March 2015

REPORT ON

Geotechnical Investigation Proposed Residential Development Riverside South Development (Phase 15) Ottawa, Ontario

Submitted to:
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REPORT

Report Number: 1406631

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development to be located within the Riverside South Community (Phase 15) in Ottawa, Ontario.

The purpose of this geotechnical investigation was to supplement the existing subsurface information and determine the general soil and groundwater conditions across the site by means of 18 boreholes. Based on an interpretation of the factual information obtained, along with existing data available for the site, engineering guidelines are provided on the geotechnical design aspects of the project, including construction considerations which could affect design decisions.

It should be noted that not all portions of the site could be accessed for this investigation, due to dense tree cover in some areas. Once those trees have been cleared, those areas can also be investigated and this report will need to be updated. In the interim, this report has been prepared using the available information.

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 a proposed residential subdivision within the Riverside South Community (Phase 15) in Ottawa, Ontario (see Key Plan, Figure 1).

The site is located south of Borbridge Avenue, between Spratt Road and the Rideau River. The subject area, as shown on the Site Plan, Figure 2, consists of three disconnected parcels of land measuring approximately 1,200 by 400 metres, 800 by 400 metres, and 240 by 220 metres, respectively, in size. The property is also divided by River Road and by a middle strip of land which is owned by a separate owner and is not part of the study area for this investigation.

It is understood that a Draft Plan of Subdivision Application for the property is being submitted to the City of Ottawa. As part of that plan, the development will include a mix of low to medium density dwellings, institutional and commercial buildings, two schools, park areas, as well as access roads and services within the subdivision.

The site topography is relatively flat with a gentle downward slope from east to west (i.e., towards the river). The majority of the site east of River Road is currently undeveloped and predominately heavily forested or covered with vegetation, while the parcel of land west of River Road is active agricultural land.

Golder Associates previously completed three geotechnical investigations within or in close proximity to the site. Existing available geotechnical data for this study area was collected from the following reports and memo:

1) Report to City of Ottawa by Golder Associates Ltd. titled “Geotechnical Considerations for Riverside South Community, Ottawa, Ontario” dated April 2008 (Report No. 07-1121-0141).
2) Report to the Riverside South Development Corporation by Golder Associates Ltd. titled “Geotechnical Investigation, Proposed Residential Development, Riverside South Development (Phase 9)” dated November 2012 (Project No. 10-1121-0260).
3) Memo to Riverside South Development Corporation by Golder Associates Ltd. titled “Addendum to Geotechnical Report (10-1121-0260 REV 1), Additional Geotechnical Investigation, Proposed Townhouse Blocks, Riverside South Community Development, Phase 9-4 – Part 4650 Spratt Road, Ottawa, Ontario” dated August 15, 2014.

Based on a review of these previous geotechnical investigations and the published geological mapping, the subsurface conditions at the site likely consist of layered silty clay, clayey silt, sandy silt and silty sand overlying glacial till, which in turn is underlain by bedrock. The bedrock surface is expected to be at depths ranging from about 5 to 25 metres, sloping down from the southeast to the northwest across the site. Based on published geological mapping, the bedrock on the site should consist of March formation sandstone and Oxford formation dolostone on the north and south parts of the site, respectively. The bedrock formations are divided by the Hazeldean Fault which crosses the site on a northwest to southeast trend.

It is noted that the intent of the current geotechnical investigation is for it to be sufficient to support an application to the City for Draft Plan approval of the overall proposed development and to also meet the subsequent requirements for detailed development applications and building permit applications for the housing, where the borehole spacing meets the requirements of the City of Ottawa’s *“Geotechnical Investigation and Reporting Guidelines for Development Applications in the City of Ottawa”.* It is, however, anticipated that once the planning process has been completed, further geotechnical investigation will be required for the detailed design of areas of the development that are not currently accessible (e.g., due to dense tree cover) as well as for any higher/heavier structures which are to be designed in accordance with Part 4 of the Ontario Building Code.

3.0 PROCEDURE

The field work for this current investigation was carried out between December 8 and 12, 2014. At that time, 18 boreholes (numbered 14-1 to 14-18) were put down at the approximate locations shown on the Site Plan, Figure 2. The borehole locations were selected as follows:

- Two boreholes (numbered 14-1 and 14-2) were advanced within the 240 by 220 metre sized parcel of land located west of River Road within the northwest portion of the site. This area is labelled as ‘Parcel A’ on the Site Plan, Figure 2. These boreholes were advanced to depths of about 6.7 and 7.6 metres below the existing ground surface.
- The remaining 16 boreholes (numbered 14-3 to 14-18) were advanced within the 800 by 400 metre sized parcel of land west of Spratt Road in the southern portion of the site. This area is labelled as ‘Parcel B’ on the Site Plan, Figure 2. Eight of these boreholes (14-6, 14-7, 14-8, 14-11, 14-12, 14-13, 14-17, and 14-18) were advanced to practical refusal to auger advancement at depths ranging from about 2.3 to 6.7 metres below the existing ground surface. The remaining boreholes were terminated at depths varying from 5.2 to 7.5 metres below the existing ground surface

No boreholes were able to be advanced within the 1,200 by 400 metre sized parcel of land south of Borbridge Avenue within the northern portion of the site due to restricted access to this area because of dense tree coverage. This area is labelled as ‘Parcel C’ on the Site Plan, Figure 2.

All of the boreholes were advanced using a track-mounted continuous flight hollow-stem auger drill rig, supplied and operated by George Downing Estate Drilling Ltd. of Grenville-Sur-La-Rouge, Quebec.

Standard Penetration Tests (SPT) were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using drive open sampling equipment. In situ vane testing was carried out where possible in the cohesive deposits to determine the undrained shear strength of these soils. In addition, three relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from boreholes 14-1, 14-2, and 14-3 using a fixed piston sampler.

Standpipe piezometers were sealed into boreholes 14-1, 14-3, 14-8, and 14-18 to allow subsequent measurement of the groundwater level across the site. The groundwater levels in these standpipe piezometers were measured on December 19, 2014.

The field work was supervised by an experienced technician from our staff who located the boreholes, directed the drilling operations and in situ testing, logged the boreholes, and took custody of the soil samples retrieved.

Upon completion of the drilling operations, samples of the soils encountered in the boreholes were transported to our laboratory for further examination by the project engineer and for laboratory testing. The laboratory testing included natural water content determinations, Atterberg limit tests, grain size distribution tests, and oedometer consolidation testing.

Soil samples from boreholes 14-1 and 14-10 were submitted to EXOVA Environmental Ontario Ltd. for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

The borehole locations were selected, picketed, and surveyed in the field by Golder Associates Ltd. The borehole locations and elevations were surveyed using a Trimble R8 Global Positioning System (GPS) unit. The elevations are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- Record of Borehole Sheets for the current investigation are provided in Appendix A.
- Record of Borehole Sheets from relevant boreholes from the previous investigations by Golder Associates are provided in Appendix B.
- The results of the basic chemical analysis carried out on soil samples from boreholes 14-1 and 14-10 are provided in Appendix C.
- Oedometer consolidation test results are provided on Figure 3.
- Grain size distribution testing results are provided on Figure 4.

The following sections present a detailed overview of the subsurface conditions on this site. Given the large geographical area of the site, for this discussion the subsurface descriptions have been discussed in terms of the three distinct parcels of land, which are labelled as parcels A, B and C on Figure 2.

However, in general, the subsurface conditions on the site consist of topsoil, underlain by layered clayey silt, silty clay, sandy silt, silty sand and silt overlying glacial till. Compressible clayey deposits were encountered in Parcel A as well as in the northwest corner and central north portion of Parcel B. In addition, shallow bedrock (i.e., at a depth of about 2 m) may be present in the south and east portions of Parcel B.

4.2 Parcel A

Parcel A includes the 240 by 220 metre sized parcel of land located west of River Road within the northwest portion of the site as shown on the Site Plan, Figure 2. Boreholes 14-1 and 14-2 were put down within Parcel A.

In general, the subsurface conditions in this area consist of topsoil underlain by up to 2.0 metres of clayey silt and silt, overlying a thick deposit of sensitive silty clay to clay. The upper 0.8 to 2.7 metres of the silty clay have been weathered to a stiff grey brown crust. The unweathered silty clay beneath the crust was proven to depths of about 6.7 and 7.6 metres.

4.2.1 Topsoil

Topsoil exists at ground surface, with thicknesses of about 250 and 300 millimetres at boreholes 14-1 and 14-2, respectively.

4.2.2 Layered Clayey Silt and Silt

About 1.1 and 1.2 metres of clayey silt underlie the topsoil at boreholes 14-1 and 14-2, respectively. SPT N values of 4 and 6 were recorded for this material, indicating a stiff to very stiff consistency. A water content of about 32 percent was measured within the clayey silt.

The clayey silt at borehole 14-2 is underlain by about 0.8 metres of silt. A water content of about 36 percent was measured in this material.

4.2.3 Silty Clay to Clay

The clayey silt and silt are underlain by a thick deposit of silty clay to clay (hereafter referenced to as silty clay). The upper 0.8 and 2.7 metres of the deposit, at boreholes 14-1 and 14-2, respectively, have been weathered to a grey brown crust. SPTs carried out within the weathered crust gave N values ranging from 2 to 4 blows per 0.3 metres of penetration, indicating a stiff consistency.

The clayey deposit below the depth of weathering is grey in colour. The unweathered deposit was proven/inferred to depths of 6.7 and 7.6 metres at boreholes, 14-1 and 14-2, respectively. The results of in situ vane testing in the deposit measured undrained shear strength values generally ranging from about 23 to 38 kilopascals, initially indicating a soft to firm consistency, with the shear strength generally increasing with depth, reaching as high as 86 kilopascals (stiff consistency) by about 8 metres depth.

The results of one Atterberg limit test carried out on a sample of the unweathered deposit gave a plasticity index value of about 32 percent and a liquid limit value of 56 percent, indicating a soil of high plasticity. A water content of about 48 percent was measured in the unweathered clay.

Oedometer consolidation testing was carried out on one Shelby tube sample of the unweathered clay. The results of this 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
14-2 / 5	5.1 / 82.5	50	130	0.71	0.009	1.33	2.6

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

4.2.4 Groundwater

The groundwater level in the piezometer in borehole 14-1 was measured on December 19, 2014. At that time, the groundwater level was approximately 0.7 metres below the existing ground surface.

It should be noted that groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

4.3 Parcel B

Parcel B includes the 800 by 400 metre sized parcel of land west of Spratt Road within the southern portion of the site as shown on the Site Plan, Figure 2. Boreholes 14-3 to 14-18, inclusive, were put down within Parcel B. No boreholes were put down within the southeast portion of the site, as this area has been designated for park land and a future school (which is beyond the scope of this investigation).

In general, the subsurface conditions in this area consist of topsoil underlain by layered clayey silt, sandy silt, silt, silty sand and silty clay extending to between about 0.3 and 4.9 metres depth. These layered deposits are underlain glacial till. Practical refusal to auger advancement was encountered at several locations within the eastern and southern portions of the area at depths ranging from 2.3 to 6.7 metres below the existing ground surface. The remaining boreholes were terminated at depths varying from about 5.2 to 7.5 metres below the existing ground surface.

4.3.1 Topsoil

Topsoil exists at ground surface at all of the boreholes locations and ranges in thickness from about 150 to 380 millimetres.

4.3.2 Sandy Silt and Silty Sand

A deposit of sandy silt or silty sand was encountered beneath the topsoil at nine of the borehole locations. At those locations, the layer is between about 0.3 and 1.5 metres thick. SPTs carried out within the deposit gave N values ranging from 3 to 5 blows per 0.3 metres of penetration, indicating a very loose to loose state of packing.

