REPORT

GEOTECHNICAL INVESTIGATION AND HYDROGEOLOGY ASSESSMENT

PROPOSED DEVELOPMENT 933 GLADSTONE AVENUE, OTTAWA, ONTARIO

Submitted to:

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation and hydrogeology assessment carried out at the site of the proposed development to be located at 933 Gladstone Avenue in in Ottawa, Ontario.

The purpose of this geotechnical investigation was to assess the general subsurface conditions at the site by means of a limited number of boreholes. Based on an interpretation of the factual information obtained, a general description of the subsurface conditions is presented. These interpreted subsurface conditions and available project details were used to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could influence design decisions.

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

2.0 DESCRIPTION OF PROJECT AND SITE

The site of the proposed development is located at 933 Gladstone Avenue in Ottawa, Ontario. The overall property is irregular in shape and measures approximately 285 meters by 115 meters in plan. The site was formerly a Federal Government Ordnance Depot prior to 2015 and is currently a vacant land. The site is bordered to the north by a Government of Canada office; to the east by an existing residential development; to the west by the O-Train Trillium line, and to the south by Gladstone Avenue. The project limits and the location of the proposed development are shown on Figure 1. The proposed development (as discussed in this report), is to be located within Block 3 and will consist of a combined residential and commercial 18 storey building with one level of underground parking as well as asphalt surfaced parking. New servicing to this structure is also proposed within the rest of the property. It should be noted that one of the deep sewer alignments is shown crossing through Block 2a.

Golder completed a Phase II Environmental Site Assessment and a preliminary geotechnical investigation at the site. Some of the boreholes from the previous investigations have been used to supplement the current investigation. The locations of those previous boreholes are shown on the attached Site Plan (Figure 1). The results of the previous investigations are contained in the following reports:

- Golder Report No. 1897188-2000 titled: "*Preliminary Geotechnical Investigation, Proposed Development, Gladstone Village, 933 Gladstone Avenue, Ottawa, ON*", and dated June 2018.
- Golder Report No. 1670949 Rev.0 titled: "*Phase Two Environmental Site Assessment, 933 Gladstone Avenue, Ottawa, ON*", and dated March 2017.

Based on the results of previous investigations and the published geology maps available from the Geologic Survey of Canada (GSC) for this area, the subsurface conditions at this site are expected to consist of a surficial layer of fill, overlying a relatively shallow deposit of silty clay, underlain by a thicker deposit of glacial till.
The glacial till is underlain by interbedded limestone bedrock of the Verulam formation. Depth to bedrock within the footprint of the proposed structure varies between about 3 metres below the existing ground surface on the south side and about 8 metres below the existing ground surface on the north side.

3.0 PROCEDURE

The field work for the current geotechnical and hydrogeological investigation was carried out between December 13 and December 15, 2021.During that time, 6 boreholes (numbered 21-01 to 21-06) were advanced at the approximate locations shown on Figure 1.

The boreholes were advanced with a truck-mounted hollow stem auger drill rig supplied and operated by CCC Geotechnical and Environmental Drilling of Ottawa, Ontario. The boreholes were advanced to depths ranging from 4.1 m to 11.1 m below the existing ground surface.

Boreholes 21-01, 21-04, 21-05, and 21-06 were advanced to refusal on the bedrock surface at depths ranging from 3.2 to 9.0 m. Upon encountering refusal to augering, these boreholes were advanced an additional 2.2 to 3.4 m into the bedrock using rotary diamond drilling techniques while retrieving HQ sized core. Borehole 21-05 was augered to 5.4 m depth below existing ground surface, without retrieving the soil samples.

Refusal to augering was also encountered in borehole 21-02 at 4.1 m depth below the existing ground surface and borehole 21-03 was advanced to 6.1 m depth below existing ground surface without encountering refusal.

Standard Penetration Tests (SPTs) were carried out within the overburden at various intervals of depth in general conformance with ASTM D 1586. Soil samples were recovered using 35 mm inside diameter split-spoon sampling equipment. To determine the undrained shear strength of the cohesive soils, in-situ vane testing was also carried out.

Monitoring wells were sealed into boreholes 21-02, 21-03, 21-05 and 21-06 to allow for subsequent measurements of stabilized groundwater levels. The monitoring wells consist of 32 mm inside diameter rigid PVC pipe with 1.5 m long slotted screen sections, installed within silica sand backfill and sealed by a section of bentonite pellet backfill. Measurement of the groundwater levels was completed on January 13, 2022.

The fieldwork was supervised by Golder staff who logged the boreholes, directed the in-situ testing, and collected the soil and rock samples retrieved in the boreholes. The samples obtained during the fieldwork were brought to our laboratory for further examination and laboratory testing.

The laboratory testing included determination of natural water content and grain size distribution on selected soil samples, as well as Uniaxial Compressive Strength (UCS) testing on selected bedrock samples. One sample of soil from borehole 21-04 was submitted to Eurofins Environment Testing for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

Shear wave velocity profiling at the site was completed using the Multichannel Analysis of Surface Waves (MASW) technique and was carried out on November 25, 2021 by Golder personnel. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at about 3 m intervals. An 8-kg sledgehammer and a 40-kg weight drop were used as the seismic sources. The source locations were offset at distances of about 5, 10, and 20 m from and collinear with the geophone array.

The borehole locations were marked in the field and surveyed by Golder. The positions and ground surface elevations at the borehole locations 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 Universal Transverse Mercator (UTM Zone 09) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

4.0 SUBSURFACE CONDITIONS

4.1 General

The following information on the subsurface conditions is provided in this report:

- Borehole records from the current investigation are provided in Appendix A;
- Laboratory test results for the current investigation are provided in Appendix B and on the relevant borehole records;
- Rock core photographs are provided in Appendix C;
- Results of the basic chemical analyses are provided in Appendix D; and,
- Results of geophysical testing are provided in Appendix E.

In general, the subsurface conditions at this site consist of fill underlain by a deposit of silty clay to clay, overlying a glacial till deposit which is in turn underlain by limestone bedrock with shale interbeds.

The following sections present a more detailed overview of the subsurface conditions encountered during the field investigation.

4.2 Topsoil and Fill

A layer of topsoil, ranging in thickness from 530 to 610 millimetres in thickness, was encountered at ground surface at boreholes 21-02, 21-03 and 21-06. The topsoil consists of gravelly silty sand to gravelly sandy silt. This deposit also contains trace organics. The results of SPT tests carried out within the topsoil gave ‘N’ values ranging from 10 to 13 blows per 0.3 m of penetration, indicating a loose to compact state of packing, but is more typically loose.

Fill was encountered at ground surface at boreholes 21-01 and 21-04 and below the topsoil at borehole 21-03. The fill consists of gravelly silty sand and extends to depths ranging between 0.9 and 1.4 m below the existing ground surface at the borehole locations. The results of SPT tests carried out within the fill gave ‘N’ values ranging from 15 to 47 blows per 0.3 m of penetration, indicating a compact to dense state of packing.

A layer of buried topsoil, consisting of gravelly sity sand to sandy silt, was encountered below the fill in borehole 21-01 and is about 250 millimetres in thickness.

4.3 Silty Clay to Clayey Silt

A deposit of silty clay to clay was encountered below the topsoil or fill at borehole locations 21-02, 21-03 and 21-06 and below/within the native sand at boreholes 21-03 and 21-04. The upper portion of the silty clay at boreholes 21-02, 21-03 and 21-06 has been weathered to a grey-brown crust. The weathered zone, where present, extends to depths of about 1.5 metres below the existing ground surface. SPT ‘N’ values ranging from 2 to 12 blows per 0.3 metres of penetration were obtained within the weathered crust portion of the clayey deposits, indicating a stiff to very stiff consistency.

Below the weathered crust or sand in boreholes 21-02, 21-03, 21-04 and 21-06, the silty clay is grey in colour. The unweathered silty clay deposit extends to depths ranging from between about 3.0 and 6.1 metres below existing ground surface. The results of in situ vane shear tests completed within the grey silty clay measured undrained shear strength values ranging from between 42 and 80 kilopascals corresponding to a firm to stiff consistency.

The results of moisture content testing on four samples of the silty clay gave results ranging from about 27 to 54 percent.

The results of Atterberg limits testing on four samples of the grey silty clay gave plasticity indices ranging from 33 to 48 percent and liquid limits ranging from 55 to 69 62 percent, indicating a high plasticity clay.

4.4 Silty Sand to Sandy Silt to Sand

Silty sand to sandy silt was encountered in boreholes 21-01, 21-03 and 21-04. These sandy deposits were encountered in borehole 21-01 below the buried topsoil, in borehole 21-03 below the silty clay to clay deposit and above the clay deposit in borehole 21-04. The sandy layers range from 0.5 to 1.5 m in thickness.

The silty sand to sandy silt deposits are typically brown in colour, with measured SPT “N” values of 3 and 11 blows per 0.3 m of penetration, indicating a very loose to compact state of packing. The results of grain size distribution testing on two samples of the sandy silt to silty sand deposits are shown on Figures 2 and 3. The results of moisture content testing on three samples of the silty sand to sandy silt gave results of about 19 to 21 percent.

A deposit of sand was encountered below the glacial till in borehole 21-06 extending to the surface of the bedrock. The sand deposit is about 2.9 m in thickness. The measured SPT values within this deposit ranged from 5 to 27 blows per 0.3 m of penetration indicating a loose to compact state of packing.

4.5 Glacial Till

A deposit of glacial till was encountered below the thin layer of silty sand to sandy silt at borehole 21-01, below the clayey deposits in boreholes 21-02 and 21-03 and above the sand deposit in borehole 21-06. The glacial till generally consists of silty sand, containing traces of gravel to gravelly. The glacial till deposit extends to depths ranging from 3.3 to 6.1 m below the existing surface. In borehole 21-03, the glacial till deposit was not fully penetrated and the borehole was terminated at about 6.1 m below existing ground surface. The results of standard penetration tests carried out within the glacial till gave SPT ‘N’ values varied from 2 to 18 blows per 0.3 m of penetration, indicating a very loose to compact state of packing.

The results of natural moisture content testing carried out on two samples of the glacial till gave values ranging of 7 and 26 percent. The results of grain size distribution testing carried out on one sample of the glacial till are presented on Figure 4.

4.6 Bedrock / Refusal

Refusal to augering was encountered in boreholes 21-01, 21-02, 21-04, 21-05 and 21-06 at depths ranging from 3.2 to 9.0 m below the existing ground surface.

The bedrock was cored in boreholes 21-01, 21-04, 21-05 and 21-06 to depths ranging between 6.7 and 11.1 m below the existing ground surface.

The following table summarizes the ground surface, bedrock or auger refusal depths and elevations, and core lengths as encountered at the borehole locations:

Borehole Number	Ground Surface Elevation (m)	Bedrock Depth or Auger Refusal (m)	Core Length (m)	Bedrock Surface or Auger Refusal Elevation (m)
21-01	60.92	3.3	3.4	57.67
21-02	61.36	4.1	–	57.27
21-04	60.68	6.2	2.1	54.53
21-05	60.04	5.4	2.4	54.67
21-06	60.08	9.0	2.0	51.04

The bedrock encountered in the cored boreholes typically consists of limestone with interbedded shale.

Rock Quality Designation (RQD) values measured in the boreholes ranges from about 60 to 96%, indicating fair to excellent quality rock.

The results of laboratory testing carried out on two samples of the cored bedrock from 21-01 and 21-04 measured Uniaxial Compressive Strengths (UCS) of about 70 and 105 MPa, respectively, indicating the sample of the rock tested is strong to very strong. Photographs of the recovered bedrock cores and results of the UCS test are presented in Appendix C.

4.7 Groundwater Conditions

Monitoring wells were sealed into boreholes 21-02, 21-03, 21-05 and 21-06 to allow for groundwater level measurements and hydraulic conductivity testing. The groundwater levels were measured on January 13, February 9 and April 26, 2022. Hydraulic conductivity testing was completed on February 9, 2022. The results of the hydraulic conductivity analyses are provided in Appendix F. The measured groundwater levels and hydraulic conductivity testing results are presented in the table below.

Borehole Number	Geologic Unit of Screened Interval	Ground Surface Elevation (m)	Groundwater Level		Measurement Dates	Hydraulic Conductivity (cm/s)
			Depth (m)	Elevation (m)		
21-02	Silty Clay and Glacial Till	61.36	1.90 2.30 1.10	59.46 59.06 60.26	January 13, 2022 February 9, 2022 April 26, 2022	8 x 10^{-4}
21-03	Silty Sand	59.84	5.41 5.59 5.28	54.43 54.25 54.56	January 13, 2022 February 9, 2022 April 26, 2022	N/A(1)
21-05	Shale Bedrock	60.04	4.91 5.75 6.20	55.13 54.29 53.84	January 13, 2022 February 9, 2022 April 26, 2022	N/A(2)
21-06	Limestone Bedrock	60.08	3.79 5.88 5.47	56.29 54.20 54.61	January 13, 2022 February 9, 2022 April 26, 2022	3 x 10^{-5}

Notes: (1) Not enough water in well to complete hydraulic conductivity testing
(2) Water level recovered too slowly following development to complete hydraulic conductivity testing

The depth to groundwater was also measured in February 2017 and April 2018 in monitoring wells installed as part of a Phase II ESA. During the site visit on April 26, 2022, an additional round of groundwater levels were measured at the wells that could be located. The groundwater levels are presented in the table below.

Borehole Number	Geologic Unit of Screened Interval	Ground Surface Elevation$^{(1)}$ (m)	Groundwater Level		Measurement Dates
			Depth (m)	Elevation$^{(1)}$ (m)	
17-01	Sandy Clay and Clay	59.5	3.18 2.12 2.51	56.32 57.38 56.99	February 6, 2017 April 30, 2018 April 26, 2022
17-04	Silty Sand	60.5	3.04 2.65	57.46 57.85	February 7, 2017 April 30, 2018
17-05	Silty Clay and Silty Sand	60.3	3.90 2.48	56.4 57.82	February 7, 2017 April 30, 2018
17-08	Silty Clay and Clay	59.7	4.69 4.90 4.86	55.01 54.80 54.84	February 6, 2017 April 30, 2018 April 26, 2022
17-10	Silty Clay	59.8	3.83 3.28 4.36	55.97 56.52 55.44	February 6, 2017 April 30, 2018 April 26, 2022
17-11	Sandy Clay (Fill) and Silty Sand	59.5	4.72 4.55 4.04	54.78 54.95 55.46	February 6, 2017 April 30, 2018 April 26, 2022
17-13	Sandy Clay and Clay	59.6	2.62 2.07 1.66	56.98 57.53 57.94	February 6, 2017 April 30, 2018 April 26, 2022
17-14	Sandy Clay and Clay	59.2	4.19 3.72 4.10	55.01 55.48 55.10	February 6, 2017 April 30, 2018 April 26, 2022
17-15	Sandy Clay	59.3	4.58 4.27 3.71	54.72 55.03 55.59	February 6, 2017 April 30, 2018 April 26, 2022
17-17	Sandy Clay and Clay	59.4	1.36 1.02 1.28	58.04 58.38 58.12	February 2, 2017 April 30, 2018 April 26, 2022
17-18	Peat and Silty Clay	60.4	2.20 1.90	58.20 58.50	February 7, 2017 April 30, 2018
17-19	Sandy Clay (Fill) and Sandy Clay	59.9	2.10 1.75	57.80 58.15	February 2, 2017 April 30, 2018
17-20	Silty Clay	60.0	3.35 2.97	56.65 57.03	February 6, 2017 April 30, 2018
17-21	Sandy Clay and Silty Clay	60.1	3.31 1.59	56.79 58.51	February 7, 2017 April 30, 2018
17-22	Sandy Clay	58.7	2.00 1.14 1.59	56.7 57.56 57.11	February 6, 2017 April 30, 2018 April 26, 2022
17-23	Silty Clay and Silty Sand	59.3	3.80 3.42 3.33	55.50 55.88 55.97	February 7, 2017 April 30, 2018 April 26, 2022

Notes: (1) Ground surface elevations not directly measured, but were interpolated based off City of Ottawa topographic mapping

Based on the groundwater levels collected during both the current and previous investigations, there is a downward vertical gradient present at the site with the overburden groundwater elevations being higher than the measurements in the bedrock wells (21-05 and 21-06). The highest groundwater elevation measured in the overburden within the proposed Phase I building footprint was approximately 58.4 metres above sea level (asl) at 17-17.

Groundwater levels are expected to fluctuate seasonally and over shorter periods of time. Higher groundwater levels are expected during wet periods of the year, such as spring after the snowmelt or during periods of heavy rain. The water table elevation at the site may decrease in localized areas after development depending on the elevation of the building drains and linear infrastructure.

4.8 Corrosion Testing

One sample of soil from borehole 21-04 was 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 are summarized below:

Borehole Number	Sample Number	Depth Intervals (m)	Chlorides (%)	Sulphates (%)	pH	Resistivity (Ohm-cm)
21-04	2	1.5 – 1.8	0.002	0.08	7.91	1,720

5.0 DISCUSSION AND GEOTECHNICAL RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the available information described herein and project requirements.

The information in this portion of the report is provided for planning and design purposes for the guidance of the design engineers and architects. The recommendations provided herein are consistent with the Ontario Building Code of 2012 (OBC 2012). Where comments are made on construction, they are provided only to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the factual information for construction, and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities, costs, sequencing and the like.

5.2 Site Grading

It is understood that, as currently proposed, the design finished grades will generally remain unchanged.

The permissible grade raises could potentially need to be limited by the capacity of the silty clay deposit to support additional loading. As a general guideline, which can be applied to the overall site, it is considered that a permissible grade raise of 1 metre (above the existing ground surface level) could be used. Grade raises in excess of 1 metre should be reviewed on a location-by-location basis.

5.3 Foundation Design

As discussed previously, the subsurface conditions at this building location consist of topsoil/fill underlain by a thick deposit of sensitive of silty clay to clay, overlaying glacial till and/or sand deposits over limestone bedrock with shale interbeds. The bedrock surface is at about 5 to 9 metres depth below the existing ground surface (i.e., elevations ranging from 54.8 to 51.0 metres), apparently sloping or stepping down from southwest to northeast across the building footprint.

Based on the preliminary information provided to Golder, the structure proposed to be constructed is planned to have 18 stories with one level of underground parking. The excavation for the building tower is expected to extend to depths of about 5 below existing site grades for construction of the basement parking slab, with deeper excavations for construction of the pad, strip or raft foundations which are to be placed on the surface of the bedrock.

Foundations supported directly on the bedrock may be designed using an Ultimate Limit States bearing resistance of 8 MPa. Provided the bedrock surface is properly cleaned of soil and loose rock at the time of construction, the settlement of footings sized using this factored bearing resistance should be negligible and therefore Serviceability Limit States (SLS) need not be considered.

Foundations should be entirely supported on rock and if the rock surface is encountered below the planned footing level at the time of construction, mass concrete should be placed to bring the surface up to the planned underside of footing. Mass concrete, if used, should extend beyond the edge of the footing a distance equal to the depth of the mass concrete.

5.4 Seismic Design Considerations

For the proposed building, the seismic design provisions of the 2012 OBC depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or rock below founding level.

Based on the results of the MASW testing carried out at this site, this site can be assigned a Site Class of B for seismic design purposes in accordance with the 2012 OBC for all structures founded on rock.

5.5 Excavations

Based on the site conditions, it is anticipated that excavations for the construction of the building foundations and services will be through the existing topsoil, fill, sands, clays and rock, and into the underlying bedrock.

