PRELIMINARY GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
151 PEEL STREET, TOWN OF COLLINGWOOD, ONTARIO

Prepared For:

Ainley & Associates

Prepared By:

Orbit Engineering Limited

Project No. OE1575A

February 2, 2016

1900 Clark Boulevard, Unit 9, Brampton, ON, L6T 0E9
Tel: +1 905-494-0074   Fax: +1 855 666 3355
www.orbitengineering.ca , info@orbitengineering.ca

ORBIT ENGINEERING
Consulting Engineers

Orbit Engineering Limited
1900 Clark Boulevard, Unit 9,
Brampton, ON, L6T 0E9
Tel: 1-905-494-0074
Fax: 1-855-666-3355
www.orbitengineering.ca
info@orbitengineering.ca

February 2, 2016

Ainley & Associates
280 Pretty River Parkway
Collingwood, ON
L9Y 4J5
Email: *kalus@ainleygroup.com*

Attention: Brad Kalus, C.E.T., LEL, Transportation Manager

Dear Mr. Kalus

RE: Preliminary Geotechnical Investigation
Proposed Residential Development
151 Peel St., Town of Collingwood, Ontario

Enclosed please find the preliminary 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}.
Senior Principal Engineer

Executive Summary

A preliminary geotechnical investigation based on six boreholes (BH1 to BH6) was carried out for the proposed residential dwelling 151 Peel St., Town of Collingwood, Ontario.

It is understood that the project will entail a residential subdivision consisting of single family houses, roads and sewers.

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

A layer of fill was encountered in all boreholes and extended to approximate depths of 0.8 to 1.5 m below the existing ground surface.

The fill is heterogeneous in nature and predominantly consisted of clayey silt to sandy silt and silty sand materials with some topsoil pockets and construction debris including asphalt pieces. The explored fill was in a very loose to compact state, and the degree of compaction varies significantly with depth and location.

The upper portion of native soils predominantly consisted of sandy silt to silty fine sand with frequent layers of clayey silt to silty clay in boreholes (excluding BH1 and BH5). The sandy deposits were typically in compact state and found wet at approximate depths varying from 1.1 to 2.3 m below the existing ground surface. Thickness of measured clay layer varied from 0.3 (BH4) to 3.4 m (BH3). The deposit in this layer was found very moist to wet and generally firm to stiff in consistency. The lower portion of native soils in all boreholes (excluding BH6) was composed of sandy silt till with occasional layers of clayey silt to silty clay. Standard Penetration tests performed in this till deposit gave ‘N’ values ranging from 10 blows/0.3 m to 50 blows/25mm. Based on these test results, the relative density of the deposit can be described as compact to very dense.

Auger refusal on possible bedrock surface was encountered in two boreholes at approximate depths of 5.8 m (BH1) and 6.2 m (BH3) below the existing grade. The bedrock was not cored in any of the boreholes, as this was not within the terms of reference.

During drilling and at completion of drilling, the short term (not stabilized) ground water was found in boreholes at shallow depths varying from 1.1 (BH4) to 2.3m (BH1) below the existing ground surface.

The groundwater levels observed in the monitoring wells were at depths ranging from 1.2 to 1.9 m below the existing grade. Where the anticipated trench base is below the groundwater level, positive dewatering such as well points will be required to lower the water table to at least 1.0 m below the excavation base. Otherwise, it will result in an unstable base and flowing sides. Test pits should be carried to further explore the groundwater and seepage conditions and to confirm the need for positive dewatering. The wet sandy deposits will require flatter slope at 3 horizontal to 1 vertical. A contractor specializing in dewatering should be retained to design the dewatering systems.

The proposed foundations for the single family houses can be supported on undisturbed native soils at or below the approximate depths of 0.8 to 1.5 m below the existing grades for geotechnical reactions of 100 to 150 kPa (2000 to 3000 psf) at the Serviceability Limit States (SLS) and factored geotechnical resistances of 150 to 225 kPa at the Ultimate Limit States (ULS). All footings exposed to seasonal freezing conditions must have at least 1.5 meters of soil cover for frost protection.

Alternatively, the proposed residential structures can be supported on engineered fill for geotechnical reactions of 100 to 150 kPa at SLS and factored geotechnical resistances of 150 to 225 kPa at ULS, provided all requirements in Appendix B are adhered to.

Based on the borehole information, the subject site for the proposed residential development can be classified as Class ‘D’ for seismic site response according to Table 4.1.8.4.A of OBC 2012, provided the footings will be supported on undisturbed native deposits.

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1 INTRODUCTION

Orbit Engineering Limited (Orbit) was retained by Ainley & Associates to undertake a preliminary geotechnical investigation for a proposed residential subdivision located at 151 Peel St., Town of Collingwood, Ontario.

It is understood that the project will entail a residential subdivision consisting of single family houses, roads and sewers.

The purpose of this geotechnical investigation was to obtain information about the subsurface conditions by means of a limited number of boreholes and from the findings in the boreholes to make recommendations pertaining to the geotechnical design of underground utilities and subdivision roads and to comment on the foundation conditions for general house construction. Furthermore, the purpose of this report is to conduct a ground water monitoring study to assess the seasonal variation in the ground water table in order to determine building foundation requirements and minimum footing elevations. In addition, the scope of the study was expanded to include a geotechnical investigation to provide recommendations with regard to the design and construction of the new road and new municipal services.

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 Ainley & Associatesand its designers. Third party use of this report without Orbit Engineering Limited 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 INVESTIGATION PROCEDURES

A total of six boreholes (BH1 to BH6, see **Drawing 1A** for locations) were drilled to a maximum depth of 6.7 m with hollow 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 760 mm. The samples from the boreholes were logged in the field and returned to the Orbit Engineering Limited laboratory for detailed examination by the project engineer and for laboratory testing.

The boreholes were staked out by a representative of Ainley& Associates.

As well as visual examination in the laboratory, all of 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 well (50 mm) were installed in three boreholes (BH1 to BH3) for an extended period of groundwater level monitoring.

The surveying of the borehole locations was undertaken by Orbit staff. The ground surface elevations at borehole locations were referenced to the top of the spindle of the fire hydrant (close to Borehole 6, refer to **Drawing 1A** for details) with an assumed elevation of 100.0 m. Note, these elevations are approximate 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 located at 151 Peel St., Town of Collingwood, Ontario. The site is vacant and located to the east of Peel Street and the west side of the Pretty River. The maximum difference in elevations at the location of boreholes was measured in the range of 2 m.

The approximate borehole locations are shown on **Drawing 1A**. Notes on sample descriptions and the general features of fill material and glacial till are presented on **Drawing 1B**. Detailed subsurface conditions are presented on the Borehole Logs**, Drawings 2 to 7**. The generalized subsurface profiles at the location of boreholes are presented on **Drawings 8 and 9**. The borehole logs indicate the subsurface conditions only at the borehole locations. Note the material boundaries indicated on the attached 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 soil and groundwater conditions are summarized as follows.

3.1 Soil Conditions

3.1.1 Topsoil

A layer of surficial topsoil or topsoil-like materials, approximately 200 mm in thickness was found at the location of borehole (BH5). Topsoil quantities should not be calculated from the borehole information, as large variations in depth may exist between boreholes.

3.1.2 Fill

A layer of fill was encountered in all boreholes and extended to approximate depths of 0.8 to 1.5 m below the existing ground surface.

The fill is heterogeneous in nature and predominantly consisted of clayey silt to sandy silt and silty sand materials with some topsoil pockets and construction debris including asphalt pieces. The explored fill was in a very loose to compact state, and the degree of compaction varies significantly with depth and location.

3.1.3 Native Soils

The upper portion of native soils predominantly consisted of sandy silt to silty fine sand with frequent layers of clayey silt to silty clay in boreholes (excluding BH1 and BH5). The sandy deposits were typically in compact state and found wet at approximate depths varying from 1.1 to 2.3 m below the existing ground surface. The typical grain size distributions of the sandy deposits (BH1-SS4 and BH5-SS3) are given on **Figure C1 to C3** (attached in **Appendix C**) and show the following gradation:

Gravel:	0%
Sand:	82-83%
Silt:	14-15%
Clay:	3%

Thickness of measured clay layer varied from 0.3 (BH4) to 3.4 m (BH3). The deposit in this layer was found very moist to wet and generally firm to stiff in consistency.

The lower portion of native soils in all boreholes (excluding BH6) was composed of sandy silt till with occasional layers of clayey silt to silty clay. Standard Penetration tests performed in this till deposit gave 'N' values ranging from 10 blows/0.3 m to 50 blows/25mm. Based on these test results, the relative density of the deposit can be described as compact to very dense.

Auger refusal on possible bedrock surface was encountered in two boreholes at approximate depths of 5.8 m (BH1) and 6.2 m (BH3) below the existing grade. The bedrock was not cored in any of the boreholes, as this was not within the terms of reference.

3.2 Groundwater Conditions

During drilling and at completion of drilling, the short term (not stabilized) ground water was found in boreholes at shallow depths varying from 1.1 (BH4) to 2.3m (BH1) below the existing ground surface.

The ground water level in monitoring wells installed at the location of boreholes (BH1 to BH3) was measured using data loggers from November 25 to December 7, (about 12 days) at approximate depths of 1.2 to 1.9 m below the existing grade, as summarized in **Table 3.1**, refer to **Drawing 10** for details. The groundwater level monitoring will be continued to establish relatively stabilized groundwater levels.

Table 3.1: Groundwater Levels Observed in Boreholes (Monitoring Wells)

BH No.	Date of Drilling	Date of Water Measurement	Depth of Groundwater with reference to the existing ground (m)	Estimated Local Elevation of Groundwater (m)
BH1	Nov. 25, 2015	December 2, 2015	1.9	98.5*
		December 7, 2015	2.0	98.4*
BH2	Nov. 25, 2015	December 2, 2015	1.2	98.0*
		December 7, 2015	1.4	97.8*
BH3	Nov. 25, 2015	December 7, 2015	1.5	98.8*
		December 7, 2015	1.7	98.6*

Note: * Elevations are local, non-geodetic. See Section 2 of this report for detail.

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.

4 DISCUSSION & RECOMMENDATIONS

It is proposed to develop the site as a residential subdivision. The lots therefore will be serviced by a network of roads, storm and sanitary sewers and water mains.

4.1 Roads

The investigation has shown that the predominant subgrade soil, after stripping the topsoil, and fill deposits and otherwise unsuitable subsoil, will generally consist of cohesionless soils (sandy silt to silty fine sand) with occasional layer of sandy silt till and clayey silt to silty clay.

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

40 mm HL3 Asphaltic Concrete

65 mm HL8 Asphaltic Concrete

150 mm Granular ‘A’

300 mm Granular ‘B’

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

40 mm HL3 Asphaltic Concrete

80 mm HL8 Asphaltic Concrete

150 mm Granular ‘A’

400 mm Granular ‘B’

These values may need to be adjusted according to the Town of Collingwood 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.

4.1.1 Stripping, Sub-excavation and Grading

The site should be stripped of all topsoil, loose fill and any organic 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.

