REPORT

Geotechnical and Hydrogeological Investigation Proposed Subdivision Development

Green Lands East and West Parcels

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1.0 INTRODUCTION

Golder Associates Limited (Golder) has been retained by Caivan Communities (Caivan) to complete a geotechnical and hydrogeological investigation for two property parcels known as the “Green Lands East” and “Green Lands West”. These two parcels form the next phase of the Fox Run Development and consist of two separate areas located immediately to the west and east of Phases 2 and 3 of Fox Run, and west of Perth Road (see Figure 1).

The purpose of this investigation is to assess the anticipated general soil and groundwater conditions across the two parcels by means of 18 new boreholes and 8 previous boreholes, as well as associated field and laboratory testing. The results of the field and laboratory investigations are used to complete a variety of geotechnical analyses and prepare this geotechnical report. This report is intended to review potential geotechnical issues, including construction considerations that might affect development planning and provided discussion and recommendations related to the design and construction of the development.

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 BACKGROUND

The location of the Green Lands East and Green Lands West parcels are shown on Figure 1.

The following is understood about the project and site:

- The site is located north of Perth Street directly west and east of the Fox Run Phases 2 and 3 developments in Richmond, Ontario
- The site of the proposed Green West Parcel is irregular in shape, and measures approximately 650 m by 230 m in plan, and the Green East Parcel is rectangular in shape, and measures approximately 650 m by 100 m in plan.
- The site has a relatively flat topography and is currently undeveloped, consisting mainly of cultivated agricultural land.
- A creek passes through the Green East Parcel
- The site will be developed with a conventional suburban subdivision.

Based on published geological mapping, the subsurface conditions on this site are indicated to consist of a thick deposit of silty clay. The depth to the bedrock surface is indicated to range from about 5 to 25 (but more typically 10 to 15) m below the ground surface. The bedrock is indicated to consist of interbedded limestone and dolomite of the Gull River Formation.

Two previous investigations were carried for the Fox Run Development. A preliminary geotechnical investigation was carried out by Jacques Whitford in 2007, followed by a geotechnical investigation carried out by Golder in 2019. The subsurface information and results of the previous investigations are contained in the reports titled:

- *Geotechnical Investigation Proposed Residential Development Phase 2 and 3, Western Development Lands, East and West of Perth Street, Richmond Village, Ottawa, Ontario*, dated August 2019 (Golder Report No. 1522173-1100).

- *Preliminary Geotechnical Investigation Report Proposed Residential Subdivision Perth and Ottawa Streets Richmond Area Ottawa, Ontario*, dated 2007 (Jacques Whitford Project No.1026929).

Portions of these previous investigations are relevant to the currently investigated parcels (i.e. borehole and test pit locations are immediately adjacent to the current subject site and are expected to be have similar sub-surface conditions).

3.0 PROCEDURE

The fieldwork for this investigation was completed between June 8 and June 24, 2020, at which time a total of 18 boreholes were advanced as follows:

- 6 boreholes in the Green Lands East area (numbered BH’s 20-101 to 20-106)
- 12 boreholes in the Green Lands West area (numbered BH’s 20-201 to 20-212)

The approximate locations of the current and previous boreholes are shown on Figure 1.

The boreholes were advanced using track and truck-mounted hollow-stem auger drill rigs supplied and operated by George Downing Estate Drilling of Hawkesbury, Ontario and OGS Drilling of Ottawa, Ontario. The boreholes were advanced to depths ranging from 2.5 to 12.6 m below 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. In situ vane testing was carried out where possible in the silty clay to determine the undrained shear strength of this soil. In addition, relatively undisturbed, 73 millimetre inside diameter thin-walled Shelby tube samples of the silty clay were obtained at various depths within selected boreholes using a fixed piston sampler. BH’s 20-101A, 20-106, 20-201, 20-203, 20-205, 20-207 and 20-209 were advanced to practical refusal using Dynamic Cone Penetration Testing (DCPT) to depths ranging from 7.3 to 12.6 m below existing ground surface.

Secondary boreholes BH’s 20-101A, 20-201A, 20-203A, 20-205A, 20-208A and 20-210A were advanced adjacent to BH’s 20-101, 20-201, 20-203, 20-205, 20-208 and 20-210 for the purpose of collecting a relatively undisturbed Shelby tube sample of the silty clay at selected depths.

Groundwater monitoring wells were installed in 6 boreholes (20-101, 20-201, 20-206, 20-208A and 20-212) for subsequent measurement of the groundwater level and for hydraulic conductivity testing. The groundwater levels in the monitoring wells were measured on July 3, 2020.

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 samples retrieved. On completion of the drilling operations, the soil samples were transported to our laboratory for further examination and laboratory testing. The laboratory testing program, which includes natural water content, grain size distribution and plasticity tests (liquid, plastic and shrinkage limits) on selected soil samples. Selected undisturbed soil samples were also selected for one-dimensional consolidation testing.

Two soil samples from BH’s 20-103 and 20-204 were also 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, marked in the field, and subsequently surveyed by Golder Associates personnel. The location and ground surface elevation at each borehole location were determined using a Trimble R8 GPS survey unit. 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 SUB-SURFACE CONDITIONS

Information on the subsurface conditions is provided as follows:

- The Record of Borehole Sheets for this investigation are provided in Appendix A.
- The Record of Previous Boreholes, Monitoring Wells, Hand-Auger Holes and Test Pits advanced as part of the previous investigations are provided in Appendix B.
- The results of the hydraulic conductivity testing are provided in Appendix C.
- The results of the basic chemical analyses are provided in Appendix D.
- A plasticity charts for the silty clay weathered crust is provided on Figure 2.
- A plasticity chart for the unweathered grey silty clay is provided on Figure 3.
- Oedometer consolidation test results are provided on Figures 4 to 6, inclusive.
- The results of grain size distribution test results are presented on Figures 7 to 9.
- The results of the natural water content and Atterberg limit testing are provided on the Record of Borehole Sheets.

The following sections provide a general overview of the sub-surface conditions at the site.

4.1 General

A total of 34 boreholes, monitoring wells, test pits and hand auger holes were advanced during previous investigations for the design of Phase 2 and 3 of the Fox Run development. Table 1 summarizes the boreholes and test pits which are most relevant to the Green Lands East and West. Copies of the historical investigation records listed in Table 1 are included in Appendix B. Locations of the previous borehole and test pit locations are indicated on Figure 1.

Table 1: Summary of Previous Boreholes and Test Pits

Site	Testhole	Site	Testhole
Adjacent to Green Lands East	MW07-1, 07-13	Adjacent to Green Lands West	MW07-7
	TP07-5		TP07-3, 07-11
	BH19-02		BH19-06
	HAH 19-103		HAH19-105

Notes: MW = monitoring well, TP = test pit, BH = borehole, and HAH = hand auger hole

In general, the subsurface conditions in Green Lands East and West consist of topsoil and/or fill over silty clay and silts, overlying glacial till. Refusal, where encountered, was at depths ranging from about 2.9 to 12.6 m below the existing ground surface.

A more detailed description of the overburden soil deposits, and groundwater conditions encountered in the current and previous investigations is provided in the following sections.

4.1.1 Topsoil

Topsoil was encountered at ground surface at all previous borehole locations and in current boreholes at the Green East lands (i.e. BH’s 20-101 to 20-106). The topsoil ranged in thickness from about 90 to 460 mm.

4.1.2 Fill

Fill was encountered at ground surface at the boreholes at the Green West lands (i.e. BH’s 20-201 to 20-212) and below the topsoil at BH 20-106 at the Green East Lands. The upper portion of the fill at BH’s 20-206, 20-208, 20-209, 20-210, 20-212 at Green West and the entire deposit at BH 20-106 at Green East Lands consisted of silty sand to sand and silt with various amounts of gravel and organic material. The granular fill extended to depths ranging from 0.3 to 0.8 m below existing ground surface at Green West Lands and 2.3 m below ground surface at BH 20-106 at Green East Lands.

The results of SPT testing gave ‘N’ values within the granular fill which ranged from 3 to 9 blows per 0.3 m of penetration, indicating a very loose to loose state of compaction. The moisture content of one sample of the granular fill tested was 18%.

The lower portions of the fill at BH’s 20-206, 20-208, 20-209, 20-210, 20-212 and the full portion of the fill at the remaining BH’s at Green West Lands (BH’s 20-201 to 20-205, 20-207, and 20-211) consisted of silty clay with various amounts of sand, gravel and organic material. The cohesive fill material extended to depths ranging from 0.6 to 2.3 m below existing ground surface.

The results of SPT testing gave ‘N’ values within the silty clay fill ranging from 4 to 16 blows per 0.3 m of penetration, indicating a very stiff to stiff consistency. The moisture content of one sample of the silty clay fill tested was 38%.

4.1.3 Clayey Silt and Silty Clay to Clay

A deposit of clayey silt to silty clay with some sand layers was encountered at all the testhole locations advanced as part of the current and previous investigations.

At all locations, the upper portion of the deposit has been weathered to a stiff crust, with the exception of BH’s 20-206, 20-207, 20-211 and 20-212 where the entire deposit has been weathered to a silty clay crust. The weathered portion extends to depths ranging from about 1.2 to 4.1 m below the existing ground surface (i.e. Elevations between 90.3 m to 94.8 m).

The results of SPT testing gave ‘N’ values within the weathered clay which ranged from 2 to 11 blows per 0.3 m of penetration, indicating a very stiff to stiff consistency. The results of in-situ vane testing in the weathered clay gave undrained shear strengths ranging from about 46 to greater than 100 kPa, indicating a firm to very stiff consistency.

At BH’s 20-101 to 106, 20-201 to 20-205, and 20-208 to 20-210 advanced as part of the current investigation and all previous testhole locations, the clay below the depth of weathering is grey in colour. The lower unweathered grey clay deposit was fully penetrated in BH’s 20-101, 20-104 to 20-106 at the Green East Lands, and 20-201 to 20-205, 20-208 to 20-210 at the Green West Lands as part of the current investigation along with previous testholes BH 19-02 and MW’s 07-1, 07-7, 07-13 and extends to depths ranging from about 2.9 to 9.7 m below the existing ground surface (i.e. Elevations 85.3 to 90.8 m).

The results of SPT testing gave ‘N’ values within the unweathered clay which ranged from “weight of hammer” to 1 blow per 0.3 m of penetration, indicating a stiff to firm consistency. The results of in-situ vane testing in this material gave undrained shear strengths ranging from about 23 to 91 kPa, but generally between 23 and 54 kPa, indicating a soft to stiff consistency.

The moisture content of the samples of weathered clay tested ranges from 34 to 69%. The results of Atterberg Limits testing completed on samples of the weathered clay indicate plasticity index values of 14 to 35% and liquid limit values of 30 to 57%, which indicate clay varying from low to high (CL to CH), but generally intermediate to high plasticity (CI to CH). The results of Atterberg Limit testing are shown on the plasticity chart on Figure 2.

The moisture content of the samples of unweathered grey clay tested ranges from 35 to 63%. The results of Atterberg Limits testing completed on samples of the grey clay indicate plasticity index values of 14 and 32% and liquid limit values of 32 and 53%, which indicate clay of low to high (CL to CH), but generally intermediate to high plasticity (CI to CH). The results of Atterberg Limit testing are shown on the plasticity chart on Figure 3.

The moisture content of the samples of the grey silty clay tested ranged from 35 to 69%.

Oedometer consolidation testing was carried out on three Shelby tube samples of the grey silty clay. The results of the consolidation testing are presented on Figures 4 to 6, inclusive, and are summarized in the following table.

Table 2: Results of Oedometer Consolidation Testing

Borehole/Sample Number	Sample Depth/Elevation (m)	C_C	C_r	e_o	σ_{VO}' (kPa)	σ_P' (kPa)	OCR
BH 20-104 Sa 4	3.25 m / 91.21 m	2.10	0.009	1.89	40	110	2.75
BH 20-205A Sa 1A	4.27 m / 90.27 m	0.806	0.002	1.22	50	200	4.0
BH 20-208A Sa 1A	4.14 m / 91.75 m	0.542	0.006	1.15	45	165	3.67

σ_o' - Initial effective stress
C_c - Compression index
e_o - Initial void ratio
σ_P' - Apparent preconsolidation pressure
C_r - Recompression index
OCR - Overconsolidation Ratio

4.1.4 Sandy Silt and Silt

Silt to sandy silt was encountered below the grey clay, where fully penetrated, in BH’s 20-101, 20-104, 20-105, 20-106, 20-201 to 20-208, and 20-210 to 20-212 as part of the current investigation along with MW’s 07-1, 07-7, 07-13 and BH 19-02 from the previous investigations. The silt layer was not fully penetrated in BH’s 20-101, 20-104, 20-105, 20-106, 20-201, 20-203 to 20-207, and 20-212 as part of the current investigation and previous testholes MW’s 07-1, 07-7, 07-13 and BH 19-02, but proven to extend to depths ranging from 2.9 up to 9.8 m below existing ground surface (i.e. Elevations of 85.3 to 90.8 m). Where the silt layer was fully penetrated, in BH’s 20-202, 20-206, 20-210 and 20-211, the silt deposit extends to a depth of 3.7 to 8.4 m below existing ground surface (i.e. Elevations of 87.8 to 91.4 m).

The results of SPT testing gave ‘N’ values ranging from 0 (“weight of hammer”) to 24 blows per 0.3 m of penetration, indicating a very loose to compact state of packing.

The results of grain size distribution testing of ten samples of the silt and sandy silt deposit are presented on Figures 7 and 8. The moisture content of selected samples of the silt tested ranged from 20 to 33%.

4.1.5 Glacial Till

A discontinuous deposit of glacial till was encountered below the silt in boreholes BH's 20-202, 20-206, 20-210 and 20-211. Glacial till in this area generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt to silty sand. The glacial till was not fully penetrated in the test holes but was proven to depths ranging from about 3.8 to 8.8 m below the existing ground surface (i.e. Elevations 86.1 to 91.3 m).

The results of SPT testing gave 'N' values in the glacial till ranging from 3 to greater than 50 blows per 0.3 metres of penetration, indicating a very loose to very dense state of packing. The higher blow counts likely reflect the presence of the boulders or bedrock surface, rather than the state of packing of the soil matrix.

The results of grain size distribution testing of two samples of the glacial till deposit is presented on Figure 9. The moisture content of the samples of the glacial till tested ranged from 11 to 18%.

4.1.6 Dynamic Cone Penetration Test (DCPT) and Refusal

Boreholes 20-101A, 20-106, 20-201, 20-203, 20-205, 20-207 and 20-209 during the current investigation were advanced using Dynamic Cone Penetration Testing (DCPT), without sampling, to DCPT refusal to depths ranging from 7.2 to 12.6 m below existing ground surface.

Practical refusal to augering/sampling was encountered below the grey clay, silt and/or glacial till in BH's 20-104, 20-105, 20-202, 20-204, 20-206, 20-208, 20-210, 20-211 and 20-212 as well as previous BH 19-06 at depths ranging from 2.9 to 8.8 m below the ground surface. Refusal could represent the bedrock surface or cobbles/boulders in the glacial till.

The following table provides a summary of refusal depths:

Table 3: Summary of Refusal Depths and Elevations

BH/ Testhole Number	Ground Surface Elevation (m)	Practical Refusal Depth (mbgs)	Practical Refusal Elevation (m)
20-101A	95.23	11.13[2]	84.11[2]
20-104	94.46	8.23[1]	86.23[1]
20-105	94.48	7.32[1]	87.16[1]
20-106	94.48	8.58[2]	85.90[2]
20-201	97.02	12.60[2]	84.42[2]
20-202	94.92	8.84[1]	86.08[1]
20-203	95.06	8.38[2]	86.68[2]
20-204	94.97	7.62[1]	87.35[1]
20-205	94.54	7.16[2]	87.38[2]
20-206	94.44	6.71[1]	87.73[1]
20-207	96.00	10.10[2]	85.90[2]
20-208	95.94	6.71[1]	89.23[1]
20-209	95.41	9.60[2]	85.81[2]
20-210	95.27	8.69[1]	86.58[1]
20-211	95.08	3.76[1]	91.32[1]
20-212	96.00	2.90[1]	93.10[1]
19-06	94.25	5.94[1]	88.31[1]

Note: (1) Indicates practical refusal to augering
(2) Indicates Dynamic Cone Penetration Test (DCPT) refusal

4.1.7 Groundwater

Monitoring wells were installed in BH's 20-101, 20-201, 20-206, 20-208 and 20-210 along with previous boreholes MW's 07-1, 07-7, 07-13 and BH's 19-02 and 19-06 to observe the stabilized groundwater level across the site.

A summary of the groundwater levels and hydraulic conductivity measured in the monitoring wells is presented in Table 4.

It is expected that the groundwater level will be subject to fluctuations both seasonally and as a result of precipitation events.

Table 4: Summary of Groundwater Conditions

Testhole	Geologic Unit at Screened Interval	Depth to Groundwater (mbgs)	Hydraulic Conductivity (cm/s)	Date of Reading
20-101	Silty Clay	1.47	$1x10^{-6}$	July 3, 2020
20-201	Silty Clay	2.52	$3x10^{-6}$	
20-206	Silty Clay and Silt	1.88	$5x10^{-5}$	
20-208A	Silty Clay	1.36	$3x10^{-4}$	
20-212	Silty Clay (Weathered Crust) and Sandy Silt	2.08	$6x10^{-5}$	
19-02 A	Silty Clay, Clayey Silt and Sandy Silt	0.4	$2x10^{-3}$	May 6, 2019
19-02 B	Clayey Silt to Silty Clay	1.1	$3x10^{-5}$	
07-1	-	1.1	N/A	June 20, 2007

5.0 DISCUSSION

5.1 General

This section of the report provides preliminary engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the existing information from investigations carried out on lands adjacent to the Green Lands East and West development, as well as our understanding of the current project requirements.

This section of the report provides engineering guidelines on the geotechnical design aspects of this project based on our interpretation of the borehole information as well as the project requirements, and is subject to the limitations in the "Important Information and Limitations of This Report" which follows the text of this report.

5.2 Site Grading

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

The site is generally underlain by firm unweathered grey silty clay and has a limited capacity to support additional stress, such as could be imposed by:

- The foundation loads of buildings/houses
- The weight of grade raise fill placed on the site
- The effects of groundwater level lowering (which reduces the buoyant forces that act between the soil particles), which could result from servicing and development of the site

An increase in stress, if excessive (i.e., increasing the magnitude of stress above, or even close to, the silty clay's pre-consolidation pressure), could lead to significant consolidation settlement. Due to the typically low hydraulic conductivity of the silty clay and the need to expel water for settlement to occur, the settlement would be long term in nature, possibly taking many months or years to complete. Grade raises on areas underlain by compressible silty clay will therefore need to be restricted, based on leaving sufficient remaining capacity for the silty clay to also support foundation loads and the effects of groundwater level lowering, without being overstressed. If the grade is raised excessively, then significant consolidation settlement will occur.

The analyses carried out for this assessment assumes that the unit weight of the grade raise fill would be between 18.0 up to 21.5 KN/m^3.