No unusual problems are anticipated in excavating the overburden using conventional hydraulic excavating equipment. The Occupational Health and Safety Act (OHSA) of Ontario indicates that side slopes in the overburden above the water table, or if the groundwater levels are lowered to below the excavation invert, could be sloped no steeper than 1 horizontal to 1 vertical (i.e., Type 3 soil) down to the bedrock surface.

5.5.1 Overburden Excavation and Temporary Excavation Shoring

The excavation for the proposed building will extend about 5 below the existing ground surface and depending on the space restrictions, vertical (or near vertical) excavation walls may be required.

Excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Occupational Health and Safety Act (OHSA) for Construction Activities.

Excavations within the overburden of up to 5 to 7 m below the existing grade through the existing fill and native sand, clay and till deposits are anticipated to reach the bedrock surface. The groundwater level was measured at depths ranging from 3.6 to 5.3 m within the building area and therefore excavations below the groundwater level are anticipated. Further details about the groundwater regime can be found in Section 5.6.

The soils at this site above the groundwater level would be generally classified as Type 3 soils (compact to loose fill material and sands and firm to stiff native clay) in accordance with the OHSA. Accordingly, excavations should be made with side slopes no steeper than 1H:1V. Any fill, sands and/or till which extend below the water table would be classified as Type 4 soil and excavations in these materials should be sloped no steeper than 3H:1V. As indicated in OHSA, if an excavation contains more than one type of soil, the soil type for the excavation shall be classified as the type with the highest number among the soil types present within the excavation.

The excavation would also need to extend an additional 1 to 2 m outside of the proposed footprint to allow for a ledge at the bedrock surface, the construction of footings and the placement of formwork. Given the constraints associated with the property limits, adjacent infrastructure and buried services, it is expected that shoring of the overburden will be necessary, at least along some of the excavation boundary.

The contractor should be fully responsible for the design of the shoring. Where shoring is required, the type of shoring to be used depends, in part, on the permissible movement. This section of the report provides some general guidelines on possible concepts for the shoring, to be used by the designers for:

1) Assessing the costs of the shoring;
2) Assessing possible impacts of the shoring design and construction on the design of the structures and site works; and,
3) To evaluate the potential for impacts of this shoring on the adjacent properties, structures, services, and roadways.

The shoring method(s) chosen to support the excavation sides must take into account: the soil and bedrock stratigraphy, the groundwater conditions, the methods adopted to manage the groundwater, the permissible ground movements associated with the excavation and construction of the shoring system, and the potential impacts on adjacent structures and utilities. In general, there are three basic shoring methods that are commonly used in local construction practice:

1) Steel soldier piles and timber lagging;
2) Driven steel sheet piles, and
3) Continuous concrete (secant pile or diaphragm) walls.

These three options are listed in order of generally increasing stiffness and ability to resist ground movements.

For design purposes, a soldier pile and timber lagging system (in combination with a suitable dewatering method) or sheet piled shoring system would likely be feasible for the proposed excavations at the site where space does not exist to accommodate open cut excavations. Due to the presence of dense sand and glacial till with boulders beneath the overlaying deposits, the shoring may require predrilling to ensure it penetrates through the till. The shoring will also need to be sufficiently fixed at the base of the shoring by either installing in rock sockets o by pinning.

Where foundations or settlement sensitive infrastructure are present within the zone of influence of the shoring system, the deflections may need to be greatly limited and therefore a soldier pile and timber lagging system might not be feasible. Golder can provide further recommendations and guideline in the detailed design stage when the distance and extent of the excavations with respect to the existing infrastructure are determined, though it will ultimately be the responsibility of the contractor to ensure the shoring system is adequate to prevent damage to existing structures.

For soldier pile and lagging system, some form of lateral support to the wall is required for excavation depths greater than about 3 to 4 m. Lateral restraint could be provided by means of tie-backs consisting of grouted soil or bedrock anchors. The presence of underground utilities, which could interfere with the tie-backs, should be considered as well as the required property permissions. Alternatively, interior struts can be considered, connected either to the opposite side of the excavation (if not too distant) or to raker piles and/or footings within the excavation.

5.5.2 Bedrock Excavation

It is likely that the bedrock removal will be carried out using drill and blast techniques or mechanical methods (such as hoe ramming or hydraulic jacks) in conjunction with line drilling. Mechanical methods of excavation would likely be slow and tedious and will require considerable effort.

If blasting is considered, blast induced damage to the bedrock must be avoided in the vicinity of existing structures (including buried structures such as the utilities), otherwise additional rock reinforcement could be required. At the final rock line, the bedrock should be line drilled at a close spacing in advance of blasting so that a clean bedrock face can be formed. It is considered that 75 mm diameter holes at a spacing of 200 mm or less would be appropriate for this purpose.

Based on the quality of the bedrock encountered in the boreholes, it is expected that near vertical bedrock walls can be provided for the construction period provided that any loose pieces of the bedrock are scaled off the faces for worker safety. Where the excavation extends deeper than 1.8 m into the bedrock, the near vertical walls should be reviewed by a geotechnical engineer for any sign of unstable pillars or slabs that should be removed or stabilized. Stabilization options could consist of rock anchors, mesh, shotcrete, sloping the side slopes or a combination thereof. The appropriate stabilization methodology, if required, will depend on the actual site conditions during construction, and further guidance can be provided at that time.

Vibration monitoring should be carried out as outlined in Section 5.5.3.

5.5.3 Vibration Monitoring

Due to the close proximity of the existing surrounding structures to the proposed development, construction vibration, particularly when blasting (if required) or while driving piles should be controlled to limit the peak particle velocities at all adjacent structures or services such that vibration induced damage will be avoided.

A pre-construction survey is recommended to be carried out on all nearby structures and services. Any area of concerns should be identified during the pre-construction survey and should be monitored for movements during construction.

The contractor should be required to submit a complete and detailed blasting design, as well as a monitoring plan prepared by a blasting/vibration specialist before starting blasting. This should be reviewed and accepted in relation to the requirements of the blasting specifications.

The contractor should be limited to only small controlled shots. Peak vibration limits dependent on the following frequencies to the nearest structures and services are suggested.

The following frequency dependent peak vibration limits at the nearest structures and services are typical, but it is suggested they be confirmed by the structural engineer for the particular structure.

Frequency Range (Hz)	Vibration Limits (mm/s)
< 10	5
10 to 40	5 to 50 (sliding scale)
> 40	50

These limits should be practical and achievable on this project. Blasting will likely generate vibrations greater than 40 Hz at the nearest structures. The majority of structures and their components have natural frequencies in the range of 4 to 24 Hz.

These limits are based on reducing the risk of structural damage. These vibration limits will need to be adjusted if there is vibration-sensitive equipment in the vicinity of the new building. Guidelines can be provided; however, it is preferable for equipment manufacturers to provide these limits.

It is recommended that the monitoring of ground vibration intensities (peak ground vibrations and accelerations) from the construction activities (e.g., blasting or piling) be carried out both in the ground adjacent to the closest structures and within or at the structures themselves.

5.6 Groundwater Control

Recorded groundwater elevations on Site vary from about 53.8 to 60.3 metres above sea level (asl), or about 1.1 to 6.2 metres below ground surface. Based on preliminary information, it is understood that the building will consist of one underground parking level with drainage below the floor slab at approximately 55.3 metres asl (4.8 metres below ground surface). During construction of the proposed Phase I building, the excavation is expected to extend to the bedrock (51.0 metres asl at 21-06) and dewatering will be required to that level. Additional excavations will also be required for the installation of the services for the structure. Based on the groundwater conditions observed on site, excavations will extend below the groundwater level and, as such, groundwater control will be required.

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

The Dupuit-Forchheimer analytical solution was used to estimate the groundwater inflow to the excavations during construction. The most significant inflow is expected to occur for the building excavation in the area of 21-06 due to the thickness of sand that is present below the silty clay and till. It is anticipated that that the hydraulic conductivity of this sand will be higher than what was measured for the glacial till (8×10^{-4} cm/s); therefore, a conservative hydraulic conductivity for the sand was assumed to be 1×10^{-2} cm/s. Assuming a water level at the highest level recorded within the area of the proposed Phase I building (58.4 metres asl at 17-17) and the base of the excavation at the top of the bedrock (51.0 metres asl at 21-06), the groundwater level would need to be lowered by approximately 7.4 metres. Based on these data, the groundwater inflow was estimated to be between 825,000 (steady-state inflow) and 14,100,000 (initial inflow) litres per day. Based on the Sichart and Kyrieleis equation, the radius of influence for the dewatering was estimated to be approximately 225 metres.

A steady-state inflow of 170,000 litres per day and radius of influence of 27 metres are considered conservative long-term estimates for the building foundation drains if they are installed at or above an elevation of 55.3 metres asl. The steady-state inflow value would increase over short-term periods during wet periods and rainfall events.

The actual rate of groundwater inflow to the excavations will ultimately depend on many factors including the contractor's schedule and rate of excavation, the size of the excavation, the type of shoring used, the excavated material, incident precipitation, and the time of year at which the excavation is made (e.g., fluctuation in seasonal groundwater elevation). Incident precipitation could add approximately 470,000 litres of water per day to the building excavation, assuming a 72-millimetre precipitation event (a 10-year event as observed at the Ottawa International Airport weather station) and an excavation with an area of 6,500 square metres.

Based on the groundwater conditions observed at the site, construction dewatering may exceed 400,000 litres per day; therefore, a PTTW is recommended for construction dewatering. Estimated inflow quantities for the various takings on the site (buildings, services, etc.) can be refined during detailed design.

The design of the dewatering system should be the responsibility of the contractor. An outlet (or outlets) should be identified which the contractor can use to dispose of the pumped groundwater and incident precipitation. The contractor will be responsible for ensuring that discharge of the water does not result in erosion, flooding or siltation. A Sewer Use Agreement would be required from the City of Ottawa before any discharge to the sewers would be permitted.

5.7 Temporary and Permanent Foundation Drainage

The measured groundwater depth at the site is variable, but it is generally considered to be between about 1.28 m (Elev. 58.12) to 6.20 metres (Elev. 53.84) below existing site grades.

In general, the subsurface conditions at the overall site and the surrounding area are indicated to consist of relatively incompressible sands and glacial till with very localized deposits of potentially compressible or shrinkage prone clays. The clay deposits are generally stiff with even more localized deposits of firm clays, which may be more compressible, underlying some of the stiff clay deposits. Based on the currently estimated dewatering zone of influence of about 27 metres and the estimated compressibility characteristics of the clay deposits, permanent lowering of the groundwater level should not result in appreciable ground settlements or settlements of lightly loaded structures (such as the adjacent single-family homes) supported on or above the clay.

Temporary dewatering for construction of less than about 12 months for the construction of the foundations and basement level until backfilled is likely feasible, particularly since the rest of the overall site has not yet been developed.

Drainage, such as a composite synthetic drainage system or equivalent, should be provided to the exterior walls above elevation 55.3 m. The composite drain must withstand the design horizontal earth pressures used for basement wall design and should be connected to the foundation drains at that level. The drainage system collector pipes should drain to a sump for collection and discharge to a sewer.

Permanent structures (e.g., elevator pits) that extend below the drainage level (i.e., 55.3 m elevation) should be designed and constructed to be watertight.

5.8 Basement Floor/Raft Slab

In preparation for the construction of the floor slab, all fill and, all loose, wet, and disturbed material should be removed from beneath the floor slab. Clear stone (19 mm nominal size) at least 200 mm in thickness should be provided below the floor slab to allow for installation of the slab drainage. A non-woven geotextile with a filter opening size (FOS) of 100 micron should be placed over the silty/clayey subgrade soils prior to placement of the clear stone.

5.9 Foundation Wall Backfill

The existing fill and native silty sands and clayey soils encountered at this site are potentially frost susceptible and should not be used as backfill against the foundation elements (e.g., grade beams/pile caps, foundation walls, etc.). To avoid problems with frost adhesion and heaving as well as to provide drainage, these foundation elements should be backfilled, within the design frost penetration depth below finished grade, with non-frost susceptible sand or sand and gravel conforming to the requirements for Ontario Provincial Standard Specification (OPSS) Granular B Type I, Granular B Type II, or Granular A.

To reduce compaction induced stresses, only light compaction rollers or plate tampers should be used within 1.0 m of the wall. In any areas where the temporary shoring wall serves as the outside form for the foundation wall, vertical drainage (such as Miradrain or a similar product) must be installed against the shoring wall.

To avoid ground settlements around the foundations, which could affect site grading and drainage, all of the backfill materials should be placed in maximum 300 mm lifts and be compacted to at least 95% of the material’s SPMDD.

If hard surfacing will be provided in the area over the edge of the foundation, differential frost heaving could occur between the granular fill and other areas. To reduce this differential heaving, the granular backfill adjacent to the foundations may be placed to form a frost taper. The frost taper should be brought up to pavement subgrade level from 1.5 m below the finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall.

5.10 Rock Anchors

If required, rock anchors could be provided to resist uplift loads on the foundations and slabs (such as due to seismic forces on the building or hydrostatic pressures), or to increase the sliding resistance. The anchors could consist of either grouted or mechanical anchors.

In designing grouted rock anchors, consideration should be given to four possible anchor failure modes.

i) failure of the steel tendon or top anchorage

ii) failure of the grout/tendon bond

iii) failure of the rock/grout bond

iv) failure within the rock mass, or rock cone pull-out

Potential failure modes i) and ii) are structural and are best addressed by the structural engineer. Adequate corrosion protection of the steel components should be provided to prevent potential premature failure due to steel corrosion, particulary in the submerged environment at the site.

For potential failure mode iii), the unfactored ULS bond stress at the concrete/rock interface may be taken as 1,500 kilopascals. The equivalent factored ULS value would be 450 kilopascals. If the response of the anchor under SLS conditions needs to be evaluated, for a preliminary assessment it may conservatively be taken as the elastic elongation of the unbonded portion of the anchor under the design loading.

For potential failure mode iv), the resistance should be calculated based on the buoyant weight of the potential mass of rock which could be mobilised by the anchor. This is typically considered as the mass of rock included within a cone (or wedge for a line of closely spaced anchors) having an apex at the tip of the anchor and having an apex angle of 60 degrees. For each individual anchor, the ULS factored geotechnical resistance can be calculated based on the following equation:

$$Q_r = \phi \frac{\pi}{3} \gamma' D^3 \tan^2(\theta)$$

where:

Q_r = factored uplift resistance of the anchor, kilonewtons

ϕ = resistance factor, 0.3

γ' = effective unit weight of rock, use 27 kN/m^3 above groundwater level, 17 kN/m^3 below groundwater level

D = anchor length in metres

θ = Half of the apex angle of the rock failure cone, use 30 degrees

The highest groundwater level was measured at about 1.28 m below the existing ground surface (i.e., about elevation 58.4 m).

For a group of anchors or for a line of closely spaced anchors the resistance must consider the potential overlap between the rock masses mobilized by individual anchors. Further guidelines by the geotechnical engineer can and must be provided for assessing the anchor resistance for these conditions.

It is suggested that pull-out tests be carried out on anchors to confirm their pull-out capacity. The pull-out tests should be carried out to 1.3 times the anchor service loads, and at least 10 percent of the anchors should be tested in this manner.

It is suggested that the installation and testing of the anchors be supervised by the geotechnical engineer. Care must be taken during grouting to ensure that the grouting pressure is sufficient to bond the entire length of the grout area with a minimum of voids. Probing of the holes should be carried out by the geotechnical engineer to ensure that the anchors are being installed in rock of adequate quality. It is also suggested that the anchor holes be thoroughly flushed with water to remove all debris, scum, and rock flour. It is essential that scum and rock flour be completely removed from the holes to be grouted to ensure an adequate bond between the grout and the rock.

Prestressing of the anchors prior to loading will minimize anchor movement due to service loads.

5.11 Lateral Earth Pressures for Design

Lateral earth pressures acting on the temporary shoring system and underground parking or foundation walls will depend on the type of retained soils, on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the magnitude of surcharge including construction loadings, on the freedom of lateral movement of the structure, and on the drainage conditions behind the walls. Seismic (earthquake) loading may also need to be taken into account in the design.

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

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

Soil	**Internal Angle of Friction**	**Unit Weight (kN/m^3)**	**Coefficients of static lateral earth pressure**	
			Active, Ka	**At rest, Ko**
Existing Fill	Ø = 28°	20.8	0.36	0.53
Silty Clay	Ø = 35°	18.5	0.27	0.43
Sands	Ø = 32°	19.0	0.31	0.47
Glacial Till	Ø = 34°	21.5	0.28	0.44

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

Material	**Internal Angle of Friction**	**Unit Weight (kN/m^3)**	**Coefficients of static lateral earth pressure**	
			Active, Ka	**At rest, Ko**
Granular A or Granular B Type II	Ø = 35°	22	0.27	0.43
Granular B Type I	Ø = 32°	22	0.31	0.47

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

The horizontal seismic coefficient, k_h, used in the calculation of the seismic active pressure coefficient is taken as 1.0 times the design PGA (i.e., $k_h = 0.276$). For structures which allow lateral yielding, k_h is taken as 0.5 times the design PGA (i.e., $k_h = 0.13$).

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

Wall Type	Site PGA (2475-year Earthquake)	K_{AE}	
		Granular A/Granular B Type II	Granular B Type I
Yielding Wall	0.276g	0.37	0.41
Non-Yielding Wall		0.49	0.54

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

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

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

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

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

K_o = Coefficient of static earth pressure;

γ = Unit weight of the backfill soil (kN/m^3); as given previously;

d = Depth below the top of the wall (m);

K_{AE} = Seismic active earth pressure coefficient;

q = Surcharge to account for traffic and compaction pressure, where applicable; and,

H = Total height of the wall (m).

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

5.12 Site Servicing

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

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

It should generally be possible to re-use the existing inorganic fill, weathered silty clay, sands and glacial till as trench backfill. Where the trench will be covered with hard surfaced areas, the type of material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment.

5.13 Pavement Design

It is understood new parking lots and access roadways will be constructed as part of the development.

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

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow (OPSS.MUNI 206/212), Select Subgrade Material (OPSS.MUNI 1010) or additional granular base if grade changes are minor. These materials should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the materials standard Proctor maximum dry density using suitable compaction equipment.

The surface of the subgrade or fill should be crowned or sloped to promote drainage of the roadway granular structure. Perforated pipe subdrains should be provided along the low sides of the roadway along the entire length. The subdrains should be installed in accordance with OPSS.MUNI 405. The subdrains should be connected to the catch basins such that the pavement structure will be positively drained and will intercept flows within the subbase.

Below the pavement structure, frost compatibility must be maintained across any new service trenches. Due to the variability of the soils within the project limits, the subsoil should be inspected by qualified geotechnical personnel to make sure that there is no potential for differential frost heaving. Frost tapers from the bottom of granular subbase to 1.8 metre depth should be constructed at 10H:1V and should be provided where necessary.

The pavement recommendations have been split up into two categories of light duty and heavy duty pavements. It has been assumed the light duty areas will consist of parking areas and lighter vehicles (i.e., no truck or bus traffic), and the heavy duty pavements will consist of occasional truck traffic and no bus traffic. The pavement in each area should be constructed as follows:

Material		Thickness of Pavement Elements (mm)	
		Light Duty	Heavy Duty
Asphaltic Concrete OPSS.MUNI 1151	Superpave 12.5 mm	40	50
	Superpave 19.0 mm	50	60
Granular Material OPSS.MUNI 1010	Granular A Base	150	150
	Granular B, Type II Subbase	400	500

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

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

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., grade raise fill has been adequately compacted to the required density and the subgrade surface not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and/or to place a woven geotextile beneath the granular materials.

