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GEOTECHNICAL REPORT

Proposed Residential Townhouse Development
821 Big Bay Point Road
Barrie, Ontario

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Table of Contents

Table of Contents (Continued)

Figures

Appendices

1 Introduction

Central Earth Engineering Inc. (CEE) was retained by Robert Gilroy to complete a subsurface investigation and geotechnical report for the proposed residential townhouse development to be located at 821 Big Bay Point Road, in Barrie, Ontario. A site location plan is provided as Figure 1. The site is bounded by a commercial property to the east, residential properties to the south and west and Big Bay Point Road to the north. The existing property is approximately 55 metres wide (east-west) and 130 metres long (north-south) with a total lot area of 0.75 ha. The property currently contains two structures surrounded by a manicured lawn and mature trees.

CEE was provided with the following conceptual site plan drawing for review:

- "*Residential Seniors Townhouse Development, 821 Big Bay Point Road, Preliminary Grading Plan*", Drawing No. FIG-6, Project No. 19105, dated August 2020, by Pearson Engineering Ltd.

Based on the provided grading plan, it is proposed to demolish the two existing buildings and construct 8 multi unit townhouse blocks (Blocks A to H). It is unknown if the proposed townhomes will have basement levels. There are no significant grade changes to accommodate the development and the development will be municipally serviced. A 6.4-metre-wide driveway / internal roadway will run from north to south through the middle of the site, connecting Big Bay Point Road and Birkhall Place. A parking lot will be located in the southeastern corner of the site and an amenity space will be located in the southwestern corner of the site.

The purpose of the geotechnical investigation was to assess the subsurface conditions at the site by advancing three (3) exploratory boreholes and installing a monitoring well in each borehole to provide geotechnical engineering recommendations in support of the proposed townhouse development. This report summarizes the borehole findings, provides design recommendations for foundations, slabs on grade, earth pressures, site servicing, and pavements, and provides considerations for constructability such as soil excavation and compaction. CEE has completed a hydrogeological study for the proposed development under a separate cover.

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 October 1, 2020. A total of three boreholes (Boreholes 1 to 3) were advanced on site using a track-mounted drill rig. To advance the boreholes, continuous flight 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 depths of 7.6 to 7.9 metres below existing grade (local Elev. 94.0 to 91.9 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 temporary benchmark (top of the catch basin located in eastbound lane of Big Bay Point Road near the property) with an assumed local elevation 100.00 metres. 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. Three (3) monitoring wells were installed in the boreholes to facilitate long-term groundwater monitoring.

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 2A (aerial image) and 2B (proposed site plan) 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 200 to 250 mm thick.

A zone of earth fill was encountered in the boreholes underlying the topsoil layer. The earth fill consisted of sand and silt, with trace clay, trace organics, and trace rootlets, and extended to a depth of 0.8 metres below grade (local Elev. 100.8 to 99.0 metres). The earth fill was brown and moist. The Standard Penetration Test (SPT) results (“N” Values) measured in the earth fill ranged from 6 to 7 blows per 300 mm of penetration, indicating a loose relative density.

Underlying the earth fill, the boreholes encountered a glacial till deposit with a cohesionless matrix consisting of silty sand, with trace clay and trace gravel. Cobbles and boulders may be embedded within the deposit. The brown and moist glacial till was encountered at a depth of 0.8 metres below grade (local Elev. 100.8 to 99.0 metres) and extended to depths of 4.6 to 7.5 metres below grade (local Elev. 97.0 to 92.3 metres). The SPT “N” Values measured in the glacial till ranged from 14 to greater than 100 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 2 metres below grade and was dense to very dense below a depth of 2 metres.

Cohesionless deposits were encountered in the boreholes underlying the glacial till at depths of 4.6 to 7.5 metres below grade (local Elev. 97.0 to 92.3 metres) and extended beyond the vertical depth of investigation at 7.6 to 7.9 metres below grade (local Elev. 94.0 to 91.9 metres). The cohesionless deposits consisted of fine sand with trace silt in Borehole 1, silty sand with trace gravel in Borehole 2, and silt with trace sand and trace clay in Borehole 3. The deposits were brown and damp to moist, becoming wet at 6 to 7 metres below grade. The SPT "N" Values measured in the deposits were greater than 50 blows per 300 mm of penetration, 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 ground water control constructability considerations that may arise. Unstabilized groundwater was encountered at 6.1 to 7.0 metres below grade. Cave was measured at a depth of 7.2 metres below grade in Borehole 1 but Boreholes 2 and 3 remained 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 / Local Elev. (m) of Groundwater	
	Depth (m)	Local Elevation (m)		Oct. 9, 2020	Oct. 13, 2020
1	6.1 to 7.6	95.5 to 94.0	Fine Sand	6.37 / 95.23	6.40 / 95.20
2	6.1 to 7.6	94.1 to 92.6	Silty Sand	6.90 / 93.36	6.93 / 93.33
3	6.0 to 7.5	93.8 to 92.3	Silty Sand Glacial Till	5.59 / 94.14	5.56 / 99.73

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 5.6 to 6.9 metres below grade. It is expected that groundwater has a hydraulic gradient that flows from the northeast to the southwest.

The silty sand glacial till contains a moderately high percentage of fines (about 30 to 40% fines) and is expected that have a lower permeability, precluding the free flow of water. The deeper cohesionless deposits consisting of sand to silty sand will typically allow for the free flow of water when wet. Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions. Additional details on groundwater and in-situ permeability are provided in the hydrogeological study under a separate cover.

4 Engineering Design Parameters & Analysis

Based on the provided grading plan, it is proposed to demolish the two existing buildings and construct 8 multi unit townhouse blocks (Blocks A to H). It is unknown if the proposed townhomes will have basement levels. There are no significant grade changes to accommodate the development and the development will be municipally serviced. A 6.4-metre-wide driveway / internal roadway will run from north to south through the middle of the site, connecting Big Bay Point Road and Birkhall Place. A parking lot will be located in the southeastern corner of the site and an amenity space will be located in the southwestern corner of the site.

Reference should be made to the Ontario Building Code which stipulate the geotechnical design and construction requirements for the type of residential structures being proposed at this site.

4.1 Foundation Design

The topsoil and earth fill are not suitable for the support of new building foundations. The undisturbed and compact glacial till encountered in the boreholes at or below 0.8 metres below existing grade (at or below local Elev. 100.8 to 99. metres) is suitable for the support of new foundations.

Foundations at this site may be constructed as conventional spread and strip footing foundations that extend down to bear on the undisturbed glacial till as described above. Foundations set on the undisturbed glacial till at or below a depth of 0.8 metres below existing grade 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.

It is important to note that these bearing capacities are applicable for foundations set onto the glacial till, which as encountered at a depth of 0.8 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 level.

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 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.

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.

The foundation subgrade must be reviewed prior to concrete placement to ensure the 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 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
Compact Glacial Till	20.0	34	0.28	0.44	3.54
Dense to Very Dense Glacial Till	21.0	38	0.24	0.38	4.20

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 Slab on Grade Design

The topsoil and any soft, wet, organic, or highly disturbed earth fill are not suitable for the support of a slab on grade. Approved earth fill and undisturbed glacial till 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 the subgrade will consist of the earth fill, it must be surface compacted to 98% Standard Proctor

Maximum Dry Density (SPMDD). A glacial till subgrade should be proof-rolled and inspected. 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.

The modulus of subgrade reaction appropriate for design of a slab on grade on the earth fill (provided it is surface compacted to 98% SPMDD) is 30,000 kPa/m. The modulus of subgrade reaction appropriate for design of a slab on grade on the undisturbed and compact 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.

4.4 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.

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 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. 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. Additional considerations are provided in the hydrogeological study under a separate cover.

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 the silty sand glacial till 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 provided it is fully wrapped in a non-woven filter fabric to prevent the migration of fines and loss of pipe support.

4.5.2 Backfill

Excavated glacial till or earth fill may be used as backfill in trenches, as foundation backfill, within excavations, etc. provided the moisture content is within 2% of optimum. The backfill should be compacted to a minimum of 95% 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 settlement sensitive areas (e.g. the roadway, parking lot, sidewalks, etc.), 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.

