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REPORT ON

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
KANATA WEST LANDS
130 HUNTMAR DRIVE
OTTAWA, ONTARIO

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REPORT

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Table of Contents

1.0 INTRODUCTION 1

2.0 DESCRIPTION OF PROJECT AND SITE 2

3.0 PROCEDURE 3

4.0 SUBSURFACE CONDITIONS 4

4.1 General 4

4.2 Area A 4

4.2.1 Topsoil 4

4.2.2 Silty Clay to Clay 4

4.2.3 Glacial Till 5

4.3 Area B 5

4.3.1 Topsoil 5

4.3.2 Silty Clay to Clay 5

4.3.3 Silt 6

4.3.4 Glacial Till 6

4.4 Groundwater 6

5.0 DISCUSSION 7

5.1 General 7

5.2 Site Grading 7

5.2.1 Area A 7

5.2.2 Area B 7

5.3 Foundations 8

5.4 Frost Protection 9

5.5 Seismic Design 9

5.6 Basement Excavations 9

5.7 Basement and Garage Floor Slabs 10

5.8 Basement Wall and Foundation Wall Backfill 10

5.9 Site Servicing 10

5.10 Pavement Design 12

5.11 Pools, Decks and Additions 13

5.11.1 Above Ground and In Ground Pools 13

5.11.2 Decks 13

5.11.3 Additions 13

5.12 Corrosion and Cement Type 14

5.13 Trees 14

5.14 Considerations Relating to the Future Transitway 14

6.0 ADDITIONAL CONSIDERATIONS 15

7.0 CLOSURE 16

Important Information and Limitations of This Report

FIGURES

Figure 1 – Site Plan

Figures 2 & 3 – Consolidation Test Results

Figures 4 – Grain Size Distribution

APPENDICES

APPENDIX A
Method of Soil Classification
Abbreviations and Terms Used on Records of Boreholes and Test Pits
List of Symbols
Record of Borehole Sheets

APPENDIX B
Results of Chemical Analysis EXOVA Environmental Ontario Report No. 1426818

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development, referred to as the Kanata West Lands, to be located north of Maple Grove Road and east of Huntmar Drive in Ottawa, Ontario.

The purpose of this geotechnical investigation was to determine the general soil and groundwater conditions across the site by means of 15 boreholes. Based on an interpretation of the factual information obtained, engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could affect design decisions, are provided herein.

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, on a property referred to as the Kanata West Lands, that is located north of Maple Grove Road and east of Huntmar Drive in Ottawa, Ontario (see Site Plan, Figure 1).

The site is roughly rectangular in shape, measuring approximately 600 by 430 metres in plan dimension. The site topography is relatively flat, with a gentle slope down to the east, towards the Carp River. The site is currently undeveloped and consists of agricultural land, with one residential property located along Huntmar Drive within the northwest corner of the property.

It is understood that the proposed development will consist largely of low-rise residential buildings, and potentially some 4-storey units. Commercial and institutional development blocks are currently proposed at the southwest end of the site; however it is understood that the development layout may change. It is also understood that there may be a need for the eastern portion of the site to be reserved for the alignment of a future arterial roadway as well as a possible section of future Transitway.

Based on the published geologic mapping and previous experience in the area, the lands within the Carp River ‘valley’, including this site, are generally underlain by relatively compressible and thick deposits of sensitive silty clay. Based on published geological mapping, the bedrock surface is expected to be at about 10 to 25 metres depth. The bedrock is indicated to consist of dolostone and limestone of the Gull River Formation.

3.0 PROCEDURE

The field work for this investigation was carried out between November 18 and 21, 2014. At that time, 15 boreholes (numbered 14-1 to 14-15) were put down at the approximate locations shown on the Site Plan, Figure 1. 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. The boreholes were advanced to depths ranging from about 5.8 to 12.0 metres below the existing ground surface.

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, six relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained using a fixed piston sampler.

Standpipe piezometers were sealed into boreholes 14-1, 14-4, 14-9, 14-11, 14-14, and 14-15 to allow subsequent measurement of the groundwater level across the site. The groundwater levels in these standpipe piezometers were measured on December 15, 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 subsurface conditions encountered in 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.

A soil sample from borehole 14-8 was 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 (Golder) personnel. 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 are provided in Appendix A.
- The results of the basic chemical analysis carried out on a soil sample from borehole 14-8 are provided in Appendix B.
- Oedometer consolidation test results are provided on Figure 2 and 3.
- Grain size distribution testing results are provided on Figure 4.

The subsurface conditions on the site generally consist of topsoil underlain by a deposit of sensitive and potentially compressible silty clay. Within the central and northeast portions of the site, the clay is thinner and deposits of silt and glacial till were encountered.

Based on the subsurface conditions encountered and the soil strengths determined within the boreholes, the site has been divided into two assessment areas (i.e., Area A and Area B, as shown on the Site Plan, Figure 1). The following sections provide a summary of the subsurface conditions for each assessment area.

4.2 Area A

Boreholes 14-1, 14-2, 14-3, 14-6, 14-7, 14-8, 14-10, 14-11, 14-13, 14-14, and 14-15 were put down within Area A. The subsurface conditions in this area generally consist of topsoil underlain by a deposit of sensitive and compressible silty clay. The upper 3 to 4 metres of the silty clay have been weathered to a grey brown crust. The silty clay beneath the crust is unweathered and was proven to depths between about 6 and 8 metres. The silty clay is underlain by a deposit of glacial till at borehole 14-7.

4.2.1 Topsoil

Topsoil exists at ground surface at all of the borehole locations and varies in thickness from about 250 to 290 millimetres.

4.2.2 Silty Clay to Clay

The topsoil is underlain by a thick deposit of sensitive silty clay to clay (generalized hereafter as silty clay). The upper 2.8 to 4.3 metres of the deposit have been weathered to a grey brown crust. SPTs carried out within the weathered crust measured N values ranging from 2 to 6 blows per 0.3 metres of penetration. The results of in situ vane testing in the deposit measured undrained shear strength values generally ranging from about 69 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 natural water contents of samples of the weathered deposit collected from several boreholes ranged from about 30 to 35 percent.

The silty clay below the depth of weathering is grey in colour. The unweathered deposit was proven/inferred to depths between about 5.8 and 7.6 metres at the borehole locations, with the exception of borehole 14-7 where the deposit was full penetrated at a depth of about 8.8 metres. The results of in situ vane testing in the deposit measured undrained shear strength values generally ranging from about 15 to 77 kilopascals, but more typically in the range of 25 to 65 kilopascals, indicating a firm to stiff consistency, with the shear strength generally increasing with depth.

The results of Atterberg limit testing carried out on two samples of the unweathered deposit gave plasticity index values of about 18 and 32 percent and liquid limit values of about 37 and 57 percent, indicating a soil of intermediate to high plasticity. Water contents of between about 40 and 62 percent were measured in the unweathered silty clay.

Oedometer consolidation testing was carried out on two Shelby tube samples of the unweathered clay. The results of this testing are provided on Figures 2 and 3 and are summarized below.

Borehole/Sample Number	Sample Depth/Elevation (m)	σ_o' (kPa)	σ_P' (kPa)	C_c	C_r	e_o	OCR
14-10 / 5	6.5 / 94.2	70	190	1.95	0.006	1.75	2.7
14-13 / 5	5.0 / 93.6	65	160	0.57	0.006	1.29	2.5

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

4.2.3 Glacial Till

A deposit of glacial till was encountered beneath the silty clay at borehole 14-7. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt. The glacial till was encountered at a depth of about 8.8 metres below the existing ground surface and proven to a depth of about 12 metres.

SPT N values of between 8 and 17 blows per 0.3 metres of penetration were measured in the glacial till, indicating a loose to compact state of packing. The measured natural water content of a sample of the glacial till from this borehole was about 11 percent.

4.3 Area B

Boreholes 14-4, 14-5, 14-9, and 14-12 were put down within Area B. In this area the subsurface conditions generally consist of topsoil underlain by about 2 to 4 metres of weathered silty clay underlain by silt and/or glacial till.

4.3.1 Topsoil

Topsoil exists at ground surface at all of the borehole locations within Area B and varies in thickness from about 220 to 290 millimetres.

4.3.2 Silty Clay to Clay

The topsoil is underlain by about 2.0 to 3.5 metres of silty clay to clay, which has been weathered to a grey brown colour. SPTs carried out within the weathered deposit measured N values ranging from 3 to 7 blows per 0.3 metres of penetration. The results of limited in situ vane testing in the deposit measured undrained shear strength values of greater than 96 kilopascals. The results of this in situ testing indicate a generally stiff to very stiff consistency for the weathered silty clay.

4.3.3 Silt

The weathered silty clay is underlain by a deposit of silt to sandy silt at boreholes 14-4, 14-5 and 14-9. The silt ranges from about 1.6 to 1.7 metres in thickness. SPTs carried out within this deposit measured N values ranging from 4 to 9 blows per 0.3 metres of penetration, indicating a loose state of packing.

The measured natural water content of one sample of the silt from borehole 14-4 was about 28 percent. The results of grain size distribution testing for the same sample of silt are shown on Figure 4.

4.3.4 Glacial Till

A deposit of glacial till was encountered beneath the weathered silty clay and/or silt. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt or silty sand. The glacial till was encountered at depths between about 3.4 and 5.3 metres below the existing ground surface and proven to depths of between about 5.9 and 8.2 metres.

SPT N values of 3 to 24 blows per 0.3 metres of penetration were measured in the glacial till, indicating a very loose to compact state of packing. The measured natural water content of one sample of the glacial till was about 10 percent.

4.4 Groundwater

The groundwater levels in the piezometers sealed in boreholes 14-1, 14-4, 14-9, 14-11, 14-14, and 14-15 were measured on December 15, 2014. The groundwater level measurements are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
14-1	100.62	1.28	99.34
14-4	97.25	0.88	96.37
14-9	100.49	1.34	99.15
14-11	100.55	1.71	98.84
14-14	98.97	4.26*	94.71
14-15	99.97	2.35	97.62

***Note**: Piezometer damaged during installation, therefore, groundwater level not necessarily representative of site conditions.