The results of the analyses indicate the following permissible grade raises:

Table 5: Permissible Grade Raise Restrictions

Assessment Area	Footing Elevation	Bearing Resistance (kPa)	Grade Raise Fill with Unit Weight up to 18.0 kN/m^3	Grade Raise Fill with Unit Weight up to 21.5 kN/m^3
Green East Parcel	Above 94.5 m	75	2.6	2.2
	93.5 to 94.5 m	75	1.8	1.5
Green West Parcel	Above 95 m	75	4.7	3.9
	94 m to 95 m	75	3.6	3.0

These limitations have been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that strip footings up to 0.6 metres in width and pad footing foundations up to 1.2 metres in width can be designed using a maximum allowable bearing pressure of 75 kPa, consistent with design in accordance with Part 9 of the Ontario Building Code.

These values should be reviewed and confirmed by Golder during detailed design based on proposed founding depths and grading plans. In the event the proposed grade raise exceeds the values provided above other options can be considered, such as the use of lightweight fill, preloading, etc. These options can be reviewed during more detailed design phases if required.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil for predictable performance of structures and services. The topsoil is not suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only

5.3 Material Reuse

Any topsoil removed during site grading or excavation activities is not considered suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only.

The overburden soils at the site should not be used as backfill directly against exterior, unheated or well insulated foundation elements.

The high moisture content of the unweathered grey silty clay and silty materials below the water table makes these soils difficult to handle and compact. The unweathered grey clay and/or wet silty soils are not considered suitable for reuse as structural/engineered fill but could be reused in non-structural areas (i.e., landscaping).

5.4 Foundations

The allowable bearing pressures for spread footing foundations at this site are based on limiting the stress increases on the “softer” compressible grey silty clay to an acceptable level so that foundation settlements do not become excessive. Four important parameters in calculating the stress increase on the grey silty clay are:

- The thickness of soil below the underside of the footings and above the compressible silty clay
- The size (dimensions) of the footings
- The amount of surcharge in the vicinity of the foundation due to landscape fill, underslab fill, floor loads, etc., as described in Section 5.2
- The effects of groundwater lowering caused by this or other construction

It is considered that conventional houses could be supported on shallow foundations founded on or within the inorganic weathered silty clay crust.

Provided that the grade raises are restricted to those indicated above, or other measures are undertaken, strip footing foundations may be designed using a maximum allowable bearing pressure of 75 kPa. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC).

For the Green Lands East and West developments, the selection of the founding levels (in relation to the groundwater level) is also impacted by City of Ottawa requirements associated with the use of sump pumps. The underside of footing (USF) elevations for all structures should be at or above the elevation of the springline of the storm sewer installed in the adjacent roadways, and at or above the groundwater level.

Following servicing of the site (as will typically occur in advance of house construction), some lowering of the groundwater level is expected.

5.5 Seismic Design Considerations

The seismic design provisions of the 2012 Ontario Building Code depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or bedrock 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 this methodology, this site can be assigned a Site Class of D, acknowledging that this requirement does not apply to ground oriented residential structures designed per part 9 of the Ontario Building Code.

The soils at this site are not considered to pose a significant risk of liquefaction or cyclic softening.

5.6 Frost Protection

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

5.7 Excavations

5.7.1 Basement Excavations

Excavation for basements will be made through stiff to very stiff weathered crust and, depending on the founding levels, might extend into the underlying wet silty clay to clay and sandy silt to silt.

No unusual problems are anticipated with excavating the overburden materials using hydraulic excavating equipment

The silty clay would be classified as a Type 3 soil in accordance with the Occupational Health and Safety Act. As such, temporary excavation side slopes in this material can be inclined at 1H:1V (horizontal:vertical). Flatter excavation side slopes could be required if excavations extend into the underlying wet sandy silt to silt. However, the USF elevations should be at or above the sustained groundwater levels which would improve the excavation conditions for deeper basements.

It is expected that groundwater inflow rates will be low following servicing of the site, and it should be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations.

Where excavations extend into wet sandy silt to silt and unweathered silty clay, consideration will need to be given to providing a working pad over the native subgrade to protect it from disturbance (e.g., a 0.3 metre thick pad of OPSS Granular A or B Type II, possibly underlain by a geotextile).

It should also be noted that it is important that excavations for house basement construction do not disturb any clay seals that are installed at the time of site servicing (discussed further in Section 5.10), which are a City of Ottawa requirement associated with the use of sump pumps.

5.7.2 Excavations for Site Servicing

Based on the plans provided, excavations for the installation of site services will be up to 6 m in depth, and be made through silty clay, sandy silt to silt, and/or glacial till.

No unusual problems are anticipated with trenching in the overburden using conventional hydraulic excavating equipment, recognizing that cobbles and boulders should be expected within the glacial till. Boulders larger than 0.3 metres in size should be removed from excavation side slopes for worker safety.

The firm to very stiff silty clay and glacial till would generally be classified as a Type 3 soil in accordance with the Occupational Health and Safety Act of Ontario. As such, these excavations may be made with side slopes at 1 horizontal to 1 vertical. Where trenches for the installation of services extend into the wet sandy silt to silt or grey silty clay deposit, the excavation side slopes would need to be no steeper than 3H:1V (Type 4 soil). Alternatively, the excavations could be carried out using steeper side slopes with all manual labour carried out within a fully braced, steel trench box for worker safety.

It should be noted that refusal was encountered at BH’s 20-211 and 20-212 at ‘shallower’ depths of 3.8 and 2.9 m below existing ground surface, i.e. Elevations of 91.3 and 93.1 m, respectively. Based on the preliminary plans provided by Caivan, the excavations within this area will not extend into possible bedrock.

Some groundwater inflow into the trenches should be expected. However, it should be possible to handle the groundwater inflow by pumping from well filtered sumps established in the floor of the excavations, provided suitably sized pumps are used.

The actual rate of groundwater inflow into the trench will depend on many factors including the contractor’s schedule and rate of excavation, the size of the excavation, and the time of year at which the excavation is carried out. There may also be instances where significant volumes of precipitation collect in an open excavation and must be pumped out.

Permit-To-Take-Water (PTTW) number 8563-ABNQ5G was issued to Richmond Village Development Corporation by the Ministry of the Environment, Conservation and Parks for Phases 1, 2 and 3 of the Fox Run project. The PTTW expires on July 5, 2026, and permits water taking from the excavations for installation of site services and the stormwater management pond. PTTW no. 8563-ABNQ5G does not cover the “Green Lands East” or “Green Lands West” parcels; however, an application to amend the PTTW could be made to add these areas to the PTTW. This would be classified as a Category 3 PTTW application.

Reported water taking rates at Fox Run in 2018 were up to about 600,000 L/d during site servicing. Based on the similar hydrogeological conditions expected to be encountered at the “Green Lands East” and “Green Lands West” parcels, , the existing PTTW, which allows up to 6,300,000 L/d of water taking, is anticipated to be sufficient for dewatering during site servicing of these parcels, if they are added to PTTW no. 8563-ABNQ5G.

5.8 Basement and Garage Floor Slabs

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

The granular base for the garage floor slabs should consist of at least 150 mm of Granular A compacted to at least 95% of the material’s Standard Proctor Maximum Dry Density (SPMDD).

The recommended type of drainage system required (perimeter drains and/or underfloor drains; damp-proofing or water-proofing) depends upon the proposed basement founding elevations, soil types in the area, and actual stabilized groundwater levels. As a general guideline, to prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base for the floor slabs be positively drained.

As indicated in Section 5.3, the founding depths should be set above the groundwater level. The groundwater level was observed to be at depths ranging from 0.4 to 2.5 m below existing grade in the monitoring wells installed during the current and previous investigations.

However, if/where the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. Where a geotextile is required, it should consist of a Class II, non-woven geotextile with a Filtration Opening Size (FOS) not exceeding about 100 microns, in accordance with Ontario Provincial Standard Specification (OPSS) 1860.

5.9 Bedding and Pipe Cover for Services

Assuming similar hydrogeological and drainage conditions as the previous development phases, at least 250 mm of 19 mm nominal size clear crushed stone should be used as pipe bedding for the storm sewers to allow for drainage. The clear stone must be fully wrapped in a suitable non-woven geotextile.

At least 150 mm of OPSS Granular A should be used as pipe bedding for sanitary sewer and water pipes, and for the storm sewer laterals to the houses. Unless fully wrapped in a non-woven geotextile, the use of clear crushed stone as a bedding layer should not be permitted anywhere for bedding and backfill of sanitary sewer and water pipes since fine particles from the sandy backfill materials or silty/sandy soils on the trench walls could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support. 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.

Cover material, from 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.

5.10 Excavation Backfill

Site Services

It should generally be possible to re-use the silty clay from the weathered zone, and glacial till as trench backfill. Where the trench will be covered with hard surfaced areas, the type of native material placed in the frost zone (between subgrade level and 1.8 m 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.

Impervious Cut-Offs

Impervious dikes or cut-offs should be constructed in the service trenches for sanitary sewers, water pipes and service laterals to each house to reduce additional groundwater lowering at the site due to the “french drain” effect. It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular materials to the trench bottom. The dikes should be at least 1.5 m wide and could be constructed using relatively dry (i.e., compactable) silty clay from the weathered zone.

Clay cut-offs should not be constructed in the service trenches for the storm sewer pipes (assuming the same drainage requirements apply as for previous phases of the development).

5.11 Basements and Garages

To avoid problems with frost adhesion and heaving, foundation elements should be backfilled with non-frost susceptible sand or sand and gravel. The backfill material inside the garages and foundation wall should have a unit weight not exceeding 21.5 kN/m^3 (i.e., uniform fine sand, OPSS Granular B Type I, or clear crushed stone). The backfill should be placed in maximum 300 mm thick lifts and be compacted to at least 95% of the material's SPMDD.

Drainage of the basement wall backfill should be provided by means of a perforated pipe subdrain 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. Conventional damp proofing of the basement walls is appropriate with the above design approach.

Where design of basement walls in accordance with Part 4 of the 2012 Ontario Building Code is required, walls backfilled with granular material and effectively drained as described above should be designed to resist lateral earth pressures calculated using a triangular distribution of the stress with a base magnitude of $K_o\gamma H$, where:

K_o=The lateral earth pressure coefficient in the ‘at rest’ state, use 0.5

γ=The unit weight of the granular backfill, use 21.5 kN/m^3

H =The height of the basement wall in metres

5.12 Pavement Design

In preparation for pavement construction, all topsoil, disturbed, or otherwise deleterious materials (i.e., those materials containing organic material) should be removed from the roadway areas.

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

For planning purposes, Table 6 outlines the City of Ottawa's minimum recommended pavement structure for residential streets.

Table 6:Preliminary Pavement Design Residential Streets

Pavement Component	Thickness (mm)	Materials
Asphaltic Concrete Pavement	Surface course – 40 Base course – 50	SP 12.5 SP 19.0
Base	150	OPSS Granular A
Subbase	400	OPSS Granular B Type II

For collector roadways, the subbase thickness should be increased to 600 mm. The asphaltic concrete thickness should be assumed to be at least 140 mm for bus routes and the subbase thickness should also be increased to 600 mm.

5.13 Corrosion and Cement Type

Two samples of soil from BH's 20-103 and 20-204 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 D and summarized below:

Table 7: Summary of Basic Chemical Results

BH No. / Sa No.	Sample Depth (m)	Chloride (%)	SO4 (%)	Electrical Conductivity (mS/cm)	pH	Resistivity (ohm-cm)
20-103 / Sa 3	1.5 – 2.1	<0.002	<0.01	0.19	8.10	5240
20-204 / Sa 3	1.5 – 2.1	<0.002	<0.01	7.70	7.70	2600

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a potential for corrosion of exposed ferrous metal, which should be considered during the design of substructures.

5.14 Trees

In general, silty clay soil has the potential to be sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clayey soil, the clay may undergo shrinkage which can result in settlement of adjacent structures.

The results of the shrinkage test indicate that the weathered crust silty clay at this site has a shrinkage limit of ranging from 16 to 18 at Green East, 19 to 20 at Green West and a shrinkage ratio of about 1.7 to 1.9 and 1.7 to 1.8 at Green East and West Lands, respectively.

The Atterberg limit testing on 12 samples of the silty clay from the current investigation, from the underside of footing level to 3.5 metres depth below the finished grade as per the tree planting guidelines, are provided in the table below:

Test Hole Location	Test Hole / Sample Number	Ground Surface Elevation (m)	Sample Depth / Elevation (m)	Water Content	Liquid Limit	Plastic Limit	Plasticity Index
Green East	BH 20-102 / 3	94.93	1.8 / 93.1	35	30	16	14
	BH 20-104 / 3	94.46	1.8 / 92.7	50	51	20	32
	BH 20-106 / 4	94.48	2.6 / 91.9	53	50	22	27
Green West	BH 20-202 / 3	94.92	1.8 / 93.1	40	37	16	21
	BH 20-202 / 4	94.92	2.6 / 92.3	60	53	21	32
	BH 20-204 / 4	94.97	2.6 / 92.4	60	53	20	33
	BH 20-205 / 3	94.54	1.8 / 92.7	54	57	22	35
	BH 20-208 / 3	95.94	1.8 / 94.1	52	55	21	34
	BH 20-208 / 5	95.94	2.6 / 93.3	39	32	17	14
	BH 20-209 / 4	95.41	2.8 / 92.6	59	51	20	30
	BH 20-210 / 3	95.27	1.8 / 93.5	50	55	23	32
	BH 20-210 / 4	95.27	2.8 / 92.5	58	46	18	29
	Average						**28**

Notes: (1) – Ground surface elevations not measured at hand augerhole locations

Within the Green East and West Parcels, the plasticity index values are generally less than 40%, and therefore, the tree to foundation setback distance can be reduced to 4.5 metres for small (mature tree height up to 7.5 metres) and medium sized trees (mature tree height of 7.5 to 14 metres), provided that the tree is of low to moderate water demand. Large trees (mature height greater than 14 metres) can also be considered provided that the setback distance is equal to or greater than the full mature height of the tree. However, in accordance with current City guidelines, the following conditions must also be met:

- The underside of footing elevation must be 2.1 metres or greater below the lowest finished grade
- Available soil volume must be provided for small and medium trees as per the guidelines
- Tree species must be very low to moderate Potential Subsistence Risk
- The foundation walls should be reinforced at least nominally, to provide ductility
- The grading must promote drainage towards the tree root zone

A list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures is attached.

As the detailed design progresses and the foundation elevations are fixed, Golder should review these recommendations to ensure they remain applicable to the final development plans.

5.15 Pools, Decks and Additions

5.15.1 Above Ground and In Ground Pools

No special geotechnical considerations are necessary for the installation of in-ground pools, provided that the pool (including piping) does not extend deeper than the house footing level. A geotechnical assessment will be required if the pool extends deeper than the house foundations.

Due to the additional loads that would be imposed by the construction of *above-ground pools*, these should be located no closer than 2 metres from the outside wall of the house. In addition, the installation of an above-ground pool should not be permitted to alter the existing grades within 3 metres of the house. Provided these restrictions are adhered to, no further geotechnical assessment should be required for above-ground pools.

A permit application will have to be submitted for City's approval for pool enclosures.

5.15.2 Decks

A geotechnical evaluation/assessment will be necessary for future decks, added by the homeowners, that:

- Are attached to the house
- Require changes to the existing grades, or
- Are heavily loaded and require spread footing or drilled pier foundations.

The geotechnical evaluation must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City prior to a building permit being issued.

The above recommendations are only applicable for decks where the foundation loading will exceed 75 kilopascals.

5.15.3 Additions

Any proposed addition to a house (regardless of size) will require a geotechnical assessment. The geotechnical assessment must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City prior to the building permit being issued.

6.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic, and frost. If construction is carried out during periods of sustained below freezing temperatures, all subgrade areas should be protected from freezing (e.g., by using insulated tarps and/or heating).

All footing and subgrade areas should be inspected by experienced geotechnical personnel to ensure that, prior to any backfilling or concreting, subgrade soil having adequate bearing capacity has been reached and the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill, pipe bedding, and pavement base and subbase materials should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction point of view.

Golder Associates should be retained to review the final grading plan and specifications for this project prior to construction to ensure that the guidelines in this report have been adequately interpreted.

Ontario Regulation 903 (Wells) would ultimately require abandonment of the monitoring wells installed within the test holes on this site (wells from both the current and previous geotechnical investigations); however, these devices may be useful during construction, and may be used as part of the groundwater level monitoring following servicing of the site. It is therefore proposed that decommissioning of these devices be undertaken following City approval. Wells should be decommissioned in accordance with the procedures outlined in Ontario Regulation 903.

7.0 CLOSURE

We trust this report satisfies your current requirements. If you have any questions regarding this report, please contact the undersigned.

