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REPORT ON

Geotechnical Investigation Proposed Residential Development 3311 Greenbank Road Ottawa, Ontario

Submitted to:
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REPORT

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development to be located at 3311 Greenbank Road (herein after referred to as “the site”) in Ottawa, Ontario.

The purpose of this subsurface investigation was to determine the general soil and groundwater conditions across the site by means of 8 boreholes. Based on an interpretation of the factual information obtained, along with the existing subsurface information available for the site from previous investigations, engineering recommendations are provided on the geotechnical design aspects of the proposed development, including construction considerations that could affect design decisions.

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

2.0 DESCRIPTION OF PROJECT AND SITE

Plans are being prepared for a proposed residential development to be located at 3311 Greenbank Road in Ottawa, Ontario (see Key Plan inset on Figure 1).

The following information is known about the site and the proposed development:

- The property is roughly rectangular in shape with a maximum length and width of approximately 400 and 120 metres, respectively.
- The site is bounded to the west by Greenbank Road, to the north by an existing high school, to the east by Jockvale Road, and to the south by undeveloped lands.
- The site has a relatively flat to gently sloping topography from about elevation 97 to 91 metres, decreasing in elevation towards the Jock River.
- The site primarily consists of undeveloped vacant and/or agricultural land, with some rows of trees.
- The property is to be developed as a residential subdivision consisting of townhomes.

Golder Associates Ltd. has carried out a previous geotechnical and hydrogeological investigation within the proposed development, and the results of that investigation are included in the following report.

- Report by Golder Associates Ltd. to Novatech Engineering Consultants Ltd. titled “Geotechnical and Hydrogeological Investigation, South Nepean Collector Phase 2, Ottawa, Ontario” dated May 2016 (report number 1523645-5).

The approximate locations of the current boreholes as well as the relevant previous boreholes and test pits from the above previous investigation are shown on the Site Plan, Figure 1.

Based on the results of the previous investigation, as well as a review of the published geological mapping, the subsurface conditions across this site are expected to predominantly consist of a thick deposit of glacial till.

Published mapping indicates the bedrock surface to be at depths of about between 5 and 15 metres below the ground surface for the majority of the site. The Geological Survey of Canada bedrock geology mapping indicates that the western portion of the study area is likely underlain by interbedded limestone and dolomite of the Gull River Formation, with interbedded sandstone and dolomite of the March Formation at the eastern portion of the site. These two formations are separated by a fault.

3.0 PROCEDURE

The fieldwork for this investigation was carried out on March 13 and 14, 2017. During this time, eight boreholes (numbered 17-01 to 17-08, inclusive) were advanced at the approximate locations shown on the Site Plan, Figure 1.

The boreholes were advanced using an ATV mounted hollow stem auger drill rig supplied and operated by CCC Geotechnical and Environmental Drilling Ltd. (CCC) of Ottawa, Ontario. The boreholes were advanced to depths ranging from about 2.0 (practical refusal to augering) to 6.1 metres below the existing ground surface.

Standard penetration tests (SPTs) were carried out in the overburden at regular intervals of depth in the boreholes and samples of the soils encountered were recovered using split spoon sampling equipment.

Monitoring wells were installed in boreholes 17-01 and 17-06 to allow for subsequent measurement of the groundwater level across the site. The groundwater level measurements were carried out on April 5, 2017.

The fieldwork was supervised by a member from our engineering staff who located the boreholes, directed the drilling and in situ testing, logged the boreholes and samples, and took custody of the soil samples retrieved.

Upon completion of the drilling operations, soil samples obtained from the boreholes were returned to our laboratory for further examination by the project engineer and for laboratory testing. The laboratory testing included natural water content determination and grain size distribution determination.

One sample of soil from borehole 17-07 was submitted to Eurofins laboratories for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried steel elements.

The borehole locations were selected in consultation with Minto Communities, and were marked in the field, and subsequently surveyed by Golder Associates personnel. The borehole coordinates and ground surface elevations were determined using a Trimble R8 GPS survey unit. The geodetic reference system used for the survey is the North American datum of 1983 (NAD83). The borehole coordinates are based on the Modified Transverse Mercator (MTM Zone 9) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is presented as follows:

- The subsurface conditions encountered in the boreholes put down for the current investigation are shown on the Record of Borehole Sheets in Appendix A.
- The results of the laboratory water content testing carried out on selected soil samples are provided on the Record of Borehole Sheets.
- The results of grain size distribution testing carried out on selected soil samples from the current investigation are provided on Figure 2.
- Relevant boreholes and test pits from the previous investigation by Golder on this site are provided on the Record of Borehole, Drillhole, and Test Pit Records in Appendix B.
- The results of the basic chemical analysis carried out a sample of soil from borehole 17-07 are provided in Appendix C.

In general, the subsurface conditions on this site consist of topsoil and fill, overlying silty clay (within the eastern portion of the site), overlying bouldery glacial till, above bedrock.

The following sections present a more detailed overview of the subsurface conditions encountered in the test holes from the current investigation. Additional subsurface information from the previous boreholes, which are generally consistent with the conditions encountered in the current study, are provided in Appendix B. It should be noted that the shallow subsurface conditions may have changed from what was documented in the previous records as a result of construction activities which were carried out after the boreholes were drilled.

4.2 Topsoil, Peat, and Fill

Topsoil or peat exists at the ground surface at most of the borehole locations. Where encountered, the topsoil and peat ranges from about 80 to 600 millimetres in thickness.

Fill was encountered at boreholes 17-01, 17-03, and 17-07. At these locations, the fill ranges from 1.1 to 2.8 metres thick. The fill consists of silty sand, sandy gravel, silty clay, and clayey silt.

4.3 Silty Clay

A deposit of silty clay exists below the topsoil in boreholes 17-04 and 17-05, and previous boreholes 15-3, 15-3A, and 15-4, towards the eastern portion of the site. The full thickness of the clay has been weathered to a grey brown crust and extends to depths ranging from about 1.5 to 2.3 metres below the existing ground surface.

Three SPT “N” values measured in the silty clay deposit ranged from 3 to 11 blows per 0.3 metres of penetration, indicating very stiff consistency.

The measured water contents of three samples of the silty clay ranged from about 37 to 51 percent.

4.4 Glacial Till and Interbedded Sand/Silt/Gravel

A deposit of glacial till, containing discontinuous interbedded sand, silt and gravel layers, exists below the topsoil, fill and silty clay (where present) in all of the boreholes and test holes from the current and previous investigations. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand, with variable amounts of silt, clay and gravel.

In borehole 17-06, the glacial till is interbedded with a layer of sand. Similar discontinuous layers of silt, sand, and gravel were encountered in previous borehole 15-2 and boreholes 15-4 to 15-7. The composition of the intermittently interbedded layers recovered from the previous investigation ranges from sandy silt, to silty sand, to sand, to gravelly sand, to sand and gravel. These layers would not typically be described as glacial till either due to the absence of fines (silt and clay) or gravel, cobbles and boulders.

The glacial till was proven to extend to depths varying from about 2.0 to 6.1 metres below the existing ground surface during the current investigation prior to the boreholes encountering practical refusal to augering or being terminated.

SPT “N” values obtained in the glacial till deposit ranged widely from 3 to greater than 50 blows per 0.3 metres of penetration, indicating a very loose to very dense state of packing. However, the higher “N” values likely reflect the presence of cobbles and boulders within the deposit, rather than the actual state of packing of the soil matrix.

The results of grain size distribution testing carried out on two samples from the glacial till deposit are provided on Figure 2. It should be noted that the split-spoon sampler used during the investigation has an inside diameter of about 35 millimetres and therefore the results of grain size distribution tests do not reflect the coarser fraction of the deposit (i.e., the larger gravel, cobbles, and boulders likely present within the glacial till. The measured water content of the glacial till ranges from about 4 to 17 percent. The measured water content of one sample of the interbedded sand was about 22 percent.

4.5 Refusal or Bedrock

Practical refusal to augering was encountered in all of the boreholes from the current investigation, except for boreholes 17-05 and 17-07, at depths varying between about 2.0 to 5.7 metres below the existing ground surface. Along the south and west sides of the site, previous boreholes were advanced into the glacial till to depths of about 6.2 to 11.7 metres. Refusal may indicate the bedrock surface; however, it could also represent boulders within the glacial till.

The following table provides a summary of the ground surface elevation, depth to refusal, and the elevation of the refusal surface at the test hole locations from the current and previous investigations; elevations are provided in metres above sea level (masl).

Investigation/ Report	Borehole/ Test Pit Number	Ground Surface Elevation (masl)	Refusal Depth (m)	Refusal Elevation (masl)
Current Investigation	17-01	94.75	5.36	89.43
	17-02	97.94	5.64	92.30
	17-03	97.75	4.44	93.31
	17-04	92.21	3.69	88.52
	17-06	93.28	5.74	87.54
	17-08	95.93	2.01	93.92
1523645-5	15-1	91.69	11.71	79.98
1523645-5	15-2	91.59	11.58(1)	80.01(1)
1523645-5	15-7	92.84	6.20(1)	86.64(1)
1523645-5	15-101	92.43	10.01	82.42
1523645-5	16-301	93.16	9.80(1)	83.36(1)
1523645-5	16-302	93.06	8.02(1)	85.04(1)

Note: [1] Bedrock was proven by extending the borehole into the bedrock and retrieving HQ sized core using diamond drilling techniques.

In the previous investigation, some of the boreholes were extended into the bedrock and recovered bedrock core consisted of slightly weathered to fresh, thinly to thickly bedded, grey dolomite. The Rock Quality Designation (RQD) values measured on the recovered bedrock core samples range from about 50 to 100 percent, indicating fair to excellent quality rock.

4.6 Groundwater and Hydraulic Conductivity

Monitoring wells or standpipe piezometers were installed in two of the boreholes from the current investigation. The groundwater level measurement was carried out on April 5, 2017.

The following table summarizes the measured groundwater levels from the current and previous investigations. The results of in situ hydraulic response testing from the previous investigation are also provided in the table below.

Investigation/ Report	Well ID	Geologic Unit of Screened Interval	Groundwater Level		Date of Measurement
			Depth (m)	Elevation (m)	
Current Investigation	17-01	Glacial Till	4.31	90.44	April 5, 2017
	17-06	Glacial till and interbedded sand	1.57	91.71	April 5, 2017
1523645-5	15-2 screen 'A'	Bedrock	4.10	87.49	August 24, 2015
1523645-5	15-2 screen 'B'	Sand and gravel (interbedded within glacial till)	3.17 2.18	88.42 89.41	August 24, 2015 April 7, 2016
1523645-5	15-3A	Glacial till	2.98	88.36	August 24, 2015
1523645-5	15-5	Glacial till and interbedded sandy silt	3.19	89.60	August 24, 2015
1523645-5	15-7	Bedrock	2.17 1.91	90.67 90.93	August 24, 2015 April 7, 2016
1523645-5	15-101	Glacial till	3.57	88.86	August 24, 2015

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

4.7 Basic Chemical Analysis

One sample of soil from borehole 17-07 was submitted to Eurofins laboratory for basic chemical analyses related to the potential for sulphate attack on buried concrete elements and the potential corrosion of buried ferrous elements. The results of this testing are provided in Appendix C and are summarized below.

