January 2018

REPORT ON

Geotechnical Investigation
Residential Development
Kanata Lakes - Phase 9
Ottawa, Ontario

Submitted to:
Urbandale Corporation
2193 Arch Street
Ottawa, Ontario
K1G 2H5

REPORT

A world of capabilities delivered locally

Report Number: 11-1121-0028 Rev-01

Distribution:

2 copies - Urbandale Corporation
7 copies - IBI Corporation
1 copy - Golder Associates Ltd.

Golder Associates

Table of Contents

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for Phase 9 of the Kanata Lakes residential development located east of Goulbourn Forced Road and north of Beaver Pond Park in Ottawa, Ontario.

The geotechnical investigation included an assessment of the general subsurface conditions across Phase 9 of the development site by means of 102 test pits, 7 boreholes, 4 hand-augerholes, and laboratory testing. Based on an interpretation of the factual information obtained, a general description of the subsurface and groundwater conditions is presented. These interpreted subsurface conditions and available project details were used to prepare engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could 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 to develop Phase 9 of the Kanata Lakes residential development located east of Goulbourn Forced Road and north of Beaver Pond Park in Ottawa, Ontario. The approximate location of the site is shown on the attached Key Plan (Figure 1).

The following is understood about the project and site:

- The site is bounded to the west by Goulbourn Forced Road, to the south by Beaver Pond Park, and to the north by an existing railway.
- The site measures approximately 190 to 330 metres wide and 1,200 metres long in plan area.
- The site will be developed with a mixture of single family homes and townhouse blocks.
- The site is currently cleared of tree cover.
- The existing ground surface elevation is generally lowest on the north and south boundaries of the site and higher in the central portions, but the ground surface also undulates significantly throughout the site. Ground surface elevations vary by up to about 15 metres, ranging from about 90 to 105 metres.

Based on published geological mapping and the results of previous investigations carried out in the vicinity of the site, the subsurface conditions within Phase 9 of the development are indicated to vary significantly due to the undulating nature of the bedrock surface. In many areas of the site, the bedrock, which is indicated to consist of variable Precambrian metamorphic and igneous rock types, is indicated to be at or near ground surface. Where the bedrock is deeper, the subsurface conditions are indicated to consist of native deposits of sensitive silty clay and/or glacial till over the Precambrian bedrock.

3.0 PROCEDURE

The fieldwork for this investigation was carried out in three phases, summarized as follows:

- Phase I was carried out between April 11 and 13, 2012. During Phase I, 102 test pits (numbered 12-01 to 12-05, 12-07, 12-09, 12-10, 12-12 to 12-20, and 12-27 to 12-111, inclusive) were advanced using a track-mounted excavator supplied and operated by Glenn Wright Excavating of Ottawa, Ontario. These test pits were advanced to depths ranging from about 0.1 (refusal on the bedrock surface) to 8.6 metres below the existing ground surface.

  Within the test pits, the subsurface conditions encountered and approximate depths to strata changes were visually logged at the time of excavating. Grab samples of the soils were retrieved from the sidewalls of selected test pits at the time of excavation. Field vanes were taken in select block samples of the silty clay to determine the "approximate" undrained shear strength of this soil unit.

  The groundwater seepage conditions within the test pits were observed and recorded during the short period that the test pits remained open.

- Phase II was carried out on August 4 and 5, 2016. During Phase II, seven boreholes (numbered 16-1 to 16-7, inclusive) were advanced using a track mounted hollow-stem auger drill rig supplied and operated by George Downing Estate Drilling of Grenville-sur-la-rouge, Quebec. These boreholes were advanced to depths ranging from about 2.2 to 8.8 metres below the existing ground surface to provide additional information about the thicker clay soils at the site.

  Standard penetration tests were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using split spoon sampling equipment. In situ vane testing was carried out, where possible, in the silty clay to determine the undrained shear strength of this soil unit. In addition, relatively undisturbed, 73-millimetre inside diameter thin-walled Shelby tube samples of the silty clay were obtained at various depths within boreholes 16-2, 16-2A, 16-4, and 16-6 using a fixed piston sampler. Borehole 16-2A was advanced immediately adjacent to 16-2 for additional Shelby tube sampling.

  Standpipe piezometers were sealed into boreholes 16-1, 16-2A, and 16-5 to allow for subsequent measurement of the groundwater level across the site. The groundwater levels in the standpipe piezometers were measured on September 2, 2016.

- Phase III was carried out on September 2, 2016. During Phase III, four hand-augerholes (numbered 16-101 to 16-104, inclusive) were advanced using manual hand auger equipment operated by Golder personnel to depths ranging from about 0.1 to 1.3 metres below the existing ground surface.

  Within the hand-augerholes, the subsurface conditions encountered and approximate depths to strata changes were visually logged at the time of drilling by examination of the auger cuttings. Grab samples were retrieved from the auger cuttings.

The approximate locations of the test pits, boreholes, and hand-augerholes from the three phases of investigation (collectively referred to as testholes) are shown on the attached Site Plan (Figure 2).

The fieldwork was supervised by experienced personnel from our staff who located the testholes, directed the drilling and excavating operations, logged the testholes and samples, directed the in situ testing, and took custody of the soil samples retrieved.

On completion of the fieldwork, samples of the soils encountered in the testholes were transported to our laboratory for examination by the project engineer and for laboratory testing which included natural water content determinations, Atterberg limits testing, and oedometer consolidation testing on selected soil samples.

Two samples of soil, one each from boreholes 16-2 and 16-6, were submitted to EXOVA Environmental Ontario for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

The testhole locations were selected and marked in the field by Golder Associates personnel. The test pit and borehole locations were subsequently surveyed by Annis O'Sullivan Vollebek (AOV) Land Surveyors. The elevations are referenced to Geodetic datum. The hand-augerholes were not surveyed.

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- Record of Test Pits are provided in Table 1.
- Record of Hand-Augerholes are provided in Table 2.
- Record of Borehole Sheets are provided in Appendix A.
- The results of the basic chemical analysis are provided in Appendix B.
- The results of the laboratory water content and Atterberg limit testing are provided on the Record of Borehole Sheets.
- Oedometer consolidation test results are provided on Figure 3.

An overview of the subsurface conditions encountered during the investigation is provided in the sections below. More detail is provided on the Record of Test Pits and Hand-Augerholes provided in Tables 1 and 2, as well as on the Record of Borehole Sheets provided in Appendix A.

4.2 Overburden

The overburden soils within the study area generally consist of topsoil overlying discontinuous deposits of silty clay and glacial till, which in turn overlie Precambrian bedrock. Surficial layers of sand and silt are also present in some areas. A summary of the soil deposits encountered during the investigation are provided in the following table.

