacial Till	5.46 / 246.29
2	4.6 to 6.1	248.3 to 246.8		Dry
3	4.6 to 6.1	248.0 to 246.5		6.00 / 246.57

Based on the groundwater level measurements and moisture contents of the recovered soil samples, it is expected that the groundwater table ranges from a depth of approximately 5.5 to 6.0 metres below grade.

The silty sand glacial till contains a moderately high percentage of fines (about 40% fines) and is expected that have a lower permeability, precluding the free flow of water. Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions.

4 Engineering Design Parameters & Analysis

4.1 Foundation Design

The topsoil, earth fill, and the upper 0.8-metre-thick weathered/disturbed zone of the silty sand glacial till deposit (in Borehole 1) are not suitable for the support of new foundations. Foundations at this site may be constructed as conventional shallow spread and strip footing foundations that bear on the undisturbed and compact to very dense native silty sand glacial till or interbedded sand deposits.

Foundations set a minimum of 0.3 metres into the compact to dense and undisturbed glacial till encountered at depths of 0.8 to 2.3 metres below grade (Elev. 249.5 to 252.1 metres) may be designed using a geotechnical reaction at SLS of 150 kPa, for an estimated settlement of 25 mm or less. The maximum factored geotechnical resistance at ULS is 225 kPa.

If the foundations are made to bear uniformly on the dense glacial till at or below a depth of 3 metres below existing grade (e.g. if the apartment building will have a basement level or if the foundations are extended deeper for an on-grade building), the spread and strip footings may be designed using a geotechnical reaction at SLS of 250 kPa, for an estimated settlement of 25 mm or less. The maximum factored geotechnical resistance at ULS is 350 kPa.

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 above 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 during construction is discussed in Section 5.1.

The foundation subgrade must be reviewed by the geotechnical engineer prior to concrete placement to ensure the foundation design parameters described above 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 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:

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

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
Weathered / Disturbed Glacial Till					
Upper Compact Glacial Till & Silty Fine Sand	21.0	33	0.29	0.46	3.39
Lower Dense to Very Dense 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.

4.3 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 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 subsoil will consist of compact to very dense silty sand glacial till with an average SPT "N" Value of greater than 15 but less than 50. Based on this, the Site Classification for this site is "D".

4.4 Slab on Grade Design

The topsoil and any soft, wet, organic, or highly disturbed earth fill or native soils are not suitable for the support of a slab on grade. Undisturbed native soils and surface compacted earth fill are suitable for the support of a lightly supported 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 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. If the subgrade will consist of earth fill or the weathered / disturbed glacial till, it should be surface compacted to 98% Standard Proctor Maximum Dry Density (SPMDD). A subgrade made on the compact to dense glacial till or silty fine sand should be proof-rolled.

The modulus of subgrade reaction appropriate for design of a slab on grade on the earth fill or weathered / disturbed glacial till (provided it is surface compacted to 98% SPMDD) is 25,000 kPa/m. The modulus of subgrade reaction appropriate for design of a slab on grade on the undisturbed and compact to dense glacial till or interbedded cohesionless deposits (generally encountered at depths ranging from 0.8 to 2.3 metres below grade) 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 clear stone and the cohesionless subgrade must be separated by a geotextile such as Terrafix 270R (or approved equivalent) to prevent the migration of fines into the clear stone layer which could result in loss of support for the slab.

4.5 Basement Drainage

For new structures that will be slab on grade with no basement levels, 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. Any small below grade areas (e.g. elevator pits) for a slab on grade building could be fully waterproofed and designed to resist hydrostatic pressure.

Where basements are constructed, all basement foundation walls must be provided with damp-proofing provisions in conformance to the Ontario Building Code. Backfill along the foundation wall must consist of Granular 'B' Type 1 (OPSS.MUNI 1010) for a minimum lateral distance of 600 mm out from the foundation wall. Alternatively, if a filtered cellular drainage media is provided adjacent to the foundation wall, the backfill may consist of common earth fill.

For buildings with basements, a perimeter drainage system must be installed that will remove any water that infiltrates into the building backfill, to ensure that any water does not infiltrate into the basement. The perimeter drains must consist of minimum 100 mm diameter perforated pipes wrapped in filter socks, sufficiently covered on all sides by 19 mm clear stone. Perimeter drains should be directed to the sump underneath the basement floor in solid pipes so as not to surcharge the underfloor drainage layer with water. The basement slab should also be provided with subfloor 100 mm diameter perforated pipes, trenched 0.3 metres below the slab granular base material and covered with 19 mm clear stone with 6 metre on-centre spacing. All sump pumps should be on emergency power for redundancy in case of a power outage. A typical basement drainage detail is included in Appendix C.