Borehole ID	Chloride (%)	Sulphate (%)	pH	Resistivity (Ohm-cm)
17-07 Sample 3	<0.002	<0.01	8.2	7690

5.0 DISCUSSION

5.1 General

This section of the report provides engineering recommendations on the geotechnical design aspects of this project based on our interpretation of the test hole information as well as the project requirements, and is subject to the limitations in the "Important Information and Limitations of This Report" attachment which follows the text of this report, but forms an integral part of this document.

5.2 Site Grading

In general, the subsurface conditions at this site consist of topsoil and/or fill, overlying a deposit of weathered silty clay crust and/or glacial till, which is in turn underlain by bedrock.

From a foundation design perspective, no practical restrictions apply to the thickness of grade raise fill that may be placed within the proposed residential development area. However, grade raises in excess of 3 metres should be reviewed and approved by the geotechnical engineer.

For predictable performance of the structures, roadways, and site services, preparation for filling of the site should include stripping the existing topsoil, peat, and fill. The topsoil, peat, and fill are not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no structures, roadways or services, the existing topsoil, peat, and fill may be left in place provided some long term settlement of the ground surface following filling above them can be tolerated.

5.3 Foundations

With the exception of the topsoil, the native undisturbed soils at this site are considered suitable for the support of conventional wood frame townhouse blocks on spread footing foundations.

For design purposes, the allowable bearing pressures for spread footings placed on the undisturbed silty clay and glacial till may be taken as 100 kilopascals

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

The glacial till at this site contains cobbles and boulders. Any boulders in footing areas that have been loosened by the excavation process should be removed and the cavity filled with lean concrete.

At some locations on the property, and depending on the amount of proposed grade raise (i.e., filling), the inorganic or native subgrade elevation may be lower than the underside of footing elevation. At these locations, the subgrade may be raised to the footing elevation using engineered fill consisting of Ontario Provincial Standard Specification (OPSS) Granular B Type II, 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).

5.4 Seismic Design

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

More favourable Site Class values could potentially be assigned for portions of the site if shear wave velocity testing were carried out. However, it is considered that a Site Class of D permits conventional foundation design for this site.

5.5 Frost Protection

The soils at this site are frost susceptible. For frost protection purposes, all exterior footings or interior footings in unheated areas should be provided with a minimum of 1.5 metres of earth cover. Isolated, exterior footings adjacent to surfaces that are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover.

5.6 Basement Excavations

Excavations for basements will be through the topsoil, peat, fill, and into the underlying silty clay (where present) and glacial till deposits.

In general, it should be feasible to excavate the overburden (e.g., fill, topsoil, peat, clay, and glacial till) using conventional hydraulic excavating equipment. It should be noted that the glacial till contains cobbles and boulders, which could be nested and/or large in size (e.g., up to 3 metres in nominal size). Excavators equipped with hoe-ramming equipment may be required to advance the excavations through the very dense and/or bouldery glacial till. Boulders larger than 0.3 metres in size should be removed from the excavation side slopes, for worker safety.

Based on the measured groundwater levels, excavations deeper than about 2 metres, depending on the area of the site, will likely extend below the groundwater level. Where this is the case, the excavation will be subject to disturbance to the soils caused by upward flow of groundwater, resulting in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes.

Excavation side slopes above the water table should be stable in short term at 1H:1V (i.e., for Type 3 soils per OSHA of Ontario). Excavation side slopes below groundwater level will need to be cut back at 3H:1V (i.e., Type 4 soils). Alternatively, excavations within the overburden soils could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation. The use of a trench box will not, however, eliminate the potential for disturbance outside the trench box limits.

The groundwater levels at this site range from about 2 to 5 metres below the ground surface. Provided that the basement excavations are no more than about 2 metres deep (relative to the current ground surface level), it is considered that it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the floor of the excavations. Where the subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel), or a 150 millimetre thick layer of OPSS Granular A underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

5.7 Basement and Garage Floor Slabs

In preparation for the construction of the basement floor slabs, all loose, wet, and disturbed material should be removed from beneath the floor slabs. Provision should be made for at least 200 millimetres of 19 millimetre crushed clear stone to form the base of the basement floor slabs. The underslab fill should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment.

To prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base for the floor slabs be positively drained. This could be achieved by providing a hydraulic link between the underfloor fill material and the exterior drainage system.

The groundwater levels at this site range from about 2 to 5 metres below the ground surface. The glacial till soils at this site are relatively permeable and therefore, if/where the groundwater level is encountered above the basement subgrade level, a geotextile could be required between the clear stone underslab fill and the subgrade soil, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. Where a geotextile is required, it should consist of a Class II non-woven geotextile with a Filtration Opening Size (FOS) not exceeding 100 microns, in accordance with OPSS 1860.

The backfill material inside the garage 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 compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of OPSS Granular A compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment.

5.8 Basement Walls and Foundation Wall Backfill

The soils at this site are frost susceptible and should not be used as backfill directly against exterior, unheated, or well insulated foundation elements. To avoid problems with frost adhesion and heaving, these foundation elements should either be backfilled with non-frost susceptible sand or sand and gravel conforming to the requirements for OPSS Granular B Type I or, alternatively, a bond break such as the Platon system sheeting could be placed against the foundation walls.

Drainage of the wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in geotextile, which leads by gravity drainage to an adjacent storm sewer or sump pit. Conventional damp proofing of the basement walls is appropriate with the above design approach.

Should the foundations be designed in accordance with Part 4 of the OBC, further guidelines on the foundation wall design will be required.

5.9 Site Servicing

Excavations for the installation of site services will be made through the topsoil, peat, fill, silty clay, and into the glacial till. Based on the observed groundwater levels at this site, the excavations for the installation of site services are expected to extend below the groundwater level.

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

Excavation side slopes above the water table should be stable in short term at 1H:1V (i.e., for Type 3 soils per OSHA of Ontario). Excavation side slopes below groundwater level will need to be cut back at 3H:1V (i.e., Type 4 soils). Alternatively, excavations within the overburden soils could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation. The use of a trench box will not, however, eliminate the potential for disturbance outside the trench box limits.

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

Additional guidelines pertaining to groundwater control are provided in Section 5.10.

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 does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. 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 sandy soils on the trench walls 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 material’s standard Proctor maximum dry density.

It should generally be possible to re-use the overburden soils as trench backfill.

Some of the overburden materials below the water table may be too wet to compact. Where that is the case, these 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 ground settlement over the trenches will likely occur. In that case, it would also be prudent to delay final paving for as long as practical and significant padding of the roadways may be required in these areas prior to final paving.

Boulders larger than 300 millimetres in diameter will also interfere with the backfill compaction and should be removed from the excavated material prior to re-use as backfill.

Where the trench will be covered with hard surfaced areas, the type of native material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment.

5.10 Groundwater Control

Groundwater inflow into the excavated trenches should feasibly be handled by pumping from sumps within the excavations. Groundwater inflows from the glacial till should be expected. The actual rate of groundwater inflow to the trenches 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.

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 m^3/day is pumped from the excavations. If the volume of water to be pumped will be less than 400 m^3/day, but more than 50 m^3/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. A Category 3 PTTW will be required for this site due to the expected high volumes of water that will need to be pumped from the trench excavations. The time required to obtain a PTTW can be several months. Consideration should therefore be given to applying for the permit well in advance of construction.

5.11 Pavement Design

In preparation for pavement construction, all topsoil peat, and deleterious fill should be removed from all pavement areas.

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material (SSM). These materials should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the materials' standard Proctor maximum dry density using suitable compaction equipment.

The surface of the subgrade or fill should be crowned 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 local roads, which will not experience bus or truck traffic (other than school bus and garbage collection), should consist of:

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

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

- Superpave 12.5 millimetres Surface Course – 40 millimetres
- Superpave 19 millimetres Base Course – 50 millimetres

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

The above pavement design is 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.

5.12 Pools, Decks and Additions

5.12.1 Above Ground and In Ground Pools

No special geotechnical considerations are necessary for the installation of in-ground or above ground pools.

5.12.2 Decks

There are no special geotechnical considerations for decks on this site.

5.12.3 Additions

Any proposed addition to a house (regardless of size) will require a geotechnical assessment. Written approval from a geotechnical engineer should be required by the City of Ottawa prior to the building permit being issued.

5.13 Trees

The clayey soils encountered within the eastern portion of the site are sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clayey soil, the clay undergoes shrinkage which can result in settlement of adjacent structures. The radial zone of influence of a tree is conventionally considered to be approximately equal to the height of the tree. Some restrictions will therefore need to be imposed on the planting of trees of higher water demand in close proximity to the foundations of houses in this area. However, these restrictions only apply to houses where the clayey soils exist at or below the founding elevation. Therefore, the limits should be re-evaluated once the final grading plan for the development has been established. Once the final grading plans have been accepted by the City of Ottawa, Golder Associates will produce a memo which identifies which Blocks that will require tree planting restrictions.

Table 1 provides a list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

5.14 Corrosion and Cement Type

One sample of soil from borehole 17-07 was submitted to Eurofins laboratory for basic chemical analyses related to the potential for sulphate attack on buried concrete elements and the potential corrosion of buried ferrous elements. The results of this testing are provided in Appendix C.

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

6.0 ADDITIONAL CONSIDERATIONS

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

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soils having adequate bearing capacity have been reached and that the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill as well as sewer bedding and backfill should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction view point.

The groundwater level monitoring devices installed at the site will require decommissioning in accordance with Ontario Regulation 128/03. However, it is expected that most of the wells will either be destroyed during construction or can be more economically abandoned as part of the construction contract. If that is not the case or is not considered feasible, abandonment of the monitoring wells can be carried out separately.

