ORBITENGINEERING
Consulting Engineers

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
7170 GOREWAY DRIVE, MISSISSAUGA, ONTARIO

Prepared for:

Rup Lal c/o Weston Consulting

By:

Orbit Engineering Limited

Project No. OE20373CG

June 9, 2021

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ORBIT ENGINEERING
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Rup Lal c/o Weston Consulting
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Attention: Mr. Rup Lal,

Dear Mr. Lal,

RE: Geotechnical Investigation
Proposed Residential Development
7170 Goreway Drive, Mississauga, ON

Enclosed please find the geotechnical investigation report related to the above noted site.

For and on behalf of Orbit Engineering Limited,

Hafiz Muneeb Ahmad, M.Sc., M.Eng., P.Eng. QP_{ESA}
Principal Engineer

EXECUTIVE SUMMARY

A Geotechnical Investigation was carried out for the proposed residential development located at 7170 Goreway Drive, Mississauga Ontario. The project will consist of 15 residential units, roads and sewers. It is our further understanding that each unit will be a 3-storey townhouse with basement.

The topsoil thickness generally ranged from 300mm to 450mm at the borehole locations. Thickness of topsoil may vary between and beyond the boreholes. The surficial topsoil was underlain by the following layers of native soils:

The Upper Weathered/disturbed Zone to depths ranging from 0.6 m to 0.8 m below the existing grade was consisted of moist to very moist, soft to firm clayey silt to silty clay with some topsoil inclusions and rootlets.

The Middle clayey silt to silty clay till layer extending to depths ranging from 2.3 m to 3.7m was generally moist and in firm to very stiff state.

The Lower till deposits including sandy silt to silt till encountered in boreholes (BH1/MW at 2.3, BH2/MW at 3.7 m, BH3/MW at 2.3 m and BH4 at 2.3 m) which extended to maximum explored depth of 6.1 m and were generally moist to wet and in compact state.

During drilling and at the completion, the short term (not stabilized) groundwater was found in boreholes at depths varying from 2.3 m to 4.6 m below the existing ground surface. A 50mm diameter monitoring well was installed in three boreholes (BH1/MW, BH2/MW and BH3/MW), and water level observations were made periodically. The summary of ground water observations is presented in Table 3.1. A perched water condition can occur due to the accumulation of surface water at the interface of weathered/disturbed native soils and till deposits. It should be noted that groundwater levels vary and are subjected to seasonal fluctuations and can respond to major precipitation events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches.

In light of borehole information, the proposed house foundations can be supported on conventional spread and/or strip footings founded on the undisturbed native soil (at or below elevations shown in Table 4.3) for a geotechnical reaction of 150 kPa at the Serviceability Limit States (SLS) and a factored geotechnical resistance (with geotechnical resistance factor of 0.5) of 225 kPa at the Ultimate Limit State (ULS). The bearing pressures and the highest founding elevations at borehole locations are given in **Table 4.3.** The recommended founding levels and geotechnical resistance for the proposed development will need to be confirmed by Orbit at the time of construction.

Alternatively, the proposed structures can be supported by conventional spread and strip footings founded on engineered fill for a geotechnical reaction of 150kPa at the Serviceability Limit States (SLS) and a factored geotechnical resistance of 225kPa ULS. The engineered fill supporting footings should be constructed in accordance with the guidelines presented in **Appendix C**. Other requirements of engineered fill are given in Section 4.4.

The floor slab can be supported on grade, provided all topsoil, existing weathered/disturbed and surficially softened or loose materials are removed, and the subgrade thoroughly proof rolled. Any loose spots or areas revealed from proof rolling must be sub-excavated, backfilled and compacted.

Prior to the placement of the engineered fill, all of the existing weathered/disturbed and softened or loose native soils must be removed, and the exposed surface proof rolled. The depths of sub-excavation required for the construction of engineered fill at the borehole locations ranged from 0.8m to 1.0m, as listed in **Table 4.2**.

No major groundwater problems are anticipated for the installation of foundations and underground services to approximate depth of 3m± as the soil is generally cohesive. Seepage from wet sandy seams/lenses should be expected but in all likelihood water seepage should be controllable by the use of conventional pumping from collection sumps and ditches for most excavations. Contractors should be prepared to employ more elaborate dewatering procedures such as well points if the flow from sand seams or pockets becomes a problem.

Discussion and recommendations for the construction of roads, sewers, excavations and backfill are presented in Section 4.

Based on the borehole information, the subject site for the proposed building structures can be classified as "Class D" for seismic site response. Consideration can be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e. Geophysical testing – Multi-channel Analysis of Surface Waves "MASW"), which can lead to an improved site classification (i.e., from Class D to Class C).

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1 INTRODUCTION

Orbit Engineering Limited (Orbit) was retained by Rup Lal c/o Weston Consulting to undertake a Geotechnical Investigation for the proposed residential development located at 7170 Goreway drive, Mississauga, Ontario. The site plan and approximate location of the proposed development are shown on **Drawings 1** and **1A** respectively.

In light of the information provided to us by the client, it is our understanding that the project will consist of 15 residential units, roads and sewers. It is our further understanding that each unit will be a 3-storey townhouse with basement.

The purpose of this Geotechnical Investigation was to obtain information about the subsurface conditions by means of a limited number of boreholes (BH1 to BH4) and from the findings in the boreholes to make recommendations pertaining to the geotechnical design of underground utilities and roads and to comment on the foundation conditions for general house construction.

This report contains the findings of the investigation, together with our recommendations and comments. The anticipated construction conditions are also discussed but only to the extent that they may affect the geotechnical design. The construction methods discussed express our opinion only and are not intended to direct contractors how to carry out the construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all factors that may have an effect upon construction.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Rup Lal. c/o Weston Consulting and its designers. Third party use of this report without Orbit consent is prohibited. The limitation conditions presented in **Appendix A** form an integral part of the report and they must be considered in conjunction with this report.

2 FIELD AND LABORATORY WORKS

Prior to drilling operations, underground utilities were cleared at the borehole locations by representatives of the public utilities company working with personnel from Orbit.

A total of four boreholes (see **Drawing 1A** for locations) were drilled on March 26, 2021 (BH1 to BH4) to a maximum depth of 5.2m with solid stem continuous flight augers by a drilling sub-contractor under the direction and supervision of Orbit personnel. Samples were retrieved with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 63.5 kg and dropping 760mm in accordance with the Standard Penetration Test (SPT) method (ASTM D1586). The samples were logged in the field and returned to the Orbit's laboratory for detailed examination by the project engineer and for index laboratory testing.

As well as visual examination in the laboratory, all the soil samples were tested for moisture content and selected samples for grain size analyses.

Water level observations were made during drilling and in the open boreholes at the completion of the drilling operations. Monitoring wells (50mm) were installed in three boreholes (BH1, BH2 and BH3) for an extended period of groundwater level monitoring.

The borehole elevations were interpreted by Orbit staff from the topographical survey provided by the client. Note, these elevations are approximate and only for the purpose of relating borehole soil stratigraphy and should not be used or relied on for other purposes

3 SITE AND SUBSURFACE CONDITIONS

The project site is at 7170 Goreway Drive, Mississauga Ontario. A total of four boreholes (BH1 to BH4) were advanced at this site. The existing ground surface elevations at borehole locations vary from 166.1m to 166.5m.

The project site location plan is presented on Drawing 1. The approximate borehole locations are shown on **Drawing 1A**. Notes on sample descriptions are presented on **Drawing 1B**. Detailed subsurface conditions are presented on the Borehole Logs, **Drawings 2 to 5**.

The borehole logs indicate the subsurface conditions only at the borehole locations. Note the material boundaries indicated on the borehole logs are approximate and based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions will vary across this site. The subsurface soil conditions are summarized as follows.

3.1 Topsoil

The thickness of the topsoil explored in the boreholes generally ranged from 300mm to 450mm. The data provided here pertaining to the topsoil thickness is confirmed at the borehole locations only and may vary between and beyond the boreholes. This information is not considered to be sufficient for estimating topsoil quantities and associated costs.

3.2 Native Soils

The surficial topsoil layer was underlain by the following layers of native soils.

3.2.1 Weathered/Disturbed Soil

The Upper Weathered Zone to depths ranging from 0.6 m to 0.8 m below the existing grade was consisted of moist to very moist, soft to firm clayey silt to silty clay with trace to some topsoil inclusions and rootlets.

3.2.2 Glacial Till

The Middle clayey silt to silty clay till layer extending to depths ranging from 2.3 m to 3.7m was generally moist and firm to very stiff state. The clayey silt to silty clay till layer was generally greyish brown to brownish grey. The results indicate that the relative density of the till deposits can be described as firm to very stiff.

Typical grain size distribution curves of the samples from different depths in boreholes BH2/MW and BH3/MW are given on **Figure B1** in **Appendix B** and show the following gradation:

Gravel:	0 – 1	%
Sand:	2 – 18	%
Silt:	38 – 58	%
Clay:	23 – 60	%

3.2.3 Sandy Silt to Silt Till

The Lower till deposits including sandy silt to silt till encountered in boreholes (BH1/MW at 2.3, BH2/MW at 3.7 m, BH3/MW at 2.3 m and BH4 at 2.3 m) which extended to maximum explored depth of 6.1 m were generally greyish brown to grey, moist to wet and in compact state.

The measured moisture contents of the native deposits are shown on the borehole logs, which are generally less than 25 percent by weight.

The grain size distribution of the sandy silt to silt till deposits is presented on **Figure B2** in **Appendix B** and show the gradation as 1-12% gravel, 0-36% sand 42-93% silt and 3-19% clay.

3.3 Groundwater Conditions

During drilling and at the completion, the short term (not stabilized) groundwater was found in boreholes at depths varying from 2.3 m to 4.6 m below the existing ground surface. Three boreholes (BH1/MW, BH2/MW and BH3/MW) were converted into monitoring wells to monitor the groundwater for an extended period of time. The summary of ground water observations is presented in **Table 3.1**

A perched water condition can occur due to the accumulation of surface water at the interface of weathered/disturbed native soils and till deposits. It should be noted that groundwater levels vary and are subjected to seasonal fluctuations and can respond to major precipitation events. The depth of groundwater table can also be influenced by the presence of underground features such as utility trenches.

