November 2013

REPORT ON

Geotechnical Investigation
Proposed Residential Development
East of Bank Street and South of Analdea Drive
Ottawa, Ontario

Submitted to:
Claridge Homes Corporation
2001-210 Gladstone Avenue
Ottawa, Ontario
K2P 0Y6

REPORT

Report Number: 13-1121-0186

Distribution:

4 copies - Claridge Homes Corporation
2 copies - Golder Associates Ltd.

Golder Associates

Table of Contents

FIGURES

APPENDICES

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development to be located east of Bank Street and south of Analdea Drive in Ottawa, Ontario.

The purpose of this subsurface investigation was to determine the general soil, bedrock, and groundwater conditions across the site by means of 12 boreholes and, based on an interpretation of the factual information obtained, along with the existing subsurface information available for the site, to provide engineering guidelines on the geotechnical design aspects of the proposed development, including construction considerations which could influence design decisions.

The reader is referred to the “Important Information and Limitation of this Report” which follows the text but forms an integral part of this report.

2.0 DESCRIPTION OF PROJECT AND SITE

Plans are being prepared to develop a residential subdivision on a parcel of land located east of Bank Street and south of Analdea Drive in Ottawa, Ontario (for location see Key Plan, Figure 1).

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

- The site is located on the east side of Bank Street, opposite Findlay Creek Drive, and south of Analdea Drive;
- The site is approximately rectangular in shape and measures about 300 metres by 950 metres in plan area;
- The site topography is relatively flat;
- The site is currently undeveloped and vegetated with grass, shrubs, and trees; and,
- The site will be developed as a conventional residential development with mixed use commercial at the west end of the development and a park at the southeast corner of the property.

Golder Associates carried out the previous geotechnical investigation for the sanitary sewer which extends along the south side of the site. The results of that investigation were provided in the following report:

- “Geotechnical Investigation, Proposed Trunk Sewers, Sundance Village Development, Ottawa, Ontario” dated December 2010 (report number 10-1121-0014).

The results of that investigation indicate that the subsurface conditions along the sewer alignment generally consist of between about 2.5 and 6 metres of silt, sand, clayey silt, and glacial till overlying bedrock. Beneath the west section of the sewer alignment, the bedrock consists of dolomitic limestone. Beneath the east section, the bedrock consists of shale. This difference is consistent with the published geologic mapping, which indicates the Gloucester Fault to cross the west portion of this site. To the west of the fault, the bedrock is mapped as being dolomitic limestone of the Oxford Formation. To the east of the fault, the bedrock is mapped as being shale of the Carlsbad Formation.

Based on the previous investigation, the overburden soils above the glacial till along the western portion of the sewer/site primarily consist of more granular soils (silt and sand over glacial till). Over the east part, more cohesive soils, consisting of clayey silt, were encountered over the glacial till.

3.0 PROCEDURE

The field work for this investigation was carried between October 7 and 16, 2013. During that time, 12 boreholes (numbered 13-1 to 13-12, inclusive) were put down at the approximate locations shown on the Site Plan, Figure 2.

The boreholes were advanced using a track-mounted hollow-stem auger drill rig supplied and operated by Marathon Drilling Company Ltd. of Ottawa, Ontario. The boreholes were advanced to practical refusal to augering which was encountered at depths ranging from about 1.5 metres to 6.7 metres below the existing ground surface.

Standard penetration tests were carried out within the boreholes at regular intervals of depth. Samples of the soils encountered were recovered using split spoon sampling equipment.

Upon encountering auger refusal on the bedrock surface, boreholes 13-5 and 13-8 were advanced about 1.4 and 0.9 metres, respectively, into the bedrock using diamond drilling techniques while retrieving NQ sized bedrock core.

To allow for subsequent measurement of the groundwater level, standpipe piezometers were installed in boreholes 13-2, 13-7, and 13-12. The groundwater levels in the standpipes were measured on October 23, 2013.

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 samples, and took custody of the samples retrieved.

On completion of the drilling operations, samples of the soils and bedrock obtained from the boreholes were transported to our laboratory for examination by the project engineer and for laboratory testing. Geotechnical index and classification tests, such as water content determinations and grain size distribution tests, were carried out on select soil samples.

Two samples of soil, one each from boreholes 13-6 and 13-11, were submitted to Exova Laboratories Ltd. for chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements.

