REPORT

Geotechnical Investigation Findlay Creek Village Stage 5 - 3100 Leitrim Road

Leitrim Development Area Ottawa, Ontario

Submitted to:

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Submitted by:

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Distribution List

1 e-copy – IBI Group

1 e-copy - Golder

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APPENDICES

1.0 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation carried out for the Findlay Creek Village Stage 5 development located between Kelly Farm Drive and Fenton Road and along the south side of Leitrim Road in Ottawa, Ontario. It is understood that this geotechnical investigation report is required in support of a development application for the subject property.

A preliminary geotechnical investigation was completed for the entire Leitrim Road development (i.e., between Bank Street and Fenton Road). The results of that investigation (which includes information obtained from boreholes advanced within the subject property and on the adjacent Lands to the east) were used to develop the geotechnical guidance provided herein for the subject property (i.e., Stage 5 development).

The purpose of this preliminary geotechnical investigation was to determine the general soil and groundwater conditions across this site by means of a limited number of widely spaced boreholes and, based on an interpretation of the factual information obtained, to provide a preliminary assessment of the geotechnical aspects of developing this site, including construction considerations which could influence design decisions.

The reader is referred to the "Important Information and Limitations of This Report" which follows the text but forms an integral part of this document.

2.0 DESCRIPTION OF PROJECT AND SITE

Consideration is being given to developing Stage 5 of Findlay Creek Village community. The site is bordered to the east by Kelly Farm Drive, to the west by Fenton Road, to the north by Leitrim Road and to the south by a future stormwater management pond, as shown on the attached Site Plan, Figure 1. The following information is known about the site and the proposed development:

- The site is somewhat rectangular in shape and measures approximately 550 m by 600 m
- The overall site topography is relatively flat, but slopes down from northwest to southeast
- The majority of the site is currently undeveloped and is used for agricultural purposes
- The majority of the site will be developed as a conventional residential development and the balance, toward the west, as future employment uses

Golder Associates and McRostie & Associates (who since joined Golder Associates) have completed previous geotechnical investigations in close proximity to the site, including a geotechnical investigation for the municipal offices located immediately southwest of the intersection of Bank Street and Leitrim Road and an investigation for a previously planned industrial park which was to be located immediately south of this site.

Based on a review of the above previous geotechnical investigations, and published geological mapping, the subsurface conditions on this site are expected to consist primarily of about 2 to 5 m of sand and glacial till overlying bedrock.

3.0 PROCEDURE

The field work for this investigation was carried out between September 9 and 28, 2011. During that time, a total of eight boreholes (numbered 11-1 to 11-8, inclusive) were advanced at the approximate locations shown on the attached Site Plan, Figure 1.

The boreholes were advanced using a track-mounted hollow-stem auger drill rig supplied and operated by Marathon Underground of Ottawa, Ontario. The boreholes were generally advanced to practical refusal to augering, which were encountered at depths ranging from about 2.1 to 7.5 m below the existing ground surface. Upon encountering refusal to augering, borehole 11-8 was advanced about 4 m further into the bedrock using rotary diamond drilling techniques while retrieving HQ sized bedrock core.

Standard penetration tests (SPT) were carried out at regular intervals of depth within the boreholes and samples of the soils encountered were recovered using drive open sampling equipment.

Monitoring wells or standpipe piezometer were sealed into boreholes 11-1, 11-5, 11-7, and 11-8, to allow subsequent measurement of the groundwater level and for groundwater sampling.

The field work was supervised by an experienced technician from our staff who located the boreholes, directed the drilling operations, logged the boreholes and samples, directed the in situ testing, and took custody of the soil and bedrock samples retrieved.

On completion of the drilling operations, samples of the soils and bedrock obtained from the boreholes were transported to our laboratory for further examination by the project engineer and laboratory testing. Grain size distribution testing was carried out on four samples obtained from the sand and silt deposits.

The groundwater levels in the monitoring devices installed in boreholes 11-1, 11-5, 11-7, and 11-8 were measured either on September 9 or 28, 2011.

The borehole locations were selected and located at the site by Golder Associates personnel. The locations of the boreholes were determined using a hand-held GPS unit. The ground surface elevations at the borehole locations were not determined.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes put down for the current investigation are shown on the Record of Borehole Sheets in Appendix A. The subsurface conditions encountered in the boreholes during the previous investigations are provided in Appendix B. The results of grain size distribution testing carried out on selected samples of soil are provided in Appendix C.

In general, the subsurface conditions across this site consist of fill material overlying variable deposits of sand and silt, overlying glacial till, with the bedrock surface at about 2 to 7 m depth.

The following sections present a more detailed overview of the subsurface conditions encountered in the boreholes put down for the current investigation, as well as boreholes 1 and 2 (McRostie & Associates Ltd) and boreholes 4 and 6 (Golder Associates) which were put down during previous investigations adjacent to the site.

4.2 Fill and Topsoil

Fill exists at the ground surface at boreholes 11-4, 11-5, and 11-7. The thickness of fill varies from about 1.5 to 4.4 m. The fill consists of sand, gravel, and silt, with some brick, organic matter, and peat.

Standard Penetration Tests (SPTs) carried out within the fill gave “N” values ranging from 10 to 34 blows per 0.3 m of penetration. The results of the in situ testing indicate the fill to be in a compact to dense state of packing.

Topsoil (some of which is fill) exists at the ground surface in most of the boreholes. The topsoil ranges from approximately 90 to 300 mm in thickness.

4.3 Silty Clay

A thin deposit of silty clay was encountered below the topsoil in borehole 6. The full thickness of the silty clay deposit has been weathered to a grey brown crust and extends to about 1.8 m depth below the ground surface.

One SPT “N” value of 2 blows per 0.3 m of penetration within the weathered silty clay indicates a stiff to very stiff consistency.

4.4 Sand and Silt

The topsoil, fill, and silty clay are underlain by variable deposits of sand and silt. These deposits are mostly comprised of sand, clayey silt, silt, and silty sand.

Where fully penetrated, these deposits extend to depths of about 0.9 to 5 m. In boreholes 11-7 and 1, these deposits were proven to extend to depths of about 6.1 m and 6.5 m, respectively, prior to the boreholes being terminated.

SPTs carried out within the sand and silt deposits gave “N” values from 1 to greater than 50 blows per 0.3 m of penetration, but more typically between 5 and 15, indicating a loose to compact state of packing.

The results of the grain size distribution testing carried out on selected samples from these deposits are provided in Appendix C.

4.5 Glacial Till

Glacial till was encountered beneath the layered deposits in all of the boreholes, with the exception of boreholes 11-7 and 11-8. In general, the glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand or sandy silt with a trace of clay.

