REPORT

Preliminary Geotechnical Investigation

Proposed Development, Gladstone Village, 933 Gladstone Avenue Ottawa, Ontario

Submitted to:

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Distribution List

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Table of Contents

1.0 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation carried out for the proposed development at Gladstone Village located at 933 Gladstone Avenue in Ottawa, Ontario.

The purpose of this preliminary geotechnical investigation was to assess the subsurface conditions in the area of the proposed residential development by means of five boreholes. Based on an interpretation of the factual information obtained, and a review of the existing information available for the site, a general description of the subsurface conditions is presented. These interpreted subsurface conditions and available project details were used to prepare preliminary engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could influence design decisions.

The reader is also 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

Plans are being prepared for the construction of a residential development to be located at 933 Gladstone Avenue in Ottawa, Ontario (see Key Map inset, Figure 1).

The following information is known about the project and site:

- The site is located at 933 Gladstone Avenue.
- The site is bound to the south by Gladstone Avenue, to the east by an existing residential development, to the west by the O-Train Trillium line, and to the north by a Government of Canada office.
- The site is irregular in shape and measures approximately 285 metres by 115 metres in plan.
- The site was formerly a Federal Government Ordnance Depot prior to 2015 and is currently vacant land.
- The proposed residential development includes five blocks with low, mid, and high rise residential, mixed-use residential and commercial, and a school.

Golder Associates carried out a Phase II Environmental Site Assessment at the site, and the results of that assessment are provided in the following report:

- Report to Ottawa Community Housing Corporation titled "*Phase Two Environmental Site Assessment, 933 Gladstone Avenue, Ottawa, ON*" dated March 2017 (Report No. 1670949 Rev.0).

Based on a review of the existing information and published geological mapping, the subsurface conditions at this site are expected to consist of silty clay over glacial till. The bedrock surface is anticipated to be about 3 to 10 metres depth below the existing ground surface, sloping down to the north. The bedrock is mapped to be interbedded limestone and shale of the Verulam Formation.

3.0 PROCEDURE

The fieldwork for this investigation was carried out on April 27 to May 1, 2018. During that time, five boreholes (numbered 18-01 to 18-05, inclusive) were put down at the approximate locations shown on the Site Plan, Figure 1.

The boreholes were advanced using a track-mounted hollow-stem auger drill rig supplied and operated by CCC Geotechnical and Environmental Drilling of Ottawa, Ontario. The boreholes were advanced to auger refusal which occurred at depths ranging from about 3.0 to 7.5 metres below the existing ground surface. Upon reaching auger refusal in boreholes 18-01 and 18-05, the boreholes were then advanced into the bedrock using rotary diamond drilling techniques for lengths of about 2.0 metres while retrieving NQ sized bedrock core.

Within the boreholes, standard penetration tests were carried out at regular intervals of depth and samples of the soils encountered were recovered using split spoon sampling equipment. In situ vane testing was carried out, where possible, in the silty clay to determine the undrained shear strength of this soil unit.

One sample of soil from borehole 18-03 was submitted to Eurofins Environment Testing Ontario for basic chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements.

The fieldwork was supervised by experienced personnel from our staff who located the boreholes, directed the drilling operations, logged the boreholes and samples, and took custody of the samples retrieved. On completion of the drilling operations, samples of the soils obtained from the boreholes were transported to our laboratory for examination by the project engineer and laboratory testing. Geotechnical index and classification tests, such as water content determinations and Atterberg limit tests, were carried out on select soil samples.

The borehole locations were selected, marked in the field and subsequently surveyed by Golder Associates personnel. The position and ground surface elevation at the borehole locations were determined using a Trimble R8 GPS survey unit. The elevations are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- Record of Borehole Sheets are provided in Appendix A.
- Record of Boreholes from the previous Phase II ESA are provided in Appendix B.
- Results of the basic chemical analysis are provided in Appendix C.

In general, the subsurface conditions at the site consist of a surficial layer of topsoil and fill, over sand or silty clay and glacial till.

The following sections present a more detailed overview of the subsurface conditions encountered in the boreholes advanced during the current investigation.

4.2 Topsoil and Fill

Borehole 18-01 was advanced through existing pavement structure at the site. The pavement structure consists of about 80 millimetres of asphaltic concrete over 160 millimetres of gavelly sand base over about 430 millimetres of sand with some gravel subbase.

A layer of topsoil was encountered at the ground surface at boreholes 18-02 to 18-05 with a thickness ranging from about 90 to 150 millimetres.

A layer of fill was encountered below the topsoil in boreholes 18-02 to 18-05 that extends down to depths ranging from about 0.4 to 1.8 metres below the existing ground surface. The fill generally consists of clayey silt with some gravel to sand with varying amounts of non-plastic fines and some gravel. The fill also contains concrete fragments, brick, mortar, cinders, ash, organics, fibre insulation, and construction debris.

Standard penetration tests carried out within the fill materials gave SPT ‘N’ values ranging from 2 to 24 blows per 0.3 metres of penetration, indicating a very loose to compact state of packing.

4.3 Sand and Gravel

A deposit of sand to sand and gravel was encountered below the fill in borehole 18-05. The sand and gravel deposit extends to a depth of about 3.0 metres below the existing ground surface.

Two standard penetration tests carried out within the sand and gravel deposits gave SPT ‘N’ values of 11 and 27 blows per 0.3 metres of penetration, indicating a compact state of packing.

4.4 Silty Clay to Clay

A deposit of silty clay to clay exists below the fill and pavement structure in boreholes 18-01 to 18-04. The silty clay extends to depths ranging from about 2.1 to 6.3 metres below the existing ground surface.

The upper portion of the silty clay deposit in boreholes 18-01 and 18-04 and the full deposit in boreholes 18-02 and 18-03 has been weathered to a grey brown crust. The weathered crust has a thickness ranging from about 0.3 to 1.9 metres and extends to depths ranging from about 1.8 to 3.1 metres below the existing ground surface. Standard penetration tests carried out within the weathered crust gave SPT ‘N’ values ranging from 3 to 6 blows per 0.3 metres of penetration, indicating a stiff to very stiff consistency for the weathered crust.

The results of Atterberg limit testing carried out on one sample of the weathered crust gave a plasticity index value of about 39 percent and a liquid limit value of about 60 percent, indicating a silty clay of high plasticity. The measured water content of three samples of the weathered crust ranges from about 44 to 66 percent.

The silty clay beneath the depth of weathering in boreholes 18-01 and 18-04 is unweathered and grey in colour. The unweathered silty clay extends to depths ranging from about 6.3 and 3.7 metres below the existing ground surface, respectively. The results of in situ vane testing in the grey silty clay generally gave undrained shear strengths ranging from about 65 to greater than 96 kilopascals, indicating a stiff to very stiff consistency.

The results of Atterberg limit testing carried out on one sample of the silty clay gave a plasticity index value of about 42 percent and a liquid limit value of about 65 percent, indicating a silty clay of high plasticity. The measured water content of two samples of the silty clay were about 53 and 50 percent.

4.5 Sandy Silt to Clayey Silt

A deposit of clayey silt, some gravel and a laminated deposit of sandy silt with some gravel and silty clay exists below the silty clay in boreholes 18-01 and 18-04. The clayey silt to sandy silt deposits have thicknesses of about 0.6 and 0.7 metres, respectively, and extend to depths of about 6.7 and 4.4 metres, respectively.

Two standard penetration tests carried out within the silty deposits gave SPT ‘N’ values of ‘weight of hammer’ and 5 blows per 0.3 metres of penetration.

The measured water content of one sample of the sandy silt was about 17 percent.

4.6 Glacial Till

A deposit of glacial till exists beneath the silty clay and silt deposits, where encountered, in boreholes 18-01 to 18-04. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt. The glacial till was not fully penetrated in all the boreholes, but was proven to depths ranging from about 4.4 to 7.5 metres below the existing ground surface.

Standard penetration tests carried out within the glacial till gave SPT ‘N’ values ranging from 4 to greater than 50 blows per 0.3 metres of penetration, but more generally between 4 and 24 blows per 0.3 metres of penetration, indicating a very loose to compact state of packing. The higher blow counts may reflect the presence of cobbles and boulders in the deposit, or the bedrock surface, rather than the state of packing of the soil matrix.

The measured water content of one sample of the glacial till was about 19 percent.

4.7 Silty Sand

A deposit of silty sand exists below the glacial till deposit in borehole 18-02. The silty sand was encountered at a depth of about 4.4 metres below the existing ground surface and was proven to a depth of about 5.6 metres below the existing ground surface.

Two standard penetration tests carried out within the silty sand gave SPT ‘N’ values of 23 and greater than 50 blows per 0.3 metres of penetration, indicating a compact to very dense state of packing. The higher blow count may reflect the presence of the bedrock surface rather than the state of packing of the soil matrix.

4.8 Auger Refusal and Bedrock

Refusal to auger advancement was encountered in the boreholes for the current investigation at depths ranging from about 3.0 to 7.5 metres below the existing ground surface.

