REPORT

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

Submitted to:

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1.0 INTRODUCTION

This report presents the results of the geotechnical investigations carried out for Phase 15 of the Riverside South Community development including new site servicing adjacent to the development along River Road in Ottawa, Ontario. This report was initially issued to the Riverside South Development Community in March 2015. However, at that time access to the northern parcel of land of Phase 15 was not possible due to dense tree cover. Therefore, the report has been revised to include the geotechnical investigations carried out within the northern parcel of land of Phase 15 as well as for new site servicing along River Road (which was not part of the original scope of work for this project).

The purpose of the geotechnical investigations were to determine the general soil, bedrock and groundwater conditions across the site. 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.

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

2.0 DESCRIPTION OF PROJECT AND SITE

Plans are being prepared for Phase 15 of the Riverside South Community development 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 (referred to herein as Areas A, B, and C) measuring approximately 240 by 220 metres, 800 by 400 metres, and 1,200 by 400 metres, respectively, in size. The property is divided by River Road and by a middle strip of land which is owned separately and is not part of the study area for this investigation.

It is understood that the development will include a mix of low to medium density dwellings, institutional and commercial buildings, a school, park areas, as well as access roads and services within the subdivision. It is also understood that new servicing (i.e., storm and sanitary sewers and a watermain) are proposed along River Road adjacent to the development, between Summerhill Street and Nicholls Island Road. New trunk storm sewers in additional to typical site servicing along River Road will consist of the following:

- An approximately 350 metre length of 1,350 to 1,650 millimetre diameter storm sewer from south of Summerhill Street to south of Borbridge Avenue with an invert at depths between about 6.5 to 7 metres below the existing pavement grade;
- An approximately 3,000 millimetre diameter trunk storm sewer crossing of River Road at Street 5 within Area C with an invert at about 7.5 metres depth below the existing pavement grade; and,
- An approximately 105 metre length of 1,800 mm diameter sewer along River Road, south of Street 7 of Area C with an invert at depths between about 8 and 9 metres below the existing pavement grade. This section of trunk sewer will likely continue along River Road down to Nicholls Island Road however the details of this sewer are not known at this time.

It is also understood that the trunk sewers along River Road will be connected to a future stormwater management pond (Pond 5) which is proposed adjacent to and south of Area A. However, it should be noted that no geotechnical investigation was carried out for the deep trunk sewers in this area (i.e., design of the trunk sewers west of River Road was outside of the scope of work of the current investigations included in this report).

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 (Area C) or covered with vegetation (Area B), while the parcel of land west of River Road is active agricultural land (Area A).

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 memorandum:

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) Memorandum 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 published geological mapping, the subsurface conditions at the site likely consist of layered clayey silt, sandy silt and silty sand overlying silty clay to clay and 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 west to east trend.

3.0 PROCEDURE

The field work for this site was carried out in various stages between December 2014 and January 2018. During that time, boreholes were put down at the approximate locations shown on the Site Plan, Figure 2, and as described below.

- Two boreholes (numbered 14-1 and 14-2) were advanced between December 11 and 12, 2014 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 'Area A' on the Site Plan, Figure 2. These 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, Québec to depths of about 6.7 and 7.6 metres below the existing ground surface.
- 16 boreholes (numbered 14-3 to 14-18) were advanced between December 8 and 11, 2014 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 'Area B' on the Site Plan, Figure 2. Nine of these boreholes (14-6, 14-7, 14-8, 14-11, 14-12, 14-13, 14-15, 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 5.9 to 7.5 metres below the existing ground surface. 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, Québec.

- 29 boreholes (numbered 17-01 to 17-09, 17-11 to 17-28, 17-07A and 17-20A) were advanced between October 11 and 26, 2017 within 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. This area is labelled as ‘Area C’ on the Site Plan, Figure 2. Seven of these boreholes (17-15, 17-17, 17-19, 17-25, 17-27, and 17-28) were advanced to practical refusal to auger advancement at depths ranging from about 1.2 to 5.9 metres below the existing ground surface. Upon reaching practical refusal to augering at a depth of about 3.5 metres below the existing ground surface, borehole 17-28 was advanced an additional 2.3 metres using rotary diamond drilling techniques while retrieving NQ sized bedrock core. The upper 0.6 metres of the core consisted of cobbles and boulders overlying the bedrock. The remaining boreholes were terminated at depths varying from 5.7 to 8.5 metres below the existing ground surface. Two boreholes, 17-07A and 17-20A were advanced adjacent to boreholes 17-07 and 17-20 to depths of about 4.5 and to 8.2 metres, respectively, to obtain the undisturbed Shelby tubes samples. All of the boreholes were advanced using a track-mounted continuous flight hollow-stem auger drill rig, supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. Borehole 17-10 was planned to be drilled as part of this investigation but was not accessible due to the presence of butternut trees in that area.
- 5 boreholes (numbered 17-101, 17-102, and 17-105 to 17-107) were advanced between December 20, 2017 and January 11, 2018 along River Road between Summerhill Street and Nicholls Island Road for new servicing. The boreholes were advanced to a depth of 8.2 metres below the existing pavement grade using a truck-mounted continuous flight hollow-stem auger drill rig, supplied and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario. Boreholes 17-103, 17-104, and 17-108 were planned to be drilled as part of this investigation but could not be completed due to inclement weather conditions and buried utilities at the time of investigation.

Standard Penetration Tests (SPTs) 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, five relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from boreholes 14-1, 14-2, 14-3, 17-07A and 17-20A using a fixed piston sampler.

Standpipe piezometers or monitoring wells were sealed into boreholes 14-1, 14-3, 14-8, 14-18, 17-01, 17-07A, 17-19, 17-20, 17-24, 17-28, 17-101, and 17-107 to allow subsequent measurement of the groundwater level across the site. The groundwater levels in the standpipe piezometers in boreholes 14-1 and 14-3 were measured on December 19, 2014, while the standpipe piezometers in boreholes 17-01, 17-07A, 17-19, 17-20, 17-24, and 17-28 were measured on November 7, 2017. The monitoring wells in boreholes 17-101 and 17-107 were measured on March 6, 2018.

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 and bedrock samples retrieved.

Upon completion of the drilling operations, samples of the soils and bedrock core 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 14-1,14-10, 17-06, 17-18, and 17-106 were submitted to EXOVA Environmental Ontario Ltd. or Eurofins Environment Testing 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 either Golder Associates Ltd. or Annis O'Sullivan Vollebekk Ltd. The borehole locations and elevations by Golder Associates Ltd. were determined using a Trimble R8 Global Positioning System (GPS) survey unit. The elevations are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- Record of Borehole and Drillhole Sheets are provided in Appendix A.
- Record of Borehole Sheets from relevant boreholes from the previous investigations by Golder Associates Ltd. are provided in Appendix B.
- The results of the basic chemical analysis carried out on soil samples from boreholes 14-1,14-10, 17-06, 17-18, and 17-106 are provided in Appendix C.
- Oedometer consolidation test results are provided on Figure 3.
- Grain size distribution testing results are provided on Figures 4 and 5.

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 along River Road, in Area A, in Area C, and in the northwest corner and central north portion of Area B. In addition, shallow bedrock may be present in the south and east portions of Area B as well as the southeast portion of Area C.

The following sections present a detailed overview of the subsurface conditions on this site from the current investigation. Given the large geographical area of the site, for this discussion the subsurface descriptions have been divided into three distinct parcels of land, labelled as Areas A, B and C on Figure 2, as well as for the investigation along River Road for the new site servicing. The record of boreholes from the previous investigations are provided for information purposes only and are not discussed further in this report.

4.2 Area A

Area 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 Area 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 deposit have been weathered to a stiff grey brown crust. The unweathered silty clay to 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 (referred to hereafter 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 silty clay 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 upper portion of the deposit measured undrained shear strength values ranging from about 23 to 38 kilopascals, indicating a soft to firm consistency. The measured shear strength generally increases with depth, reaching as high as 86 kilopascals (stiff consistency) by about 8 metres depth. The remoulded strengths within the deposit are low, reflecting a sensitive soil.

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 Area B

Area 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 Area 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 sandy silt and silty sand, clayey silt, silty clay, and clay, and sandy silt and silt 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 5.9 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 generally been 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, a deposit of grey unweathered clayey silt, silty clay and clay underlies a 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 remolded strengths in this deposit are low, reflecting a sensitive soil. 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 Sandy Silt and 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 where 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.

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.

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. 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. 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.

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 from Area B are shown on Figure 4.

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 nine of the borehole locations (i.e., boreholes 14-6, 14-7, 14-8, 14-11, 14-12, 14-13, 14-15, 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 Area C

Area 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. Boreholes 17-01 to 17-09, 17-11 to 17-28, 17-07A and 17-20A were advanced within Area C. No boreholes were put down within the central north portion of the site (Blocks 327 and 329), as this area has been designated for a future school and institutional development (which is beyond the scope of this investigation).

In general, the subsurface conditions in this area consist of topsoil underlain by layered sandy silt, silty sand, silt and sand, overlying a deposit of clayey silt and sensitive silty clay to clay and glacial till. In the east half of the site the layered deposits are underlain by glacial till at the depths ranging from 0.8 to 3.4 metres below the existing ground surface. Bedrock was proven at borehole 17-28 at the southeast corner of the site and consist of limestone with thin shale interbeds. The boreholes in the west half of the site generally terminated in the clay deposit at depths varying from about 6.1 to 8.5 metres below the existing ground surface.

4.4.1 Topsoil

Topsoil exists at ground surface at the majority of the boreholes locations and ranges in thickness from about 100 to 460 millimetres.

4.4.2 Sandy Silt, Silty Sand, Silt and Sand

A deposit of sandy silt, silty sand, silt and sand was encountered beneath the topsoil at twelve of the borehole locations. Where present, the layer is between about 0.2 and 1.4 metres thick. SPTs carried out within the deposit gave N values ranging from 2 to 10 blows (but more typically 4 to 7 blows) per 0.3 metres of penetration, indicating a generally loose state of packing.

A deposit of sandy silt to silty sand to gravelly sand was also encountered beneath the silty clay layer at boreholes 17-14, 17-15, 17-19, 17-24, 17-26, and 17-27. Where present, this layer generally ranged from about 0.2 to 0.8 metres in thickness, with the exception of borehole 17-19, where the thickness was 2.1 metres. SPTs carried out within this deposit gave N values ranging from 3 to greater than 50 blows per 0.3 metres of penetration, indicating a very loose to very dense state of packing.

The measured water contents of these deposits ranged from about 7 to 29 percent. The results of grain size distribution testing on two samples of these deposits are shown on Figure 5.

4.4.3 Clayey Silt, Silty Clay and Clay

The topsoil and/or silty sand/sandy silt are underlain by a deposit of clayey silt, silty clay and clay. This deposit was encountered at ground surface at borehole 17-05.

The upper portion of silty clay deposit has generally been weathered to a grey brown colour. The weathered deposit extends to depths between about 0.8 and 3.6 metres below the existing ground surface. SPT N values obtained within this deposit range from “weight of hammer” to about 7 blows per 0.3 metres of penetration. The results of in situ vane testing in the weathered silty clay gave undrained shear strengths of about 72 to greater than 96 kilopascals. The results of this in situ testing indicate a generally stiff to very stiff consistency for the weathered crust.

Atterberg limit testing carried out on two samples of the weathered crust measured plasticity indices of about 32 and 37 percent and liquid limit values of about 47 and 56 percent, indicating that the deposit has an intermediate to high plasticity. The measured water contents of the weathered deposit ranged from about 29 to 58 percent.

At boreholes 17-08, 17-16, 17-17, 17-18, and 17-20, the upper clayey deposits consist of layered weathered silty clay to clay, sandy clayey silt and sandy silt with a thickness between about 1.6 to 2.9 metres. SPTs carried out within the layered deposit gave N values ranging from "weight of hammer" to 5 blows per 0.3 metres of penetration. The results of in situ vane testing in the layered deposit gave undrained shear strengths of about 50 to 95 kilopascals. The results of in situ testing indicate a generally stiff to very stiff consistency in the layered deposit.

Atterberg limit testing carried out on one sample of the layered deposit measured a plasticity index of about 19 percent and a liquid limit value of about 32 percent, indicating an intermediate plasticity. The measured water contents of the layered deposit ranged from about 18 to 53 percent.

A deposit of grey unweathered clayey silt, silty clay, and clay underlies the upper weathered crust, layered deposit and sandy silt layer (where present) with the exception of boreholes 17-15, 17-17, 17-19, 17-24, 17-25, 17-27, and 17-28. The deposit was fully penetrated at boreholes 17-09 and 17-16 at depths of 4.6 and 3.4 metres, respectively and proven to depths between about 5.7 to 8.5 metres below the existing ground surface at all of the remaining borehole locations. The results of in situ testing in this deposit gave undrained shear strength values ranging from 33 to greater than 96 kilopascals indicating a firm to very stiff consistency. The remoulded strengths within the deposit are low, reflecting a sensitive soil.

Atterberg limit testing carried out on three samples of unweathered deposit measured plasticity indices of about 24 to 43 percent and liquid limit values of about 43 to 63 percent, indicating that the deposit has an intermediate to high plasticity. The measured water contents of selected samples of unweathered portion of the deposit ranged from about 38 and 68 percent.

4.4.4 Glacial Till

A deposit of glacial till was encountered below the clayey soils at nine borehole locations in the eastern portion of the site. 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 0.8 and 4.6 metres below the existing ground surface and proven to extend to depths of between about 1.2 and 5.9 metres below the existing ground surface.

SPT N values of 2 to in excess of 50 blows per 0.3 m of penetration were measured in the glacial till, indicating a very loose to very dense state of packing, although the higher N values could reflect the presence of cobbles and boulders, rather than the state of packing of the soil matrix.

The measured natural water content of selected samples of the glacial till was about 7 to 8 percent. The results of grain size distribution testing on two samples of the glacial till from Area C are shown on Figure 4. It should be noted that the split-spoon sampler used during the investigation has an inside diameter of about 35 millimetres and therefore the results of grain size distribution tests do not reflect the coarser fraction of the deposit (i.e., the larger gravel, cobbles and boulders likely present within the glacial till).

4.5 Refusal and Bedrock

Practical refusal to auger advancement was encountered at six of the borehole locations (i.e., boreholes 17-15, 17-17, 17-19, 17-25, 17-27, and 17-28) at depths ranging from about 1.2 to 5.9 metres below the existing ground surface. These refusals were encountered within the eastern half of the site. Refusal could indicate the bedrock surface or may reflect the presence of cobbles and boulders in the glacial till deposit.

Bedrock was proven beneath the glacial till and lower boulder and cobbles at borehole 17-28 where it was cored for length of about 1.7 metres. The bedrock encountered in the borehole consists of grey limestone with shale interbeds. The bedrock is fresh to slightly weathered, fine grained and non-porous.

The Rock Quality Designation (RQD) value measured on the recovered bedrock core sample is about 85 percent, indicating a good quality rock.

4.5.1 Groundwater

The groundwater levels in the piezometers sealed in boreholes 17-01, 17-07A, 17-19, 17-20, 17-24, and 17-28 were measured on November 7, 2017. The observed groundwater levels are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
17-01	87.7	2.6	85.1
17-07A	89.9	0.0	89.9
17-19	93.4	0.2	93.2
17-20	90.0	0.7	89.3
17-24	92.2	0.1	92.1
17-28	93.4	0.1	93.3

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.

4.6 River Road Servicing

An investigation was carried out along a roughly 1.3 kilometre long section of River Road, between Summerhill Street to 300 metres north of Nicholls Island Road for the design of new servicing along River Road. Boreholes 17-101, 17-102, 17-105, 17-106 and 17-107 were advanced at the locations shown on the Site Plan, Figure 2.

In general, the subsurface conditions along this section of River Road consist of pavement structure and fill underlain by a deposit of sensitive silty clay to clay. At borehole 17-101, at a depth of 8.2 metres below the existing ground surface, the silty clay is underlain by glacial till.

4.6.1 Pavement Structure and Fill

In general, the pavement structure along River Road consists of asphaltic concrete overlying granular base/subbase. Within most of the boreholes, it was not possible to discern between the base and subbase layers (if/where present). The composition of the granular pavement structures consists of gravelly sand.

The asphaltic concrete ranged from 70 to 150 millimetres in thickness, with an average thickness of 105 millimetres. The pavement granulars extend to depth between 350 and 510 millimetres below the road surface.

Heterogeneous fill underlies the pavement structure at all five boreholes, and extends to depths ranging from about 0.9 to 1.7 metres below the existing ground surface. The composition of the fill generally consists of sand to sandy silt, with trace to some gravel. Silty clay and clayey silt layers were present within the fill at borehole 17-107 and organics were noted in the fill at borehole 17-106.

SPTs carried out within the fill gave N values ranging from 22 to greater than 50 blows per 0.3 metres of penetration, indicating a compact to very dense state of packing. However, the higher N values may be the result of frozen ground during the drilling.

4.6.2 Buried Topsoil

A layer of buried topsoil was encountered at boreholes 17-105 and 17-106, which was 220 to 240 millimetres in thickness.

4.6.3 Silty Sand

The buried topsoil layer at boreholes 17-105 and 17-106 is underlain by a 100 to 400 millimetre thick layer of silty sand, which extends to between 1.8 and 1.6 metres below the existing pavement surface, respectively.

4.6.4 Silty Clay to Clay

A deposit of silty clay to clay (referred to hereafter as silty clay) was present at all of the borehole locations. The upper portion of silty clay deposit has generally been weathered to a grey brown colour. The weathered deposit extends to depths between about 4.6 to 5.9 metres below the existing ground surface, corresponding to thicknesses of between about 3.3 to 4.3 metres. SPT N values obtained within this deposit range from about 2 to 14 blows per 0.3 metres of penetration. The results of in situ vane testing in the weathered silty clay gave undrained shear strengths of greater than 96 kilopascals, indicating a generally very stiff consistency for the weathered crust. Natural water contents of about 30, 32, and 40 percent were measured within the weathered portion of the silty clay.

Underlying the weathered silty clay, a layer of unweathered grey silty clay was encountered. The grey silty clay layer was fully penetrated at a depth of about 7.6 metres at borehole 17-101, and was proven to extend to a depth of about 8.2 metres at the remaining boreholes. The results of in situ vane shear testing in the unweathered grey silty clay gave undrained shear strength values ranging from 42 to 77 kilopascals indicating a firm to stiff consistency. The remoulded strengths in this deposit are low, reflecting a sensitive soil.

Atterberg limit testing carried out on two samples of the unweathered deposit measured plasticity indices of about 28 and 42 percent, and liquid limit values of about 46 and 61 percent, indicating that the deposit has an intermediate to high plasticity. The measured water contents of the unweathered deposit ranged from about 42 to 69 percent.

4.6.5 Glacial Till

A deposit of glacial till was encountered below the silty clay at borehole 17-101. The glacial till consists of a heterogeneous mixture of gravel, cobbles and boulders in a matrix of silty sand. The glacial till was encountered at a depth of 7.6 metres below the existing pavement surface and proven to extend to a depth of about 8.2 metres below the existing pavement surface.

One SPT N value of “weight of hammer” for 0.3 m of penetration was measured in the glacial till, indicating a very loose state of packing.

4.6.6 Groundwater

The groundwater levels in the monitoring wells sealed in boreholes 17-101 and 17-107 were measured on March 6, 2018. The observed groundwater levels are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
17-101	89.5	4.3	85.2
17-107	90.4	1.6	88.8

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.

This report provides geotechnical engineering guidelines and recommendations for the detailed design of the overall site development, low-rise housing and new site servicing along River Road. Additional geotechnical investigation will need to be carried out for any non-residential buildings (i.e., schools, commercial building etc.) on a site-by-site basis for detailed design as well as for the trunk sewers between River Road and Pond 5 (if not already completed by others).

5.2 Site Grading

The subsurface conditions in Area A, the western portion and northeast corner of Area C, and at borehole 14-3 generally consist of topsoil and/or silty sand/sandy silt underlain by stiff to very stiff and/or weathered clayey silt, silty clay, clay, and silt, overlying a thick deposit of unweathered and compressible sensitive clayey silt, silty clay and clay extending to at least 6 to 8 metres depth. The subsurface conditions within Area B and the remainder of Area C 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 to 4.9 metres (not including boreholes 14-3, 17-08, 17-18, 17-26). The lower portions of the layered deposits at boreholes 14-3 and 14-6 in Area B and 17-08, 17-18 and 17-26 in Area C 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 areas where compressible soils exist (i.e., all of Area A, at boreholes 14-3 and 14-6 in Area B, the western portion and northeast corner of Area C as well as at boreholes 17-08, 17-18, and 17-26 in Area C). 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
4	2.9

Note: *There are no practical grade raise restrictions in Zone 3, where the clayey soils are stiff to 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., at or within about 2.5 metres below ground surface). Excavations for basement construction which extend below the groundwater level will therefore likely 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 Area B as well as the southeast portion of Area C.

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 clayey deposits (hereafter referred to as silty clay) 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, 2, and 4 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 near Borehole 14-13 in Area B and borehole 17-25 in Area C) can be designed using a maximum allowable bearing pressure of 250 kilopascals.
The settlement of footings 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 surficial sand and 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 surficial layers).

The glacial till overburden materials in Areas B and C 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.

Insulating the bearing surface with high density insulation could be considered as an alternative to earth cover for frost protection. Further details could be provided if required.

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, 3 and 4. 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 shear wave velocity testing in the Phase 9 site to the north of Area 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, sands, silts and clays, as well as the underlying glacial till (where the till surface is shallow). Excavation into the bedrock could potentially be required in the vicinity of boreholes 14-13 in Area B and 17-25 in Area C, 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. However, if the water table is encountered within the excavations, the sand and silt layers would be considered as Type 4 soils and side slopes of 3 horizontal to 1 vertical will 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 between ground surface and up to about 2.5 metres depth will extend below the groundwater level. Where this is the case and the excavation encounters the relatively more permeable silty and sandy 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 relatively shallow (i.e., at or within about 2.5 metres below ground surface). The layered sandy and silty soils at this site are 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 will need to be provided.

5.9 Site Servicing

It is understood that site servicing will typically be within about 4 to 6 metres depth below the existing ground surface with the exception of the proposed trunk storm sewers along River Road which will be up to about 9.4 metres depth below the existing pavement grade. The trunk sewers along River Road also vary from about 1,350 to 3,000 millimetres in diameter. Only preliminary details of the site servicing and servicing along River Road were known at the time of the investigation and borehole depths were therefore limited to about 8 metres below the existing ground/pavement surface. Where excavations for the trunk sewers will need to extend below 8 metres depth, additional geotechnical investigation will be required to confirm the subsurface conditions at/below invert level. In addition, no geotechnical investigation was carried out for the trunk sewers which are adjacent to and south of Area A (i.e., for the trunk sewer between River Road and Pond 5).

5.9.1 Open-Cut Excavations in Overburden

Excavations for the installation of site services will be made through the topsoil, layered sands, silts and clays, as well as the glacial till and possibly into the underlying bedrock (at least on the east/high part of the development). 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 for worker safety.

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 and glacial till 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, the excavations could be carried out using steeper side slopes with all manual labour carried out within fully braced, steel trench boxes for worker safety. Due to the depth of the trunk sewer excavations (some up to about 9.5 metres), it is anticipated that stacked trench boxes, possibly in conjunction with steel plates and/or pre-cut/unsupported slopes at the surface, may be required. Deep excavations, particularly within the existing roadways (where space is restricted by the need to maintain traffic flow or existing services), could also be temporarily supported with a slide rail system.

Stockpiling of soil beside the excavations should also be avoided; the weight of the stockpiled soil could lead to basal instability of braced excavations or slope instability of unsupported excavations. The contractor should be directed to place stockpiles of excavated material no closer than twice the depth of the excavation from the edge of the trench. This is of particular importance where the excavations are underlain by firm silty clay (i.e., within Zone 1 and along River Road).

5.9.1.1 Basal Instability

Basal instability results when the shear strength of the soil beneath a shored excavation is inadequate to support the weight of the soil retained by the shoring (i.e., to resist the unbalanced weight of the external/retained soil versus the ‘excavated’ condition within the shoring). The factor of safety against basal instability depends on the width, depth and length of the excavation, as well as the shear strength and unit weight (i.e., the density) of the retained and underlying silty clay.

The stability of braced excavations which extend into the unweathered grey silty clay should be assessed individually based on the length, width, and depth of the trench box. For example, the factor of safety against basal instability of a braced excavation 5 metres wide by 10 metres long by up to 9.4 metres deep (the deepest required excavation in the silty clay for the trunks storm sewer along River Road based on the available profile drawings) for the measured shear strengths at this site would be greater than 1.5, which is generally acceptable provided that some adjacent ground surface deformations (e.g., lateral yielding and settlement) are tolerable. The magnitude of deformations will ultimately depend on the duration that the excavation is left open, the trench geometry, and other factors.

While shear failure due to basal instability is not anticipated, some uplift of the clay at the base of the excavation may occur, and recovery of this deformation upon backfilling of the trench in areas could result in some post-construction settlement (i.e., low-spots/sumps) along the profile of the pipe. The following best practices are recommended for installation of the trunk sewers along River Road to limit the risk of uplift deformations and subsequent settlement:

- Use short sections of trench. Do not create long sections of open trench.
- Complete the operation of excavation, placing of bedding, sewer pipe, and cover material, followed by backfilling to the ground surface in the shortest time possible. Deep trenches must not be kept open for any extended periods, such as overnight.
- Extend the temporary trench support (e.g., driven steel plates) below the depth of excavation.
- If the above measures are not sufficiently effective, provide stress relief of the excavation by excavating a shallow, wide bench into the ground adjacent to the deep trench excavations.

5.9.1.2 Basal Heave

Basal heave can result when only a limited thickness of low-permeability soil (e.g., clay) beneath the base of the excavation is underlain by higher permeability soil (e.g., glacial till) or bedrock with high groundwater pressures. This condition can result in a disturbed/destabilized subgrade, which would not be suitable for support of the sewer pipes, and the recompression of which, upon backfilling, would lead to unacceptable pipe settlements. For this project, basal heave is anticipated to be a risk in Zones 2, 3 and 4. However, the extent of this risk can be confirmed once the design sewer levels are known.

During excavation under these conditions, there will be a high piezometric pressure on the underside of the silty clay (even if groundwater is pumped out from within the excavation). If the glacial till layers and bedrock are not depressurized in advance of excavation, the groundwater pressure will be high enough that there is a risk of basal heave of the overlying lower permeability overburden soils which form the floor of the excavation. Upon backfilling of the trench in areas of basal heave, this deformation could result in some post-construction settlement (i.e., low-spots/sumps) along the profile of the pipe. Furthermore, if the subgrade becomes disturbed, the disturbed material would need to be sub-excavated and replaced with compacted engineered fill to avoid future settlement of the pipe.