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

7.0 CLOSURE

We trust that this report meets your current requirements. If you have any questions, or if we may be of further assistance, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Stephen Dunlop, P.Eng.
Senior Geotechnical Engineer

Troy Skinner, P.Eng.
Associate, Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
T.M. SKINNER
100048673
PROVINCE OF ONTARIO

KM/SD/TMS/mvrd
n:\active\2017\3 proj\1773927 minto barrhaven town center\05_report\geotech\1773927 final rpt-geotech minto_02.docx

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TABLE 3

SOME COMMON TREES IN DECREASING ORDER OF WATER DEMAND

Broad Leaved Deciduous

Poplar

Alder

Aspen

Willow

Elm

Maple

Birch

Ash

Beech

Oak

Deciduous Conifer

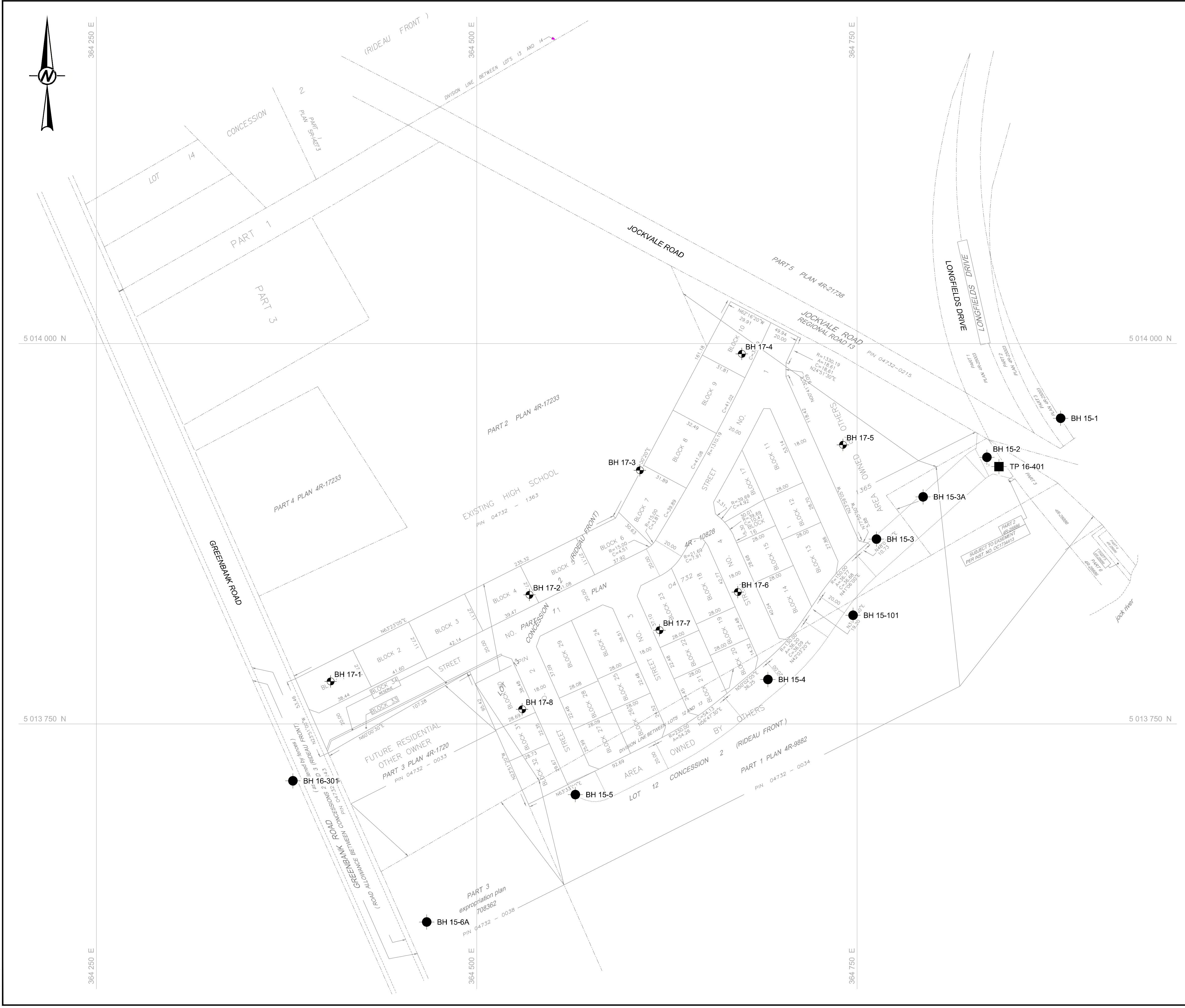
Larch

Evergreen Conifers

Spruce

Fir

Pine



KEY MAP

SCALE 1:25,000

LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
●	APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD., REPORT NO. 1523645
■	APPROXIMATE TEST PIT LOCATION, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD., REPORT NO. 1523645

REFERENCE(S)

1. BASE PLAN PROVIDED BY MINTO COMMUNITIES - CANADA, DATED 2017-02-23, FILE NO. 161613630-131-3311 Greenbank_d1_c3d-Feb 1-17.dwg
2. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 50 100

1:2,500 METRES

CLIENT
MINTO COMMUNITIES - CANADA

PROJECT
GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
3311 GREENBANK ROAD, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-30
DESIGNED	----
PREPARED	JM
REVIEWED	TMS
APPROVED	TMS

PROJECT NO.	PHASE	REV.	FIGURE
1773927	1000	0	1

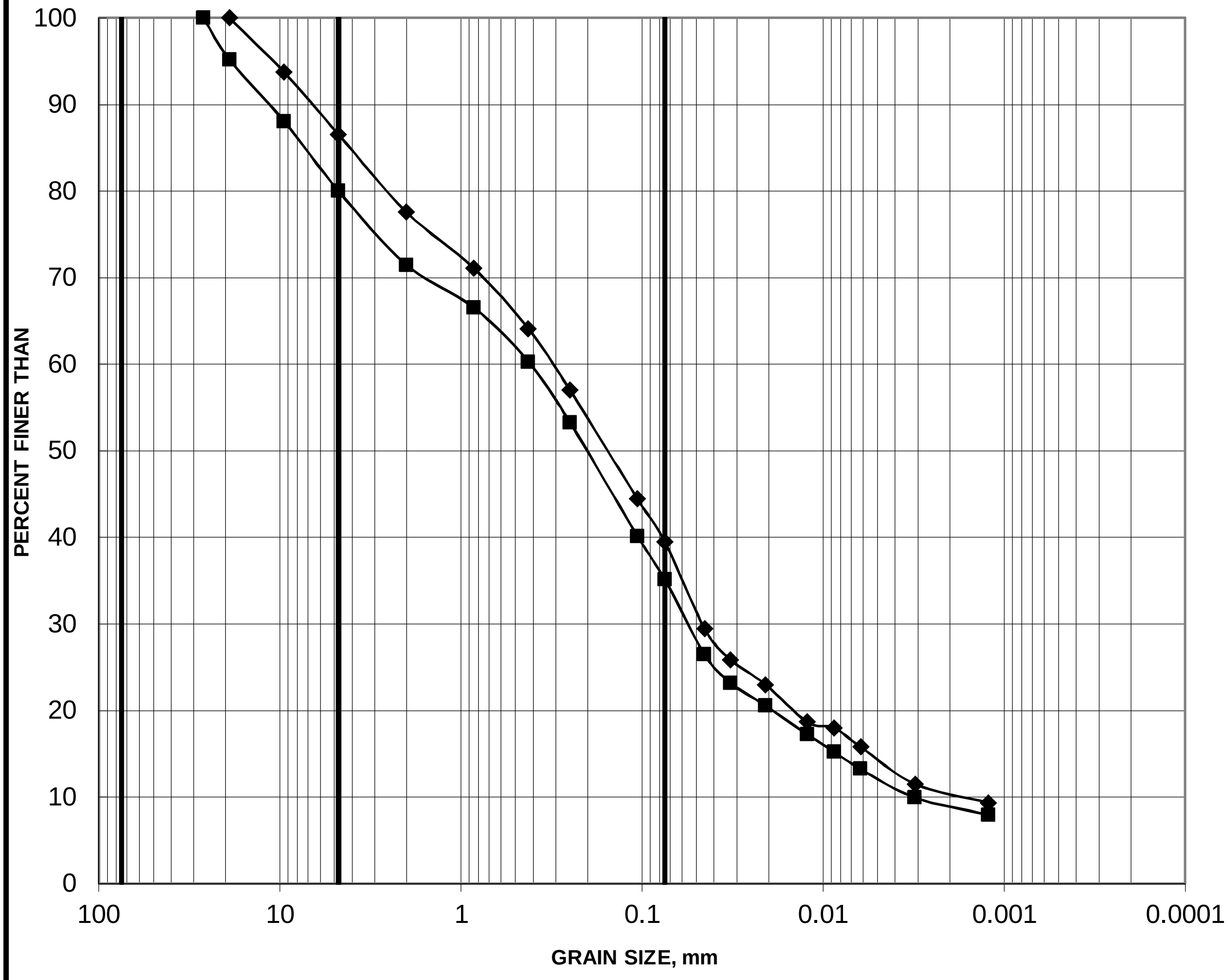
Path: \\golder.gds\gal\ottawa\Active\Spatial_IM\Minto_Communities\BarrhavenTownCentre\99_PROJ\1773927_Minto_ProposedDevelopment\40_PROD\Phase1000_Geotech | File Name: 1773927-1000-BG-0001.dwg | Last Edited By: jmckenzie Date: 2017-04-12 Time:3:03:37 PM | Printed By: jmckenzie Date: 2017-06-09 Time:9:09:46 AM

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

GRAIN SIZE DISTRIBUTION

FIGURE 2

GLACIAL TILL



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

Borehole	Sample	Depth (m)
■ 17-4	3	1.52-2.13
◆ 17-8	3	1.52-1.98

Project: 1773927

Golder Associates

Created by: CNM
Checked by: MI

APPENDIX A

Method of Soil Classification
List of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Record of Borehole Sheets
Current Investigation

PROJECT: 1773927

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 14, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	94.75
FILL - (SM) SILTY SAND; dark brown, contains rootlets; non-cohesive, moist, compact	0.00
FILL - (GP) sandy GRAVEL; brown; non-cohesive, moist, dense	94.14 0.61
(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense	93.65 1.10
End of Borehole Auger Refusal	89.39 5.36

SAMPLES NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT
1	SS	12	
2	SS	>50	
3	SS	39	○
4	SS	>50	
5	SS	>50	
6	SS	28	○
7	SS	36	

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:

- Bentonite Seal
- Native Backfill and Bentonite
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- WL in Screen at Elev. 90.44 m on April 5, 2017

DEPTH SCALE 1 : 50

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	97.94							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00	1	SS	12				
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense	97.33 0.61	2	SS	>50				
1										
2				3	SS	32				
				4	SS	30				
3				5	SS	39				
4		(SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense	94.13 3.81	6	SS	>50				
5				7	SS	50				
				8	SS	>50				
		End of Borehole Auger Refusal	92.30 5.64							
6										Open borehole dry upon completion of drilling
7										
8										
9										
10										