4.6 Pavement Design

4.6.1 Subgrade Preparation

A review of the borehole data suggests that the proposed road subgrade will consist of loose earth fill or compact glacial till. The topsoil is not a suitable subgrade and must be removed. The loose earth fill will be an adequate subgrade for the support of a pavement structure, provided it is surface compacted to 98% SPMDD, inspected, and approved by a geotechnical engineer at the time of construction and does not contain excessive amounts of organics or deleterious materials. A glacial till subgrade should be proof rolled and inspected 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 slab on grade on the earth fill (provided it is surface compacted to 98% SPMDD) is 30,000 kPa/m. The modulus of subgrade reaction appropriate for design of a slab on grade on the undisturbed and compact glacial till is 50,000 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 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 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. Light duty pavement is recommended for car parking and driving areas. Heavy duty pavement is recommended for fire truck, garbage truck, or bus routes, or for the road through the site if it will be assumed by the City of Barrie. The heavy-duty pavement design meets the recommended pavement minimums for a local road as specified within Appendix C of the City of Barrie's "*Transportation Design Manual, Engineering Department*". The following pavement thickness design is 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	150 mm	150 mm

Pavement Layer	**Compaction Requirements**	**Minimum Component Thickness**	
		Light Duty	**Heavy Duty**
<u>*Subbase Course:*</u> Granular B Type I or II (OPSS.MUNI 1010)	Dry Density (ASTM-D698)	300 mm	450 mm*

*This granular thickness assumes an average annual daily traffic (AADT) of 2,500. If the AADT is more than this value and the road is being assumed by the City, the granular subbase course should be increased to 530 mm as per City of Barrie standards.

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 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. For this site, the cohesionless glacial till and earth fill 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. The glacial till deposit may contain embedded cobbles and boulders that may be encountered in excavations and will need to be accounted for during construction.

As excavations are expected to be above the prevailing groundwater 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 rainfall runoff or any perched groundwater seepage in this scenario. Additional details on groundwater control and regulatory requirements for water taking are provided in the hydrogeological study under a separate cover.

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 explorations. 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 Central Earth Engineering 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, most of the soils at this site are at or near optimum moisture content. Any 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 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 subgrades for site servicing, slabs on grade, pavement.

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 residential dwelling and townhouse foundations may be field reviewed by the geotechnical engineer as required by the municipal regulating authority.
- 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;
    - 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 Robert Gilroy. 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

LICENSED PROFESSIONAL ENGINEER
A.WINKELMANN
100150146
Oct. 23, 2020
PROVINCE OF ONTARIO

R. Wiginton

Russell Wiginton, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
R. Wiginton
R. M. WIGINTON
100193069
Oct. 23, 2020
PROVINCE OF ONTARIO

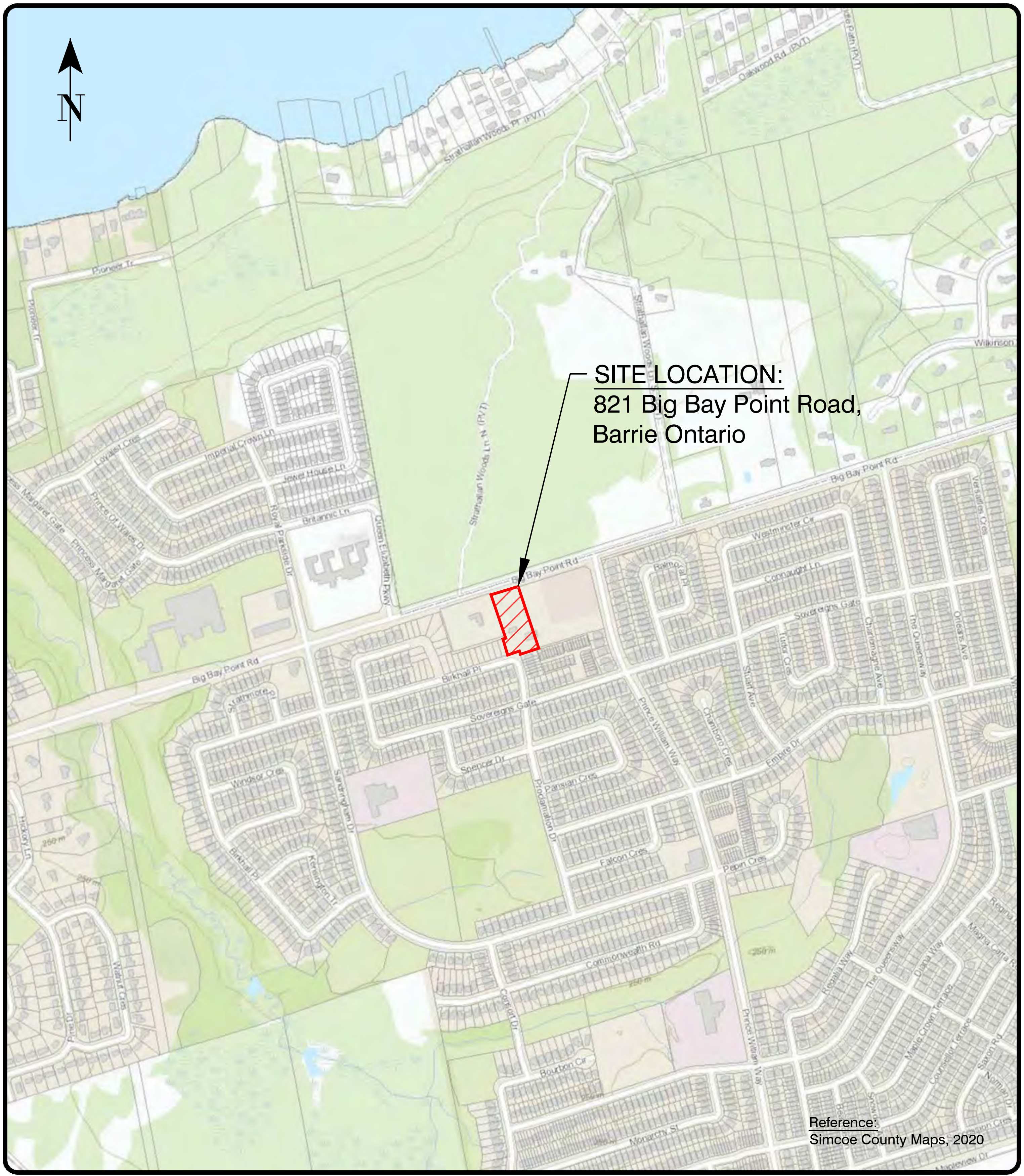
Figures –

SITE LOCATION PLAN

BOREHOLE LOCATION PLAN (AERIAL IMAGE)

BOREHOLE LOCATION PLAN (PROPOSED SITE)

SUBSURFACE PROFILE (LOOKING EAST)



SITE LOCATION:
821 Big Bay Point Road,
Barrie Ontario

Reference:
Simcoe County Maps, 2020

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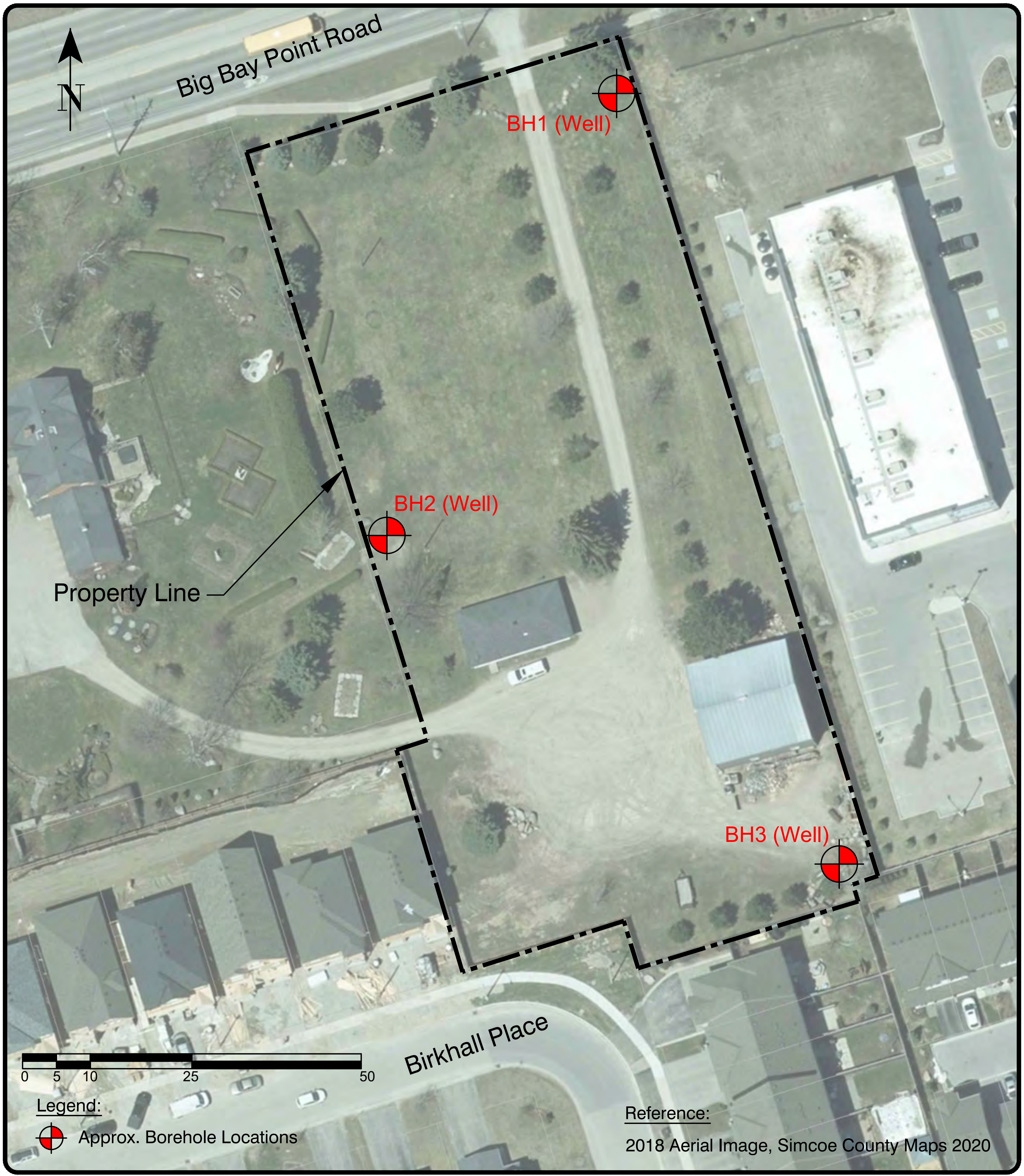
Geotechnical Engineering and Construction
Materials Testing & Inspection