Owing to the clayey (i.e. impervious) nature of the subsoil at some locations of the site, 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 SPMDD. The degree of compaction should be increased to 98% within the top 1.0 m of the subgrade, or as per City Standards. The compaction of the new fill should be checked by frequent field density tests.

4.1.2 Construction

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

4.1.3 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.

4.2 Sewers

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

4.2.1 Trenching

As indicated in the boreholes, the trenches will be dug generally through cohesionless soils (sandy silt to silty fine sand) and with occasional layer of sandy silt till and clayey silt to silty clay.

The groundwater levels observed in the monitoring wells were at depths ranging from 1.2 to 1.9 m below the existing grade. Where the anticipated trench base is below the groundwater level, positive dewatering such as well points will be required to lower the water table to at least 1.0 m below the excavation base. Otherwise, it will result in an unstable base and flowing sides. Test pits should be carried to further explore the groundwater and seepage conditions and to confirm the need for positive dewatering. The wet sandy deposits will require flatter slope at 3 horizontal to 1 vertical. A contractor specializing in dewatering should be retained to design the dewatering systems.

Standard geotechnical site investigations may not determine dewatering or depressurizing requirements for situation where there is planned excavation or construction below the groundwater table. To quantify conditions for dewatering purposes and to apply for required permits, both for construction and long term drainage (if applicable), hydrogeological study is necessary to adequately engineer a construction dewatering system and/or permanent groundwater control. Orbit Engineering Limited advises that the geotechnical conditions at this site require such study. The company is qualified and prepared to undertake this study upon proper authorization. Otherwise Orbit accepts no responsibility for the design and construction of the dewatering details.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the compact cohesionless soils (sandy silt, silty fine sand, sandy silt till) above the water table and stiff clayey silt to silty clay can be classified as Type 3 soil. Cohesionless soils below the water table, such as the sandy silt to silty fine sand can be classified as Type 4.

As a general rule, the excavations in Type 3 soil can be carried out using minimum side slopes of 1 to 1.5H: 1V. The excavations in Type 4 soils will require at a 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.

4.2.2 Bedding

The undisturbed compact cohesionless soils (sandy silt to silty fine sand, sandy silt till) and stiff to clayey silt to silty clay 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 150 mm. 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 such are encountered, especially when the soil at the trench base level consists of wet, dilatant silts, sandy silts and soft to firm clayey silt to silty clay. 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 300 mm 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.

4.2.3 Backfilling of Trenches

Based on visual and tactile examination, the on-site excavated inorganic sandy silt to silty fine sand, sandy silt till and clayey silt to silty clay deposits are generally considered to be suitable for re-use as backfill in the service trenches provided their moisture contents at the time of construction are at or near optimum. The 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 when excavated below the water table. Under unfavorable conditions, they may not be suitable for trench backfill.

The clayey silt especially when its consistency is stiff to very stiff likely to be excavated in cohesive chunks or blocks and will be difficult to compact in confined areas. For use as backfill, the clayey material will have to pulverized and placed in thin layers. The clayey soils will have to be compacted using heavy equipment suitable for these soils which may be difficult to operate in the narrow confines of the trenches. Unless the clayey materials are properly pulverized and compacted in sufficiently thin lifts post-construction settlements could occur. Their use in narrow trenches such as laterals (where heavy compaction equipment can not be operated) may not be feasible.

The backfill should be placed in maximum 200 mm 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 and especially the clayey soils should 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.

4.3 Engineered Fill and Sub-Excavation

The elevation of the existing grade varies significantly across the site. Detailed site grading plans for the proposed development were not available to us at the time of preparation of this report. However based on the 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 fill, the loose possible fill/disturbed soil, and surficially softened 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 test pit locations ranged from 0.7 to 0.9 m, as listed on Table 4.1

The short term (not stabilized) groundwater levels observed in boreholes (BH4 to BH6) were at depths ranging from 1.1 to 2.8 m and groundwater levels in monitoring wells (BH1 to BH3), after 12 days of installation were measured 1.4 to 2.0 m below the existing ground surface. Where the excavation base for engineered fill consists of cohesionless soils (sandy silt to silty fine sand) 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 0.6 to 1.0 m by pumping from perimeter sumps and trenches.

Table 4.1: Depths of Sub-Excavation for Engineered Fill Construction

Borehole No.	Depth of Sub-Excavation of Loose Materials (i.e. Depth of Top of Undisturbed Soils) (m)	Depth of Observed Groundwater (m)
BH1/MW	1.5	2.0 (after 12 days)
BH2/MW	0.9	1.4 (after 12 days)
BH3/MW	0.8	1.7 (after 12 days)
BH4	0.8	1.1 (at completion)
BH5	0.8	1.5 (during drilling)
BH6	0.8	1.5 (during drilling)

Where the excavations extend well into the cohesionless soils (sandy silt to silty fine sand) below the groundwater level, such as for the deep service trenches, a positive dewatering system such as well points will be required to lower the water table below the excavation base.

General guidelines for the placement and preparation of engineered fill are presented on Appendix “D”. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) at the Serviceability Limit States (SLS) and factored geotechnical resistances of 150 to 225 kPa at the Ultimate Limit States (ULS) can be used on engineered fill, provided that all requirements on Appendix “D” 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 fill 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 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.

6. Full-time geotechnical inspection by Orbit Engineering Limited 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. A geotechnical reaction of 100 to 150 kPa (2000 to 3000 psf) 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 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 inorganic native soils are considered suitable for use as engineered fill, provided that their moisture contents at the time of construction are at or near optimum. The 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 before in Section 4.2.3 of this report, the clayey soils are likely to be excavated in cohesive chunks or blocks and will be difficult to compact. They should be pulverized and placed in thin layers not exceeding 150 to 200 mm and compacted using heavy equipment suitable for these types of soils (e.g. heavy sheep foot compactors).

4.4 House Foundation Conditions

In the area of boreholes (BH1, BH4 and BH5), the proposed house foundations can be supported on undisturbed native soils at or below the approximate depths of 0.8 to 1.5 m below the existing grades fora geotechnical reaction of 150 kPa (3000 psf) at the Serviceability Limit States (SLS) and a factored geotechnical resistance of 225 kPa at the Ultimate Limit States (ULS). For remaining boreholes, the house foundations can be supported on undisturbed native soils at or below the approximate depths of 0.9 m below the existing grades for a geotechnical reaction of 100 kPa (2000 psf) at SLS and a factored geotechnical resistance of 150 kPa at ULS. These values would be suitable for the use of normal spread footing foundations to support normal single family dwellings.

Where the existing grade needs to be raised, the proposed structures can be supported by spread and strip footings founded on engineered fill for a geotechnical reaction of 150 kPa (3000 psf) at the Serviceability Limit States (SLS) and a factored geotechnical resistance of 225 kPa ULS. These bearing values will need to be reduced to 100kPa (3000 psf) at SLS and 150kPa at ULS, assuming the grades will not be raised more than 1.5 m at the location of boreholes (BH2, BH3 and BH6). The engineered fill supporting footings should be constructed in accordance with the guidelines presented in Appendix D. Other requirements of engineered fill are given in Section 4.3.

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.

Foundations designed to the specified bearing values are expected to settle less than 25 mm total and 20 mm differential.

All footings exposed to seasonal freezing conditions must have at least 1.5 meters of soil cover for frost protection.

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 test pits and 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.

4.5 Floor Slab and Permanent Drainage

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

The fill present on the site is not suitable for supporting the slab-on-grade. The floor slab can be supported on grade provided the existing topsoil, fill and surficial weak/softened native soil must be removed and the base thoroughly proof rolled and any soft or unstable areas detected are further 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 fill free from topsoil and organics 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 200 mm) and compacted to at least 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

As an alternate option, but not preferable, the floor slab can be supported on a vertical moisture barrier overlying the subgrade; sub excavated and re-compacted with suitable fill to at least 600 mm below the bottom level of the proposed moisture barrier. In preparation of the subgrade, all topsoil, organically stained or surficial softened soils must be removed, and the base thoroughly proof rolled. Any soft or unsuitable soils detected during proof rolling should be further sub-excavated and replaced with compacted engineered fill, which can consist of inorganic soil placed in shallow lifts and compacted to 98% of Standard Proctor Maximum Dry Density (SPMDD).

A moisture barrier consisting of at least 200 mm thick layer of well compacted 19 mm 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 vapor 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 (ks) 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

300 mm, 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.

If the floor slab is more than about 200 mm higher than the exterior grade, then perimeter drainage is not considered to be necessary. If the floor is lower, then use of a perimeter drainage system (**Drawing 11**).

The perimeter and under floor drainage system shown on **Drawing 12** is recommended for the basement area along the entire perimeter. The first row of the underfloor weeper must be placed close to the perimeter wall. From there-on, the underfloor weepers should be placed in parallel rows not more than 8 m centers one way.

Where the exposed subgrade in the basements consists of cohesionless soil below the water table, all openings including the subgrade and permanent drainage systems must be covered or wrapped with filter fabric, typically a Class II non-woven textile with a filtration opening size (F.O.S.) of 50 to 100 m. The design of permanent drainage systems should be reviewed by this office prior to the construction.

4.6 Earth Pressures

The lateral earth pressures acting on the retaining walls or basement walls 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 Granular B 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 buildup of any hydrostatic pressure behind the wall.

4.7 Earthquake Considerations

Based on our borehole information and according to the 2012 Ontario Building Code (OBC 2012), the subject site seismic response for the proposed residential structures can be classified as “Class D” (Table 4.1.8.4.A of OBC 2012). Accordingly, the foundation factors Fa can be obtained from Table 4.1.8.4.B and F_v from Table 4.1.8.4.C for the design of the proposed structure. This must be reviewed by the geotechnical engineer at the design stage.

Consideration may be given to conduct an earthquake site assessment with the use of in-situ testing of the seismic characteristics (i.e. Geophysical testing) which may lead to an improved site classification.

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 this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact this office.