Deposit/Layer Description	Testholes where Deposit was Encountered	Deposit Thickness (m)	N Values (blows)/ Shear Strength (Su) / Consistency or Relative Density	Laboratory Testing
Topsoil – (CL) Silty Clay to (ML) Sandy Silt; dark brown	All except 16-1 and 16-2	0.05 to 0.95 (avg. 0.35)	n/a	n/a
(SP) Sand to **(SM) Silty Sand to (ML) Sandy Silt**; brown to red brown to grey; non-cohesive	12-30, 12-37, 12-48, 12-51, 12-52, 16-5, 16-7	0.3 to 3.8	N = 8 to 14 **Loose to compact**	n/a
(CI/CH) Silty Clay to Clay, trace sand; grey brown **(Weathered Crust)**; cohesive, w>PL	12-02, 12-03, 12-05, 12-07, 12-09, 12-13, 12-15 to 12-19, 12-27 to 12-29, 12-31, 12-33 to 12-37, 12-39 to 12-44, 12-46, 12-49, 12-50, 12-52, 12-54 to 12-62, 12-64 to 12-68, 12-71, 12-75 to 12-83, 12-85 to 12-91, 12-97 to 12-105, 12-107, 12-109, 12-111, 16-204, 16-1 to 16-7	0.2 – 5.0	N = 1 to 14 S_u = 55 to 240 kPa **Stiff to Hard**	**w = 31 to 54%** **w_l = 61 to 62%** **w_p = 23 to 24%**

Deposit/Layer Description	Testholes where Deposit was Encountered	Deposit Thickness (m)	N Values (blows)/ Shear Strength (Su)	Laboratory Testing
			Consistency or Relative Density	
(Cl/CH) Silty Clay; grey; cohesive, w>PL	12-05, 12-09, 12-19, 12-34, 12-54 to 12-57, 12-61, 12-76, 12-77, 12-80 to 12-82, 12-89 to 12-91, 12-99 to 12-103, 12-109, 12-111, 16-204, 16-1, 16-2, 16-6	0.4 to >6.1	N = WH to 1 S_u = 27 to 85 kPa **Firm to Stiff**	**w = 46 to 55%** **w_l = 52%** **w_p = 21%**
(SM) Silty Sand, some gravel; grey, contains cobbles and boulders **(Glacial Till)**; non-cohesive	12-10, 12-27, 12-28, 12-29, 12-38 to 14-41, 12-43, 12-49, 12-53, 12-64, 12-65, 12-67, 12-71, 12-84, 12-94, 12-106, 12-108, 16-202, 16-1, 16-2, 16-3, 16-4, 16-7	0.1 to 4.2	N = 3 to >50 **Very Loose to Very Dense**	n/a

Where:
N = SPT 'N'-value; number of blows for 0.3 m of penetration
s_u = Undrained Shear Strength (kPa)
w = Natural Moisture Content (%)
w_p = Plastic Limit (%)
w_l = Liquid Limit (%)

Notes:

[1] Consistency/relative density based primarily on results of in situ testing in the boreholes.

[2] Standard penetration tests were carried out in the boreholes only. SPT 'N' values of greater than 50 blows may reflect the presence of cobbles, boulders, and/or the bedrock surface rather than the state of packing of the soil matrix.

Oedometer consolidation testing was carried out on one Shelby tube sample of the grey silty clay from borehole 16-6. The results of the testing are provided on Figure 3, and are also summarized below.

Borehole/Sample Number	Sample Depth/Elevation (m)	σ_o' (kPa)	σ_P' (kPa)	C_c	C_r	e_o	OCR
16-6 / 7	5.0 / 85.9	50	160	1.29	0.012	1.55	3.2

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

4.3 Bedrock

Refusal to excavating on the bedrock surface was encountered in most of the test pits (except test pits 12-05, 12-19, 12-55, 12-56, 12-57, 12-76, 12-82, 12-90, 12-99, 12-101, 12-102, and 12-103). Refusal to auger advancement was encountered in boreholes 16-1, 16-3, and 16-5. Refusal to auger advancement could represent the bedrock surface; however, it could also represent cobbles or a boulder within or on the surface of the glacial till. The ground surface elevation, bedrock surface elevation, and bedrock surface depth for each test pit and borehole are shown on the attached Site Plan (Figure 2). The bedrock surface values shown on Figure 2 for boreholes 16-1, 16-3, and 16-5 assume that auger refusal represents the bedrock surface; however, as stated earlier, auger refusal could also represent cobbles or a boulder within or on the surface of the glacial till, rather than the bedrock surface.

4.4 Groundwater

Standpipe piezometers were installed in boreholes 16-1, 16-2A, and 16-5 to allow for subsequent measurement of the groundwater levels at the site. The groundwater levels in the piezometers were measured on September 2, 2016 and is indicated below in the following table.

Borehole Number	Ground Surface Elevation	Water Level Depth (m)	Water Level Elevation (m)	Date of Measurement
16-1	98.82	2.62	96.20	September 2, 2016
16-2A	95.07	1.48	93.59	September 2, 2016
16-5	92.33	1.29	91.04	September 2, 2016

Groundwater seepage was also noted in some of the test pits and, where encountered, was typically between about 1 and 4 metres depth.

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

4.5 Corrosion

Two samples of soil, one each from boreholes 16-2 and 16-6, were submitted to Exova Environmental Ontario for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results of this testing are provided in Appendix B, and are summarized below.

Borehole Number / Sample Number	Sample Depth (m)	Chloride (%)	SO_4 (%)	pH	Resistivity (Ohm-cm)
BH 16-2 / Sa 3	1.5 – 2.1	< 0.002	< 0.01	7.3	6,670
BH 16-6 / Sa 3	1.5 – 2.1	< 0.002	< 0.01	7.5	6,250

5.0 DISCUSSION

5.1 General

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

5.2 Site Grading

The overburden soils within the study area generally consist of topsoil overlying discontinuous deposits of silty clay and glacial till, which in turn overlie Precambrian bedrock.

The areas underlain by unweathered grey silty clay are shown on the attached Site Plan (Figure 2). The grey silty clay has limited capacity to support additional stress, such as could be imposed by:

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

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

Based on a geotechnical assessment carried out using data from the current investigation, the maximum permissible grade raise for areas underlain by grey silty clay, assuming conventional backfill materials (i.e., clay or sand with a maximum unit weight of 19.0 kilonewtons per cubic metres), is 3.0 metres. This limitation has been assessed based on leaving sufficient remaining capacity in the silty clay deposit, such that the proposed vertical effective stress does not exceed 80 percent of the difference between the preconsolidation pressure and the existing/initial vertical effective stress. This assessment allows for strip footings, up to 0.6 metres in width, to be designed using a maximum allowable bearing pressure of 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code.

Based on the preliminary grading information provided, it is anticipated that grades raises will generally be less than, or equal to, the maximum permissible grade raise of 3.0 metres, except for the northeast corner of the site near HAH 16-204 where a grade raise of about 3.5 metres is indicated. In that area, it is anticipated that the most feasible method of increasing the permissible grade raise will be to use lighter backfill materials within the garage and porch, such as Geofoam (EPS) lightweight fill. The maximum permissible grade raise, if using Geofoam backfill within the garage and porch, is 3.5 metres, which would satisfy the grading requirements in the northeast corner of the site. It should be noted that the geotechnical assessment in this area is based on very limited geotechnical data provided by the shallow hand-augerhole and that a higher permissible grade raise may be possible in this area, but would need to be confirmed with a supplemental investigation.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil for predictable performance of structures, services, and pavements. The topsoil is not suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the topsoil may be left in place provided some settlement of the ground surface following filling can be tolerated.

5.3 Foundations

With the exception of the topsoil, the native undisturbed soils and bedrock on this site are considered suitable for the support of conventional wood frame houses on spread footing foundations. For design purposes, strip footing foundations, up to 0.6 metres in width, can be designed using a maximum allowable bearing pressure of 75 kilopascals for the overburden soils, consistent with design in accordance with Part 9 of the Ontario Building Code. For footings founded on or within bedrock, an allowable bearing pressure of 500 kilopascals may be used.

In areas underlain by grey silty clay (as shown on Figure 2), the permissible grade raises provided in Section 5.2 cannot be exceeded for the bearing pressure provided above to be applicable.