A water content of about 33 percent was measured for the sandy silt in borehole 14-11.

4.3.3 Clayey Silt, Silty Clay and Clay

The topsoil and/or silty sandy/sandy silt are underlain by a deposit of clayey silt, silty clay and clay (hereafter referred to as silty clay) which has been generally weathered to a grey brown colour. The weathered deposit extends to depths between about 1.5 and 4.9 metres below the existing ground surface. SPT N values obtained within this deposit range from about 1 to 7 blows per 0.3 metres of penetration. The results of two in situ vane tests in the weathered silty clay gave undrained shear strengths of about 73 to greater than 96 kilopascals. The results of this in situ testing indicate a generally stiff to very stiff consistency for the weathered crust.

The measured water contents of the weathered deposit ranged from about 43 to 53 percent.

At borehole 14-3, the weathered silty clay is underlain by layers of sandy silt and silt which extend to about 3 metres depth. A water content of about 38 percent was measured in the silt layer. A deposit of grey unweathered clayey silt, silty clay and clay underlies this silt layer and was proven to a depth of 5.9 metres. The results of in situ testing in this deposit gave undrained shear strength values ranging from 29 to 54 kilopascals indicating a firm to stiff consistency. The measured water content of one sample of the unweathered soil was about 38 percent.

At borehole 14-6, the weathered silty clay forms a crust which is underlain by about 1.6 metres of unweathered grey clayey silt. The results of in situ testing in this deposit gave undrained shear strength values of about 42 and 63 kilopascals indicating a firm to stiff consistency.

4.3.4 Silt

A layer of silt was encountered beneath the weathered crust at borehole 14-7. The silt was fully penetrated to a depth of 3.3 metres were practical refusal to auger advancement was encountered. One SPT N value of 4 blows per 0.3 metres of penetration was encountered in this deposit, indicating a loose state of packing.

4.3.5 Glacial Till

A deposit of glacial till was encountered directly beneath the topsoil at borehole 14-8 and below the sandy silt and/or clayey soils at essentially all the other borehole locations with the exception of boreholes 14-3 and 14-7 where no glacial till was present; borehole 14-3 presumably did not extend to sufficient depth and borehole 14-7 encountered refusal at shallow depth. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand or sandy silt. The glacial till was encountered at depths between about 0.3 and 4.9 metres below the existing ground surface and proven to extend to depths of between about 2.3 and 7.5 metres below the existing ground surface. The till generally extends to increasing depth from east to west across the site.

SPT N values of ‘hydraulic pressure’ to 102 blows per 0.3 metres of penetration were measured in the glacial till, indicating a very loose to very dense state of packing. However, the higher N values likely reflect the presence of cobbles and boulders within the glacial till, rather than the actual state of packing.

The measured natural water content of one sample of the glacial till was about 12 percent. The results of grain size distribution testing on one sample of the glacial till are shown on Figure 4.

Layers of clayey silt, silt, silty sand or sandy silt between about 0.1 and 1.7 metres in thickness were encountered within/beneath the glacial till deposit at several locations. Measured natural water contents of about 14 and 24 percent were measured in the silt layer in borehole 14-11 and the silty sand layer at borehole 14-17, respectively.

4.3.6 Refusal

Practical refusal to auger advancement was encountered at eight of the borehole locations (i.e., boreholes 14-6, 14-7, 14-8, 14-11, 14-12, 14-13, 14-17, and 14-18) at depths ranging from about 2.3 to 6.7 metres below the existing ground surface. These refusals were encountered within the east and south parts of the site. Refusal could indicate the bedrock surface or may reflect the presence of cobbles and boulders in the glacial till deposit. The refusal depths typically increase from east to west across the site.

Refusal on probable boulders was encountered at a depth of about 5.2 metres at borehole 14-15.

4.3.7 Groundwater

The groundwater levels in the piezometers sealed in boreholes 14-3, 14-8, and 14-18 were measured on December 19, 2014. The observed groundwater levels are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
14-3	90.8	0.7	90.1
14-8	94.7	1.3	93.4
14-18	92.3	0.8	91.5

It should be noted that groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

4.4 Parcel C

Parcel C includes the 1,200 by 400 metre sized parcel of land south of Borbridge Avenue, between River Road and Spratt Road, within the northern portion of the site as shown on the Site Plan, Figure 2. Due to restricted access to this area because of dense tree coverage, no boreholes have yet been drilled on this portion of the site. However, two boreholes (boreholes 13-101 and 13-102) from a previous investigation carried for Phase 9-4 of the Riverside South Community are located adjacent to Parcel C (just southwest of the intersection of Borbridge Avenue and Brian Good Avenue), as shown on the Site Plan, Figure 2.

Based on these boreholes it is expected that the subsurface conditions in Parcel C consist of topsoil underlain by layered silty sand, sandy silt and silty clay, overlying glacial till. The upper portion of the silty clay has likely been weathered to a grey brown crust. The underlying silty clay is likely unweathered and grey in colour, with a firm to stiff consistency.

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 borehole information as well as the project requirements, and is subject to the limitations in the "Important Information and Limitations of This Report" which follows the text of this report.

This report provides geotechnical engineering guidelines and recommendations which should be generally suitable to support an application to the City for Draft Plan approval of the overall proposed development. In addition, the guidelines and recommendations provided should also be considered acceptable for detailed development applications and building permit applications for the housing in Parcels A and B. However, additional geotechnical investigation will need to be carried out for Parcel C (once access is available) as well as for any non-residential buildings (i.e., schools, commercial building etc.) on a site-by-site basis for detailed design.

5.2 Site Grading

The subsurface conditions in Parcel A and at borehole 14-3 generally consist of topsoil underlain by stiff and/or weathered clayey silt, silty clay and silt, overlying a thick deposit of unweathered and potentially compressible sensitive silty clay to clay extending to at least 6 to 8 metres depth. The subsurface conditions within Parcel B generally consist of topsoil underlain by relatively stiff or low-compressibility layered clayey silt, sandy silt, silt, silty sand and silty clay overlying glacial till at depths varying from about 0.3 metres on the northeastern portion of Parcel B to 4.9 metres beneath the northwestern portion of the Parcel B (not including borehole 14-3). A limited thickness of compressible clayey silt was also encountered beneath the layered deposit at borehole 14-6 in Parcel B. The lower portions of the layered deposits in Parcel A as well as at boreholes 14-3 and 14-6 in Parcel B are somewhat compressible.

The "softer" layered grey silty clay, clay and clayey silt deposits have limited capacity to accept additional load from the weight of grade raise fill and from the foundations of houses without undergoing consolidation settlements. This condition is true for all of Parcel A as well as at boreholes 14-3 and 14-6 in Parcel B where compressible soil exist. Therefore, for these areas, to leave sufficient remaining capacity for the silty clay, clay and clayey silt to support house foundations, with reasonable footing sizes, the thicknesses of grade raise fill will need to be limited.

The following table provides the maximum grade raises which are permitted for each of the assessment zones indicated on Figure 2. These grade raise limitations have been assessed based on leaving sufficient remaining capacity in the silty clay, clay and clayey silt deposits such that strip footings up to 0.6 metres in size can be designed using an allowable bearing pressure of at least 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code.

Assessment Zone	Maximum Permissible Grade Raise (metres)
1	2.1
2	3.0
3*	No Limitation

Note: * There are no practical grade raise restrictions in Zone 3, where the clayey soils are very stiff and are underlain by glacial till. However, proposed grade raises of more than 4 metres would require additional review.

In addition, with regards to site grading, the surficial sand and silt deposits which were encountered across the site are relatively permeable and the measured groundwater levels are relatively shallow (i.e., about 0.7 metres below ground surface). Excavations for basement construction which extend below the groundwater level could therefore encounter groundwater inflows. Limiting the required depth of excavation into these materials could be advantageous as it would reduce the groundwater management requirements (and costs),

Similarly, the grading should also ideally be selected so as to avoid or limit the bedrock excavation on the south and east parts of Parcel B.

If the grading restrictions given above cannot be accommodated, then further recommendations from Golder Associates could be provided, if and when they are required.

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

It is considered that the proposed residences may be supported on spread footings founded at conventional depth on or within the native overburden.

As discussed in the preceding section, the silty clay deposits have limited capacity to accept the combined load from site grading fill and foundation loads. The allowable bearing pressures for spread footing foundations in Zones 1 and 2 are therefore based on limiting the stress increases on the firm, compressible, grey silty clay at depth to an acceptable level so that foundation settlements do not become excessive. Four important parameters in calculating the stress increase on the grey silty clay are:

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

Provided that the grade raises are restricted to those indicated in Section 5.2, strip footing foundations up to 0.6 metres in width and pad footings up to 2.0 metres square can be designed using a maximum allowable bearing pressure of 75 kilopascals. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC).

This same maximum allowable bearing pressure can be used for houses in Zone 3, but without restrictions on footing size.

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

The tolerance of the house foundations to accept those settlements could be increased by providing nominal levels of reinforcing steel in the top and bottom of the foundation walls.

Further, the provided maximum allowable bearing pressure for footings founded within the silty clay correspond 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.

Footings supported on bedrock (such as might be encountered in the extreme east part of Parcel B near Borehole 14-13) can be designed using a maximum allowable bearing pressure of 250 kilopascals. The settlement of footing on bedrock should be negligible.

If any existing ditches are found to underlie future houses, these ditches will need to be filled. The ditches should be dry and cleaned of all organic or disturbed soil prior to filling. The ditches should be lined with a Class II non-woven geotextile with a Filtration Opening Size (FOS) not exceeding 100 microns, in accordance with Ontario Provincial Standard Specification (OPSS) 1860. Filling to the underside of footing elevation should be carried out using engineered fill consisting of OPSS Granular B Type II (or similar approved material), placed in maximum 300 millimetre thick lifts, and compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable vibratory compaction equipment. The engineered fill should extend out and down from the outside edge of the footings at a slope not steeper than 1 horizontal to 1 vertical. Footings founded on or within properly placed engineered fill (as described above) can also be designed using a maximum allowable bearing pressure of 75 kilopascals.

If the proposed grading may also result in some of the footing levels being above the surface of the native inorganic subgrade soil (following removal of the topsoil and any surficial fill material), the engineered fill guidelines provided above should similarly be followed.

There may be portions of the site where the shallow sandy silt deposits will be exposed at footing/subgrade level. Prior to construction of footings or the placement of engineered fill within these areas, the surface of the native sandy material should be proof-rolled to provide surficial densification of any loose or disturbed material (which may require pre-drainage of these thin surficial layers).

The glacial till overburden materials in Parcel B contain boulders which may be encountered when excavating to founding level. If those boulders extend below founding level and are dislodged by the excavator, the soils around the boulders will have become disturbed. In that case, the boulders will need to be fully removed (and not pushed back in place) and the void filled with engineered fill (i.e., OPSS Granular A, Granular B Type II or clear stone) or concrete. Otherwise recompression of the disturbed soils could lead to larger than expected post-construction settlements.

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, or removing additional bedrock to provide a more gradual transition) may be required. The details will need to be developed on a case-by-case basis, and the structural engineering consultant will need to be involved in the development of those measures. Wherever possible, it is recommended that individual units all be founded on the same medium, i.e., all soil or all bedrock.