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.

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.

5.2 Site Grading

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.

5.2.1 Area A

The subsurface conditions in Area A consist of topsoil underlain by a deposit of sensitive and compressible silty clay. The “softer” unweathered portions of the silty clay deposit at depth have limited capacity to accept additional load from the weight of grade raise fill and/or from the foundations of houses without undergoing consolidation settlements. Therefore, to leave sufficient remaining capacity for the silty clay to support house foundations without undue settlement, with reasonable footing sizes, the thickness of grade raise fill will need to be limited.

Therefore, the maximum grade raise which is permitted for Area A is 2.4 metres. This grade raise limitation has been assessed based on leaving sufficient remaining capacity in the silty clay deposit at depth such that 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.

It should also be noted that this maximum permissible grade raise was calculated assuming that any fill required for site grading (above original grade) and the backfill within the garages would have a unit weight of no more than 19.5 kilonewtons per cubic metre. Silty clay, clay, sandy silt and silt (such as present on this site), as well as crushed clear stone and uniform fine sand (for garage backfill) may be suitable for this purpose. Sand and gravel, glacial till, and crushed stone typically have a higher unit weight and, if these materials are to be used, the maximum permissible grade raises would be reduced and would need to be re-evaluated.

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

5.2.2 Area B

The subsurface conditions in Area B consist of topsoil underlain by stiff weathered silty clay, over a discontinuous layer of silt, over glacial till.

From a foundation design perspective, there are no practical restrictions grade raise (i.e., filling) of Area B. However, additional assessment should be carried out if grade raises greater than 4 m are proposed in this area.

As described in more detail in Section 5.6 of this report, it is recommended that excavations for basements within Area B should be set at or above an elevation of 97 metres in order to minimize the potential for subgrade disturbance and/or need for dewatering/depressurization of the silty soils.

5.3 Foundations

It is considered that the proposed residences may be supported on spread footings founded on or within the surficial weathered silty clay deposit.

As discussed in the preceding section, the unweathered silty clay present at depth in Area A has limited capacity to accept the combined load from site grading fill and foundation loads. The allowable bearing pressures for spread footing foundations are therefore based on limiting the stress increases on the compressible, unweathered 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 unweathered silty clay are:

- The thickness of soil below the underside of the footings and above 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, spread 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).

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 improved 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 clayey soils is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the allowable bearing pressure should be the full dead load plus sustained live load.

The 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). Where this is the case, the subgrade should be raised to the footing elevation using engineered fill consisting of crushed clear stone having a unit weight not exceeding about 17.5 kilonewtons per cubic metre (i.e., similar to the native soil). The use of clear stone is recommended so as to avoid possible settlements associated with the use of heavier material. The engineered fill should be placed to occupy the full house footprint and the full zone of influence/support for the foundations. That zone is considered to extend down and out from the outside edge of the perimeter foundations at a slope of 1H:1V (horizontal:vertical). The engineered fill 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 vibratory compaction equipment. To avoid settlements resulting from loss of soil into the voids in the clear stone, it should be fully encapsulated in a geotextile. The geotextile should be placed on the bottom, sides, and over the top of the clear stone. A Class II non-woven geotextile should be used, with a Filtration Opening Size (FOS) not exceeding 150 microns, in accordance with Ontario Provincial Standard Specifications (OPSS) 1860. Footings founded on or within properly placed engineered fill can also be designed using a maximum allowable bearing pressure of 75 kilopascals.

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 a Site Class of E would be applicable to the design of low-rise structures in Areas A and B. 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 likely be assigned for the site, if seismic shear wave velocity testing is carried out, particularly in Area B where a limited thickness of very stiff clay was encountered above the glacial till.

5.6 Basement Excavations

Excavations for basements will extend through the topsoil and into the weathered silty clay. No unusual problems are anticipated with excavating the overburden soils using conventional hydraulic excavating equipment.

Side slopes in the stiff weathered silty clay materials above the water table 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 silty overburden soils in Area B 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.

Some groundwater inflow into the excavations could be expected. However, for the planned basement excavation depths, it should be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations.

The silt deposits encountered beneath the surficial weathered silty clay in Area B are saturated and would be highly susceptible to disturbance as a result of construction activities. The upward flow of groundwater caused by excavations into the silt would result in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes. Therefore it is recommended that excavations for basements within Area B should be set at or above an elevation of 97 m in order to minimize the potential for subgrade disturbance and/or need for dewatering/depressurization of the silty soils.

Where the silty clay subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel) or a 150 millimetre thick layer of OPSS Granular A underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

5.7 Basement and Garage Floor Slabs

In preparation for the construction of the basement floor slabs, all loose, wet and disturbed 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 backfill material inside the garage should have a unit weight no greater than 19.5 kilonewtons per cubic metre (i.e., uniform fine sand or clear crushed stone). The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the 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 Granular A compacted to at least 95 percent of the material's 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 a geotextile, which leads by gravity drainage to an adjacent storm sewer or sump pit. Conventional damp proofing of the basement walls is appropriate with the above design approach.

Should the foundations be designed in accordance with Part 4 of the Ontario Building Code, further guidelines on the foundation wall design will need to be provided.

5.9 Site Servicing

Excavations for the installation of site services will be made through the topsoil and silty clay. In Area B the excavations will also be made through the silt layer and potentially into the glacial till. 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.

In accordance with the OHSA of Ontario, both the weathered and unweathered silty clay as well as the glacial till would generally be classified as Type 3 soils and side slopes in the short term may be sloped at 1 horizontal to 1 vertical. Excavation side slopes below the groundwater level in the silt will slough to a somewhat flatter inclination and excavation side slopes in the silt 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.

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 the silt layers that were encountered in Area B. In these areas, disturbance of the silt subgrade soils could occur and remedial measures such as use an increased thickness of bedding or subexcavation of the silt to expose the underlying till could be needed.

The actual rate of groundwater inflow to the trench 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 and Climate Change (MOECC) for this work.

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. This will be particularly likely where the trench floor level is within silt, but also in the unweathered silty clay. 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 silty 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 weathered silty clay, silt and glacial till as trench backfill.

However, the high moisture content of the deeper unweathered silty clay deposit makes this soil difficult to handle and compact. The silt may also not be feasible to 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 and 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.

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. Previous experience with the soils along this part of the Carp River valley has shown them to be highly frost susceptible and prone to frost heaving and therefore the backfilling will be important.

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) or Earth Borrow. The SSM or Earth Borrow should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material’s standard Proctor maximum dry density using suitable compaction equipment.

The 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

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 Part 9 of 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

A sample of soil from borehole 14-8 was 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 B. The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a potential for corrosion of exposed ferrous metal, 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.

5.14 Considerations Relating to the Future Transitway

It is understood that a portion of the east side of the site may need to be reserved for a future Transitway corridor. It is further understood that the future Transitway may have a grade separated crossing of Maple Grove Road, and therefore the adjacent potion of the Transitway to be built on this site may have an elevated profile and need to be constructed on a high embankment. In regards to the geotechnical conditions on this site, the following should be noted:

- The ground conditions in the area of the potential embankment consist of a thick deposit of relatively weak and compressible silty clay. It is therefore possible that flatter than typical embankment side slopes could be required, in order to provide a stable embankment arrangement (i.e., one for which there would be an acceptable factor of safety against shearing of the underlying clay and a rotational failure of the embankment). The determination of the corridor width to be reserved for the future Transitway should consider this issue.

- Embankments constructed using conventional earth fills could experience excessive and unacceptable settlements. The mitigation measures to address those potential settlements could include a preloading program and the installation of wick drains to accelerate the settlements. Therefore, it should not be planned to install services which cross under this portion of the Transitway, since they would be impacted by the settlements and might interfere with the wick drain installation.

- Preloading of the embankment, if used for settlement mitigation, could also induce significant settlements of the immediately adjacent ground. The presence of adjacent structures could present a constraint on that work, which should be considered in the selection of the development layout and Transitway corridor width.

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 placement 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 final drawings and specifications for this project prior to construction to ensure that the guidelines in this report have been adequately interpreted.

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 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.

S Trickey

Susan Trickey, P.Eng.
Geotechnical Engineer

Mike C.

Mike Cunningham, P.Eng.
Principal, Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
M. I. CUNNINGHAM
PROVINCE OF ONTARIO

SAT/KN/MIC/ob
n:\active\2014\1121 - geotechnical\1406416 urbandale 130 huntmar drive ottawa\06-report\final\1406416 rpt-001.docx

IMPORTANT INFORMATION AND LIMITATIONS
OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently 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, **Lioness Developments Inc.** The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