At Gladstone Avenue and pavement intersections, the new pavement structure should be continued at least to the limits of construction or the end of the curb “return” (i.e., the start of the constant width portion of the side road). At Gladstone, the pavement should be milled back beyond the curb return by 300 mm to a depth of 90 mm and an additional 300 mm to a depth of 40 or 50 mm to accept the new upper binder course and surface course asphaltic concrete mixes forming in a stepped joint. At local intersections, the pavement should be milled back beyond the curb return by 300 mm to a depth of 40 or 50 mm to accept the new upper binder course and surface course asphaltic concrete mixes forming in a stepped joint

The granular courses and subbase level should be tapered between the new and existing pavements by using 10H:1V tapers up or down as required, starting from behind the curb return. At driveways and commercial entrances, butt joints may be used.

A tack coat should be provided on all vertical and horizontal surfaces. The tack coat should consist of an SS-1 emulsified asphalt diluted with an equal amount of water. The undiluted and emulsified asphalt shall be in conformance with OPSS.MUNI 1103.

5.14 Corrosion and Cement Type

One soil sample from borehole 21-04, was submitted to Eurofins Laboratories Ltd. for chemical analysis related to potential corrosion of exposed buried steel and concrete elements (corrosion and sulphate attack). The results of this testing are provided in Appendix D. The results indicate that concrete made with Type GU Portland cement should be acceptable for concrete substructures.

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

6.0 IMPACTS TO ADJACENT STRUCTURES OR UTILITIES

As indicated in Sections 5.6 and 5.7, it is anticipated that the planned temporary or permanent dewatering for construction of the planned development will not result in adverse impacts to off-site structures or utilities.

The existing O-Train line extends in a cut along the western border of the site. Based on the depth of the cut, the separation distance and the limited grade raise anticipated for this site, it is not considered that the cut slopes for the rail line will be adversely affected by the development.

7.0 TREES

There are limited and localized deposits of sensitive marine clays (as defined in the City guideline, “Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines” draft version 2.0, dated January 7, 2019) within and adjacent to the building footprint. However, since the building will be founded on bedrock at depth, no tree planting setback restrictions are required for this part of the development.

8.0 ADDITIONAL CONSIDERATIONS

At the time of writing this report, only conceptual details related to the proposed building were available. This information suggests this building will consist of 18 storey building with one parking level to be located at the north side of the property and servicing at the south site. Golder Associates should review the final drawings and specifications for this project prior to tendering to confirm that the guidelines in this report have been adequately interpreted.

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

All bearing surfaces must be inspected by Golder prior to filling or concreting to ensure that strata having adequate bearing capacity have been reached and that the bearing surfaces have been properly prepared.

9.0 CLOSURE

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

Signature Page

Golder Associates Ltd.

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-

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https://golderassociates.sharepoint.com/sites/151656/project files/6 deliverables/2-final/rev1/21490294-rev1-geotech investigation-933 gladstone avenue-may 2022.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, **Ottawa Community Housing Corporation**. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

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

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

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

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

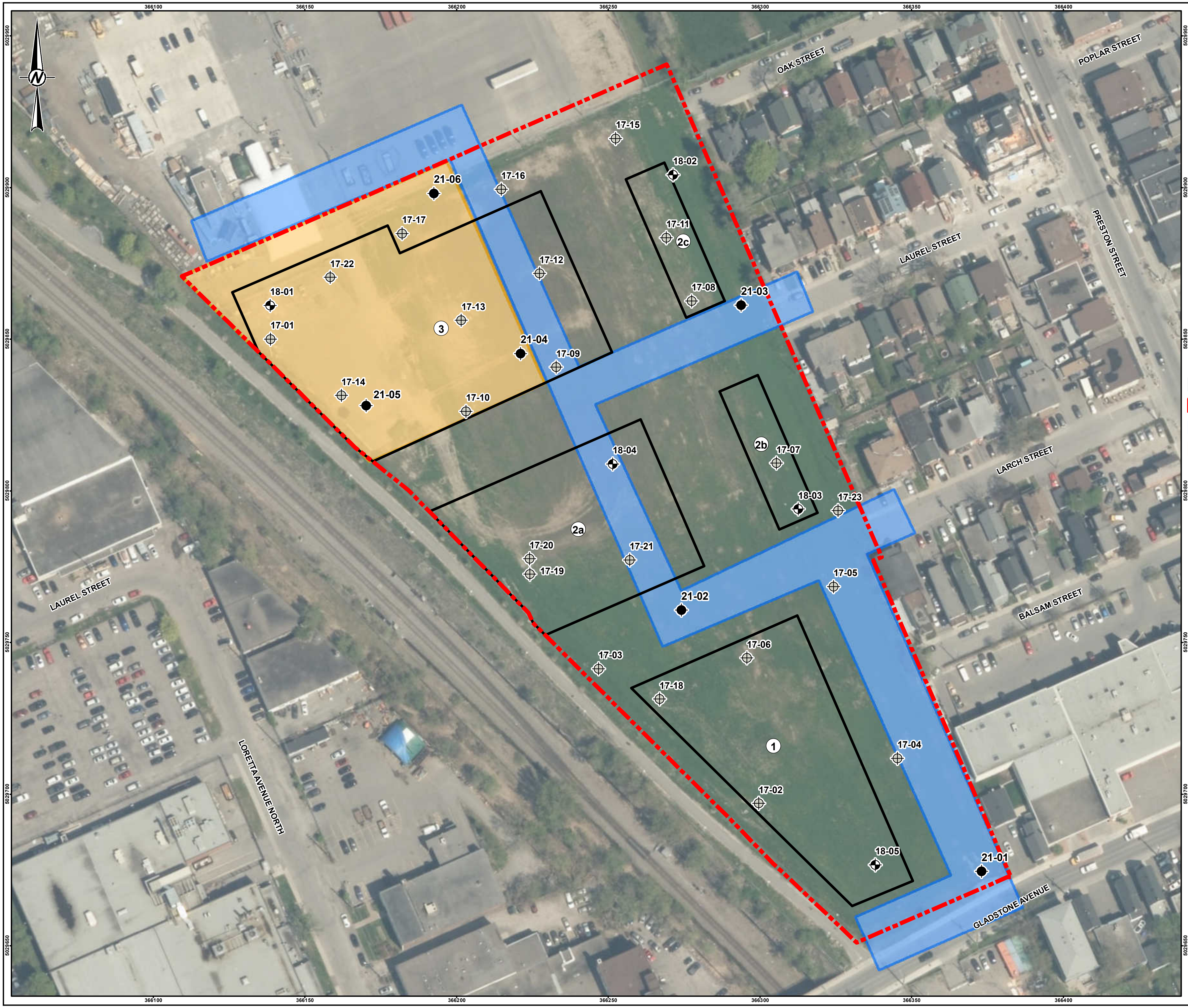
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

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

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

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

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



KEY MAP

SCALE 1:25,000

LEGEND

●	APPROXIMATE BOREHOLE LOCATION
⯐	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION (2018)
⌖	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION (2017)
①	BLOCK NUMBERING
☐	PROPOSED BUILDING FOOTPRINT
🟥	APPROXIMATE SITE BOUNDARY
🟦	DEEP COLLECTOR SEWERS PROPOSED ROUTE
🟨	PROPOSED BUILDING LOCATION FOR GLADSTONE VILLAGE PHASE 1

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. GLADSTONE VILLAGE DESIGN CONCEPT PROVIDED BY CLIENT, 06/21/2017. REV. NO. 05.
2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2020
3. SERVICE LAYER CREDITS: © OPENSTREETMAP (AND) CONTRIBUTORS, CC-BY-SA
4. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 12.5 25 50
1:1,250 METRES

CLIENT
OTTAWA COMMUNITY HOUSING CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION, GLADSTONE VILLAGE
933 GLADSTONE AVENUE, OTTAWA, ON

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-02
DESIGNED	----
PREPARED	BR/JEM/MG
REVIEWED	AKP
APPROVED	WC

PROJECT NO.	CONTROL	REV.	FIGURE
21490294	0001	0	1

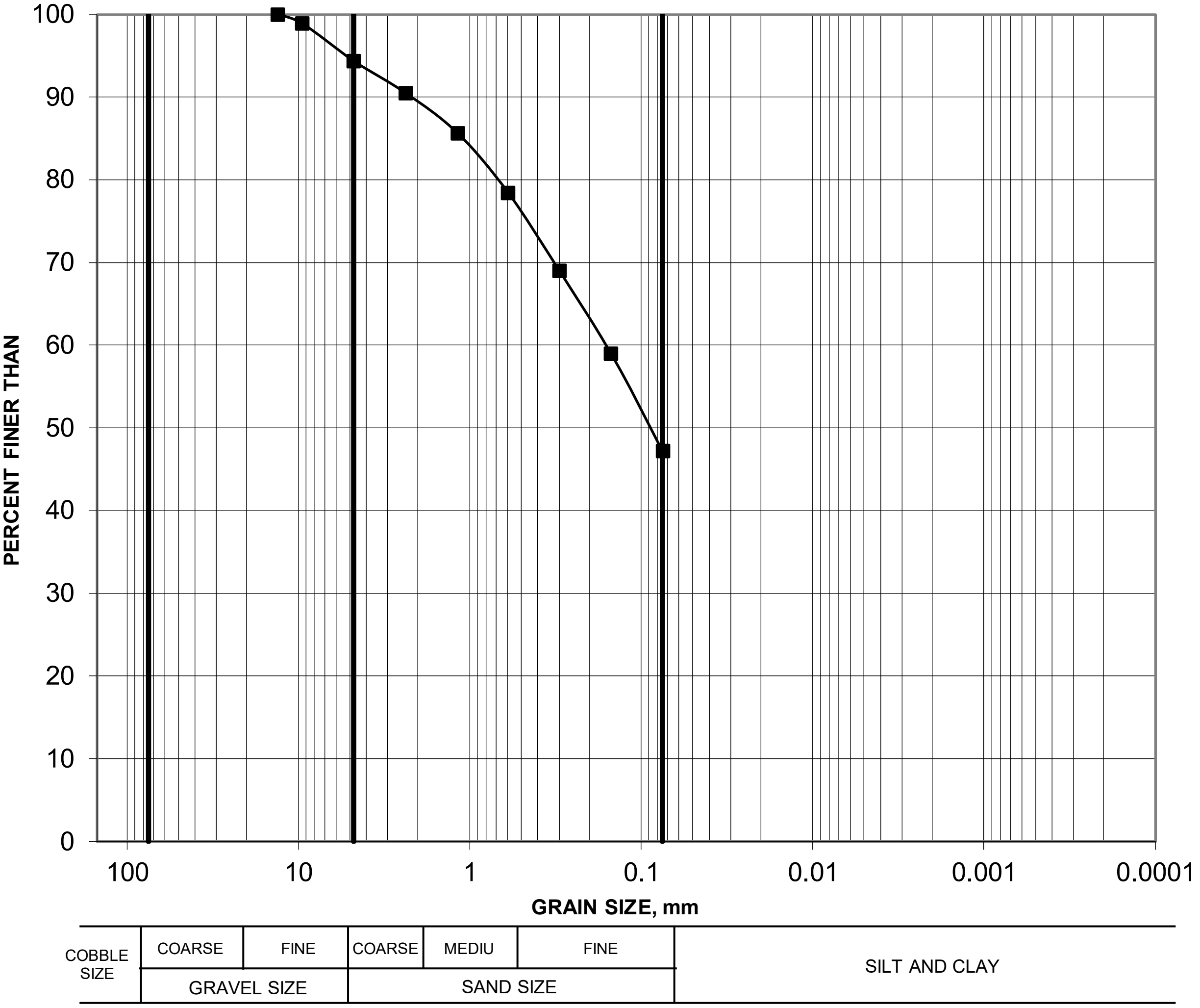
Path: N:\Active\Spatial_IM\OCHC\933_Gladstone_Ave\99_PROJ\21490294_OCHC_Geotec\40_PROD\0001_Tower_Survey\21490294-0001-BG-0001.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:
25mm
0

GRAIN SIZE DISTRIBUTION

FIGURE 2

SILTY SAND



				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	21-01	3	1.52-2.13	6	47	47	

Project: 21490294/2200

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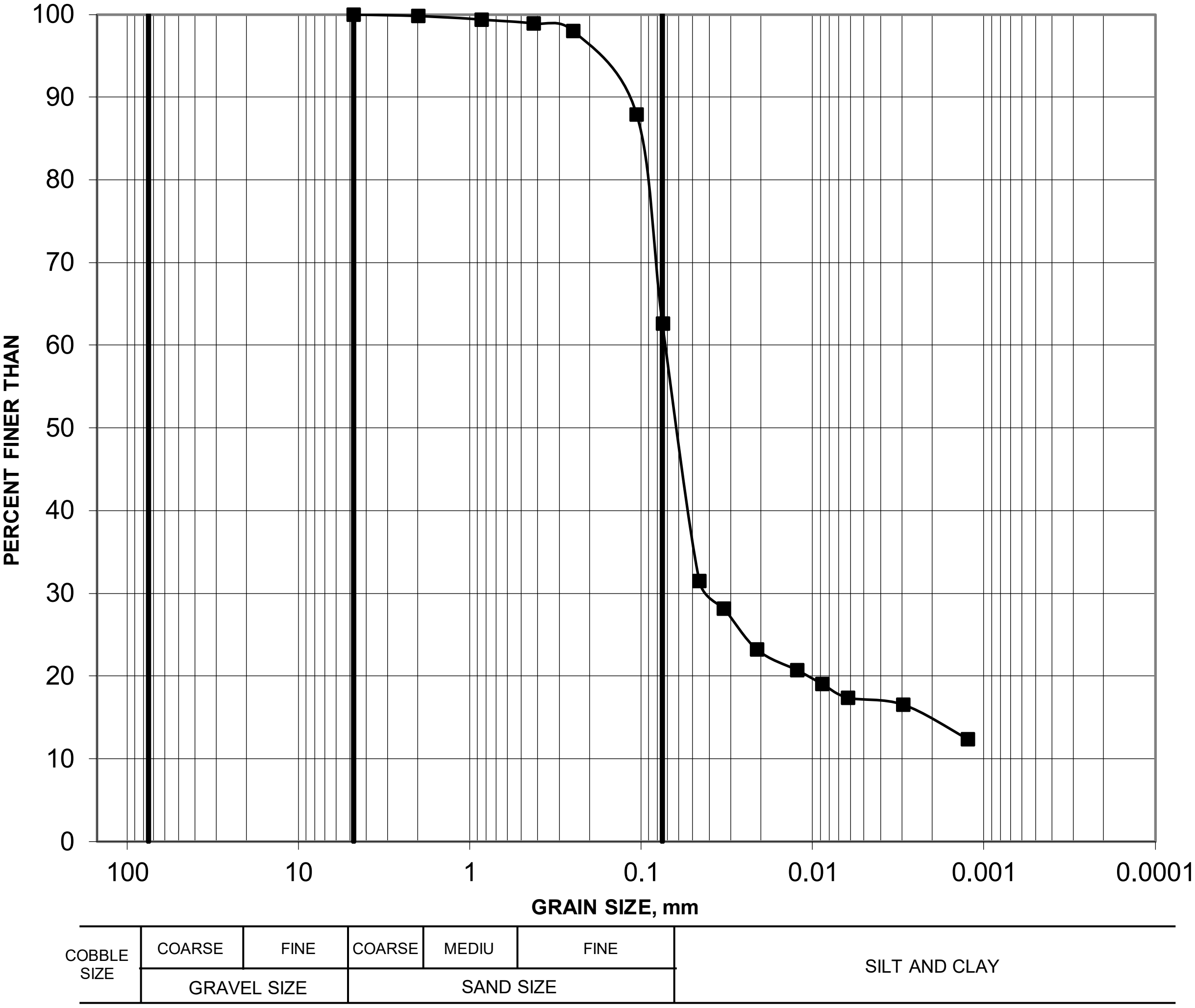
Checked by: JB

GRAIN SIZE DISTRIBUTION	FIGURE 3

SANDY SILT



			Constituents (%)			
Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
—■— 21-04	2	1.52-2.13	0	37	48	15

Project: 21490294/2200

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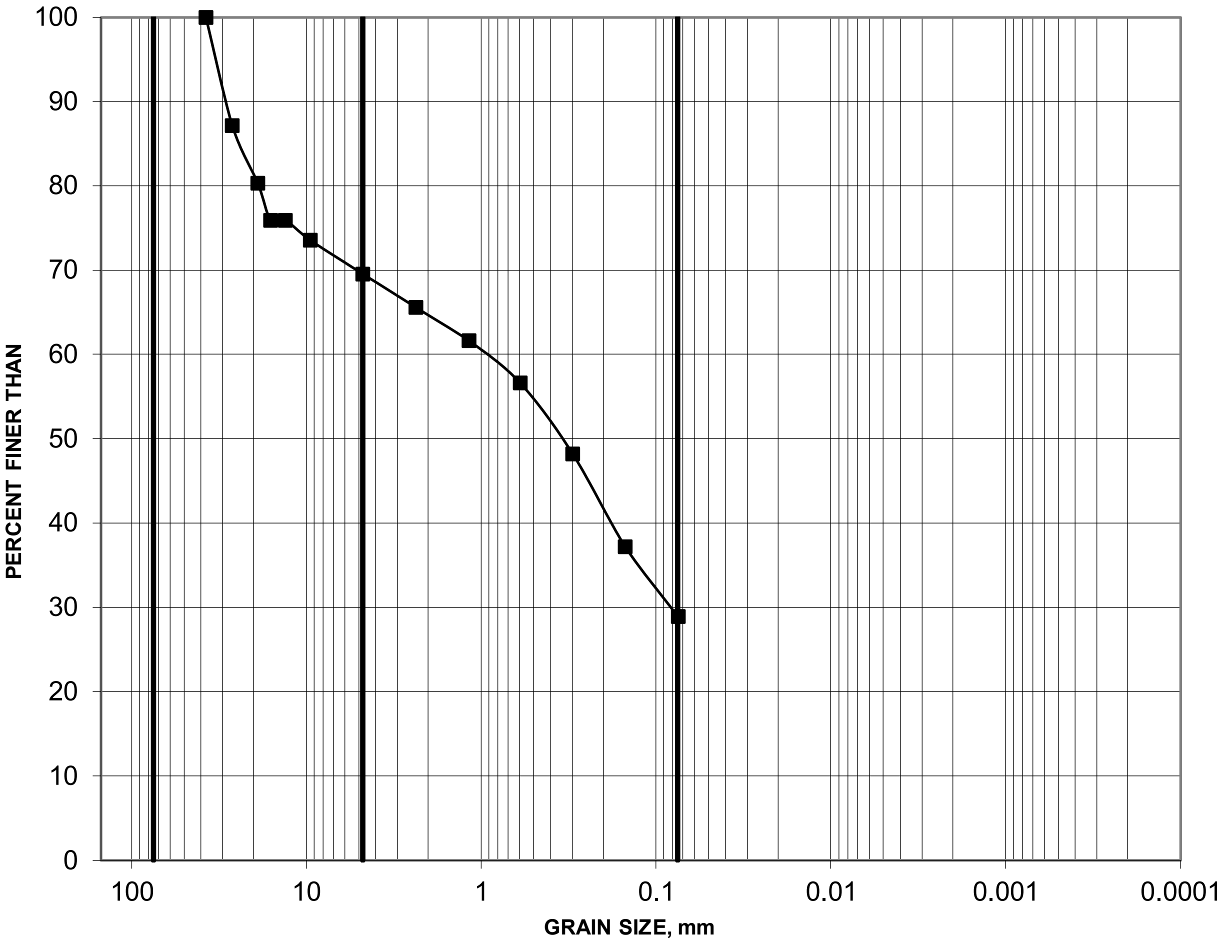
GRAIN SIZE DISTRIBUTION	FIGURE 4