647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	821 Big Bay Point Road, Barrie, ON				
Title:	Site Location Plan				
Approved by:	A.W.	Date:	October 2020	Project No.:	20-1199A
Drawn by:	B.H.	Scale:	N.T.S.	Figure No.:	1



Reference:

2018 Aerial Image, Simcoe County Maps 2020

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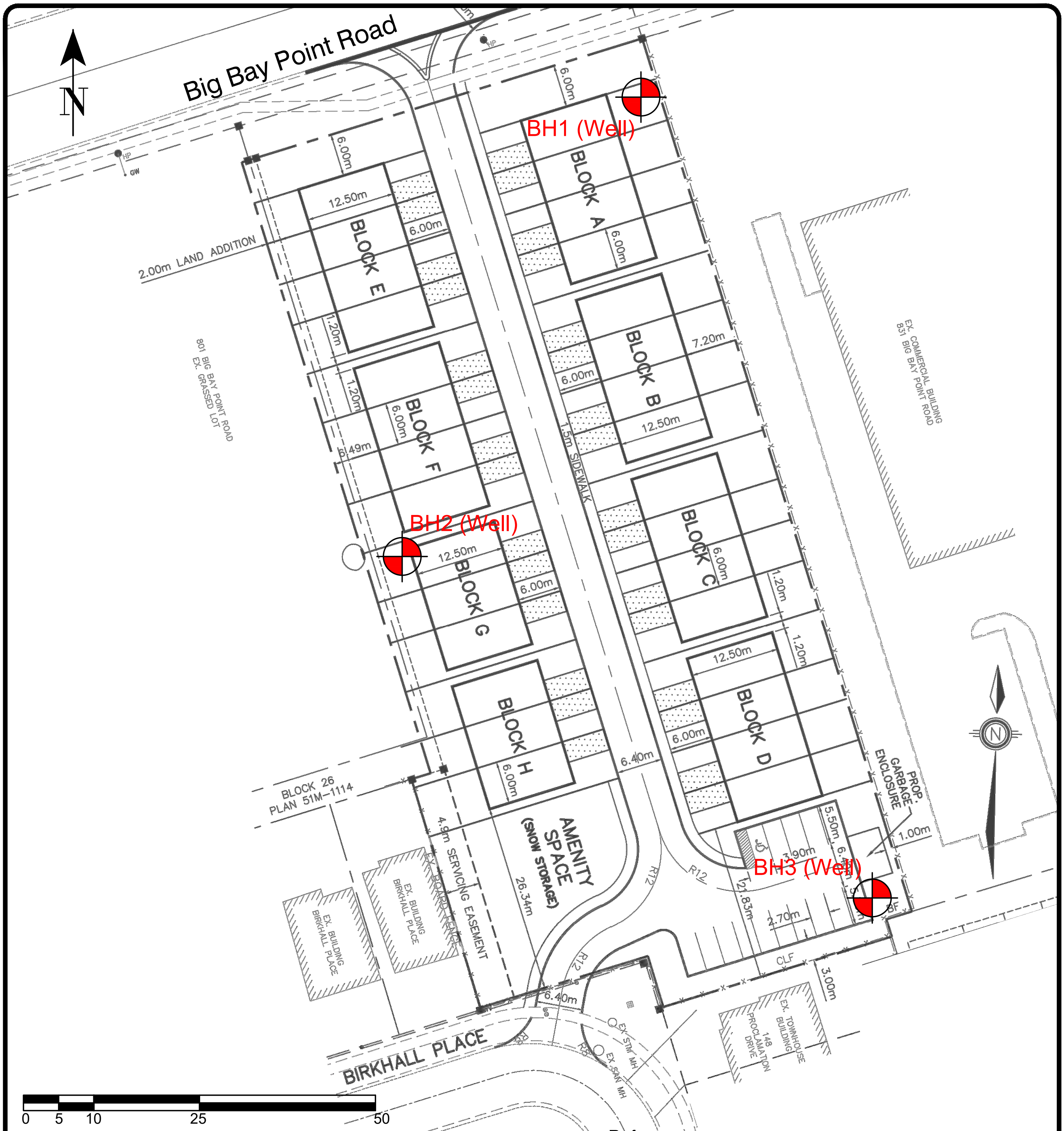
647 Welham Rd, Unit 14, Barrie, ON, L4N 0B7
P: (705) 719-7994 | E: info@centralearth.ca

Project:	821 Big Bay Point Road, Barrie, ON				
Title:	Borehole Location Plan (Aerial Image)				
Approved by:	A.W.	Date:	October 2020	Project No.:	20-1199A
Drawn by:	B.H.	Scale:	1:1000	Figure No.:	2A



Legend:

🟥 Approx. Borehole Locations

Reference:

"*Site Plan,*" Dwg. No. SP-1, Proj. No. 19105, revision 2
dated July 24, 2020, by Pearson Engineering Ltd.

