

### REPORT

## **Geotechnical Investigation**

Proposed Central Library 555 Albert Street Ottawa, Ontario

Submitted to:

### **Richard Fouchard**

City of Ottawa 100 Constellation Crescent Ottawa, Ontario

Submitted by:

## Golder Associates Ltd.

1931 Robertson Road, Ottawa, Ontario, K2H 5B7

+1 613 592 9600

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### **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) was retained by the City of Ottawa (the City) to conduct a geotechnical investigation in order to provide geotechnical input to the detailed design of the proposed Ottawa Central Library site located at 555 Albert Street in Ottawa, Ontario. A Site Location Plan is attached as Figure 1. It is understood that the development will consist of a 4 to 5 storey structure with up to two levels of underground parking as well as an asphalt surfaced laneway with parking. The investigation and reporting were carried out in general accordance with the scope of work provided in our proposal no. P19131600 dated October 4, 2019.

The purpose of this investigation was to assess the general subsurface and groundwater conditions within the study area by means of a limited number of boreholes and associated laboratory testing. Based on an interpretation of the factual information obtained during the current investigation, along with the existing subsurface information available for the site from previous investigations, a general description of the soil and groundwater conditions is presented. These interpreted subsurface conditions and available project details were used to prepare engineering guidelines on the geotechnical design aspects of the project, 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

The site is currently owned by the City of Ottawa and was recently being used as a staging area for the construction of the Combined Sewage Storage Tunnel (CSST) and Ottawa Light Rail Transit (OLRT) projects. The property is bordered to the north by the west OLRT tunnel portal, and the CSST tunnel passes beneath the site.

The preliminary plans and information provided indicate that the proposed building footprint is an irregularly shaped rectangular area measuring approximately 60 m by 130 m. It is assumed that below grade excavations would extend to approximately 1 m below the founding slab to a depth of 5 to 7 mbgs.

Seven existing boreholes from previous investigations (completed by Golder Associates) have been used to supplement the current investigation. The locations of these previous boreholes are shown on the attached Site Plan (Figure 1). The results of the previous investigations are contained in the following reports:

- Golder Report No. 10-1121-0222 titled "Geotechnical Data Report, Geotechnical and Hydrogeological Investigation, Ottawa Light Rail Transit, (OLRT) Tunnel (Segment 2), Ottawa, Ontario" and dated December 2011.
- Golder Report No. 13-1121-0143 titled "Geotechnical Data Report, Geotechnical and Hydrogeological Investigation, Combined Sewage Storage Tunnel (CSST), Ottawa, Ontario" and dated July 2015.
- Golder Report No. 1522242 titled: "Summary of Phase II Environmental Site Assessment Results, 557 Wellington Street and Adjacent Property, Ottawa, Ontario", and dated May 2015.
- Golder Report No. 06-1120-331-300 titled "Phase II Environmental Site Assessment, Lemieux Island High Pressure Transmission Main (HPTM) Replacement Program Part 2, City Centre Drive to Commissioners Avenue, Ottawa, Ontario", and dated December 2006.

Based on the results of previous investigations and the published geology maps available from the Geologic Survey of Canada (GSC) for this area, the subsurface conditions at this site are expected to consist of a surficial layer of fill, overlying a thick deposit of glacial till. The glacial till is underlain by interbedded limestone and shale bedrock of the Verulam formation. Depth to bedrock within the footprint of the proposed structure varies between about 6 m below the existing ground surface on the north side and 13 m below the existing ground surface in the center of the proposed structure.

### 3.0 PROCEDURE

The fieldwork for this investigation was carried out between November 20 and December 3, 2019. During that time, a total of 18 boreholes (numbered 19-01 to 19-09, 19-101, and 19-102) were advanced at the approximate locations shown on the attached Site Plan (Figure 1). At boreholes 19-04, 19-09, and 19-101, additional holes were advanced adjacent to the borehole (i.e. 19-04A, 19-04B, 19-09A, 19-09B, 19-09C, 19-101A, and 19-101B) to attempt to obtain additional samples below the depth of original refusal.

The boreholes were advanced using a truck-mounted hollow-stem auger drill rig supplied and operated by CCC Drilling of Ottawa, Ontario. The boreholes were advanced to depths ranging from between 0.7 and 8.2 m below the existing ground surface.

Standard Penetration Tests (SPTs) were carried out within the overburden at regular intervals of depth. Samples of the soils encountered were recovered using 35 mm diameter split-spoon sampling equipment.

The fieldwork was supervised by technicians from our staff who located the boreholes, directed the drilling and in-situ testing operations, logged the boreholes and samples, and took custody of the soil and bedrock samples retrieved. On completion of the drilling operations, the soil samples were transported to our laboratory for further examination and laboratory testing, which included natural water content and grain size distribution tests on selected soil samples.

Two samples of soil, one from each of boreholes 19-101 and 19-102 was submitted to Eurofins Environment Testing for basic chemical analyses related to potential sulphate attack on buried concrete elements and potential corrosion of buried ferrous elements.

The borehole locations were selected in consultation with the City of Ottawa, marked in the field, and subsequently surveyed by City of Ottawa personnel. The geodetic reference system used for the survey is the North American Datum of 1983 (NAD83). The borehole coordinates are based on the Modified Transverse Mercator (MTM Zone 9) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

### 4.0 SUBSURFACE CONDITIONS

### 4.1 General

Information on the subsurface conditions is presented as follows:

- Borehole records from the current investigation are provided in Appendix A.
- Borehole records and results of UCS testing from previous investigations are provided in Appendix B.
- Results of the basic chemical analyses are provided in Appendix C.
- Results of hydraulic conductivity testing carried out during previous investigations are provided in Appendix D.

- Results of the water content testing are provided on the Record of Borehole Sheets.
- Results of the grain size distribution testing are provided on Figures 4 and 5.

The Record of Borehole sheets describe the subsurface conditions at the borehole locations only. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling in some cases, observations of drilling progress as well as results of SPTs and, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface soil, bedrock and groundwater conditions will vary between and beyond the borehole locations.

Unless otherwise noted, the following sections present an overview of the subsurface conditions encountered in the boreholes advanced during the current investigation. It should be noted that the shallow subsurface conditions noted on the borehole logs from the previous investigations may have changed since the boreholes were drilled, as such only auger refusal/bedrock depths and hydraulic response tests from previous drilling are discussed herein.

### 4.2 Overview of Subsurface Conditions

In general, the subsurface stratigraphy within the area of the investigation consists of surficial fill materials overlying glacial till at depths of 1.4 to 3.7 m below the existing ground surface.

### 4.3 Fill Material

Fill material was encountered in each of the boreholes from ground surface. The fill is heterogeneous in nature and consists of gravelly sand, to gravelly silty sand, to silty sand, to sand and gravel, to sand, and contains brick fragments, concrete fragments, pockets of silty clay, ash, and cobbles and boulders.

SPT "N" values measured within the fill ranged from 2 to 100 blows per 0.3 m of penetration. The SPT "N" values suggest that the fill has a highly variable very loose to very dense state of packing.

The fill material was fully penetrated in most of the boreholes at depths of between about 1.4 and 3.7 m below the existing ground surface.

The results of natural moisture content testing carried out on six samples of the fill gave values ranging from between 8 and 22 percent. The results of grain size distribution testing carried out on three samples of the fill are presented on Figure 4.

Auger refusal was encountered within the fill material at a depth of about 2.4 m below the existing ground surface in borehole 19-07. Auger refusal was also encountered at shallow depths in unsampled boreholes 19-04A, 19-09A, 19-09B, 19-101A, and 19-101B at depths of between about 0.7 and 3.4 m below the existing ground surface. It is likely that at many locations' auger refusal was caused by the presence of cobbles and boulders.

### 4.4 Glacial Till

A deposit of glacial till was encountered beneath the fill material at all of the boreholes. The glacial till typically consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sand and silt with a trace to some clay. At some locations, the till consists of clayey sand containing gravel, cobbles and boulders. The glacial till was not fully penetrated in the current investigation but was proven to depths of between about 2.9 and 8.2 m below the existing ground surface.

SPT "N" values within the glacial till layer gave 'N' values ranging from 8 blows to 100 blows per 0.3 m of penetration, but more generally between 35 and greater than 50 blows per 0.3 m of penetration indicating a loose, but more generally dense to very dense state of packing. Higher blow counts, however, could be indicative of boulders and cobbles in the till rather than the state of packing.

The results of natural moisture content testing carried out on four samples of the glacial till gave values ranging from 5 to 10 percent. The results of grain size distribution testing carried out on three samples of the glacial till are presented on Figure 5.

### 4.5 Bedrock

Previous boreholes were extended through the glacial till deposit into the underlying bedrock using rotary diamond drilling techniques. The depths and elevations to bedrock surface are summarized below:

Borehole No.	Ground Surface Elevation (masl)	Depth to Bedrock (m)	Elevation of Bedrock (masl)
T-1	65.71	6.99	59.22
T-2	66.32	8.09	58.72
T-74	63.41	6.29	57.12
T-75	61.79	11.08	50.71
W-058	61.40	7.36	54.04
W-059	61.68	9.84	51.84
W-060	61.23	9.17	52.06
W-061	61.55	9.01	52.54
W-062	62.95	5.88	57.07
13-3	62.49	11.08	51.41
13-4	62.20	10.64	51.56
13-5	62.11	11.51	51.33
13-6	61.95	11.15	50.8
14-601	62.34	13.43	48.91
14-602	63.00	11.3	51.70
14-603	61.41	8.38	53.03
14-604	56.44	4.34	52.10

The bedrock consists of limestone with shale interbeds of the Verulam formation. Additional description of the bedrock is provided on the Borehole records provided in Appendix B.

The results of laboratory testing carried out on samples of the cored bedrock from previous investigations measured Uniaxial Compressive Strengths (UCS) of between about 19 and 64 MPa, indicating the samples of the rock tested is medium strong to strong. Results of the UCS testing carried out are presented in Appendix B.

### 4.6 Groundwater Conditions

Monitoring wells were installed in boreholes 19-01, 19-02, 19-03, 19-05, 19-06, 19-07, 19-08, 19-09C, and 19-102 in the current investigation. Monitoring wells were also installed in boreholes 13-3, 13-4, 13-6, T-75, W-058, W-060, and W-062 during the previous investigations. The groundwater levels observed in the monitoring wells have been summarized in the following table:

Well	Geologic Unit of	Groundwater Level			Hydraulic
ID	Screened Interval	Depth (mbgs)	Elevation (masl)	Date of Measurement	Conductivity (cm/s)
19-01	Glacial Till	2.60	58.39	December 10, 2019	
19-02	Glacial Till	3.36	60.27	December 10, 2019	
19-03	Glacial Till	5.66	56.92	December 10, 2019	
19-05	Glacial Till	5.17	56.54	December 10, 2019	
19-06	Fill/Glacial Till	2.34	62.04	December 10, 2019	
19-07	Fill	2.14	58.97	December 10, 2019	
19-08	Glacial Till	5.52	56.86	December 10, 2019	
19-09C	Glacial Till	4.50	58.16	December 10, 2019	
19-102	Glacial Till	4.25	58.44	December 10, 2019	
13-3	Glacial Till			February 22, 2013	4 x 10 <sup>-5</sup>
13-4	Fill/Glacial Till			February 22, 2013	6 x 10 <sup>-5</sup>
13-6	Bedrock			February 22, 2013	1 x 10 <sup>-4</sup>
T-75	Glacial Till	3.06	58.73	June 28, 2011	
W-058	Glacial Till	3.71	57.69	January 20, 2011	2 x 10 <sup>-6</sup>
W-060	Fill/Glacial Till	3.51	57.72	January 20, 2011	5 x 10 <sup>-6</sup>
W-062	Glacial Till	2.58	60.37	January 20, 2011	1 x 10 <sup>-6</sup>
15-01	Glacial Till	4.53	57.65	March 9, 2015	
15-02	Glacial Till	5.52	56.32	March 9, 2015	
15-03	Glacial Till	6.1		March 3, 2015	
06-24	Glacial Till	2.60	59.92	December 8, 2006	
06-25	Glacial Till	1.98	60.64	December 8, 2006	
06-26	Glacial Till	3.47	60.57	December 8, 2006	
06-27	Glacial Till	3.30	62.42	December 8, 2006	

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.

### 4.7 Corrosion Testing

Two samples of soil, one each from boreholes 19-101 and 19-102 were submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results of this testing are provided in Appendix C and are summarized below.

Borehole / Sample Number	Sample Depth (m)	Chloride (%)	Sulphate (%)	рН	Resistivity (Ohm-cm)
19-101 SA 4	2.4 – 2.9	0.016	0.01	8.3	3330
19-102 SA 7	4.6 – 5.2	0.007	0.02	8.5	4170

### 5.0 DISCUSSION AND GEOTECHNICAL RECOMMENDATIONS

This section of the report provides engineering information related to the geotechnical design aspects of the project based on our interpretation of the available subsurface information and on our understanding of the project requirements. The discussion below focuses on the development of the proposed structure.

The information in this portion of the report is provided for detailed design purposes in support of the design by the engineers and architects. The recommendations provided herein are consistent with the Ontario Building Code of 2012 (OBC 2012), including the latest amendment under O. Reg. 88/19. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

This report addresses only the geotechnical aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including the consequences 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 report. The results of a concurrent Phase II Environmental Site Assessment for this project are provided under separate cover.

### 5.1 Site Grading

It is understood that a grade raise of up to 2.4 m is proposed at the site to match the proposed grade raise of Albert Street. The proposed grade raise is within acceptable limits for the soils at this site. A proposed grading plan was not available for review at the time of writing this report.

### 5.2 Foundation Design

Based on the conceptual design information provided to Golder, the proposed structure will have one to two underground parking levels. As such, the excavation for the structure is expected to extend to depths of about 5 to 7 m below existing site grades.

The subsurface conditions present below the fill at this site generally consist of glacial till over limestone bedrock.

### 5.2.1 Shallow Spread Footings

In some areas of the structure, the structure may be founded on spread footings supported on the underlying bedrock provided that they can be designed using the bearing resistance values provided below. Where bedrock is deeper than the footing elevation, footings may be placed on glacial till.

### 5.2.1.1 Footings on Bedrock

Spread footings founded on clean, sound and undisturbed bedrock are considered to be a feasible option. For spread footings placed on sound bedrock, a factored Ultimate Limit States (ULS) bearing resistance of 1,000 kPa can be used for design of the foundations. Serviceability Limit States (SLS) net bearing resistances do not generally apply to the design of foundations on the bedrock, provided the bedrock surface is properly cleaned of soil and loose highly weathered/fractured bedrock at the time of construction. The ULS bearing resistance for foundations on bedrock may need to be reduced within the vicinity of the existing CSST which crosses over the site (as outlined in Section 5.3 of this report) in order to comply with CSST requirements.

For ULS sliding resistance of a cast-in-place footing placed on bedrock, an unfactored sliding friction coefficient of 0.70 can be used. In accordance with OBC 2012 requirements, a resistance factor of 0.8 should be applied to the sliding resistance between the footings and the underlying bedrock.

### 5.2.1.2 Footing on Glacial Till

The structure may be also founded on spread footings supported on the underlying glacial till provided that they can be designed using the bearing resistance values provided below.

Spread footings founded on the compact to dense glacial till (i.e., SPT 'N' values higher than about 25) below about Elevation 58.0 m are considered to be a feasible option. An SLS net bearing resistance of 250 kPa and a factored ULS bearing resistance of 400 kPa can be used for design of pad footings up to 5.0 m in width and for strip footings up to 2.0 m in width placed on native and undisturbed glacial till below this elevation. The SLS values provided correspond to calculated total and differential settlement values of 25 and 19 mm, respectively.

It should be noted that because the expected settlements of spread footings placed directly on the underlying bedrock are very small, differential settlements of up to about 25 mm may occur between the spread footings placed on glacial till and those placed directly on the underlying bedrock. The design of the new structure will have to consider these differential settlements between the foundations supported on bedrock, and those supported on the more compressible glacial till. Structural separation maybe required between the foundations supported on bedrock, and those supported on glacial till.

For ULS sliding resistance of a cast-in-place footing placed on glacial till, an unfactored friction coefficient of 0.45 can be used. In accordance with OBC 2012 requirements, a resistance factor of 0.8 should be applied to the sliding resistance between the footings and the underlying glacial till.

### 5.2.2 Concrete Caisson Foundations

It is understood that the west portion of the proposed structure will be founded on concrete caissons, and that pile driving is not permitted at this site. It is further understood that the foundation loads will be transferred across the underlying CSST with the use of a "bridge" structure such that the loads will be carried by caissons at a distance of at least 3 metres from the CSST.

The proposed caissons will be socketed into the limestone bedrock. The use of a casing will be required to advance the caisson through the glacial till material into the underlying bedrock. If a casing is used, it should be extended so that it is "seated" a minimum of 500 mm into the bedrock.

### 5.2.2.1 Axial Geotechnical Resistance

Due to the difficulty in socketing liners into the limestone bedrock to completely cut off the water infiltrations, it may not be feasible to dewater and clean the base of the caisson, or to inspect the base prior to concreting. As such, end-bearing support may not be fully developed and should be neglected in the design. The axial geotechnical resistance for rock-socketed caissons is therefore recommended to be based on the side-wall (shaft) resistance of the rock socket rather than end-bearing.

Rock-socketed caissons should be designed based on the side-wall (shaft) resistance of the rock socket and a <u>factored</u> geotechnical resistance at ULS of 1.1 MPa, provided that the caisson socket is within competent bedrock (i.e., RQD greater than 75 percent). For preliminary design this condition can be assumed to be 1 metre below the bedrock surface. This value assumes that the side wall of the socket will be cleaned of any cuttings or smeared material.

To provide full fixity, the caissons should be provided with a minimum socket length equal to the greater of 2 times the caisson diameter below the depth of any broken or highly weathered surficial bedrock. The structural engineer should check that the shear strength of the concrete is adequate to support these loads.

For a 600 mm diameter caisson socketed 1.2 metres into the competent bedrock, a factored axial geotechnical resistance at ULS of about 2,450 kN is achievable. For a 900 mm diameter caisson socketed 1.8 metres into the competent bedrock, a factored axial geotechnical resistance at ULS of about 5,500 kN is achievable. For a 1200 mm diameter caisson socketed 2.4 metres into the competent bedrock, a factored axial geotechnical resistance at ULS of about 9,750 kN is achievable.

SLS resistances do not apply to caissons founded within the limestone bedrock, because the SLS resistance for 25 mm of settlement is greater than the factored axial

Group action for lateral and vertical loading should be considered when the pile spacing in the direction of the loading is less than three to four pile diameters.

### 5.2.2.2 Lateral Geotechnical Resistance

For preliminary design, the SLS geotechnical response of the soil in front of the caissons under lateral loading may be calculated using subgrade reaction theory where the coefficient of horizontal subgrade reaction, k<sub>h</sub>, is based on the equation given below, as described by Terzaghi (1955) and the Canadian Foundation Engineering Manual (3rd Edition). It may be assumed that this resistance (from the soil in front of the piles) will be nearly the same for vertical and inclined piles.

For cohesionless soils:

$$k_h = \frac{n_h z}{B}$$

Where: n<sub>h</sub> is the constant of horizontal subgrade reaction, as given below;

- z is the depth (m); and,
- B is the pile diameter/width (m).

For the glacial till deposit at this site, the values of  $n_h$  can be taken as 6.6 MN/m<sup>3</sup> above the groundwater table and 4.4 MN/m<sup>3</sup> below the groundwater table.

The proposed lengths of the caissons were not available at the time of writing this report. The ULS geotechnical response under lateral loading should be confirmed once details are available for the proposed caissons.

### 5.3 Impacts to Existing Structures

The existing CSST tunnel crosses beneath the proposed development. It is also understood that there is limited rock cover of the CSST at this site location and it is understood that this pipe was installed by tunneling (i.e. not open cut).

As outlined in section 5.2.2, the proposed caisson foundations will be designed/located to have a minimum setback in accordance with the requirements set out in the design criteria outlined by the CSST team of 3 metres from the side of the pipe to avoid additional stresses from the deep foundations being imposed onto the tunnel. The loading above the CSST will be transferred using a bridge structure between adjacent caissons. Preliminary guidance provided by the CSST team is found in the Structural Design Criteria and Site Construction Approaches for Building Over the Combined Sewage Storage Tunnel, 557 Wellington/Albert and 584 Wellington/Albert Development Blocks. In addition, the ULS capacity for shallow footings on the underlying bedrock should be reduced to 500 kPa within 10 metres of the CSST.

The existing Interceptor Outfall Sewer (IOS) tunnel crosses below the northwest side of the site in alignment with the proposed building foundation wall. It is further understood that additional loading from the foundations is not permitted to transfer to the IOS tunnel. A numerical analysis will be completed to confirm the required caisson termination depth in this vicinity to ensure that no additional loading is transferred to the IOS tunnel once design details are available for the proposed caissons. This analysis will be presented in an addendum to this report.

The existing OLRT right-of-way crosses to the northwest of the proposed development. For design purposes, the proposed shallow foundations or piles for the new building should be designed/located to have a minimum setback in accordance with the requirements set out in the design criteria provided by the OLRT team. In addition, any shoring design will need to consider impacts due to ground movements on the adjacent OLRT as outlined in Section 5.7 below.

A high-pressure watermain is also present adjacent to the site along Albert and Commissioner Streets. A hydro duct is also located in close proximity to the proposed excavation along Albert Street.

Excavations in overburden must not undermine the zone of influence of adjacent utility infrastructure. The zone of influence is defined by a theoretical 1 horizontal to 1 vertical surface extending down and away from the underside of the pipe bedding, to the outside edge of the excavation, or the sound (defined as bedrock with RQD values equal to or greater than 70 percent) bedrock surface at that location, whichever is encountered first. Where the excavations are within the zone of influence of adjacent structures, it is recommended that stiffer temporary protection systems be designed by the contractor to prevent movement of these structures. In addition, monitoring of the hydro duct and watermain for tilt, cracks and/or settlement would be warranted. Further assistance in this regard can be provided, if required.

Care will be also required for excavations carried out in close proximity to the existing watermains and hydro duct which are in close proximity to the proposed excavation. Excavations which are made parallel and in close proximity to the hydro duct and watermains should be supported to reduce potential movements that could

damage structures or utilities. Conceptually, excavations could be made with a shoring system as described in Section 5.7 to minimize disturbance to the supporting/surrounding soil. Consideration should be given to methods such as hydrovac excavation or manual excavation in the area immediately above, beside, and beneath the hydro duct (where in overburden), to minimize the potential for damage during excavation.

It is understood that the proposed shoring system may abut the existing hydro duct. Support should be provided to the exposed/suspended hydro duct at all times during construction until backfilling is completed. It is expected that the displacements during construction will need to be significantly restricted, likely to negligible levels. The utility owner should specify the maximum permissible displacement of the hydro duct. These requirements should be reflected in the project specifications. Displacements should be monitored while the excavation is made adjacent to the duct and up until the excavation is backfilled.

Settlement and vibration monitoring should be carried out during excavation activities for all sensitive infrastructure, including but not limited to the OLRT, CSST, IOS, hydro duct, and high pressure watermains. Monitoring for vibrations, tilt, cracks and/or settlement should also be carried out

### 5.4 Frost Protection

All perimeter and exterior foundation elements or interior foundation elements (i.e., footings, pile caps, grade beams, etc.) in unheated areas should be provided with a minimum of 1.5 m of earth cover for frost protection purposes. Isolated, unheated exterior foundation elements 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.

As an alternative to earth cover, consideration could be provided to the use of an insulation detail. Additional guidance on insulation details can be provided if required.

### 5.5 Seismic Design Considerations

The OBC 2012 contains seismic analysis and design methodology. The seismic Site Class value, as defined in Section 4.1.8.4 of the OBC 2012, depends on the average shear wave velocity of the upper 30 m of soil and/or rock below founding level. The OBC permits the Site Class to be specified based solely on the stratigraphy and in situ testing data (i.e., shear strengths and standard penetration test results), rather than from direct measurements of the shear wave velocity.

Based on the in situ testing data, this site can be assigned a Site Class of C for seismic design purposes according to the 2012 OBC. A higher site class (i.e. a Site Class A or B) would likely be applicable for footings on or within 3 m of the limestone bedrock; however, this would need to be confirmed with site specific shear wave velocity testing.

### 5.6 Garage Excavation and Groundwater Control

It is understood that the two levels of underground garage parking will extend about 5 to 7 m below the existing ground surface. Accordingly, excavation to these depths will be through surficial fill and into the underlying glacial till.

The bulk of the groundwater inflow to the proposed excavation will occur through the glacial till unit. Based on previous investigations conducted by Golder, the average ground surface elevation measured onsite was determined to be 62.3 meters above sea level (masl), and the geometric mean of groundwater elevation was

measured to be 58.5 masl. It is understood that the proposed excavation will be about 130 m by 60 m in plan and will extend to an elevation of about 57 masl. The hydraulic conductivity of the glacial till was determined to be as high as 6x10<sup>-5</sup> cm/s, based on the maximum hydraulic conductivity of in-situ measurements at three on-site locations.

The equation for groundwater flow into an unconfined circular excavation was used to estimate the groundwater inflow to the proposed excavation, based on an average water table depth of 3.8 mbgs and a glacial till hydraulic conductivity of 6x10<sup>-5</sup> cm/s. The rate of groundwater inflow into the proposed excavation is estimated to be between approximately 110,000 L/day and 45,000 L/day (see Appendix E). A safety factor of 1.5 was applied to the inflow calculations. The radius of influence for the proposed excavation for steady-state flow was estimated to be approximately 5 m from the edge of the excavation (see Appendix E). Higher rates of inflow could occur following rainfall events and during snowmelt. Incident precipitation will also add to the water to be pumped out of the excavation. A 100 mm precipitation event would result in the accumulation of approximately 780,000 litres of direct precipitation, assuming all overland flow is diverted away from the excavation.

The rate of groundwater inflow to the excavation will depend on many factors including the contractor's schedule and rate of excavation, the size of the excavation, the material, incident precipitation, and the time of year at which the excavation is made (e.g., fluctuation in seasonal groundwater elevation). The estimate rates of groundwater inflow are moderate and therefore should be possible to control by pumping with suitably sized pumps from well filtered sumps within the excavations. Groundwater inflow for the proposed service trenches should also be possible to control by pumping from within the excavations. The contractor should be fully responsible for design of the groundwater control system.

According to O.Reg 63/16 and O.Reg 387/04, if the volume of water to be pumped from excavations for the purpose of construction dewatering is greater than 50,000 litres per day and less than 400,000 litres per day, the water taking will need to be registered as a prescribed activity in the Environmental Activity and Sector Registry (EASR) and requires the completion of a "Water Taking Plan" and a "Discharge Plan". Alternatively, a Permit to Take Water (PTTW) is required from the Ministry of the Environment, Conservation (MECP) if a volume of water greater than 400,000 litres per day is to be pumped from the excavations. It is understood that a PTTW application is being submitted for this project.

No unusual problems are anticipated in excavating the overburden using conventional hydraulic excavating equipment, recognizing that cobbles and boulders could be present in the fill and glacial till.

In accordance with the Occupational Health and Safety Act (OHSA) of Ontario, the soil that will be encountered within the excavations (fill and glacial till) would be generally classified as Type 3 soils. Below the groundwater level, the glacial till soils would be classified as Type 4 soil. Provided that the groundwater level is lowered as the excavation progresses, excavations may be made with side slopes at 1 horizontal to 1 vertical, or flatter, otherwise excavations below the groundwater level in these deposits would likely require flatter side slopes (e.g., 3 horizontal to 1 vertical) to remain stable.

Where site conditions (such as the presence of soft or weak soils, proximity of existing structures and utilities, or space restrictions) do not allow for the above noted side slopes then suitable safety and support measures must be undertaken according to the requirements of the OSHA. These measures include installation of a suitable shoring system to create and maintain positive support to the sidewalls of the excavation. Guidelines on excavation shoring are provided in Section 5.7.

The glacial till soils that will form the floor of the foundation excavations are expected to be sensitive to disturbance. Consideration should therefore be given to protecting the subgrade in foundation areas with a mud slab of lean concrete or a layer of compacted granular fill materials. The thickness of the mud slab and/or compacted granular fill working mat will depend on the size and weight of the equipment to be used at the bottom of the excavation. Any disturbed soil will need to be removed prior to placing the protective layer. That mud slab/granular fill materials should be placed immediately following inspection and approval of the subgrade. The period of time between exposure of the subgrade and covering with the protective layer should be limited to as brief as possible and, in the interim, no construction traffic should be permitted on the subgrade.

### 5.7 Garage Floor Slab

In preparation for the construction of the garage floor slab, all fill and all loose, wet, and disturbed material should be removed from beneath the floor slab down to the undisturbed native soil or bedrock. Provision should be made for at least 250 mm of OPSS Granular A to form the base of the floor slab. Any bulk fill required to raise the grade up to the underside of the Granular A should consist of OPSS Granular B Type II. The underslab fill should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the Standard Proctor Maximum Dry Density (SPMDD) using suitable vibratory compaction equipment.

Provision should be made for drainage underneath the floor slab consisting of perforated pipe subdrains in a surround of 19 mm clear stone, fully wrapped in geotextile, which leads by gravity drainage to an adjacent storm sewer or sump pit from which the water is pumped. For preliminary design purposes, these drains should be placed at approximately 6 m centres.

### 5.8 Temporary Building Excavation Shoring

The excavation for the proposed structure will extend about 5 to 7 m below the existing ground surface and may be close to the property limits and, as such, vertical (or near vertical) excavation walls may be required. The contractor is fully responsible for the detailed design and performance of the temporary shoring systems. However, this section of the report provides some general guidelines on possible concepts for the shoring to be used by the designers for assessing the possible impacts of the shoring design and site works as well as to evaluate, at the design stage, the potential for impacts of this shoring on the adjacent properties. Temporary shoring can be used in combination with open cuts above the top of shoring, however, the earth pressure distribution must take into account the effects of the soil pressures from the upper open cut section.

The shoring method(s) chosen to support the excavation sides must take into account the soil and bedrock stratigraphy, the permissible movement of the shoring, the groundwater conditions, the methods adopted to manage the groundwater and construct the shoring systems, the potential ground movements associated with the excavation and construction of the shoring system, and their impact on adjacent structures and utilities.

It is understood that the excavation floor level will generally be about 5 to 7 m in depth below the existing ground surface elevation. The City of Ottawa right-of-ways for Commissioner Street and Albert Street, which contain below grade services, are located adjacent to the east and south sides, respectively, of the proposed excavation for the building. As such, any services located in close proximity to and/or within the zone of influence of the shoring system could be affected by ground movements behind the shoring. Details on the utilities in these areas should be confirmed during the detailed design studies to better tailor the shoring guidelines provided herein. Additionally, the right-of-way for the OLRT is located adjacent to the north side of the proposed excavation for the building and, if in close proximity to and/or within the zone of influence of the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements of the north side of the proposed excavation for the building and, if in close proximity to and/or within the zone of influence of the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring system could be affected by ground movements behind the shoring.

For preliminary design purposes, a soldier pile and timber lagging system is considered a suitable shoring method that may be considered for the proposed 5 to 7 m deep excavation at the site. Due to the presence of very dense till with boulders at shallow depth on the site, the soldier piles may require predrilling to provide sufficient embedment for toe fixity. The shoring system must be provided with appropriate lateral support.

Where foundations or settlement sensitive infrastructure, such as buried utilities, are present within the zone of influence of the shoring system the deflections may need to be greatly limited and a secant pile wall with pre-stressed tie backs may be required. Steel sheet pile systems would not be suitable where very dense till is present at shallow depth. Soldier pile and lagging walls are considered suitable for the sides of the excavations (provided that settlement-sensitive structures or utilities are not present in the zone of influence of the walls) where the objective is to maintain an essentially vertical excavation wall and the movements above and behind the wall need only be sufficiently limited so that relatively flexible features (such as roadways or sidewalks) will not be adversely affected.

For all of the above systems, some form of lateral support to the wall is required for excavation depths greater than about 3 to 4 m. Lateral restraint could be provided by means of tie-backs consisting of grouted soil or bedrock anchors. However, the use of rock/ground anchor tie-backs would require the permission of the adjacent property owners since the anchors would be installed beneath their properties. The presence of utilities beneath the adjacent streets, which could interfere with the tie-backs, should also be considered. Alternatively, interior struts can be considered, connected either to the opposite side of the excavation (if not too distant) or to raker piles and/or footings within the excavation.

### 5.9 Ground Movements

During the excavation for the underground levels of the proposed buildings, lateral deformation and vertical settlement of the adjacent ground will occur as a result of installation and deflection of the retaining/shoring system and dewatering activities. The ground movements induced could affect the stability or performance of buildings or underground utilities adjacent to the excavation. Therefore, the magnitude and extent of ground movement and potential impacts on surrounding infrastructure should be assessed prior to construction to confirm movements will be in tolerable limits and monitored during construction.

### 5.10 Foundation Wall Backfill

Foundation/basement walls should be backfilled with free draining non-frost susceptible granular fill meeting the requirements of OPSS Granular B Type I or II materials. The backfill should be compacted to 95 percent of the material's SPMDD using suitable compaction equipment. To reduce compaction induced stresses, only light compaction rollers or plate tampers should be used within 1.0 m of the wall. In any areas where the temporary shoring wall serves as the outside form for the foundation wall, vertical drainage must be installed against the shoring wall. The drainage channels could consist of filtered drainage wick such as Miradrain (or proven equivalent).

Water flow from either the granular backfill or drainage channels should be collected by means of a perforated drain line located at the base of the wall. This drain line should be provided with a granular surround and should lead to a sump pit from which water can be pumped.

Beneath hard surfacing (e.g., pavements or sidewalks/walkways), the granular backfill for the foundation wall should be placed to form a frost taper at 3 horizontal to 1 vertical to a depth of 1.8 m (i.e., the frost depth). The purpose of this frost taper is to limit the severity of differential heaving that could occur between areas backfilled with non-frost susceptible engineered fill and the adjacent areas underlain by the existing frost susceptible soils.

## 5.11 Lateral Earth Pressures for Design

The lateral earth pressures acting on the garage/foundation walls will depend on the existing soil conditions, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, and on the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The details on the wall backfill drainage are provided in Section 5.12 of this report.

The following recommendations are made concerning the design of the foundation walls.

Where the wall support and structure allow lateral yielding, (e.g., for unrestrained retaining walls), active earth pressures may be used in the design of the wall. Where the support does not allow lateral yielding, (i.e., for the proposed basement walls) at-rest earth pressures should be assumed for design.

If a shored excavation (in overburden) is used as part of the formwork for the wall, the lateral earth pressures for foundation walls are based on the existing retained soils and the following parameters (unfactored) may be used:

Soil	Unit Weight	Coefficients of static lateral earth pressure	
	(kN/m³)	Active, Ka	At rest, Ko
Existing Fill	21	0.33	0.50
Glacial Till	22	0.31	0.47

The shoring designer should carefully review the subsurface information and determine appropriate earth pressure parameters for use in their design. In particular, higher values may need to be assumed in order to limit deflection of the shoring near existing structures.

If the garage/foundation wall is backfilled with granular free draining fill either in a zone with width equal to at least 50 percent of the height of the wall or within the wedge-shaped zone defined by a line drawn at 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of the footing/pile cap/grade beam, the following parameters (unfactored) may be used:

Material	Unit Weight	Coefficients of static lateral earth pressure	
	(kN/m³)	Active, Ka	At rest, Ko
Granular A or Granular B Type II	22	0.27	0.43
Granular B Type I	22	0.31	0.47

Seismic loading will result in increased lateral earth pressures acting on the walls. The walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given above, plus the earthquake-induced dynamic earth pressure.