It is expected that depressurization, carried out in advance of the excavation, may be required in some areas to prevent basal heave, such as for the trunk storm sewers along River Road as well as the site servicing in Zones 2, 3, and 4 of the development. However, the need for such depressurization in these areas is dependant on pipe inverts, soil stratigraphy and groundwater level. Therefore, this issue will need to be reviewed once more information on the pipe inverts is known at which time further guidance can be provided. Conceptually, passive relief wells (i.e., boreholes advanced through the clay into the more permeable glacial till, then backfilled with pea gravel) which discharge into the trench could be considered as a means of depressurizing the underlying higher permeability soil or bedrock and preventing basal heave.

It is understood, that there are existing structures (i.e., houses) at the north end of the proposed trunk sewer alignment, just south of Summer Hill Street and at the south end of the alignment, north of Nicholls Island Road. If the above depressurization is carried out, this could result in temporary lowering of the groundwater level in these areas. While there are compressible clay deposits in these areas, the temporary groundwater level lowering due to dewatering within the trenches is not considered an issue in terms of clay consolidation settlement and impacts to the adjacent structures. However, it would be prudent to carry out a precise survey/monitoring of the elevations of the adjacent structures in order to manage damage claims that may be unrelated to the construction and to provide baseline information against which such claims can be evaluated.

5.9.1.3 Subgrade Destabilization/Disturbance

Where saturated permeable sandy layers are present within or above the glacial till at the base of the excavation, such as was encountered at boreholes 14-14, 14-17, 14-18, 17-15, 17-19, and 17-24, upward seepage of water through the subgrade soils is likely to occur, which could disturb the subgrade. Because these deposits occur irregularly with depth, it is considered that these layers could be encountered at the base of the excavations. Because these layers are potentially discontinuous, it is likely not practical to actively dewater them in advance of the excavation, although localized pumping from sumps excavated ahead of the trench, as required, may be feasible. If the subgrade becomes disturbed, the disturbed material would need to be sub-excavated and replaced with compacted engineered fill to avoid future settlement of the pipe.

Given the sensitivity of the grey silty clay subgrade, it is recommended that the base of the trench be cut with an excavator using a smooth bladed bucket (i.e., no teeth) to avoid disturbance.

5.9.2 Open-Cut Excavations in Bedrock

Bedrock removal 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.

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.

5.9.3 Groundwater and Surface Water Control and Management

Some groundwater inflow into the excavations should 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 Area B and at borehole 17-19 at the eastern limit of Area C. 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. According to Ontario Regulation 63/16 and Ontario Regulation 387/04, a Permit to Take Water (PTTW) is required from the Ministry of the Environment and Climate Change (MOECC) if a volume of water greater than 400,000 Litres/day is pumped from the excavations. A PTTW has already been obtained from the MOECC for the overall site development work, which includes site servicing for Phases 13, 14 and 15 of the Riverside South Development (i.e., PTTW No. 3410-AGTQG6).

5.9.4 Pipe Bedding and Cover

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. Where the sewers will likely be installed directly in the unweathered silt clay, it is 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.

5.9.5 Trench Backfill

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.

5.9.6 Impermeable Cutoffs / Seepage Barriers

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. Groundwater level lowering could lead to long term settlement of structures surrounding the development that are supported on the sensitive silty clay soil. 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.

For Zones 1, 2, and 4, 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.

There are no restrictions for above-ground pools in Zone 3.

5.11.2 Decks

For Zone 3, no special geotechnical considerations area necessary for decks.

For Zones 1, 2 and 4, a geotechnical evaluation/assessment will be necessary for future decks that:

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

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

5.11.3 Additions

For Zones 1, 2, 3 and 4, 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 14-1,14-10, 1706, 17-18, and 17-106 were submitted to EXOVA Environmental Ontario Ltd. or Eurofins Environment Testing 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 to elevated potential for corrosion of exposed ferrous metal, which should be considered in the design of substructures.

5.13 Trees

The clayey 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.

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 and servicing along River Road were available. Golder Associates should be retained to review the guidelines provided in this report once additional details are known.

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 or preliminary in nature), particularly in the areas of the site where potentially shallow bedrock was encountered or deep trunk sewers are proposed. In this case, further investigation would likely be required to confirm the depth and type of the bedrock as well as the subsurface conditions at excavation depth for trunk sewers.

For development of Area 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.

S Trickey

LICENSED PROFESSIONAL ENGINEER
S. A. TRICKEY
100104579
May 22/18
PROVINCE OF ONTARIO

Susan Trickey, P.Eng.
Geotechnical Engineer

Bill Cavers, P.Eng.
Associate, Senior Geotechnical Engineer

SAT/MIC/ESO/WC/mvrd
n:\active\2014\1121 - geotechnical\1406631 rsdc phase 15 lands ottawa\07-report\2018\1406631-001-r-rev0-rsdc phase 15 lands ottawa-may 2018.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **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.

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

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

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

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

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

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

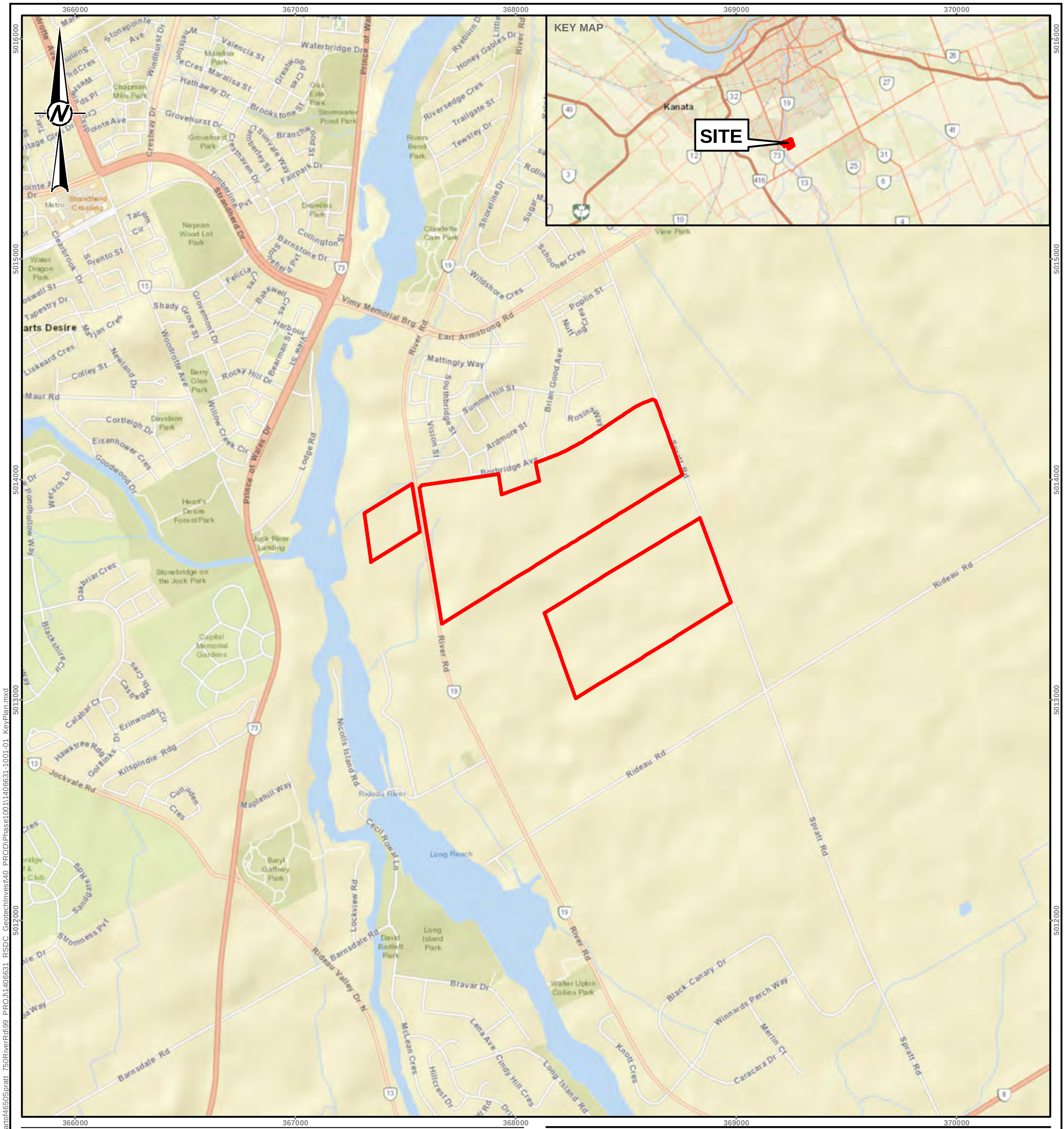
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

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

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

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

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



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, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), MAPMYINDIA, NGCC, © 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)
OTTAWA, ONTARIO

TITLE
KEY PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-13
DESIGNED	----
PREPARED	BR
REVIEWED	SAT
APPROVED	ESO

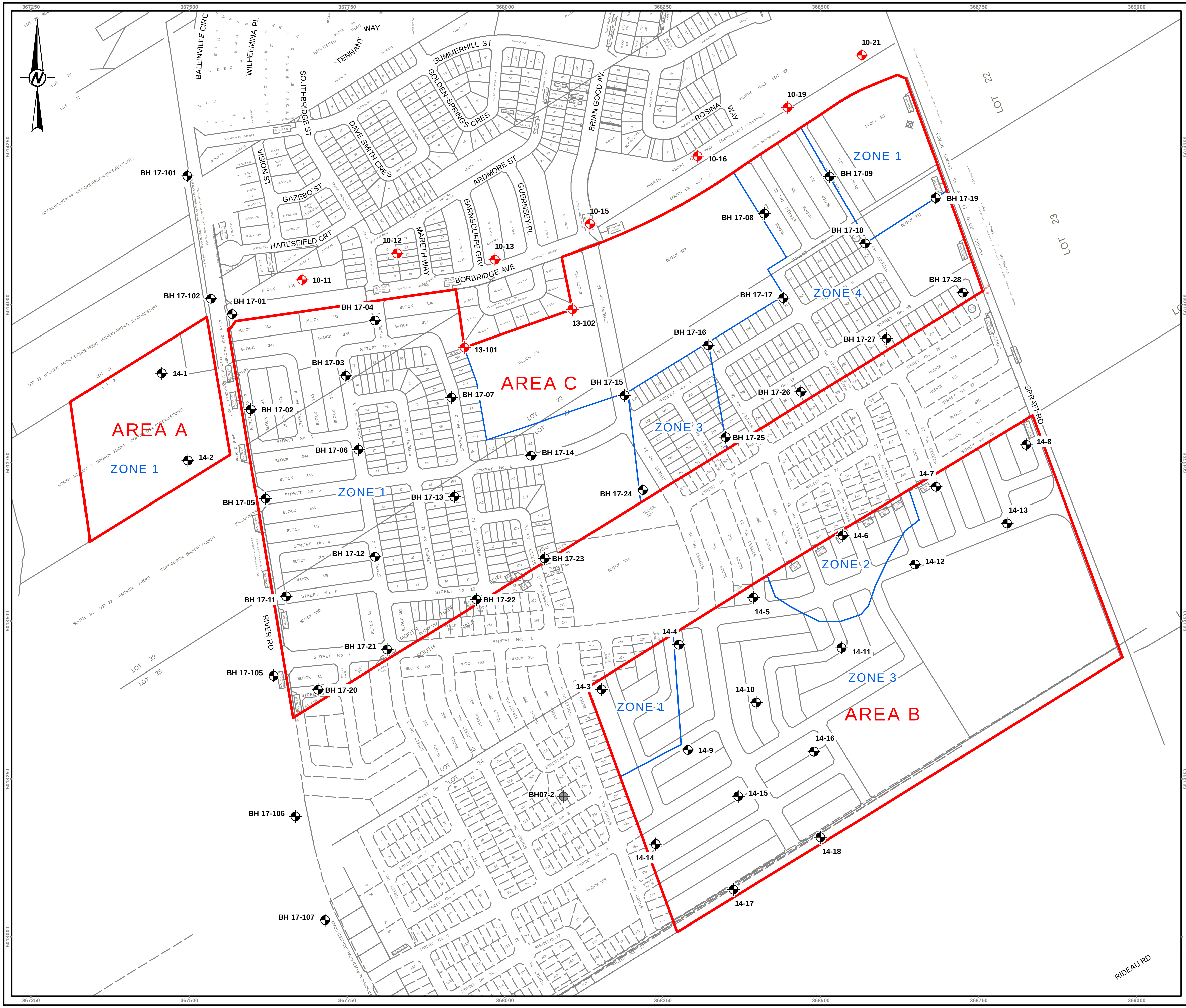
PROJECT NO.	PHASE	REV.	FIGURE
1406631	1000	0	**1**

Path: \\golder.gds\gal\Ottawa\Active\Spatial IM\Riverside South Development Corporation\Partof4650Spratt 750RiverRd\99 PROJ\1406631 RSDC Geotechinvest\40 PROD\Phase1001\1406631-1001-01 KeyPlan.mxd

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

25mm

0



LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
⊕	APPROXIMATE BOREHOLE LOCATION PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD., PROJECT NO. 10-1121-0260
⊕	APPROXIMATE BOREHOLE LOCATION PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD.,PROJECT NO. 07-1121-0141
🟥	SITE LIMITS
▭	ASSESSMENT ZONE

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. DEVELOPMENT PLAN PROVIDED BY RIVERSIDE SOUTH DEVELOPMENT CORPORATION IN CAD FORMAT, DRAWING "XRF-18253-17 URBANDALE PT LT 22 23 24 BF RF GL PHASE 15 BOREHOLESWITH ELEVATIONS C32", 2017-11-09.
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

0 50 100 200
1:6,000 METRES

CLIENT
RIVERSIDE SOUTH DEVELOPMENT CORPORATION

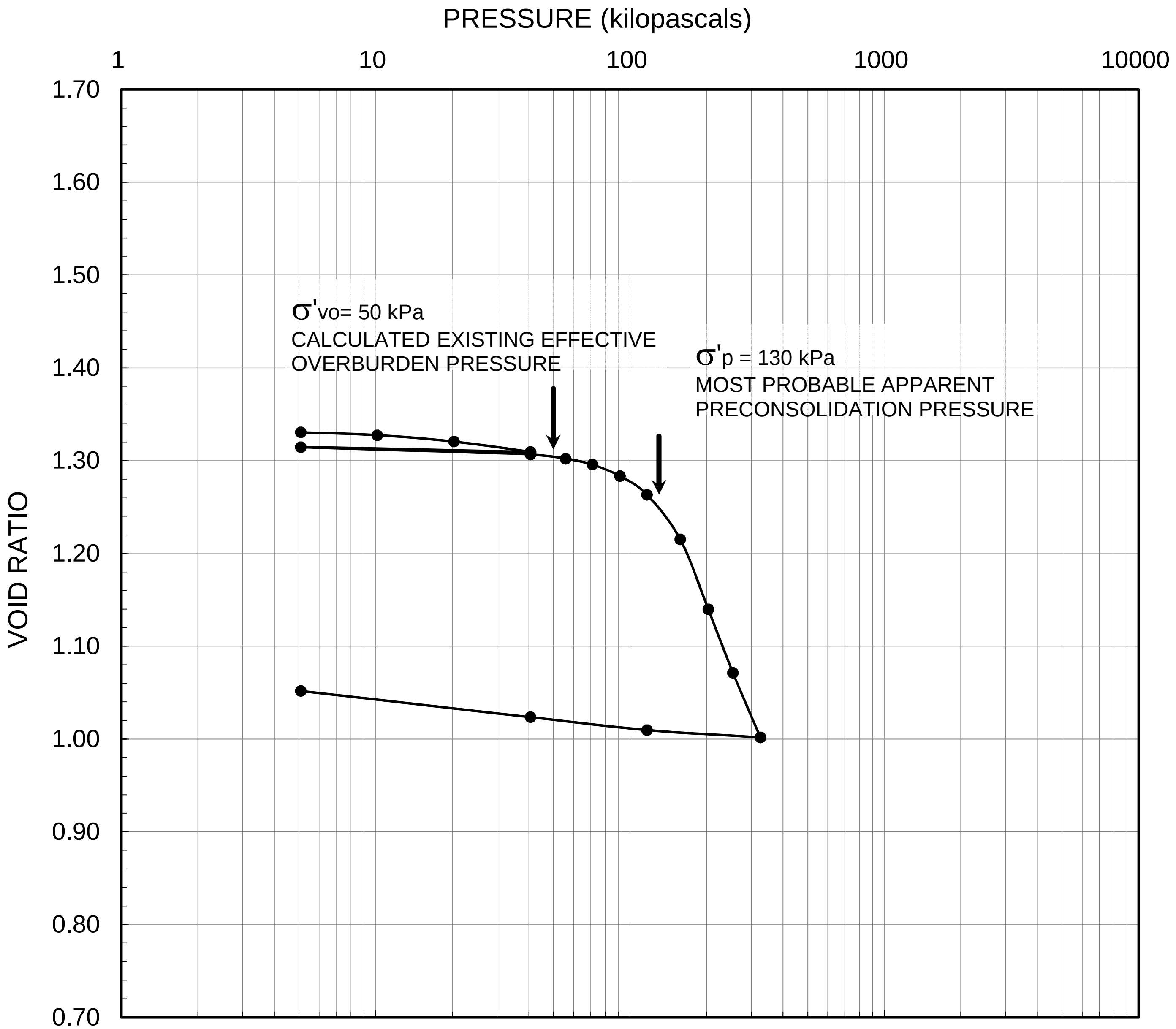
PROJECT
GEOTECHNICAL INVESTIGATION
RIVERSIDE SOUTH DEVELOPMENT (PHASE 15)
OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-04-24
DESIGNED	----
PREPARED	BR/ABD
REVIEWED	SAT
APPROVED	ESO

PROJECT NO.	PHASE	REV.	FIGURE
1406631	1000	0	**2**



LEGEND

Borehole: 14-2
Sample: 5
Depth (m): 5.1
Elevation (m): 82.5

w_i = 48%
w_f = 39%
w_l = 56%
w_p = 24%

S_o = 100%
e_o = 1.33
C_c = 0.71
C_r = 0.009

γ = 17.2 kN/m³
G_s = 2.77

GOLDER

SCALE AS SHOWN
DATE 05/14/18
CADD N/A
ENTERED MI
CHECK CNM
REVIEW SAT

FILE No. Consolidation summary
PROJECT No. 1406631 REV. 3

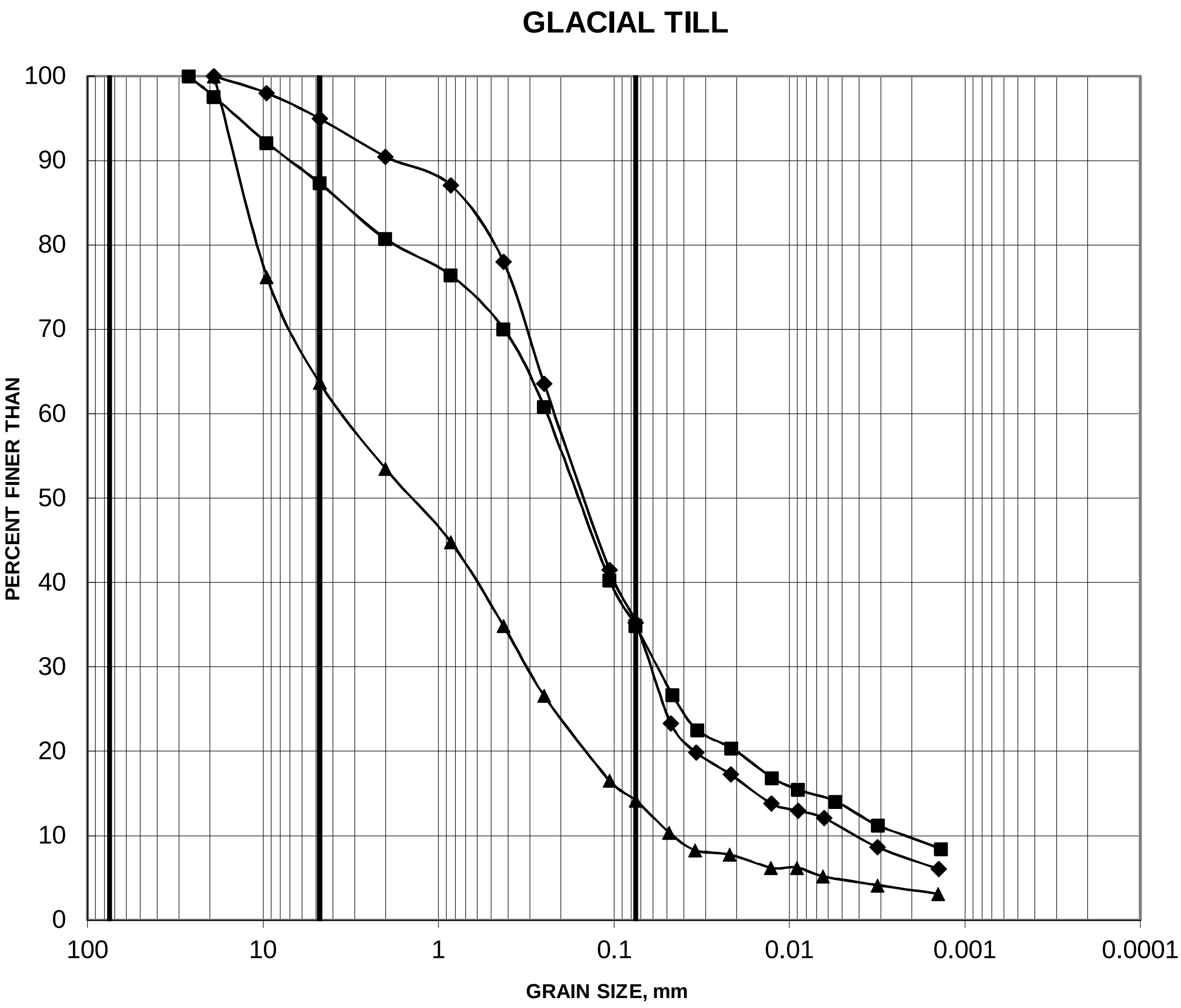
TITLE

CONSOLIDATION TEST RESULTS

FIGURE **3**

GRAIN SIZE DISTRIBUTION

FIGURE 4



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

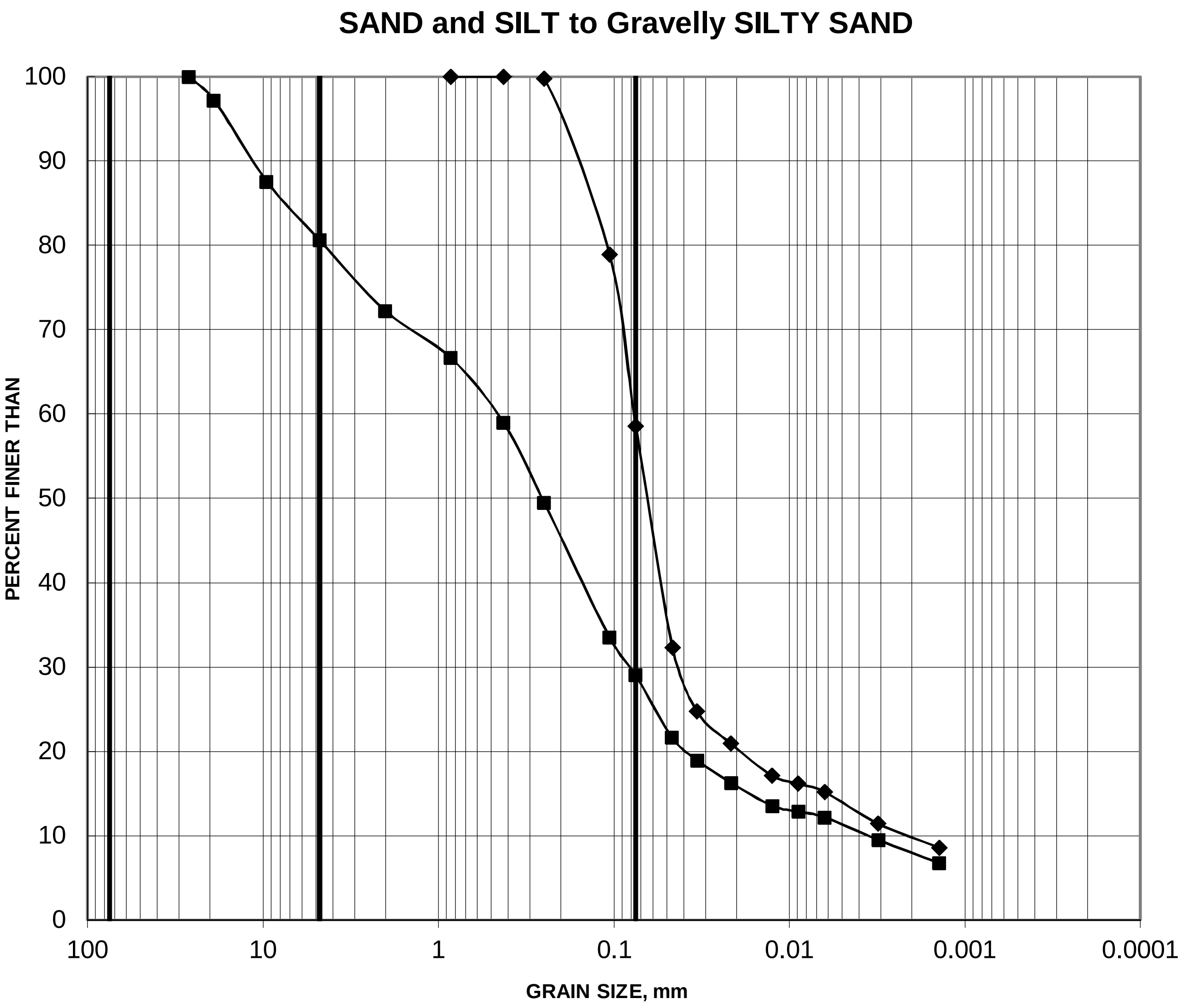
Borehole	Sample	Depth (m)
■ 14-11	5	4.57-5.18
◆ 17-15	4	2.29-2.90
▲ 17-19	6	3.81-4.42

Project: 1406631

Golder Associates

Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION	FIGURE 5



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

Borehole	Sample	Depth (m)
■ 17-19	4	2.29-2.90
◆ 17-20	2	0.76-1.37

Created by: MI
Checked by: CNM

Project: 1406631

Golder Associates

APPENDIX A

Method of Soil Classification

Abbreviations and Terms Used on Records of Boreholes and Test Pits

Lithological and Geotechnical Rock Description Terminology

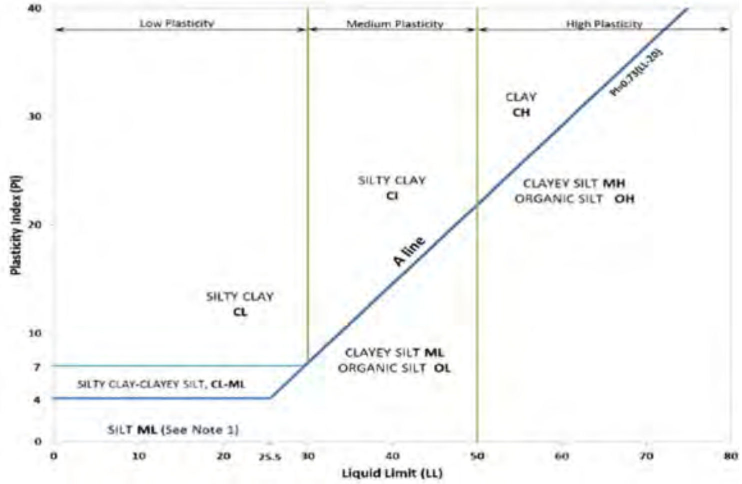
Record of Borehole and Drillhole Sheets

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BORHEOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