The post-construction total and differential settlements of footings supported on soil and sized using the above maximum allowable bearing pressure should be less than 25 and 15 millimetres, respectively, provided that the soil at or below founding level is not disturbed before or during construction. Suitable control of the groundwater inflow will be required where sandy overburden deposits exist, if such disturbance is to be avoided. Footings on bedrock should experience negligible settlements.

The tolerance of the house foundations to accept those settlements could be increased by providing nominal amounts of reinforcing steel in the top and bottom of the foundation walls. Houses without projecting garages, but rather garages that are more interior with the overall house foundation/footprint would also be more tolerant to these settlements.

The maximum allowable bearing pressure provided for footings founded within the silty clay corresponds to settlement resulting from consolidation of these deposits. Consolidation of the silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the allowable bearing pressure should be the full dead load plus sustained live load.

The glacial till on this site contains cobbles and boulders. Any cobbles or boulders in footing areas which 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 subgrade elevation may be lower than the underside of footing elevation. At these locations, the subgrade may be raised to the footing elevation using suitable engineered fill. In areas of grey silty clay, the fill should consist of 19 millimetre crushed clear stone. In other areas, the engineered fill should consist of Ontario Provincial Standard Specification (OPSS) Granular B Type II. All fill material should be placed in maximum 300 millimetre thick lifts and compacted to at least 95 percent of the material's standard Proctor maximum dry density (SPMDD) 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.

Where the subgrade at footing level changes from bedrock to overburden, differential settlement could result at this transition due to the different settlement properties of these materials. To limit the magnitude of the differential settlement, transition details (such as placing additional reinforcing steel in the foundation walls) may be required. Where sloping bedrock is encountered, stepped footings may also need to be considered. The structural engineering consultant should be contacted for input on these issues.

If overbreak of the bedrock occurs at/below footing level, the geotechnical engineer should be consulted to assess the potential implications for foundation design/construction.

5.4 Seismic Design

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

More favourable Site Class values could potentially be assigned for portions of the site if shear wave velocity testing were carried out. The founding levels versus the bedrock levels would also need to be known. However, it is considered that the Site Class of D permits conventional foundation design for this site.

The soils at this site are not considered liquefiable.

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 which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover. Houses with conventional depth basements would satisfy these requirements.

Shallow bedrock may be frost susceptible especially if there is an upper fractured zone that contains joints filled with frost susceptible soil. Therefore, if/where the earth cover requirements over the rock bearing surface cannot be provided, the absence of soil-filled seams in the underlying rock should be confirmed at the time of construction. This assessment can be carried out by drilling 50 millimetre diameter probe holes within the footing areas at a 3 metre spacing and to at least 1.8 metres below the finished grade level. In the case that soil-filled seams are encountered, then the following two options could be considered:

- The footing and bearing surface could be insulated; or,
- The potentially frost-susceptible bedrock could be removed (sub-excavated) and replaced with mass concrete, or the footing founded at that new lower depth.

Further geotechnical guidance can be provided regarding insulation of the bearing surface if and when required.

5.6 Basement and Garage Floor Slabs

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

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

The general groundwater level at this site is within about 2 metres of the existing ground surface. The fine sand at this site is somewhat permeable and therefore ideally, from a constructability perspective, excavations below the groundwater level in this soil should be avoided. However, if/where the groundwater level is encountered above subgrade level, a geotextile would be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. In the extreme case, loss of fines into the clear stone could cause ground loss beneath the slab and plugging of 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.

For houses underlain by silty clay, the backfill material inside the garage should have a unit weight no greater than 19.0 kilonewtons per cubic metre (i.e., sand or clear crushed stone). The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the materials SPMDD using suitable vibratory compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of Granular A compacted to at least 95 percent of the materials SPMDD using suitable vibratory compaction equipment.

5.7 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 Ontario Building Code, further guidelines on the foundation wall design will be required.

5.8 Excavations

Excavations for basements and services will be through topsoil, silty clay, sand and silt, and glacial till. In some areas, bedrock excavation will also be required.

5.8.1 Overburden

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. In accordance with the Occupational Health and Safety Act (OHSA) of Ontario, the overburden soils would be generally classified as a Type 3 soil. Accordingly, excavations may be made with unsupported side slopes at 1 horizontal to 1 vertical, or flatter. In the event that the excavations extend into sandy soils below the groundwater level, or into grey silty clay, side slopes as flat as 3 horizontal to 1 vertical will be required (Type 4 soil).

Trenched excavations could also be carried out using steeper side slopes with all manual labour carried out within a fully braced, steel trench box for worker safety. It is expected that open-cut methods and/or braced trench box support will generally be feasible.

Stockpiling of soil beside the excavations should be avoided; the weight of the stockpiled soil could lead to basal instability of braced excavations or slope instability of unsupported excavations. Stockpiles should be setback from the top of the slope a minimum distance equal to twice the depth of the excavation.

5.8.2 Bedrock

The bedrock is shallow in many areas of the site and therefore it is anticipated that some bedrock excavations will be required. It should be noted that the Precambrian bedrock on this site is likely hard and abrasive. Mechanical methods of rock removal (such as hoe ramming) could likely be carried out for shallow excavations; however, this may be time-consuming and inefficient. Consideration could also be given to tightly spaced line drilling combined with hoe ramming to increase the productivity of the rock excavation. Where significant bedrock removal is required, it is anticipated that the most efficient form of excavation will include drill and blast techniques.

Near vertical trench walls in the bedrock should stand unsupported for the construction period.

If blasting is used, it should be controlled to limit the peak particle velocities at all adjacent structures or services such that blast induced damage will be avoided. This will require blast designs by a specialist in this field.

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

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

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

It is recommended that the monitoring of ground vibration intensities (peak ground vibrations and accelerations) from the blasting/hoe-ramming operations be carried out both in the ground adjacent to the closest structures and within the structures themselves.

If permanent rock cuts are required, the final rock walls will need to be well defined by means of closely spaced line drilling and will need to be scaled in accordance with OPSS 206. The scaling operations should be carried out under the supervision of the geotechnical engineer. Blasting will need to be controlled to prevent overbreak, which could affect the stability of the final rock wall. A ditch should be provided at the base of the rock wall to retain any pieces of rock that may fall in the future.

5.8.3 Groundwater and Dewatering

Based on present groundwater levels, excavations deeper than about 1.3 to 2.6 metres will extend below the groundwater level. Groundwater inflow into the excavations should feasibly be handled by pumping from sumps within the excavations. Groundwater inflow from the silty clay and glacial till is expected to be low to moderate, while higher inflows may be encountered in sand/silt deposits below the groundwater level. However, the actual rate of groundwater inflow will depend on many factors including the contractor's schedule and rate of excavation, the size of the excavation, the number of working areas being excavated at one time, and the time of year at which the excavation is made. Also, there may be instances where significant volumes of precipitation, surface runoff and/or groundwater collects in an open excavation, and must be pumped out.

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.

Under the new regulations, a Permit-To-Take-Water (PTTW) is required from the Ministry of the Environment and Climate Change (MOECC) if a volume of water greater than 400,000 litres per day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 litres per day, but more than 50,000 litres per day, the water taking will not require a PTTW, but will need to be registered in the Environmental Activity and Sector Registry (EASR) as a prescribed activity. Considering the size of the development and the groundwater information collected during the investigation, it is considered likely that a PTTW would be required for this project. Assistance with carrying out the PTTW application can be provided, if requested.

