# REVISED REPORT ON

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION
Areas 'A' to 'D' – MILLCROFT GOLF CLUB
2155 COUNTRY CLUB DRIVE
BURLINGTON, ONTARIO

## PREPARED FOR:

MILLCROFT GREENS CORPORATION

**Project No:** 19-199-100 R2
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# 1. INTRODUCTION

DS Consultants Ltd (DS) was retained by Millcroft Greens Corporation to undertake a preliminary geotechnical investigation for the proposed development at Areas 'A' to 'D' of Millcroft Golf Club located at 2155 Country Club Drive in Burlington, Ontario.

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

This geotechnical report is a combined report for all four Areas (Area A, Area B, Area C and Area D) and supersedes our previously issued geotechnical report (Project No. 18-687-100, dated January 21, 2019) for Areas A & B.

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 preliminary recommendations pertaining to the geotechnical design of underground utilities and subdivision roads and to comment on the foundation conditions for general house 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 Millcroft Greens Corporation and its architects and designers. Third party use of this report without DS Consultants Ltd (DS) consent is prohibited.

# 2. FIELD AND LABORATORY WORK

Nine (9) boreholes (BH18-1 through BH18-9) were drilled in Areas 'A' and 'B' in December 2018 to depths ranging from 2.5 to 6.3m. Three (3) boreholes (BH19-100 to BH19-102) were drilled in Area 'C' and three (3) boreholes (BH19-200 to BH19-202) were drilled in Area 'D' in December 2019, to a depth of 6.2m.

Boreholes were drilled with solid stem continuous flight auger equipment by a drilling sub-contractor under the direction and supervision of DS personnel. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N and dropping 760 mm in

accordance with the Standard Penetration Test (SPT) method. The samples were logged in the field and returned to the DS laboratory for detailed examination by the project engineer and for laboratory testing.

As well as visual examination in the laboratory, all soil samples were tested for moisture contents. Eleven (11) soil samples were subjected to grain size analyses and seven (7) samples for Atterberg Limits testing.

Water level observations were made during drilling and in the open boreholes at the completion of the drilling operations. Monitoring wells were installed in all boreholes except BH18-3 and BH18-6, for groundwater level monitoring.

The surface elevations at the borehole locations were surveyed by DS staff using differential GPS system.

# 3. SITE AND SUBSURFACE CONDITIONS

The borehole location plan and borehole logs for Areas 'A' and 'B' are attached in Appendix A of this report. The borehole location plan and borehole logs for Area 'C' and Area 'D' are attached in Appendix B and Appendix C of this report respectively. Notes on sample description are presented on Drawing 1A. The subsurface conditions in the boreholes are summarized in the following paragraphs.

## 3.1 Soil Conditions

**Topsoil/ Fill Material:** A surficial topsoil layer, ranging in thickness from 50 to 350 mm was found at borehole locations. The thickness of the topsoil in each borehole was shown in the borehole log. It should be noted that the thickness of the topsoil explored at the borehole locations may not be representative for the site and should not be relied on to calculate the amount of topsoil at the site.

Underneath the topsoil, firm to very stiff fill material was found in all boreholes extending to depths of 0.8 to 2.6 below grade. The fill consisted of clayey silt, trace rootlets, trace topsoil.

**Clayey Silt to Sandy Silt Till:** Native soil consisting of clayey silt to sandy silt till was found in all of the boreholes below the fill material, extending to a clayey silt till/shale complex or the shale bedrock. The clayey silt till was present in a very stiff to hard, generally hard consistency, with measured SPT 'N' values ranging from 15 to over 100 blows per 300 mm penetration. The sandy silt till was present in a compact to very dense, generally very dense relative density, based on the measured SPT "N" values ranging from 29 to in excess of 100 blows per 300 mm penetration. The till is known to contain layers and pockets of sand. Large boulders are also known to be present in the till.

Grain size analyses of eleven (11) till samples (BH18-1/SS4, BH18-2/SS5, BH18-4/SS4, BH18-5/SS4, BH18-6/SS2, BH18-7/SS3, BH18-9/SS4, BH19-100/SS3, BH19-102/SS6, BH19-200/SS3 and BH19-201/SS4) were conducted and the results are presented on Drawings 2 and 3, with the following fractions:

Clay: 5 to 18%
Silt: 29 to 61%

Sand: 17 to 40%
Gravel: 3 to 12%

Atterberg limits tests of seven (7) till samples (BH18-1/SS4, BH18-4/SS5, BH18-5/SS4, BH18-9/SS4, BH19-100/SS3, BH19-102/SS6, and BH19-200/SS3) were conducted. Based on the test results, the soil is classified as inorganic clays and silts of low plasticity (CL, CL-ML). The results are shown on the borehole logs and are summarized as follows:

Liquid limit ($W_L$): 20 to 25%
Plastic limit ($W_P$): 13 to 15%
Plasticity index (PI): 5 to 11

**Clayey Silt Till/Shale Complex:** Underlying the clayey silt till and/or overlying the shale bedrock, a deposit termed clayey silt till /shale complex was encountered in some boreholes (BH18-1, BH18-9, BH19-101, BH19-200, and BH19-201). The deposit consisted of clayey silt till mixed with highly weathered shale. The till/shale complex was in a hard state.

**Shale Bedrock:** Shale bedrock of Queenston Formation was encountered at most borehole locations, except BH18-8 and BH18-9 which were terminated in clayey silt till or clayey silt till/shale complex upon auger refusal. The highly weathered shale was encountered below depths ranging from 1.5 to 6.1m, corresponding to Elevations 135.6 to 142.8m. The shale bedrock was not proven by core drilling. The approximate depth and elevation of the shale bedrock surface in the boreholes are listed on Table 1 below.

**Table 1: Approximate Depth and Elevation of Shale Bedrock Surface**

| Area Name | Borehole No. | Depth of Shale Bedrock Surface below Existing Ground (m) | Approximate Elevation of Shale Bedrock Surface (m) |
|---|---|---|---|
| Areas 'A' & 'B' | BH18-1 | 6.1 | 136.7 |
| | BH18-2 | 4.7 | 137.5 |
| | BH18-3 | 3.4 | 138.3 |
| | BH18-4 | 4.6 | 136.0 |
| | BH18-5 | 4.6 | 135.6 |
| | BH18-6 | 1.5 | 136.6 |
| | BH18-7 | 2.3 | 136.3 |
| | BH18-8 | Auger refusal at 4.7 m | Auger refusal 135.7 |
| | BH18-9 | Auger refusal at 4.1 m | Auger refusal 136.7 |
| Area 'C' | BH19-100 | 4.6 | 139.3 |
| | BH19-101 | 3.3 | 141.7 |
| | BH19-102 | 6.1 | 139.7 |
| Area 'D' | BH19-200 | 4.6 | 141.7 |
| | BH19-201 | 3.7 | 142.7 |
| | BH19-202 | 4.6 | 142.8 |

Commonly the till overlying the shale contains slabs of limestone which would give a false indication of the bedrock level. Similarly, the depth of weathering cannot be determined accurately due to the presence of limestone layers.

The shale bedrock generally contains layers of sandstone, limestone and dolostone. Typically, the hard layers comprise about 15 to 20 percent of the unit. However, higher concentrations of hard layers can be present. The hard layers are usually less than 100 to 150 mm thick, but some layers are much thicker. The thicker layers have been observed to be as much as 750 to 900 mm at other sites. The layers are actually lenses and they can vary significantly in thickness over short distance.

Methane gas is anticipated in the bedrock. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly for caissons. Stress relief features such as folds and faults are common in the shale bedrock. **Appendix D** presents more details and general comments about the shale bedrock.

### 3.2 Groundwater Conditions

No groundwater was found in the boreholes during drilling or upon completion of drilling, except in BH18-7 where groundwater level was measured at 2.1 m below grade upon completion of the borehole. The stabilized groundwater levels observed in the monitoring wells installed in the boreholes are listed on Table 2.