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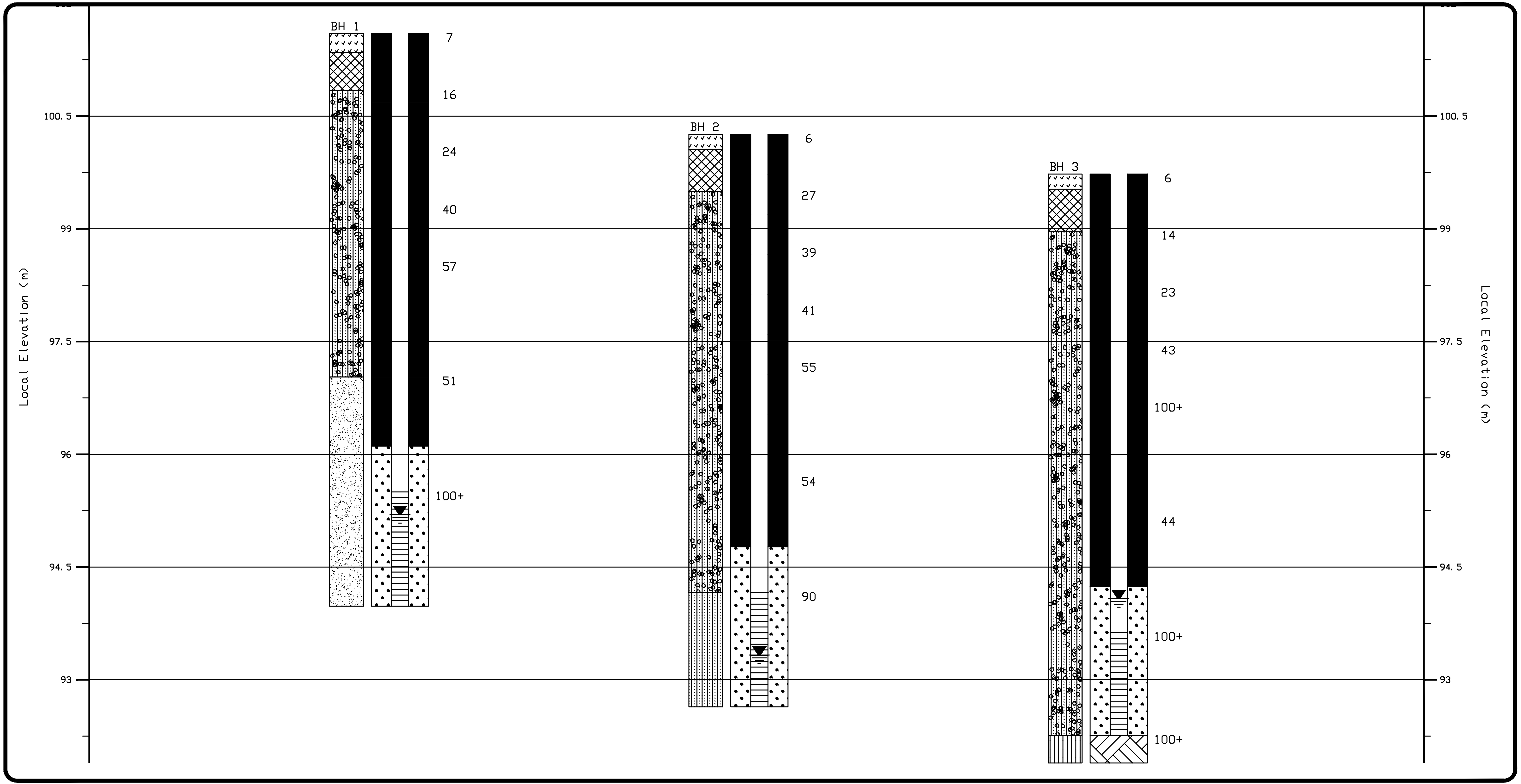
Project:	821 Big Bay Point Road, Barrie, ON
Title:	Borehole Location Plan (Proposed Site Plan)

Approved by:	A.W.	Date:	October 2020	Project No.:	20-1199A
Drawn by:	B.H.	Scale:	1:1000	Figure No.:	2B



Legend:

- ▼ Water Level in Monitoring Well
- ▦ Topsoil
- ▩ Earth Fill
- ▒ Sand
- ▥ Silty Sand
- ▨ Silty Sand Glacial Till
- ▥ Silt

Notes:

1. Numbers shown next to boreholes are SPT "N" Values.
2. Subsurface conditions known only at borehole locations.
3. Water Levels measured in wells on October 13, 2020.

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Project:	821 Big Bay Point Road, Barrie ON
Title:	Subsurface Profile (Looking East)
Approved by:	A.W.
Date:	October 2020
Project No.:	20-1199A
Drawn by:	B.H.
Scale:	Vertical: 1:50 Horizontal: N.T.S.
Figure No.:	3

Appendix A –

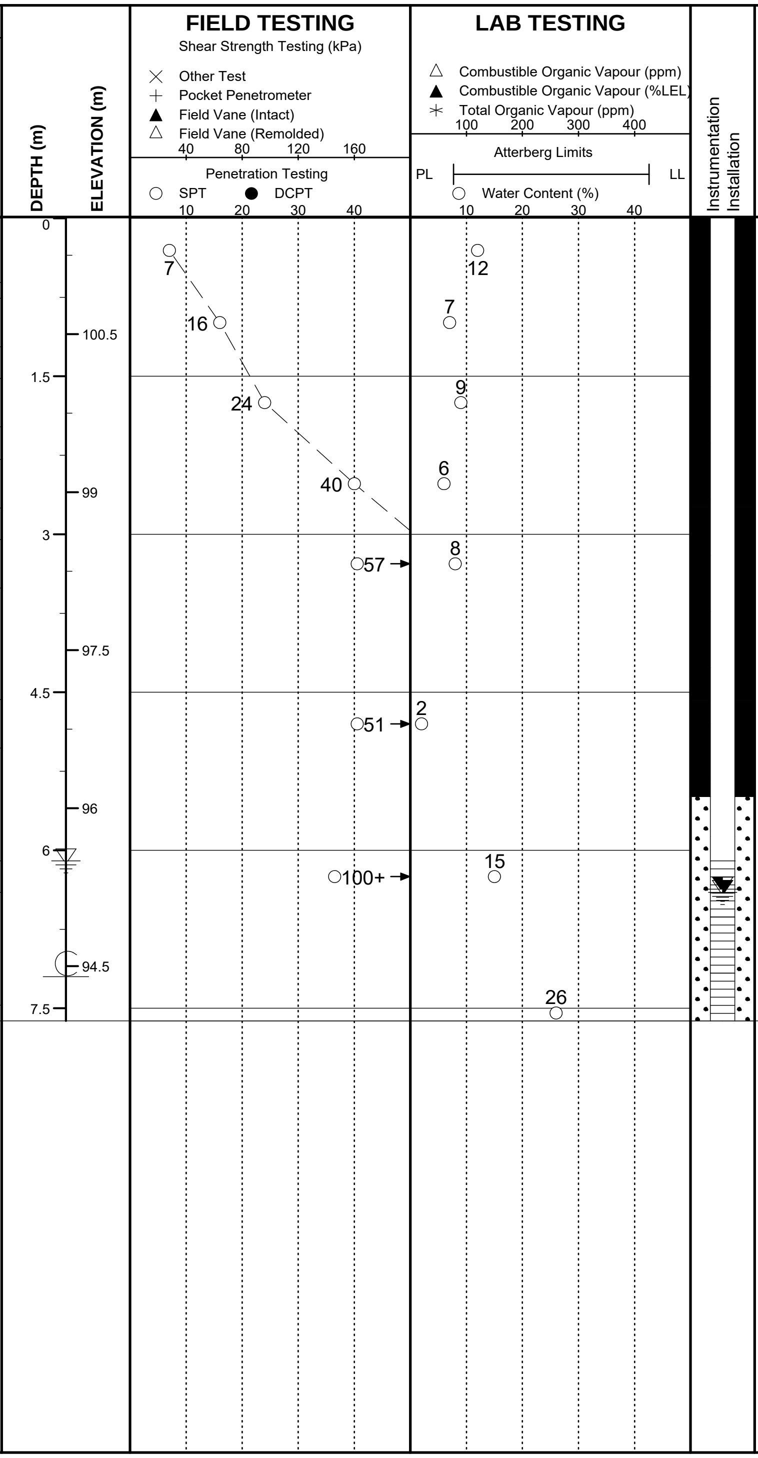
BOREHOLE LOGS

RECORD OF BOREHOLE No. 1

Project Number: **20-1199A**
Project Client: **Baldwin Planning and Development**
Project Name: **821 Big Bay Point Rd.**
Project Location: **Barrie, Ontario**
Drilling Location: **Northeast corner of site**

Drilling Method: **Hollow Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **BH**
Reviewed By: **AW**
Northing: **4913188**
Easting: **610162**
Date Started: **Oct. 1, 2020**
Date Completed: **Oct. 1, 2020**

LITHOLOGY PROFILE		SOIL SAMPLING						LAB TESTING	COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Depth / Elevation (Local 101.60m)	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT "N" Value			Water Content (%)	GR	SA	SI	CL
0.3 / 101.4	Topsoil = 250mm											
0.8 / 100.8	FILL: Sand & Silt, Trace Organics & Rootlets, Trace Clay, Loose, Brown, Moist	SS	1	100	7			12				
	SILTY SAND GLACIAL TILL, Trace Gravel, Trace Clay, Compact to Dense, Brown, Moist	SS	2	100	16			7				
		SS	3	100	24			9				
		SS	4	100	40			6				
	--- Very Dense ---	SS	5	100	57			8				
4.6 / 97.0	FINE SAND, Trace Silt, Very Dense, Brown, Damp	SS	6	100	51			2	0	92	(8)	
	- - - Moist - - -	SS	7	100	100+			15				
7.6 / 94.0	- - - Wet - - -	AS	8	100				26				
	End of Borehole @7.6m											



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Groundwater depth encountered on completion of drilling: **6.1m**

Cave depth after auger removal: **7.2m**

Groundwater depth observed on **Oct. 9/20** at a depth of: **6.37m**

Observed on **Oct. 13/20** at a depth of: **6.40m**

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'.