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

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

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

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

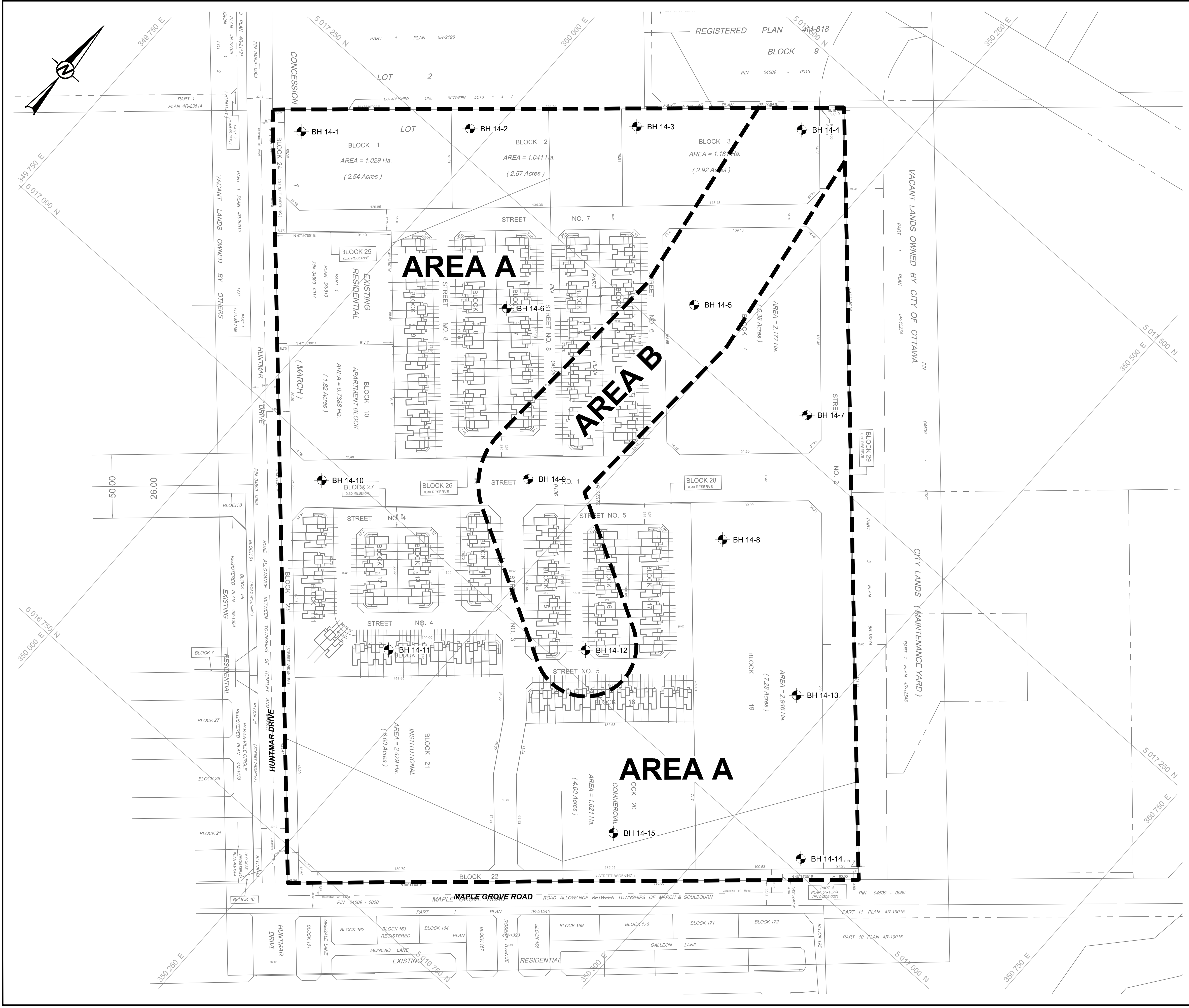
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

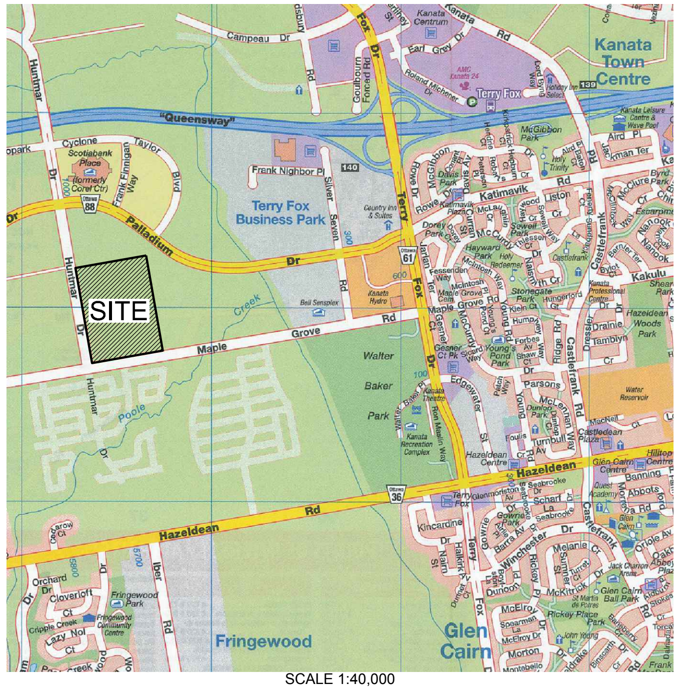
Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

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

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

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





KEY MAP

SCALE 1:40,000

LEGEND

- BOREHOLE LOCATION IN PLAN
- ASSESSMENT AREA

NOTES

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT No. 1406416

REFERENCE

1. BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY ANNIS, O'SULLIVAN VOLLEBEKK LTD. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 50 100
1:3,000 METRES

CLIENT
LIONESS DEVELOPMENTS INC.

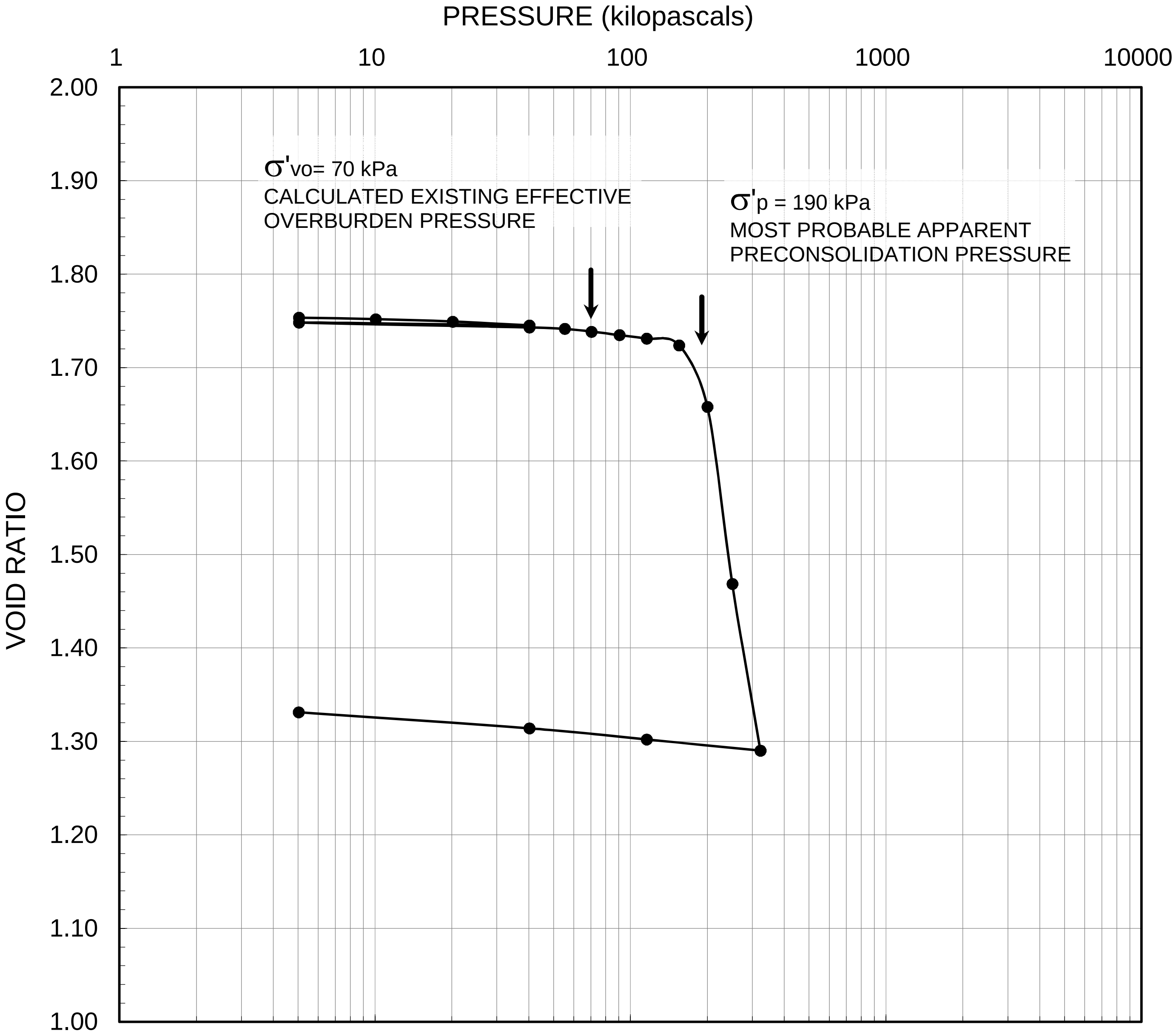
PROJECT
GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
KANATA WEST LANDS, 130 HUNTMAR DRIVE, OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-12-17
PREPARED	JM
DESIGN	----
REVIEW	SAT
APPROVED	MIC

PROJECT No.	PHASE	Rev.	FIGURE
1406416	1000	A	1



LEGEND

Borehole:	14-10	w_i = 64%	S_o = 100%	γ = 16.2 kN/m³
Sample:	5	w_f = 50%	e_o = 1.75	G_s = 2.77
Depth (m):	6.5	w_l = 57%	C_c = 1.95	
Elevation (m):	94.18	w_p = 25%	C_r = 0.006	