The horizontal seismic coefficient,  $k_h$ , used in the calculation of the seismic active pressure coefficient is taken as 1.0 times the design PGA (i.e.,  $k_h = 0.32$ ). For structures which allow lateral yielding,  $k_h$  is taken as 0.5 times the design PGA (i.e.,  $k_h = 0.16$ ).

The following seismic active pressure coefficients ( $K_{AE}$ ) may be used in design; these coefficients reflect the  $K_{AE}$  obtained using the  $k_h$  values described above and assumed no vertical acceleration and wall to soil friction. These seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.

		K <sub>AE</sub>		
Wall Type	Site PGA (2475-year Earthquake)	Granular A/Granular B Type II	Granular B Type I	
Yielding Wall	0.00-	0.39	0.43	
Non-Yielding Wall	0.32g	0.53	0.59	

The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e., an inverted triangular pressure distribution).

A minimum surcharge pressure of 12 kPa due to traffic and compaction induced pressure should be included in the total lateral earth pressures for the structural design of the wall.

The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_o \lor d + (K_{AE} - K_a) \lor (H-d) + q$$

Where:  $\sigma_h(d)$  = Lateral earth pressure at depth, d, (kPa)

- K<sub>o</sub> = Coefficient of static earth pressure
- Y = Unit weight of the backfill soil (kN/m<sup>3</sup>); as given previously
- d = Depth below the top of the wall (m)
- K<sub>AE</sub> = Seismic active earth pressure coefficient
- q = Surcharge to account for traffic and compaction pressure, where applicable
- H = Total height of the wall (m)

All of the lateral earth pressure equations are given in an unfactored format and will need to be factored for Ultimate Limit States design purposes.

### 5.12 Permanent Drainage

The measured groundwater depth at the site is variable, but it is generally considered to be between about 2 to 4 m below existing site grades. To manage the long term groundwater levels and the interaction with the proposed development, a drainage system diverting collected groundwater inflow to the sewer system is

recommended. It is recommended that a hydrogeological assessment be completed to provide input toward the volumes of water anticipated to be diverted to the municipal sewer system.

The subfloor drainage system (i.e., below the lowest garage level) may consist of a network of robust sub-drain pipes conveying collected groundwater to a sump or sumps from which the groundwater can be pumped to a municipal sewer. The drainage system would consist of interconnected perforated drain pipes (bedded and backfilled with free draining granular soils) installed around the perimeter and within the building footprint. The capacity of the subfloor drainage system should be modified during construction as required.

Drainage, such as a composite synthetic drainage system or equivalent, should be provided to the exterior walls. The composite drain must withstand the design horizontal earth pressures used for basement wall design, and should be connected to the basement level underslab drainage system. The drainage system collector pipes should drain to a sump for collection and discharge to a sewer.

### 5.13 Site Servicing

At least 150 mm of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface occurs during construction, it may be necessary to place a sub-bedding layer consisting of 300 mm of compacted OPSS Granular B Type II beneath the Granular A. The bedding material should, in all cases, extend to the spring line of the pipe and should be compacted to at least 95% of the material's SPMDD. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials and native soils could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

Cover material, from the spring line of the pipe to at least 300 mm above the top of pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 mm. The cover material should be compacted to at least 95% of the material's SPMDD.

It should generally be possible to re-use the existing inorganic fill and glacial till as trench backfill provided it is properly moisture conditioned. Where the trench will be covered with hard surfaced areas, the type of material placed in the frost zone (between subgrade level and 1.8 mm depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the material's SPMDD using suitable vibratory compaction equipment.

Seepage barriers should be constructed at periodic intervals along the trench and at the connection points to offsite infrastructure to reduce the potential for groundwater level lowering in the surrounding area due to the "french drain" effect on the granular bedding and surround. Groundwater level lowering could lead to long-term settlement of nearby structures that are supported on the sensitive silty clay soil underlying the site.

It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular surround materials to the trench bottom. The seepage barriers should be at least 1.5 metres long. In addition to providing a drainage cut-off, these cut-offs also serve as impenetrable cut-offs to stop the potential migration of contaminants along the relatively permeable backfill in the trenches.

Construction of the seepage barriers should also be in accordance with the City of Ottawa's Standard Drawing No. S8 of the Department of Public Works and Services, Infrastructure Services branch.

### 5.14 Pavement Design

In preparation for pavement construction, all topsoil, unsuitable fill, disturbed, or otherwise deleterious materials (i.e., those materials containing organic material) should be removed from the pavement areas. Some of the existing fill could remain provided that it is free of organic matter, and that the subgrade be subjected to a proof roll with a loaded tandem truck to reveal weak or soft areas prior to the construction of the new pavement structure. Soft or weak areas should be removed and repaired with acceptable earth borrow or OPSS Select Subgrade Material (SSM) or Granular B.

Pavement areas requiring grade raising to proposed subgrade level should be brought to grade using acceptable (compactable and inorganic) earth borrow, OPSS SSM or Granular B. These materials should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

The surface of the pavement subgrade should be crowned or sloped to promote drainage of the pavement granular structure towards perimeter swales or subdrains placed at the subgrade level

Material		Light Duty Pavement Thickness of Pavement Elements (mm)	Heavy Duty Pavement Thickness of Pavement Elements (mm)	Loading Dock Thickness of Pavement Elements (mm)
Bituminous	Superpave 12.5 mm	60	40	-
Concrete OPSS 1150	Superpave 19.0 mm	-	50	-
Portland Cement Concrete	Portland Cement Concrete	-	-	200
Granular Material	Granular A Base	150	150	150
OPSS 1010	Granular B, Type II Subbase	300	450	450
	Prepared and Approved Subgrade			

The following pavement designs are recommended for this project:

The granular base and subbase materials should be uniformly compacted as per OPSS 310, Method A. The asphaltic concrete should be compacted in accordance with the procedures outlined in OPSS 310.

The asphaltic cement should consist of PG 58-34 and the design of the mixes should be based on a Traffic Category B.

The Portland cement concrete should meet the requirements of CSA A 23.1 Class C2 exposure. Concrete joint specifications and spacing should be in accordance with OPSD 552.020 and 551.010.

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., grade raise fill has 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.

Where the new pavements will connect to existing pavements, the new pavement structures should be continued at least to the limits of construction, with any longitudinal transitions and/or tapers occurring thereafter. At these locations, the longitudinal transitions should be constructed by cutting the existing pavement structure vertically to the bottom of the existing subbase. The new granular layers should then be tapered up or down, as required, at a slope of 5 horizontal to 1 vertical to match the existing pavement structure. The asphaltic concrete does not need to be tapered between the new construction and the existing pavement. However, the asphaltic concrete of the existing pavement should be milled back an additional 300 mm to a depth of about 60 mm or 40 mm in areas where its thickness is greater than 100 mm, matching the proposed surface course of the new asphaltic concrete. A tack coat should be provided and the new surface course asphaltic concrete placed over the milled surface to form the new pavement joint. Where the existing pavement is less than 100 mm, then a butt joint on a vertical saw cut surface is acceptable. A tack coat should be placed on the vertical saw cut surface. The tack coat should be in accordance with the City SP F-3107.

### 5.15 Corrosion and Cement Type

Two samples of soil, one from each boreholes 19-101 and 19-102 were submitted to EXOVA Laboratories Ltd. for chemical analysis related to potential corrosion of exposed buried steel and concrete elements (corrosion and sulphate attack). The results of this testing are provided in Appendix C. The results indicate that concrete made with Type GU Portland cement should be acceptable for concrete substructures.

The results also indicate an elevated potential for corrosion of buried ferrous elements, which should be considered in the design of substructures and pile foundations.

### 6.0 ADDITIONAL CONSIDERATIONS

At the time of writing this report, only conceptual details related to the proposed building as well as adjacent significant structures such as the CSST and OLRT were available. This information suggests this building will consist of a 4 to 5 storey tower with up to two garage levels to be located at the property. Golder Associates should review the final drawings and specifications for this project prior to tendering to confirm that the guidelines in this report have been adequately interpreted.

The construction activities could impact the existing adjacent structures and buildings. Appropriate damage assessments (pre and post condition surveys for example) should be carried out as necessary.

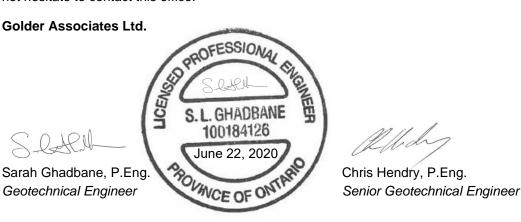
During construction, sufficient foundation inspections, subgrade inspections, in-situ density tests, materials testing, pile and rock anchor installation monitoring should be carried out to confirm that the conditions exposed are consistent with those encountered in the boreholes, and to monitor conformance to the pertinent project specifications. Concrete testing should be carried out in a CCIL certified laboratory.

The soils at this site are sensitive to disturbance from ponded water, construction traffic and frost. All bearing surfaces must be inspected prior to filling or concreting to ensure that strata having adequate bearing capacity have been reached and that the bearing surfaces have been properly prepared.

#### 7.0 **CLOSURE**

We trust that this report provides sufficient geotechnical engineering information to facilitate the design of this project. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact this office.

Golder Associates Ltd.



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**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, <u>City of Ottawa.</u> 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.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface Golder Associates Page 1 of 2

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

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 offsite 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.

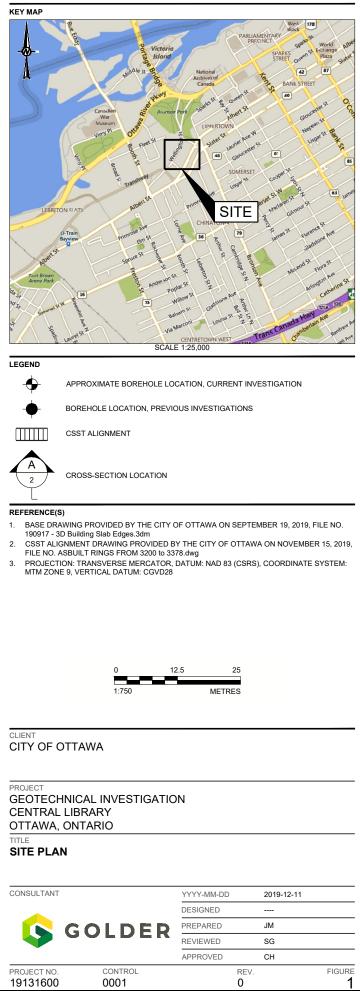
**Follow-Up and Construction Services:** All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

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.



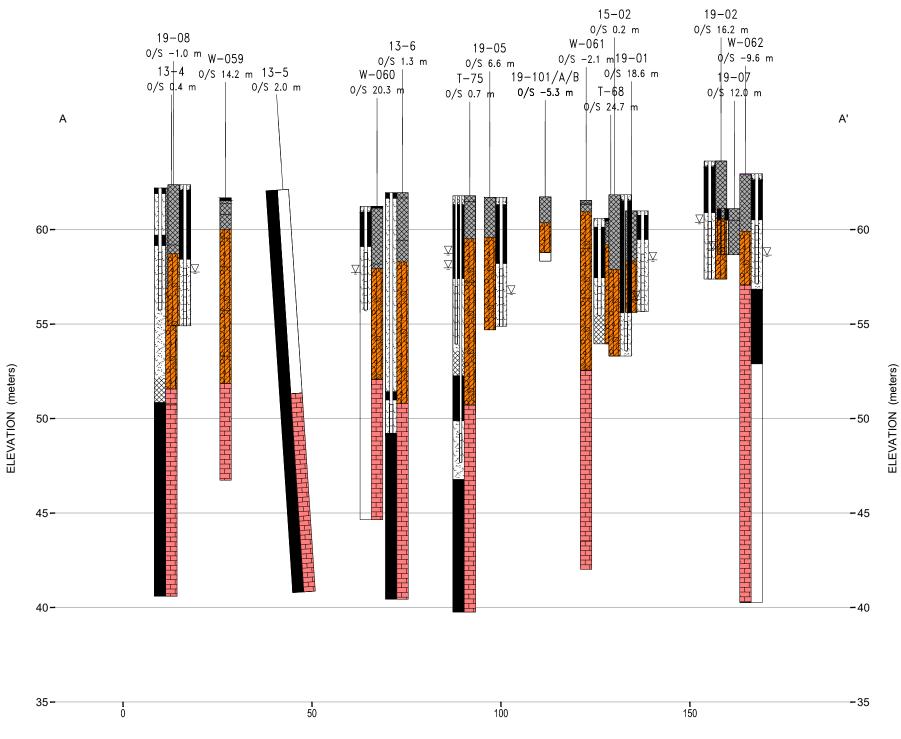


CONTROL

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REV. 0

FIGURE



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#### TITLE **CROSS-SECTION A-A'**

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PROJECT GEOTECHNICAL INVESTIGATION CENTRAL LIBRARY OTTAWA, ONTARIO

#### CLIENT CITY OF OTTAWA

0	5	10
1:200 VERTICAL		METRES
0	25	50
1:1,000 HORIONTAL		METRES



SUBSURFACE STRATIGRAPHY

TOPSOIL

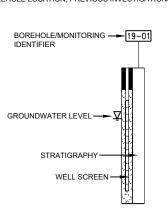
FILL

ASPHALTIC CONCRETE

GLACIAL TILL

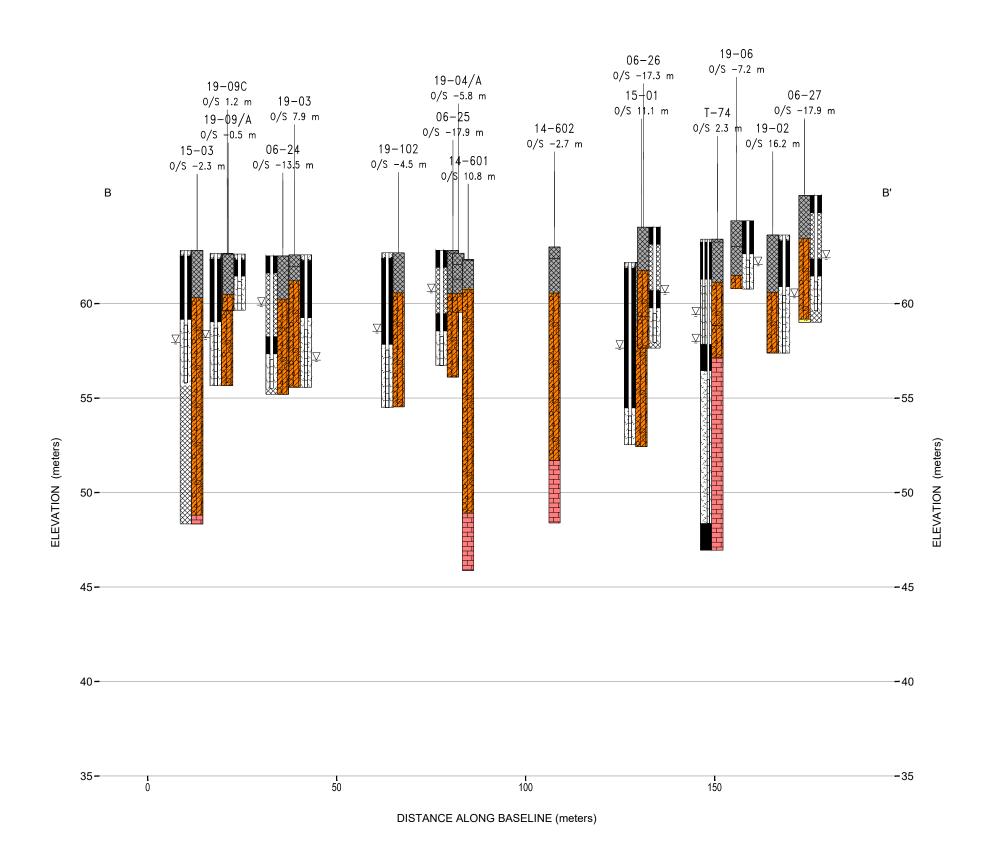
LIMESTONE BEDROCK





APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION

BOREHOLE LOCATION, PREVIOUS INVESTIGATIONS



SOLDER	COLDED	PREPARED	ZS	
	REVIEWED	SG		
		APPROVED	СН	
PROJECT NO. 19131600	CONTROL 0001		REV. 0	FIGURE

YYYY-MM-DD

DESIGNED

2020-01-23

-----

#### TITLE **CROSS-SECTION B-B'**

CONSULTANT

PROJECT GEOTECHNICAL INVESTIGATION CENTRAL LIBRARY OTTAWA, ONTARIO

#### CLIENT CITY OF OTTAWA

0	5	10
1:200 VERTICAL		METRES
0	25	50
1:1,000 HORIONTAL		METRES



TOPSOIL



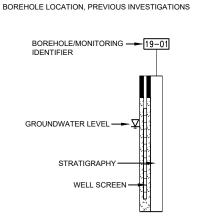
FILL

SAND

GLACIAL TILL

SUBSURFACE STRATIGRAPHY ASPHALTIC CONCRETE





LEGEND  $\bullet$ 

APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION

APPENDIX A

# **Borehole Logs – Current Investigation**

### 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

Spacing
Greater than 3 m
1 m to 3 m
0.3 m to 1 m
50 mm to 300 mm
Less than 50 mm

#### **GRAIN SIZE**

Term	<u>Size*</u>
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° 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	К	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

Organic or Inorganic	Soil Group	Туре	of Soil	Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}} \qquad \qquad Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$		$(D_{60})^2$ Organic Content		USCS Group Symbol	Group Name								
		GRAVELS (>50% by mass of coarse fraction is coarse fraction is direction is di direction is dir		Poorly Graded	<4			≤1 or ≥3			GP	GRAVEL						
s)	(mm 2			ELS EELS fines (sem vd) -7.22 m m s (sem vd) -7.22		E 212% Sanit 22 E Sanit 22 E San		Since the since of the since o		Well Graded		≥4		1 to 3	3		GW	GRAVEL
by mas	SOILS n 0.07!			Below A Line			n/a				GM	SILTY GRAVEL						
ANIC ≤30%	INED (	(>5 cot large	>12% fines (by mass)	Above A Line			n/a				GC	CLAYEY GRAVEL						
NORG	E-GRA s is lar	, f	Sands with	Poorly Graded		<6		≤1 or ≩	≥3	≤30%	SP	SAND						
INORGANIC (Organic Content S30% by mass)	OARSI y mas	DS mass c iction is 4.75 m	≤12% fines (by mass)	Well Graded		≥6		1 to 3	3		SW	SAND						
(Org	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with	Below A Line			n/a				SM	SILTY SAND						
	÷	(≥5i coa smalle	>12% fines (by mass)	Above A Line			n/a				SC	CLAYEY SAND						
Organic	Soil		(by mass)	Laboratory			Field Indica	tors		Organic	USCS Group	Primary						
or Inorganic	Group	Туре	of Soil	Tests	Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)	Content	Symbol	Name						
		plot	_	I favoid I facili	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT						
(sc	<sup>5</sup> mm)	and LI	ine sity ow)	Liquid Limit <50	Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT						
INORGANIC (Organic Content ≤30% by mass)	OILS an 0.07	SILTS (Non-Plastic or Pl and LL plot	below A-Line on Plasticity Chart below)		Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT						
ANIC ≤30%	FINE-GRAINED SOILS mass is smaller than 0.	-Plasti	el Pel Pel	Liquid Limit	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	МН	CLAYEY SILT						
INORGANIC Content ≤30%	-GRAIN	Nor		≥50	None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	ОН	ORGANIC SILT						
ganic C	FINE y mas	CLAYS (Pl 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%	CL	SILTY CLAY						
(O	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)			LAYS nd LL p A-Line icity Ch elow)		Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium	to 30%	CI	SILTY CLAY				
	2)			Liquid Limit ≥50	None	High	Shiny	<1 mm	High	(see Note 2)	СН	CLAY						
<u></u> ,υ,	() ()		mineral soil					30% to		SILTY PEAT, SANDY PEAT								
HIGHL) ORGANI SOILS	Peat and mineral soil mixtures Predominantly peat, may contain some mineral soil, fibrous or								75% 75% to	PT	PEAT							
40			ous peat	1edium Plasticity	<b>≺</b> Hig	gh Plasticity		•		<sup>100%</sup> symbol is	two symbols s SW-SC and CI	separated by						
A hyphen, for example, GP-GM, SW-SC and CL-ML. For non-cohesive soils, the dual symbols must be used with the soil has between 5% and 12% fines (i.e. to ident transitional material between "clean" and "dirty" sand gravel. For cohesive soils, the dual symbol must be used when liquid limit and plasticity index values plot in the CL-ML a of the plasticity chart (see Plasticity Chart at left). Borderline Symbol — A borderline symbol is two symbol separated by a slash, for example, CL/CI, GM/SM, CL/M A borderline symbol should be used to indicate that the has been identified as having properties that are on transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil typ within a stratum.				<ul> <li>a. to identify rty" sand or</li> <li>ed when the CL-ML area</li> <li>b.</li> <li>two symbols</li> <li>SM, CL/ML.</li> <li>that the soil</li> <li>are on the a borderline</li> </ul>														

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

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.

#### ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

#### PARTICI E 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>i.e.</i> , 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<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); Nd: 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

Compactness <sup>2</sup>				
Term	SPT 'N' (blows/0.3m) <sup>1</sup>			
Very Loose	0 to 4			
Loose	4 to 10			
Compact	10 to 30			
Dense	30 to 50			
Very Dense	>50			

NON-COHESIVE (COHESIONLESS) SOILS

- 1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
- 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' 2. 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.		
	Dry Moist		

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
ТО	Thin-walled, open - note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

#### SOIL TESTS

water content
plastic limit
liquid limit
consolidation (oedometer) test
chemical analysis (refer to text)
consolidated isotropically drained triaxial test1
consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
relative density (specific gravity, Gs)
direct shear test
specific gravity
sieve analysis for particle size
combined sieve and hydrometer (H) analysis
Modified Proctor compaction test
Standard Proctor compaction test
organic content test
concentration of water-soluble sulphates
unconfined compression test
unconsolidated undrained triaxial test
field vane (LV-laboratory vane test)
unit weight

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

	COHESIVE SOILS	
	Consistency	
Term	Undrained Shear Strength (kPa)	SPT 'N' <sup>1,2</sup> (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.

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 2 measurement of undrained shear strength or other manual observations.

Water Content											
Term Description											
w < PL	L 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.										

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

I.	GENERAL	(a) w	Index Properties (continued) water content
π	3.1416	w <sub>l</sub> or LL	liquid limit
ln x	natural logarithm of x	w <sub>p</sub> or PL	plastic limit
log <sub>10</sub>	x or log x, logarithm of x to base 10 acceleration due to gravity	l₀ or PI NP	plasticity index = (w <sub>l</sub> – w <sub>p</sub> ) non-plastic
g t	time	Ws	shrinkage limit
		IL	liquidity index = $(w - w_p) / I_p$
		lc	consistency index = $(w_l - w) / I_p$
		emax	void ratio in loosest state
		emin	void ratio in densest state
II.	STRESS AND STRAIN	lD	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)
	shear strain	(b)	Hydraulic Properties
$\gamma \Delta$	change in, e.g. in stress: $\Delta \sigma$	h	hydraulic head or potential
2 8	linear strain	q	rate of flow
εv	volumetric strain	V	velocity of flow
η	coefficient of viscosity	i	hydraulic gradient
υ	Poisson's ratio	k	hydraulic conductivity
σ	total stress		(coefficient of permeability)
σ	effective stress ( $\sigma' = \sigma - u$ )	j	seepage force per unit volume
$\sigma'_{vo}$	initial effective overburden stress		
σ1, σ2, σ3	principal stress (major, intermediate, minor)	(c)	Consolidation (one-dimensional)
	minory	C <sub>c</sub>	compression index
σoct	mean stress or octahedral stress		(normally consolidated range)
	$= (\sigma_1 + \sigma_2 + \sigma_3)/3$	Cr	recompression index
τ	shear stress		(over-consolidated range)
u	porewater pressure	Cs	swelling index
E	modulus of deformation	Cα	secondary compression index
G K	shear modulus of deformation	m <sub>v</sub>	coefficient of volume change coefficient of consolidation (vertical
ĸ	bulk modulus of compressibility	Cv	direction)
		Ch	coefficient of consolidation (horizontal direction)
		Tv	time factor (vertical direction)
III.	SOIL PROPERTIES	U	degree of consolidation
(a)	Index Properties	σ′ρ OCR	pre-consolidation stress over-consolidation ratio = $\sigma'_{p} / \sigma'_{vo}$
<b>(α)</b> ρ(γ)	bulk density (bulk unit weight)*	OOK	$OVEI-CONSCIDENTIATIO = O_p / O_{VO}$
ρ(/) ρd(γd)	dry density (dry unit weight)	(d)	Shear Strength
ρw(γw)	density (unit weight) of water	τp, τr	peak and residual shear strength
ρs(γs)	density (unit weight) of solid particles	φ΄ δ	effective angle of internal friction
$\gamma'$	unit weight of submerged soil	δ	angle of interface friction
_	$(\gamma' = \gamma - \gamma_w)$	μ	coefficient of friction = tan $\delta$
D <sub>R</sub>	relative density (specific gravity) of solid	C'	effective cohesion
•	particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )	Cu, Su	undrained shear strength ( $\phi = 0$ analysis)
e n	void ratio porosity	p n'	mean total stress ( $\sigma_1 + \sigma_3$ )/2 mean effective stress ( $\sigma'_1 + \sigma'_3$ )/2
S	degree of saturation	p' q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
-		Ч Qu	compressive strength ( $\sigma_1 - \sigma_3$ )
		St	sensitivity
* D	ty overholic - Unit weight such - L'	Notoo: 4	
	ity symbol is $\rho$ . Unit weight symbol is $\gamma$ e $\gamma = \rho g$ (i.e. mass density multiplied by	<b>Notes:</b> 1 2	$\tau = c' + \sigma' \tan \phi'$ shear strength = (compressive strength)/2
	eration due to gravity)	£	

PROJECT: 19131600

#### LOCATION: N 5030969.3 ;E 366627.0

SAMPLER HAMMER, 64kg; DROP, 760mm

### RECORD OF BOREHOLE: 19-01

BORING DATE: November 28, 2019

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BY SS LL SOIL PROFILE		SOIL PROFILE			SA	AMPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	AL	PIEZOMETER	
METRES		DRING MET	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q ● Cu, kPa rem V. ⊕ U C	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup> WATER CONTENT PERCENT Wp ├────────────────────────────────────	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
-	6	ă	GROUND SURFACE	STF	(m)			BL(	20 40 60 80	20 40 60 80		
0			FILL - (SW/GW) SAND and GRAVEL, fine to coarse, some non-plastic fines; brown to grey brown; non-cohesive, wet, very loose to dense		60.99 0.00	1	ss	36			м	
1						2	ss	10			Be	entonite Seal
2						3	ss	3			Si	lica Sand
	Wash Boring	HW Casing	(SM/ML) SAND and SILT, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive,		58.34 2.65	4	ss	3				
3			wet, compact to very dense			5	ss	21				<u> </u>
4						6	ss	33			32 #1	2 mm Diam. PVC 0 Slot Screen
5					55.00	7	ss	88			100	L in screen
6			End of Borehole		55.62 5.37							easured at 59 mbgs (Elev. 8.40) on Dec. 11, 119
7												
8												
9												
10												
DE	PT	TH S	CALE	<u> </u>	<u> </u>				GOLDER		LOG	GED: DG

PROJECT: 19131600

### RECORD OF BOREHOLE: 19-02

SHEET 1 OF 1 DATUM: Geodetic

LOCATION: N 5030975.7 ;E 366666.5 SAMPLER HAMMER, 64kg; DROP, 760mm BORING DATE: November 28, 2019

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Ш.	THOD		SOIL PROFILE	1.		SA	MPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	NG	PIEZOMETER
DEPTH SCALE METRES		BURING MEI HUD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q - € Cu, kPa rem V. ⊕ U - ○ 20 40 60 90			OR STANDPIPE NSTALLATION
	_		GROUND SURFACE	0	63.63			ш	20 40 60 80	20 40 60 80		
0			FILL - (SP) gravelly SAND, some non-plastic fines; dark brown to grey brown, contains brick, concrete fragments and ash; non-cohesive, moist, loose to compact		0.00	1	ss	18			Flush N Casing	lount
1						2	ss	7			Benton	ite Seal
2						3	SS	11				
						4	SS	14				ţ.
3	Wash Boring	HW Casing	(SM/ML) SAND and SILT, some gravel and low plasticity fines; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, loose to very dense		60.58 3.05		ss	8			Silica S	and
4						6	ss	33			МН	<u>17,41,41,41,41,</u> 41,41
5						7	ss	55			32 mm #10 Sic	Diam. PVC t Screen
6						8	ss	66				47, VC, VC, VC
			End of borehole Sampler Refusal	9782	57.38 6.25		SS	>50				4
7			Sanipiei Kelusai								WL in s measu 3.25 ml 60.38) 2019	creen red at ogs (Elev. on Dec. 11,
8												
9												
10												
DE 1:			CALE						GOLDER		LOGGEI	

PROJECT: 19131600

### RECORD OF BOREHOLE: 19-03

SHEET 1 OF 1 DATUM: Geodetic

LOCATION: N 5030859.5 ;E 366615.9

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: November 26, 2019

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

ц ,	ПОН	SOIL PROFILE	1.		SA	MPLE		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	μġ	PIEZOMETER
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	түре	BLOWS/0.30m	20         40         60         80         '           SHEAR STRENGTH         nat V. + Q Q.         rem V. ⊕ U C.         20         40         60         80	10 <sup>6</sup> 10 <sup>5</sup> 10 <sup>4</sup> 10 <sup>3</sup> WATER CONTENT PERCENT Wp I W WI 20 40 60 80	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
0	e	GROUND SURFACE FILL - (SP) gravelly SAND, fine to coarse, some non-plastic fines; grey; non-cohesive, moist, dense		62.58 0.00	1	ss	35				Flush Mount
1	Power Auger I Diam. (Hollow Stem)			61.97 0.61	2	ss	20				
2	Power 200 mm Diam.	(SM/ML) SAND and SILT, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, dense to very dense		61.21 1.37	3	SS	33				Bentonite Seal
					4	RC	DD				
3					5		73 83			мн	
4					7		87				Silica Sand
	Wash Boring HW Casing				8	SS	82				
5					9	ss					32 mm Diam. PVC
6					10	RC					32 mm Diam. PVC #10 Slot Screen ⊥
					11 12 13	RC	55 DD 50				
7		End of Borehole	, TEES	55.57 7.01							WL in screen measured at 5.57 mbgs (Elev. 57 01) on Dec. 11.
8											57.01) on Dec. 11, 2019
9											
10											
DEI	PTH S	GCALE	1					GOLDER		LC	DGGED: DG

### LOCATION: N 5030891.6 ;E 366647.9 SAMPLER HAMMER, 64kg; DROP, 760mm

**RECORD OF BOREHOLE: 19-04** 

SHEET 1 OF 1 DATUM: Geodetic

BORING DATE: November 21, 2019

Ц Д.,-		탈	SOIL PROFILE	1.		SA	MPL		DYNAMIC PENETRA RESISTANCE, BLOW	S/0.3m	HYDRAUL k,	IC CONDU cm/s		r,	₽g	PIEZOMETER
METRES		BORING METHOD		STRATA PLOT		ER		BLOWS/0.30m	20 40	60 80	10 <sup>-6</sup>	10 <sup>-5</sup>	10-4	10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	OR
ΞΨ		RING	DESCRIPTION	ATA I	ELEV. DEPTH	NUMBER	түре	WS/C	SHEAR STRENGTH Cu, kPa	nat V. + Q - ● rem V. ⊕ U - O		ER CONTE	NT PER W		ADDI AB. T	INSTALLATION
Ċ		<u>ğ</u>		STR,	(m)	ž		BLO	20 40	60 80	Wp ⊢ 20		60	- WI 80		
			GROUND SURFACE		62.66					Ĩ	Ĩ	Ť	Ť	Ť		
0		Π	FILL - (SP) gravelly SAND, fine to		0.00											
			medium, some non-plastic fines; grey brown; non-cohesive, moist, very dense			1	SS	100								
					62.06											
			FILL - (SM) SILTY SAND, some gravel; grey, contains brick and ash;		0.60											
1			non-cohesive, moist, loose													
		Stem)				2	SS	7								
	rger	lo lo	(SM) gravelly SILTY SAND: brown.		61.29 1.37											
	ver A	200 mm Diam. (Hollow S	(SM) gravelly SILTY SAND; brown, contains pockets of silty clay; non-cohesive, moist, compact													
	Ро	Di	non-conesive, moist, compact			3	SS	11								
2		200 m			60.53											
			(SM/ML) SAND and SILT, some gravel		2.13											
			to gravelly; grey brown, contains cobbles and boulders (GLACIAL TILL);													
			non-cohesive, moist, very dense			4	SS	54								
-																
3	⊢		End of Borehole		59.54 3.12	5	ss	60								
	ĺ		Auger Refusal		0.12											
	ĺ															
4																
	ĺ															
	ĺ															
5																
	ĺ															
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	ĺ															
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7	ĺ															
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9	ĺ															
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	ĺ															
	ĺ															
10																
	L															
DE	PT	гнs	CALE					个	GOL	DFP					LO	GGED: DG
4.	50						<	V							CHE	CKED: CRG

#### LOCATION: N 5030891.6 ;E 366647.9

## **RECORD OF BOREHOLE: 19-04A**

BORING DATE: November 25, 2019

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

	Τ	ac	SOIL PROFILE			SA	MPL	ES	DYNA		ETRATIO	DN /0.3m	<u>\</u>	HYDRA		ONDUCT	IVITY,		(1)	
DEPTH SCALE	RES	BORING METHOD		10 <u>-</u>		~		30m					ю <b>``</b>					0-3	ADDITIONAL LAB. TESTING	PIEZOMETER OR
PTH S	METF	NG N	DESCRIPTION		ELEV.	NUMBER	ТҮРЕ	BLOWS/0.30m			1	i at V. + em V. ⊕		w	ATER C	L ONTENT	PERCE	NT	3. TE	STANDPIPE INSTALLATION
DEF	-	BORI		TRA	DEPTH (m)	INN	F	BLOW						vvp	• <b></b>			WI	LAE	
-			GROUND SURFACE	0)	62.66			ш	2	0 4	10 E	0 8	0	2	0 4	06	8 0	30		
Ē	0	ger Stem)	No Sampling - Alternate to 19-04 advanced to obtain samples below previous refusal		0.00															
Ē		er Aug	previous refusal																	
-		Power Auger am. (Hollow Stem)			61.97															
Ē		200 mm Dia	End of Borehole Auger Refusal		0.69															
F	1	200 n	5																	-
Ē																				
E																				
Ē																				
F	2																			-
F																				
Ē																				
F																				-
F	3																			-
F																				
Ē																				
E																				-
F	4																			-
E																				
F																				
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F	5																			_
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F	6																			-
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E	7																			_
F																				-
E																				-
F																				:
E	8																			-
ZS	Ű																			:
1/20																				-
- 5/2																				-
S.GD	9																			-
SIM-	ษ																			-
GAL																				-
0.GPJ																				-
3160(	10																			
191	10																			-
MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS	1								·			1			1	1				
S-BH			CALE					C	5 (	GΟ	) L [	ΟE	R							DGGED: DG
Ĭ	1:5	50					_		-										CH	ECKED: CRG