For and on behalf of Orbit

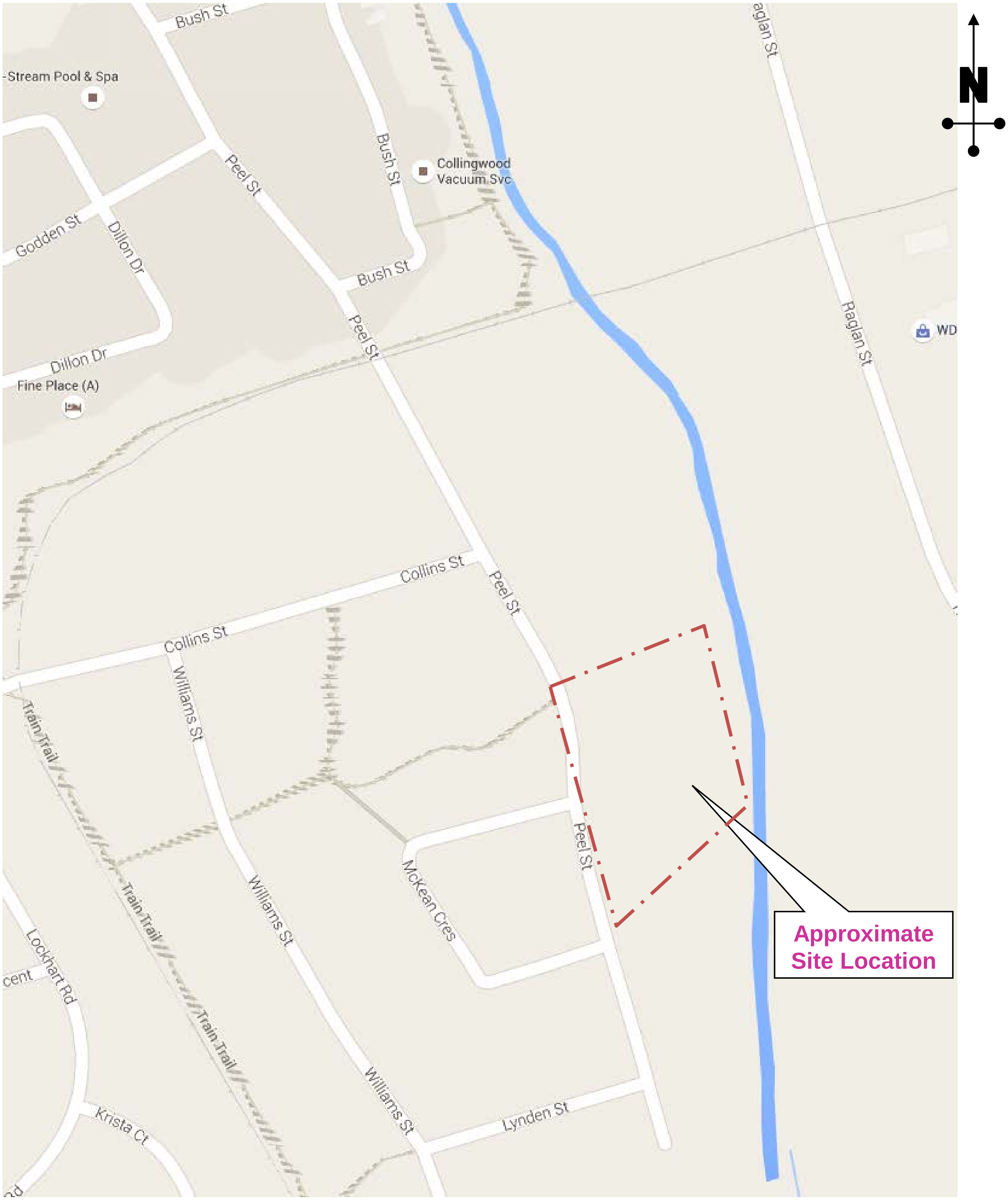
LICENSED PROFESSIONAL ENGINEER
M.I.A.KHOKHAR
100197668
Feb/2/2016
PROVINCE OF ONTARIO

M. Irfan Ahmad Khokhar, PhD, P.Eng.
Manager, Materials Engineering and Testing

LICENSED PROFESSIONAL ENGINEER
H.M.Ahmad
100101997
Feb/2//2016
PROVINCE OF ONTARIO

Hafiz Muneeb Ahmad, M.Eng. M.Sc., P.Eng.
Principal Geotechnical Engineer

Drawings



ORBITENGINEERING

APPROXIMATE SITE LOCATION PLAN

Date:
December, 2015

Project:
OE1575A

Proposal for Groundwater Monitoring Study

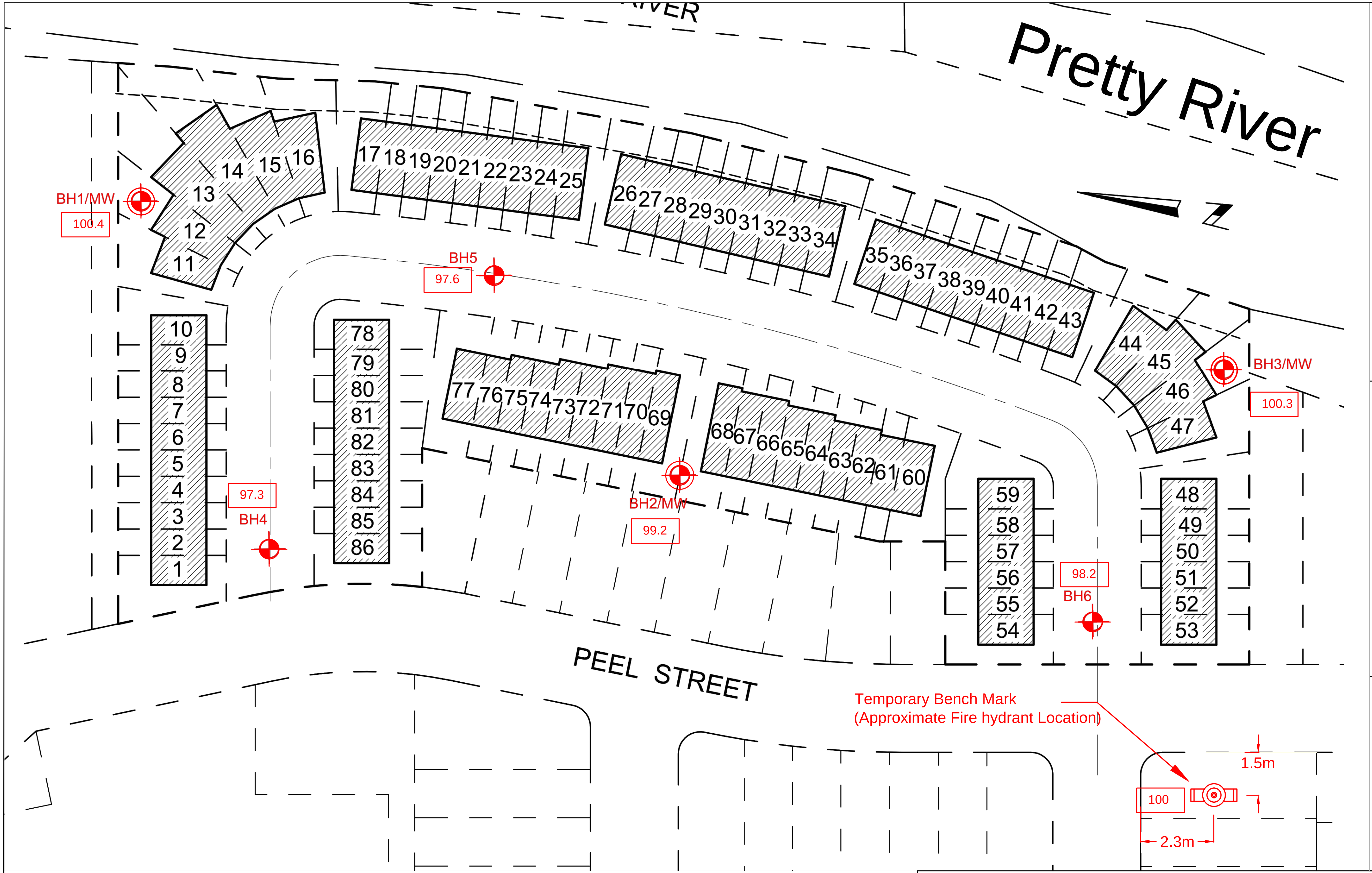
151 Peel St., Town of Collingwood

Prepared for: **Ainley & Associates**

Prepared By:
A.T

Reviewed By:
H.A.

Drawing No **1**



NOTES:

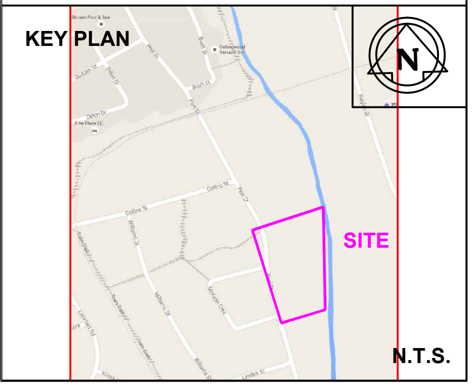
1. The boundaries and soil types have been established only at borehole locations. Between boreholes they are assumed and may be subject to considerable error.
2. Soil samples will be retained in storage for three months then discarded unless the client advises an extended time period is required.
3. Topsoil, Asphalt, Concrete and Granular materials quantities should not be established from the information provided at the borehole locations.
4. Borehole elevations should not be used to design building 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**

227.9 **Local Elevation at the time of Field Investigation**

⊕ **Approximate Borehole/MW Location**



drawn A.T.
approved I.K.
date December, 2015
scale As shown
original size Tabloid

ORBIT ENGINEERING
Consulting Engineers

client: **Ainley & Associates**

project: **Proposal for Groundwater Monitoring Study for 151 Peel St., Town of Collingwood**

title: **Approximate Borehole/MW Location Plan**

project no: **OE1575A** 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.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

0.002	0.006	0.02	0.06	0.2	0.6	2.0	6.0	20	60	200

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

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.