5.4 Frost Protection

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

5.5 Seismic Design

The seismic design provisions of the 2012 OBC depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or bedrock below founding level. The OBC also permits the Site Class to be specified based solely on the stratigraphy and in situ testing data, rather than from direct measurement of the shear wave velocity. Based on this methodology, it is considered that for the design of low-rise structures a Site Class of D (or better) would be applicable to houses in Zones 2 and 3. However, for houses in Zone 1 (see Figure 2), it is not possible to specify better than an E using the available information. It should be noted that the seismic Site Class is not directly applicable to structures designed in accordance with Part 9 of the OBC (i.e., conventional housing), however this assessment is provided to address City of Ottawa requirements that relate to housing on Site Class E sites. It should also be noted that a more favourable Site Class value could potentially be assigned for houses in Zone 1. Based on previous testing in the Phase 9 site to the north of Parcel C, it is considered reasonably likely that a Site Class of at least D might feasibly be assigned to Zone 1 on the basis of such testing.

5.6 Basement Excavations

Excavations for basements will be through the topsoil, layered clayey silt, silt, silty clay, sandy silt, silty sand, and underlying glacial till (where the till surface is shallow). Excavation into the bedrock could potentially be required in the northeast portion of Parcel B, where the bedrock surface is likely shallow. No unusual problems are anticipated with excavating the overburden soils using conventional hydraulic excavating equipment. Bedrock removal could be carried out by blasting or hoe ramming.

Side slopes in the overburden materials should be stable in the short term at 1 horizontal to 1 vertical in accordance with the Occupational Health and Safety Act (OHSA) of Ontario for Type 3 soils. If the water table is encountered within the excavations, the sand and silt layers may be considered as Type 4 soils and side slopes of 3 horizontal to 1 vertical may be required to prevent sloughing of the materials.

Near-vertical excavation side slopes in the bedrock should be feasible, for shallow depths of excavation.

Based on *present* groundwater levels, excavations deeper than about 0.7 metres may, in some areas, extend below the groundwater level. Where this is the case and the excavation encounters the relatively more permeable silty sand and sandy silt soils, the excavation subgrade will be subject to time dependent disturbance caused by the upward flow of groundwater, resulting in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes. However, considering the limited thickness of these deposits, it is considered that, for conventional excavation depths for basement construction, it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the floor of the excavations. Where the subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a 150 millimetre thick layer of OPSS Granular A (following inspection and approval by geotechnical personnel) underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

In these areas (of excavation below the groundwater level in sandy soils), some pre-drainage of the site using ditching or one or more shallow wells to lower the groundwater level to at least 0.5 metres below the floor of the excavation would assist in avoiding subgrade disturbance.

5.7 Basement and Garage Floor Slabs

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

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

The general groundwater level at this site is within 0.7 metres of the existing ground surface. The layered silty sand and sandy silt soils at this site are somewhat permeable and therefore, if/where the groundwater level is encountered above basement subgrade level in these soil conditions, a geotextile could be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. 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 FOS not exceeding 100 microns, in accordance with OPSS 1860.

The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of OPSS Granular A compacted to at least 95 percent of the materials standard Proctor maximum dry density using suitable compaction equipment.

5.8 Basement Wall 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, a bond break such as Platon system sheeting should 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 need to be provided.

5.9 Site Servicing

Excavations for the installation of site services will be made through the topsoil, layered clays, silts, sand, as well as the glacial till and possibly bedrock (at least on the east/high part of the site). No unusual problems are anticipated with excavating the overburden using conventional hydraulic excavating equipment. However, it should be expected that boulders will be encountered within the glacial till. Boulders larger than 0.3 metres in size should be removed from the excavation side slopes.

It should be noted that no bedrock was cored as part of this investigation. The drilling of additional boreholes cored into the bedrock should be considered, if once the sewer profiles are determined, it will be the case that the service excavations are expected to extend into the bedrock. However, the following provides preliminary recommendations for excavation into bedrock.

Based on the geological mapping, the bedrock (as expected to be present within the south and east portions of Parcel B) likely consists of March formation sandstone and Oxford formation dolostone, which are known to be quite strong and abrasive (which could impact on equipment wear). Bedrock removal within these formations could be accomplished using mechanical methods (such as hoe ramming) for shallow excavation depths. However, deeper excavations will likely require drill and blast procedures, as hoe ramming would be slow and inefficient.

In accordance with the OHSA of Ontario, the overburden soils above the water table would generally be classified as Type 3 soils and side slopes in the overburden in the short term may be sloped at 1 horizontal to 1 vertical. Excavation side slopes below the groundwater level in the sandier overburden soils as well as within the soft clayey soils will slough to a somewhat flatter inclination and these excavation side slopes would need to be cut back at 3 horizontal to 1 vertical (i.e., Type 4 soils). Alternatively, excavations within the overburden could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation.

Near-vertical excavation side slopes in the bedrock should be feasible, at least for shallow depths of excavation (e.g., less than about 2 to 3 metres deep). The stability of deeper excavations would need further assessment.

Blasting should be controlled to limit the peak particle velocities at all adjacent structures or services (such as may be created by the development phasing) such that blast induced damage will be avoided. Blast designs should be prepared by a specialist in this field.

A pre-blast survey should be carried out of all the surrounding structures and utilities.

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

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

Frequency Range (Hz)	Vibration Limits (mm/sec)
< 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 operations be carried out both in the ground adjacent to the closest structures/utilities and within the structures/utilities themselves. Some groundwater inflow into the excavations could be expected. However, it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations provided suitably sized pumps are used. Somewhat higher rates of groundwater inflow could be expected where the excavation extends into/through deep sandy layers such as were encountered at boreholes 14-14, 14-17, and 14-18 in the southwest part of Parcel B. In these areas, active dewatering of the sandy layers in advance of excavation could be necessary, such as by pumping from shallow wells. However, the need for such measures will depend on the design invert levels of the sewers. This issue should be reviewed further once the design sewer levels are known. Consideration should also be given to carrying out a test excavation at the bidding stage so that the contractors can directly view the groundwater flow conditions.

The hydraulic conductivity of the bedrock is also not known, but trenches in the bedrock could also potentially encounter significant groundwater inflow. The bedrock formations which are mapped to underlie this site are known to often have a very high hydraulic conductivity. A significant fault is also mapped to cross this site. If trenches into the bedrock will be required, further investigation to evaluate the bedrock hydraulic conductivity should be considered.

The actual rate of groundwater inflow to the trenches will depend on many factors including the contractor’s schedule and rate of excavation, the size of the excavation, and the time of year at which the excavation is made. There also may be instances where significant volumes of precipitation and/or groundwater collects in an open excavation, and must be pumped out. A Permit-To-Take-Water (PTTW) should be obtained from the provincial Ministry of the Environment (MOE) for this work.

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes (or 300 millimetres where the trench is in bedrock). Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. In Zones 1 and 2, where the sewers will likely be installed directly in the unweathered silt and clay, it is particularly likely that additional bedding thickness (e.g., 300 millimetres) will be required. The bedding material should, in all cases, extend to the spring line of the pipe and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density. The use of crushed clear stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or sandy soils on the trench walls could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

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

It should generally be possible to re-use the drier silty clay, clayey silt, sandy silt, silty sand and glacial till as trench backfill.

However, the high moisture content of the deeper silt and clay deposits (i.e., silt, silty clay, clay and clayey silt) makes these soils difficult to handle and compact. If these materials are excavated during installation of the site services, they should be wasted or should only be used as backfill in the lower portion of the trenches to limit the amount of long term settlement of the roadway surface. If the unweathered silty clay, clay or clayey silt are used in trenches under roadways, long term settlement of the pavement surface should be expected. Some significant padding of the roadways may be required prior to final paving. In that case, it would also be prudent to delay final paving for as long as practical.

Well fractured or well broken bedrock will be acceptable as backfill for the lower portion of the service trenches in areas where the excavation is in rock. The rock fill, however, should only be placed from at least 300 millimetres above the pipes to minimize damage due to impact or point load. The rock fill should be limited to a maximum of 300 millimetres in size.

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

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.

5.10 Pavement Design

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

Pavement areas requiring grade raising to proposed subgrade level should be filled using acceptable OPSS Select Subgrade Material (SSM). The SSM should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment.

Transitions from bedrock to earth subgrade (if this condition is encountered) should be carried out in accordance with Ontario Provincial Standard Drawing (OPSD) 205 series. The transition depth ‘t’ should be taken as 1.8 metres.

The surface of the pavement subgrade should be crowned to promote drainage of the roadway granular structure. Perforated pipe sub-drains should be provided at subgrade level extending from the catch basins for a distance of at least 3 metres longitudinally, parallel to the curb in two directions.

The pavement structure for local roads without bus or truck traffic should consist of:

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

The pavement structure for collector roadways which will include bus and truck traffic should consist of:

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

For arterial roadways, the subbase thickness should be increased to 600 millimetres.

The granular base and subbase materials should be uniformly compacted as per OPSS 501, Method A. The asphaltic concrete should be compacted in accordance with the procedures outlined in OPSS 310

The composition of the asphaltic concrete pavement should be as follows:

Superpave 12.5 mm Surface Course	40 mm
Superpave 19 mm Base Course	50 mm

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

In regards to the above pavement structure for local roads, it should be noted that the 50 millimetres of asphaltic concrete base course would provide sufficient structural support and would therefore be adequate for the initial periods of roadway service. However, the 90 millimetres of asphaltic concrete is specified for the local roadways based on the typical construction sequence which would require a surface course placement following substantial completion of the house construction.

In addition, if a similar paving sequence is proposed for collector roads, with an additional course being required upon substantial completion of site development, then a thicker overall asphaltic concrete layer would be required (to allow for three lifts), since two initial lifts will likely be required to support the construction traffic. Alternatively, a thicker base course could be provided during construction phase and a 40 millimetre surface course provided at the substantial completion. Further guidelines for both options can be provided, if required.

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 Pools, Decks and Additions

The following guidelines are provided to address some typical requirements of the City of Ottawa.

5.11.1 Above Ground and In Ground Pools

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

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

5.11.2 Decks

It is considered that, in general, no particular geotechnical evaluation/assessment will be necessary for future decks, added by the homeowners, except where:

- The deck will be attached to the house; and/or,
- The deck will be heavily loaded and require spread footing or drilled pier foundations (i.e., where the deck will be designed in accordance with the OBC and require a building permit).

5.11.3 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 of Ottawa prior to the building permit being issued.

5.12 Corrosion and Cement Type

Samples of soil from boreholes 14-1 and 14-10 were submitted to EXOVA Environmental Ontario for basic chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix C. The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a moderate potential for corrosion of exposed ferrous metal, which should be considered in the design of substructures.

5.13 Trees

The clay soils on this site are potentially sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from clay soil, the clay undergoes shrinkage which can result in settlement of adjacent structures. Some restrictions could therefore need to be imposed on the planting of trees of higher water demand in close proximity to the foundations of houses or other structures founded at shallow depth. The required set-backs can be evaluated once further details are available on the site grading design. For example, where the grading will result in structures founded on engineered fill, the restrictions may not apply.

6.0 ADDITIONAL CONSIDERATIONS

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

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that 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.

At the time of the writing of this report, only preliminary details for the proposed subdivision were available. Golder Associates should be retained to review the guidelines provided in this report once additional details are known.

It was also not possible to investigate all portions of the site, due to the dense tree coverage. Once the development plans have been confirmed, and the trees removed, the additional investigation requirements should be evaluated. In particular, depending on the required sewer excavation depths, additional hydrogeological investigation could be required in order to evaluate the hydraulic conductivity of (and potential inflow from) the deep sand layers and/or the bedrock in order to support a PTTW application. It should also be confirmed that the boreholes drilled as part of this investigation extend below the required excavation depths for the sewers (since the invert levels are not currently known), particularly in the areas of the site where potentially shallow bedrock was encountered. In this case, further investigation would likely be required to confirm the depth and type of the bedrock.

For development of Parcel A, an assessment of the stability of the slope adjacent to the Rideau River (and the required set-back to the Limit of Hazard Lands) has not been included as part of this investigation, because it is understood that an assessment of the slope has already been carried out by others.