SILTY SAND



COBBLE SIZE	COARSE	FINE	COARSE	MEDIU	FINE	SILT AND CLAY
	GRAVEL SIZE		SAND SIZE			

				Constituents (%)			
	Borehole	Sample	Depth (m)	Gravel	Sand	Silt	Clay
■	21-06	7	4.57-5.18	30	41	29	

Project: 21490294/2200

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Checked by: JB

APPENDIX A

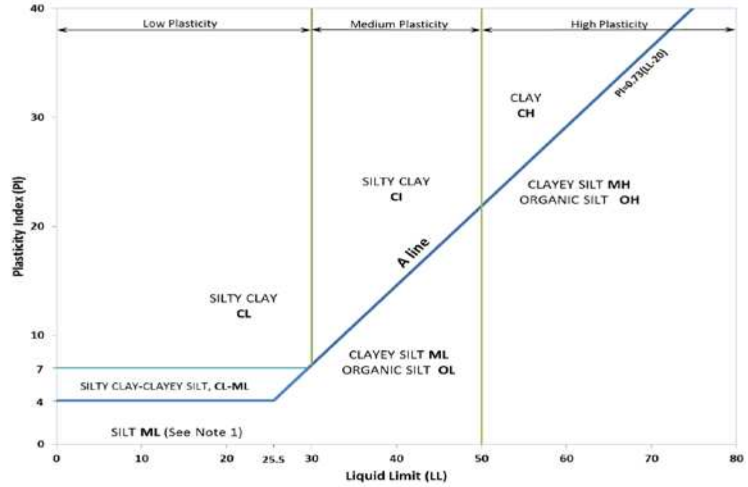
Borehole Records (Current Investigation)

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	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10}xD_{60}}$	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: 21490294

RECORD OF BOREHOLE: 21-01

SHEET 1 OF 2

LOCATION: N 5029674.6 ;E 366373.1

BORING DATE: December 15, 2021

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

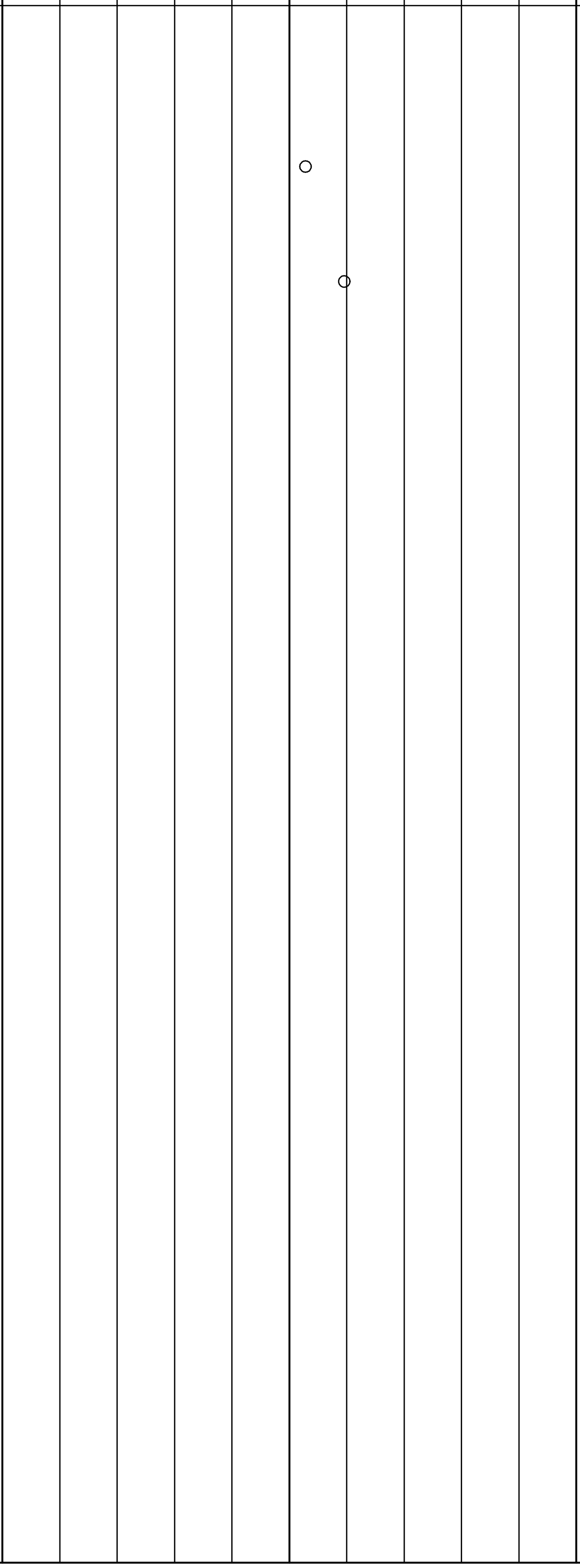
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		60.92					
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM/ML) gravelly SILTY SAND to sandy SILT; grey; non-cohesive, moist		0.00	1	GS	-		
1					2	SS	47		
		TOPSOIL - (SM/ML) gravelly SILTY SAND to sandy SILT, trace to some clay; black to dark brown, contains rootlets; non-cohesive, moist		59.55 1.37					
2		(SM/ML) gravelly SILTY SAND to sandy SILT; grey brown; non-cohesive, moist, compact		59.30 1.62	3	SS	11	M	
		(SM/ML) gravelly SILTY SAND to sandy SILT; grey (TILL); non-cohesive, wet, compact		58.79 2.13	4	SS	18		
3					5	SS	>50		
		Borehole continued on RECORD OF DRILLHOLE 21-01		57.67 3.25					
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: BW

CHECKED: WC

MIS-BHS 001 21490294.GPJ GAL-MIS.GDT 4/7/22 ZS

PROJECT: 21490294

RECORD OF DRILLHOLE: 21-01

SHEET 2 OF 2

LOCATION: N 5029674.6 ;E 366373.1

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 15, 2021

DRILL RIG: CME 75

DRILLING CONTRACTOR: CCC Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

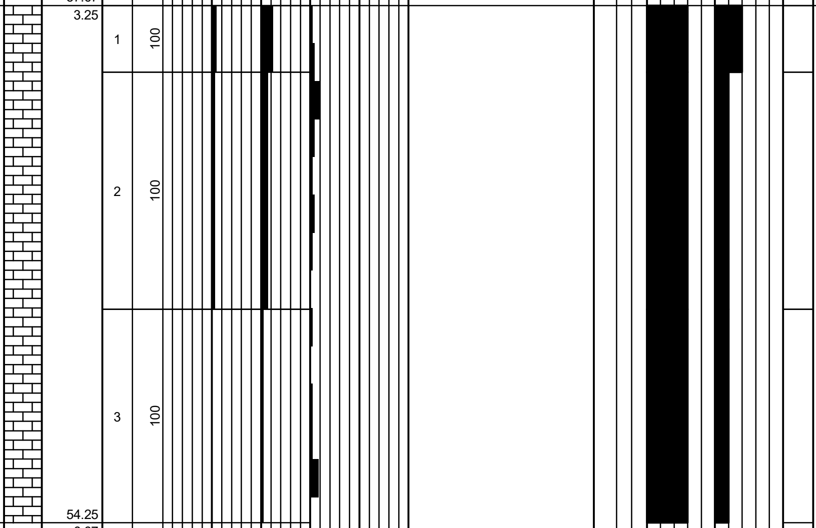
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	
		BEDROCK SURFACE		57.67 3.25			
4 5 6	Rotary Drill HQ3 Core	Fresh to slightly weathered, thin to medium bedded, fine to medium grained, grey to dark grey, slightly to non-porous, weak to medium strong LIMESTONE. with shale interbeds			1 2 3	100 100 100	UCS= 70 MPa
				54.25			
7 8 9 10 11 12 13		End of Drillhole		6.67			



DEPTH SCALE
1 : 50

GOLDER

LOGGED: BW
CHECKED: WC

PROJECT: 21490294

RECORD OF BOREHOLE: 21-02

SHEET 1 OF 1

LOCATION: N 5029760.8 ;E 366274.1

BORING DATE: December 15, 2021

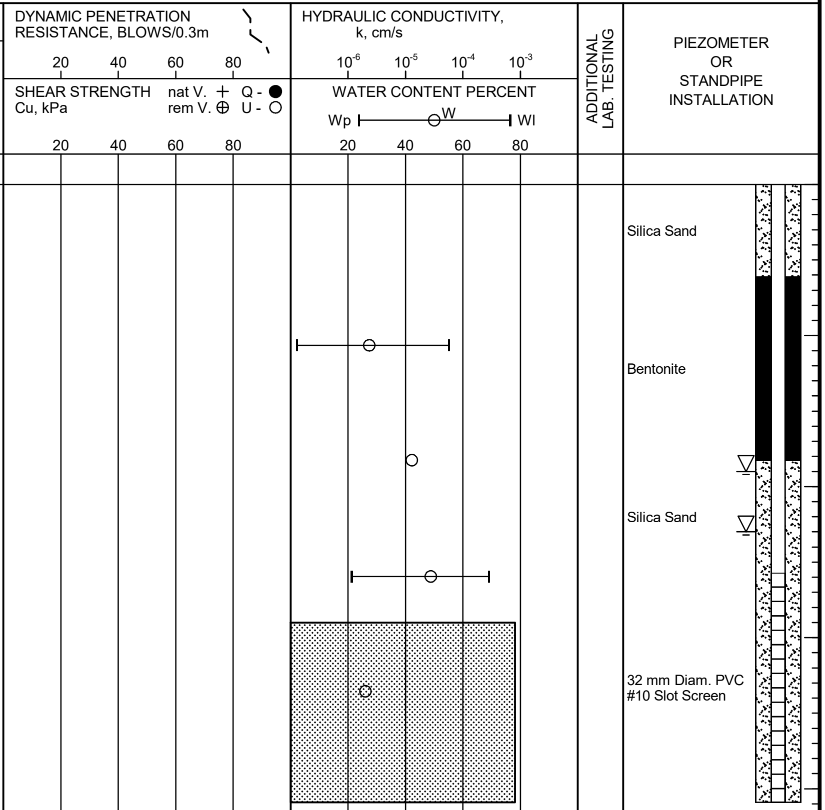
DATUM: Geodetic

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
GROUND SURFACE	61.36			
TOPSOIL - (SM) SILTY SAND, some gravel; dark brown; non-cohesive, moist, compact	0.00	1	SS	11
(CL) SILTY CLAY; brown; cohesive, w<PL, firm	60.83 0.53			
(CL/CH) SILTY CLAY to CLAY; brown, highly fissured (WEATHERED CRUST); cohesive, w<PL, very stiff	60.60 0.76	2	SS	12
(ML/CL) SILTY CLAY to CLAYEY SILT; grey brown; cohesive, w~PL, stiff	59.84 1.52	3	SS	4
(ML/CL) SILTY CLAY to CLAYEY SILT, trace sand; grey brown; cohesive, w>PL, stiff	59.07 2.29	4	SS	2
(ML) sandy SILT, some clay; grey (TILL); non-cohesive, wet, very loose	58.31 3.05	5 6	SS SS	2 >50
End of Borehole	57.27 4.09			



Note(s):

1. Water level in screen measured at a depth of 1.90 m (Elev. 59.46 m) on January 13, 2022

2. Water level in screen measured at a depth of 2.30 m (Elev. 59.06 m) on February 9, 2022

DEPTH SCALE 1 : 50

LOGGED: BW

CHECKED: WC

PROJECT: 21490294

RECORD OF BOREHOLE: 21-03

SHEET 1 OF 1

LOCATION: N 5029861.3 ;E 366293.7

BORING DATE: December 13, 2021

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: POwer AUger, 200 mm Diam. (Hollow Stem) (0 to 6.10 m)

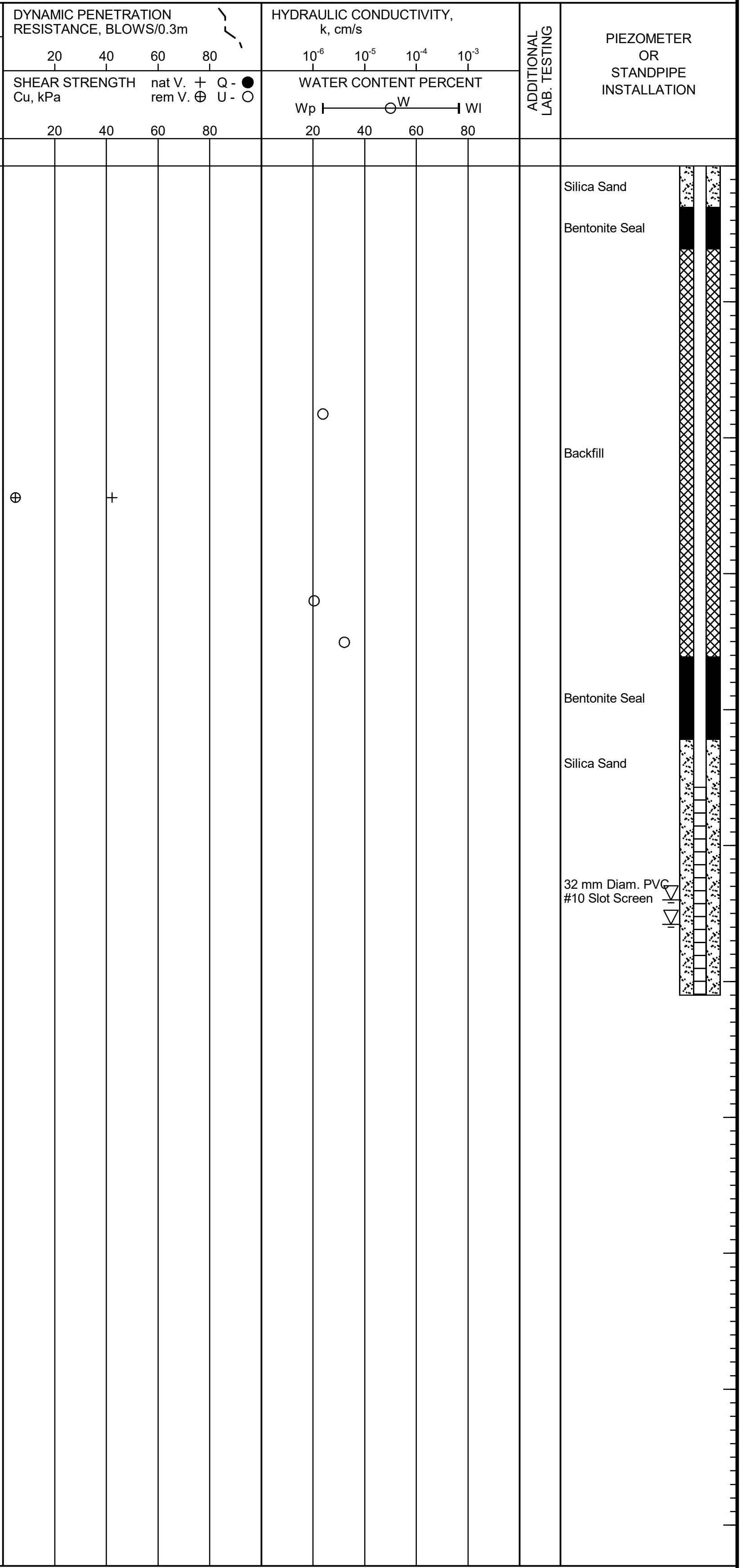
SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	59.84
TOPSOIL - (SM) SILTY SAND, trace organic matter; brown; non-cohesive, moist, compact	0.00
FILL - (SM/ML) SILTY SAND to sandy SILT, some gravel; brown, possible cobbles; non-cohesive, moist, compact	59.23 0.61
(CL/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w~PL, stiff to firm	58.47 1.37
(ML/SM) sandy SILT to SILTY SAND, trace to some gravel, angular; grey; non-cohesive, moist	57.10 2.74
(CL) CLAY, some silt, some to trace sand; grey brown; cohesive, w>PL	56.49 3.35
(ML/SM) sandy SILT to SILTY SAND, trace to some gravel, angular; grey (TILL); non-cohesive, mosit to wet, loose to compact	56.18 3.66
End of Borehole	53.74 6.10

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	10
2	SS	9
3	SS	2
4	SS	4
5	SS	4
6	SS	10
7	SS	13

Note(s):

1. Water level in screen measured at a depth of 5.40 m (Elev. 54.44 m) on January 13, 2022

2. Water level in screen measured at a depth of 5.58 m (Elev. 54.26 m) on February 9, 2022



DEPTH SCALE 1 : 50

LOGGED: BW

CHECKED: WC

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PROJECT: 21490294

RECORD OF BOREHOLE: 21-04

SHEET 1 OF 2

LOCATION: N 5029845.4 ;E 366221.1

BORING DATE: December 14, 2021

DATUM: Geodetic

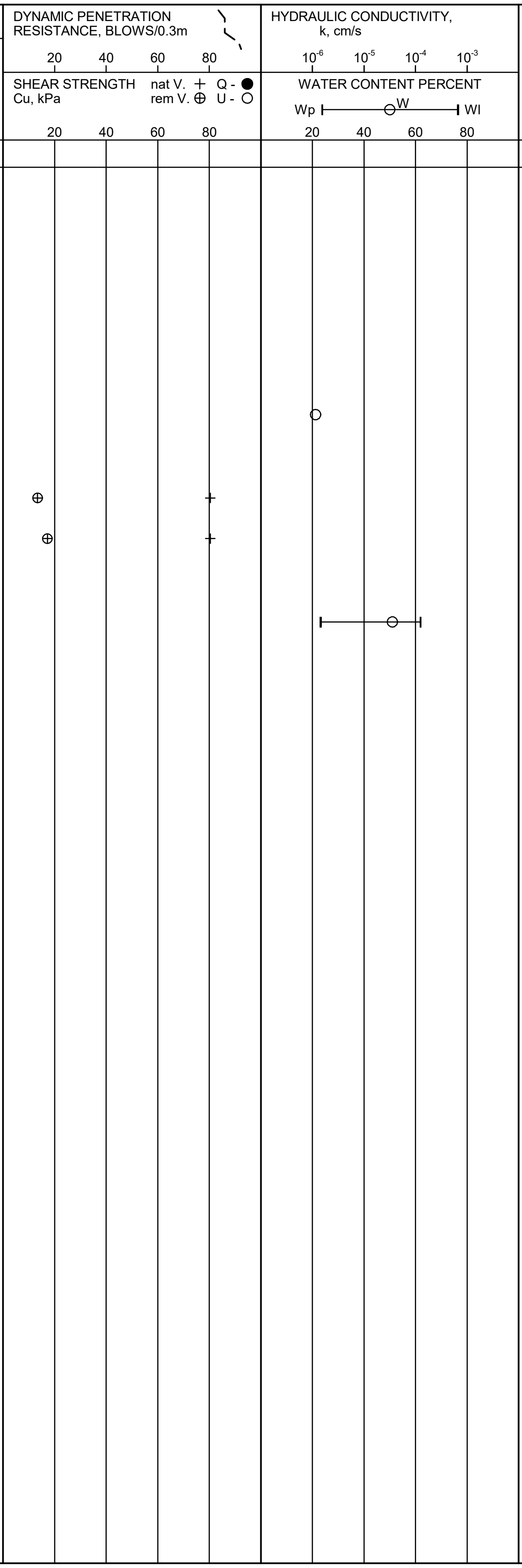
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	60.68
FILL - (SM) gravelly SILTY SAND; brown to dark brown, possible cobbles; non-cohesive, moist, compact	0.00
(ML) sandy SILT; grey brown, sensitive; non-cohesive, moist, loose	59.77 0.91
(CH) CLAY; grey; cohesive, w>PL, stiff	58.24 2.44
(CL/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	56.41 4.27
Borehole continued on RECORD OF DRILLHOLE 21-04	54.53 6.15