**Table 2: Groundwater Levels Observed in Monitoring Wells**

| Area No | Borehole No. | Date of installation | Date of Observation | Depth of Groundwater (m) | Elevation of Groundwater (m) |
|---|---|---|---|---|---|
| Areas 'A' & 'B' | BH18-1 | Dec. 18, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 4.2<br>4.3 | 138.6<br>138.5 |
| | BH18-2 | Dec. 18, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 1.1<br>1.4 | 141.1<br>140.8 |
| | BH18-4 | Dec. 19, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 1.8<br>2.1 | 138.8<br>138.5 |
| | BH18-5 | Dec. 19, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 2.6<br>3.4 | 137.5<br>136.7 |
| | BH18-6 | Dec. 19, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 1.6<br>1.5 | 136.5<br>136.6 |
| | BH18-7 | Dec. 20, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 2.1<br>2.1 | 136.5<br>136.5 |
| | BH18-9 | Dec. 20, 2018 | Jan. 3, 2019<br>Jan. 7, 2019 | 1.7<br>2.0 | 139.1<br>138.8 |
| Area 'C' | BH19-100 | Nov. 26, 2019 | Dec. 4, 2019 | 3.2 | 140.7 |
| | BH19-101 | Nov. 26, 2019 | Dec. 4, 2019 | 4.5 | 140.4 |
| | BH19-102 | Nov. 27, 2019 | Dec. 4, 2019 | 1.4 | 144.3 |
| Area 'D' | BH19-200 | Nov. 27, 2019 | Dec. 4, 2019 | 1.1 | 145.1 |
| | BH19-201 | Nov. 27, 2019 | Dec. 4, 2019 | 0.5 | 145.8 |
| | BH19-202 | Nov. 28, 2019 | Dec. 4, 2019 | 4.5 | 142.9 |

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events.

# 4. DISCUSSION AND RECOMMENDATIONS

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

## 4.1 Roads

The investigation has shown that the predominant subgrade soil, after stripping the topsoil, loose fill and any other organic and otherwise unsuitable subsoil, will generally consist of clayey silt.

Based on the above and assuming that traffic usage will be residential minor local or local, the following minimum pavement thickness is recommended for roads to be constructed within the subdivision:

40 mm HL3 Asphaltic Concrete

50 mm HL8 Asphaltic Concrete

150 mm Granular 'A'

350 mm Granular 'B'

For collector streets/bus routes, 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 City of Burlington 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 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 re-grading 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 the 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

The City of Burlington requires the installation of full-length subdrains on all roads. The subdrains should be properly filtered to prevent the loss of (and clogging by) soil fines.

All paved surfaces should be sloped to provide satisfactory drainage towards catchbasins. As discussed in Section 4.1.1, by means of good planning any water trapped in the granular sub-base materials should be drained rapidly towards subdrains or other interceptors.

## 4.2 Sewers

As a part of the site development, a network of new storm and sanitary sewers is to be constructed. It is assumed that the trenches are generally within 4 to 5 m below the existing grade.

### 4.2.1 Trenching

Based on the boreholes, the trenches will be dug through the fill material clayey silt to sandy silt till, and weathered shale. No major problems due to groundwater seepage are anticipated during construction in trenches dug through the clayey soils and shale bedrock. It is expected that seepage through the glacial till deposits will be slow and can be removed by pumping from sumps. Seepage from the interface of till and shale is expected to be more than the till deposits, however, it is also expected to be controllable by pumping from sumps.

RJ Burnside is currently carrying out a hydrogeology study at the subject site. Detailed comments regarding the type and extent of groundwater control required at this site will be provided in the hydrogeology report by RJ Burnside.

Excavations can be carried out with heavy hydraulic backhoe. Excavation of the shale can be carried out using heaviest available single tooth ripper equipment. The limestone beds may overly the shale bedrock surface at some locations and it may be necessary at some locations to utilize jackhammer type equipment to "open" the limestone layers for the ripper.

The sides of excavations in the natural strata above groundwater can be expected to be temporarily stable at relatively steep side slopes for short periods of time but they should be cut back at slopes no steeper than 1:1 in order to comply with the safety regulations. If steep side slopes are required, the sides should be supported by braced skeleton or close sheeting.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the fill and compact sandy silt till above the water table can be classified as Type 3 soil. The very stiff to hard clayey silt till and very dense sandy silt till can be classified as Type 2 Soil above the groundwater table and Type 3 below the groundwater table.

### 4.2.2 Bedding

The undisturbed native soils will 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 are encountered, especially when the soil at the trench base level consists of wet, dilatant 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 300 mm above the obvert of the pipe, or as set out by the local Authority, should

be placed. Where the bedding falls below the anticipated water table, the bedding stone must be surrounded with a geotextile filter cloth.

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.

For deep trenches, i.e. more than 2.0 m below the shale surface, a minimum 50 mm thick polystyrene etc. layer will be required at both sides of the pipe to avoid rock squeezing. The polystyrene layer should extend vertically to at least 0.3 m above the pipe. The rock trench should be wide enough so that at each side, the horizontal distance between the pipe side and the cut rock surface is at least 0.3 m.

### 4.2.3 Backfilling of Trenches

Based on visual and tactile examination, the on-site excavated inorganic clayey silt and sandy silt till deposits, free from topsoil and organics are 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.

Granular B material should be used as backfill for trenches located under slab on grade or paved areas. Compaction of the granular soils should be carried out with vibratory compactors and loose lifts not exceeding about 200 mm.

The clayey till especially when its consistency is hard is likely to be excavated in cohesive chunks or Areas 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 cannot 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 catchbasins 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

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

General guidelines for the placement and preparation of engineered fill are presented on **Appendix E**. Bearing capacity values of 150 kPa at SLS and 225 kPa at ULS can be used on engineered fill, provided that all requirements on **Appendix E** 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.

The following is a recommended procedure for an 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 DS. Without this confirmation no responsibility for the performance of the structure can be accepted by DS. 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 a DS 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 DS during placement of engineered fill is required. Work cannot commence or continue without the presence of the DS 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. Bearing capacity values of 150 kPa at SLS and 225 kPa at ULS 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 DS 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 DS.

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 clayey silt and sandy silt (till) are considered suitable for use as engineered fill, provided that their moisture contents at the time of construction are at or near optimum. As mentioned before in Section 4.2.3 of this report, the clayey tills are likely to be excavated in cohesive chunks or Areas 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 sheepsfoot compactors).

### 4.4 Foundation Conditions

The boreholes show that provided the foundation soil is undisturbed during the construction, in general, soil bearing values 150 kPa at SLS and 225 kPa at ULS are feasible in the undisturbed inorganic natural (native) soils at or below the depths as given in Table 3. These values would be suitable for the use of conventional spread and strip footings to support normal single-family dwellings.

**Table 3: Bearing Values and Founding Levels of Footings**

| Area No | BH No. | Founding Soil | Bearing* Capacity at SLS (kPa) | Factored* Geotechnical Resistance at ULS (kPa) | Minimum Depth below Existing Ground (m) | Founding Level At or Below Elevation (m) |
|---|---|---|---|---|---|---|
| Areas 'A' & 'B' | BH18-1 | Sandy Silt Till | 150 | 225 | 1.8 | 141.0 |
| | BH18-2 | Clayey Silt Till | 150 | 225 | 1.5 | 140.7 |
| | BH18-3 | Sandy Silt Till | 150 | 225 | 1.8 | 139.9 |
| | BH18-4 | Clayey Silt Till | 150 | 225 | 1.8 | 138.8 |
| | BH18-5 | Clayey Silt Till | 150 | 225 | 1.9 | 138.3 |
| | BH18-6 | Sandy Silt Till | 150 | 225 | 0.8 | 137.3 |
| | BH18-7 | Clayey Silt Till | 150 | 225 | 1.5 | 137.1 |
| | BH18-8 | Sandy Silt Till | 150 | 225 | 1.8 | 138.6 |
| | BH18-9 | Clayey Silt Till | 150 | 225 | 0.8 | 140.0 |
| Area 'C' | BH19-100 | Clayey Silt Till | 150 | 225 | 1.2 | 142.7 |
| | BH19-101 | Clayey Silt Till | 150 | 225 | 1.2 | 143.7 |
| | BH19-102 | Clayey Silt Till | 150 | 225 | 2.8 | 143.0 |
| Area 'D' | BH19-200 | Clayey Silt Till | 150 | 225 | 1.2 | 145.1 |
| | BH19-201 | Clayey Silt Till | 150 | 225 | 1.1 | 145.5 |
| | BH19-202 | Clayey Silt Till | 150 | 225 | 1.3 | 146.1 |

*Higher bearing pressure values are available if required

Where the grade needs to be raised, the proposed structures can be supported by spread and strip footings founded on engineered fill for bearing capacity values of 150 kPa at SLS and 225 kPa at ULS. The engineered fill supporting footings should be constructed in accordance with the guidelines presented in **Appendix E**. 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.

### 4.5 Pre-condition Survey and Vibration Monitoring

Due to the presence of existing structures in the area, pre-construction survey prior to the start of construction and vibration monitoring during the construction should be completed.