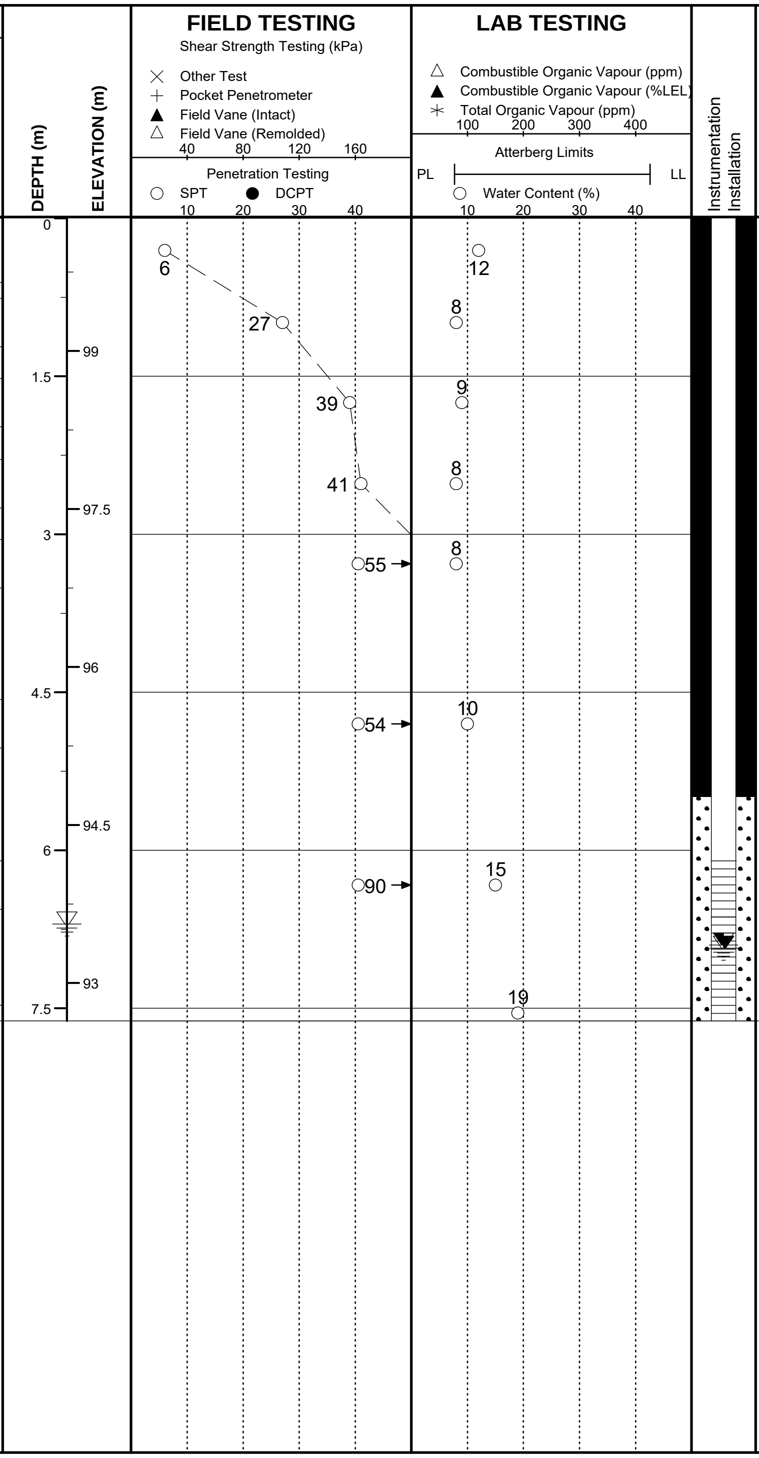
Scale: **1 :75**

RECORD OF BOREHOLE No. 2

Project Number: **20-1199A**
Project Client: **Baldwin Planning and Development**
Project Name: **821 Big Bay Point Rd.**
Project Location: **Barrie, Ontario**
Drilling Location: **Middle West of site**

Drilling Method: **Hollow Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **BH**
Reviewed By: **AW**
Northing: **4913123**
Easting: **610131**
Date Started: **Oct. 1, 2020**
Date Completed: **Oct. 1, 2020**

LITHOLOGY PROFILE			SOIL SAMPLING						LAB TESTING	COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Depth (m)	DESCRIPTION (Local 100.26m)	Elevation (m)	Sample Type	Sample Number	Recovery (%)	SPT "N" Value			Water Content (%)	GR	SA	SI	CL
0.2	Topsoil = 200mm	100.1											
0.8	FILL: Sand & Silt, Trace Organics & Rootlets, Trace Clay, Loose, Brown, Moist	99.5	SS	1	100	6			12				
	SILTY SAND GLACIAL TILL, Trace Gravel, Trace Clay, Compact to Dense, Brown, Moist		SS	2	100	27			8				
			SS	3	100	39			9	2	58	30	10
			SS	4	100	41			8				
	--- Very Dense ---		SS	5	100	55			8				
6.1		94.2	SS	6	100	54			10				
	SILTY SAND, Trace Gravel, Very Dense, Brown, Moist		SS	7	100	90			15				
7.6	- - - Wet - - -	92.6	AS	8	100				19	1	68	(21)	
	End of Borehole @7.6m												



CENTRAL EARTH ENGINEERING

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Groundwater depth encountered on completion of drilling: **6.7m**

Cave depth after auger removal: **Open**

Groundwater depth observed on **Oct. 9/20** at a depth of: **6.90m**

Observed on **Oct. 13/20** at a depth of: **6.93m**

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'.

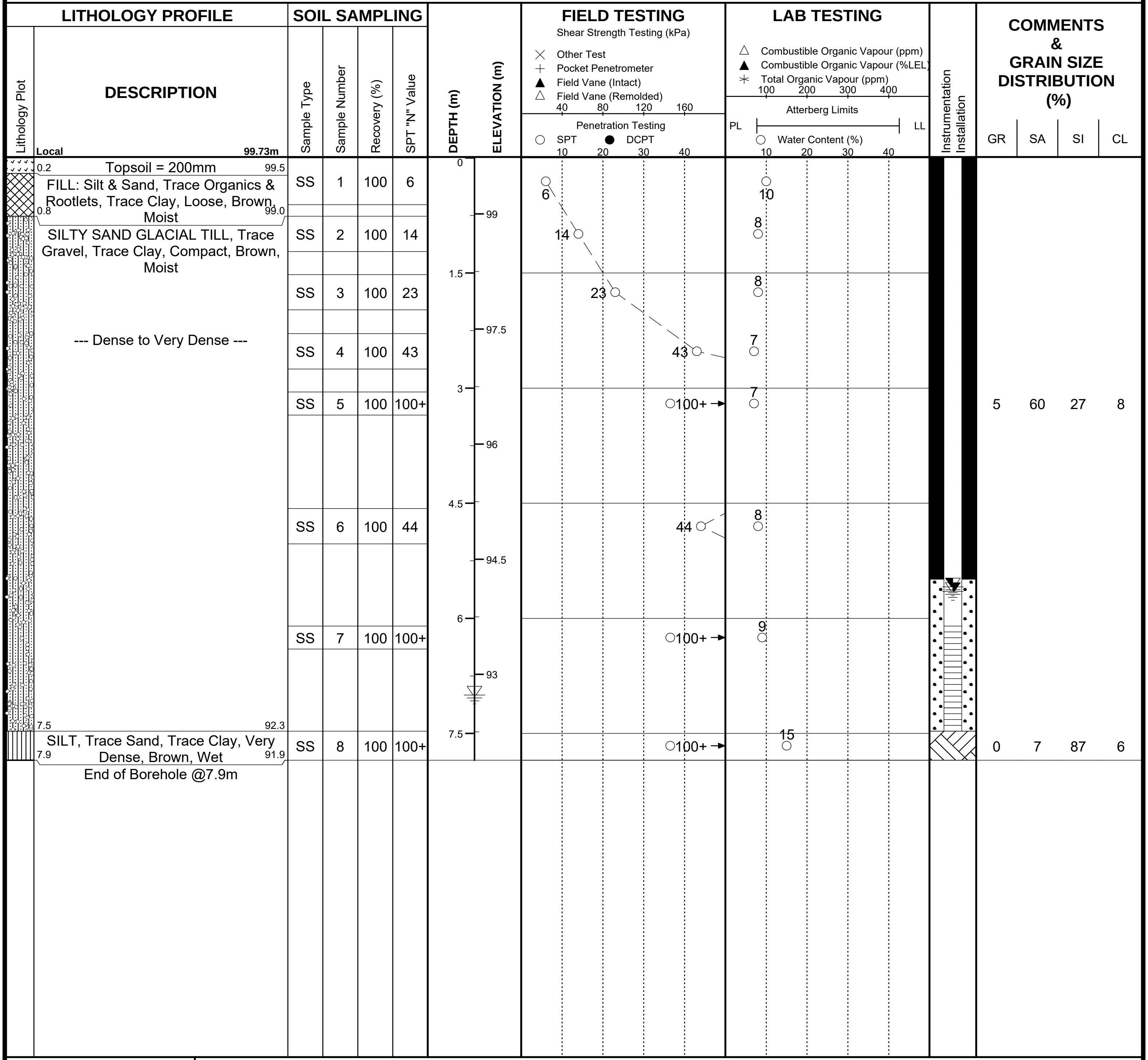
Scale: **1 :75**

Page: **1 of 1**

RECORD OF BOREHOLE No. 3

Project Number: **20-1199A**
Project Client: **Baldwin Planning and Development**
Project Name: **821 Big Bay Point Rd.**
Project Location: **Barrie, Ontario**
Drilling Location: **South east of site**