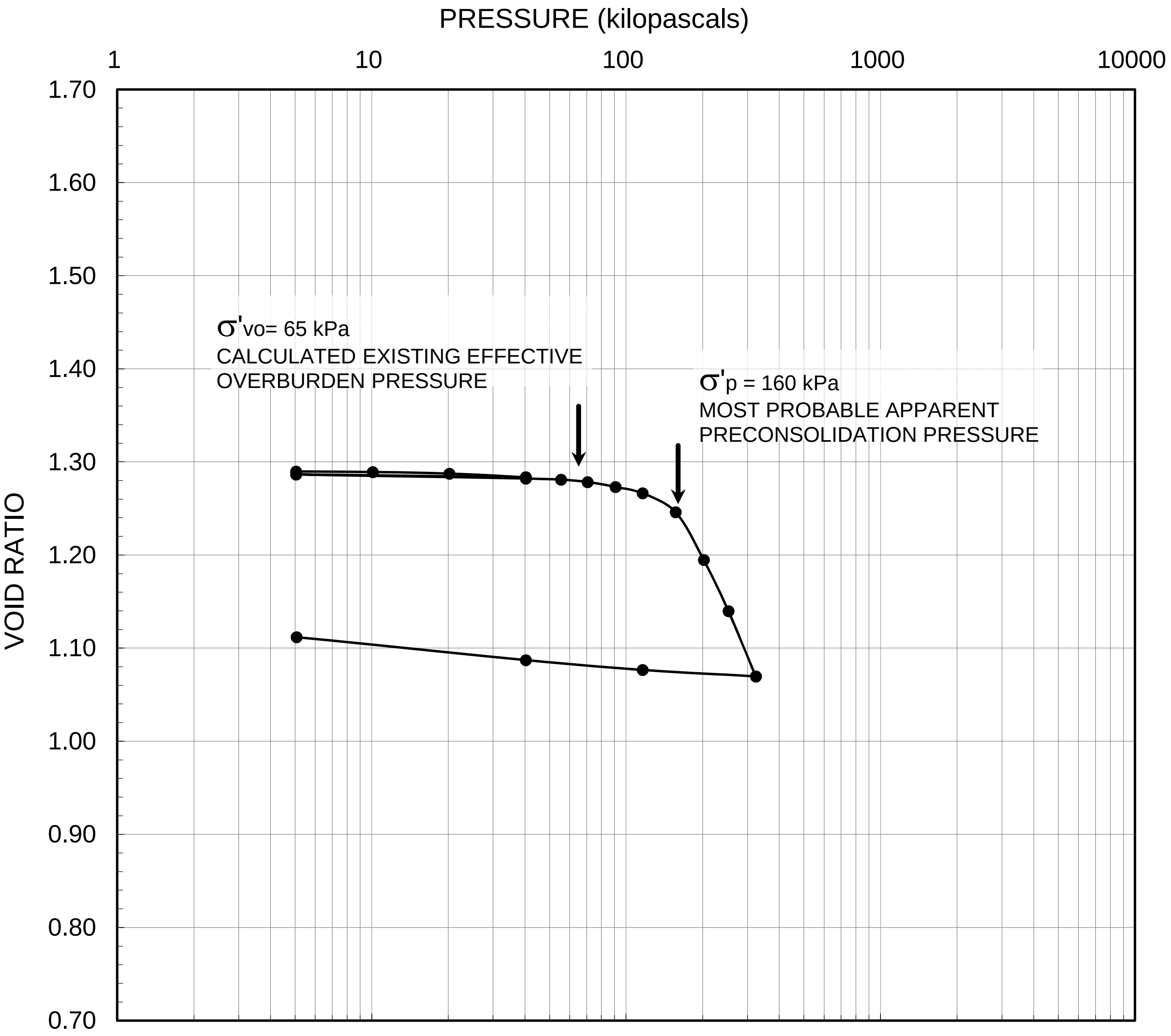
Golder Associates

SCALE	AS SHOWN
DATE	04/20/15
CADD	N/A
ENTERED	MI
CHECK	CNM
REVIEW	SAT
FILE No.	Consolidation summary
PROJECT No.	1406416
REV.	2

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 2



σ'vo= 65 kPa
CALCULATED EXISTING EFFECTIVE
OVERBURDEN PRESSURE

σ'p = 160 kPa
MOST PROBABLE APPARENT
PRECONSOLIDATION PRESSURE

LEGEND

Borehole:	14-13	w_i = 47%	S_o = 100%	γ = 17.4 kN/m³
Sample:	5	w_f = 41%	e_o = 1.29	G_s = 2.77
Depth (m):	5.0	w_l = 37%	C_c = 0.57	
Elevation (m):	93.60	w_p = 19%	C_r = 0.006	

Golder Associates

FILE No. Consolidation summary
PROJECT No. 1406416 REV. 1

SCALE AS SHOWN
DATE 02/24/15
CADD N/A
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REVIEW SAT

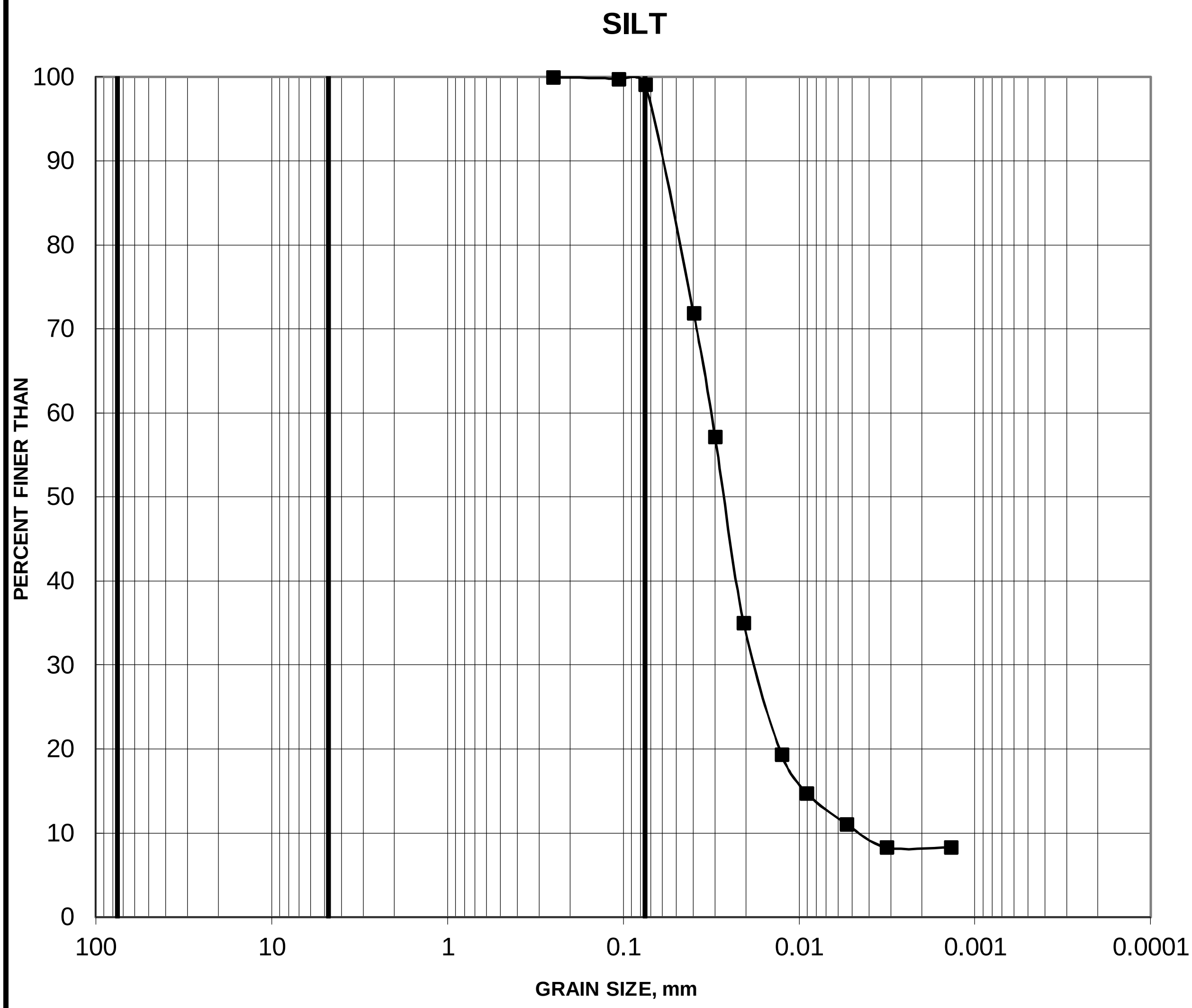
TITLE

CONSOLIDATION TEST RESULTS

FIGURE **3**

GRAIN SIZE DISTRIBUTION

FIGURE 4



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

Borehole	Sample	Depth (m)
■ 14-4	5	3.81-4.41

Project: 1406416

Golder Associates

Created by: MI
Checked by: CNM

APPENDIX A

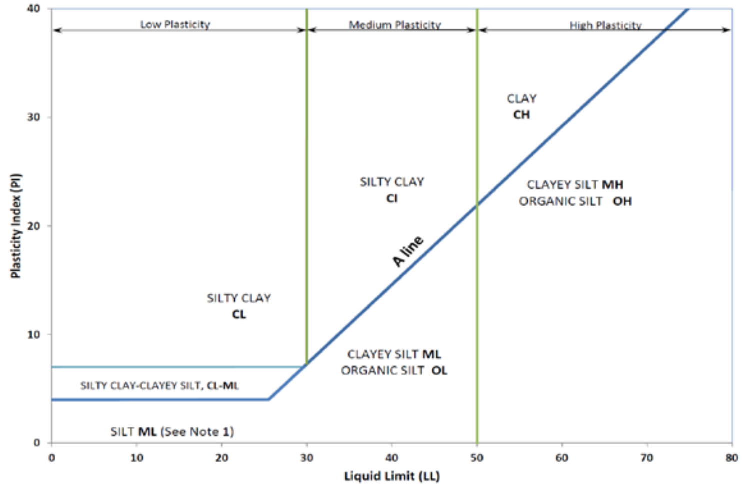
Method of Soil Classification
Abbreviations and Terms Used on Records of Boreholes and Test Pits
List of Symbols
Record of Borehole Sheets

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: 1406416

RECORD OF BOREHOLE: 14-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 21, 2014