It should also be noted that, although one oedometer consolidation test was carried out on one of the Shelby tube samples retrieved for this investigation, there are additional samples currently in storage that could be tested if the permissible grade raises specified in Section 5.2 cannot be accommodated and further refinement is required. However, these samples are generally only maintained for a period of 3 months following issuance of the report.

For any higher/heavier structures (e.g., schools, commercial buildings etc.) proposed for the site that will be designed in accordance with Part 4 of the OBC, further investigation will be required to support the site plan and building permit applications and additional geotechnical guidelines will need to be provided for detailed design.

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

7.0 CLOSURE

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

GOLDER ASSOCIATES LTD.

Susan Trickey, P.Eng.
Geotechnical Engineer

Mike Cunningham, P.Eng.
Principal, Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
M. I. CUNNINGHAM
PROVINCE OF ONTARIO

SAT/MIC/bg

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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 practising 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, Riverside South Development 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.

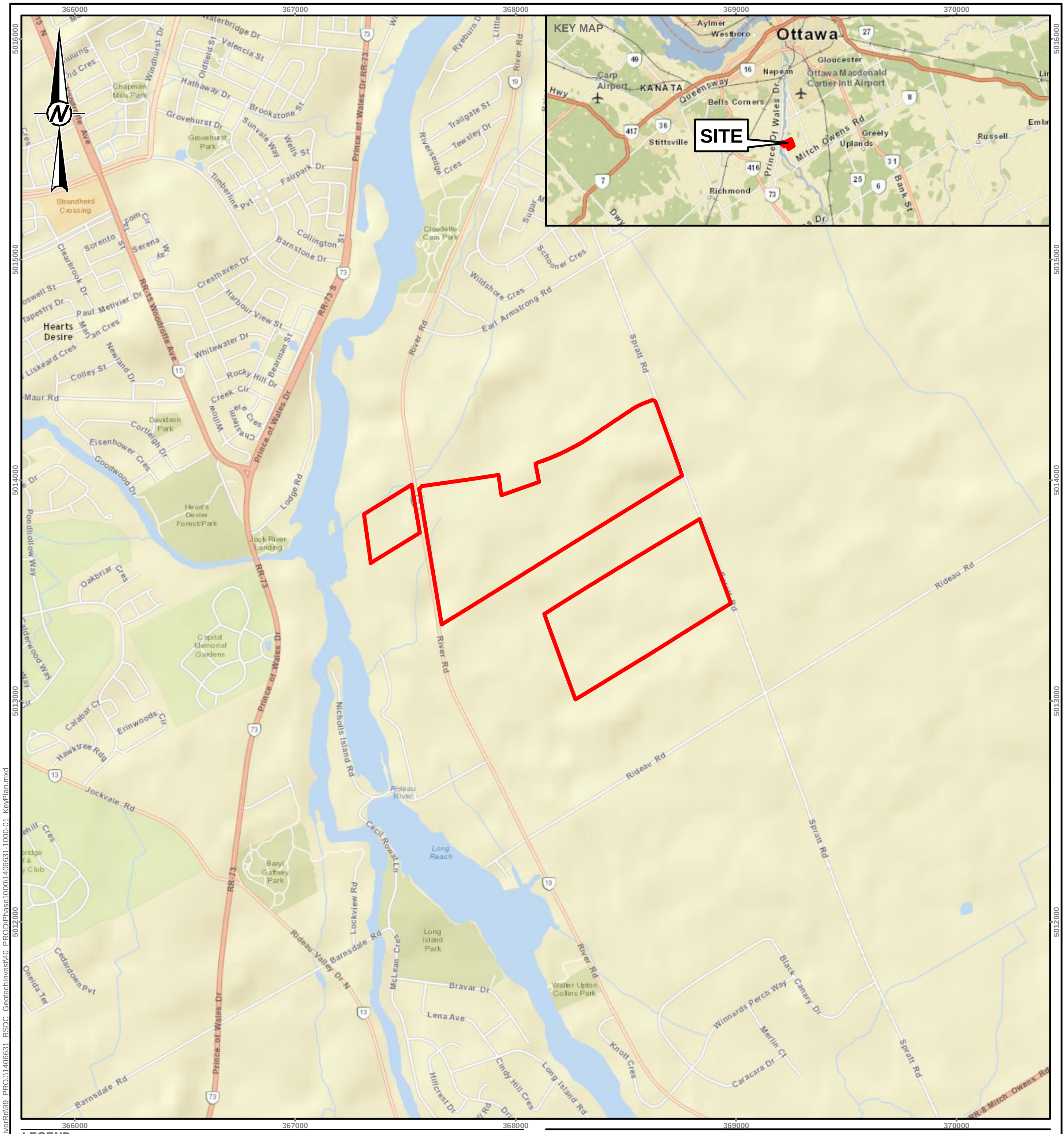
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater 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.



LEGEND

🟥 SITE LIMITS

0 250 500 1,000

1:25,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1406631.

REFERENCE(S)

1. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, DELORME, USGS, INTERMAP, INCREMENT P CORP., NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI (THAILAND), TOMTOM, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83

CLIENT

RIVERSIDE SOUTH DEVELOPMENT CORPORATION

PROJECT

GEOTECHNICAL INVESTIGATION
RIVERSIDE SOUTH DEVELOPMENT (PHASE 15) PROPOSED RESIDENTIAL DEVELOPMENT, OTTAWA, ONTARIO

TITLE

KEY PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-02-24
DESIGNED	----
PREPARED	BR
REVIEWED	SAT
APPROVED	MIC

PROJECT NO.	PHASE	REV.	FIGURE
1406631	1000	A	1

Path: N:\Active\Spatial_IM\Riverside_South_Development_Corporation\Part4860Spratt_760RiverRd\99_PROJ\1406631_RSDC_GeotechInvest\40_PROD\Phase1000\1406631-1000-01_KeyPlan.mxd

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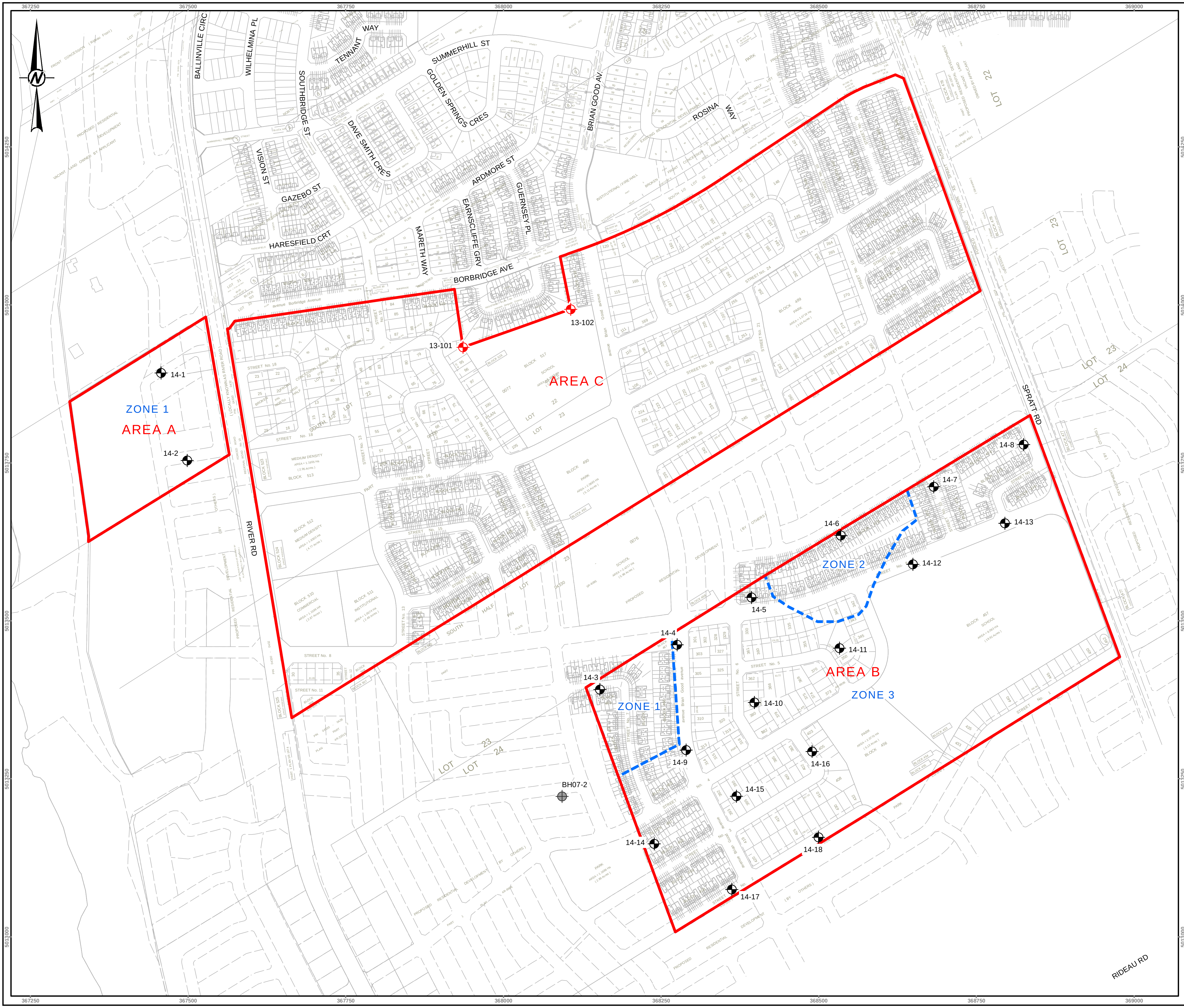

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LEGEND

- ⊕ BOREHOLE LOCATION IN PLAN
- ⊕ BOREHOLE FROM PREVIOUS GOLDER ASSOCIATES LTD. INVESTIGATION PROJECT NO. 10-1121-0260
- ⊕ BOREHOLE FROM PREVIOUS GOLDER ASSOCIATES LTD. INVESTIGATION PROJECT NO. 07-1121-0141
- 🟥 SITE LIMITS
- ⬚ ASSESSMENT ZONE

0 50 100 200

1:6,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1406631.