The glacial till was proven to extend to depths of between about 2.6 and 7.5 m below the ground surface prior to encountering practical refusal to augering or the boreholes being terminated.

SPTs carried out within the glacial till gave “N” values of 9 to greater than 50 blows per 0.3 m of penetration, indicating a loose to very dense state of packing. The higher “N” values likely reflect the presence of cobbles and boulders within the glacial till, rather than the state of packing of the soil matrix.

4.6 Auger Refusal and Bedrock

Practical refusal to augering was encountered at depths varying from approximately 2 to 7.5 m below the existing ground surface. Auger refusal may indicate the bedrock surface; however, it could also indicate the presence of cobbles and/or boulders within the glacial till.

Within borehole 11-8, bedrock was encountered beneath the overburden materials at about 1.9 m depth. The borehole was extended into the bedrock for a depth of about 4 m using rotary diamond drilling techniques, while retrieving HQ sized core.

The bedrock consists of grey dolomitic limestone. The bedrock is generally fresh, fine-grained, and thinly bedded. The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples were quite variable and ranged from 35 to 78 percent, indicating a poor to good rock quality.

4.7 Groundwater

The following provides a summary of the measured groundwater levels across the site:

Borehole Number	Date	Geologic Unit	Water Level Depth (m)
11-1	Sept 28, 2011	Silt	2.0
11-5	Sept 9, 2011	Glacial Till	2.3
11-7	Sept 28, 2011	Silt and Fill	4.9
11-8	Sept 28, 2011	Bedrock	3.5
6	Oct 28, 1993	Glacial Till	0.3

It should be noted that groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

5.0 DISCUSSION

5.1 General

This section of the report provides preliminary engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the borehole data and the project requirements.

It should be emphasized that the scope of this investigation is appropriate for preliminary design and site planning only. Additional investigation will be required at the detailed design stage.

5.2 Site Grading

The subsurface conditions on this site generally consist of topsoil underlain by layered sands and silts, overlying glacial till. Based on the results of this preliminary investigation, there is no practical restriction on the amount of grade raise fill that can be placed on this site from a geotechnical perspective.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil for predictable performance of structures and services.

The topsoil is not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the topsoil may be left in-place provided some settlement of the ground surface following filling can be tolerated.

5.3 Foundations

5.3.1 Residential Structures

It is considered that conventional houses could be supported on shallow footings founded on or within the inorganic overburden soils on this site. The topsoil and fill material encountered at this site would not be considered suitable to support the house foundations and therefore need to be removed from the house footprints.

Strip footing foundations may be designed using a maximum allowable bearing pressure of 75 kilopascals. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC).

The post-construction total and differential settlements of footings sized using the above maximum allowable bearing pressure should be less than about 25 and 15 mm, respectively, provided that the subgrade at or below the founding level is not disturbed during construction.

5.3.2 Commercial Structures

It is understood that the west portion of the site may be developed with commercial structures.

It is considered that the proposed commercial structures can be founded on shallow footings (square or strip) placed on or within the native inorganic undisturbed soils. For preliminary design, the net bearing resistance for spread footings at Serviceability Limit States (SLS) and the factored bearing resistance at Ultimate Limit States (ULS) may be taken as 100 and 150 kilopascals, respectively.

The post-construction total and differential settlements of footings sized using the above SLS net bearing resistance values should be less than about 25 and 15 mm, respectively, provided that the soil at or below the founding level is not disturbed during construction.

5.4 Frost Protection

The native subgrade soils on this site are considered to be frost susceptible. Therefore, all exterior perimeter foundation elements or foundation elements in unheated areas should be provided with a minimum of 1.5 m of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 m of earth cover.

Insulating the bearing surface with high density insulation could be considered as an alternative to earth cover for frost protection.

5.5 Basement and Garage Floor Slabs

In preparation for the construction of the basement and garage floor slabs, all loose, wet, and disturbed materials should be removed from beneath the floor slabs. Provision should be made for at least 200 mm of 19 mm crushed clear stone to form the base of the floor slabs.

To prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base for the floor slabs be positively drained.

The groundwater level in the boreholes was measured at about 2 to 5 m depth. The sandy/silty soils at this site are somewhat permeable. If the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the sandy/silty subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. In the extreme case, loss of fines into the clear stone could cause ground loss beneath the slab and plugging of the drainage system.

5.6 Excavation and Site Servicing

Excavations for the installation of basements and site services will be through the overburden soils and, at least on some portions of the site, into the dolomitic limestone bedrock.

No unusual problems are anticipated in excavating in the overburden using conventional hydraulic excavating equipment, recognizing that large boulders may be encountered. Boulders larger than 0.3 m in size should be removed from the excavation side slopes.

The Occupational Health and Safety Act (OHSA) of Ontario indicates that side slopes in the overburden materials above the water table could be sloped at a minimum of 1 horizontal to 1 vertical (i.e., Type 3 soils). Excavation side slopes below groundwater level in the overburden soils will slough to a somewhat flatter inclination. In accordance with the OHSA of Ontario, these excavation side slopes would likely need to be cut back at 3 horizontal to 1 vertical (i.e., Type 4 soils). If deeper excavations or steeper side slopes are required, or space restrictions exist, the excavation could be carried out within closed sheeting which is fully braced to resist lateral earth pressure.

For shallow depths of excavation, bedrock removal could be accomplished using mechanical methods (such as hoe ramming). Excavations deep into the rock will likely require drill and blast procedures. Near vertical trench walls in the bedrock should stand unsupported for the construction period, at least for moderate depths (i.e., less than about 3 m).

Provided that the excavations extend no deeper than about 2 m below the existing ground surface, it is considered that the rate of groundwater inflow should be modest and it should be feasible to handle the groundwater inflow by pumping from well filtered sumps in the floor of the excavations.

Where excavations extend more than about 2 m below ground surface, more active groundwater control (such as pumping from wells or well points in the overburden and/bedrock) could be required.

A Permit-To-Take-Water (PTTW) from the Ministry of the Environment of Ontario is required for rates of groundwater inflow in excess of 50,000 Litres per day. Depending on the depths and size of excavations, a PTTW could be required for this site, especially if the excavations are carried out during the wetter periods of the year (i.e., spring). Based on previous works in the area, a PTTW will likely be required. The time required to obtain a PTTW can be several months and it is therefore generally impractical to make obtaining the PTTW the responsibility of the contractor. Consideration should therefore be given to applying for the permit well in advance of the construction tender. Further assistance on this issue can be provided.

It is envisioned that conventional service installation (bedding, cover, backfill, etc.) will be appropriate for this site.