Considering a full depth basement (in the event that one level basement is included in the conceptual design) of about 3 metres, the basement level is not expected to extend below the groundwater table which is approximately 5.5 to 6.0 metres below existing grade.

4.6 Site Servicing

4.6.1 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 the earth fill or native soils at the site 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 98% SPMDD. Clear stone or high-performance bedding is permitted at this site but it must be fully wrapped in a non-woven filter fabric to prevent the migration of fines and loss of pipe support.

4.6.2 Backfill

Excavated native soils 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 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. 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.

4.7 Pavement Design

4.7.1 Subgrade Preparation

All topsoil, organics, and earth fill containing excessive moisture or organics must be removed from beneath the pavement structures. A review of the borehole data suggests that the proposed parking lot and driveway subgrade will consist of loose to compact earth fill or cohesionless glacial till. These types of soil are an adequate subgrade for the support of a pavement structure, provided the subgrade surfaced is compacted to 98% SPMDD, inspected, and approved by a geotechnical engineer at the time of construction and does not contain excessive amounts of organics, moisture, or deleterious materials (as may be the case for zones within the any earth fill).

A proof-roll is recommended to facilitate the subgrade inspection by the geotechnical engineer. 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. Any fill placed to raise the grades of the pavement subgrade must be compacted to 98% SPMDD. The modulus of subgrade reaction appropriate for design of a pavement structure on the earth fill (surface compacted to 98% SPMDD) is 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.

4.7.2 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 both sides of the roadway and parking areas 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/manhole due to frost action, the backfill around the structures should consist of free-draining granular material. Typical pavement drainage details are included in Appendix C.

4.7.3 Pavement Structure

There are two different types of pavements that need to be designed for:

- Light Duty: Includes driveways and parking lots which will not see frequent heavy traffic loads such as buses, delivery or fire trucks, etc., and will mostly service small vehicles such as cars or pickup trucks.
- Heavy Duty: Includes driveways and parking lots which are designated fire truck routes, or will see frequent heavy traffic loads such as buses, delivery or garbage trucks, etc.

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	70 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 be compacted to a minimum of 100% SPMDD for both granular base and 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

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. For this site, the earth fill and cohesionless native soil deposits are classified as Type 3 soils, which require excavation 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. 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.

It is not expected that excavations for the basement level or foundations will extend below the prevailing groundwater table that was encountered at depths of approximately 5.5 to 6.0 metres below existing grade. It is expected that any minor seepage of perched water or precipitation can be controlled using local sump pumps. If the elevator pit excavation extends into the groundwater table, continuously pumping with sump pumps is expected to be sufficient to temporarily control groundwater in that 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 the 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 content, it is expected that about one-third of the in-situ soils are at optimum moisture content, one-third are above optimum, and one-third are below optimum. Any zones with higher or lower 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 noted that the above percentages can change significantly 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, pavement and slab on grade 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 (OBC). 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 foundations must be field reviewed by the geotechnical engineer as required by 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:
  - Slab-on-grades.
  - Pavements.
  - Bedding/backfilling of site servicing.
- Testing of the concrete (compressive strength, slump, air content, etc.) is 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 Morriello Construction Ltd. 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.