Table 3.1 Groundwater Levels Observed in Boreholes

BH No.	Date of Drilling	Date of Water Measurement	Depth/Elevation of the Tip of Monitoring well (m)	Depth/Elevation of Groundwater (m)	Monitoring Well
BH1/MW	Mar 26, 2021	During drilling	5.8/160.3	2.3/163.8	Yes
		29 Mar 2021		1.9/164.2	
		07 Apr 2021		1.9/164.2	
		08 Apr 2021		2.0/164.1	
BH2/MW	Mar 26, 2021	During drilling	4.3/162.2	4.6/161.9	Yes
		29 Mar 2021		2.5/164.0	
		07 Apr 2021		2.5/164.0	
		08 Apr 2021		2.5/164.0	
BH3/MW	Mar 26, 2021	During drilling	4.8/161.4	3.1/163.1	Yes
		29 Mar 2021		2.5/163.7	
		07 Apr 2021		2.6/163.6	
		08 Apr 2021		2.5/163.7	

4 DISCUSSION & RECOMMENDATIONS

It is proposed to develop the site with 15 residential units. The units therefore will be serviced by a network of roads, storm and sanitary sewers and watermains. It is our further understanding that each unit will be a 3-storey townhouse with basement.

The following discussion and recommendations are based on the factual data obtained from this investigation and are presented for guidance of the design professionals only.

4.1 Frost Susceptibility of Soils

The frost depth penetration in this area is considered to be 1.2m. Based on the grain size analysis and using the Ministry of Transportation (MTO) category for frost susceptibility soils, the on-site native soils to can be classified as low susceptible to frost heaving.

4.2 Roads

The investigation has shown that the predominant subgrade soil, after stripping the topsoil, soft to firm weathered/disturbed clayey silt to silty clay and otherwise unsuitable subsoil, will generally consist of cohesive soils.

Based on the above and assuming that traffic usage will be residential minor local or local, the following minimum pavement thickness is recommended:

40mm HL3 Asphaltic Concrete

65mm HL8 Asphaltic Concrete

150mm Granular ‘A’

300mm Granular ‘B’

For bus routes and collector roads, the following minimum pavement thickness is recommended:

40mm HL3 Asphaltic Concrete

80mm HL8 Asphaltic Concrete

150mm Granular ‘A’

400mm Granular ‘B’

These values may need to be adjusted according to the City of Mississauga Standards. The site subgrade and weather conditions (i.e., if wet) at the time of construction may necessitate the placement of thicker granular sub-base layer in order to facilitate the construction. Furthermore, heavy construction equipment may have to be kept off the newly constructed roads before the placement of asphalt and/or immediately thereafter, to avoid damaging the weak subgrade by heavy truck traffic.

4.2.1 Stripping, Sub-excavation and Grading

The site should be stripped of all topsoil, weathered/disturbed native and any topsoil or otherwise unsuitable soils to the full depth of the roads, both in cut and fill areas.

Following stripping, the site should be graded to the subgrade level and approved. The subgrade should then be proof rolled, in the presence of the Geotechnical Engineer, by at least several passes of a heavy compactor having a rated capacity of at least 8 tonnes. Any soft spots thus exposed should be removed and replaced by select fill material, similar to the existing subgrade soil and approved by the Geotechnical Engineer. The subgrade should then be re-compacted from the surface to at least 98% of its Standard Proctor Maximum Dry Density (SPMDD). The final subgrade should be cambered or otherwise shaped properly to facilitate rapid drainage and to prevent the formation of local depressions in which water could accumulate.

In view of the low to medium permeability of the subsoil, proper cambering and allowing the water to escape towards the sides (where it can be removed by means of subdrains) is considered to be beneficial for this project. Otherwise, any water collected in the granular sub-base materials could be trapped thus causing problems due to softened subgrade, differential frost heave, etc. For the same reason damaging the subgrade during and after placement of the granular materials by heavy construction traffic should be avoided. If the moisture content of the local material cannot be maintained at ±2% of the optimum moisture content, imported granular material may need to be used.

Any fill required for regarding the site or backfill should be select, clean material, free of topsoil, organic or other foreign and unsuitable matter. The fill should be placed in thin layers and compacted to at least 95% of its Standard Proctor Maximum Dry Density (SPMDD). The degree of compaction should be increased to 98% within the top 1.0m of the subgrade, or as per City Standards. The compaction of the new fill should be checked by frequent field density tests.

4.2.2 Construction

Once the subgrade has been inspected and approved, the granular base and sub-base course materials should be placed in layers not exceeding 200mm (uncompacted thickness) and should be compacted to at least 100% of their respective SPMDD. The grading of the material should conform to current OPS (Ontario Provincial Standards) Specifications.

The placing, spreading and rolling of the asphalt should be in accordance with OPS Specifications or, as required by the local authorities.

Frequent field density tests should be carried out on both the asphalt and granular base and sub-base materials to ensure that the required degree of compaction is achieved.

4.2.3 Drainage

All paved surfaces should be sloped to provide satisfactory drainage towards catch basins. Installation of full-length subdrains on all roads is recommended. The subdrains should be properly filtered to prevent the loss of (and clogging by) soil fines.

4.3 Sewers

As a part of the site development, a network of new storm and sanitary sewers is to be constructed.

4.3.1 Trenching

As indicated in the boreholes, the trenches will be generally dug through Clayey soils (clayey silt to silty clay till) or sandy soils (sandy silt till).

The groundwater levels observed in the monitoring wells were at depths ranging from 1.9 m to 2.6 m below the existing grade. Where the anticipated trench base is below the groundwater level, no major groundwater problems are anticipated for the installation of foundations and underground utilities to approximate depth of 3m± as the soil is generally cohesive. Seepage from wet sandy seams/lenses should be expected but in all likelihood water seepage should be controllable by the use of conventional pumping from collection sumps and ditches for most excavations. Contractors should be prepared to employ more elaborate dewatering procedures such as well points if the flow from sand seams or pockets becomes a problem.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the firm to stiff weathered/disturbed soil, clayey silt to silty clay till and compact sandy silt to silt till above water table can be classified as **Type 3 soils**. The native soils consisting of very stiff clayey silt to silty clay till can be classified as **Type 2 soils**. Wet sandy deposits can be classified as **Type 4 soils**. As a general rule, the excavations in Type 2 soils can be carried out without support using side slopes 1H:1V, while the bottom 1.2m of the excavation can be cut vertically and could retain the wall for a short period of time. The excavation in Type 3 soil can be carried out maintaining the side slopes not steeper than 1H:1V. The excavations in Type 4 soils will require minimum flatter side slopes of 3H to 1V. These slopes should be visually monitored for any movement especially if workers are present within the excavation. These temporary slopes should only be utilized for a short duration. If an excavation contains more than one type of soil, the soil shall be classified as the type with the highest number among the types present.

4.3.2 Bedding

The undisturbed stiff to very stiff clayey native soils and compact sandy silt to silt till can provide adequate support for the sewer pipes and allow the use of normal Class B type bedding. The recommended minimum thickness of granular bedding below the invert of the pipes is 150mm. The thickness of the bedding may, however, have to be increased depending on the pipe diameter or in accordance with local standards or if wet or weak subgrade conditions are encountered, especially when the soil at the trench base level consists of wet, dilatant silts and sandy silts to clayey silt. The bedding material should consist of well graded granular material such as Granular ‘A’ or equivalent. After installing the pipe on the bedding, a granular surround of approved bedding material, which extends at least 300mm above the obvert of the pipe, or as set out by the local Authority, should be placed.

To avoid the loss of soil fines from the subgrade, uniformly graded clear stone should not be used unless, below the granular bedding material, a suitable approved filter fabric (geotextile) is placed. The geotextile should extend along the sides of the trench and should be wrapped all around the poorly graded bedding material.

4.3.3 Backfilling of Trenches

The native soils free from topsoil and organics can be used as general construction backfill where it can be adequately compacted with suitable type compactors. Loose lifts of soil, which are to be compacted, should not exceed 200mm. It should be noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should be compacted at the surface or be covered with tarpaulins to minimize moisture intake.

The on-site native very stiff clayey soils will excavate in blocks or chunks, which should be adequately pulverized prior to placement in the trenches. Heavy sheep’s foot compactors would be best suited for these soils, but such heavy equipment may be difficult to operate within the narrow confines of the trenches. These soils may therefore present some difficulty in compacting. If such soils are not adequately pulverized, placed in thin lifts and carefully compacted then excessive post construction settlements at the ground surface could occur.

The backfill should be placed in maximum 200mm thick layers at or near (±2%) their optimum moisture content and each layer should be compacted to at last 95% SPMDD. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling.

The on-site excavated soils may not be used in confined areas (e.g., around catch basins and laterals under roadways) where heavy compaction equipment cannot be operated. The use of imported granular fill together with an appropriate frost taper would be preferable in confined areas and around structures, such as catch basins.

The excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

In light of borehole information, it is recommended that underground services should be kept as high as possible to avoid penetrating the excavation below the wet sandy deposits.

4.3.4 Thrust Blocks

Pressurized fluids in buried pipelines generate unbalanced, thrust forces at bends, junctions, valves pump starts or stops, valve closures, air vents and all restrictions to, and changes in direction of flows. Generally, the thrust forces depend on the internal pressure, the cross-sectional area of the pipe and the deflection angle. For pipes which are not anchored, the unbalanced thrust forces must be resisted either by thrust blocks and collars or by thrust restraint systems or a combination of both.

Thrust blocks are passive systems which prevent the pipe joint leaking by blocking the pipe movements and the separation of unrestrained joints. Depending on the source of the thrust force, their resistance comes either from the mobilization of soil bearing capacity or dead weight: the bearing type thrust blocks resist thrust forces corresponding to concave vertical and horizontal bends, while the gravity ones secure the convex vertical bends. Because they need to immobilize the pipes, the allowable soil stresses must be considerably smaller than those required to cause ultimate failure of the thrust block itself. The thrust block design is satisfactory if the design force, F_d, is less than the ultimate resistance R_{ult}, reduced by a suitable reduction (safety) factor which will ensure that the displacements will be relatively small.

Values for thrust reduction factors for thrust blocks are given in **Table 4.1** for different soil and rock types. If these lead to unacceptably large thrust blocks, the reduction factor may be re-assessed by determining the actual relationship between thrust reduction factor and displacement under defined load and ground conditions.