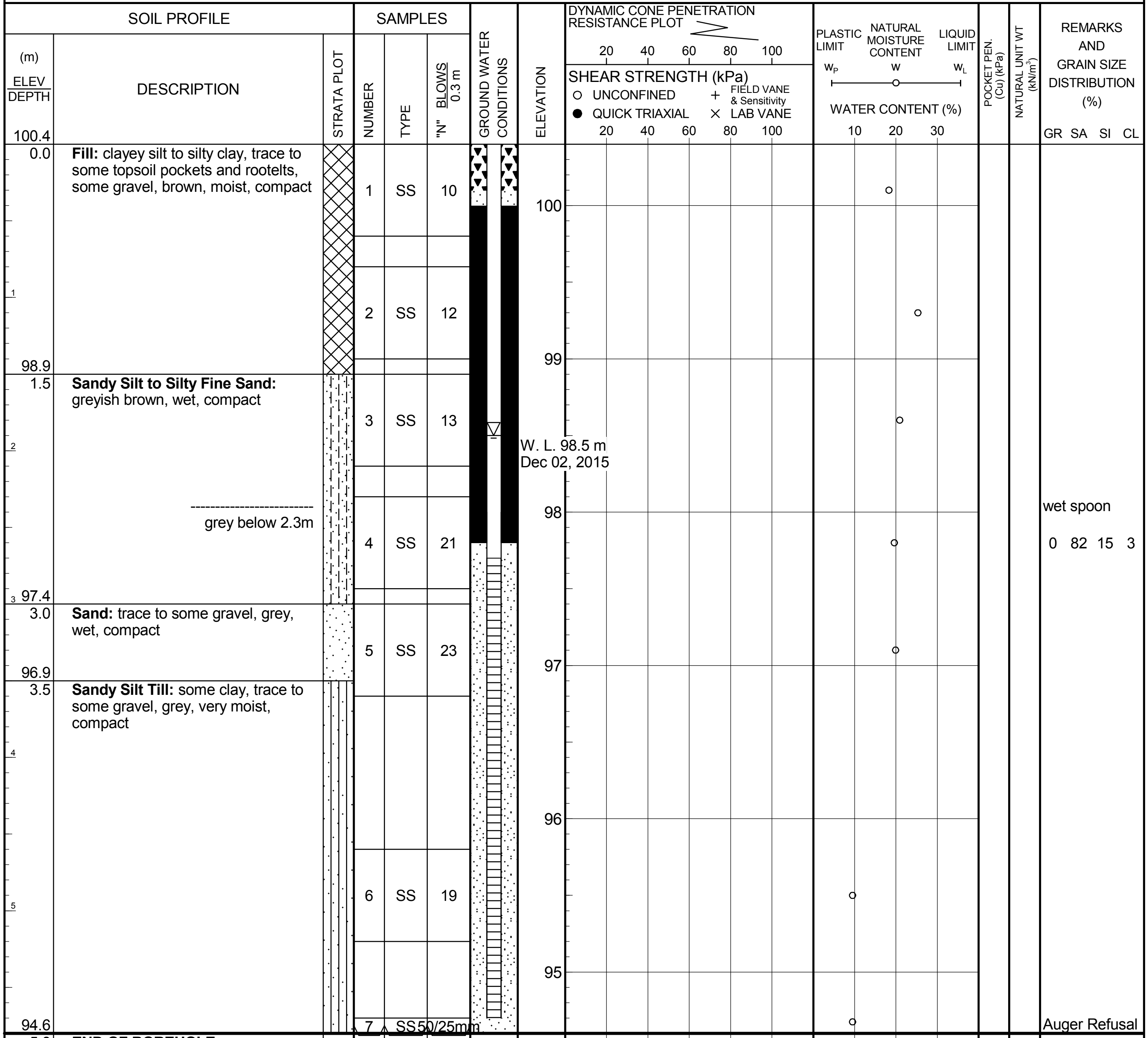
3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, 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.

LOG OF BOREHOLE BH 1 / MW 1

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 2



(m) ELEV DEPTH	DESCRIPTION
100.4	
0.0	**Fill:** clayey silt to silty clay, trace to some topsoil pockets and rootelts, some gravel, brown, moist, compact
98.9 1.5	**Sandy Silt to Silty Fine Sand:** greyish brown, wet, compact ------------------------ grey below 2.3m
97.4 3.0	**Sand:** trace to some gravel, grey, wet, compact
96.9 3.5	**Sandy Silt Till:** some clay, trace to some gravel, grey, very moist, compact
94.6 5.8	**END OF BOREHOLE** 50mm monitoring well was installed at 5.7 m During drilling Nov. 25, 2015 2.3 m At completion Nov. 25, 2015 2.2 m Water level in monitoring well (m) Dec. 2, 2015 1.9 m Dec. 7, 2015 2.0 m

NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	10	
2	SS	12	
3	SS	13	
4	SS	21	wet spoon 0 82 15 3
5	SS	23	
6	SS	19	
7	SS	50/25mm	Auger Refusal

GROUNDWATER ELEVATIONS

Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

ORBITENGINEERING

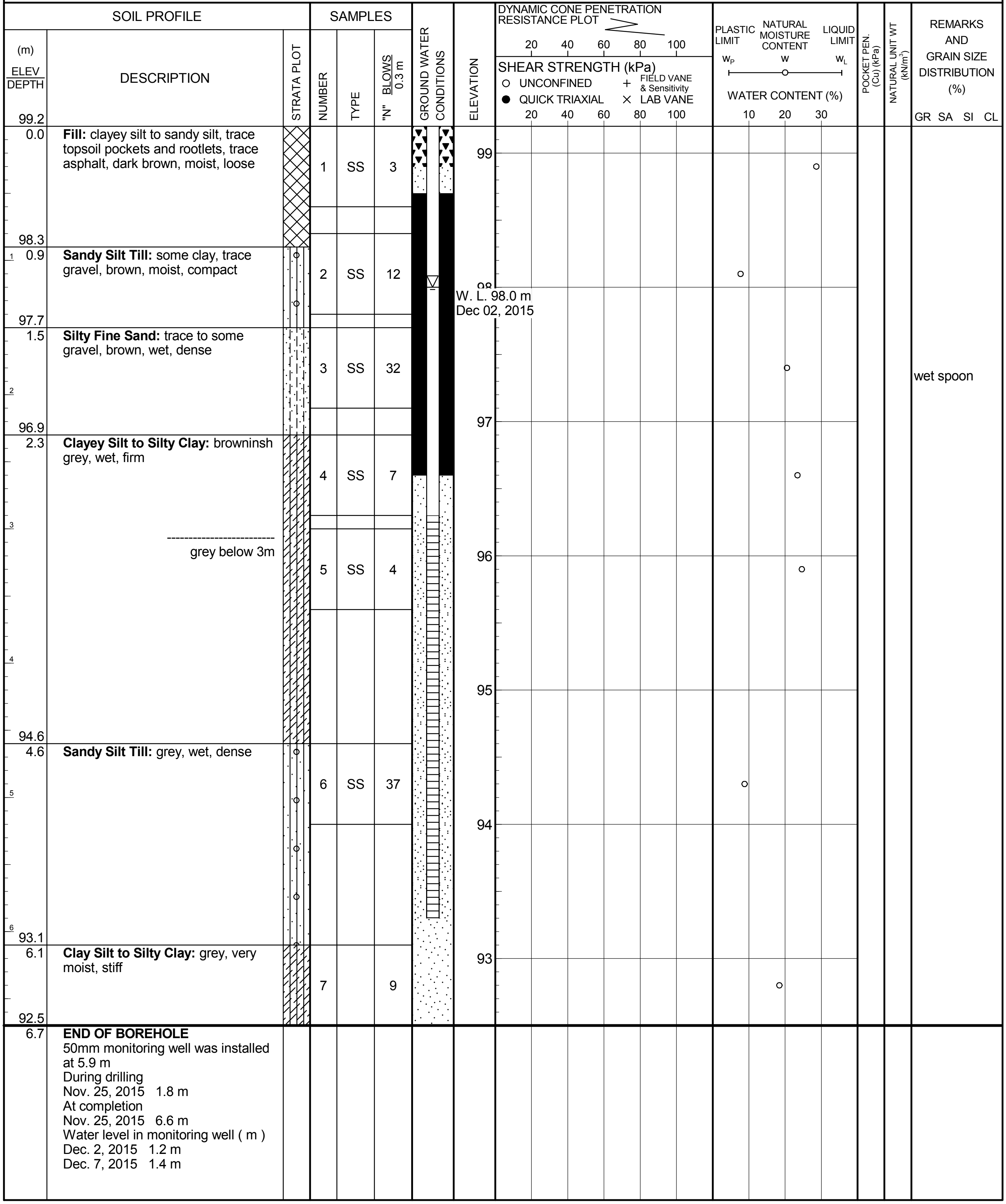
LOG OF BOREHOLE BH 2 / MW 2

1 OF 1

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 3



ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	REMARKS
99.2 0.0	**Fill:** clayey silt to sandy silt, trace topsoil pockets and rootlets, trace asphalt, dark brown, moist, loose	1	SS	3	
98.3 0.9	**Sandy Silt Till:** some clay, trace gravel, brown, moist, compact	2	SS	12	
97.7 1.5	**Silty Fine Sand:** trace to some gravel, brown, wet, dense	3	SS	32	wet spoon
96.9 2.3	**Clayey Silt to Silty Clay:** browninsh grey, wet, firm	4	SS	7	
	------------------------- grey below 3m	5	SS	4	
94.6 4.6	**Sandy Silt Till:** grey, wet, dense	6	SS	37	
93.1 6.1	**Clay Silt to Silty Clay:** grey, very moist, stiff	7		9	
92.5 6.7	**END OF BOREHOLE** 50mm monitoring well was installed at 5.9 m During drilling Nov. 25, 2015 1.8 m At completion Nov. 25, 2015 6.6 m Water level in monitoring well (m) Dec. 2, 2015 1.2 m Dec. 7, 2015 1.4 m				