5.9 Site Servicing

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where bedrock is present at the invert level, the bedding should be thickened to 300 millimetres. Where unavoidable disturbance to the subgrade surface occurs, it may be necessary to place a sub-bedding layer consisting of 300 millimetres of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding 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 SPMDD. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the native sand or silty sand backfill 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 SPMDD.

It should generally be possible to re-use the excavated overburden soils from above the groundwater level as trench backfill. The high moisture content of the grey silty clay will make this material difficult to compact. If grey silty clay is excavated, this material should be wasted or re-used in landscaping applications only. If the grey silty clay is used in trenches under roadways, some long term settlement of the pavement surface should be expected.

Where the trench will be covered with a hard surfaced area (e.g., pavements, sidewalks, or paving stones), the type of material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility.

All trench backfill should be placed in maximum 300 millimetre loose lifts and be uniformly compacted to at least 95 percent of the material's SPMDD using suitable compaction equipment. Backfilling operations carried out during cold weather should avoid inclusions of frozen lumps of soil, snow and ice.

Excavated bedrock is expected to be acceptable as backfill for the lower portion of the trench in areas where the excavations are in rock, provided that the rock fill is broken/crushed to form a well-graded material. However, the reuse of such rock fill should be reviewed and approved by the geotechnical engineer at the time of construction once the grading of the material proposed for reuse can be determined. The rock fill should only be placed higher than at least 300 millimetres above the pipe to minimize damage due to impact or point load. The pieces of the rock fill used as trench backfill should be limited to a maximum of 300 millimetres in nominal size and the rock fill should be disseminated throughout (i.e., nests of large rock pieces should not be permitted).

Impervious dykes or cut-offs should be constructed at 100 metre intervals in the service trenches to reduce groundwater lowering at the site due to the 'french drain' effect of the granular bedding and surround for the service pipes. It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular materials to the trench bottom. The dykes should be at least 1.5 metres wide and could be constructed using relatively dry (i.e., compactable) grey brown silty clay from the weathered zone.

If the construction schedule allows, a delay between the service installation/trench backfilling and final paving should be made to allow for settlement of the trench backfill material, which will reduce the magnitude of differential movement (i.e., sagging) of pavements placed over backfilled trenches.

5.10 Pavement Design

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

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

Transition from bedrock to earth subgrade should be carried out in accordance with the OPSD 205 series. The transition depth "t" should be taken as 1.8 metres.

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 in bedrock cut sections, regardless of the type of traffic (i.e., with or without truck traffic) should be:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	300

Bedrock shatter could potentially be used in lieu of the Granular B Type II subbase, but would need to be approved at the time of construction by the geotechnical engineer. Where undulations/depressions are present on the bedrock subgrade, consideration should be given to filling the depressions with lean concrete up to the bottom of the subbase layer to prevent areas of ponding beneath the pavement structure.

The pavement structure for local roads which will not experience bus or truck traffic (other than school bus and garbage collection) should consist of the City of Ottawa's minimum recommended pavement structure:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	400

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

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	600

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the materials SPMDD 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 mm Surface Course – 40 millimetres

Superpave 19 mm 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 C for collector roads.

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

5.11 Corrosion and Cement Type

Samples of soil from boreholes 16-2 and 16-6 were submitted to EXOVA Environmental Ontario for chemical analysis related to potential corrosion of exposed buried ferrous elements and potential sulphate attack on buried concrete elements. The results of that testing are provided in Appendix B.

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

5.12 Trees

The silty clay on this site is potentially 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. Therefore, 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. Trees which have a high water demand should not be planted closer to structures than the ultimate height of the tree. This restriction could potentially be relaxed if it can be relaxed if it can be shown that the soils have a low shrinkage potential. However, additional testing is required before this decision could be made. Table 3 provides a list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

5.13 Pools, Decks and Additions

5.13.1 Above Ground and In Ground Pools

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

In areas underlain by silty clay (as shown on Figure 2), there will be restrictions regarding the placement of above-ground pools. Due to the additional loads that would be imposed by the construction of above-ground pools, these should be located no closer than about 2 metres from the edge of the house. It should also be noted that the City of Ottawa does not allow alterations to grading within 1.2 metres of the property line. This being the case, there will be restrictions on the size of above-ground pools. These restrictions will depend on the location of the lot, the location of the house on the lot, and the size of the rear-yards. Therefore, a geotechnical assessment will be required for the placement of any above-ground pools within these areas. This assessment should be carried out at the “pool permit” applicable stage.

5.13.2 Decks

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

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

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

5.13.3 Additions

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

6.0 ADDITIONAL CONSIDERATIONS

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

The test pits excavated and filled on site constitute zones of disturbance to the surficial soils. These could affect the performance of surface structures/foundations. The test pit locations were generally selected to be outside of proposed building areas (i.e., within the roadways); however, there may be instances where a test pit underlies a proposed structure. In that case, the backfill soil in the test pit will need to be removed and replaced with engineered fill.

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soil having adequate bearing capacity has 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 point of view.

Ontario Regulation 903 would ultimately require abandonment of the piezometers installed within the boreholes for this investigation. The decommissioning of these devices should be made part of the construction contract.

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

7.0 CLOSURE

We trust that this report meets your current needs. If you have any questions, or if we may be of further assistance, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

for Stephen Dunlop, P.Eng.
Geotechnical Engineer

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

WAM/SD/TMS/ob

n:\active\2011\1121 - geotechnical\11-1121-0028 phase 9 kanata lakes\report\11-1121-0028 rpt 001 rev-01 final geotechnical investigation january 2018.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, **Urbandale Corporation.** The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

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

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

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

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

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

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

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

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

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

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-01 (101.19)	0.00 – 0.31 0.31	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-02 (100.22)	0.00 – 0.40 0.40 – 3.00 3.00	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Water seepage at 3.00 metres below ground surface
12-03 (99.84)	0.00 – 0.30 0.30 – 0.71 0.71	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Field Vane: 80 kPa at Depth (m): 0.5
12-04 (102.21)	0.00 – 0.57 0.57	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-05 (98.57)	0.00 – 0.20 0.20 – 3.60 3.60 – 6.50 6.50	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-07 (99.02)	0.00 – 0.50 0.50 – 1.54 1.54	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.54 metres below ground surface Field Vane: 90 kPa at Depth (m): 1.20
12-09 (95.85)	0.00 – 0.30 0.30 – 3.20 3.20 – 7.03 7.03	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion
12-10 (99.61)	0.0 – 0.30 0.30 – 1.46 1.46	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion Sample: 1 at Depth (m): 1.20
12-12 (98.14)	0.00 – 0.10 0.10	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-13 (92.48)	0.00 – 0.20 0.20 – 4.59 4.59	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 4.59 metres below ground surface