DATUM: Geodetic

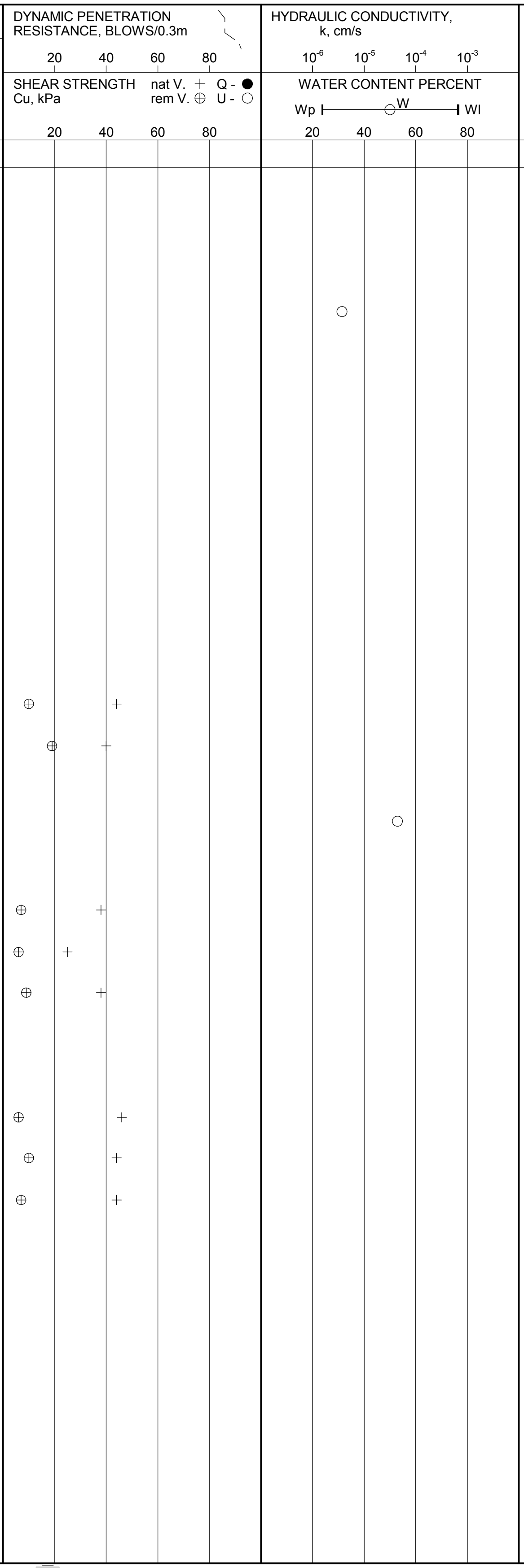
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

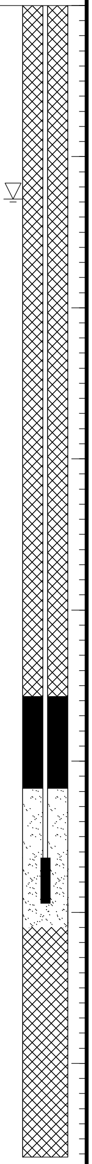
BORING METHOD: Power Auger
200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.62
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	100.36 0.26
(CI/CH) SILTY CLAY to CLAY, trace sand; grey, with silt seams; cohesive, w>PL, stiff to firm	97.57 3.05
End of Borehole	93.00 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	4
3	SS	3
4	SS	4
5	TP	PH
6	SS	PH



PIEZOMETER OR STANDPIPE INSTALLATION



Native Backfill

Bentonite Seal

Silica Sand

Standpipe

Silica Sand

Cave

WL in Standpipe at Elev. 99.34 m on Dec. 15, 2014

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-2

SHEET 1 OF 1

LOCATION: See Site Plan

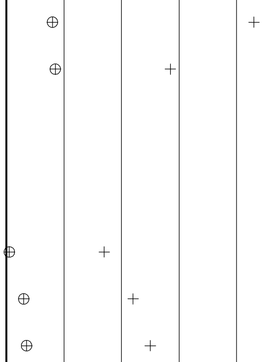
BORING DATE: November 21, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE		99.85					
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown		0.00					
	(CI/CH) SILTY CLAY to CLAY, trace to some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		99.58 0.27					
				1	SS	6		
				2	SS	4		
				3	SS	2		
				4	SS	3		
	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff		95.60 4.25					
				5	SS	PH		
	End of Borehole		93.75 6.10					



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 21, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

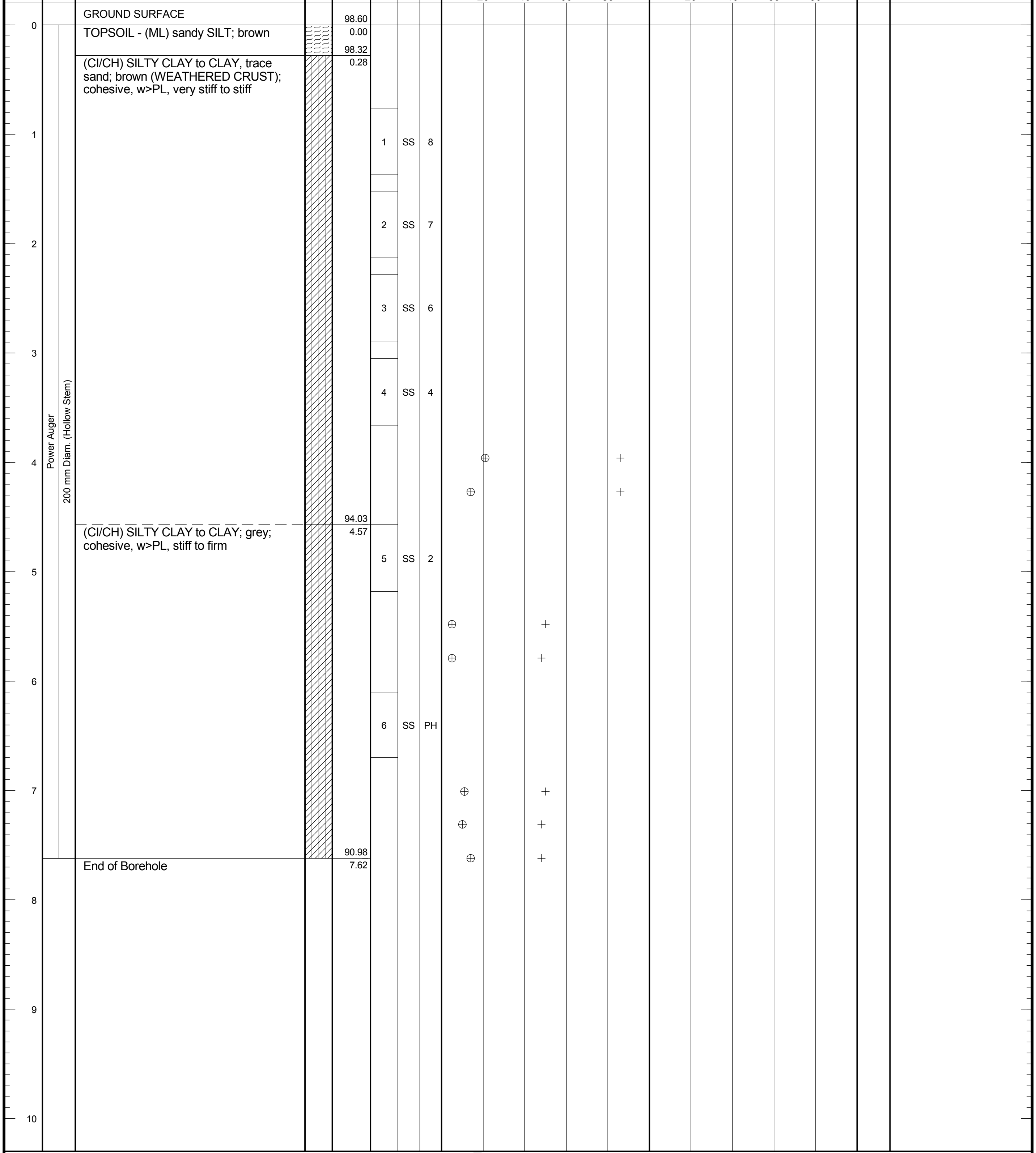
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	98.60
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	98.32 0.28
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff to firm	94.03 4.57
End of Borehole	90.98 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	8
2	SS	7
3	SS	6
4	SS	4
5	SS	2
6	SS	PH



DEPTH SCALE
1 : 50

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 20, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

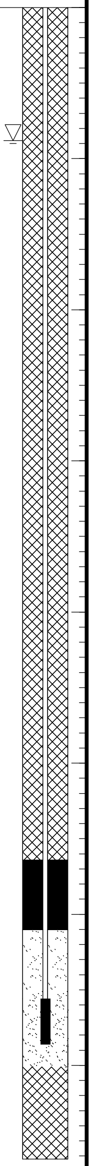
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	97.25					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown	0.00					
		(CI/CH) SILTY CLAY to CLAY, trace sand; brown, with dark brown mottling, friable (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	97.03 0.22					
1				1	SS	6		
2				2	SS	4		
				3	SS	3		Native Backfill
3		(ML) SILT; grey; non-cohesive, wet, loose	94.20 3.05	4	SS	6		
4				5	SS	5	MH	
		(SM/ML) SILTY SAND to sandy SILT, some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, loose to compact	92.63 4.62	6	SS	6		
5				7	SS	13		
6								Bentonite Seal
				8	SS	11		Silica Sand
								Standpipe
7								Silica Sand
				9	SS	24		Cave
		End of Borehole	89.63 7.62					
8								WL in Standpipe at Elev. 96.37 m on Dec. 15, 2014
9								
10								



DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 20, 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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	98.86	
TOPSOIL - (ML) sandy SILT; brown		0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff	98.61	0.25
(ML) SILT, some sand to sandy SILT; brown to grey; non-cohesive, wet, loose	96.58	2.28
(SM) SILTY SAND, some gravel; grey, with sand seams and cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, very loose to compact	94.90	3.96
End of Borehole	91.24	7.62

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	SS	6
2	SS	7
3	SS	9
4	SS	6
5	SS	3
6	SS	21
7	SS	10
8	SS	14
9	SS	7