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

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

ORBITENGINEERING

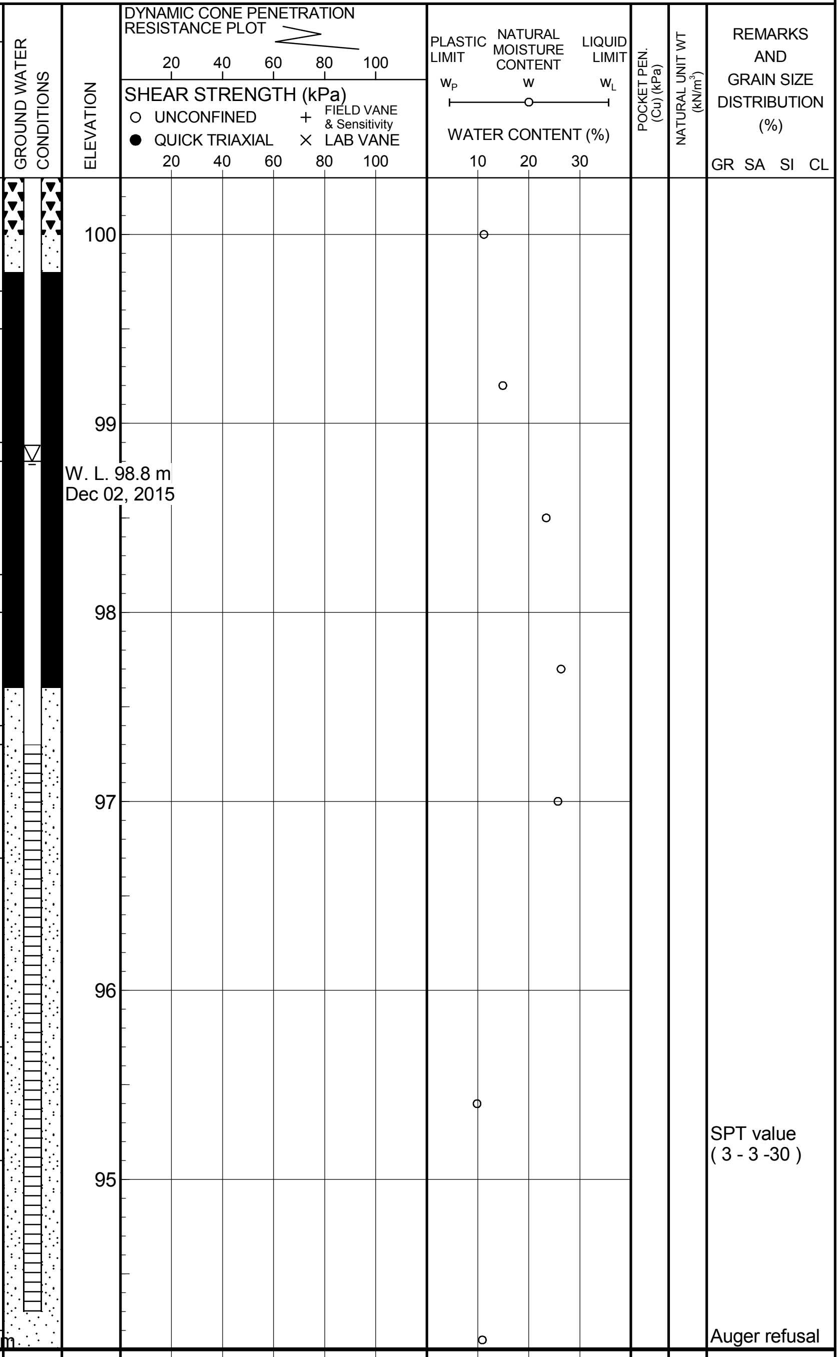
LOG OF BOREHOLE BH 3 / MW 3

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 4

(m) ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.3 0.0	**Fill:** silty sand, topsoil pockets and rootlets, brown, moist, loose	1	SS	3	
99.5 0.8	**Silty Sand:** brownish grey, moist, compact	2	SS	12	
98.8 1.5	**Clayey Silt to Silty Clay:** grey, moist to wet, stiff to firm	3	SS	10	
		4	SS	4	
		5	SS	5	
95.4 4.9	**Sandy Silt till:** some gravel, grey, wet, dense to very dense	6	SS	33	SPT value (3 - 3 -30)
		7	SS	50/50mm	Auger refusal
94.1 6.2	**END OF BOREHOLE** 50mm monitoring well was installed at 6.0 m During drilling Nov. 25, 2015 5m At completion Nov. 25, 2015 3.2 m Water level in monitoring well (m) Dec. 2, 2015 1.5 m Dec. 7, 2015 1.7 m				



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

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

ORBITENGINEERING

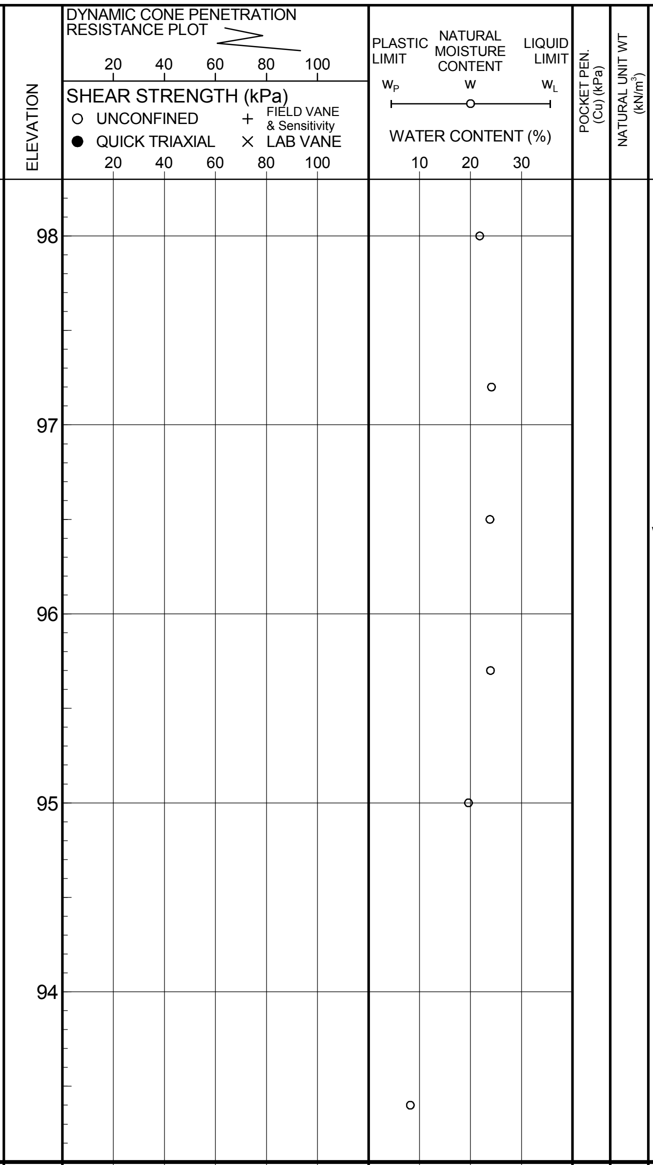
LOG OF BOREHOLE BH 4

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 5

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
98.3 0.0	**Fill:** clayey silt mixed with topsoil and gravel, rootlets, grey, moist,compact	1	SS	15		
97.5 0.8	**Silty Fine Sand:** trace topsoil, rootlets, greyish brown, very moist, compact	2	SS	14		
97.1 1.2	**Clayey Silt:** trace topsoil, greyish brown, moist, stiff					
96.8 1.5	**Silty Sand:** brownish grey, wet, compact ------------------------- grey below 1.8m	3	SS	21		wet spoon
		4	SS	15		
		5	SS	10		
93.7 4.6	**Sandy Silt Till:** trace clay and some gravel, grey, very moist to moist, compact	6	SS	19		
93.1 5.2	**END OF BOREHOLE** Water level During drilling 1.7 m At completion 1.1m Caving at 1.8m					



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

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

ORBIT ENGINEERING

LOG OF BOREHOLE BH 5

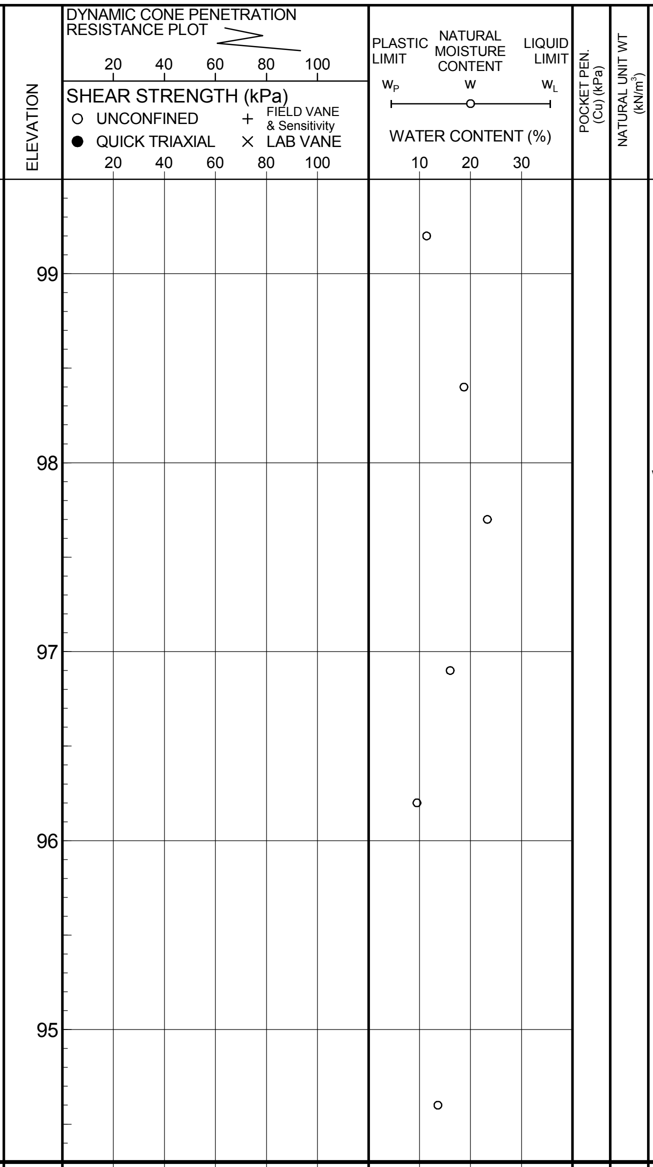
1 OF 1

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 6

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
99.5 0.0	**Topsoil:** 200mm				
99.3 0.2	**Fill:** trace clayey silt and topsoil pockets, dark brown, moist, compact	1	SS	7	
98.7 0.8	**Sandy Silt to Silty Fine Sand:** trace clay, trace to some gravel, brownish grey, moist to wet, compact	2	SS	15	
	grey below 1.5m	3	SS	26	wet spoon 0 83 14 3
		4	SS	16	
96.4 3.1	**Sandy Silt Till:** some clay and gravel, grey, wet, compact	5	SS	10	
	300 mm layer of clayey silt at 4.5 m	6	SS	11	
94.3 5.2	**END OF BOREHOLE** Water level During drilling 1.5 m At completion 1.8 m				



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

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

ORBIT ENGINEERING

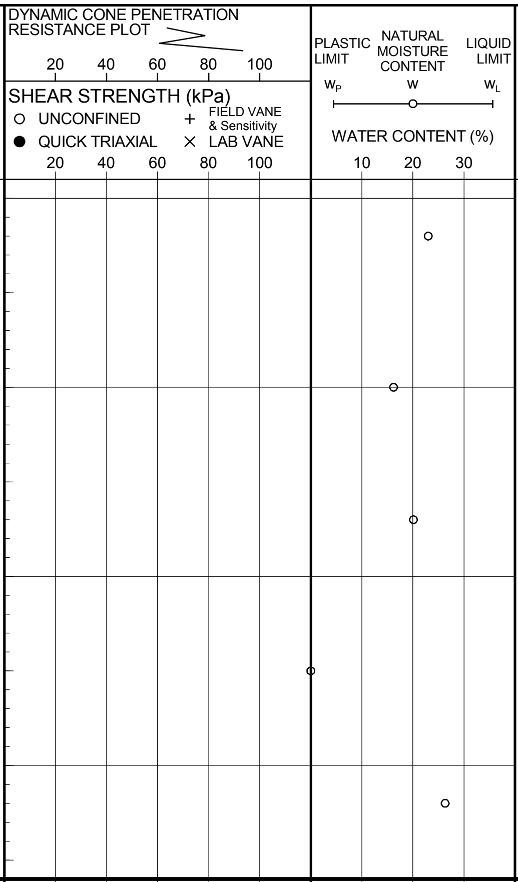
LOG OF BOREHOLE BH 6

PROJECT: Proposed Residential Development
CLIENT: Ainley Associates
PROJECT LOCATION: 151 Peel st., Town of Collingwood, ON
DATUM: Local
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 75 mm
Date: Nov/25/2015

REF. NO.: OE1575A
DRAWING NO.: 7

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			
99.1								
0.0	**Fill:** sandy silt, trace topsoil and gravel, rootlets, brown, moist, loose	⊠	1	SS	3		99	
98.3 0.8	**Sandy Silt to Silty Fine Sand:** greyish brown, very moist to wet, compact		2	SS	20		98	
97.7 1.4	**Clayey Silt to Silty Clay:** trace sand and gravel, grey, very moist to wet, firm	▨	3	SS	8			wet spoon
							97	
			4	SS	5			No recovery
			5	SS	4		96	
95.4 3.7	**END OF BOREHOLE** Water level During drilling 1.5 m At completion 1.7 m							