### LOCATION: N 5030891.6 ;E 366647.9 SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: 19-04B

SHEET 1 OF 1

BORING DATE: November 25, 2019

DATUM: Geodetic PENETRATION TEST HAMMER, 64kg; DROP, 760mm

	$\top$	Q	SOIL PROFILE			S/	AMPL	ES	DYNAMIC PE RESISTANCE	NETRATI	ON	<u>}</u>	HYDRAULI	IC CONDUC	FIVITY,		
DEPTH SCALE METRES		BORING METHOD		OT	1				RESISTANCE 20			<sub>ه</sub> ۲,	k, o 10 <sup>-6</sup>		0 <sup>-4</sup> 10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
PTH S		МQN	DESCRIPTION	TA PL	ELEV.		TYPE	S/0.3	SHEAR STRE Cu, kPa	_			WATE	R CONTENT	PERCENT		STANDPIPE INSTALLATION
DEF	-	BORI		STRATA PLOT	DEPTH (m)	Ĩ	1	BLOWS/0.30m									
			GROUND SURFACE	0,	62.66				20	40	60 8	0	20	40 6	<u>50 80</u>		
Ē	0		No Sampling - Alternate to 19-04 advanced to obtain samples below		0.00												
F			previous refusal														
Ē																	
F																	
E	1																-
-		(me)															
-		ger ollow S															
-		Power Auger Diam. (Hollo															
-	2	200 mm Diam. (Hollow Stem)															-
-		200 n															
-																	
-																	
-	3		(SM/ML) SILTY SAND to sandy SILT,		59.61 3.05		-										-
-			some gravel to gravelly; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist,			1	SS	66									
-			very dense		59.00												
E			End of Borehole Auger Refusal		3.66												
E	4																-
-																	
-																	
-																	
-	5																-
-																	
-																	
-																	
-	6																-
-																	
E																	
F																	
E	7																-
F																	
Ē																	
F																	
	8																-
1 1																	
5/21																	
GDT																	
-MIS	9																-
GAL																	
I I																	
1 1																	
1910	10																-
MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS												-	I I		<u> </u>	I	
S-BH			SCALE						G		DE	R					DGGED: DG
Σ	1:5	U														CH	ECKED: CRG

# RECORD OF BOREHOLE: 19-05

BORING DATE: December 2, 2019

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030930.6 ;E 366620.5 SAMPLER HAMMER, 64kg; DROP, 760mm

	дон.	SOIL PROFILE	1,		S/	AMPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	RG NG	PIEZOMETER
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O	10 <sup>6</sup> 10 <sup>5</sup> 10 <sup>4</sup> 10 <sup>3</sup> WATER CONTENT PERCENT Wp	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
,	BOI		STR	(m)	z		BLO	20 40 60 80	20 40 60 80		
0		GROUND SURFACE FILL - (SW) gravelly SAND, fine to coarse, some non-plastic fines; brown to grey, contains cobbles and boulders; non-cohesive, wet, very dense		61.71 0.00	1	ss	>50				Flush Mount Casing
1					2	ss	57				
2		(SM/ML) SAND and SILTY SAND, some		59.58 2.13		ss	>50				Bentonite Seal
0		(Gravel; grey, with brown mottling, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense			4	ss	50				
3	Wash Boring HW Casing				5	ss	>50				Silica Sand
4					6	ss	60				<u>17,847,847,847,8</u> 47,8
5					7	ss	42			мн	↓ 32 mm Diam. PVC #10 Slot Screen
6					8	ss	43				#10 Slot Screen
					9	ss ss	73 >50				
7 .		End of Borehole	\$18	54.70 7.01							WL in screen measured at 5.08 mbgs (Elev. 56.63) on Dec. 10, 2019
8											
9											
10											
DEI		CALE	<u> </u>					GOLDER			DGGED: JS ECKED: CRG

# RECORD OF BOREHOLE: 19-06

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030956.4 ;E 366683.0

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: November 21, 2019

:	ç	员	SOIL PROFILE			SA	MPL		DYNAMIC PENETRATION	HYDRAULIC CONDUCTIVITY, k, cm/s	μŪ	PIEZOMETER
RES	Ē	MET		LOT		Ř		30m	20 40 60 80	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup>	IONA	OR
METRES	CINIC	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	STANDPIPE INSTALLATION
i i		BOF		STR/	(m)	۲	-	BLO/	20 40 60 80	Wp	LA A	
		+	GROUND SURFACE		64.38							
0		Π	FILL - (SP) gravelly SAND, angular gravel, some non-plastic fines; grey		0.00							
			brown; non-cohesive, moist, loose			1	SS	8				
												Bentonite Seal
1						2	SS	9				Bentonite Seal
		Ê			63.01							
	-	ow Ste	FILL - (SM/GM) SAND and GRAVEL, some non-plastic fines to silty; grey		1.37							
	Auge	(Hollo	some non-plastic fines to silty; grey brown, contains brick fragments, pieces of wood and fly ash; non-cohesive, moist									
2	Power Auger	Diam.	to wet, loose to compact			3	SS	7				Silica Sand
		200 mm Diam. (Hollow										
		20										¥() 
						4	SS	21				
			(SM) arough SII TV SAND. arou hrow		61.49 2.89							32 mm Diam. PVC #10 Slot Screen
3			(SM) gravelly SILTY SAND; grey brown, contains cobbles and boulders(GLACIAL									100 A
			TILL); non-cohesive, wet, dense			5	ss	41				10.20
ļ		Ц	End of Borehole	PP &	60.78 3.60							
			Auger Refusal		3.00							WL in screen
4												measured at 2.31 mbgs (Elev.
												measured at 2.31 mbgs (Elev. 62.07) on Dec. 10, 2019
5												
6												
Ū												
7												
8												
9												
10												
10												
DEF	РТ	THS	CALE					Ļ	GOLDER		LC	DGGED: DG
1:5									GOLDER			ECKED: CRG

# RECORD OF BOREHOLE: 19-07

DATUM: Geodetic

LOCATION: N 5030990.5 ;E 366645.3 SAMPLER HAMMER, 64kg; DROP, 760mm BORING DATE: December 2, 2019

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

	4		SOIL PROFILE			SA	MPL	ES	DYNAMIC RESISTAN			ON S/0.3m	<u>}</u>	HYDR	AULIC ( k, cm/	CONE	DUCT	IVITY,		(1)	
METRES		BORING MEI HOD		PLOT	ELEV.	ËR	ш	J.30m	20	40	)	60	80	1	0-6	10 <sup>-5</sup>	10	)-4	10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE
ΞΨ		5 NINO	DESCRIPTION	STRATA PLOT	DEPTH (m)	NUMBER	ТҮРЕ	BLOWS/0.30m	SHEAR ST Cu, kPa	TRENG	GTH	nat V. rem V.	+ Q-● ⊕ U-O	w w	/ATER (				ENT I WI	ADDI <sup>T</sup> LAB. T	INSTALLATION
		<u></u>	GROUND SURFACE	S	61.11			B	20	40	)	60	80	:	20	40	6	0	80		
0			FILL - (SP) gravelly SAND, some non-plastic fines; grey; non-cohesive, moist, compact		61.11 0.00 60.50	1	ss	21													Bentonite Seal
1	Power Auger	200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, some gravel; brown to dark brown, contains brick and concrete fragments; moist to wet, very loose to loose		0.61		ss	7													Silica Sand
	Powe	200 mm Dian				3	ss	2													32 mm Diam. PVC
2					50.07	4		>50													
			End of Borehole Auger Refusal		58.67 2.44	4	- 33	-50													WL in screen
3																					measured at 2.14 mbgs (Elev. 58.97) on Dec. 10, 2019
4																					
5																					
6																					
7																					
8																					
9																					
10																					
DE	L PT	нs	CALE	1	I	I			G	 		╵ ┐╒	. D	1	1					L	DGGED: JS
1:	50												. 17								ECKED: CRG

SHEET 1 OF 1

# RECORD OF BOREHOLE: 19-08

BORING DATE: December 3, 2019

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030852.8 ;E 366588.8 SAMPLER HAMMER, 64kg; DROP, 760mm

	DOH.	SOIL PROFILE	L .	r	SA	AMPL	_	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	RG₽	PIEZOMETER
METRES	BORING METHOD		STRATA PLOT	ELEV.	3ER	Щ	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q - ●	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	OR STANDPIPE
ΞΨ	ORING	DESCRIPTION	RATA	DEPTH (m)	NUMBER	TYPE	OWS	Cu, kPa rem V. ⊕ U - O		ADD LAB.	INSTALLATION
_	ñ	GROUND SURFACE	ST		-	-	В	20 40 60 80	20 40 60 80	+ +	
0		FILL - (SP) gravelly SAND, fine to medium, some non-plastic fines; grey, contains brick, concrete fragments, cobbles and boulders; non-cohesive, moist, very dense to loose		62.38 0.00	1	ss	55				Elush Mount
1					2	ss	37				
2					3	ss	29				
					4	ss	8				
3	Auger (Hollow Stem)	compact		59.18 3.20 58.72	5	ss	13				Bentontie Seal
4	Power Auger 200 mm Diam (Hollow	GLACIAL TILL); non-cohesive, moist to wet, very dense		3.66	6	ss	91				Silica Sand
5					7	ss	>50				
6					8	ss	>100			:	32 mm Diam. PVC #10 Slot Screen
					9	ss	91				17.20 20 20 20 20 20 20 20 20 20 20 20 20 2
7		End of Borehole		54.91 7.47	10	ss	72				1. N. N. N. N.
8											WL in screen neasured at 4.63 mbgs (Elev. 57.75) on Dec. 10, 2019
9											
10											
DE	PTH	SCALE	<u> </u>					GOLDER			GGED: JS :CKED: CRG

## **RECORD OF BOREHOLE: 19-09**

SHEET 1 OF 1

DATUM: Geodetic PENETRATION TEST HAMMER, 64kg; DROP, 760mm

LOCATION:	N 5030839.9 ;E 366615.3
SAMPLER H	AMMER, 64kg; DROP, 760mm

BORING DATE: November 20, 2019

ш Д	BORING METHOD	SOIL PROFILE			SA	MPL		DYNA RESIS	MIC PEN TANCE,	BLOW	ION 5/0.3m	2		k, cm/s	ONDUC			NG	PIEZOMETER
DEPTH SCALE METRES	MET		STRATA PLOT	ELEV.	ER	10	BLOWS/0.30m		1	1	1	80		1		1	10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	OR STANDPIPE
ЦЩ ЦЩ	RING	DESCRIPTION	ATA	DEPTH	NUMBER	түре	WS/C	SHEAI Cu, kP	R STREI 'a	NGTH	nat V rem V. 6	+ Q-● ● U- O	W			PERCE		AB. T	INSTALLATION
ō	BOF		STR,	(m)	Ĭ	ľ	BLO					80	VVP	o <b> </b>			WI 80	< ┘	
		GROUND SURFACE		62.62		-	-		Ĭ	1	1		-				Ť		
- 0		FILL - (SM/GM) SAND and GRAVEL	<b>**</b>	62.62			$\square$		+	1	+					1			Flush Mount
		fine to coarse, some non-plastic fines to silty; grey brown, contains brick, concrete fragments, wood pieces and ash; non-cohesive, moist to wet, loose to			1	SS	40												Casing
		concrete fragments, wood pieces and			`														
		ash; non-cohesive, moist to wet, loose to dense																	
		dense			<u> </u>														Bentontie Seal
- 1	Ê																		
	Ster				2	SS	5												
	ger																		Silica Sand
	E A																		
	200 mm Diam. (Hollow Stem)																		
	- E				3	SS	12											м	
- 2	200			60.49															
		(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet,	1	2.13		1													32 mm Diam. PVC #10 Slot Screen
		brown, contains cobbles and boulders																	
		very dense			4	SS	83												
																			陸
- 3				59.62		1													122
3		End of Borehole Auger Refusal		3.00															
			1																
- 4																			
			1																
			1																
- 5			1																
			1																
			1																
			1								1								
6																			
- 6																			
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- 10																			
									~ ~		DE								
DEF	- I H S	SCALE						2 (	: <b>C</b>		D F	D						L	OGGED: DG



## **RECORD OF BOREHOLE: 19-09A**

BORING DATE: November 25, 2019

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030839.9 ;E 366615.3 SAMPLER HAMMER, 64kg; DROP, 760mm

	6	2	SOIL PROFILE			SA	MPL	ES	DYNAMIC F			)N 0.3m	>	HYDR	AULIC C k, cm/s	ONDUCT	IVITY,		(1)	
DEPTH SCALE METRES		BORING MEI HOD		01		~		m	2 <u>0</u>	40			0	1			0 <sup>-4</sup> 1	Q <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
PTH (		Z Z	DESCRIPTION	<u> </u>	ELEV.	NUMBER	TYPE	BLOWS/0.30m	SHEAR STI Cu, kPa	RENG	STH n	at V. +	Q - ●	w		ONTENT		NT	B. TE	STANDPIPE INSTALLATION
DEI				STRA	DEPTH (m)	INN	-	BLOW						VV P				WI	LAE	
			GROUND SURFACE	0)	62.62				20	40	6	08	0		0 4	0 6	3 Oi	30		
- 0			No Sampling - Alternate to 19-09 advanced to obtain samples below		0.00															
-		Ê	previous refusal																	
-		ow Ste																		
E	- Auge	(Hollo																		
- 1	Power Auger	200 mm Diam. (Hollow Stem)																		
E		mm 00																		
E .		5																		:
E			End of Borehole		60.79 1.83															
- 2			Auger Refusal																	-
F																				
-																				
F																				
- 3																				
Ē																				
E																				
F																				
- 4																				-
F																				:
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- 8																				_
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DT 5/																				-
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AL-M																				
9 - -																				
00.6																				
- 1316																				
11 15																				
MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS 1. m . m . m . m . m . m . m . m	EPT	нs	CALE						G	$\frown$			D						LC	DGGED: DG
I:	50						<						R							ECKED: CRG

## **RECORD OF BOREHOLE: 19-09B**

BORING DATE: November 25, 2019

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030839.9 ;E 366615.3 SAMPLER HAMMER, 64kg; DROP, 760mm

ш		DD	SOIL PROFILE			SA	MPL	ES	DYNAM		ETRATIO BLOWS	DN /0.3m	ì	HYDR,	AULIC Co k, cm/s	ONDUCT	IVITY,		. (7	
DEPTH SCALE	<u>p</u>	BORING METHOD		-OT		r		30m	2				10		0 <sup>-6</sup> 1			0 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
HLC		NGN	DESCRIPTION		ELEV.	NUMBER	ТҮРЕ	BLOWS/0.30m				iat V. + em V. ⊕	Q - •	w	ATER C	ONTENT		NT	DITIO	STANDPIPE INSTALLATION
DEF		BORI		TRA	DEPTH (m)	N	i F	PON						VV	• <b></b>			WI	AD	
		_	GROUND SURFACE	0	62.62			ш	2	0 4	ιο e	0 8	0	2	0 4	06	8 0	0		
-	0	Т	No Sampling - Alternate to 19-09 advanced to obtain samples below		02.02															
Ē		tem)	advanced to obtain samples below previous refusal																	-
E		low S																		
E		Power Auger																		-
È.	1 1	n Dian																		-
Ē		200 mm Diam. (Hollow Stem)																		-
F					61.05															-
Ē		-	End of Borehole Auger Refusal		1.57															
Ē	2																			-
E	2																			-
F																				-
Ē																				-
F																				-
F	3																			-
Ē																				-
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MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS				<u> </u>							I	1	1	I	1	1	1	1		L
HBHG			CALE					C		GΟ	L	ΟE	R							DGGED: DG
MIS	1:5	0						V											CH	ECKED: CRG

## RECORD OF BOREHOLE: 19-09C

BORING DATE: November 27, 2019

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030840.5 ;E 366613.6 SAMPLER HAMMER, 64kg; DROP, 760mm

	0		SOIL PROFILE			5/	AMPL	FS	DYNAMIC PENETRAT RESISTANCE, BLOW	ION Y	HYDR	RAULIC C	ONDUC	FIVITY,			
METRES	BORING METHOD	}		F	1							k, cm/s			D <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
ETRE	U ME			STRATA PLOT	ELEV.	NUMBER	щ	BLOWS/0.30m	20 40	60 80						TES <sup>-</sup>	STANDPIPE
ME	RING		DESCRIPTION	RATA	DEPTH	IW N	TYPE	SWC	SHEAR STRENGTH Cu, kPa	rem V. $\oplus$ U - C	5 w	/p				ADD -AB.	INSTALLATION
	BC	1		STF	(m)	<u> </u>		BLO	20 40	60 80				<u>80 8</u>		_	
0			GROUND SURFACE No Sampling - Alternate to 19-09	_	62.66 0.00						_						<b>1</b> 51 15 <b>1</b>
			advanced to obtain samples below		0.00												Flush Mount Casing
			previous refusal														
1																	
2																	Bentontie Seal
					59.61												
3		ł	(SM) gravelly SILTY SAND; grey,		3.05	1	-	>50									
	oring	sing	contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to			Ļ.		- 00									
	Wash Boring	HQ Casing	wet, very dense			2	RC	DD									13 13
	≥	-			×	-											Silica Sand
1																	
					Š	3	SS	69									
																	¥.H
					\$	4	RC	DD									
5						5	ss	>50									
							-										
																	32 mm Diam. PVC #10 Slot Screen
						6	SS	>50									
6						7	RC	DD									
-																	
						8	SS	>50									
							1										
					55.65	9	RC	DD									
7		1	End of Borehole		7.01												
																	WL in screen measured at
																	4.47 mbgs (Elev. 58.19) on Dec. 10,
																	2019
8																	
9																	
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_				1	1	I				1 1		1	I	<u> </u>			
		H S(	CALE					Ċ	GOL	DER							DGGED: DG
1:	50															CH	ECKED: CRG

#### LOCATION: N 5030938.2 ;E 366637.7

SAMPLER HAMMER, 64kg; DROP, 760mm

### **RECORD OF BOREHOLE: 19-101**

BORING DATE: November 21, 2019

SHEET 1 OF 1

DATUM: Geodetic

ц Д			SOIL PROFILE	1.		SA	MPLI		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	부승	PIEZOMETER
DEPTH SCALE METRES	BORING METHOD	אוואס ואובו	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - C	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup> WATER CONTENT PERCENT Wp	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
د د	C			STR	(m)	z		BLC	20 40 60 80	20 40 60 80		
0 -			GROUND SURFACE FILL - (SW) gravelly SAND, fine to coarse, some non-plastic fines; grey brown, contains brick; non-cohesive, moist, very dense to compact		61.73 0.00	1	ss	53				
1	Power Auger	200 mm Diam. (Hollow Stem)	(SM) SILTY SAND, some gravel; grey		60.36 1.37	2	SS	14				
2	Power	200 mm Diam.	(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense			3	SS	55				
						4	SS	74				
3			End of Borehole Auger Refusal	. Addi	58.79 2.94							
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7												
8												
9												
5												
10												
DEF	PTł	H S(	CALE	1	I				GOLDER			GED: DG

#### LOCATION: N 5030938.2 ;E 366637.7

## RECORD OF BOREHOLE: 19-101A

BORING DATE: November 25, 2019

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

<b>.</b>		g	SOIL PROFILE		s	AMP	LES	DYNAMI RESISTA			DN	>	HYDRA		ONDUCT	IVITY,			
CALE	METRES	BORING METHOD		01				RESISTA 20				<sup>۰</sup>	10				0 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
TH S	1ETR	NG M	DESCRIPTION	STRATA PLOT		TYPE	BLOWS/0.30m	SHEAR S Cu, kPa					w	ATER C	ONTENT	PERCE		DITIC	STANDPIPE INSTALLATION
DEP	2	<b>30RIN</b>		TRAT (r	<sup>Σ</sup> Π	F	ΓΟŇ						vvp					AD LAB	
	_	ш	GROUND SURFACE		_	-	B	20	4	06	0 8	0	2	0 4	06	s 0	30		
F	0	em)	No Sampling - Alternate to 19-101 advanced to obtain samples below		1.73 0.00	-													
F		200 mm piam. (Hollow Stem)	advanced to obtain samples below previous refusal																
F		ower . (Holl																	
E		Diam	Find of Borobolo		0.97 0.76														
F	1	00 mm	End of Borehole Auger Refusal		5.70														-
F		20																	
E																			-
F																			
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E	2																		-
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MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS			l	1 1							1	I		I	I	l	I	I	
HBHS			CALE				C	G	i O	LC	)E	R							DGGED: DG
MIS	1:5	50				•												CH	ECKED: CRG

#### LOCATION: N 5030938.2 ;E 366637.7

SAMPLER HAMMER, 64kg; DROP, 760mm

## RECORD OF BOREHOLE: 19-101B

BORING DATE: November 25, 2019

SHEET 1 OF 1

DATUM: Geodetic

		g	SOIL PROFILE			SAI	MPLE	s D	YNAMIC RESISTAN			N 0.3m	<u>}</u>	HYDRA		ONDUCT	TIVITY,			
DEPTH SCALE	ρ Γ	BORING METHOD		LOT		۴		m m m m m	20 20	чсе, ы 40			io <b>`</b>					0 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER OR
HTH	ME	NG N	DESCRIPTION		LEV.	NUMBER	TYPE		HEAR ST Cu, kPa	TRENG	STH n	at V. +	Q - •	W	ATER C	ONTENT	PERCE	NT	DITIO 3. TE	STANDPIPE INSTALLATION
DEF	-	BORI		TRA-	EPTH (m)	IN								A A A		W		WI	AD	
			GROUND SURFACE		61.73		-		20	40	6	0 8	0	2	0 4	06	30 6 	0		
E	0		No Sampling - Alternate to 19-101 advanced to obtain samples below		0.00															
E			previous refusal																	-
-																				-
_																				-
-	1																			-
-		v Stem																		-
-		Hollov																		-
-		Power Auger Diam. (Hollov																		-
-	2	Power Auger 200 mm Diam. (Hollow Stem)																		-
-		20(																		-
E																				
F																				
F	3																			
F					58.33															-
-	ľ		End of Borehole Auger Refusal		3.40															-
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MIS-BHS 001 19131600.GPJ GAL-MIS.GDT 5/21/20 ZS		י ידר -		<u> </u>					_	_		_					•	•		
S-BH			SCALE				Į		G	0		)E	R							DGGED: DG
Σ	1:5	NU																	СH	ECKED: CRG

# LOCATION: N 5030878.2 ;E 366639.5

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: 19-102 BORING DATE: November 20, 2019

SHEET 1 OF 1

DATUM: Geodetic

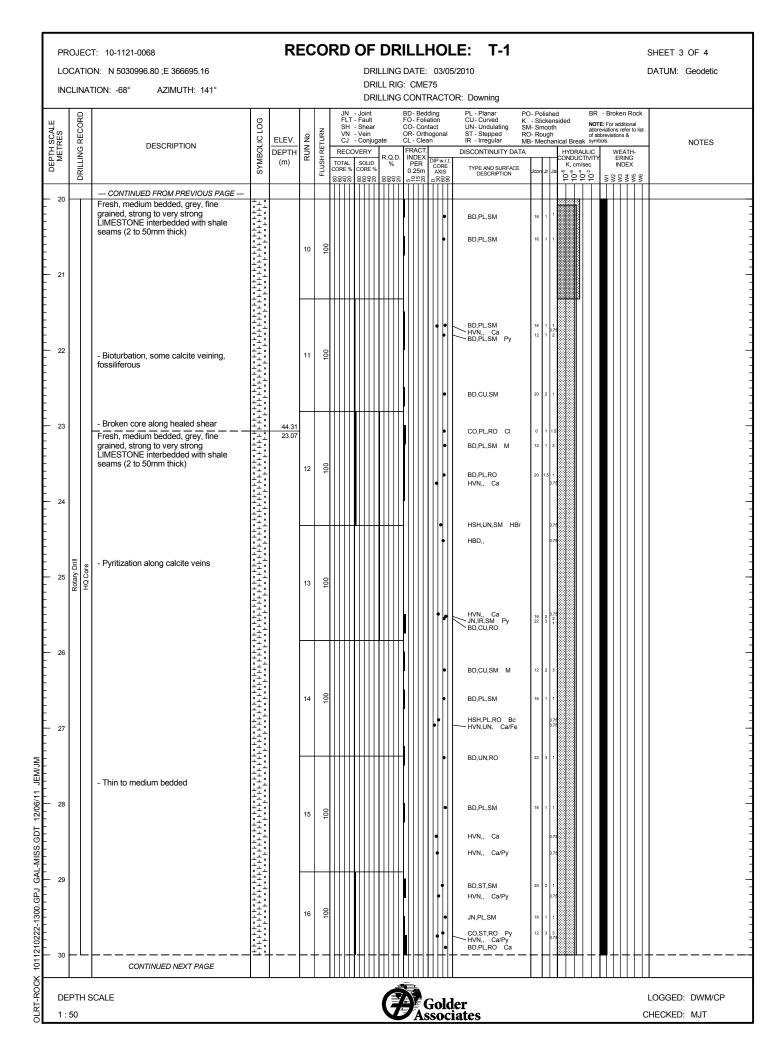
Ц	ДОН	SOIL PROFILE	1. 1		SA	MPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	4 <sup>E</sup>	PIEZOMETER
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 SHEAR STRENGTH nat V. + Q. ● Cu, kPa rem V. ⊕ U - O	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup> WATER CONTENT PERCENT Wp	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
		GROUND SURFACE	S	62.69		$\left  - \right $	ā	20 40 60 80	20 40 60 80		
0		FILL - (SW) gravelly SAND, fine to coarse, some non-plastic fines to silty; grey to dark brown, contains brick and ash; non-cohesive, moist, very dense to loose		0.00	1	ss	95				Flush Mount Casing
1					2	SS	10			м	
2				60.56	3	SS	9				
		(SM) SILTY SAND, fine to coarse, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, dense to very dense		2.13	4	ss	37				Bentonite Seal
3	V #	(mm)			5	ss	68				
4	Power Auger	200 mm Diam. (Hollow Stern)			6	ss	53				Ţ
5	000	200			7	ss	59				Silica Sand
6					8	ss	>100				<u>यत्</u> यत् <u>यत्</u> यत् यत्यत्यत्
					9	ss	60				32 mm Diam. PVC #10 Slot Screen
7					10	SS	65				
8		End of Borehole		<u>54.54</u> 8.15		SS	80				<u>ম</u> ,ম,ম,
9		Auger Refusal									WL in screen measured at 4.17 mbgs (Elev. 58.52) on Dec. 10, 2019
10											
DE 1::		I SCALE			<u> </u>			GOLDER			DGGED: DG ECKED: CRG

APPENDIX B

Borehole Logs and Results of UCS Testing - Previous Investigation

		CT: 10-1121-0068		R	EC	:0	RE	) (								LE: T-1														GHEET 1 (		
		'ION: N 5030996.80 ;E 366695.16 ATION: -68° AZIMUTH: 141°							DI	RILI	RI	G:	CM	IE7	5	05/2010 OR: Downing													C	DATUM: G	eoaetic	
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	F S V C	LT - H - N - J - COV	Joint Fault Shea Vein Conj /ERY SOLII CORE	ugati	e R.Q.E %893	C O C C D. I	0- C	T. X Di n	t	IR - Irregular DISCONTINUITY D/ t. TYPE AND SURFAC DESCRIPTION	I I I DAT/	PO- K - SM- RO- MB- A	Slicl Smo Rou	ken: ooth igh	nical	Bre YDR NDU K, cn	1	NOT abbro of ab symb IC /ITY c	E: Fo eviati brevi xols.	or ad iation WE Ef	Idition refer ns & EATI RIN(	H- G	st	٦	NOTES	
— o		GROUND SURFACE		65.71																												
	Wash Boring	OVERBURDEN (no recovery)		0.00																												
- - 7 - -		- Recovered 20cm gravel/boulders     Fresh to slightly weathered, medium brownish grey, fine to medium grained crystalline, non porous, thinly to medium bedded, medium strong to strong, CALCARENITIC LIMESTONE.	× + × × + × + × + × + × + × + × + × + ×	59.22 6.99	1	100									•	JN,UN,SM Sa			12 2	2 3												-
- - - - - - -		subordinate nodular limestone, minor thin lithoclastic limestone beds and interbeds of dark grey, bedding laminations and very thin to thinly bedded, calcareous, slake susceptible shale at semi regular intervals of 0.25 to	××4××4××4 444444 44×44×4444			0									•	JN,ST,RO BD,PL,SM			22 3	3 1												-
- - - - - 9	Rota	§ 2.5 m. Contains traces of fossil fragments. Top contact of formation marked by thin bed of shale and shaley limestone. Shale and shaley limestone comprise 7.5 % to 10 % of sequence.	· · · · · · · · · · · · · · · · · · ·		2	100										BD,PL,RO			20 1.	.5 1												-
		VERULAM FORMATION UNIT 2 - Soft clay infill	×		3	100									•	JN,PL,SM JN,UN,SM CI JN,PL,SM M			16 1	1 3												
- 10	FL		÷÷.	+				┦	╢	┼┛	╞╢╄	╎┝	+	╎╂┤	-	JN,PL,SM M — JN,UN,SM BR	<u>-</u>	-	12 1	2 3			<u>.</u>	+	Ţ	Ļ	+	•	+			
	EPTH : 50	I SCALE	1	I							G			G SS	ole	der ciates														.ogged: Hecked:		

			T: 10-1121-0068 N: N 5030996.80 ;E 366695.16		R	EC	:0	RI	D	0	DRI	LLIN	١G	DAT	ſE:	03/		<b>.E: T-1</b>									SHEET 2 DATUM:		
IN	CLI		TION: -68° AZIMUTH: 141°										١G		NTR	AC	ТС	R: Downing											
DEPTH SCALE METRES		ואוררוואפ אברטאט	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RI COR	CJ ECO TAL E %	- Fai - Shi - Vei - Co VER SO COF	ult ear njug: Y LID E %	R.Q	).D.	BD-I FO-I OR- CL- FRA IND PE 0.2	Conta Ortho Clear CT. EX R 5m	DIP w. CORI	r.t. E	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY DA TYPE AND SURFAC DESCRIPTION	H F N ATA		ensid oth h ianica	ed NC abl	DTE: brevi abbre mbol:	WI E IN	/EATI ERING	nal to list H- G K	-	NOTES	
- 10	1	<u> </u>	CONTINUED FROM PREVIOUS PAGE					88	246	89	240	800	20	192	28 2	-88	6							~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	23	ž ž			
-				× 4 × × 4 + 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	55.90		100																						
- - - - - - - - - - - - - - - - - - -			Fresh to slightly weathered, medium bedded, fine grained, strong LIMESTONE	. * + + * + + * + + * + + * + * + * + *	10.58	4	100									•		BD,PL,SM BD,PL,SM BD,CU,SM BR BD,UN,SM Ca HCO,, CO,PL,SM		16 1 16 1 6 2 16 2 16 1	1 1 4 2 0.76 1								
- - - - - - - - - - - - - - - - - - -				+ + + + + + + + + + + + + + + + + + +		5	100									•	•	BD,PL,SM M BD,PL,SM Go		6 1 6 1	4 6								
- - - - - - - - - - - - - - - - - - -	/ Drill	HQ Core		× + × × + × × + × × + × × + × + × + × +		6	100									*		HCO,, SHALE BD,PL,SM		20 1	0.76 1								
				*** *** **													•	CO,PL,SM CO,CU,SM Ca		16 1 16 2	12								-
- - - 16 -				4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		7	100											CO,PL,SM BD,PL,SM Ca		16 1	1 0000000000000000000000000000000000000								
-				× + × × + × + × + × + × + × + × + × + ×														BD,PL,SM Ca		16 1									-
- - - 17 -			- Clay gouge, soft clay with pieces of broken shale	× 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4														JN,UN,RO Go BD,CU,RO Go		0 1 0 1	1.5 1.5								
- - - - - - - - - - - - - - - - - - -				b b x b x b x b x b x b x b x b x b x b		8	100											CO,PL,SM		16 1	1								
				4 × × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4	47.36	9	100										•	CO,PL,SM		16 1	1								
- 20	L	L		× × ×	19.79		100	H		Ŧ	F	-	$\left  \right $	4 -	╞╢┠	$\left  \right $	.							+	- +		+		
DE	EPT	нs	CALE	<u> </u>	<u> </u>								Ĩ		G	iii Fol		er ates									LOGGED	DWM/CP MJT	



LO	CATI	CT: 10-1121-0068 CN: N 5030996.80 ;E 366695.16 .TION: -68° AZIMUTH: 141°		RE	C	0	RD		DR DR	ILLI ILL	NG RIG	DA G: C	TE: ME	03/ 75	05/	E: T-1 2010 R: Downing												HEET 4 OF 4 ATUM: Geodetic
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	FL SH VN C.	COVE	ault hear 'ein onjug	- R.		CO- OR- CL - FR/ INE PI 0.2	ACT.	ling tion act ogona n DIP w.i CORI AXIS	r.t. E	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY DA TYPE AND SURFAC DESCRIPTION	K SN RC ME	)- Po - Sli /- Sn D- Ro 3- Me	cken nooth ugh	nical	Bre YDR NDU K, crr		ote: abbrev abbr mbol	For a lations eviations s. W E	/EAT ERIN	Rock nal r to lis	st	NOTES
- 30		CONTINUED FROM PREVIOUS PAGE																								_	$\square$	
- - - - - - - - - - - - - - - -	Rotary Drill HO Core	Fresh, thinly to medium bedded, grey, fine grained, strong to very strong LIMESTONE interbedded with shale seams (2 to 50mm thick)	$\begin{array}{c} + \times + \times \times$	37.50 30.42	16	100 100								•	Þ	JN,UN,SM BD,PL,RO		20	2 1									
- 32 - 32 - 33 - 33 - 34 - 34 - 36 - 36 - 36 - 37 - 37 - 37 - 37 - 37 - 37 - 38		- LOST CORE downhole (end of run) End of Drillhole		36.09																								
- 39 - 39 - 39 - 40																												
DE 1:		SCALE		I I						(	Ĵ	S	As	 Fol	de	er ates			<u> </u>	1	_1	<u> </u>	_1	<u></u>				OGGED: DWM/CP IECKED: MJT

	PR	OJE	CT: 10-1121-0068		R	EC	:0	RE	) (	DF	- [	DF	RII	LL	H	OI	LE: T-2											SHEET 1 OF 4
			ON: N 5030988.22 ;E 366705.01 ATION: -70° AZIMUTH: 270°							DF	RILI	L RI	G:	СМ	E75	5	05/2010 OR: Downing											DATUM: Geodetic
LE LE		CORD		90			7	FI SI	LT - H -	Joint Fault Shea	ar		BI FC C	D- Be D- Fo D- Co	ddir liatio	ig on ct	PL - Planar CU- Curved UN- Undulating	K	)- Po - Sli /I- Sn	cken	sideo	4	NO	t - B	or adv	ditions	al	
PTH SC/	METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	С	J - COV	Vein Conji ERY	ugat	R.Q.E	Cl F 0. 1	R- Or L - Cle RAC NDE	ean T.		ST - Stepped IR - Irregular DISCONTINUITY D	DATA	D- Ro 3- Me	echa	H)	/DRA	abb of a k sym ULIC	ibbrev ibols. Y	WE EF	ATH RING	-	NOTES
DE		DRIL	GROUND SURFACE	SYI			FLUS	CORE 889		SOLIE CORE		% 8898 	(	PER ).25n 유완용		Pw.r.t. CORE AXIS RGG	TYPE AND SURFAI DESCRIPTION	CE	Jcon	Jr Ji	10 <sup>-8</sup>	(, cm/	sec ⊇ 2 □	W1		DEX		
	0		OVERBURDEN (no recovery)		<u>66.32</u> 0.00																							
	1																											
	2																											
	3																											
		g																										
	4	Wash Boring HW Casing																										
	5																											
	6																											
	7																											
	8			×	58.72 8.09																							
				L L + + × + + × + + × + + × + + × + + × + + × + + × + + × + × + × + × + × + × + × + × × × × × × × × × × × × × × × × × × × ×		1										•   •   •   •	HVN,, Ca JN,UN,SM BD,UN,SM CI BD,UN,SM CI		12 12	0.7 2 1 2 3 2 3								
	9	Rotary Drill HO Core		× ⊥ × ⊥ ⊥ × ⊥ ⊥ × ⊥ ⊥ × × ⊥ ⊥ × × ⊥ ⊥ × × ⊥ ⊥ × × × × ⊥ × × × × ×		2										•	BD,PL,SM BD,UN,SM Ca	1	16	1 1 2 2								
	10 -										    + -						JN,UN,SM CI BD,CU,RO BD,PL,SM		12 22 16	2 3 3 1 1 1		_ _				+.		
			CONTINUED NEXT PAGE																									
	DEI 1:		SCALE									G		A	G .ss	olc oc	der ciates											LOGGED: CP CHECKED: MJT