Boreholes 18-01 and 18-05 were advanced into the bedrock to a depth of about 2.0 metres below the bedrock surface using rotary diamond drilling techniques. The inferred depth to bedrock and elevation of the bedrock surface is summarized in the table below:

Borehole No.	Ground Surface Elevation (m)	Refusal Depth/Bedrock (m)	Refusal/Bedrock Elevation (m)
18-01	60.30	7.47	52.83
18-02	59.44	5.58	53.88
18-03	61.07	5.72	55.35
18-04	60.87	5.18	55.69
18-05	61.61	3.00	58.61

The bedrock encountered at this site typically consists of fresh, medium to thickly bedded, grey limestone bedrock with shale interbeds. The measured RQD values of the bedrock core ranged from 90 to 100 percent, indicating an excellent quality rock.

4.9 Groundwater

The groundwater levels in the monitoring wells installed within the boreholes from the previous Phase II ESA were measured on February 6 and 7, 2017 and again on April 30, 2018. The groundwater level was encountered at depths ranging from about 1.0 to 4.9 metres below the existing ground surface and are summarized in the table below.

Borehole No.	Ground Surface Elevation[1] (m)	Groundwater Level Depth (m)	Groundwater Level Elevation[1] (m)	Measurement Dates
17-01	59.5	3.2 2.1	56.3 57.4	February 6, 2017 April 30, 3018
17-04	60.5	3.0 2.7	57.5 57.9	February 7, 2017 April 30, 3018
17-05	60.3	3.9 2.5	56.4 57.8	February 7, 2018 April 30, 3018
17-08	59.7	4.7 4.9	55.0 54.8	February 6, 2018 April 30, 3018
17-10	59.8	3.8 3.3	56.0 56.5	February 6, 2018 April 30, 3018
17-11	59.5	4.7 4.6	54.8 55.0	February 6, 2018 April 30, 3018
17-13	59.6	2.6 2.1	57.0 57.5	February 6, 2018 April 30, 3018
17-14	59.2	4.2 3.7	55.0 55.5	February 6, 2018 April 30, 3018
17-15	59.3	4.6 4.3	54.7 55.1	February 6, 2018 April 30, 3018
17-17	59.4	1.4 1.0	58.0 58.3	February 2, 2018 April 30, 3018
17-18	60.4	2.2 1.9	58.2 58.5	February 7, 2018 April 30, 3018
17-19	59.9	2.1 1.8	57.8 58.2	February 2, 2018 April 30, 3018
17-20	60.0	3.4 3.0	56.6 57.0	February 6, 2018 April 30, 3018
17-21	60.1	3.3 1.6	56.8 58.5	February 7, 2018 April 30, 3018
17-22	58.7	2.0 1.1	56.7 57.6	February 6, 2018 April 30, 3018
17-23	59.3	3.8 3.4	55.5 55.8	February 7, 2018 April 30, 3018

Note (1) – The ground surface elevations were not directly measured, but were interpolated based off City of Ottawa topographic mapping.

Groundwater levels are, however, expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

4.10 Corrosivity

One soil sample from borehole 18-03 was submitted to Eurofins Environmental Ontario 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 B and are summarized below.

Borehole Number / Sample Number	Sample Depth (m)	Chloride (%)	SO_4 (%)	pH	Resistivity (Ohm-cm)
BH 18-03 / 3	1.5 – 2.1	0.005	<0.01	7.6	4,540

5.0 DISCUSSION

5.1 General

This section of the report provides preliminary engineering information for the geotechnical design aspects of the project based on our interpretation of the borehole information and on our understanding of the project requirements. These guidelines are appropriate for project planning, but not detailed design. Additional investigation will need to be carried out at the design stage and additional geotechnical engineering input provided.

The guidelines in this section of the report are also subject to the ‘Important Information and limitations of this Report’ which follows the text but forms as integral part of this document.

5.2 Overview

Plans are being prepared for a residential development to be located at 933 Gladstone Avenue in Ottawa, Ontario. The proposed residential development includes five blocks with low rise residential, mid to high rise mixed-use residential and commercial, and a school.

- Block 1: mid to high rise mixed use commercial and residential building. The residential building will have a height ranging from 8 to 30 storeys with about 600 units;
- Block 2a: mid to high rise residential building. The residential building will have a height ranging from 3 to 22 storeys with about 207 units;
- Blocks 2b and 2c: low rise residential townhouses that will have a height of 4 storeys with 6 units each;
- Block 3: mid to high rise mixed use school and residential building. The school will have a height of 3 stories and the residential building will have a height ranging from 8 to 22 storeys with about 378 units; and,
- It is understood that Blocks 1, 2a, and 3 will have at least two levels of underground parking or basement levels.

Based on the boreholes advanced as part of this investigation, the site is underlain by up to about 1.8 metres of fill over silty clay over glacial till or sand over limestone bedrock. The unweathered clay has limited capacity to accept additional loading from foundation loads, grade raises from filling, and from a drawdown in the water table.

Based on these subsurface conditions encountered at the Site, the following preliminary geotechnical issues should be considered:

- For Block 2b, the use of shallow spread footings founded on the weathered silty clay crust or glacial till is considered feasible for a building of up to 4 storeys in height with 1 basement level, depending on the loads and foundation configuration.
- For Block 2c, which has a portion of the footprint underlain by compressible unweathered silty clay, shallow spread footings may be feasible (as noted above for Block 2b) but it may be necessary to found the structure on a raft slab, depending on the building loads.
- For Blocks 2b and 2c, it is considered that either a slab on grade or one basement level could be built without any special requirements (other than potentially a raft slab at Block 2c, as noted above).
- For Blocks 1, 2a and 3, provided that the basement levels extend to or below the surface of the bedrock, the use of shallow spread footings is also considered feasible for mid to high rise buildings. Bedrock excavation will be required for Blocks 1 and 2a, and possibly Block 3, depending on the number of basement levels.
- For Blocks 1, 2a, and 3, where several levels of underground levels are proposed, the lower levels may need to be built as a water tight structure to mitigate potential lowering of the ground water table. Long term lowering of the ground water level could cause excessive settlements in the area, which could extend beyond the limits of any proposed basements and impact adjacent structures (including buried utilities within public streets).
- The founding elevation of Blocks 1, 2a, and 3 need to be considered in relation to the O-Train line. The foundations should be deepened such that the cut for the O-Train rail line is not within the zone of influence of the new foundations. The zone of influence is considered as a line extending out and down from the edge of the footings at a slope of 1 horizontal to 1 vertical.
- Excavations for Blocks 1, 2a, and 3 may need to be sloped at about 3 horizontal to 1 vertical within the overburden below the groundwater level, which is expected to be the case for this site. Where space restrictions exist, due to property limits or existing buildings or services, consideration may need to be given to shoring the excavation to allow for vertical, or near vertical, excavation walls.
- Raising the grade across along the west side of the site should take into consideration the slope along the O-Train line. The grade on the west side of the site slopes down from about 60 metres elevation along the pathway on the west side of the site to about 55 metres elevation along the O-Train line. Any grade raise should not negatively impact the stability of the existing slope of the O-Train line trench.

The following sections provide further preliminary geotechnical guidance based on the above options.

5.3 Excavations

5.3.1 Overburden

The subsurface conditions on the site generally consist of up to about 1.8 metres of fill over silty clay and glacial till or sand over limestone bedrock. The depth to bedrock ranges from about 3.0 to 7.5 metres below the existing ground surface, sloping down to the north. The measured groundwater levels range from about 1.0 to 4.9 metres below the existing ground surface.

Excavation for foundations will be through fill, silty clay, glacial till, sand, and, for the high-rise buildings, into the limestone bedrock.

No unusual problems are anticipated with excavating in the overburden using conventional hydraulic excavating equipment, recognizing that boulders should be expected within the glacial till. The Occupational Health and Safety Act (OHSA) of Ontario indicates that side slopes in the overburden above the water table should be sloped no steeper than 1 horizontal to 1 vertical (i.e., Type 3 soil). Excavations below the water table should be sloped as flat as 3 horizontal to 1 vertical (i.e., Type 4 soil). Boulders larger than 0.3 metres in diameter should be removed from the excavation side slopes for worker safety. Where space restrictions dictate, the excavation could also be carried out within shoring, closed sheeting or a steel trench box which is fully braced to resist lateral earth pressure.

Excavated materials should not be stockpiled near to the crest of the excavations. Similarly, construction equipment/vehicles should not travel near the crest of the excavations.

5.3.2 Bedrock

Bedrock removal will be required for basement and foundation construction for Blocks 1, 2a, and 3. Bedrock removal could be accomplished using mechanical methods (such as hoe ramming), although this method may be slow and tedious. Excavations extending deeper into the rock will more-efficiently be carried out using drill and blast procedures.

It is considered that near vertical bedrock walls in the unweathered limestone bedrock will be feasible for the construction period. Blast induced damage to the bedrock must be avoided; otherwise rock reinforcement could be required. It should therefore be planned to either line drill the bedrock along the perimeter of the excavation at a close spacing in advance of blasting so that a clean bedrock face is formed, or to carry out perimeter drilling and pre-shearing of the excavation limits using controlled blasting.