5.7 Pavement Design

In preparation for pavement construction, all topsoil and deleterious material (i.e., soil containing organic material) should be removed from all pavement areas.

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material.

The pavement structure for local roads which will not experience bus or truck traffic (other than school bus and garbage collection) should be:

Pavement Component	Thickness (mm)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	375

The pavement structure for collector roadways which will experience bus and/or truck traffic should be:

Pavement Component	Thickness (mm)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	450

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 10 of OPSS 310.

The composition of the asphaltic concrete pavement should be as follows:

- Superpave 12.5 mm Surface Course - 40 mm
- Superpave 19 mm Base Course - 50 mm

The pavement design should be based on a Traffic Category of Level B on local roads and Level C on collector roads. The asphalt cement should be PG 58-34.

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., where the trench backfill and grade raise fill have been adequately compacted to the required density and the subgrade surface not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and/or to place a woven geotextile beneath the granular materials. Given that the roadway subgrade in some locations could consist of relatively wet trench backfill, it should be planned to include a contingency for such works.

5.8 Trees

Clayey silt was encountered in borehole 11-2. The clayey silt is sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clayey soil, the material undergoes shrinkage which can result in settlement of adjacent structures. The zone of influence of a tree is considered to be approximately equal to the height of the tree. Therefore, in areas where the buildings will be founded on the clayey soil, trees which have a high water demand should not be planted closer to structures than the ultimate height of the trees.

For buildings which are founded on the silt, sand, glacial till, or bedrock, it is considered that there is no restriction on tree type or the proximity of the tree to the house, from a geotechnical point of view.

5.9 Seismic Considerations – Commercial Site

The area which is being proposed to be developed with commercial buildings (i.e., the west portion of the site) is underlain by about 3.3 m of loose to compact silt, overlying glacial till. The water level was measured to be at about 2 m depth. The looser portions of the silt, which are located towards the bottom of the deposit, are saturated and the potential for seismic liquefaction of this material therefore needs to be assessed.

Seismic liquefaction occurs when earthquake vibrations cause an increase in pore water pressures within the soil. The presence of excess pore water pressures reduces the effective stress between the soil particles, and the soil’s frictional resistance to shearing. This phenomenon, which leads to a temporary reduction in the shear strength of the soil, may cause:

- Large lateral movements of even gently sloping ground, referred to as “lateral spreading”
- Reduced shear resistance (i.e., bearing capacity) of soils which support foundations, as well as reduced resistance to sliding
- Reduced shaft resistance for deep foundations as well as reduced resistance to lateral loading

In addition, “seismic settlements” may occur once the vibrations and shear stresses have ceased. Seismic settlement is the process whereby the soils stabilize into a denser arrangement after an earthquake, causing potentially large surface settlements.

A preliminary assessment of the liquefaction potential of the silt was carried out using the Seed and Idriss (1971) simplified procedure based on the SPT N_{60}-values from borehole (11-1). The results of this assessment suggest that the native submerged silt at the proposed commercial site would be classified as liquefiable under an earthquake with a magnitude of 6.2 (Ottawa area specified design value) and a peak ‘firm ground’ acceleration of 0.42 g (per the 2006 OBC).

The following preliminary comments are offered regarding the potential for liquefaction beneath the commercial site:

- The anticipated settlement of the liquefiable native silt at the commercial site under the analyzed earthquake event could be up to about 25 mm. These settlements would be in addition to the anticipated settlements under ‘static’ loading. The amount of settlement is highly dependant on the earthquake event, the thickness of the deposit and its liquefaction potential, and therefore settlements could be highly variable. If the foundations of buildings on the proposed commercial site are founded above or within these materials, then the structures should be designed to accept this differential settlement without experiencing collapse.

Note: Guarding against collapse (i.e., allowing for ‘safe exit’) is considered to be the Building Code objective of design for earthquake conditions (recognizing that the ‘design’ earthquake has a return period of 2,475 years), though the structure may be damaged and rendered unserviceable.

- The seismic settlements could result in floor slab settlements, cracking, or heaving during/following an earthquake event.
- The presence of liquefiable soils may reduce the ULS bearing resistances for foundation design applicable for seismic loading conditions. However, the bearing resistances will depend on the finished grade around the structures and the underside of footing elevations and cannot be confirmed until additional design details are available.
- The seismic design provisions of the 2006 OBC depend, in part, on the shear wave velocity of the upper 30 m of soil and/or rock below founding level. The presence of liquefiable soils also impacts on the Site Class. A Site Class of D (and possibly C, which will need to be confirmed at the detailed design) can be used for this site provided that the structures will have a fundamental period of vibration of less than or equal to 0.5 seconds. If the fundamental period of vibration of the structures is greater than 0.5, then additional seismic assessments will be required.
- Alternatively, the commercial buildings could be founded on the underlying non-liquefiable glacial till, or the liquefiable soils could be improved (i.e., densified) to reduce their liquefaction potential. Consideration could also be given to subexcavating the liquefiable soils and replacing them with engineered fill.

6.0 ADDITIONAL CONSIDERATIONS

The guidelines in this report are preliminary in nature, are based on a limited number of widely spaced boreholes, and are intended solely to provide a preliminary assessment of the geotechnical issues relating to the development of this site. Once the planning process has been completed, additional investigation will be required at the detailed design stage.

We trust this report contains sufficient information for your present requirements. If you have any questions concerning this report, or if we can be of further service to you on this project, please call us.

Signature Page

Golder Associates Ltd.

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IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **IBI Group**. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then the client may authorize the use of this report for such purpose by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process, provided this report is not noted to be a draft or preliminary report, and is specifically relevant to the project for which the application is being made. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