MIS-BHS 001 1773927.GPJ GAL-MIS.GDT 06/09/17 JM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 14, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.75					
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00					
		FILL - (SM) SILTY SAND, some gravel; brown, contains cobbles and boulders; non-cohesive, moist, dense to very loose		0.08	1	SS	37		
1					2	SS	9		
2					3	SS	28		
					4	SS	3		
3		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact		94.92 2.83	5	SS	11		
4					6	SS	28		
		End of Borehole Auger Refusal		93.31 4.44					
5									Open borehole dry upon completion of drilling
6									
7									
8									
9									
10									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-04

SHEET 1 OF 1

LOCATION: See Site Plan

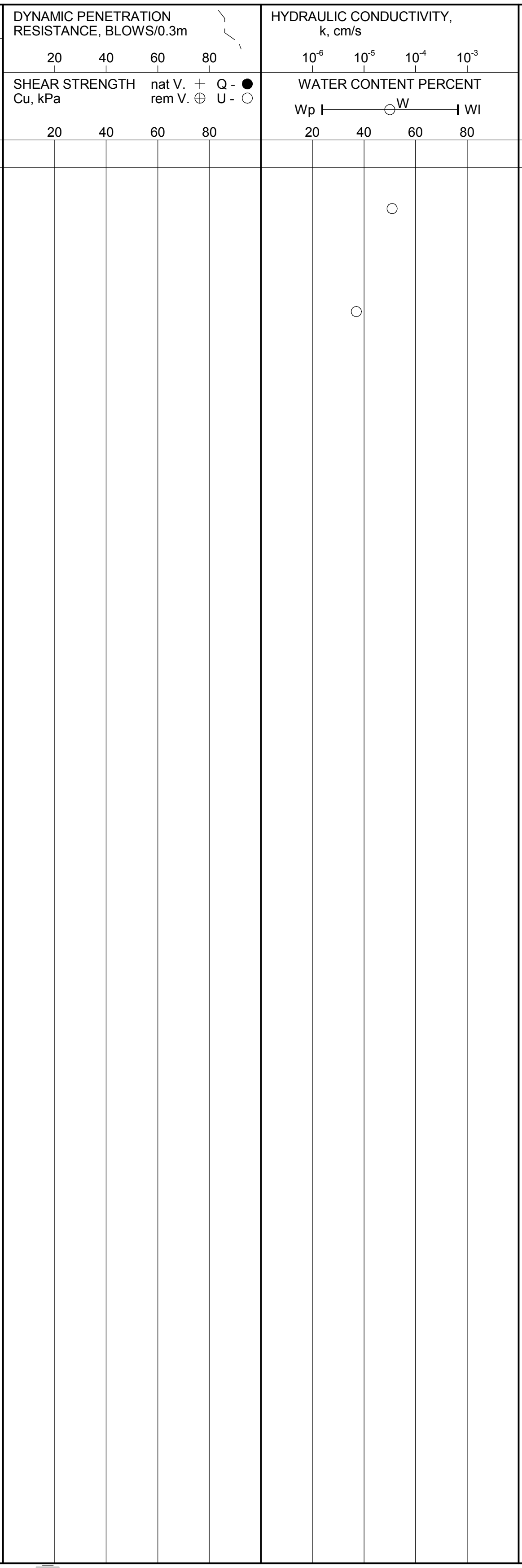
BORING DATE: March 14, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.21 0.00					
0	Power Auger 200 mm Diam. (Hollow Stem)	(PT) Fibrous PEAT; dark brown; non-cohesive							
		(CI/CH) SILTY CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		92.01 0.20	1	SS	6		
1					2	SS	8		
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact		90.69 1.52	3	SS	15	MH	
2					4	SS	13		
3		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact		89.16 3.05	5	SS	15		▽
		End of Borehole Auger Refusal		88.52 3.69					WL in open borehole at 3.20 m depth below ground surface upon completion of drilling
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-05

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 14, 2017

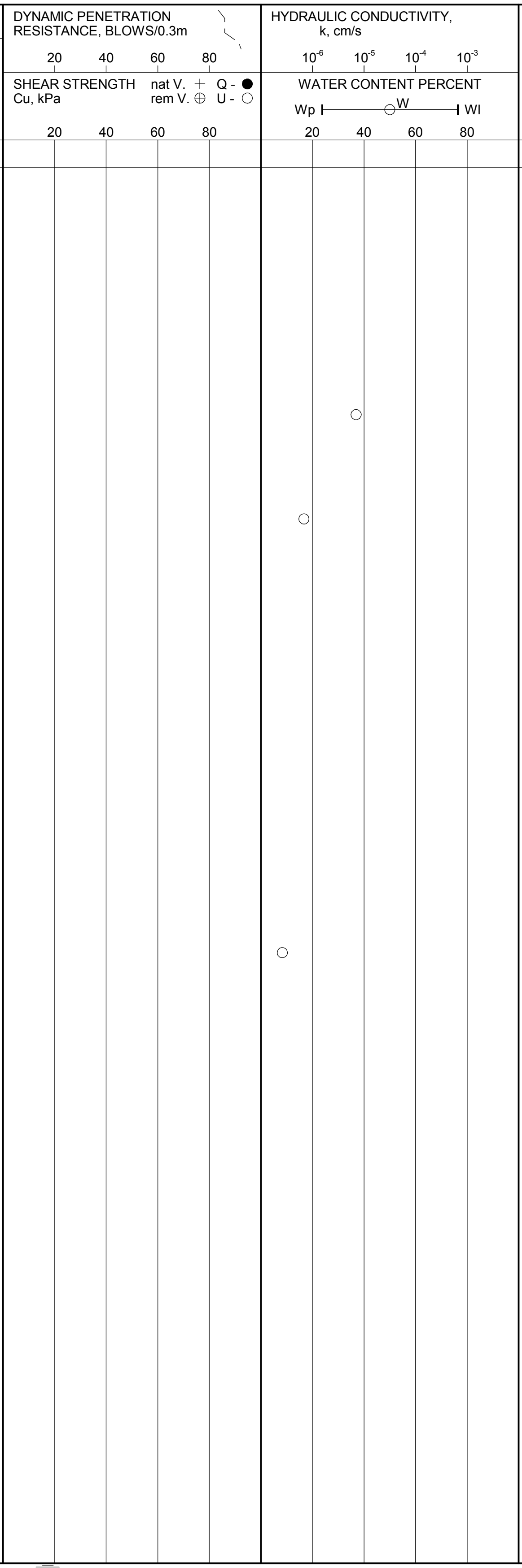
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	91.44
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00
	(CI/CH) SILTY CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	0.15
	(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, loose	89.15 2.29
	(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very loose to very dense	88.09 3.35
	End of Borehole	85.34 6.10

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	5
3	SS	3
4	SS	7
5	SS	7
6	SS	3
7	SS	53
8	SS	54



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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

∇

WL in open borehole at 1.22 m depth below ground surface upon completion of drilling

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

ADDITIONAL LAB. TESTING

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	93.28
TOPSOIL - (SM) SILTY SAND; dark brown; non-cohesive, moist	0.00
(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to very dense	92.67 0.61
(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact	89.47 3.81
(SP) SAND, fine, trace to some non-plastic fines; grey; non-cohesive, wet, compact	88.71 4.57
(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very dense	88.13 5.15
End of Borehole Auger Refusal	87.54 5.74

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	11
3	SS	>50
4	SS	17
5	SS	>50
6	SS	27
7	SS	17
8	SS	>50

PIEZOMETER OR STANDPIPE INSTALLATION

- Bentonite Seal
- Native Backfill and Bentonite
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen
- WL in Screen at Elev. 91.71 m on April 5, 2017

DEPTH SCALE 1 : 50

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

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		93.66							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL/TOPSOIL - (CL/ML) SILTY CLAY to CLAYEY SILT; dark brown; cohesive, moist		0.00	1	SS	4				
1					2	SS	6				
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, compact to dense		92.44 1.22	3	SS	32				
2					4	SS	15				
3		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to dense		90.61 3.05	5	SS	12				
4					6	SS	10				
5					7	SS	40				∇
					8	SS	13				
6		End of Borehole		87.56 6.10							WL in open borehole at 4.88 m depth below ground surface upon completion of drilling
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: TMS

PROJECT: 1773927

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.93					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00	1	GRAB	-		
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		95.62 0.31					
1					2	SS	>50		
					3	SS	47	MH	
2		End of Borehole Auger Refusal		93.92 2.01					Open borehole dry upon completion of drilling
3									
4									
5									
6									
7									
8									
9									
10									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: TMS

APPENDIX B

Borehole and Test Pit Records
Previous Investigations

PROJECT: 1523645

RECORD OF BOREHOLE: 15-1

SHEET 1 OF 1

LOCATION: N 5013950.9 ;E 364883.8

BORING DATE: August 20, 2015

DATUM: CGVD28

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^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.69							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, some gravel; brown, presence of organic matter; non-cohesive, moist	▨	0.00	1	AS	-				
		FILL - (SM) gravelly SILTY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (RE-WORKED GLACIAL TILL); non-cohesive, moist, dense to loose	▨	0.21							
1					2	SS	31		○		
2					3	SS	14				
					4	SS	9		○		
3		FILL - (SC) gravelly CLAYEY SAND; grey brown (RE-WORKED GLACIAL TILL); cohesive, w~PL	▨	88.34 3.35	5	SS	6				
4					6	SS	4		○	MH	
5					7	SS	9		○		
		(SM/SC) gravelly SILTY SAND to gravelly CLAYEY SAND; grey, contains sand seams (GLACIAL TILL); non-cohesive, wet, loose		86.05 5.64	8	SS	4				
6					9	SS	6		○		
7					10	SS	6		○	MH	
		(SM) gravelly SILTY SAND; grey, contains sand layers up to 150 mm in thickness, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact to very dense		84.07 7.62	11	SS	17				
8					12	SS	44		○	MH	
9					13	SS	53				
10											
11					14	SS	130		○	M	
		End of Borehole Auger Refusal		79.98 11.71							
12											
13											
14											
15											

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 2

LOCATION: N 5013925.3 ;E 364835.3

BORING DATE: August 14-17, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)
	GROUND SURFACE	91.59
Power Auger 200 mm Diam. (Hollow Stem)	FILL - (SM) SILTY SAND, trace to some gravel, trace organic matter; dark brown; non-cohesive, moist	0.10
	TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown; moist	0.34
	(SM) gravelly SILTY SAND; grey brown, with oxidation staining, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, dense to compact	87.78 3.81
	(SW/GW and SM) SAND and GRAVEL and gravelly SILTY SAND; grey brown, interbedded, presence of cobbles and boulders inferred from observations in adjacent test pit excavations; non-cohesive, wet, compact	85.49 6.10
Power Auger 200 mm Diam. (Hollow Stem); Wash Boring NW Casing	(SM and SP) gravelly SILTY SAND and gravelly SAND; grey brown to grey, interbedded, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, dense to very dense	80.01 11.58
	Borehole continued on RECORD OF DRILLHOLE 15-2	