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: 1406416

RECORD OF BOREHOLE: 14-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 20, 2014

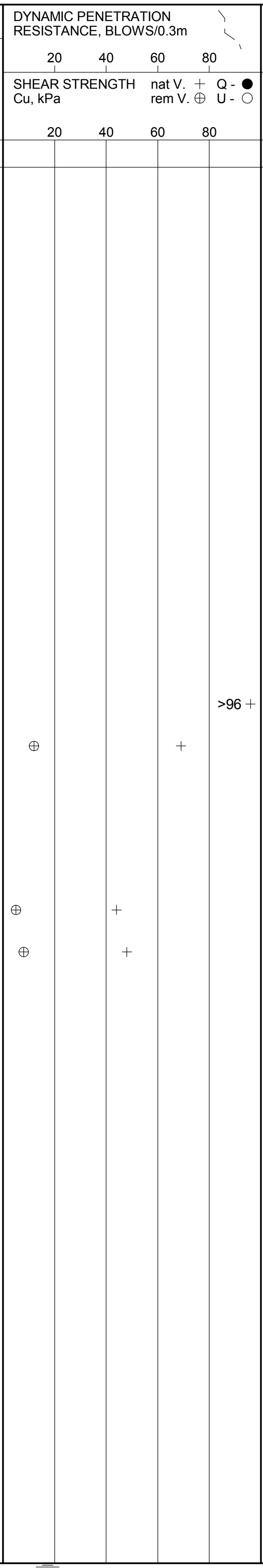
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		99.81
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown		0.00
		(CI/CH) SILTY CLAY to CLAY, trace to some sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		99.53 0.28
		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm		95.24 4.57
		End of Borehole		94.02 5.79

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	3
3	SS	4
4	SS	3
5	SS	PH



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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406416.GPJ GAL-MIS.GDT 12/17/15 JM

PROJECT: 1406416

RECORD OF BOREHOLE: 14-7

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: November 20, 2014

DATUM: Geodetic

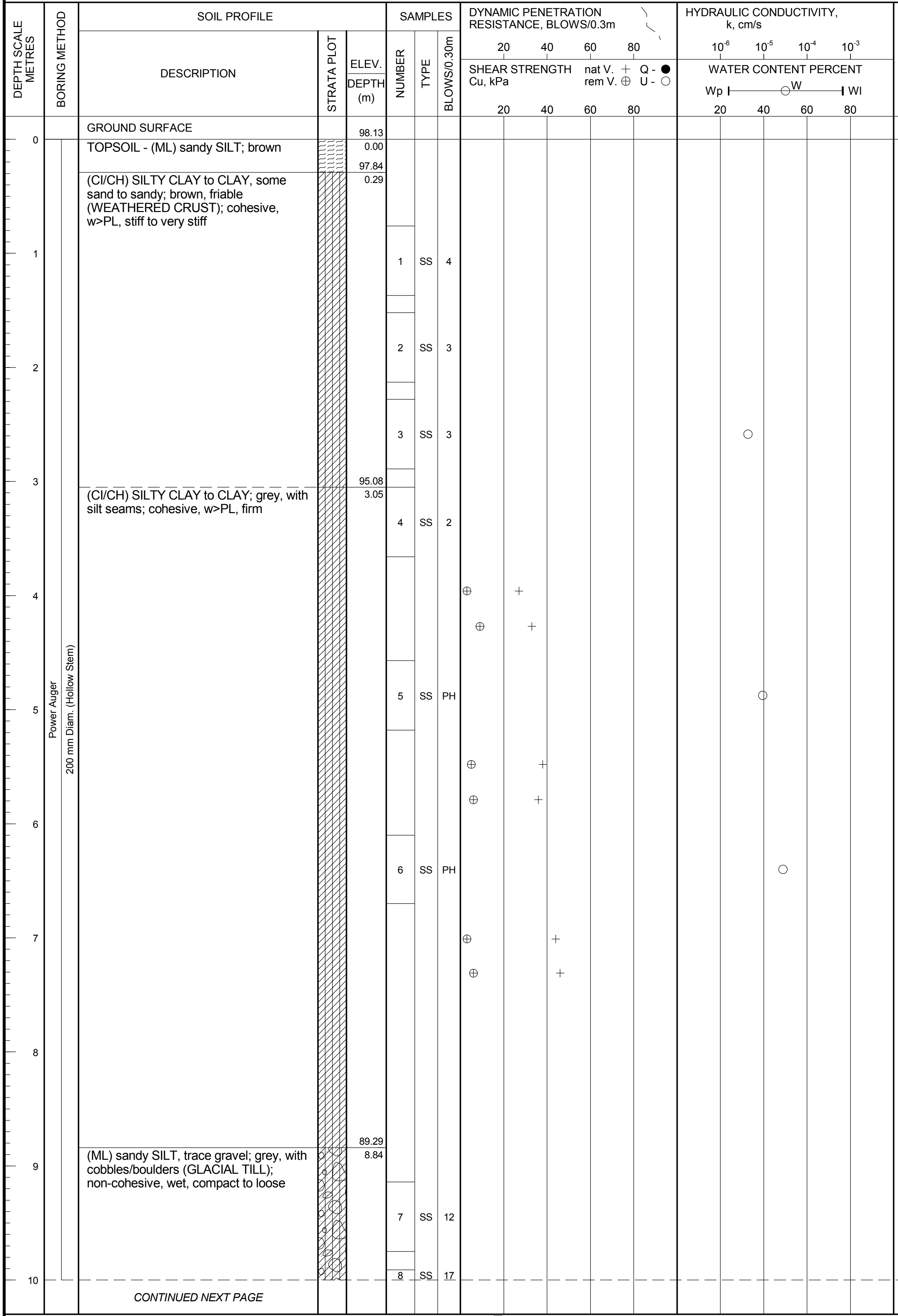
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	98.13
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, some sand to sandy; brown, friable (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	97.84 0.29
(CI/CH) SILTY CLAY to CLAY; grey, with silt seams; cohesive, w>PL, firm	95.08 3.05
(ML) sandy SILT, trace gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to loose	89.29 8.84

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	3
3	SS	3
4	SS	2
5	SS	PH
6	SS	PH
7	SS	12
8	SS	17



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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MIS-BHS 001 1406416.GPJ GAL-MIS.GDT 12/17/15 JM

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-7

SHEET 2 OF 2

LOCATION: See Site Plan

BORING DATE: November 20, 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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Power Auger 200 mm Diam. (Hollow Stem)	(ML) sandy SILT, trace gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to loose			8	SS	17				
11					9	SS	9				
					10	SS	8		○		
12				86.09 12.04							
		End of Borehole									
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1406416.GPJ GAL-MIS.GDT 12/17/15 JM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-8

SHEET 1 OF 1

LOCATION: See Site Plan

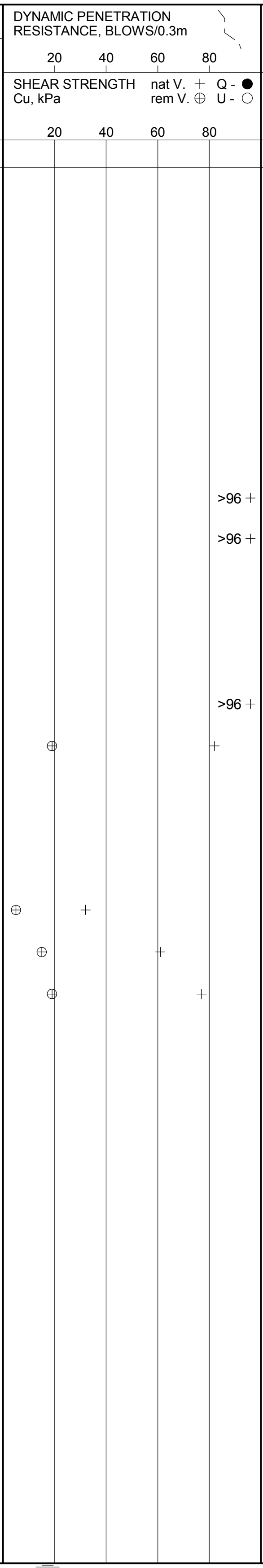
BORING DATE: November 19, 2014

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	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		99.20					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown		0.00					
		(CI/CH) SILTY CLAY to CLAY, trace sand; brown, with dark brown mottling (WEATHERED CRUST); w>PL, stiff to very stiff		98.95 0.25					
1					1	SS	4		
2					2	SS	4	CHEM	
3					3	SS	4		
4									
		(CI/CH) SILTY CLAY to CLAY, some sand; grey; cohesive, w>PL, firm to stiff		94.63 4.57					
5					4	SS	WR		
6		End of Borehole		93.10 6.10					
7									
8									
9									
10									



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

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-9

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 19, 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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	100.49				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown	0.00				
		(CI/CH) SILTY CLAY to CLAY, some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	100.20 0.29				
1				1	SS	7	
2				2	SS	3	
				3	SS	4	
3				4	SS	6	Native Backfill
4		(ML) SILT, some sand to sandy; grey brown; non-cohesive, wet, loose	96.68 3.81	5	SS	8	
5		(ML) sandy SILT, trace to some gravel; grey, layered; non-cohesive, wet, loose	95.92 4.57	6	SS	4	
		(ML) sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet, loose	95.16 5.33	7	SS	4	
6		(SM) SILTY SAND, some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact	94.39 6.10	8	SS	20	Bentonite Seal
7				9	SS	17	Silica Sand Standpipe
8				10	SS	15	Cave
		End of Borehole	92.26 8.23				WL in Standpipe at Elev. 99.15 m on Dec. 15, 2014
9							
10							