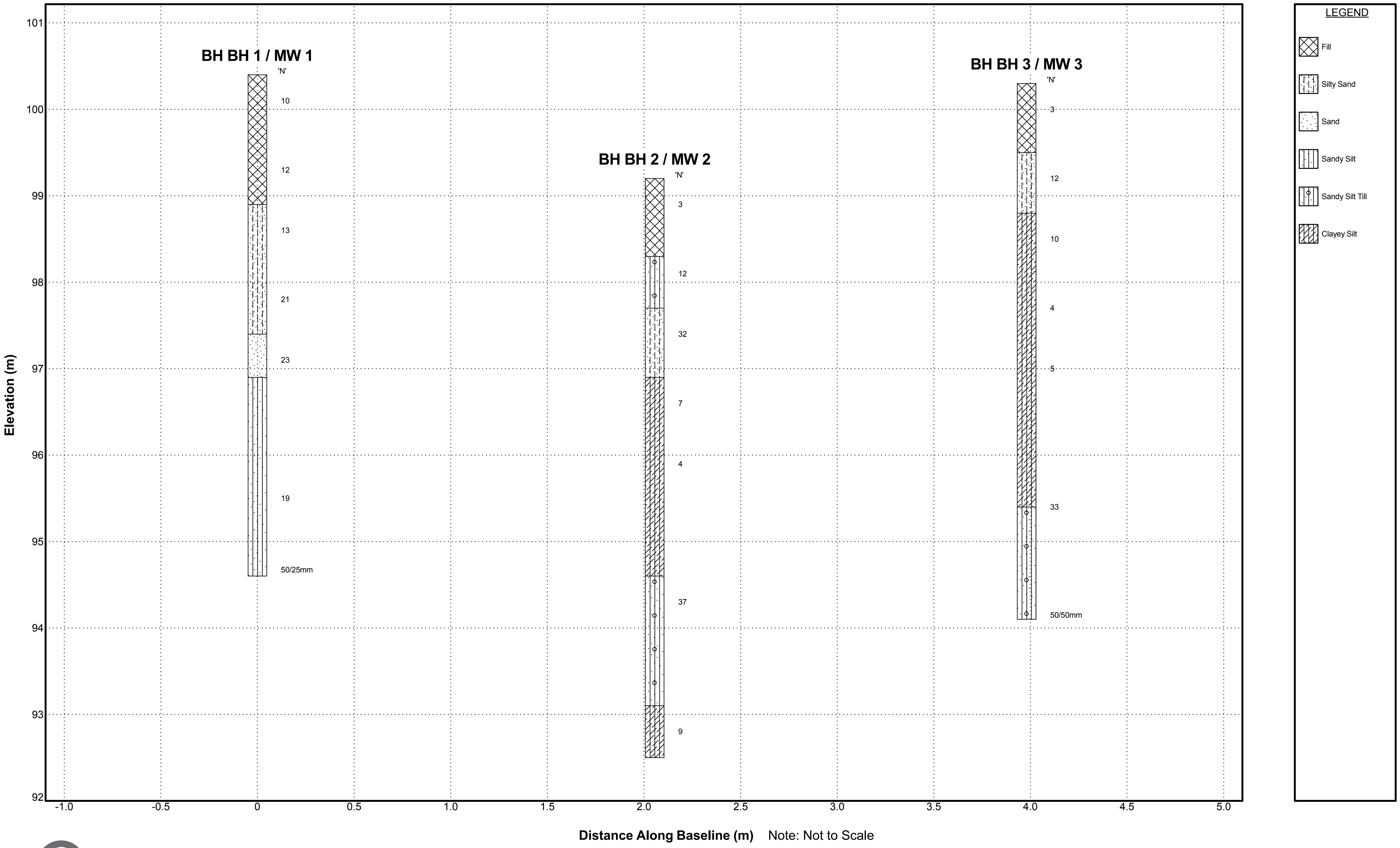


POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m^3)

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

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

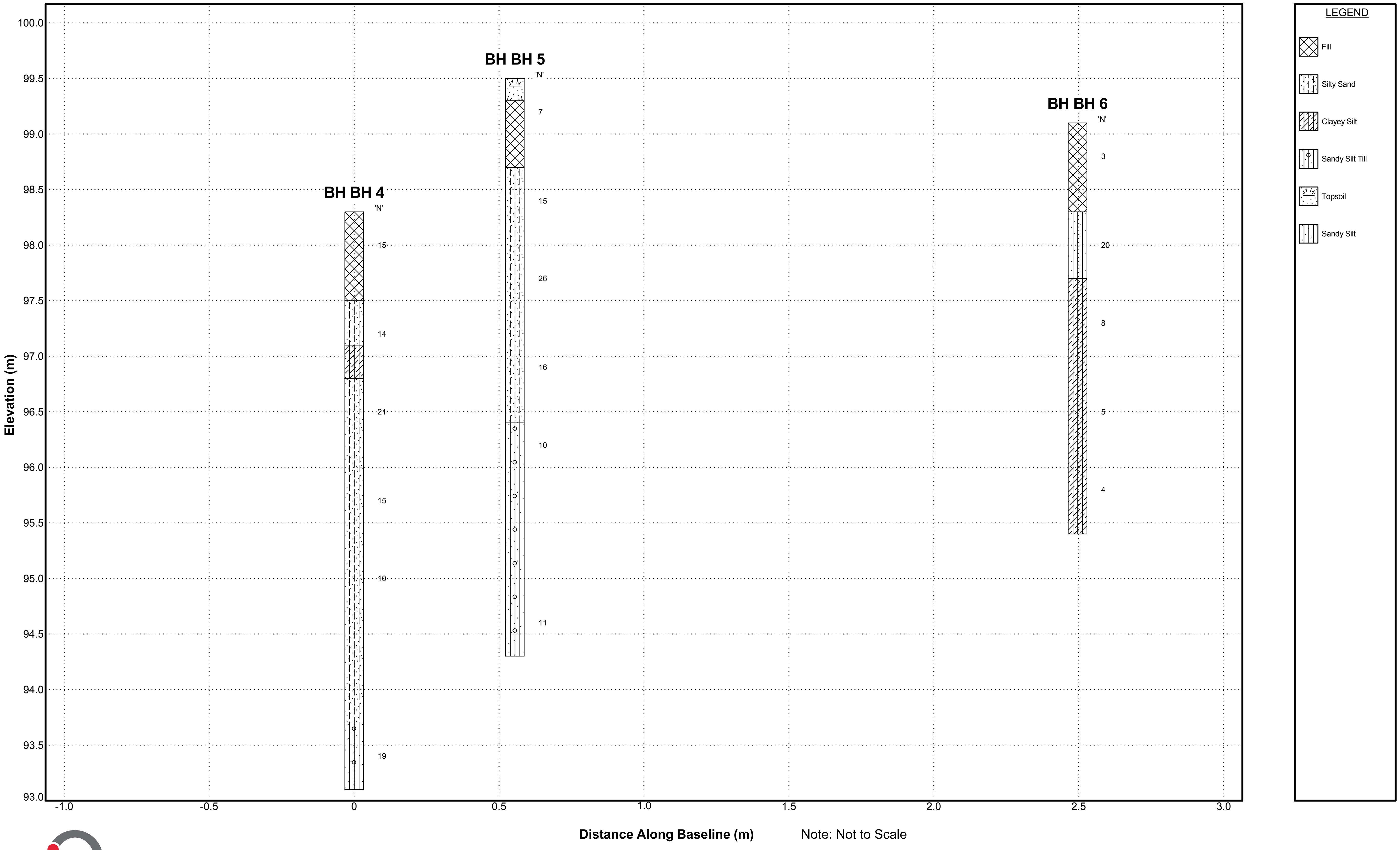


COMPATIBLE GEO-CANADA FENCE (B) BH 1-6.GPJ 12/14/15

ORBIT ENGINEERING

Generalized Subsurface Profiles at the Location of Boreholes

DRAWING NO.	8
JOB NO. OE1575A	
DATE	December 14, 2015



COMPATIBLE GEO-CANADA FENCE (B) BH 1-6.GPJ 12/14/15

ORBIT ENGINEERING

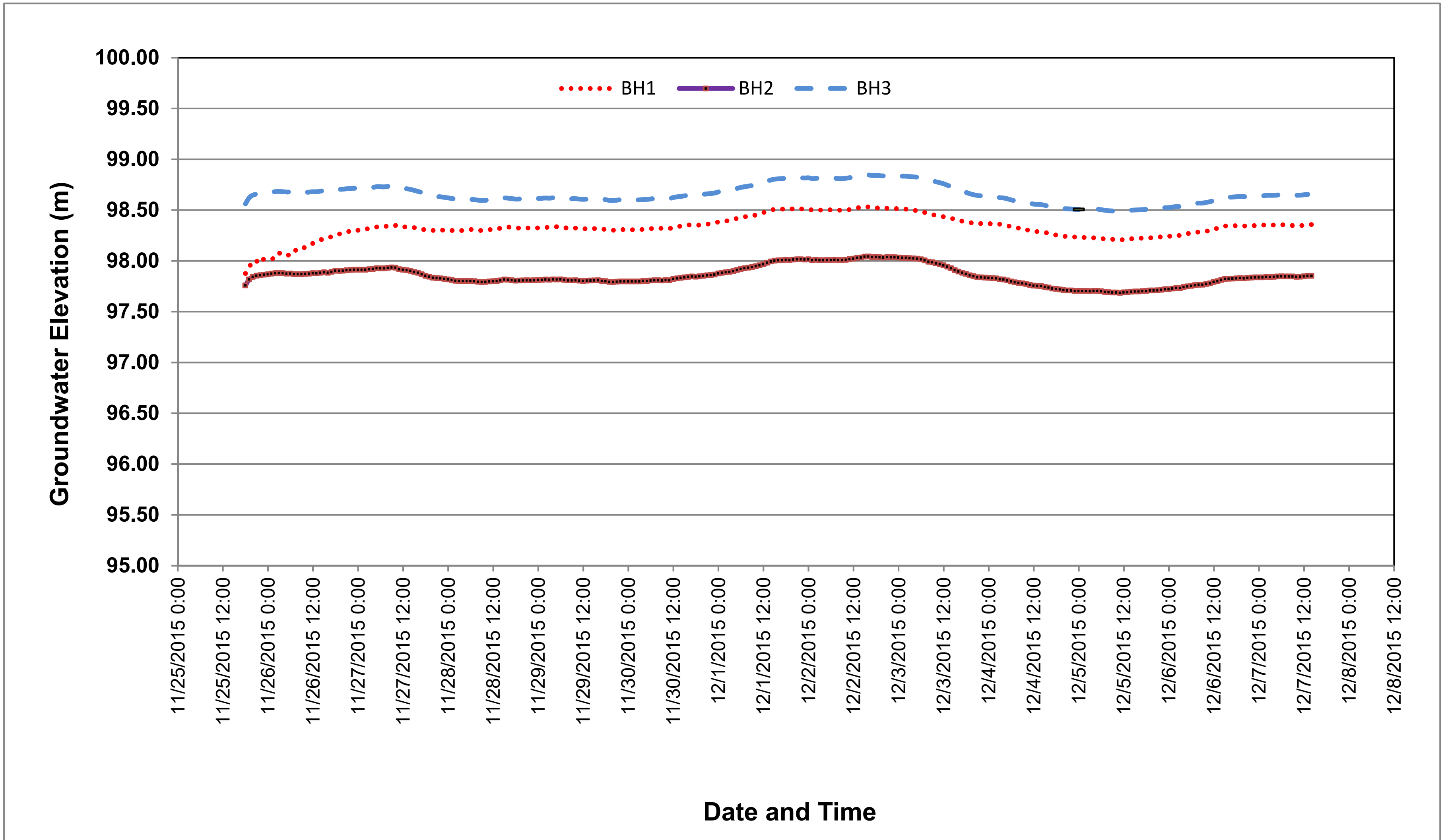
Generalized Subsurface Profiles at the Location of Boreholes