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

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

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness terms are based on SPT-'N' ranges as provided in Terzaghi, Peck and Mesri (1996) and correspond to typical average N_{60} values. Many factors affect the recorded SPT-'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), groundwater conditions, and grainsize. As such, the recorded SPT-'N' value(s) should be considered only an approximate guide to the compactness term. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

2 shear strength = (compressive strength)/2

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

PROJECT: 1406631

RECORD OF BOREHOLE: 14-1

SHEET 1 OF 1

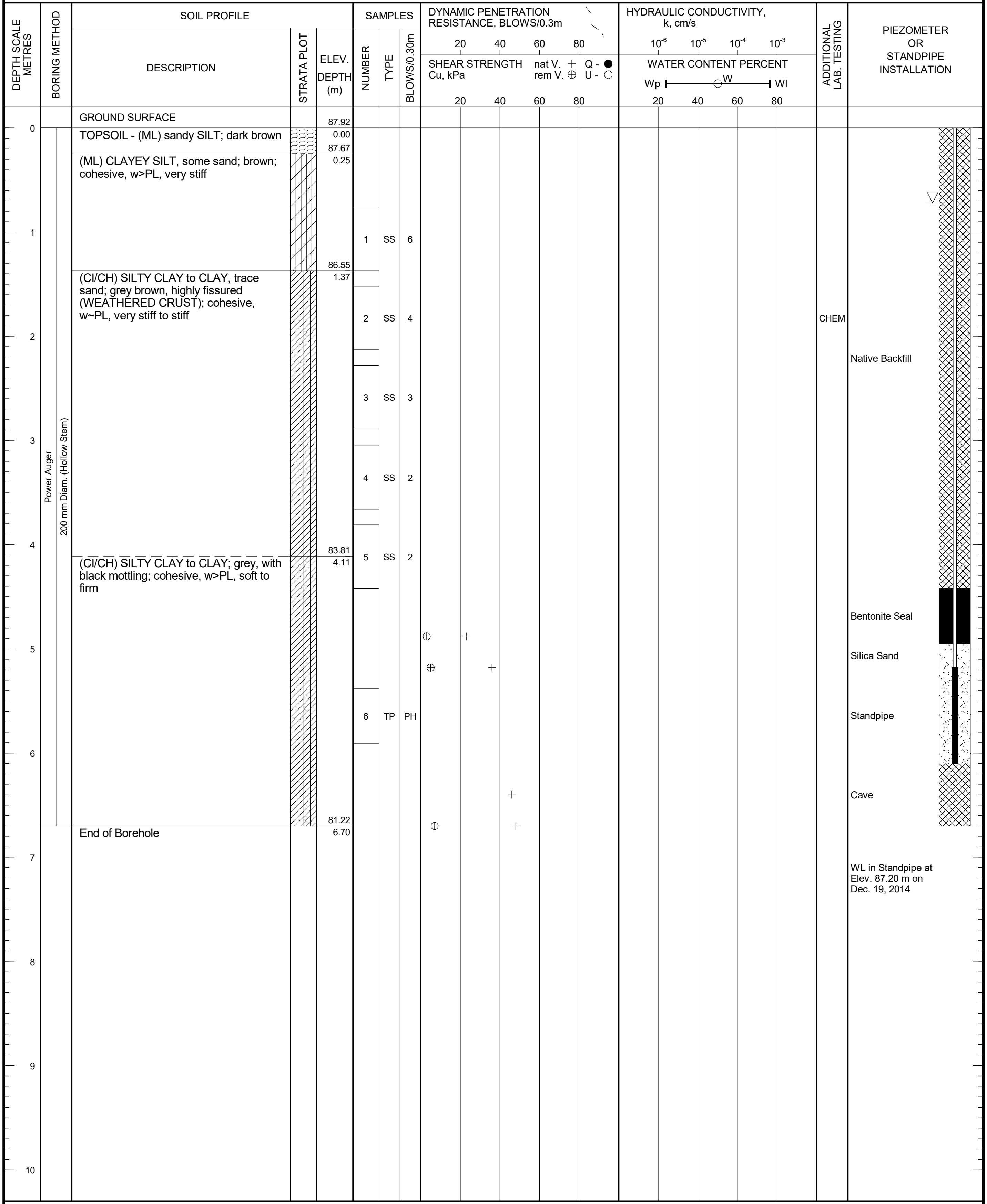
LOCATION: See Site Plan

BORING DATE: December 12, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
GROUND SURFACE	87.92				
TOPSOIL - (ML) sandy SILT; dark brown	0.00				
(ML) CLAYEY SILT, some sand; brown; cohesive, w>PL, very stiff	87.67 0.25	1	SS	6	
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured (WEATHERED CRUST); cohesive, w~PL, very stiff to stiff	86.55 1.37	2	SS	4	CHEM
		3	SS	3	
		4	SS	2	
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, soft to firm	83.81 4.11	5	SS	2	
		6	TP	PH	
End of Borehole	81.22 6.70				

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-2

SHEET 1 OF 1

LOCATION: See Site Plan

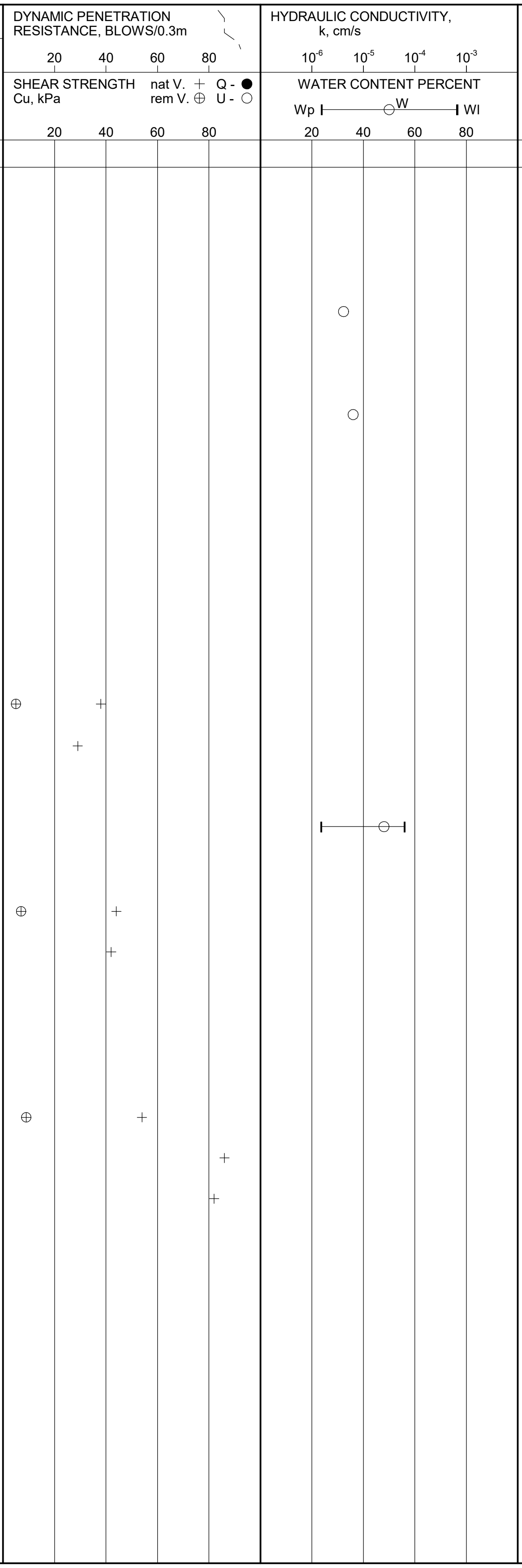
BORING DATE: December 11, 2014

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	TYPE	BLOWS/0.30m	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, very stiff		87.29 0.30					
1					1	SS	4		
		(ML) SILT; grey brown; non-cohesive, very loose		86.07 1.52	2	SS	2		
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		
3		(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		
4									
5					5	TP	PH	C	
6					6	SS	PH		
7									
		End of Borehole		79.97 7.62					
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

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

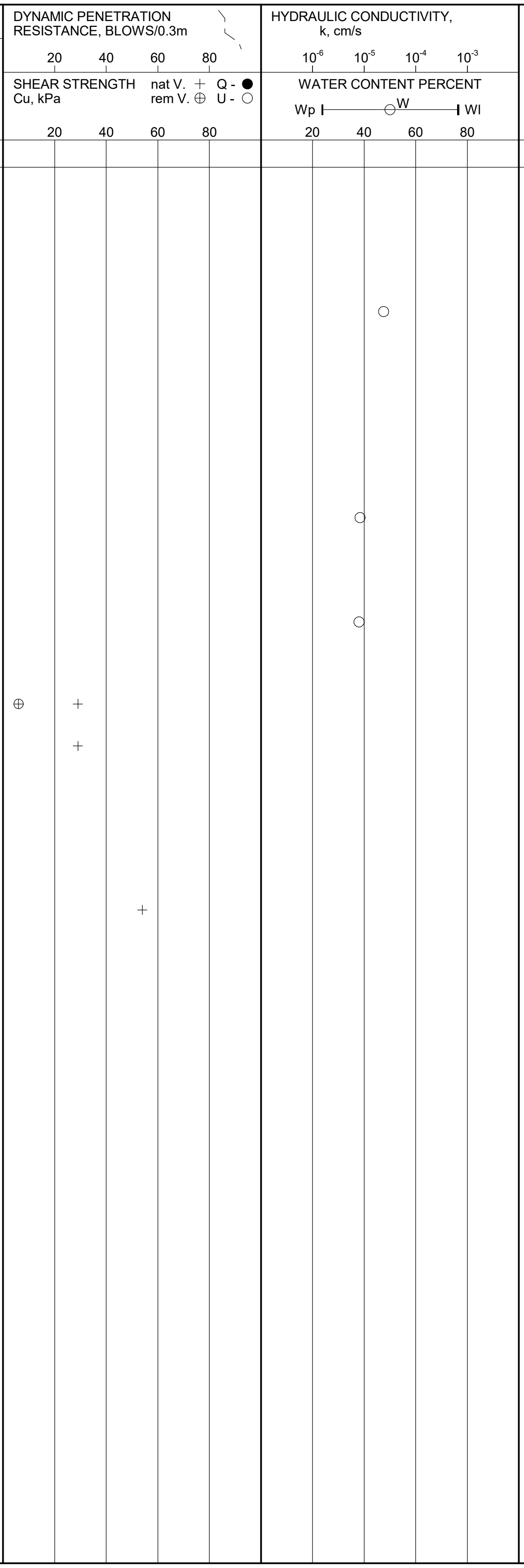
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

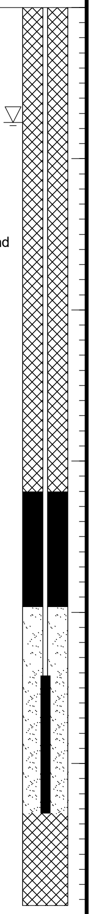
ELEV. / DEPTH (m)	SOIL PROFILE – DESCRIPTION
90.82	GROUND SURFACE
90.82 0.00	TOPSOIL - (ML) sandy SILT; dark brown
90.52 0.30	(CI/CL) SILTY CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w~PL, very stiff
89.30 1.52	(ML) sandy SILT; grey brown; non-cohesive, moist to wet, very loose
88.54 2.28	(ML) SILT, some sand, trace gravel; grey; non-cohesive, wet
87.77 3.05	(CH/CI-ML) SILTY CLAY to CLAY/CLAYEY SILT, trace sand; grey; cohesive, w>PL, firm to stiff
84.88 5.94	End of Borehole

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



Native Backfill and Bentonite

Bentonite Seal

Silica Sand

Standpipe

Cave

WL in Standpipe at Elev. 90.06 m on Dec. 19, 2014

DEPTH SCALE

1 : 50

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

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	91.32
TOPSOIL - (ML) sandy SILT; dark brown	0.00
(ML) sandy SILT; grey brown; non-cohesive, moist, very loose	90.99 0.33
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, fissured (WEATHERED CRUST); cohesive, w~PL, very stiff to stiff	89.49 1.83
(SM) SILTY SAND, some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to dense	86.45 4.87
(SM) gravelly SILTY SAND; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, moist to wet, very dense	84.46 6.86
End of Borehole	83.85 7.47

NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	3
3	SS	3
4	SS	3
5	SS	1
6	SS	24
7	SS	39
8	SS	14
9	SS	84

▽

WL in open borehole at ground surface upon completion of drilling

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

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

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	93.04
TOPSOIL - (ML) sandy SILT; dark brown	0.00
(ML) sandy SILT, some clay; brown; non-cohesive, moist to wet, very loose	92.76 0.28
(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
(ML) sandy SILT, trace gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact	89.23 3.81
(SM) SILTY SAND, trace to some gravel; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very loose to compact	88.47 4.57
End of Borehole	87.10 5.94

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	3
2	SS	20
3	SS	58
4	SS	37
5	SS	11
6	SS	2
7	SS	23

PIEZOMETER OR STANDPIPE INSTALLATION: ∇

WL in open borehole at 0.28 m depth below ground surface upon completion of drilling

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-6

SHEET 1 OF 1

LOCATION: See Site Plan

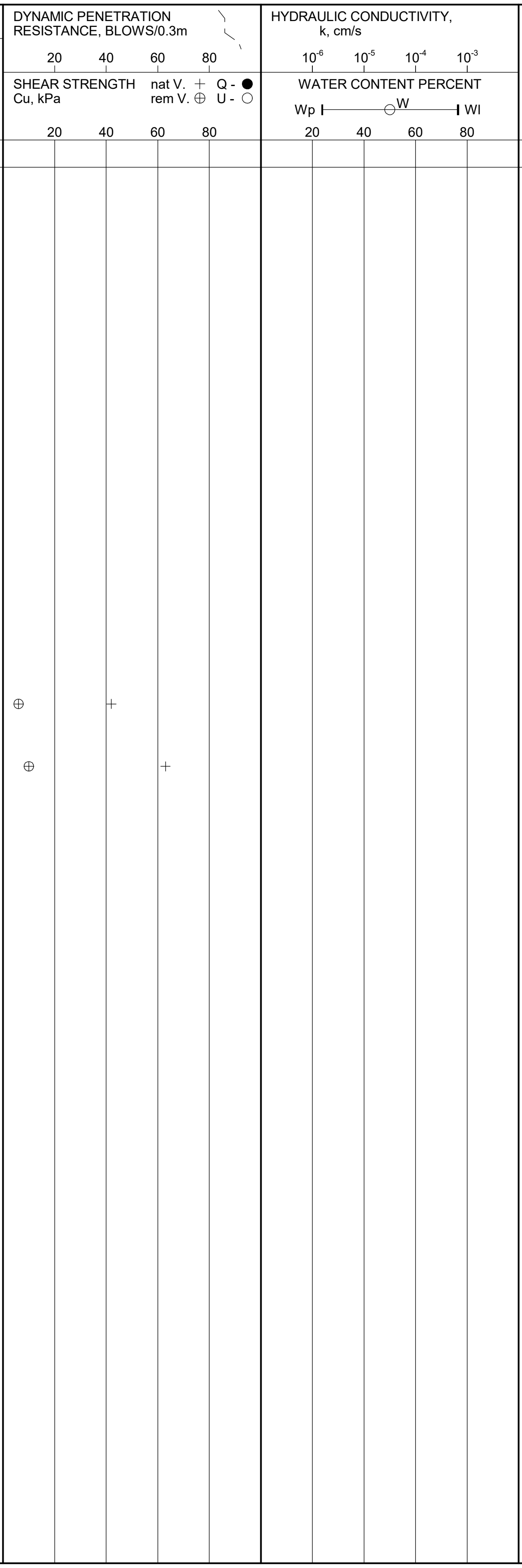
BORING DATE: December 11, 2014

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	92.74					
Power Auger 200 mm Diam. (Hollow Stem)	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 3	SS SS	3 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					WL in open borehole at 4.57 m depth below ground surface upon completion of drilling



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-7

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 11, 2014

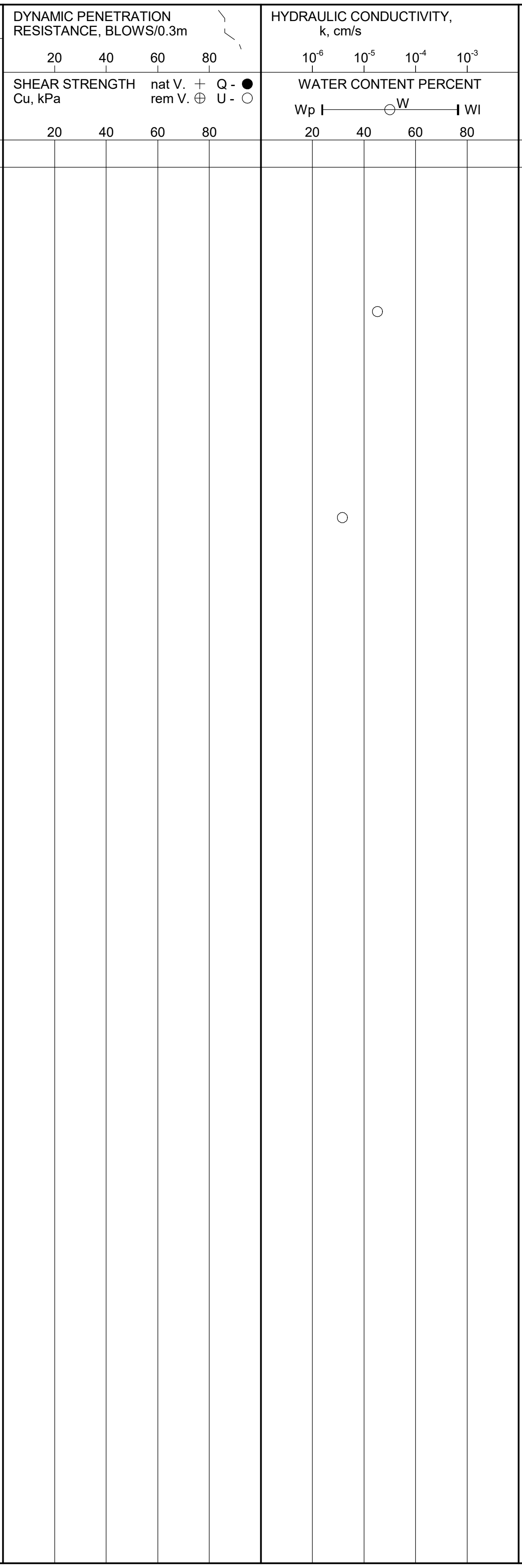
DATUM: Geodetic

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
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 METRES: 0 – 10

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

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

Chart columns (no data plotted):

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

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

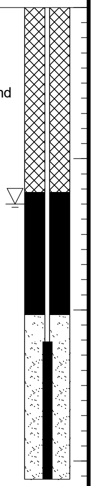
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}

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

ADDITIONAL LAB. TESTING

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	94.69				
0	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	4	SS	>50	
	End of Borehole Auger Refusal	3.12				WL in Standpipe at Elev. 93.39 m on Dec. 19, 2014



DEPTH SCALE
1 : 50

GOLDER

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

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		90.97							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT, trace sand; dark brown		0.00							
1		(ML) sandy SILT; grey brown; non-cohesive, moist		90.61 0.36	1	SS	4				
2 3		(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	2 3 4	SS SS SS	3 5 2	>96+			
4 5 6 7		(SM) SILTY SAND, trace gravel to gravelly; grey, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to vey dense		87.01 3.96	5 6 7 8	SS SS SS SS	39 102 18 12				∇
8 9 10		End of Borehole		83.50 7.47							WL in open borehole at 4.57 m depth below ground surface upon completion of drilling

DEPTH SCALE

1 : 50

GOLDER

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

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	92.00
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
(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
End of Borehole	86.06 5.94

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	3	
2	SS	4	CHEM
3	SS	31	
4	SS	18	
5	SS	12	
6	SS	8	
7	SS	5	

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

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

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

GOLDER

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

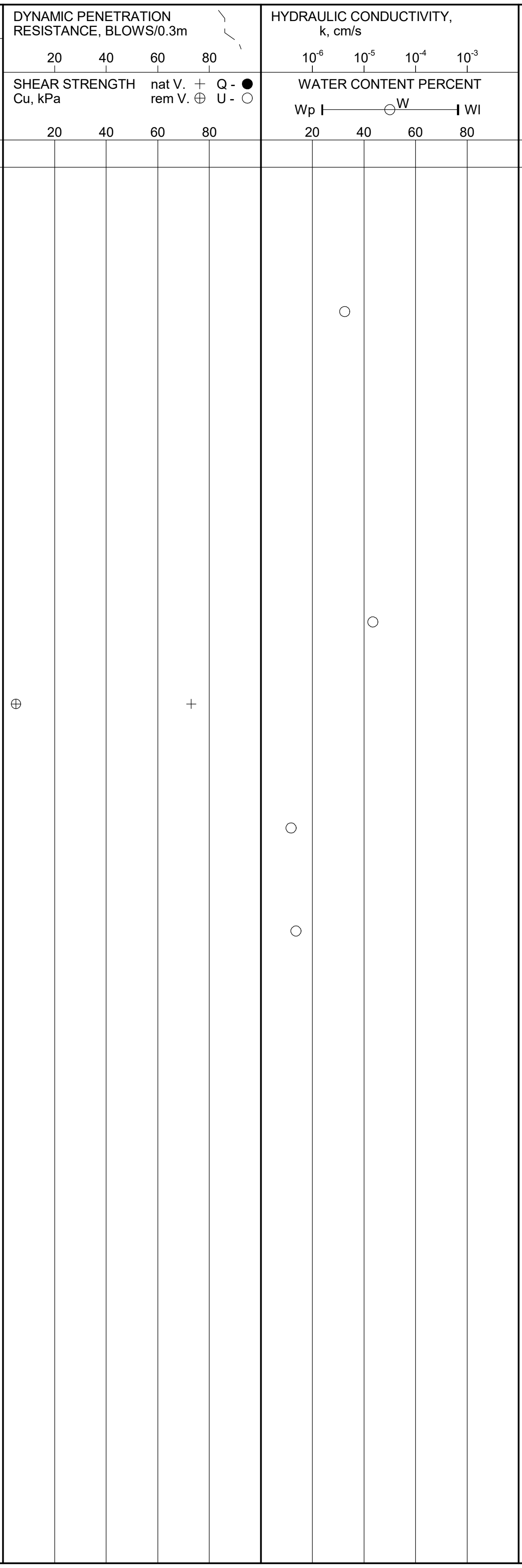
SAMPLER HAMMER, 64kg; DROP, 760mm

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: ∇ at 1.22 m

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

DEPTH SCALE 1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

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

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

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

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

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

ADDITIONAL LAB. TESTING

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	92.93				
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	SS	9	
			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	
						∇
			4	SS	50	
	(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	
	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

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

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

GOLDER

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m
		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	SS	3
2						
			91.39 2.33	3	SS	>50
		End of Borehole Auger Refusal				
3						
4						
5						
6						
7						
8						
9						
10						

DEPTH SCALE

1 : 50

GOLDER

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.09				
0	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				
1				1	SS	5	
		(CI/CH) SILTY CLAY to CLAY, trace sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff	89.57 1.52	2	SS	5	
2				3	SS	4	
3		(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	4	SS	35	
4				5	SS	51	
							∇
5				6	SS	10	
		(SM) SILTY SAND; brown; non-cohesive, wet, compact	85.76 5.33	7	SS	27	
6		End of Borehole	85.15 5.94				WL in open borehole at 4.57 m depth below ground surface upon completion of drilling
7							
8							
9							
10							

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

1 : 50

GOLDER

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

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		91.63							▽
0	Power Auger 200 mm Diam. (Hollow Stem)	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	1	SS	5				
1		(CI/CH) SILTY CLAY to CLAY, trace sand; brown, friable (WEATHERED CRUST); cohesive, w>PL, very stiff		90.41 1.22	2 3	SS SS	5 5				
2 3 4 5		(SM) SILTY SAND, some gravel; brown, with cobbles/boulders and silt seams (GLACIAL TILL); non-cohesive, wet, compact to dense		88.89 2.74	4 5 6	SS SS SS	13 42 37				
		End of Borehole Refusal on Possible Boulders		86.45 5.18							WL in open borehole at ground surface upon completion of drilling
6 7 8 9 10											

DEPTH SCALE

1 : 50

GOLDER

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	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	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	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				2	SS	5				
				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

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 14-17

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: December 9, 2014

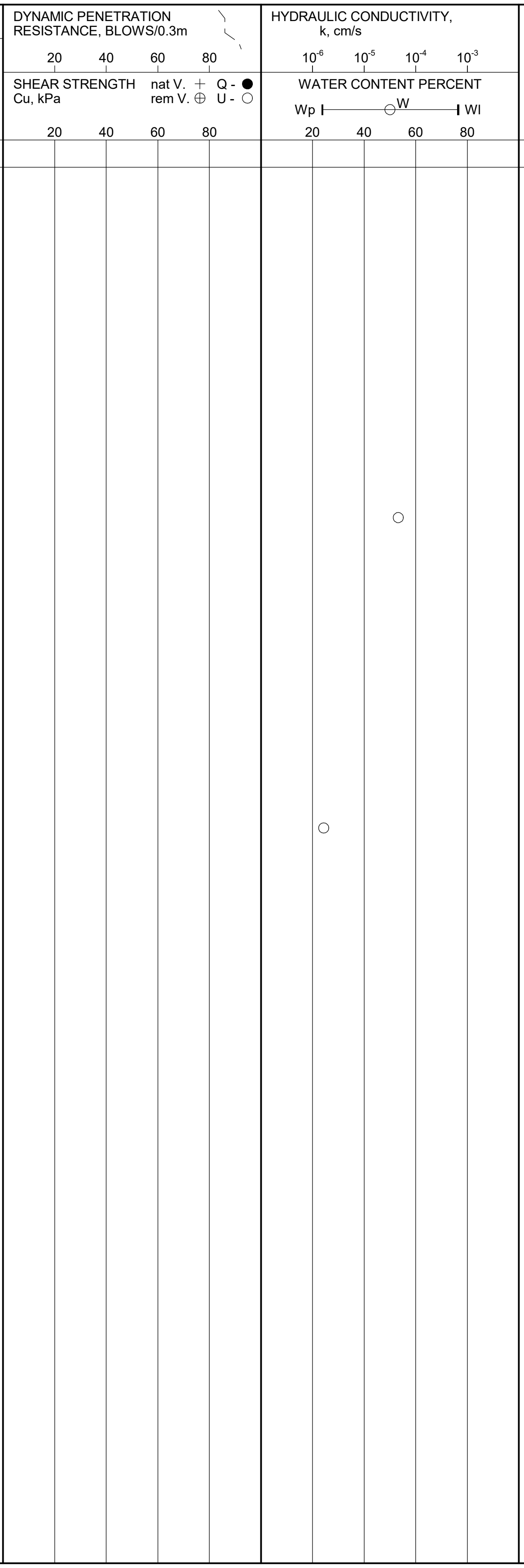
DATUM: Geodetic

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)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
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	1	SS	5
		2	SS	4
		3	SS	3
(ML) sandy SILT, trace gravel; brown (GLACIAL TILL); non-cohesive, wet, loose	88.18 3.35	4	SS	3
(SM) SILTY SAND; brown; non-cohesive, wet, compact	87.72 3.81	5	SS	21
		6	SS	21
(ML) sandy SILT, trace gravel; grey brown (GLACIAL TILL); non-cohesive, wet	86.05 5.48	7	SS	>50
End of Borehole Auger Refusal	85.84 5.69			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