Drilling Method: **Hollow Stem Augers**
Drilling Machine: **Track Mount**
Logged By: **BH**
Northing: **4913077**
Date Started: **Oct. 1, 2020**
Reviewed By: **AW**
Easting: **610194**
Date Completed: **Oct. 1, 2020**



Depth (m)	Elevation (m)	Description	Sample Type	Sample Number	Recovery (%)	SPT "N" Value	Water Content (%)	GR	SA	SI	CL
	Local 99.73m										
0.2	99.5	Topsoil = 200mm									
0.8	99.0	FILL: Silt & Sand, Trace Organics & Rootlets, Trace Clay, Loose, Brown, Moist	SS	1	100	6	10				
		SILTY SAND GLACIAL TILL, Trace Gravel, Trace Clay, Compact, Brown, Moist	SS	2	100	14	8				
			SS	3	100	23	8				
		--- Dense to Very Dense ---	SS	4	100	43	7				
			SS	5	100	100+	7	5	60	27	8
			SS	6	100	44	8				
7.5	92.3		SS	7	100	100+	9				
7.9	91.9	SILT, Trace Sand, Trace Clay, Very Dense, Brown, Wet	SS	8	100	100+	15	0	7	87	6
		End of Borehole @7.9m									

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Groundwater depth encountered on completion of drilling: **7.0m**

Cave depth after auger removal: **Open**

Groundwater depth observed on **Oct. 9/20** at a depth of: **5.59m**

Observed on **Oct. 13/20** at a depth of: **5.65m**

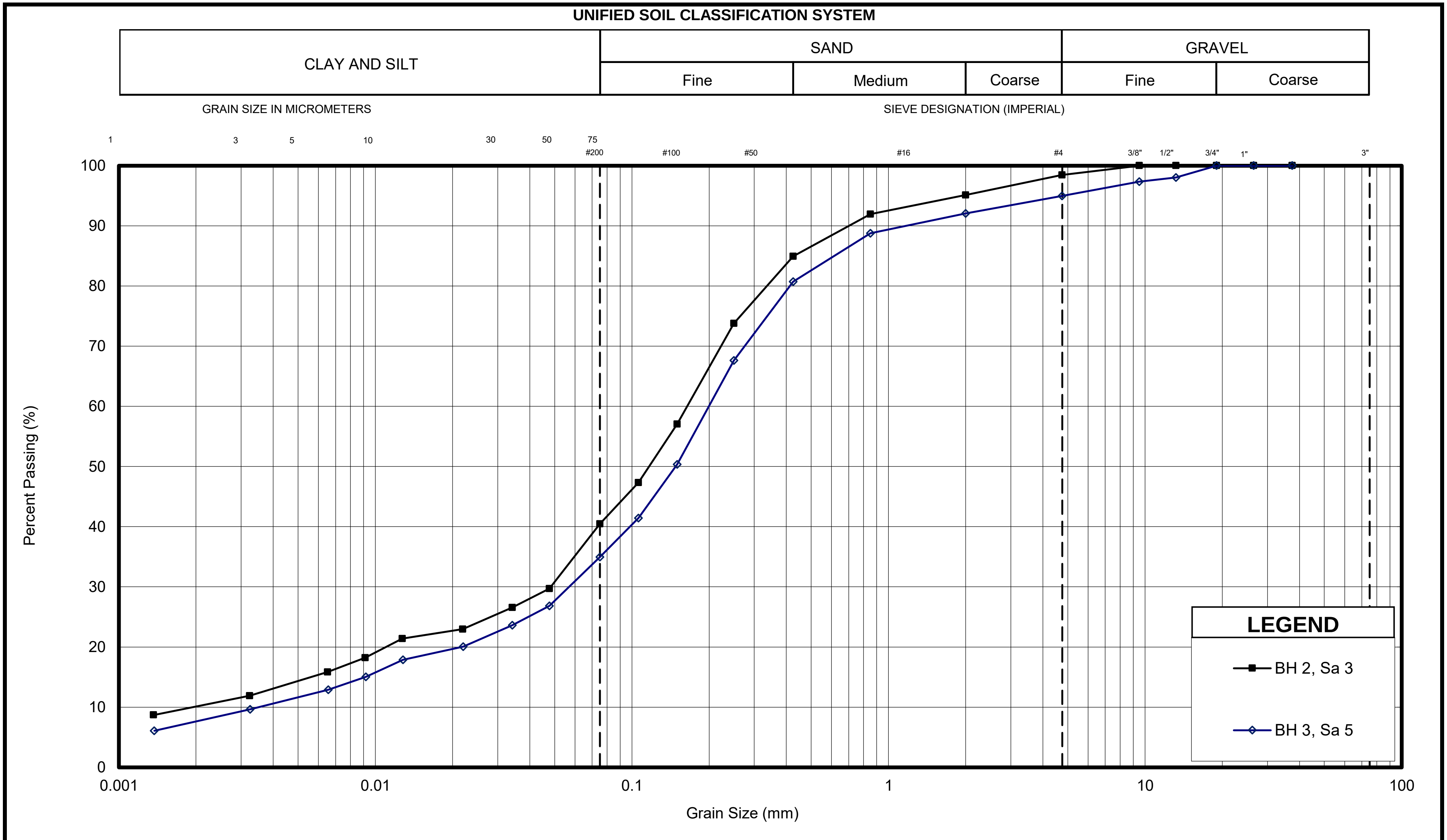
Borehole details presented do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified geotechnical engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and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

Scale: **1 :75**

Page: **1 of 1**

Appendix B –

GEOTECHNICAL LABORATORY DATA



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 2, Sa 3	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	2	58	30	10	0.001	0.048	0.15	84.87	7.32
BH 3, Sa 5	SILTY SAND GLACIAL TILL, Trace Clay, Trace Gravel	5	60	27	8	0.003	0.077	0.15	57.05	4.63