LICENSED PROFESSIONAL ENGINEER
A.WINKELMANN
100150146
Dec. 3, 2020
PROVINCE OF ONTARIO

Alexander Winkelmann, P.Eng.
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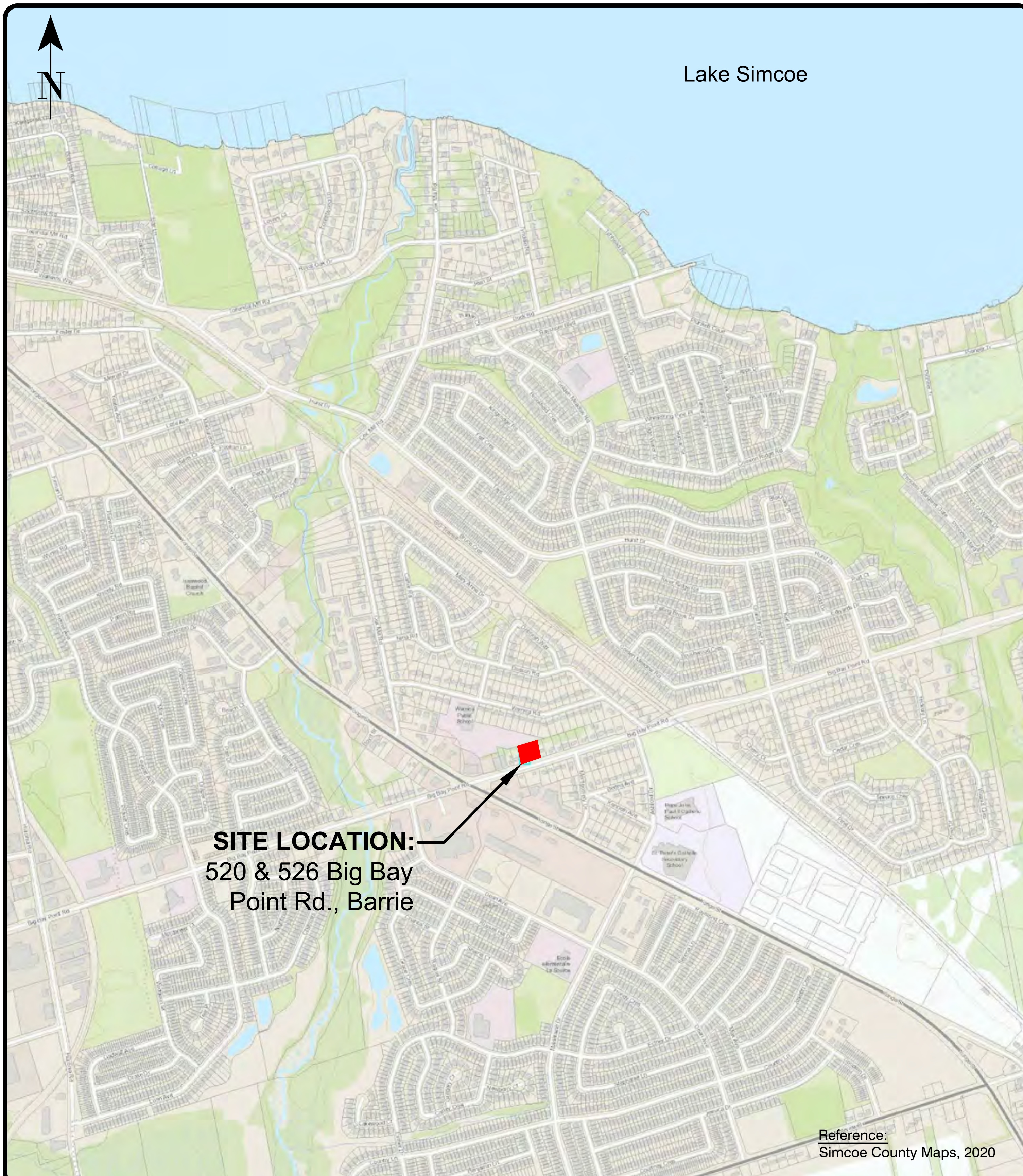
Anar Jafarov, P.Eng.
Geotechnical Engineer

Figures –

SITE LOCATION PLAN

BOREHOLE LOCATION PLAN



Central Earth Engineering

Geotechnical Engineering and Construction Materials Testing & Inspection

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Project:	520 & 526 Big Bay Point Road, Barrie				
Title:	SITE LOCATION PLAN				
Approved by:	A.W.	Date:	December 2020	Project No.:	20-1016A
Drawn by:	A.J.	Scale:	N.T.S.	Figure No.:	1

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Project:	520 & 526 Big Bay Point Road, Barrie				
Title:	BOREHOLE LOCATION PLAN				
Approved by:	A.W.	Date:	December 2020	Project No.:	20-1016A
Drawn by:	A.J.	Scale:	1:600	Figure No.:	2

Appendix A –

BOREHOLE LOGS

RECORD OF BOREHOLE No. 1

Central Earth ENGINEERING

Project Number:	20-1016A		
Project Client:	Morriello Construction Ltd.		
Project Name:	520 & 526 Big Bay Point Road	Drilling Method: Hollow Stem Augers	Drilling Machine: Track Mount
Project Location:	Barrie, Ontario	Logged By: AJ	Northing: 4912503	Date Started: 2020-11-09
Drilling Location:	See Figure 2	Reviewed By: AW	Easting: 607906	Date Completed: 2020-11-09

LITHOLOGY PROFILE | **SOIL SAMPLING** | **FIELD TESTING** | **LAB TESTING** | **COMMENTS & GRAIN SIZE DISTRIBUTION (%)**

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 — LL; ○ Water Content (%); 10 20 30 40

Geodetic 251.75m

Depth (m) / Elev.	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	GR	SA	SI	CL
0.2 / 251.6	Topsoil = 200mm									
1.5 / 250.2	FILL: Silty Sand, Trace to Some Clay, Trace Organics/Rootlets, Loose, Dark Brown, Moist	SS	1	42	8	15				
		SS	2	61	6	21				
2.3 / 249.5	Weathered/Disturbed	SS	3	61	8	16				
6.1 / 245.7	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel, Compact, Brown, Moist	SS	4	86	15	11	3	55	33	9
	- - - Very Dense - - -	SS	5	44	60	9				
	- - - Dense - - -	SS	6	61	31	9				
6.6 / 245.2	GRAVELLY SAND, Some Silt, Very Dense, Brown, Wet	SS	7	78	59	8				
	End of Borehole @ 6.6m									