REFERENCE(S)

1. DEVELOPMENT PLAN PROVIDED BY RIVERSIDE SOUTH DEVELOPMENT CORPORATION IN CAD FORMAT, DRAWING "14763-14 URBANDALE PT LT 22 23 24 BF RF GL SK N D7", 2014-06-13.
2. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
3. SERVICE LAYER CREDITS:
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: MTM ZONE 9 VERTICAL DATUM: CGVD28

CLIENT
RIVERSIDE SOUTH DEVELOPMENT CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
RIVERSIDE SOUTH DEVELOPMENT (PHASE 15) PROPOSED
RESIDENTIAL DEVELOPMENT, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-02-24
DESIGNED	----
PREPARED	BR
REVIEWED	SAT
APPROVED	MIC

PROJECT NO.	PHASE	REV.	FIGURE
1406631	1000	A	**2**

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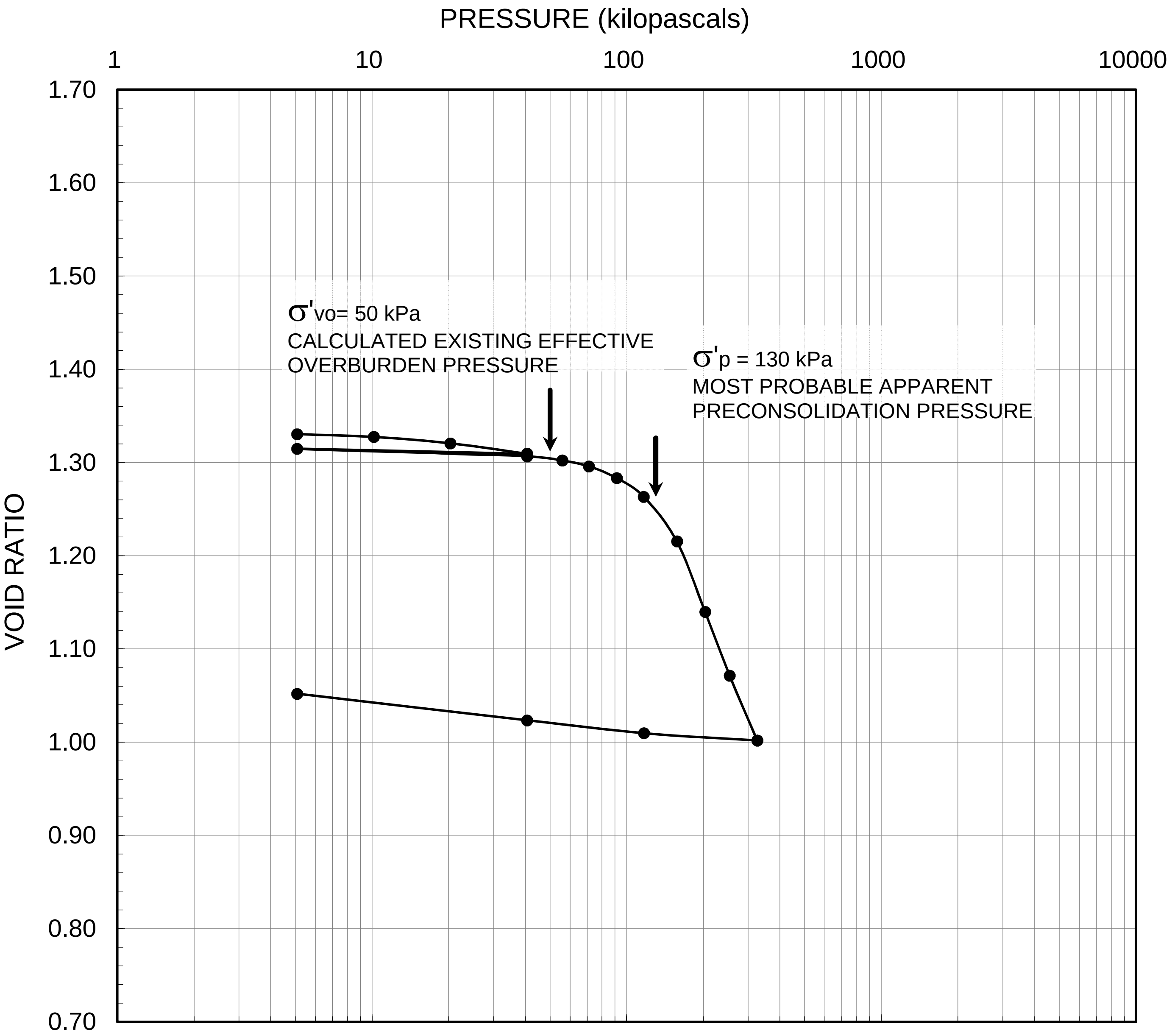


LEGEND

Borehole:	14-2	w_i =	48%	S_o =	100%	γ =	17.2 kN/m³
Sample:	5	w_f =	39%	e_o =	1.33	G_s =	2.77
Depth (m):	5.1	w_l =	56%	C_c =	0.71		
Elevation (m):	82.5	w_p =	24%	C_r =	0.009		

Golder Associates

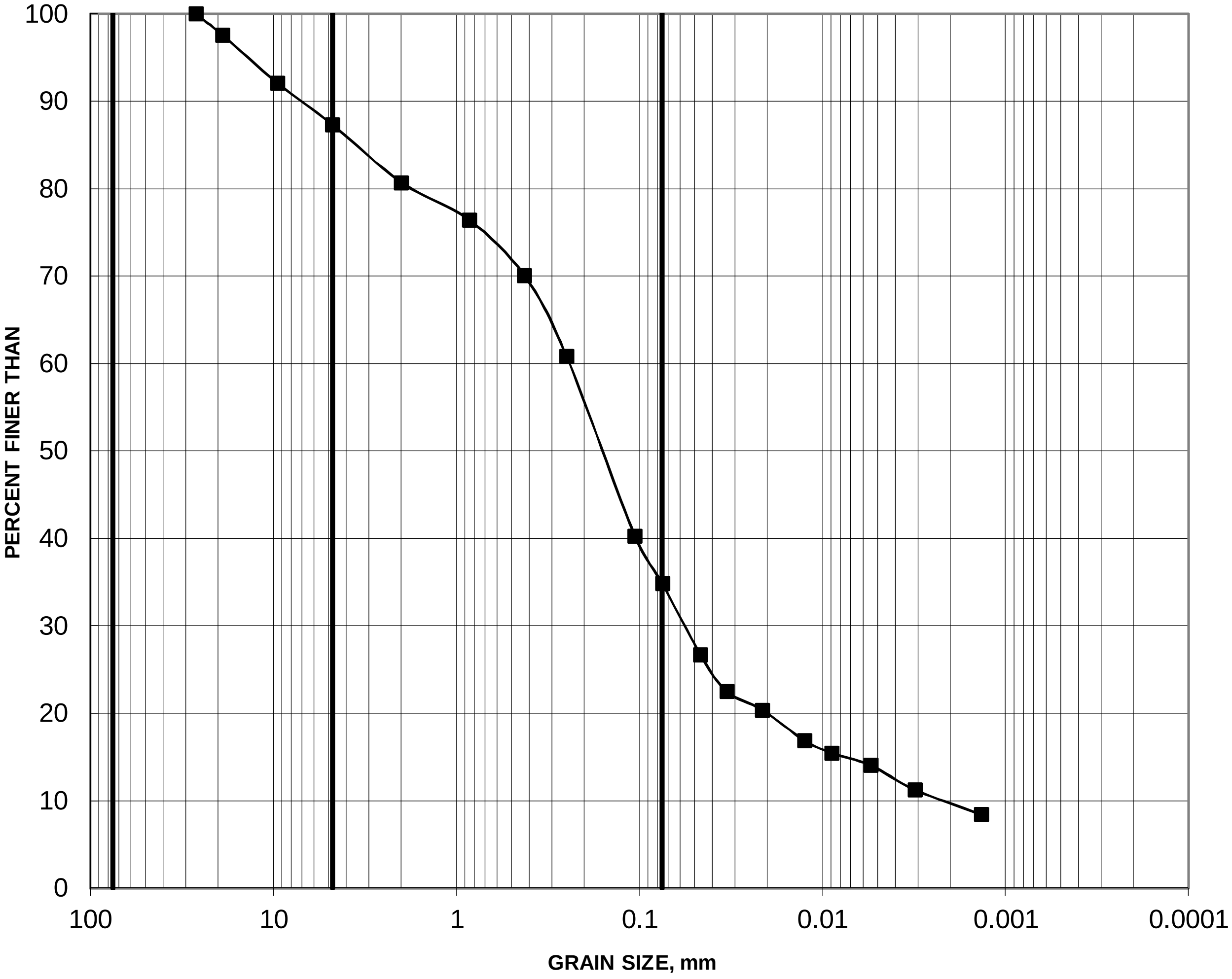
FILE No. Consolidation summary
PROJECT No. 1406631 REV. 2
SCALE AS SHOWN
DATE 03/04/15
CADD N/A
ENTERED MI
CHECK CNM
REVIEW SAT
TITLE

CONSOLIDATION TEST RESULTS

FIGURE **3**

GRAIN SIZE DISTRIBUTION	FIGURE 4

GLACIAL TILL



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

Borehole	Sample	Depth (m)
■ 14-11	5	4.57-5.18

Project: 1406631

Golder Associates

Created by: CW
Checked by: CNM

APPENDIX A

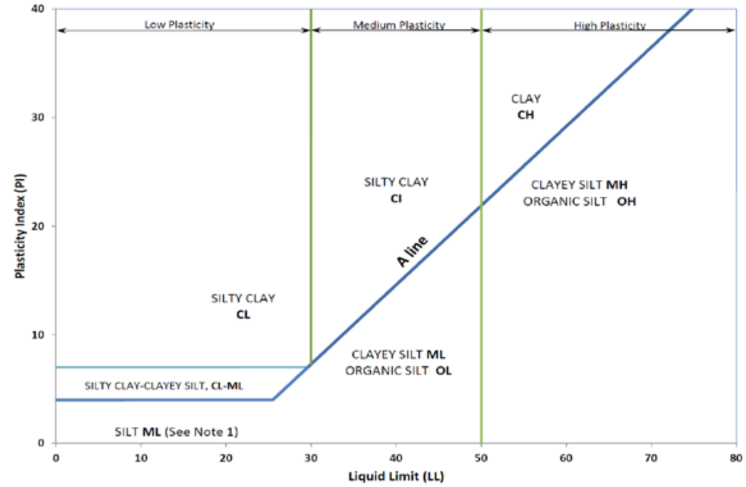
List of Abbreviations and Symbols
Record of Borehole Sheets

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, 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 $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

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

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

PROJECT: 1406631

RECORD OF BOREHOLE: 14-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 12, 2014

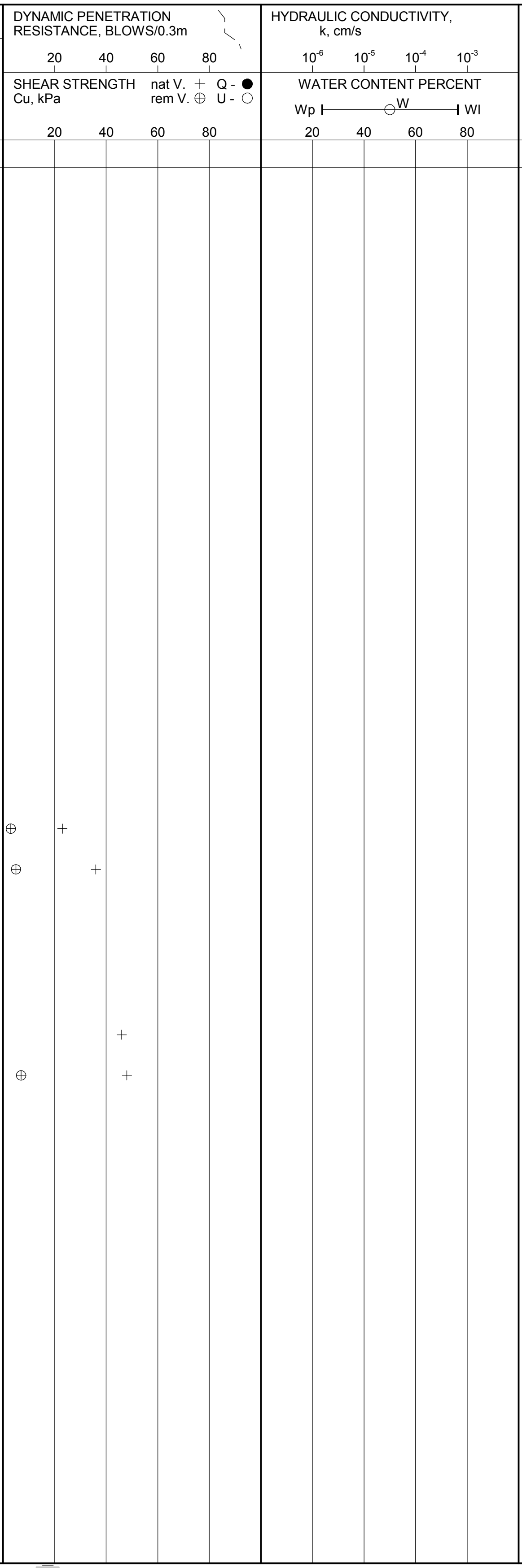
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