DRILLING RECORD DEPTH SCALE METRES

LOCATION: N 5030988.22 ;E 366705.01

#### T\_2

INCLINATION: -70° AZIMUTH: 270°

DESCRIPTION

SYMBOLIC LOG

	R	EC	0	RI	D	C	)F		D	R		_L	ŀ	10	C	LE: 1	-2												S	SHEET 2	OF 4			L
							DF	RIL	LIN	١G	D	ATI	Ξ:	06	5/0	5/2010													[	DATUM:	Geode	etic		
							DF	RIL	LF	RIG	:	C№	IE:	75																				
							DF	RIL	LIN	١G	С	ON	TF	RAG	CT	OR: Downin	g																	
E	LEV.	No.	'URN	1 5 1	/N	- F - S - V	ault hea		te		FC CC OF	0- B 0- F 0- C 2- C R- O	olia ont rthe	tion act ogoi		PL - Plana CU- Curve UN- Undu ST - Stepp IR - Irregu	d ating ed	PO- K - SM- RO- MB-	Slie Sm Ro	cke 100 ugl	nsi th	ded cal Bre		BR NOTI abbre of ab symb	E: Fo iviati brevi	r add	ditior efer	nal			NOTE	<u> </u>		
D	EPTH	RUN	REI		ECC			Ť	R.C		FI		~			DISCONTIN					_	HYDR ONDU		_		WE	ATI	H-			NOTE	.0		
	(m)	æ	FLUSH RETURN	TOT COR	E %	CC	OLID DRE 9	) %	%		c	9EF	t n		RE	TYPE AND DESCE	SURFAC	CE	lcon	Jr		0000 K, cr پې 19 0	n/se	с		11 N N N N N N		K	0//					
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-		2									ľ			•	Ī	JN,ST,RC	) Ca		20	3	2	T												-
		3	100													BD,PL,R( JN,UN,R BD,UN,R BD,PL,R( JN,CU,R( BD,PL,R(	D Ca D Ca		I	3 1.5 3	1 2 2 1 1												-	
					Ш						l					BD,UN,R				3	1													-
															•	BD,CU,R BD,PL,R0 BD,UN,S	D D W Ca		22 20 16 12	3 1.5 2	1 1 2 3												-	
·		4									I				I	CO,UN,S					5													-
		4														BD,PL,R( BD,PL,R(			20 20		1												-	-
											I				•	BD,PL,SI	4		16	1	1													-
-				╈	+	╟	╟	╞	$\parallel$	╫	Ł				$\left  \right $	JN,PL,SM	1		16	1	1													-
-															•	BD,CU,S BD,CU,S BD,CU,S JN,CU,R	M M		20 20 20 20	2	1 1 1 2													

ļ	- 1	0		CONTINUED FROM PREVIOUS PAGE	L .				Ĩ				$\prod$	Ţ	Π								
ļ				Fresh to slightly weathered, medium brownish grey, fine to medium grained crystalline, non porous, thinly to medium	+ + + × + + × + + × + + × + + + +		2								•	JN,ST,RO Ca	20	3 2					
Ē				bedded, very strong to strong, CALCARENITIC LIMESTONE, subordinate nodular limestone, minor												BD,PL,RO	20	1.5 1					
	- 1	1		thin lithoclastic limestone beds and interbeds of dark grey, bedding laminations and very thin to thinly bedded, calcareous, slake susceptible											•	JN,UN,RO Ca BD,UN,RO Ca	20 20	3 2 3 2					
	-			shale at semi regular intervals of 0.25 to 2.5 m. Contains traces of fossil	4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 ×		3	100							•	BD,PL,RO	20	1.5 1					
Ē				fragments. Top contact of formation marked by thin bed of shale and shaley limestone. Shale and shaley limestone	4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 ×											JN,CU,RO BD,PL,RO	22 20	3 1 1.5 1					
	1	2		comprise 7.5 % to 10 % of sequence. VERULAM FORMATION UNIT 2	4 × 4 × 4 × 4 × 4											BD,UN,RO BD,CU,RO BD,PL,RO	22 22 20	3 1 3 1 1.5 1					
					+ + + + + + + + + + + + + + + + + + +										•	BD,UN,SM Ca	16 12	2 2 2 3					
					× + + × + × + × + × + × + × + × + × + ×		4									BD,PL,RO BD,PL,RO	20 20	1.5 1 1.5 1					
	- 1	3													-	BD,PL,SM	16	1 1					
					44 × 4 4 × 4 × 4 4 + 4 + ×		$\vdash$									JN,PL,SM	16	1 1					
	1	4			+ + + + + + + + + + + + + + + + + + +											BD,CU,SM BD,CU,SM BD,CU,SM JN,CU,RO Ca	20 20 20 20	2 1 2 1 3 2					
				- Many breaks along weak shale seams	+ × + × + × + × +		5	80							•	BD,PL,SM	16	1 1					
		=	=		4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4										•	CO,UN,SM Ca	16	2 2					
Ē	1	5	HQ Core																				
ŀ					4 × 4 × 4 × 4 × 4											BD,UN,SM M BD,PL,SM	12 16	2 3					
							6	60 to 80								VN,IR,RO Ca BD,ST,SM BD,CU,SM CI	22 20 12	3 2 2 1 2 3					
	- 1	6														BD,PL,RO BD,CU,RO	20 22	1.5 1 3 1					
							┝								ŀ	JN,UN,SM	20	2 1					
	- 1	7		- 16.81 - 4cm broken core/fracture zone, crushed rock, trace clay, possibly	4 × × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4										8	BD,UN,VR BR FLT,PL,RO BR FLT,CU,RO Ca FLT,UN,RO CI	0 0 12 12	1 5 1 5 3 3 3 3					
Σ				mechanical breaks - 16.95 - 10cm broken core/fracture zone - 17 - 2cm of stiff gouge - 17.29 - 6cm fracture zone along calcite		50.02 17.35									•	BD,UN,SM CI VN,PL,RO JN,PL,RO Go BD,PL,RO Go	12 20 6	2 3 1.5 1 1 8					
ML/M				Vein / Fresh, thinly bedded, grey, fine grained,	<u>-</u> + ?										•	BD,UN,RO Ca/Py BD,UN,RO Ca BD,PL,SM	6 20 20	3 2					
12/06/1	1	8		strong to very strong, fossiliferous LIMESTONE interbedded with shale seams (2 to 50mm thick) - 17.45 - 4mm of stiff gouge	+ × × + × + × + × + × + × + × + × + × +		$\vdash$									BD,PL,SM	16	1.5 1					
S.GDT				- 17.45 - 411in of sun gouge	+ + + + + + + + + + + + + + + + + + +											BD,CU,RO	22	3 1					
AL-MIS					4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 ×		8								•	BD,UN,RO HJN,,	22	3 1 0.71					
1011210222-1300.GPJ GAL-MISS.GDT 12/06/11	- 1	9			+ + + + + + + + + + + + + + + + +																		
2-1300.					4 + × + + + + + + + + × + + + ×						+					BD,CU,RO	22	3 1					
1121022		20 -			× × × × × × × × × × × × × × × × × × ×		9		H	 	ļ					HVN,, Ca/Py BD,UN,RO Py BD,PL,RO Ci	20 12	3 2 1.5 3	-		_ _		+
				CONTINUED NEXT PAGE									 -										
OLRT-ROCK		DEP		CALE							(	G		G	ol	der ciates						6	LOGGED: CP CHECKED: MJT
ō			<u> </u>										A			.1atC3							

LOC	ATIC	T: 10-1121-0068 N: N 5030988.22 ;E 366705.01 FION: -70° AZIMUTH: 270°		RE	C	OI	RD	) (	DF	RILL	ING	G DA		06		<b>E: T-2</b>								Sheet 3 O Datum: Ge		
	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.		FL SH VN C.	T - 1 H - 1 N - 7 J - 1 COV	DF Joint Fault Shea Vein Conju ERY SOLIE	ugate		BD FO CO OR CL FF IN F	- Bede - Folia - Cont - Orth - Clea	ding ation act ogor	nal w.r.t. RE	R: Downing PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular DISCONTINUITY D/ TYPE AND SURFAC DESCRIPTION	K SI R M ATA	D- Polished - Slickens M- Smooth D- Rough B- Mechani	ided cal Brea	NO abb of a ak sym AULIC CTIVIT n/sec	Y	additio	nal r to list 'H- G X	N	OTES	
20		CONTINUED FROM PREVIOUS PAGE Fresh, thinly bedded, grey, fine grained, strong to very strong, fossiliferous LIMESTONE interbedded with shale seams (2 to 50mm thick)	× + × + × + × + × + × + × + × + × + × +		9									•	•	BD,UN,SM HVN,, Ca/Py BD,PL,RO CI BD,PL,RO CI BD,PL,RO CI		20 2 1 .75 12 1.5 3 12 1.5 3 12 1.5 3 12 1.5 3								
- 22			+ × × + × + × + × + × + × + × + × + × +		10										• •	BD,UN,SM BD,CU,RO BD,PL,RO		20 2 1 22 3 1 16 1.5 1								
- 23			┙┝┥╸┥┝┑┙┝┙╸┝┝╸┝┝╍┝┝┙┝┝┙┝┍┙┝╕┙┝╕┙┝╕┙┝┑┙┝╕╸┝┓┙┝┓┙┝┓┙┝┓┙┝┓┙┝╕┙┝╕┙┝╕┙┝╕┙┝╕┙┝ ┙┝╽╴┙┝┑┙┝╕┙┝╸┙┝╺┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┝┙┙┝┙┙┝┙┙┝┙		11											BD,UN,SM Py BD,CU,RO Py BD,PL,RO BD,PL,RO		16 2 2 20 3 2 16 1.5 1 16 1.5 1								
- 24	HQ Core		× + + × + × + × + × + × + × + × + × + ×	-	12										•	BD,ST,SM BD,CU,SM		20 2 1 20 2 1								
- 26			× + + × + + × + × + × + × + × + × + × +		13										• •	BD,UN,RO JN,CU,SM BD,PL,RO		22 3 1 20 2 1 16 1.5 1								
- 27 			+ + + + + + + + + + + + + + + + + + +		14	50 to 60								•	•	BD,PL,RO Ca BD,PL,RO HVN,, Ca		12 1.5 2 16 1.5 1 p.75								
- 29					15										•	BD,UN,SM BD,PL,RO		20 2 1								
- 30 -		CONTINUED NEXT PAGE						+ -							+ -		· —		- +- -					+		
DEP 1 : 5		SCALE								(	G		As	30 SC	ld oci	er ates								LOGGED: ( CHECKED: M		

LC	CAT	ECT: 10-1121-0068 TION: N 5030988.22 ;E 366705.01 NATION: -70° AZIMUTH: 270°		RE	EC	O	RD	) (	DR DR	RILL	.ING . RIC	i DA 3: (	ATE: CME	: 0 E75	6/05	<b>.E: T-2</b> 5/2010 DR: Downing											SHEET 4 DATUM:	OF 4 Geodetic	
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	Sł Vi C.	H - S N - V J - ( COV	Joint Fault Shear Vein Conju ERY SOLID ORE %	gate	Q.D.	CC OR CL FF IN F	- Bec - Foli - Cor - Cle RACT IDEX PER .25m	DIP CC		PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular DISCONTINUITY D TYPE AND SURFAC DESCRIPTION	K F N	PO-P C-S SM-S RO-R MB-N Jco	licker mootl	nical	Brea YDRA NDUC K, cm/	NC abl of a k syr	DTE: breviabbre mbol:	For a ations eviations s. W E	dditio s refer ons & (EAT ERING	'H- G	t	NOTES	
- 30 		CONTINUED FROM PREVIOUS PAGE     Fresh, thinly bedded, grey, fine to     medium grained, strong to very strong     LIMESTONE interbedded with shale     seams (2 to 40mm thick)     - 30.91 - 3cm clay seam: soft, grey, no     rock pieces     g     g	× + × + × × + × × + × + × + × + × + × +	37.98 30.16	15	50									•	HBD.,			D.7.	75									
- 32 - 32 			   ► + × + + × + + × + + × + + × + + × + + × + + × + × + × + × + × + × + = × + × +	35.12	17									•	•	HBD,, HVN,, Ca/Py BD,UN,SM BD,,		20	0.7 0.7 2 1 0.7	75 1 75									-
- - - - - - - - - - - - - - - - - - -		End of Drillhole		33.20																									-
- - - - - - - - - - - - - - - - - - -																													
																													-
DE		H SCALE												Go		er iates													

#### RECORD OF BOREHOLE: **T-68**

BORING DATE: September 1, 2011

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030967.29 ;E 366619.07

PENETRATION TEST HAMMER, 64kg; DROP, 760mm DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m HYDRAULIC CONDUCTIVITY, k, cm/s SAMPLES SOIL PROFILE BORING METHOD ADDITIONAL LAB. TESTING DEPTH SCALE METRES STRATA PLOT 40 60 80 10<sup>-8</sup> 10<sup>-6</sup> 10-4 10-2 BLOWS/0.3m 20 NUMBER ELEV. TYPE SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O WATER CONTENT PERCENT DESCRIPTION DEPTH -0<sup>W</sup> WpH - wi (m) 20 40 40 60 80 60 80 GROUND SURFACE 60.59 0 Flush Mount ASPHALTIC CONCRETE 0.00 Protective Casing set in Sand Silica Sand Grey crushed stone (FILL) 0.15 Brown coarse sand, some gravel (FILL) 2 0.29 59.77 Very dense brown sandy silt, some gravel, with cobbles (FILL) 0.82 50 DO 100 0 1 Μ 59.22 1.37 Dense to very dense brown to grey brown SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL) 50 DO Bentonite Seal 2 43 2 50 DO 47 3 3 Power Auger Hollow 50 DO 54 0 4 мн Silica Sand Diam 200mm 50 DO >50 5 4 32mm Diam. PVC #10 Slot Screen 50 DO >50 6 5 50 DO >50 7 Cave 6 8 50 DO >50 53.95 50 DO >50 0 End of Borehole 6.64 Auger Refusal 7 1011210222-1300.GPJ GAL-MIS.GDT 12/16/11 JEM/JM 8 9 10 OLRT-SOIL DEPTH SCALE LOGGED: KS Golder 1:50 CHECKED: SD Associates

#### RECORD OF BOREHOLE: T-74

BORING DATE: April 4, 2011

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030956.27 ;E 366672.13

PENETRATION TEST HAMMER, 64kg; DROP, 760mm DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m HYDRAULIC CONDUCTIVITY, k, cm/s SOIL PROFILE SAMPLES BORING METHOD ADDITIONAL LAB. TESTING DEPTH SCALE METRES STRATA PLOT 40 60 80 10<sup>-8</sup> 10<sup>-6</sup> 10-4 10<sup>-2</sup> BLOWS/0.3m 20 NUMBER ELEV. TYPE SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O WATER CONTENT PERCENT DESCRIPTION DEPTH -0<sup>W</sup> Wp 🛏 - WI (m) 40 20 40 60 80 20 60 80 GROUND SURFACE 'B' 'A' 63.41 0 Flush mount Grey crushed stone (FILL) 0.00 protective casing set in Bentonite 0.15 Compact to dense brown sandy silt, A.S 1 trace gravel and clay (FILL) 50 DO 20 2 Bentonite Seal 50 DO 3 41 2 61.13 Silica Sand Very dense brown SANDY SILT, trace 2.28 gravel, with cobbles and sand layers (GLACIAL TILL) 50 DO 59 4 Power Auger Diam. (Hollow 3 50 DO 55 0 5 мн 200 mm 32mm Diam. PVC #10 Slot Screen 'B' 4 50 DO >100 6 58.84 4.57 Very dense dark grey SANDY SILT, some gravel, trace clay, with cobbles (GLACIAL TILL) 50 DO 55 7 5 50 DO  $\nabla$ 8 57 0 MH Bentonite Seal W.L. in Screen at Elev. 57.96m on June 28, 2011 6 57.12 Borehole continued on RECORD OF DRILLHOLE T-74 7 1011210222-1300.GPJ GAL-MIS.GDT 12/16/11 JEM/JM 8 9 10 OLRT-SOIL DEPTH SCALE LOGGED: JMR/DAC Golder 1:50 CHECKED: MRR Associates

LOCATION: N 5030956.27 ;E 366672.13

# **RECORD OF DRILLHOLE: T-74**

DRILL RIG: CME 75

DRILLING CONTRACTOR: Downing

DRILLING DATE: April 4, 2011

SHEET 1 OF 2

DATUM: Geodetic

INCLINATION:	-90°	AZIMUTH:	

RES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	No.	TURN		VN -	- Fai - Shi - Vei	ult ear	ate	F	0 - F 0 - C 0 R - C 0 L - C	Beddir oliati Conta Orthog Clean	oñ ct	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	K SM RO	- Slic - Sm - Roi	ooth Jgh	sided	N	IOTE Ibbre	: For viation	additi	er to list		NOTES
METE	-LING	DESCRIPTION	MBOL	DEPTH (m)	RUN	FLUSH RETURN	TOT	ECO' TAL	VER SO		R.Q	.D.	FRA INDE PEI		P w.r.t	DISCONTINUITY D.				CONE	RAULI UCTIV cm/sec	ITY		NEA ERIN	١G		
	DRIL		sΥ			FLU	COR 88	8E %	COF 88	RE %	80	20	0.25 ₀₽€	im 02 0	Pw.r.1 CORE AXIS	TYPE AND SURFAC DESCRIPTION	CE	Jcon	Jr Ja		0 0 0 4 0 0 7 0 0				× 2 00		
	_	BEDROCK SURFACE	±.×	57.12																							'B'
		Fresh, thinly to medium bedded, fine grained, light grey to black, slightly porous, medium strong to strong LIMESTONE BEDROCK, interbedded	* 4 4 4 4 × 4 4 × 4 4 × 4 4	6.29												BD,PL,SM Br		12	1 2								
_		with laminated shale layers	*** *** ***		1																						
7		VERULAM FORMATION UNIT 2 - Broken core from 6.42m to 6.54m, large sub-rounded, re-drilled core	+ + + + + + + + + + + + + +												•	BD,PL,Ro CI		12	1.5 4								Silica Sand
		fragments - Shale layer from 6.71m to 6.78m - Shale layer from 6.88m to 6.95m	+ + × + + + + + + + + + + + +												-	BD,UN,SM CIE 30mm	3r	0	1 10								
8		- Shale layer from 7.01m to 7.05m	++ × +- × × + ×												•	BD,PL,SM Br 4	4mm	6	1 4								
Ŭ		- Shale layer from 7.09m to 7.21m	++ × + × × + × × + ×		2											BD,UN,Ro Br		12	3 3								
		- Shale layer from 7.77m to 7.86m	** * ** * * * *													BD,ST,SM Br		16	2 2								
			** × ** * * * *													BD,UN,Ro CI/E	r 2mr	112	3 4								
			* * *- * *- *									Шľ															
9		- Shale layer from 8.97m to 9.05m	** * *** ***													BD,UN,SM Br											
		- Shale layer from 9.15m to 9.26m - Shale layer from 9.34m to 9.39m	*** *** ***													BD,UN,SM Br		16	2		8						
		-			3											BD,PL,SM Br JN,UN,Ro Cl		12 12 0	1 2 3 4								
		- Shale layer from 9.65m to 9.75m	*** *** ***		Ŭ											BD,PL,Ro CI/B	r 6mm	0	1 10								Č.
10			** * *** ***													BD,UN,Ro Br		20									
		- Shale layer from 10.28m to 10.32m	** * *** ***												$\ $	BD,UN,RO Br		20	3 2								
		- Shale layer from 10.46m to 10.49m	*_ * *_* *_*																								
		- Shale layer from 10.57m to 10.62m	*_ * *_* *_*													BD,UN,Ro Br		20	3 2								
11	=		×+ ÷ ++ *												-	BD,PL,SM Br BD,PL,Ro Cl		12	1 2								
ľ	HQ Core	- Shale layer from 11.19m to 11.22m	×+++ ++++× +++*		4											BD,PL,Ro Ci		12 12	1.5 4								32mm Diam. PVC #10 Slot Screen 'A'
1	δ Η	- Shale layer from 11.29m to 11.32m	× ± + + + × + + ×																								
		- Shale layer from 11.33m to 11.37m	×±+ ±+× + ×													BD,PL,Ro CI BD,UN,Ro Br		12 20	1.5 4 3 2								
12		- Shale layer from 11.42m to 11.45m	×_+ ++ ++ ++ *				$\square$																				
		- Shale layer from 11.52m to 11.60m	*** *** ***																								
		- Shale layer from 11.63m to 11.68m - Shale layer from 12.44m to 12.51m	× + + × + + × × + +													BD,UN,SM CI BD,PL,Ro Br		12 16	2 4 1.5 2								
		- Shale layer from 12.58m to 12.65m	*** *** ***		5																						
13		- Shale layer from 12.84m to 12.97m	*** *** ***													BD,UN,Ro Br BD,UN,Ro Br		20 20	3 2								
			** * ****		$\vdash$				H	++																	
			*** *** ***													BD,UN,SM Ca		12	2 4								
14		- Shale layer from 13.92m to 13.94m	*_* *_* *_*																								
		- Shale layer from 14.20m to 14.22m	*** ***		6																						
		- Shale layer from 14.34m to 14.36m	× × × × × × × × × × × × × × × × × × ×													BD,UN,Ro Br		20	3 2								
			×++ ++ ++ +																								2
15			× ± ÷ ± ± × ± + ×		$\vdash$		╟┼	++	₩	+	$\parallel$	$\left  \right $				BD,PL,Ro Br			3 3								
			×±+ ±+× ±,×													BD,UN,Ro Ca		12	3 3								
			× ± ± ± ± × ± ± ×																								
			× ± ± ± ± × ± ± ×		7																						Bentonite Seal
10			× × ×												•	BD,UN,Ro Br		20	3 2								
16			*** *** ***																								
	_ L_			<u>+</u>						Ħ			+ -			+	· ·				<u>-</u>						
DEF	PTH S	SCALE									1	7	T.		~1											LC	) GGED: JMR/DAC
1:5											K	Ë	1	6	Ol( OC	der ziates									,		ECKED: MRR

		T: 10-1121-0222 N: N 5030956.27 ;E 366672.13		RE	СС	DR	RD	) (											2011	T-7	74												HEET 2 OF 2 ATUM: Geodeti	c
INC	CLINA	FION: -90° AZIMUTH:													ME NT			FOR	R: Dowr	ning														
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	글	F S V	FLT SH VN CJ ECC FAL E %	- Jo - Fa - Sh - Ve - Co VEF	ault near ein onju RY	igat	te R.Q. %	0 ( D.	CO- OR- CL - FR/ INI P 0.2	Bed Foli Con Orth Clea ACT. DEX ER 25m 25m	ntac noge an DIF C	t	r.t.	PL - Pla CU- Cui UN- Uni ST - Ste IR - Irre DISCONT TYPE A DES	dulati epped egular FINUI	TY DA	K SM RO MB	Т	kens	ided ical E HY CON	Brea DRA DUC , cm/	NC ab of ik syn ULIC	DTE: I brevia abbre mbols	For a ations eviations s. W E I	dditio s refer ons & (EAT ERING	H-	ŧ	NOTES	
-		CONTINUED FROM PREVIOUS PAGE	* + + * +	46.95	7		$\prod$															_	_										Bentonite Seal	'B' 'A'
- 17 - 17 - 17 - 18 - 18 - 18 - 18 - 19 - 19 - 19 - 19 - 20 - 20 - 20		End of Drillhole		16.46																													W.L. in Screen at Elev. 57.96m on June 28, 2011	
- 21 - 21 - 21 - 22 - 22																																		
23 - 23 - 24 - 24 - 25 - 25 - 25 - 26 - 26																																		
DE		CALE									(	C			A	Go	ol	de cia	er ates														ogged: JMR/E Iecked: MRR	DAC

### **RECORD OF BOREHOLE: T-75**

BORING DATE: March 23-24, 2011

SHEET 1 OF 2

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030923.18 ;E 366623.23

PENETRATION TEST HAMMER, 64kg; DROP, 760mm HYDRAULIC CONDUCTIVITY, k, cm/s DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m SOIL PROFILE SAMPLES BORING METHOD ADDITIONAL LAB. TESTING DEPTH SCALE METRES STRATA PLOT 60 80 10<sup>-8</sup> 10<sup>-6</sup> 10-4 10<sup>-2</sup> BLOWS/0.3m 20 40 NUMBER ELEV. TYPE SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O WATER CONTENT PERCENT DESCRIPTION DEPTH -0<sup>W</sup> WpH - wi (m) 40 60 80 20 40 60 80 'B' 'A' GROUND SURFACE 61.79 0 Flush mount Grey crushed stone (FILL) 0.00 protective casing set in Bentonite Native Backfill XXXXX XXXXX 61.49 0.30 A.S 1 Compact dark brown silty sand, some gravel, trace brick (FILL) 50 DO 2 11 50 DO 26 3 2 59.51 Dense to very dense brown SILTY 2.28 Bentonite Seal SAND, some gravel, with cobbles and boulders (GLACIAL TILL) 50 DO 47 4 3 50 DO 5 >50 50 DO >50 Stem) 6 4 Power Auger MolloH 57.22 4.57 i c Silica Sand Very dense grey SANDY SILT to SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL) 50 DO >50 7 5 50 DO >50 8 6 9 50 >50 32mm Diam. PVC #10 Slot Screen 'B' 10 50 DO >50 7 1011210222-1300.GPJ GAL-MIS.GDT 12/16/11 JEM/JM 11 50 DO >50 ∄ 8 Silica Sand 12 50 DO >50 50 DO >50 Native Backfill 9 Rotary Drill Core 19 19 Bentonite Seal 10 CONTINUED NEXT PAGE OLRT-SOIL DEPTH SCALE LOGGED: KS Golder 1:50 CHECKED: MRR Associates

# **RECORD OF BOREHOLE: T-75**

BORING DATE: March 23-24, 2011

SHEET 2 OF 2

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030923.18 ;E 366623.23

S/	AM	PLE	R HAMMER, 64kg; DROP, 760mm														ST HAM	IMER,	64kg; DROP, 760mm
щ		aot	SOIL PROFILE			SA	MPL	ES	DYNAMIC PENE RESISTANCE, E	TRATI	ON 5/0.3m	Ž	HYDRA	ULIC CO	ONDUCT	TIVITY,		טר	
DEPTH SCALE METRES		BORING METHOD		LOT		2		.3m	20 40			30	10			0-4 10	) <sup>-2</sup>	ADDITIONAL LAB. TESTING	
METH		D N C	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAR STREN Cu, kPa		nat V. +	Q - ●	w			PERCEN	VТ	DITIO	
DE		BOR		TRA	DEPTH (m)	Ę	⊢	BLOV					vvp					LAI	
	╈		CONTINUED FROM PREVIOUS PAGE	0		-		-	20 40	j (	60 8	30	2	u 4	06	800	U		'B' 'A'
- 10 -		П	Very dense arey SANDY SILT to SILTY			⊨	=												
-	≣		SAND, some gravel, with cobbles and boulders (GLACIAL TILL)			14	50 DO	>50											W/L is Ossess at
-	Rotary Drill	HQ Core		X)															W.L. in Screen at Elev. 58.73m on June 28, 2011
E .	ß	Ξ																	0010 20, 2011
- 11				K	50.71														_
F			Borehole continued on RECORD OF DRILLHOLE T-75																
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OLRT-SOIL 1011210222-1300.GPJ GAL-MIS.GDT 12/16/11 JEMJM		1																	-
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оs- L	EPT	нs	CALE						Â		Golde	r						LC	DGGED: KS
1 OLR	: 50									7 <sub>As</sub>	socia	ates						СН	ECKED: MRR

INC		tion: -90° azimuth:	_					4 -	DF DF	RILL	RIC	G: C G CO	NTF	RAC		23-24, 2011 R: Downing	PO	- Polis	hod		BI	P . B	roker	n Rock	_	
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	Sł Vi C.	H - : N - ' J - ! COV	Joint Fault Shea Vein Conju ERY SOLIE	r Jgate R	.Q.D	OR- CL - FRA INE PE 0.2	Cont Ortho Clear ACT. DEX ER 25m	act ogon	v.r.t. RE IS	CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY DA TYPE AND SURFAC DESCRIPTION	K SM RO MB	<ul> <li>Slick</li> <li>Smo</li> <li>Rought</li> </ul>	kensi oth gh hanio	Aded Al Bre HYDR CONDU K, cm % 0	AULIC AULIC CTIVIT	DTE: Fo breviati abbrevi mbols.	or addit ions rel iations WEA ERI IND	tional fer to list & ATH- ING		NOTES
		BEDROCK SURFACE	±.×	50.71																						
		Fresh to slightly weathered, thinly to very thinly bedded, fine grained, medium to dark grey, moderately to faintly porous, strong LIMESTONE BEDROCK, interbedded with shale beds ranging from 1mm to 16cm thick	$4 \times 4 \times$	11.08	1	100										BD,UN,Ro BD,UN,Ro BD,UN,Ro BD,UN,SM BD,PL,SM BD,PL,SM		20 3 22 3 22 3 20 2 16 1 16 1	2 1 1 1 1							Bentonite Seal
- 12		VERULAM FORMATION UNIT 2 - Shale layer from 11.65m to 11.69m - Shale layer from 11.74m to 11.78m	+ + × + + + + + + + + + + + + + + + + +												•	BD,FL,SM BD,IR,SM BD,CU,SM BD,PL,SM BD,UN,SM BD,CU,SM		20 2 20 2 16 1 20 2 20 2	1 1 1 1 1							Silica Sand
		- Shale layer from 11.83m to 11.85m	+ + × + × + × + × + × + × + × + × + × +		2	100										BD,CU,SM BD.CU.SM		20 2 20 2 20 2	1							
- 13		- Shale layer from 13.04m to 13.07m	$4 \times 4 \times$												8 -	BD, UN, SM BD, UN, SM BD, UN, SM BD, UN, SM BD, UN, SM BD, UN, SM		20 2 20 2 20 2 20 2 20 2 20 2 20 2 20 2	111100000000000000000000000000000000000							32mm Diam. PVC #10 Slot Screen 'A'
- 14		- Shale layer from 14.19m to 14.24m - Shale layer from 14.52m to 14.78m	× + + × × + × × + × + × + × + × + × + ×		3	100										BD,CU,SM		20 2	1							Silica Sand
- 16	Rotary Drill HQ Core	- Shale layer from 15.78m to 15.80m	· · · · · · · · · · · · · · · · · · ·		4	100									•	BD,UN,SM BD,CU,SM BD,CU,SM		20 2 20 2 20 2	1							
- 17		- Shale layer from 16.68m to 16.74m																								
		- Shale layer from 17.38m to 17.48m	+ + × + × + × + × + × + × + × + × + × +		5	100									•	BD,UN,SM BD,UN,SM		20 2 20 2	1							
- 18		- Shale layer from 17.86m to 17.90m - Shale layer from 17.95m to 18.02 - Shale layer from 18.23m to 18.54m	* 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4																							Bentonite Seal
- 19		- Shale layer from 18.66m to 18.69m - Shale layer from 18.82m to 18.84m	* * 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 ×		6	100									   •   •   -	BD,UN,SM JN,ST,Ro BD,CU,Ro		20 2 22 3 22 3	1							
- 20		- Shale layer from 19.53m to 19.56m - Shale layer from 19.70m to 19.72m	$4 \times 4 \times$																							
- 21		- Shale layer from 20.77m to 20.79m	× × → × × → × × → → → → → → → → → → → →		7	100										BD,UN,SM BD,UN,Ro BD,UN,SM BD,CU,SM		20 2 22 2 20 2 20 2	1 1 1 1							
		CONTINUED NEXT PAGE	- -±	†			Ħ	†ſ	ΗF	ţ∣Ŧ	17		†  †	1	†  <b>†</b>		-	-†	┤ौ		1†		+ -	††	t	

	LOC	CATIC	T: 10-1121-0222 IN: N 5030923.18 ;E 366623.23 FION: -90° AZIMUTH:		RE	C	OF	RD	0	DI	RIL	LIN	G	DAT		Ма		E: <b>T-75</b> 23-24, 2011	,								SHEET 2 OF 2 DATUM: Geodetic	:
DEPTH SCALE		DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	S V C	% C	Joint Fault Shea Vein Conj	t ar ugat <u>_</u>		D.	3D- E 0- F 00- 0	Bedd Foliat Conta Drtho Clear CT. EX R Sm	ing ion act gona	al .r.t. E S	R: Downing PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular DISCONTINUITY D/ TYPE AND SURFAC DESCRIPTION	K SN RC MI ATA	Л- Sn D- Ro	cken nooth ugh echai	nical B HYE CONE K,	N	IOTE: F bbrevia f abbre ymbols C ITY	For add ations reviation wiation WE EF INI	en Rock ditional efer to list s & ATH- RING DEX	NOTES	
-			CONTINUED FROM PREVIOUS PAGE	<u> </u>		8											4									+++		'B' 'A'
-		Rotary Drill HQ Core	- Shale layer from 21.20m to 21.22m - Shale layer from 21.78m to 21.94m	× ⊣ × × ⊣ × × ⊣ × + ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ × ⊣ ⊣ × ⊣ + × ⊣ × × ⊣ + × ⊣ ×		8	100									,		BD,PL,SM BD,CU,SM BD,UN,SM			1 1 2 1 2 1						Bentonite Seal	
-	22		End of Drillhole	*_* *_* * *_* *	39.76 22.03										$\parallel$					$\square$								-
	23 24 25 26																										W.L. in Screen at Elev. 58,73m on June 28, 2011	
	28																											
- פ	29																											
		PTH S	CALE																								LOGGED: KS	
0 LKI	1:5	50										V	Ē	1	ls	rul SO	ci	er ates								C	CHECKED: MRR	

# RECORD OF BOREHOLE: W-058

BORING DATE: October 18, 2010

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030845.23 ;E 366541.33

Ц	НОБ	SOIL PROFILE	1.	1	SA	MPLE		DYNAMIC PEN RESISTANCE,	ETRAT BLOW	TION S/0.3m	~	HYDR/	AULIC CO k, cm/s	NDUCT	FIVITY,		NG		
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.3m	20 4 SHEAR STREN Cu, kPa		60 8 nat V. + rem V. ⊕	30 Q - • U - O	w	0 <sup>-8</sup> 10 ATER CO	ONTENT	PERCI	10 <sup>-2</sup> ENT	ADDITIONAL LAB. TESTING		
ر	во	GROUND SURFACE	STR	(m)			BLO	20 4	0	<u>60 8</u>	30		0 4			80			
0		Dense to very loose brown to grey to black silty sand, some gravel, trace to some reddish brick fragments, trace black cinders/asphalt, trace ash (FILL)		<u>61.40</u> 0.00														Flush Mount Protective Casing set in Bentonite	
1					1	50 DO	34												
2					2	50 DO	8											Bentonite Seal	
3	Stem)			58.35		50 DO	7												
	Power Auger 200 mm Diam. (Hollow Sl	Compact to very dense brown to grey SANDY SILT, trace to some gravel, trace clay (GLACIAL TILL)		3.05		50 DO	18					0					м	Silica Sand	
4	200 r				5	50 DO	81											ि दिस् दुस्प्रेस् स्प्रेस् स्वर्थस्य स्वर स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्थस्य स्वर्	
5					6	50 DO	50											32mm Diam PVC	the second se
6					7	50 DO	50											32mm Diam. PVC #10 Slot Screen	
				54.56		50 DO 50 DO	50 50					0					МН	W.L. in Screen at Elev. 57.69m on Jan. 20, 2011	
7		Borehole continued on RECORD OF DRILLHOLE W-058																	
8																			
9																			
10																			
DEI		CALE		I	L	<u>ı I</u>		(		Golde	er	1	I		1			I OGGED: JC IECKED: MRR	_