## 5. GENERAL COMMENTS AND LIMITATIONS OF REPORT

DS Consultants Ltd (DS) 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, DS will assume no responsibility for interpretation of the recommendations in the 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 DS at the time of preparation. Unless otherwise agreed in writing by DS,

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 sub-surface conditions are interpreted as relevant to the design and construction of the proposed sanitary sewer. Comments relating to construction are intended for the guidance of the design engineer to establish constructability and must not be considered as being specifications or recommendations to the prospective contractors, or as being the only suitable methods. Prospective contractors should evaluate all of the factual information, obtain additional subsurface information as they might deem necessary and should select their construction methods, sequencing and equipment based on their own experience in similar ground conditions. The readers of this report are also reminded that the conditions are known only at the borehole locations and in view of the generally wide spacing of the boreholes, conditions may vary significantly between boreholes.

The conclusions and recommendations given in this report are based on information determined at the test hole 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 test holes may differ from those encountered at the test hole 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 test hole 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.

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. DS 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.

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

**DS CONSULTANTS LTD.**

Alka Sangar, M.Eng., P.Eng.

Nirodha Widyaratne, P.Eng.

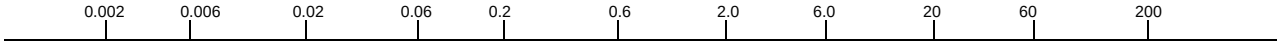
# Drawings

# Drawing 1: Notes On Sample Descriptions

1. All sample descriptions included in this report generally follow the Unified Soil Classification. Laboratory grain size analyses provided by DSCL also follow the same system. Different classification systems may be used by others, such as the system by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). Please note that, with the exception of those samples where a grain size analysis and/or Atterberg Limits testing have 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 | | |




EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

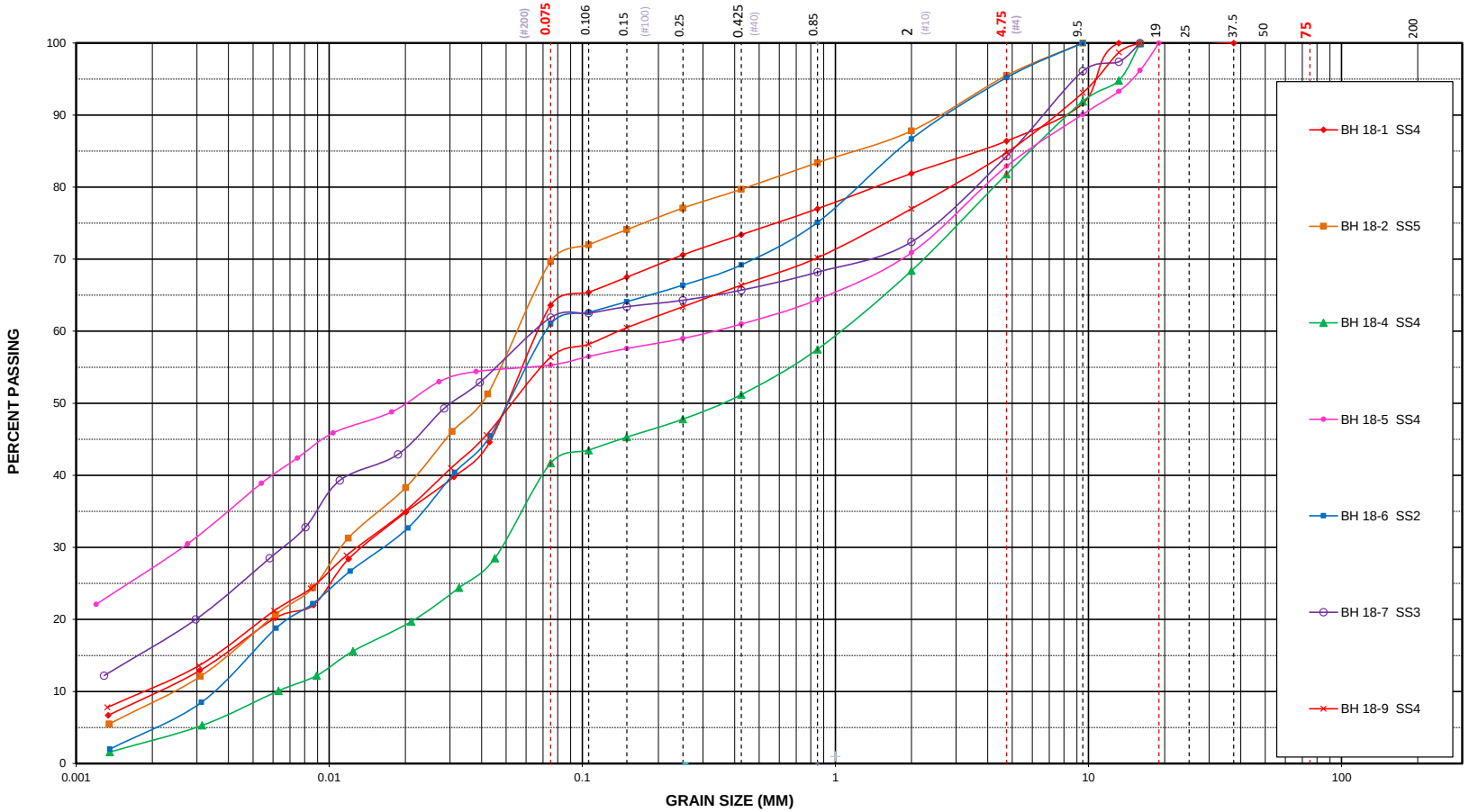
| CLAY (PLASTIC) TO | FINE | MEDIUM | CRS. | FINE | COARSE |
|---|---|---|---|---|---|
| SILT (NONPLASTIC) | SAND | | | GRAVEL | |

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 advise 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 preliminary 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.

# Particle Size Distribution (ASTM-D421/D422)



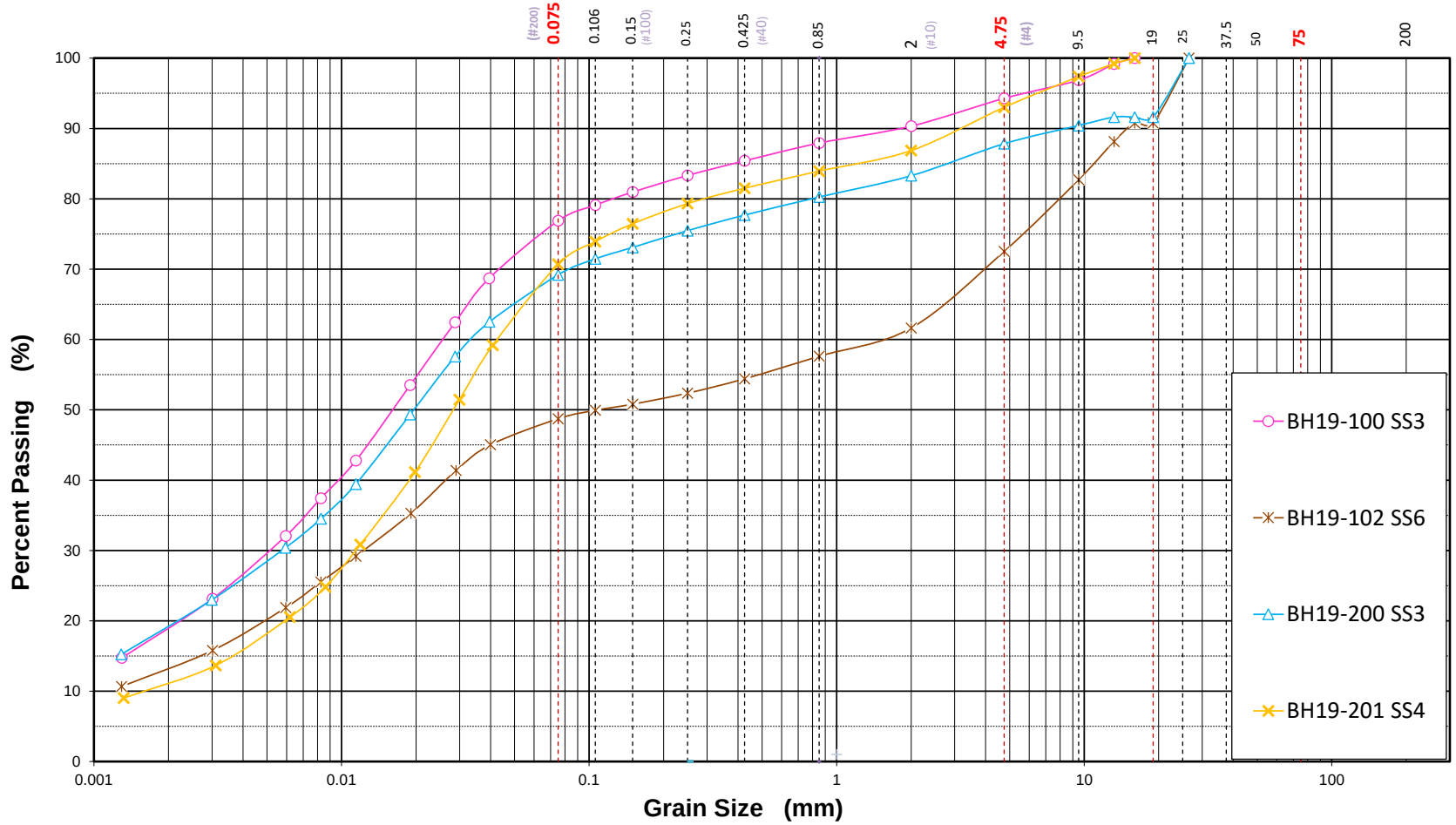

| Silt and Clay | | Sand | | | Gravel | | Cobble + |
|---|---|---|---|---|---|---|---|
| Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | |

Specification and Comments:

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| | | | |
|---|---|---|---|
| Project: | **100 Millcroft Golf Course** | Project No.: | **18-687-10** |
| Client: | **MILCROFT GREENS CORP.** | Date: | **January 21, 2019** |
| Location: | **Burlington, ON** | Figure No.: | 2 |

# Particle Size Distribution (ASTM-D421/D422)




| Silt and Clay | | Sand | | | Gravel | | Cobble + |
|---|---|---|---|---|---|---|---|
| Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | |

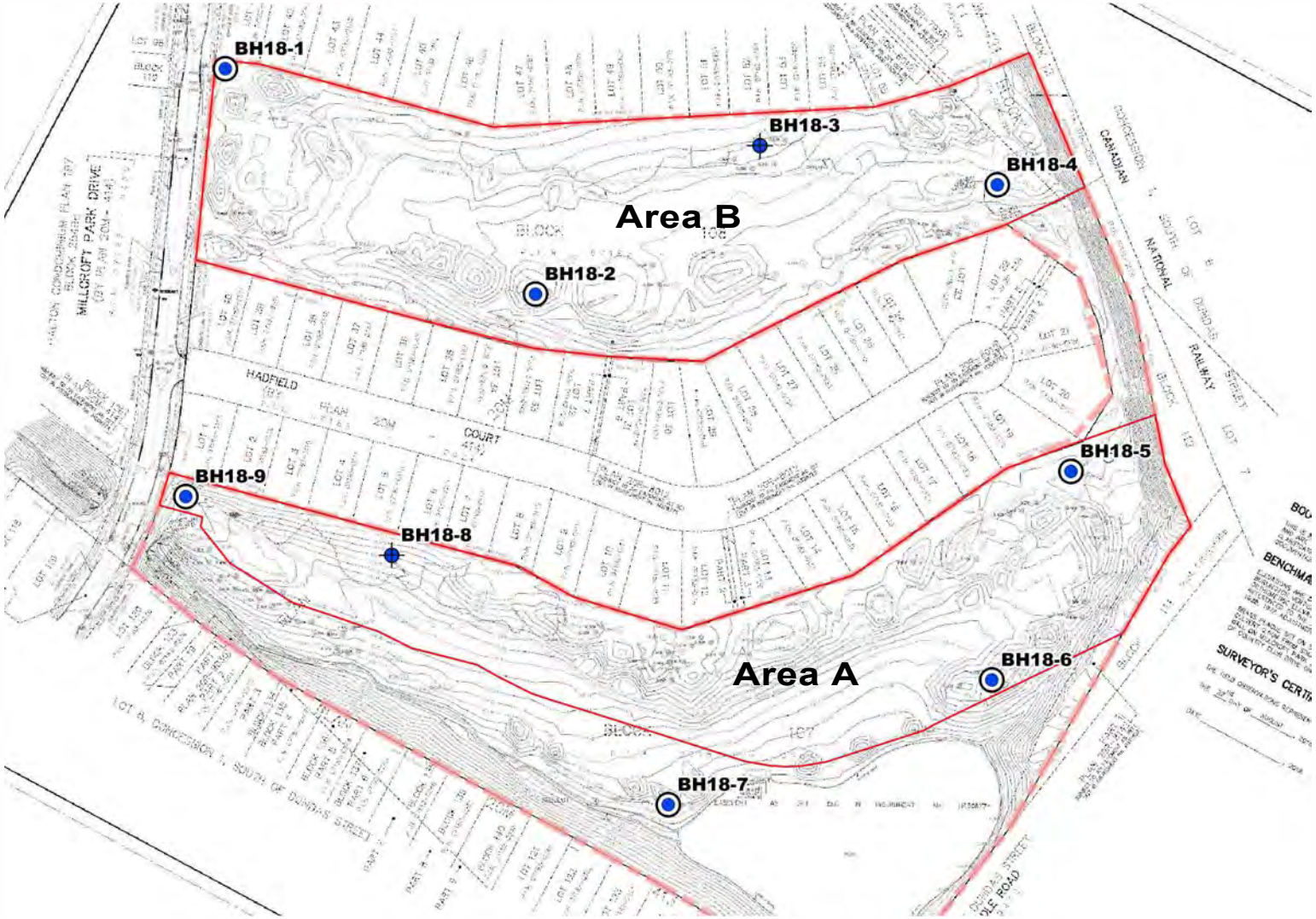

DS CONSULTANTS LTD.
6221 Highway 7, Unit 16
Vaughan, Ontario, L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca


| | | | |
|---|---|---|---|
| Project | **Milcroft Golf Course, Blocks 'C' & 'D'** | Project No | **19-199-100** |
| Location | **Burlington, ON** | Date | **Dec-09-2019** |
| Client | **MILLCROFT GREENS CORPORATION** | Figure No | 3 |

# Appendix A

## Borehole Logs & Location Plan for Areas 'A' & 'B'

J:\-GIS\18-687-20 Millcroft Golf Course_Argo (Millcroft) Ltd\1-QGIS\Geotechnical\Figure 1 - Borehole Locations-W Survey




Legend

- Borehole Location
- Monitoring Well Location
- Phase One Boundary
- Site Boundary

0 50 100 m


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www.dsconsultants.ca


Client: MILCROFT GREENS CORP.

Project: GEOTECHNICAL INVESTIGATION
2155 Counrty Club Drive, Burlington, ON

Title: **BOREHOLE AND MONITORING WELL LOCATIONS**

| Approved By: | Drawn By: | Date: |
|---|---|---|
| N.W | S.Y | January 2019 |

| Scale: | Project No.: | Figure No.: |
|---|---|---|
| As Shown | 18-687-20 | **A1** |

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# LOG OF BOREHOLE BH18-1



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805100.1 E 597203.488

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/18/2018

REF. NO.: 18-687-100
ENCL NO.: A2

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142.8 | | | | | | | | | | | | |
| 142.0 | **TOPSOIL:** 140 mm | | | | | | | | | | | |
| 0.1 | **FILL:**clayey silt, trace rootlets, moist, dark brown to brown, loose to compact | | 1 | SS | 8 | | | | | | | HEX: 35ppm IBL: 0ppm |
| | | | 2 | SS | 20 | | 142 | | | | | HEX: 55ppm IBL: 0ppm |
| | | | | | | | Bentonite | | | | | |
| 141.0 | | | 3 | SS | 32 | | 141 | | | | | HEX: 35ppm IBL: 0ppm |
| 1.8 | **SANDY SILT TILL:**some gravel/cobbles, trace clay, greyish brown, moist, dense to very dense | | | | | | | | | | | |
| | reddish brown below 2.3 m | | 4 | SS | 80/ 230mm | | Filter Pack | | | | | HEX: 40ppm IBL: 0ppm 14 23 54 9 |
| 139.7 | | | | | | | | | | | | |
| 3.1 | **CLAYEY SILT TILL/SHALE COMPLEX:** reddish brown, moist, hard | | 5 | SS | 50/ 50mm | | 139 | | | | | HEX: 55ppm IBL: 0ppm |
| | | | | | | ▽ | W. L. 138.6 m Jan 03, 2019n Jan 07, 2019 | | | | | |
| | | | | | | | Slotted Pipe | | | | | |
| | | | 6 | SS | 50/ 50mm | | 138 | | | | | HEX: 60ppm IBL: 0ppm |
| | | | | | | | 137 | | | | | |
| 136.7 | | | | | | | | | | | | |
| 6.1 | **SHALE BEDROCK:** Highly weathered shale | | 7 | SS | 50/ 100mm | | | | | | | HEX: 70ppm IBL: 0ppm |
| 136.5 | | | | | | | | | | | | |
| 6.3 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 4.16 |
| Jan. 7, 2019 | 4.27 |