SAMPLES NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT	ADDITIONAL LAB. TESTING
1	AS	-		
2	AS	-		
3	SS	39		
4	SS	18		
5	SS	25	○	MH
6	SS	21		
7	SS	16		
8	SS	25		
9	SS	26	○	M
10	SS	38		
11	SS	45		
12	SS	114	○	MH
13	SS	132		
14	SS	>120		
15	SS	>150		
16	RC	DD		
17	SS	>250		

PIEZOMETER OR STANDPIPE INSTALLATION

- Native Backfill
- Bentonite Seal
- Native Backfill ▽
- Bentonite Seal
- Granitic Sand and Native Backfill ▽
- 32 mm Diam. PVC #10 Slot Screen 'B'
- Granitic Sand
- Bentonite Seal
- Granitic Sand
- Native Backfill

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF DRILLHOLE: 15-2

SHEET 2 OF 2

LOCATION: N 5013925.3 ;E 364835.3

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: August 14-17, 2015

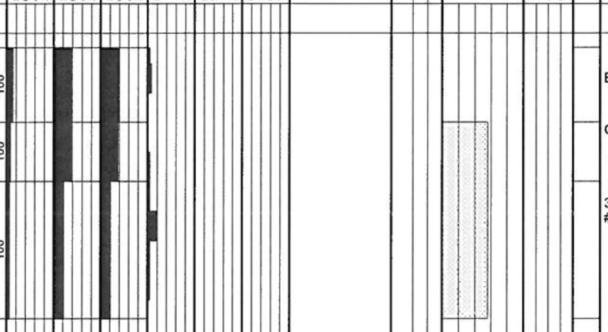
DRILL RIG: CME 850

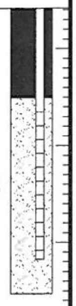
DRILLING CONTRACTOR: Marathon Drilling

DATUM: CGVD28

JN - Joint	BD - Bedding	PL - Planar	PO - Polished	BR - Broken Rock
FLT - Fault	FO - Foliation	CU - Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR - Shear	CO - Contact	UN - Undulating	SM - Smooth	
VN - Vein	OR - Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB - Mechanical Break	

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.25 m	DISCONTINUITY DATA B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	
		BEDROCK SURFACE		80.01																
	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK		11.58																
12					1	100														Bentonite Seal
13					2	100														Granitic Sand
																				32 mm Diam. PVC #10 Slot Screen 'A'
14				77.06	3	100														
		End of Drillhole		14.53																
15																				WL in Screen 'A' at Elev. 87.49 m on Aug. 24, 2015 WL in Screen 'B' at Elev. 89.41 m on April 7, 2016
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				
25																				
26																				





DEPTH SCALE

1 : 75

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-3

SHEET 1 OF 1

LOCATION: N 5013871.5 ;E 364762.7

BORING DATE: August 13, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
		GROUND SURFACE	91.39				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00	1	AS	-	
		(CI) sandy SILTY CLAY; grey brown, with oxidation staining, contains rootlets and silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	0.25				
1				2	SS	6	
			89.41	3	SS	3	
2		(SM/SC) gravelly SILTY SAND to gravelly CLAYEY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance and auger refusal (GLACIAL TILL); non-cohesive, wet, compact to very loose to dense - Auger Refusal in Glacial Till at 2.97 m	1.98	4	SS	21	
3	Wash Boring NW Casing			5	SS	8	
4				6	SS	4	
5				7	SS	20	M
			85.45	8	SS	45	
6		(SM) gravelly SILTY SAND; grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense	5.94	9	SS	105	
7				10	SS	90	
8			83.16	11	SS	62	
		End of Borehole	8.23				
9							
10							
11							
12							
13							
14							
15							

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-3A

SHEET 1 OF 1

LOCATION: N 5013899.3 ;E 364793.3

BORING DATE: August 17, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 15

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

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

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

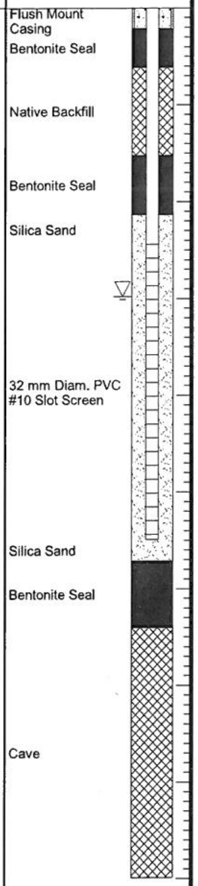
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.34
FILL - (SM) SILTY SAND; dark brown, contains organic matter; non-cohesive, moist	0.00
FILL - (SM/GM) SILTY SAND and GRAVEL; red brown and grey brown, contains organic matter; non-cohesive, moist, compact	0.21
TOPSOIL - (ML) CLAYEY SILT; dark brown; moist	90.63 0.71
(CI) sandy SILTY CLAY; grey brown, with oxidation staining, contains rootlets and silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	0.91
(SM/SC) gravelly SILTY SAND to gravelly CLAYEY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact to very loose	89.51 1.83
(SM/GM) SILTY SAND and GRAVEL; grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact	86.77 4.57
(SM/GM and SP) SILTY SAND and GRAVEL and gravelly SAND; grey, interbedded, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense	84.63 6.71
End of Borehole	82.35 8.99

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	AS	-	
2	SS	11	
3	SS	5	
4	SS	15	
5	SS	2	MH
6	SS	3	
7	SS	23	
8	SS	15	
9	SS	31	
10	SS	67	
11	SS	306	

PIEZOMETER OR STANDPIPE INSTALLATION



WL in Screen at Elev. 88.36 m on Aug. 24, 2015

DEPTH SCALE
1 : 75

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1

LOCATION: N 5013779.2 ;E 364691.4

BORING DATE: August 18, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING
		GROUND SURFACE		92.00				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown; moist		0.00	1	AS	-	
		(CI) SILTY CLAY, some sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		91.72 0.28				
1					2	SS	9	
		(SC) gravelly CLAYEY SAND; grey brown to grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, loose to compact		90.55 1.45	3	SS	2	
2					4	SS	13	
3					5	SS	4	
4					6	SS	4	
		(SM/GM) SILTY SAND and GRAVEL; grey, presence of cobbles and boulders inferred from auger resistance and auger refusal (GLACIAL TILL); non-cohesive, wet, very dense		87.43 4.57	7	SS	65	
5					8	SS	>50	
		- 175 mm limestone cobble encountered at 5.79 m			9	RC	DD	
6		(ML/SM) sandy SILT to SILTY SAND, trace to some gravel; grey; non-cohesive, wet, dense to very dense		85.90 6.10	10	SS	42	M
7								
8					11	SS	60	
		(SM) gravelly SILTY SAND; grey, contains sand layers, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense		83.31 8.69				
9					12	SS	>50	
10		End of Borehole		81.94 10.06				
11								
12								
13								
14								
15								

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-5

SHEET 1 OF 1

LOCATION: N 5013703.6 ;E 364564.8

BORING DATE: August 18-19, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

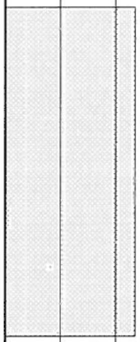
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

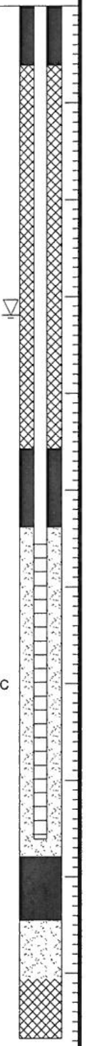
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	92.79					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00					Bentonite Seal
		(SM/GM/SC) SILTY SAND and GRAVEL to CLAYEY SAND, some gravel; grey brown, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, moist, compact	92.51 0.28					
1				1	SS	20		
		(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact	91.42 1.37					
2				2	SS	21		
				3	SS	11		Native Backfill
3								▽
				4	SS	13		
4		(SC) gravelly CLAYEY SAND; grey brown to grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very loose to loose	88.98 3.81	5	SS	9		
5				6	SS	2		Bentonite Seal
		(SM/GM and SP) SILTY SAND and GRAVEL and SAND; grey, interbedded, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact	87.15 5.64	7	SS	11		Silica Sand
6				8	SS	16		
7				9	SS	22		32 mm Diam. PVC #10 Slot Screen
		(ML) sandy SILT, trace gravel; grey, contains clayey silt seams; non-cohesive, wet, compact	85.17 7.62					
8				10	SS	25	M	
		(ML and SM) sandy SILT and SILTY SAND, some gravel; grey, interbedded (GLACIAL TILL); non-cohesive, wet, very dense	84.41 8.38	11	SS	55		Silica Sand
9								Bentonite Seal
				12	SS	51		Silica Sand
10				13	SS	76		Cave
		End of Borehole	82.12 10.67					
11								WL in Screen at Elev. 89.60 m on Aug. 24, 2015
12								
13								
14								
15								





DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-6A

SHEET 1 OF 1

LOCATION: N 5013619.9 ;E 364467.1

BORING DATE: August 20, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

PIEZOMETER OR STANDPIPE INSTALLATION

Depth scale metres	Boring method	Soil profile: Description	Elev. / Depth (m)	Samples: Number	Type	Blows/0.30m	Additional lab. testing
		GROUND SURFACE	94.09				
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - Mixture of (SW/GW) SAND and GRAVEL and (SM) SILTY SAND; brown, contains organic matter and fragments of concrete and mortar; non-cohesive, moist	0.00	1	AS	-	
1		(SM/GM) SILTY SAND and GRAVEL; grey brown to grey, with oxidation staining, contains sandy silt seams, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense	93.02 1.07	2	SS	22	
2				3	SS	39	
				4	SS	43	
3				5	SS	57	
4				6	SS	23	
5				7	SS	93	
6				8	SS	42	
7		(ML and SM) gravelly sandy SILT and SILTY SAND, trace gravel; grey, laminated; non-cohesive, wet, dense to compact	87.08 7.01				
8				9	SS	39	M
9				10	SS	26	
10		(SW/GW) SAND and GRAVEL, medium to coarse; grey, presence of cobbles and boulders inferred from auger resistance; non-cohesive, wet, very dense	84.34 9.75				
11		(ML) sandy SILT; grey; non-cohesive, wet, very dense	83.12 10.97	11	SS	168	
		End of Borehole	11.13				

Note:

The lead auger and cutting head (a 1.5 m long hollow-stem auger) became dislodged during extraction. The auger is likely located at the bottom of the hole (about 11 m depth).