		CT: 10-1121-0222 ON: N 5030845.23 ;E 366541.33	R	ECC	R						<b>W-05</b>	8						SHEET 1 OF 1 DATUM: Geodetic
		ATION: -90° AZIMUTH:					DRILL R	IG: C	ME 75	5	R: Downing							Scoular
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	тн 2	10	RECOVE TOTAL SO CORE % CO	ault near ein onjugate	FO- CO- OR- CL - D. FR4 IND PE 0.2	EX DIF R CI 5m A	h	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY DA TYPE AND SURFAC DESCRIPTION	ATA	lickens mooth tough lechan	ided	LIC VITY 60	r additional	al o list -	NOTES
		BEDROCK SURFACE	5	54.56		0040	10,40			500							>>	
- - 7 -		Quartz (Boulder) - No recovery from 7.04m to 7.36m		6.84 C1 54.04														32mm Diam. PVC #
- 8		Fresh, medium bedded to irregular laminated, grey to dark grey, fine to medium grained, slightly porous, medium strong to strong LIMESTONE BEDROCK, interbedded with shale - Broken core from 7.36m to 8.02m - No recovery from 8.02m to 8.92m	<ul> <li>↓</li> <li>↓</li></ul>	7.36 C2														
9  10 10	Rotary Drill HO Core	2 5 5 5 7 7 7	×┥┥>┙┥×┥┥×┥┑┥┥┥┥┥┥┥┥┥┥┥┥╸┥╸┥╸┥╸╴	СЗ						•	JN,PL,RO JN,UN,RO JN,CU,RO Br JN,CU,RO Br JN,CU,RO Br	12 22 20 20	3 2 3 2					Grout
- 11		- Broken core from 11.33m to 11.44m	- + × + + × + + × + + × + + × + + × + + × +	C4						•	JN,PL,SM JN,CU,RO JN,CU,RO –JN,CU,RO –JN,CU,SM Shal JN,UN,RO Br –JN,PL,RO Br	16 22 22 16	3 1 3 1 2 2 3 2					
- 12 		End of Drillhole		11.95														W.L. in Screen at Elev. 57.69m on Jan. 20, 2011
- 14 - 14 WC/W																		
OLRT-ROCK 1011210222-1300.GPJ GAL-MISS.GDT 12/06/11 JEMJM 																		
OLRT-ROCK 101.		SCALE						Ð	G	olde oci:	er ates							.ogged: JC Hecked: MRR

101121

# RECORD OF BOREHOLE: W-059

BORING DATE: November 11-12, 2010

SHEET 1 OF 1

DATUM: Geodetic

LOCATION: N 5030871.95 ;E 366581.57

	ДОН	SOIL PROFILE	1.		SAN	IPLES	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ĘĘ	
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE BLOWS/0.3m	20         40         60         80           SHEAR STRENGTH         nat V. + Q Q.           Cu, kPa         rem V. ⊕ U C.           20         40         60         80	10 <sup>8</sup> 10 <sup>4</sup> 10 <sup>4</sup> 10 <sup>2</sup> WATER CONTENT PERCENT Wp	ADDITIONAL LAB. TESTING	
0		GROUND SURFACE		61.68						
Ŭ		ASPHALTIC CONCRETE Grey crushed stone (FILL)		0.00						
		Brown silty sand to sand, trace gravel (FILL)		0.29						
1		Compact to dense grey brown silty fine sand, trace to some gravel, trace organic matter, occasional brown fine to medium sand layer (FILL)		60.79 0.89	1	50 DO 18				
2		Dense brown SANDY SILT, trace gravel (GLACIAL TILL)		60.00 1.68 59.55	2	50 DO 42				
		Dense to very dense grey brown SILTY SAND, trace to some gravel, occasional cobbles (GLACIAL TILL)		2.13	3	50 20 44				
3						50				
		Very dense grey to grey brown SILTY SAND, some gravel, occasional cobbles		58.02 3.66	4	50 DO 82		0	MH	
4	er w Stem)	(GLACIAL TILĽ)			5	50 50 96				
5	Power Auger 200mm Diam. (Hollow				6	50 50 55				
	200				7	50 50 53				
6		Very dense grey SANDY SILT, trace to some gravel, occasional cobbles (GLACIAL TILL)		55.73 5.95	8	50 50 80				
7					9	50 DO >10				
8					10	50 DO >10				
o		Very dense grey SANDY SILT, trace gravel and clay, occasional cobbles (GLACIAL TILL)		53.30 8.38	11	50 DO >10		0	мн	
9					12	50 DO >10				
10		Borehole continued on RECORD OF DRILLHOLE W-059		51.84						

PR	OJI	EC	Г: 10-1121-0222		REC	CC	R	D	0	F	D	RI	LI	∟⊦	10	LI	E: W-0	)59									S	SHEET 1 OF 1
			N: N 5030871.95 ;E 366581.57 ION: -90° AZIMUTH:							D	RIL	L R	IG:	CN	1E 7	5	ember 11-12, 2	2010									[	DATUM: Geodetic
DEPTH SCALE METRES		אורבוואס אבעטאט	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	F S V	ELT - SH - VN - CJ - ECO	Join Fau She Con VER SOL	it lt ar juga Y ID		B F C C D.	D- B O- F O- C R- C R- C R- C RAC INDE PEF 0.25	eddir oliatic ontac orthog lean CT. CT. CT. DI R DI CT.	g in t	IR - Irregular DISCONTINUIT	ng SN RC ME	- Si /- Sr )- Ro	lishe cken: nooth ugh echar	nical E HY CON	Break DRAU DUCT , cm/s	NOT abbr of at syml ILIC IVITY ec	,	weA	tional fer to & ATH- ING DEX	list	NOTES
		HQ Core	BEDROCK SURFACE Fresh to slightly weathered, medium bedded, grey to dark grey, fine to medium grained, medium strong to strong LIMESTONE BEDROCK, with wavy thin shale beds	L+x+L+x+L+x+L+x+L+x+L+x+L+x+L+x+L+x+L+x	51.84 9.84	3											BD,ST,R0/S BD,CU,R0/S BD,PL,SM JN,UN,R0/S	m Cl m Cl/Gr m Sa/S n Cl m Si/Cl	22 16 16 16 16 22 16 16 22 16 16 22 18	1 3 1 3 1 3 1 3 1 3 1 3 1 3 1 3			10 <sup>2</sup>		M2 000 000 000 000 000 000 000 000 000 0	W4	M6	
			End of Drillhole		46.74																							
DE 1 :		нs	CALE									G	Ż		G	olo oc	der ciates											LOGGED: RI HECKED: MRR

OLRT-ROCK 1011210222-1300.GPJ GAL-MISS.GDT 12/06/11 JEM/JM

### RECORD OF BOREHOLE: W-060

LOCATION: N 5030910.36 ;E 366594.56

BORING DATE: November 24, 2010

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

SAMPLER HAMMER, 64kg; DROP, 760mm

۲ <u>.</u>	ЪН	SOIL PROFILE		,	SAI	MPLE		DYNAMIC PE RESISTANC		/S/0.3m	Ľ,			NDUCTI	RGAL	
METRES	BORING METHOD	<b>_</b>	STRATA PLOT	ELEV.	3ER	щ	BLOWS/0.3m	20 SHEAR STR		1					ADDITIONAL LAB. TESTING	
E E	JRING	DESCRIPTION	RATA	DEPTH	NUMBER	TYPE	OWS	SHEAR STR Cu, kPa	ENGIH	nat v. + rem V. €	U-0			ONTENT P	ADDI ABDI	
-	Я		STF	(m)	-	i	В	20	40	60 8	30		0 4			
0		GROUND SURFACE		61.23			$ \rightarrow$		_							Flush Mount
1		Loose to dense brown sandy silt, trace medium sand layers (FILL)		<u>0.00</u> 0.10												Protective Casing set in Bentonite
I						DO	9									Bentonite Seal
2						50	35									Silica Sand
3		Grey brown silty sand, trace gravel,		58.18 3.05		50 DO 50 DO >	100									
		some pieces of wood (FILL) Very dense grey brown SILTY fine SAND, trace gravel (GLACIAL TILL)		57.93 3.30												32mm Diam. PVC #10 Slot Screen
4	Power Auger 200mm Diam. (Hollow Stem)					50	78					C			МН	#10 Slot Screen
5	Pov 200mm Diar						97									
6						50 DO > 50 DO >	100									Silica Sand
_						50 >										
7						50	100									
8					-	00										Grout
9				52.06												W.L. in Screen at Elev. 57.72m on Jan. 20, 2011
10		Borehole continued on RECORD OF DRILLHOLE W-060														
DEI	PTH S	CALE							2	Golde	2 <b>4</b>					OGGED: JD

			CT: 10-1121-0222		REC	CC	DR	D	С									E: W-06	0									SHEET 1		
			DN: N 5030910.36 ;E 366594.56 TION: -90° AZIMUTH:								DR	RILL	RIC	G: (	CME	E 75	5	ember 24, 2010 OR: Downing										DATUM:	Geodetic	
ALE		CORD		LOG			z		FLT SH	- Jo - Fa - Si - Ve	oint ault hear			BD FO CO	- Bec - Foli - Cor	ding ation	1	PL - Planar CU- Curved UN- Undulating	K SN	- Slie 1- Srr	lished ckens hooth	sided		NOT	E. For	additid	Rock onal er to list			
DEPTH SCALE		DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	F	CJ	- C	onju	R	.Q.D	CL FF	- Cle RACT	an		ST - Stepped IR - Irregular DISCONTINUITY D/	ME ATA	D- Ro 3- Me	ichan	HY CON	Break DRAU DUCTI , cm/se	Symt LIC VITY	DOIS.	WEAT ERIN INDE		-	NOTES	
ā		DRIL	BEDROCK SURFACE	SY	52.06		FLU	CO 86	RE %	CO	RE 9	6	848	0.	.25m ₽₽≈		XIS XIS X88	TYPE AND SURFAC DESCRIPTION	CE	Jcon	Jr Ja		2 2 2 2 2 2 2				× 24			
			Fresh, grey, fine to medium grained, slightly porous, strong LIMESTONE BEDROCK, interbedded with undulating, wavy shale laminates	* + * * + * * + * * + * * + * * + *	9.17	1																								-
	10		No core recovery from 9.17m to 10.42m- redrill	+ + + + + + + + + + + + + + + + + + +		2																								-
-				4 × × 4 × × 4 × × 4 + 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4																										-
	1					3											•	BD,PL,Ro		20	1.5 0.75									
-				× + × × + × + × + × + × + × + × + × + ×														BD,CU,SM CI BD,PL,Ro BD,PL,SM		20 20 16 16	2 1 1.5 0.75 1 0.75									-
	12			$\frac{1}{2}$						┞								BD,PL,SM BD,PL,Ro Sh/B	Br		1 0.75									-
-		Rotary Drill HO Core		$\frac{1}{2}$		4												BD,PL,Ro Sh/B BD,CU,SM Br	Br	16 16 16	1.5 2 2 2							Grout		-
- ·	13	H Rot		×× + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + × + + + × +														BD,CU,Ro		22	3 0.75									
				$\frac{1}{2}$														BD,CU,SM CI		20	2 1									-
	14			+ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$		5												BD,CU,Ro BD,CU,Ro Br		22 20	3 D.75 3 2									
	15																													
																		BD,CU,Ro Br			3 2									
	16			、× ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × × ┥ × ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥ ┥		6												BD,CU,Ro JN,ST,Ro BD,CU,Ro Br		22 22 20	3 0.75 3 0.75 3 2									-
				× ⊥ × ⊥ × × ⊥ × × ⊥ × × ⊥ × ⊥ × × ⊥ ×	44.65 16.58																									-
111 JEM/J	17		End of Drillhole		10.56																							Elev. 57	Screen at .72m on	
GDT 12/06																												Jan. 20,	2011	-
GAL-MISS.	18																													
1300.GPJ																														-
1011210222-1300.GPJ GAL-MISS.GDT 12/06/11 JEM/JM	19																													-
Х ОСК	DEF	PTH	SCALE	1			<u> </u>						Ē			 Ge	)   	ler iates										LOGGED	: JD	
	1:5	50										1	V	J	A	SS	00	iates									(	CHECKED	MRR	

PROJECT: 10-1121-0222

# RECORD OF BOREHOLE: W-061

BORING DATE: October 18, 2010

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030949.23 ;E 366639.83

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m HYDRAULIC CONDUCTIVITY, k, cm/s SAMPLES SOIL PROFILE BORING METHOD ADDITIONAL LAB. TESTING DEPTH SCALE METRES STRATA PLOT 40 60 80 10<sup>-8</sup> 10<sup>-6</sup> 10-4 10<sup>-2</sup> BLOWS/0.3m 20 NUMBER ELEV. TYPE SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O WATER CONTENT PERCENT DESCRIPTION DEPTH \_\_\_\_W Wp 🛏 - WI (m) 20 40 60 80 20 40 60 80 GROUND SURFACE 61.55 0 Grey crushed stone (BASE) 0.00 Brown sand, trace silt and gravel (FILL) Dark brown silty sand, some gravel, occasional cobbles, brick (FILL) XXX 0.15 RAE 3 60.94 Dense brown to grey brown SILTY SAND, some gravel, trace clay, with cobbles and sand seams (GLACIAL TILL) 0.61 50 DO 32 1 - Layer of cobbles at 1.22m 50 DO 2 41 2 50 DO 37 4 59.01 Very dense grey brown to grey SILTY SAND, some gravel, trace clay, with cobbles and sand seams (GLACIAL TILL) 2.54 3 50 DO 60 5 6 50 DO 26 0 мн 4 Power Auger mm Diam. 50 DO 92 7 200 5 56.37 Very dense grey SILTY SAND, some 5.18 gravel, trace clay, with cobbles (GLACIAL TILL) 50 DO 8 80 6 50 DO 51 0 9 MH 7 1011210222-1300.GPJ GAL-MIS.GDT 12/06/11 JEM/JM 10 50 55 8 52.54 ss. 9 Borehole continued on RECORD OF DRILLHOLE W-061 10 OLRT-SOIL DEPTH SCALE LOGGED: RI Golder 1:50 CHECKED: MRR Associates

PROJECT: 10-1121-0222

### RECORD OF DRILLHOLE: W-061

SHEET 1 OF 2

LOCATION: N 5030949.23 ;E 366639.83

DRILLING DATE: October 18, 2010 DRILL RIG: CME 75 DRILLING CONTRACTOR: Downing DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	ETURN		FLT SH VN	- Joir - Fau - She - Vei - Cor	ilt ear n	ate	OF CL	) - Be ) - Fol ) - Co R- Ort Cle	ntact hogo an		PL - Planar CU- Curved UN- Undulat ST - Stepped IR - Irregula	t r		Slic Sm Rou	kens ooth igh	sided	Break	NO' abb of a	TE: F	Broke For ade tions r viation	dition	al	NOTES	
DEPTH MET	DRILLING	DESCRIPTION	SYMBOI	DEPTH (m)	RUN	FLUSH RETURN	TO COF	_	VER SOL COR	.ID E %	R.Q.E %	). II C	RACT NDEX PER 1.25m	DIP CC A	w.r.t. DRE KIS	DISCONTINUI TYPE AND SU DESCRIP	JRFACE		lcon .	Jr Ja	CON K	DRAU DUCT cm/se 0	IVIT ec	Ý	EF	EATH RING IDEX	i l		
		BEDROCK SURFACE	±. ×	52.54 9.01				П		$\prod$																			
- 10		Fresh to slightly weathered, medium brownish grey, fine to medium grained crystalline, non porous, thinly to medium bedded, strong, CALCARENITIC LIMESTONE, subordinate nodular limestone, minor thin lithoclastic limestone beds and interbeds of dark grey, bedding laminations and very thin to thinly bedded, calcareous, slake susceptible shale at semi regular	+ × + × + × + × + × + × + × + × + × + ×	9.01	C1										<b>a</b> . <b>a</b> .	BD,CU,RO BD,UN,RO BD,CU,SM BD,PL,RO BD,CU,RO	Br Br Br		20 20 16 1 16 1	3 1 3 1 .5 1 1 4									
		intervals of 0.25 to 2.5 m. Contains traces of fossil fragments. Top contact of formation marked by thin bed of shale and shaley limestone. Shale and shaley limestone comprise 7.5 % to 10 % of	1 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 × × 4 ×												•	BD,CU,SM BD,CU,SM			12 12	14									
- 11		sequence	4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4 ×		C2										• •	BD,CU,RO BD,CU,SM BD,CU,RO	CI		20 12 12	3 3 1 4 1 4									
10			+ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$									-																	
- 12			× + × × + × × + × + × + × + × + × + × +		СЗ										•	BD,PL,RO BD,UN,SM	Са		16 1 20	.52 21									
- 13			* × 4 × × 4 × 4 × 4 × 4 × 4 × 4 × 4 × 4																										
- 14	Rotary Drill HQ Core		┥┥××┥××┥××┥××┥××┥××		C4											BD,UN,SM	Fossi	ls	16	2 2									
· 15 · 16			+ + × + × + × + × + × + × + × + × + × +		C5										•	BD,UN,RO BD,UN,RO BD,PL,RO	Br		20 20 12	3 0.75 3 0.75 1 4									
- 17			× × ⊣ × × ⊣ × × ⊣ × × ⊣ × ⊣ + × ⊣ + × ⊣ × + × × ⊣ × × + × × + × × + × × + × × + × +		C6										•	BD,UN,SM			16	2 1									
- 18		Fresh, medium to thickly bedded, grey, fine to medium grained, medium strong LIMESTONE BEDROCK, with thinly laminated black shale layers	× + × + × + × + × + × + × + × + × + × +	<u>43.51</u> 18.04	C7										•	BD,PL,RO BD,PL,SM BD,ST,RO	Sa		16 1 12	.5 0.75 1 2 2 3									
- 19	-└		- <u>+</u> + ×	+	╞╴┥		╏╟┥	$\left  + \right $		$\left  \right $	╙╢┼	┤┞┥	- +	$\left  \right $	┽╎╉			-+	-	$\left  \right $	╞┝	- -	+		$\left +\right $	+	+	+	
DEF 1:5		CALE	1	1										Go	) JII	er ates								11				LOGGED: RI CHECKED: MRR	

PF	ROJEC	T: 10-1121-0222		REC	CC	R	D	0	F	D	RI	L	Lŀ	Ю	)L	E	: W-06	1										SHEET 2 OF 2	
		DN: N 5030949.23 ;E 366639.83												E: ME 7		ctob	er 18, 2010											DATUM: Geodetic	
		TION: -90° AZIMUTH:	1					IN -			LIN.			NTR Beddi		то	R: Downing PL - Planar	PC	D- Po	lisho	d		BI	R - I	Brok	en F	Rock	-	
CALE	DRILLING RECORD		C LOG		o.	JRN	1	JN - =LT - SH - VN -	She	ar 1		F	:0- F :0- ( )R- (	Foliat Conta Ortho	ion act gona	al	CU- Curved UN- Undulating ST - Stepped	K SM R(	- Sli M- Sm D- Ro	cken nooth ough	isideo 1		NC ab of	DTE: I brevia abbre	For an ations		nal to list	st	
DEPTH SCALE METRES	LING R	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN		ECO	Conj /ER\ SOLI	Y	R.Q	.D.	FRA			.r.t.	IR - Irregular DISCONTINUITY D	ATA	B- Me	echai	H) COM	DRA			W	EAT	H- G	NOTES	
D	DRIL		SYI	(11)		FLUS	COR	E %	CORE	E %	% 888		PE 0.25 ہے؟	R 5m 28 0		RE S S S S S S S	TYPE AND SURFAC DESCRIPTION	CE	Jcon	Jr Ja		(, cm) φ	/sec	M/1	I	NDE:	x %8 %8	2	
	e J	CONTINUED FROM PREVIOUS PAGE Fresh, medium to thickly bedded, grey,	* <u>+</u> *									+	$\parallel$						$\square$		H	+							
-	Rotary Drill HQ Core	fine to medium grained, medium strong LIMESTONE BEDROCK, with thinly laminated black shale layers	* + + + + + + + + + + + + + + + + + + +	42.02	C7																								
		End of Drillhole		19.53																									-
- - 20																													_
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28 																													
	EPTH S	SCALE		•	•	•		1			1	Ź	Y						•		• •		<u>، ا</u>					LOGGED: RI	
1:	50										K	ľ	1	G As	i0  50	id ci	er ates											CHECKED: MRR	

#### RECORD OF BOREHOLE: W-062

BORING DATE: October 19, 2010

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

LOCATION: N 5030983.21 ;E 366665.88

PENETRATION TEST HAMMER, 64kg; DROP, 760mm DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m HYDRAULIC CONDUCTIVITY, k, cm/s SAMPLES SOIL PROFILE BORING METHOD ADDITIONAL LAB. TESTING DEPTH SCALE METRES STRATA PLOT 40 60 80 10<sup>-8</sup> 10<sup>-6</sup> 10-4 10<sup>-2</sup> BLOWS/0.3m 20 NUMBER ELEV. TYPE SHEAR STRENGTH nat V. + Q - ● Cu, kPa rem V. ⊕ U - O WATER CONTENT PERCENT DESCRIPTION DEPTH OW - WI WpH (m) 20 40 20 40 60 80 60 80 GROUND SURFACE 62.95 0 Flush Mount Protective Casing set in Bentonite Black organic TOPSOIL 8:89 Loose to dense miscellaneous red brick, broken cement (FILL) 50 DO 5 1 Bentonite Seal 50 DO 2 50 2 <u> 122/222</u> 50 DO Silica Sand 3 45 Power Auger 59.90 3.05 3 mm Diam. Compact to very dense fine grey SILTY SAND, some gravel, trace clay (GLACIAL TILL) 50 DO 4 20 Ş  $\overline{\Delta}$ 4 5 50 DO 54 32mm Diam. PVC #10 Slot Screen 50 DO 74 6 5 W.L. in Screen at Elev. 60.37m on Jan. 20, 2011 50 DO Ö 7 50 мн 57.07 Borehole continued on RECORD OF Silica Sand 6 DRILLHOLE W-062 7 1011210222-1300.GPJ GAL-MIS.GDT 12/06/11 JEM/JM 8 9 10 OLRT-SOIL DEPTH SCALE LOGGED: CC Golder 1:50 CHECKED: MRR Associates

PROJECT: 10-1121-0222

OLRT-ROCK 1011210222-1300.GPJ GAL-MISS.GDT 12/06/11 JEMJM

### RECORD OF DRILLHOLE: W-062

SHEET 1 OF 2

LOCATION: N 5030983.21 ;E 366665.88

DRILLING DATE: October 19, 2010 DRILL RIG: CME 75 DATUM: Geodetic

INC	CLINA	TION: -90° AZIMUTH:									LL RI					OF	R: Downing											
DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	TURN		JN FLT SH VN CJ	- Sh - Ve	near	ate	C O C	D - Bed O - Foli O- Cor R- Orth L - Clea	nta hog	ct		PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular	K SN RC	)- Poli - Slic 1- Sm 1- Rou 3- Med	kens ooth uah	ided		NOT abbr	E: For eviation	r odditi	Rock ional er to list &		NOTES
DEPTH MET	DRILLING		SYMBO	DEPTH (m)	RUN	FLUSH RETURN	TO COF	TAL RE %	SC COI	RY DLID RE % 398	R.Q.E %	). I	RACT INDEX PER 0.25m		IP w.r CORE AXIS	.t.	DISCONTINUITY DA		Jcon .	Jr Ja	COND K, (		VITY c			٧G		
- - 6 -		BEDROCK SURFACE Fresh to slightly weathered, medium brownish grey, fine to medium grained crystalline, non porous, thinly to medium bedded, strong. CALCARENITIC	× + × + × + × + × + × + × + × + × + × +	57.07 5.88													BD,CU,RO		20	3 1							Sil	lica Sand
- - - -		bedded, strong, CALCARENITIC LIMESTONE, subordinate nodular limestone, minor thin lithoclastic limestone beds and interbeds of dark grey, bedding laminations and very thin to thinly bedded, calcareous, slake	×		C1											1/ /	BD,PL,RO BD,CU,SM CI BD,CU,SM CI BD,ST,RO Br BD,PL,RO CI		20 1 12 12 20 12 1	1.5 1 2 4 2 4 3 2 1.5 4								
- 7 - - -		susceptible shale at semi regular intervals of 0.25 to 2.5 m. Contains traces of fossil fragments. Top contact of formation marked by thin bed of shale and shalev limestone. Shale and shalev	× × ⊣ × × ⊣ × × ⊣ × × - ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ × ⊣ ⊣ × ⊣ ⊣ × ⊣ ⊣ ×														BD,PL,SM Br JN,ST,RO CI/Sa BD,PL,SM		12 6 12	1 2 1 8 1 1								
- - - - 8 -		limestone comprise 7.5 % to 10 % of sequence	*** **** ***														BD,CU,RO BD,PL,SM BD,UN,RO		20 12 20	2 1 1 1 2 1							Be	entonite Seal
-			× + × × + × + × + × + × + × + × + × + ×		C2																							
- - 9 -			4 + 3 + 3 + 3 + 3 + 3 + 3 + 3 + 3 + 3 +														BD,PL,SM BD,PL,RO		16 20 1 12 1	1 3 1.5 3 1.5 1								
- - - - - - -			+ + + + + + + + + + + + + + + + + + +		СЗ												— BD,PL,RO BD,ST,RO JN,CU,SM Ca		12 1 20 1 12 1	3 1 2 3								
-			+ + + + + + + + + + + + + + + + + + +														BD,CU,RO BD,PL,SM Br		20 12	3 2 1 2								
- - - 11 -	Rotary Drill HQ Core		+ + × + × + + + + + + + + + + + + + + +														BD,PL,SM Br		12	1 2								
- - - -			4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		C4										9		BD,CU,RO JN,CU,RO BD,ST,RO		20 20 20	3 2 3 2 3 2								
- 12 - 12 - -			+ × × + × × + × × + × × + × × + × × + × × + × × + × × + × × + × × + × × + × × + ×														BD,PL,RO Br BD,PL,RO Br		12 1									
- - - - 13 -			×		C5												BD,CU,RO Ca BD,PL,RO Br			3 3							Gr	rout
			4 + 4 + 4 + 4 + 4 + 4 + 4 + 4 + 4 + 4 +														BD,PL,SM Br		12	1 2								
- - - 14 -			· · · · · · · · · · · · · · · · · · ·		C6												JN,CU,SM Br BD,CU,SM BD,PL,SM Br		16 20	2 2 2 2 1 2								
			4 × × 4 × × 4 × × + × 4 4 × 4 4 4 4 4 4												.		BD,UN,RO Br		20	3 2								
- 15 			· × ⊣ × × ⊣ × × ⊣ ⊣ × ⊣ ⊣ ⊣ ⊣ ⊣ ⊣ × ⊣ ⊣ × ⊣ ⊣ ×		C7												BD,PL,SM Br		12	1 2								
   - 	_L		*** *** ***					-				ŀ		╞		-	BD,CU,SM Br	_	16	2 2			+ .	-	+ -	╞┝┥	+-	
DE	PTH	CONTINUED NEXT PAGE										1				_ 											LOG	GED: CC
1:	50										V		A	S	01 500		er ates									C	CHEC	KED: MRR

### RECORD OF DRILLHOLE: W-062

SHEET 2 OF 2

LOCATION: N 5030983.21 ;E 366665.88

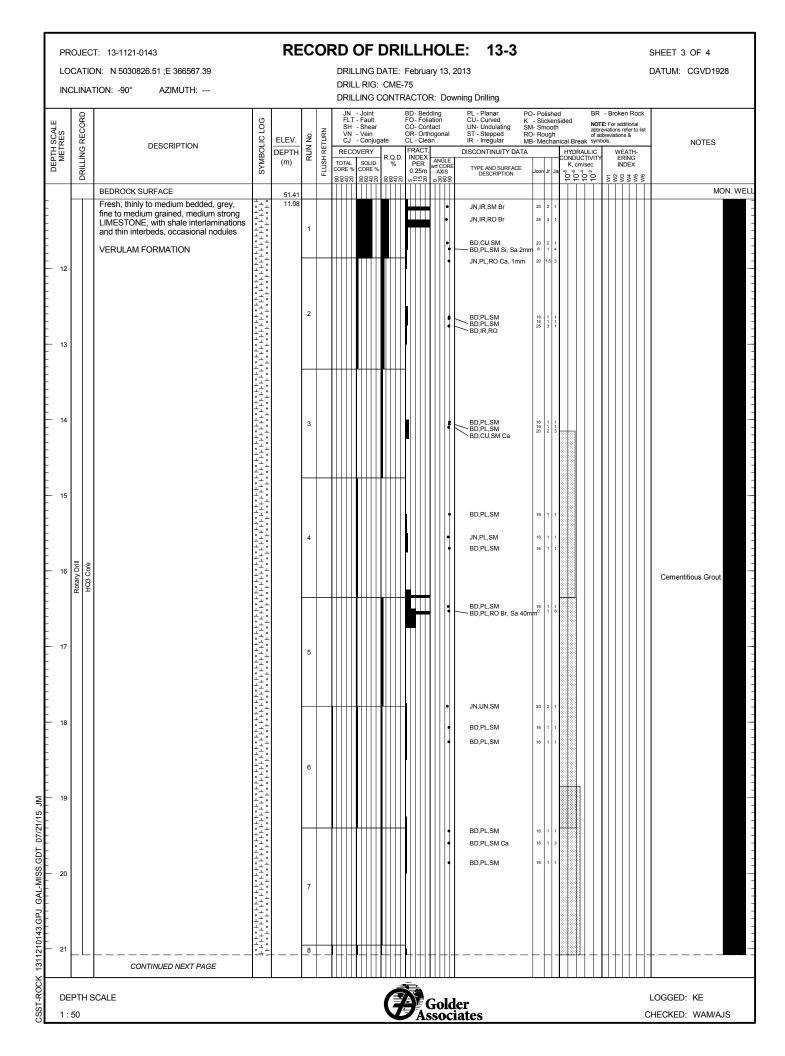
DRILLING DATE: October 19, 2010 DRILL RIG: CME 75 DRILLING CONTRACTOR: Downing DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV.	RUN No.	TURN		JN FLT SH VN CJ	- Fa - Sh - Ve	ult ear	ate		BD-Be FO-Fo CO-Co OR-O CL-CI	oliatio ontac rthog ean	on st	IR - Irregular	K S F N	: - SI M- SI 10- R 18- M	olishe icken mooth ough echai	nside h nical	Brea	NO abb of a ak syn	npois.	For ad itions viation	dditior refer ns &	nal to list	NOTES
DEPTH MET	DRILLING		SYMBO	DEPTH (m)	RUN	FLUSH RETURN	R TO COF	ε%	SO COF	LID	R.C	6	FRAC INDE PER 0.25r	n	Pw.r CORE AXIS	DISCONTINUITY		Jcor	n Jr Ja	a 900 10 <sup>-6</sup> 10-2	YDRA NDUC K, cm			IN		+ w5 × ° +	
- 16 - 17 - 18 - 19 - 20 - 21	Rotary Drill HQ Core	CONTINUED FROM PREVIOUS PAGE Fresh to slightly weathered, medium brownish grey, fine to medium grained crystalline, non porous, thinly to medium bedded, strong, CALCARENITIC LIMESTONE, subordinate nodular limestone beds and interbeds of dark grey, bedding laminations and very tin to thinly bedded, calcareous, slake susceptible shale at semi regular intervals of 0.25 to 2.5 m. Contains traces of fossil fragments. Top contact of formation marked by thin bed of shale and shaley limestone. Shale and shaley limestone comprise 7.5 % to 10 % of sequence	ווי או לא הוא הוא הוא הוא הוא הוא הוא הוא הוא הו		C7 C8 C9 C10											BD,PL,RO BD,PL,RO BD,CU,RO BD,CU,RO BD,CU,RO BD,CU,RO BD,PL,RO BD,PL,RO BD,PL,SM Br BD,PL,SM Br BD,PL,SM Br BD,PL,SM Br	ir r	12 16 16 16 16 16 12 16 12 12 20 16	1.5 2 1.5 1 3 1 2 1 1 1 3 1 1 2 3 2 1 3 1 3 1 3 1 3 1 3 1 1 3 1 1 1 1								Grout
- 22			· ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × ⊣ × × + × × + ×	40.27	C11											BD,PL,SM B	r	12	1 2								
- 23		End of Drillhole		22.68																							W.L. in Screen at Elev. 60.37m on Jan. 20, 2011
- 24																											
- 25																											
DEF 1 : {		SCALE									(	Ĩ	Ż	G	ol	der ciates											LOGGED: CC CHECKED: MRR

PR	ROJE	CT: 13-1121-0143		RE	ECO	DF	RD	OF B	BORE	EHO	OLE	: 1	13-3					Sł	HEET 1 OF 4	
		ion: N 5030826.51 ;E 366567.39 Ation: -90° Azimuth:						RILLING DA RILL RIG: C		ruary	13, 20	13						D	ATUM: CGVD1928	
		ER HAMMER, 64kg; DROP, 760mm						RILLING CC	ONTRAC			ing Drilli	-				ST HAN	IMER,	64kg; DROP, 760mm	۱
JL E	DOH.	SOIL PROFILE			SAM	MPLE	_	DYNAMIC RESISTAN				Ì,	HYDR/	AULIC Co k, cm/s	ONDUCT	TIVITY,		AL NG	PIEZOMETER	
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	20 SHEAR ST		60     na	8 t V. +		10 W		0 <sup>-6</sup> 10 L ONTENT	i	0 <sup>-2</sup> I NT	ADDITIONAL LAB. TESTING	OR STANDPIPE	
M DEP.	BORIN	DESCRIPTION	STRAT,	DEPTH (m)	NUN	2	BLOW	Cu, kPa		rer	n V. ⊕	U - O	Wp		W		WI	ADI LAB.	INSTALLATION	
- 0		GROUND SURFACE	~~~~	62.49				20	40	60	8	U	2	0 4	0 6	30 E	30		MON.	WELL
-		(SP/GP) SAND and GRAVEL, with brick, ash, and glass fragments; brown, (FILL); non-cohesive		0.00 62.19 0.30															Bentonite Seal	
-		(SP/GP) SAND and GRAVEL, presence of cobbles and/or boulders inferred from		0.50																
-		auger resistance, trace glass, bricks, and mortar fragments; brown to dark grey, (FILL); non-cohesive, moist, loose																	16. N. R.	1
- 1 -					1	SS	9												생각	20020 
-		(SM) SILTY SAND, some gravel, trace		60.97 1.52																
-		medium to coarse brown sand seams, presence of cobbles and/or boulders		1.02		SS	61												24.)N24	
_ 2		inferred from auger resistance; grey brown, (GLACIAL TILL); non-cohesive, wet, very dense																	Silica Sand and Bentonite	<u> </u>
-																				2863
-					3	SS	58												28.JA2	111
- - 3																				<u></u>
-					4	SS	35													<u>(</u> 286)
-		- Becoming wet at 3.51 m depth																		111
- 4					5	ss	44												Bentonite Seal	-
-																				
Ē	i i	( stem)			6	ss :	>50												Silica Sand	20,22
- 5	Power Auger				-															
-	Powe																			111
-		- Becoming grey			7	ss	>50													
-																			51 mm Diam. PVC #10 Slot Screen	
- 6 - -																				
Ē					8	SS	50													
-																				- 1월 - - 1월 -
- 7 -					9	ss	>50													
-																				-
-		(ML) sandy SILT, some gravel, presence of cobbles and/or boulders inferred from		54.87 7.62	10	ss	>50													-
- 8		auger resistance; grey, (GLACIAL TILL); non-cohesive, wet, very dense																		-
					11	ss	>50												Cementitious Grout	
5-																				
9																				
					12	ss	>50													
- 5 - 5 -					$\left[ \right]$															
- - - - -	μL			<b>1</b>	13_	<u>ss</u>	> <u>50</u>	└─┼-		_						L	<u> </u>			
2		CONTINUED NEXT PAGE																		
DE	PTH	SCALE								G	olde	r						LC	DGGED: KE	
ś 1:	50								<u>V</u>	Ass	olde ocia	tes						CH	ECKED: WAM/AJS	