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

Cave depth after auger removal: **Open**

Groundwater depth observed on **Nov. 24/20** at a depth of: **5.46m**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

RECORD OF BOREHOLE No. 2

Central Earth ENGINEERING

Project Number:	**20-1016A**
Project Client:	**Morriello Construction Ltd.**
Project Name:	**520 & 526 Big Bay Point Road**
Project Location:	**Barrie, Ontario**
Drilling Location:	**See Figure 2**

Drilling Method:	**Hollow Stem Augers**			Drilling Machine:	**Track Mount**
Logged By:	**AJ**	Northing:	**4912533**	Date Started:	**2020-11-09**
Reviewed By:	**AW**	Easting:	**607929**	Date Completed:	**2020-11-09**

LITHOLOGY PROFILE | **SOIL SAMPLING** | **FIELD TESTING** | **LAB TESTING** | **COMMENTS & GRAIN SIZE DISTRIBUTION (%)**

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 – LL. ○ Water Content (%); 10, 20, 30, 40

Lithology Plot | DESCRIPTION (Geodetic 252.88m) | Instrumentation Installation

Depth (m) / Elev.	Description	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	GR	SA	SI	CL
0.0 – 0.3 / 252.6	Topsoil = 300mm									
0.3 – 0.8 / 252.1	FILL: Sandy Silt, Some Clay, Trace Rootlets, Comapct, Dark Brown, Moist	SS	1	67	14	23				
0.8 – 2.3 / 250.6	SILTY SAND GLACIAL TILL, Trace to Some Clay, Trace Gravel, Compact, Brown, Moist	SS	2	100	13	7	7	46	31	16
		SS	3	94	21	23				
2.3 – 3.1 / 249.8	SILTY FINE SAND, Compact, Light Brown, Damp	SS	4	72	24	2				
3.1 – 6.6 / 246.3	SILTY SAND GLACIAL TILL, Trace Gravel, Trace Clay, Dense, Brown, Moist	SS	5	83	32	10				
	- - - Very Dense - - -	SS	6	94	71	7				
		SS	7	100	59	7				
6.6	End of Borehole @ 6.6m									

DEPTH (m): 0, 1, 2, 3, 4, 5, 6. ELEVATION (m): 252, 251, 250, 249, 248, 247

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

Cave depth after auger removal: **Open**

Groundwater depth observed on **Nov. 24/20** at a depth of: **Dry**

Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

RECORD OF BOREHOLE No. 3

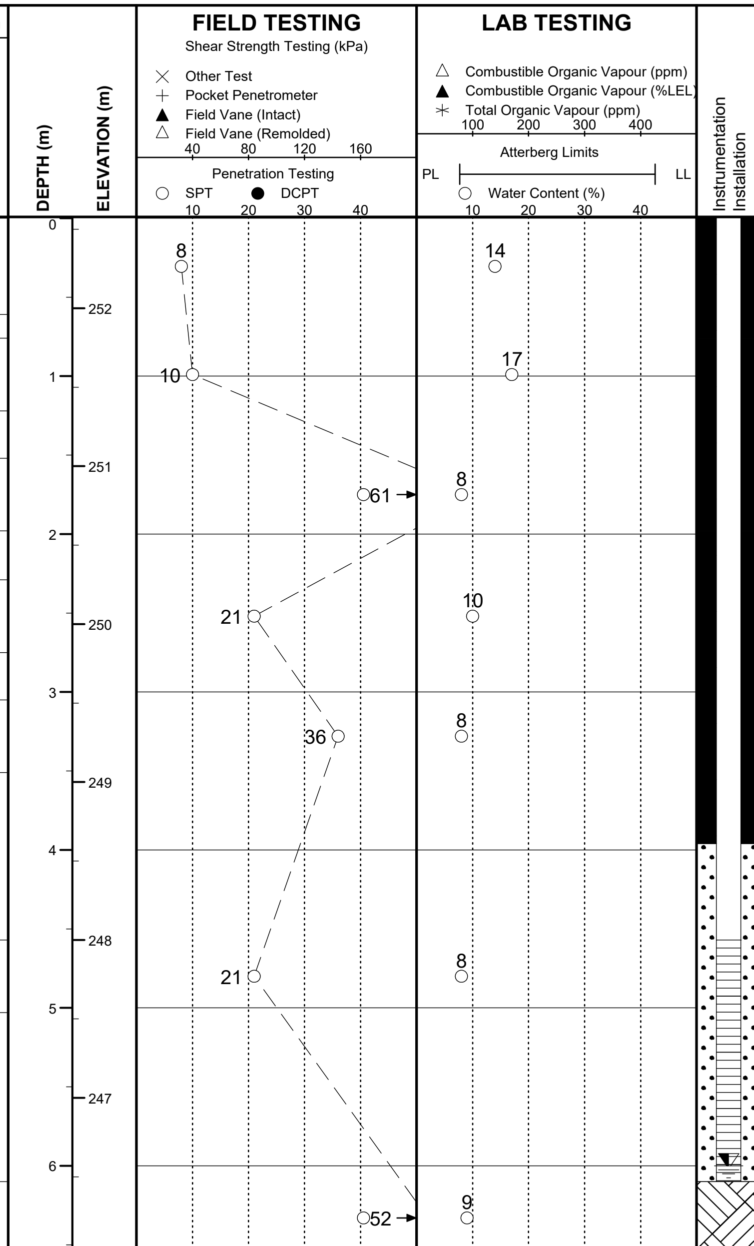
Project Number: **20-1016A**
Project Client: **Morriello Construction Ltd.**
Project Name: **520 & 526 Big Bay Point Road**
Project Location: **Barrie, Ontario**
Drilling Location: **See Figure 2**