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-10

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 19, 2014

DATUM: Geodetic

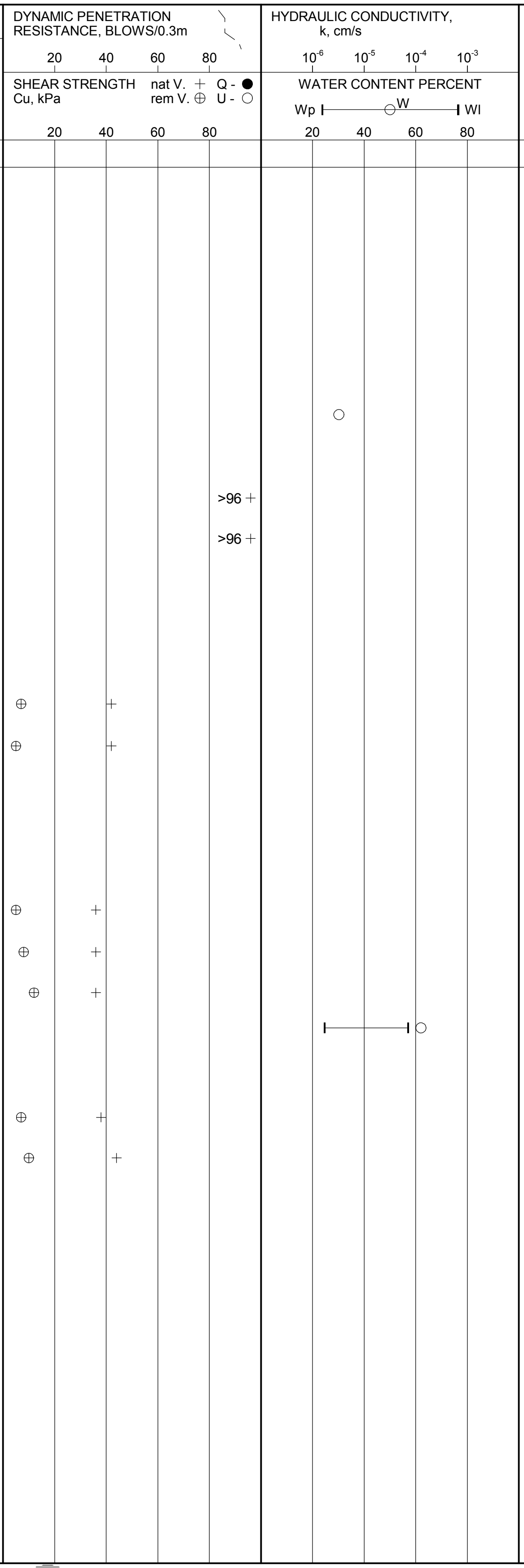
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	100.68
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	100.40 0.28
(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL, firm	97.02 3.66
End of Borehole	93.37 7.31

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



PIEZOMETER OR STANDPIPE INSTALLATION

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: 1406416

RECORD OF BOREHOLE: 14-11

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 18, 2014

DATUM: Geodetic

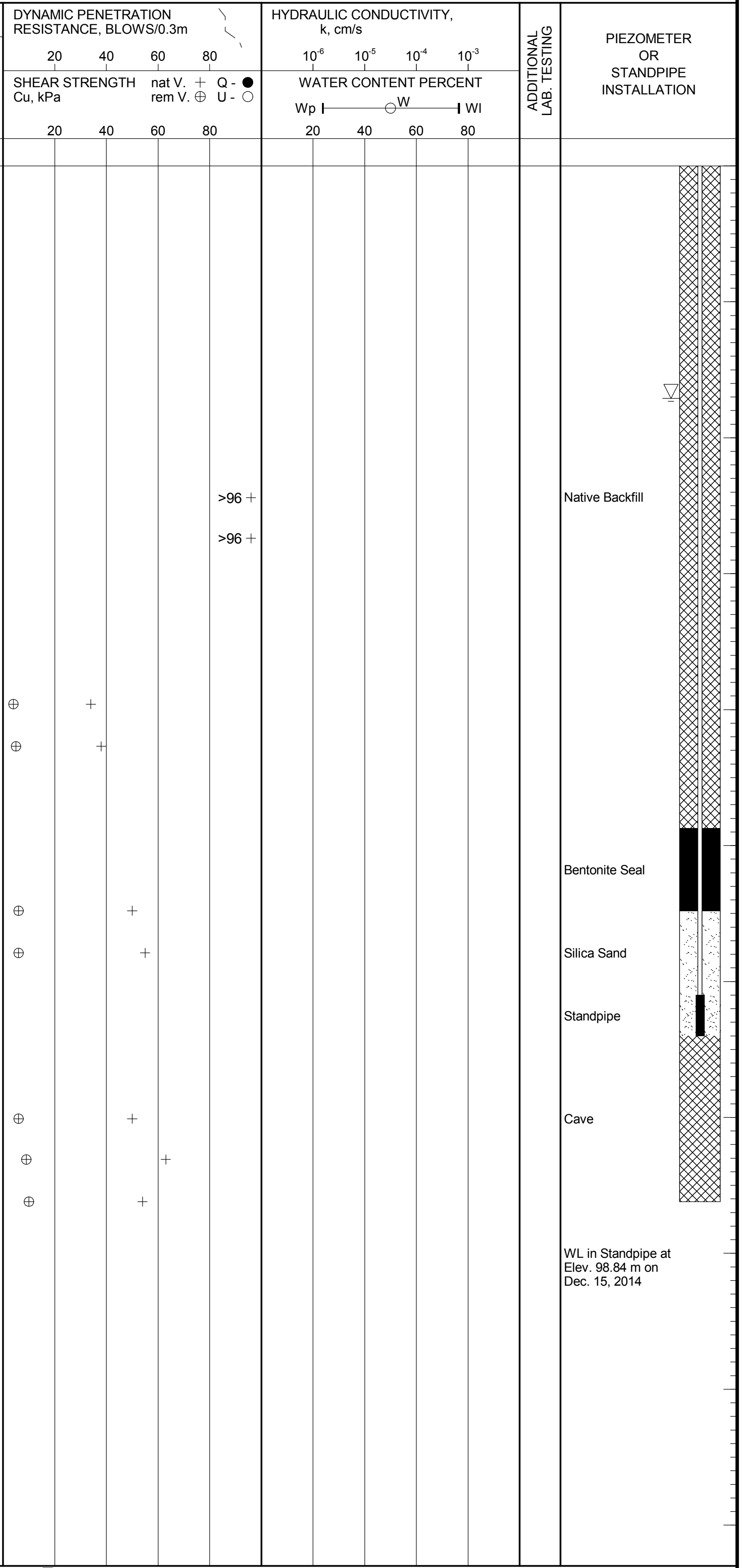
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	100.55
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	100.27 0.28
(CI/CH) SILTY CLAY to CLAY; grey, with silt seams; cohesive, w>PL, firm to stiff	97.50 3.05
End of Borehole	92.93 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	2
3	SS	2
4	TP	PH
5	SS	1



Native Backfill

Bentonite Seal

Silica Sand

Standpipe

Cave

WL in Standpipe at Elev. 98.84 m on Dec. 15, 2014

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406416.GPJ GAL-MIS.GDT 12/17/15 JM

PROJECT: 1406416

RECORD OF BOREHOLE: 14-12

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: November 18, 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	100.26
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	99.99 0.27
(SM/ML) sandy SILT to SILTY SAND, trace gravel; brown to grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, loose to compact	96.91 3.35
End of Borehole	94.32 5.94

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	SS	4
2	SS	3
3	SS	14
4	SS	7
5	SS	5
6	SS	11

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

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

>96 +

>96 +

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-13

SHEET 1 OF 1

LOCATION: See Site Plan

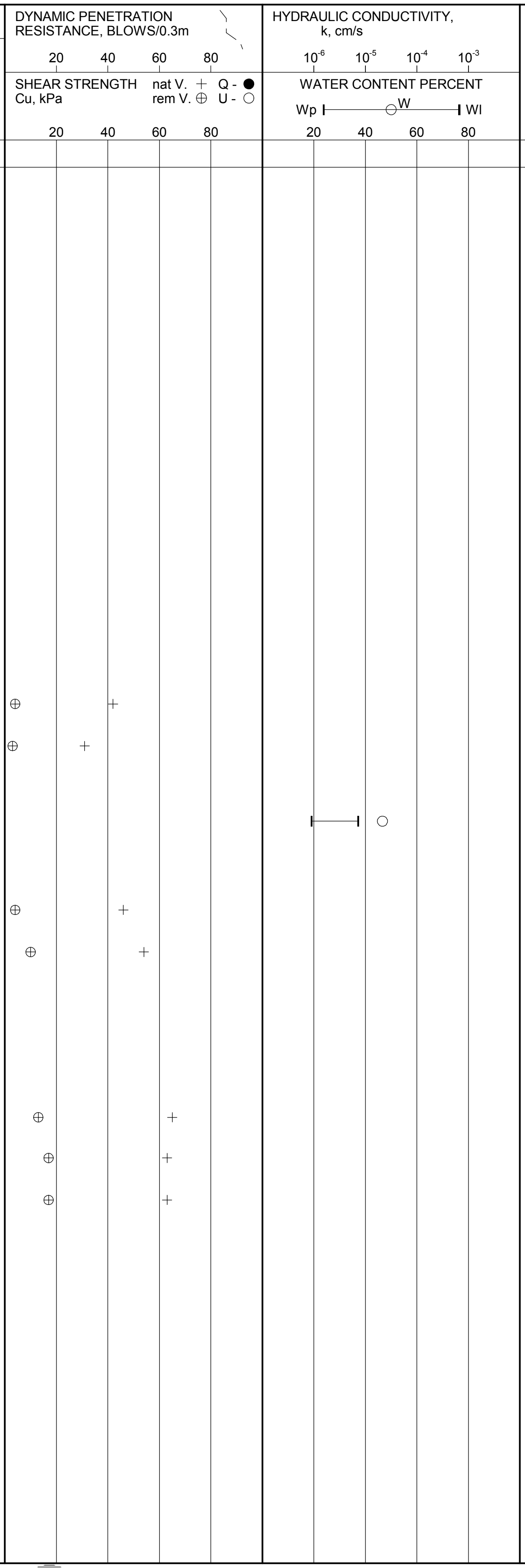
BORING DATE: November 18, 2014

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	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		98.60					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown; non-cohesive		0.00					
		(CI/CH) SILTY CLAY, trace to some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff		98.32 0.28					
1					1	SS	4		
2					2	SS	3		
					3	SS	3		
3		(CI/CH) SILTY CLAY to CLAY, trace sand; grey; cohesive, w>PL, firm to stiff		95.55 3.05					
					4	SS	3		
4									
5					5	TP	PH	C	
6					6	SS	PH		
7									
		End of Borehole		90.98 7.62					
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-14