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	15	
2	SS	3	MH
3	SS	2	
4	SS	WH	
5	SS	>50	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

GOLDER

LOGGED: BW

CHECKED: WC

PROJECT: 21490294

RECORD OF DRILLHOLE: 21-04

SHEET 2 OF 2

LOCATION: N 5029845.4 ;E 366221.1

DRILLING DATE: December 14, 2021

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 75

DRILLING CONTRACTOR: CCC Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

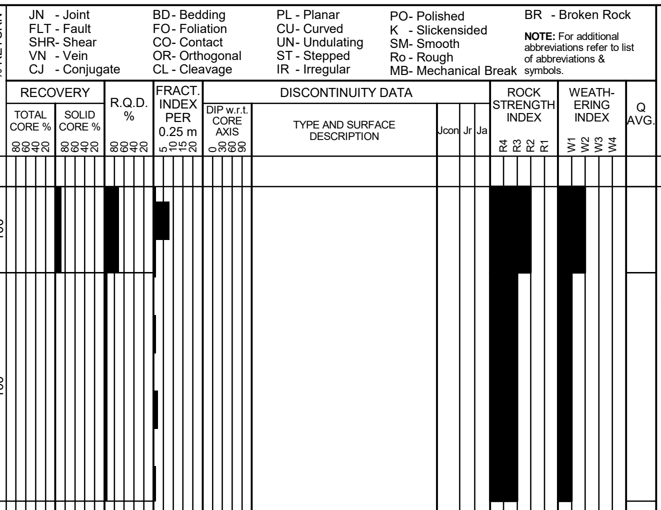
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN		
		BEDROCK SURFACE		54.53				
7 8	Rotary Drill HQ3 Core	Fresh to slightly weathered, thin to medium bedded, pale to dark grey, fine to medium grained, slightly to non-porous, weak to medium strong LIMESTONE, with shale interbeds		6.15	1	100		
				52.45 8.23	2	100		UCS= 108 MPa
9 10 11 12 13 14 15 16		End of Drillhole						



DEPTH SCALE

1 : 50

GOLDER

LOGGED: BW

CHECKED: WC

PROJECT: 21490294

RECORD OF BOREHOLE: 21-05

SHEET 1 OF 2

LOCATION: N 5029828.1 ;E 366170.0

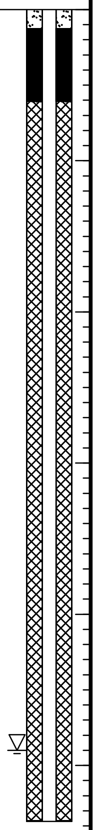
BORING DATE: December 15, 2021

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		60.04							
0	Power Auger 200 mm Diam. (Hollow Stem)	- Not sampled, augered to bedrock		0.00							Silica Sand Bentonite
1											
2											
3											Backfill
4											
5											
		Borehole continued on RECORD OF DRILLHOLE 21-05		54.67							Bentonite
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

GOLDER

LOGGED: BW

CHECKED: WC

PROJECT: 21490294

RECORD OF DRILLHOLE: 21-05

SHEET 2 OF 2

LOCATION: N 5029828.1 ;E 366170.0

DRILLING DATE: December 15, 2021

DATUM: Geodetic

DRILL RIG: CME 75

INCLINATION: -90° AZIMUTH: ---

DRILLING CONTRACTOR: CCC Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

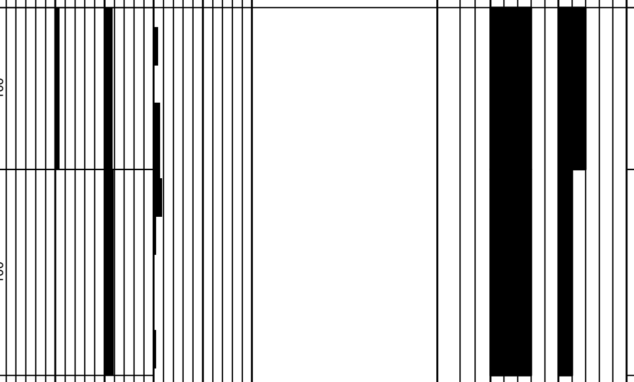
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

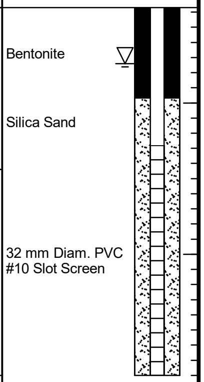
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH
		BEDROCK SURFACE		54.67		
6 7	Rotary Drill HQ3 Core	Fresh to slightly weathered, thin to medium bedded, fine grained, grey to black, weak to medium strong SHALE, with limestone interbeds		5.37 52.24	1 2	100 100
8 9 10 11 12 13 14 15		End of Drillhole Note(s): 1. Water level in screen measured at a depth of 4.90 m (Elev. 55.14 m) on January 13, 2022 2. Water level in screen measured at a depth of 5.74 m (Elev. 54.30 m) on February 9, 2022		7.80		





DEPTH SCALE
1 : 50

GOLDER

LOGGED: BW
CHECKED: WC

RECORD OF BOREHOLE: 21-06

PROJECT: 21490294
LOCATION: N 5029898.2 ;E 366192.6
SAMPLER HAMMER, 64kg; DROP, 760mm

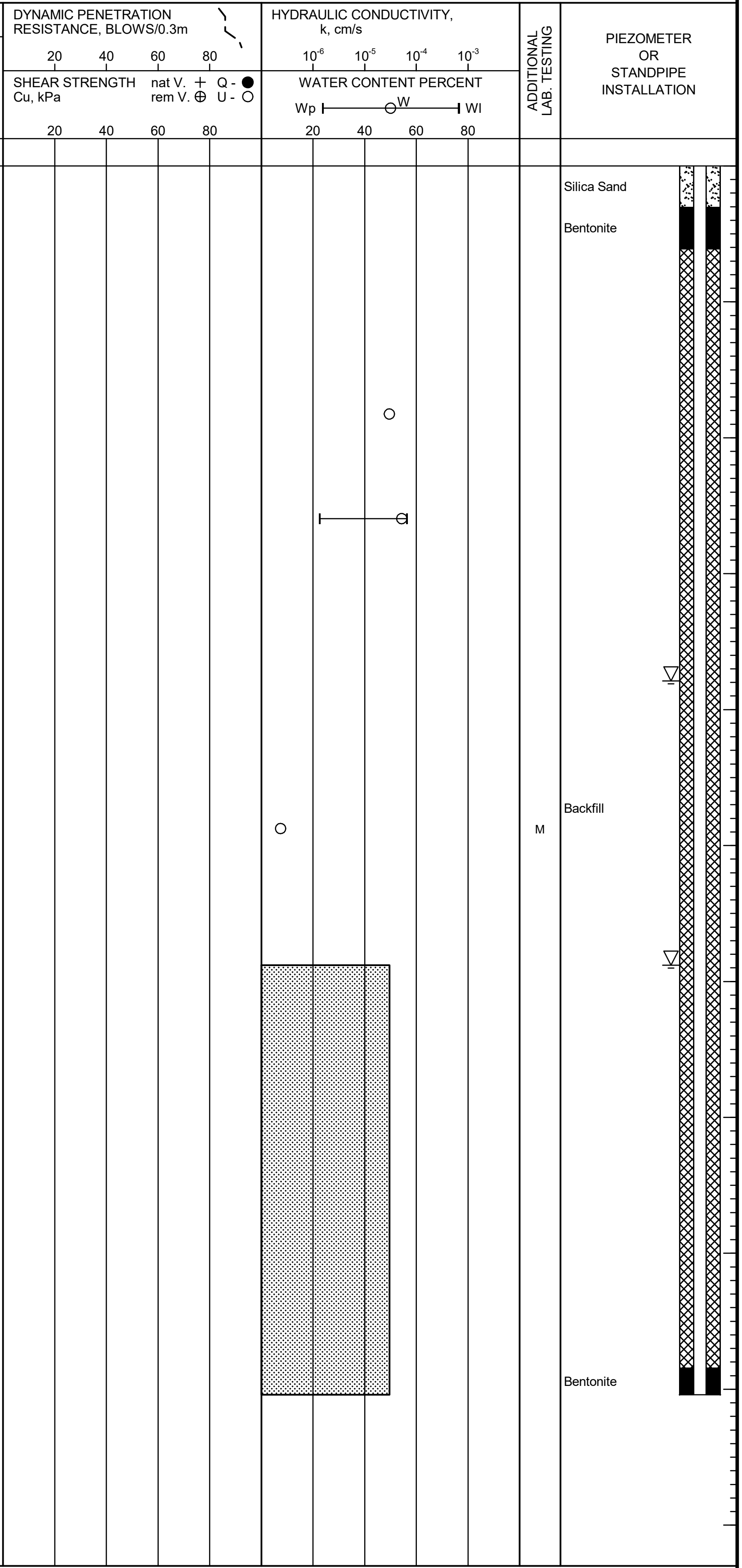
BORING DATE: December 13, 2021

SHEET 1 OF 2
DATUM: Geodetic
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	60.08
TOPSOIL - (SM) gravelly SILTY SAND, angular to sub-angular, fine to medium, trace organic matter (rootlets); brown, organic mottled; non-cohesive, moist, compact	0.00
(CL/CH) SILTY CLAY to CLAY; brown, contains very thin to thin laminations of silty sand, highly fissured (WEATHERED CRUST); cohesive, w<PL, very stiff	59.47 0.61
(CL/CH) SILTY CLAY to CLAY; brown; cohesive, w~PL, very stiff	58.71 1.37
(CL/CH) SILTY CLAY to CLAY; grey brown; cohesive, w>PL, stiff	57.79 2.29
(SM) SILTY SAND, trace to some gravel; grey, possible cobbles (TILL); non-cohesive, moist to wet, loose to compact	56.42 3.66
(SP) SAND, fine to medium brown; non-cohesive, wet, loose to compact	53.98 6.10
(SP) SAND, coarse; brown; non-cohesive, wet	51.81 8.27
Borehole continued on RECORD OF DRILLHOLE 21-06	51.04 9.04

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	13	
2	SS	5	
3	SS	5	
4	SS	2	
5	SS	2	
6	SS	5	
7	SS	16	M
8	SS	5	
9	SS	18	
10	SS	8	
11	SS	27	



DEPTH SCALE
1 : 50

GOLDER

LOGGED: BW
CHECKED: WC

PROJECT: 21490294

RECORD OF DRILLHOLE: 21-06

SHEET 2 OF 2

LOCATION: N 5029898.2 ;E 366192.6

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: December 13, 2021

DRILL RIG: CME 75

DRILLING CONTRACTOR: CCC Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

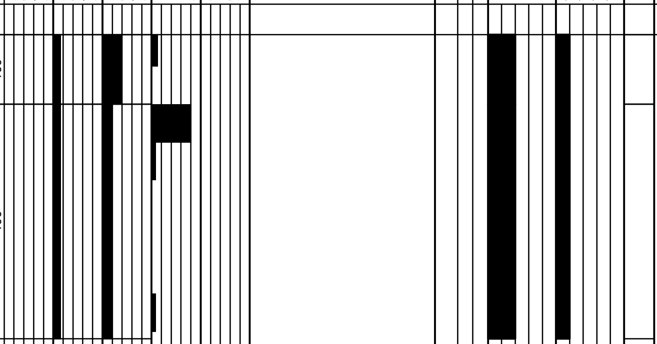
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

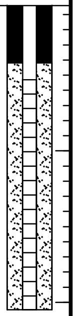
PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	COLOUR / % RETURN / FLUSH	
		BEDROCK SURFACE	51.04			
10	Rotary Drill HQ3 Core	Fresh, medium bedded, pale to dark grey, medium grained, slightly to non-porous, medium strong to strong NODULAR LIMESTONE, with very thin to thin laminations of shale, numerous calcite vanes and healed joints - Broken core from 9.50 m to 9.69 m	9.04	1	100	Bentonite Silica Sand
				2	100	32 mm Diam. PVC #10 Slot Screen
11			49.03 11.05			
		End of Drillhole Note(s): 1. Water level in screen measured at a depth of 3.79 m (Elev. 56.29 m) on January 13, 2022 2. Water level in screen measured at a depth of 5.88 m (Elev. 54.20 m) on February 9, 2022				
12						
13						
14						
15						
16						
17						
18						
19						





DEPTH SCALE

1 : 50

GOLDER

LOGGED: BW

CHECKED: WC

APPENDIX B

Laboratory Test Results

PROJECT: 1670949

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1

LOCATION: N 5028292.0 ;E 443935.0

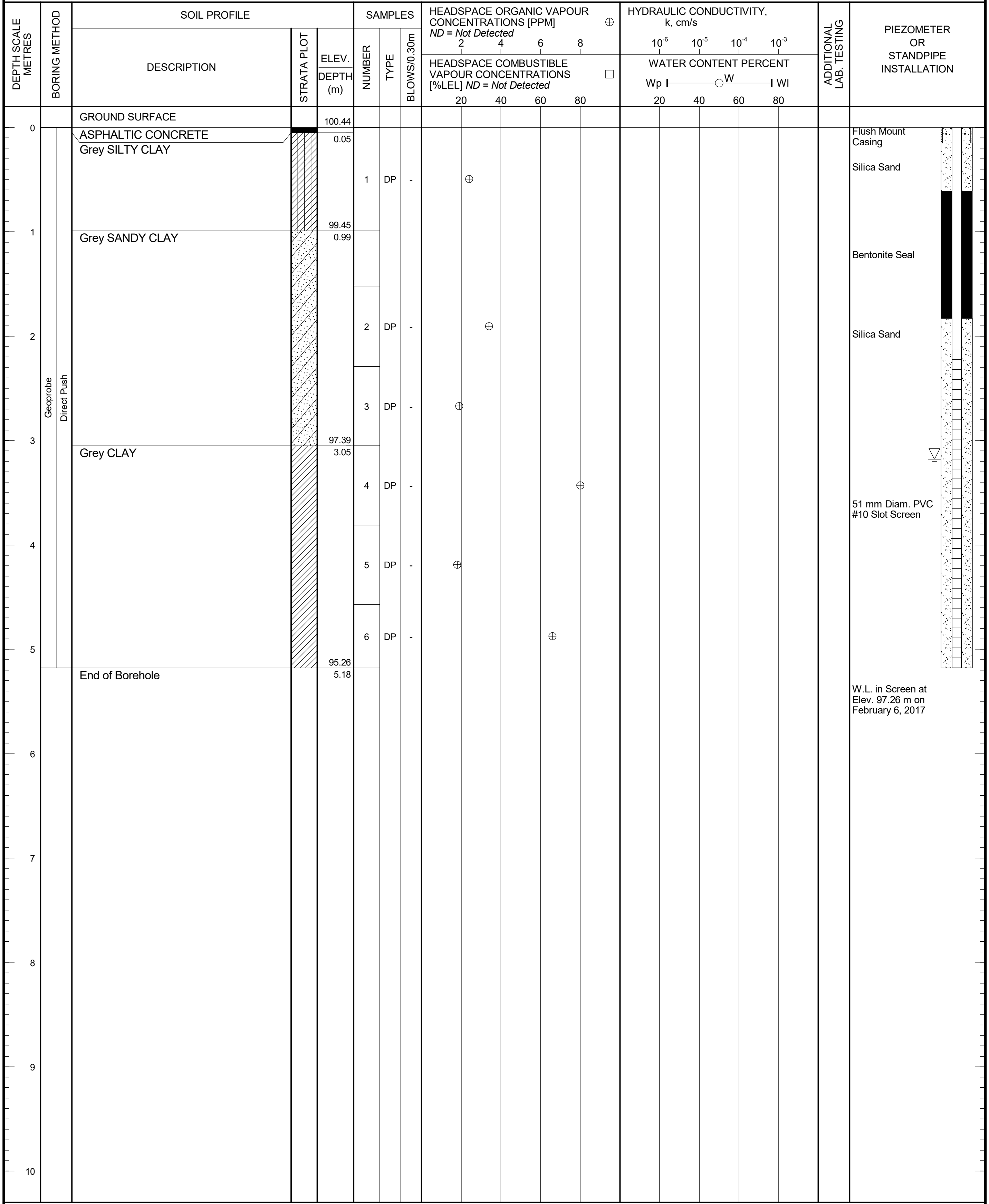
BORING DATE: January 30, 2017

DATUM: CGVD28

BORING METHOD: Geoprobe Direct Push

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.44
ASPHALTIC CONCRETE	0.05
Grey SILTY CLAY	99.45 0.99
Grey SANDY CLAY	97.39 3.05
Grey CLAY	95.26 5.18
End of Borehole	

NUMBER	TYPE	BLOWS/0.30m
1	DP	-
2	DP	-
3	DP	-
4	DP	-
5	DP	-
6	DP	-



Flush Mount Casing

Silica Sand

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

W.L. in Screen at Elev. 97.26 m on February 6, 2017

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: N 5028136.0 ;E 444093.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8) / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] ND = Not Detected (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		101.39							
0	Geoprobe Direct Push	Brown SILTY SAND, with gravel (FILL)		0.00							
					1	DP	-	⊕			
1											
2					3	DP	-				
		End of Borehole		98.95 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: N 5028181.0 ;E 444041.0

BORING DATE: January 27, 2017

DATUM: CGVD28

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	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8); HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ (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		101.21							
0	Geoprobe Direct Push	Brown SILTY CLAY, trace gravel and brick (FILL)	▨	0.00	1	DP	-	⊕			
1					2	DP	-	⊕			
2					3	DP	-	⊕			
		End of Borehole		98.77 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

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DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-04

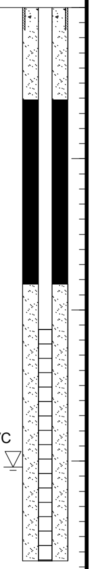
SHEET 1 OF 1

LOCATION: N 5028150.0 ;E 444139.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8); HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ☐ ND = Not Detected (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		101.48							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	▨	0.00	1	DP	-	⊕			Flush Mount Casing Silica Sand
1		Grey SILTY fine SAND		101.02 0.46							Bentonite Seal
2					2	DP	-	⊕ ND			Silica Sand
3					4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen ∇
4		End of Borehole Refusal		97.67 3.81							W.L. in Screen at Elev. 98.44 m on February 7, 2017