Drilling Method: **Hollow Stem Augers** Drilling Machine: **Track Mount**
Logged By: **AJ** Northing: **4912506** Date Started: **2020-11-09**
Reviewed By: **AW** Easting: **607949** Date Completed: **2020-11-09**

LITHOLOGY PROFILE / SOIL SAMPLING

Geodetic 252.57m

Depth/Elev.	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value
0.1 / 252.5	Topsoil = 75mm				
	FILL: Silty Sand, Trace to Some Gravel, Trace Clay, Loose, Dark Brown, Moist	SS	1	67	8
		SS	2	72	10
1.5 / 251.1	SILTY SAND GLACIAL TILL, Trace to Some Gravel, Trace Clay, Very Dense, Brown, Moist	SS	3	61	61
	- - - Compact to Dense - - -	SS	4	83	21
		SS	5	11	36
		SS	6	89	21
	- - - Very Dense - - -	SS	7	52	52
6.6 / 246.0	End of Borehole @ 6.6m				



COMMENTS & GRAIN SIZE DISTRIBUTION (%)

Sample	GR	SA	SI	CL
SS 6	10	51	30	9

Groundwater depth encountered on completion of drilling: **Dry**
Cave depth after auger removal: **Open**
Groundwater depth observed on **Nov. 24/20** at a depth of: **6.00m**