Significant caution should be exercised in carrying out blasting due to the near proximity of existing buildings. The blasting should therefore be controlled to limit the peak particle velocities at all adjacent structures or services such that blast induced damage will be avoided. This will require blast designs by a specialist in this field.

The contractor should be limited to only small controlled shots. The following frequency dependent peak vibration limits at the nearest structures and services are suggested:

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

A pre-construction survey should be carried out of all of the surrounding structures and utilities. Selected existing interior and exterior cracks in the structures identified during the pre-construction survey should be monitored for lateral or shear movements by means of pins, glass plate telltales, and/or movement telltales.

The contractor should be required to submit a complete and detailed blasting design and monitoring proposal prepared by a blasting/vibrations specialist prior to commencing blasting. This plan would have to be reviewed and accepted in relation to the requirements of the blasting specifications.

If practical, blasting should commence at the furthest points from the closest structure or service to assess the ground vibration attenuation characteristics and to confirm the anticipated ground vibration levels based on the contractor’s blasting methods.

5.4 Excavation Shoring

5.4.1 Excavation Shoring Options

The excavations for Blocks 1, 2a, and 3 will extend beyond the limits of the property along the west, south and north sides of the site and therefore vertical (or near vertical) excavation walls will likely be required.

The contractor is fully responsible for the detailed design and performance of the temporary shoring systems. However, the following general guidelines on possible concepts for the shoring are provided for use by the designers in:

- Assessing the costs of the shoring;
- Assessing possible impacts of the shoring design and construction on the design of the structures and site works; and,
- Evaluating, at the design stage, the potential for impacts of the movements associated with excavation works on the adjacent 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 potential ground movements associated with the excavation;
- The construction methods used to install the shoring system(s); and,
- Their impact on adjacent structures and utilities.

In general, there are three shoring methods that are commonly used in local construction practice:

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

Soldier piles and lagging systems are suitable where the objective is to maintain an essentially vertical excavation wall and the movements above and behind the wall need only be sufficiently limited that relatively flexible features (such as roadways) will not be adversely affected. Where foundations lie within the zone of influence of the shoring, the shoring deflections need to be greatly limited. Interlocking steel sheet piling systems with pre-stressed tie backs are often used for these conditions. Secant pile or diaphragm walls would be appropriate where difficulties may be encountered installing sheet piles, where heavily loaded foundations exist adjacent to the shoring, or where groundwater inflow needs to be controlled.

The glacial till beneath this site contains cobbles and boulders. The sheet piles will likely have difficulty penetrating the cobbles and boulders present within the glacial till. If the sheet piles are obstructed prior to reaching the target depth, the contractor may need to alter the design and/or make efforts to remove the obstructions during excavation.

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

It should be planned to drive the toes of the soldier piles to refusal on sound/fresh bedrock. If rock socketed steel H piles are used, they should be set back from the excavation face at least 1 metre and be socketed at least 2 metres into the fresh/sound bedrock. For sheet piles, it should be planned to pin the toes of the sheet piles at the bedrock surface.

To minimize vibrations which may distress the existing buildings which are in close proximity to the site, consideration could be given to installing the piles in predrilled holes which are subsequently concreted within the bedrock.

5.4.2 Ground Movements

Some unavoidable inward horizontal deformation and vertical settlement of the adjacent ground will occur as a result of excavation, installation of shoring, deflection of the ground support system (including bending of the walls, compression of the struts and/or extension of the tie-backs) as well as deformation of the soil/rock in which the toes of the walls are embedded. The ground movements could affect the performance of buildings, surface structures or underground utilities adjacent to the excavation.

As a preliminary guideline, typical settlements behind soldier pile and lagging shoring systems are less than about 0.3 percent of the excavation depth, provided good construction practices are used, voids are not left behind the lagging, and also provided that large foundation loads from existing buildings are not applied behind the shoring. This guideline would suggest that less than about 10 to 15 millimetres of ground settlement would occur for shoring systems installed through the overburden to about 5 metres depth. Movements behind a properly constructed steel sheet pile or contiguous caisson wall would be less than what would be expected for a soldier pile and lagging wall. However, this is only a preliminary guideline and is provided only to assist the owner’s designers in carrying out an initial assessment of the expected settlements and the potential impacts of these settlements. A more detailed assessment of the expected settlements should be undertaken by the contractor and must consider the effects of adjacent foundation loads. However, should the preliminary assessment carried out using this estimated settlement indicate unacceptably large settlements to adjacent structures, roadways, or utilities, then a more detailed assessment should be carried out at the design stage (prior to tender) to better assess the shoring requirements, or a more rigid form of shoring should be selected.

A preconstruction survey of all of these structures should be carried out prior to commencement of the excavation.

5.5 Groundwater Management

Based on present groundwater levels, excavations deeper than about 1.2 metres will extend below the groundwater level. Groundwater inflow into the excavations could feasibly be handled by pumping from sumps within the excavations. The actual rate of groundwater inflow will depend on many factors including the contractor’s schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where significant volumes of precipitation, surface runoff and/or groundwater collects in an open excavation, and must be pumped out.

Under the new regulations, a Permit-To-Take-Water (PTTW) is required from the Ministry of the Environment and Climate Change (MOECC) if a volume of water greater than 400,000 litres per day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 litres per day, but more than 50,000 litres per day, the water taking will not require a PTTW, but will need to be registered in the Environmental Activity and Sector Registry (EASR) as a prescribed activity. Based on the groundwater information collected during the current and previous investigation, it is considered unlikely that a PTTW would be required during construction for this project. However, registration in the EASR may be required. The requirement for registration (i.e., if more than 50,000 litres per day is being pumped) can be assessed at the time of construction. Registration is a quick process that will not significantly disrupt the construction schedule.

5.6 Foundations

5.6.1 Overburden

For Block 2b, it is considered that the low-rise structures could feasibly be supported on or within the native overburden soils (or on engineered fill placed on the native soils) using conventional spread footing foundations in accordance with Part 9 of the 2012 OBC.

For design purposes, the maximum bearing resistance for strip footing foundations up to 0.6 metres in width and pad footings up to 2 metres in size may be taken as 100 kilopascals for Serviceability Limit State (SLS) and 150 kPa for the Ultimate Limit State (ULS). The post-construction total and differential settlements of footings sized using the above maximum allowable bearing pressure should be less than about 25 and 15 millimetres, respectively, provided that the subgrade at or below founding level is not disturbed during construction.

In some areas of the site, the native subgrade elevation may be lower than the underside of footing elevation. At these locations, and following removal of any existing fill, the subgrade may be raised to the footing elevation using engineered fill consisting of Ontario Provincial Standard Specification (OPSS) Granular B Type II (or similar approved material), placed in maximum 300 millimetre thick lifts, and compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment. The engineered fill material must be placed within the full zone of influence of the house foundations. The zone of influence is considered to extend out and down from the edge of the perimeter footings at a slope of 1 horizontal to 1 vertical (1H:1V).

For Block 2c, the above guidance may also apply but if the results of the previous investigations indicate that at least a portion of this block may be underlain by potentially compressible silty clay. If subsequent investigation and analysis during detailed design indicate that the compressible clay limits the bearing resistances of shallow foundations, then a raft slab foundation may need to be considered for Block 2c. If a raft slab is required, the bearing resistances provided for strip and pad footings above may be used for preliminary design, but these resistances will need to be confirmed during detailed design.

5.6.2 Bedrock

It is understood that Blocks 1, 2a, and 3 will have at least 2 levels of underground parking (or basement levels). Therefore, the foundations for these structures will be up to about 7 to 10 metres depth below the existing ground surface, which will be on or within the limestone bedrock.

Foundations bearing on or within competent limestone bedrock can be sized using an Ultimate Limit States (ULS) factored bearing resistance of 5 MPa. Provided the bedrock surface is acceptably cleaned of loose bedrock, the settlement of footings at the corresponding service (unfactored) load levels will be less than 25 millimetres and therefore Serviceability Limit States (SLS) need not be considered in the foundation design.

5.7 Seismic Site Response Classification

The 2010 National Building Code of Canada (NBCC 2010) contains seismic analysis and design methodology. The seismic Site Class value, as defined in Section 4.1.8.4 of the NBCC 2010, depends on the average shear wave velocity of the upper 30 metres of soil and/or rock below founding level. No geophysical testing has been carried out on this site to confirm that value. However, based on the boreholes advanced at this site and using the guidance provided in Table 4.1.8.4.A of the NBCC, it is considered that a Site Class D can likely be specified for Blocks 2b and 2c, and a Site Class of C can be specified for Blocks 1, 2a, and 3, provided the blocks are founded on or within the bedrock for preliminary design purposes.

Consideration can be given to completing shear wave velocity testing at the site to achieve a better site class for Blocks 1, 2a, and 3 that will be founded on the bedrock (i.e., Site Class A or B).

5.8 Basement Floor Slab

In preparation for the construction of the basement floor slab, all loose, wet, and disturbed material should be removed from beneath the floor slab.