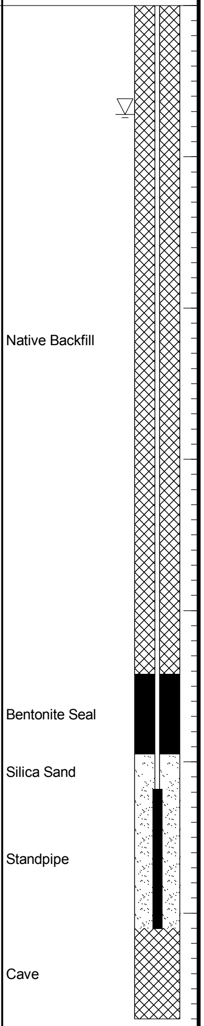
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	87.92
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown	0.00
	(ML) CLAYEY SILT, some sand; brown; cohesive, w>PL, stiff	87.67 0.25
	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured (WEATHERED CRUST); cohesive, w~PL, stiff	86.55 1.37
	(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, soft to firm	83.81 4.11
	End of Borehole	81.22 6.70

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	6	
2	SS	4	CHEM
3	SS	3	
4	SS	2	
5	SS	2	
6	TP	PH	



PIEZOMETER OR STANDPIPE INSTALLATION



WL in Standpipe at Elev. 87.20 m on Dec. 19, 2014

DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-2

SHEET 1 OF 1

LOCATION: See Site Plan

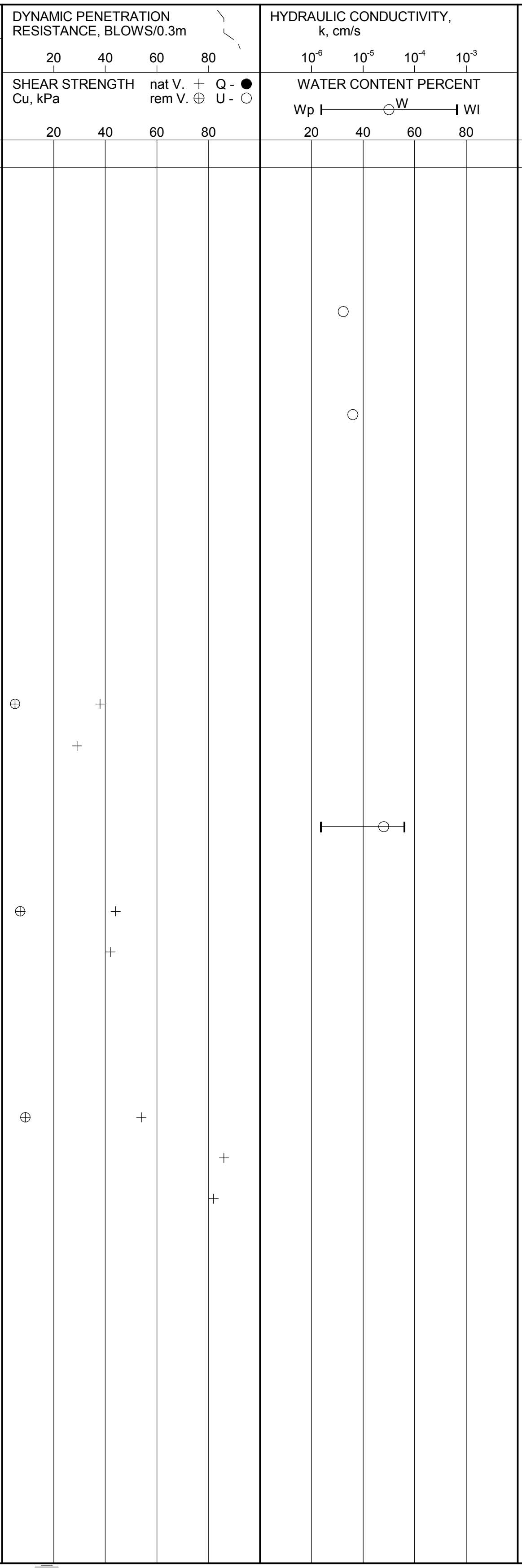
BORING DATE: December 11, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		87.59					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00					
		(ML) CLAYEY SILT, trace sand; brown; cohesive, w>PL, stiff		87.29 0.30	1	SS	4		
		(ML) SILT; grey brown; cohesive, w>PL		86.07 1.52	2	SS	2		
		(CI/CL-ML) SILTY CLAY/CLAYEY SILT; grey brown, with sand seams (WEATHERED CRUST); cohesive, w>PL, stiff		85.31 2.28	3	SS	2		
		(CH/CI-ML) SILTY CLAY to CLAY, some silt seams; grey, with black mottling below 6.1 m depth; cohesive, w>PL, firm to stiff		84.54 3.05	4	SS	PH		
					5	TP	PH	C	
					6	SS	PH		
		End of Borehole		79.97 7.62					



DEPTH SCALE
1 : 50

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-3

SHEET 1 OF 1

LOCATION: See Site Plan

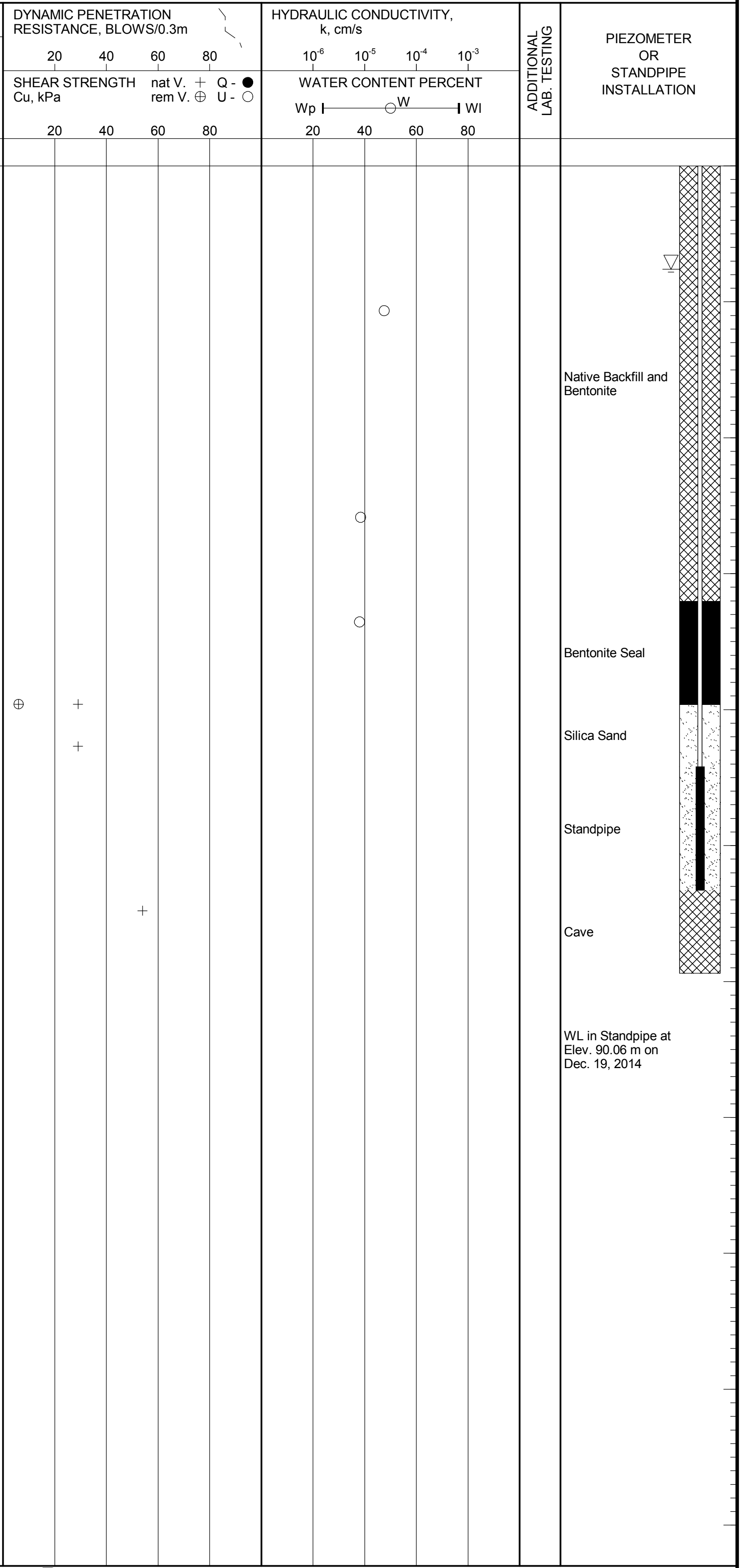
BORING DATE: December 10, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		GROUND SURFACE		90.82			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00			
		(CI/CL) SILTY CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w~PL, very stiff		90.52 0.30			
1					1	SS	7
		(ML) sandy SILT; grey brown; non-cohesive, moist to wet, very loose		89.30 1.52	2	SS	2
2		(ML) SILT, some sand, trace gravel; grey; non-cohesive, wet		88.54 2.28	3	SS	1
3		(CH/CI-ML) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; grey; cohesive, w>PL, firm to stiff		87.77 3.05	4	SS	1
4					5	TP	PH
5					6	SS	1
6		End of Borehole		84.88 5.94			
7							
8							
9							
10							



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 10, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE / SHEAR STRENGTH	HYDRAULIC CONDUCTIVITY / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
	GROUND SURFACE		91.32							▽
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00							
	(ML) sandy SILT; grey brown; non-cohesive, moist, very loose		90.99 0.33	1	SS	4				
	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, fissured (WEATHERED CRUST); cohesive, w~PL, very stiff to stiff		89.49 1.83	2 3 4 5	SS SS SS SS	3 3 3 1				
	(SM) SILTY SAND, some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to dense		86.45 4.87	6 7 8	SS SS SS	24 39 14				
	(SM) gravelly SILTY SAND; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, very dense		84.46 6.86	9	SS	84				
	End of Borehole		83.85 7.47							WL in open borehole at ground surface upon completion of drilling

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 03/09/15 JM

PROJECT: 1406631

RECORD OF BOREHOLE: 14-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 10, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.04							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00							∇
1		(ML) sandy SILT, some clay; brown; non-cohesive, moist to wet, very loose		92.76 0.28	1	SS	3				
2		(SM) SILTY SAND, trace gravel to gravelly; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense		91.52 1.52	2	SS	20				
					3	SS	58				
3					4	SS	37				
4		(ML) sandy SILT, trace gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact		89.23 3.81	5	SS	11				
5		(SM) SILTY SAND, trace to some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very loose to compact		88.47 4.57	6	SS	2				
					7	SS	23				
6		End of Borehole		87.10 5.94							WL in open borehole at 0.28 m depth below ground surface upon completion of drilling
7											
8											
9											
10											