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-14 (99.35)	0.00 – 0.15 0.15	TOPSOIL – (CL) SILTY CLAY; dark brown, contains cobbles and boulders; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-15 (93.10)	0.00 – 0.30 0.30 – 2.54 2.54	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.00 metres below ground surface
12-16 (92.05)	0.00 – 0.10 0.10 – 2.07 2.07	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Sample Depth (m) 1 1.30
12-17 (94.46)	0.00 – 0.40 0.40 – 1.74 1.74	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-18 (93.40)	0.00 – 0.50 0.50 – 0.80 0.80	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-19 (90.51)	0.00 – 0.25 0.25 – 4.00 4.00 – 8.55 8.55	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff END OF TEST PIT Note: Water seepage at 8.55 metres below ground surface Field Vane: 54 kPa at Depth (m): 4.5
12-20 (96.08)	0.00 – 0.95 0.95	TOPSOIL – (CL) SILTY CLAY, trace sand; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-27 (101.03)	0.00 – 0.30 0.30 – 0.90 0.90 – 5.10 5.10	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.90 metres below ground surface Sample / Depth (m): 1 / 0.20; 2 / 1.00; 3 / 3.50
12-28 (101.20)	0.00 – 0.10 0.10 – 0.80 0.80 – 2.50 2.50	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-29 (100.73)	0.00 – 0.10 0.10 – 1.10 1.10 – 2.13 2.13	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.00 metres below ground surface
12-30 (101.36)	0.00 – 0.10 0.10 – 1.67 1.67	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND; brown; non-cohesive; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Sample 1 – Depth (m) 0.80
12-31 (101.54)	0.00 – 0.10 0.10 – 0.77 0.77	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-32 (102.40)	0.10 – 0.21 0.21	TOPSOIL – (CL) SILTY CLAY; red brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-33 (100.77)	0.00 – 0.20 0.20 – 0.66 0.66	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-34 (100.54)	0.00 – 0.20 0.20 – 3.20 3.20 – 4.78 4.78	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Sample 1 Depth (m) 0.30 Sample 2 Depth (m) 3.40 Sample 3 Depth (m) 4.00
12-35 (101.16)	0.00 – 0.90 0.90 – 4.02 4.02	TOPSOIL – (CL) SILTY CLAY; red brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.00 metres below ground surface
12-36 (100.27)	0.00 – 0.05 0.05 – 5.03 5.03	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.00 metres below ground surface
12-37 (100.32)	0.00 – 0.05 0.05 – 0.60 0.60 – 3.91 3.91	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SP) SAND; light brown; non cohesive; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.00 metres below ground surface
12-38 (100.41)	0.00 – 0.10 0.10 – 6.88 6.88	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey, contains silty layers, cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.00 metres below ground surface

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-39 (100.32)	0.00 – 0.30 0.30 – 0.70 0.70 – 3.96 3.96	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown to grey, contains silt layers, cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Sample / Depth (m) 1 / 1.50 2 / 2.70
12-40 (100.83)	0.00 – 0.30 0.30 – 0.60 0.60 – 2.55 2.55	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains: H layers, cobbles and boulders (GLACIAL TILL); non-cohesive; moist to wet END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Water seepage at 1.00 metres below ground surface
12-41 (100.51)	0.00 – 0.30 0.30 – 1.00 1.00 – 3.27 3.27	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Water seepage at 3.27 metres below ground surface
12-42 (100.47)	0.00 – 0.30 0.30 – 1.60 1.60	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.60 metres below ground surface Field Vane / Depth (m) 55 kPa / 0.60

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-43 (100.54)	0.00 – 0.30 0.30 – 2.20 2.20 – 3.30 3.30	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 3.30 metres below ground surface
12-44 (99.89)	0.00 – 0.50 0.50 – 1.90 1.90	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock
12-45 (99.72)	0.00 – 0.60 0.60	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock (sloping) Notes: -Test pit excavated beside bedrock outcrop -Test pit dry upon completion
12-46 (99.58)	0.00 – 0.50 0.50 – 1.24 1.24	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion Field Vane: 60 kPa; Depth (m): 1.00
12-47 (99.89)	0.00 – 0.56 0.56	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-48 (98.95)	0.00 – 0.30 0.30 – 1.41 1.41	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND; brown; non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.00 metres below ground surface Sample 1 — Depth (m) 0.70
12-49 (98.58)	0.00 – 0.40 0.40 – 2.20 2.20 – 2.53 2.53	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion
12-50 (99.62)	0.00 – 0.20 0.20 –0.94 0.94	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping)
12-51 (101.09)	0.00 – 0.40 0.40 – 4.24 4.24	TOPSOIL – (CL) SILTY CLAY; red brown; moist (SP) SAND; dark grey; non cohesive; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 4.24 metres below ground surface Sample 1 — Depth (m) 1.20
12-52 (99.13)	0.00 – 0.10 0.10 – 0.70 0.70 – 1.84 1.84	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (ML) Sandy SILT; red brown; non cohesive; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-53 (100.38)	0.00 – 0.10 0.10 – 0.84 0.84	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; red brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-54 (94.87)	0.00 – 0.20 0.20 – 2.90 2.90 – 4.03 4.03	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 4.03 metres below ground surface
12-55 (95.26)	0.00 – 0.30 0.30 – 4.00 4.00 – 7.40 7.40	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT Note: Water seepage at 1.50 metres below ground surface
12-56 (95.28)	0.00 – 0.40 0.40 – 3.85 3.85 – 5.50 5.50	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT Note: Water seepage at 2.40 metres below ground surface
12-57 (96.12)	0.00 – 0.30 0.30 – 3.40 3.40 – 5.40 5.40	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT Note: Water seepage at 2.20 metres below ground surface

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-58 (96.54)	0.00 – 0.40 0.40 – 1.43 1.43	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.43 metres below ground surface
12-59 (99.84)	0.00 – 0.50 0.50 – 1.16 1.16	TOPSOIL – (ML) Sandy SILT; red brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock
12-60 (98.54)	0.00 – 0.40 0.40 – 3.06 3.06	TOPSOIL – (ML) Sandy SILT; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.50 metres below ground surface
12-61 (98.28)	0.00 – 0.30 0.30 – 2.40 2.40 – 3.27 3.27	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 3.27 metres below ground surface Field Vane: 130 kPa; Depth (m): 0.8
12-62 (98.66)	0.00 – 0.60 0.60 – 1.50 1.50	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-63 (97.98)	0.00 – 0.42 0.42	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion
12-64 (97.08)	0.00 – 0.25 0.25 – 1.70 1.70 – 2.82 2.82	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.82 metres below ground surface
12-65 (96.86)	0.00 – 0.25 0.25 – 2.80 2.80 – 4.36 4.36	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.00 metres below ground surface
12-66 (97.13)	0.00 – 0.40 0.40 – 0.65 0.65	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-67 (99.59)	0.00 – 0.50 0.50 – 1.10 1.10 – 2.76 2.76	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.20 metres below ground surface

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-68 (100.50)	0.00 – 0.80 0.80 – 1.28 1.28	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping)
12-69 (101.57)	0.00 – 0.34 0.34	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-70 (99.06)	0.00 – 0.11 0.11	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-71 (98.10)	0.00 – 0.50 0.50 – 2.60 2.60 – 3.55 3.55	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 3.55 metres below ground surface
12-72 (96.63)	0.00 – 0.55 0.55	TOPSOIL – (CL) SILTY CLAY; red brown to dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-73 (95.87)	0.00 – 0.43 0.43	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-74 (95.16)	0.00 – 0.30 0.30 – 0.74 0.74	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; brown, contains silt layers, cobbles and boulders (GLACIAL TILL); non-cohesive, moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Sample 1 — Depth (m) 0.50
12-75 (92.86)	0.00 – 0.30 0.30 – 2.56 2.56	TOPSOIL – (ML) Sandy SILT; black; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.56 metres below ground surface
12-76 (92.33)	0.00 – 0.40 0.40 – 3.00 3.00 – 6.20 6.20	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT Note: Water seepage at 6.20 metres below ground surface
12-77 (92.46)	0.00 – 0.30 0.30 – 1.70 1.70 – 3.30 3.30	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion
12-78 (92.27)	0.00 – 0.30 0.30 – 1.44 1.44	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-79 (92.42)	0.00 – 0.20 0.20 – 2.16 2.16	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-80 (92.12)	0.00 – 0.20 0.20 – 2.30 2.30 – 6.53 6.53	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 2.00 metres below ground surface
12-81 (92.23)	0.00 – 0.20 0.20 – 2.10 2.10 – 3.91 3.91	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 3.91 metres below ground surface Field Vane: 130 kPa — Depth (m): 0.5
12-82 (92.32)	0.00 – 0.20 0.20 – 2.40 2.40 – 4.00 4.00 – 8.36 8.36	TOPSOIL – (CL) SILTY CLAY; black; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT Note: Test pit dry upon completion Sample: 1 — Depth (m): 8.00