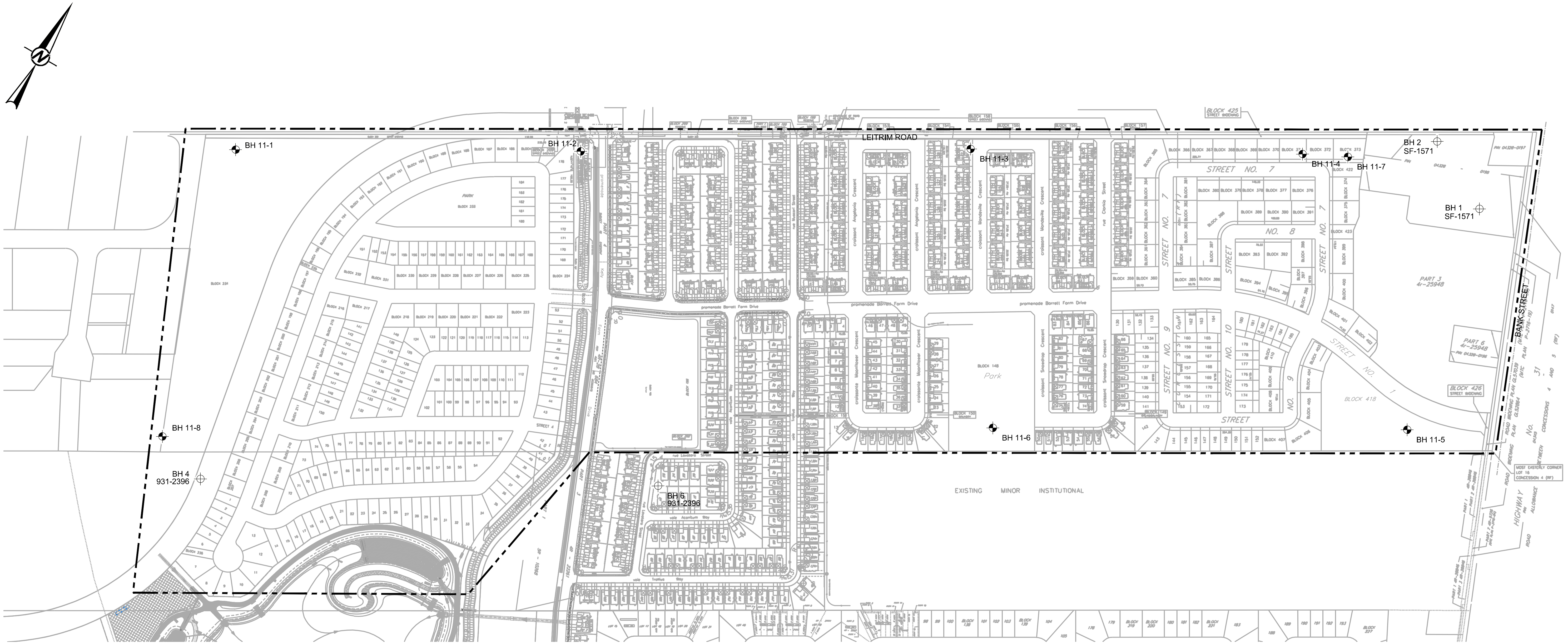
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



0 100 200

1:5,000 METRES

LEGEND

◈	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
▭	APPROXIMATE SITE BOUNDARY

REFERENCE(S)

1. BASE PLAN PROVIDED IN ELECTRONIC BY IBI GROUP, OCTOBER 22, 2019
2. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

CLIENT
IBI GROUP

CONSULTANT

GOLDER

YYYY-MM-DD	2019-10-31
DESIGNED	AG
PREPARED	ABD
REVIEWED	AG
APPROVED	WC

PROJECT
GEOTECHNICAL INVESTIGATION - PROPOSED
RESIDENTIAL DEVELOPMENT, BARRETT LANDS - STAGE 5
3100 LEITRIM ROAD, OTTAWA, ONTARIO

TITLE
SITE PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
19129142	0002	0	1

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

APPENDIX A

List of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Record of Borehole Sheets

Current Investigation by Golder Associates

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of rock material weathering.

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)
The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)
The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)
The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index
A count of the number of naturally occuring discontinuities (physical separations) in the rock core. Mechanically induced breaks caused by drilling are not included.

Dip with Respect to Core Axis
The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes
An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

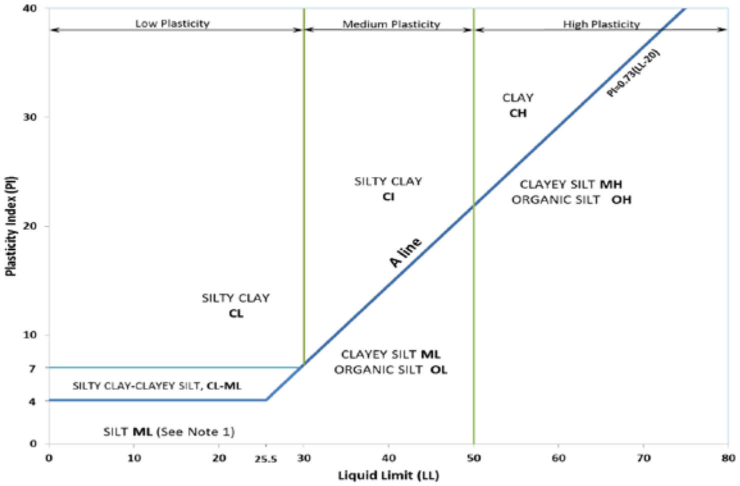
JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.

Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l – w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index $= (w – w_p) / I_p$
I_C	consistency index $= (w_l – w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} – e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes:
1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

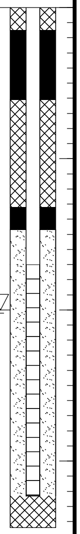
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○: 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ├──○W──┤ Wl: 20 40 60 80

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE						
TOPSOIL	0.00					Native Backfill
Brown SAND, trace silt	0.21	1	GRAB			Bentonite Seal
Compact brown SILT, trace sand and clay	0.56	2	50 DO	12		Native Backfill
		3	50 DO	16		Bentonite Seal Silica Sand
Loose to compact grey SILT, trace sand and clay	1.95	4	50 DO	6	MH	51 mm Diam. PVC #10 Slot Screen
Very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	3.26	5	50 DO	>50		Native Backfill
End of Borehole Auger Refusal	3.44					W.L. in Screen at 2.0 m depth on September 28, 2011



DEPTH SCALE

1 : 50

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING
		GROUND SURFACE					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		Brown CLAYEY SILT, trace sand	0.15	1	GRAB		
1				2	50 DO	7	MH
		Very dense brown SILTY SAND, trace gravel and clay, with cobbles and boulders (GLACIAL TILL)	1.37	3	50 DO	>50	
2				4	50 DO	>50	
		End of Borehole Auger Refusal	2.59				
3							
4							
5							
6							
7							
8							
9							
10							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 12, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		Brown SILTY SAND	0.09				
		Brown SILT, trace gravel, clay, and sand	0.61				
1		Compact to very dense brown SAND, some gravel, trace silt and clay, with cobbles and boulders (GLACIAL TILL)	0.98	1	50 DO	15	∇
2				2	50 DO	37	
				3	50 DO	20	
3				4	50 DO	57	
4				5	50 DO	>50	
		End of Borehole Auger Refusal	4.10				W.L. in open hole at 1.3 m depth at time of drilling
5							
6							
7							
8							
9							
10							