For Blocks 2b and 2c (i.e., those with fully drained foundations), provision should be made for at least 300 millimetres of free draining granular material, such as 16 millimetre clear crushed stone, to form the base of the floor slab. To prevent hydrostatic pressure build up beneath the floor slab, it is suggested that the granular base for the floor slab be drained. This should be achieved by installing rigid 100 millimetre diameter perforated pipes in the floor slab bedding at 6 metre centres. The perforated pipes should discharge to a positive outlet such as a sump from which the water is pumped.

Any bulk fill required to raise the grade to the underside of the clear stone should consist of OPSS Granular B Type II. The underslab fill 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.

If or where an asphalt surface will be provided for the basement level, at least 150 millimetres of OPSS Granular A base should be provided above the clear stone, compacted to at least 100 percent of the material’s standard Proctor maximum dry density.

For Blocks 1, 2a and 3, the foundations may need to be constructed as watertight structures and the floor slab for those structures will need to be constructed of concrete and may placed directly on a suitably prepared subgrade or properly placed and compacted Granular A.

5.9 Foundation / Basement Wall Backfill

The backfill and drainage requirements for basement walls, as well as the lateral earth pressures, will depend on the type of excavation that is made to construct the basement levels, the drainage level and the forming methods.

5.9.1 Overburden Excavations

The following guidelines apply to the upper portions of the basement walls, above the bedrock surface.

The soils at this site are frost susceptible and should not be used as backfill against exterior, unheated, or well insulated foundation elements within the depth of potential frost penetration (1.5 metres) to avoid problems with frost adhesion and heaving. Free draining backfill materials are also required if hydrostatic water pressure against the basement walls (and potential leakage) is to be avoided. The foundation and basement walls therefore should be backfilled with non-frost susceptible sand or sand and gravel conforming to the requirements for OPSS Granular B Type I. For structures with watertight foundations, any suitable, compactable earth borrow or granular fill may be used up the drainage level and OPSS granular B Type I above the drainage level.

To avoid ground settlements around the foundations, which could affect site grading and drainage, all of the backfill materials should be placed in 0.3 metre thick lifts, compacted to at least 95 percent of the material’s standard Proctor maximum dry density.

The basement wall backfill (for the full height of the wall) should be drained by means of a perforated pipe subdrain in a surround of 19 millimetres clear stone, fully wrapped in a geotextile, which leads by positive drainage to a storm sewer or to a sump from which the water is pumped.

5.9.2 Excavations in Bedrock

The following guidelines apply to the deeper portions of the basement walls, which will be constructed in the bedrock. It is assumed that the basement walls and slabs within the rock will be of watertight construction.

It may be feasible to pour the basement walls directly against the bedrock. However, directly pouring concrete against bedrock can exacerbate shrinkage cracking of the concrete. If concrete is to be cast directly against bedrock (after application of a watertight membrane or other treatment on the rock walls) the concrete should be made with a low shrinkage mix design to reduce the potential for shrinkage cracking.

Where the basement walls will be constructed using formwork, it will be necessary to backfill a narrow gallery between the shoring or bedrock face and the outside of the walls. The backfill should consist of 6 millimetre clear stone ‘chip’, placed by a stone slinger or chute.

In no case should the clear stone chip be placed in direct contact with other soils. For example, surface landscaping or backfill soils placed near the top of the clear stone backfill should be separated from the clear stone with a geotextile.

5.9.3 Lateral Earth Pressures

It is considered that three design conditions exist with regards to the lateral earth pressures that will be exerted on the basements walls:

1) Walls cast directly against the bedrock face.

2) Walls cast against formwork with a narrow backfilled gallery provided between the basement wall and the adjacent excavation bedrock face.

3) Walls cast against formwork with a wide backfilled gallery provided between the basement wall and the adjacent excavation face (including the upper portions of the walls, above the bedrock surface).

For the first case, the walls should be designed to resist the hydrostatic pressures.

For the second case, the magnitude of the lateral earth pressure depends on the magnitude of the arching which can develop in the backfill and therefore depends on the width of the backfill, its angle of internal friction, as well as the interface friction angles between the backfill and both the rock face and the basement wall. The magnitude of the lateral earth pressure can be calculated as:

$$\sigma_h(z) = \frac{\gamma B}{2\tan\delta}\left(1 - e^{-2K\frac{z}{B}\tan\delta}\right) + K\,q$$

Where: $\sigma_h(z)$ = Lateral earth pressure on the basement wall at depth z, kilopascals;

K = Earth pressure coefficient, use 0.6;

γ = Unit weight of retained soil, use 20 kilonewtons per cubic metre for clear stone chip;

B = Width of backfill (between basement wall and bedrock face), metres;

δ = Average interface friction angle at backfill-basement wall and backfill-rock face interfaces, use 15 degrees;

z = Depth below top of formwork, metres; and,

q = Surcharge at ground surface to account for traffic, equipment, or stock piled materials (use 15 kilopascals). Additional/higher surcharge loads associated with existing building foundations should also be accounted for where existing buildings are located adjacent to the basement walls.

For the third case, the basement walls should be designed to resist lateral earth pressures calculated as:

$$\sigma_h(z) = K_o\,(\gamma z + q)$$

Where: $\sigma_h(z)$ = Lateral earth pressure on the wall at depth z, kilopascals;

K_o = At-rest earth pressure coefficient, use 0.5;

γ = Unit weight of retained soil, use 22 kilonewtons per cubic metre;

z = Depth below top of wall, metres; and,

q = Uniform surcharge at ground surface behind the wall to account for traffic, equipment, or stockpiled soil (use 15 kilopascals). Additional/higher surcharge loads associated with existing building foundations should also be accounted for where existing buildings are located adjacent to the basement walls.

For all cases, hydrostatic groundwater and different lateral earth pressures (e.g., effective unit weights of the soils would apply to the above equations) would also need to be considered if the structure is designed to be water-tight. Additional guidelines will therefore need to be provided if the basement is to be designed to be water-tight.

Conventional damp proofing of the basement walls, above the drainage level, is appropriate with the above design approach. For concrete walls poured against shoring or bedrock (i.e., without a drainage layer), damp proofing using a crystalline barrier such as Crystal Lok or Xypex could be used. The use of a concrete additive that provides reduced permeability should also be considered.

These lateral earth pressures would increase under seismic loading conditions. 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). The combined pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(z) = K_o \gamma z + (K_{AE} - K_o) \gamma (H\text{-}z)$$

Where: K_{AE} = The seismic earth pressure coefficient, use 0.8; and,

H = The total depth to the bottom of the foundation wall (metres).

Hydrodynamic groundwater pressures would also need to be considered if the structure is designed to be water-tight. However, if this option is selected, more sophisticated analyses would need to be carried out before guidelines could be provided.

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

It has been assumed that the underground parking levels will be maintained at minimum temperatures but will not be permitted to freeze. If these areas are to be unheated, additional guidelines for the design of the basement walls and foundations will need to be provided.

In areas where pavement or other hard surfacing will abut the building, differential frost heaving could occur between the granular fill immediately adjacent to the building and the more frost susceptible backfill placed beyond the wall backfill. To reduce the severity of this differential heaving, the backfill adjacent to the wall may have to be placed to form a frost taper, depending on the composition of the existing fill. The frost taper should be brought up to pavement subgrade level from 1.5 metres below finished exterior grade at a slope of 3 horizontal to 1 vertical, or flatter, away from the wall. The granular fill 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.

5.10 Impacts on Adjacent Developments

Impacts on surrounding structures could result from:

- Ground movements around the excavation shoring.
- Ground settlements due to the planned temporary and permanent groundwater level lowering, if sensitive and compressible clay soils exist within the expected zone of influence of the groundwater level lowering.

The shoring and underpinning requirements and the potential impacts on surrounding structures due to ground movements are discussed in Section 5.4.2 of this report.

Temporary and permanent groundwater level lowering may be an issue with regards to surrounding ground settlements if sensitive and compressible clay soils exist within the expected zone of influence of the groundwater level lowering (both during construction and in the long term due to the foundation drainage system). Additional investigations and analysis should be undertaken during detailed design to further assess the clay compressibility, zone of influence of dewatering and the potential impacts.

A preconstruction survey of all structures located within close proximity to this site should be carried out prior to commencement of any excavation.

5.11 Frost Protection

All perimeter and exterior foundation elements or interior foundation elements in unheated areas should be provided with a minimum of 1.5 metres of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover.

For Blocks 1, 2a, and 3, it is expected that these requirements will be satisfied due to the deep founding level required to accommodate the below grade parking, and assuming that the parking garage will not be allowed to freeze.

5.12 Site Servicing

Excavations for the installation of site services will be through the fill and into the native silty clay and glacial till.

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

Excavation side slopes above the water table should be stable in the short term at 1 horizontal to 1 vertical. Side slopes below the water table should be sloped at 3 horizontal to 1 vertical. Alternatively, the excavations could be carried out using steeper side slopes with all manual labour carried out within a fully braced steel trench box for worker safety.

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

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, it will be necessary to remove the disturbed material, and place a sub-bedding layer consisting 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 or surrounding soil could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

Cover material, from 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 standard Proctor maximum dry density.