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

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

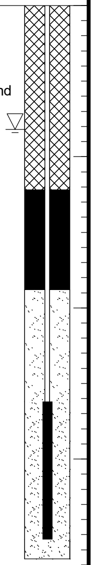
SHEAR STRENGTH Cu, kPa: 20 40 60 80 — nat V. + Q - ● rem V. ⊕ U - ○

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

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

ADDITIONAL LAB. TESTING

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	92.34				
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
(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	Standpipe
(SP) gravelly SAND; brown, with cobbles/boulders (GLACIAL TILL); non-cohesive, wet, very dense	89.29 3.05	4	SS	85	Silica Sand
End of Borehole Auger Refusal	88.68 3.66				WL in Standpipe at Elev. 91.52 m on Dec. 19, 2014



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: 17-01

SHEET 1 OF 1

LOCATION: N 5013985.4 ;E 367568.0

BORING DATE: October 11, 2017

DATUM: Geodetic

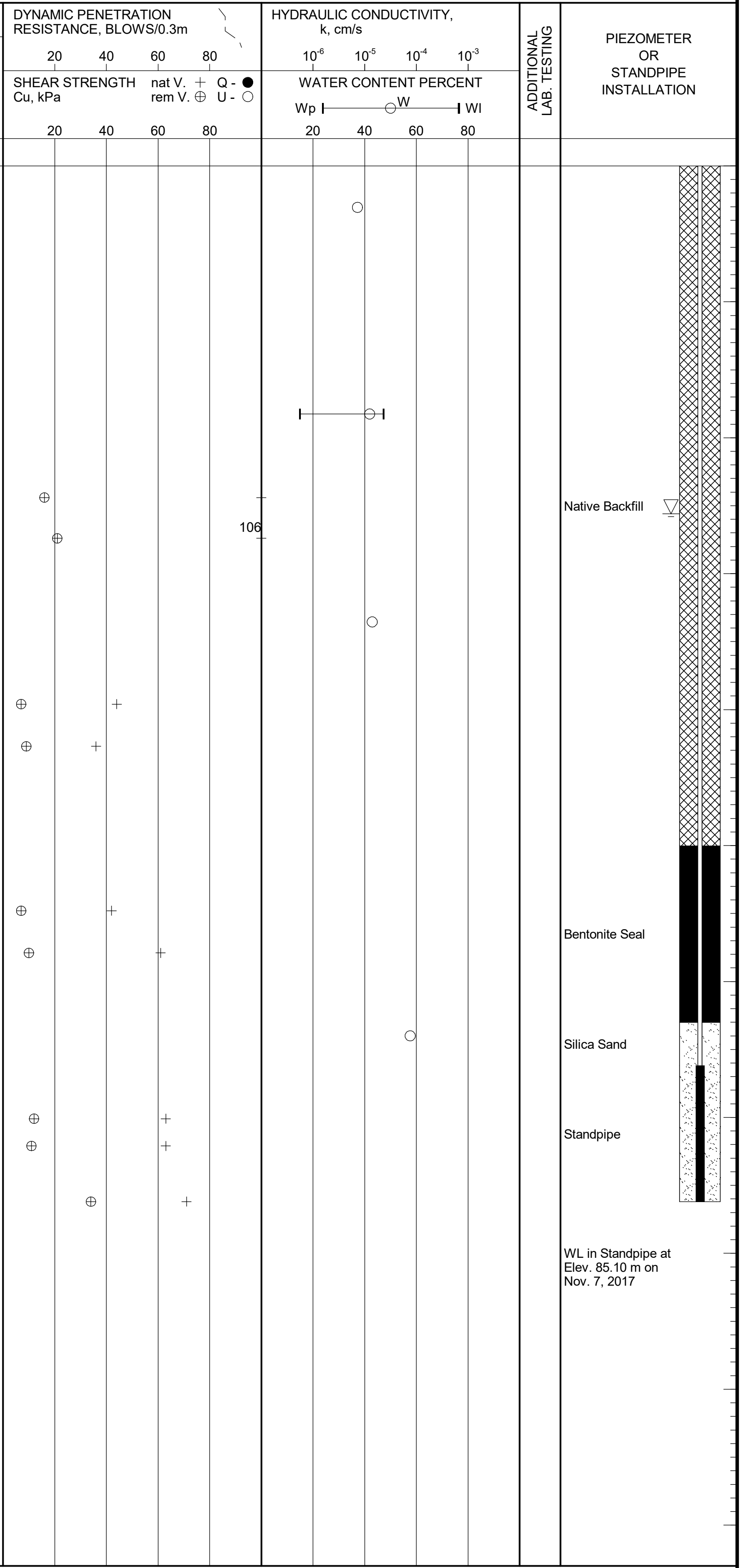
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	87.66
TOPSOIL - (SM) SILTY SAND; brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff	0.15
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm to stiff	84.61 3.05
End of Borehole	80.04 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	7
2	SS	4
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



WL in Standpipe at Elev. 85.10 m on Nov. 7, 2017

DEPTH SCALE 1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: N 5013834.9 ;E 367597.5

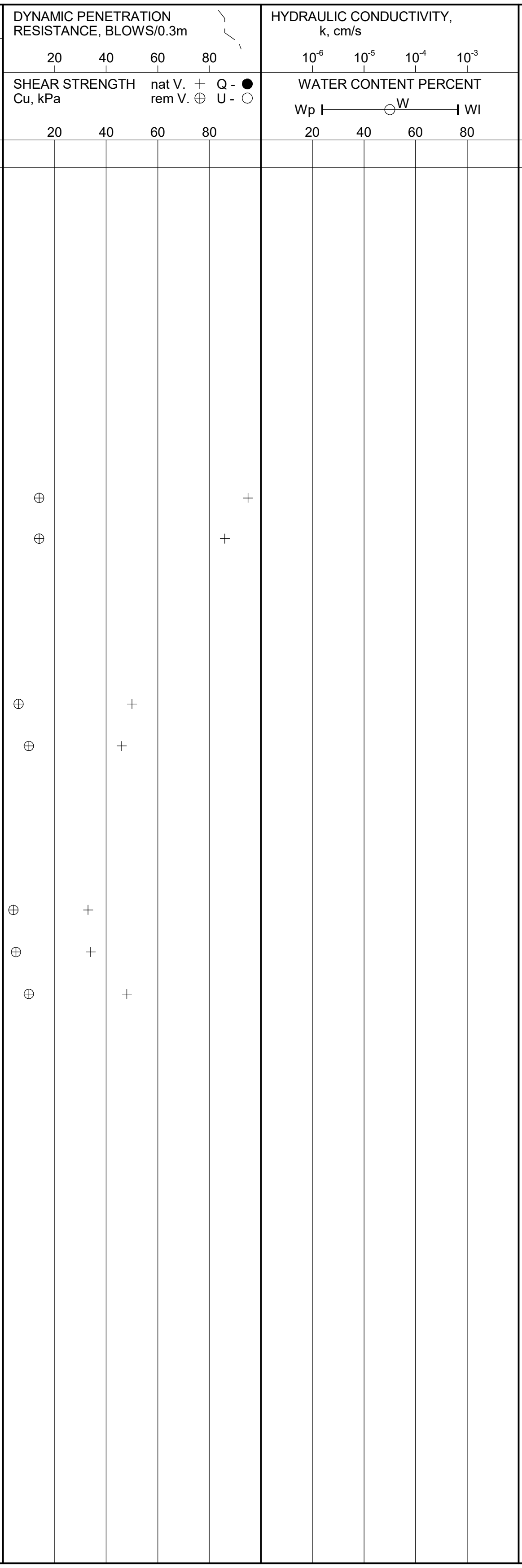
BORING DATE: October 11, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		88.34					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown	▤	0.00					
		(CL/CI) SILTY CLAY; brown, contains sand and silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	▨	88.04 0.30	1	SS	3		
1					2	SS	6		
2					3	SS	4		
3		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff to firm	▨	85.29 3.05	4	SS	3		
5					5	SS	WH		
6		End of Borehole		82.24 6.10					
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: N 5013888.0 ;E 367748.0

BORING DATE: October 12, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

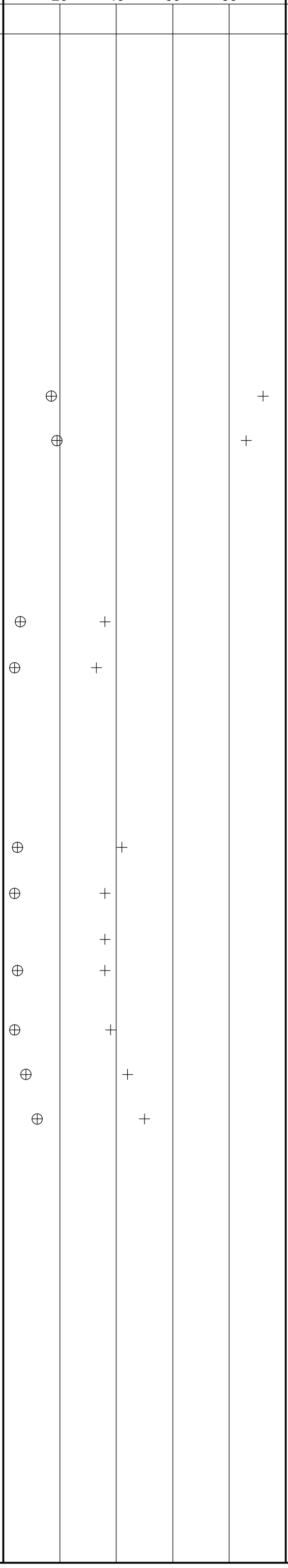
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	89.72			
TOPSOIL - (SM) SILTY SAND; brown	0.00			
(SM/ML) SILTY SAND to sandy SILT; brown; moist, loose	89.52 0.20	1	SS	4
		2	SS	6
(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); w>PL, stiff	88.20 1.52	3	SS	1
(CI/CH) SILTY CLAY to CLAY; grey, contains sandy silt and silt seams; cohesive, w>PL, firm to stiff	86.67 3.05	4	SS	WH
		5	SS	WH
End of Borehole	82.41 7.31			

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

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



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

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 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

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-04

SHEET 1 OF 1

LOCATION: N 5013975.6 ;E 367794.5

BORING DATE: October 12, 2017

DATUM: Geodetic

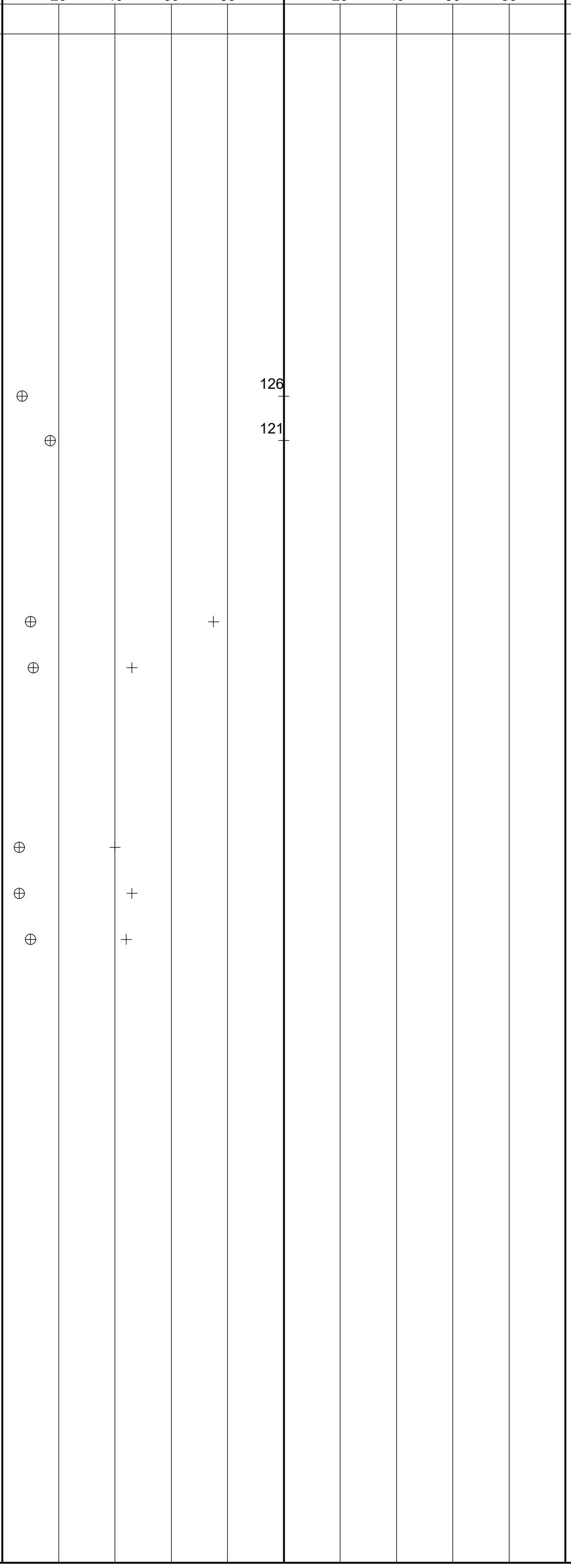
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	89.52
TOPSOIL - (SM) SILTY SAND; brown	0.00
(ML) sandy SILT; brown, contains organic matter (rootlets); non-cohesive, moist, loose	89.22 0.30
(SM/ML) SILTY SAND to sandy SILT; brown; non-cohesive, moist, loose	88.76 0.76
(CL/CI) SILTY CLAY; grey brown, contains sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	88.00 1.52
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm	85.25 4.27
End of Borehole	83.42 6.10

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-05

SHEET 1 OF 1

LOCATION: N 5013693.5 ;E 367621.0

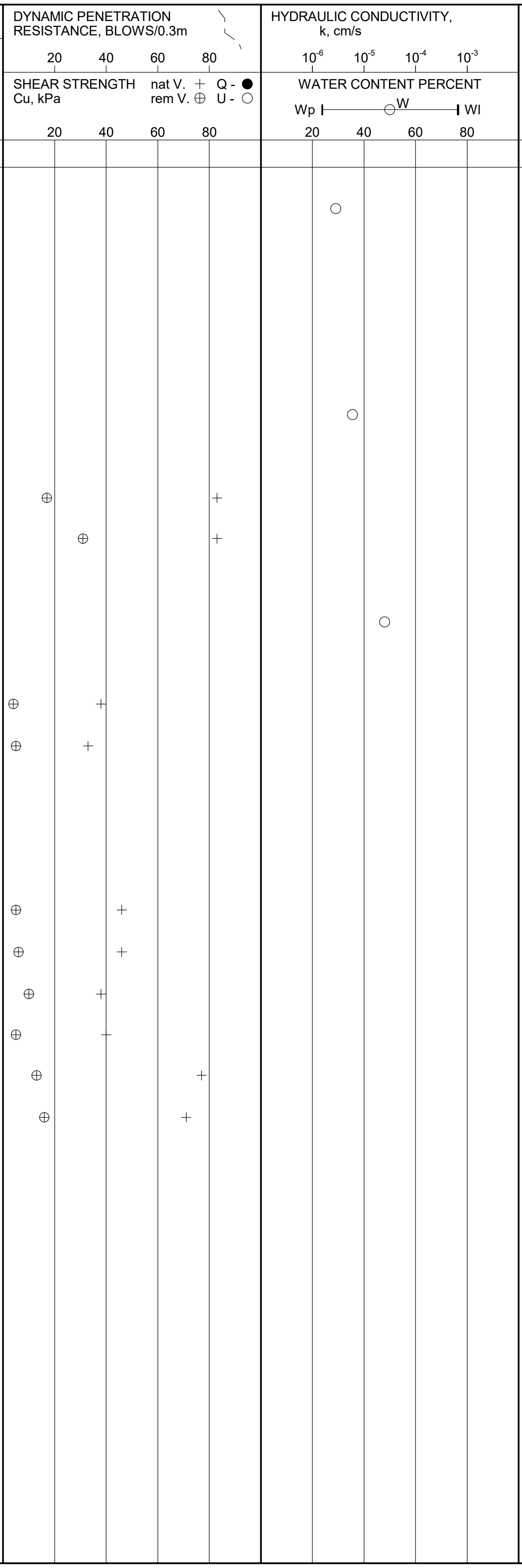
BORING DATE: October 10-11, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	87.62			
0	Power Auger 200 mm Diam. (Hollow Stem)	(ML/CI) CLAYEY SILT to SILTY CLAY, some sand; dark brown to brown, contains organic matter (rootlets); cohesive, firm	0.00	1	SS	1
1		(CL/CI) SILTY CLAY; brown, contains sandy silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff	86.86 0.76	2	SS	4
2		(CL/CI) SILTY CLAY; brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, stiff	86.10 1.52	3	SS	2
3		(CI/CH) SILTY CLAY to CLAY; grey, with black mottling, contains sandy silt seams; cohesive, w>PL, firm to stiff	84.57 3.05	4	SS	WH
5				5	SS	WH
7		End of Borhole	80.61 7.01			
8						
9						
10						



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-06

SHEET 1 OF 1

LOCATION: N 5013771.4 ;E 367767.8

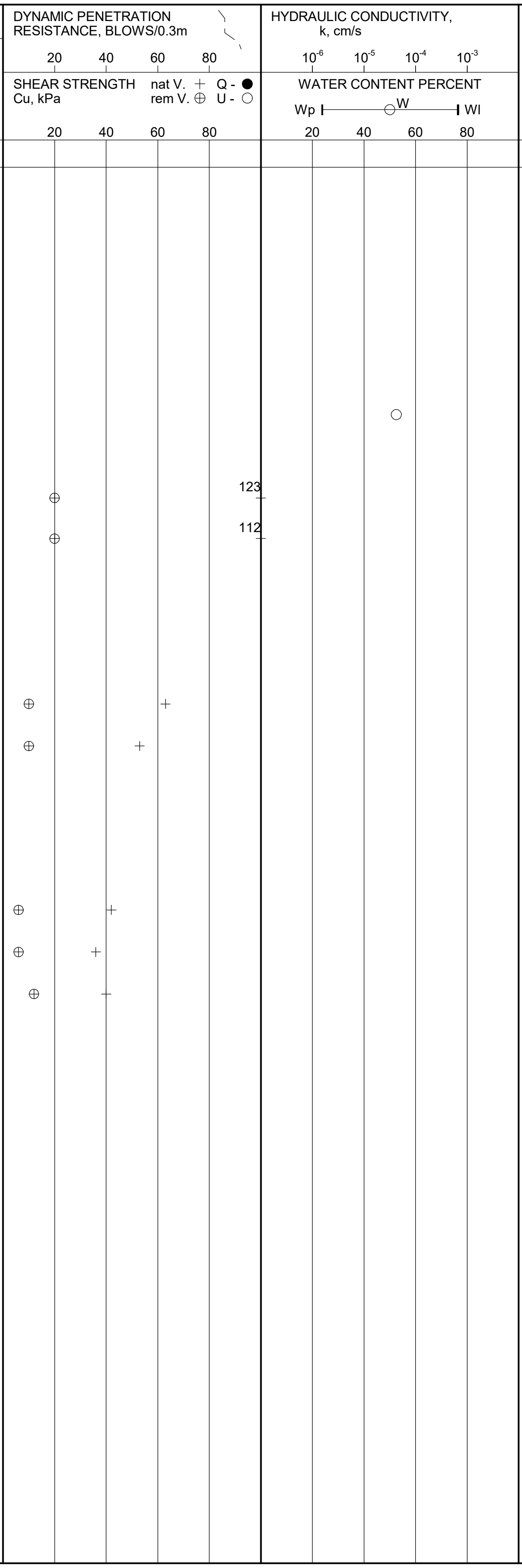
BORING DATE: October 11, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		89.92					
0		TOPSOIL - (SM) SILTY SAND; brown, contains organic matter		0.00	1	SS	3		
		(SM) SILTY SAND; brown; non-cohesive, moist, very loose		89.46 0.46					
1		(ML/SM) sandy SILT to SILTY SAND; brown, layered; non-cohesive, moist, loose		89.16 0.76	2	SS	6		
2		(CL/CI) SILTY CLAY; brown, contains sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff		88.40 1.52	3	SS	3	CHEM	
3 4 5 6		(CI/ML) SILTY CLAY to CLAYEY SILT; grey, contains sand and silt seams; cohesive, w>PL, stiff to firm		86.87 3.05	4 5	SS SS	3 WH		
7 8 9 10		End of Borehole		83.82 6.10					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

PROJECT: 1406631

RECORD OF BOREHOLE: 17-07

SHEET 1 OF 1

LOCATION: N 5013853.5 ;E 367915.4

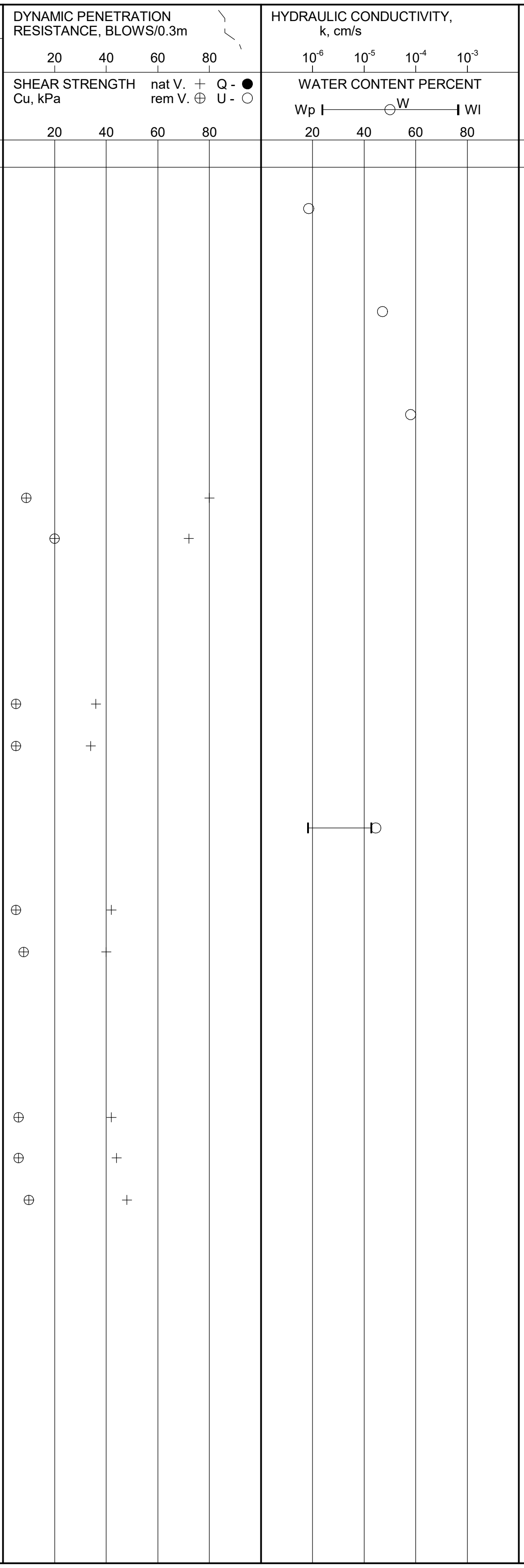
BORING DATE: October 16, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m
		GROUND SURFACE	89.90			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown	0.00			
		(SM) SILTY SAND; brown, contains organic matter (rootlets); non-cohesive, wet	89.60 0.30	1	SS	4
1		(CL/CI) SILTY CLAY, some sand; grey brown, contains organic matter (rootlets) (WEATHERED CRUST); cohesive, w>PL, stiff	88.99 0.91	2	SS	3
2		(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, stiff	88.38 1.52	3	SS	2
3		(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams and shells pieces; cohesive, w>PL, firm	86.85 3.05	4	SS	WH
4 5 6 7		(CI/CH) SILTY CLAY to CLAY; grey, with black mottling, contains silty sand seams; cohesive, w>PL, firm	85.33 4.57	5 6	SS SS	WH WH
8 9 10		End of Borehole	82.28 7.62			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-07A

SHEET 1 OF 1

LOCATION: N 5013853.5 ;E 367915.4

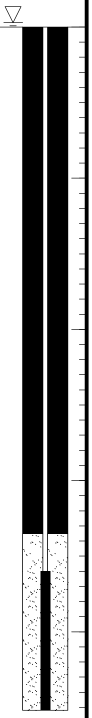
BORING DATE: October 16, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	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		89.90							
0	Power Auger 200 mm Diam. (Hollow Stem)	For soil stratigraphy refer to Record of Borehole 17-07		0.00							
2											Bentonite Seal
3											Silica Sand
4					1	TP	PH				Standpipe
		End of Borehole		85.38 4.52							
5											WL in Standpipe at Elev. 89.93 m on Nov. 7, 2017
6											
7											
8											
9											
10											



MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-08

SHEET 1 OF 1

LOCATION: N 5014144.5 ;E 368410.5

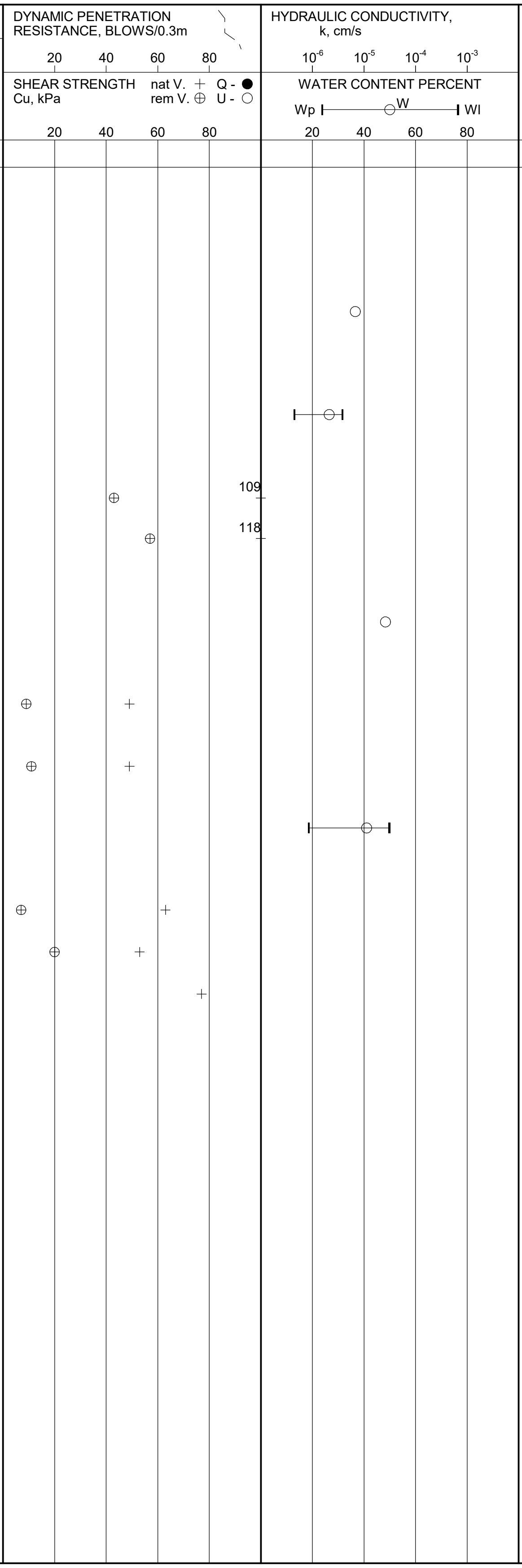
BORING DATE: October 23, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE		91.84			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00			
		(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.15	1	SS	5
1					2	SS	5
		(CI/ML) SILTY CLAY, CLAYEY SILT and sandy SILT; brown, layered; cohesive, w>PL, very stiff		90.32 1.52	3	SS	4
2							
3		(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains silt seams; cohesive, w>PL, firm to stiff		88.79 3.05	4	SS	1
4							
5					5	SS	WH
6		End of Borehole		85.74 6.10			
7							
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-09

SHEET 1 OF 1

LOCATION: N 5014203.7 ;E 368514.2

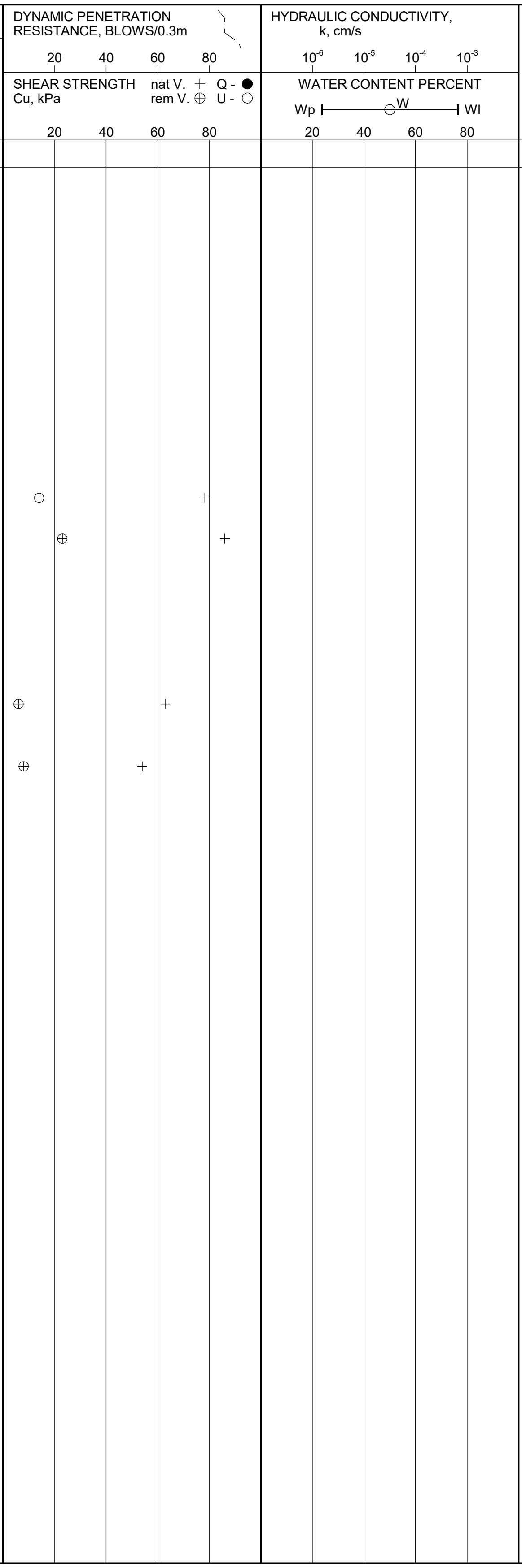
BORING DATE: October 23, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	92.86					
	TOPSOIL - (ML) sandy SILT; dark brown	0.00					
	(ML) CLAYEY SILT, some sand; brown (WEATHERED CRUST); cohesive, w>PL, stiff	92.66 0.20	1	SS	3		
	(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	92.10 0.76	2 3 4	SS SS SS	4 WH 2		
	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff	89.20 3.66					
	(SM/ML) sandy SILT to SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive; wet, loose to very loose	88.29 4.57	5 6	SS SS	4 3		
	End of Borehole	86.92 5.94					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-11

SHEET 1 OF 1

LOCATION: N 5013539.2 ;E 367653.7

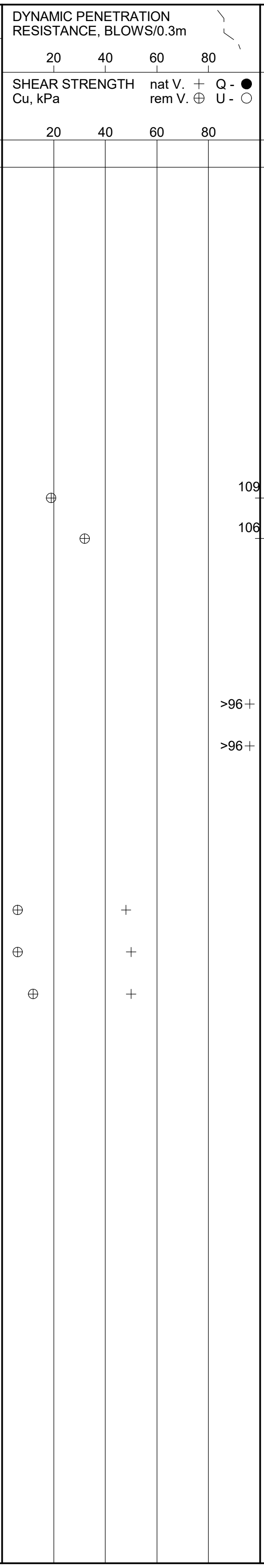
BORING DATE: October 10, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	89.64			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - SILTY SAND; brown	0.00			
		(SM) SILTY SAND; brown; non-cohesive, moist, loose	0.15	1	SS	5
1		(SM/ML) SILTY SAND to sandy SILT; brown, layered; moist, loose to compact	88.73 0.91	2	SS	10
2		(CI/CH) SILTY CLAY to CLAY; brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL , very stiff	88.12 1.52	3	SS	4
3		(CI/CH) SILTY CLAY to CLAY; grey, contains sandy silt seams; cohesive, w>PL, very stiff	86.59 3.05	4	SS	2
5		(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, firm to stiff	85.07 4.57	5	SS	WH
6		End of Borehole	83.54 6.10			



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

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-12

SHEET 1 OF 1

LOCATION: N 5013601.7 ;E 367794.5

BORING DATE: October 13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

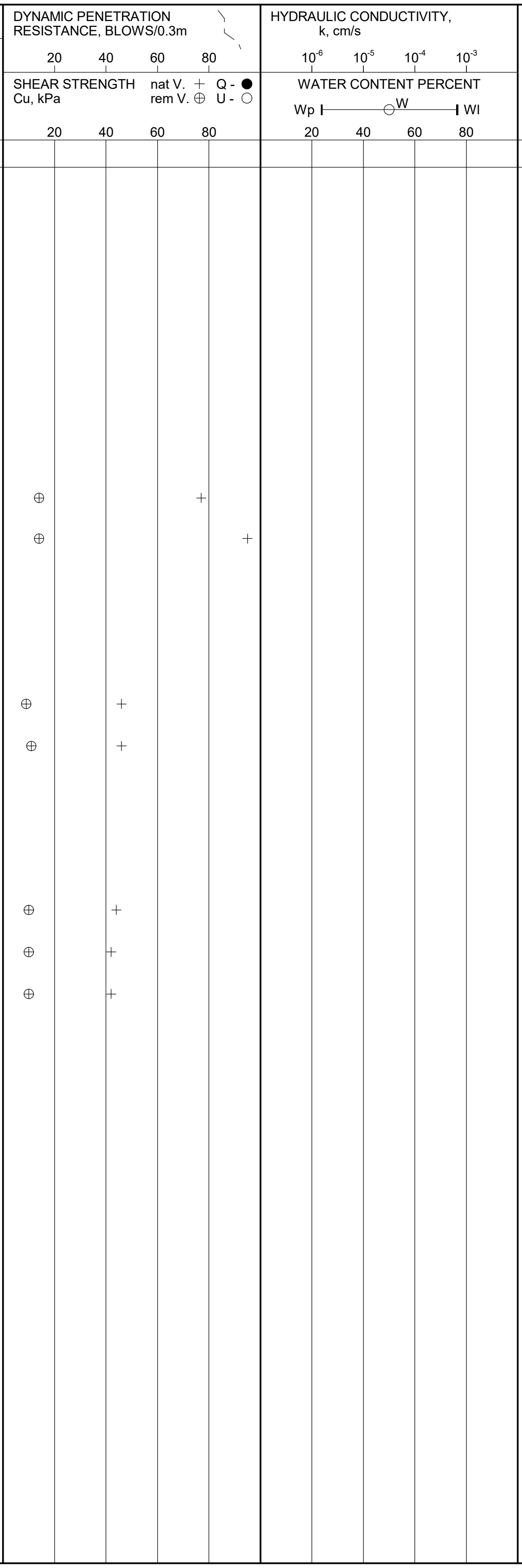
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	89.68
TOPSOIL - (SM) SILTY SAND; brown	0.00 89.48
(SM) SILTY SAND; brown, contains silt seams and organic matter (rootlets); non-cohesive, moist, very loose to loose	0.20 88.92
(SM) SILTY SAND; brown, contains silt seams; non-cohesive, wet, loose	0.76 88.46
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff	1.22 86.63
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm - Black streaks	3.05 83.58
End of Borehole	6.10

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-13

SHEET 1 OF 1

LOCATION: N 5013696.5 ;E 367919.5

BORING DATE: October 16, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.04
TOPSOIL - (ML/SM) sandy SILT to SILTY SAND; brown	0.00
(ML/SM) sandy SILT to SILTY SAND; brown, contains organic matter (rootlets); non-cohesive, wet, very loose to loose	89.84 0.20
(CL/CI) SILTY CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff	88.52 1.52
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams and shell pieces; cohesive, w>PL, firm	86.99 3.05
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling, contains sandy silt seams; cohesive. w>PL, firm	85.47 4.57
End of Borehole	83.94 6.10

SAMPLES

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

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

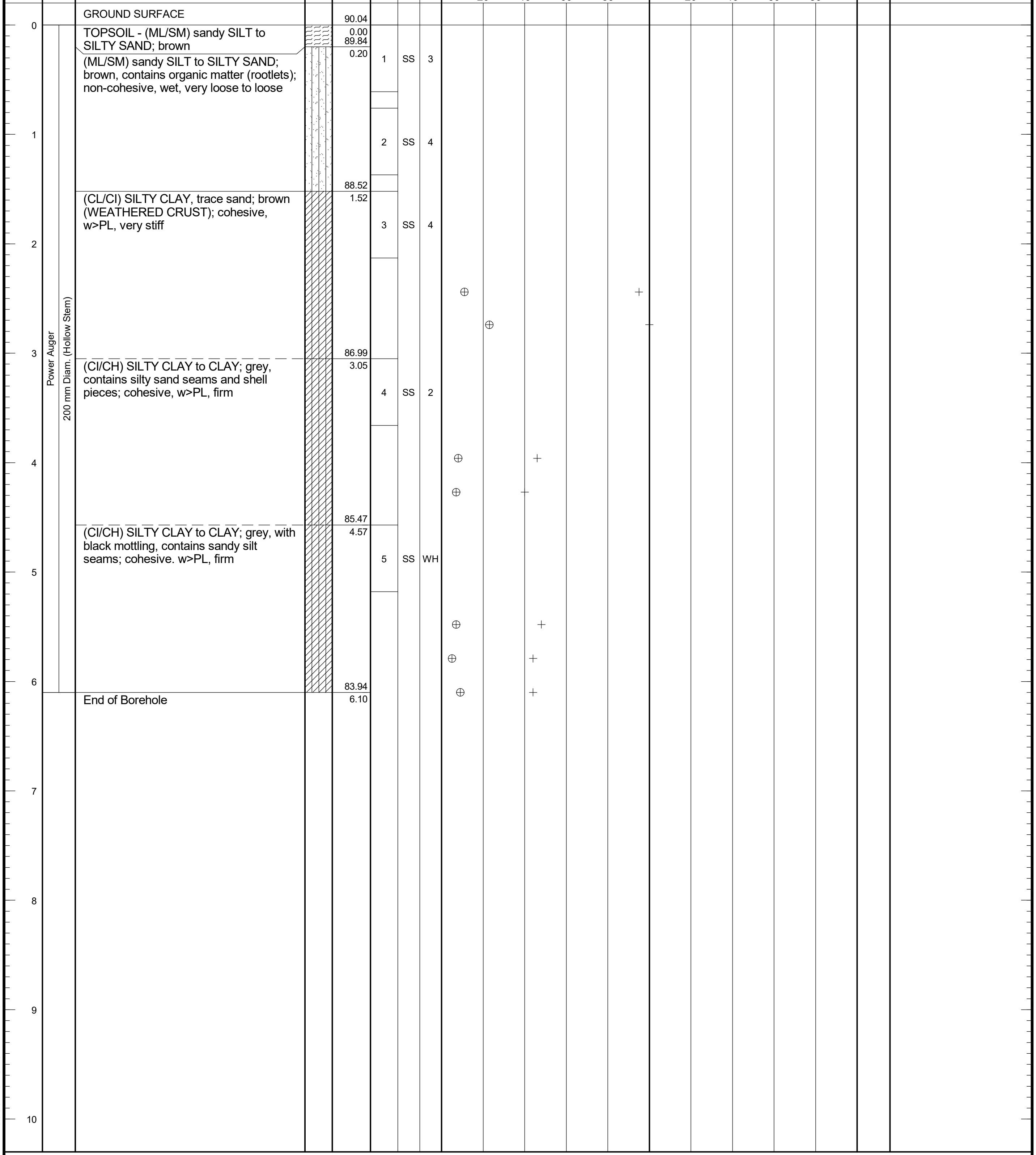
SHEAR STRENGTH Cu, kPa — nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

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



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-14

SHEET 1 OF 1

LOCATION: N 5013761.7 ;E 368041.3

BORING DATE: October 17, 2017

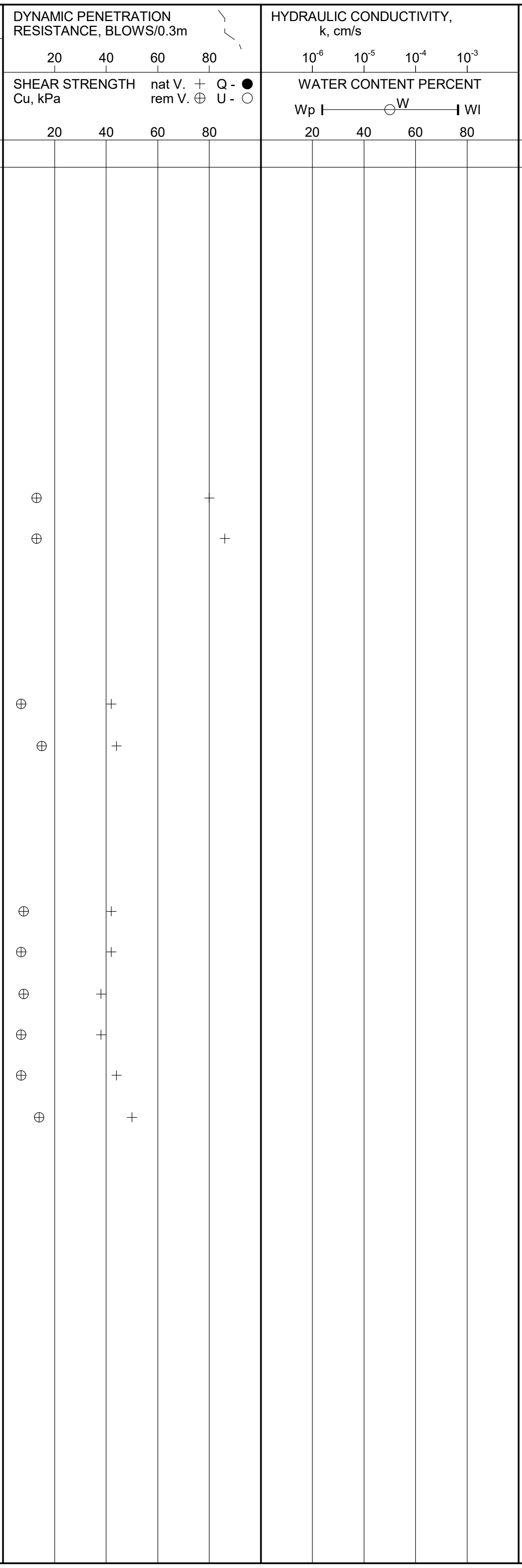
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	89.96
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown	0.00
		(CL/CI) SILTY CLAY; brown, contains silty sand and sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	89.76 0.20
2		(ML) sandy SILT; grey; non-cohesive, wet, very loose	88.13 1.83
		(CI/CH) SILTY CLAY to CLAY; grey, contains sandy silt seams; cohesive, w>PL, firm to stiff	87.83 2.13
7		End of Borehole	82.95 7.01

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-15

SHEET 1 OF 1

LOCATION: N 5013856.9 ;E 368189.6

BORING DATE: October 18, 2017

DATUM: Geodetic

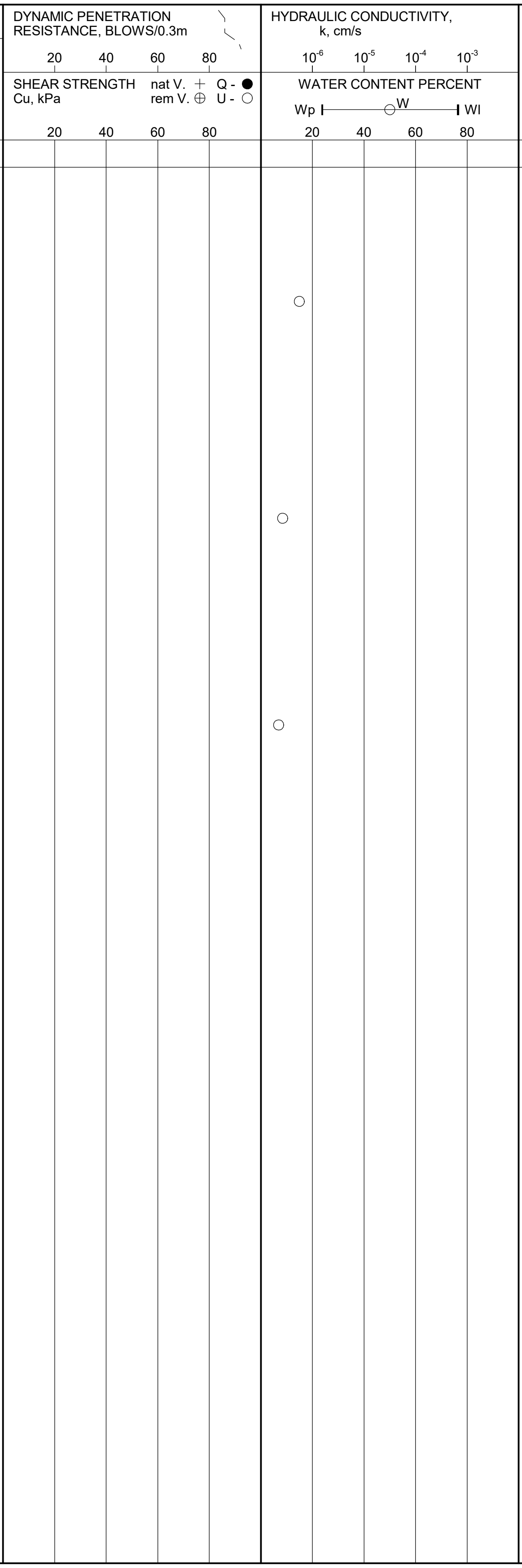
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	91.79	
TOPSOIL - (ML) sandy SILT; brown, contains organic matter		0.00
(CI) SILTY CLAY; brown (WEATHERED CRUST); cohesive, w>PL	91.33	0.46
(SM) SILTY SAND, trace gravel; brown; non-cohesive, moist, very dense	91.03	0.76
(SM/SP) SILTY SAND, trace to some gravel; light brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, very dense, moist	90.57	1.22
(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, dense to compact	87.98	3.81
End of Borehole Auger Refusal	86.56	5.23

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	1	
2	SS	>50	
3	SS	87	
4	SS	61	MH
5	SS	52	
6	SS	40	
7	SS	29	



PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-16

SHEET 1 OF 1

LOCATION: N 5013936.1 ;E 368321.3

BORING DATE: October 23, 2017

DATUM: Geodetic

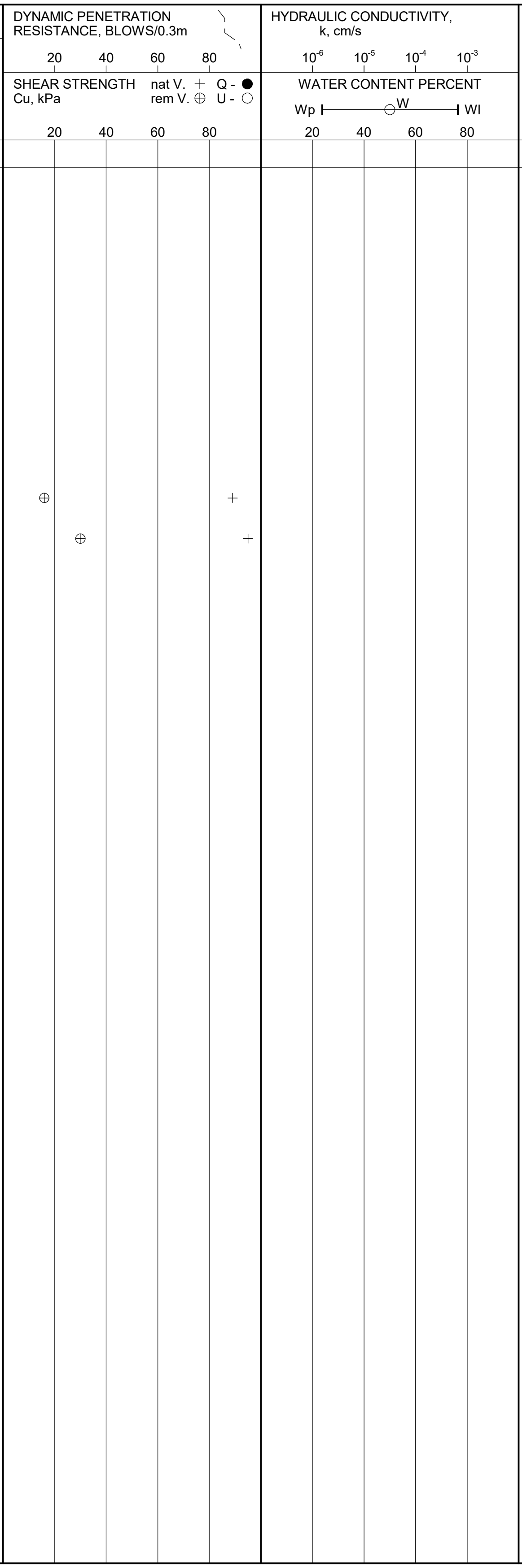
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	92.08
TOPSOIL - (ML) sandy SILT; brown	0.00
(CI) SILTY CLAY, some sand; brown, contains organic matter (WEATHERED CRUST); cohesive, w>PL	0.15
(ML) sandy CLAYEY SILT; brown; cohesive, w>PL, very stiff	91.32 0.76
(ML) sandy CLAYEY SILT; grey brown; cohesive, w>PL, stiff	90.56 1.52
(CI/CH) SILTY CLAY, trace to some sand; grey; cohesive, w>PL	89.03 3.05
(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); wet, loose to dense	88.73 3.35
End of Borehole	86.14 5.94

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	4
3	SS	2
4	SS	7
5	SS	41
6	SS	13
7	SS	8



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

PROJECT: 1406631

RECORD OF BOREHOLE: 17-17

SHEET 1 OF 1

LOCATION: N 5014011.0 ;E 368440.4

BORING DATE: October 23, 2017

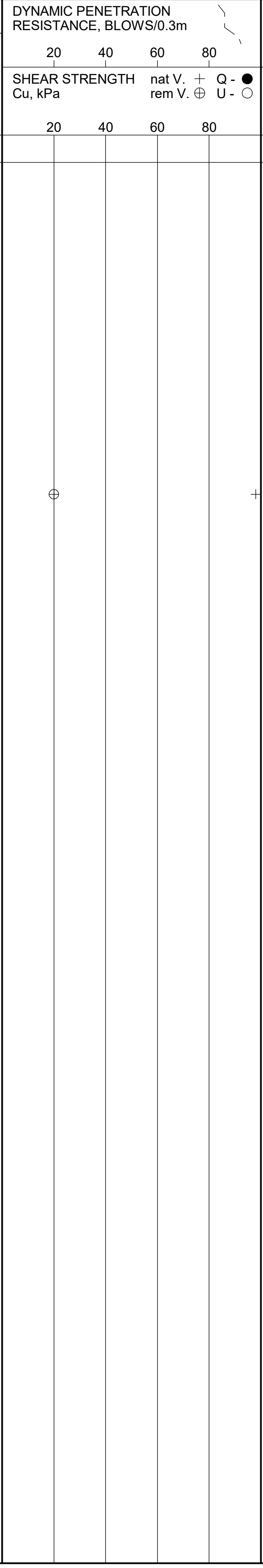
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	92.32			
TOPSOIL - (ML) sandy SILT; dark brown	0.00			
(ML) sandy CLAYEY SILT; brown; cohesive, w>PL, very stiff	0.10	1	SS	5
(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff	91.56 0.76	2 3	SS SS	5 5
(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very dense to very loose	89.65 2.67	4 5 6	SS SS SS	61 2 >50
End of Borehole Auger Refusal	87.60 4.72			