DRAWING NO. 9

JOB NO. OE1575A

DATE December 14, 2015

Drawing 10



Groundwater Level Fluctuation at Monitroing Wells

Orbit Engineering Limited
1900 Clark Blvd, Unit 9
Brampton, ON
L6T 0E9

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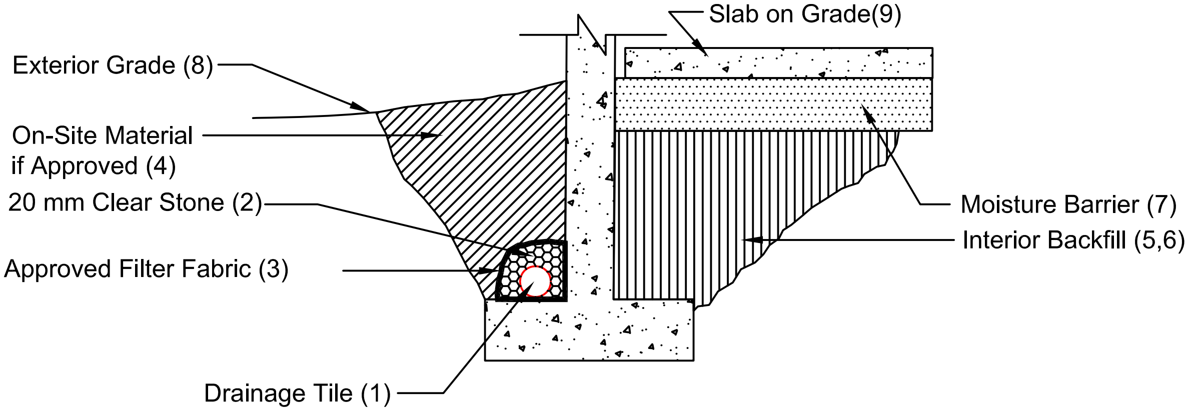


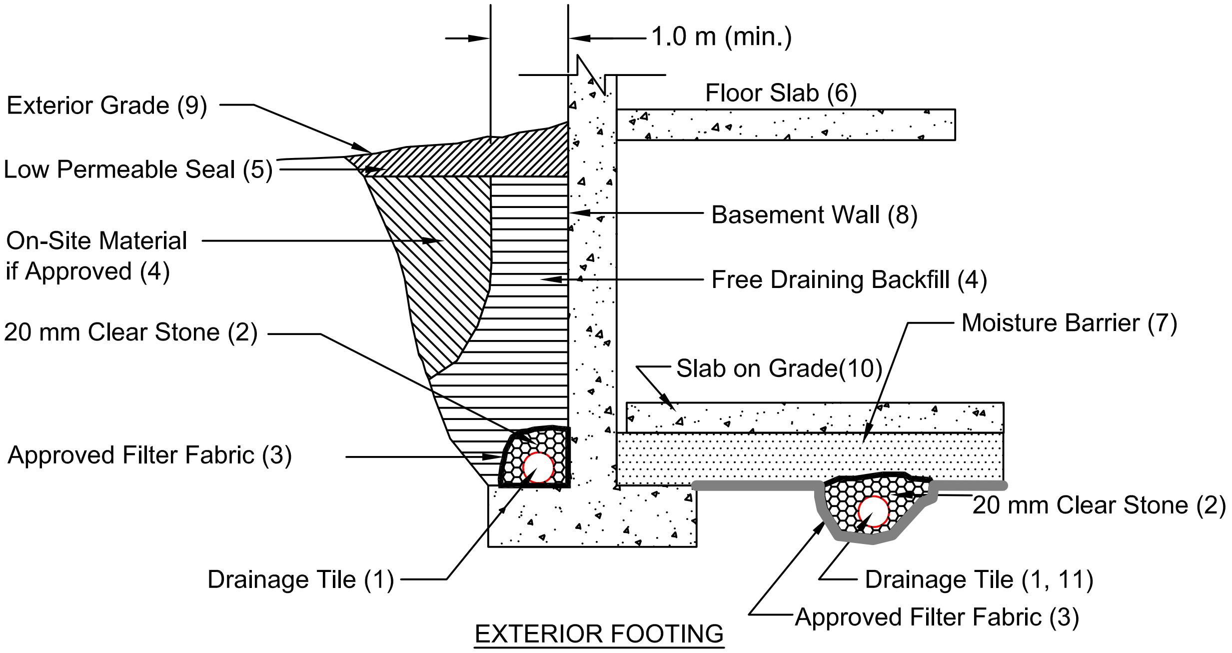
EXTERIOR FOOTING

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 270R or equivalent).
4. The on-site material, if approved, can be used as backfill.
5. The interior fill may be any clean non-organic soil which can be compacted to the specified density in this confined space.
6. Do not use heavy compaction equipment within 450 mm (18") of the wall. Do not fill or compact within 1.8 m (6') of the wall unless fill is placed on both sides simultaneously.
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. Exterior grade to slope away from building.
9. 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.
10. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE AND BACKFILL RECOMMENDATIONS
Slab on Grade Construction Without Underfloor Drainage

(not to scale)



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: Site Photographs

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Project # OE1575B

SITE PHOTOGRAPHS
Preliminary Geotechnical Investigation
Proposed Residential Development
151 Peel Street, Town Of Collingwood, Ontario

Photo No.: 1

Description:

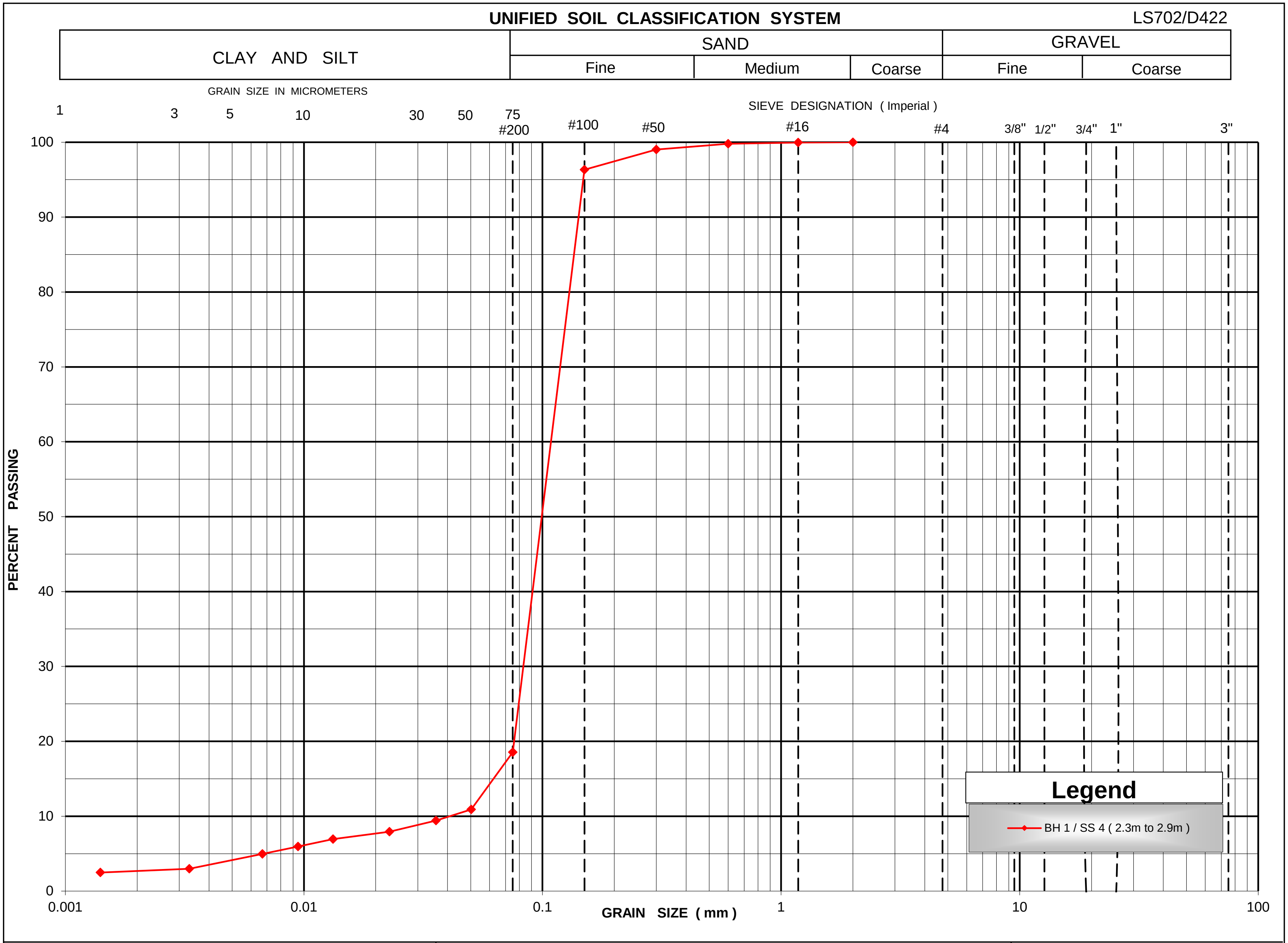
Borehole BH2/MW
Looking West

Photo No.: 2

Description:

Borehole BH3/MW
Looking West

Appendix C: Geotechnical Laboratory Test Results



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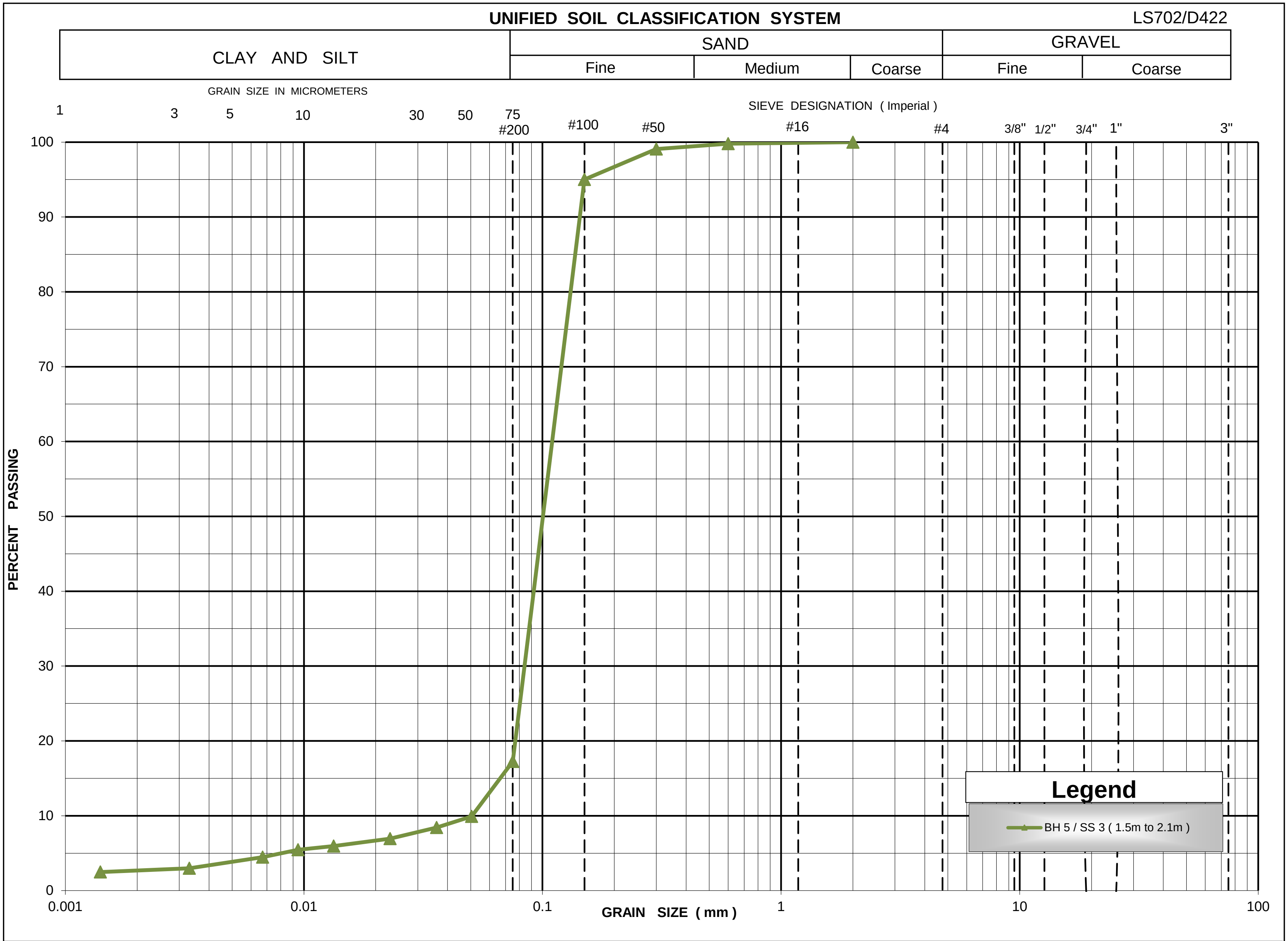
GRAIN SIZE DISTRIBUTION

Fine Sand, Some Silt, Trace Clay

Figure # : C1

PROJECT # : OE1575A

DATE : Nov 13, 2015



ORBITENGINEERING
Consulting Engineers

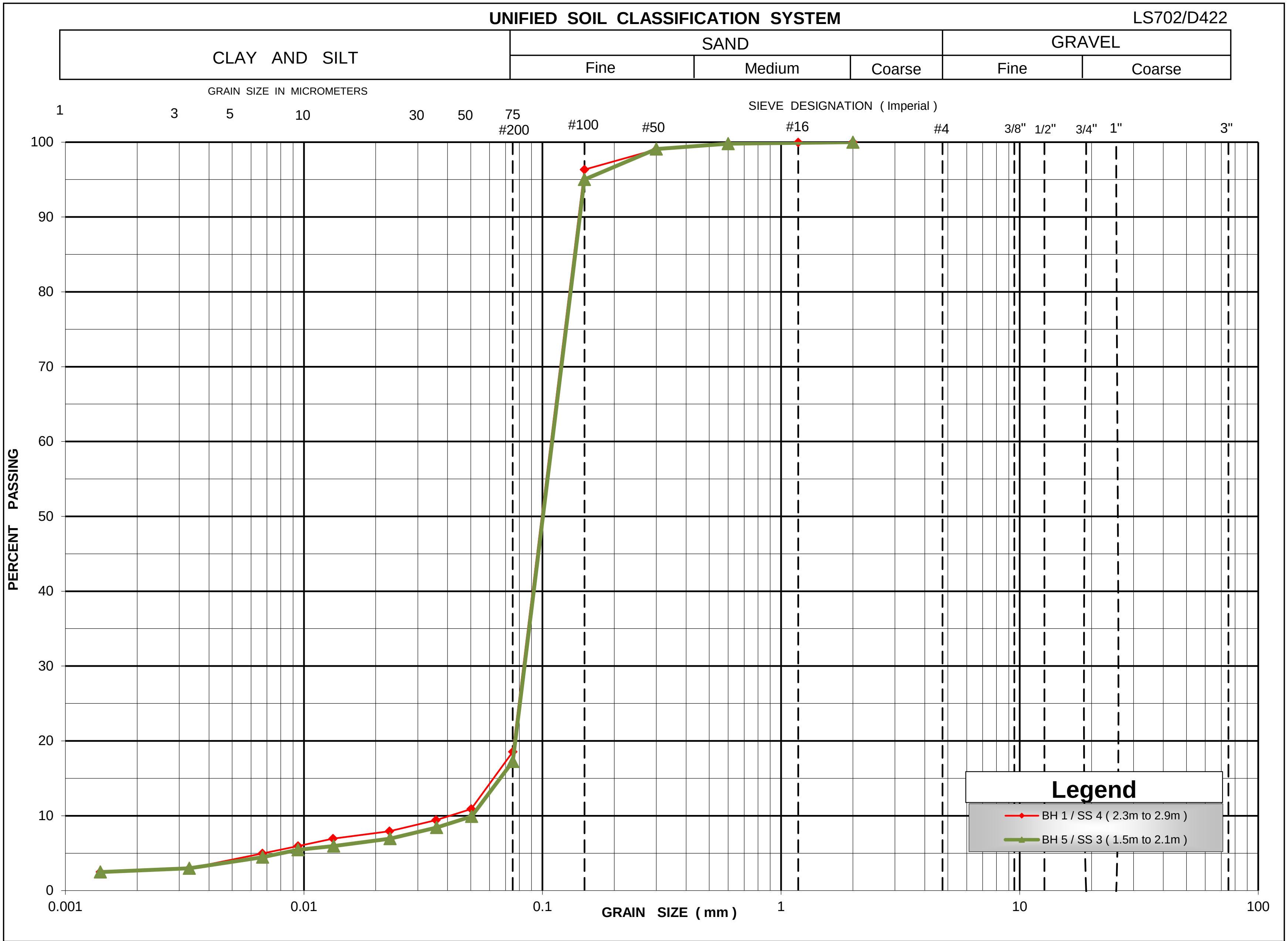
GRAIN SIZE DISTRIBUTION

Fine Sand, Some Silt, Trace Clay

Figure # : C2

PROJECT # : OE1575A

DATE : Nov 13, 2015



ORBIT ENGINEERING
Consulting Engineers

GRAIN SIZE DISTRIBUTION

Fine Sand, Some Silt, Trace Clay

Figure # : C3

PROJECT # : OE1575A

DATE : Nov 13, 2015

Appendix D: 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.

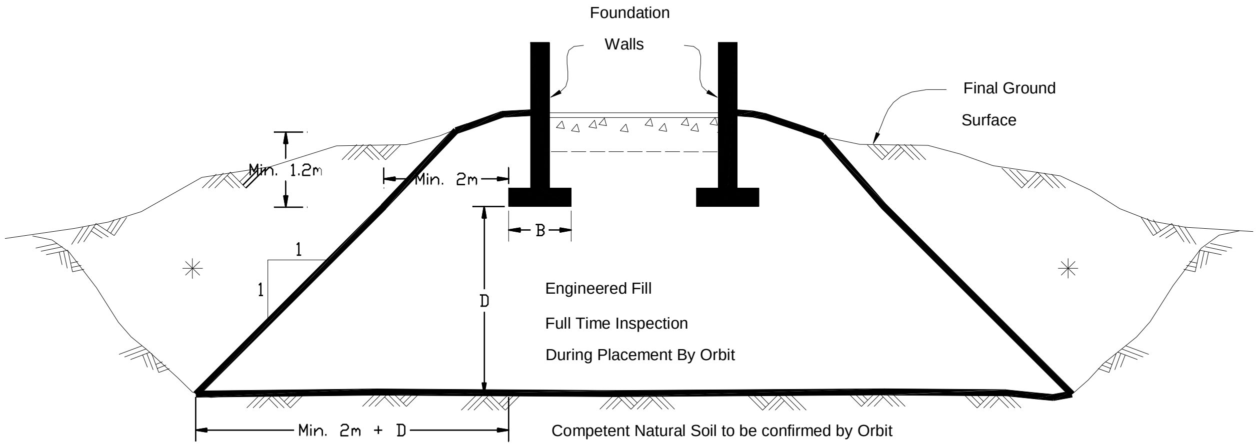
10. After completion of the pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from Orbit Engineering Limited prior to footing concrete placements. All excavations must be backfilled under full time Orbit Engineering Limited 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.

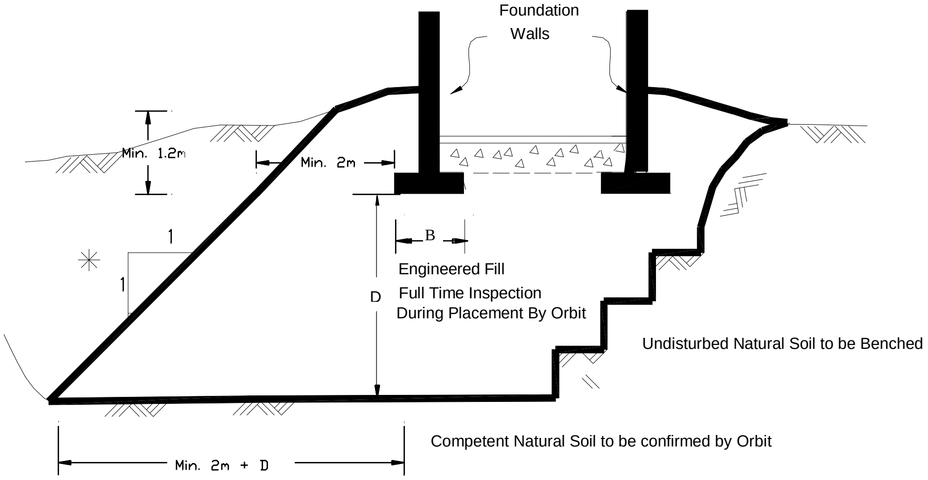
11. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proofrolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work 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