The borehole locations were selected by Golder Associates and located in the field in relation to the existing site features. The final location and the ground surface elevation at each borehole were surveyed by Golder Associates using a Trimble R8 GPS survey unit. The elevations are referenced to Geodetic Datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes advanced for the present investigation are shown on the Record of Borehole and Drillhole Sheets in Appendix A. The borehole and test pit records along with relevant laboratory test results from previous Golder report number 10-1121-0014 are provided in Appendix B. The results of the basic chemical analysis carried out on samples of soil from boreholes 13-6 and 13-11 are provided in Appendix C. The results of the grain size distribution testing are shown on Figures 3 and 4.

The subsurface conditions on this site generally consist of sandy and silty soil underlain by a deposit of glacial till, which in turn overlies limestone bedrock on the western portion of the site and shale bedrock on the eastern portion of the site. The bedrock surface typically exists at depths ranging from about 1.5 to 6.6 metres below the existing ground surface, increasing in depth from the west to the east.

The following sections present an overview of the subsurface conditions encountered in the testholes from both the present and previous investigations.

4.2 Topsoil

Topsoil exists at the ground surface at all of the borehole and test pit locations. The topsoil ranges from approximately 50 to 530 millimetres in thickness, but is more generally between 150 and 360 millimetres.

4.3 Silty Clay and Clayey Silt

Silty clay and clayey silt exist at several of the testhole locations (numbered 13-3, 13-6, 13-9 to 13-11, 10-104, and 10-106 to 10-111, and test pit 10-B).

These deposits varying from about 0.3 to 3.9 metres in thickness and extend to depths of 0.6 to 5.3 metres below the existing ground surface.

The results of standard penetration testing carried out within the silty clay and clayey silt gave ‘N’ values ranging from 2 to 21 blows per 0.3 metres of penetration, indicating a firm to very stiff consistency.

The measured water contents of two samples of the clayey silt were about 24 and 30 percent.

The results of grain size distribution testing on two samples of this deposit are provided on Figure 3.

4.4 Silty Sand to Sandy Silt, Silt, and Sand

The topsoil and shallow silty and clayey soils are often underlain by variable deposits of silty sand, sandy silt, silt, and sand. These deposits exists at depths ranging from about 0.1 to 0.8 metres below the existing ground surface and have a thicknesses varying from about 0.7 to 4.4 metres.

The results of standard penetration testing carried out within these deposits gave ‘N’ values ranging from 3 to 81, but more generally from 8 to 20, blows per 0.3 metres of penetration, indicating a very loose to very dense state of packing.

The measured water contents of samples from these deposits from 6 to 20 percent.

4.5 Glacial Till

A deposit of glacial till underlies the topsoil, clayey soils, and silty and sandy deposits in most of the test holes, with the exception of boreholes 13-2 and 13-3. In general, the glacial till is a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of sandy silt to silty sand.

The glacial till was fully penetrated in all of the test pits, and varies from about 0.2 to 1.9 metres in thickness. The glacial till was fully penetrated in about half of the boreholes (i.e., bedrock was encountered) and varies from about 1.1 to 3.4 metres in thickness. In the remainder of the boreholes, practical refusal to augering was encountered within the glacial till at depths ranging from about 1.8 to 6.6 metres depth.

SPT ‘N’ values obtained in this material ranged widely from 13 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 likely reflect the presence of cobbles and boulders within the deposit, or the surface of the bedrock, rather than the actual state of packing of the soil matrix. Boulders of up to about 1.5 metres in diameter were encountered within the test pits.

The measured water contents of samples of the glacial till ranged from 7 to 12 percent.

The results of grain size distribution testing on one sample of glacial till are provided on Figure 4.

4.6 Bedrock and Refusal

Practical refusal to augering was encountered within the overburden soils in 14 of the boreholes. The refusals were encountered at depths varying between about 1.5 and 6.6 metres below the existing ground surface. Refusal may indicate the bedrock surface; however, it could also represent cobbles and/or boulders within the overburden soils.

Bedrock was encountered (i.e., verified to be bedrock within the test pits or boreholes) in the remaining 16 testholes. The bedrock was encountered at depths varying from about 1.5 to 6.7 metres below the existing ground surface. Several of the boreholes from the current and previous investigations were extended into the bedrock using rotary diamond drilling techniques, while retrieving NQ sized core. A summary of the Rock Quality Designation, Solid Core Recovery, and Total Core Recovery are provided on the Drillhole Records. In several of the boreholes, the upper portion of the bedrock is weathered and the borehole was advanced into the bedrock by up to an additional 0.1 to 2.9 metres before encountering practical refusal to augering.

In general, the bedrock appears to slope downward toward the east.