Table 4.1 Reduction Factors for Thrust Blocks

Soil or Rock Type	Reduction Factor (T_r)
Dense sandy deposit/stiff to very stiff clayey silt	2 to 3
Compact sandy deposit/firm clayey silt	3 to 4
Very loose to loose sandy deposit/soft clayey silt	4 to 5

Thrust blocks normally consist of a volume of concrete, usually of nominal strength (20-40 MPa), which may be lightly reinforced. The size and shape of the block is decided on the basis of the forces to be restrained, the size and style of the pipe fitting or component, and local ground conditions. The effectiveness of any thrust block is determined by its mass, shape, position relative to the pipeline, the soil reactions on the block, and friction between the pipeline and the surrounding ground.

Thrust blocks for the underground services under pressure may be constructed in native soils in areas where there is no risk of future excavations. The back of the thrust blocks should be vertical and should be cast directly against undisturbed natural soils. The ultimate lateral resistance of thrust blocks can be calculated in accordance with **Drawing 6**.

Thrust restraint systems are alternative to thrust blocks. They are active systems in the sense that they rely on the mobilization of pipe/soil friction and/or passive resistance in the soil for a sufficient length away from the junction. The length of pipeline required to develop the resisting force crucially depends on the type of junction, pipeline material, type and compaction/consistency of the backfill, etc.

4.4 Engineered Fill and Sub-Excavation

The elevation of the existing grade at the site is relatively flat. However, based on the grading plan and existing topography at the site, cut and fill operations are expected to require as part of the proposed development.

In the areas where earth fill is required for site grading purposes, engineered fill can be constructed below house foundations, roads, boulevards, etc.

Prior to the placement of the engineered fill, all of the existing topsoil and surficially weathered/disturbed native soils must be removed and the exposed surface proof rolled. Any soft spots revealed during proof rolling must be sub-excavated and re-engineered. The depths of sub-excavation required for the construction of engineered fill at the borehole locations approximately ranged from 0.8m to 1.0m, as listed in **Table 4.2**.

The groundwater levels observed in boreholes were at depths ranging from 1.9 m to 2.5m below the existing ground surface (refer to **Table 3.1**). Where the excavation base for engineered fill is below the groundwater level, dewatering will be required to lower the water table below the excavation base. It is possible to lower the groundwater table for about 0.6m to 1.0m by pumping from perimeter sumps and trenches.

Table 4.2 Depths of Sub-Excavation for Engineered Fill Construction

Borehole No.	Depth of Sub-Excavation of weathered/disturbed Materials (m)	Depth of Groundwater (m)
BH1/MW	1.0	1.9
BH2/MW	0.8	2.5
BH3/MW	1.0	2.5
BH4	0.8	-

General guidelines for the placement and preparation of engineered fill are presented on **Appendix C**. A geotechnical reaction 150kPa at the Serviceability Limit States (SLS) and factored geotechnical resistance 225kPa at the Ultimate Limit States (ULS) can be used on engineered fill, provided that all requirements on **Appendix C** are adhered to. To reduce the risk of improperly placed engineered compacted fill, full-time supervision of the contractor is essential. Despite full time supervision, it has been found that contractors frequently bulldoze loose fill into areas and compact only the surface. The inspector, either busy on other portions of the site or absent during “off hours” will be unaware of this condition. For this reason, we cannot guarantee the performance of the engineered fill, and this guarantee must be the responsibility of the contractor. The owner and his representatives must accept the risk involved in the use of engineered fill and offset this risk with the monetary savings of avoiding deep foundations. This potential problem must be recognized and discussed at a pre-construction meeting. Procedures can then be instigated to reduce the risk of settlement resulting from un-compacted fill.

In the areas where earth fill is required for site grading purposes, an engineered fill may be constructed below house foundations, roads, boulevards, etc.

The following is a recommended procedure for engineered fill:

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known

where all fill material will be obtained and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and Orbit Engineering Limited. Without this confirmation no responsibility for the performance of the structure can be accepted by Orbit Engineering Limited. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and weathered/disturbed materials. Subgrade must be proof rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by Orbit Engineering Limited engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard SPMDD throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur.

6. Full-time geotechnical inspection by Orbit Engineering Limited during placement of engineered fill is required.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2m. The base of the compacted pad extends 2m plus the depth of excavation beyond the edge of the footing.

8. A geotechnical reaction of 100kPa (2000psf) may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500mm (20 inches) is suggested and footings should be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

10. After completion of the pad, a second contractor may be selected to install footings. All excavations must be backfilled under full time supervision by Orbit to the same degree as the

engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of Orbit.

11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

The native soils are considered suitable for use as engineered fill, provided that they comprise no topsoils and rootlets and their moisture contents at the time of construction are at or near optimum. The clay and silts are poorly graded soils and are very sensitive to their moisture contents. As such, they will be very difficult to handle and to compact, especially at wet conditions. Under unfavourable conditions, they may not be suitable for engineered fill as mentioned in Section 4.3.3.

4.5 House Foundations

Based on the borehole information, the proposed house foundations can be supported on conventional spread and/or strip footings founded on the undisturbed native soil 0.9m to 1.0m for a geotechnical reaction of 150 kPa at the Serviceability Limit States (SLS) and a factored geotechnical resistance (with geotechnical resistance factor of 0.5) of 225 kPa at the Ultimate Limit State (ULS). The recommended founding levels and geotechnical resistances for the proposed structure will need to be confirmed by Orbit at the time of construction. The bearing pressures and the highest founding elevations at borehole locations are given in **Table 4.3.**

Table 4.3 Bearing Values and Founding Levels of Footings on Native Soils

BH No.	Material	Geotechnical Reaction at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Grade (m)	Founding Level at or Below Elevation (m)
BH1/MW	Sandy silty till	150	225	2.7	163.4
BH2/MW	Clayey silt to silty clay till	150	225	2.7	163.8
BH3/MW	Sandy silty till	150	225	2.7	163.5
BH4	Sandy silty till	150	225	2.7	163.5

Alternatively, the proposed structures can be supported by conventional spread and strip footings founded on engineered fill for a geotechnical reaction of 150kPa at the Serviceability Limit States (SLS) and a factored geotechnical resistance of 225kPa ULS. The engineered fill supporting footings should be constructed in accordance with the guidelines presented in **Appendix C**. Other requirements of engineered fill are given in Section 4.4.

Variations in the soil conditions are expected in between the borehole locations, and during construction, the soil bearing pressures should be confirmed by the Geotechnical Engineer. The base of all footings must be inspected by this office to ensure of their placement on the competent native soil or engineered fill.

All footings exposed to seasonal freezing conditions must have at least 1.2m of earth cover or equivalent thermal insulation against frost action. Foundations designed to the specified bearing values are expected to settle less than 25mm total and 20mm differential.

Where it is necessary to place footings at different levels, the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing.

It should be noted that the recommended bearing capacities have been calculated by Orbit Engineering Limited from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by Orbit Engineering Limited to validate the information for use during the construction stage.

4.6 Floor Slab and Permanent Drainage

The basement floor slab can be supported by engineered fill, if engineered fill is used to support the foundations.

The weathered/disturbed layer present on the site is not suitable for supporting the slab-on-grade. The floor slab can be supported on grade, provided all topsoil, existing weathered/disturbed and surficially softened or loose materials are removed, and the subgrade thoroughly proof rolled. Any loose spots or areas revealed from proof rolling must further be sub-excavated and replaced with imported Granular A and/or Granular B Type 2. The imported granular material must meet the specifications defined in OPSS-1010-13. The existing weathered/disturbed soil free from topsoil and rootlets may be used to raise the grade, provided it is confirmed by a qualified geotechnical professional from Orbit at the time construction. The fill required to raise the grade must be placed in shallow lifts (each lift not more than 200mm) and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

A moisture barrier consisting of at least 200mm thick layer of well compacted 19mm clear crushed stone is recommended to place directly under the floor slab. The stone bed would act as a barrier and prevent capillary rise of moisture from the subgrade to the floor slab. This moisture barrier has been proven to be effective for conventional floor surfaces such as carpet, vinyl tile and ceramic tile. However, if special floor coverings such as sheet P.V.C. with heat sealed seams, as is used in gymnasiums, is considered, either a high efficiency vapour barrier or venting may be required to prevent moisture accumulating between the concrete floor and the P.V.C. flooring.

The estimated modulus of subgrade reaction (k_s) equal to 25 MN/m^3 may be used for the design of slab-on-grade supported on native or structural fill soils, provided that the construction is in accordance with the recommendations provided herein. If structural fill (Granular A or B Type II) having minimum thickness of 300mm, this value can be increased to 30 MN/m^3. The estimated value provided above may need to be adjusted based on the structure size and locations of detail design.

The floor slabs should not be tied to any load-bearing walls or columns unless they have been designed accordingly. Contraction/expansion joints should be provided for the slabs as required by the structural engineer.

Considering the basement floor slab, the perimeter drainage shown on (**Drawing 7**) is considered to be necessary.

4.7 Earth Pressures

The lateral earth pressures acting on retaining walls (if any) may be calculated from the following expression:

$$p = K (\gamma h + q)$$

where:

p : Lateral earth pressure in kPa acting at depth h

K : Earth pressure coefficient equal to 0.4 for vertical walls and horizontal backfill used for permanent construction. Water pressure must be considered, if continuous wall drains are not used.

γ : Unit weight of backfill, a value of 20.5 kN/m^3 may be assumed

h : Depth to point of interest in meters

q : Equivalent value of surcharge on the ground surface in kPa

The above expression assumes that the perimeter drainage system prevents the build-up of any hydrostatic pressure behind the wall.

4.8 Earthquake Considerations

Based on boreholes information and according to the 2012 Ontario Building Code (OBC 2012), the subject site seismic response for the proposed building structures can be classified as “Class D” (Table 4.1.8.4.A of

OBC 2012). Accordingly, the foundation factors F_a can be obtained from Table 4.1.8.4.B and F_v from Table 4.1.8.4.C of the OBC for the design of the buildings.

Consideration can be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e., Geophysical testing – Multi-channel Analysis of Surface Waves “MASW”), which can lead to an improved site classification (i.e., from Class D to Class C).

5 GENERAL COMMENTS

The recommended bearing capacities and the corresponding founding elevations would need to be confirmed by the representative of Orbit during construction. It should be noted that the recommended bearing capacities have been calculated by Orbit from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by Orbit to validate the information for use during the construction.

In this regard, Orbit should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, Orbit 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 design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much 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.

The information in this report in no way reflects on the environmental aspects of the soil condition at the site and has not been specifically addressed in this report, since this aspect was beyond the scope and terms of reference. Should specific information be required, additional testing may be required.