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

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-18

SHEET 1 OF 1

LOCATION: N 5014097.5 ;E 368569.9

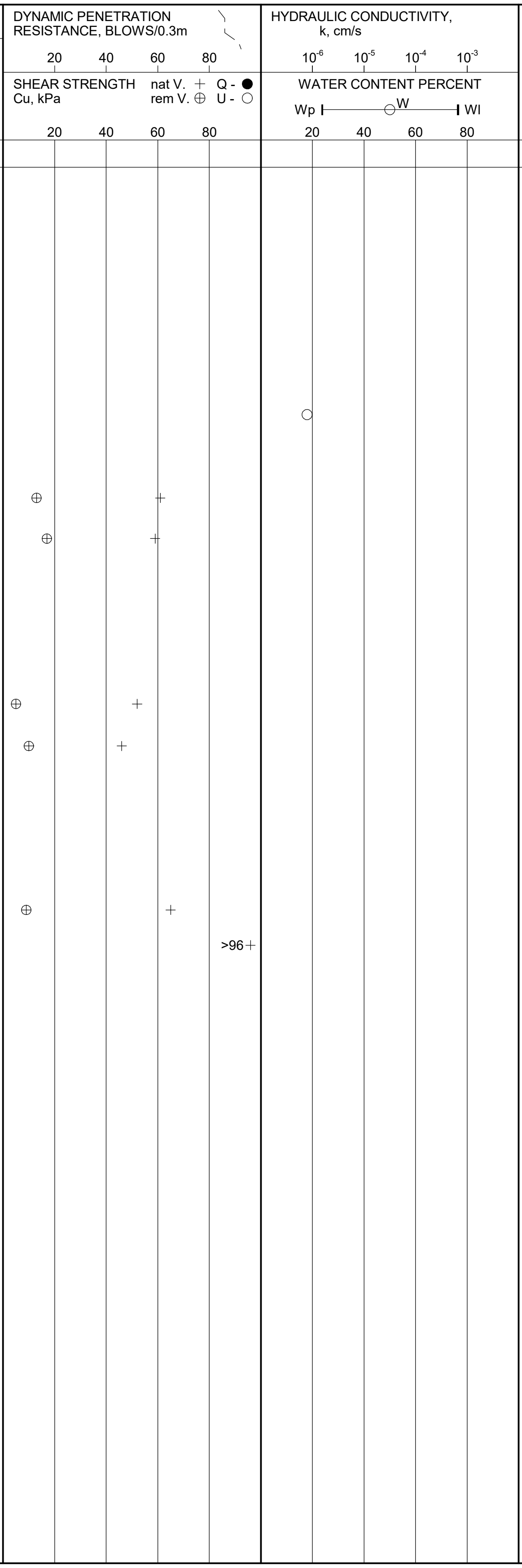
BORING DATE: October 24, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	92.71					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown	0.00					
		(ML/SM) sandy SILT to SILTY SAND; brown, contains silty clay seams and organic matter (rootlets); non-cohesive, moist, very loose to loose	92.41 0.30	1	SS	4		
1		(ML) sandy CLAYEY SILT; brown, contains silty sand layers; cohesive, w>PL, very stiff to stiff	91.95 0.76	2	SS	4		
2				3	SS	WH	CHEM	
3		(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, stiff to firm	89.66 3.05	4	SS	WH		
4								
5		(CI/CH) CLAYEY SILT to SILTY CLAY, trace sand; grey, contains silt seams; cohesive, w>PL, stiff to very stiff	88.14 4.57	5	SS	2		
6		End of Borehole	86.97 5.74					
7								
8								
9								
10								



DEPTH SCALE

1 : 50

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-19

SHEET 1 OF 1

LOCATION: N 5014169.7 ;E 368681.8

BORING DATE: October 25, 2017

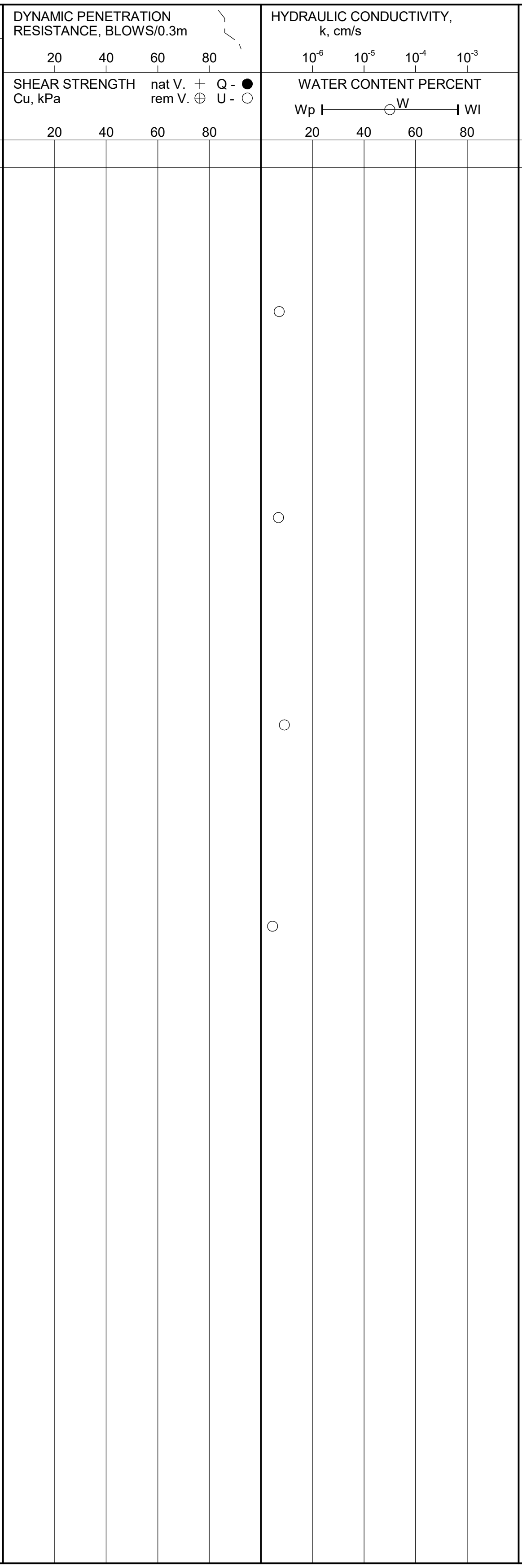
DATUM: Geodetic

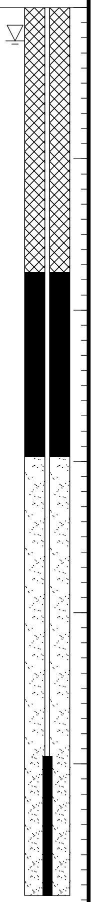
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	93.38					
TOPSOIL - (ML) sandy SILT; brown	0.00					
(SM) SILTY SAND; brown; non-cohesive, moist, very loose	93.20 0.18	1	SS	4		
(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w~PL, very stiff	93.02 0.36					Native Backfill
(SM) SILTY SAND, some gravel to gravelly; brown; non-cohesive, moist, dense to very dense	92.47 0.91	2	SS	54		
		3	SS	>50		Bentonite Seal
		4	SS	43	MH	
(SM/GM) gravelly SILTY SAND to gravelly SAND, some silt; grey brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact	90.33 3.05	5	SS	12		
		6	SS	25	MH	Silica Sand
		7	SS	33		
		8	SS	31		Standpipe
End of Borehole Auger Refusal	87.51 5.87					WL in Standpipe at Elev. 93.16 m on Nov. 7, 2017





DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-20

SHEET 1 OF 1

LOCATION: N 5013391.5 ;E 367704.1

BORING DATE: October 10, 2017

DATUM: Geodetic

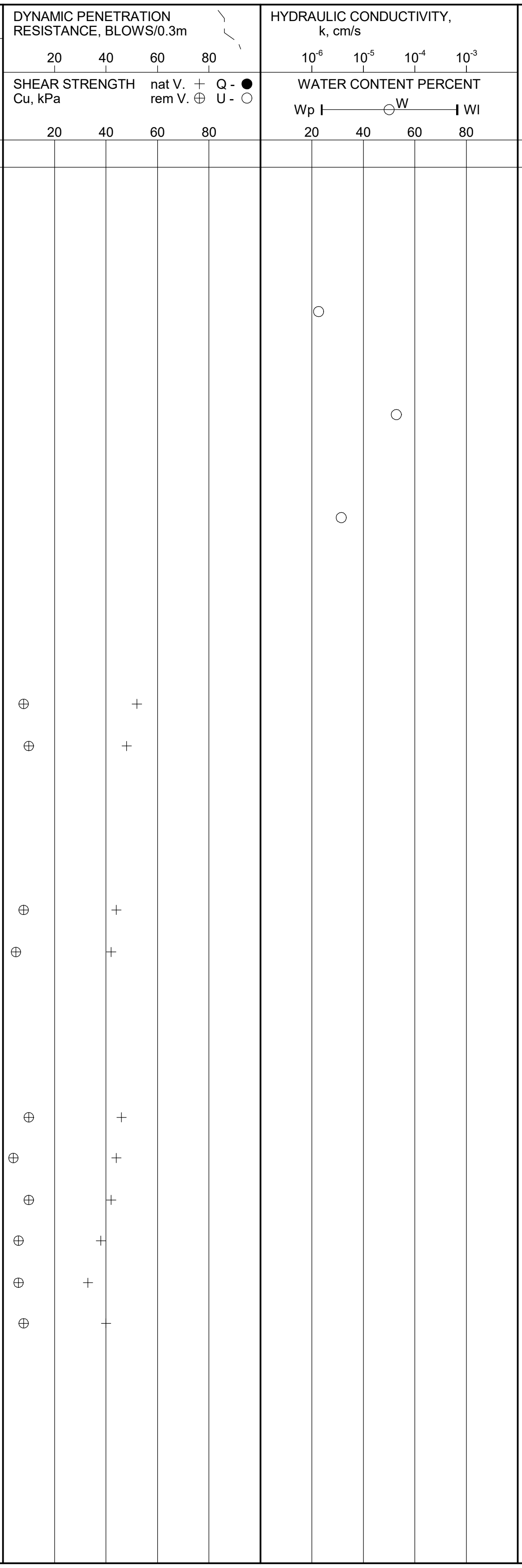
SAMPLER HAMMER, 64kg; DROP, 760mm

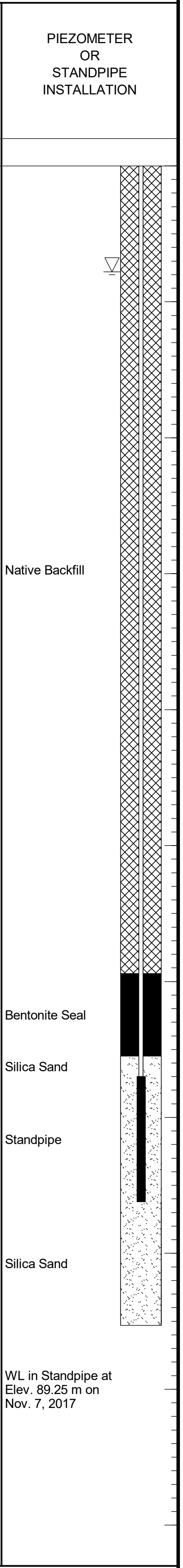
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem) (0.00 to 8.53 m)

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.03
TOPSOIL - (SM) SILTY SAND; brown	0.00
(SM/SP) SILTY SAND; light brown, moist, loose	0.15
(SM/ML) SAND and SILT; brown; non-cohesive, moist, loose	89.27 0.76
(CI/CH) SILTY CLAY to CLAY, trace sand; brown (WEATHERED CRUST); w>PL, very stiff	88.51 1.52
(ML) sandy CLAYEY SILT; brown; cohesive, w>PL, stiff	87.75 2.28
(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains silt seams; cohesive, w>PL, stiff to firm	86.98 3.05
End of Borehole	81.50 8.53

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	5	
2	SS	7	MH
3	SS	3	
4	SS	2	
5	SS	1	
6	SS	WH	
7	SS	WH	





WL in Standpipe at Elev. 89.25 m on Nov. 7, 2017

DEPTH SCALE 1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-20A

SHEET 1 OF 1

LOCATION: N 5013391.5 ;E 367704.1

BORING DATE: October 12-13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		90.03							
0	Power Auger 200 mm Diam. (Hollow Stem)	For soil stratigraphy refer to Record of Borehole 17-20		0.00							
8					1	TP	PH				
		End of Borehole		81.85 8.18							

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

PROJECT: 1406631

RECORD OF BOREHOLE: 17-21

SHEET 1 OF 1

LOCATION: N 5013454.8 ;E 367813.5

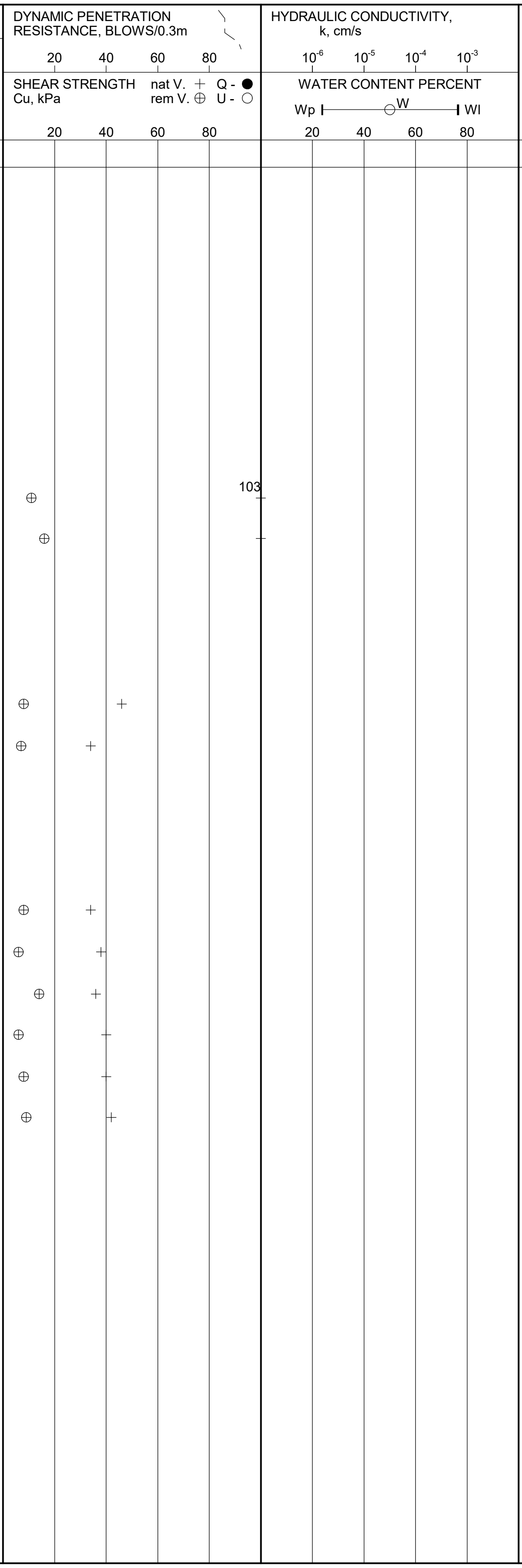
BORING DATE: October 13, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		89.94					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) sandy SILT; brown		0.00	1	SS	6		
		(CL/ML) SILTY CLAY to CLAYEY SILT, some sand; brown (WEATHERED CRUST); cohesive, w>PL		89.48 0.46					
1		(CL/CI) SILTY CLAY, some sand; brown, contains sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff		89.03 0.91	2	SS	3		
2		(CI/CH) SILTY CLAY to CLAY, some sand; brown (WEATHERED CRUST); w>PL, very stiff		88.42 1.52	3	SS	3		
3		(CI/CH) SILTY CLAY to CLAY; grey, with black mottling, contains silt seams; cohesive, w>PL, firm		86.89 3.05	4	SS	WH		
4									
5					5	SS	WH		
6									
7		End of Borehole		82.93 7.01					
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-22

SHEET 1 OF 1

LOCATION: N 5013533.9 ;E 367954.6

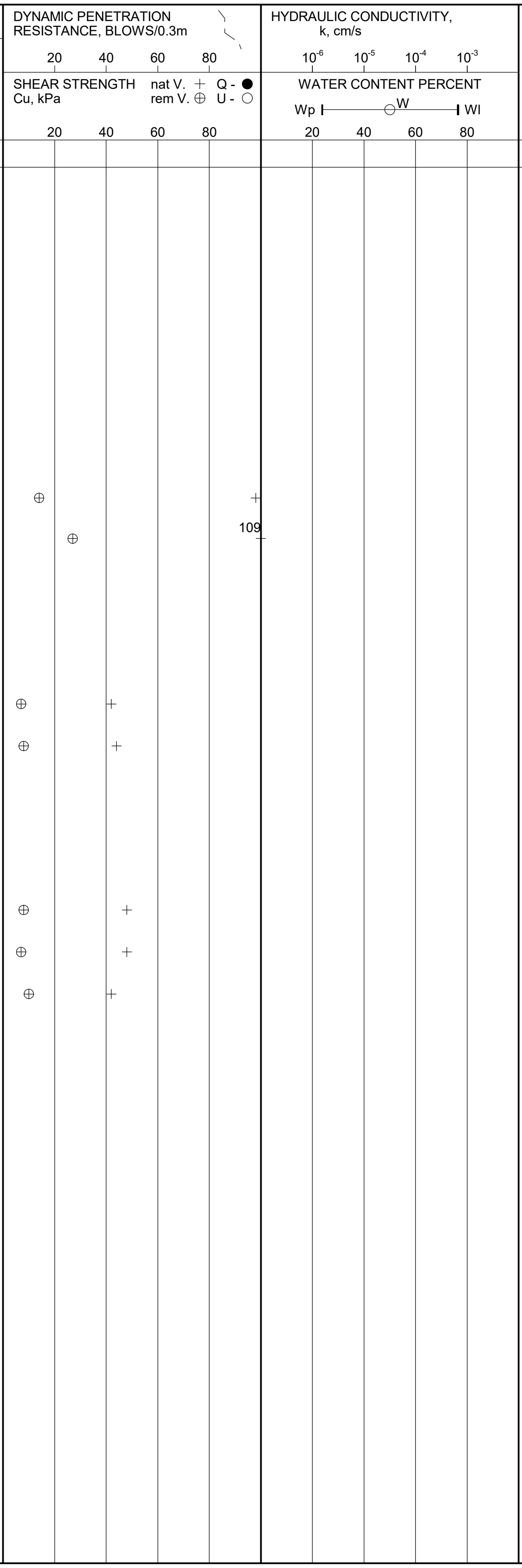
BORING DATE: October 16, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE		90.32			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown		0.00			
		(SM) SILTY SAND; brown; non-cohesive, moist, loose		90.02 0.30	1	SS	5
1		(CL/ML) SILTY CLAY to CLAYEY SILT; brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff		89.56 0.76	2	SS	3
2		(CI) SILTY CLAY, trace sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff		89.25 1.07	3	SS	3
3 4		(CI/CH) SILTY CLAY to CLAY; grey, contains sand seams; cohesive, w>PL, firm		87.27 3.05	4	SS	WH
5					5	SS	WH
6 7 8 9 10		End of Borehole		84.22 6.10			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-23

SHEET 1 OF 1

LOCATION: N 5013598.9 ;E 368063.2

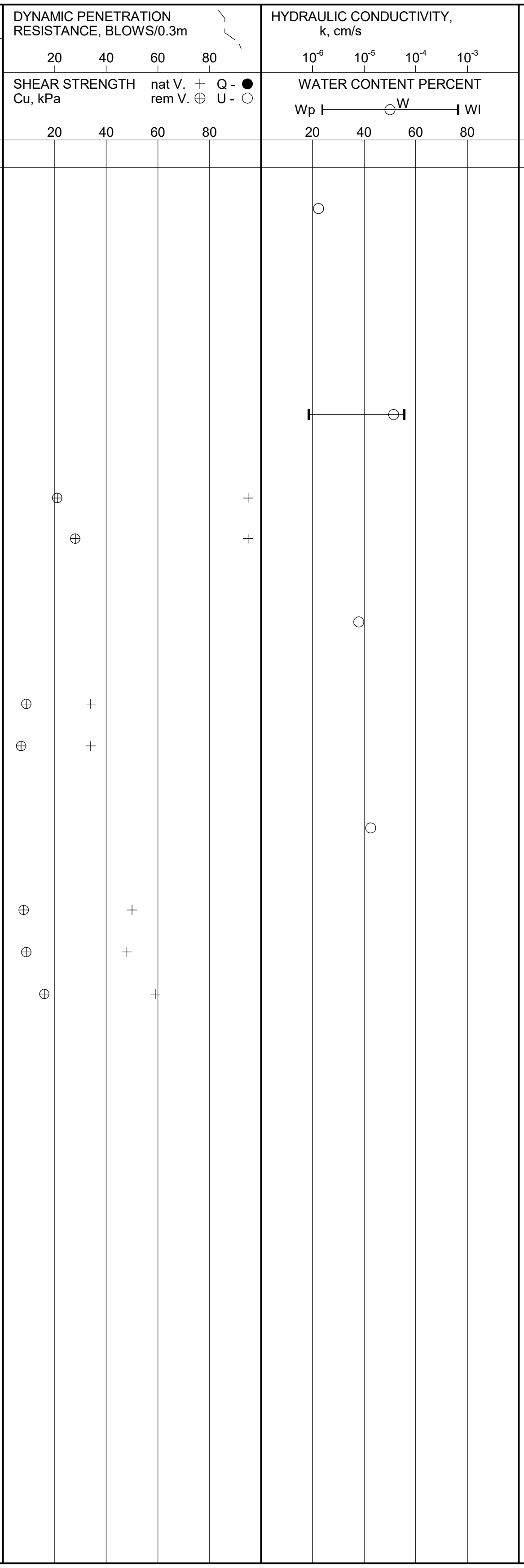
BORING DATE: October 17, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE		90.11			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00			
		(ML) sandy SILT; non-cohesive, moist, very loose to loose		0.15	1	SS	2
1					2	SS	4
		(CL/CI) SILTY CLAY, trace sand; brown to grey brown, contains sandy silt seams (WEATHERED CRUST); w>PL, very stiff to stiff		88.59 1.52	3	SS	3
3		(CI/CH) SILTY CLAY to CLAY; grey, contains sandy silt seams; w>PL, firm to stiff		87.06 3.05	4	SS	WH
5					5	SS	WH
6		End of Borehole		84.01 6.10			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-24

SHEET 1 OF 1

LOCATION: N 5013707.2 ;E 368218.4

BORING DATE: October 17, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

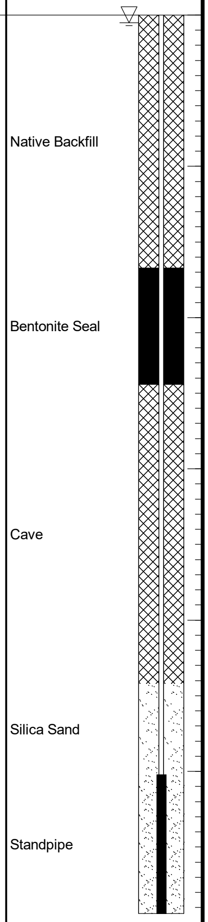
WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl: 20 40 60 80

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	92.15
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown, contains organic matter (rootlets)	0.00
		(CI) SILTY CLAY, some sand; brown, contains organic matter (rootlets) (WEATHERED CRUST); cohesive, w>PL, stiff	0.15
1		(SM) SILTY SAND, trace gravel; brown; moist	91.24 0.91
		(SP/SM) SILTY SAND, some gravel to gravelly; brown to grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, compact to very dense	1.07
6		End of Borehole	86.21 5.94

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	3
2	SS	30
3	SS	50
4	SS	52
5	SS	80
6	SS	26
7	SS	23
8	SS	52

PIEZOMETER OR STANDPIPE INSTALLATION



WL in Standpipe at Elev. 92.10 m on Nov. 7, 2017.