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

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

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# LOG OF BOREHOLE BH18-2



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805001.917 E 597344.446

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/18/2018

REF. NO.: 18-687-100
ENCL NO.: A3

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142.2 | | | | | | | | | | | | |
| 142.0 | **TOPSOIL:** | | | | | | | | | | | |
| 0.1 | **FILL:**clayey silt, trace topsoil, very moist, brown, loose to compact | | 1 | SS | 5 | | 142 | | | | | HEX: 45ppm IBL: 0ppm |
| 1 | | | 2 | SS | 15 | ▽ | | | | | | HEX: 40ppm IBL: 0ppm |
| 140.7 | | | | | | ▼ | W. L. 141.1 m Jan 03, 2019 | | | | | |
| 1.5 | **CLAYEY SILT TILL:** sandy, trace gravel/cobble, greyish brown, moist, hard | | 3 | SS | 32 | | W. L. 140.8 m Jan 07, 2019 | | | | | HEX: 30ppm IBL: 0ppm |
| 2 | | | | | | | 140 | | | | | |
| 139.9 | | | | | | | | | | | | |
| 2.3 | **SANDY SILT TILL:** trace clay, trace gravel/cobbles, reddish brown, moist, very dense | | 4 | SS | 50 | | | | | | | HEX: 25ppm IBL: 0ppm |
| | | | | | | | Filter Pack | | | | | |
| 3 | | | | | | | 139 | | | | | |
| | | | 5 | SS | 50/ 150 mm | | | | | | | HEX: 30ppm IBL: 0ppm 5 26 61 8 |
| 4 | | | | | | | Slotted Pipe | | | | | |
| | | | | | | | 138 | | | | | |
| 137.6 | | | | | | | | | | | | |
| 137.6 4.7 | **CLAYEY SILT TILL:** trace sand, reddish brown, moist, hard | | 6 | SS | 50/ 75mm | | | | | | | HEX: 30 ppm IBL: 0ppm |
| 137.3 4.9 | **SHALE BEDROCK:** Highly weathered shale | | | | | | | | | | | |
| | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 1.04 |
| Jan. 7, 2019 | 1.36 |

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

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

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# LOG OF BOREHOLE BH18-3



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805069.474 E 597444.447

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/18/2018

REF. NO.: 18-687-100
ENCL NO.: A4

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 141.7 | | | | | | | | | | | | |
| 141.6 | **TOPSOIL:** | | | | | | | | | | | |
| 0.1 | **FILL:** clayey silt, trace topsoil, very moist, brown to reddish brown, loose to compact | | 1 | SS | 7 | | | | ○ | | | HEX: 20ppm IBL: 0ppm |
| | | | 2 | SS | 21 | | 141 | | ○ | | | HEX: 40ppm IBL: 0ppm |
| 139.9 | | | 3 | SS | 29 | | 140 | | ○ | | | HEX: 30ppm IBL: 0ppm |
| 1.8 | **SANDY SILT TILL:** silt pockets, trace gravel/cobbles, reddish brown, moist, compact to very dense | | | | | | | | | | | |
| 139.4 | | | | | | | | | | | | |
| 2.3 | **CLAYEY SILT TILL:** trace sand, reddish brown to grey, hard | | 4 | SS | 84/ 280mm | | 139 | | ○ | | | HEX: 40ppm IBL: 0ppm |
| 138.3 | | | 5 | SS | 87/ 255mm | | | | ○ | | | HEX: 45ppm IBL: 0ppm |
| 3.4 | **SHALE BEDROCK:** Highly weathered shale | | | | | | | | | | | |
| 138.1 | | | | | | | | | | | | |
| 3.6 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) Borehole dry upon completion

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

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

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# LOG OF BOREHOLE BH18-4



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805053.465 E 597551.071

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/19/2018

REF. NO.: 18-687-100
ENCL NO.: A5

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140.6 | | | | | | | | | | | | |
| 0.0 / 140.4 | **TOPSOIL:** 180 mm | | | | | | | | | | | |
| 0.2 | **FILL:** clayey silt, trace rootlets, moist, dark brown to brown, compact | | 1 | SS | 11 | | | | | | | HEX: 0ppm IBL: 0ppm |
| | | | 2 | SS | 11 | | 140 Bentonite | | | | | HEX: 0ppm IBL: 0ppm |
| 138.8 | | | 3 | SS | 61 | ▽ | 139 W. L. 138.8 m Jan 03, 2019 | | | | | HEX: 0ppm IBL: 0ppm |
| 1.8 | **CLAYEY SILT TILL:** trace sand, trace gravel/cobbles, reddish brown, moist, hard | | | | | | W. L. 138.5 m Jan 07, 2019 | | | | | |
| 138.3 | | | | | | | Filter Pack | | | | | |
| 2.3 | **SANDY SILT TILL:** trace clay, some gravel/cobbles, reddish brown, moist, very dense | | 4 | SS | 50/ 50mm | | 138 | | | | | HEX: 5ppm IBL: 0ppm 15 40 39 3 |
| | | | 5 | SS | 50/ 25mm | | Slotted Pipe 137 | | | | | HEX: 5ppm IBL: 0ppm |
| 136.0 | | | | | | | 136 | | | | | |
| 4.6 / 135.8 | **SHALE BEDROCK:** Highly weathered shale | | 6 | SS | 50/ 25mm | | | | | | | HEX: 0ppm IBL: 0ppm |
| 4.8 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 1.76 |
| Jan. 7, 2019 | 2.07 |

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

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

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# LOG OF BOREHOLE BH18-5



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804925.877 E 597586.938

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/19/2018

REF. NO.: 18-687-100
ENCL NO.: A6

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140.2 | | | | | | | | 20 40 60 80 100 | 10 20 30 | | | |
| 0.0 / 139.8 | **TOPSOIL:** 350 mm | | 1 | SS | 4 | | 140 | | | | | HEX: 35ppm IBL: 0ppm |
| 0.4 | **FILL:**clayey silt, trace topsoil, moist, dark brown to brown, loose | | | | | | Bentonite | | | | | |
| 1 | | | 2 | SS | 9 | | Filter Pack | | | | | HEX: 15ppm IBL: 0ppm |
| 138.3 | | | 3 | SS | 26 | | | | | | | HEX: 45ppm IBL: 0ppm |
| 2 1.9 | **CLAYEY SILT TILL:** sandy, some gravel/cobbles, reddish brown, moist, very stiff to hard | | | | | | 138 | | | | | |
| | | | 4 | SS | 77 | ▽ | W. L. 137.5 m Jan 03, 2019 | | | | | HEX: 30ppm IBL: 0ppm 17 28 29 26 |
| 3 | trace shale fragments below 3.1 m | | | | | | Slotted Pipe 137 | | | | | |
| | | | 5 | SS | 99 | ▽ | W. L. 136.7 m Jan 07, 2019 | | | | | HEX: 30ppm IBL: 0ppm |
| 4 135.6 | | | | | | | 136 | | | | | |
| 4.6 / 135.4 | **SHALE BEDROCK:** Highly weathered shale | | 6 | SS | 50/ 100mm | | | | | | | HEX: 35ppm IBL: 0ppm |
| 4.8 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 2.62 |
| Jan. 7, 2019 | 3.44 |

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

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

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# LOG OF BOREHOLE BH18-6



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804813.93 E 597552.765

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/19/2018

REF. NO.: 18-687-100
ENCL NO.: A7

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 138.1 | | | | | | | | | | | | |
| 138.0 / 0.0 | **TOPSOIL:** | | | | | | | | | | | |
| 0.1 | **FILL:** clayey silt, very moist, brown, loose | | 1 | SS | 4 | | 138 | | | | | HEX: 50ppm IBL: 0ppm |
| 137.3 | | | | | | Bentonite / Filter Pack | | | | | | |
| 0.8 | **SANDY SILT TILL:** trace clay, trace gravel/cobbles, trace shale fragments, reddish brown, moist, very dense | | 2 | SS | 59 | | 137 | | | | | HEX: 45ppm IBL: 0ppm 5 34 57 4 |
| 136.6 | | | | | | | | | | | | |
| 1.5 | **SHALE BEDROCK:** Highly weathered shale | | 3 | SS | 67 | W. L. 136.6 m Jan 03, 2019n Jan 07, 2019 | 136 | | | | | HEX: 35ppm IBL: 0ppm |
| 135.6 | | | 4 | SS | 50/ 25mm | | | | | | | HEX: 40ppm IBL: 0ppm |
| 2.5 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) Auger refusal at 2.3 m
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 1.49 |
| Jan. 7, 2019 | 1.60 |

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 7/7/20

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS CONSULTANTS LTD.
Geotechnical ◆ Environmental ◆ Materials ◆ Hydrogeology