12 13 14 15

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-6B

SHEET 1 OF 1

LOCATION: N 5013655.3 ;E 364419.6

BORING DATE: August 21, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	94.06					
0	Power Auger 200 mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE	0.00					
		FILL - (GW) sandy GRAVEL, angular; grey (PAVEMENT STRUCTURE)	0.15	1	AS	-		
			0.33	2	AS	-		
		FILL - (SP) gravelly SAND; brown (PAVEMENT STRUCTURE)	0.54	3	AS	-		
1		TOPSOIL - (SM/ML) SILTY SAND to sandy SILT, trace gravel; dark brown to black; wet	93.20 0.86	4	SS	7		
		(ML) sandy SILT, trace gravel; brown, contains clayey silt seams; non-cohesive, moist, loose		5	SS	22		
2		(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to dense	92.23 1.83					
3				6	SS	37		
4		(SP) SAND, trace gravel; grey brown, contains silty sand layers; non-cohesive, wet, dense	89.64 4.42					
5				7	SS	34	M	
6		(ML and SM) sandy SILT and SILTY SAND; grey brown, interbedded; non-cohesive, wet, very dense	88.42 5.64	8	SS	67		
7		(ML/SM) gravelly sandy SILT to gravelly SILTY SAND; grey, presence of cobbles inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, very dense	87.35 6.71					
8				9	SS	50	MH	
9								
10				10	SS	102		
11				11	SS	162		
		End of Borehole	82.78 11.28					
12								
13								
14								
15								

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-7

SHEET 1 OF 2

LOCATION: N 5013739.7 ;E 364291.3

BORING DATE: August 12, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-8} 10^{-6} 10^{-4} 10^{-2}

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	92.84					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML/SM) sandy SILT to SILTY SAND; dark brown; moist	0.00 92.56	1	AS	-		Native Backfill
		(SM) gravelly SILTY SAND; grey brown, with oxidation staining, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense	0.28					Bentonite Seal
1				2	SS	>50		
				3	SS	17		▽
2								
				4	SS	46		
3			89.64					
		(SM) SILTY SAND, fine, trace gravel; brown; non-cohesive, wet, compact	3.20	5	SS	12		Native Backfill
4			88.72	6	SS	22	M	
		(SM) gravelly SILTY SAND; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact	4.12					
			87.81	7	SS	21		
5		(ML) gravelly sandy SILT; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact	5.03					
				8	SS	11		
6			86.64	9	SS	>50		
		Borehole continued on RECORD OF DRILLHOLE 15-7	6.2					
7								
8								
9								
10								
11								
12								
13								
14								
15								

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

LOCATION: N 5013739.7 ;E 364291.3

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: 15-7

DRILLING DATE: August 12, 2015

DRILL RIG: CME 850

DRILLING CONTRACTOR: Marathon Drilling

SHEET 2 OF 2

DATUM: CGVD28

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

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

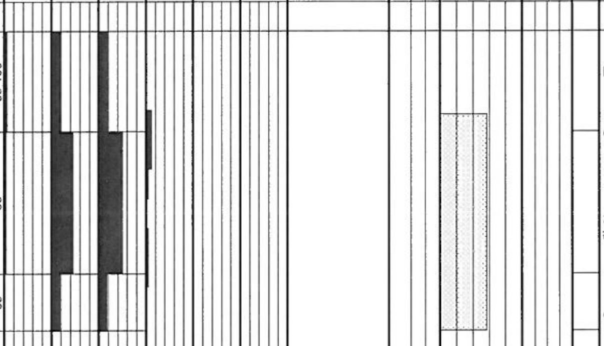
PL - Planar
CU - Curved
UN - Undulating
ST - Stepped
IR - Irregular

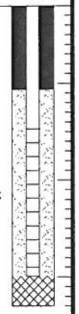
PO - Polished
K - Slickensided
SM - Smooth
Ro - Rough
MB - Mechanical Break

BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH	COLOUR % RETURN
		BEDROCK SURFACE		86.64			
	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK	▨	6.20	1		85-100
8					2		85
9				83.54 9.30	3		85
		End of Drillhole					





WL in Screen at Elev. 90.93 m on April 7, 2016

DEPTH SCALE
1 : 75

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 15-17

SHEET 1 OF 1

LOCATION: N 5013731.1 ;E 364221.7

BORING DATE: August 11, 2015

DATUM: CGVD28

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^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		GROUND SURFACE		93.79							
0	Power Auger 200 mm Diam. (Hollow Stem)	FILL - (ML) gravelly sandy SILT; dark brown and red brown, contains organic matter; non-cohesive, moist, compact		0.00	1	SS	15				
1					2	SS	15				
		FILL - (ML) CLAYEY SILT, some gravel; dark grey; cohesive, w>PL		92.57 1.22	3	SS	7				
2		TOPSOIL - (OL) ORGANIC SILT; black; moist		91.75 2.04	4	SS	11				
		(ML) gravelly sandy SILT; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		2.23	5	SS	24				
3					6	SS	29				
4		(SM) gravelly SILTY SAND; grey, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, wet, compact		90.13 3.66	7	SS	20				
					8	SS	13				
5		End of Borehole		88.91 4.88							
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 1523645

RECORD OF PROBEHOLE: 15-17A

SHEET 1 OF 1

LOCATION: N 5013728.8 ;E 364221.0

BORING DATE: August 12, 2015

DATUM: CGVD28

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^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		GROUND SURFACE		93.62							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 15-17 for stratigraphy		0.00							
1											
2											
3											
4											
5		Probable Glacial Till	▨	88.74 4.88							
		End of Probehole Auger Refusal		88.08 5.54							
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1523645.GPJ GAL-MIS.GDT 05/13/16 JM

PROJECT: 1523645

RECORD OF BOREHOLE: 15-101

SHEET 1 OF 1

LOCATION: N 5013821.4 ;E 364747.3

BORING DATE: August 19, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 15

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem) (0 to 10 m)

SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	92.43
FILL - (SM/GM) SILTY SAND and GRAVEL; red brown and brown, contains organic matter, presence of cobbles and boulders inferred from auger resistance; non-cohesive, moist	0.00
TOPSOIL - (SM) SILTY SAND; black; moist	91.36 1.07
(SM) gravelly SILTY SAND; grey brown, presence of cobbles and boulders inferred from auger resistance (GLACIAL TILL); non-cohesive, moist to wet, compact to dense	1.22
(SM/GM) gravelly SILTY SAND to SILTY SAND and GRAVEL; grey, contains sand layers, presence of cobbles inferred from auger resistance (GLACIAL TILL); wet, loose to dense	88.62 3.81
(ML) sandy SILT, some gravel; grey, contains clayey silt seams (GLACIAL TILL); non-cohesive, wet, compact	83.74 8.69
End of Borehole Sampler Refusal	82.42 10.01

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	12
2	SS	20
3	SS	36
4	SS	12
5	SS	12
6	SS	12
7	SS	8
8	SS	24
9	SS	43
10	SS	22
11	SS	>50

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^{-8} 10^{-6} 10^{-4} 10^{-2}

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION:
- Bentonite Seal
- Native Backfill
- Bentonite Seal
- Granitic Sand
- 38 mm Diam. PVC #10 Slot Screen
- Granitic Sand
- Bentonite Seal
- Silica Sand
- Native Backfill

WL in Screen at Elev. 88.86 m on Aug. 24, 2015

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 1523645

RECORD OF BOREHOLE: 16-301

SHEET 1 OF 2

LOCATION: N 5013712.6 ;E 364379.1

BORING DATE: March 4-7, 2016

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^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.16							
0		Probable Sand		0.00							
											▽
1		Probable Glacial Till		92.25 0.91							
2											
3											
4											
5	Wash Boring NW Casing										
6											
7											
8											
9											WL in open borehole at 0.78 m depth below ground surface upon completion of drilling
10		Borehole continued on RECORD OF DRILLHOLE 16-301		83.36 9.8							
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

PROJECT: 1523645

RECORD OF DRILLHOLE: 16-301

SHEET 2 OF 2

LOCATION: N 5013712.6 ;E 364379.1

INCLINATION: -90° AZIMUTH: —

DRILLING DATE: March 4-7, 2016

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC

DATUM: CGVD28

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

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

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

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

BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	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	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	
		BEDROCK SURFACE		83.36																
10	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK		9.80	1	100														
11					2	100														
12					3	100														
13		End of Drillhole		80.16 13.00																WL in open borehole at 0.78 m depth below ground surface upon completion of drilling
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21																				
22																				
23																				
24																				

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

PROJECT: 1523645

RECORD OF BOREHOLE: 16-302

SHEET 1 OF 2

LOCATION: N 5013746.6 ;E 364217.4

BORING DATE: March 4, 2016

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^{-8} 10^{-6} 10^{-4} 10^{-2} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.06							
0	Wash Boring NW Casing	Probable Sand		0.00							
1		Probable Glacial Till		92.15 0.91							
8		Borehole continued on RECORD OF DRILLHOLE 16-302		85.04 8.02							

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

PROJECT: 1523645

LOCATION: N 5013746.6 ;E 364217.4

INCLINATION: -90° AZIMUTH: —

RECORD OF DRILLHOLE: 16-302

DRILLING DATE: March 4, 2016

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC

SHEET 2 OF 2

DATUM: CGVD28

JN - Joint	BD- Bedding	PL - Planar	PO- Polished	BR - Broken Rock
FLT - Fault	FO- Foliation	CU- Curved	K - Slickensided	**NOTE:** For additional abbreviations refer to list of abbreviations & symbols.
SHR- Shear	CO- Contact	UN- Undulating	SM- Smooth	
VN - Vein	OR- Orthogonal	ST - Stepped	Ro - Rough	
CJ - Conjugate	CL - Cleavage	IR - Irregular	MB- Mechanical Break	

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	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-8} 10^{-6} 10^{-4} 10^{-2}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.
		BEDROCK SURFACE		85.04															
	Rotary Drill NQ Core	Fresh, thinly to thickly bedded, grey DOLOMITE BEDROCK		8.02	1	100													
9					2	0													
10					3	0													
11				81.86 11.20															
		End of Drillhole																	
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			

DEPTH SCALE

1 : 75

Golder Associates

LOGGED: DWM

CHECKED:

RECORD OF TEST PIT

Test Pit Number (Elevation)	Depth (metres)	Description
TP 16-401 (~91.6)	0.0 – 0.3	TOPSOIL/FILL - (ML) Clayey sandy SILT; brown to black, non-cohesive, moist
	0.3 – 1.0	FILL - (SM) SILTY SAND, some gravel to gravelly; dark brown, with organics, metal, plastic, glass, rubber, wood, cobbles and boulders up to 600 mm; non-cohesive, moist
	1.0 – 3.7	(SM) Gravelly SILTY SAND; brown to grey brown, with cobbles and boulders up to 1400 mm (GLACIAL TILL); non-cohesive, moist
	3.7 – 4.7	(SM) Gravelly SILTY SAND; grey, with cobbles and boulders up to 400 mm (GLACIAL TILL); non-cohesive, moist to wet
	4.7 – 6.0	(SP-GP) SAND and GRAVEL, some non-plastic fines; grey brown, with cobbles and boulders up to 500 mm; non-cohesive, wet
	6.0 – 8.2	(SM) Gravelly SILTY SAND; grey, with cobbles and boulders (GLACIAL TILL); non-cohesive, wet
	8.2	END OF TEST PIT

Notes:

1) Water seepage noted at about 4.0 m below ground surface.
2) Significant groundwater inflow observed between about 4.7 and 6.0 m below ground surface (from sand and gravel layer).
3) Test pit walls sloughing within sand and gravel layer (between about 4.7 and 6.0 m below ground surface).