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-83 (94.75)	0.00 – 0.40 0.40 – 1.65 1.65	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-84 (94.13)	0.00 – 0.30 0.30 – 4.14 4.14	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 4.14 metres below ground surface
12-85 (94.82)	0.00 – 0.40 0.40 – 1.41 1.41	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Field Vane: 120 kPa Depth (m): 0.4
12-86 (94.44)	0.00 – 0.40 0.40 – 1.94 1.94	TOPSOIL – (ML) Sandy SILT; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, hard to very stiff END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Field Vane: 240 kPa Depth (m): 0.5
12-87 (93.56)	0.00 – 0.50 0.50 – 0.70 0.70	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-88 (92.39)	0.00 – 0.60 0.60 – 3.10 3.10	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Test pit dry upon completion Field Vane 150 kPa — Depth (m) 0.6
12-89 (92.17)	0.00 – 0.40 0.40 – 2.80 2.80 – 4.70 4.70 – 5.12 5.12	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-90 (92.41)	0.00 – 0.30 0.30 – 3.90 3.90 – 4.90 4.90 – 8.45 8.45	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT Note: Test pit dry upon completion
12-91 (92.50)	0.00 – 0.30 0.30 – 2.10 2.10 – 4.20 4.20 – 6.39 6.39	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion Field Vane 130 kPa — Depth (m) 0.5

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-92 (93.72)	0.00 – 0.20 0.20	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-93 (101.64)	0.00 – 0.51 0.51	TOPSOIL – (CL) SILTY CLAY; red brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-94 (97.36)	0.00 – 0.55 0.55 – 2.40 2.40	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Water seepage at 1.00 metres below ground surface
12-95 (96.43)	0.00 – 0.55 0.55	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-96 (95.62)	0.00 – 0.62 0.62	TOPSOIL – (CL) SILTY CLAY; dark brown, contains cobbles and boulders; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-97 (93.93)	0.00 – 0.30 0.30 – 1.51 1.51	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-98 (92.67)	0.00 – 0.30 0.30 – 2.62 2.62	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-99 (92.44)	0.00 – 0.40 0.40 – 4.20 4.20 – 8.00 8.00	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff END OF TEST PIT Note: Test pit dry upon completion Field Vane: 70 kPa at Depth (m): 4.3
12-100 (91.41)	0.00 – 0.30 0.30 – 4.00 4.00 – 7.16 7.16	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 7.16 metres below ground surface Sample: 1 at Depth (m): 1.00 Sample: 2 at Depth (m): 4.20
12-101 (91.28)	0.00 – 0.20 0.20 – 4.00 4.00 – 7.55 7.55	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm END OF TEST PIT Note: Test pit dry upon completion Field Vane: 30 kPa at Depth (m): 4.2

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-102 (91.49)	0.00 – 0.30 0.30 – 2.90 2.90 – 3.80 3.80 – 8.60 8.60	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff END OF TEST PIT Note: Test pit dry upon completion Field Vane 50 kPa — Depth (m) 4.2
12-103 (91.11)	0.00 – 0.30 0.30 – 1.70 1.70 – 3.70 3.70 – 7.75 7.75	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF TEST PIT Note: Water seepage at 7.75 metres below ground surface
12-104 (90.69)	0.00 – 0.40 0.40 – 2.70 2.70	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-105 (91.00)	0.00 – 0.20 0.20 – 2.24 2.24	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-106 (93.88)	0.00 – 0.30 0.30 – 1.34 1.34	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock (sloping) Note: Water seepage at 1.34 metres below ground surface
12-107 (94.60)	0.00 – 0.40 0.40 – 2.10 2.10	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion
12-108 (94.25)	0.00 – 0.30 0.30 – 3.60 3.60	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (SM) SILTY SAND, some gravel; grey brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist to wet END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.00 metres below ground surface
12-109 (93.91)	0.00 – 0.80 0.80 – 2.80 2.80 – 4.47 4.47	TOPSOIL – (CL) SILTY CLAY; dark brown; moist (CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL END OF TEST PIT - Refusal to excavating on bedrock Note: Water seepage at 1.20 metres below ground surface
12-110 (97.20)	0.00 – 0.53 0.53	TOPSOIL – (CL) SILTY CLAY; dark brown; moist END OF TEST PIT - Refusal to excavating on bedrock Note: Test pit dry upon completion

TABLE 1

RECORD OF TEST PITS

TEST PIT NUMBER (ELEVATION)	DEPTH (METRES)	DESCRIPTION
12-111	0.00 – 0.30	TOPSOIL – (CL) SILTY CLAY; dark brown; moist
(93.67)	0.30 – 2.70	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL
	2.70 – 4.40	(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL
	4.40 – 8.08	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL
	8.08	END OF TEST PIT - Refusal to excavating on bedrock
		Note: Test pit dry upon completion

TABLE 2

RECORD OF HAND-AUGERHOLES

HAND AUGERHOLE NUMBER	DEPTH (METRES)	DESCRIPTION
16-201	0.00 – 0.13 0.13	TOPSOIL – (SM) SILTY SAND, trace gravel; brown; moist END OF HAND-AUGERHOLE Sample / Depth (m) 1 / 0.00 – 0.13
16-202	0.00 – 0.20 0.20 – 0.95 0.95	TOPSOIL – (SM) SILTY SAND, trace gravel; dark brown; moist (SM) SILTY SAND, some gravel to gravelly; brown, contains cobbles and boulders (GLACIAL TILL); non cohesive, moist END OF HAND-AUGERHOLE Sample / Depth (m) 1 / 0.30 2 / 0.90
16-203	0.00 – 0.35 0.35	TOPSOIL – (SM) SILTY SAND; brown, contains cobbles; moist END OF HAND-AUGERHOLE Sample / Depth (m) 1 / 0.30
16-204	0.00 – 0.25 0.25 – 0.55 0.55 – 1.30 1.30	TOPSOIL – (SM) SILTY SAND, trace gravel; dark brown, contains cobbles; moist (CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL (CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL END OF HAND-AUGERHOLE Sample / Depth (m) 1 / 0.40 2 / 1.30