It is should be generally acceptable to re-use the excavated native overburden soils as trench backfill. However, some of the native overburden materials may be too wet to compact. Where that is the case, the wet materials should be wasted (and drier materials imported) or these materials should be placed only in the lower portions of the trench, recognizing that some future settlement of the ground surface or roadway may occur.

In areas where the trench will be covered with hard surfaced materials, the type of material placed within the frost zone (between finished grade and about 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.

5.13 Pavement Design

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

Those portions of the fill not containing organic matter may be left in place provided that some limited long term settlement of the pavement surface can be tolerated. However, the surface of the fill material at subgrade level should be proof rolled with a heavy smooth drum roller under the supervision of qualified geotechnical personnel to compact the existing fill and to identify soft areas requiring sub-excavation and replacement with more suitable fill.

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material meeting the requirements of OPSS 212 and 1010, respectively. These materials 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.

The surface of the subgrade or fill should be crowned to promote drainage of the pavement granular structure. Perforated pipe subdrains should be provided at subgrade level extending from the catch basins for a distance of at least 3 metres in four orthogonal directions or longitudinally where parallel to a curb.

The pavement structure for car parking areas should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	50
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	300

The pavement structure for access roadways and truck traffic areas should consist of:

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

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

The composition of the asphaltic concrete pavement in car parking areas should be as follows:

- Superpave 12.5 Surface Course – 50 millimetres.

The composition of the asphaltic concrete pavement in access roadways and truck traffic areas should be as follows:

- Superpave 12.5 Surface Course – 40 millimetres.
- Superpave 19.0 Binder Course – 50 millimetres.

The asphalt cement should consist of PG 58-34.

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

5.14 Corrosion and Cement Type

One sample of soil from borehole 18-03 was submitted to Eurofins Environmental Ontario for basic 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 B.

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate an elevated potential for corrosion of exposed ferrous metal.

6.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic, and frost.

All subgrade areas should be inspected by experienced geotechnical personnel prior to filling to ensure that the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction view point.

During or prior to detailed design, further investigations and analysis should be undertaken to assess the extent and compressibility characteristics of the clay soils and the potential impacts of groundwater lowering during construction and over the long term and to confirm the design guidance provided in this preliminary report. Additional geophysical investigations may also be considered to define the Seismic Site class for design.

Signature Page

Golder Associates Ltd.

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https://golderassociates.sharepoint.com/sites/1897188/deliverables/geotechnical/1897188-001-r-rev0-gladstone village geotechnical investigation-june 2018.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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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.

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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, CURRENT INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION
①	BLOCK NUMBERING
▭	PROPOSED BUILDING FOOTPRINT
▭	APPROXIMATE SITE BOUNDARY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. GLADSTONE VILLAGE DESIGN CONCEPT PROVIDED BY CLIENT, 06/21/2017. REV. NO. 05.
2. SERVICE LAYER CREDITS: © OPENSTREETMAP (AND) CONTRIBUTORS, CC-BY-SA
3. 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
PRELIMINARY GEOTECHNICAL INVESTIGATION
GLADSTONE VILLAGE, 933 GLADSTONE AVENUE, OTTAWA, ON

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-05-09
DESIGNED	----
PREPARED	BR/JEM
REVIEWED	WAM
APPROVED	WC

PROJECT NO.	CONTROL	REV.	FIGURE
1897188	0001	0	1

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

Path: N:\Active\Spatial_IM\OCHC\933_Gladstone_Ave\99_PROJ\1897188_OCHC_Geotech\40_PROD\0001_Geotech_Investigation\1897188-0001-BG-0001.mxd

APPENDIX A

List of Abbreviations and Symbols

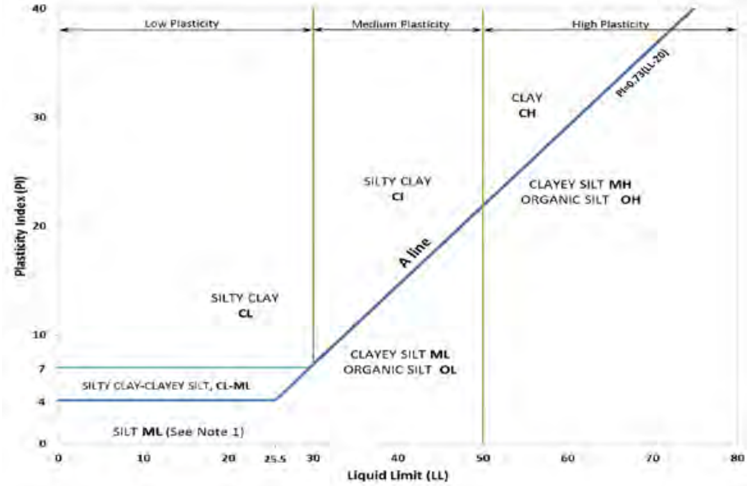
Record of Borehole Sheets

METHOD OF SOIL CLASSIFICATION

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

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

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



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BORHEOLES 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.).

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
FS	Foil sample
GS	Grab Sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
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 - 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 overburden pressure effects.
2. Definition of compactness terms are based on SPT-'N' ranges as provided in Terzaghi, Peck and Mesri (1996) and correspond to typical average N_{60} values. Many factors affect the recorded SPT-'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), groundwater conditions, and grainsize. As such, the recorded SPT-'N' value(s) should be considered only an approximate guide to the compactness term. 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 = $(w_l - w_p)$
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: 1897188

RECORD OF BOREHOLE: 18-01

SHEET 1 OF 2

LOCATION: N 5029861.2 ;E 366138.5

BORING DATE: April 27, 2018

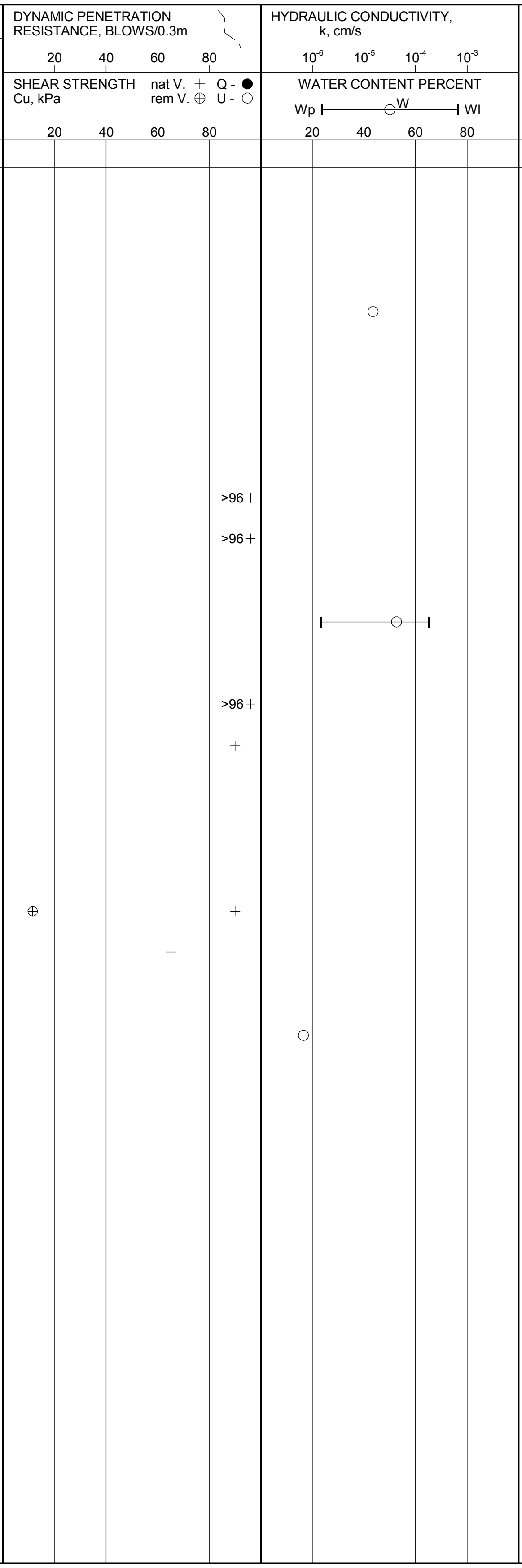
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	60.30			
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	-
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	59.63 0.67	3	SS	3
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, very stiff to stiff	58.47 1.83	4 5 6	SS SS SS	WH 1 WH
(ML-CL) sandy SILT, some gravel and SILTY CLAY; grey, thickly laminated; non-cohesive, wet, very loose	54.05 6.25	7	SS	WH
(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			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: PAH

CHECKED: WAM

PROJECT: 1897188

RECORD OF DRILLHOLE: 18-01

SHEET 2 OF 2

LOCATION: N 5029861.2 ;E 366138.5

DRILLING DATE: April 27, 2018

DATUM: Geodetic

DRILL RIG:

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.	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								
		End of Drillhole		9.51								
10												
11												
12												
13												
14												
15												
16												
17												

DEPTH SCALE
1 : 50

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 | BORING METHOD | SOIL PROFILE | SAMPLES | 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