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-25

SHEET 1 OF 1

LOCATION: N 5013791.3 ;E 368349.4

BORING DATE: October 18, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.25							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00							
		(CL/CI) SILTY CLAY, some gravel and sand; brown; cohesive, w>PL, stiff		92.05 0.20	1	SS	3				
1		(SM) SILTY SAND, some gravel; brown, contains cobbles and boulders (GLACIAL TILL); non-cohesive, moist, very dense		91.49 0.76	2	SS	64				
		End of Borehole Auger Refusal		91.03 1.22							
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-26

SHEET 1 OF 1

LOCATION: N 5013862.8 ;E 368468.6

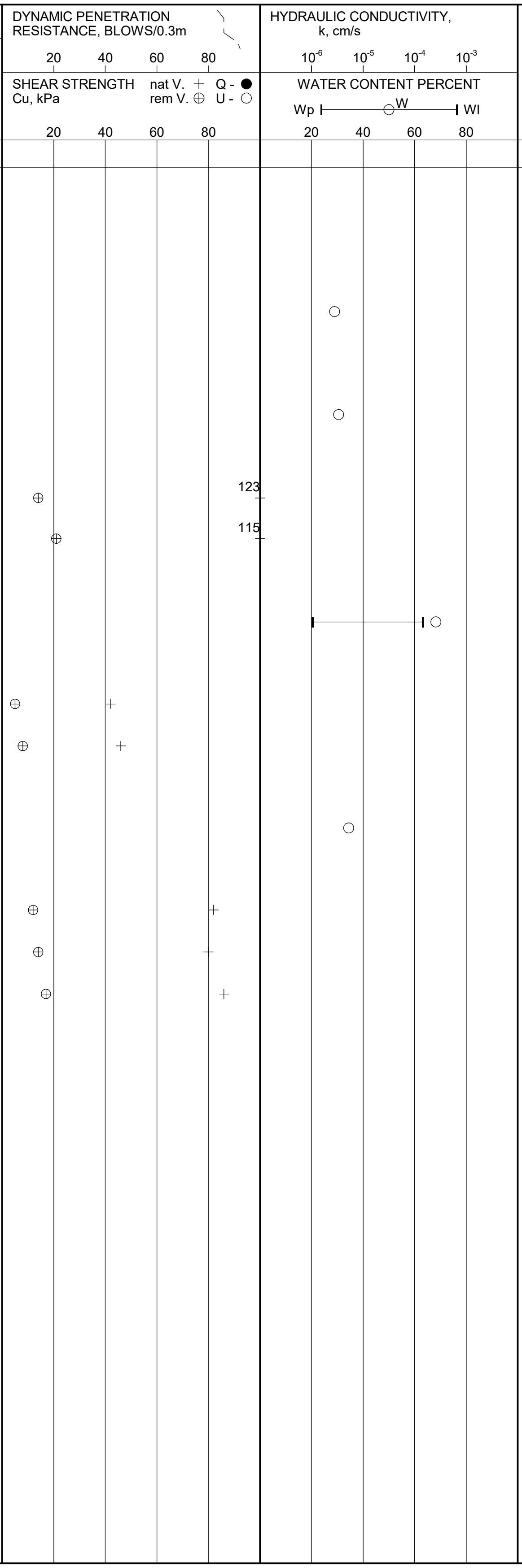
BORING DATE: October 18, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.76					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown		0.00					
		(ML) sandy CLAYEY SILT; brown; cohesive, w>PL, stiff		92.46 0.30	1	SS	3		
1		(ML/SM) sandy SILT to SILTY SAND; brown; non-cohesive, moist, loose		92.00 0.76	2	SS	5		
2		(CI/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w>PL, very stiff		91.24 1.52	3	SS	2		
3		(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm		89.71 3.05	4	SS	WH		
4–5		(ML) CLAYEY SILT; grey; cohesive, w>PL, stiff		88.19 4.57	5	SS	WH		
6		End of Borehole		86.66 6.10					



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-27

SHEET 1 OF 1

LOCATION: N 5013947.1 ;E 368604.0

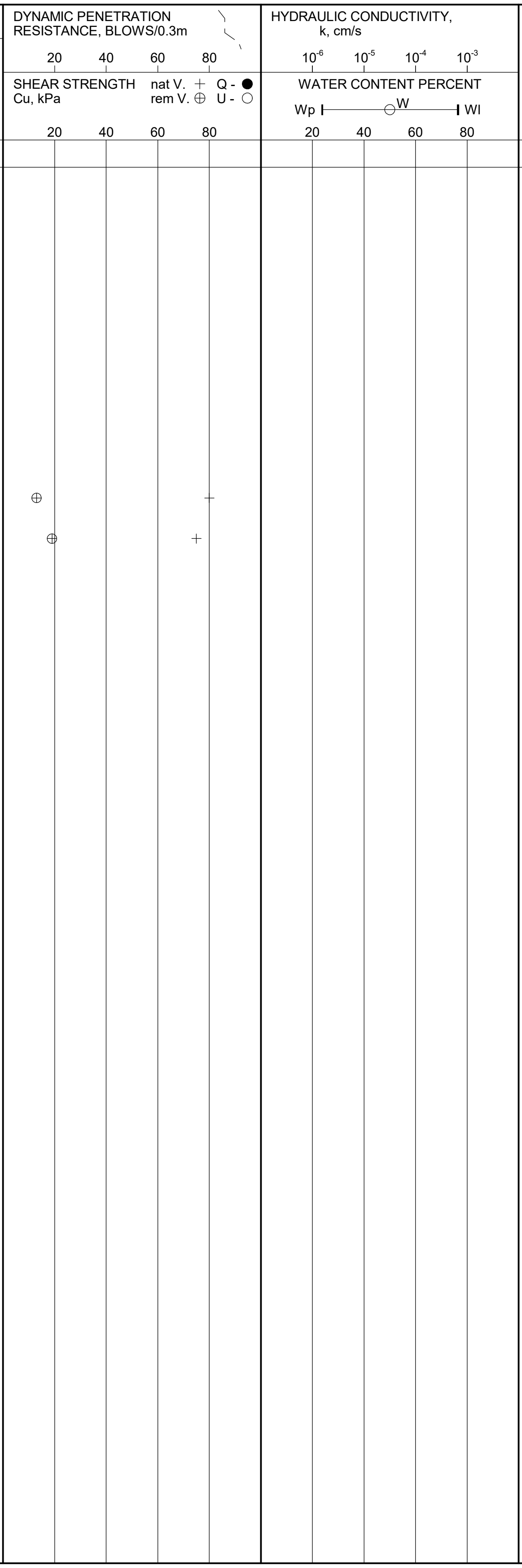
BORING DATE: October 26, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.99					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) SILT, some sand; dark brown		0.00					
		(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff		92.69 0.30	1	SS	4		
		(SM) SILTY SAND; brown; non-cohesive, wet		92.23 0.76					
1		(CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.91	2	SS	3		
2					3	SS	3		
3		(ML/SM) sandy SILT, some gravel; grey, contains cobbles and boulders (GLACIAL TILL); moist, loose		89.64 3.35	4	SS	4		
					5	SS	>50		
4		End of Borehole Auger Refusal		89.03 3.96					
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-28

SHEET 1 OF 2

LOCATION: N 5014019.4 ;E 368725.1

BORING DATE: October 24-25, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○)	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	93.43					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown	0.00					∇
		(CL/CI) SILTY CLAY, some sand; brown (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	93.23 0.20	1 2	SS SS	3 6		Native Backfill
1 2		(ML-CI) CLAYEY SILT to SILTY CLAY; brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, very stiff	91.91 1.52	3	SS	4	123 ⊕ >143	
3		(SM) gravelly SILTY SAND; grey brown (GLACIAL TILL); non-cohesive, moist, loose	90.38 3.05	4	SS	5		
		BOULDERS	89.98 3.45	5	RC	DD		Bentonite Seal
		GRAVEL/COBBLES	89.73 3.70	6 7	RC RC	DD DD		
4		Borehole continued on RECORD OF DRILLHOLE 17-28	89.37 4.06					
5 6 7 8 9 10								

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 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

1 : 50

GOLDER

LOGGED: DWM

CHECKED: SAT

PROJECT: 1406631

RECORD OF DRILLHOLE: 17-28

SHEET 2 OF 2

LOCATION: N 5014019.4 ;E 368725.1

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: October 24-25, 2017

DRILL RIG: CME 850

DRILLING CONTRACTOR: CCC Drilling

DATUM: Geodetic

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

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

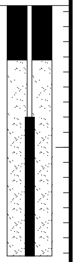
PL - Planar
CU- Curved
UN- Undulating
ST - Stepped
IR - Irregular

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

BR - Broken Rock

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.25 m 5 10 15 20	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	
		BEDROCK SURFACE		89.37								
5	Rotary Drill NQ Core	Fresh to slighlty weathered, grey, fine grained; non-porous, LIMESTONE, occasional shale seams		4.06 87.71 5.72	1	100						Bentonite Seal Silica Sand Standpipe
6		End of Drillhole										WL in Standpipe at Elev. 93.32 m on Nov. 7, 2017
7												
8												
9												
10												
11												
12												
13												
14												



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DWM
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-101

SHEET 1 OF 1

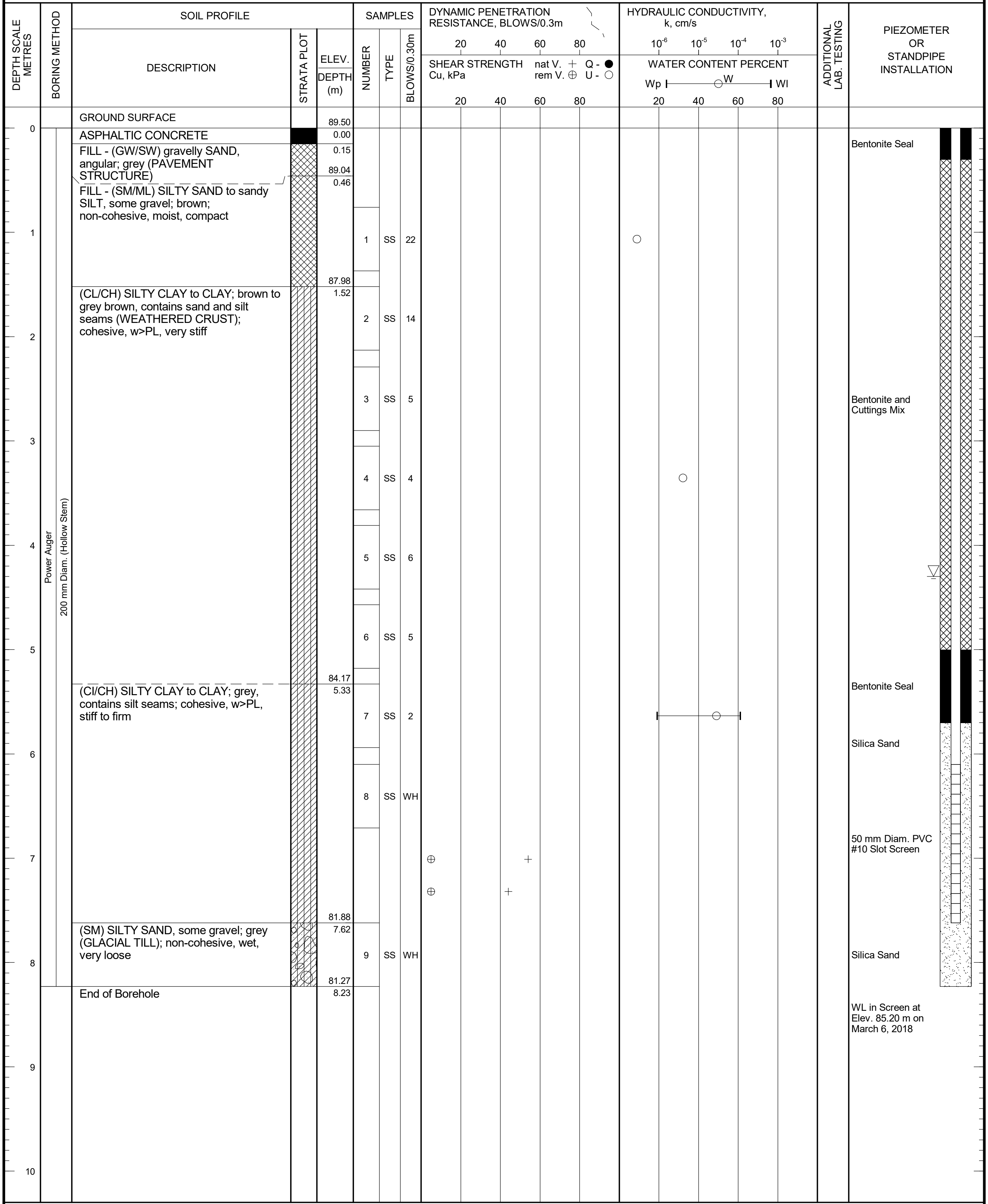
LOCATION: N 5014204.6 ;E 367497.3

BORING DATE: December 20, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



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

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	89.50
ASPHALTIC CONCRETE	0.00
FILL - (GW/SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)	0.15
FILL - (SM/ML) SILTY SAND to sandy SILT, some gravel; brown; non-cohesive, moist, compact	89.04 0.46
(CL/CH) SILTY CLAY to CLAY; brown to grey brown, contains sand and silt seams (WEATHERED CRUST); cohesive, w>PL, very stiff	87.98 1.52
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, stiff to firm	84.17 5.33
(SM) SILTY SAND, some gravel; grey (GLACIAL TILL); non-cohesive, wet, very loose	81.88 7.62
End of Borehole	81.27 8.23

NUMBER	TYPE	BLOWS/0.30m
1	SS	22
2	SS	14
3	SS	5
4	SS	4
5	SS	6
6	SS	5
7	SS	2
8	SS	WH
9	SS	WH

PIEZOMETER OR STANDPIPE INSTALLATION
Bentonite Seal
Bentonite and Cuttings Mix
Bentonite Seal
Silica Sand
50 mm Diam. PVC #10 Slot Screen
Silica Sand
WL in Screen at Elev. 85.20 m on March 6, 2018

DEPTH SCALE
1 : 50

GOLDER

LOGGED: CRG
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-102

SHEET 1 OF 1

LOCATION: N 5014009.9 ;E 367534.6

BORING DATE: December 21, 2017

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	88.75
ASPHALTIC CONCRETE	0.00
FILL - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)	0.15
FILL - (SP) SAND, trace gravel; grey brown; non-cohesive, moist	88.34 0.41
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	87.84 0.91
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, stiff	84.18 4.57
End of Borehole	80.52 8.23

SAMPLES: NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	GRAB	-
3	SS	12
4	SS	11
5	SS	3
6	SS	2
7	SS	WH
8	SS	WH
9	SS	3

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

LOGGED: DG
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-105

SHEET 1 OF 1

LOCATION: N 5013413.1 ;E 367633.8

BORING DATE: January 9, 2018

DATUM: Geodetic

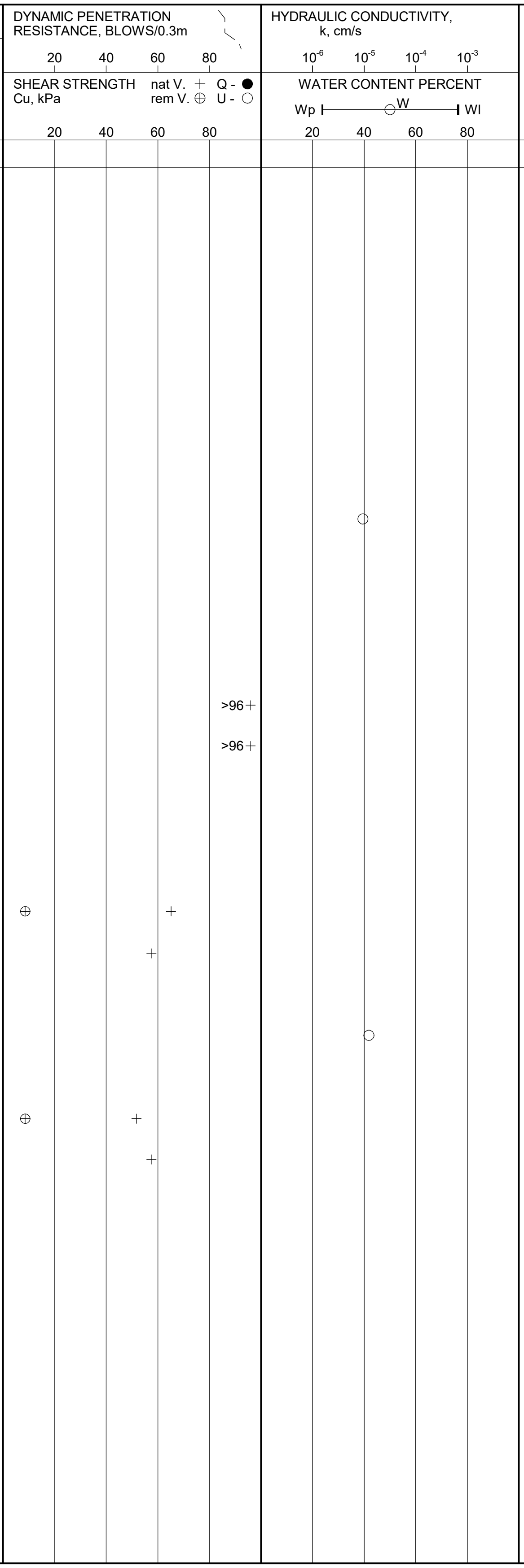
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.27
ASPHALTIC CONCRETE	0.07
FILL - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)	0.24
FILL - (SW) gravelly SAND, angular and subrounded gravel; brown (PAVEMENT STRUCTURE)	89.77 0.50
FILL - (SP/SM) SAND to SILTY SAND, some gravel; brown; non-cohesive	89.05 1.22
TOPSOIL - (ML) CLAYEY SILT; dark grey	88.83 1.44
(SM) SILTY SAND; grey brown; non-cohesive, moist	88.44 1.83
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	85.09 5.18
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling, contains silty sand seams; cohesive, w>PL, stiff	82.04 8.23
End of Borehole	

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	GRAB	-
3	GRAB	-
4	SS	>50
5	SS	11
6	SS	7
7	SS	3
8	SS	3
9	SS	WH
10	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH

CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-106

SHEET 1 OF 1

LOCATION: N 5013190.6 ;E 367668.4

BORING DATE: January 10, 2018

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa	ADDITIONAL LAB. TESTING
GROUND SURFACE	89.56					
ASPHALTIC CONCRETE	0.00					
FILL - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)	0.08					
FILL - (SW) SAND, some gravel, trace silt; brown; non-cohesive	89.10 0.46	1	GRAB	-		
FILL - (SM) SILTY SAND, trace organics; dark grey to black; non-cohesive	88.55 1.01	2	SS	>50		
TOPSOIL - (ML) CLAYEY SILT; dark grey to black	88.34 1.22					
(SM) SILTY SAND; dark grey	88.10 1.46					
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty fine sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	1.60	3	SS	7		
		4	SS	6		
		5	SS	3		
					>96	
					>96	
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, stiff	84.68 4.88	6	SS	3		
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, firm to stiff	84.07 5.49					
		7	SS	WH		CHEM
		8	SS	WH		
End of Borehole	81.33 8.23					

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

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE
1 : 50

GOLDER

LOGGED: PAH
CHECKED: SAT

PROJECT: 1406631

RECORD OF BOREHOLE: 17-107

SHEET 1 OF 1

LOCATION: N 5013026.2 ;E 367715.6

BORING DATE: January 10-11, 2018

DATUM: Geodetic

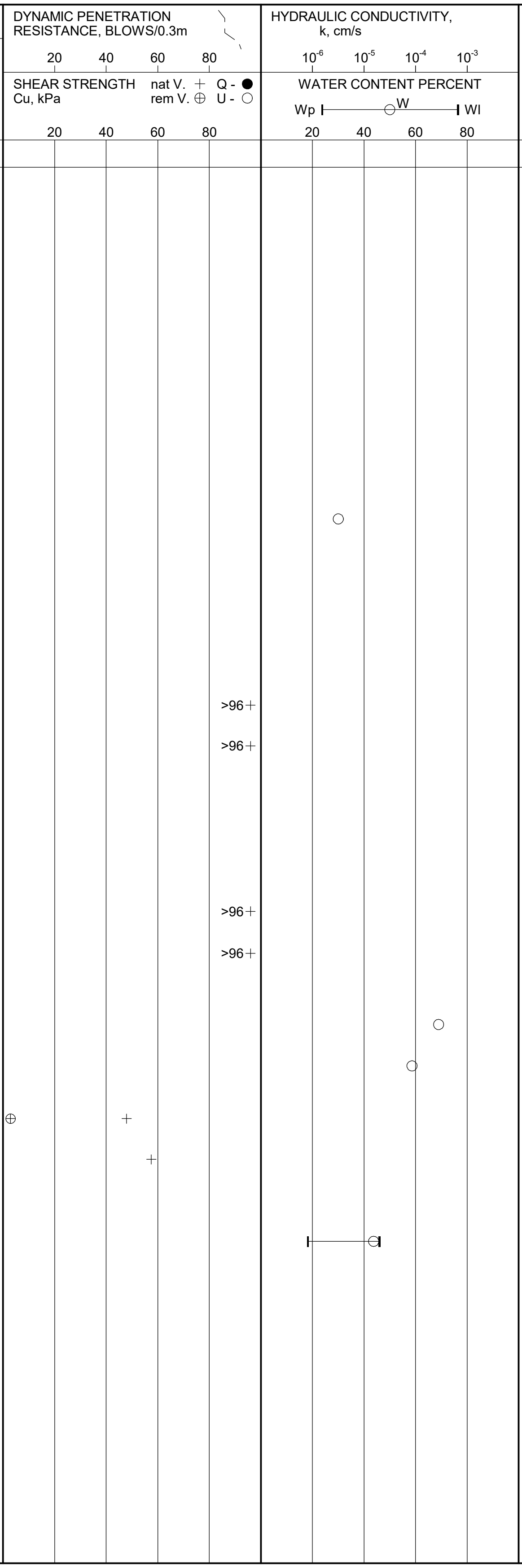
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

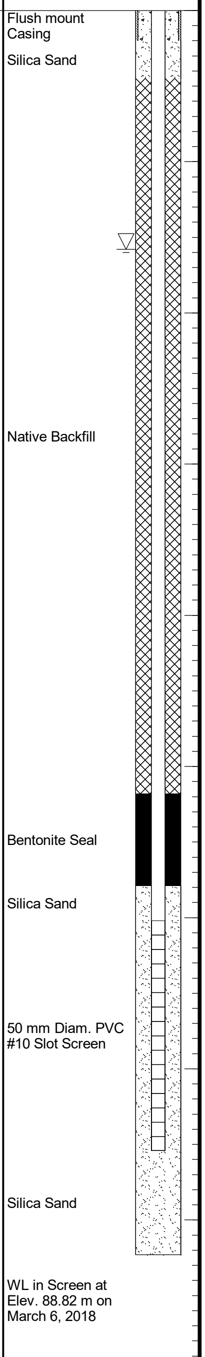
DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.40
ASPHALTIC CONCRETE	0.00
FILL - (SW) gravelly SAND, angular; grey (PAVEMENT STRUCTURE)	0.08
FILL - (SW) gravelly SAND, angular; brown (PAVEMENT STRUCTURE)	0.20
FILL - (SP/SM) SAND to SILTY SAND, some gravel; grey brown; non-cohesive	0.35
FILL - (CL/ML/SM) SILTY CLAY, CLAYEY SILT, SILTY SAND, layered; dark grey; cohesive	89.53 0.87
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty fine sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	88.72 1.68
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, firm to stiff	84.46 5.94
End of Borehole	82.17 8.23

NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	GRAB	-
3	GRAB	-
4	SS	>50
5	SS	4
6	SS	5
7	SS	3
8	SS	4
9	SS	WH
10	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE 1 : 50

LOGGED: PAH

CHECKED: SAT

MIS-BHS 001 1406631.GPJ GAL-MIS.GDT 18-5-22 JM

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

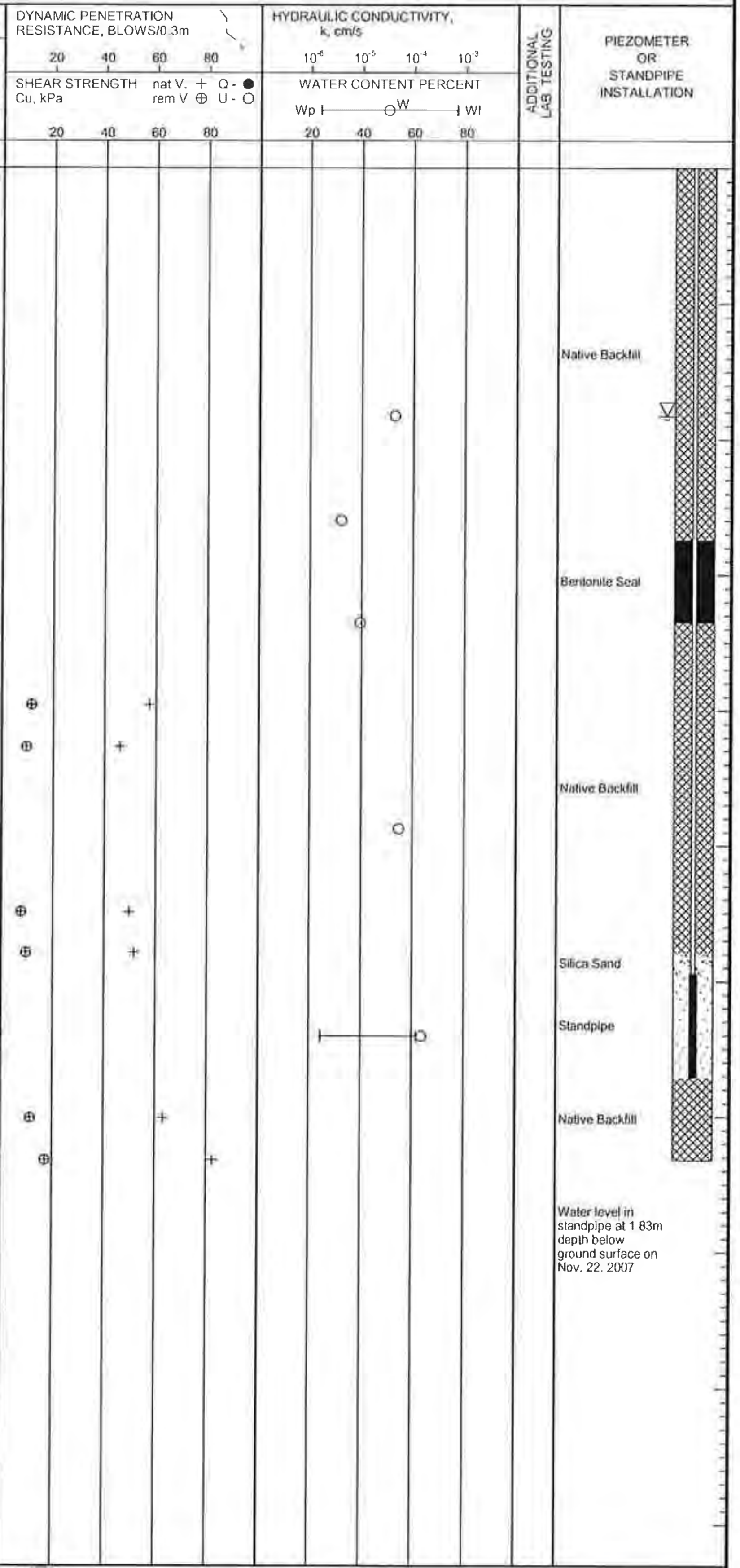
DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE				
TOPSOIL	0.00			
Grey brown SILTY fine SAND	0.22			
Very stiff grey brown and red brown SILTY CLAY, some silty fine sand layers and seams (Weathered Crust)	0.91	1	50 DO	8
		2	50 DO	5
		3	50 DO	3
Stiff grey SILTY SAND	3.05	4	50 DO	2
Stiff to firm grey SILTY CLAY	3.66	5	50 DO	WH
Stiff grey SILTY CLAY	5.18	6	50 DO	WH
End of Borehole	7.32			



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: 10-11

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: Dec 16-17,2010

DATUM: Geodetic

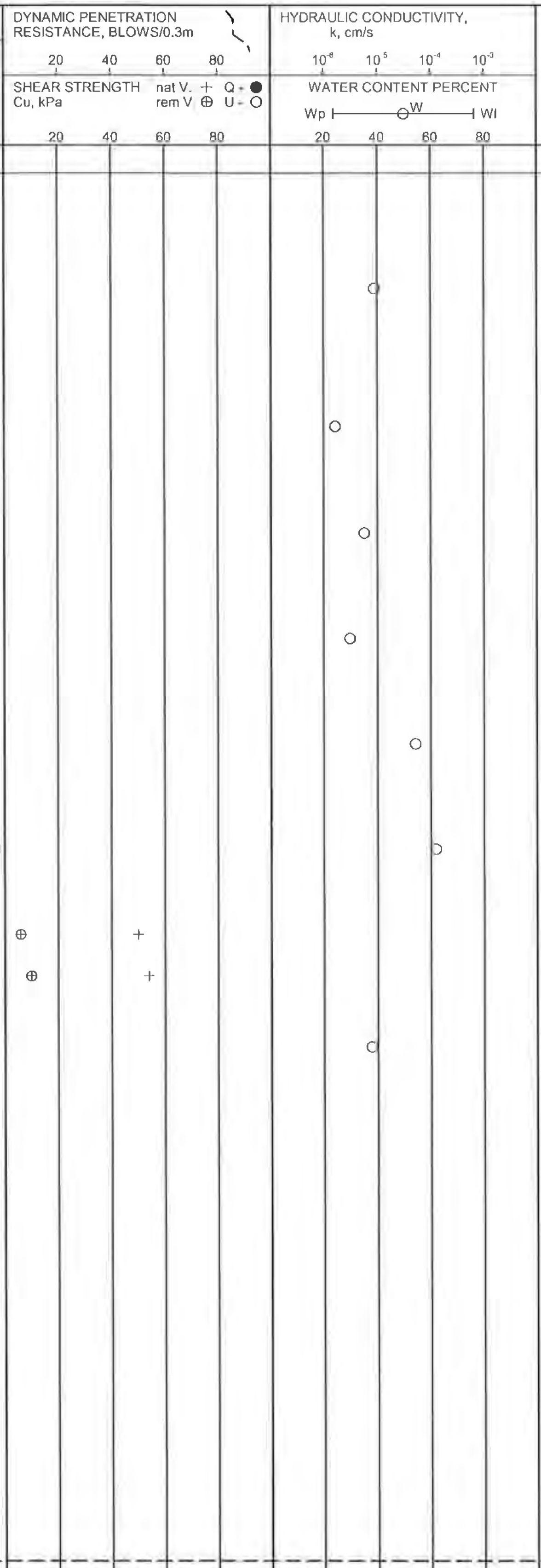
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV DEPTH (m)
GROUND SURFACE	88.70
Black silty TOPSOIL	0.00
Very stiff grey brown SILTY CLAY (Weathered Crust)	88.45 0.25
Very loose grey brown SANDY SILT, some clay	87.48 1.22
Firm to stiff grey SILTY CLAY	85.64 3.06
Loose grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	82.22 6.48
Dense grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	79.56 9.14

NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	10	
2	50 DO	2	MH
3	50 DO	3	
4	50 DO	3	
5	50 DO	2	
6	50 DO	WH	
7	50 DO	2	
8	50 DO	7	
9	50 DO	8	
10	50 DO	6	
11	50 DO	41	



PIEZOMETER OR STANDPIPE INSTALLATION

∇

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

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-11

SHEET 2 OF 2

LOCATION: See Site Plan

BORING DATE: Dec.16-17,2010

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/0.3m				
		--- CONTINUED FROM PREVIOUS PAGE ---									
10				78.62							
		End of Borehole Auger Refusal		10.08							W L in open borehole at 4 27m depth below ground surface upon completion of drilling
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1011210260.GPJ GAL-MIS.GDT 4/19/11 A.B.D

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-12

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 16-17,2010

DATUM: Geodetic

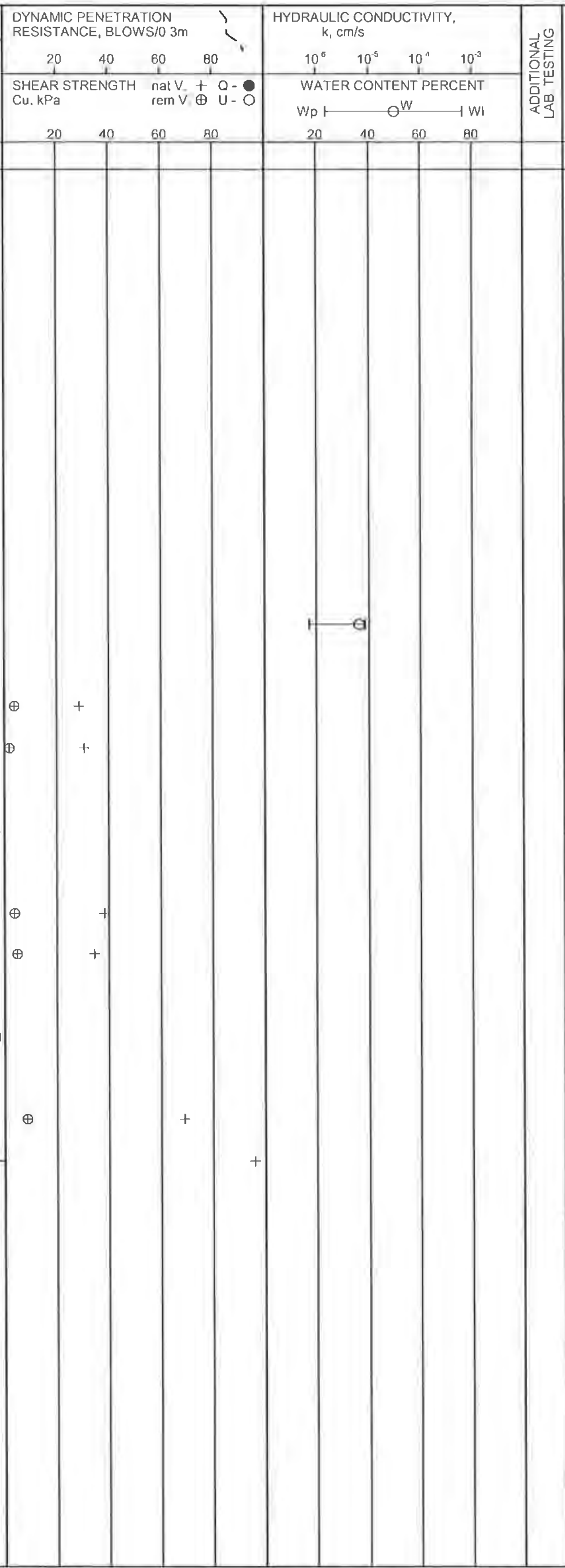
SAMPLER HAMMER, 64kg; DROP, 760mm

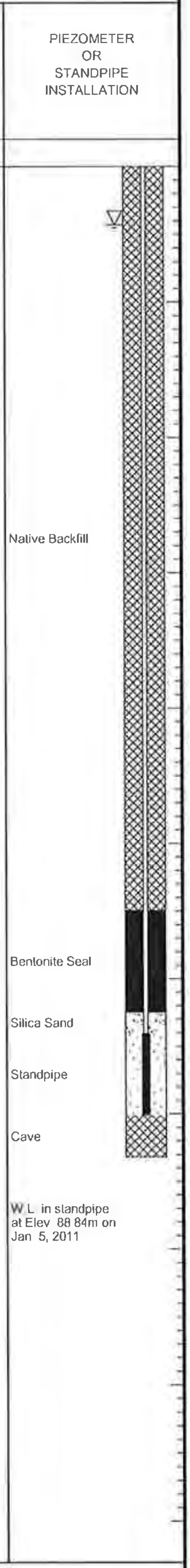
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
GROUND SURFACE	89.27			
Brown SILTY fine SAND	0.00			
Very stiff to stiff grey brown SILTY CLAY, occasional sand seams (Weathered Crust)	88.36 0.91	1	50 DO	6
		2	50 DO	4
Very loose brown SILTY fine SAND	87.34 1.93			
Firm to stiff grey brown SILTY CLAY	87.14 2.13			
Very loose brown SILTY fine SAND, some clay	86.78 2.49	3	50 DO	1
Firm grey SILTY CLAY	86.07 3.20	4	50 DO	WH
		5	50 DO	WH
Stiff grey SILTY CLAY	82.87 6.40	6	50 DO	WH
End of Borehole	81.95 7.32			





MIS-BHS 001 1011210260.GPJ GAL-MIS.GDT 4/19/11 A B D

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: H.E.C.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-12A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 17,2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	89.27			
0	Brown SILTY fine SAND	0.00			
		88.36			
1	Very stiff to stiff grey brown SILTY CLAY, occasional sand seams (Weathered Crust)	0.91			
		87.34			
2	Very loose brown SILTY fine SAND	1.93			
		87.14			
	Firm to stiff grey brown SILTY CLAY	2.13			
		86.78			
	Very loose brown SILTY fine SAND, some clay	2.49			
3		86.07			
	Firm grey SILTY CLAY	3.20	1	73 TP	PH
		85.61			
	End of Borehole Note: Soil profile inferred from Borehole 10-12	3.66			
4					
5					
6					
7					
8					
9					
10					

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

DEPTH SCALE
1 : 50

LOGGED: D G
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-13

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 16,2010

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
		GROUND SURFACE		90.22			
0	Power Auger 200 mm Diam (Hollow Stem)	Dark brown fine SAND, some silt, some organic matter (TOPSOIL)		0.00			
		Brown fine SAND		89.91 0.31			
		Very loose brown SILTY fine SAND		89.46 0.76			
1		Stiff to very stiff grey brown SILTY CLAY (Weathered Crust)		89.15 1.07	1		4
2					2		4
		Very loose grey brown to brown SILTY fine SAND to SANDY SILT		87.93 2.29	3		WH
3		Firm to stiff grey SILTY CLAY		87.17 3.05	4		WH
5					5		WH
6					6		WH
7		End of Borehole		82.90 7.32			
8							
9							
10							

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

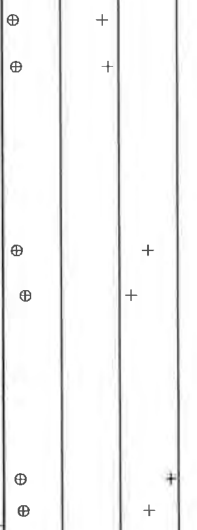
SHEAR STRENGTH Cu, kPa — nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

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



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: H.E.C.

CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-15

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 16,2010

DATUM: Geodetic

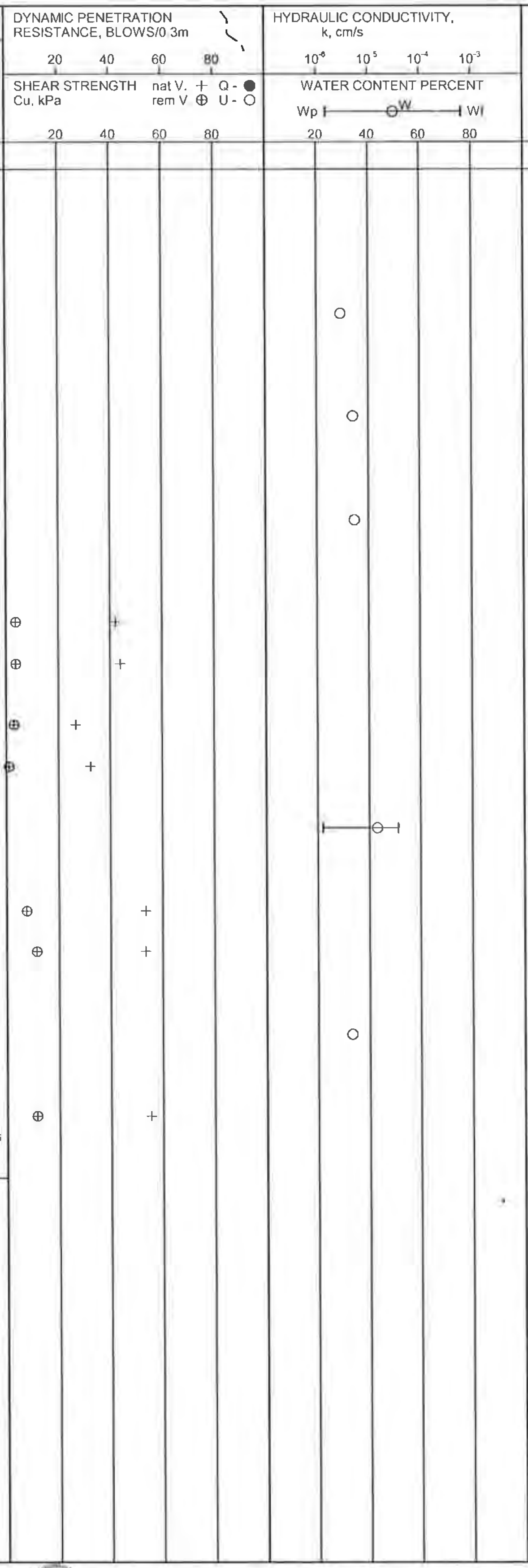
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	90.60			
Dark brown CLAYEY SILT, trace to some organic matter (TOPSOIL)	0.00			
Brown SANDY SILT to CLAYEY SILT	90.35 0.25			
Stiff grey brown SILTY CLAY, occassional sand seams (Weathered Crust)	89.84 0.76			
Loose brown to grey brown SILTY fine SAND, trace clay	89.61 0.99	1	50 DO	7
Very loose brown CLAYEY SILT to SILTY fine SAND, trace clay	89.08 1.52	2	50 DO	2
Firm to stiff grey brown to grey SILTY CLAY	88.31 2.29	3	50 DO	1
Firm grey SILTY CLAY	87.70 2.90			
Stiff grey SILTY CLAY	85.72 4.88	4	50 DO	1
		5	50 DO	2
Very dense grey fine SAND, trace silt, some gravel (GLACIAL TILL)	83.51 7.09	6	50 DO	96
End of Borehole	83.13 7.47			



ADDITIONAL LAB TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: H.E.C.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-16

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 15,2010

DATUM: Geodetic

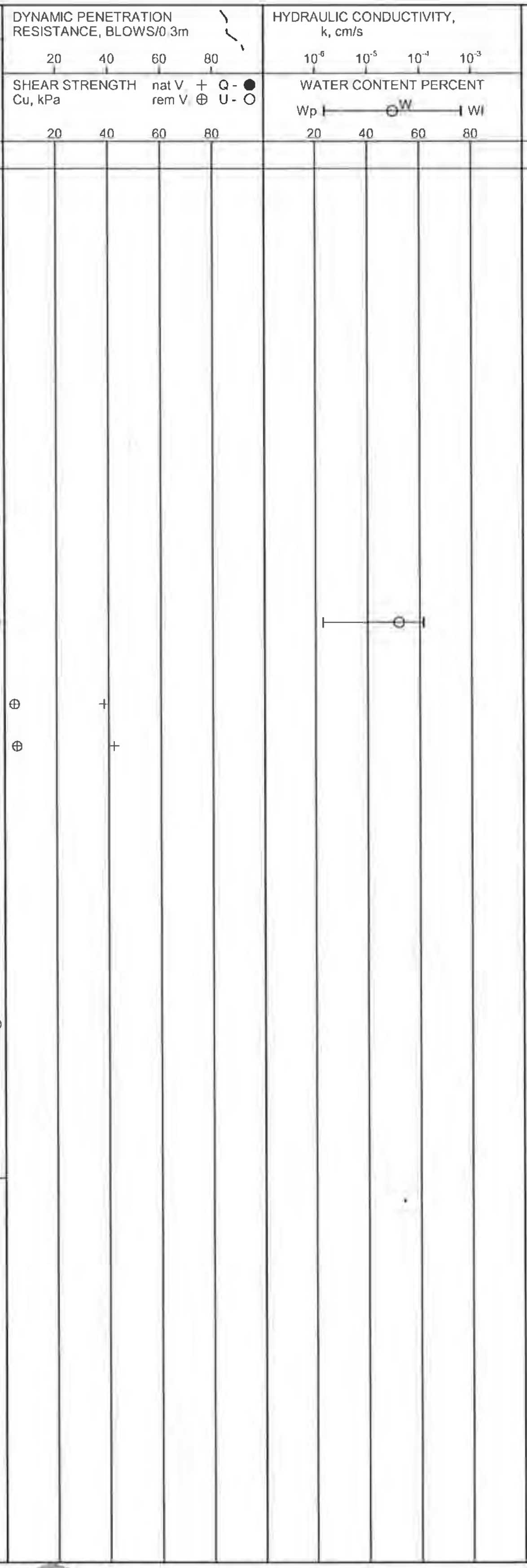
SAMPLER HAMMER, 64kg; DROP, 760mm

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/0.3m	ADDITIONAL LAB TESTING
GROUND SURFACE	91.50				
Dark brown SILTY fine SAND, trace organic matter (TOPSOIL)	0.00				
Loose to very loose brown SILTY fine SAND to SANDY SILT, some clay	91.25 0.25	1	50 DO	5	
		2	50 DO	2	MH
Firm to stiff grey SILTY CLAY	88.91 2.59	3	50 DO	WH	
		4	50 DO	WH	
Firm grey CLAYEY SILT, trace sand	86.62 4.88	5	50 DO	2	
		6	50 DO	2	
Compact to very dense grey SILTY fine SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	85.23 6.27	7	50 DO	>50	
		8	50 DO	18	
End of Borehole	84.03 7.47				

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



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

LOGGED: H.E.C.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-19

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 15,2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

ADDITIONAL LAB TESTING

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
0	GROUND SURFACE	92 19			
	Dark brown sandy silt, some organic matter (TOPSOIL)	0 00			
	Very loose brown SILTY fine SAND	91 94 0 25			
1			1	50 DO	3
	Very stiff grey brown SILTY CLAY	90 92 1 27			
	Dense brown fine SAND, trace silt, some gravel, with cobbles (GLACIAL TILL)	1 37			
			2	50 DO	39
2					
			3	50 DO	36
3	Dense grey SILTY fine SAND, some gravel, with cobbles (GLACIAL TILL)	89 14 3 05			
			4	50 DO	37
4			5	50 DO	33
	Loose to dense grey SILTY fine SAND, trace gravel, with cobbles and boulders (GLACIAL TILL)	87 62 4 57			
5			6	50 DO	15
			7	50 DO	38
6					
			8	50 DO	5
7			9	50 DO	5
	End of Borehole	84 72 7 47			
8					
9					
10					

PIEZOMETER OR STANDPIPE INSTALLATION

Native Backfill

Bentonite Seal

Silica Sand

Standpipe

Cave

W L in standpipe at Elev 91 77m on Jan 5, 2011

DEPTH SCALE

1 : 50

LOGGED: H E.C.

CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 10-21

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec 14,2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

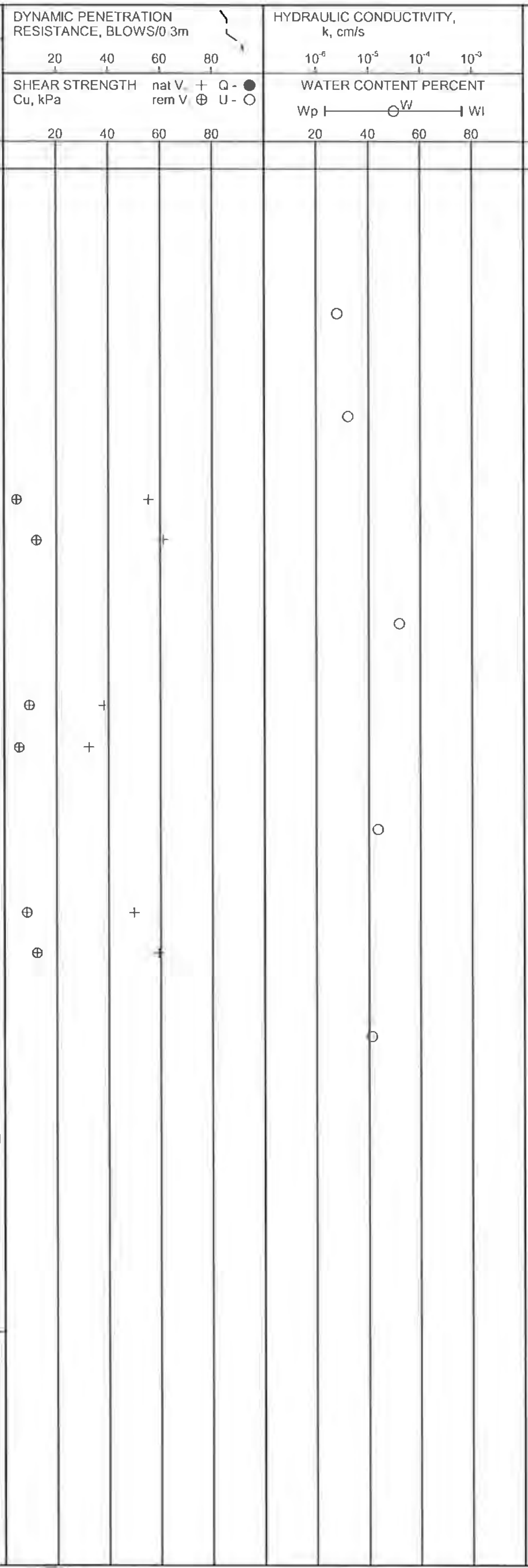
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	92.07
Very loose brown SILTY fine SAND	0.00
Firm to stiff grey SILTY CLAY	90.27 1.80
Very loose grey SILTY fine SAND, some gravel (GLACIAL TILL)	85.80 6.27
End of Borehole Auger Refusal	83.48 8.59

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB TESTING
1	50 DO	2	
2	50 DO	2	
3	50 DO	WH	
4	50 DO	2	
5	50 DO	2	
6	50 DO	WH	MH
7	50 DO	3	
8	50 DO	31	

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE
1 : 50

LOGGED: H.E.C.
CHECKED: CK

MIS-BHS 001 1011210260.GPJ GAL-MIS.GDT 4/19/11 A B D

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 13-101

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Nov. 1, 2013

DATUM: Geodetic

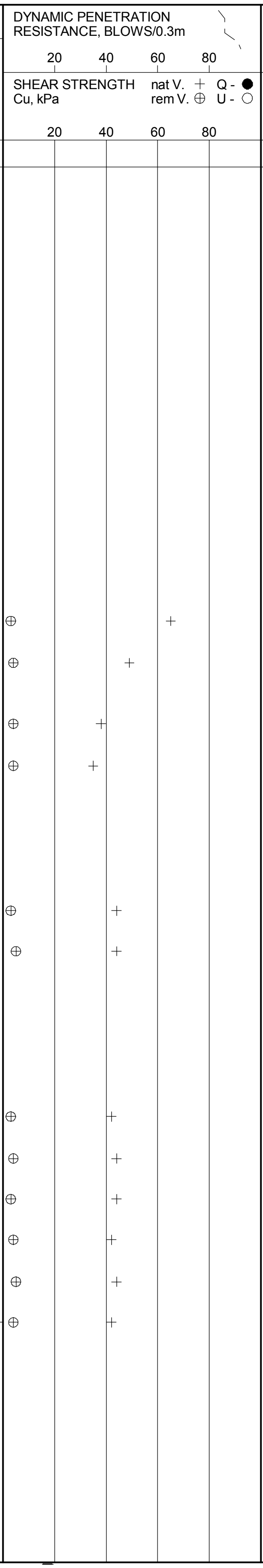
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.05
Black sandy silt with organic matter (TOPSOIL)	0.00
Very loose grey brown SILTY fine SAND to SANDY SILT	89.82 0.23
Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	88.98 1.07
Firm grey SILTY CLAY	86.39 3.66
End of Borehole	81.52 8.53

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	50 DO	3
2	50 DO	3
3	50 DO	1
4	50 DO	WH
5	50 DO	WH



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

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

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: H.E.C.
CHECKED: CK

PROJECT: 10-1121-0260

RECORD OF BOREHOLE: 13-102

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Nov. 1, 2013

DATUM: Geodetic

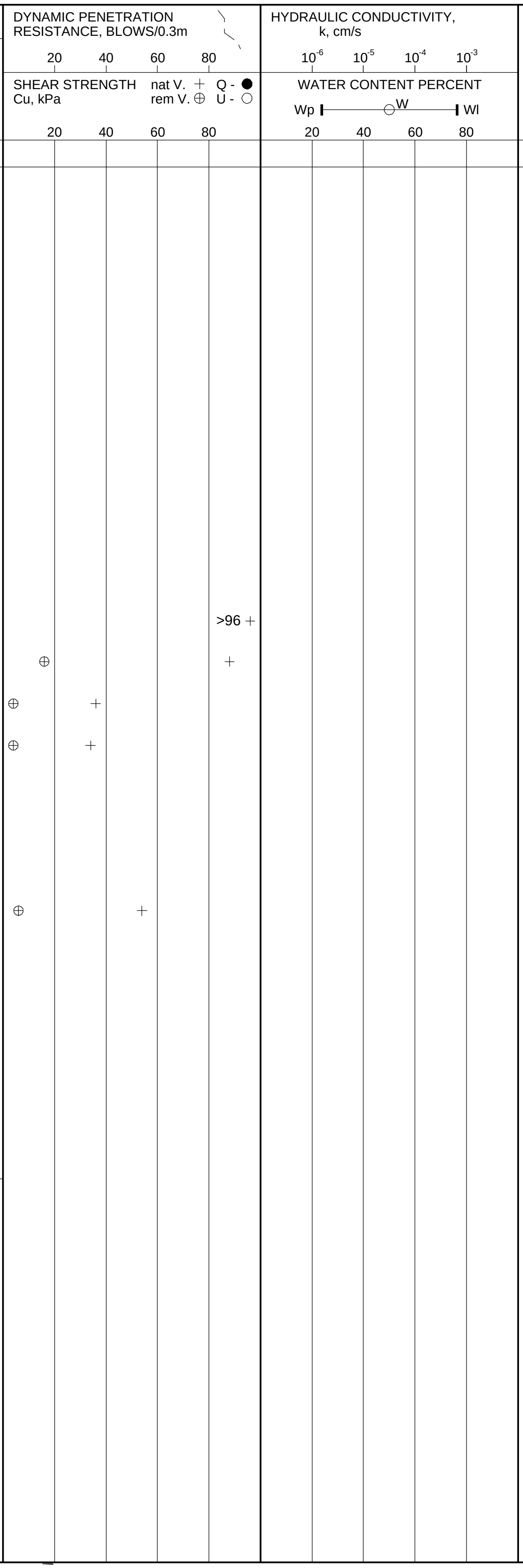
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.58
Black sandy silt, with organic matter (TOPSOIL)	0.00
Very stiff red brown to grey brown SILTY CLAY (Weathered Crust)	90.35 0.23
Very loose grey brown SILTY fine SAND, trace to some clay	89.28 1.30
Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	88.45 2.13
Firm to stiff grey SILTY CLAY	86.92 3.66
Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	85.02 5.56
End of Borehole	83.11 7.47

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	50 DO	9
2	50 DO	2
3	50 DO	3
4	50 DO	WH
5	50 DO	11
6	50 DO	26



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: H.E.C.

CHECKED: CK

APPENDIX C

Results of Chemical Analysis
EXOVA Environmental Ontario Report No. 1426815
Eurofins Environment Testing Report No. 1722750 and 1802198

EXOVA ENVIRONMENTAL ONTARIO

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. Sample Matrix Sample Type Sampling Date Sample I.D.	1153409 Soil 2014-12-12 BH 14-1 SA2/5'-7'	1153410 Soil 2014-12-08 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

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Susan Trickey
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1722750
Date Submitted: 2017-11-23
Date Reported: 2017-11-30
Project: 1406631
COC #: 826084

				Lab I.D.	1334437	1334438
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2017-10-11	2017-10-24
				Sample I.D.	17-06 SA 3/5-7	17-18 SA 3/5-7
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Agri. - Soil	pH	2.0			7.4	7.8
	SO4	0.01	%		<0.01	<0.01
General Chemistry	Cl	0.002	%		0.003	0.006
	Electrical Conductivity	0.05	mS/cm		0.29	0.17
	Resistivity	1	ohm-cm		3450	5880

Guideline = *** = Guideline Exceedence**

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

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Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Ms. Susan Trickey
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1802198
Date Submitted: 2018-02-14
Date Reported: 2018-02-16
Project: 1406631
COC #: 828343

Lab I.D.	1345111
Sample Matrix	Soil
Sample Type	
Sampling Date	2018-01-10
Sample I.D.	17-106 SA7/20-22

Group	Analyte	MRL	Units	Guideline	1345111
Agri. - Soil	pH	2.00			8.04
	SO4	0.01	%		0.03
General Chemistry	Cl	0.002	%		0.029
	Electrical Conductivity	0.05	mS/cm		0.50
	Resistivity	1	ohm-cm		2000

Guideline = *** = Guideline Exceedence**

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

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