A summary of the depths and elevations (if available) of the bedrock surface or refusal, as well as the ground surface elevations at the testhole locations, is provided in the following table.

Test Pit / Borehole Number	Ground Surface Elevation (m)	Bedrock Surface / Refusal Depth (m)	Bedrock Surface / Refusal Elevation (m)	Remarks
13-1	96.38	3.96	92.42	Auger Refusal
13-2	94.55	1.47	93.08	Auger Refusal
13-3	96.38	1.52	94.86	Bedrock Proven by Sampling
13-4	92.37	1.78	90.59	Auger Refusal
13-5	93.08	3.07	90.01	Bedrock Cored
13-6	90.46	5.05	85.41	Auger Refusal
13-7	92.19	2.82	89.37	Auger Refusal
13-8	91.20	5.94	85.26	Bedrock Cored
13-9	90.39	5.51	84.88	Auger Refusal
13-10	90.38	4.90	85.48	Auger Refusal
13-11	90.48	6.58	83.90	Auger Refusal
13-12	89.99	6.55	83.44	Auger Refusal
10-1	93.66	4.62	89.04	Bedrock Cored
10-2	90.45	4.85	85.60	Bedrock Proven by Sampling
10-3	90.30	6.25	84.05	Bedrock Proven by Sampling
10-101	94.24	2.49	91.75	Auger Refusal
10-102	94.30	2.57	91.73	Auger Refusal
10-103	93.49	2.13	91.36	Bedrock Proven by Sampling
10-104	92.04	3.20	88.84	Bedrock Proven by Augering
10-105	92.51	4.72	87.79	Bedrock Proven by Augering
10-106	90.13	4.95	85.18	Auger Refusal
10-107	89.62	4.80	84.82	Bedrock Proven by Augering
10-108	89.54	4.57	84.97	Bedrock Proven by Sampling
10-109	89.60	5.84	83.76	Auger Refusal
10-110	90.06	6.71	83.35	Bedrock Proven by Augering
10-111	90.34	5.49	84.85	Bedrock Proven by Augering
10-A	-	2.20	-	Bedrock Exposed in Test Pit
10-B	-	2.70	-	Bedrock Exposed in Test Pit
10-C	-	4.50	-	Bedrock Exposed in Test Pit
10-D	-	1.90	-	Bedrock Exposed in Test Pit

The results of additional previous laboratory testing on the bedrock (from Golder report 10-1121-0014), including compressive strength testing and ‘whole rock’ analyses, are provided in Appendix C.

4.7 Groundwater and Hydraulic Conductivity

Standpipe piezometers were installed in three of the boreholes on the site, a summary of the depths and elevations of the groundwater level measurements is provided in the following table. Also included in this table are the data for the relevant boreholes previously advanced along the south side of the site (Golder report 10-1121-0014).

Borehole Number	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Observation
13-2	94.55	0.48	94.07	October 23, 2013
13-7	92.19	0.93	91.26	October 23, 2013
13-12	89.99	0.98	89.01	October 23, 2013
10-1 deep	93.66	3.17	90.49	September 28, 2010
10-1 shallow	93.66	3.72	89.94	February 16, 2010
10-2	90.45	0.04	90.41	March 29, 2010
10-3	90.30	0.05	90.25	March 29, 2010
10-103	93.49	0.17	93.32	September 28, 2010
10-108 deep	89.54	0.06	89.48	September 28, 2010
10-108 shallow	89.54	0.70	88.84	September 28, 2010

The groundwater conditions were also observed in the test pits during the short time that they remained open. Groundwater seepage was generally observed at depths varying from 1.0 to 3.8 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.

The following table summarizes the measured hydraulic conductivities which were measured during the previous investigation.

Borehole Number	Geological Unit	Date of Measurement	Calculated Hydraulic Conductivity (cm/sec)
10-1A	Dolomitic Limestone	September 28, 2010	2.2×10^{-4}
10-1B	Dolomitic Limestone	February 16, 2010	9.3×10^{-4}
10-103	Glacial Till / Shale Bedrock	September 28, 2010	3.4×10^{-4}
10-2	Sand/Glacial Till	March 29, 2010	2.8×10^{-4}
10-108A	Shale Bedrock	September 28, 2010	9.7×10^{-4}
10-108B	Glacial Till	September 28, 2010	4.1×10^{-6}
10-3	Silt	March 29, 2010	3.5×10^{-5}
10-113	Clayey Silt / Glacial Till	September 28, 2010	6.2×10^{-4}

5.0 DESIGN AND CONSTRUCTION CONSIDERATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the testhole information and project requirements, and is subject to the limitations in the “Important Information and Limitations of This Report” which follows the text but forms an integral part of this report.