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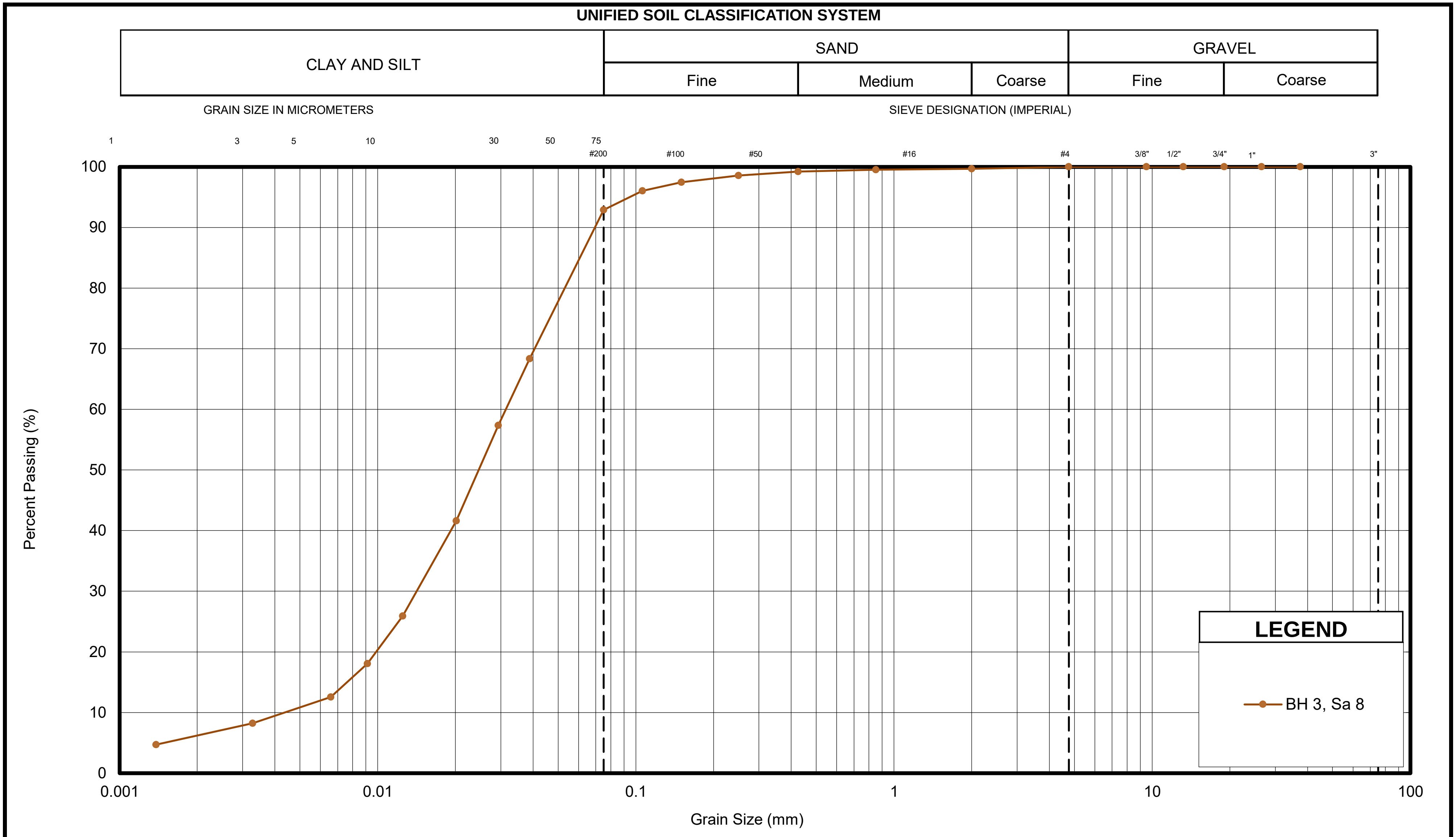
GRAIN SIZE DISTRIBUTION

SILTY SAND GLACIAL TILL

APP. No.	B1
REF. No.	20-1199A
DATE	October 2020



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 3, Sa 8	SILT, Trace Sand, Trace Clay	0	7	87	6	0.003	0.012	0.029	7.22	1.46

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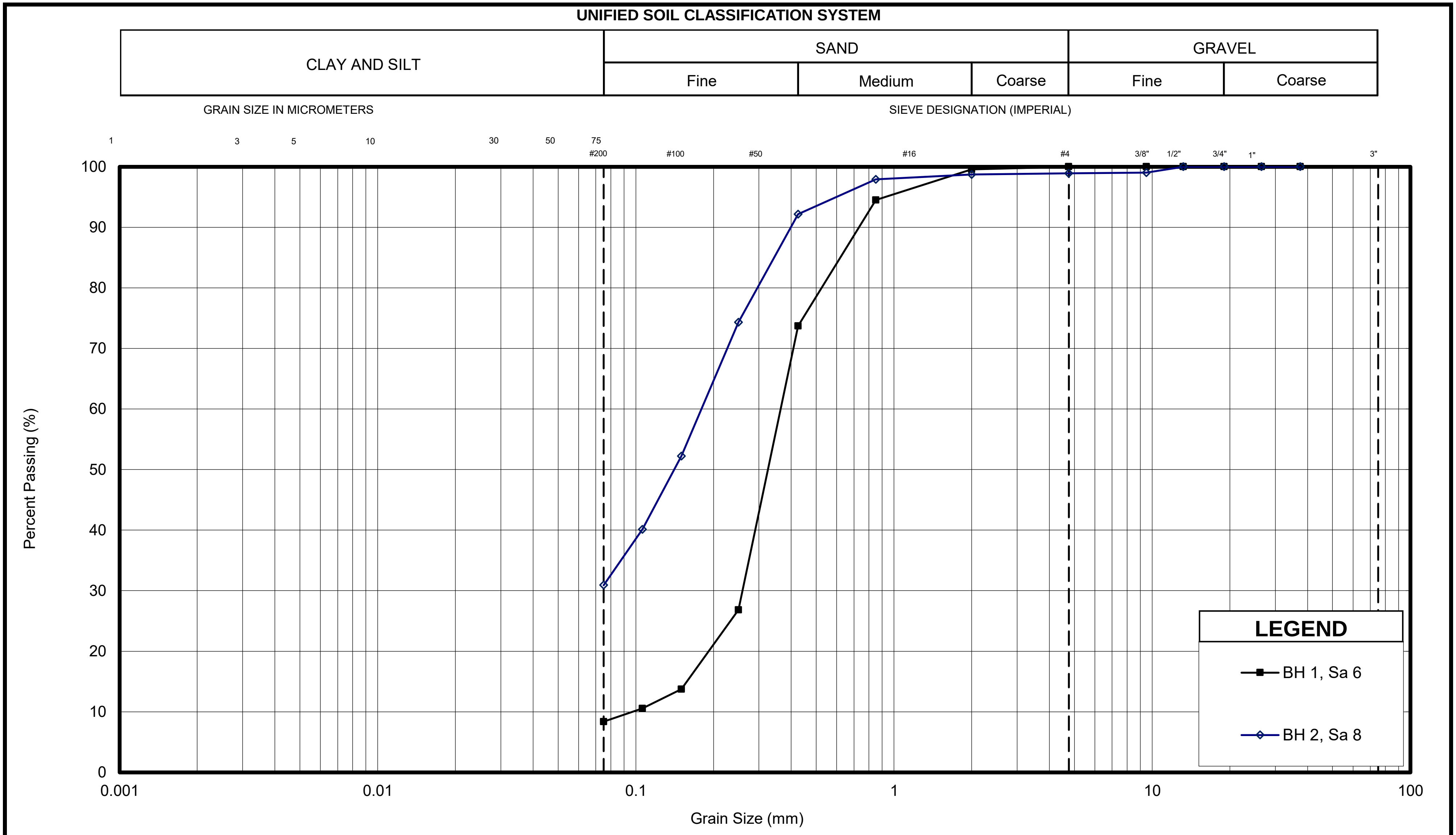
GRAIN SIZE DISTRIBUTION

SILT

APP. No.	B2
REF. No.	20-1199A
DATE	October 2020



Sample	Description	Gr.	Sa.	Si.	Cl.	D_{10}	D_{30}	D_{60}	C_u	C_c
BH 1, Sa 6	SAND, Trace Fines	0	92	8		0.075	0.25	0.25	3.76	1.91
BH 2, Sa 8	SAND, Some fines, Trace Gravel	1	68	21		0	0	0.15	-	-