Signature Page

Golder Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
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PROVINCE OF ONTARIO

Kim MacDonald
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Senior Geotechnical Engineer

KM/CH/hdw

Attachments: Important Information and Limitations of This Report

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https://golderassociates.sharepoint.com/sites/128209/project files/6 deliverables/green parcels final/2020-07-27 final rpt green east and west lands.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **Caivan Communities.** 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 conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

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

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

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

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

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

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

TABLE 1
SOME COMMON TREES IN DECREASING ORDER OF WATER DEMAND

BROAD LEAVED DECIDUOUS

Poplar

Alder

Aspen

Willow

Elm

Maple

Birch

Ash

Beech

Oak

DECIDUOUS CONIFER

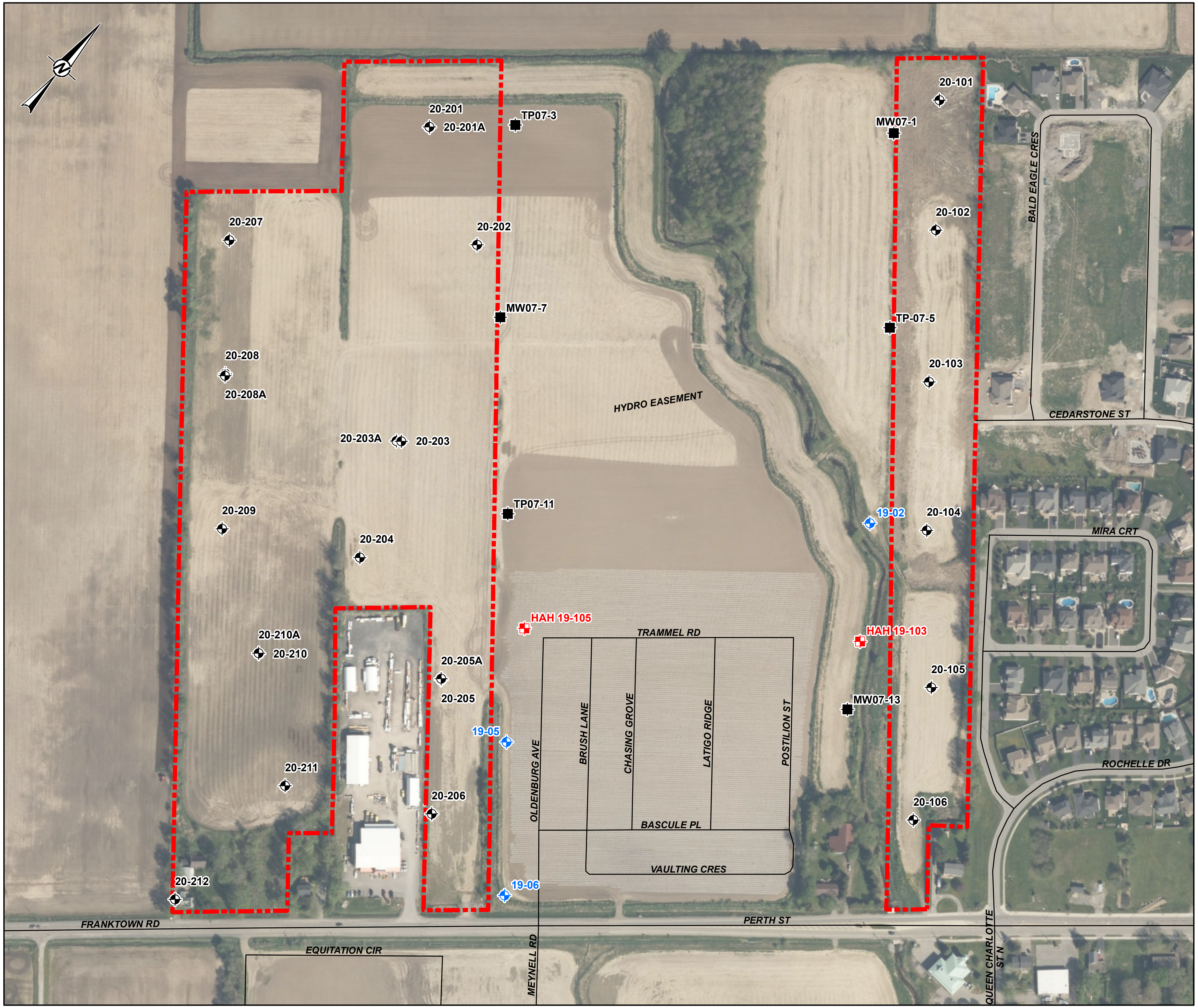
Larch

EVERGREEN CONIFERS

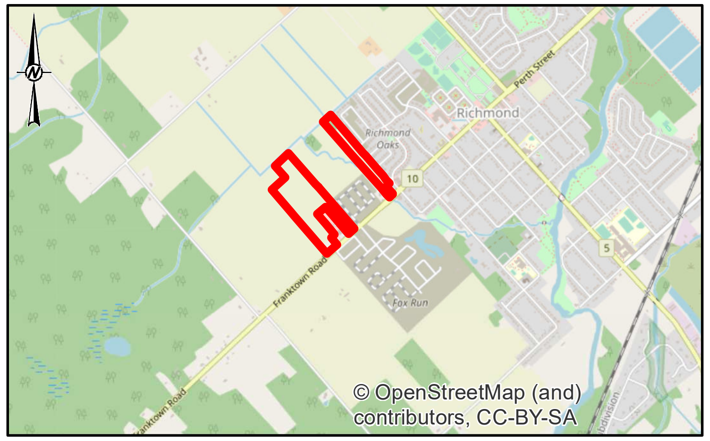
Spruce

Fir

Pine



KEY MAP



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SCALE 1:50,000

LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
🟥	APPROXIMATE HAND AUGERHOLE LOCATION, PREVIOUS INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
■	APPROXIMATE TESTHOLE LOCATION, PREVIOUS INVESTIGATION BY JACQUES WHITFORD, JUNE 2007
—	ROADWAY
▭	APPROXIMATE SITE BOUNDARY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 30 60 120

1:3,000 METRES

CLIENT

CAIVAN (RICHMOND NORTH) LIMITED

PROJECT

GEOTECHNICAL AND HYDROGEOLOGICAL INVESTIGATION,
GREEN EAST LANDS AND GREEN WEST LANDS,
RICHMOND, ONTARIO

TITLE

SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2020-07-22
DESIGNED	----
PREPARED	JEM
REVIEWED	KM
APPROVED	CH

PROJECT NO.	CONTROL	REV.	FIGURE
20144864	0005	0	1

Path: N:\Active\Spatial_IM\Caivan\RichmondProposedSWMP\99_PROJ\20144864_Caivan_Enviro\0005_Geotech_Memo_GreenEW\20144864-0005-BG-0001.mxd

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

25mm

0

APPENDIX A

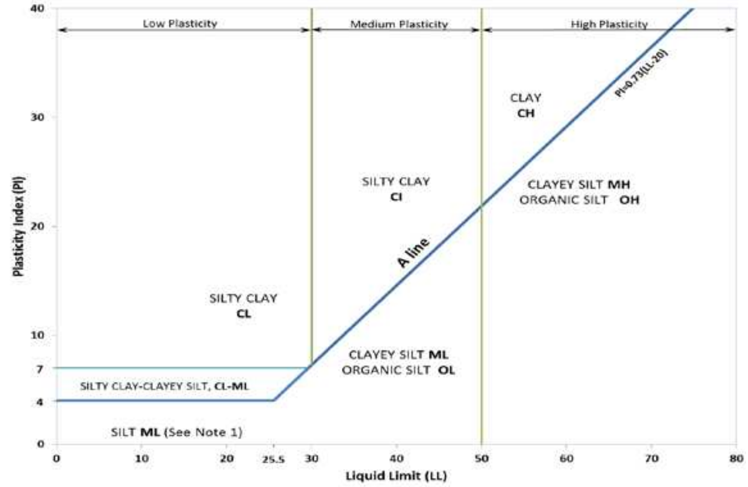
List of Abbreviations and Symbols, Record of Borehole Sheets - Current Investigation

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

PROJECT: 20144864

RECORD OF BOREHOLE: 20-101

SHEET 1 OF 1

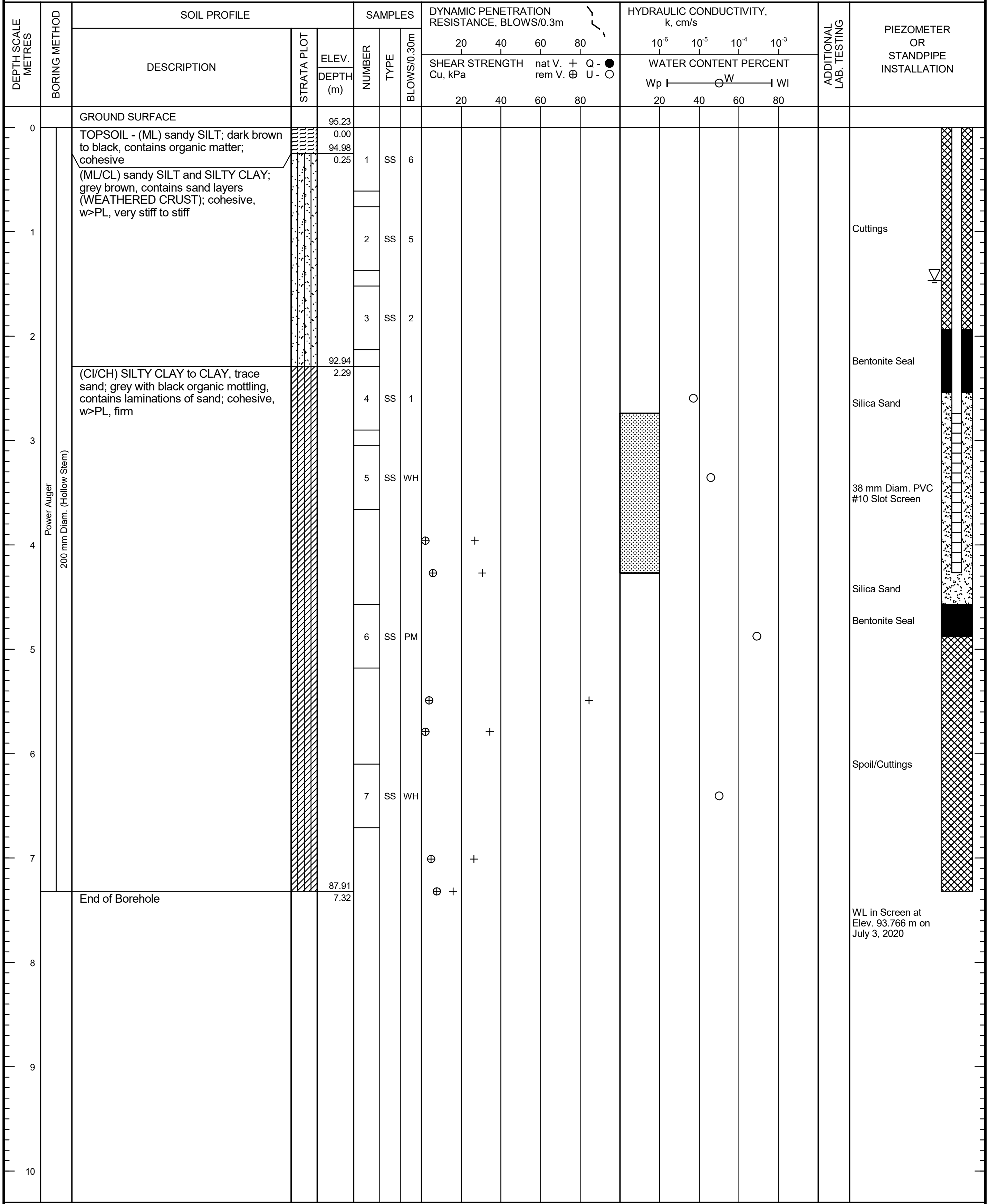
LOCATION: N 5006189.4 ;E 355720.1

BORING DATE: June 8, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	95.23
TOPSOIL - (ML) sandy SILT; dark brown to black, contains organic matter; cohesive	0.00
(ML/CL) sandy SILT and SILTY CLAY; grey brown, contains sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	94.98 0.25
(CI/CH) SILTY CLAY to CLAY, trace sand; grey with black organic mottling, contains laminations of sand; cohesive, w>PL, firm	92.94 2.29
End of Borehole	87.91 7.32

NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	5
3	SS	2
4	SS	1
5	SS	WH
6	SS	PM
7	SS	WH

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-101A

SHEET 1 OF 2

LOCATION: N 5006189.4 ;E 355720.1

BORING DATE: June 12, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.23							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-101 for Stratigraphy		0.00							
1											
2											
3					1	TP	PH				
4											
5											
6								⊕ +			
7											
		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	▨	87.61 7.62	2	SS	WH				
8											
		(CH/CI) CLAYEY SILT/SILTY CLAY, some sand, trace gravel; cohesive, w>PL, stiff	▨	86.70 8.53	3	SS	3				
9		(ML) SILT, some sand; grey; non-cohesive, wet, very loose		86.09 9.14	4	SS	2				
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-101A

SHEET 2 OF 2

LOCATION: N 5006189.4 ;E 355720.1

BORING DATE: June 12, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Power Auger	(ML) SILT, some sand; grey; non-cohesive, wet, very loose		84.56							
11	DCPT	Dynamic Cone Penetration Testing		10.67 84.10					156 156		
		End of Borehole DCPT Refusal		11.13							
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-102

SHEET 1 OF 1

LOCATION: N 5006112.7 ;E 355785.9

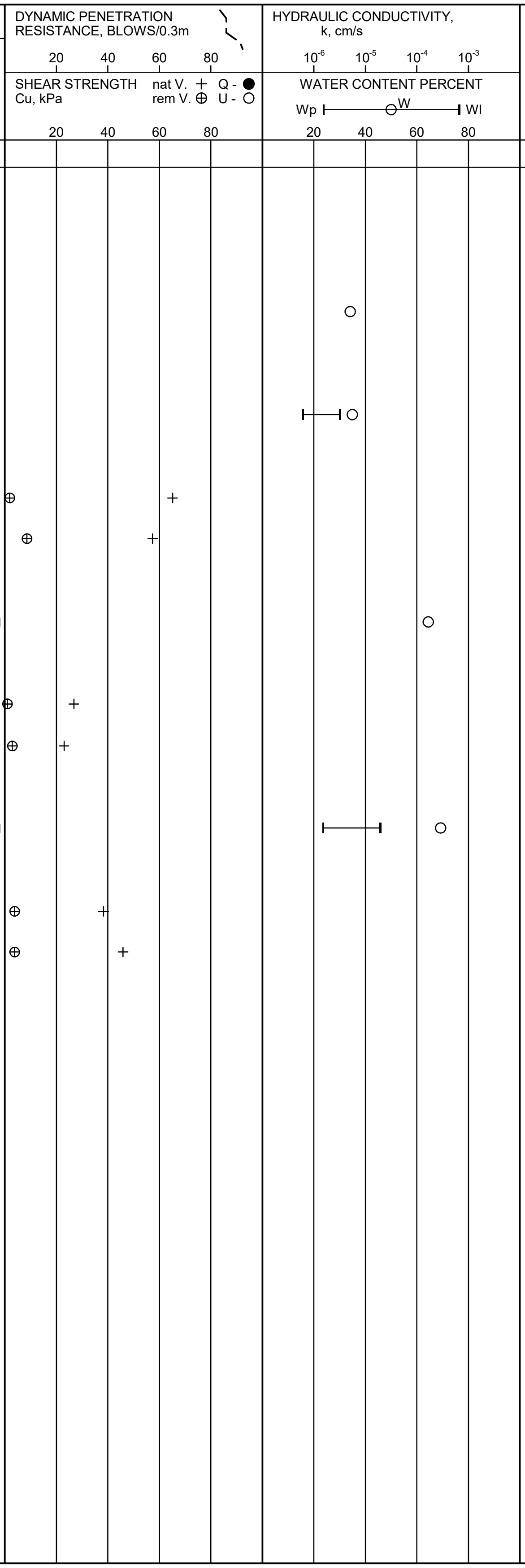
BORING DATE: June 10, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		GROUND SURFACE		94.93			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT, some plasticity fines; dark brown, contains organic matter; non-cohesive		0.00			
		(CL/CI) SILTY CLAY, some sand; grey brown, contains laminations of sand (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		94.60 0.33	1	SS	9
1					2	SS	2
2					3	SS	2
3		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft to firm		91.88 3.05	4	SS	WH
4							
5					5	SS	WH
		End of Borehole		89.14 5.79			
6							
7							
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED: CH

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PROJECT: 20144864

RECORD OF BOREHOLE: 20-103

SHEET 1 OF 1

LOCATION: N 5006021.4 ;E 355861.1

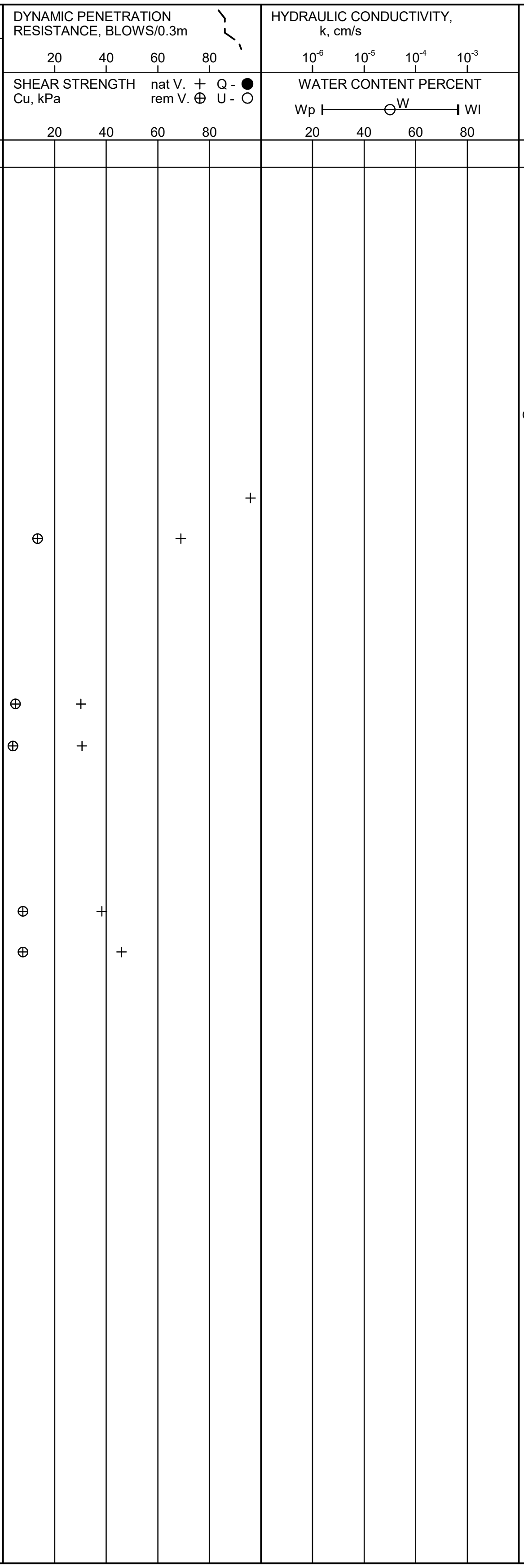
BORING DATE: June 10, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.73					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace to some sand; dark brown, contains organic matter; cohesive		0.00	1	SS	7		
1		(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains laminations of sand (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		94.32 0.41	2	SS	2		
2					3	SS	2	CHEM	
3		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm		91.68 3.05	4	SS	WH		
4									
5					5	SS	WH		
6		End of Borehole		88.94 5.79					
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-104

SHEET 1 OF 1

LOCATION: N 5005934.4 ;E 355937.2

BORING DATE: June 10, 2020

DATUM: Geodetic

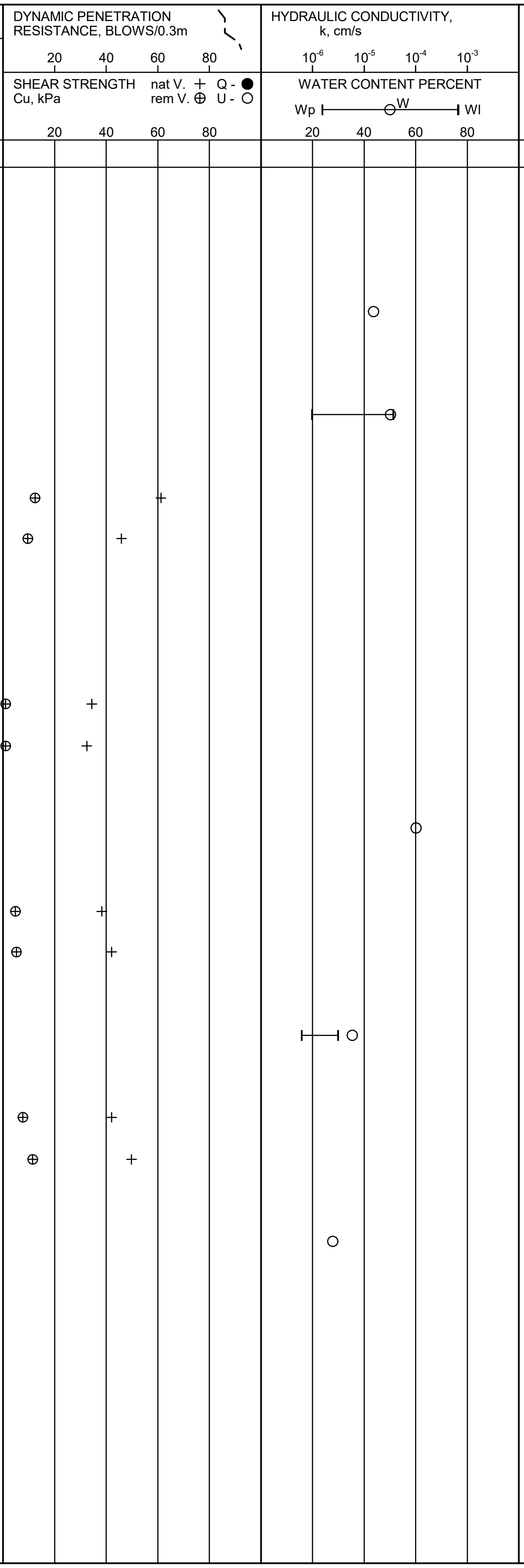
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV.	DEPTH (m)
GROUND SURFACE		94.46	0.00
TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown, contains organic matter; cohesive		94.05	0.41
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains laminations of sand (WEATHERED CRUST); cohesive, w>PL, stiff to firm		91.41	3.05
(CI/CH) SILTY CLAY to CLAY; grey, contains laminations of silt; cohesive, w>PL, firm		88.36	6.10
(CL/CI) SILTY CLAY, some sand; grey; cohesive, w>PL, firm to stiff		86.84	7.62
(ML) SILT, some sand; grey; non-cohesive, wet, loose		86.23	8.23
End of Borehole Auger Refusal			