SHEET 1 OF 1

LOCATION: See Site Plan

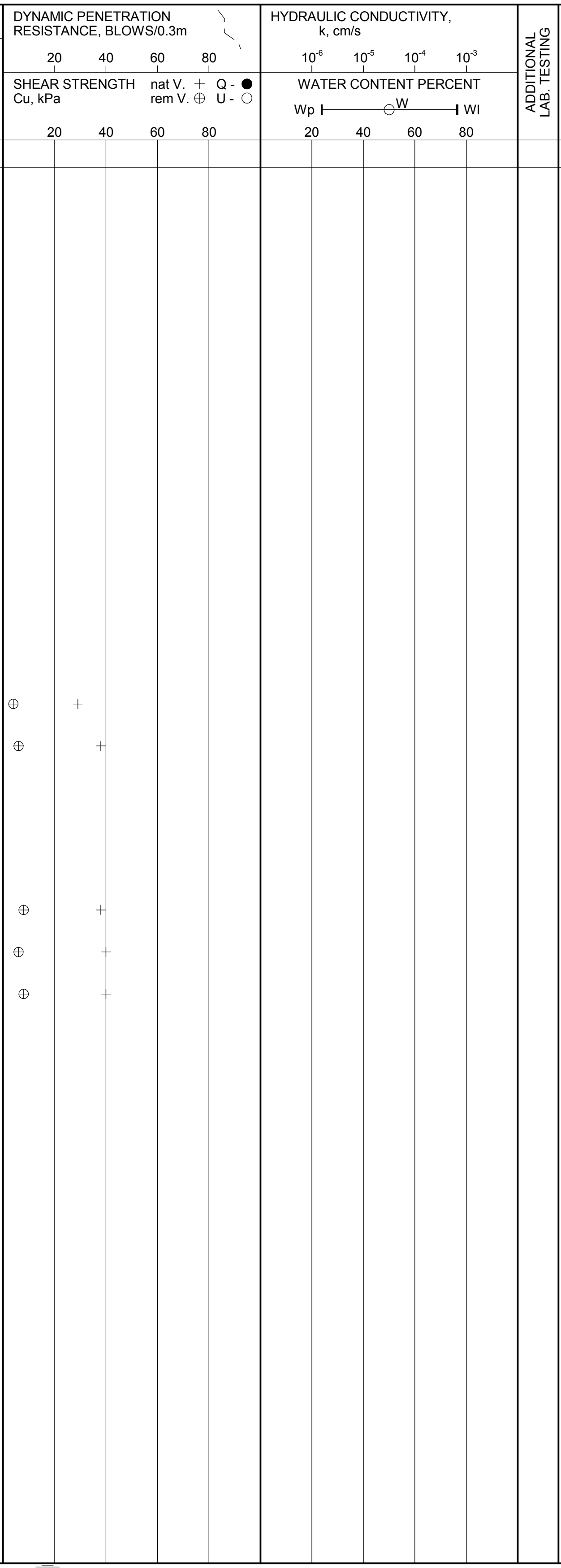
BORING DATE: November 18, 2014

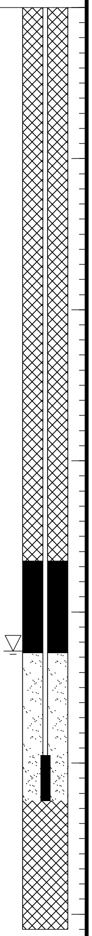
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	98.97				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; brown	0.00				
		(CI/CH) SILTY CLAY to CLAY, some sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	98.70 0.27				
1				1	SS	3	
2				2	SS	4	Native Backfill
				3	SS	4	
3				4	SS	4	
		(CI/CH) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; grey brown, with silt layers; cohesive, w>PL, firm	95.31 3.66				
4							Bentonite Seal
				5	TP	PH	Silica Sand
5							Standpipe
							Cave
6		End of Borehole	92.87 6.10				
		Note: Piezometer damaged during installation, therefore, groundwater level not necessarily representative of site conditions.					WL in Standpipe at Elev. 94.71 m on Dec. 15, 2014
7							
8							
9							
10							





DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406416

RECORD OF BOREHOLE: 14-15

SHEET 1 OF 1

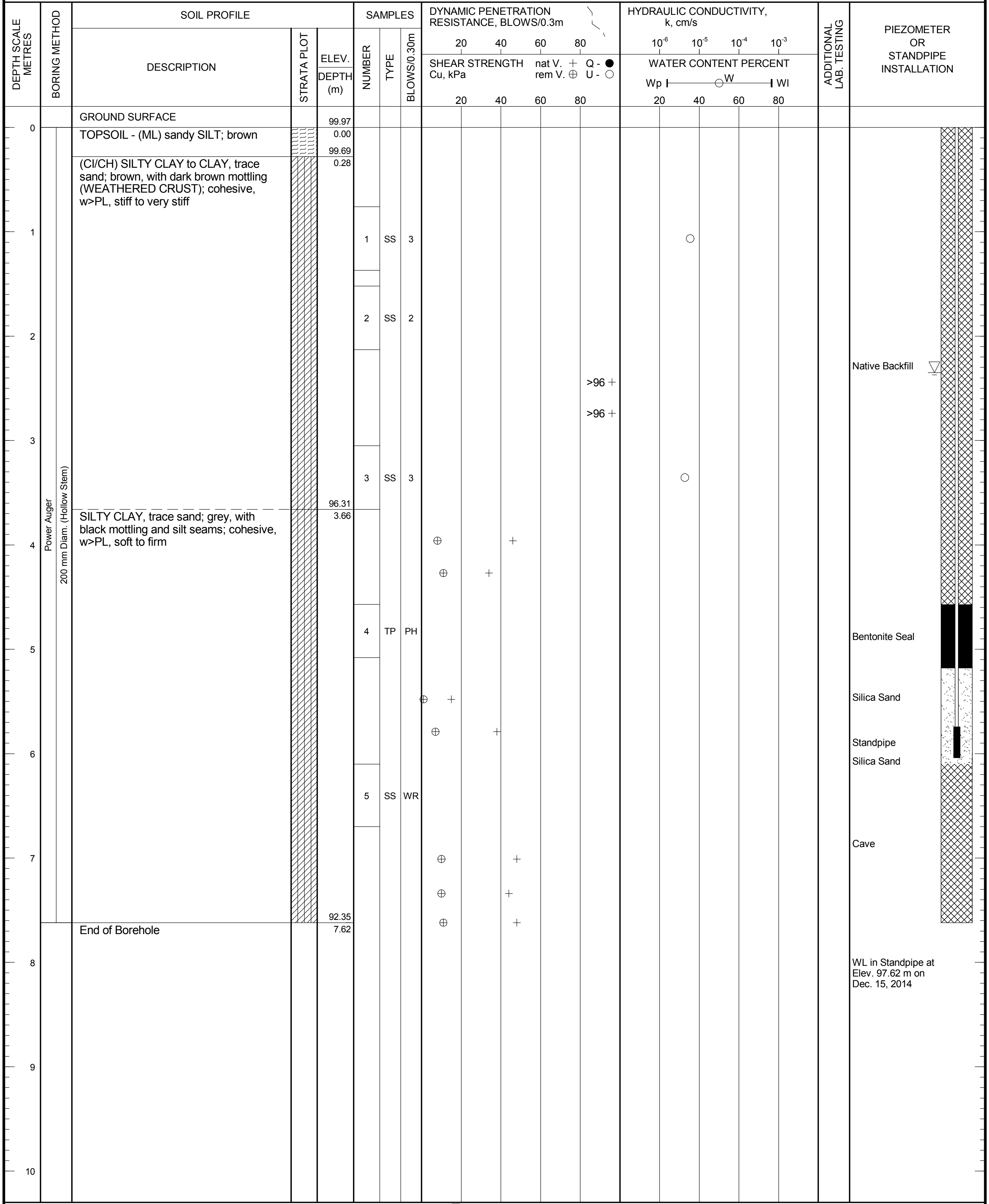
LOCATION: See Site Plan

BORING DATE: November 19, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	99.97
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; brown, with dark brown mottling (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	99.69 0.28
SILTY CLAY, trace sand; grey, with black mottling and silt seams; cohesive, w>PL, soft to firm	96.31 3.66
End of Borehole	92.35 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	3
2	SS	2
3	SS	3
4	TP	PH
5	SS	WR

Native Backfill

Bentonite Seal

Silica Sand

Standpipe

Silica Sand

Cave

WL in Standpipe at Elev. 97.62 m on Dec. 15, 2014

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: SAT

APPENDIX B

Results of Chemical Analysis
EXOVA Environmental Ontario Report No. 1426818

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: 1426818
Date Submitted: 2014-12-22
Date Reported: 2014-12-30
Project: 1406631
COC #: 792754

				Lab I.D.	1153414
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2014-11-19
				Sample I.D.	BH 14-8 SA 2/5'-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Agri. - Soil	pH	2.0			7.7
General Chemistry	Cl	0.002	%		<0.002
	Electrical Conductivity	0.05	mS/cm		0.13
	Resistivity	1	ohm-cm		7690
	SO4	0.01	%		<0.01

Guideline = *** = Guideline Exceedence**

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

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

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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