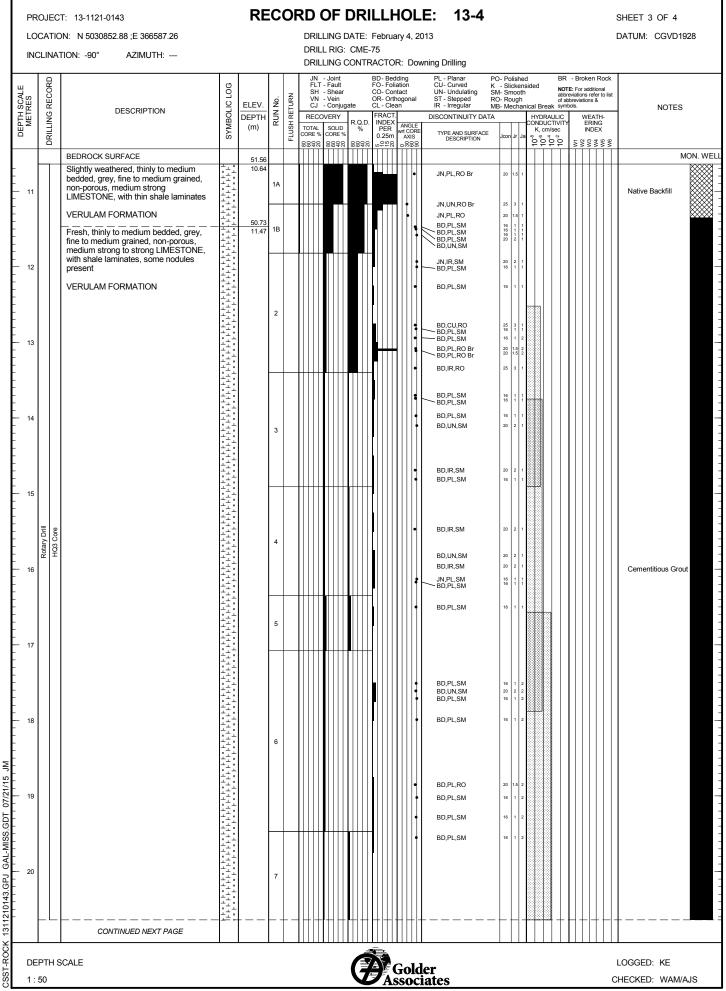
ſ	PF	ROJE	CT: 13-1121-0143	RI	ECO	RD	) OF	BORE	HOLE:	13-3				SHEET 2 OF 4
			ON: N 5030826.51 ;E 366567.39						ary 13, 2013					DATUM: CGVD1928
			ATION: -90° AZIMUTH: ER HAMMER, 64kg; DROP, 760mm					: CME-75 CONTRACT	DR: Downing D	Drilling	PENE	TRATION TE	EST HAMME	R, 64kg; DROP, 760mm
ľ	ш	DO	SOIL PROFILE		SAMP	LES	DYNAM	AIC PENETRA	TION		ULIC CONI k, cm/s	DUCTIVITY,		5
	DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT (m) (m)	NUMBER	BLOWS/0.3m	2	0 40 R STRENGTH	60 80 nat V. + Q - rem V. ⊕ U -	`10	<sup>-8</sup> 10 <sup>-6</sup>	TENT PERCE		PIEZOMETER OR STANDPIPE INSTALLATION
		ă		UII)		B	2	0 40	60 80	20	0 40	60 8	30	MON. WELL
	- 10		CONTINUED FROM PREVIOUS PAGE (ML) sandy SILT, some gravel, presence of cobbles and/or boulders inferred from auger resistance; grey, (GLACIAL TILL);											
		Power Auger	non-cohesive, wet, very dense		<u>14</u> SS	5 >50								
	- 11	Lon Lon	Borehole continued on RECORD OF DRILLHOLE 13-3	51.4										
	- 12													
	- 13													
	- 14													
	- 15													
	- 16													
	- 17													
ML G	- 18													
GAL-MIS.GUI 0//21/15	- 19													
1311210143.GPJ	- 20													
CSSI-SOIL 1		EPTH 50	SCALE		<u> </u>		I	<b>Ø</b>	Golder	<u>s</u>				Logged: Ke Checked: Wam/Ajs



Р	ROJE	CT: 13-1121-0143		RE	C	OF	RD	) (	)F	6	R	IL	.LI	Ю	C	_E:	13	3-3										SHEET 4	OF 4	
L	OCATI	DN: N 5030826.51 ;E 366567.39									ATE: CME			ary	13,	, 2013												DATUM:	CGVD19	28
11	ICLINA	.TION: -90° AZIMUTH:												R:	Do	owning Di	rilling													
DEPTH SCALE METRES	DRILLING RECORD		SYMBOLIC LOG	ELEV.	No.	TURN		JN - =LT - 3H - /N - CJ -	Shea	ar	te	C( OF	D- Be D- Fo D- Co R- Or Cle	ntac	t	CU- ( UN- I	Planar Curved Undula Steppe Irregula	itina	K - SM- RO-	Polisi Slick Smoo Roug Mech	ensid oth Ih		No ab of	OTE:	For ad ations	en Ro Iditiona refer t ns &	al		NOTES	
METH	DNIJ	DESCRIPTION	YMBOL	DEPTH (m)	RUN No.	FLUSH RETURN	RE TOT			, 	R.Q.D %		RACI NDE> PER	wit	NGLE COR	DISCO	NTINU	ITY DA	TA			HYDR DNDU K, cn	AULIC CTIVI n/sec	) TY	WE	EATH RING NDEX	l-		NOTED	
	DR	CONTINUED FROM PREVIOUS PAGE	ίο Ο			Ч	COR 88				3848	2 2	).25m S≘≌≲	1 A	XIS R85	Г	ESCRIP	SURFACE PTION		con Jr	Ja		10 <sup>2</sup>	2 5/97	<u> </u>	\$ ¥ \$	6M 9M		м	ON. WEL
-	Rotary Drill HO3 Core				8							I			•	BD,I	PL,SM	CL 2m	m	6 1	8							Cementi	ious Grou	
-	Rota	End of Drillhole	*_* *_* *_*	40.91 21.58						$\left  \right $				+										-						
- - 2: -	2	Notes: 1. The results of constant head packer tests are as follows: - 18.85 m to 21.58 m: K = 4x10 -6 cm/s																												
		<ol> <li>Falling head packer test results and slug test results are shown on the log above.</li> </ol>																												
- - - 2: -	3																													- - -
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- - - 24	L																													-
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- - - 2!	5																													
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1311210144.6PJ GAL-MIDS.GUI 0//2/13 JM																														
- 3 - 3 - 1 - 1 - 1	)																													- - -
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0	EPTH : 50	SCALE									G		Ì	Go	ole	der ciates					<b>.</b>		1					LOGGED: HECKED:		JS

PF	ROJEC	CT: 13-1121-0143		RE	C	OF	RD	OF BOREHOLE:	13-4	Sł	HEET 1 OF 4
		DN: N 5030852.88 ;E 366587.26 TION: -90° AZIMUTH:						RILLING DATE: February 4, 2013 RILL RIG: CME-75		DA	ATUM: CGVD1928
		R HAMMER, 64kg; DROP, 760mm						RILLING CONTRACTOR: Downing Dri	Iling PENETRATION TEST HAN	IMER,	64kg; DROP, 760mm
Ш Т.	ПОН	SOIL PROFILE	1.		SA	MPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	R₽	PIEZOMETER
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	20 40 60 80 SHEAR STRENGTH nat V. + Q € Cu, kPa rem V. ⊕ U C 20 40 60 80	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
— o		GROUND SURFACE (SM) SILTY SAND, trace to some	×××	62.20 0.00							MON. WELL
- - - - - - - - - - - - - - - - - - -		(SM) SILTY SAND, some gravel, non-cohesive (SM) SILTY SAND, some gravel, presence of cobbles and/or boulders inferred from auger resistance, trace mortar, glass, ash, brick fragments, and organic matter; grey to brown, (FILL); non-cohesive, moist, loose to compact		<u>61.79</u> 0.41		SS	20				Silica Sand
- - - - - 3					3	SS	53				Bentonite Seal
					4	SS	22				Silica Sand
- 4 - 4 	(tem)	- Becoming very dense below 3.81 m depth			5	SS	50				
- - - 5 - -	Power Auger 200 mm Diam. (Hollow Stem)	- Becoming wet at 4.88 m depth		56.87	6	SS	50				51 mm Diam. PVC
- - - - - - 6		(SM/ML) sandy SILT to SILTY SAND, some gravel, trace sand seams, presence of cobbles and/or boulders inferred from auger resistance; (GLACIAL TILL); non-cohesive, wet, very dense		5.33	7	SS	73				
					8	SS	50				
- 7 - 7 					9	SS	50				
					10	SS	89				Silica Sand
						SS SS					
		— — — — — — — — — — — — — — — — — — —			-13-	SS	50				
	<u> </u>		1								
-	EPTH \$ 50	SCALE						Golder			ogged: Ke Ecked: WAM/AJS

Р	RO	JEC.	T: 13-1121-0143		RE	C	OF	RD	) OF	во	REH	OLE	:	13-4					Sł	HEET 2 OF 4	
			DN: N 5030852.88 ;E 366587.26 FION: -90° AZIMUTH:						RILLING RILL RIG		Februar -75	y 4, 201	3						D	ATUM: CGVD	1928
			R HAMMER, 64kg; DROP, 760mm			_			RILLING	CONTR	RACTOF		ning Drilli	-				ST HAN	MMER,	64kg; DROP, 7	'60mm
Ш		ДОН	SOIL PROFILE			SA	MPL		DYNAI RESIS	MIC PEN TANCE,	ETRATIC BLOWS	ON /0.3m	Ì,	HYDRA	AULIC CO k, cm/s	ONDUCT	IVITY,		NG	PIEZOME	ETER
DEPTH SCALE METRES		BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		L R STREI	l NGTH r	iat V. +	30	W	0 <sup>-8</sup> 10 ATER C0		PERCE	0 <sup>-2</sup> NT WI	ADDITIONAL LAB. TESTING	OR STANDF INSTALL4	PIPE
_		8	CONTINUED FROM PREVIOUS PAGE	S	( )			-	2	20 4	40 E	3 Oi	30	2	0 4	06	3 0	30			MON. WELL
- 11 - - -	Power Auger																				
-	<u>a</u>		Borehole continued on RECORD OF	922	51.56															Native Backfill	-
- 1			DRILLHOLE 13-4																		-
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	FPI	тн 9	GCALE	•	•					A	<u></u>			•					<u>ــــــــــــــــــــــــــــــــــــ</u>	DGGED: KE	
<u>.</u>	: 50									G		folde socia	er ates							ECKED: WAM	I/AJS



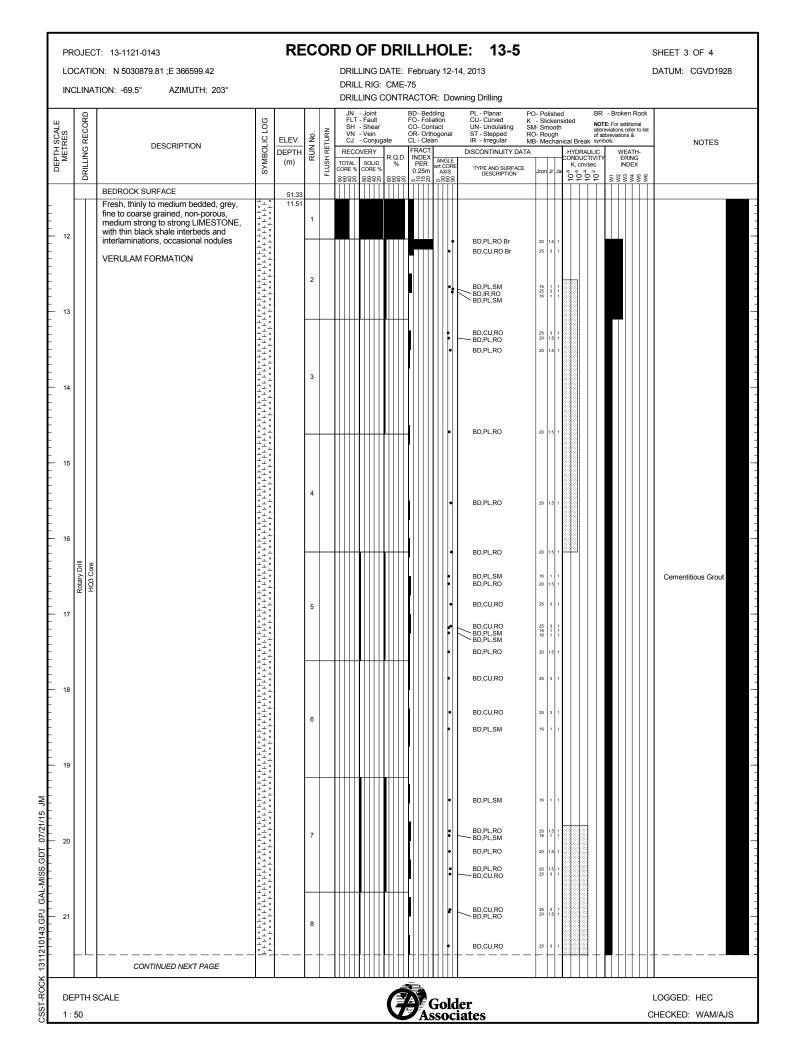
1311210143.GPJ GAL-MISS.GDT 07/21/15

CSST-ROCK

	PRO	OJEC.	Т: 13-1121-0143		RE	C	O	RD	) (	DF	: [	DR	IL	_Lŀ	łC	)L	E:	1	3-4	ŀ									S	SHEET 4 OF 4	
			N: N 5030852.88 ;E 366587.26									ATE: CME		ebrua 5	ary 4	4, 2	2013												C	DATUM: CGVD1	928
			AZIMOTH		1	-	1					ONT						g Drillin PL - Plan	-	PC	)- Pol	isher	4		BR	- B	roker	n Roc	.k		
DEPTH SCALE	MEIKES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RE TOT	ECO	She Veir Con	ar 1 ijuga Y	ite R.Q.E	C C C	D - Beo O - Fol O - Cor R - Ort L - Cle RACT INDEX PER	ntact hogo an			PL - Plan CU- Curv JN- Undu ST - Step R - Irreg SCONTIN	ulating ped ular NUITY D	K SN RC ME	- Slic - Slic - Sm - Rou - Rou - Me	ckens looth ugh	ical E HYI CONI		NO abb of a sym JLIC TIVIT	TE: Fo reviation bbrevi nbols.	or addit ons ref	tional fer to l &		NOTES	5
Ω		DRII		S			FLL	COR		CORE 885		884		0.25m දෙදෙකු	A	XIS SGG		TYPE ANI DESC	D SURFA RIPTION	CE	Jcon	Jr Ja		0 2 2 4				W5	W6		MON. WEL
- - - - - -	21	Rotary Drill HQ3 Core	CONTINUED FROM PREVIOUS PAGE Fresh, thinly to medium bedded, grey, fine to medium grained, non-porous, medium strong to strong LIMESTONE, with shale laminates, some nodules present VERULAM FORMATION	× ↓ × ↓ × ↓ × ↓ × ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓		7										•		BD,PL,R	:0		20	1.5 2								Cementitious Gro	
-	╞		End of Drillhole	+ <u>+</u> * +-**	40.60 21.60								ł			•		BD.PL.S	M		16	1 2									
- :	22		Notes: 1. The results of constant head packer tests are as follows: - 16.57 m to 21.60 m: K = 4x10 -5 cm/s 2. Falling head packer test results and																												-
:	23		slug test results are shown on the log above.																												-
	24																														-
- :	25																														-
	26																														-
	27																														-
	28																														-
21/15 JM																															
- MISS.GDT 07/2	29																														-
1311210143.GPJ GAL-MISS.GDT 07/21/15 JM	30																														-
ST-ROCK	DEF 1 : 5		CALE									G	7	<b>X</b>	 Go	)) blc bc	ler iat	es												.ogged: ke Hecked: Wam	AJS

PF	ROJ	DJECT: 13-1121-0143		RE	CO	RD	) OF	BO	REH	OLE	: '	13-5					SI	HEET 1 OF 4
		CATION: N 5030879.81 ;E 366599.42						DATE:		y 12-14	, 2013						D	ATUM: CGVD1928
		LINATION: -69.5° AZIMUTH: 203° IPLER HAMMER, 64kg; DROP, 760mm						CONTF		: Down	ing Drill	ing	PEN	NETRAT	TION TE	ST HAN	MMER,	64kg; DROP, 760mm
ш		SOIL PROFILE			SAM	PLES	DYNA	VIC PEN TANCE,	ETRATIO	0N 0.3m	ì	HYDRA	AULIC CO k, cm/s	ONDUCT	IVITY,		. (7)	
DEPTH SCALE METRES		O SOIL PROFILE UN DESCRIPTION	LOT		с	.3m					10	10			0 <sup>-4</sup> 10	0 <sup>-2</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER
EPTH MET				ELEV. DEPTH	NUMBER	BLOWS/0.3m	SHEAI Cu, kP	R STREN a	lGTH r	at V. + em V.⊕	Q - ● U - O		ATER CO				ADDIT AB. TE	STANDPIPE INSTALLATION
		BO	STR	(m)	z	BLO	2	0 4	0 6	0 8	0		0 4			0	<u> </u>	
— o	_	GROUND SURFACE Overburden - Not Sampled		62.11 0.00		-												
	Power Auger	v Stem)		0.00														Cementitious Grout
		CONTINUED NEXT PAGE																
5	EPT : 50	PTH SCALE 0						Q	<b>D</b> As	- olde socia	er ates							DGGED: HEC ECKED: WAM/AJS

F	PRO	OJEC	CT: 13-1121-0143		RE	С	OF	RD	OF	во	REH	IOLE	: ·	13-5					Sł	HEET 2 OF 4
			DN: N 5030879.81 ;E 366599.42						RILLING			ry 12-14	, 2013						D	ATUM: CGVD1928
			TION: -69.5° AZIMUTH: 203° R HAMMER, 64kg; DROP, 760mm						RILL RIG			R: Dowr	ning Drill	ing	PEI	NETRAT	FION TE	EST HAI	MMER,	64kg; DROP, 760mm
щ		ДŎ	SOIL PROFILE			SA	MPL	ES	DYNAM RESIS	/IC PEN TANCE,	IETRATIO BLOWS	ON /0.3m	ì	HYDR	AULIC Co k, cm/s		TIVITY,		٥	
DEPTH SCALE METDES		BORING METHOD		гот		ШR		0.3m	2		1		30		0 <sup>-8</sup> 1			0-2	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE
DEPTH		RING	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	TYPE	BLOWS/0.3m	SHEAF Cu, kP	R STREM a	NGTH r	nat V. + rem V.⊕	Q - ● U - ○		ATER C		PERCE		ADDI AB. T	INSTALLATION
		BO		STF	(m)	2		В	2	0 4	40 6	50 E	30					30		
- 1	0	ger	CONTINUED FROM PREVIOUS PAGE Overburden - Not Sampled			-														
-		Power Auger																		
E		8	-																	
-		Drill																		
	1	Rotary Drill HQ3 Core																		
-					51.33															
-			Borehole continued on RECORD OF DRILLHOLE 13-5																	
Ē	2																			-
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2 [			SCALE							G		Golde	er							DGGED: HEC
۲ ک	1:5	JU								- V	🗲 AS	SUCI	ales						UH	ECKED: WAM/AJS



PF	ROJE	ECT:	13-1121-0143		RE	С	OF	RD	0	F	D	RI	LI	LH	10	)LI	E: 13-5										:	SHEET 4 OF	4	
			N 5030879.81 ;E 366599.42					DR	ILL I	RIG	: Cl	ME-	75				4, 2013										l	DATUM: CG	VD1928	
					1				ILLII N - J T - F		COI			TOF Bede Folia			PL - Planar CU- Curved	PC	)- Poli	shed			BR	- B	roke	en Ro	ock			
DEPTH SCALE METRES	DRILLING RECORD		DESCRIPTION	SYMBOLIC LOG	ELEV.	N	TURN	SI	H - S N - V	Shear			CO- OR-	Con Orth Clea	act ogor		UN- Undulating ST - Stepped IR - Irregular	RC	- Slic I- Sm )- Rou 3- Med	igh		reak	abb of a	reviati bbrev	or add ons re iations	efer ti	al o list	NO	TES	
DEPTH MET	UN I		DESCRIPTION	YMBOI	DEPTH (m)	RUN No.	FLUSH RETURN	RE TOTA CORE		ERY Solid Ore %		Q.D. %	INI P	ACT. DEX ER 25m	ANC wrt C AX	SLE ORE	DISCONTINUITY DA		loon			cm/s	ec	Y	WE. ER	ATH RING DEX	-			
			CONTINUED FROM PREVIOUS PAGE				u.	884	8 8	848	88	848	92 92	202	<u></u>	88	DESCRIPTION				10 <sup>°</sup>	⊇ <u>þ</u>	9	W1	<u>8</u> 3 83	W4	9M			
È		fi	resh, thinly to medium bedded, grey, ne to coarse grained, non-porous, aedium strong to strong LIMESTONE	× + × × + × + + ×		8																								
- - 22 -	Rotary Drill	w g g Core ir	nedium strong to strong LIMESTONE, vith thin black shale interbeds and iterlaminations, occasional nodules	* + * + + * + + * + + *		Ů																						Cementitious	Grout	-
Ē	Rot	<sup>₽</sup> v	ERULAM FORMATION	× 4 × × 4 × × 4 × × 4 × 4 × 4 × 4 × 4 ×		9																								
Ē	$\vdash$	╞	nd of Drillhole	±± ×	40.85 22.70										+															
23 		1	lotes: . The results of constant head packer ests are as follows:																											-
Ē		-	19.80 m to 22.70 m: $K = 5x10 - 5$ cm/s																											
- - - 24		fo h	value of the second sec																											-
Ē		3 a	. Other falling head packer test results re shown on the log above.																											
— 25 -																														-
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	EPTH	H SCA	ALE								1	Ì				14	er iates											LOGGED: HE	EC	
3 1:	50											Z	J	As	SC	Ci	iates										С	HECKED: W	AM/AJS	6

	PR	OJEC	T: 13-1121-0143		RE	EC	OF	RD	O OF BOREHOLE:	13-6	S	HEET 1 OF 4
			DN: N 5030907.61 ;E 366614.54 TION: -90° AZIMUTH:						RILLING DATE: February 8, 2013 RILL RIG: CME-75		D	ATUM: CGVD1928
		MPLE	R HAMMER, 64kg; DROP, 760mm								/MER,	, 64kg; DROP, 760mm
ALE	s	тнор	SOIL PROFILE	F	-	SA	MPL		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ING	PIEZOMETER
DEPTH SC	METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	20 40 60 80 SHEAR STRENGTH nat V. + Q. ● Cu, kPa rem V. ⊕ U - ○ 20 40 60 80	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
_	0		GROUND SURFACE		61.95						<u> </u>	MON. WELL
	0 · · 1 2 3	Power Auger         Dower Auger           200 mm Diam. (Hollow Stem)         BO	(SM) SILTY SAND, some gravel; brown, (FILL); non-cohesive (SM) SILTY SAND, trace gravel, mortar, ash, brick, and glass fragments; grey brown, (FILL); non-cohesive, dry, very loose to very dense (SP) SAND, fine to medium, trace gravel, brick, ash, and mortar, some low plasticity fines; brown, (FILL); non-cohesive, moist, dense (SM) SILTY SAND, some gravel, trace brown medium to coarse sand seams, presence of cobbles and/or boulders inferred from auger resistance, grey brown, (GLACIAL TILL); non-cohesive, wet, dense to very dense				55 55 55 55 55 55 55	3 64 49 >50 53 53 66 >50				Silica Sand
210143.GPJ GAL-MIS.GDI 07/21	9						SS	>50 >50				
1311			CONTINUED NEXT PAGE									
	DEI 1: {		SCALE						Golder			ogged: Ke Iecked: WAM/AJS

	PR	OJE	CT: 13-1121-0143		RE	ECC	R	D	OF	во	REH	OLE	E: '	13-6					SI	HEET 2 OF 4	
			ION: N 5030907.61 ;E 366614.54 ATION: -90° AZIMUTH:						ILLING ILL RIG		Februa	ry 8, 20 <sup>-</sup>	13						D	ATUM: CGVD1	1928
			ATION: -90° AZIMUTH: ER HAMMER, 64kg; DROP, 760mm									R: Dowr	ning Drill	ing	PEI	NETRAT	ION TE	ST HAN	/MER,	64kg; DROP, 7	60mm
	ų	ДŎ	SOIL PROFILE			SAM	PLE	s	DYNAM RESIS	IC PEN	ETRATIO	DN /0.3m	ì	HYDRA	ULIC Co k, cm/s	ONDUCT	IVITY,		ں _	DIFTON	
	METRES	BORING METHOD		гот		R.		.3m	2	0 4	10 E	i0 8	80	10	<sup>-8</sup> 1	D <sup>-6</sup> 10	)-4 1	0-2	ADDITIONAL LAB. TESTING	PIEZOME OR STANDP	
E C		RING	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER		BLOWS/0.3m	SHEAF Cu, kP	R STREM	NGTH r	at V. + em V. €	Q - O			ONTENT			ADDIT AB. TE	INSTALLA	
	ב	BO		STR	(m)	z	i	BLO	2	0 4	10 E	i0 8	80	20		0 6		30	Ľ		
	10		CONTINUED FROM PREVIOUS PAGE	6757			+	_													MON. WELL
Ē			brown medium to coarse sand seams, presence of cobbles and/or boulders			13 5	s 4	42												Silica Sand	
Ē		Power Auger																			- 44
F		Powe	<ul> <li>inferred from auger resistance; grey</li> <li>brown, (GLACIAL TILL); non-cohesive,</li> <li>wet, dense to very dense</li> </ul>			14 5	s :	33												Bentonite Seal	
F	11				50.80															Silica Sand	- - - -
E			Borehole continued on RECORD OF DRILLHOLE 13-6																		
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	ECT: 13-1121-0143 FION: N 5030907.61 ;E 366614.54		RE	C	OF												LI , 20	E: 13-6	•							SHEET 3 OF 4 DATUM: CGVD1	1928
	IATION: -90° AZIMUTH:					D	RIL	L	RI	G:	С	ME	-75	5	-			ning Drilling							I	DATOM. COVD	1920
METRES DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RI TO COF	JN FLT SH CJ EC EC	- J - F - S - \ - \ OVE	Ioin Faul Shei Zon Con ERN SOLI	it ar ijug Y ID	ate R	.Q.D %	BE FC CC OF CL D. II	0 - B0 0 - F0 0 - C0 C1 RAC NDE PEF 0.25r	eddir oliatio ontao rthog lean T. X A wr	ng on ct gona	al LE DRE S	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY D TYPE AND SURFA DESCRIPTION	K S R M	O- Polisł - Slicke M- Smoc O- Roug IB- Mech	nsided th anical Bre HYDR CONDU K, cr	NOT abbr of at ak sym AULIC CTIVITY	E: For eviation boreviation	ken Ro additiona s refer t ions & VEATH ERING INDEX	ial to list H-	. NOTES	6
	BEDROCK SURFACE		50.80			88	40	80	384	58 FR	00	848	2	,92 2 2 2 2 2			58					Ī	33	\$ \$ \$	\$ \$		MON. \
12	Fresh, thinly to medium bedded, grey, non-porous, medium strong to strong, fossiliferous LIMESTONE, with thin shale interbeds and interlaminations, occasional nodules VERULAM FORMATION	×	. 11.15	1														BD,IR,RO BD,IR,SM BD,PL,SM BD,PL,SM BD,PL,SM BD,CU,SM BD,CU,SM BD,PL,SM BD,PL,SM BD,PL,SM		25 3 20 2 16 1 16 1 20 2 20 2 20 2 16 1 20 2 20 2 16 1 20 2 16 1 20 2						Silica Sand 51 mm Diam. PV #10 Slot Screen	
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PF	ROJEC	DT: 13-1121-0143		RE	C	OF	RE	) (	0	F	D	RI	L	Lł	Н	DL	_E: 13-6	6										;	SHEET 4 OF 4
LC	CATIO	DN: N 5030907.61 ;E 366614.54													ary	8, 2	2013											I	DATUM: CGVD1928
IN	CLINA	TION: -90° AZIMUTH:										ME- NTF			R:	Do	wning Drilling												
	RD		U					JN FLT	- Fa	ult			BD FO	- Be - Fol	ddin liatio	g n	PL - Planar CU- Curved	ĸ	)- Pol - Slid	kon	ohia	d			- Bro				
DEPTH SCALE METRES	DRILLING RECORD		SYMBOLIC LOG	ELEV.	N	URN	· ·	SH VN CJ	- Ve	ein	ate		CO OR	- Co - Ort - Cle	ntac thog	t	UN- Undulating	SM RC MF	- Slid I- Sm D- Ro B- Me	iooth ugh char	n nical	Bre	ak s	abbre of abb	E: For viatio previa ols.	ns rel itions	fer to	list	NOTES
PTH (	I SNI-	DESCRIPTION	ABOL	DEPTH	RUN No.	FLUSH RETURN	R	ECC	OVEF	٦Y	- R	Q.D.	FF IN	RACT		NGLE	DISCONTINUITY E	DATA			-coi	YDR. NDU	AULI CTIV	IC /ITY	,	WEA ERI	ATH- ING		NOTES
DE	DRILL		SYA	(m)		FLUS	COF	TAL RE %	CO	DLID RE % 응우응	•	29400 29400	0.	PER .25m 문원 없	wrt	CORE	E TYPE AND SURFA	ACE	Jcon	Jr Ja		K, cn	n/sec	:	1 M	IND	)EX		
		CONTINUED FROM PREVIOUS PAGE						40	00	1		140				1	0				Í				>>		$\overline{ }$		MON. WELI
E					8																								Cementitious Grout
-		End of Drillhole	<u>_</u>	40.44 21.51			$\left  \right $								╈					+									
- - - - - - - - - - - -		Notes: 1. Falling head packer test results and slug test results are shown on the log above.																											
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THE ROBERT M. BUCHAN DEPARTMENT OF MINING

Goodwin Hall Queen's University Kingston, Ontario, Canada K7L 3N6 Tel 613 533-2230 Fax 613 533-6597

April 29, 2013

Mr. Stephen Dunlop Golder Associates Limited 32 Steacie Drive Kanata, ON K2K 2A9

Re: Golder Ottawa CSST Project #13-1121-0005

Dear Mr. Dunlop:

Ten core specimens were received in a single shipment from which nine unconfined compression and nine Brazilian indirect tensile strength assessments were made.

The unconfined test specimens, of adequate received length, were subjected to a process of preparation that included:

-diamond sawing to prepare cylindrical samples having parallel end faces -diamond lathing, to prepare sample faces parallel to within  $\pm 0.025$  mm -testing to failure within a servo-controlled compression frame

Test results are tabled, photographs of pre- and post-test specimens are illustrated, and a summary billing statement for work that has been completed are included with this report.