Sample	Depth (m)
1	5.0

APPENDIX C

Results of Basic Chemical Analysis
Eurofins Laboratories Report No. 1704248

Certificate of Analysis

Client:	Golder Associates Ltd. (Ottawa) 1931 Robertson Road Ottawa, ON K2H 5B7	Report Number:	1704248
		Date Submitted:	2017-03-24
		Date Reported:	2017-03-30
		Project:	1773927
Attention:	Mr. Alex Meacoe	COC #:	816818
PO#:			
Invoice to:	Golder Associates Ltd. (Ottawa)		

Dear Alex Meacoe:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL:

Addrine Thomas
Team Leader, Inorganics

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Eurofins Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Eurofins(Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Eurofins(Mississauga) is accredited for specific parameters by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Eurofins recommends consulting the official provincial or federal guideline as required.

eurofins
Environment Testing

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: 1704248
Date Submitted: 2017-03-24
Date Reported: 2017-03-30
Project: 1773927
COC #: 816818

				Lab I.D.	1285612
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2017-03-03
				Sample I.D.	BH 17-7 Sa3 15-7
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Agri. - Soil	pH	2.0			8.2
General Chemistry	Cl	0.002	%		<0.002
	Electrical Conductivity	0.05	mS/cm		0.13
	Resistivity	1	ohm-cm		7690
	SO4	0.01	%		<0.01

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Certificate of Analysis

Client:	Golder Associates Ltd. (Ottawa) 1931 Robertson Road Ottawa, ON K2H 5B7	Report Number:	1704248
Attention:	Mr. Alex Meacoe	Date Submitted:	2017-03-24
PO#:		Date Reported:	2017-03-30
Invoice to:	Golder Associates Ltd. (Ottawa)	Project:	1773927
		COC #:	816818

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No 323665 **Analysis/Extraction Date** 2017-03-28 **Analyst** C N			
Method Ag Soil			
pH			90-110
Method Cond-Soil			
Electrical Conductivity			85-115
Method Resistivity - soil			
Resistivity	<1 ohm-cm		
Run No 323708 **Analysis/Extraction Date** 2017-03-29 **Analyst** C F			
Method C CSA A23.2-4B			
Chloride		101	90-110
Run No 323769 **Analysis/Extraction Date** 2017-03-29 **Analyst** C F			
Method C SM4500-SO4--D			
SO4	<0.01 %	110	70-130

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX D

Hyrdogeology Results
Previous Investigation

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-2A

INTERVAL (metres below ground surface)

Top of Interval = 12.50
Bottom of Interval = 14.53

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

where K=m/sec

where:

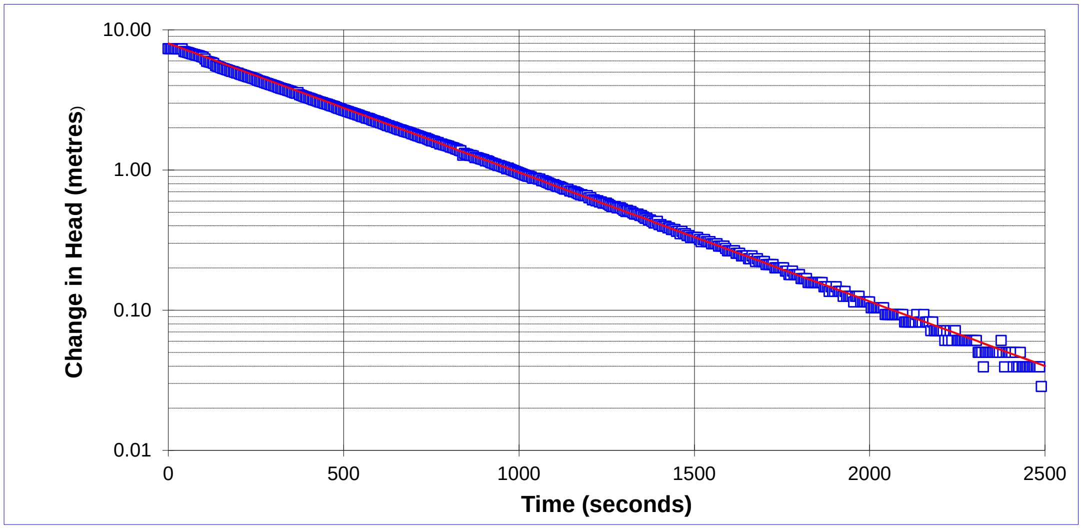
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.04
L_e =	2.03
$\ln(R_e/r_w)$	2.74
y_0 =	8.00
y_t =	0.04
t =	2500

RESULTS

K=	4E-07	m/sec
K=	4E-05	cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/25/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/3/2015

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-2B

INTERVAL (metres below ground surface)

Top of Interval = 3.82
Bottom of Interval = 6.05

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

where K=m/sec

where:

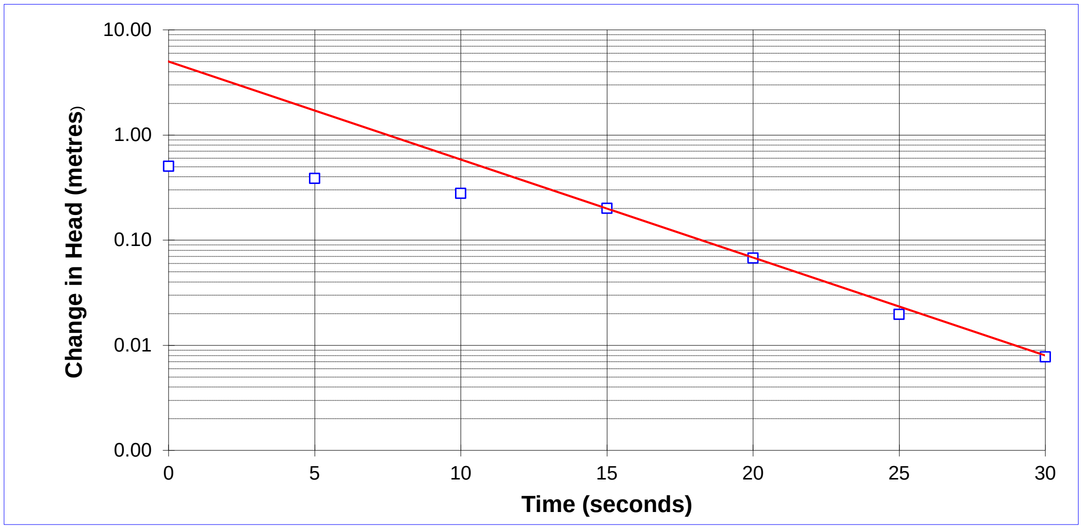
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c = 0.02
r_w = 0.10
L_e = 2.23
$\ln(R_e/r_w)$ 2.07
y_0 = 5.00
y_t = 0.01
t = 30.0

RESULTS

K= 3E-05 m/sec
K= 3E-03 cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/25/15

Analysis By: BH
Checked By: BTB
Analysis Date: 9/3/2015

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-5

INTERVAL (metres below ground surface)

Top of Interval = 5.38
Bottom of Interval = 8.79

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

where K=m/sec

where:

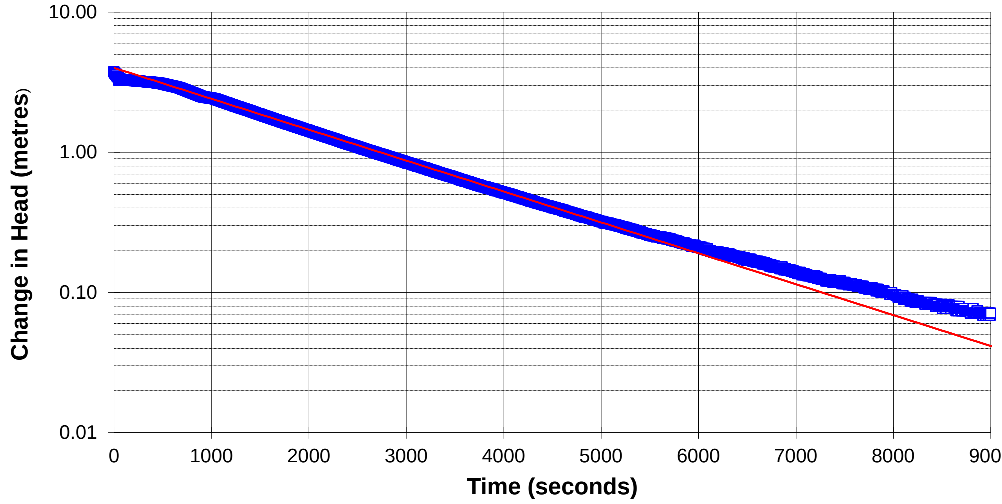
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.10
L_e =	3.41
$ln(R_e/r_w)$	2.56
y_0 =	4.00
y_t =	0.03
t =	10000.0

RESULTS

K=	5E-08	m/sec
K=	5E-06	cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/25/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/3/2015

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-7

INTERVAL (metres below ground surface)

Top of Interval = 7.06
Bottom of Interval = 9.30

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

where K=m/sec

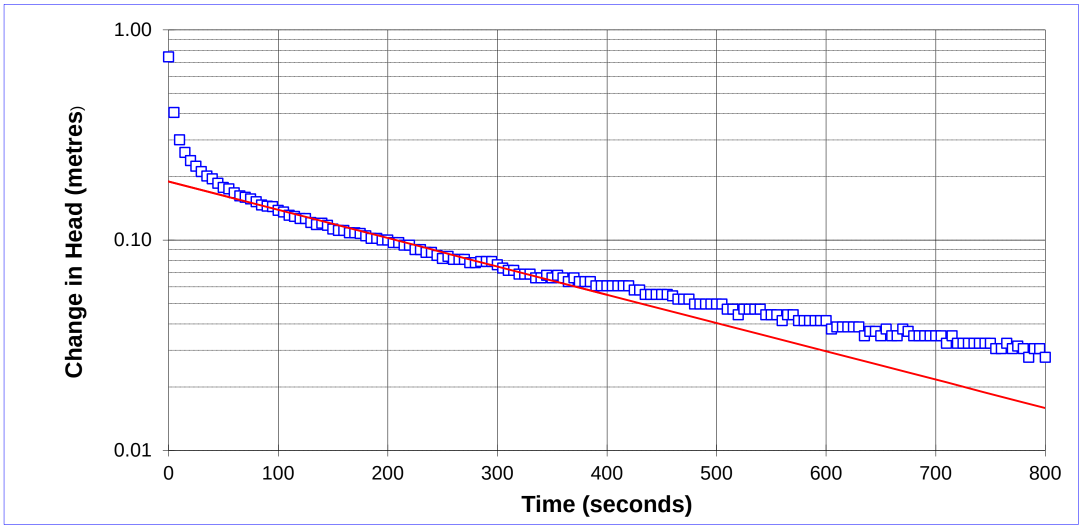
where:

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

INPUT PARAMETERS	
r_c =	0.02
r_w =	0.04
L_e =	2.24
$\ln(R_e/r_w)$	2.82
y_0 =	0.19
y_t =	0.06
t =	400

RESULTS

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



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/26/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/4/2015

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BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-9A

INTERVAL (metres below ground surface)

Top of Interval = 6.93
Bottom of Interval = 9.14

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

where K=m/sec

where:

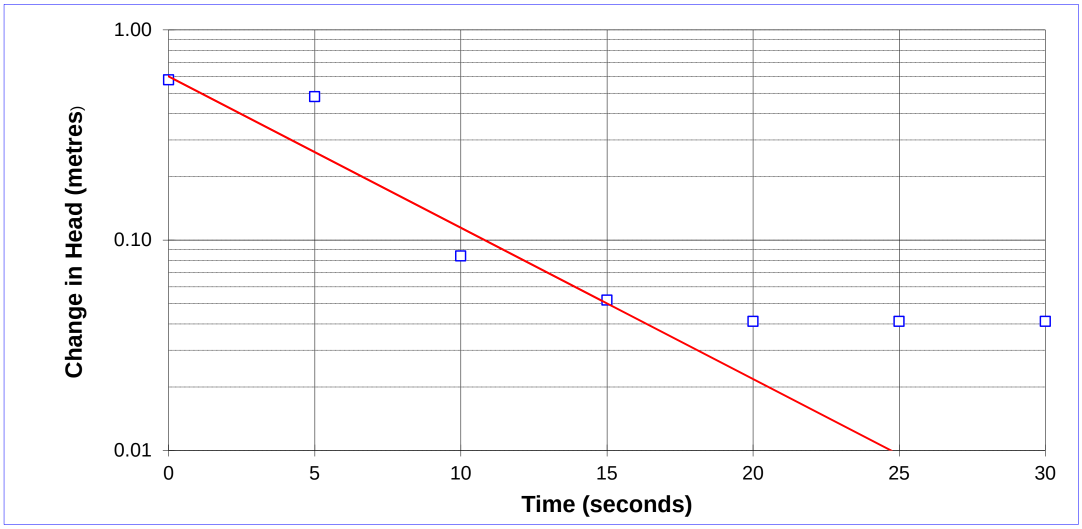
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.10
L_e =	2.21
$\ln(R_e/r_w)$	1.85
y_0 =	0.60
y_t =	0.05
t =	15.0

RESULTS

K=	3E-05	m/sec
K=	3E-03	cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/26/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/4/2015

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BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-12A

INTERVAL (metres below ground surface)

Top of Interval = 10.36
Bottom of Interval = 12.19

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

where K=m/sec

where:

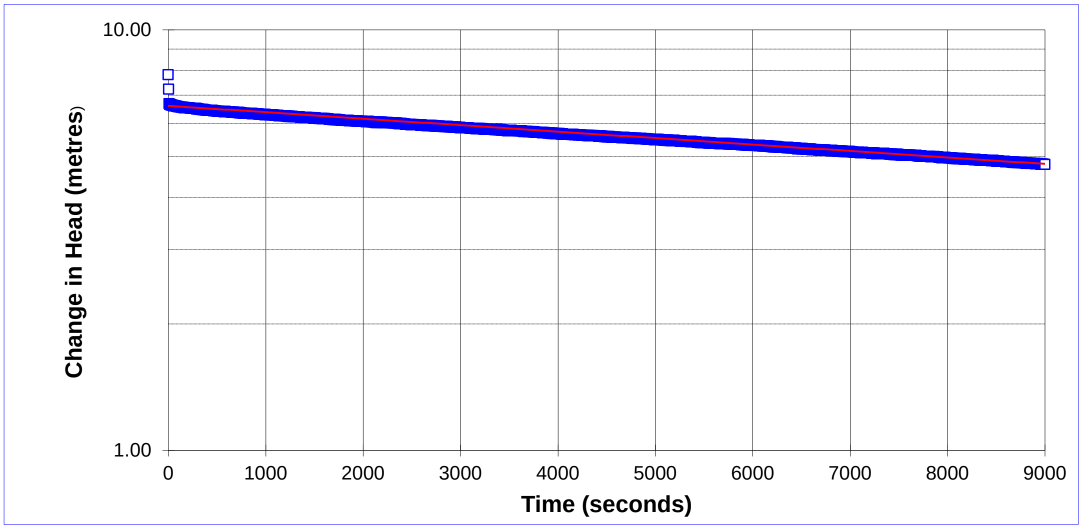
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.10
L_e =	1.83
$\ln(R_e/r_w)$	1.75
y_0 =	6.60
y_t =	4.80
t =	9000

RESULTS

K=	6E-09	m/sec
K=	6E-07	cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/26/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/4/2015

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-12B

INTERVAL (metres below ground surface)

Top of Interval = 4.27
Bottom of Interval = 8.08

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

where K=m/sec

where:

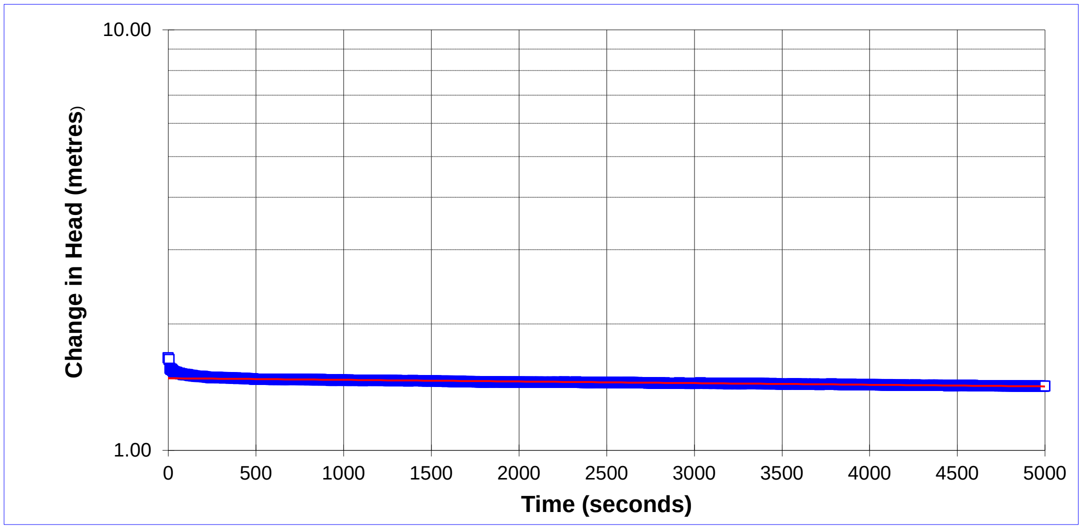
r_c = casing radius (metres);
R_e = effective radius (metres);
L_e = length of screened interval (metres);
r_w = radial distance to undisturbed aquifer (metres)
y_0 = initial drawdown (metres)
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.10
L_e =	3.81
$\ln(R_e/r_w)$	2.51
y_0 =	1.49
y_t =	1.42
t =	5000.0

RESULTS

K=	1E-09	m/sec
K=	1E-07	cm/sec



Project Name: Novatech/SNC Phase 2/Ottawa
Project No.: 1523645
Test Date: 08/26/15

Analysis By: BH
Checked By: DH
Analysis Date: 9/4/2015

BOUWER AND RICE SLUG TEST ANALYSIS
RISING HEAD TEST 15-15

INTERVAL (metres below ground surface)

Top of Interval = 5.13
Bottom of Interval = 7.62

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

where K=m/sec

where:

r_c = casing radius (metres);

R_e = effective radius (metres);

L_e = length of screened interval (metres);

r_w = radial distance to undisturbed aquifer (metres)

y_0 = initial drawdown (metres)

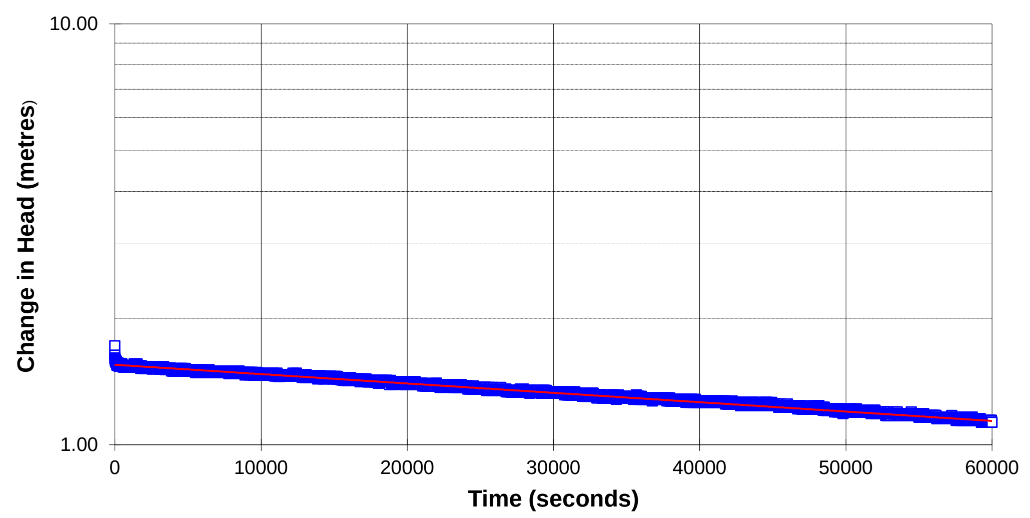
y_t = drawdown (metres) at time t (seconds)

INPUT PARAMETERS

r_c =	0.02
r_w =	0.10
L_e =	2.49
$\ln(R_e/r_w)$	2.12
y_0 =	1.55
y_t =	1.14
t =	60000.0

RESULTS

K=	8E-10	m/sec
K=	8E-08	cm/sec



Project Name:	Novatech/SNC Phase 2/Ottawa	Analysis By:	BH
Project No.:	1523645	Checked By:	DH
Test Date:	08/26/15	Analysis Date:	9/4/2015

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