DEPTH SCALE
1 : 50

GOLDER

LOGGED: ALB
CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-05

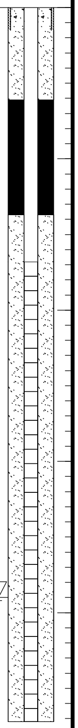
SHEET 1 OF 1

LOCATION: N 5028207.0 ;E 444119.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected 2 4 6 8 / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] ND = Not Detected 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		101.28							
0	Geoprobe Direct Push	Brown SILTY CLAY (FILL)		0.00	1	DP	-	⊕			Flush Mount Casing Silica Sand
		Grey SILTY CLAY		100.65 0.63							
1											Bentonite Seal Silica Sand
2					2	DP	-	⊕			
					3	DP	-	⊕			
3					4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen
		Grey SILTY fine SAND		97.47 3.81							
4					5	DP	-	⊕			
					6	DP	-	⊕			
5		End of Borehole		96.25 5.03							W.L. in Screen at Elev. 97.38 m on February 7, 2017
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 1

LOCATION: N 5028184.0 ;E 444090.0

BORING DATE: January 27, 2017

DATUM: CGVD28

HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ *ND = Not Detected* 2 4 6 8

HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] *ND = Not Detected* 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	HEADSPACE ORGANIC VAPOUR / COMBUSTIBLE VAPOUR	HYDRAULIC CONDUCTIVITY / WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		101.40							
0	Geoprobe Direct Push	Brown SANDY CLAY, trace gravel (FILL)	▨	0.00	1	DP	-	⊕			
1		Brown SILTY CLAY	▨	100.33 1.07							
2					2	DP	-	⊕			
		End of Borehole		98.96 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

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DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 1

LOCATION: N 5028248.0 ;E 444101.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8) / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] ND = Not Detected (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		101.01							
0	Geoprobe Direct Push	Brown SILTY SAND (FILL)	░	0.00	1	DP	-	⊕			
1		Brown SILTY CLAY	▨	100.25 0.76	2	DP	-	⊕			
2			▨		3	DP	-	⊕			
		End of Borehole		98.57 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

DEPTH SCALE
1 : 50

GOLDER

LOGGED: ALB
CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: N 5028302.0 ;E 444074.0

BORING DATE: January 27, 2017

DATUM: CGVD28

BORING METHOD: Geoprobe Direct Push

HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8)

HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ (20, 40, 60, 80)

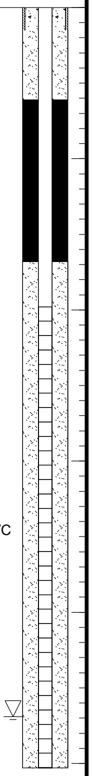
HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3})

WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20, 40, 60, 80)

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.69
Brown SANDY CLAY (FILL)	0.00
Brown SILTY CLAY	100.00 0.69
Grey CLAY	97.64 3.05
End of Borehole	95.51 5.18

NUMBER	TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR
1	DP	-	⊕
2	DP	-	⊕
3	DP	-	⊕
4	DP	-	⊕
5	DP	-	⊕
6	DP	-	⊕

PIEZOMETER OR STANDPIPE INSTALLATION



Flush Mount Casing

Silica Sand

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

W.L. in Screen at Elev. 96.00 m on February 6, 2017

DEPTH SCALE 1 : 50

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-09

SHEET 1 OF 1

LOCATION: N 5028281.0 ;E 444029.0

BORING DATE: January 26, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	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		100.67							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-				
1					2	DP	-				
				99.15							
		Brown SILTY fine SAND		1.52							
2					3	DP	-				
				98.23							
		End of Borehole		2.44							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-10

SHEET 1 OF 1

LOCATION: N 5028267.0 ;E 443999.0

BORING DATE: January 27, 2017

DATUM: CGVD28

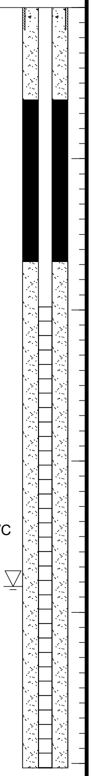
HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected: 2, 4, 6, 8

HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐: 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	TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR / COMBUSTIBLE VAPOUR	HYDRAULIC CONDUCTIVITY / WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		100.75							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00							Flush Mount Casing
					1	DP	-	⊕			Silica Sand
1		Brown SILTY CLAY		99.86 0.89							Bentonite Seal
2					2	DP	-	⊕			Silica Sand
		Grey SILTY CLAY		98.46 2.29	3	DP	-	⊕			
3					4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen
4					5	DP	-	⊕			
5					6	DP	-	⊕			
		End of Borehole		95.57 5.18							W.L. in Screen at Elev. 96.92 m on February 6, 2017
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-11

SHEET 1 OF 1

LOCATION: N 5028323.0 ;E 444066.0

BORING DATE: January 26, 2017

DATUM: CGVD28

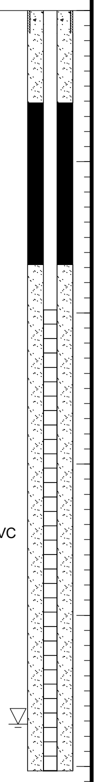
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	100.50					
0	Geoprobe Direct Push	Brown SANDY CLAY, trace wood (FILL)	0.00	1	DP	-		Flush Mount Casing Silica Sand
1								Bentonite Seal
2				2	DP	-		Silica Sand
3				3	DP	-		
				4	DP	-		51 mm Diam. PVC #10 Slot Screen
4		Grey SILTY fine SAND	96.69 3.81	5	DP	-		
5				6	DP	-		▽
		End of Borehole	95.32 5.18					W.L. in Screen at Elev. 95.78 m on February 6, 2017
6								
7								
8								
9								
10								



MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-12

SHEET 1 OF 1

LOCATION: N 5028312.0 ;E 444024.0

BORING DATE: January 26, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	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		100.51							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-				
		Brown SILTY fine SAND		100.21 0.30	2	DP	-				
1											
2					3	DP	-				
		End of Borehole		98.07 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-13

SHEET 1 OF 1

LOCATION: N 5028297.0 ;E 443998.0

BORING DATE: January 26, 2017

DATUM: CGVD28

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

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

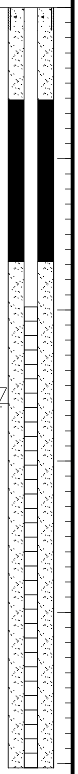
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	100.53			
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	0.00	1	DP	-
2				2	DP	-
		Grey SANDY CLAY	98.09 2.44	3	DP	-
3		Grey CLAY	97.48 3.05	4	DP	-
4				5	DP	-
5				6	DP	-
		End of Borehole	95.35 5.18			

PIEZOMETER OR STANDPIPE INSTALLATION



Flush Mount Casing

Silica Sand

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

W.L. in Screen at Elev. 97.91 m on February 6, 2017

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-14

SHEET 1 OF 1

LOCATION: N 5028273.0 ;E 443958.0

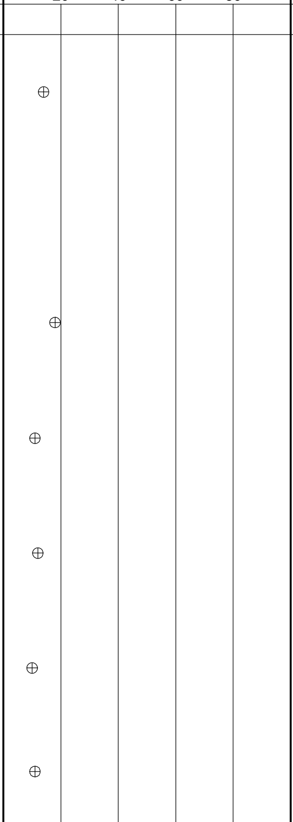
BORING DATE: January 25, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	100.20			
0	Geoprobe Direct Push	ASPHALTIC CONCRETE				
		Brown SILTY SAND (FILL)	0.05	1	DP	-
		Grey SANDY CLAY	99.44 0.76			
2				2	DP	-
		Grey CLAY	97.91 2.29	3	DP	-
				4	DP	-
				5	DP	-
5				6	DP	-
		End of Borehole	95.02 5.18			

HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected

HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected □

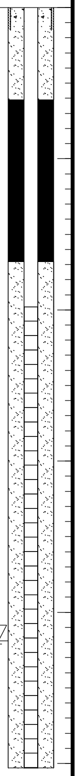


HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



Flush Mount Casing	
Silica Sand	
Bentonite Seal	
Silica Sand	
51 mm Diam. PVC #10 Slot Screen	
W.L. in Screen at Elev. 96.01 m on February 6, 2017	

DEPTH SCALE 1 : 50

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-15

SHEET 1 OF 1

LOCATION: N 5028356.0 ;E 444050.0

BORING DATE: January 26, 2017

DATUM: CGVD28

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

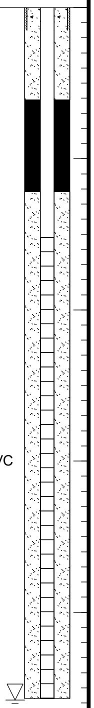
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	100.29				
0	Geoprobe Direct Push	Brown SANDY CLAY	0.00				Flush Mount Casing
				1	DP	-	Silica Sand
1							Bentonite Seal
							Silica Sand
2				2	DP	-	
				3	DP	-	
3							51 mm Diam. PVC #10 Slot Screen
				4	DP	-	
4				5	DP	-	
		Grey SILTY fine SAND	95.72 4.57	6	DP	-	W.L. in Screen at Elev. 95.71 m on February 6, 2017
5		End of Borehole	95.11 5.18				
6							
7							
8							
9							
10							



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DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-16

SHEET 1 OF 1

LOCATION: N 5028340.0 ;E 444012.0

BORING DATE: January 25, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8); HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] ND = Not Detected (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		100.29							
0	Geoprobe Direct Push	Grey brown SILTY SAND, trace gravel (FILL)		0.00	1	DP	-	⊕			
		Brown SANDY CLAY		99.68 0.61	2	DP	-	⊕			
1											
2					3	DP	-	⊕			
		End of Borehole		97.85 2.44							
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-17

SHEET 1 OF 1

LOCATION: N 5028326.0 ;E 443979.0

BORING DATE: January 26, 2017

DATUM: CGVD28

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

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

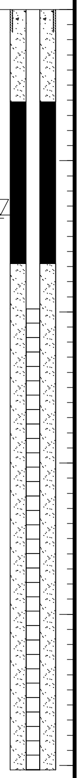
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	100.32			
0	Geoprobe Direct Push	Brown SILTY fine SAND (FILL)	0.00	1	DP	-
1		Brown SANDY CLAY	99.56 0.76			
2				2	DP	-
		Grey CLAY	98.03 2.29	3	DP	-
3				4	DP	-
4				5	DP	-
				6	DP	-
5		End of Borehole	95.14 5.18			
6						
7						
8						
9						
10						

PIEZOMETER OR STANDPIPE INSTALLATION



Flush Mount Casing

Silica Sand

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

W.L. in Screen at Elev. 98.96 m on February 2, 2017

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-18

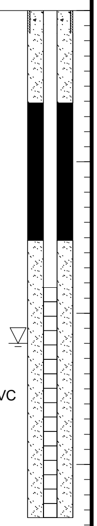
SHEET 1 OF 1

LOCATION: N 5028171.0 ;E 444061.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8); HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS ☐ [%LEL] ND = Not Detected (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	101.37							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	0.00	1	DP	-	⊕			Flush Mount Casing Silica Sand
		Dark brown PEAT	100.76 0.61							Bentonite Seal
1										Silica Sand
2				2	DP	-	⊕			
		Grey SILTY CLAY	99.04 2.33							51 mm Diam. PVC #10 Slot Screen
3				4	DP	-				
		End of Borehole Refusal	98.02 3.35							W.L. in Screen at Elev. 99.17 m on February 7, 2017
4										
5										
6										
7										
8										
9										
10										



MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

RECORD OF BOREHOLE: 17-19

PROJECT: 1670949

LOCATION: N 5028213.0 ;E 444019.0

BORING DATE: January 27, 2017

SHEET 1 OF 1

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8) / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ (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		100.87							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	▨	0.00	1	DP	-				Flush Mount Casing Silica Sand
		Grey brown SANDY CLAY, trace brick at 1.52 m depth (FILL)	▨	100.39 0.48							Bentonite Seal
1											
2					2	DP	-				Silica Sand
3		Grey SANDY CLAY	▨	97.82 3.05	4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen
		End of Borehole		97.06 3.81							W.L. in Screen at Elev. 98.77 m on February 2, 2017
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-20

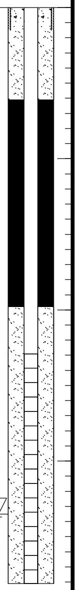
SHEET 1 OF 1

LOCATION: N 5028218.0 ;E 444019.0

BORING DATE: January 27, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2 4 6 8) HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ (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		100.96							
0	Geoprobe Direct Push	Brown SILTY CLAY		0.00							Flush Mount Casing Silica Sand
					1	DP	-	⊕ ND			
1											Bentonite Seal
2					2	DP	-	⊕ ND			Silica Sand
		Grey SILTY CLAY		98.67 2.29							
					3	DP	-	⊕ ND			
3											51 mm Diam. PVC #10 Slot Screen
					4	DP	-	⊕ ND			
4		End of Borehole Refusal		97.00 3.96							W.L. in Screen at Elev. 97.61 m on February 6, 2017
5											
6											
7											
8											
9											
10											



DEPTH SCALE
1 : 50

GOLDER

LOGGED: ALB
CHECKED: EDW

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

PROJECT: 1670949

RECORD OF BOREHOLE: 17-21

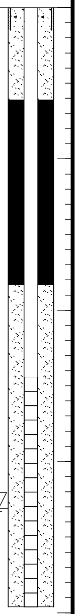
SHEET 1 OF 1

LOCATION: N 5028217.0 ;E 444052.0

BORING DATE: January 27, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ND = Not Detected ⊕ 2 4 6 8 / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ 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		101.05							
0	Geoprobe Direct Push	Brown SILTY CLAY (FILL)	▨	0.00	1	DP	-	⊕			Flush Mount Casing Silica Sand
1		Brown SANDY CLAY	▨	100.19 0.86	2 3	DP DP	- -	⊕ ⊕			Bentonite Seal Silica Sand
3		Grey SILTY CLAY	▨	98.00 3.05	4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen ∇
4		End of Borehole		97.09 3.96							W.L. in Screen at Elev. 97.74 m on February 7, 2017
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

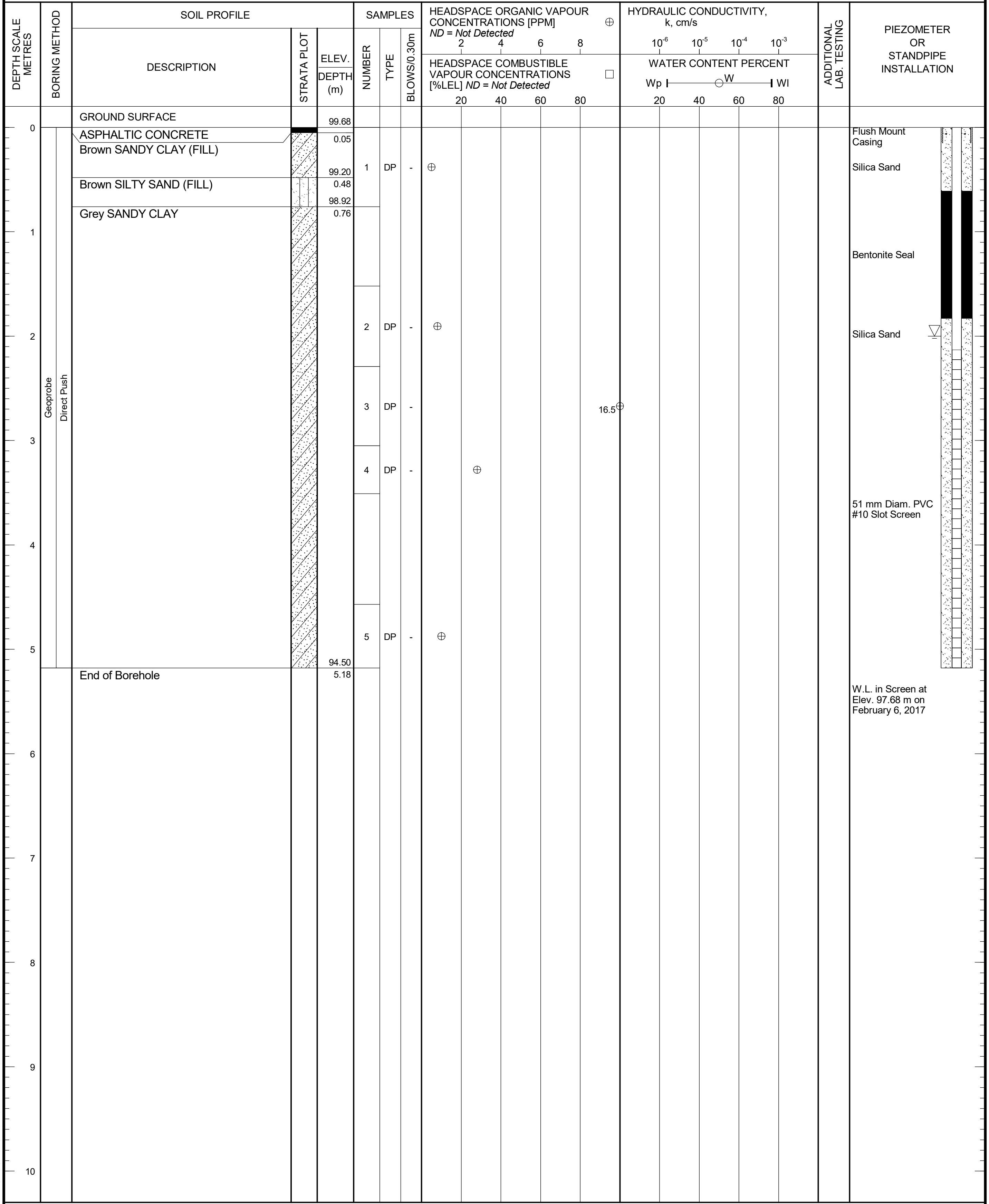
RECORD OF BOREHOLE: 17-22

SHEET 1 OF 1

LOCATION: N 5028312.0 ;E 443955.0

BORING DATE: January 25, 2017

DATUM: CGVD28



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	99.68
ASPHALTIC CONCRETE	0.05
Brown SANDY CLAY (FILL)	99.20 0.48
Brown SILTY SAND (FILL)	98.92 0.76
Grey SANDY CLAY	94.50 5.18
End of Borehole	

NUMBER	TYPE	BLOWS/0.30m
1	DP	-
2	DP	-
3	DP	-
4	DP	-
5	DP	-

Flush Mount Casing

Silica Sand

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

W.L. in Screen at Elev. 97.68 m on February 6, 2017

DEPTH SCALE
1 : 50

GOLDER

LOGGED: ALB
CHECKED: EDW

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 10/10/18 JEM

PROJECT: 1670949

RECORD OF BOREHOLE: 17-23

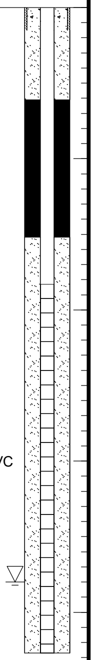
SHEET 1 OF 1

LOCATION: N 5028232.0 ;E 444121.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected (2, 4, 6, 8) / HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐ (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		100.22							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-				Flush Mount Casing Silica Sand
		Brown SILTY CLAY		99.79 0.43							
1											Bentonite Seal
2					2	DP	-	⊕			Silica Sand
					3	DP	-	⊕			
3		Grey SILTY fine SAND		97.17 3.05							51 mm Diam. PVC #10 Slot Screen
					4	DP	-	⊕			
4					5	DP	-	⊕			
		End of Borehole Refusal		95.95 4.27							W.L. in Screen at Elev. 96.42 m on February 7, 2017
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