6 CLOSURE

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

For and on behalf of Orbit,

Mohd Razeen

Mohammed Razeen, M.Eng.
Geotechnical EIT

Reviewed by

Aly Ahmed

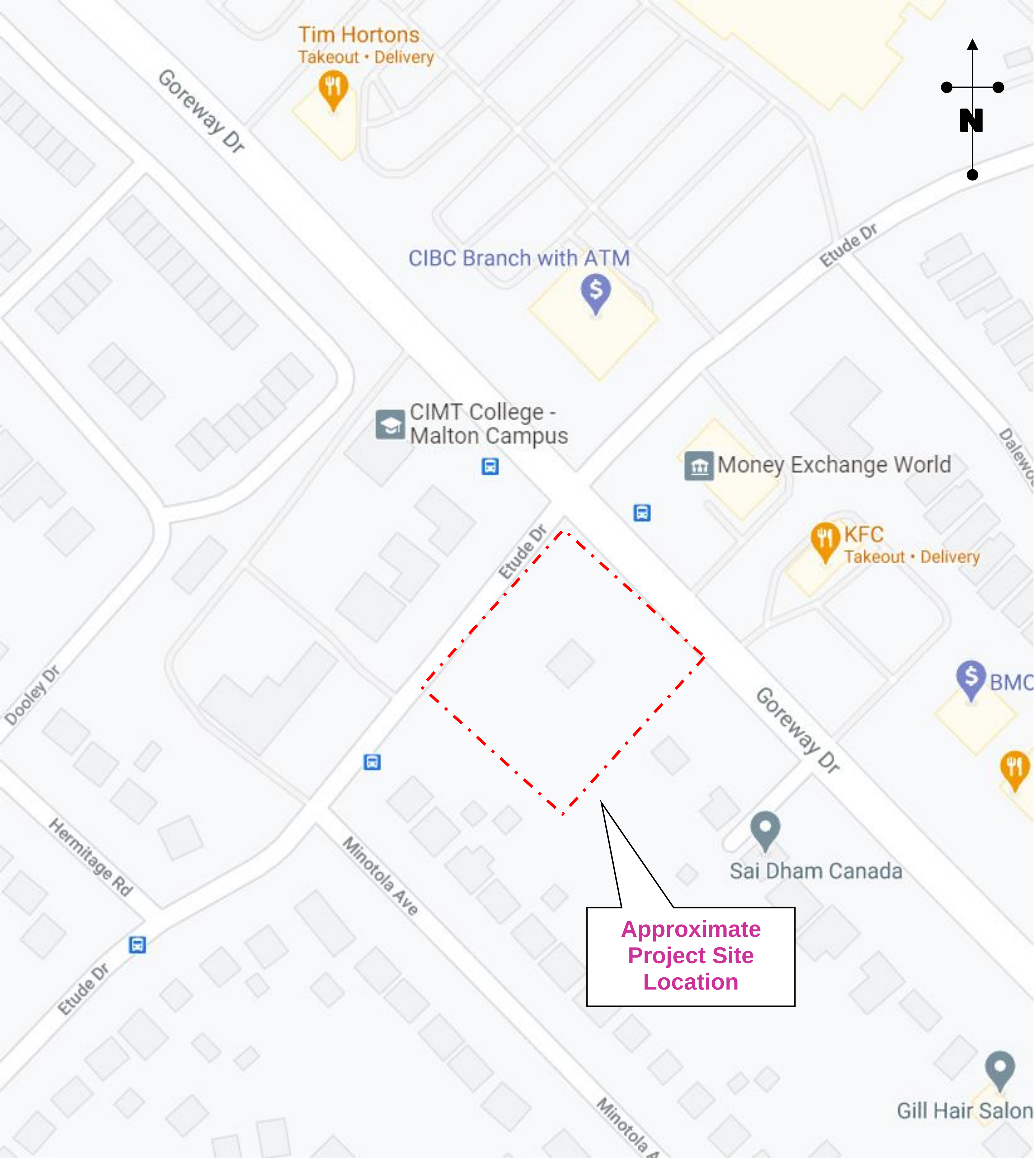
Aly Ahmed, Ph.D., P.Eng
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
A.A.A. Ahmed
100183630
June 9, 2021
PROVINCE OF ONTARIO

Hafiz Muneeb Ahmad, M.Eng., M.Sc., P.Eng., QP_{ESA}
Senior Principal

LICENSED PROFESSIONAL ENGINEER
H.M.Ahmad
100101997
June 9, 2021
PROVINCE OF ONTARIO

Drawings



Approximate Project Site Location

ORBIT ENGINEERING

APPROXIMATE SITE LOCATION PLAN

Date: **MAY 2021**

Project: **OE20373CG**

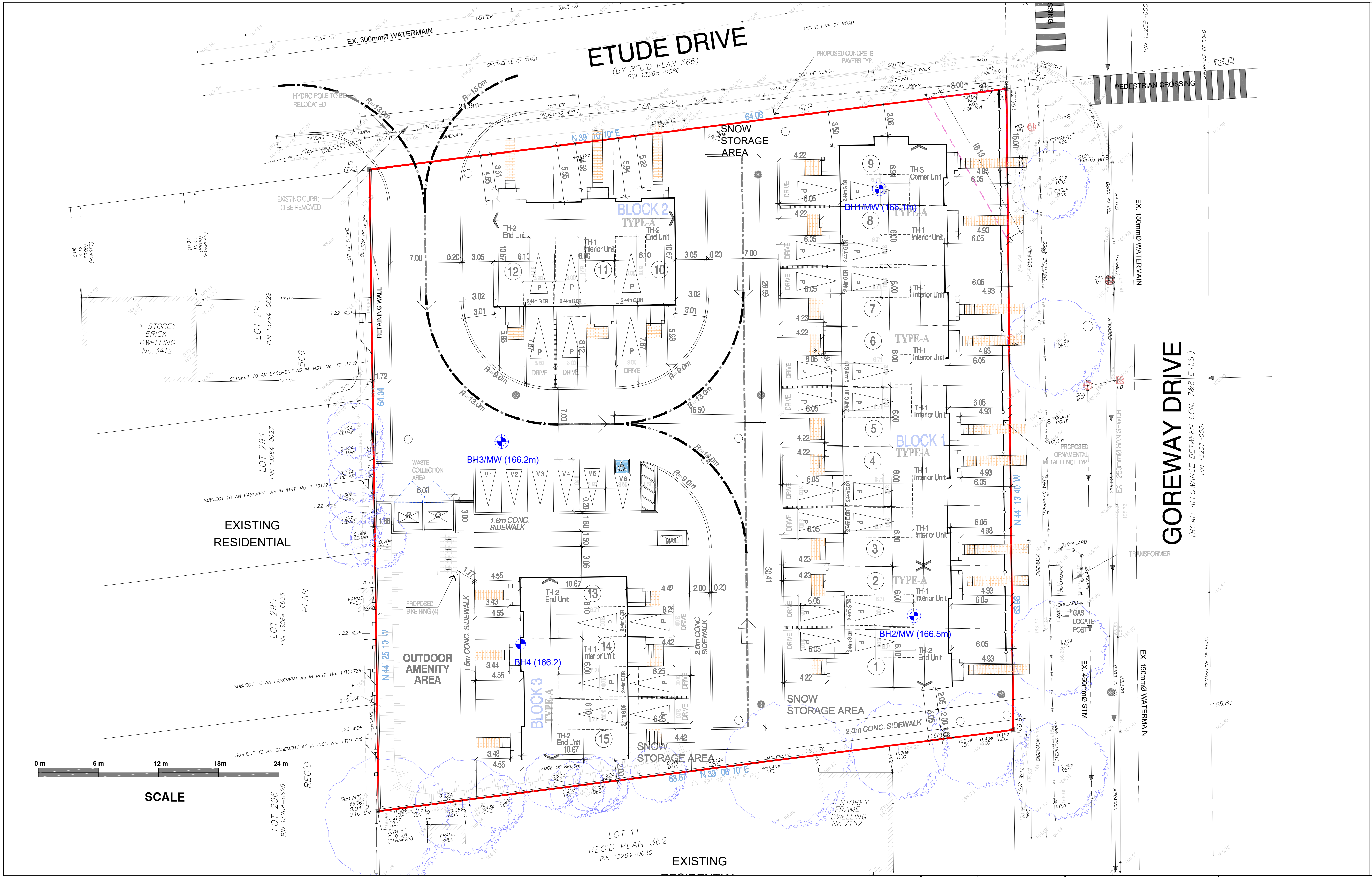
PROPOSED RESIDENTIAL DEVELOPMENT
7170 GOREWAY DRIVE, MISSISSAUGA, ON

Prepared for: **MR. RUP LAL C/O**
WESTON CONSULTING

Prepared By: **TZ**

Reviewed By: **HA**

Drawing No. **1**



NOTES:

1. The boundaries and soil types have been established only at borehole locations. Between boreholes they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for three months and then destroyed unless the client advises an extended time period is required.
3. Granular base fill quantities should not be established from the information provided at the borehole locations.
4. Borehole elevations should not be used to design building(s) or floor slab(s) or parking lot(s) grades.
5. This drawing forms part of the report (project number as referenced) and should only be used in conjunction with this report.

LEGEND

⌖	**Approximate Borehole Location**
⌖ BH/MW	**Approximate Borehole/Monitoring Well Location**
166.1	**Existing Grade Geodetic Elevation**

Drawn	TZ
Approved	HA
Date	MAY 2021
Scale	As Shown
Original size	TABLOID

ORBIT ENGINEERING
Consulting Engineers

Client: **RUP LAL C/O WESTON CONSULTING**

Project: **GEOTECH AND HYDROG INVESTIGATION OF PROPOSED RESIDENTIAL DEVELOPMENT**
7170 GOREWAY DRIVE, MISSISSAUGA, ON

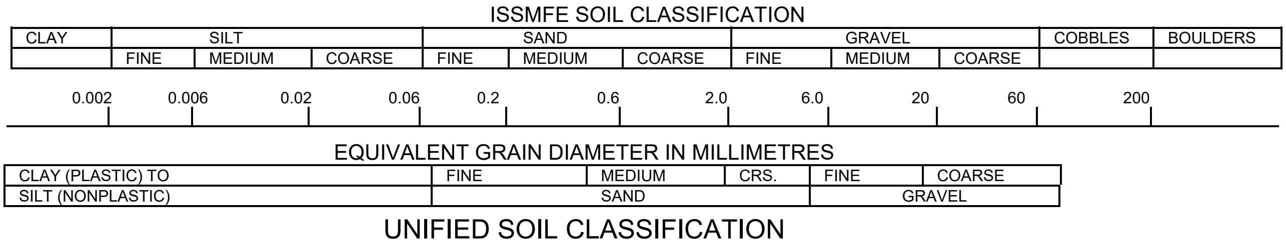
Title: **APPROXIMATE BOREHOLE LOCATION PLAN**

Project no: **OE20373CG**

Drawing no: **1A**

Drawing 1B: Notes on Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by Orbit Engineering Limited also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.