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

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

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

0
1
2
3
4
5
6
7
8
9
10

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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

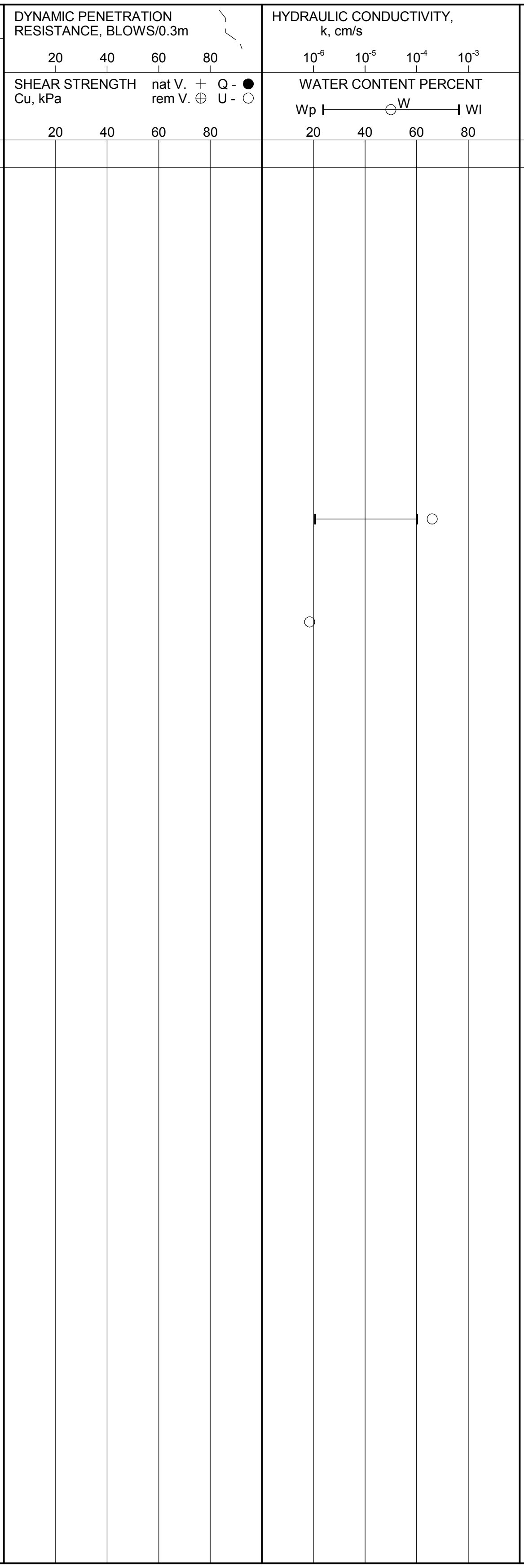
DATUM: Geodetic

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

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DEPTH SCALE
1 : 50

GOLDER

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

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT
GROUND SURFACE	60.87				
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	60.72 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	2	SS	6	○
		3	SS	4	
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff	58.58 2.29	4	SS	WH	
		5	SS	1	○
(ML) CLAYEY SILT, some gravel; grey, contains cobbles; cohesive, w>PL, stiff	57.14 3.73	6	SS	5	
(ML) sandy SILT, some gravel; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, loose	56.45 4.42	7	SS	>50	
End of Borehole Auger Refusal	55.69 5.18				

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/0.30m	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		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 4	SS SS	27 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

RECORD OF DRILLHOLE: 18-05

PROJECT: 1897188

SHEET 2 OF 2

LOCATION: N 5029676.7 ;E 366338.0

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		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							
5		End of Drillhole		56.66 4.95								
6												
7												
8												
9												
10												
11												
12												
13												

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: WAM

APPENDIX B

Borehole Logs

Previous Phase II ESA Investigation

PROJECT: 1670949

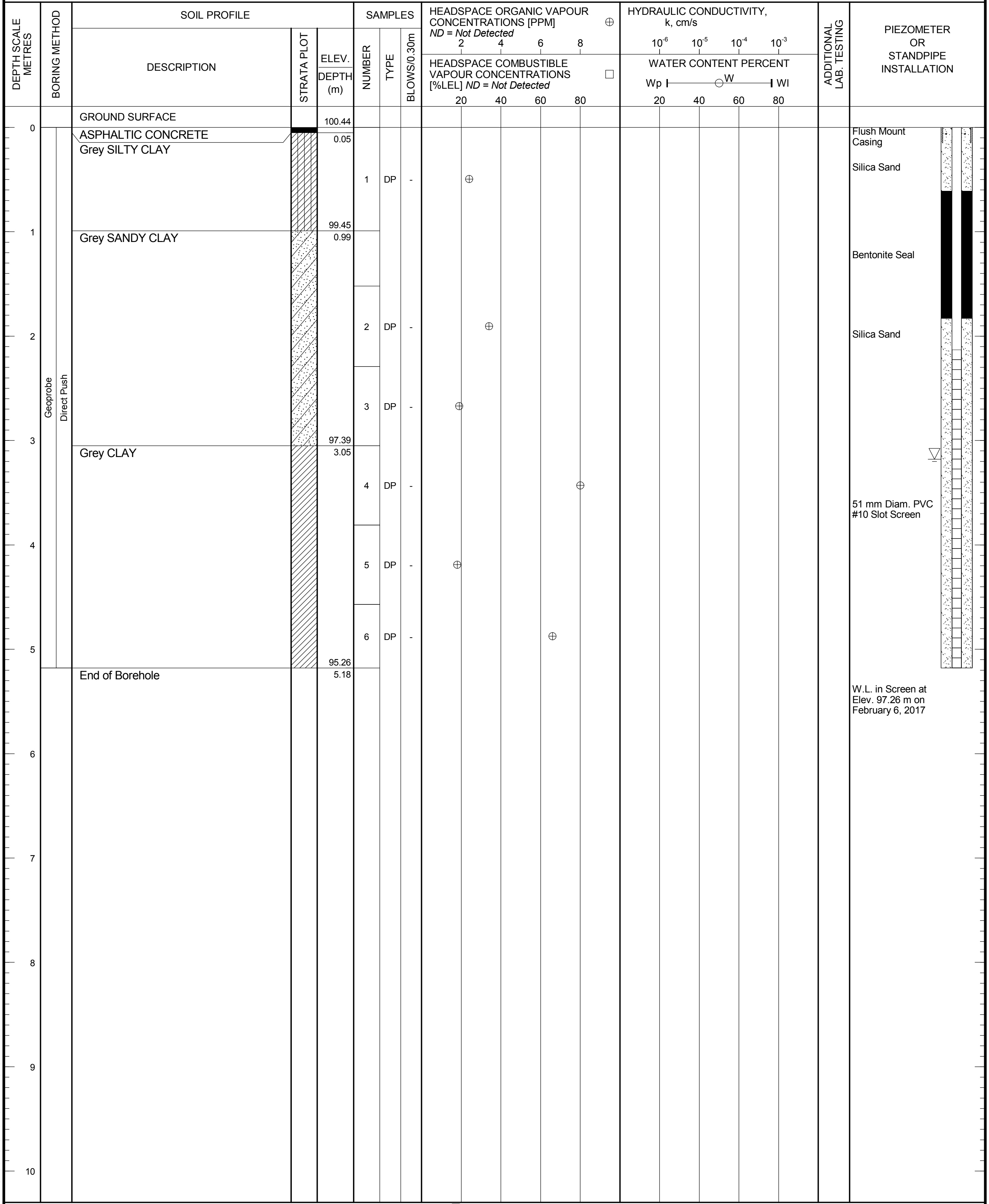
RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1

LOCATION: N 5028292.0 ;E 443935.0

BORING DATE: January 30, 2017

DATUM: CGVD28



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	-

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. 97.26 m on February 6, 2017

DEPTH SCALE

1 : 50

Golder Associates

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	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		101.39							
0	Geoprobe Direct Push	Brown SILTY SAND, with gravel (FILL)	▨	0.00	1	DP	-	⊕			
1											
2					3	DP	-				
				98.95 2.44							
		End of Borehole									
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

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											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-04

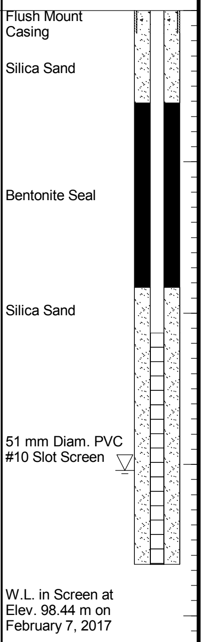
SHEET 1 OF 1

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	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		101.48							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-	⊕			Flush Mount Casing Silica Sand
		Grey SILTY fine SAND		101.02 0.46							
1											Bentonite Seal
2					2	DP	-	⊕ ND			Silica Sand
3											51 mm Diam. PVC #10 Slot Screen
					4	DP	-	⊕			
		End of Borehole Refusal		97.67 3.81							W.L. in Screen at Elev. 98.44 m on February 7, 2017
4											
5											
6											
7											
8											
9											
10											



MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-05

SHEET 1 OF 1

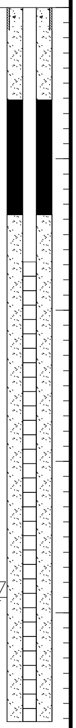
LOCATION: N 5028207.0 ;E 444119.0

BORING DATE: January 30, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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
		GROUND SURFACE	101.28						
0	Geoprobe Direct Push	Brown SILTY CLAY (FILL)	0.00	1	DP	-	⊕		
		Grey SILTY CLAY	100.65 0.63	2 3 4	DP DP DP	- - -	⊕ ⊕ ⊕		
4		Grey SILTY fine SAND	97.47 3.81	5 6	DP DP	- -	⊕ ⊕		
5		End of Borehole	96.25 5.03						

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

Golder Associates

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	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR / COMBUSTIBLE VAPOUR	HYDRAULIC CONDUCTIVITY / WATER CONTENT PERCENT	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											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

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	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		101.01							
0	Geoprobe Direct Push	Brown SILTY SAND (FILL)		0.00	1	DP	-	⊕			
				100.25							
1		Brown SILTY CLAY		0.76	2	DP	-	⊕			
2					3	DP	-	⊕			
				98.57							
		End of Borehole		2.44							
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

DEPTH SCALE
1 : 50

Golder Associates

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)

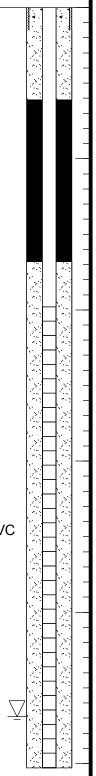
HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3})

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

SOIL PROFILE 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

Golder Associates

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	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		100.67							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-				
1					2	DP	-				
				99.15							
		Brown SILTY fine SAND (FILL)		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 Associates

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

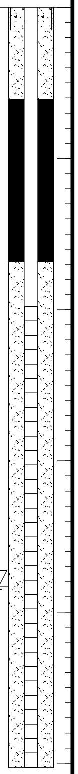
HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR
	GROUND SURFACE		100.75				
Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-	⊕
	Brown SILTY CLAY		99.86 0.89	2	DP	-	⊕
	Grey SILTY CLAY		98.46 2.29	3	DP	-	⊕
				4	DP	-	⊕
				5	DP	-	⊕
				6	DP	-	⊕
	End of Borehole		95.57 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. 96.92 m on February 6, 2017

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

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

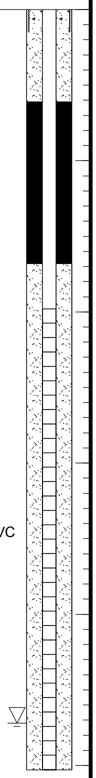
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	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							



DEPTH SCALE
1 : 50

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	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		100.51							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)		0.00	1	DP	-				
		Brown SILTY fine SAND (FILL)		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											

DEPTH SCALE

1 : 50

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

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			

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

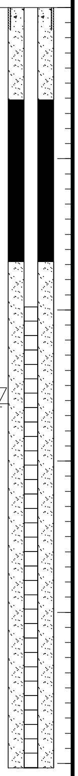
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

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



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 Associates

LOGGED: ALB
CHECKED: EDW

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

PROJECT: 1670949

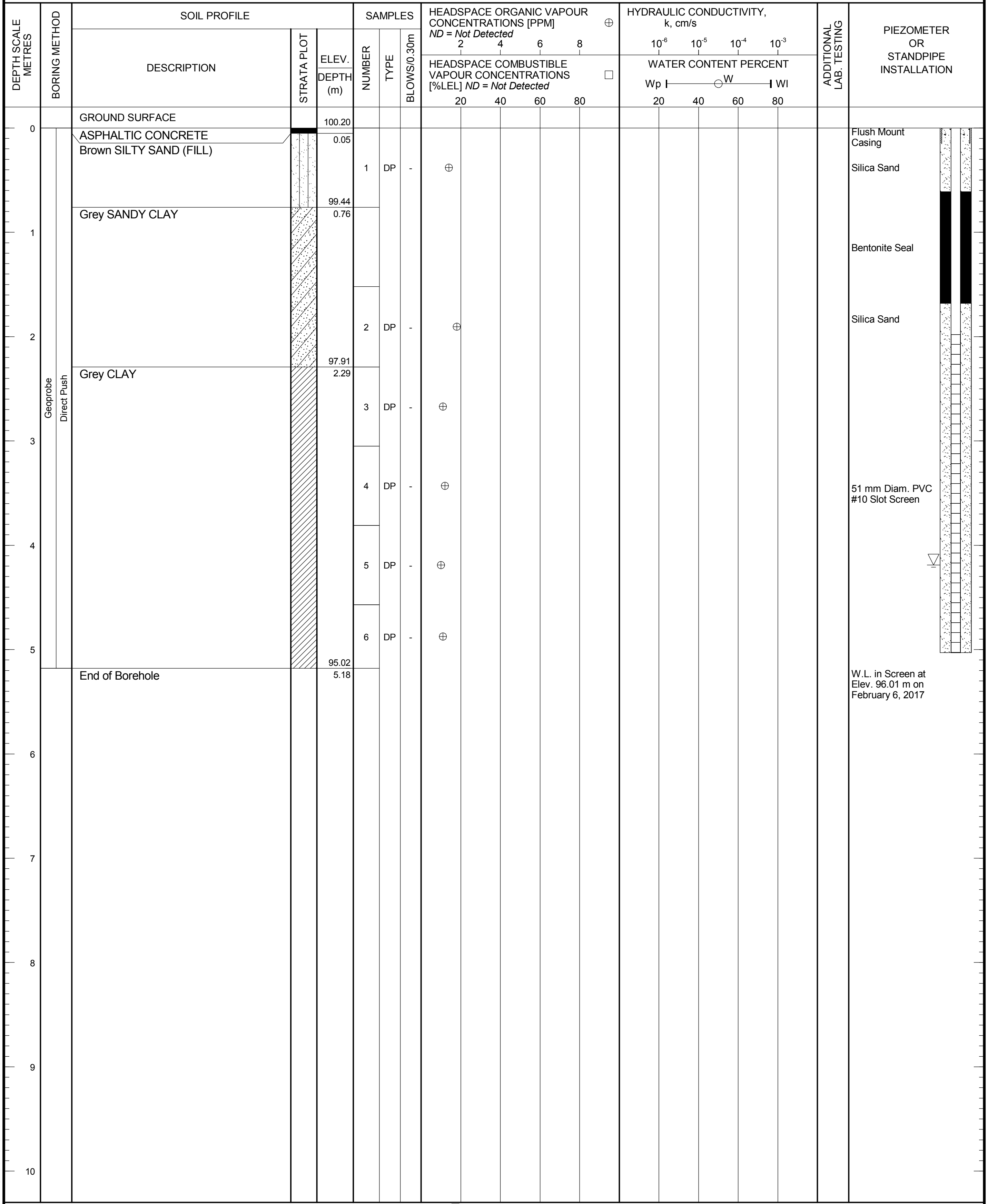
RECORD OF BOREHOLE: 17-14

SHEET 1 OF 1

LOCATION: N 5028273.0 ;E 443958.0

BORING DATE: January 25, 2017

DATUM: CGVD28



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.20
ASPHALTIC CONCRETE	
Brown SILTY SAND (FILL)	0.05
Grey SANDY CLAY	99.44 0.76
Grey CLAY	97.91 2.29
End of Borehole	95.02 5.18

NUMBER	TYPE	BLOWS/0.30m
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. 96.01 m on February 6, 2017

DEPTH SCALE

1 : 50

Golder Associates

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	100.29					
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	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					
5				6	DP	-		W.L. in Screen at Elev. 95.71 m on February 6, 2017
		End of Borehole	95.11 5.18					
6								
7								
8								
9								
10								

DEPTH SCALE
1 : 50

Golder Associates

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	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		100.29							
0	Geoprobe Direct Push	Grey brown SILTY SAND, trace gravel (FILL)		0.00	1	DP	-	⊕			
				99.68							
1		Brown SANDY CLAY (FILL)		0.61	2	DP	-	⊕			
2					3	DP	-	⊕			
				97.85							
		End of Borehole		2.44							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-17

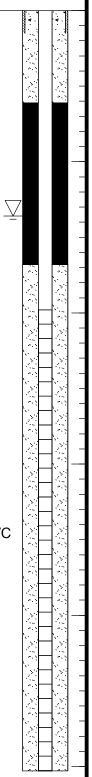
SHEET 1 OF 1

LOCATION: N 5028326.0 ;E 443979.0

BORING DATE: January 26, 2017

DATUM: CGVD28

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		100.32							
0	Geoprobe Direct Push	Brown SILTY fine SAND (FILL)		0.00	1	DP	-				Flush Mount Casing Silica Sand
		Brown SANDY CLAY (FILL)		99.56 0.76	2	DP	-				Bentonite Seal Silica Sand
		Grey CLAY		98.03 2.29	3	DP	-				
					4	DP	-				51 mm Diam. PVC #10 Slot Screen
					5	DP	-				
					6	DP	-				
		End of Borehole		95.14 5.18							W.L. in Screen at Elev. 98.96 m on February 2, 2017