GOLDER

LOGGED: ALB

CHECKED: EDW

PROJECT: 1897188

RECORD OF BOREHOLE: 18-01

SHEET 1 OF 2

LOCATION: N 5029861.2 ;E 366138.5

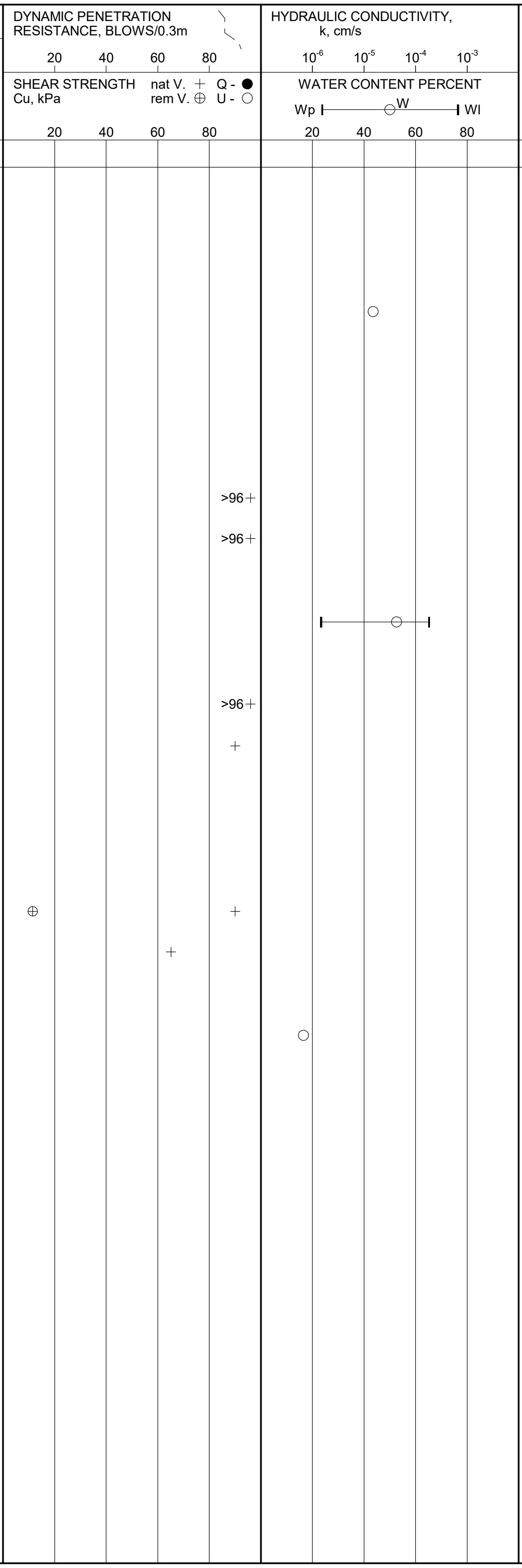
BORING DATE: April 27, 2018

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	60.30			
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE	0.00			
		FILL - (SP) gravelly SAND, angular; grey (PAVEMENT STRUCTURE); non-cohesive, moist	0.08	1	GRAB	-
		FILL - (SP) SAND, some gravel; brown (PAVEMENT STRUCTURE); non-cohesive, moist	0.24	2	GRAB	-
1		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	59.63 0.67	3	SS	3
2		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, very stiff to stiff	58.47 1.83	4	SS	WH
3				5	SS	1
4						
5				6	SS	WH
6		(ML-CL) sandy SILT, some gravel and SILTY CLAY; grey, thickly laminated; non-cohesive, wet, very loose	54.05 6.25	7	SS	WH
7		(ML) sandy SILT, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, loose	53.44 6.86	8	SS	7
		Borehole continued on RECORD OF DRILLHOLE 18-01	52.83 7.47			
8						
9						
10						



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: WAM

PROJECT: 1897188

RECORD OF DRILLHOLE: 18-01

SHEET 2 OF 2

LOCATION: N 5029861.2 ;E 366138.5

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: April 27, 2018

DRILL RIG:

DRILLING CONTRACTOR: CCC Drilling

DATUM: Geodetic

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25 m 5 10 15 20	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}
		BEDROCK SURFACE		52.83								
	Rotary Drill NQ Core	Fresh, grey, fine to medium grained, medium to thickly bedded, medium strong rock LIMESTONE, with shale interbedding		7.47								
8					R1							
9					R2							
				50.79 9.51								
		End of Drillhole										
10												
11												
12												
13												
14												
15												
16												
17												

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: WAM

PROJECT: 1897188

RECORD OF BOREHOLE: 18-02

SHEET 1 OF 1

LOCATION: N 5029904.3 ;E 366271.3

BORING DATE: April 30, 2018

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 to 10

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

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	59.44
FILL/TOPSOIL - (SM) SILTY SAND; brown; non-cohesive	0.00
FILL - (ML) CLAYEY SILT, some gravel; grey brown, contains mortar, brick, organics, fibre insulation and construction debris; non-cohesive, wet, loose to very loose	0.10
(CI/CH) SILTY CLAY to CLAY; grey brown, fissured (WEATHERED CRUST); cohesive, w>PL	57.61 1.83
(ML) sandy SILT, some gravel; grey brown to grey, contains clayey silt seams, cobbles and boulders (GLACIAL TILL); wet, loose to compact	57.31 2.13
(SM) SILTY SAND, trace gravel; grey; non-cohesive, wet, compact to very dense	55.02 4.42
End of Borehole Auger Refusal	53.88 5.56

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	7
2	SS	2
3	SS	9
4	SS	4
5	SS	8
6	SS	15
7	SS	23
8	SS	>50

MIS-BHS 001 1897188.GPJ GAL-MIS.GDT 06/08/18

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

PROJECT: 1897188

RECORD OF BOREHOLE: 18-03

SHEET 1 OF 1

LOCATION: N 5029794.0 ;E 366312.6

BORING DATE: April 30, 2018

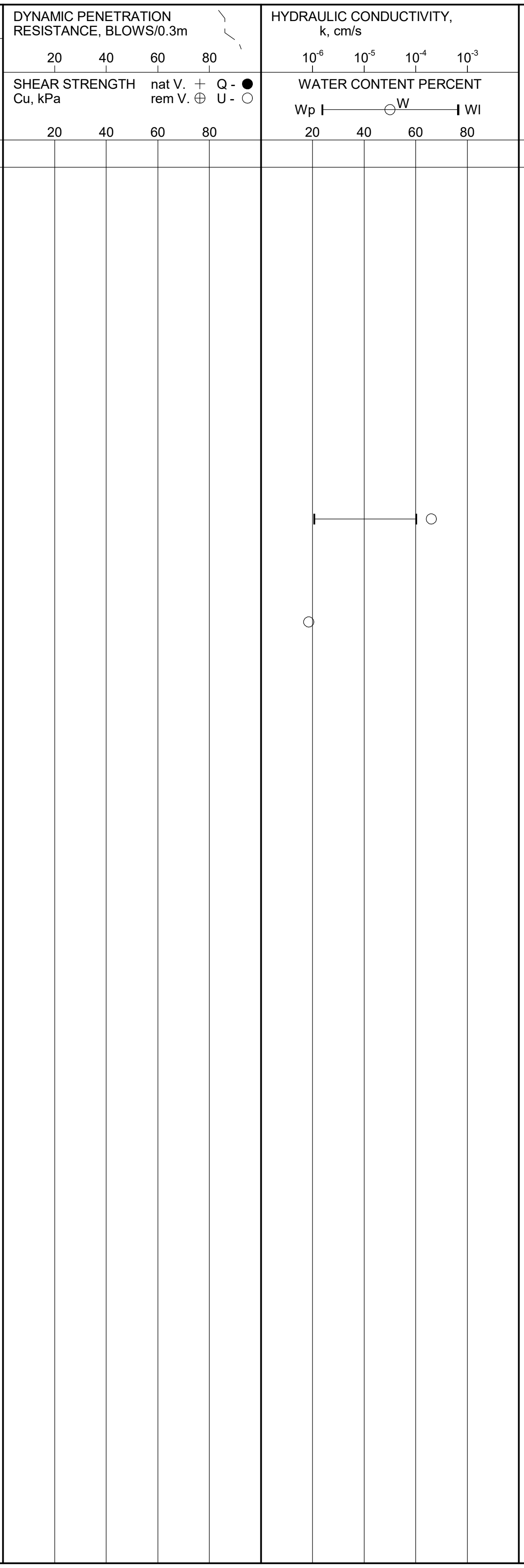
DATUM: Geodetic

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
GROUND SURFACE	61.07			
FILL/TOPSOIL - (SM) SILTY SAND; brown; non-cohesive	0.00			
FILL - (ML) CLAYEY SILT, some gravel; grey brown, contains wood, organics, mortar, and concrete; non-cohesive, mosit loose	0.12	1	SS	6
		2	SS	5
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	59.85 1.22	3	SS	6
		4	SS	4
(ML) sandy SILT, some gravel; grey brown, contains clayey silt seams (GLACIAL TILL); non-cohesive, wet, loose	58.02 3.05	5	SS	4
(ML) sandy SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact	57.26 3.81	6	SS	24
		7	SS	33
		8	SS	>50
End of Borehole Auger Refusal	55.35 5.72			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: PAH

CHECKED: WAM

PROJECT: 1897188

RECORD OF BOREHOLE: 18-04

SHEET 1 OF 1

LOCATION: N 5029808.9 ;E 366251.5

BORING DATE: May 1, 2018

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	SAMPLES – TYPE	SAMPLES – BLOWS/0.30m
		GROUND SURFACE	60.87			
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (SM) SILTY SAND; brown; non-cohesive	0.00			
		FILL - (SP) SAND, some gravel; grey brown, contains clayey silt pockets, mortar, and concrete; non-cohesive, moist	0.15	1	SS	21
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	60.46 0.41			
1				2	SS	6
				3	SS	4
2		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff	58.58 2.29	4	SS	WH
3				5	SS	1
		(ML) CLAYEY SILT, some gravel; grey, contains cobbles; cohesive, w>PL, stiff	57.14 3.73			
4				6	SS	5
		(ML) sandy SILT, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, loose	56.45 4.42	7	SS	>50
5		End of Borehole Auger Refusal	55.69 5.18			
6						
7						
8						
9						
10						

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: WAM

PROJECT: 1897188

RECORD OF BOREHOLE: 18-05

SHEET 1 OF 2

LOCATION: N 5029676.7 ;E 366338.0

BORING DATE: April 27, 2018

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/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		61.61							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; non-cohesive		0.00							
		FILL - (SM-ML) SILTY SAND and sandy SILT, some gravel; grey brown, contains concrete fragments, brick, and organics; non-cohesive, moist, loose		0.09	1	SS	8				
1		FILL - (SM-SP) SILTY SAND to SAND, some low plasticity fines, some gravel; brown and black, contains cinders and ash; non-cohesive, moist, compact		60.70 0.91	2	SS	24				
2		(SP) SAND; light brown; non-cohesive, moist, compact		59.93 1.68	3	SS	27				
					4	SS	11				
		(SP/GP) SAND and GRAVEL; grey brown; non-cohesive, moist, compact		58.94 2.67							
3		Borehole continued on RECORD OF DRILLHOLE 18-05		58.61 3.00							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

PROJECT: 1897188

RECORD OF DRILLHOLE: 18-05

SHEET 2 OF 2

LOCATION: N 5029676.7 ;E 366338.0

DRILLING DATE: April 27, 2018

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR: CCC Drilling

JN - Joint
FLT - Fault
SHR- Shear
VN - Vein
CJ - Conjugate

BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

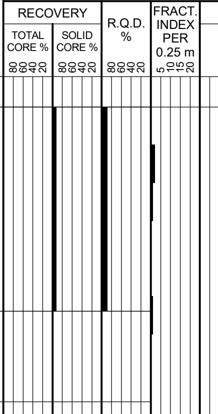
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

PO- Polished
K - Slickensided
SM- Smooth
Ro - Rough
MB- Mechanical Break

BR - Broken Rock

NOTE: For additional abbreviations refer to list of abbreviations & symbols.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN
		BEDROCK SURFACE		58.61			
3	Rotary Drill NQ Core	Fresh, grey, fine to medium grained, medium to thickly bedded LIMESTONE, with shale interbedding		3.00	R1		
4					R2		
				56.66 4.95			
5		End of Drillhole					
6							
7							
8							
9							
10							
11							
12							
13							



HYDRAULIC CONDUCTIVITY K, cm/sec

10^{-6} 10^{-5} 10^{-4} 10^{-3}

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

APPENDIX C

Bedrock Core Photographs

TABLE 1
SUMMARY OF WATER CONTENT DETERMINATIONS

PROJECT NUMBER 21490294/2200
PROJECT NAME OCH/ 933 Gladstone/ Ottawa
DATE TESTED January 14, 2022

Borehole No.	Sample No.	Depth (m)	Water Content (%)	Borehole No.	Sample No.	Depth (m)	Water Content (%)
21-01	2	0.76-1.37	5.6%				
21-01	3	1.52-2.13	19.1%				
21-02	2	0.76-1.37	27.4%				
21-02	3	1.52-2.13	42.2%				
21-02	4	2.29-2.90	48.8%				
21-02	5	3.05-3.66	26.0%				
21-03	3	1.52-2.13	23.8%				
21-03	4A	3.05-3.35	20.4%				
21-03	4B	3.35-3.66	32.1%				
21-04	2	1.52-2.13	21.2%				
21-04	3	3.05-3.66	51.0%				
21-06	3	1.52-2.13	49.5%				
21-06	4	2.29-2.90	54.3%				
21-06	7	4.57-5.18	7.4%				

GOLDER
MEMBER OF WSP

Tested By: MI
Checked By:

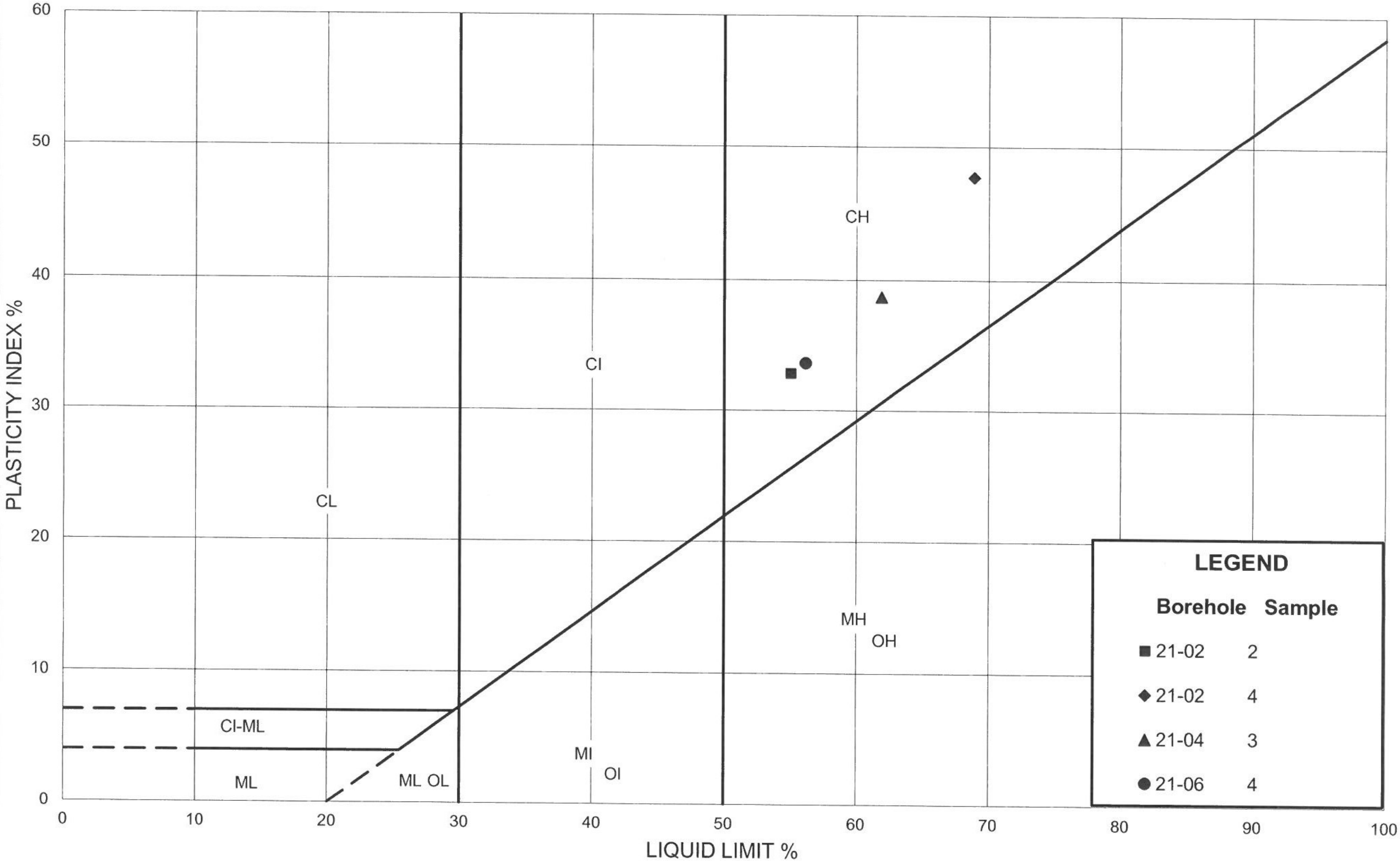
TABLE 1
SUMMARY OF WATER CONTENT AND ATTERBERG LIMITS DETERMINATIONS

PROJECT NUMBER 21490294/2200
PROJECT NAME OCH/ 933 Gladstone/ Ottawa
DATE TESTED January 31, 2022

Borehole	Sample	Depth	Water Content	Atterberg Limits			
No.	No.	(m)	(%)	W_L	W_P	LI	PI
21-02	2	0.76-1.37	27.40	55.0	22.2	0.2	32.8
21-02	4	2.29-2.90	48.80	68.9	21.2	0.6	47.7
21-04	3	3.05-3.66	51.00	61.9	23.2	0.7	38.7
21-06	4	2.29-2.90	54.30	56.2	22.6	0.9	33.6

Tested By: MI
Checked By:

GOLDER
MEMBER OF WSP



GOLDER
MEMBER OF WSP

PLASTICITY CHART

Figure:

Project: 21490294/2200

Created By: MI Checked By:

APPENDIX D

Results of Basic Chemical Analyses

eurofins | Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd (Ottawa)
1931 Robertson Road,
Ottawa, Ontario
-
Attention: Mr. Arthur Kuitchoua Petke
PO#:
Invoice to: Golder Associates Ltd

Report Number: 1970202
Date Submitted: 2022-01-18
Date Reported: 2022-01-25
Project: 21490294
COC #: 885203

Lab I.D.	1606098
Sample Matrix	Soil
Sample Type	
Sampling Date	2021-12-14
Sample I.D.	21-04 sa2 / 5-7'

Group	Analyte	MRL	Units	Guideline	1606098
Anions	SO4	0.01	%		0.08
Cl in Concrete	Cl	0.002	%		<0.002
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.59
	pH	2.00			7.91
	Resistivity	1	ohm-cm		1720

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

APPENDIX E

Results of Geophysical Test

GOLDER
MEMBER OF WSP

TECHNICAL MEMORANDUM

DATE January 12, 2022

Project No. 21490294

TO Arthur Kuitchoua Petke
Golder Associates Ltd.