5.2 Site Grading

In general, the subsurface conditions on this site consist of silty sand, sand, clayey silt and sandy silt, underlain by glacial till, over limestone (western end of the site) and shale bedrock. The depth to the bedrock surface typically ranges from about between 1.5 to 6.7 metres below the existing ground surface. The depth to the bedrock surface increases from west to east. The groundwater level is typically within about 0.5 to 1.0 metres of the existing ground surface.

From a foundation design perspective, no practical restrictions apply to the thickness of grade raise fill that may be placed within the proposed residential development area. However, the feasibility of grade raises in excess of 4 metres, if proposed for portions of this site, should be reviewed.

With regards to the site grading, it should also be noted that the silt and sand deposits are relatively permeable and the groundwater levels are shallow. Excavations for basement construction and the installation of the site services in these areas which extend below the groundwater level could encounter problematic groundwater inflows. Therefore, there would be some advantage to limiting the required depth of excavation since the groundwater management requirements (and costs) increase with excavation depth below the groundwater level. Limiting the groundwater management requirements would be particularly important for the basement excavations since these are not made in a single operation and thus re-mobilization of groundwater control equipment to the site for each excavation requiring this treatment could be prohibitively costly. To this end, it would be preferred, from a geotechnical perspective, to limit the depth of excavation for basement construction to no more than about 1.0 metres below the *existing* ground surface level.

In addition, the shale bedrock at this site has the potential to expand (swell) following exposure to oxygen. This process involves a series of chemical reactions, some of which are purely chemical and others of which are at least catalyzed by micro-organisms. The general mechanism is considered to be that pyrite (FeS_2), which is present at low concentrations in the shale, is weathered in the combined presence of oxygen and water to form sulphuric acid. That sulphuric acid then reacts with calcite, which is also present within the shale either as an integral part of the rock or as filling within joints, to form gypsum. The gypsum crystals tend to form within existing fractures and to be volumetrically larger than the materials that formed them, thus resulting in heaving. Other mineral by-products of these reactions, such as the mineral jarosite, form a yellowish powder that is a characteristic indicator of this process.

For the above reactions to occur there must be both water and oxygen available. An increase in the ground temperature, such as due to the heat from the basement area, is also considered to promote the above reactions.

Heaving of the shale could damage the foundations, basement floor slabs, and superstructures.

It is also possible for the products of the above reactions to attack the concrete (i.e., sulphate attack).

To prevent expansion of the shale and/or reaction with the concrete, the shale must be protected from exposure to oxygen both in the long term as well as temporarily during construction. As discussed in Section 5.5, the bedrock will need to be protected/covered with a mud slab of lean concrete wherever the founding levels will be within shale bedrock. If possible, the grading for this site should be set so that at least 0.5 metres of soil remain between the underside of the footing and the shale bedrock surface. In areas where this is not feasible (i.e., there will be less than 0.5 metres of cover above the shale bedrock), the overburden soils should be excavated to the bedrock surface, the bedrock covered as soon as practical with a 50 millimetre thick concrete mud slab, and the subgrade level raised to the underside of footing elevation with compacted engineered fill. The engineered fill should consist of Ontario Provincial Standard Specification (OPSS) Granular B Type II, placed in maximum 300 millimetre thick lifts, and should be compacted to 95 percent of its standard Proctor maximum dry density using suitable vibratory compaction equipment. The engineered fill material must be placed within the full zone of influence of the house foundations. The zone of influence is considered to extend out and down from the edge of the perimeter footings at a slope of 1 horizontal to 1 vertical.

The concrete mud slab should be made with sulphate resistant cement (Type HS or equivalent). Construction planning should ensure the shale is not left exposed and uncovered overnight.

In addition, the houses should be designed so that a uniform subgrade level will be provided for the entire house such that no areas of higher bedrock are left in-place which would be vulnerable to drying (i.e., stepped foundations or walk-outs should be avoided).

Furthermore, where the footings are founded on or within bedrock, the grading should be set so that there is no more than about 0.3 metres difference between the underside of footing elevations between adjacent houses, to prevent draining and drying of the shale bedrock.

For predictable performance of the structures, roadways, and site services, preparation for filling the site should include stripping the existing topsoil. The topsoil is not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only.