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: ALB
CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-18

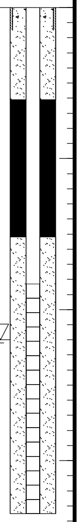
SHEET 1 OF 1

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 (FILL)	100.76 0.61							Bentonite Seal
1										
2				2	DP	-	⊕			Silica Sand
		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										



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-19

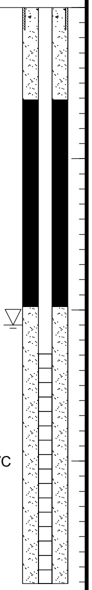
SHEET 1 OF 1

LOCATION: N 5028213.0 ;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	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		100.87							
0	Geoprobe Direct Push	Brown SANDY CLAY (FILL)	▨	0.00	1	DP	-				Flush Mount Casing Silica Sand
1 2		Grey brown SANDY CLAY, trace brick at 1.52 m depth (FILL)	▨	100.39 0.48	2	DP	-				Bentonite Seal Silica Sand
3		Grey SANDY CLAY	▨	97.82 3.05	4	DP	-	⊕			51 mm Diam. PVC #10 Slot Screen
4		End of Borehole		97.06 3.81							W.L. in Screen at Elev. 98.77 m on February 2, 2017
5 6 7 8 9 10											



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: ALB
CHECKED: EDW

PROJECT: 1670949

RECORD OF BOREHOLE: 17-20

SHEET 1 OF 1

LOCATION: N 5028218.0 ;E 444019.0

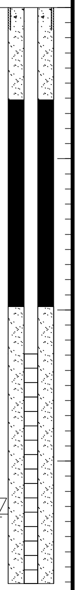
BORING DATE: January 27, 2017

DATUM: CGVD28

BORING METHOD: Geoprobe Direct Push

SOIL PROFILE		SAMPLES			HEADSPACE ORGANIC VAPOUR CONCENTRATIONS [PPM] ⊕ ND = Not Detected HEADSPACE COMBUSTIBLE VAPOUR CONCENTRATIONS [%LEL] ND = Not Detected ☐	HYDRAULIC CONDUCTIVITY, k, cm/s WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl	ADDITIONAL LAB. TESTING
DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m			
GROUND SURFACE	100.96						
Brown SILTY CLAY (FILL)	0.00	1	DP	-	⊕ ND		
		2	DP	-	⊕ ND		
Grey SILTY CLAY	98.67 2.29	3	DP	-	⊕ ND		
		4	DP	-	⊕ ND		
End of Borehole Refusal	97.00 3.96						

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. 97.61 m on February 6, 2017

DEPTH SCALE 1 : 50

LOGGED: ALB

CHECKED: EDW

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 JEM

PROJECT: 1670949

RECORD OF BOREHOLE: 17-21

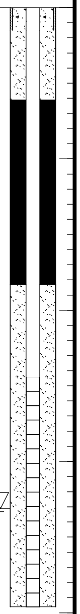
SHEET 1 OF 1

LOCATION: N 5028217.0 ;E 444052.0

BORING DATE: January 27, 2017

DATUM: CGVD28

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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 (FILL)	100.19 0.86							Bentonite Seal
2				2	DP	-	⊕			Silica Sand
				3	DP	-	⊕			
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

LOGGED: ALB

CHECKED: EDW

PROJECT: 1670949

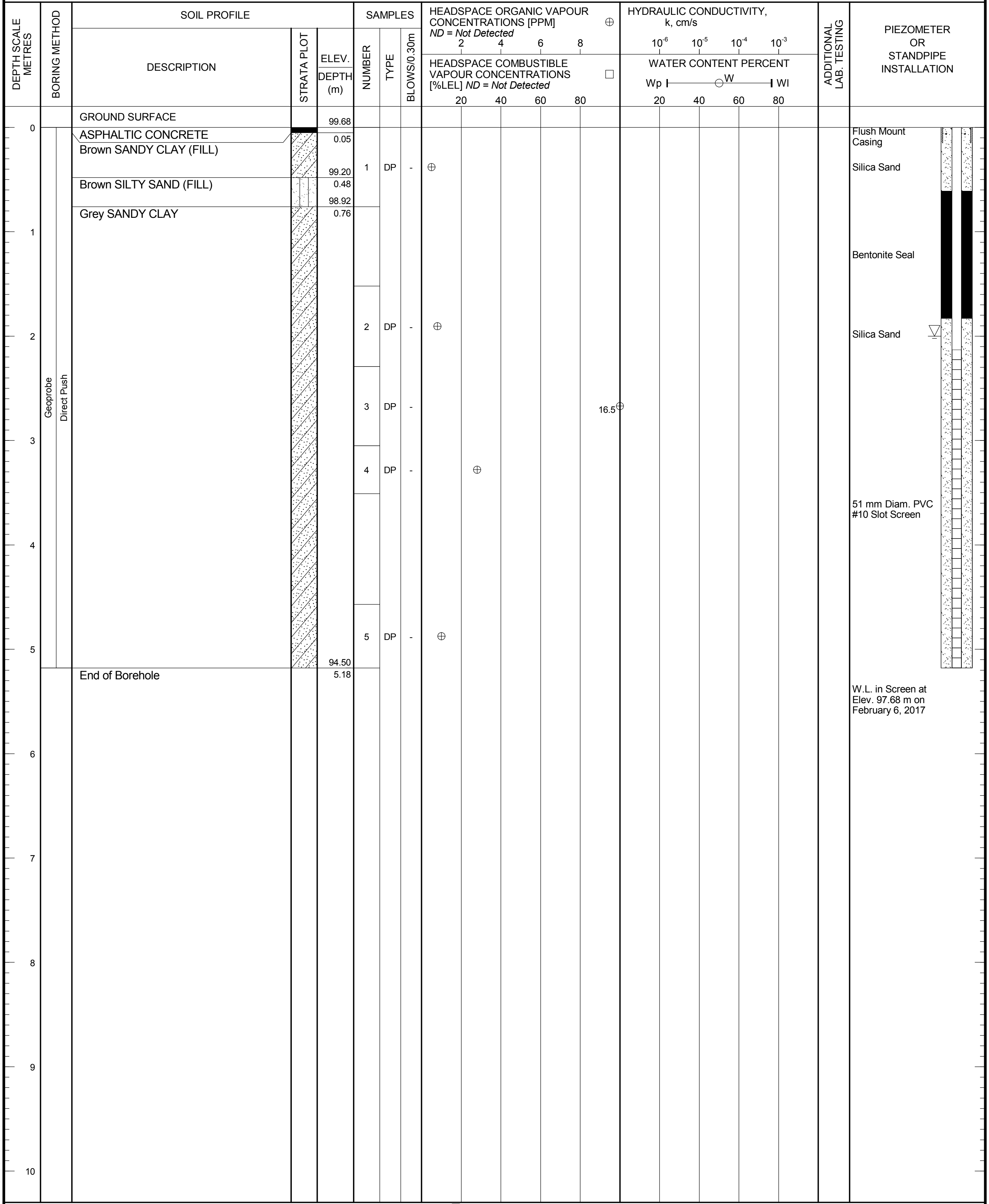
RECORD OF BOREHOLE: 17-22

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	-

DEPTH SCALE

1 : 50

LOGGED: ALB

CHECKED: EDW

MIS-BHS 001 1670949.GPJ GAL-MIS.GDT 03/21/17 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

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}

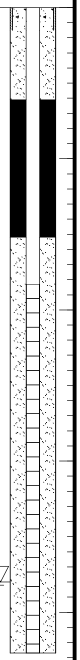
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20, 40, 60, 80

BORING METHOD: Geoprobe Direct Push (0 to 4.27 m)

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.22
Brown SANDY CLAY (FILL)	0.00
Brown SILTY CLAY (FILL)	99.79 0.43
Grey SILTY fine SAND	97.17 3.05
End of Borehole Refusal	95.95 4.27

SAMPLE NUMBER	TYPE	BLOWS/0.30m	HEADSPACE ORGANIC VAPOUR
1	DP	-	
2	DP	-	⊕
3	DP	-	⊕
4	DP	-	⊕
5	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. 96.42 m on February 7, 2017

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: ALB
CHECKED: EDW

APPENDIX C

Results of Basic Chemical Analysis

Eurofins Environment Report Number 1807032

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Alex Meacoe
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1807032
Date Submitted: 2018-05-08
Date Reported: 2018-05-15
Project: 1897188
COC #: 188728

				Lab I.D.	1357823
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2018-04-30
				Sample I.D.	18-03 SA3/5-7
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Agri. - Soil	pH	2.00			7.59
	SO4	0.01	%		<0.01
General Chemistry	Cl	0.002	%		0.005
	Electrical Conductivity	0.05	mS/cm		0.22
	Resistivity	1	ohm-cm		4540

Guideline = *** = Guideline Exceedence**

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

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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