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

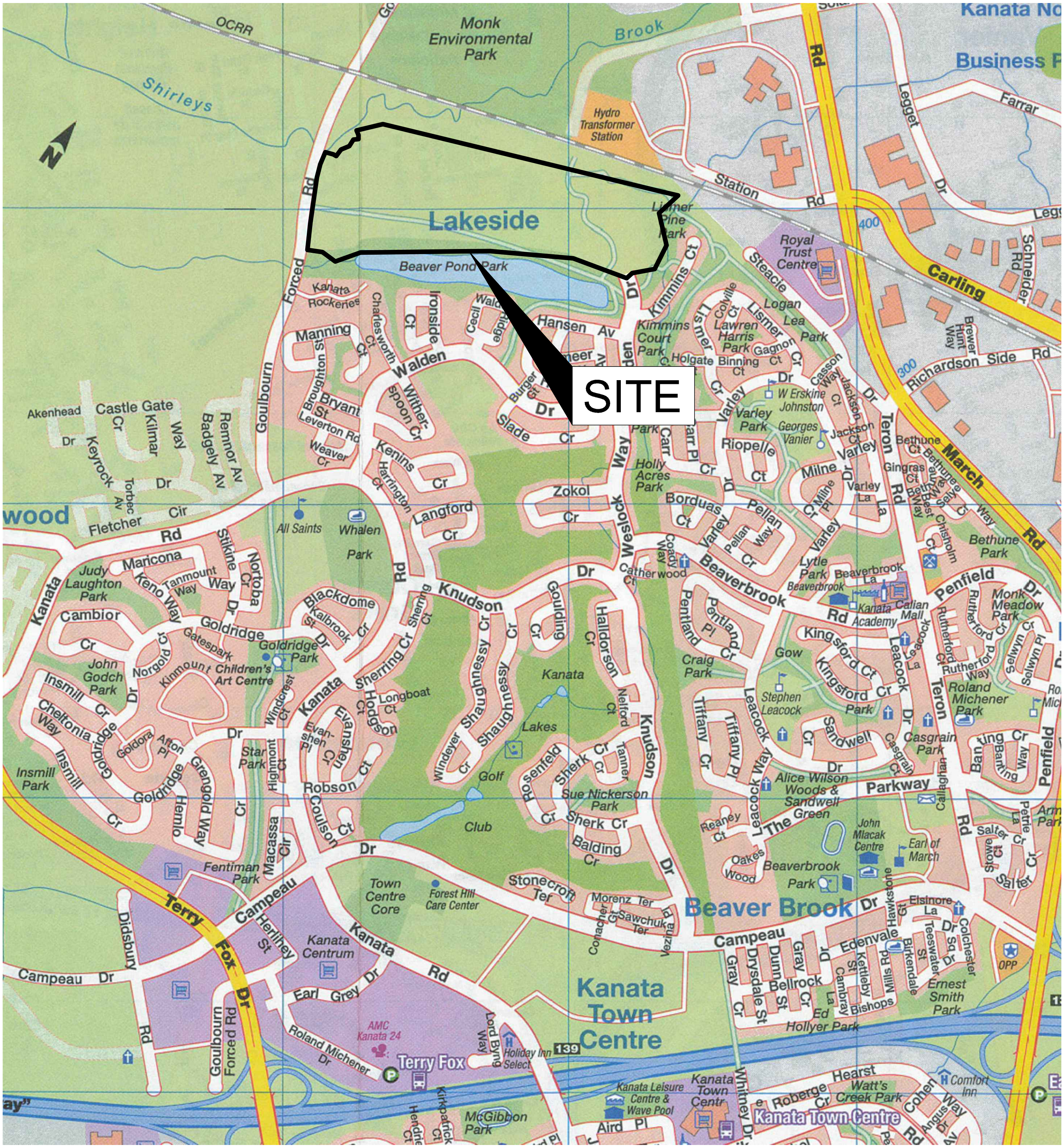
Larch

EVERGREEN CONIFERS

Spruce

Fir

Pine



0	500	1,000
1:20,000		METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 11-1121-0028

CLIENT
URBANDALE CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
KANATA LAKES - PHASE 9
OTTAWA, ONTARIO

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-03
DESIGNED	----
PREPARED	JM
REVIEWED	SD
APPROVED	TMS

TITLE
KEY PLAN

PROJECT NO.	PHASE	REV.	FIGURE
11-1121-0028	1000	0	1

LEGEND

- APPROXIMATE BOREHOLE LOCATION
- APPROXIMATE TEST PIT LOCATION
- APPROXIMATE HAND-AUGERHOLE LOCATION
- GRADE RAISE ASSESSMENT AREAS
- G.S. 102.21 — GROUND SURFACE ELEVATION, metres
- B.R. 101.64 / D. 0.57 — BEDROCK SURFACE ELEVATION, metres / DEPTH TO BEDROCK, metres

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 11-1121-0028

REFERENCE(S)

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY ANNIS, O'SULLIVAN, VOLLEBEKK LTD.

CLIENT
URBANDALE CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
KANATA LAKES - PHASE 9
OTTAWA, ONTARIO

TITLE
SITE PLAN

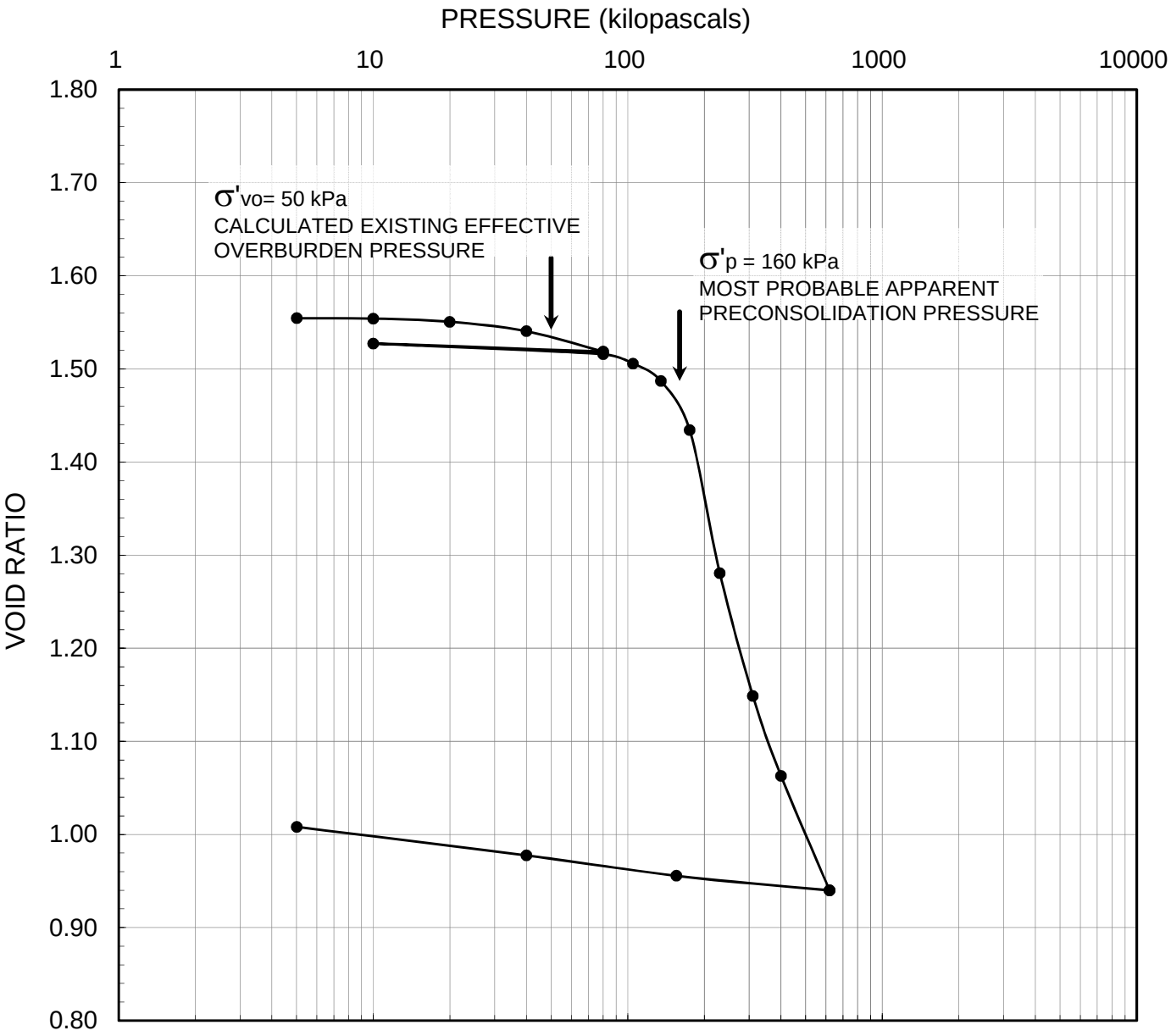
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-02-02
PREPARED	----
DESIGN	JM
REVIEW	SD
APPROVED	TMS