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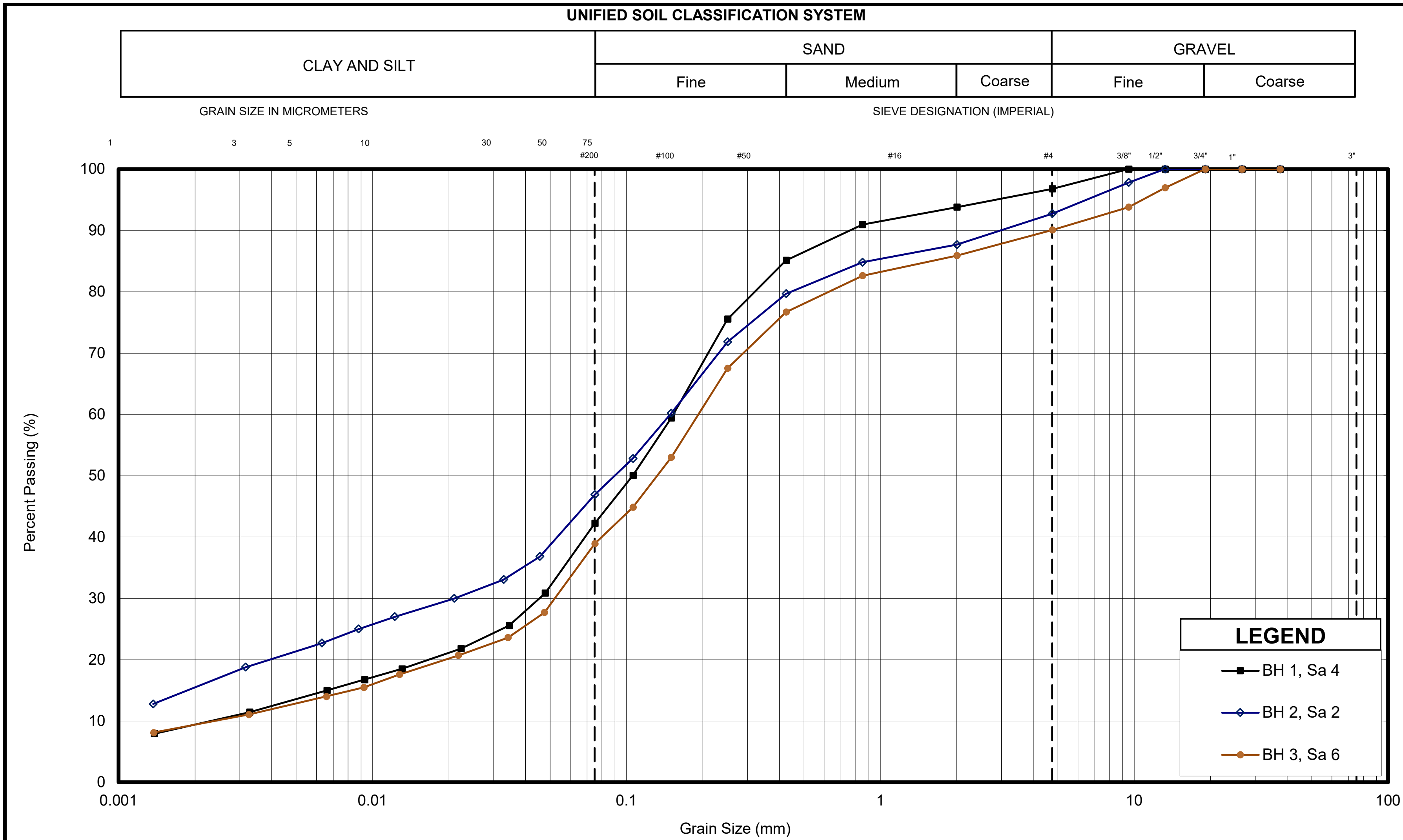
Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Boring Log'.

Scale: **1 :50**

Appendix B –

GEOTECHNICAL LABORATORY DATA



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 1, Sa 4	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	3	55	33	9	0.002	0.045	0.15	66.7	5.9
BH 3, Sa 6	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	10	51	30	9	0.002	0.052	0.19	80.4	5.9
BH 2, Sa 2	SILTY SAND GLACIAL TILL, Some Clay, Trace Gravel	7	46	31	16	-	0.021	0.15	-	-

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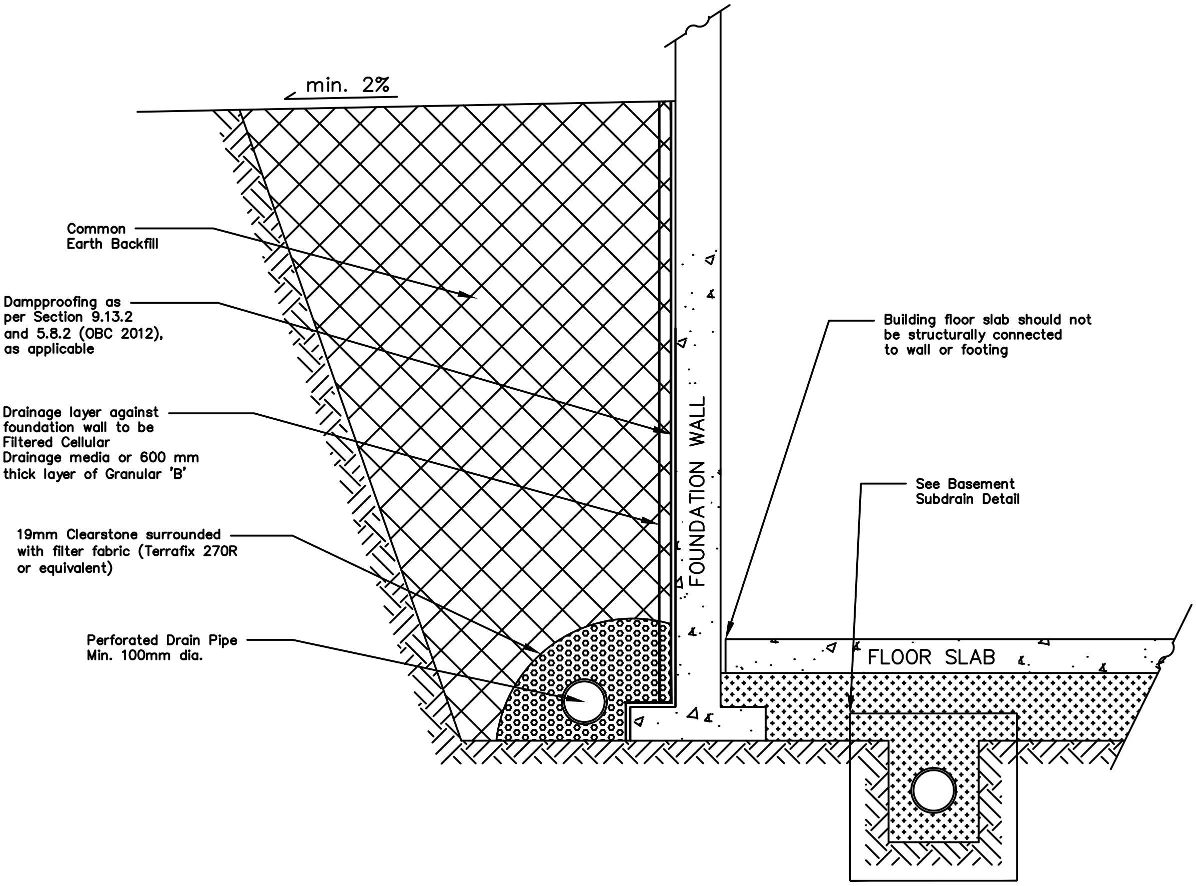
GRAIN SIZE DISTRIBUTION