DEPTH SCALE
1 : 50

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 11, 2014

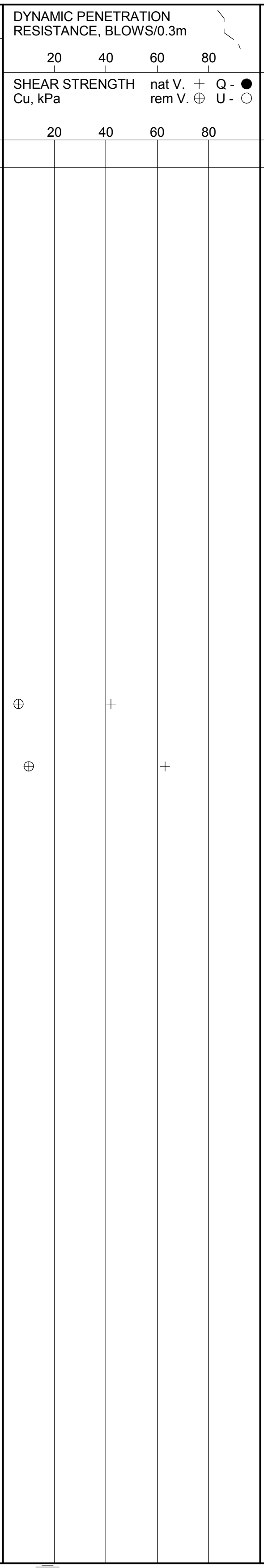
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	92.74			
TOPSOIL - (ML) sandy SILT; dark brown, with roots	0.00			
(ML) sandy SILT; grey brown; non-cohesive, moist to wet, very loose to loose	92.36 0.38	1	SS	4
(ML-CI/CL) CLAYEY SILT/SILTY CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff to firm	91.22 1.52	2	SS	3
		3	SS	1
(ML) CLAYEY SILT, trace sand; grey, with silt seams; cohesive, w>PL, firm to stiff	89.69 3.05	4	SS	1
(ML) sandy SILT, trace gravel; grey, with silt seams (GLACIAL TILL); non-cohesive, wet, very loose	88.17 4.57	5	SS	3
(ML) CLAYEY SILT, some sand, trace gravel; grey; non-cohesive, wet, very loose	87.41 5.33	6	SS	2
End of Borehole Auger Refusal	86.90 5.84			



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

▽ WL in open borehole at 4.57 m depth below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-7

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 11, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	93.00							
TOPSOIL - (ML) sandy SILT; dark brown	0.00							
(ML/SM) sandy SILT/SILTY SAND; brown; non-cohesive, moist	92.67 0.33							
(CI/CL) SILTY CLAY, trace sand; brown, highly fissured (WEATHERED CRUST); cohesive, w>PL, stiff	92.39 0.61							
		1	SS	4		○		
		2	SS	4				
(ML) SILT, trace sand; brown; non-cohesive to slightly cohesive, w>PL, loose	90.72 2.28							
		3	SS	4		○		
		4	SS	>50				
End of Borehole Auger Refusal	89.75 3.25							

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-8

SHEET 1 OF 1

LOCATION: See Site Plan

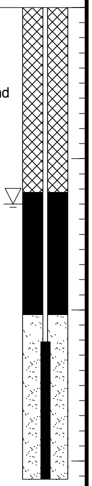
BORING DATE: December 11, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.69							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00							
		(SM) SILTY SAND, some gravel; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist, loose		94.41 0.28							Native Backfill and Bentonite
1					1	SS	7				
		(ML-SM) sandy SILT/SILTY SAND, trace gravel; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, very dense		93.17 1.52	2	SS	23				Bentonite Seal
2											Silica Sand
					3	SS	51				Standpipe
3		(ML) sandy SILT; brown; non-cohesive, dense		91.64 3.12	4	SS	>50				
		End of Borehole Auger Refusal									WL in Standpipe at Elev. 93.39 m on Dec. 19, 2014
4											
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-9

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 9, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.97
TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown	0.00
(ML) sandy SILT; grey brown; non-cohesive, moist	90.61 0.36
(CI/CH-ML) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	89.14 1.83
(SM) SILTY SAND, trace gravel to gravelly; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to vey dense	87.01 3.96
End of Borehole	83.50 7.47

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	3
3	SS	5
4	SS	2
5	SS	39
6	SS	102
7	SS	18
8	SS	12

Shear strength at approx. 4.0 m depth: >96 +

PIEZOMETER OR STANDPIPE INSTALLATION: ∇

WL in open borehole at 4.57 m depth below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-10

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.00							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, some sand; dark brown		0.00							
		(CL) sandy CLAYEY SILT; brown; non-cohesive		91.77 0.23							
		(ML-CI/CL) CLAYEY SILT/SILTY CLAY, trace to some sand; brown (WEATHERED CRUST); cohesive, w>PL, stiff		91.47 0.53							
1					1	SS	3				
					2	SS	4			CHEM	
2											
		(SM-ML) SILTY SAND/sandy SILT, trace to some gravel; brown to grey, with cobbles/boulders (GLACIAL TILL), non-cohesive, moist to wet, compact to loose		89.87 2.13							
					3	SS	31				
3											
					4	SS	18				
4											
					5	SS	12				
											∇
5											
					6	SS	8				
					7	SS	5				
6		End of Borehole		86.06 5.94							WL in open borehole at 4.57 m depth below ground surface upon completion of drilling
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-11

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 10, 2014

DATUM: Geodetic

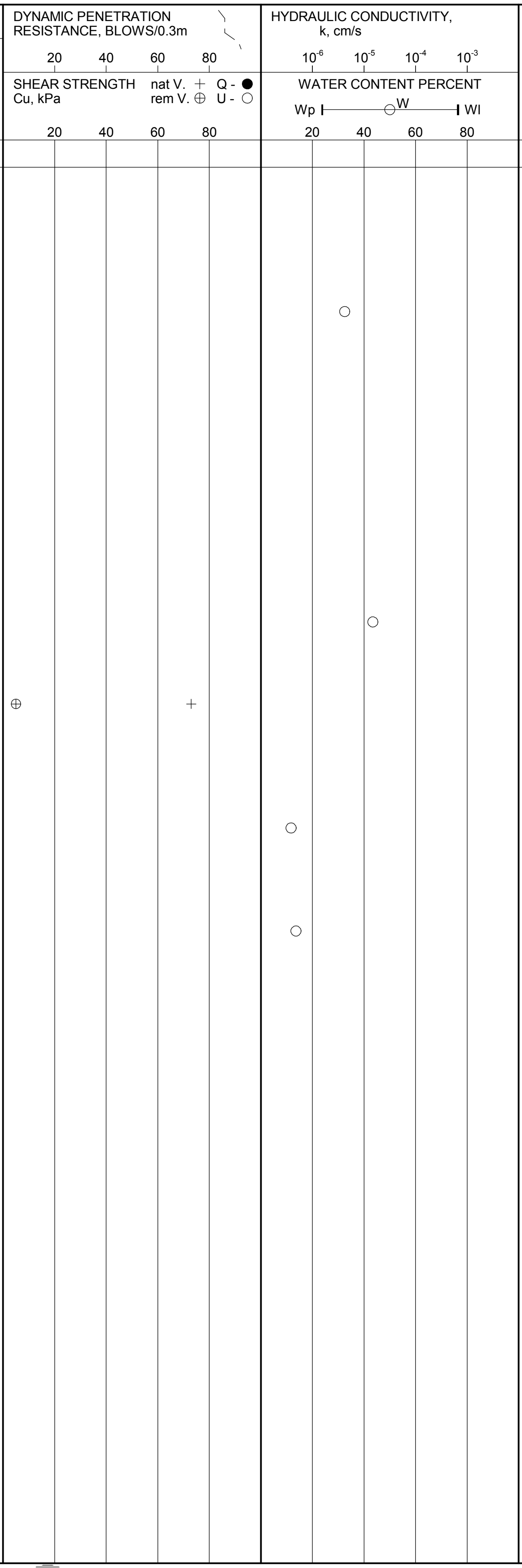
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	92.57
TOPSOIL - (ML) sandy SILT; dark brown	0.00
(ML) sandy SILT; brown; non-cohesive, wet, loose	92.29 0.28
(CI/CH-ML) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; grey brown, fissured (WEATHERED CRUST); cohesive, w>PL, stiff	91.05 1.52
(SM) SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive, wet, very loose	88.30 4.27
(ML) SILT, some sand, trace gravel; grey; non-cohesive, wet, loose	87.24 5.33
(ML) sandy SILT, trace gravel; grey (GLACIAL TILL); non-cohesive, wet, loose	86.47 6.10
End of Borehole Auger Refusal	85.92 6.65

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	3	
2	SS	3	
3	SS	PH	
4	SS	1	
5	SS	PH	MH
6	SS	8	
7	SS	9	



PIEZOMETER OR STANDPIPE INSTALLATION

∇

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

DEPTH SCALE 1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-12

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ├──○W──┤ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m				
		GROUND SURFACE		92.93							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, some sand; dark brown		0.00							
		(SM) SILTY SAND; brown; non-cohesive, moist		92.70 0.23							
		(CI/CH) SILTY CLAY to CLAY, trace sand; brown, highly fissured (WEATHERED CRUST); cohesive, w>PL, very stiff		92.42 0.51							
1					1	SS	9				
2					2	SS	6				
		(ML-SM) sandy SILT/SILTY SAND, some gravel; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, dense to very dense		90.80 2.13	3	SS	>50				
3					4	SS	50				∇
4		(SM/GM) SILTY SAND and GRAVEL; grey brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very dense		89.12 3.81	5	SS	93				
					6	SS	>50				
5		End of Borehole Auger Refusal		88.01 4.92							WL in open borehole at 3.05 m depth below ground surface upon completion of drilling
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-13

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	93.72							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown	0.00							
		(CI/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive	0.15							
		(SM) SILTY SAND, trace gravel; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, very dense to very loose	0.31							
1				1	SS	56				
2				2	SS	3				
				3	SS	>50				
		End of Borehole Auger Refusal	91.39 2.33							
3										
4										
5										
6										
7										
8										
9										
10										

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 03/09/15 JM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-14

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 9, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
	GROUND SURFACE	91.09	
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown		0.00
	(ML) sandy SILT; brown; non-cohesive, moist, loose	90.76	0.33
	(CI/CH) SILTY CLAY to CLAY, trace sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff	89.57	1.52
	(SM) SILTY SAND, trace to some gravel; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense	88.20	2.89
	(SM) SILTY SAND; brown; non-cohesive, wet, compact	85.76	5.33
	End of Borehole	85.15	5.94

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	5
3	SS	4
4	SS	35
5	SS	51
6	SS	10
7	SS	27

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

∇

WL in open borehole at 4.57 m depth below ground surface upon completion of drilling

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

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-15

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 9, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	91.63	
TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown		0.00
(ML) CLAYEY SILT, some sand; grey brown; cohesive, w>PL, very stiff	91.27	0.36
(CI/CH) SILTY CLAY to CLAY, trace sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff	90.41	1.22
(SM) SILTY SAND, some gravel; brown, with cobbles/boulders and silt seams (GLACIAL TILL); non-cohesive, wet, compact to dense	88.89	2.74
End of Borehole Refusal on Possible Boulders	86.45	5.18

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	5
3	SS	5
4	SS	13
5	SS	42
6	SS	37

▽

WL in open borehole at ground surface upon completion of drilling

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

DEPTH SCALE
1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-16

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.08							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown		0.00							
		(CI/CH) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; grey brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		91.88 0.20							
1					1	SS	4				
					2	SS	5				
2											
					3	SS	3				
3											
					4	SS	3				∇
		(SM) SILTY SAND, some gravel; grey brown to grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to dense		88.38 3.70							
4					5	SS	18				
5					6	SS	19				
					7	SS	44				
6		End of Borehole		86.14 5.94							WL in open borehole at 3.66 m depth below ground surface upon completion of drilling
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-17

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 9, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