FROM Geophysics Group

EMAIL epineda@golder.com; cphillips@golder.com

MASW SURVEY RESULTS – 933 GLADSTONE AVENUE, OTTAWA, ONTARIO

This technical memorandum presents the processing and results of the Multichannel Analysis of Surface-Waves (MASW) test performed for the purpose of Seismic Site Classification for a site on 933 Gladstone Avenue, located in Ottawa, Ontario. The geophysical testing was performed by Golder Associates Ltd. (Golder) personnel on November 25th, 2021, along the survey line shown in Plate 1, below.

Plate 1: MASW Survey Line Location in red.

Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface-waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface-waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface-wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium surface-waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that wavelength of surface-wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledgehammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors and water-wave action (in near-shore environments).

The geophone receivers measure the wave-train associated with the surface-wave travelling from a seismic source at different distances from the source.

The participation of surface-waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the ‘dispersion curve’) is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear modulus of the medium as a function of depth.

Field Work

The MASW field work was conducted on November 25th, 2021, by personnel from the Golder Mississauga office. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at 3 metre intervals. An 8-kilogram (kg) sledgehammer and 40 kg seismic weight drop were used as seismic sources for this investigation. Seismic records were collected with seismic sources located 5, 10, and 20 metres from and collinear to the geophone array.An example of an active seismic record collected at the site is shown in Figure 1.

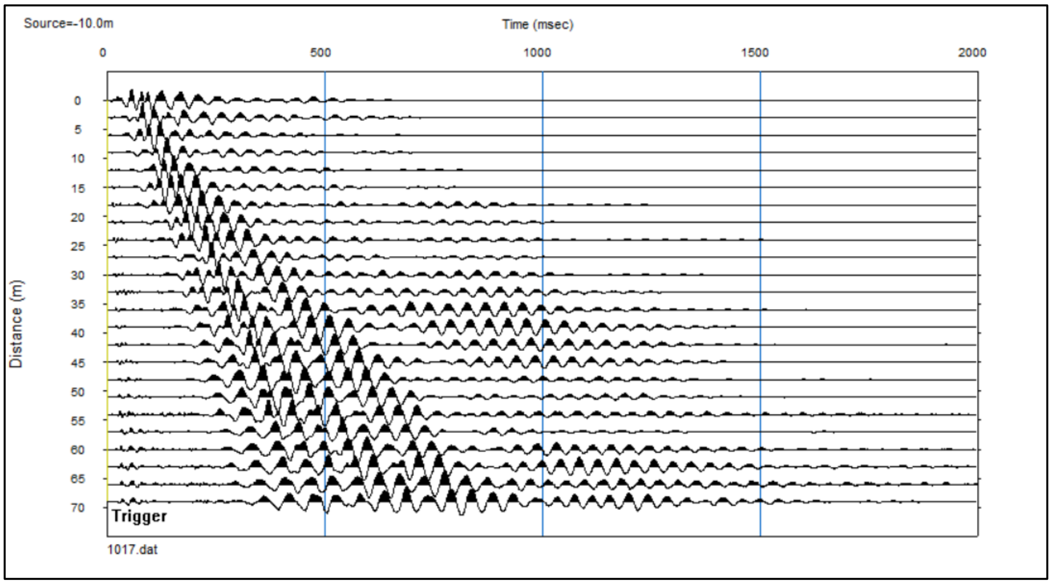


Figure 1: Typical seismic record collected for the MASW Line.

Data Processing

Processing of the MASW test results consisted of the following main steps:

1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;

2) Calculation of the phase for each frequency component;

3) Linear regression to calculate phase velocity for each frequency component;

4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient (r^2) between the data and the linear regression best fit line used to calculate phase velocity;

5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and

6) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figure 2. Shear-wave velocity (V_s) profiles were generated through inverse modelling to best fit the calculated dispersion curves.

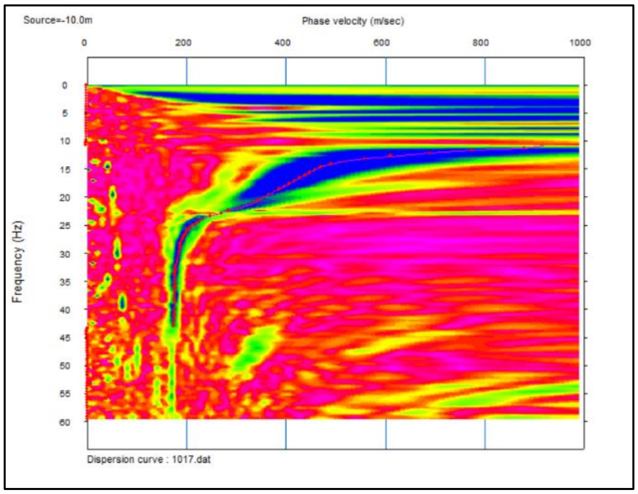


Figure 2: MASW Dispersion Curve Picks (red dots) for the MASW Line.

The minimum measured surface-wave frequency with sufficient signal-to-noise ratio to accurately measure phase velocity was approximately 10 Hz for the MASW Line.

Results

The MASW test results are presented on Figures 3, which present the calculated shear-wave velocity profile measured from the MASW Line. There is good correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 5%.

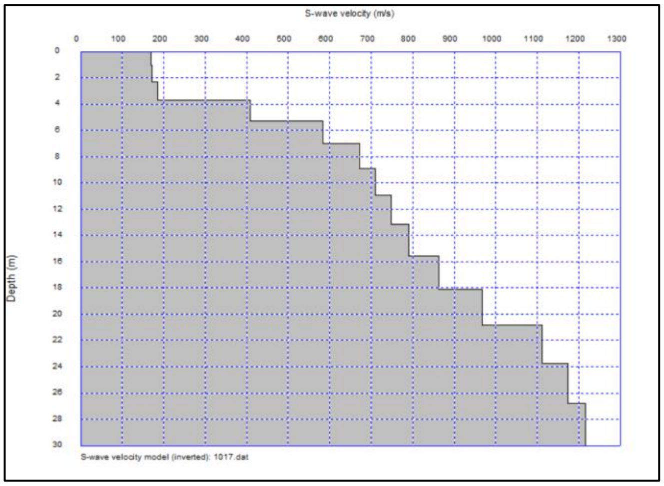


Figure 3: MASW Modelled Shear-Wave Velocity Depth profile for the MASW Line.

Table 1: Shear-Wave Velocity Profile MASW Line

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.0	1.1	1.1	169	0.006509
1.1	2.3	1.2	172	0.006977
2.3	3.7	1.4	187	0.007487
3.7	5.3	1.6	409	0.003912
5.3	7.0	1.7	584	0.002911
7.0	8.9	1.9	673	0.002823
8.9	11.0	2.1	710	0.002958
11.0	13.2	2.2	749	0.002937
13.2	15.6	2.4	791	0.003034
15.6	18.1	2.5	861	0.002904
18.1	20.9	2.8	967	0.002896
20.9	23.7	2.8	1111	0.002520
23.7	26.8	3.1	1175	0.002638
26.8	30.0	3.2	1216	0.002632
Vs Average to 30 mbgs (m/s)				**565**

To calculate the average shear-wave velocity as required by Seismic Site Classification, the results were modelled to 30 metres below ground surface (mbgs).

The average shear-wave velocity (Vs30) for the MASW Line was found to be 565 m/s (Table 1).

Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

Golder Associates Ltd.

Esteban Pineda, MSc., GIT
Junior Geophysicist

Christopher Phillips, MSc., PGeo
Senior Geophysicist, Principal

EP/CRP/jl

APPENDIX F

Hydraulic Conductivity Testing Results

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 21-02

INTERVAL (metres below ground surface)

Top of Interval = 2.57
Bottom of Interval = 4.09

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

where K = (m/sec)

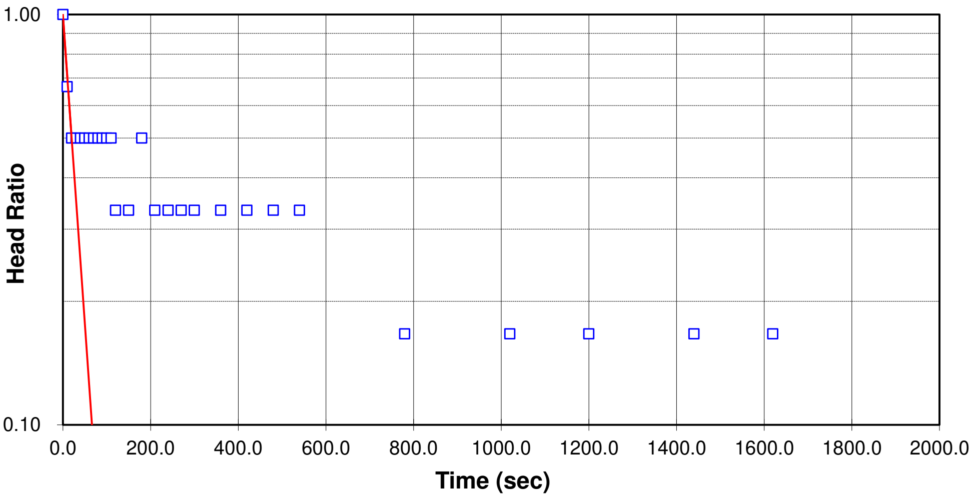
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	1.6E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	20
h_1/h_0 =	1.00
h_2/h_0 =	0.50

RESULTS

K=	8E-06	m/sec
K=	8E-04	cm/sec



Project Name: 933 Gladstone Avenue
Project No.: 21490294
Test Date: 2022-02-09

Analysis By: SPS
Checked By: BH
Analysis Date: 2022-02-14

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
FALLING HEAD TEST 21-06

INTERVAL (metres below ground surface)

Top of Interval = 9.53
Bottom of Interval = 11.05

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

where K = (m/sec)

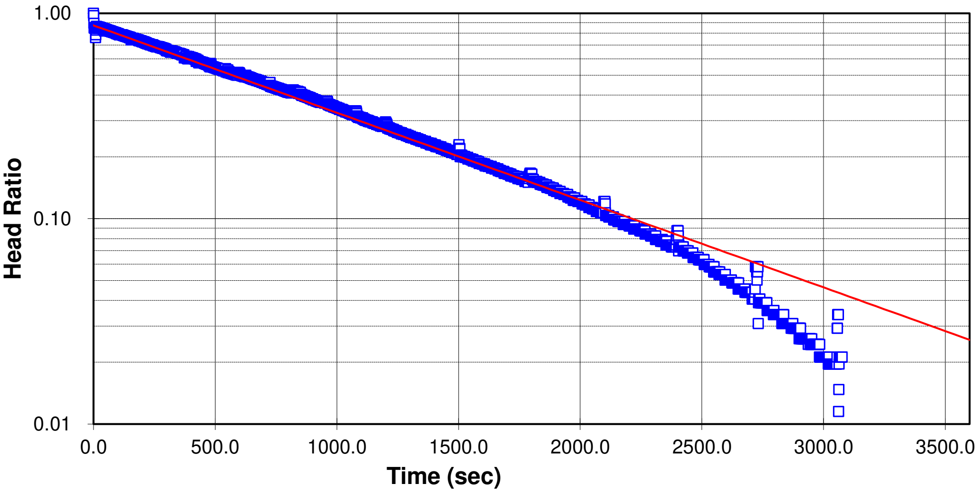
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	1.6E-02
R_e =	4.8E-02
L_e =	1.5
t_1 =	40
t_2 =	1636
h_1/h_0 =	0.84
h_2/h_0 =	0.18

RESULTS

K=	3E-07	m/sec
K=	3E-05	cm/sec



Project Name: 933 Gladstone Avenue
Project No.: 21490294
Test Date: 2022-02-09

Analysis By: SPS
Checked By: BH
Analysis Date: 2022-02-14

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APPENDIX G

Rock Photos and Results of UCS Testing

BH 21-01 (Dry)
Cored Length of 3.25 to 6.67 metres
Core Box 1 to 2 of 2

Depth 3.25 m Top of Bedrock

Depth 6.67 m EOH

CLIENT
Ottawa Community Housing Corporation

PROJECT
Geotechnical Investigation 933 Gladstone Avanue

CONSULTANT
GOLDER

DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-01 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C1

BH 21-01 (Wet)
Cored Length of 3.25 to 6.67 metres
Core Box 1 to 2 of 2

Depth 3.25 m Top of Bedrock

Depth 6.67 m EOH

CLIENT
Ottawa Community Housing Corporation

PROJECT
Geotechnical Investigation 933 Gladstone Avanue

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PREPARED BW
DESIGN
REVIEW
APPROVED

TITLE
BOREHOLE 21-01 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C2

BH 21-04 (Dry)
Cored Length of 6.15 to 8.23 metres
Core Box 1 to 1 of 1

Depth 6.15 m Top of Bedrock

Depth 8.23 m EOH

CLIENT
Ottawa Community Housing Corporation

PROJECT
Geotechnical Investigation 933 Gladstone Avanue

CONSULTANT
GOLDER

DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-04 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C3

BH 21-04 (Wet)
Cored Length of 6.15 to 8.23 metres
Core Box 1 to 1 of 1

Depth 3.25 m Top of Bedrock

Depth 8.23 m EOH

CLIENT
Ottawa Community Housing Corporation

PROJECT
Geotechnical Investigation 933 Gladstone Avanue

CONSULTANT
GOLDER

DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-04 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C4

BH 21-05 (Dry)
Cored Length of 5.37 to 7.80 metres
Core Box 1 to 1 of 1

Depth 5.37 m Top of Bedrock

Depth 7.80 m EOH

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Ottawa Community Housing Corporation

PROJECT
Geotechnical Investigation 933 Gladstone Avanue

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DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-05 (DRY)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C5

BH 21-05 (Wet)
Cored Length of 5.37 to 7.80 metres
Core Box 1 to 1 of 1

Depth 5.37 m Top of Bedrock

Depth 7.80 m EOH

CLIENT	PROJECT
Ottawa Community Housing Corporation	Geotechnical Investigation 933 Gladstone Avanue

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DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-05 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C6

BH 21-05 (Dry)
Cored Length of 9.04 to 11.05 metres
Core Box 1 to 1 of 1

CLIENT Ottawa Community Housing Corporation	PROJECT Geotechnical Investigation 933 Gladstone Avanue
CONSULTANT GOLDER	TITLE **BOREHOLE 21-05 (DRY) CORE PHOTOGRAPHS**

DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C7

BH 21-06 (Wet)
Cored Length of 9.04 to 11.05 metres
Core Box 1 to 1 of 1

Depth 9.04 m Top of Bedrock

Depth 11.05 m EOH

CLIENT	PROJECT
Ottawa Community Housing Corporation	Geotechnical Investigation 933 Gladstone Avanue

CONSULTANT

GOLDER

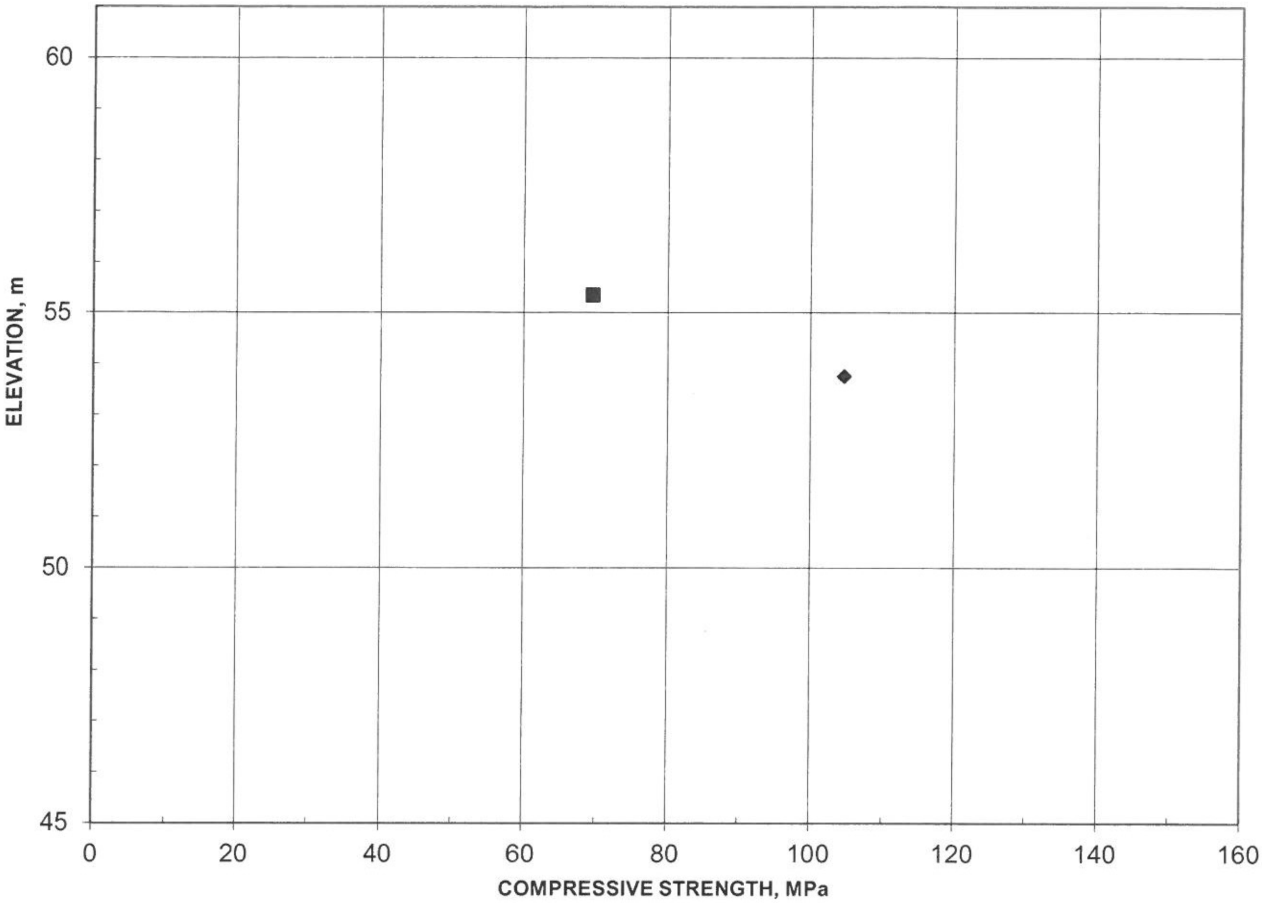
DD/MM/YYYY	1/21/2022
PREPARED	BW
DESIGN	
REVIEW	
APPROVED	

TITLE
BOREHOLE 21-06 (WET)
CORE PHOTOGRAPHS

PROJECT No.	PHASE	Rev.	FIGURE
21490294	2000		C8

ASTM D7012 - Method C
UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE
SUMMARY OF LABORATORY TEST RESULTS

FIGURE



	Borehole	Depth (m)	L/D	Bulk Density (kg/m^3)	Lithology	UCS (MPa)	Failure Type
■	BH21-01 RC1	5.6	2.4	2689	Limestone	70	1
◆	BH21-04 RC1	6.9	2.4	2670	Limestone	105	1

Notes:

Failure Types

1. Well formed cones on both ends

Remarks

- Cores tested in vertical direction.
- Cores tested in air-dry condition.
- Time to failure > 2 and < 15 minutes.

Project: 21490294

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Checked by: Cw

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