Yours sincerely,

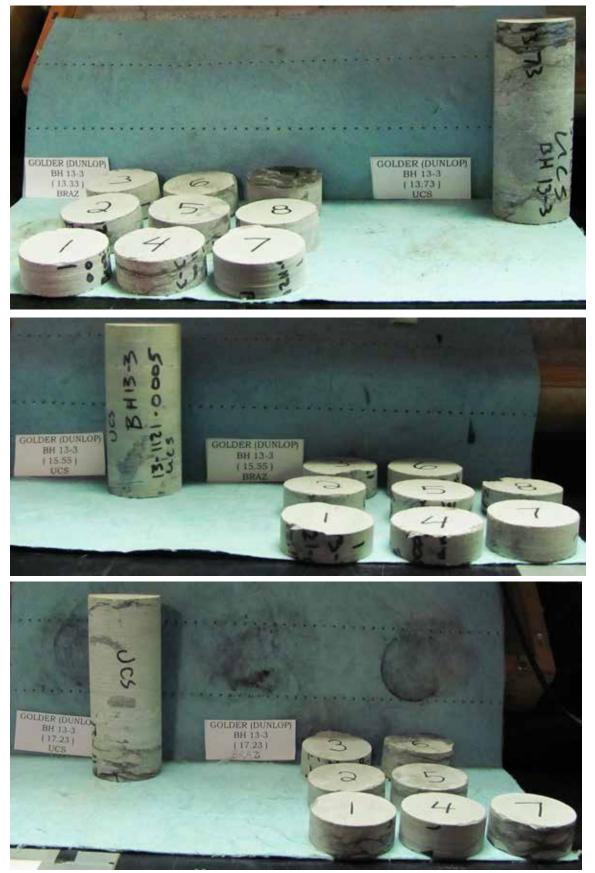
J. F. Archibald, Ph.D., P. Eng., FCIM

Sample Hole	Density	UCS	Young's	Poisson's	Brazilian Indirect Tensile
(depth)			Modulus	ratio	Strength
					(and range)
	$(g/cm^3)$	(MPa)	(GPa)	(μ)	(MPa)
13-3 (13.33-13.64 m)					7.8 (4.7-9.2)
13-3 (13.73-14.02 m)	2.70	48.0	20.532	0.21	
13-3 (15.55-16.02 m)	2.70	28.8 (pf)	12.168	0.15	9.1 (6.2-10.8)
13-3 (17.23-17.61 m)	2.70	44.6 (f)	18.243	0.12	9.6 (7.4-11.9)
13-4 (12.42-12.77 m)	2.70	51.1	19.466	0.12	9.6 (8.3-12.2)
13-4 (14.10-14.47 m)	2.70	43.4 (pf)	20.143	0.14	8.4 (5.4-12.0)
13-4 (16.53-16.86 m)	2.68	18.5 (pf)	14.221		9.5 (7.3-11.5)
13-6 (12.11-12.47 m)	2.69	32.7 (pf)	8.792		8.0 (6.1-10.3)
13-6 (14.97-15.31 m)	2.70	63.9 (pf)	36.749	0.13	7.3 (5.5-10.3)
13-6 (16.47-16.77 m)	2.70	35.0 (pf)	12.385	0.16	7.1 (5.9-8.1)

Sample Failure Test Results (Ottawa CSST Project #13-1121-0005) – April, 2013

(pf) – indicates that sample failure occurred partially along pre-existing foliation surface (f) - indicates that sample failure occurred entirely along pre-existing foliation surface

# **Photographs of Pre-Test Samples**







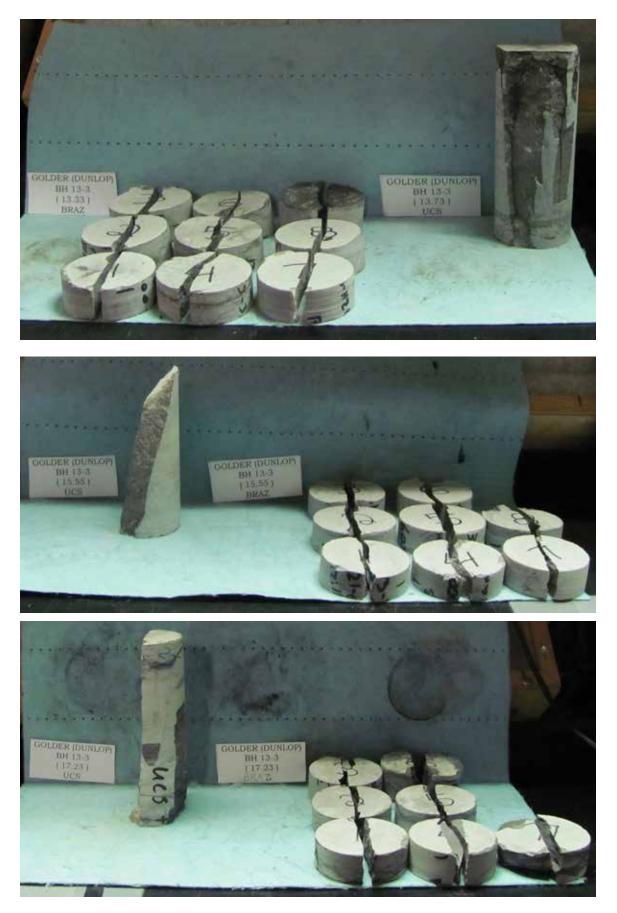








# **Photographs of Post-Test Samples**















PF	ROJ	ECT	Г: 13-1121-0143		REC	co	RI	D	of Bor	EHC	DLE:	14	<b>1-60</b>	1				SH	HEET 1 OF 3
			N: N 5030901.52 ;E 366634.38								ber 26-2	7, 2014						DA	ATUM: CGVD1928
			'ION: -90° AZIMUTH: R HAMMER, 64kg; DROP, 760mm						RILL RIG: CME		R: Marat	hon Dril	ling	PE	NETRA	TION TE	ST HAN	/MER,	64kg; DROP, 760mm
щ	4	p p	SOIL PROFILE			SA	MPL	ES	DYNAMIC PEN RESISTANCE,	ETRATIO	DN /0.3m	~	HYDR/	AULIC C k, cm/s	ONDUCT	TIVITY,		_ <u>0</u>	PIEZOMETER
DEPTH SCALE METRES				PLOT	ELEV.	ER		0.3m	20 4			i0		L			0-2	ADDITIONAL LAB. TESTING	OR STANDPIPE
DEPTF		אואכ	DESCRIPTION	STRATA PLOT	DEPTH	NUMBER	TYPE	BLOWS/0.3m	SHEAR STREN Cu, kPa	GTH r	at V. + em V.⊕	Q - ● U - ○				PERCE	NT WI	ADDI LAB. T	INSTALLATION
_		ň	GROUND SURFACE	STI	(m)			BL	20 4	06	8 0	0					30		
0 	-		FILL - (GW) gravelly SAND, angular;	***	62.34 8:89			_											-
-			\grey FILL - (SM/GM) SILTY SAND and GRAVEL; brown, with cobbles and ash;																-
-			non-cohesive, moist, compact RDR = 2-3																-
- - - 1																			-
-						1	SS	22											-
-			(SM) SILTY SAND, fine; dark brown		60.82														-
-			(BURIED TOPSOIL); non-cohesive, moist		1.58	2	SS	13											-
_ 2		w Stem)	(SM) gravelly SILTY SAND, 20-40% low to medium plasticity fines; grey brown to																-
-	Power Auger	n. (Hollow	grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense			3	SS	>50											-
-	Powe	mm Diam.	RDR 3 - ≥ 5																-
- 3		200 m																	-
-	3 N 4 SS 78																		
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4 						5	SS	>50											-
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Р	RO	JEC	T: 13-1121-0143		REC	co	R	D	of e	OR	EHC	DLE:	14	4-60 <sup>-</sup>	1				Sł	HEET 2 OF 3
			0N: N 5030901.52 ;E 366634.38 TION: -90° AZIMUTH:						RILLING I RILL RIG:			oer 26-2	7, 2014						D	ATUM: CGVD1928
			R HAMMER, 64kg; DROP, 760mm						RILLING			: Marat	hon Dril	ling	PEI	NETRA	TION TE	ST HAN	MMER,	64kg; DROP, 760mm
Ш		ПОН	SOIL PROFILE	1.		SA	MPL	ES	DYNAM RESIST	IC PEN ANCE,	ETRATIO BLOWS	0N 10.3m	~	HYDR/	AULIC Co k, cm/s	ONDUCT	FIVITY,		AL NG	PIEZOMETER
H SCA TRES		3 MET		PLOT	ELEV.	ER	ш	/0.3m	20						I		1	0-2	TION	OR STANDPIPE
DEPTH SCALE METRES		BORING METHOD	DESCRIPTION	STRATA PLOT	DEPTH (m)	NUMBER	түре	BLOWS/0.3m	SHEAR Cu, kPa		igih r	at V. + em V.⊕	U - O		ATER C				ADDITIONAL LAB. TESTING	INSTALLATION
	-	ā	CONTINUED FROM PREVIOUS PAGE	ST	(11)			BI	20	) 4	06	8 0	0	2	20 4	06	30 E	30		
- 10 -		2 5	(SM) gravelly SILTY SAND, 20-40% low																	
F	Moch Boring	HW Casing	to medium plasticity fines; grey brown to grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, moist,																	-
Ē	20/01	H	(GLÁCIAL TILL); non-cohesive, moist, compact to very dense RDR 3 - ≥ 5			10	ss	>50												-
- 1	1																			-
Ē																				-
F						11	RC	DD												-
Ē																				-
- 1:		HQ3 Core																		-
Ē	400	Ŭ Ŭ				12	SS	>50												-
Ē																				-
-						13	RC	DD												-
- 1: -	5																			-
Ē		-	Borehole continued on RECORD OF	12	48.91															-
-			DRILLHOLE 14-601																	-
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PR	OJI	ECT	·: 13-1121-0143		REC	0	R	D	0	F	D	R	ILI	∟⊦	łC	)L	E:	14-60	01								s	HEET 3 OF	3
			N: N 5030901.52 ;E 366634.38 ION: -90° AZIMUTH:					D	RIL	L RI	G:	CN	1E 8	50			26-27, 20 Narathon I										D	ATUM: CGV	D1928
DEPTH SCALE METRES			DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	R TO COF	JN FLT SH VN CJ	- Joir - Fau - She - Vei - Cor VER	nt ult n njuga Y LID E %		1.D.	3D- E :0- F :0- ( :0- (	Beddi Foliat Conta Drtho Clean CT EX R w	ing ion act gona	All PL - CU- UN- IR - DISCO	Planar Curved Undulating Stepped Irregular NTINUITY I	K SI R( M DATA	D- Po - Slie M- Sm D- Ro B- Me	ckens hooth ugh	nical E HY CON	NOT abbr of at symi JLIC TVITY iec	E: For eviatio brevia bols.	additions refe tions & WEA <sup>*</sup> ERIN INDE	TH-	st	NOT	ES
- - - - - - - - - - - -			BEDROCK SURFACE Fresh, thinly to medium bedded, dark grey, fine to medium grained, non-porous, medium strong LIMESTONE, with black shale partings, interlaminates and thin interbeds. Occasional nodular intervals (~5-10% shale) VERULAM FORMATION	+ + + × + × + × + × + × + × + × + × + ×	48.91 13.43	1	100											PL,RO IIR,RO PL,RO PL,RO PL,RO PL,RO PL,RO PL,SM IIR,SM CU,SM PL,RO PL,SM		20 16 25 20	1.5 1 3 1 1.5 1 1.5 1 1.5 1 1.5 1 1.5 1 1 1 3 1 2 1 2 1 1.5 1 1.5 1 1 1 1 1 1 1								
- - - - - - - - - - - - - - - - - - -	Rotary Drill	HQ3 Core	- Broken core from 15.89 m to 15.93 m - Broken core from 16.14 m to 16.17 m - Broken/lost core from 16.30 m to	× + × + × + × + × + × + × + × + × + × +	45.88	2	100											CU,RO IR,RO PL,RO CU,RO CU,RO PL,RO PL,RO PL,RO PL,RO PL,RO PL,RO JN,RO JN,RO PL,RO PL,RO PL,RO		20 25 20 20 25 20 25 20 20 20 20 25 25 25 20 20 20 20 20 20 20 20 20 20 20 20 20	3 1 1.5 1 3 1 1.5 1 3 1 1.5 1 3 1 1.5								
- - - - - - - - - - -			16.33 m End of Drillhole	<u> </u>	16.46												N'BD	PL,RO PL,RO PL,RO PL,RO											
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- 21 - 22 - 22 - 23 - 23																													
		-IS	CALE										Ĩ		G		lder											OGGED: HE	

		rion: -90° Azimuth: R HAMMER, 64kg; DROP, 760mm		,			RILL RIG: Port RILLING CONT	FRACT	DR: Mara	athon Dri	-				EST HA	AMMER,	64kg; DROP, 760m
	BORING METHOD	SOIL PROFILE		ELEV.	NUMBER	ш	20 SHEAR STRE	RESISTANCE, BLOWS/0.3m					ONDUC 0 <sup>-6</sup> 1  ONTEN	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION		
	BORIN		STRAT	DEPTH (m)	NN F		Cu, kPa 20	40		9 U- () 80			+0 W		WI 80	AD	into intel thiol
_		GROUND SURFACE		63.00			20	40	00	00			+0	50	00		
0		FILL - (SP) SAND, some gravel; brown, with cobbles; non-cohesive, moist,		0.00													
		compact			1 S	S 29											
		FILL - (SM) SILTY SAND, some gravel;		62.39 0.61													
		brown, with mica, organic matter and cobbles; non-cohesive, moist, compact			2 S	S 10											
1																	
				ſ													
					3 S	S 11											
2					4 S	S 19											
				60.56													
		(SM) gravelly SILTY SAND, 20-40% low to medium plasticity fines; grey brown,		2.44	5 S	S >5											
		with cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet, very		ŀ													
3		dense															
					6 S	S 52											
4																	
					7 R												
	ĝ																
	Portable Drill - Wash Boring NW Casing																
5	ill - Wash Casing																
	ble Dril				8 S	S >5											
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			DN: N 5030915.66 ;E 366656.86								ber 28 -	Decemb	per 3, 2014				DA	ATUM: CGVD1928
			TION: -90° AZIMUTH: R HAMMER, 64kg; DROP, 760mm					RILL RIC RILLING			R: Marat	hon Dril	lling PE	NETRAT	TION TE	ST HAN	IMER,	64kg; DROP, 760mm
ш		QO	SOIL PROFILE			SAM	PLES	DYNA		ETRATIO	DN /0.3m	ì	HYDRAULIC ( k, cm/		IVITY,		. (7)	
DEPTH SCALE	X EX	BORING METHOD		LOT		۲	.3m					0			0 <sup>-4</sup> 10	0 <sup>-2</sup>	ADDITIONAL LAB. TESTING	PIEZOMETER
EPTH	MET	RING	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	BLOWS/0.3m	SHEA Cu, kF	R STREI Pa	NGTH r	at V. + em V.⊕	Q - ● U - O	WATER (				ABDIT AB. TE	STANDPIPE INSTALLATION
ā		BOF		STR.	(m)	ž	BLC		20 4	40 E	0 8	0				0	< ⊃	
-	10		CONTINUED FROM PREVIOUS PAGE (SM) gravelly SILTY SAND, 20-40% low	arke														
F			to medium plasticity fines; grey brown, with cobbles and boulders (GLACIA)															-
Ē		Core	TILL); non-cohesive, moist to wet, very dense															-
-		Portable Drill NQ3 Core																-
-	11																	-
-			Borehole continued on RECORD OF	- 11 P	51.70													-
Ē			DRILLHOLE 14-602															-
F	10																	1
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0			SCALE						G		- folde socia	r						DGGED: HEC
3	1:5	50							N N	🖊 AS	SOC18	ites					CH	ECKED: SD

LC	CA	TIO	<ul> <li>F: 13-1121-0143</li> <li>N: N 5030915.66 ;E 366656.86</li> <li>TON: -90° AZIMUTH:</li> </ul>		REC	0	RI	DF DF	RILLI RILL	NG RIG	DA i: P	TE: Porta	Nc ible	overr Drill	iber :	28 -	<b>14-60</b> December 3, 20 thon Drilling										Sheet 3 of 3 DATUM: CGVD1928
DEPTH SCALE METRES		DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	S V C RE TOT/ CORE	J - ( COV	Shea Vein Conji ERY SOLIE	r ugate	2.Q.D.	CO OR CL FF IN F	- Bed - Folia - Con - Orth - Clea ACT. IDEX PER 25m	tact logona	LE DRE S	PL - Planar CU- Curved UN- Undulating ST - Stepped IR - Irregular DISCONTINUITY D TYPE AND SURFAC DESCRIPTION	K SI R M DATA	D- Polis - Slick M- Smo D- Roug B- Mecl	ension oth gh hanic		NO abb of a ak syn AULIC CTIVIT V/sec	Y	WEA WEA IND	tional fer to I & ATH- NG	list	NOTES
_			BEDROCK SURFACE Fresh, thinly to medium bedded, dark	*_* *_*	51.70 11.30												BD,PL,RO		20 1.5								
- - - - - - -			grey, fine grained, non-porous, medium strong LIMESTONE, with black shale partings, interlaminates and thin interbeds (~5% shale)			1	100										BD,PL,RO BD,PL,RO BD,PL,RO BD,PL,RO		20 1.8 20 1.8 20 1.8 20 1.8	5 1 5 1 5 1							
_ '2			VERULAM FORMATION																								
- - - - - - - - - - - - - - - - - - -	Portable Drill	NQ3 Core	- Broken core from 11.40 m to 11.50 m	+ + + + + × + × + × + × + × + × + × + ×		2	100						-			•	BD,PL,SM		16 1	1							-
- - - - - -						3	100									•-	— BD,CU,SM CI <1	1 mm	16 1 16 2	4							
-	-		End of Drillhole	*** * ** *	48.39 14.61								+								+			$\left  \right $	$\left  \right $		
- - - - - - - - - - - - - - - - - - -																											
- - - - - - 18 - -																											_
- - - - - - - - - - - - - - - - - - -																											
1311210143.GPJ GAL-MISS.GDI 07/17/15 JM																											
DE	EPT 50		CALE												Gol	lde ci:	er ates										LOGGED: HEC HECKED: AJS

PR	OJEC	T: 13-1121-0143		REC	co	RI	D	OF BC	REH	OLE:	14	4-60	3				SI	HEET 1 OF 2	
		DN: N 5030855.87 ;E 366544.85								ary 13, 20	15						D	ATUM: CGVD192	28
		TION: -90° AZIMUTH: R HAMMER, 64kg; DROP, 760mm						RILL RIG: CI RILLING COI		DR: Mara	thon Dril	lling	PE	NETRAT	TION TE	ST HAM	IMER,	64kg; DROP, 760	mm
щ	дo	SOIL PROFILE			SA	MPLI	ES	DYNAMIC F			,	HYDRA	AULIC C k, cm/s	ONDUCT	IVITY,		ō۲	PIEZOMETE	.D
DEPTH SCALE METRES	BORING METHOD		PLOT	ELEV.	ER		0.3m	20	40		B0		I	i	0 <sup>-4</sup> 10	) <sup>-2</sup>	ADDITIONAL LAB. TESTING	OR	
DEPTI-	ORING	DESCRIPTION	STRATA PLOT	DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR ST Cu, kPa	RENGTH	nat V. + rem V. ∉	Q - ● U - O					NT WI	ADDI LAB. T	INSTALLATIO	
	ā	GROUND SURFACE	ST			_	B	20	40	60 8	30				8 0			MC	ON. WELL
— 0 _		FILL - (SM) SILTY SAND, fine, trace gravel; dark brown, with organic matter;	***	61.41 0.00														Monument Casing	- 1
-		non-cohesive, moist RDR = 3			1	SS	33												- 20
-		- Blow count high due to frozen soil	/	60.80 0.61															- 200
- - - 1		FILL - (SM) SILTY SAND, fine, trace gravel; brown; non-cohesive, moist, loose			2	SS	5												
Ē		RDR = 2			2	55	э												88 -
Ē		FILL - (SM) gravelly SILTY SAND; dark		59.89 1.52															88 -
-		brown, with cobbles; moist, compact RDR = 2			3	ss	18												- 19
- 2																			88-
-																			- 88
Ē					4	ss	15												88 -
- 3		FILL - (SM) SILTY SAND, some gravel;		58.51 2.90															- 88
Ē		dark brown to black, with crushed stone and organic matter; moist, dense																	88 -
-		RDR = 2-3			5	SS	32												88 -
-	Stem)	(SM) groupilly SILTY SAND 20 40% low		57.60 3.81															- 88
- 4	Auger Hollow	(SM) gravelly SILTY SAND, 20-40% low to medium plasticity fines; brown to grey brown, presence of cobbles and/or		3.01		SS	22											Native Backfill and	
Ē	Power Auger Diam. (Hollov	boulders inferred from auger resistance (GLACIAL TILL); moist, compact to very																Bentonite	88 -
-	Power Auger 200 mm Diam. (Hollow	dense RDR = 3-4																	= 🛯
-	Ñ				7	ss	56												- 1
- 5 - -																			
Ē																			- 200
Ē					8	SS	65												- 88
- - 6				55.31															
-		(SM) gravelly SILTY SAND, 20-40% low to medium plasticity fines; grey,		6.10	9	SS	>50												- 1988
Ē		presence of cobbles and/or boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist, very dense																	88 -
Ē		RDR = 5																	
- 7 - -					10	SS	>50												
Ē																			88 -
-					11	ss	>50												- 1
- 8																			
-				53.03														Bentonite Seal	
		Borehole continued on RECORD OF DRILLHOLE 14-603																	
																			-
- 9 -																			
																			-
																			-
- 10																			-
DE	PTH	SCALE						(	Ŵ	Galda	er.						LC	OGGED: HEC	
1:	50								JA	Golde ssocia	ates						СН	ECKED: SD	

			T: 13-1121-0143 DN: N 5030855.87 ;E 366544.85		REC	0	R						L <b>HC</b> Januar			<b>: 14-60</b>	)3						SHEET 2 OF 2 DATUM: CGVD1928
			TION: -90° AZIMUTH:					DRI	ILL F	RIG:	СМ	E 5	i5	-		athon Drilling							
DEPTH SCALE	METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	SH VN CJ	COVE	hear 'ein Conjug	R.Q. %	.D.	BD- Bed CO- Foli CO- Cor DR- Ortf CL - Cles FRACT INDEX PER 0.25m	ation nogo an ANG wrt C A	1	PL - Planar CU - Curved UN - Undulating ST - Stepped IR - Irregular DISCONTINUITY D TYPE AND SURFAC DESCRIPTION	K S R N DATA	O- Polist M- Slicke M- Smoo O- Roug IB- Mech	enside h anical COl	d N	OTE: F bbrevia f abbre ymbols. C ITY	For add tions re viations WE/ ER INE	. NOTES
E	-		BEDROCK SURFACE Fresh, thinly to medium bedded, dark	*×	53.03 8.38																	+	MON. WELL
	9	Drill	grey, fine to medium grained, non-porous, medium strong LIMESTONE, with black shale partings, interlaminates and thin interbeds, occasional nodular intervals (~5-10% shale)	$\frac{1}{4}$ $\frac{1}$		1	100								• • •	JN,PL,RO BD,PL,SM BD,PL,SM BD,PL,VR		20 1.5 16 1 16 1 22 1.5	1 1 1				Bentonite Seal
	10	Rotary Drill NQ3 Core	VERULAM FORMATION - Broken core from 8.55 m to 8.66 m	+ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$ $+$		2	100								•	BD,PL,RO BD,PL,RO BD,PL,RO		20 1.5 20 1.5 20 1.5	1 1 1				Silica Sand 19 mm Diam. PVC Standpipe
Ē	ł		End of Drillhole	*** *** ***	51.05 10.36		_												+			+	
	11 12 13 14																						
17/15 JM	16																						
CSST-ROCK 1311210143.GPJ GAL-MISS.GDT 07/17/15 JM	17																						
CSST-ROCK	DEF 1:5		SCALE								(	Ż	<b>X</b>	Go	old oci	er ates							LOGGED: HEC CHECKED: AJS

F	PRO	DJEC.	T: 13-1121-0143		REG	CC	R	D	OF E	BOR	EHC	DLE:	14	4-60 <i>4</i>	4				Sł	HEET 1 OF 2
			N: N 5030851.90 ;E 366526.55						RILLING			/ 15, 201	5						DA	ATUM: CGVD1928
			rion: -90° Azimuth: R Hammer, 64kg; Drop, 760mm						rill Rig Rilling			R: Marat	hon Dril	ling	PEN	VETRAT	ΓΙΟΝ ΤΕ	ST HAN	IMER,	64kg; DROP, 760mm
	-		SOIL PROFILE			SA	MPL	ES	DYNAM		ETRATIO	DN (0.2m)	<u>\</u>	HYDR	AULIC CO	ONDUCT				-
DEPTH SCALE METRES	2	BORING METHOD		от				Ĕ	RESIS		BLOWS		i0 \	10	k, cm/s 0 <sup>-8</sup> 10		0-4 1	0-2	ADDITIONAL LAB. TESTING	PIEZOMETER OR
PTH S		NG M	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	SHEAF		IGTH r	nat V. +	Q - ●	W	ATER CO	L ONTENT	I PERCE	NT	DITIC 3. TES	STANDPIPE
DEP	-	BORI		TRA	DEPTH (m)	Ñ	Ĥ	BLOW	Cu, kPa			em V. ⊕			⊳ <b> </b>				LAE	
			GROUND SURFACE	0)	56.44			-	2	0 4	10 E	800	0	2	0 4	<u>о е</u>	80 8	30		
Ē	0		TOPSOIL/FILL - (SM) SILTY SAND; dark brown; moist		0.00															-
F			FILL - (SM) SILTY SAND, trace to some		56.13 0.31															-
Ē			gravel; brown, with metal wire; moist, very loose to loose																	-
-		Stem)	RDR = 1																	-
E	1	uger Hollow				1	SS	3												
-		Power Auger Diam. (Hollov																		-
-		Power Auger 200 mm Diam. (Hollow Stem)																		-
F		200				2	SS	5												-
F	2																			
F					50.00	3	SS	>50												-
Ē			Reinforced PORTLAND CEMENT CONCRETE (Retaining Wall Footing)		53.90 2.54															-
F			CONCRETE (Retaining Waii Footing)			4	RC	DD												-
F	3	_																		
-	1	Rotary Drill NQ3 Core					RC	DD												
Ē	1	Rota NQ:	(SM) gravelly SILTY SAND; grey, with		52.86 3.58		RC	DD												-
F			cobbles (GLACIAL TILL); non-cohesive, moist																	-
-	4						RC	DD												
-		-	Borehole continued on RECORD OF	KR I	\$ 52.10															-
F			DRILLHOLE 14-604																	-
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	10																			-
2																				
2	DEF	PTH S	CALE							Â		کما م							LC	OGGED: HEC
20 10	1:5	50								V	<b>7</b> As	- socia	ites						CH	ECKED: SD

	PR	OJEC	T: 13-1121-0143		REC	c	R	DO	OF	D	RI	LI	LH	0	LE	: 14-60	)4								SHEET 2 OF 2	
			DN: N 5030851.90 ;E 366526.55 TION: -90° AZIMUTH:					DR	ILL	RIG:	СМ	E 5													DATUM: CGVD1928	
		Ð		(1)					N - J LT - F		JON		BD- Beo			PL - Planar CU- Curved		)- Poli			BF	R - Br	oken	Rock		
SCALE	METRES	DRILLING RECORD		SYMBOLIC LOG	ELEV.	No.	TURN	SI VI	H - S N - N	Shear	ate	0	CO- Cor OR- Ort CL - Cle	ntac hog	:t	UN- Undulating ST - Stepped IR - Irregular	SN RC	- Slicl 1- Smo 2- Rou 3- Meo	ooth igh	ided cal Bre	abl of a	TE: For previation abbrevia mbols.	r additi ns ref itions i	ional er to list &	NOTES	
EPTH	METF	LLING	DESCRIPTION	MBOL	DEPTH (m)	RUN	FLUSH RETURN	TOTA	COVE	SOLID	- R.Q. %	.D.	FRACT INDEX PER		NGLE CORE AXIS		DATA			HYDR CONDU K, cn	AULIC		WEA ERIN	TH- NG EX		
		DRI		ŝ			FL	CORE		0RE % 889 %	889	56	0.25m ගුදි: දිසි	0	AXIS RGB	TYPE AND SURFAC DESCRIPTION	CE	Jcon J	lr Ja	10 <sup>°°</sup>		۶.		W 8		
-			BEDROCK SURFACE Fresh, thinly to medium bedded, dark	* × * ×	52.10 4.34	-								╈												
-			grey, fine grained, non-porous, medium strong LIMESTONE, with black shale partings, interlaminates and thin													BD,PL,SM BD,CU,RO		16 1 25 3	1 1							-
-	5	Rotary Drill NQ3 Core	interbeds, occasional nodular intervals (~5-10% shale)			1	0									22,00,110										-
-		Rota	VERULAM FORMATION	× × × × _ × _ ×												BD,CU,RO		25 3								-
-				+_ × + + × × + + + + ×	50.00											BD,CU,RO BD,PL,RO BD,PL,SM		20 1. 16 1								-
-	6		End of Drillhole	×	50.66 5.78									T												_
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7/15 .												$\left  \right  \right $														-
T 07/1												$\left  \right  \right $														-
SS.GD	13											$\left  \right  \right $														-
AL-MIS												$\left  \right  \right $														-
PJ G												$\left  \right  \right $														-
0143.G	14											$\left  \right  \right $														_
31121(												$\left  \right  \right $														-
CK 1																										
CSST-ROCK 1311210143.GPJ GAL-MISS.GDT 07/17/15 JM			SCALE									Ţ		G	old	er ates									LOGGED: HEC	
SO	1:	UC										U	• A	SS	<u>OCİ</u>	ates									CHECKED: AJS	

PROJECT: 1522242-3000

### RECORD OF BOREHOLE: 15-01

LOCATION: See Site Plan

BORING DATE: February 28, 2015

SHEET 1 OF 1

DATUM: Geodetic

L L L	DOH.	SOIL PROFILE			S/	AMPLI	ES	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s	NG	PIEZOMETER
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	20 40 60 80 HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [PPM] □ ND = Not Detected	10 <sup>-6</sup> 10 <sup>-5</sup> 10 <sup>-4</sup> 10 <sup>-3</sup> WATER CONTENT PERCENT Wp	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
	á	GROUND SURFACE	ST				ВГ	20 40 60 80	20 40 60 80	+	
0		FILL - (SW/SM) gravelly SAND, angular, some brown sand; grey; non-cohesive		62.18 0.00 61.42							
1		FILL - Mixture of SILTY SAND; black, orange brick, fly ash, gravel		0.76	1	ss				СНЕМ	
2		FILL - (SM) SILTY SAND, some gravel; non-cohesive, moist		60.66 1.52							
					2	SS	Æ				
3		FILL - Orange brick, fly ash, gravel (SM) SILTY SAND, some gravel; brown (GLACIAL TILL); non-cohesive, moist		59.13 3.05 3.20	3	ss	¢			CHEM	
4		,			ЗA	SS				СНЕМ	Bentonite Seal
5	Percussion Drill 105 mm Diam Casing				4	ss	¢				<u>.</u>
6		(SM) SILTY SAND, trace gravel; brown, trace cobbles and boulders (GLACIAL TILL); moist		56.08 6.10		ss	¢				
7		(SM) SILTY SAND, some gravel, trace silt; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive; moist to wet		55.17 7.01		ss	ŧ				
8											Silica Sand
9											51 mm Diam. PVC #10 Slot Screen
10		End of Borehole		52.43 9.75							W.L. in Screen at Elev. 57.645 m on March 9, 2015
DE	PTH	SCALE	_	L	1			Golder		LC	OGGED: HEC

PROJECT: 1522242-3000

### RECORD OF BOREHOLE: 15-02

LOCATION: See Site Plan

BORING DATE: February 28, 2015

SHEET 1 OF 1

DATUM: Geodetic

SPLE	тнор	SOIL PROFILE	⊢		SA	AMPL		HEADSPACE ORGANIC VAPC CONCENTRATIONS [PPM] ND = Not Detected 20 40 60	$\oplus$	HYDRAULIC CONDUCTIVITY, k, cm/s	ING	PIEZOMETER
METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH	NUMBER	ТҮРЕ	BLOWS/0.30m	HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS	80 [PPM] 🗌	10 <sup>6</sup> 10 <sup>5</sup> 10 <sup>4</sup> 10 <sup>3</sup> WATER CONTENT PERCENT Wp ├───── <sup>W</sup> I WI	ADDITIONAL LAB. TESTING	OR STANDPIPE INSTALLATION
ڏ	BOI		STR	(m)	z		BLO	ND = Not Detected 20 40 60	80	20 40 60 80		
0		GROUND SURFACE FILL - (SW) gravelly SAND, angular; grey		61.84 0.00								
1		FILL - (SP) SAND, fine; brown; non-cohesive, moist		60.32 1.52	1	ss	e	•				
3					2	SS	€	•			CHEM	
		FILL - Mixture of fine SAND orange		58.18 3.66	3 3A	ss ss	e				СНЕМ	Bentonite Seal
4	Casing	FILL - Mixture of fine SAND, orange brick; hydro carbon odour, black staining (SM) SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive, moist		57.88 3.96							OFILM	
	Percussion Drill 105 mm Diam. Casing	(GLÁCIAL TILL); non-cohesive, moist			4	SS		₽⊕			CHEM	
5					4A	ss	€	•				Ÿ
6					5	SS		⊕		7150		Silica Sand
7		(SM) SILTY SAND, trace gravel, trace coarse sand; (GLACIAL TILL); non-cohesive, moist to wet		<u>55.21</u> 6.63	5A	ss	e	• •				
8					6	SS	6	9		Jaco	СНЕМ	51 mm Diam. PVC #10 Slot Screen
				53.31								Silica Sand
9		End of Borehole		8.53								W.L. in Screen at Elev. 56.315 m on March 9, 2015
10												
DE	PTH S	SCALE		1	1	1		Golder	1			I OGGED: HEC

PROJECT: 1522242-3000

### RECORD OF BOREHOLE: 15-04

LOCATION: See Site Plan

BORING DATE: March 1, 2015

SHEET 1 OF 1

DATUM: Geodetic

L.			SOIL PROFILE	1.		SA	MPL			PACE NTRA	ORGANI TIONS [P cted 40	C VAPO PM]	UR ⊕	HYDRAU k	LIC CONI , cm/s	DUCTIVI	TY,	4F	PIEZOMETER
METRES	DODING METHOD			STRATA PLOT		ER		BLOWS/0.30m					80 I	10-6		10-4	10-3	ADDITIONAL LAB. TESTING	OR
ME			DESCRIPTION	ATA I	ELEV. DEPTH	NUMBER	TYPE	WS/0	VAPOU	IR CON	COMBUS	TIBLE	[PPM] 🗆		ER CON			AB. TI	INSTALLATION
i	G			STR/	(m)	ž		BLO	ND = No 20	ot Dete	cted		80	Wp H 20	40	60	WI 80		
_			GROUND SURFACE							5									
0			FILL - Gravel, blast rock, wood, boulders		0.00														4. 31
1																			
			FILL - Orange brick, fly ash, gravel		1.22		-												
			TILL - Orange brick, ny asin, graver																
						1	SS	•	e t									CHEM	
2																			Bentonite Seal
			(SM) SILTY SAND, trace to some		2.44	1A	ss	.	e c	ב	1							CHEM	📕
			gravel; grey brown (GLACIAL TILL); non-cohesive, moist to wet			-	-												
3																			
	Drill	Casing				2	SS		₽□		1								
	sion L	iam. C									1								
	Percussion Drill	105 mm Diam. Casing									1								
	ш	105				2A	SS	6	₽□		1								Silica Sand
4											1								
					1						1								
						3	SS	•	Ð										
5											1								
			(SM) SILTY SAND, some gravel; grey brown, with cobbles and boulders		5.35		-												51 mm Diam. PVC #10 Slot Screen
			(GLACIAL TILL); non-cohesive, wet																
6						4	SS	€	₽□										
0																			
				<b>B</b>							1								
						4A	SS	6	• 🗆		1								
											1								[4]
7		Ч	End of Borehole	PTX	7.01		-				1								
											1								W.L. in Screen at 6.1 m depth on March 3, 2015
											1								March 3, 2015 Note: W.L. not measured on
				1															March 9, 2015
8											1								
											1								
				1															
				1															
				1															
9											1								
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											1								
											1								
10				1															
				1															
_																	I	•	
			CALE							G	olde socia	r							OGGED: HEC
1:	50								V	Ass	<u>50Cia</u>	<u>tes</u>						CH	IECKED: AC

PROJECT:	06-1120-331
LOCATION:	See Site Plan

### RECORD OF BOREHOLE: BH 06-24

BORING DATE: Nov. 6-7, 2006

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

DATE. NOV. 0-7, 2006

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

щ		ĝ	SOIL PROFILE			s/	MP	LES	DYNA	MIC PE		TION /S/0.3m	)	HYDRAU		NDUC	TIVITY	<i>r</i> ,	T	1
DEPTH SCALE METRES		BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	2	O STRE	40	60	80 + 0.0 ⊕ U.0	10 <sup>4</sup> WAT	cm/s 10 ER CO	NTEN		10 <sup>-3</sup> CENT	ADDITIONAL LAB. TESTING	PIEZOMETE OR STANDPIPI INSTALLATIO
٥	1	-		STR/	(m)	ž		BLO	2		40	60	80	Wp H 20	40	-04	60	-1 WI 80	2.A	
- 0		Π	GROUND SURFACE Loose to compact grey black sand, some gravel with cobbles, boulders and brick (FILL)		62.52 0.00	1	50 DO	9												Flush mount casing set in bentonite
- 2			Dense brown SILTY SAND, some		60.23 2.29	$\vdash$	50 DO	13												Native Backfill 🖓
• 3		ollow Stem)	gravel, trace clay with cobbles and boulders (GLACIAL TILL)				50 DO 50 DO	45 >100											мн	Native Backfill 🗸
•	Power Auge	200mm Diam. (H	Very dense grey SANDY SILT, trace clay with cobbles and boulders GLACIAL TILL)		<u>58.71</u> 3.51	5	50 DO	⊳100												
5								>100										1		Bentonite Seal Silica Sand
6								91												50mm Diam. PVC #10 Slot Screen
7			-		55.20		50 DO 50 DO	100												#10 Slot Screen
8			nd of Borehole iampler Refusal		7.32										22					Water level in screen at elev. 59.92m on Dec. 8, 2006
9																				
10																				
11																				
12																				
13																				
14																				
15																				
DEPT 1:75		CAL	E			1		(	9	Gol	der									GED: D.G. KED: S.A.T.