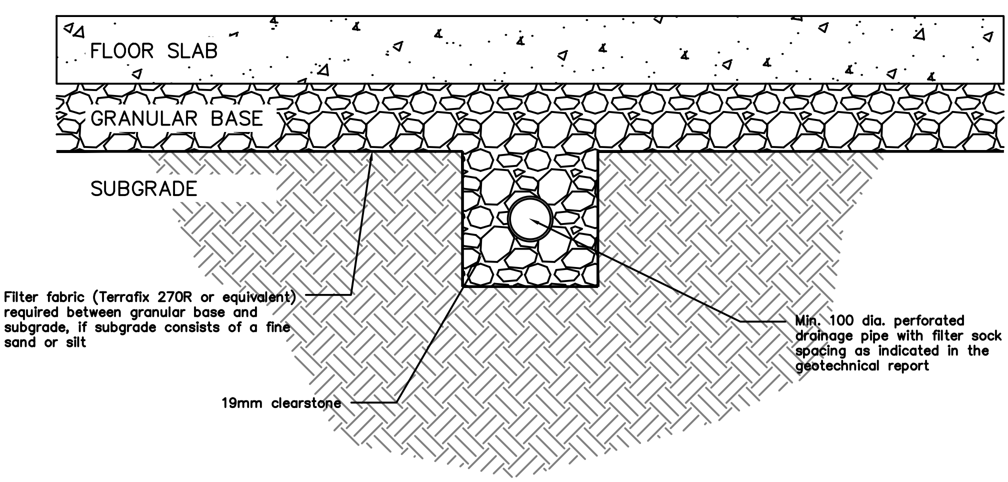
SILTY SAND GLACIAL TILL

FIGURE No.	B1
REF. No.	20-1016A
DATE	December 2020

Appendix C –

TYPICAL DETAILS





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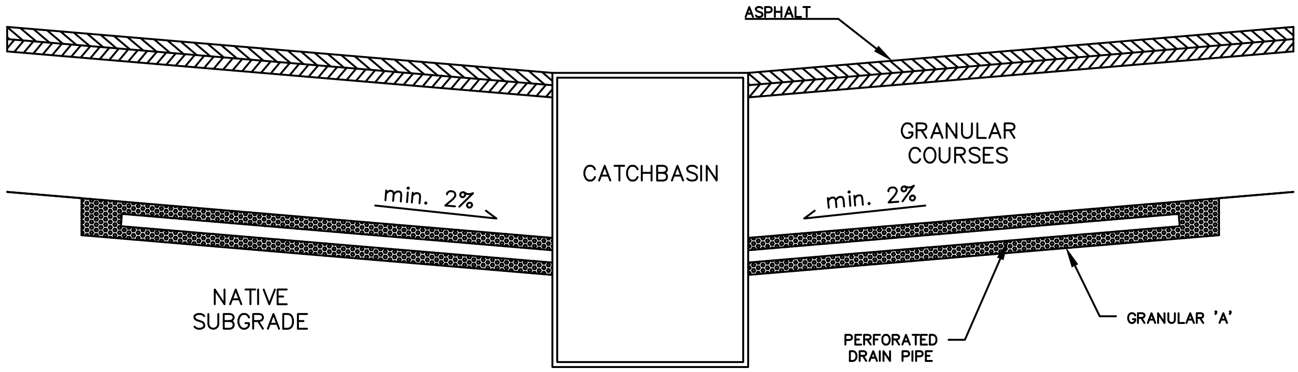
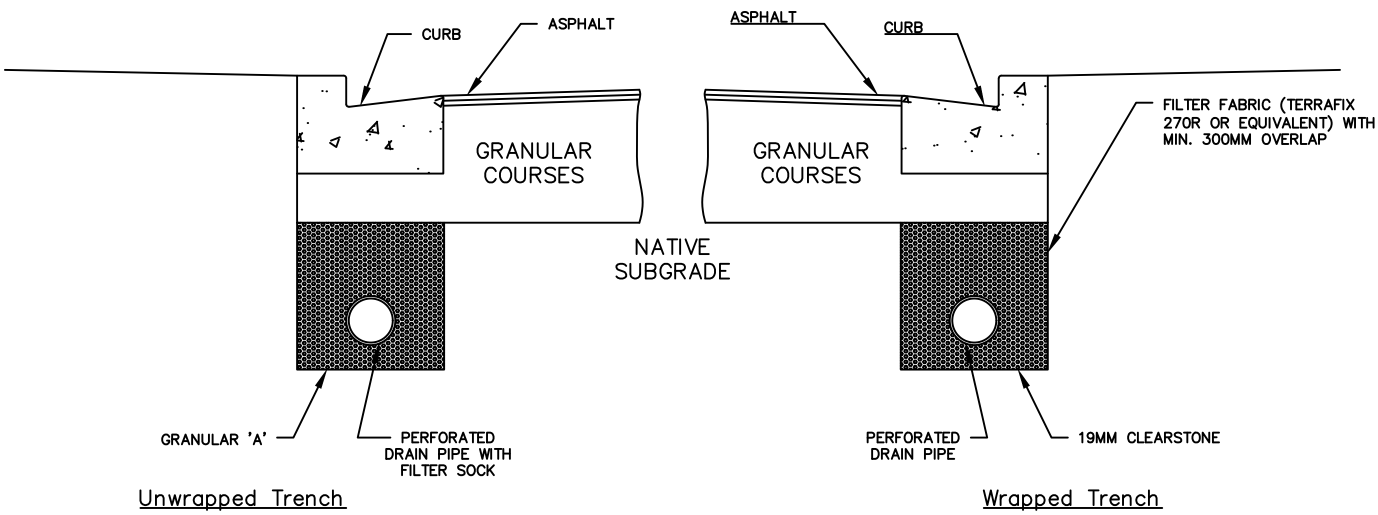