PROJECT No. 11-1121-0028 | PHASE | Rev. 0 | FIGURE 2

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

Path: \\golder.gds\gal\ottawa\Active\2011\1121 - Geotechnical\11-1121-0028 Phase 9 Kanata Lakes\Spatial\MXD\AO | File Name: 1112102028-02.dwg | Last Edited By: jmcconnell | Date: 2017-02-13 Time: 1:45:05 PM | Printed By: jmcdavid | Date: 2017-02-16 Time: 10:24:42 AM



LEGEND

Borehole:	16-6	w_i = 55%	S_o = 98%	γ = 16.6 kN/m³
Sample:	7	w_f = 37%	e_o = 1.55	G_s = 2.79
Depth (m):	5.0	w_l = 52%	C_c = 1.29	
Elevation (m):	85.9	w_p = 21%	C_r = 0.012	

Golder Associates	SCALE AS SHOWN	TITLE	
	DATE 01/27/17	**CONSOLIDATION TEST RESULTS**	
	CADD N/A		
	ENTERED CW		
FILE No. Consolidation summary	CHECK CNM		
PROJECT No. 11-1121-0028 REV. 1	REVIEW SD		FIGURE **3**

APPENDIX A

List of Abbreviations and Symbols
Record of Borehole Sheets

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

2 shear strength = (compressive strength)/2

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 4, 2016

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	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, 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		98.82							
0	Power Auger 200 mm Diam. (Hollow Stem)	(CI/CH) SILTY CLAY to CLAY; grey brown, contains rootlets (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.00	1	SS	10				
1					2	SS	14				
2					3	SS	7				Native Backfill
3					4	SS	6				
					5	SS	1				
				95.16							
4		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		3.66				⊕ ⊕ + +			Silica Sand
5					6	SS	WH	⊕ +			Standpipe
				93.18							Silica Sand
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very loose		5.64	7	SS	3				Cave
6				92.60	8	SS	>50				
		End of Borehole Auger Refusal		6.22							WL in Standpipe at Elev. 96.20 m on Sept. 2, 2016
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 4, 2016

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	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.07							
0	Power Auger 200 mm Diam. (Hollow Stem)	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains rootlets (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.00	1	SS	12		W		
1					2	SS	10				
2					3	SS	6		W		
					4	SS	3				
3					5	SS	PM	>96 +			
								>96 +	W		
				91.11							
4		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm		3.96				⊕ +			
								⊕ +			
					6	TP	PH				
5				89.97							
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet		5.13							
		End of Borehole									
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-2A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 4, 2016

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^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.07							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Record of Borehole 16-2 for stratigraphy		0.00							Native Backfill
1											
2											
3											
				91.11							Silica Sand
4		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		3.96	1	TP	PH				Standpipe
				90.55							Silica Sand
		End of Borehole		4.52							
5											WL in Standpipe at Elev. 93.59 m on Sept. 2, 2016
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 5, 2016

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^{-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		92.52							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00							
				92.17	1	SS	7				
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.35							
1					2	SS	8				
					3	SS	8				
2				90.46							
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet		2.06							
		End of Borehole Auger Refusal		2.16							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 5, 2016

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	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		92.48							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00							
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.15	1	SS	13				
1					2	SS	10				
					3	TP	PH				
2								>96 +			
					4	SS	6				
3					5	SS	3				
		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (TILL); non-cohesive, wet, very loose		88.97 3.51							
		End of Borehole		3.66							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 5, 2016

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	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		92.33							
0	Power Auger 200 mm Diam. (Hollow Stem)	(PT) Fibrous PEAT		0.00 / 92.10							
		(SM) SILTY SAND, fine; brown; non-cohesive, moist, compact		0.23 / 91.77	1	SS	14				
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains rootlets (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.56							
1					2	SS	11				
					3	SS	5				Native Backfill
2											
					4	SS	3				
3					5	SS	3				Silica Sand
4					6	SS	3				Standpipe
				87.66	7	SS	>50				
		End of Borehole Auger Refusal		4.67							WL in Standpipe at Elev. 91.04 m on Sept. 2, 2016
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

LOGGED: DG

CHECKED: SD

Golder Associates

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 5, 2016

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	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		90.93							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM/ML) SILTY SAND to sandy SILT; dark brown; moist		0.00							
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains sand interbeds (WEATHERED CRUST); cohesive, w>PL, very stiff		0.15	1	SS	10				
1					2	SS	11				
2					3	SS	10				
					4	TP	PH				
3					5	SS	3	>96 +			
4					6	SS	3	>96 +			
		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		86.66 4.27	7	TP	PH			C	
5											
6					8	SS	1				
7											
8					9	SS	WH				
				82.09							
9		End of Borehole		8.84							
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

PROJECT: 11-1121-0028

RECORD OF BOREHOLE: 16-7

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 5, 2016

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	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, 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		93.61							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00							
		(SM/ML) SILTY SAND to sandy SILT, trace gravel; brown; non-cohesive, moist, loose		0.15	1	SS	10				
1					2	SS	8				
				92.27							
		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		1.34							
2					3	SS	6				
					4	SS	3				
3					5	SS	3				
4					6	SS	2				
				89.04							
		(CL/CH) SILTY CLAY to CLAY; grey brown, contains sand layers (WEATHERED CRUST); cohesive, stiff		4.57	7	SS	1				
5				88.46							
		(SM) SILTY SAND, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very loose		5.15	8	SS	3				
				87.82							
6		End of Borehole		5.79							
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1111210028-1000.GPJ GAL-MIS.GDT 02/16/17 JEM

APPENDIX B

Basic Chemical Analysis
Exova Environmental Ontario Report No. 1615827

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Exova

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: 1615827
Date Submitted: 2016-09-07
Date Reported: 2016-09-14
Project: 11-1121-0028
COC #: 811517

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1259040 Soil 2016-09-04 BH16-2 Sa3 5-7	1259041 Soil 2016-09-05 BH16-6 Sa3 5-7
Agri. - Soil	pH	2.0				7.3	7.5
General Chemistry	Cl	0.002	%			<0.002	<0.002
	Electrical Conductivity	0.05	mS/cm			0.15	0.16
	Resistivity	1	ohm-cm			6670	6250
	SO4	0.01	%			<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

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario, K2H 5B7
Canada
T: +1 (613) 592 9600

Golder Associates