2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advice of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

ORBITENGINEERING

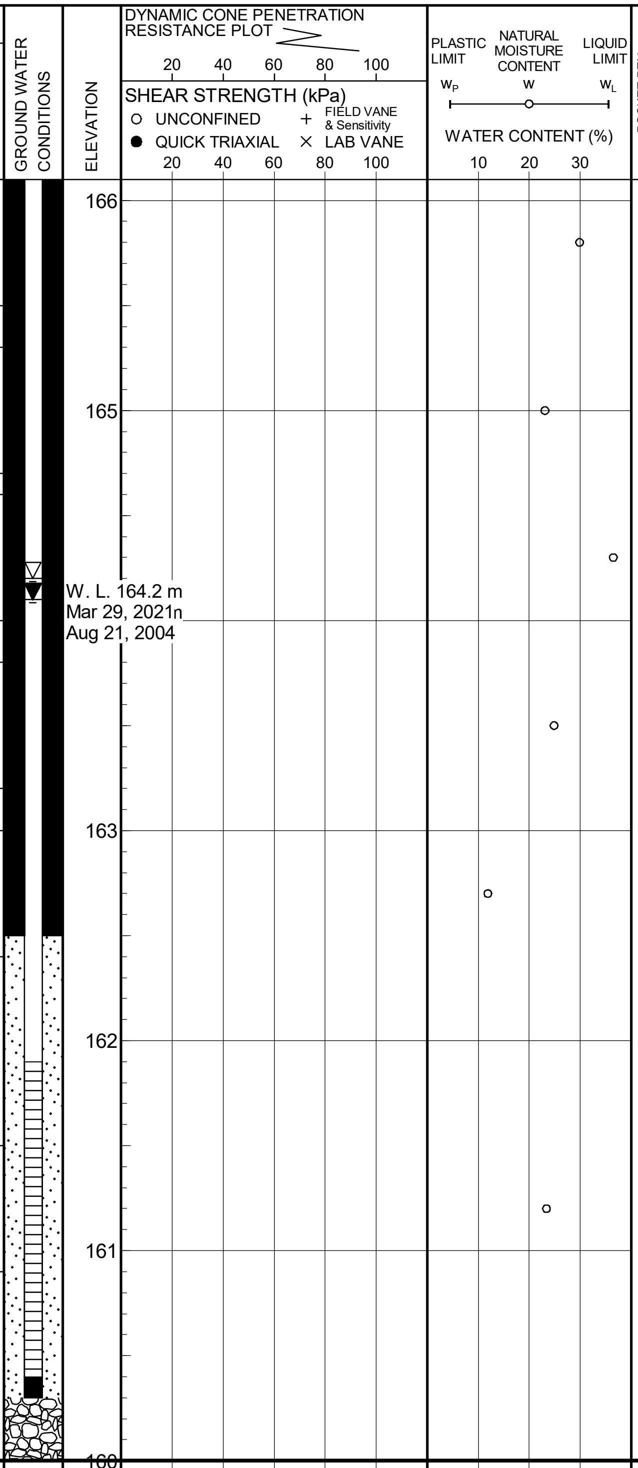
LOG OF BOREHOLE BH1/MW

PROJECT: Geotech and HydroG of Proposed Residential Development
CLIENT: Rup Lal
PROJECT LOCATION: 7170 Goreway Drive, Mississauga, Ontario
DATUM: Geodetic
BH LOCATION: Refer to Borehole Location Plan (Drawing 1A) N 4841320 E 609838.97

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Mar-26-2021

PROJECT NO.: OE20373CG
DRAWING NO.: 2

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GR	SA	SI	CL
166.1								
0.0	**Topsoil:** 450mm	1	SS	5				
165.6 0.5	**Clayey Silt to Silty Clay:** weathered/disturbed, some topsoil and rootlets, trace sand, greyish brown, moist, firm							
165.3 0.8	**Clayey Silt to Silty Clay till:** some sand, trace gravel, brownish grey, moist, stiff	2	SS	11				
		3	SS	10	0	10	49	41
163.8 2.3	**Sandy Silt Till:** some clay, trace gravel, grey, wet, compact	4	SS	20				
163.0 3.1	**Silt Till:** trace clay and gravel, grey, wet, compact	5	SS	10	4	31	51	14
		6	SS	16	1	0	93	6
160.0 6.1	**End of Borehole:**							



Notes:
Water Levels:
(i) During Drilling: 2.3m
(ii) At Completion: (50mm monitoirng well was installed)
(iii) (29 March 2021): 1.9m
(iv) (07 April 2021): 1.9m
(v) (08 April 2021): 2.0m

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ 8 =3% Strain at Failure

ORBITENGINEERING

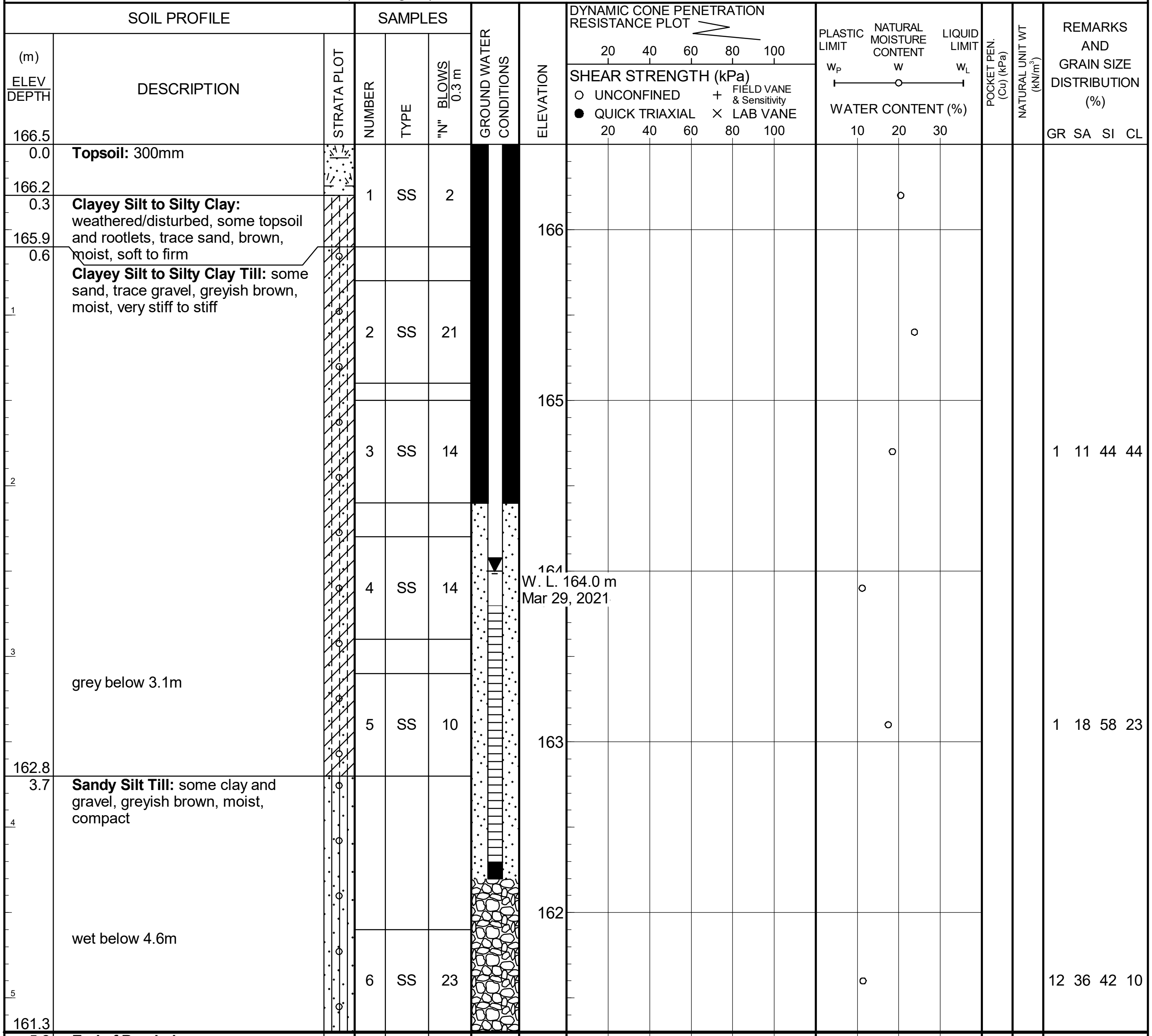
LOG OF BOREHOLE BH2/MW

1 OF 1

PROJECT: Geotech and HydroG of Proposed Residential Development
CLIENT: Rup Lal
PROJECT LOCATION: 7170 Goreway Drive, Mississauga, Ontario
DATUM: Geodetic
BH LOCATION: Refer to Borehole Location Plan (Drawing 1A) N 4841296.29 E 609863.05

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Mar-26-2021

PROJECT NO.: OE20373CG
DRAWING NO.: 3



ELEV (m) DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.5						
0.0	**Topsoil:** 300mm					
166.2 0.3	**Clayey Silt to Silty Clay:** weathered/disturbed, some topsoil and rootlets, trace sand, brown, moist, soft to firm	1	SS	2	166	
165.9 0.6	**Clayey Silt to Silty Clay Till:** some sand, trace gravel, greyish brown, moist, very stiff to stiff	2	SS	21		
		3	SS	14	165	1 11 44 44
		4	SS	14	164	
	grey below 3.1m	5	SS	10	163	1 18 58 23
162.8 3.7	**Sandy Silt Till:** some clay and gravel, greyish brown, moist, compact				162	
	wet below 4.6m	6	SS	23		12 36 42 10
161.3 5.2	**End of Borehole:**					

Notes:
Water Levels:
(i) During Drilling: 4.6m
(ii) At Completion: (50mm monitoring well was installed)
(iii) (29 March 2021): 2.5m
(iv) (07 April 2021): 2.5m
(v) (08 April 2021): 2.5m