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	6	
2	SS	2	
3	SS	3	
4	SS	PH	C
5	SS	WH	
6	SS	WH	
7	SS	6	MH



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-105

SHEET 1 OF 1

LOCATION: N 5005845.9 ;E 356021.8

BORING DATE: June 16, 2020

DATUM: Geodetic

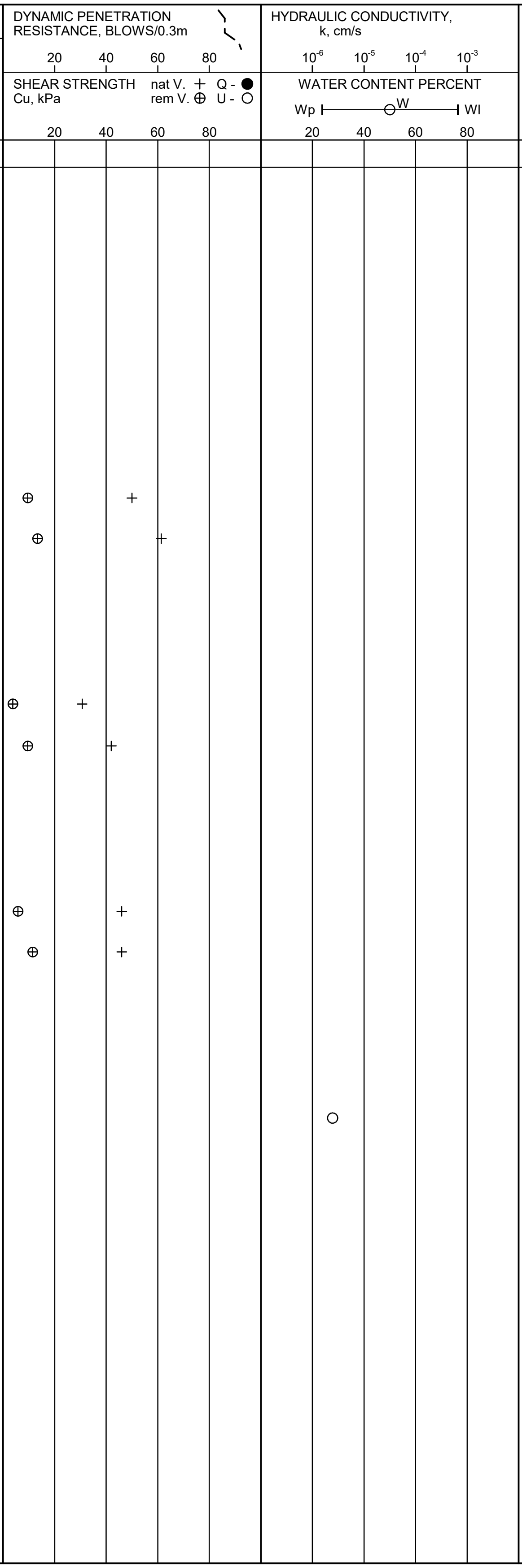
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	94.48					
TOPSOIL - (CL) SILTY CLAY, trace sand; brown, contains organic matter; cohesive	0.00	1	SS	7		
(CI/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	94.02 0.46	2	SS	3		
		3	SS	2		
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	91.43 3.05	4	SS	WH		
		5	SS	WH		
(ML) CLAYEY SILT, some sand; grey; cohesive, w>PL, very stiff	88.38 6.10	6	SS	6		
(ML) SILT, some low plasticity fines to clayey; non-cohesive, wet, very loose to loose	87.77 6.71	7	SS	4	MH	
End of Borehole Auger Refusal	87.16 7.32					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: SG

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-106

SHEET 1 OF 1

LOCATION: N 5005760.1 ;E 356080.5

BORING DATE: June 18, 2020

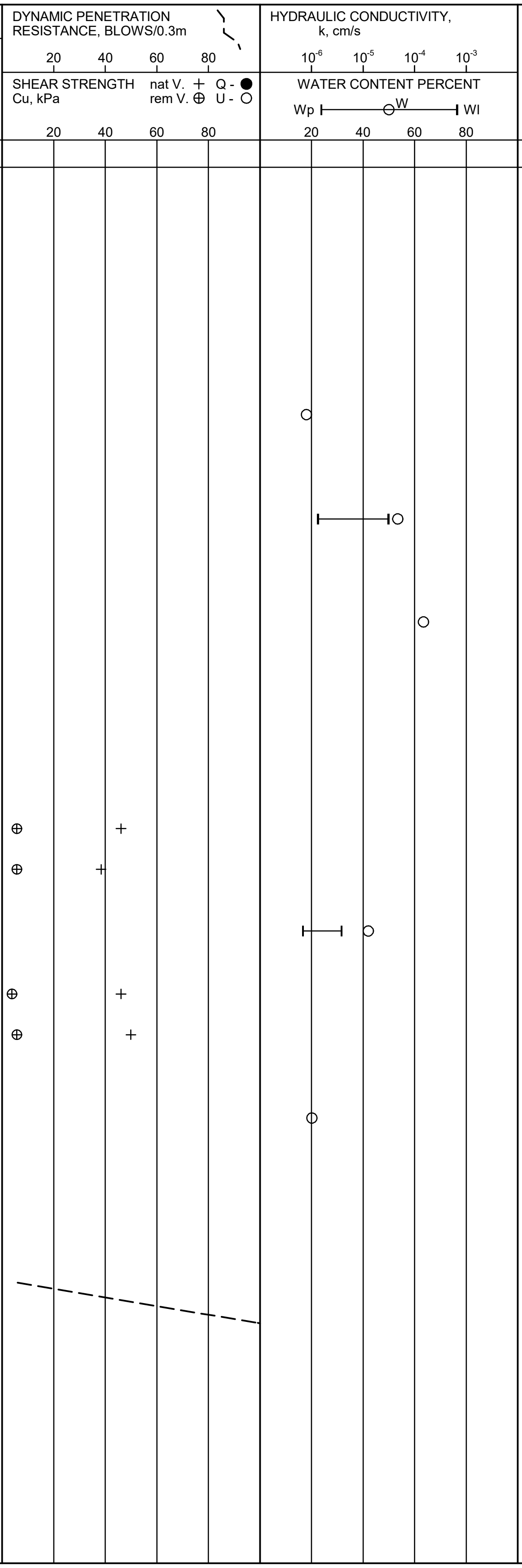
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		94.48
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown, contains organic matter; non-cohesive		0.00
		FILL - (ML/SM) SILT and SAND; grey brown, contains layers of silty clay; non-cohesive, moist, loose		0.15
2		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff to firm		92.19 2.29
4		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		90.67 3.81
7		(ML) SILT, some low plasticity fines; grey; non-cohesive, wet, loose		87.78 6.70
8	Dynamic Cone Penetration Testing	Dynamic Cone Penetration Testing		86.25 8.23
9		End of Borehole DCPT Refusal		85.90 8.58

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	11
2	SS	7
3	SS	4
4	SS	3
5	SS	WH
6	TP	PH
7	SS	WH
8	SS	8
9	SS	8



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: SG

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-201

SHEET 1 OF 2

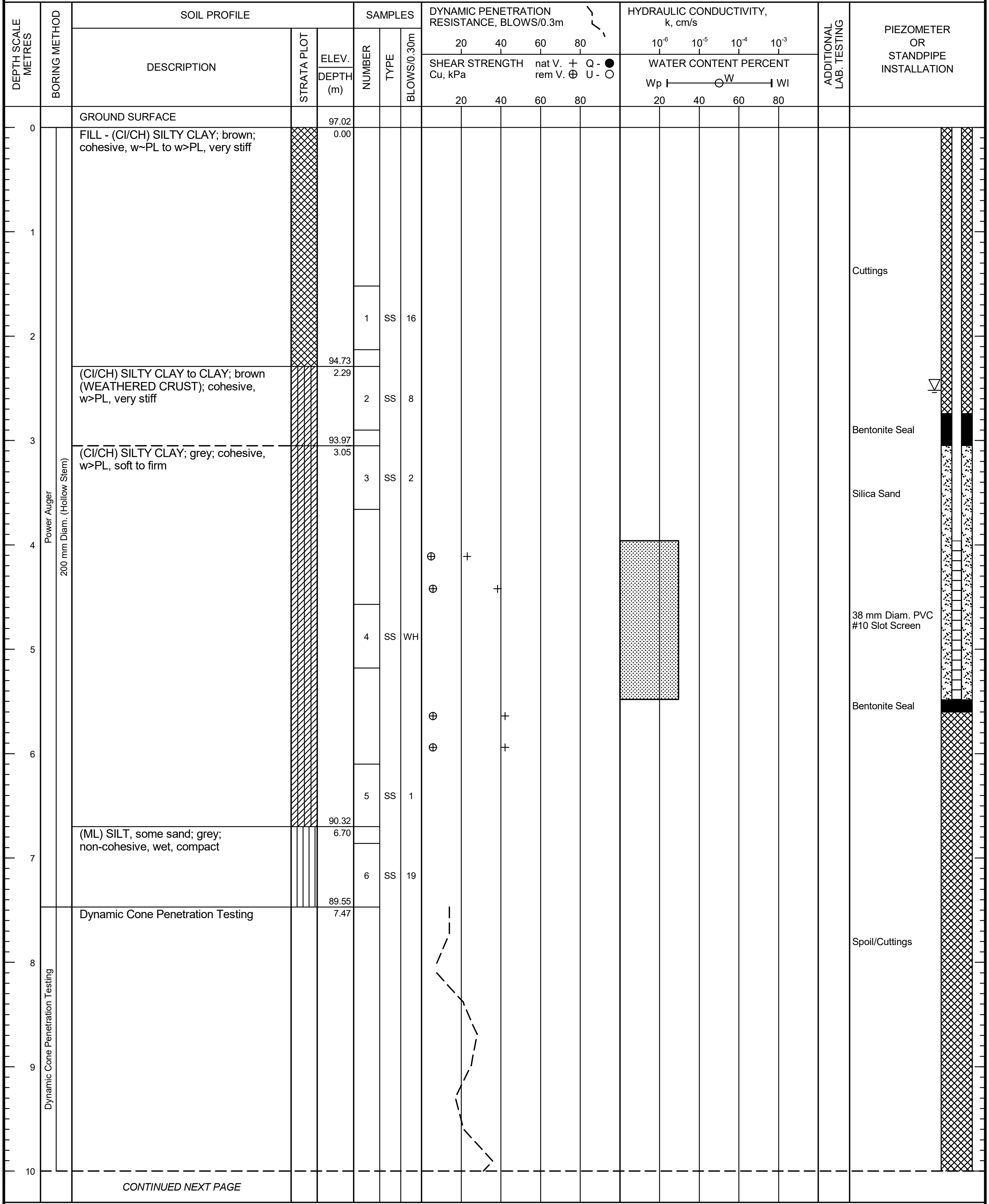
LOCATION: N 5005908.0 ;E 355439.6

BORING DATE: June 22, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	97.02
FILL - (CI/CH) SILTY CLAY; brown; cohesive, w~PL to w>PL, very stiff	0.00
(CI/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w>PL, very stiff	94.73 2.29
(CI/CH) SILTY CLAY; grey; cohesive, w>PL, soft to firm	93.97 3.05
(ML) SILT, some sand; grey; non-cohesive, wet, compact	90.32 6.70
Dynamic Cone Penetration Testing	89.55 7.47

NUMBER	TYPE	BLOWS/0.30m
1	SS	16
2	SS	8
3	SS	2
4	SS	WH
5	SS	1
6	SS	19

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-201

SHEET 2 OF 2

LOCATION: N 5005908.0 ;E 355439.6

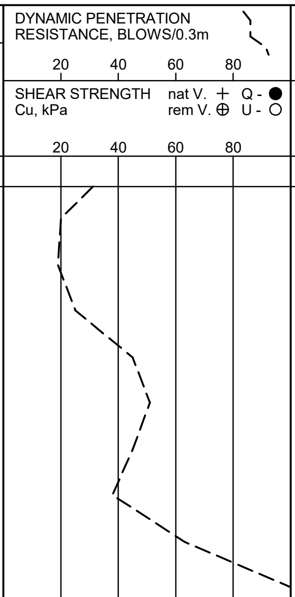
BORING DATE: June 22, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10 11 12	Dynamic Cone Penetration Testing	Dynamic Cone Penetration Testing							▩ Spoil/Cuttings
13 14 15 16 17 18 19 20		End of Borehole		84.42 12.60					WL in Screen at Elev. 94.503 m on July 3, 2020



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

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

PROJECT: 20144864

RECORD OF BOREHOLE: 20-201A

SHEET 1 OF 1

LOCATION: N 5005908.0 ;E 355439.6

BORING DATE: June 22, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.02							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-201 for Stratigraphy		0.00							
1											
2											
3											
4					1A	TO	PH				
		End of Borehole		92.45 4.57							
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-202

SHEET 1 OF 1

LOCATION: N 5005864.9 ;E 355528.6

BORING DATE: June 22, 2020

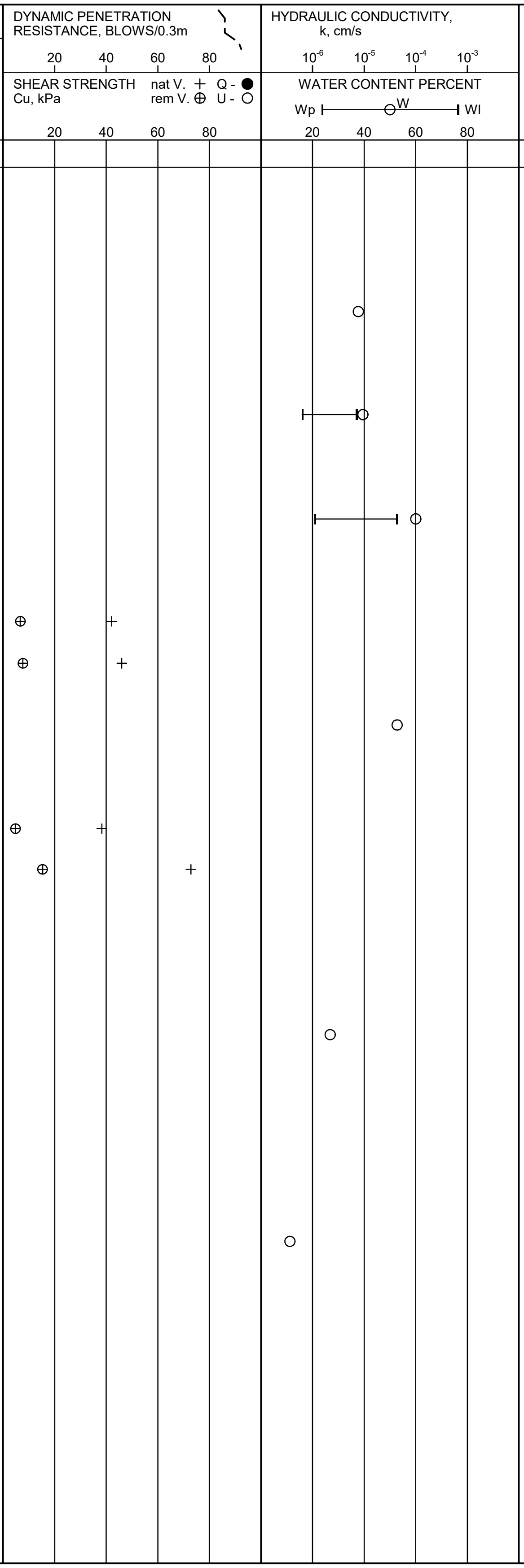
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
GROUND SURFACE	94.92				
FILL - (CL) sandy SILTY CLAY; brown; cohesive, w~PL to w>PL, very stiff	0.00	1	SS	8	
		2	SS	5	
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	93.40 1.52	3	SS	2	
(CI/CH) SILTY CLAY to CLAY; grey, contains laminations of silt; cohesive, w>PL, firm to stiff	92.63 2.29	4	SS	2	
		5	SS	WH	
(ML) SILT, some sand to sandy; grey; non-cohesive, wet, loose to very loose	89.59 5.33	6	SS	4	
		7	SS	4	MH
(SM/ML) SILT and SAND, some gravel and low plasticity fines; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to compact	87.76 7.16	8	SS	3	
		9	SS	5	MH
		10	SS	32	
End of Borehole Spoon Refusal	86.08 8.84				