# LOG OF BOREHOLE BH18-7



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804773.829 E 597407.198

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/20/2018

REF. NO.: 18-687-100
ENCL NO.: A8

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | TYPE | BLOWS/0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 138.6 | | | | | | | | | | | | |
| 138.6 0.0 | **TOPSOIL:** | | | | | | | | | | | |
| 0.1 | **FILL:** clayey silt, trace rootlet/ topsoil, moist, dark brown to brown, loose | | 1 | SS | 4 | | | | | | | HEX: 30ppm IBL: 0ppm |
| | | | | | | | Bentonite | | | | | |
| 1 | | | 2 | SS | 8 | | | | | | | HEX: 55ppm IBL: 0ppm |
| 137.1 | | | | | | | Filter Pack | | | | | |
| 1.5 | **CLAYEY SILT TILL:** sandy, some gravel/cobbles, reddish brown to grey, moist, hard | | 3 | SS | 43 | | 137 | | | | | HEX: 45ppm IBL: 0ppm 16 22 46 16 |
| 2 | | | | | | W. L. 136.5 m Jan 03, 2019 Jan 07, 2019 | | | | | | |
| 136.3 | | | | | | | | | | | | |
| 2.3 | **SHALE BEDROCK:** Highly weathered shale | | 4 | SS | 50/ 50mm | | 136 | | | | | HEX: 55ppm IBL: 0ppm |
| 3 | | | | | | | Slotted Pipe | | | | | |
| | | | 5 | SS | 50/ 100mm | | 135 | | | | | HEX: 45ppm IBL: 0ppm |
| 4 | | | 6 | SS | 50/ 25mm | | | | | | | HEX: 45ppm IBL: 0ppm |
| 134.0 | | | | | | | 134 | | | | | |
| 4.6 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) Water level at 2.1 mbgl upon completion of drilling
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 2.06 |
| Jan. 7, 2019 | 2.14 |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 7/7/20

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# LOG OF BOREHOLE BH18-8



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804883.544 E 597281.841

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/20/2018

REF. NO.: 18-687-100
ENCL NO.: A9

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES NUMBER | TYPE | "N" BLOWS 0.3 m | GROUND WATER CONDITIONS | ELEVATION |
|---|---|---|---|---|---|---|---|
| 140.4 / 0.0 | **TOPSOIL:** | | | | | | |
| 0.1 | **FILL:**clayey silt, trace rootlet/ topsoil, trace organics, moist, dark brown to brown, loose | | 1 | SS | 8 | | 140 |
| | | | 2 | SS | 8 | | 139 |
| 138.6 / 1.8 | **SANDY SILT TILL :**trace clay, trace gravel/cobbles, reddish brown, moist, compact | | 3 | SS | 16 | | |
| | | | 4 | SS | 23 | | 138 |
| 137.3 / 3.1 | **CLAYEY SILT TILL:** sandy, trace gravel/cobbles, trace shale fragments, reddish brown, moist, hard | | 5 | SS | 66/ 230mm | | 137 |
| 135.7 / 4.7 | **END OF BOREHOLE** Notes: 1) Auger refusal at 4.6 m 2) Borehole dry upon completion | | 6 | SS | 50/ 100mm | | 136 |

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

| METHANE AND GRAIN SIZE DISTRIBUTION (%) | GR | SA | SI | CL |
|---|---|---|---|---|
| HEX: 45ppm IBL: 0ppm | | | | |
| HEX: 75ppm IBL: 0ppm | | | | |
| HEX: 55ppm IBL: 0ppm | | | | |
| HEX: 50ppm IBL: 0ppm | | | | |
| HEX: 40ppm IBL: 0ppm | | | | |
| HEX: 45ppm IBL: 0ppm | | | | |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 7/7/20

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# LOG OF BOREHOLE BH18-9



PROJECT: Geotechnical Investigation - Area 'A' & 'B'
CLIENT: Millcroft Green Corporation
PROJECT LOCATION: 2155 Country Club Drive, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804908.419 E 597188.154

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150 mm
Date: Dec/20/2018

REF. NO.: 18-687-100
ENCL NO.: A10

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | SAMPLES: NUMBER | TYPE | BLOWS/0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140.8 | | | | | | | | | | | | |
| 140.7 | **TOPSOIL:** 130 mm | | | | | | | | | | | |
| 0.1 | **FILL:** clayey silt, trace rootlet/ topsoil, moist, dark brown to brown, loose | | 1 | SS | 7 | | | | | | | HEX: 40ppm IBL: 0ppm |
| 140.0 | | | | | | | 140 | | | | | |
| 0.8 | **CLAYEY SILT TILL:** some sand, trace gravel/cobbles, greyish brown, moist, hard | | 2 | SS | 30 | | Bentonite | | | | | HEX: 35ppm IBL: 0ppm |
| 139.3 | | | | | | | | | | | | |
| 1.5 | **SANDY SILT TILL:** trace to some clay, some gravel/cobbles, reddish brown, moist, dense to very dense | | 3 | SS | 47 | | W. L. 139.1 m Jan 03, 2019 W. L. 138.8 m Jan 07, 2019 | | | | | HEX: 45ppm IBL: 0ppm |
| | | | 4 | SS | 81 | | | | | | | HEX: 45ppm IBL: 0ppm 15 28 47 10 |
| | | | | | | | 138 | | | | | |
| | | | 5 | SS | 95/ 250mm | | Slotted Pipe | | | | | HEX: 45ppm IBL: 0ppm |
| 137.0 | | | | | | | 137 | | | | | |
| 3.8 | **CLAYEY SILT TILL/SHALE COMPLEX:** reddish brown, trace shale fragments, moist, hard | | 6 | SS | 99/ 180mm | | | | | | | |
| 136.7 | | | | | | | | | | | | |
| 4.1 | **END OF BOREHOLE** | | | | | | | | | | | |

Notes:
1) Auger refusal at 3.9 m
2) 50mm dia. monitoring well installed upon completion.
3) Water Level Readings

| Date | Water Depth (mbgs) |
|---|---|
| Jan. 3, 2019 | 1.74 |
| Jan. 7, 2019 | 1.95 |

HEX: 40ppm IBL: 0ppm

DS SOIL LOG 18-687-100 - MILLCROFT GOLF COURSE, BURLINGTON.GPJ DS.GDT 7/7/20

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

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

# Appendix B

## Borehole Logs & Location Plan for Area 'C'




**DS CONSULTANTS LTD.**
6221 Highway 7, UNIT 16
Vaughan, Ontario L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

| | |
|---|---|
| Project: | Geotechnical Investigation |
| Title: | **Millcroft Golf Course, Burlington, ON** |
| Client: | MILCROFT GREENS CORP. |
| Size: | 8.5 x 11 |
| Rev: | 0 |
| Approved By: | |
| Drawn By: | MM |
| Date: | Dec 09, 2019 |
| Scale: | As Shown |
| Project No.: | 19-199-101 |
| Figure No.: | **B 1** |
| Image/Map Source: | *Google Satellite Image* |

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# LOG OF BOREHOLE BH19-100



PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804785.16 E 596345.5

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/26/2019

REF. NO.: 19-199-101
ENCL NO.: B2

| (m) ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION |
|---|---|---|---|---|---|---|
| 143.9 / 0.0 | **TOPSOIL:** 150mm | | | | | |
| 143.7 / 0.2 | **FILL:** clayey silt, trace gravel, brown, moist, very stiff | 1 | SS | 18 | | |
| 142.8 / 1.1 | **CLAYEY SILT TILL:** some sand, trace gravel, brown, moist, very stiff to hard<br>reddish brown below 1.5m | 2 | SS | 19 | | 143 |
| | | 3 | SS | 32 | | 142 |
| | trace shale fragments below 2.3m | 4 | SS | 59 | | 141 |
| | sandy below 3.1m | 5 | SS | 79/230 | W. L. 140.7 m Dec 04, 2019 | 140 |
| 139.3 / 4.6 | **SHALE:** weathered, reddish brown | 6 | SS | 50/50mm | | 139 |
| 137.7 / 6.2 | **END OF BOREHOLE:** | 7 | SS | 50/50mm | | 138 |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

| Date: | Water Level (mbgl): |
|---|---|
| Dec 04, 2019 | 3.2 |

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

| GR | SA | SI | CL |
|---|---|---|---|
| 6 | 17 | 59 | 18 |

Bentonite
Filter Pack
Slotted Pipe

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
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# LOG OF BOREHOLE BH19-101



PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804895.06 E 596313.79

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/26/2019

REF. NO.: 19-199-101
ENCL NO.: B3

| (m) ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS 0.3 m "N" | ELEVATION |
|---|---|---|---|---|---|
| 144.9 | | | | | |
| 0.0 / 144.7 | **TOPSOIL:** 180mm | | | | |
| 0.2 / 143.9 | **FILL:** clayey silt, trace rootlets/ topsoil, brown, moist, stiff | 1 | SS | 8 | |
| 1.0 / 142.6 | **CLAYEY SILT TILL:** some sand, trace gravel, greyish brown, moist, hard | 2 | SS | 31 | 144 |
| | | 3 | SS | 30 | 143 |
| 2.3 / 141.7 | **TILL/ SHALE COMPLEX:** trace cobble, brown, moist, hard | 4 | SS | 49 | 142 |
| | | 5 | SS | 50/ 50 | |
| 3.3 / 138.7 | **SHALE:** weathered, reddish brown | 6 | SS | 50/ 50mm | 141 |
| | | 7 | SS | 50/ 50mm | 140 |
| 6.2 | **END OF BOREHOLE:** | | | | 139 |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

| Date: | Water Level (mbgl): |
|---|---|
| Dec 04, 2019 | 4.5 |

GROUND WATER CONDITIONS: Bentonite; W. L. 140.4 m Dec 04, 2019; Filter Pack; Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

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# LOG OF BOREHOLE BH19-102



PROJECT: Preliminary Geotechnical Investigation - Area 'C'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4804795.87 E 596253.44

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-101
ENCL NO.: B4

| (m) ELEV / DEPTH | DESCRIPTION | STRATA PLOT | NUMBER | TYPE | BLOWS 0.3 m "N" | GROUND WATER CONDITIONS | ELEVATION | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 145.8 | | | | | | | | | | | | |
| 0.0 | **FILL:** clayey silt, trace rootlets/ topsoil, brown, wet, firm | | 1 | SS | 6 | | | | | 50 | | |
| 145.0 | | | | | | | 145 | | | | | |
| 0.8 | **FILL:** silty clay, trace gravel, brown, very moist, firm to stiff | | 2 | SS | 6 | | | | | 50 | | |
| | | | 3 | SS | 9 | ▽ | W. L. 144.3 m Dec 04, 2019 | | | 50 | | |
| | | | | | | | 144 | | | | | |
| | | | | | | | Bentonite | | | | | |
| 143.2 | | | 4 | SS | 18 | | | | | 225 | | |
| 2.6 | **CLAYEY SILT TILL:** some sand, trace gravel, trace shale fragments, brown, moist, very stiff to hard | | | | | | 143 | | | | | |
| | | | 5 | SS | 46 | | | | | 225 | | |
| | | | | | | | 142 | | | | | |
| | sandy below 4.6m | | 6 | SS | 50/ 50mm | | 141 | | | | | 27 24 36 13 |
| | | | | | | | Filter Pack | | | | | |
| | | | | | | | Slotted Pipe | | | | | |
| | | | | | | | 140 | | | | | |
| 139.7 | | | | | | | | | | | | |
| 139.6 | **SHALE:** weathered, reddish brown | | 7 | SS | 50/ 25mm | | | | | | | |
| 6.2 | **END OF BOREHOLE:** | | | | | | | | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

| Date: | Water Level (mbgl): |
|---|---|
| Dec 04, 2019 | 1.4 |

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

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

DS SOIL LOG 19-199-101_C.GPJ DS.GDT 7/7/20

# Appendix C

## Borehole Logs & Location Plan for Area 'D'




**DS CONSULTANTS LTD.**
6221 Highway 7, UNIT 16
Vaughan, Ontario L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project: Geotechnical Investigation

Title: **Millcroft Golf Course, Burlington, ON**

N

Client: MILCROFT GREENS CORP.

| Size: | Approved By: | Drawn By: | Date: |
|---|---|---|---|
| 8.5 x 11 | | MM | Dec 09, 2019 |
| Rev | Scale: As Shown | Project No.: 19-199-100 | Figure No.: **C 1** |
| 0 | Image/Map Source: *Google Satellite Image* | | |

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# LOG OF BOREHOLE BH19-200



PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805673.28 E 596926.73

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-100
ENCL NO.: C2

| ELEV / DEPTH (m) | DESCRIPTION | NUMBER | TYPE | BLOWS "N" 0.3 m | ELEVATION |
|---|---|---|---|---|---|
| 146.3 | | | | | |
| 146.2 / 0.1 | **TOPSOIL:** 75mm<br>**FILL:** clayey silt, trace topsoil/ rootlets, brown, moist, firm | 1 | SS | 4 | 146 |
| 145.2 / 1.1 | **CLAYEY SILT TILL:** some sand to sandy, trace gravel, occasional cobble/ boulder, brown, moist, very stiff to hard | 2 | SS | 15 | |
| | | 3 | SS | 30 | |
| | | 4 | SS | 69 | 144 |
| 142.9 / 3.4 | **TILL/ SHALE COMPLEX:** brown, moist, hard | 5 | SS | 80/ 255mm | 143 |
| 141.7 / 4.6 | **SHALE:** highly weathered, reddish brown | 6 | SS | 50/ 100mm | 142 |
| 140.1 / 6.2 | **END OF BOREHOLE:** | 7 | SS | 50/ 50mm | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

| Date: | W.L. Depth (mbgl): |
|---|---|
| Dec 04, 2019 | 1.1 |

W. L. 145.1 m
Dec 04, 2019

Bentonite
Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa): 158, 225

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL: 12 19 51 18

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

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# LOG OF BOREHOLE BH19-201



PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805714.39 E 596960.66

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/27/2019

REF. NO.: 19-199-100
ENCL NO.: C3

| (m) ELEV / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS / 0.3 m "N" | ELEVATION |
|---|---|---|---|---|---|
| 146.4 / 0.0 | **TOPSOIL:** 150mm | | | | |
| 0.2 / 145.6 | **FILL:** clayey silt, some topsoil, grey to brown, moist, stiff | 1 | SS | 8 | 146 |
| 0.8 | **CLAYEY SILT TILL:** some sand, trace gravel, greyish brown, moist, very stiff | 2 | SS | 20 | |
| | | 3 | SS | 23 | 145 |
| 144.1 | | | | | |
| 2.3 / 143.3 | **SANDY SILT TILL:** some clay, trace gravel, trace cobble, reddish brown, moist, very dense | 4 | SS | 80/ 280mm | 144 |
| 3.1 / 142.7 | **TILL/ SHALE COMPLEX:** reddish brown, moist, hard | 5 | SS | 50/ 100mm | 143 |
| 3.7 | **SHALE:** highly weathered, reddish brown | 6 | SS | 50/ 50mm | 142 |
| 140.2 | | 7 | SS | 50/ 50mm | |
| 6.2 | **END OF BOREHOLE:** | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

| Date: | W.L. Depth (mbgl): |
|---|---|
| Dec 04, 2019 | 0.5 |

W. L. 145.8 m
Dec 04, 2019

Bentonite

Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa): 210 (0.2 m), 225 (0.8 m)

NATURAL UNIT WT (kN/m³)

METHANE AND GRAIN SIZE DISTRIBUTION (%)

| | GR | SA | SI | CL |
|---|---|---|---|---|
| 2.3 m | 7 | 22 | 60 | 11 |

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

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

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

DS CONSULTANTS LTD.
Geotechnical ◆ Environmental ◆ Materials ◆ Hydrogeology

# LOG OF BOREHOLE BH19-202



PROJECT: Preliminary Geotechnical Investigation - Area 'D'
CLIENT: Millcroft Greens Corporation
PROJECT LOCATION: Millcroft Golf Club, Burlington, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4805761.36 E 596976.46

**DRILLING DATA**
Method: Solid Stem Auger
Diameter: 150mm
Date: Nov/28/2019

REF. NO.: 19-199-100
ENCL NO.: C4

| ELEV / DEPTH (m) | DESCRIPTION | NUMBER | TYPE | BLOWS "N" 0.3 m | ELEVATION |
|---|---|---|---|---|---|
| 147.4 | | | | | |
| 147.3 / 0.1 | **TOPSOIL:** 50mm | | | | |
| | **FILL:** clayey silt, some topsoil, trace gravel, grey to brown, moist, firm to very stiff | 1 | SS | 7 | 147 |
| 146.3 | | 2 | SS | 25 | |
| 1.1 | **CLAYEY SILT TILL:** sandy, trace gravel, occasional cobble/ boulder, greyish brown, moist, very stiff to hard | 3 | SS | 46 | 146 |
| 144.3 | | 4 | SS | 75 | 145 |
| 3.1 | **SANDY SILT TILL:** some clay, trace gravel, greyish brown, moist, very dense | 5 | SS | 50/ 125mm | 144 |
| 142.8 | | | | | 143 |
| 4.6 | **SHALE:** highly weathered, reddish brown | 6 | SS | 50/ 75mm | |
| 141.2 | | 7 | SS | 50/ 50mm | |
| 6.2 | **END OF BOREHOLE:** | | | | |

Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level readings:

| Date: | W.L. Depth (mbgl): |
|---|---|
| Dec 04, 2019 | 4.5 |

Bentonite
W. L. 142.9 m Dec 04, 2019
Filter Pack
Slotted Pipe

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT $w_P$ | NATURAL MOISTURE CONTENT $w$ | LIQUID LIMIT $w_L$
WATER CONTENT (%)
10 20 30

| POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³) | METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|
| 75 | | |
| 225 | | |

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

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

DS SOIL LOG 19-199-100_J.GPJ DS.GDT 7/7/20

# Appendix D

## General Comments on Shale Bedrock in GTA

## General Comments – Bedrock in Greater Toronto Area

The bedrock that makes spread footings or caissons a popular choice for high-rise foundation support is a shale or shale limestone composition. The highest member, the Queenston Formation, is generally found west of Toronto, while the Georgian Bay Formation underlies most of Metro Toronto, with the Collingwood and Whitby Formations east of Toronto. The Queenston is, relatively speaking, the weaker of the four formations that are likely to support caissons or footings.