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

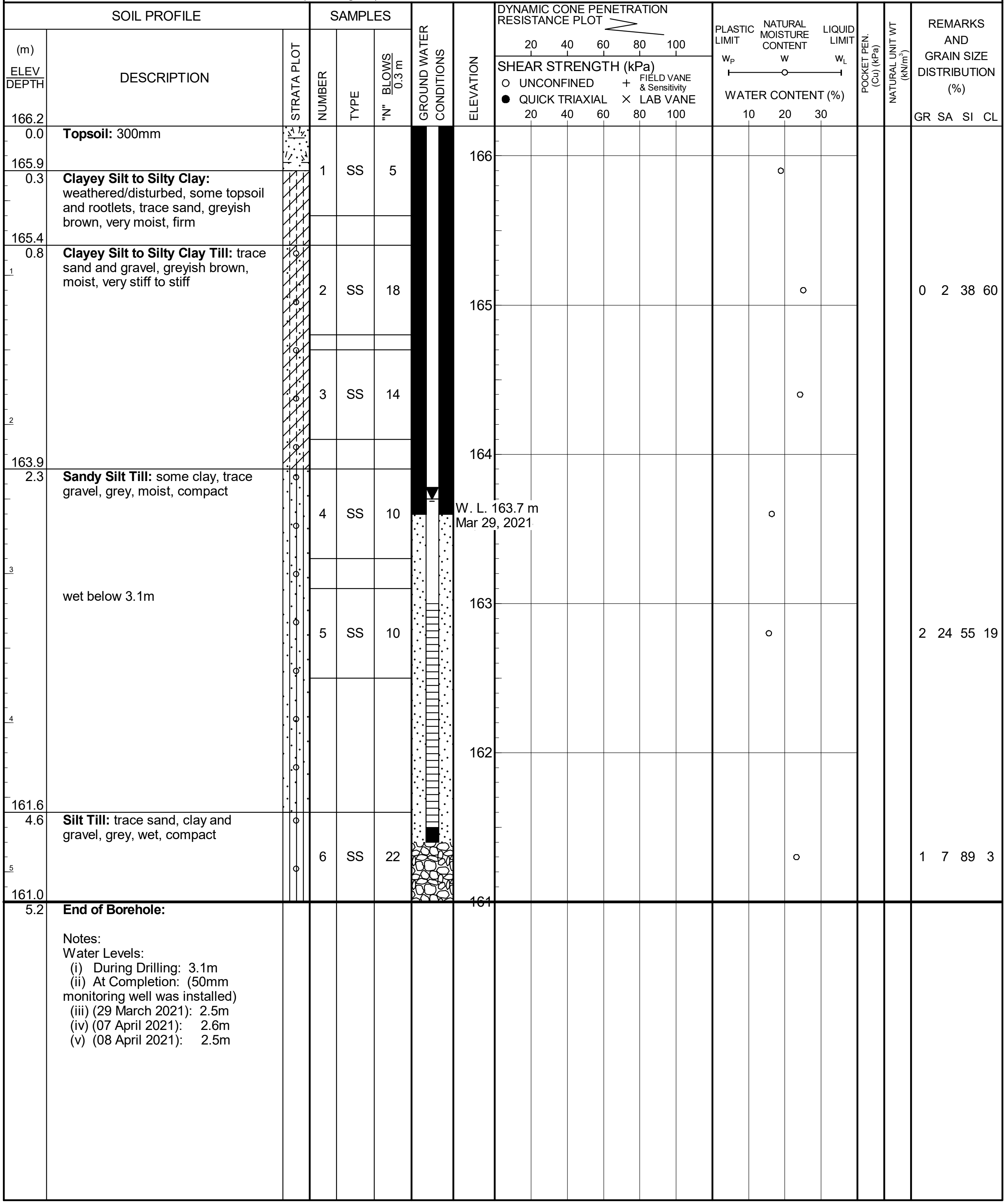
GRAPH NOTES
+ ^{3}, × ^{3}: Numbers refer to Sensitivity
○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH3/MW

PROJECT: Geotech and HydroG of Proposed Residential Development
CLIENT: Rup Lal
PROJECT LOCATION: 7170 Goreway Drive, Mississauga, Ontario
DATUM: Geodetic
BH LOCATION: Refer to Borehole Location Plan (Drawing 1A) N 4841279.09 E 609823.93

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Mar-26-2021

PROJECT NO.: OE20373CG
DRAWING NO.: 4



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.2					
0.0	**Topsoil:** 300mm				
165.9 0.3	**Clayey Silt to Silty Clay:** weathered/disturbed, some topsoil and rootlets, trace sand, greyish brown, very moist, firm	1	SS	5	
165.4 0.8	**Clayey Silt to Silty Clay Till:** trace sand and gravel, greyish brown, moist, very stiff to stiff	2	SS	18	0 2 38 60
		3	SS	14	
163.9 2.3	**Sandy Silt Till:** some clay, trace gravel, grey, moist, compact	4	SS	10	
	wet below 3.1m	5	SS	10	2 24 55 19
161.6 4.6	**Silt Till:** trace sand, clay and gravel, grey, wet, compact	6	SS	22	1 7 89 3
161.0 5.2	**End of Borehole:**				

Notes:
Water Levels:
(i) During Drilling: 3.1m
(ii) At Completion: (50mm monitoring well was installed)
(iii) (29 March 2021): 2.5m
(iv) (07 April 2021): 2.6m
(v) (08 April 2021): 2.5m

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

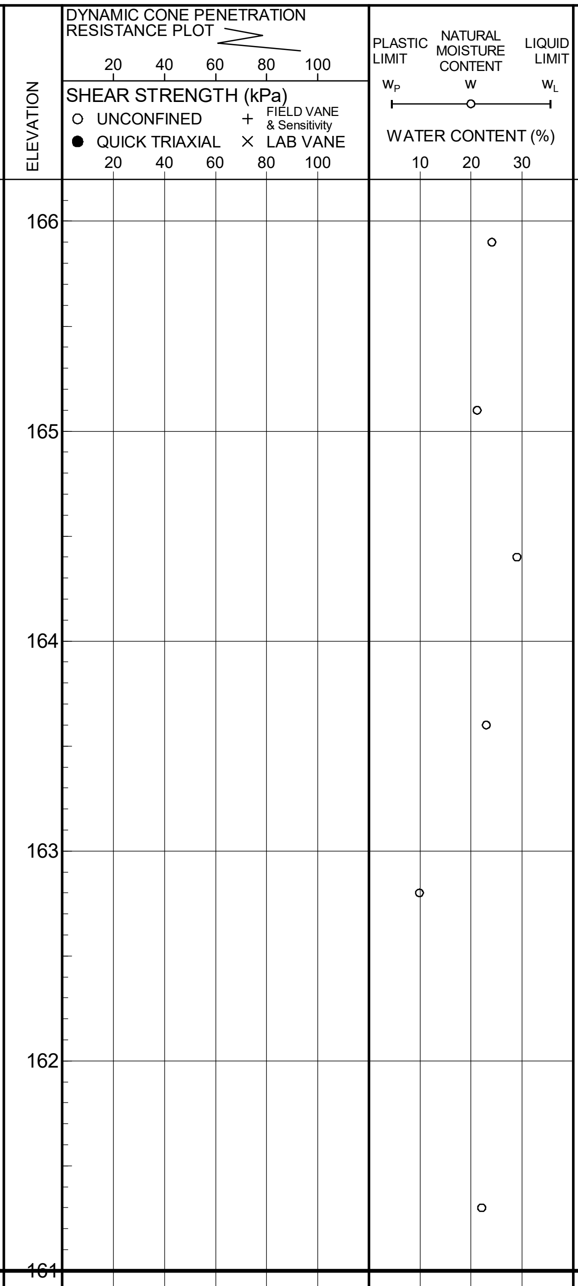
LOG OF BOREHOLE BH4

PROJECT: Geotech and HydroG of Proposed Residential Development
CLIENT: Rup Lal
PROJECT LOCATION: 7170 Goreway Drive, Mississauga, Ontario
DATUM: Geodetic
BH LOCATION: Refer to Borehole Location Plan (Drawing 1A) N 4841261.75 E 609836.12

DRILLING DATA
Method: Solid Stem Auger
Diameter: 150mm
Date: Mar-26-2021

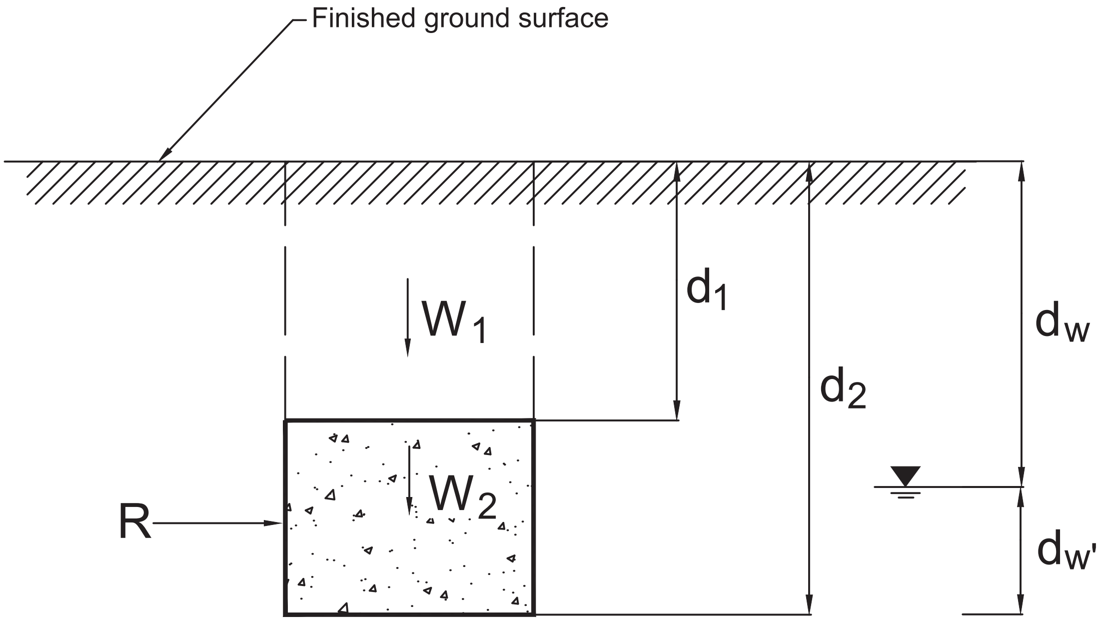
PROJECT NO.: OE20373CG
DRAWING NO.: 5

SOIL PROFILE		SAMPLES							
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
166.2 0.0	**Topsoil:** 300mm							
165.9 0.3	**Clayey Silt to Silty Clay:** weathered/disturbed, some topsoil and rootlets, trace sand, greyish brown, very moist, firm	1	SS	6				
165.5 0.7	**Clayey Silt to Silty Clay Till:** trace sand and gravel, greyish brown, moist, stiff	2 3	SS SS	11 10				
163.9 2.3	**Sandy Silt Till:** some clay, trace gravel, grey, moist, compact wet below 3.1m	4 5	SS SS	18 11				
161.6 4.6	**Silt Till:** trace sand, clay and gravel, grey, wet, compact	6	SS	14				
161.0 5.2	**End of Borehole:** Notes: Water Levels: (i) During Drilling: 3.1m							