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-203

SHEET 1 OF 1

LOCATION: N 5005712.0 ;E 355587.2

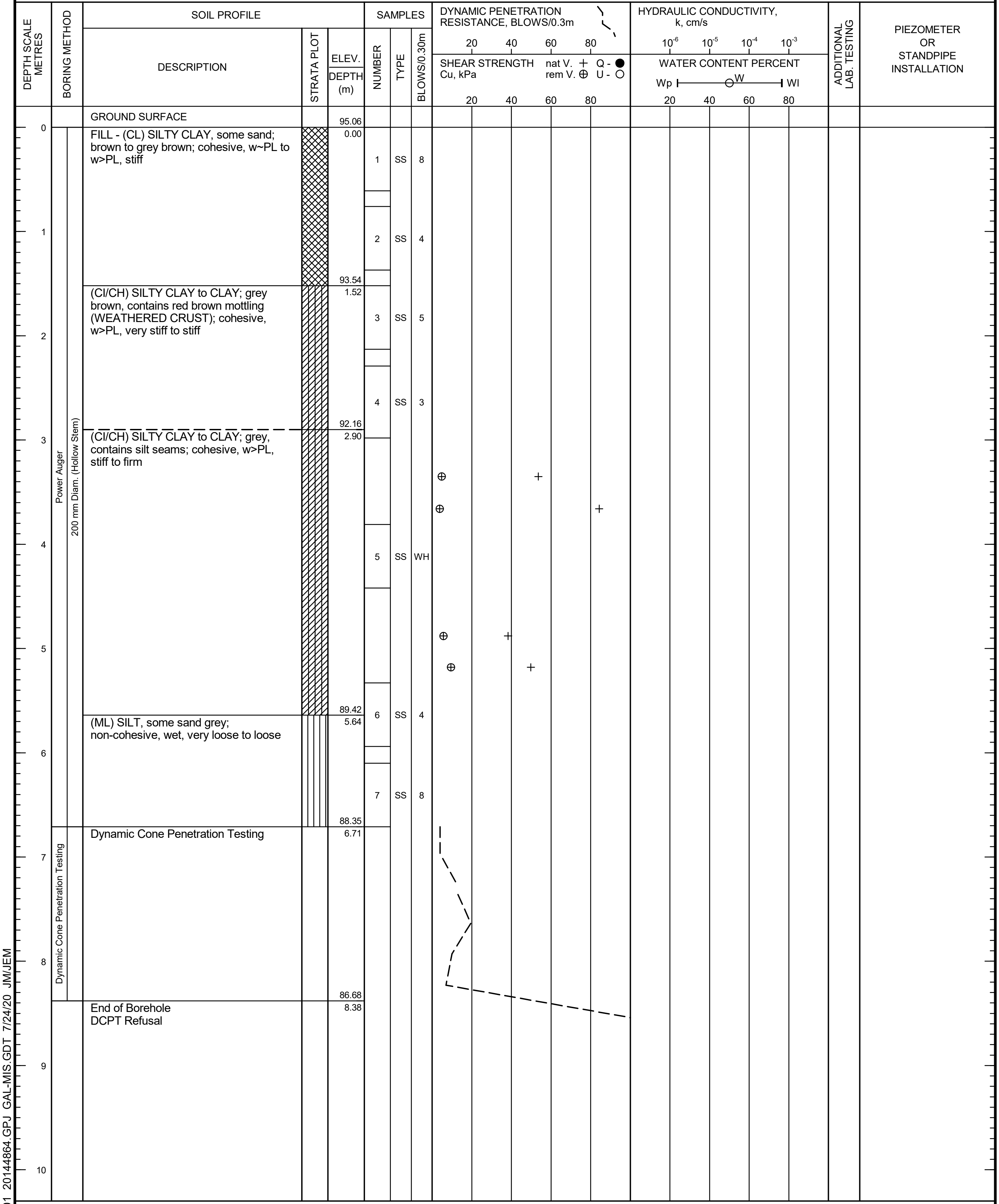
BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE		95.06			
Power Auger 200 mm Diam. (Hollow Stem)	FILL - (CL) SILTY CLAY, some sand; brown to grey brown; cohesive, w~PL to w>PL, stiff		0.00	1 2	SS SS	8 4
	(CI/CH) SILTY CLAY to CLAY; grey brown, contains red brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		93.54 1.52	3 4	SS SS	5 3
	(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, stiff to firm		92.16 2.90	5	SS	WH
	(ML) SILT, some sand grey; non-cohesive, wet, very loose to loose		89.42 5.64	6 7	SS SS	4 8
Dynamic Cone Penetration Testing	Dynamic Cone Penetration Testing		88.35 6.71			
	End of Borehole DCPT Refusal		86.68 8.38			



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-203A

SHEET 1 OF 1

LOCATION: N 5005709.6 ;E 355584.3

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.11							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-203 for Stratigraphy		0.00							
1											
2											
3											
4											
5					1A	TP	PH				
		End of Borehole		89.93 5.18							
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

LOGGED: RK
CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-204

SHEET 1 OF 1

LOCATION: N 5005623.1 ;E 355623.7

BORING DATE: June 23, 2020

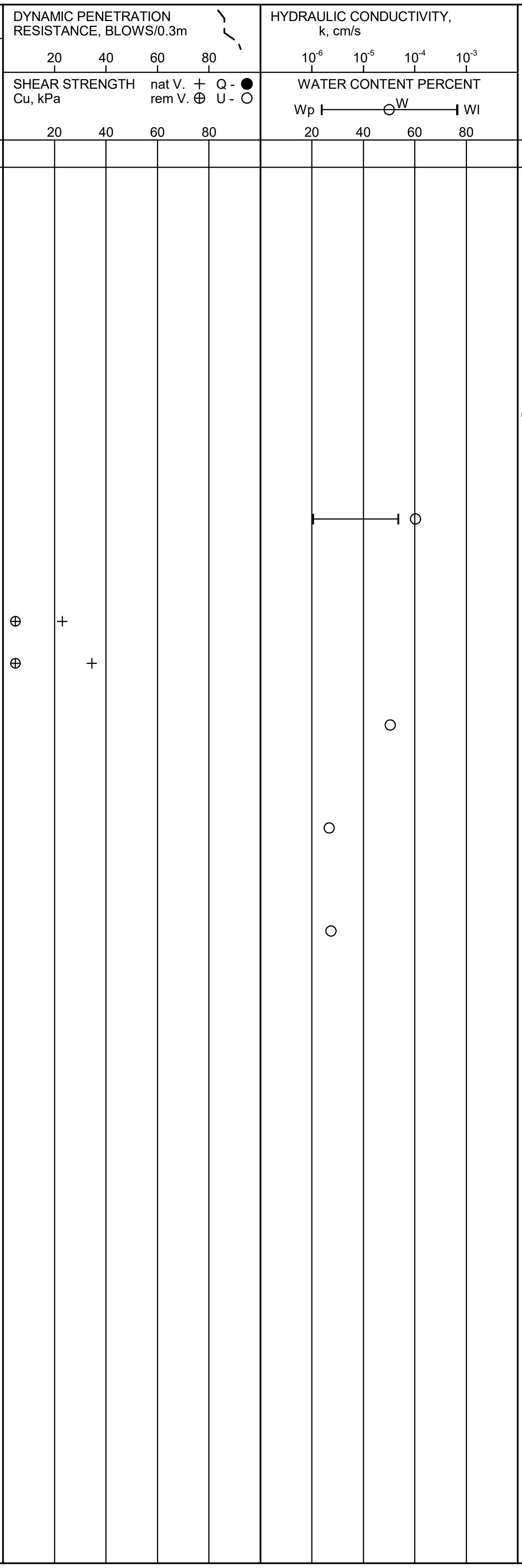
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
GROUND SURFACE	94.97				
FILL - (CL) sandy SILTY CLAY; grey brown; cohesive, w~PL, stiff	0.00	1	SS	8	
		2	SS	5	
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	93.45 1.52	3	SS	4	CHEM
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey, contains clayey silt layers; cohesive, w>PL, stiff to soft	92.68 2.29	4	SS	1	
		5	SS	WH	
(ML) SILT, some sand to sandy; grey; non-cohesive, wet very loose to loose	90.40 4.57	6	SS	3	MH
		7	SS	WH	
		8	SS	9	
		9	SS	9	MH
End of Borehole Auger Refusal	87.35 7.62				



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-205

SHEET 1 OF 1

LOCATION: N 5005594.9 ;E 355734.5

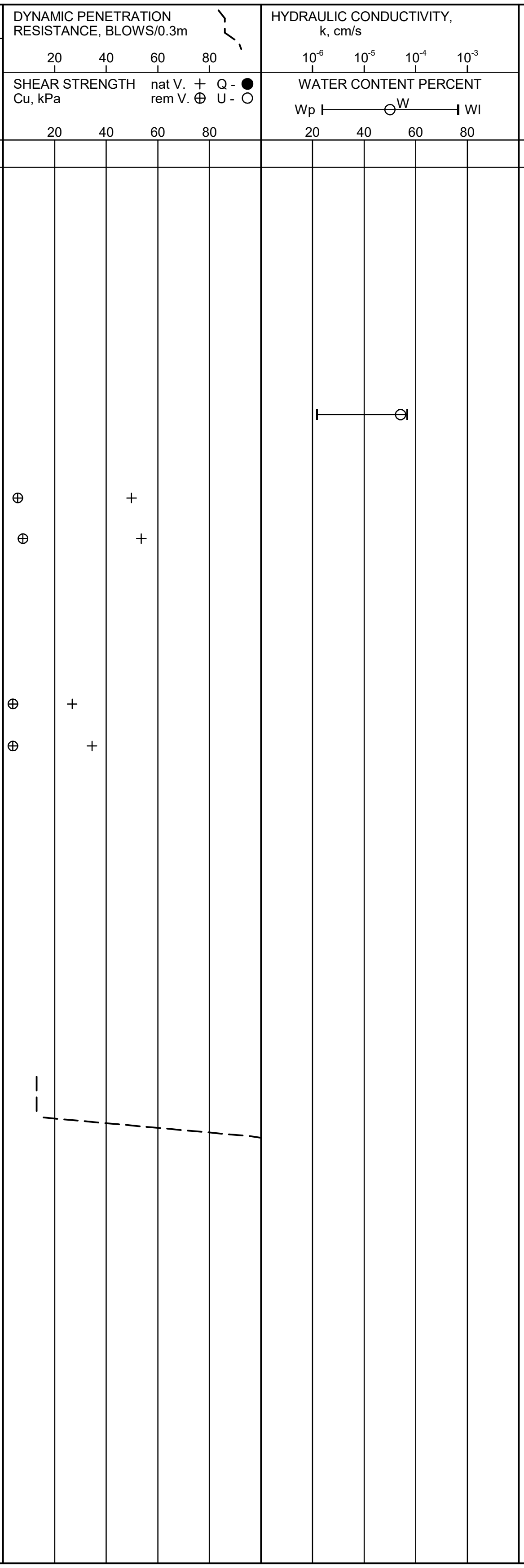
BORING DATE: June 19, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	94.54			
Power Auger 200 mm Diam. (Hollow Stem)	FILL - (CL) sandy SILTY CLAY; brown, contains organic matter, wood; cohesive, w~PL, very stiff	0.00	1	SS	9
			2	SS	5
	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff	93.17 1.37	3	SS	3
	(CI/CH) SILTY CLAY to CLAY; grey brown; cohesive, w>PL, stiff to firm	92.41 2.13	4	SS	WH
			5	SS	WH
	(ML) SILT, some sand; grey; non-cohesive, wet, loose to compact	89.21 5.33	6	SS	10
			7	SS	12
DCPT	Dynamic Cone Penetration Testing	87.83 6.71			
	End of Borehole DCPT Refusal	87.38 7.16			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RK
CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-205A

SHEET 1 OF 1

LOCATION: N 5005594.9 ;E 355734.5

BORING DATE: June 20, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.54							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-205 for Stratigraphy		0.00							
4					1A	TP	PH				
				90.17 4.37							
		End of Borehole									

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-206

SHEET 1 OF 1

LOCATION: N 5005512.5 ;E 355798.9

BORING DATE: June 19, 2020

DATUM: Geodetic

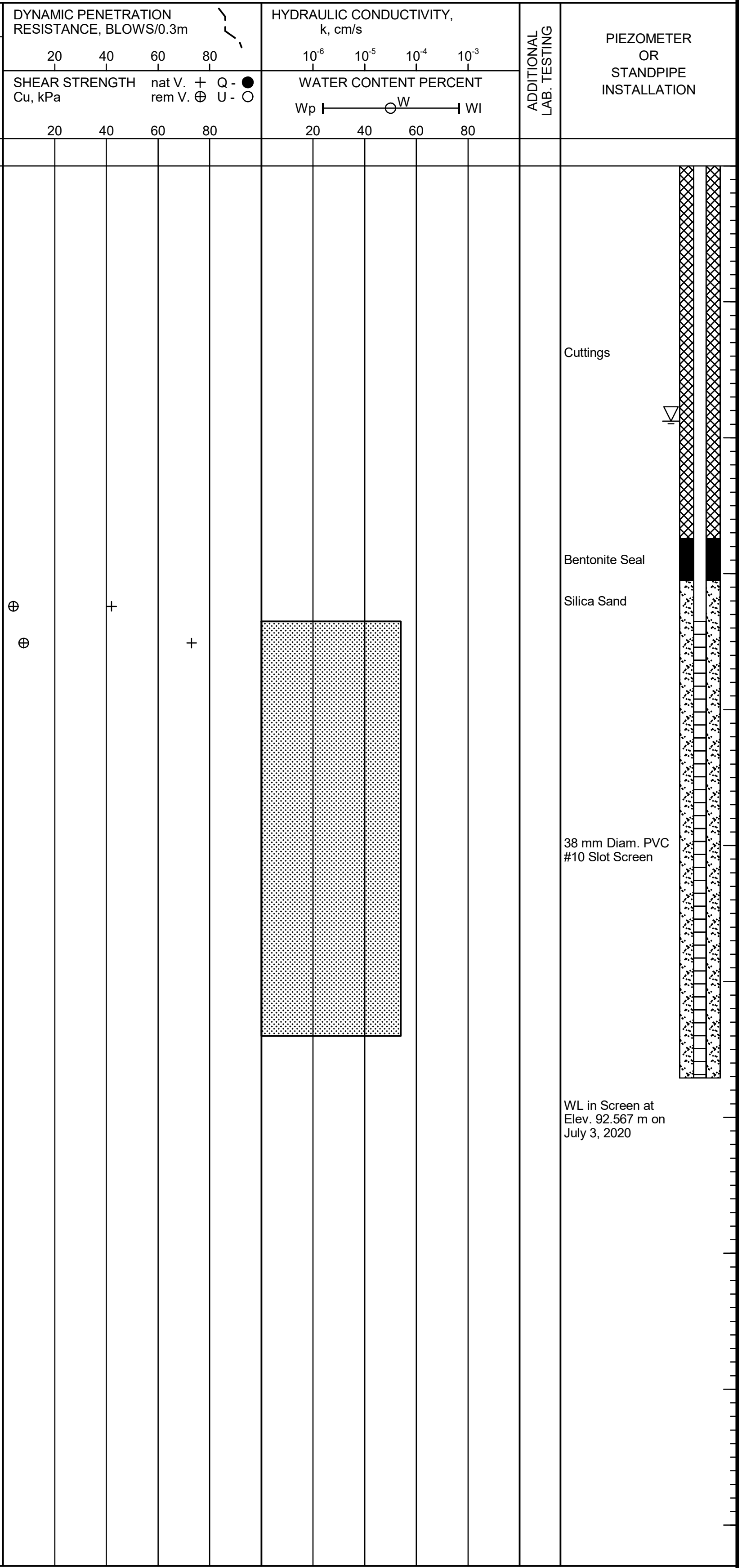
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	94.44
FILL - (SP) gravelly SAND, trace to some non-plastic fines, angular; non-cohesive, moist, loose	0.00
FILL - (CI) sandy SILTY CLAY; brown; cohesive, w>PL, very stiff	93.83 0.61
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	92.92 1.52
(ML) SILT, some sand; grey; non-cohesive, wet, very loose to loose	90.33 4.11
(ML) sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet, compact	88.04 6.40
End of Borehole Auger Refusal	87.73 6.71

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	6
3	SS	4
4	SS	2
5	SS	2
6	SS	10
7	SS	8
8	SS	21



Cuttings

Bentonite Seal

Silica Sand

38 mm Diam. PVC
#10 Slot Screen

WL in Screen at
Elev. 92.567 m on
July 3, 2020

DEPTH SCALE
1 : 50

GOLDER

LOGGED: KM
CHECKED: BB

PROJECT: 20144864

RECORD OF BOREHOLE: 20-207

SHEET 1 OF 2

LOCATION: N 5005738.4 ;E 355382.9

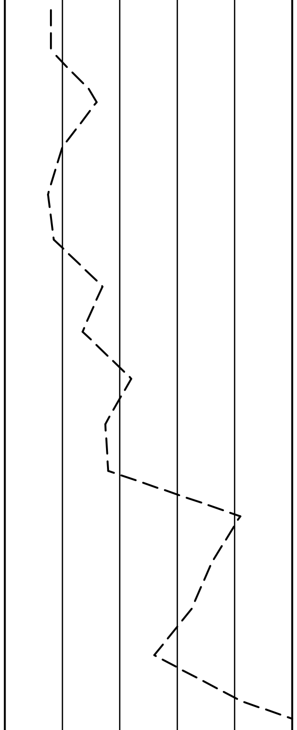
BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT (Wp W Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.00						
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND; brown; non-cohesive, moist, loose	▨	0.00	1	SS	4			
		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	▨	95.39 0.61	2	SS	9			
1		(ML) SILT, some sand to sandy SILT; grey; non-cohesive, moist to wet, compact		94.78 1.22	3	SS	24			
2					4	SS	16			
3					5	SS	12	○ (W ≈ 20)	MH	
4					6	SS	23			
5					7	SS	21			
	Dynamic Cone Penetration Testing	Dynamic Cone Penetration Testing		90.82 5.18						
10		*CONTINUED NEXT PAGE*								



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-207

SHEET 2 OF 2

LOCATION: N 5005738.4 ;E 355382.9

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10											
		End of Borehole DCPT Refusal		85.90 10.10					128		
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-208

SHEET 1 OF 1

LOCATION: N 5005659.2 ;E 355450.2

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

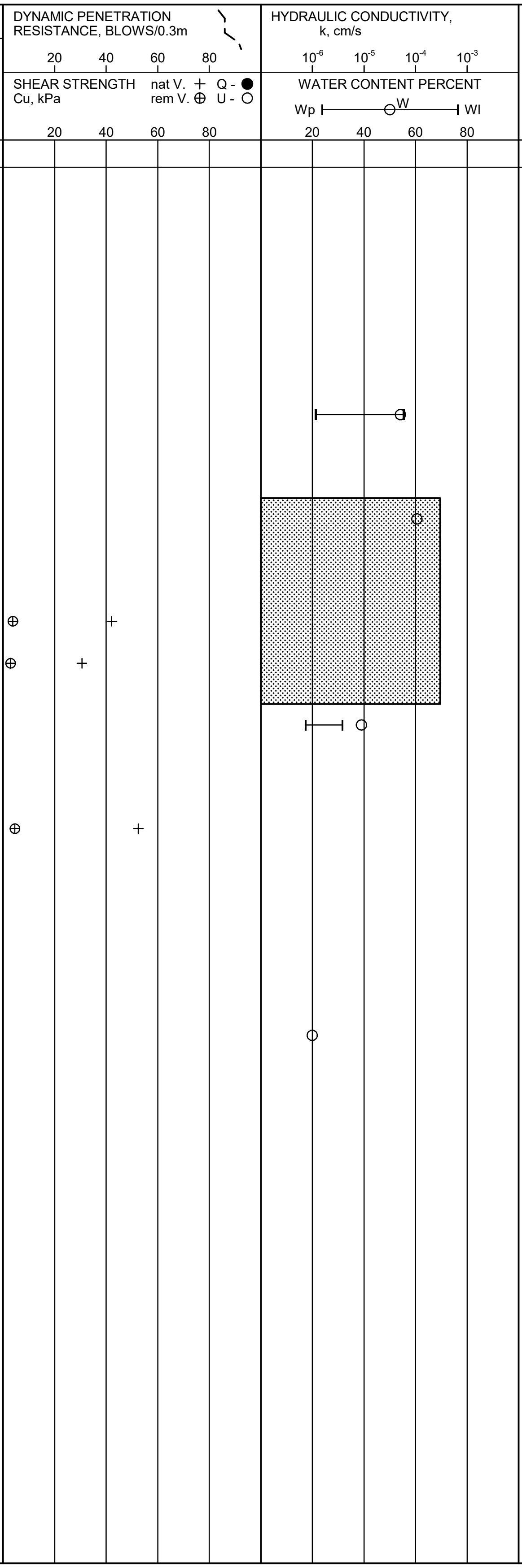
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES: 0 – 10

SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)
GROUND SURFACE		95.94
FILL - (SM) SILTY SAND; brown to dark brown; non-cohesive, moist, very loose	▩	0.00
FILL - (CL) SILTY CLAY; grey brown, contains red brown mottling; cohesive, w>PL, very stiff	▩	95.48 0.46
(CI/CH) SILTY CLAY to CLAY; grey brown, contains red brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff	▨	94.57 1.37
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff to firm	▨	93.65 2.29
(ML) SILT, some sand and low plasticity fines; grey; non-cohesive, wet, compact	▥	90.15 5.79
End of Borehole Auger Refusal		89.23 6.71

SAMPLES – NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	3	
2	SS	4	
3	SS	4	
4	SS	WH	
5	SS	WH	
6	SS	WH	
7	SS	21	MH



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RK
CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-208A

SHEET 1 OF 1

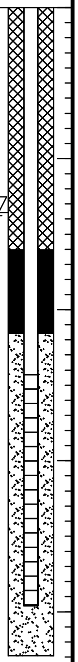
LOCATION: N 5005657.9 ;E 355451.3

BORING DATE: June 23, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.89							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-208 for Stratigraphy		0.00							
											Cuttings
1											∇
											Bentonite Seal
2											Silica Sand
3											38 mm Diam. PVC #10 Slot Screen
4					1A	TP	PH			C	Silica Sand
		End of Borehole		91.60 4.29							WL in Screen at Elev. 94.530 m on July 3, 2020
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-209

SHEET 1 OF 1

LOCATION: N 5005568.0 ;E 355529.3

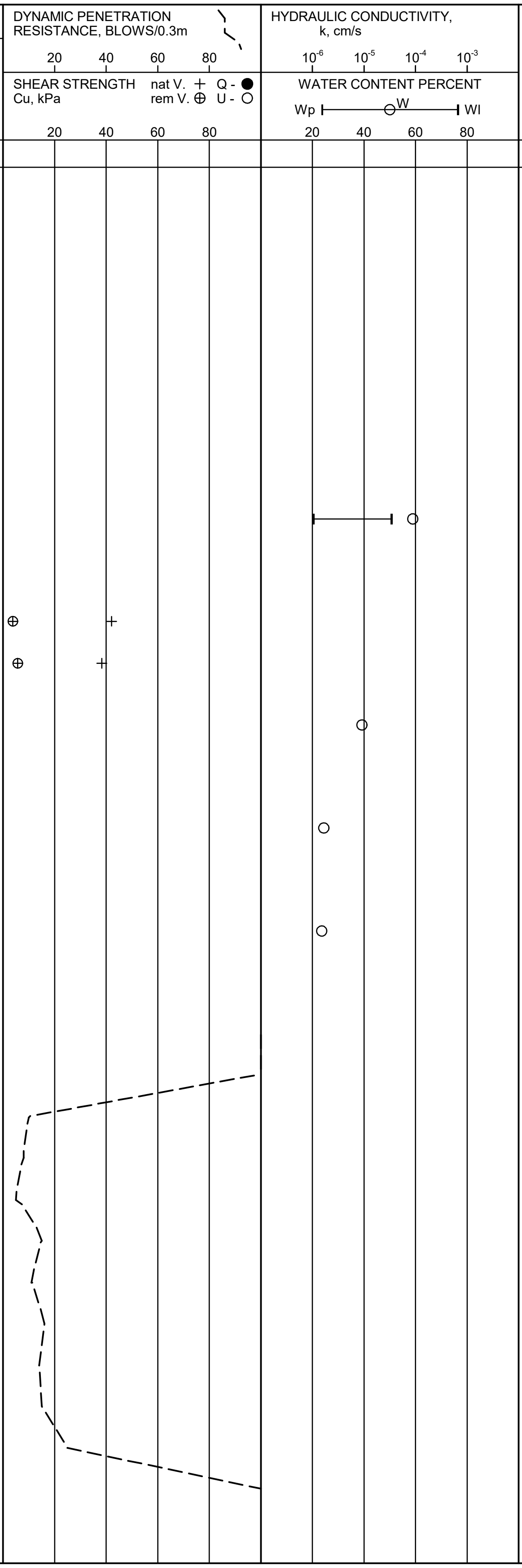
BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	95.41					
Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND; brown, contains organic matter; non-cohesive, moist	0.00					
	FILL - (CL) SILTY CLAY; grey brown; cohesive, w>PL, stiff	95.11 0.30	1	SS	5		
			2	SS	5		
	(CI/CH) SILTY CLAY; grey brown with reddish brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff	94.19 1.22	3	SS	3		
	(CI/CH) SILTY CLAY; grey; cohesive, w>PL, stiff to firm	93.12 2.29	4	SS	WH		
			5	SS	WH		
	(ML) SILT, some sand, fine; grey; non-cohesive, wet, compact to loose	90.84 4.57	6	SS	13		
			7	SS	7	MH	
Dynamic Cone Penetration Testing	Dynamic Cone Penetration Testing	89.01 6.40					
	End of Borehole DCPT Refusal	85.81 9.60					



DEPTH SCALE

1 : 50

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-210

SHEET 1 OF 1

LOCATION: N 5005515.0 ;E 355615.5

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

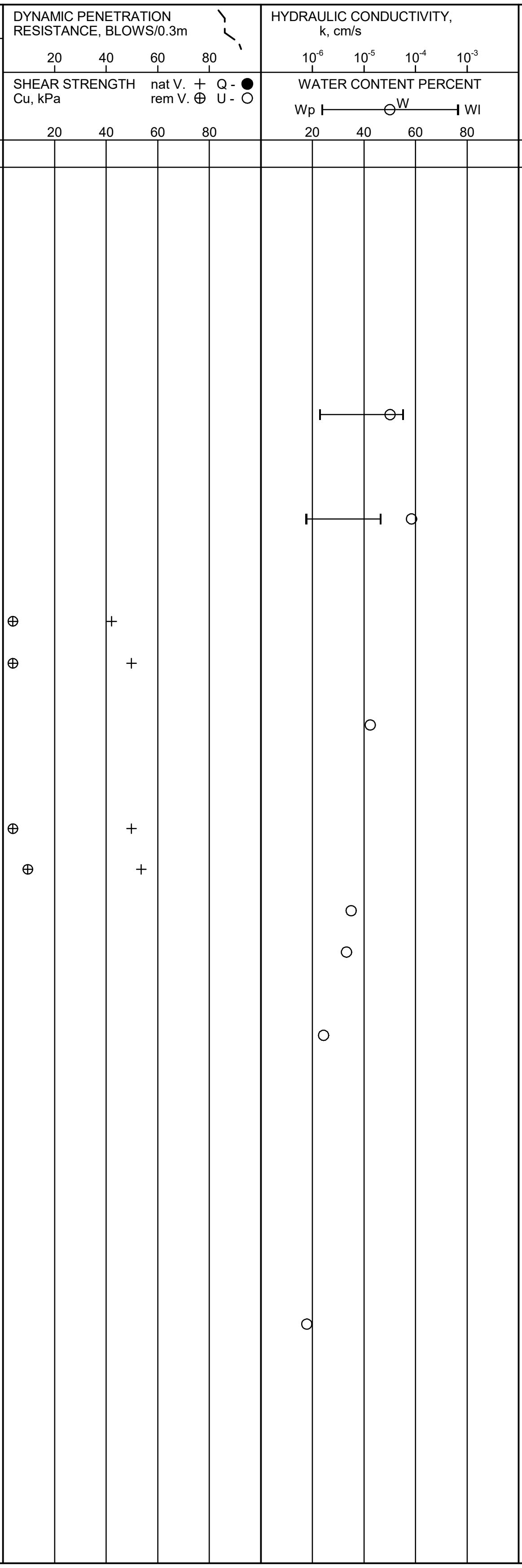
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	95.27	
FILL - (SM) SILTY SAND; brown to grey brown, contains organic matter; non-cohesive, moist, loose		0.00
FILL - (CL) SILTY CLAY; grey brown; cohesive, w>PL, stiff	94.66	0.61
(CI/CH) SILTY CLAY; grey brown with red brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff	94.20	1.07
(CI/CH) SILTY CLAY; grey; cohesive, w>PL, stiff to firm	92.98	2.29
(ML) SILT, some sand to sandy; grey; non-cohesive, wet, loose to compact	89.63	5.64
(ML) sandy SILT, some gravel, trace plasticity fines; grey (GLACIAL TILL); non-cohesive, wet, very dense	86.89	8.38
End of Borehole Sampler Refusal	86.58	8.69

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	5	
2	SS	5	
3	SS	4	
4	SS	1	
5	SS	WH	
6	SS	WH	
7	SS	9	MH
8	SS	12	
9	SS	14	
10	SS	>50	MH

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

MIS-BHS 001 20144864.GPJ GAL-MIS.GDT 7/24/20 JM/JEM

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RK
CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-210A

SHEET 1 OF 1

LOCATION: N 5005515.0 ;E 355615.5

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE / SHEAR STRENGTH	HYDRAULIC CONDUCTIVITY / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.27							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 20-210 for Stratigraphy		0.00							
4					1A	TP	PH				
		End of Borehole		90.70 4.57							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-211

SHEET 1 OF 1

LOCATION: N 5005452.3 ;E 355699.7

BORING DATE: June 24, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	95.08			
0	FILL - (SM) SILTY SAND; dark brown, contains organic matter; non-cohesive, moist, loose	0.00			
	FILL - (CL) sandy SILTY CLAY; grey brown; cohesive, w>PL, stiff	94.78 0.30	1	SS	6
1			2	SS	7
	(CI/CH) SILTY CLAY to CLAY; grey brown with red brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff	93.56 1.52	3	SS	1
2					
	(ML) SILT, some sand to sandy; grey brown; non-cohesive, moist, loose to compact	92.49 2.59	4	SS	6
3			5	SS	21
	(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, compact	91.42 3.66			
4	End of Borehole Auger Refusal	3.76			
5					
6					
7					
8					
9					
10					

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RK

CHECKED: CH

PROJECT: 20144864

RECORD OF BOREHOLE: 20-212

SHEET 1 OF 1

LOCATION: N 5005329.4 ;E 355695.3

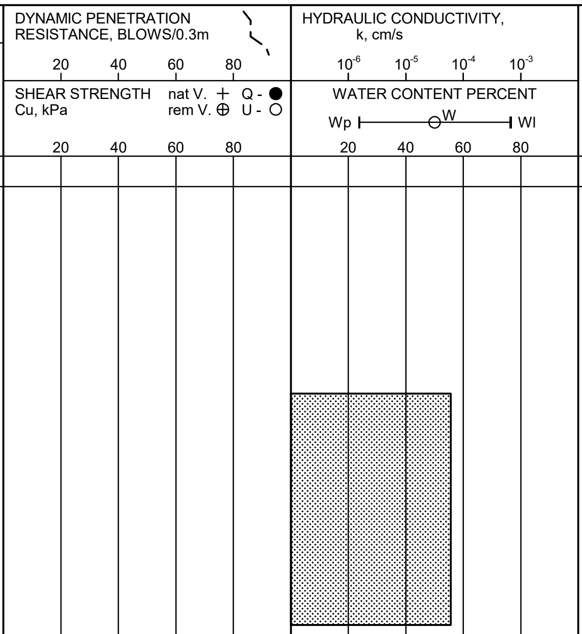
BORING DATE: June 18, 2020

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

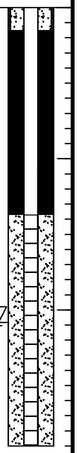
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	96.00			
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SP/SM) SILTY SAND, some gravel; brown; non-cohesive, moist, loose	0.00	1	SS	9
		FILL - (CL/CI) SILTY CLAY, some sand to sandy; cohesive, w>PL, very stiff	95.24 0.76	2	SS	8
		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff	94.48 1.52	3	SS	4
		(ML) sandy SILT, trace plasticity fines; moist, compact	93.41 2.59	4	SS	1
3		End of Borehole Auger Refusal	93.10 2.90			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



Flush Mount Casing

Cuttings

Silica Sand

38 mm Diam. PVC #10 Slot Screen

WL in Screen at Elev. 93.916 m on July 3, 2020

DEPTH SCALE
1 : 50

GOLDER

LOGGED: KM
CHECKED: CH

APPENDIX B

Record of Borehole, TestPit, Monitoring Well Record and Hand Augerhole Sheets - Previous Investigations

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of rock material weathering.

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

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

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

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

DISCONTINUITY DATA

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

Dip with Respect to Core Axis
The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° 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

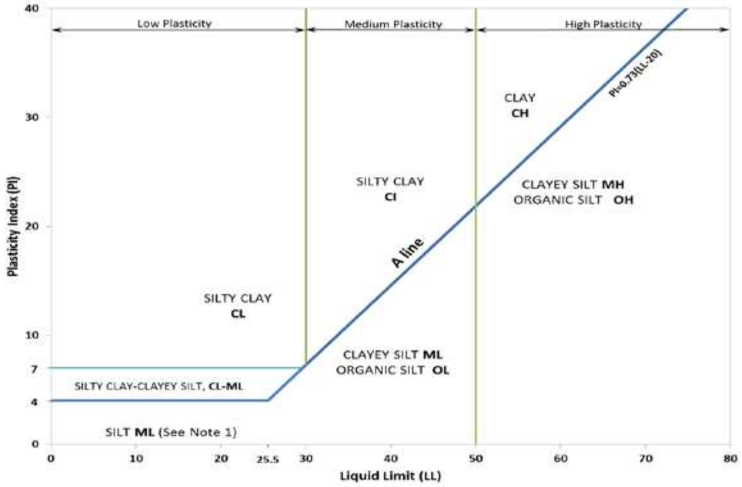
JN	Joint
FLT	Fault
SH	Shear
VN	Vein
FR	Fracture
SY	Stylolite
BD	Bedding
FO	Foliation
CO	Contact
AXJ	Axial Joint
KV	Karstic Void
MB	Mechanical Break
PL	Planar
CU	Curved
UN	Undulating
IR	Irregular
K	Slickensided
PO	Polished
SM	Smooth
SR	Slightly Rough
RO	Rough
VR	Very Rough

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

PROJECT: 1522173

RECORD OF BOREHOLE: 19-02

SHEET 1 OF 1

LOCATION: N 5005908.9 ;E 355900.6

BORING DATE: April 23, 2019

DATUM: Geodetic

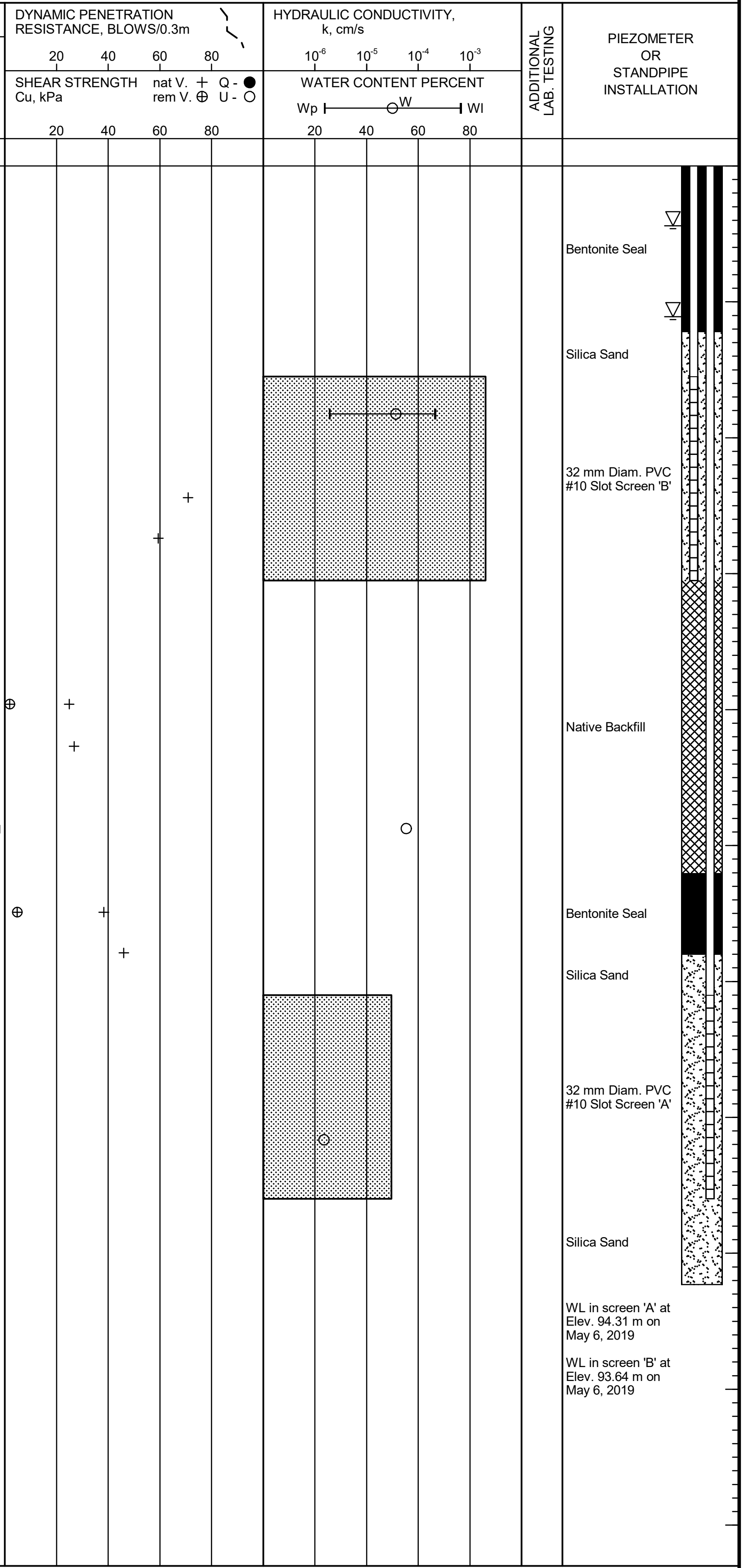
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	94.75
TOPSOIL- (ML) sandy SILT; dark brown	0.00
(CL-ML) CLAYEY SILT to SILTY CLAY; grey brown, fissured, contains silty sand seams (WEATHERED CRUST); cohesive, w<PL, very stiff	94.50 0.25
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff	93.38 1.37
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	91.70 3.05
(CI/CH-ML) SILTY CLAY to CLAYEY SILT; grey; cohesive, w>PL	88.65 6.10
(ML) sandy SILT; grey; non-cohesive, wet, loose to very loose	88.35 6.40
End of Borehole	86.52 8.23

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	6
3	SS	2
4	TP	PH
5	SS	WH
6	SS	4
7	SS	7
8	SS	2



WL in screen 'A' at Elev. 94.31 m on May 6, 2019

WL in screen 'B' at Elev. 93.64 m on May 6, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