The Georgian Bay as well as the Queenston and Collingwood/Whitby Formation are of Middle Ordovician Age. It is defined as the rock unit that overlies the bluish grey shales of the Collingwood Formation and is in turn overlain by the red shale of the Queenston Formation. The Georgian Bay Formation consists of bluish and grey shale with interbeds of sandstone, limestone and dolostone. Towards the west where the Georgian Bay formation underlies the Queenston Formation, the limestone content increases significantly and limestone and/or sandstone may comprise as much as 70 to 90 percent of the bedrock. The hard layers are usually less than about 100 to 150 mm thick but some layers are much thicker. The thicker layers have been observed to be as much as 750 to 900 mm at some sites. The layers are actually lenses and they can vary significantly in thickness over short distances.

The upper portion of the bedrock is commonly weathered for a depth of 600 to 1000 mm and within this weathered zone hard limestone layers or lenses are common. These hard limestone layers can result in contractual problems for augers, and can provide misleading bedrock elevations. Where the weathering is more extensive a shale till layer may be found above the bedrock. In the sound bedrock, the limestone, sandstone, dolostone is hard to very hard.

Stress relief features such as folds and faults are common in the bedrock. In these features, the rock is heavily fractured and sheared, and contains layers of shale rubble and clay. Weathering is much deeper than the surrounding rock in these features and often there is a lateral migration of the stress relief features resulting in sound unweathered bedrock overlying fractured and weather bedrock. The stress relief features are usually in the order of 4 to 6 m wide, but the depth can vary from 4 to 5 m to in excess of 10 m. These features occur randomly.

The bedrock contains significant high locked in horizontal stresses. These stresses can impose significant loads on tunnel walls but the slower rate of construction for basements allows for a relaxation of these stresses and they are not normally a problem for basement construction.

Groundwater seepage below the top 1000 mm is generally small, however, at several locations in Toronto and Mississauga large quantities have been encountered.

Bedding joints in the bedrock are very close-to-close, smooth planar in the shale and rough planar in the limestone. Significant vertical jointing is common.

Where the bedrock was cored, a detailed description of the rock core is appended to the borehole log.

Design features related to the bedrock are discussed in other sections of this report, and these general comments must be considered with these comments.

Methane gas exists in the bedrock, normally below the top 1000 mm and more concentrated with depth. Appropriate care and monitoring is essential in all confined bedrock excavations, particularly caissons and tunnels.

# Appendix E

## 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. 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, we recommend use of OPSS Granular 'B' sand and gravel fill material.

Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill cannot be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year.

The location of the foundations on the engineered fill 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. Excavations within the engineered fill 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 from 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 DS Consultants Ltd (DS). Without this confirmation no responsibility for the performance of the structure can be accepted by DS. 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 a DS engineer prior to placement of fill.

5. The approved engineered fill material must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Engineered fill should not be placed 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 DS during placement of engineered fill is required. Work cannot commence or continue without the presence of the DS representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to the attached 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 bearing capacity of 150 kPa at SLS (225 kPa at ULS) can 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.

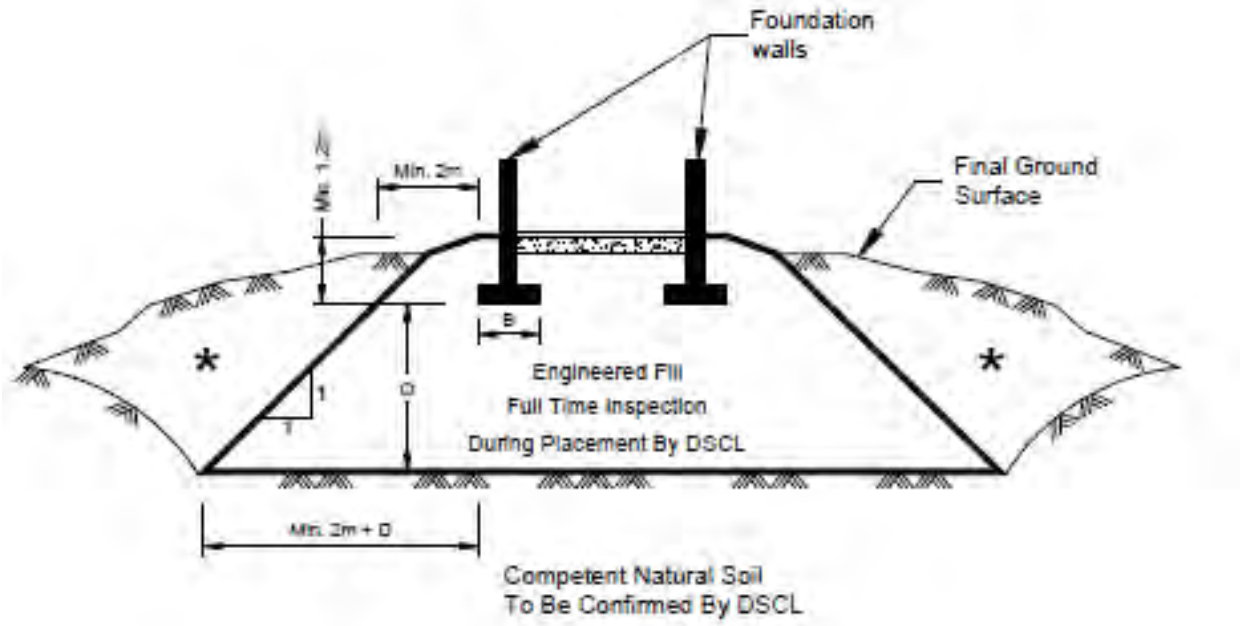
10. After completion of the engineered fill pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from DS prior to footing concrete placements. All excavations must be backfilled under full time supervision by DS to the same degree 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 DS.

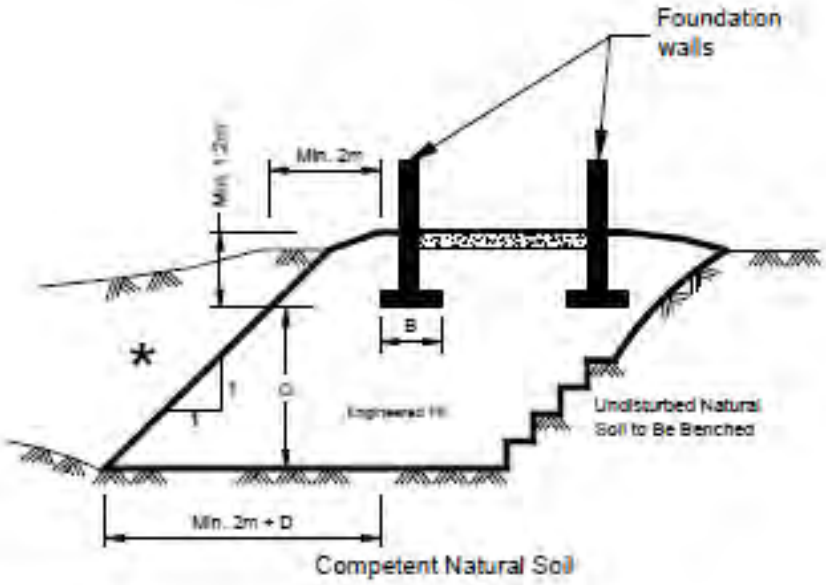
11. After completion of compaction, the surface of the engineered fill pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof-rolled and sloped/crowned at the end of each day, prior to weekends and any 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 DS Consultants Ltd report attached.




* Backfill in this area to be as per the DSCL report