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
$+^3$, $\times^3$: Numbers refer to Sensitivity
○ ^{8}=3% Strain at Failure



R = ultimate lateral resistance of thrust block

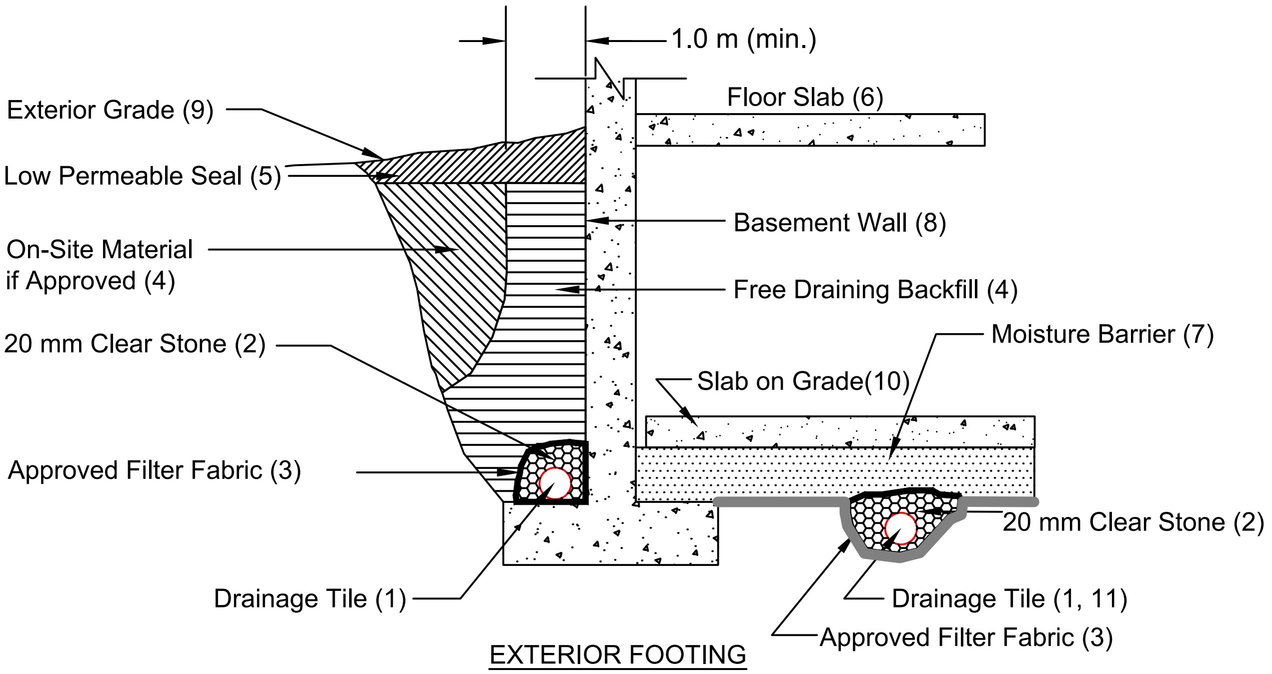
Case 1 $dw < d1$
$R = B[1/2\ Kp\gamma'(d2^2 - d1^2) + Kp\ \gamma w\ dw\ (d2 - d1)] + (W1 + W2)f$

Case 2 $d1 < dw < d2$
$R = B[1/2\ Kp\gamma(d2^2 - d1^2) - 1/2\ Kp\gamma w\ (dw')^2] + (W1 + W2)f$

Case 3 $d2 < dw$
$R = B[1/2\ Kp\gamma(d2^2 - d1^2)] + (W1 + W2)f$
R = Ultimate earth resistance, kN.
B = width of block, m.
Kp = coefficient of passive earth pressure = 2.5
γ = total unit weight of soil = 19 kN/m^3
γ' = submerged unit weight of soil = 9 kN/m^3
γw = unit weight of water = 10 kN/m^3
W1 = weight of soil above thrust block
W2 = weight of thrust block
f = coefficient of friction between block and soil = 0.3

Thrust Block Analysis

Drawing No. 6



Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place100 mm (4 inches) of stone below drain .
3. Wrap the clear stone with an approved filter fabric (Terrafix 400R or equivalent).
4. Free Draining backfill - OPSS Granular B or equivalent compacted to the specified density. Do not use heavy compaction equipment within 450 mm (18") of the wall. Use hand controlled light compaction equipment within 1.8 m (6') of wall. The minimum width of the Granular 'B' backfill must be 1.0 m.
5. Low permeable backfill seal - compacted clay, clayey silt or paved with concrete/asphalt or equivalent. If original soil is free-draining, seal may be omitted. Maximum thickness of seal to be 0.5 m.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
8. Basement wall to be water proofed.
9. Exterior grade to slope away from building.
10. Typically slab on grade is not structurally connected to the wall or footing. However, if it is connected to the wall, it should be designed accordingly.
11. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
12. Drainage tile placed in parallel rows 4 to 6 m (15 to 20') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
13. The entire subgrade to be sealed with approved filter fabric (Terrafix 400R or equivalent).
14. Do not connect the underfloor drains to perimeter drains.
15. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE AND BACKFILL RECOMMENDATIONS
Basement with Underfloor Drainage

(not to scale)

Appendices

Appendix A

Limitations of Report

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Orbit Engineering Limited at the time of preparation. Unless otherwise agreed in writing by Orbit Engineering Limited, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

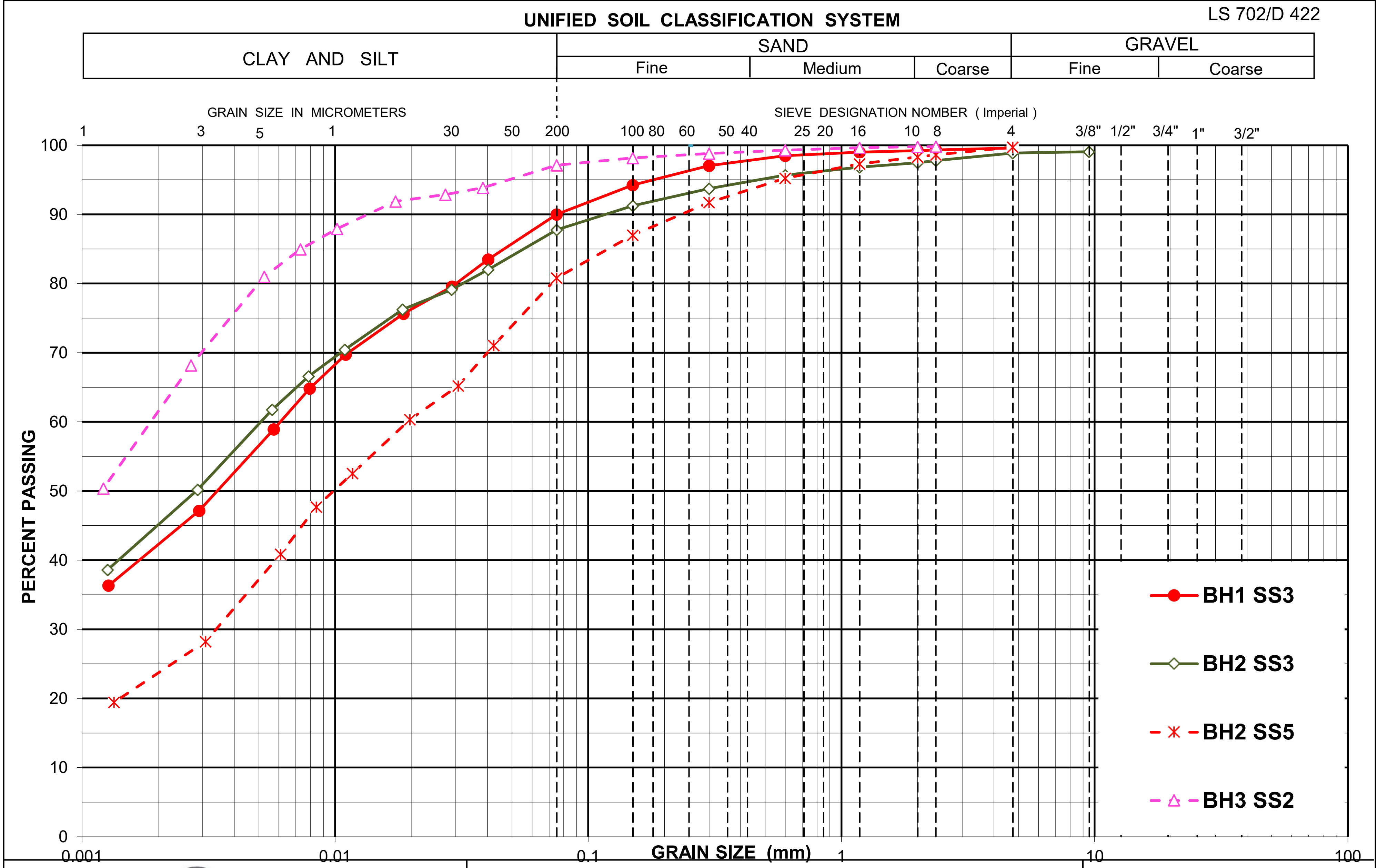
The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

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. Orbit Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time. Any user of this report specifically denies any right to claims against the Consultant, Sub-Consultants, their officers, agents and employees in excess of the fee paid for professional services.