PROJECT: 1522173

RECORD OF BOREHOLE: 19-06

SHEET 1 OF 1

LOCATION: N 5005503.4 ;E 355883.6

BORING DATE: April 25, 2019

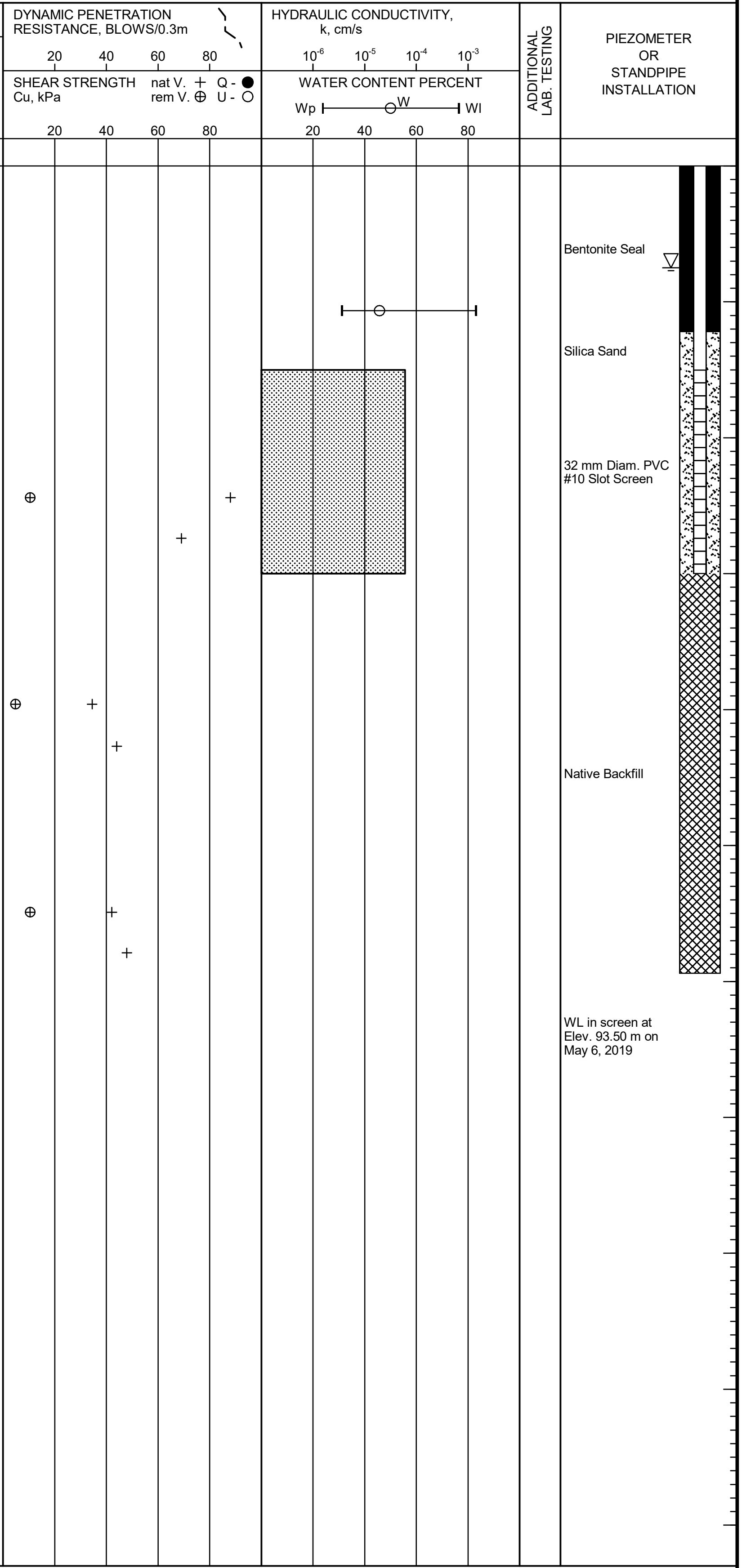
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	94.25			
0	TOPSOIL - (CL) SILTY CLAY; dark brown	0.00	1	AS	-
	(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL very stiff to stiff	94.03 0.22			
1			2	SS	7
2			3	SS	5
3	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	91.20 3.05	4	SS	1
4					
5	(CI/CH-ML) SILTY CLAY, CLAYEY SILT and sandy SILT; grey, laminated; cohesive, w>PL, firm	89.68 4.57	5	TP	PH
6	End of Borehole Auger Refusal	88.31 5.94			
7					
8					
9					
10					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

TABLE 1

RECORD OF HAND AUGERHOLES

Hand Augerhole Number	Depth (metres)	Description
19-103	0.0 – 0.3	TOPSOIL – (ML) CLAYEY SILT some sand; brown; non-cohesive, moist
	0.3 – 0.5	(ML) CLAYEY SILT, some sand; brown (WEATHERED CRUST); cohesive, w>PL
	0.5 – 1.9	(ML-CI/CH) CLAYEY SILT to SILTY CLAY, trace to some sand; grey brown (WEATHERED CRUST); cohesive, w>PL
	1.9 – 2.5	(CI/CH) SILTY CLAY to CLAY trace sand; grey; cohesive, w>PL
	2.50	END OF AUGERHOLE

Note: water seepage at 1.1 m depth upon completion

Sample	Depth (m)	Lab Testing
1	1.1 – 1.5	w_n = 51%, PI=35%, LL=56%
2	1.5 – 1.9	
3	1.9 – 2.3	
4	2.3 – 2.5	

19-105	0.00 – 0.20	TOPSOIL – (ML) CLAYEY SILT some sand; brown; non-cohesive, moist
	0.20 – 1.60	(CI/CH-ML) SILTY CLAY to CLAYEY SILT, some sand; grey brown (WEATHERED CRUST); cohesive, w>PL
	1.60 – 2.00	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL
	2.00 – 2.50	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL
	2.50	END OF AUGERHOLE

Note: water seepage at 1.1 m depth upon completion

Sample	Depth (m)	Lab Testing
1	0.7 – 1.1	w_n = 43%, PI=27%, LL=52%
2	1.1 – 1.6	
3	1.6 – 2.0	
4	2.0 – 2.5	

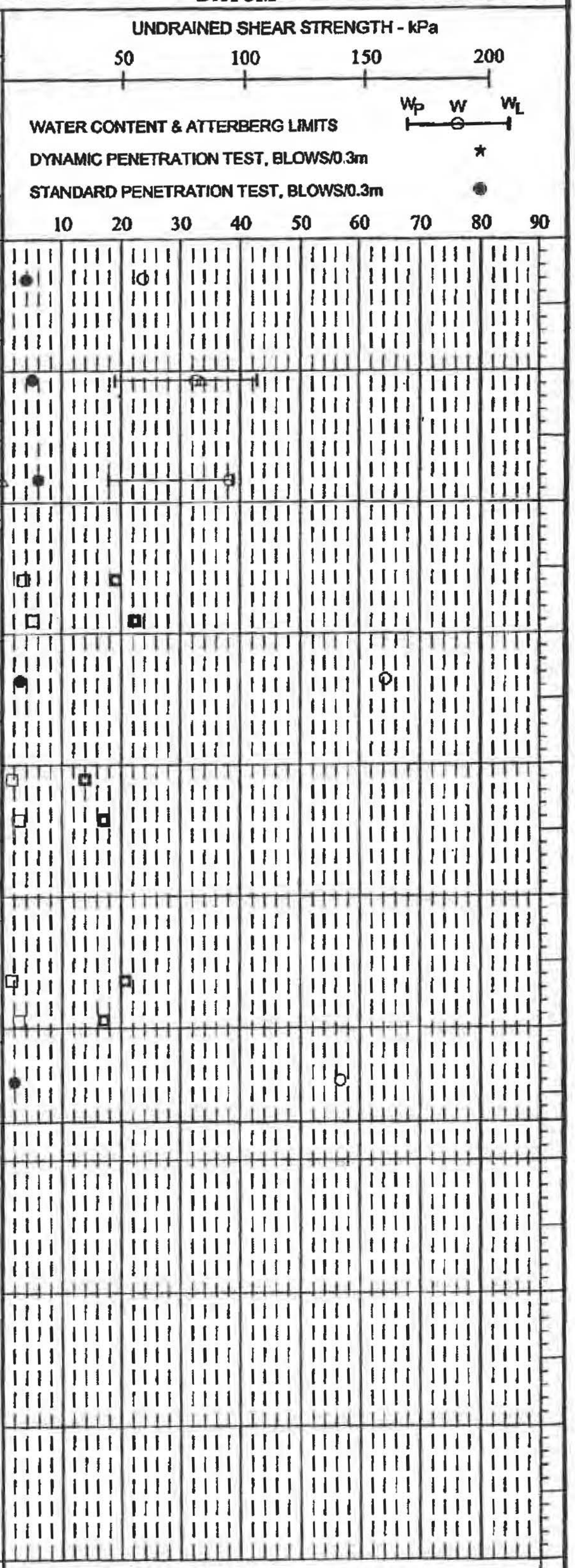
1 of 1

MONITORING WELL RECORD

MW07-1

CLIENT Mattamy Homes
LOCATION Proposed Subdivision, Richmond, ON
DATES: BORING June 18, 2007 WATER LEVEL June 20, 2007
BOREHOLE No. MW07-1
PROJECT No. 1026929
DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	WATER LEVEL	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	100.32 100.2	150 mm TOPSOIL					
		Firm to stiff, greyish brown lean CLAY (CL)		SS	1	300	4
1			▼	SS	2	610	5
2			∇	SS	3	610	6
3	97.3	Firm to stiff, grey lean CLAY		SS	4	610	3
5				ST	5	610	
6	93.8			SS	6	610	2
7	93.6	Very loose, grey SANDY SILT (ML)					
		End of Borehole Monitoring Well Installed					
8							
9							
10							



∇ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

App'd ______
Date ______

JWL-OLD 1026929.GPJ SMART.GDT 07/06/22

Jacques Whitford

MONITORING WELL RECORD

MW07-7

1 of 1

CLIENT Mattamy Homes

LOCATION Proposed Subdivision, Richmond, ON

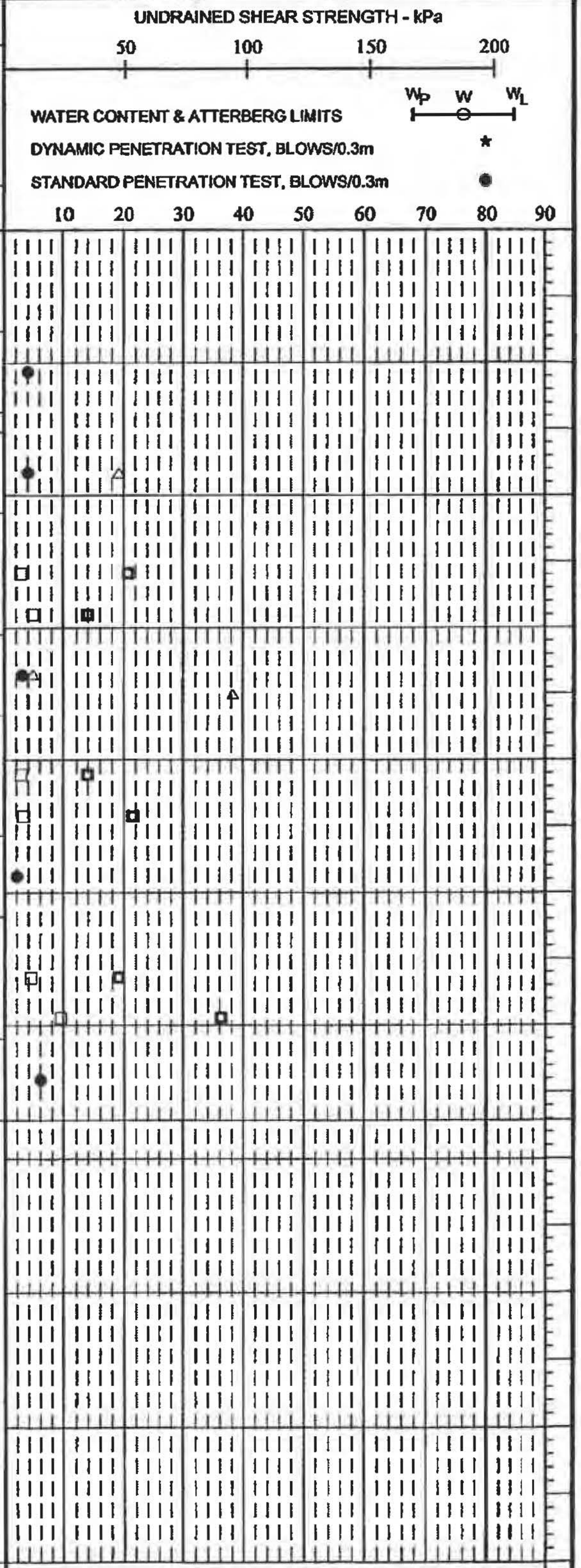
DATES: BORING June 18, 2007 WATER LEVEL June 20, 2007

BOREHOLE No. MW07-7

PROJECT No. 1026929

DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	100.21	Firm to stiff, greyish brown lean CLAY (CL)	▨					
1			▨		SS	1	610	4
			▨	▼				
2			▨		SS	2	610	4
3	97.2	Firm to stiff, grey lean CLAY	▨	▽				
			▨		SS	3	610	3
5			▨		SS	4	610	2
	93.8	Loose, grey SANDY SILT (ML)			SS	5	150	6
	93.5	End of Borehole Monitoring Well Installed						



▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

☐ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd ________

Date ________

Jacques Whitford

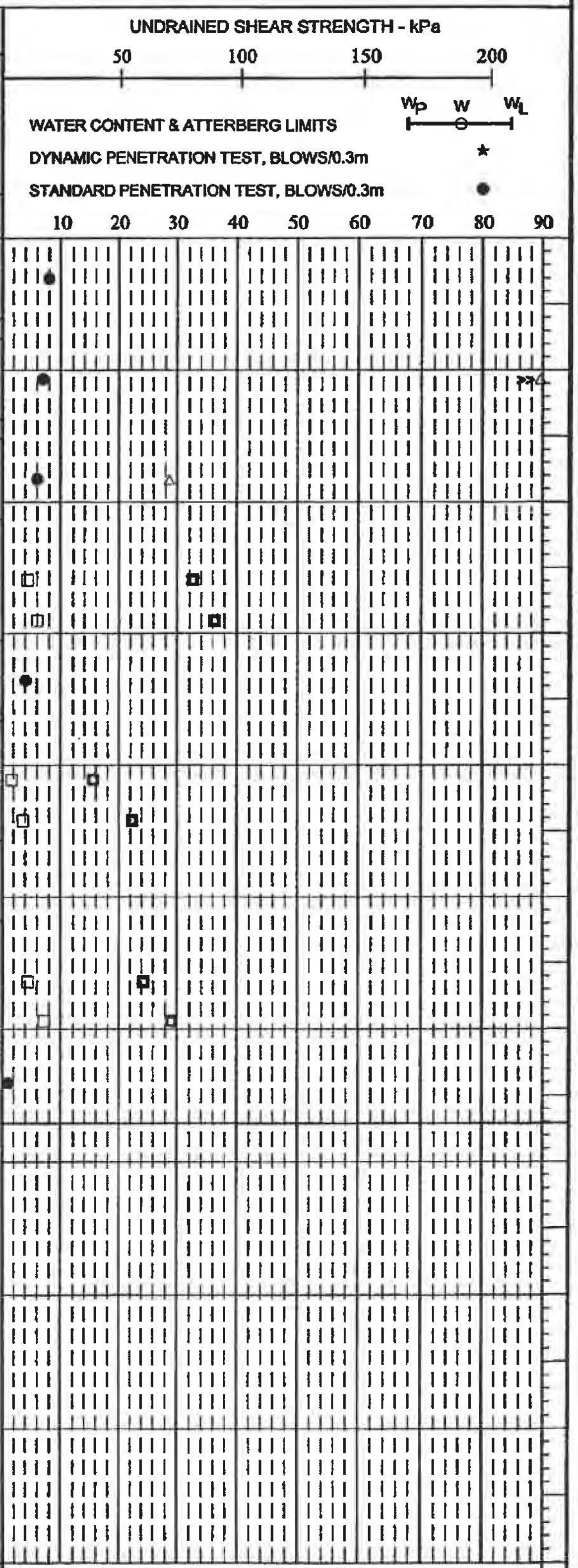
MONITORING WELL RECORD

MW07-13

1 of 1

CLIENT Mattamy Homes
LOCATION Proposed Subdivision, Richmond, ON
DATES: BORING June 18, 2007 WATER LEVEL June 20, 2007
BOREHOLE No. MW07-13
PROJECT No. 1026929
DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	99.30	Stiff, greyish brown lean CLAY (CL)	▨		SS	1	120	8
1			▨	▼	SS	2	75	7
2			▨		SS	3	610	6
3	96.3	Firm to stiff, grey lean CLAY	▨	▽	SS	4	40	4
5			▨		ST	5	610	
6	93.2	Very loose, grey SANDY SILT (ML)			SS	6	300	1
	92.6	End of Borehole Monitoring Well Installed						



▽ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

◘ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

App'd
Date

1 of 1

Jacques Whitford

TEST PIT RECORD

TP07-3

CLIENT Mattamy Homes

LOCATION Proposed Subdivision, Richmond, ON

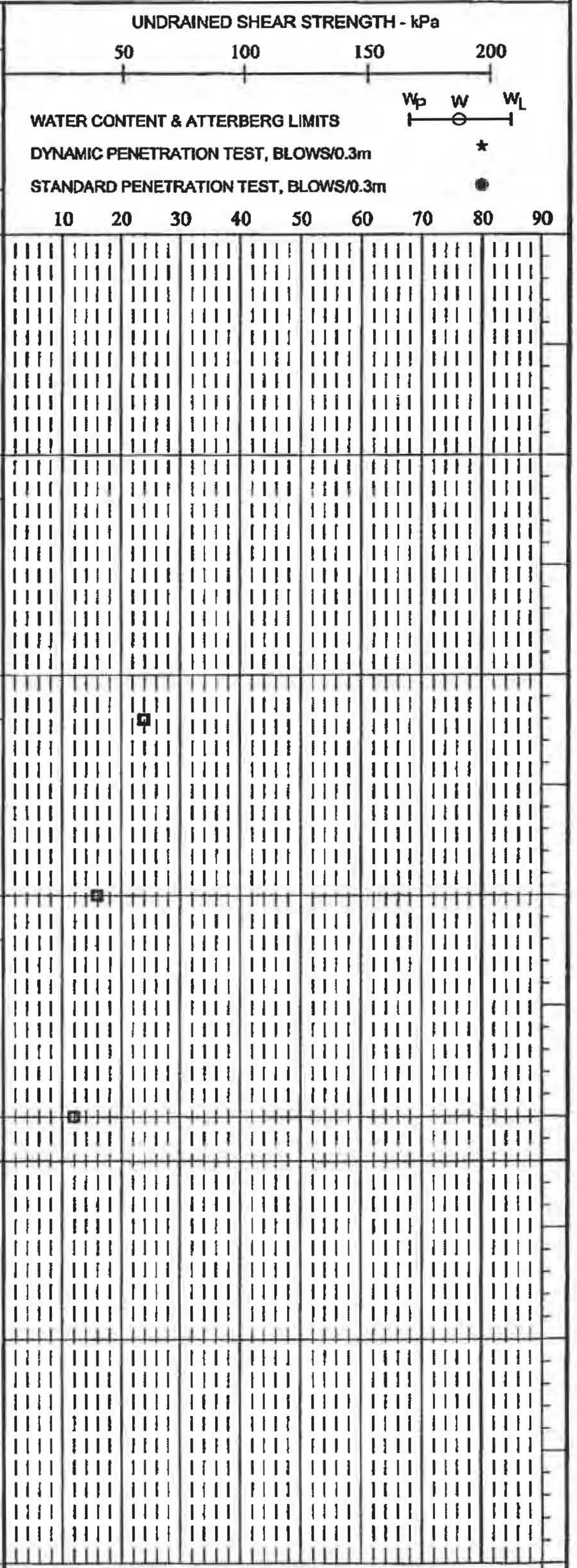
DATES: BORING June 16, 2007 WATER LEVEL

BOREHOLE No. TP07-3

PROJECT No. 1026929

DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	100.27	230 mm TOPSOIL						
	100.0	Stiff, greyish brown lean CLAY (CL)		▽				
1					BS	1		
2					BS	2		
	97.7	Firm, grey lean CLAY (CL)						
3					BS	3		
4					BS	4		
	96.1	End of Borehole						
5								
6								



▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

▣ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd

Date

JWL-OLD 1026929.GPJ SMART.GDT 07/06/21

Jacques Whitford

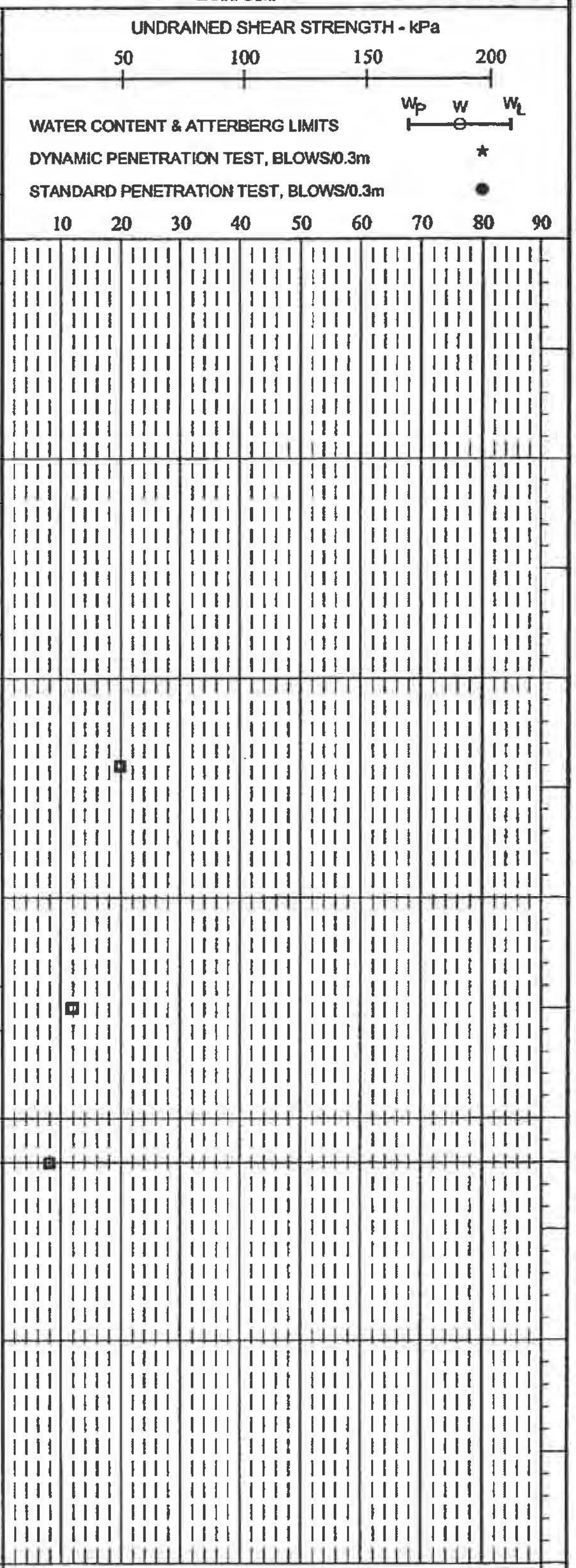
1 of 1

TEST PIT RECORD

TP07-5

CLIENT Mattamy Homes
LOCATION Proposed Subdivision, Richmond, ON
DATES: BORING June 16, 2007 WATER LEVEL
BOREHOLE No. TP07-5
PROJECT No. 1026929
DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	100.11	250 mm TOPSOIL			BS	1		
	99.9	Stiff, greyish brown lean CLAY (CL)		∇				
1					BS	2		
					BS	3		
2	98.1	Firm, grey lean CLAY (CL)						
					BS	4		
3					BS	5		
4					BS	6		
	95.9	End of Borehole						
5								
6								



∇ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

▣ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

App'd ________
Date ________

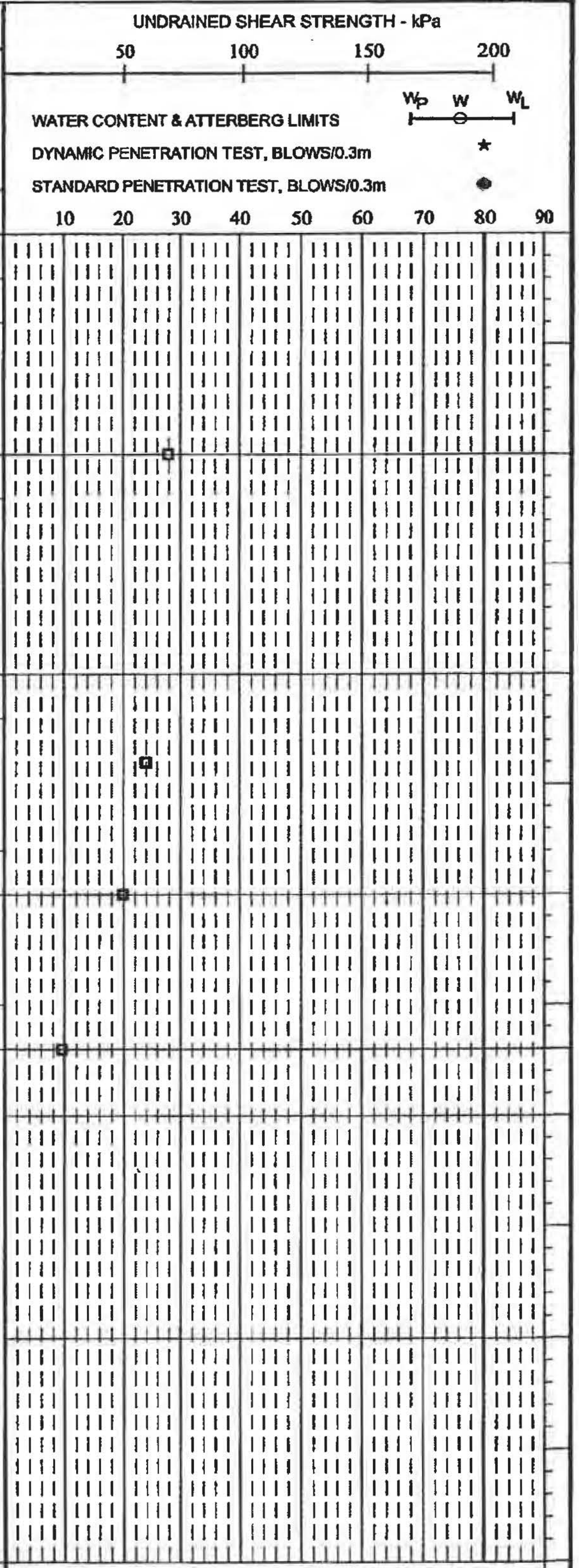
Jacques Whitford

TEST PIT RECORD

TP07-11

CLIENT Mattamy Homes
LOCATION Proposed Subdivision, Richmond, ON
DATES: BORING June 16, 2007 WATER LEVEL
BOREHOLE No. TP07-11
PROJECT No. 1026929
DATUM Local

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES			
					TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	99.89	250 mm TOPSOIL						
	99.6	Stiff, brown and grey lean CLAY (CL)			BS	1		
				▽				
1					BS	2		
2					BS	3		
					BS	4		
3	96.9	Firm, grey lean CLAY (CL)						
					BS	5		
	96.2	End of Borehole						
4								
5								
6								



▽ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

App'd
Date

APPENDIX C

Results of Hydraulic Conductivity Analyses

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST BH20-101

INTERVAL (metres below ground surface)

Top of Interval = 2.74
Bottom of Interval = 4.27

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

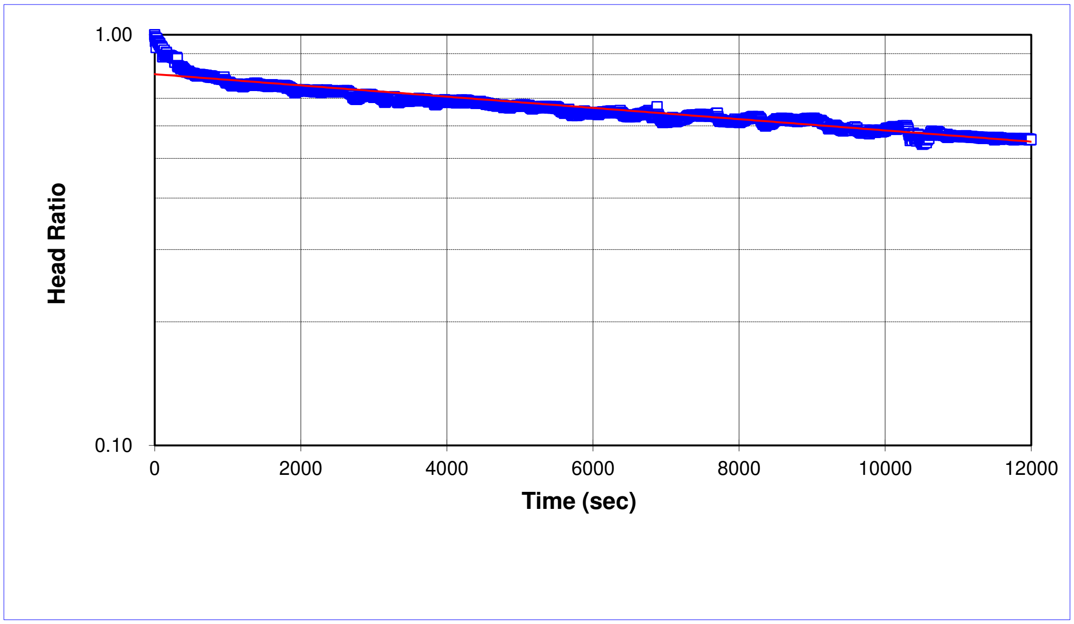
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c = 1.9E-02
R_e = 1.0E-01
L_e = 1.5
t_1 = 915
t_2 = 10000
h_1/h_0 = 0.78
h_2/h_0 = 0.59

RESULTS

K=	**1E-08**	**m/sec**
K=	**1E-06**	**cm/sec**



Project Name: Caivan/Ph1 ESA Richmond/Ottawa
Project No.: 20144864
Test Date: 2020-07-06

Analysis By: SPS
Checked By: BH
Analysis Date: 2020-07-08

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST BH20-206

INTERVAL (metres below ground surface)

Top of Interval = 3.35
Bottom of Interval = 6.40

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

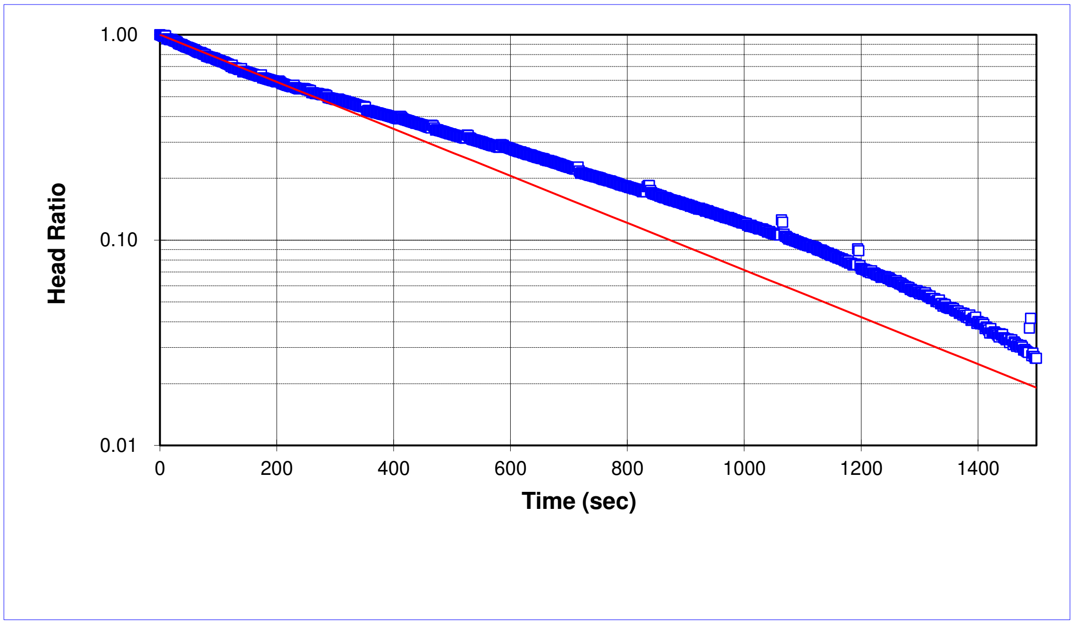
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c = 1.9E-02
R_e = 1.0E-01
L_e = 3.1
t_1 = 0
t_2 = 200
h_1/h_0 = 1.00
h_2/h_0 = 0.59

RESULTS

K=	5E-07	m/sec
K=	5E-05	cm/sec



Project Name: Caivan/Ph1 ESA Richmond/Ottawa
Project No.: 20144864
Test Date: 2020-07-06

Analysis By: SPS
Checked By: BH
Analysis Date: 2020-07-08

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST BH20-208A

INTERVAL (metres below ground surface)

Top of Interval = 2.44
Bottom of Interval = 3.96

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

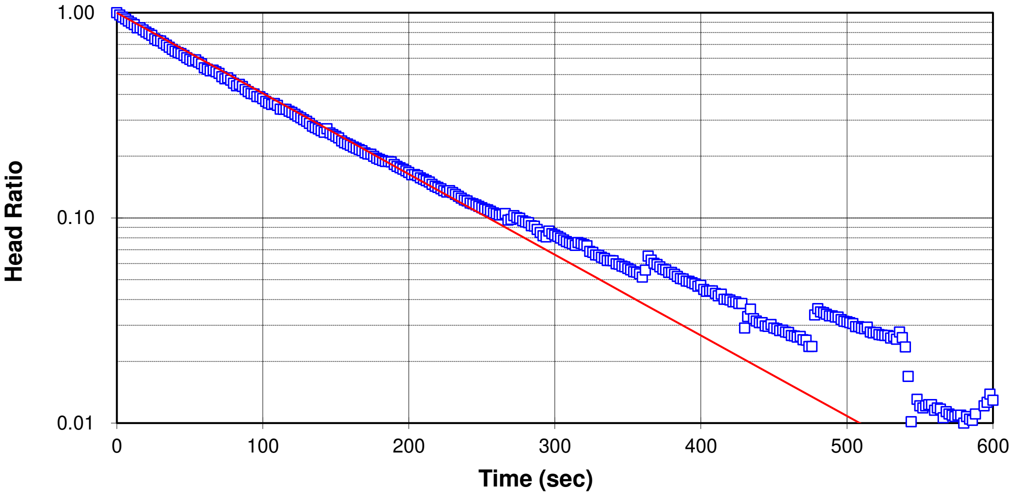
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c = 1.9E-02
R_e = 8.9E-02
L_e = 1.5
t_1 = 0
t_2 = 184
h_1/h_0 = 1.00
h_2/h_0 = 0.19

RESULTS

K= 3E-06 m/sec
K= 3E-04 cm/sec



Project Name: Caivan/Ph1 ESA Richmond/Ottawa
Project No.: 20144864
Test Date: 2020-07-06

Analysis By: SPS
Checked By: BH
Analysis Date: 2020-07-08

Golder Associates Ltd.

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST BH20-212

INTERVAL (metres below ground surface)

Top of Interval = 1.37
Bottom of Interval = 2.90

$$K = \frac{r_c^2 \ln\left(\frac{R_e}{r_w}\right)}{2L_e} \frac{1}{t} \ln \frac{y_0}{y_t}$$

where K=m/sec

where:

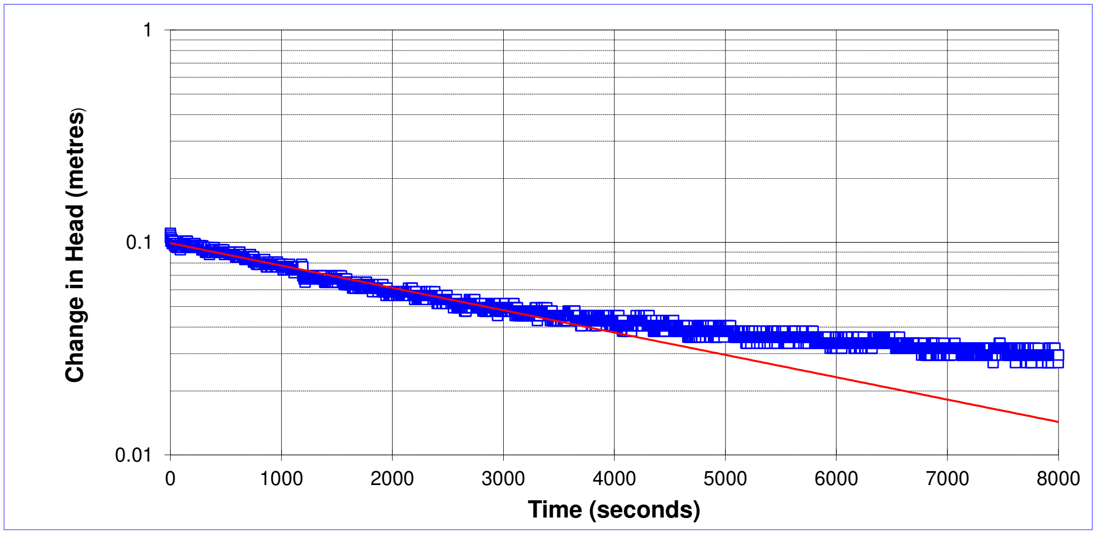
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.06
r_w =	0.10
L_e =	0.73
$\ln(R_e/r_w)$	1.06
y_0 =	0.10
y_t =	0.05
t =	2819

RESULTS

K=	6E-07	m/sec
K=	6E-05	cm/sec



Project Name: Caivan/Ph1 ESA Richmond/Ottawa
Project No.: 20144864
Test Date: 07-06-20

Analysis By: SPS
Checked By: BH
Analysis Date: 2020-07-08

APPENDIX D

Basic Chemical Results, Eurofins Environmental Report No. 1933383

Certificate of Analysis

Client:	Golder Associates Ltd. (Ottawa) 1931 Robertson Road Ottawa, ON K2H 5B7	Report Number:	1933383
Attention:	Ms. Kim MacDonald	Date Submitted:	2020-07-02
PO#:		Date Reported:	2020-07-08
Invoice to:	Golder Associates Ltd. (Ottawa)	Project:	20144864 / 3000
		COC #:	859511

				Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1501968 Soil 2020-06-10 20-103 sa3 / 5-7'	1501969 Soil 2020-06-23 20-204 sa3 / 5-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Anions	Cl	0.002	%		<0.002	0.003
	SO4	0.01	%		<0.01	<0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.19	0.38
	pH	2.00			8.10	7.70
	Resistivity	1	ohm-cm		5240	2600

Guideline = *** = 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

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