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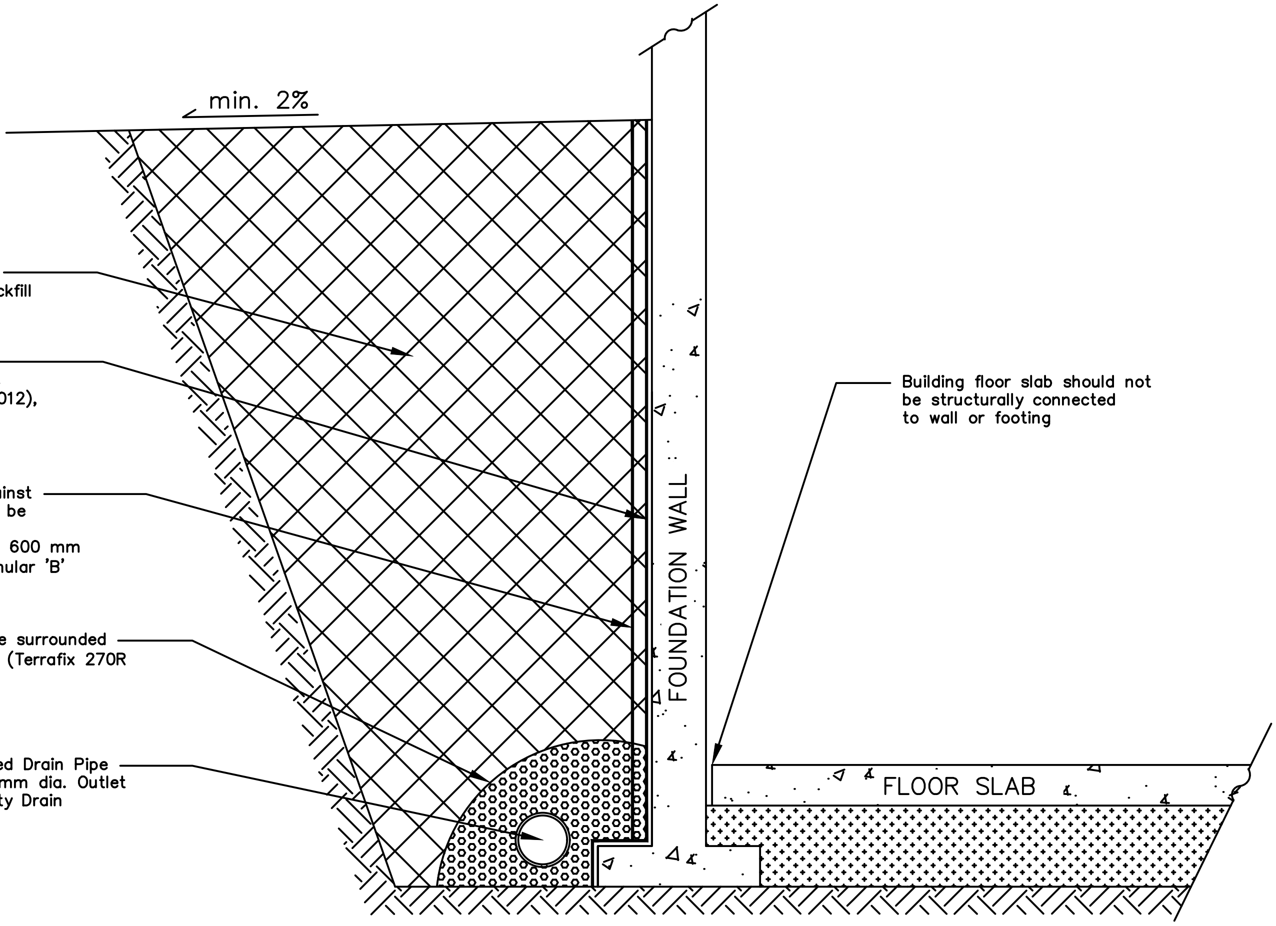
GRAIN SIZE DISTRIBUTION

SAND

APP. No. B3
REF. No. 20-1199A
DATE October 2020

Appendix C –

TYPICAL DETAILS



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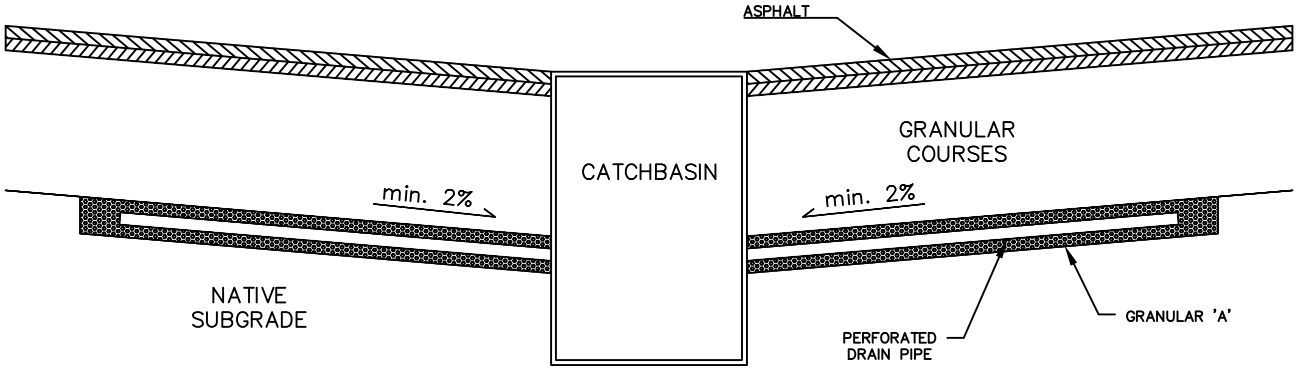
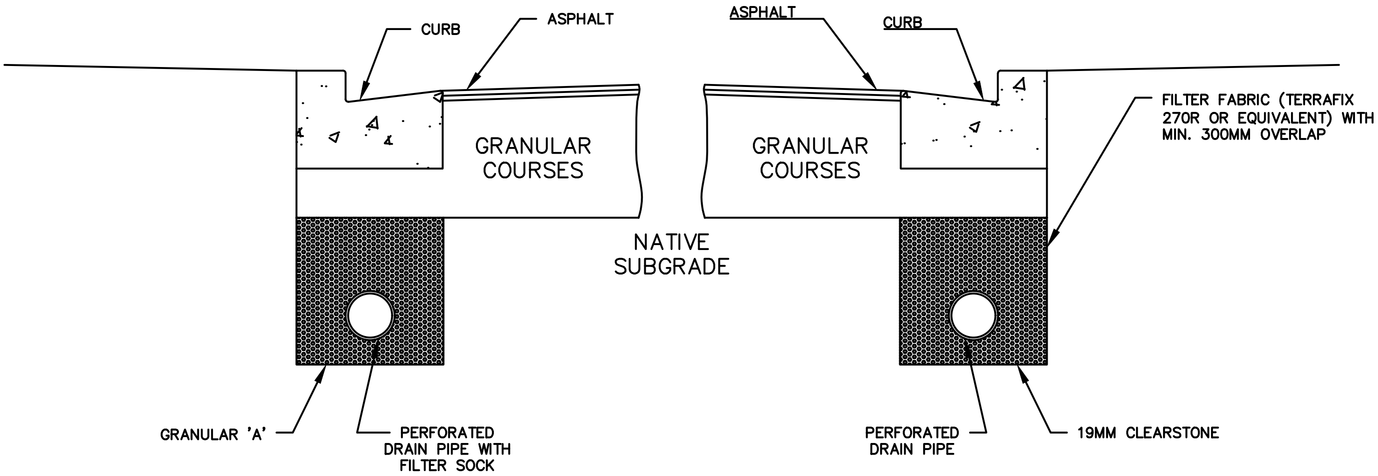
BASEMENT FOUNDATION WALL DRAINAGE TYPICAL DETAIL

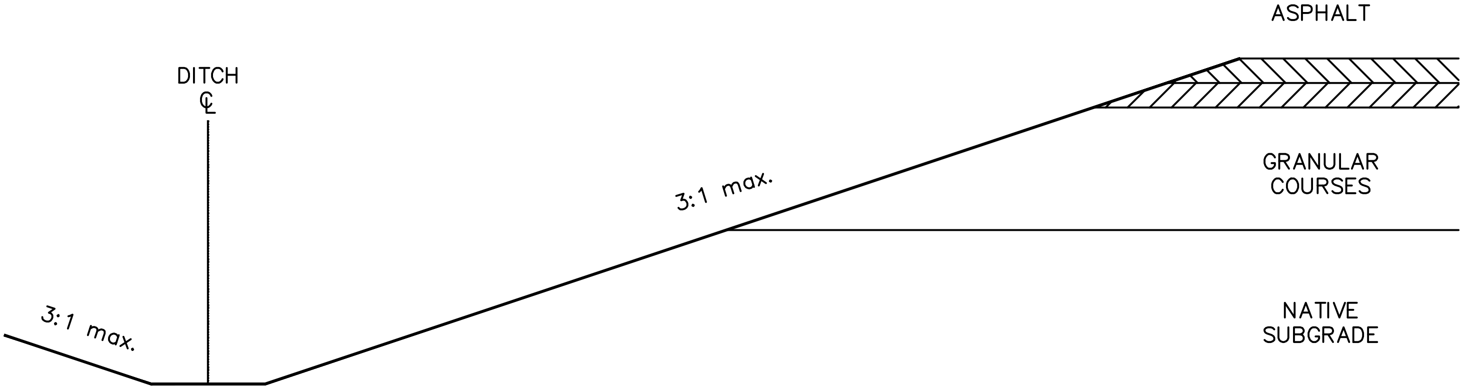




Unwrapped Trench

Wrapped Trench

Urban Cross Sections



Rural Cross Section

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PAVEMENT DRAINAGE ALTERNATIVES
TYPICAL DETAILS