Appendix B

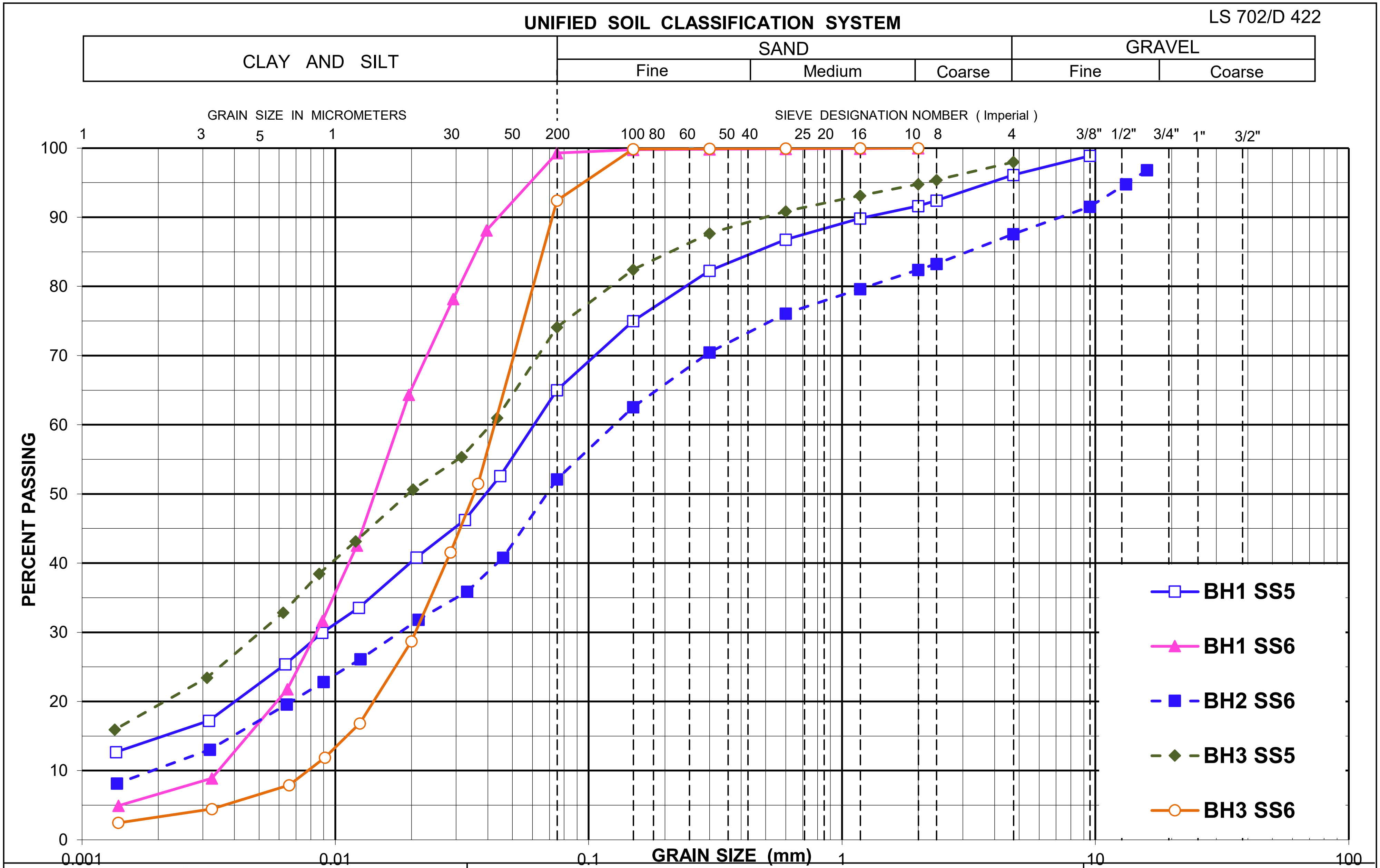
Geotechnical Laboratory Test Results



ORBITENGINEERING
Consulting Engineers

GRAIN SIZE DISTRIBUTION

Figure No.:	**B1**
PROJECT No. :	**OE20373CG**
DATE :	**April 06, 2021**



ORBITENGINEERING
Consulting Engineers

GRAIN SIZE DISTRIBUTION

Figure No.:	**B2**
PROJECT No. :	**OE20373CG**
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Appendix C

General Requirements for Engineered Fill

GENERAL REQUIREMENTS FOR ENGINEERED FILL

Compacted imported soil that meets specific engineering requirements and is free of organics and debris and that has been continually monitored on a full-time basis by a qualified geotechnical representative is classified as engineered fill. Engineered fill that meets these requirements and is bearing on suitable native subsoil can be used for the support of foundations.

Imported soil used as engineered fill can be removed from other portions of a site or can be brought in from other sites if suitable. In general, most of Ontario soils are too wet to achieve the 100% Standard Proctor Maximum Dry Density (SPMDD) and will require drying and careful site management if they are to be considered for engineered fill. Imported non-cohesive granular soil is preferred for all engineered fill. For engineered fill, Orbit Engineering Limited (Orbit) recommends use of OPSS Granular 'B' sand and gravel fill material only.

Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill should not be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year. If the project demands placement of engineered fill in winter (December 15- April1) it can be placed only under the following conditions:

- All frozen material and or snow must be removed before placement of engineered fill on a daily basis

- Only Granular B Type 2 or Granular A (including crushed concrete or crushed limestone)

- The fill placement must be supervised on a full time basis by a geotechnical consultant

The location of the foundations on the engineered soil pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie. Foundations placed within the engineered soil pad must be backfilled with the same conditions and quality control as the original pad.

To perform satisfactorily, engineered fill requires the cooperation of the designers, engineers, contractors and all parties must be aware of the requirements. The minimum requirements are as follows, however, the geotechnical report must be reviewed for specific information and requirements.

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained and samples must be provided to the geotechnical engineer for review, and approval before filling begins.

2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.

3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and Orbit Engineering Limited. Without this confirmation no responsibility for the performance of the structure can be accepted by Orbit Engineering Limited. Survey drawing of the pre and post fill location and elevations will also be required.

4. The area must be stripped of all topsoil and fill materials. Subgrade must be proofrolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by an Orbit engineer prior to placement of fill.

5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur and should be evaluated prior to placing the fill.

6. Full-time geotechnical inspection by Orbit during placement of engineered fill is required. Work cannot commence or continue without the presence of the Orbit representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. The allowable bearing pressure provided in the accompanying report may be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.

9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

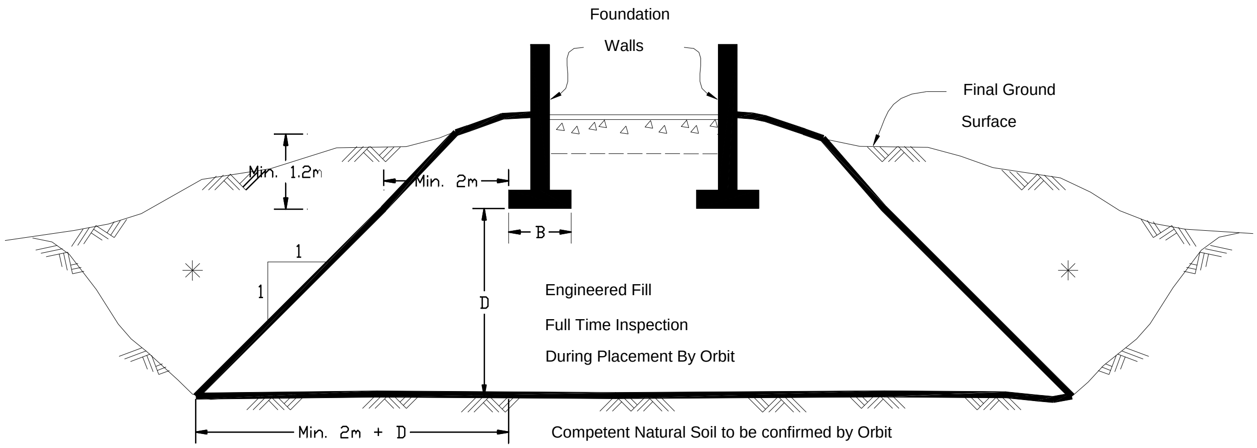
10. After completion of the pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from Orbit Engineering Limited prior to footing concrete placements. All excavations must be backfilled under full time Orbit Engineering Limited supervision by Orbit to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of Orbit Engineering Limited.

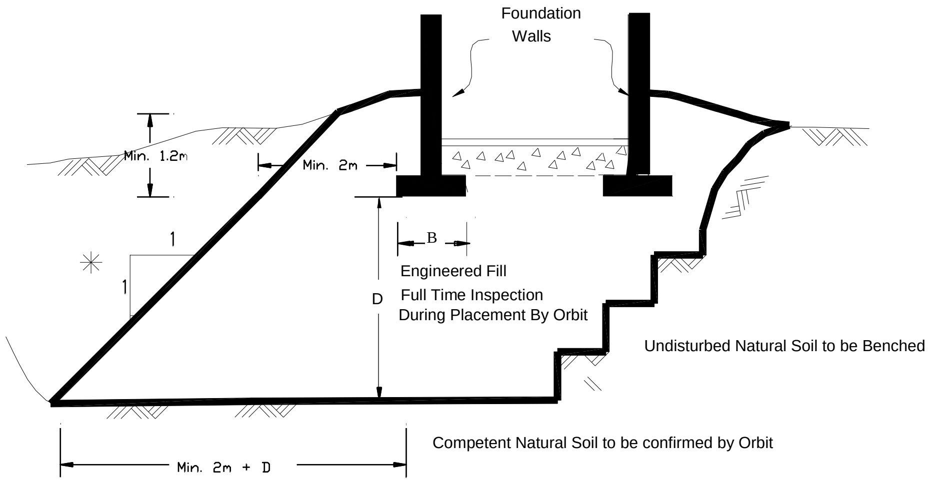
11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof rolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work in order to promote rapid runoff of rainwater and to avoid any ponding surface water. Any stockpiles of fill intended for use as engineered fill must also be smooth-bladed to promote runoff and/or protected from excessive moisture take up.

12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

13. The geometry of the engineered fill as illustrated in these General Requirements is general in nature. Each project will have its own unique requirements. For example, if perimeter sidewalks are to be constructed around the building, then the projection of the engineered fill beyond the foundation wall may need to be greater.

14. These guidelines are to be read in conjunction with Orbit Engineering Limited report attached.





✳ Backfill in this area to be as per the Orbit report