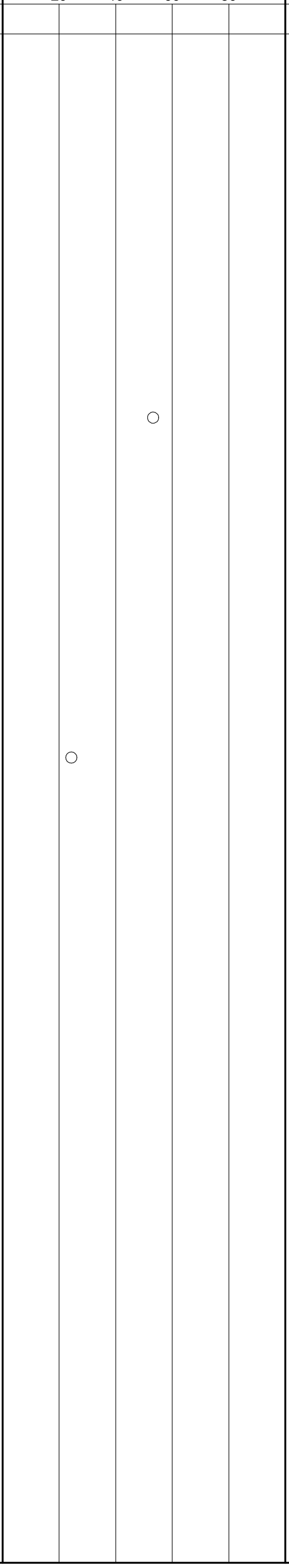
SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	91.53	
TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown		0.00
(ML) sandy SILT; brown; non-cohesive, moist to wet	91.25	0.28
(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.77	0.76
(ML) sandy SILT, trace gravel; brown (GLACIAL TILL); non-cohesive, wet, loose	88.18	3.35
(SM) SILTY SAND; brown; non-cohesive, wet, compact	87.72	3.81
(ML) sandy SILT, trace gravel; grey brown (GLACIAL TILL); non-cohesive, wet	86.05	5.48
End of Borehole Auger Refusal	85.84	5.69

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	4
3	SS	3
4	SS	3
5	SS	21
6	SS	21
7	SS	>50

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

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

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE
1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-18

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 8, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	92.34				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown	0.00				Native Backfill and Bentonite
		(CI/CH-ML) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; brown, mottled (WEATHERED CRUST); cohesive, w>PL, very stiff	92.01 0.33	1	SS	7	Bentonite Seal
2		(SM) SILTY SAND, trace gravel; brown, with iron staining; non-cohesive, wet	90.51 1.83	2	SS	14	Silica Sand
		(SM/GM) SILTY SAND and GRAVEL; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very dense	90.06 2.28	3	SS	100	
3		(SP) gravelly SAND; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very dense	89.29 3.05	4	SS	85	Standpipe Silica Sand
		End of Borehole Auger Refusal	88.68 3.66				WL in Standpipe at Elev. 91.52 m on Dec. 19, 2014

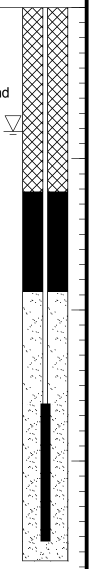
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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

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

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

ADDITIONAL LAB. TESTING



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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

APPENDIX B

Record of Borehole Sheets
Previous Investigations by Golder Associates Ltd.

PROJECT: 07-1121-0141

RECORD OF BOREHOLE: 07-2

SHEET 1 OF 1

LOCATION: See Site Plan

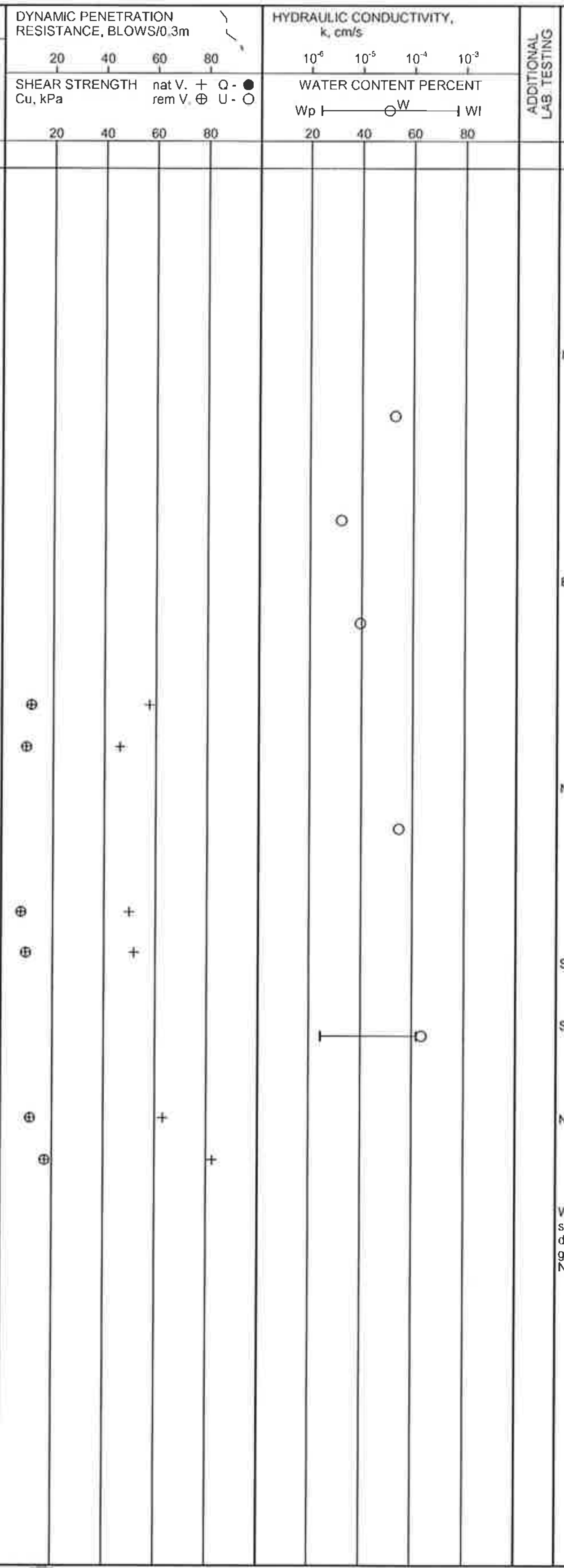
BORING DATE: Oct. 16, 2007

DATUM:

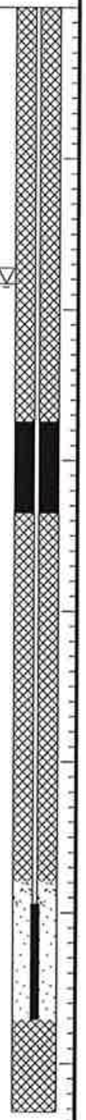
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE				
0	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL	0.00			
		Grey brown SILTY fine SAND	0.22			
1		Very stiff grey brown and red brown SILTY CLAY, some silty fine sand layers and seams (Weathered Crust)	0.91	1	50 DO	6
2				2	50 DO	5
				3	50 DO	3
3		Stiff grey SILTY SAND	3.05	4	50 DO	2
4		Stiff to firm grey SILTY CLAY	3.66	5	50 DO	WH
5		Stiff grey SILTY CLAY	5.18	6	50 DO	WH
7		End of Borehole	7.32			



PIEZOMETER OR STANDPIPE INSTALLATION



Native Backfill

Bentonite Seal

Native Backfill

Silica Sand

Standpipe

Native Backfill

Water level in standpipe at 1.83m depth below ground surface on Nov. 22, 2007

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: P.A.H.

CHECKED:

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 13-101

SHEET 1 OF 1

LOCATION: See Site Plan

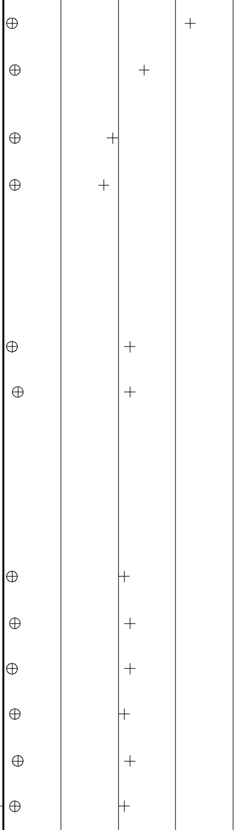
BORING DATE: Nov. 1, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	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		90.05							
0	Power Auger 200mm Diam (Hollow Stem)	Black sandy silt with organic matter (TOPSOIL)		0.00							
		Very loose grey brown SILTY fine SAND to SANDY SILT		89.82 0.23							
1					1	50 DO	3				
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		88.98 1.07							
2					2	50 DO	3				
					3	50 DO	1				
3											
		Firm grey SILTY CLAY		86.39 3.66							
4											
5					4	50 DO	WH				
6					5	50 DO	WH				
7											
8											
		End of Borehole		81.52 8.53							
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: H.E.C.

CHECKED: CK

MIS-BHS 001 1011210260.GPJ GAL-MIS.GDT 12/10/13 A.B.D.

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 13-102

SHEET 1 OF 1

LOCATION: See Site Plan

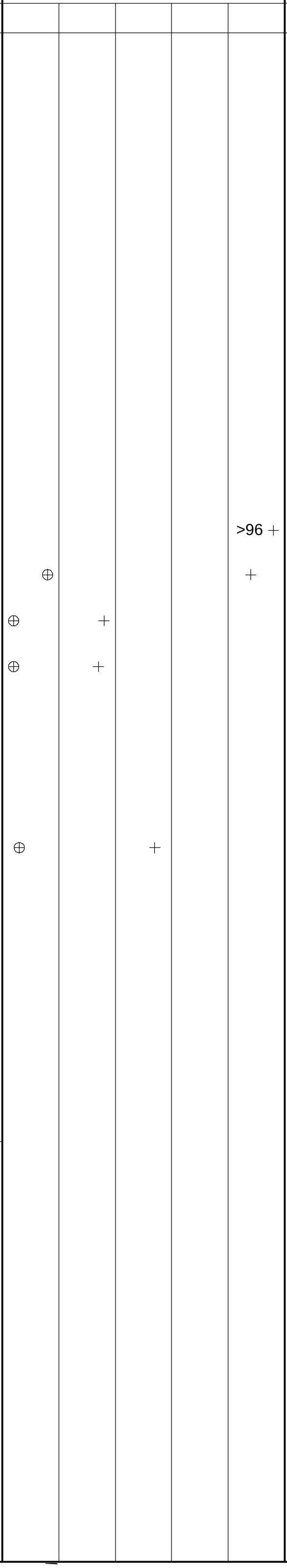
BORING DATE: Nov. 1, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		90.58							
0	Power Auger 200mm Diam (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)		0.00							
		Very stiff red brown to grey brown SILTY CLAY (Weathered Crust)		90.35 0.23	1	50 DO	9				
1		Very loose grey brown SILTY fine SAND, trace to some clay		89.28 1.30	2	50 DO	2				
2		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		88.45 2.13	3	50 DO	3	>96 +			
3		Firm to stiff grey SILTY CLAY		86.92 3.66	4	50 DO	WH				
5		Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		85.02 5.56	5 6	50 DO 50 DO	11 26				
7		End of Borehole		83.11 7.47							
8											
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: H.E.C.

CHECKED: CK

APPENDIX C

Results of Chemical Analysis
EXOVA Environmental Ontario Report No. 1426815

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
32 Steacie Drive
Kanata, ON
K2K 2A9
Attention: Ms. Susan Trickey
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1426815
Date Submitted: 2014-12-22
Date Reported: 2014-12-30
Project: 1406631
COC #: 792753

				Lab I.D.	1153409	1153410
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2014-12-12	2014-12-08
				Sample I.D.	BH 14-1 SA2/5'-7'	BH 14-10 SA2/5'-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Agri. - Soil	pH	2.0			7.4	7.5
General Chemistry	Cl	0.002	%		<0.002	0.003
	Electrical Conductivity	0.05	mS/cm		0.15	0.15
	Resistivity	1	ohm-cm		6670	6670
	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

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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