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Power Auger 200 mm Diam. (Hollow Stem)	Topsoil (FILL)		0.00							
		Brown silty sand (FILL)		0.23							
1		Loose to compact brown sand, some gravel, trace silt (FILL)		0.70	1	50 DO	13				
2					2	50 DO	19				∇
					3	50 DO	7				
3		Loose brown SILT, trace sand, gravel, and clay		2.68	4	50 DO	9			MH	
4		Compact grey SILT, trace clay and sand		3.81	5	50 DO	17				
5					6	50 DO	10				
6		Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		5.03	7	50 DO	21				
					8	50 DO	26				
7					9	50 DO	27				
8		End of Borehole Auger Refusal		7.47							W.L. in open hole at 2.4 m depth at time of drilling
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE							
0	Power Auger 200 mm Diam. (Hollow Stem)	Topsoil (FILL)	▨	0.00					Native Backfill
		Brown sand, trace gravel and silt (FILL)	▨	0.21	1	GRAB			Bentonite Seal
1		Compact brown silty sand, some gravel (FILL)	▨	0.82	2	50 DO	11		
		Compact brown SILT, trace to some sand		1.52	3	50 DO	28		
2					4	50 DO	16		▽
3		Loose grey SILT, trace to some sand		2.77	5	50 DO	8		Native Backfill
4					6	50 DO	6	MH	
5		Compact to very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		4.63	7	50 DO	16		
6					8	50 DO	19		Bentonite Seal Silica Sand
					9	50 DO	14		19 mm Diam. PVC #10 Slot Screen
7					10	50 DO	>50		Native Backfill
		End of Borehole Auger Refusal		7.19					W.L. in Screen at 2.3 m depth at time of drilling
8									
9									
10									

MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 9, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl 20 40 60 80

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE						
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00					
1		Loose brown SILT, trace to some sand and clay	0.15	1	50 DO	5		
		Loose grey brown SILT, trace to some gravel	1.14					
2		Loose grey SILT, trace to some sand	1.74	2	50 DO	5		
3		Loose to very dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	2.29	3	50 DO	29		
4				4	50 DO	14		
5				5	50 DO	25		
				6	50 DO	9		
				7	50 DO	>50		
6		End of Borehole Auger Refusal	5.64					
7								
8								
9								
10								

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PH

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-7

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 27, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

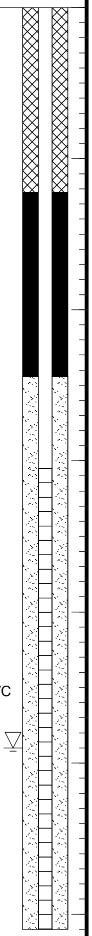
WATER CONTENT PERCENT: Wp ├──○W──┤ Wl : 20 40 60 80

ADDITIONAL LAB. TESTING

BORING METHOD: Power Auger 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE				
0	Topsoil (FILL)	0.00			
	Compact to dense brown sand, some gravel, trace silt, some brick pieces, organics, and peat (FILL)	0.15	1	50 DO	10
1			2	50 DO	14
2			3	50 DO	21
			4	50 DO	34
3			5	50 DO	33
4			6	50 DO	20
	Compact grey SILT, trace sand	4.37	7	50 DO	15
5			8	50 DO	12
6	End of Borehole	6.10			
7					
8					
9					
10					

PIEZOMETER OR STANDPIPE INSTALLATION



W.L. in Screen at 4.9 m depth on September 28, 2011

DEPTH SCALE

1 : 50

LOGGED: DK

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF BOREHOLE: 11-8

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: September 27 & 28, 2011

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80

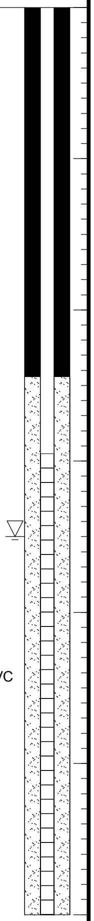
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20, 40, 60, 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl : 20, 40, 60, 80

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		Grey brown SILT, trace gravel and sand	0.10	1	50 DO	10	
1				2	50 DO	24	Bentonite Seal
				3	50 DO		
2		Highly weathered grey DOLOMITIC LIMESTONE BEDROCK	1.88				
	Rotary Drill HQ Core	Fresh, fine grained, thinly bedded, grey DOLOMITIC LIMESTONE BEDROCK	2.13				Silica Sand
3				C1	HQ RC	DD	
4				C2	HQ RC	DD	19 mm Diam. PVC #10 Slot Screen
5				C3	HQ RC	DD	
6			6.00				W.L. in Screen at 3.5 m depth on September 28, 2011
7							
8							
9							
10							



MIS-BHS 001 1111210198-1000.GPJ GAL-MIS.GDT 01/27/12 JEM

DEPTH SCALE

1 : 50

LOGGED: DK

CHECKED: C.K.

PROJECT: 11-1121-0198-1000

RECORD OF DRILLHOLE: 11-8

SHEET 2 OF 2

LOCATION: See Site Plan

DRILLING DATE: September 27 & 28, 2011

DATUM:

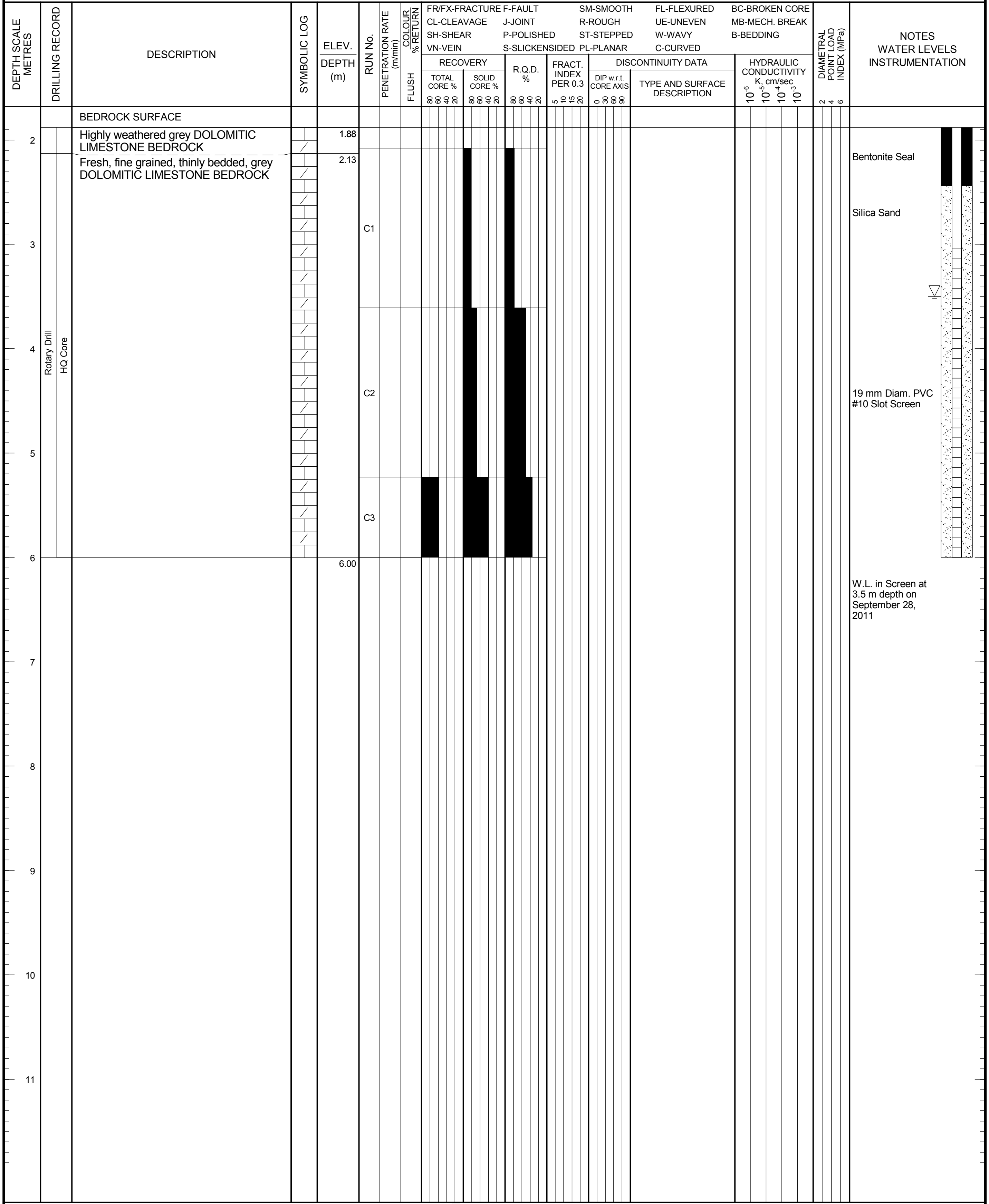
INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Downing Drilling

FR/FX-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE			
2		Highly weathered grey DOLOMITIC LIMESTONE BEDROCK	1.88		Bentonite Seal
	Rotary Drill HQ Core	Fresh, fine grained, thinly bedded, grey DOLOMITIC LIMESTONE BEDROCK	2.13	C1 C2 C3	Silica Sand 19 mm Diam. PVC #10 Slot Screen
6			6.00		W.L. in Screen at 3.5 m depth on September 28, 2011



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DK

CHECKED: C.K.

APPENDIX B

Borehole Records

Previous Investigations

FORM S-10-4

McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

GLOUCESTER TOWN HALL
LEITRIM HIGHWAY No.31

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 343.0′ DATE OCT. 5, 1961

REMARKS B.M. EL.341.32′ GEODETIC TOP OF HIGHWAY MONUMENT AT STATION 14+54.95 ON WEST SIDE OF HIGHWAY No.31

HOLE No. 1

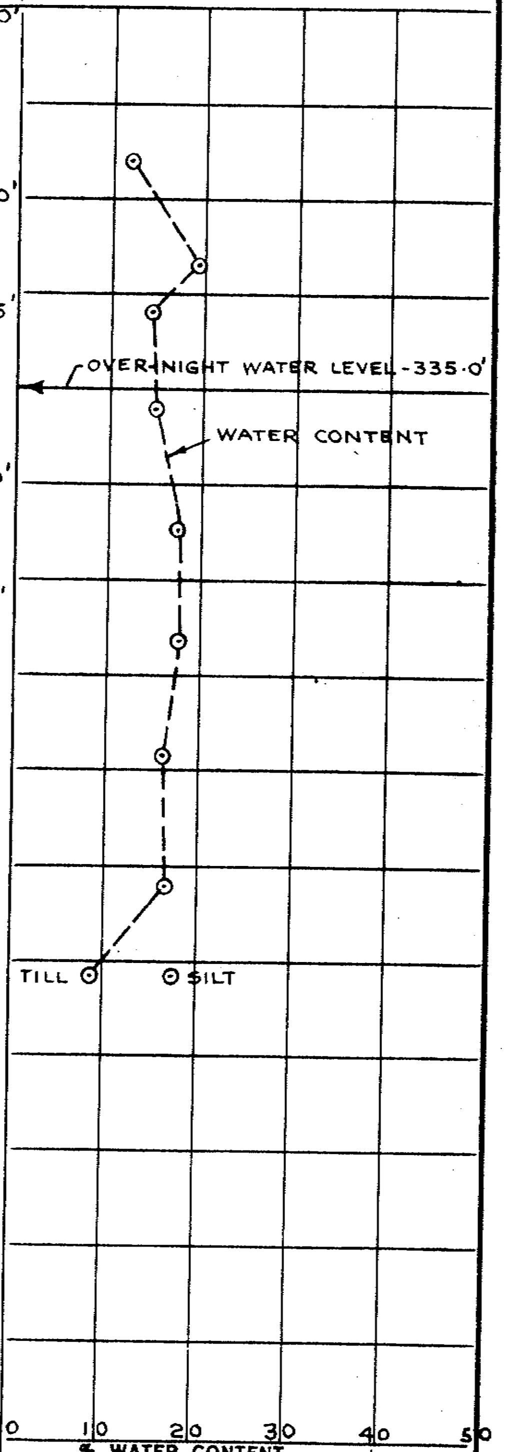
UNCONFINED COMPRESSIVE STRENGTH KIPS/FT.²	SMALL SCALE PENETROMETER KIPS/FT.²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION
				GROUND SURFACE	0′	343.0′
				TOPSOIL	0.5′	
				MEDIUM DENSE TILL	3′	
		8 for 6″ 47	1-1	DENSE TILL	4′	339.0′
		20	1-2A 1-2B	MEDIUM DENSE TILL	6.5′	336.5′
		17	1-3	MEDIUM DENSE SANDY SILT	10′	333.0′
		29	1-4	MEDIUM DENSE SILT WITH A LITTLE CLAY	12.5′	330.5′
		50 40 39	1-5 1-6 1-7	DENSE SILT WITH A LITTLE CLAY	20′	323.0′
		66	1-8A 1-8B	DENSE TILL WITH A FEW SILT LAYERS	21.3′	321.7′
				BOTTOM OF HOLE		