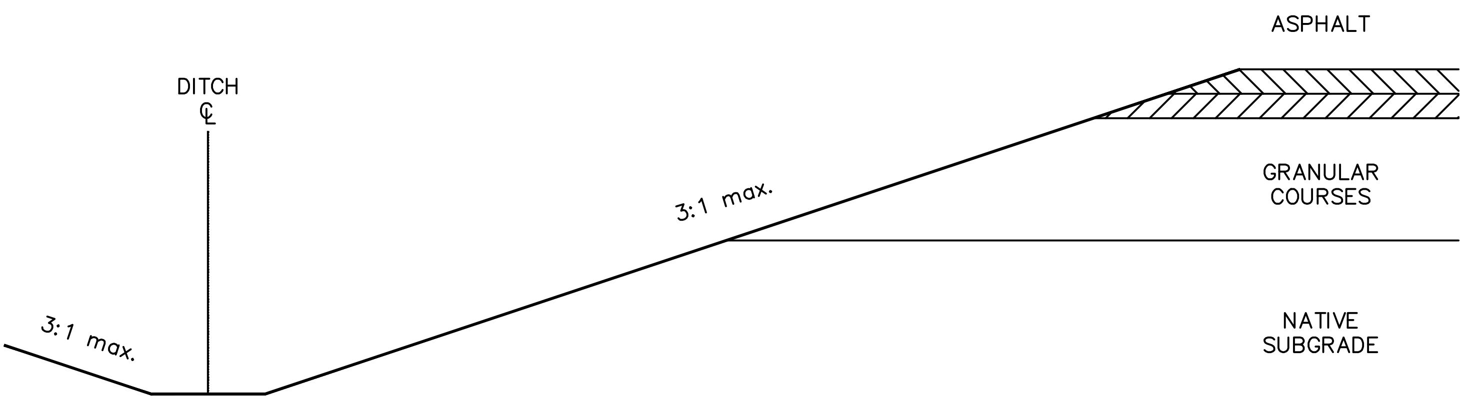
BASEMENT FOUNDATION WALL & SUBFLOOR DRAINAGE TYPICAL DETAIL





Urban Cross Sections



Rural Cross Section

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PAVEMENT DRAINAGE ALTERNATIVES TYPICAL DETAILS