#### PROJECT: 06-1120-331

LOCATION: See Site Plan

## RECORD OF BOREHOLE: BH 06-25

BORING DATE: Nov. 7, 2006

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760m

щ		B	SOIL PROFILE			SA	MPL	ES	DYNAMIC PENETRA RESISTANCE, BLOW	NON Y	HYDRAULIC CONDUCTIVITY,		1
DEPTH SCALE METRES			DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	20 40 SHEAR STRENGTH Cu, kPa 20 40	60 80	k, cm/s 10 <sup>-6</sup> 10 <sup>-6</sup> 10 <sup>-4</sup> 10 <sup>-3</sup> WATER CONTENT PERCENT Wp - OW I WI	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
- 0	L	_	UND SURFACE	-	62.82						20 40 50 80	-	
- •		Loos	crushed stone (EILL) e to compact brown sand and sitty , some gravel with cobbles, brick, rete and organic matter (FILL)		<u>0.00</u> 0.15		50 DO	16					Flush mount casing set in bentonite
- 2		Vas	doors have DAUDY OUT		60.53		~	11					Native Backfill 🗸
- 3	1.1	Grave bould	dense brown SANDY SILT, some A, trace clay with cobbies and lers (GLACIAL TILL) pact to very dense grey SILTY		2.29 59.77 3.05	3	50 DO						
• •	Power Auger		o, some gravel, trace day with es and boulders (GLACIAL TILL)					22				мн	Bentonite Seal
5						=		26				MET	Silica Send
6						7	50	78					50mm Diam. PVC #10 Slot Screen
7		End of	fBorehole		56.11 6.71	•	50 DO	96					Water level in screen at elev. 60.64m on Dec. 6, 2006
8													
9													
10													
11													
12													
13													
14													
15													
DEPTH 1 : 75	нs	CALE			I.,	1		(	Golder			LOG	GED: D.G.

PROJECT: 06-1120-331 LOCATION: See Site Plan

## RECORD OF BOREHOLE: BH 06-26

BORING DATE: Nov. 7-8, 2006

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760

ų,	UCH.	SOIL PROFILE			SA	MPL	ES	DYNAMIC PEN RESISTANCE	BLOV	TION VS/0.3m	2	HYDRAULIC ( k, cm/	CONDU	CTIVITY	:	T	T
DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	20 SHEAR STREE Cu, kPa	40 NGTH		80 <b>`</b>		10 <sup>4</sup>	10*	10 <sup>-3</sup>	ADDITIONAL LAB. TESTING	PIEZOMETE OR STANDPIP
õ	806		STRA	(m)	N	-	BLOV		10		80 80	Wp H		<u>v</u>	-l wi	ABA	INSTALLATI
- 0	-	GROUND SURFACE		64.0					ľ	T	Ĩ	1	T	60	_80	-	
- 1		Dark grey sand with sät, gravel, brick, concrete, ash and coal (FILL)		0.00	,	50 DO 50	4									мн	Flugh mount casing set in benionite
- 2 -	Auger	Dense grey brown SANDY SILT, some gravel, trace clay with cobbles and bouiders (GLACIAL TILL)		61.75 2.29	Ħ		47										Nelive Beckfil
4	amor Cumor						31 97									мн	오 Bentonite Seal
5		Very dense grey SANDY SILT, some gravel, trace clay with cobbles, boulders and sand layers (GLACIAL TILL)		59,32 4.72	6	80	100										Silice Sand
6					_		12										50mm Diam. PVC #10 Slot Screen
,	-	End of Borehole Sampler Refusal		57.64 6.40	8 0	8 >1										-	Native Backfill
8																	50.57m on Dec. 8, 2006
10																	
11																	
12																	
13																	
14												-					
5																	
DEPTH : : 75	sc	ALE						Gold	ler								GED: D.G. KED: S.A.T.

PROJECT: 06-1120-331

#### LOCATION: See Site Plan

## RECORD OF BOREHOLE: BH 06-27

BORING DATE: Nov. 8, 2006

SHEET 1 OF 1

DATUM: Geodetic

.

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

	щ	₽	SOIL PROFILE			s	AMP	LES	DYNA		ENETR	ATION	2	1	HYDRAULIC	CONDL	CTIVIT	ry,	-	T
PROME SUBJECT         10         10         10         00	TH SCA	VG METH	DESCRIPTION	A PLOT	ELEV.	BER	1	M0.3m		20	40	60	8		10*	10*	- 1		IONAL	PIEZOMET OR
OPCOMD SUFFICE         Disk         Disk <thdisk< th="">         Disk         Disk</thdisk<>	Det -	BORIN	o Lookin now	TRAT		NUM	E	TOWS	Cu, kP	a	ENGIF	rem	V. <b>⊕</b>	u- 0			NT PE		ADDIT	INSTALLAT
2         1         50         1         50         1         1000 ddg gy y and will brick and sources (FL)         1000 ddg gy y and will brick and sources (FL)         1         50         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1         1000 ddg gy y and will brick and sources (FL)         1				ŝ	-	+	+	100		20	40	60	8	0	20				-	
2			Loose dark grey sand with brick and concrete (FILL)				50													casing set in bentonite
	- 2				63.43	2														Native Reckfill
	. 3 India	ollow Stam)	Compact to very dense brown to grey SILTY SAND, some gravel, trace clay with cobbies and boulders (GLACIAL TILL)		2.29	3	50 DO	27												Cacking
a         a         b	Power	Domm Diam. (H						30											мн	Į Į
		3				-								14						Silica Sand
	5		2			-														50mm Diam. PVC #10 Slot Screen
2     End of Borehole     8.73       0     8.73       10       11       12       13	6		Brown fine SAND		59.17	5	50 DO	85			•									Native Backfill
	7		End of Borehole																	screen at elev. 52.42m on Dec. 8.
	8																			2006
	9																			
	10																			
	11																			
	12																			
	13																			
	14																			
	5																			
LOGGED: D.G.	)ЕРТН S : 75	SCA	LE			1	-	1		Gol	lder								LOG	GED: D.G.

APPENDIX C

# **Results of Chemical Analysis**

### **Certificate of Analysis**

# Environment Testing

Client:	Golder Associates Ltd. (Ottawa)	Report Number:	1924174
enerra.			
	1931 Robertson Road	Date Submitted:	2020-01-16
	Ottawa, ON	Date Reported:	2020-01-23
	K2H 5B7	Project:	
Attention:	Chaitanya Raj Goyal	COC #:	853358
PO#:			
Invoice to:	Golder Associates Ltd. (Ottawa)		

				Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1475824 Soil 2020-01-16 19-101 sa4	1475825 Soil 2020-01-16 19-102 sa7
Group	Analyte	MRL	Units	Guideline		
Anions	Cl	0.002	%		0.016	0.007
	SO4	0.01	%		0.01	0.02
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.30	0.24
	рН	2.00			8.31	8.54
	Resistivity	1	ohm-cm		3330	4170

Guideline =

🛟 eurofins

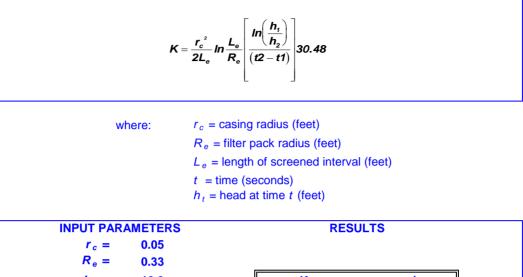
\* = Guideline Exceedence

Results relate only to the parameters tested on the samples submitted. Methods references and/or additional QA/QC information available on request. MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

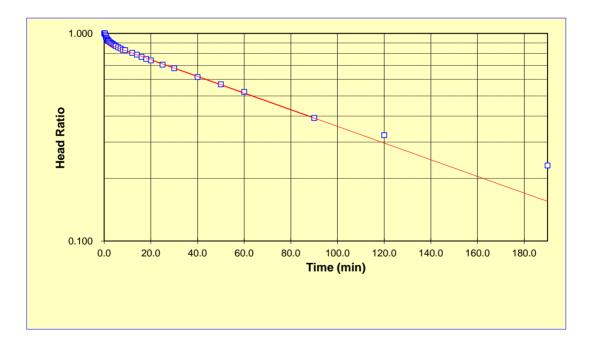
#### APPENDIX D

# Results of Hydraulic Conductivity Testing – Previous Investigation

#### HVORSLEV SLUG TEST ANALYSIS RISING HEAD TEST W-058

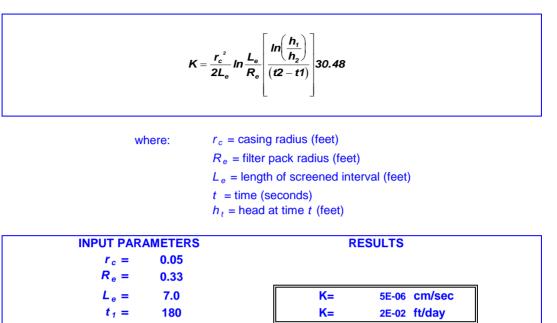


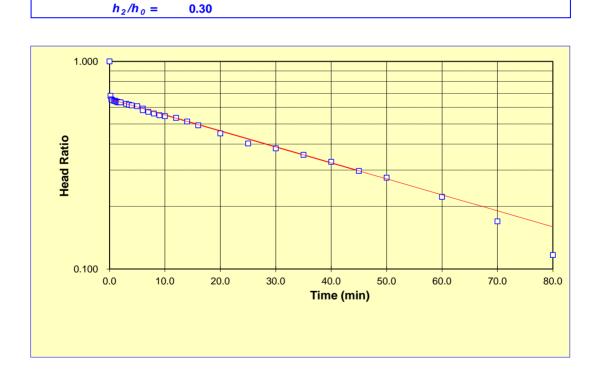
$R_{e} =$	0.33		
L <sub>e</sub> =	12.9	K=	2E-06 cm/sec
$t_1 =$	<b>480</b>	K=	5E-03 ft/day
<i>t</i> <sub>2</sub> =	<b>5400</b>		
$h_1/h_0 =$	0.83		
$h_2/h_0 =$	0.39		



Project Name: CTP OLRT Ottawa Project No.: 10-1121-0222 Test Date: 12/7/2010 Analysis By: MSL Checked By: SRW Analysis Date: 1/27/2011

#### HVORSLEV SLUG TEST ANALYSIS RISING HEAD TEST W-060





Project Name: CTP OLRT Ottawa Project No.: 10-1121-0222 Test Date: 12/21/2010

 $t_2 =$ 

 $h_1/h_0 =$ 

2700

0.63

Analysis By: MSL Checked By: SRW Analysis Date: 1/27/2011

#### HVORSLEV SLUG TEST ANALYSIS RISING HEAD TEST W-062

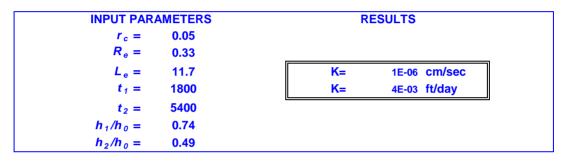
$$K = \frac{r_c^2}{2L_e} ln \frac{L_e}{R_e} \left[ \frac{ln \left( \frac{h_1}{h_2} \right)}{(t2 - t1)} \right] 30.48$$
  
where:  $r_c = \text{casing radius (feet)}$ 

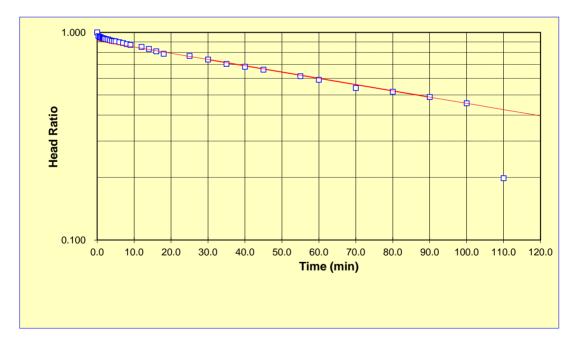
 $R_e$  = filter pack radius (feet)

 $L_e$  = length of screened interval (feet)

$$t = time (seconds)$$

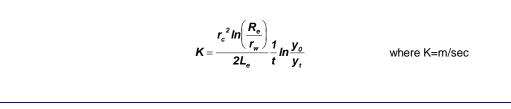
 $h_t$  = head at time t (feet)





Project Name: CTP OLRT Ottawa Project No.: 10-1121-0222 Test Date: 12/7/2010 Analysis By: MSL Checked By: SRW Analysis Date: 1/27/2011

#### BOUWER AND RICE SLUG TEST ANALYSIS FALLING HEAD TEST BH13-3



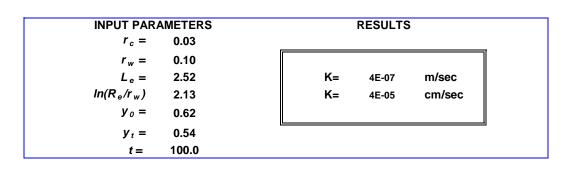
where:

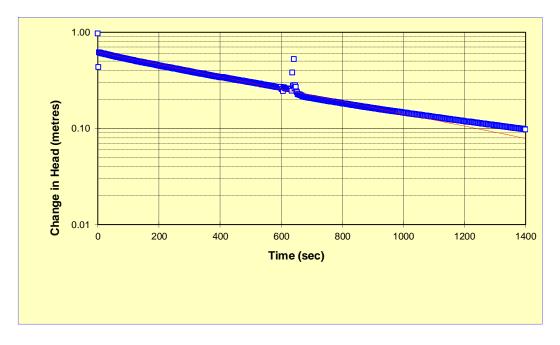
 $r_c$  = casing radius (metres);

 $r_w$  = radial distance to undisturbed aquifer (metres)

 $R_e$  = effective radius (metres);

 $y_0$  = initial drawdown (metres)  $L_e$  = length of screened interval (metres);  $y_t$  = drawdown (metres) at time t (seconds)

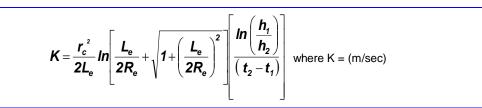




Project Name: City of Ottawa/CSST Tunnel Project No.: 13-1121-0005 Test Date: 02/22/13

Analysis By: DH Checked By: SRW Analysis Date: 2/27/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-3 Test 1



where:  $r_c$  = casing radius (metres)

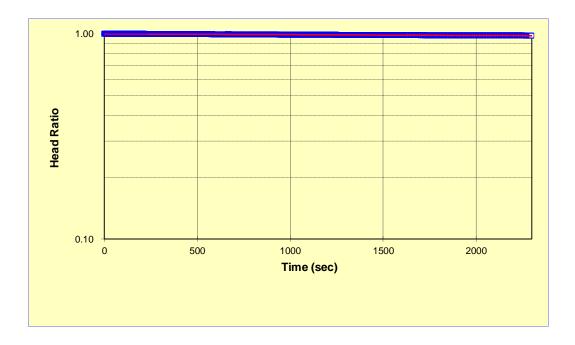
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

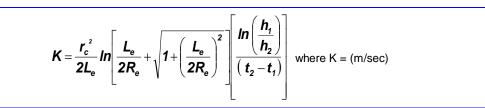
 $h_t$  = head at time t (metres)

INPUT PARAMETERS $r_c = 1.9E-02$	S RESULTS
$R_e = 5.0$ E-02	
$L_{e} = 0.9$	K= 5E-09 m/sec
$t_1 = 0$	K= 5E-07 cm/sec
$t_2 = 2500$	
Head Ratio <sub>1</sub> = 1.00	
Head Ratio $_2 = 0.98$	



Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/14/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-3 Test 2

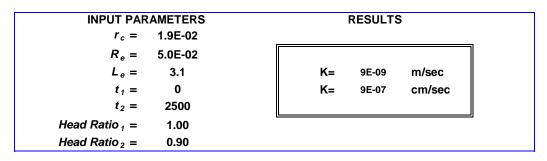


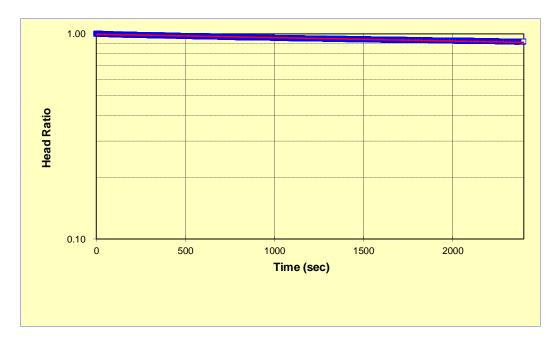
where:  $r_c$  = casing radius (metres)

 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

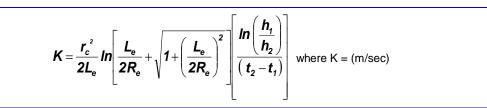
- t = time (seconds)
- $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/14/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-3 Test 3



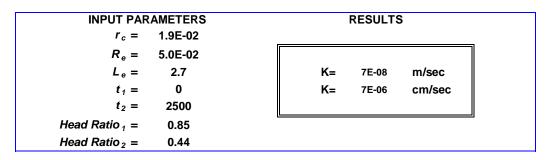
where:  $r_c$  = casing radius (metres)

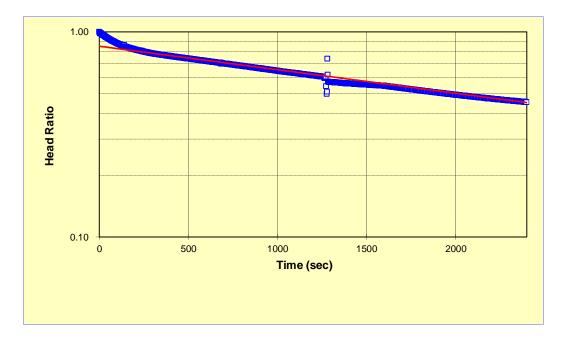
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/15/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### BH13-3 Test 1

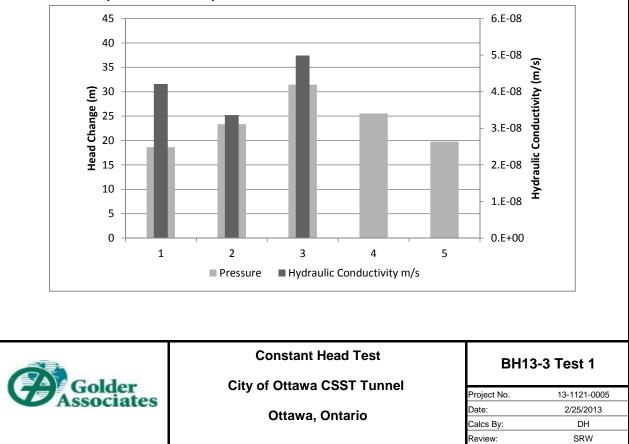
Interval Information

Borehole Radius [R]	Interval Information								
(m)	Top (m)	Bottom (m)	Length (m)						
0.048	18.85	21.58	2.73						

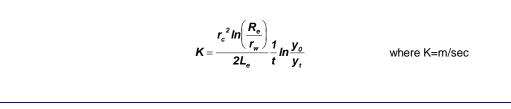
		Test III
	te Equation: D)+sqrt(1+(L/D)^2)]/[2(PI)LP] )6)	1
	Hydraulic Conductivity	2
Steps	m/s	
1	4.E-08	
2	3.E-08	3
3	5.E-08	
4	No Take	
5	No Take	4
		_
RESULTS: K= K=		5

Test Inforr	nation	
	Test Data	
1	Flow Rate (Q) =	3.3E-06 m^3/sec
	Pressure (P) =	18.6 mH2O
2	Flow Rate (Q) =	3.3E-06 m^3/sec
	Pressure (P) =	23.3 mH2O
3	Flow Rate (Q) =	6.7E-06 m^3/sec
	Pressure (P) =	31.5 mH2O
4	Flow Rate (Q) =	0.0E+00 m^3/sec
	Pressure (P) =	25.6 mH2O
5	Flow Rate (Q) =	0.0E+00 m^3/sec
5	Pressure $(P) =$	19.8 mH2O

Pressure and Hydraulic Conductivity



#### BOUWER AND RICE SLUG TEST ANALYSIS **FALLING HEAD TEST BH13-4**

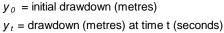


where:

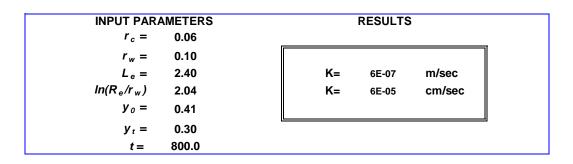
 $r_c$  = casing radius (metres);

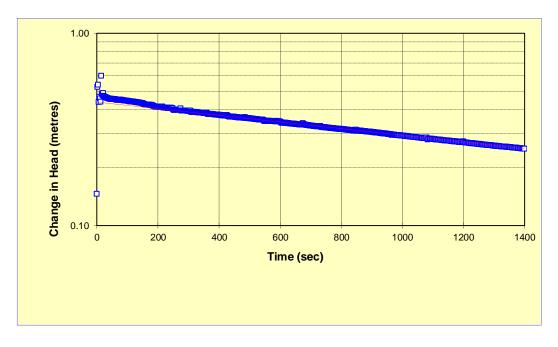
 $r_w$  = radial distance to undisturbed aquifer (metres)

 $R_e$  = effective radius (metres);



 $L_e$  = length of screened interval (metres);





Project Name: City of Ottawa/CSST Tunnel Project No.: 13-1121-0005 Test Date: 02/22/13

Analysis By: DH Checked By: SRW Analysis Date: 2/27/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-4 Test 2

$$K = \frac{r_c^2}{2L_e} \ln \left[ \frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2} \right] \left[ \frac{\ln \left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)} \right] \text{ where } K = (m/\text{sec})$$

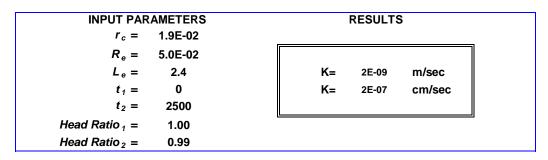
where:  $r_c$  = casing radius (metres)

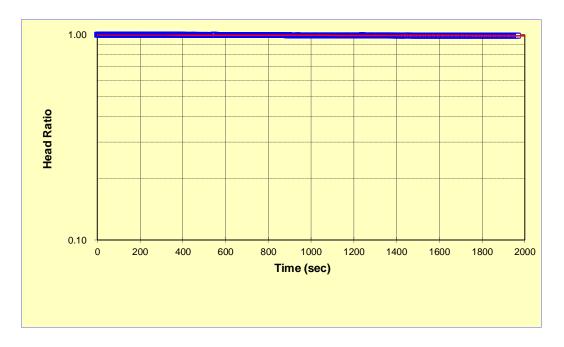
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/5/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-4 Test 3

$$K = \frac{r_c^2}{2L_e} \ln \left[ \frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2} \right] \left[ \frac{\ln \left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)} \right] \text{ where } K = (m/\text{sec})$$

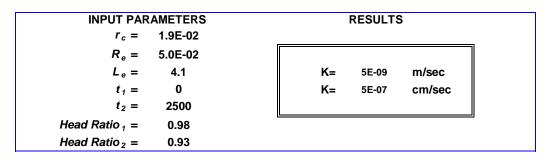
where:  $r_c$  = casing radius (metres)

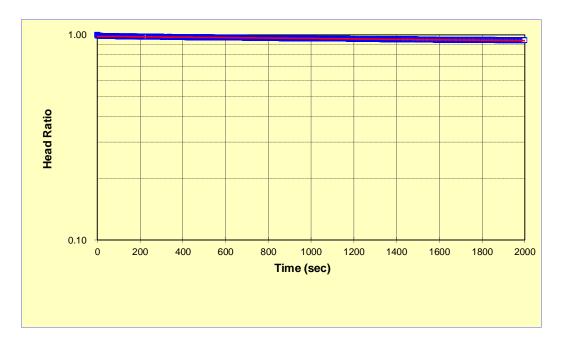
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/5/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-4 Test 4

$$K = \frac{r_c^2}{2L_e} \ln \left[ \frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2} \right] \left[ \frac{\ln \left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)} \right] \text{ where } K = (m/\text{sec})$$

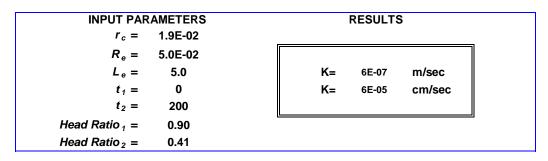
where:  $r_c$  = casing radius (metres)

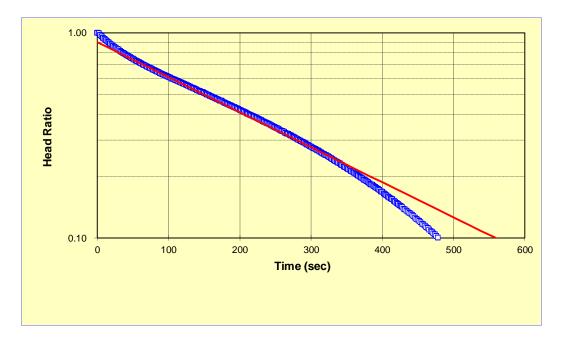
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/6/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/20/2013

#### BH13-4 Test 1

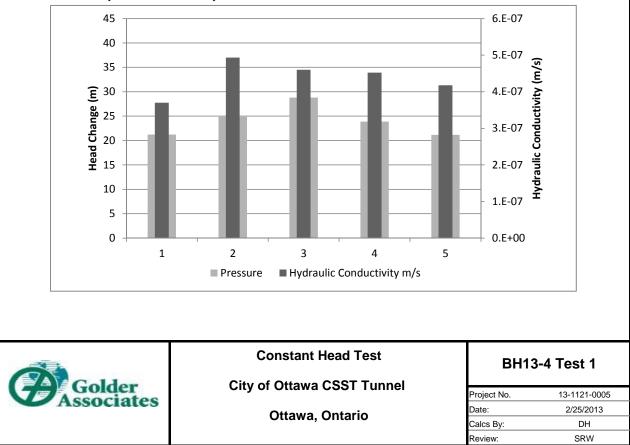
Interval Information

Borehole Radius [R]	Interval Information								
(m)	Top (m)	Bottom (m)	Length (m)						
0.048	16.57	21.60	5.03						

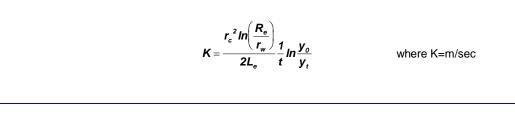
(Thiem 1906) Hydraulic Conductivity						
Steps	m/s					
1	4.E-07					
2	5.E-07					
3	5.E-07					
4	5.E-07					
5	4.E-07					

Test Inforr	nation	
	Test Data	
1	Flow Rate (Q) =	5.3E-05 m^3/sec
	Pressure (P) =	21.2 mH2O
2	Flow Rate (Q) =	8.3E-05 m^3/sec
	Pressure (P) =	24.9 mH2O
3	Flow Rate (Q) =	9.0E-05 m^3/sec
	Pressure (P) =	28.8 mH2O
4	Flow Rate (Q) =	7.3E-05 m^3/sec
	Pressure (P) =	23.9 mH2O
5	Flow Rate (Q) =	6.0E-05 m^3/sec
	Pressure (P) =	21.1 mH2O

Pressure and Hydraulic Conductivity



#### BOUWER AND RICE SLUG TEST ANALYSIS FALLING HEAD TEST BH13-6



where:

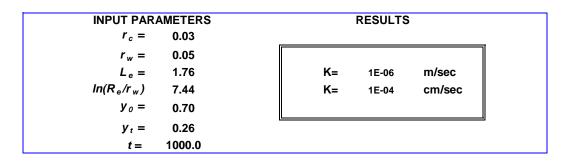
 $r_c$  = casing radius (metres);

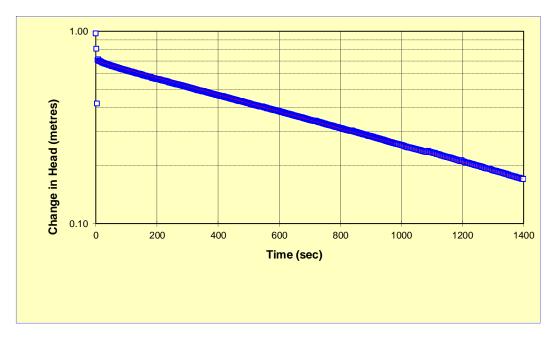
 $r_w$  = radial distance to undisturbed aquifer (metres)

 $R_e$  = effective radius (metres);

 $y_0$  = initial drawdown (metres)  $y_t$  = drawdown (metres) at time t (seconds)

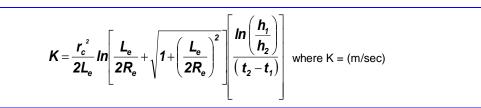
 $L_e$  = length of screened interval (metres);





Project Name: City of Ottawa/CSST Tunnel Project No.: 13-1121-0005 Test Date: 02/22/13 Analysis By: DH Checked By: SRW Analysis Date: 2/27/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-6 Test 1



where:  $r_c$  = casing radius (metres)

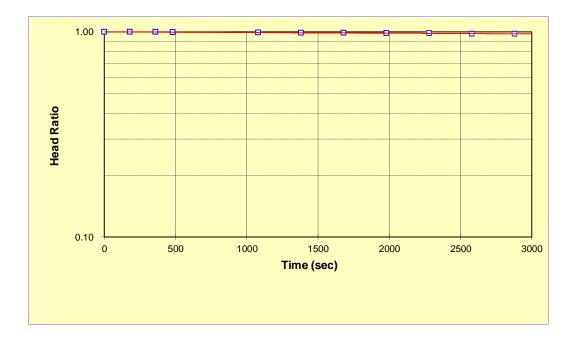
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)

INPUT PARAMI $r_c = 1.3$	ETERS 8E-02	RESULTS		
$R_e = 4.3$	8E-02			
L <sub>e</sub> =	3.6	K=	2E-09	m/sec
t <sub>1</sub> =	0	K=	2E-07	cm/sec
$t_2 = 2$	2000			
Head Ratio 1 =	1.00	L		
Head Ratio <sub>2</sub> =	0.98			



Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/11/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/21/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-6 Test 2

$$K = \frac{r_{c}^{2}}{2L_{e}} \ln \left[ \frac{L_{e}}{2R_{e}} + \sqrt{1 + \left(\frac{L_{e}}{2R_{e}}\right)^{2}} \right] \left[ \frac{\ln \left(\frac{h_{1}}{h_{2}}\right)}{(t_{2} - t_{1})} \right] \text{ where } K = (m/\text{sec})$$

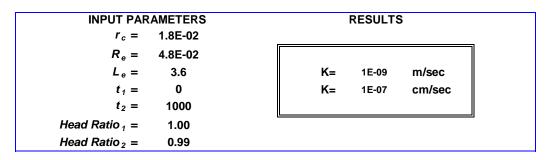
where:  $r_c$  = casing radius (metres)

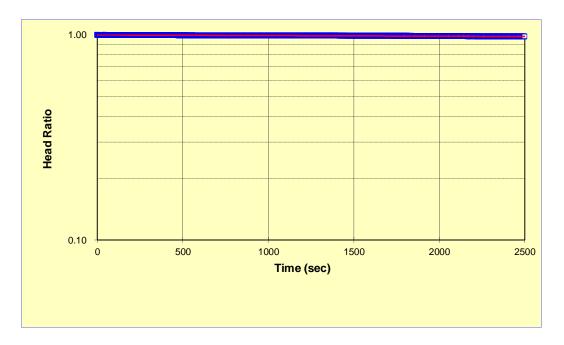
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/12/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/21/2013

#### HVORSLEV TEST ANALYSIS FALLING HEAD TEST BH13-6 Test 3

$$K = \frac{r_c^2}{2L_e} \ln \left[ \frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2} \right] \left[ \frac{\ln \left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)} \right] \text{ where } K = (m/\text{sec})$$

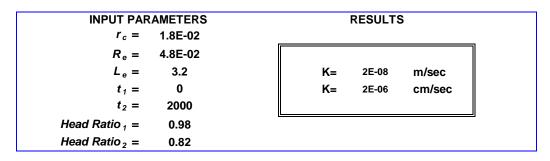
where:  $r_c$  = casing radius (metres)

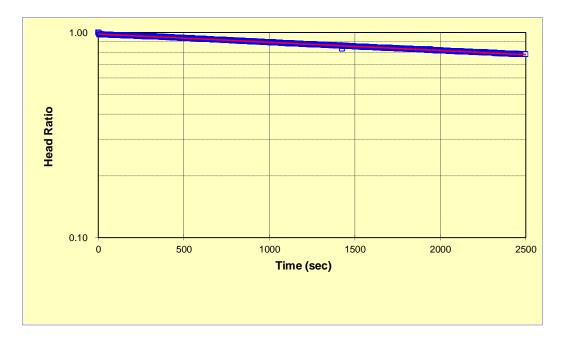
 $R_e$  = filter pack radius (metres)

 $L_e$  = length of screened interval (metres)

$$t = time (seconds)$$

 $h_t$  = head at time t (metres)





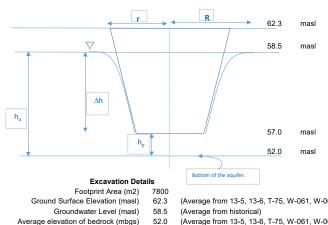
Project Name: CSST Tunnel/City of Ottawa Project No.: 13-1121-0005 Test Date: 2/12/2013 Analysis By: DH Checked By: SRW Analysis Date: 2/21/2013

APPENDIX E

# **Groundwater Inflow**

#### Inflow to Excavation Dupuit-Forchheimer Equation: Q=πK((h<sub>o</sub><sup>2</sup>- hp<sup>2</sup>)/ln(R/r))

K (m/sec)	6E-07	Maximum Till K-Testing at: 13-3, 13-4, W-058, W-060, W-062					
h <sub>0</sub> (m)	6.5	r - radius of pit					
հ <sub>թ</sub> (m)	5.0	R - radius of influence					
r (m)	49.8	SF - Safety Factor					
SF	1.5	-					
	Q	R	Rad of Inf. from edge	m³/day	L/day		
Initial*	1.2E-03	52	2	107	107,122		
Steady-State**	5.1E-04	55	5	44	44,085		
	2.7E-04	60	10	23	23,049		
	1.9E-04	65	15	16	16,019		
	1.4E-04	70	20	12	12,492		
	1.0E-04	80	30	9	8,945		
	8.3E-05	90	40	7	7,153		
	7.0E-05	100	50	6	6,067		
	6.2E-05	110	60	5	5,334		
	5.1E-05	130	80	4	4,402		
	4.4E-05	150	100	4	3,829		
	3.5E-05	200	150	3	3,035		
	3.0E-05	250	200	3	2,615		



(Average from 13-5, 13-6, T-75, W-061, W-062, 14-601, 14-602, T-74, 15-1, 15-2, 15-3) (Average from 13-5, 13-6, T-75, W-061, W-062, 14-601, 14-602, T-74, 15-1, 15-2, 15-3)

#### Sichart and Kyrieleis Equation: R=3000Δh(K<sup>1/2</sup>)

5

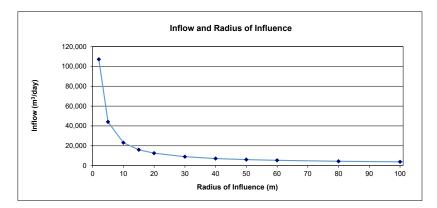
Radius of Influence of Excavation (m)

#### Notes

L - litres m - metres mbgs - metres below ground surface Initial\*: Potential worst-case inflow rate when trench is initially rapidly dewatered Steady-State\*\*: Steady state inflow rate

#### Rainfall Amount - Based on a 100 mm precipitation event in 24 hours with a return of 10 years

Excavation Area (m <sup>2</sup> )	7,800
10 year Rainfall event (m)	0.1
Max Vol Precipiation (L)	780,000





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