~~PROBING OR VANE TEST~~

.........LB. HAMMER ....INCH DROP

NO CASING ....INCH DIA. ROD

~~BLOWS PER FOOT OR SHEAR STRENGTH IN KIPS PER FT.²~~



% WATER CONTENT
NATURAL ⊙
LIQUID LIMIT □
PLASTIC LIMIT △

R - REMOULDED

PLATE 2

LOWE-MARTIN CO. LTD.—A50147

FORM S-10-4

McROSTIE & ASSOCIATES LTD.
CONSULTING ENGINEERS
OTTAWA CANADA

SOIL PROFILE AND SUMMARY OF FIELD AND LABORATORY TESTS

GLOUCESTER TOWN HALL
LEITRIM HIGHWAY No. 31

ELEVATION OF GROUND SURFACE (ZERO DEPTH) 334.0' DATE OCT. 4, 1961

REMARKS SEE PLATE No. 2

HOLE No. 2

UNCONFINED COMPRESSIVE STRENGTH KIPS/FT.²	SMALL SCALE PENETROMETER KIPS/FT.²	STANDARD PENETRATION BLOWS/FT.	SAMPLE NUMBER	DESCRIPTION OF SOIL	DEPTH IN FEET	ELEVATION
				GROUND SURFACE	0'	334.0'
				TOPSOIL	0.5'	
				MEDIUM DENSE SILTY FINE SAND	3'	
		8 for 6" 43	2.1	DENSE SILTY FINE SAND	5'	329.0'
		25	2.2	MEDIUM DENSE SILTY FINE SAND	7.5'	326.5'
		18	2.3	MEDIUM DENSE SILT WITH A FEW THIN CLAY LAYERS	10'	324.0'
		9 for 6" 64	2.4	MEDIUM DENSE SANDY TILL	10.5'	
		131	2.5	DENSE SANDY TILL		
		82	2.6		16.5'	317.5'
				BOTTOM OF HOLE		

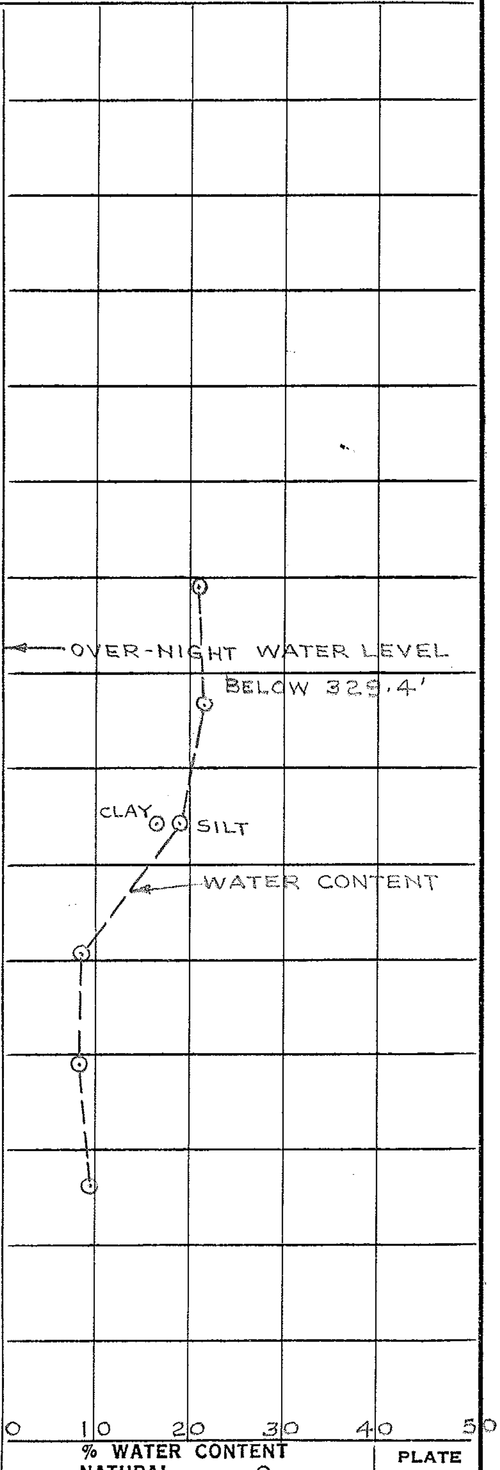
R - REMOULDED

~~PROBING OR VANE TEST~~

........LB. HAMMER ....INCH DROP

NO CASING ....INCH DIA. ROD

~~BLOWS PER FOOT OR~~ ~~SHEAR STRENGTH IN KIPS PER FT.²~~



% WATER CONTENT
NATURAL ⊙
LIQUID LIMIT □
PLASTIC LIMIT △

PLATE 3

LOWE-MARTIN CO. LTD.—A50147

PROJECT: 931-2396

RECORD OF BOREHOLE 4

SHEET 1 OF 1

LOCATION: See Plan

BORING DATE: Oct.25&26,1993

DATUM:

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m SHEAR STRENGTH Cu, kPa nat.V - + Q - ● rem.V - ⊕ U - ○	HYDRAULIC CONDUCTIVITY, k, cm/s WATER CONTENT, PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m				
0		Ground Surface									
	Power Auger 200mm Diam (Hollow Stem)	Brown SANDY SILT, scattered trace gravel with depth		0.00							∇
1		Loose to compact brown to grey sandy silt to silty sand, some gravel and clay occasional boulder (GLACIAL TILL)		0.88	1	50 DO	12		○		
					2	50 DO	9		○		
2		End of Hole Auger Refusal		2.19							W.L in open hole at 0.06m depth on completion of drilling Oct. 26, 1993
3											
4											
5											
6											
7											
8											
9											
10											

NOTE : AH 4A - 1.5m East
Auger Refusal at 1.98m

AH 4B - 7.0m South
Auger Refusal at 2.19m

DATA INPUT: Disk 17, S.Leighton

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: R.A.M

CHECKED:

PROJECT: 931-2396
LOCATION: See Plan
SAMPLER HAMMER, 63.5kg; DROP, 760mm

RECORD OF BOREHOLE 6

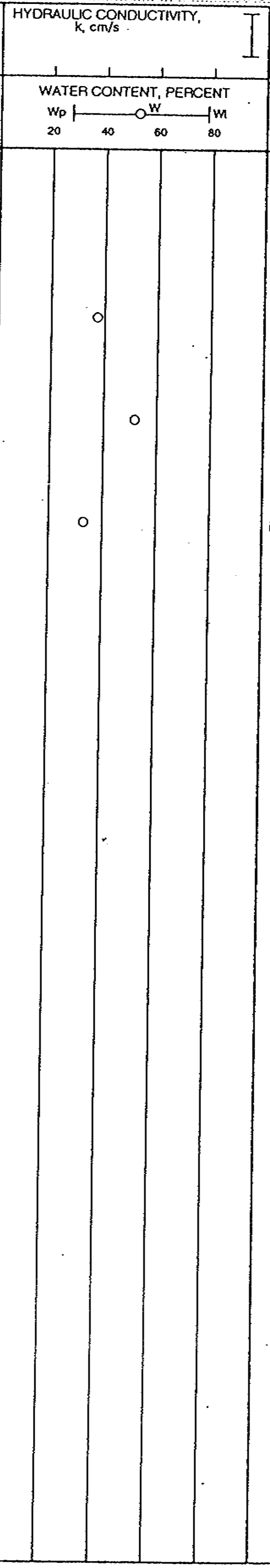
BORING DATE: Oct 26,1993

SHEET 1 OF 1
DATUM:
PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

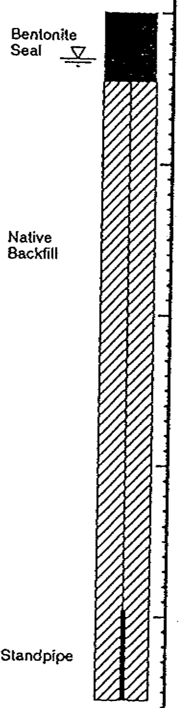
DEPTH SCALE METRES | BORING METHOD: Power Auger, 200mm Diam (Hollow Stem)

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
Ground Surface					
Dark brown silty TOPSOIL	0.00				
Stiff to very stiff grey brown SILTY CLAY, trace to some sand seams (Weathered Crust)	0.24	1	50 DO	2	
Very loose to loose dark grey to grey SILT, some sand, scattered trace gravel	1.83	2	50 DO	WH 5	
		3	50 DO	WH	MH
Compact grey sandy silt to silty sand, some gravel and clay, occasional boulders (GLACIAL TILL)	2.99	4	50 DO	17	
		5	50 DO	17	
End of Hole	4.57				

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH Cu, kPa nat.V - + Q - ● rem.V - ⊕ U - ○
HYDRAULIC CONDUCTIVITY, k, cm/s



PIEZOMETER OR STANDPIPE INSTALLATION



W.L in Standpipe at 0.30m depth Oct.28, 1993

DEPTH SCALE
1 to 50

Golder Associates

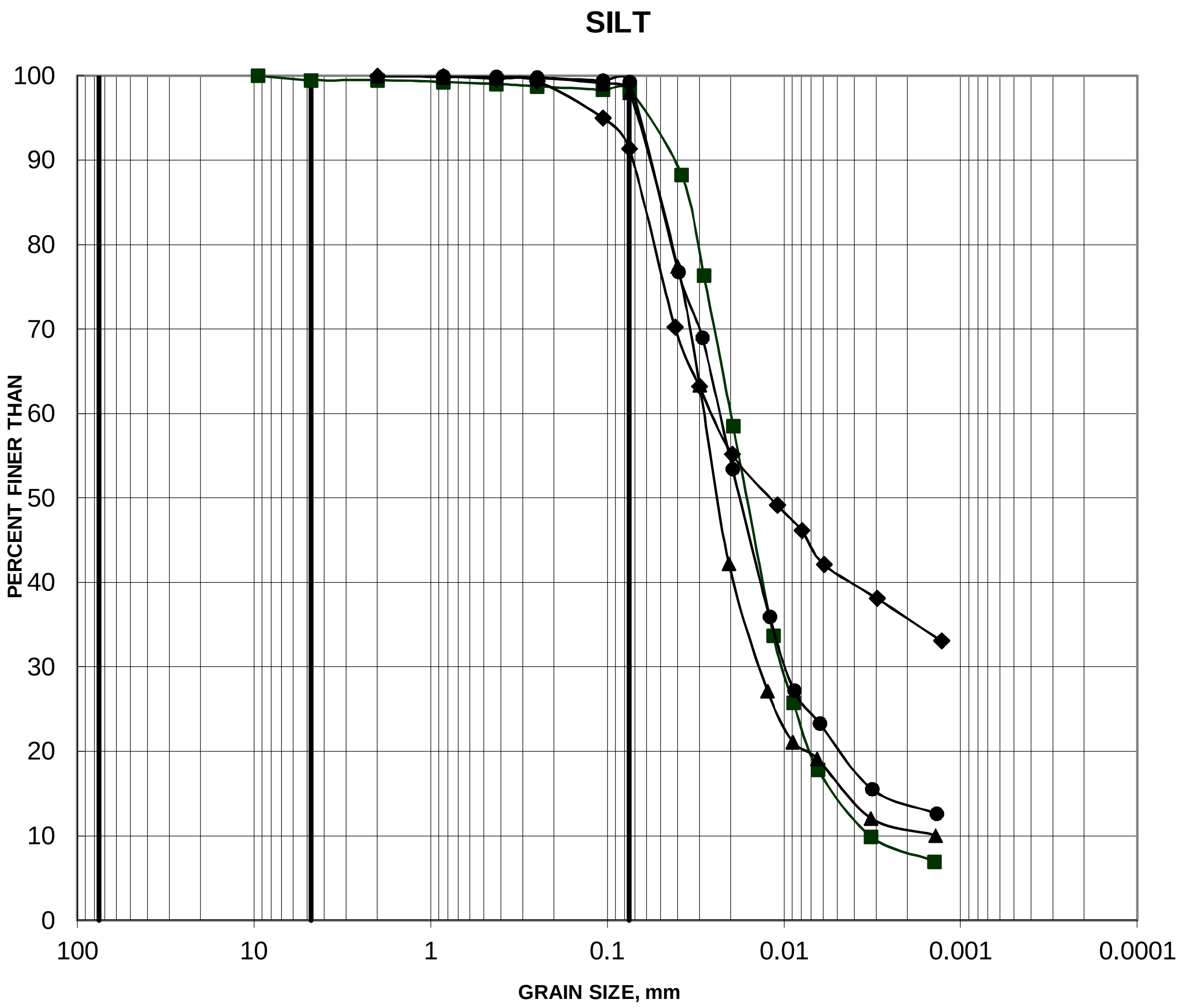
LOGGED: R.A.M
CHECKED:

APPENDIX C

Grain Size Distribution Test Results

GRAIN SIZE DISTRIBUTION

SILT



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
■ 11-1	4	2.29-2.90
◆ 11-2	2	0.76-1.37
▲ 11-4	4	3.05-3.66
● 11-5	6	3.81-4.42

Created by: CW
Checked by: CNM

Project: 11-1121-0198

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