5.3 Foundations

With the exception of the topsoil, the native soils and bedrock on this site are considered suitable for the support of conventional wood frame houses and townhouse blocks on spread footing foundations. For design purposes, the allowable bearing pressures for spread footings may be taken as 75 kilopascals for the sandy silt, clayey silt, silty clay, silty sand, sand, and glacial till provided these soils have not been disturbed by groundwater inflow or construction traffic. For footings founded on or within bedrock, an allowable pressure of 250 kilopascals may be used. These maximum allowable bearing pressures would be applicable for strip footings up to 1 metre in width and pad footings up to 2 metres in size.

Based on these allowable bearing pressure values, the house footings may be sized in accordance with Part 9 of the Ontario Building Code.

The post-construction total and differential settlements of footings supported on soil and sized using the above maximum allowable bearing pressures should be less than 25 and 15 millimetres, respectively, provided that the soil at or below founding level is not disturbed before or during construction. Suitable control of the groundwater inflow is required if such disturbance is to be avoided. Footings on bedrock should experience negligible settlements. Protection of the shale bedrock (if encountered) is also required, to avoid heaving, as discussed in Sections 5.2 and 5.5.

The overburden materials on this site contain cobbles and boulders. Any cobbles or boulders in footing areas which have been loosened by the excavation process should be removed and the cavity filled with lean concrete.

At some locations on the property, and depending on the amount of proposed grade raise (i.e., filling), the inorganic subgrade elevation may be lower than the underside of footing elevation. At these locations, the subgrade may be raised to the footing elevation using engineered fill consisting of Ontario Provincial Standard Specification (OPSS) Granular B Type II, placed in maximum 300 millimetre thick lifts, and compacted to 95 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment. The engineered fill material must be placed within the full zone of influence of the house foundations. The zone of influence is considered to extend out and down from the edge of the perimeter footings at a slope of 1 horizontal to 1 vertical.

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

There may be portions of the site where the shallow silty sand 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.

Since these shallow sandy deposits, wherever present, are typically loose, they could be potentially liquefiable in an earthquake (i.e., potentially subject to temporary strength loss and post-earthquake settlements). That potential issue is not however considered relevant to the house design because:

- The expected long term groundwater level will generally be below these soils, such that they will be above the water level and therefore non-liquefiable.
- The potential post-earthquake differential settlements would be relatively small in relation to the expected collapse potential of a house (and the objective of earthquake-resistant design is only to avoid collapse and to provide for safe exit).
- The proof rolling of the sandy subgrade soils, as specified above, would densify any such soils in the immediate area of the footings and therefore the directly supporting soils would be non-liquefiable.

5.4 Seismic Design

The seismic design provisions of the 2006 Ontario Building Code depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or bedrock below founding level. Based on the 2006 Ontario Building Code methodology, this site can be assigned a Site Class of D, acknowledging that this requirement does not apply to ground oriented residential structures designed per part 9 of the Ontario Building Code. More favourable Site Class values could potentially be assigned for portions of the site if shear wave velocity testing were carried out. The founding levels versus the bedrock levels would also need to be known. However, it is considered that the Site Class of D permits conventional foundation design for this site.

5.5 Basement Excavations

Excavations for basement areas and the construction of foundation elements will be through topsoil, silts and sands, and glacial till. In some areas, bedrock excavation may also be required, which could be the case within the western portion of the site, in the vicinity of test pit 10-D and boreholes 13-2, 13-3, and 13-4.

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

For shallow depths of excavation, it may be possible to remove the upper weathered portion of the shale, to at least about 1.0 metres depth, using large hydraulic excavating equipment. Further bedrock removal could be accomplished using mechanical methods (such as hoe ramming). Even shallow depths of bedrock removal within the limestone will require mechanical methods. Excavations deep into the bedrock will likely require drill and blast procedures. Near vertical trench walls in the bedrock should stand unsupported for the construction period, at least for moderate depths.

Based on present groundwater levels, excavations deeper than about 1.0 metres will likely extend below the groundwater level. Where this is the case, the excavation will be subject to disturbance to the granular soils caused by the upward flow of groundwater, resulting in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes.

Provided that the basement excavations are no more than about 1.0 metres deep (relative to the current ground level), it is considered that it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the floor of the excavations. Where the subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel) or a 150 millimetre thick layer of OPSS Granular A underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

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. These measures would be particularly necessary wherever the excavation will extend more than about 1.0 metres below the existing ground surface.

It should be noted that the installation of site services will likely result in some limited lowering of the general groundwater level and improved excavating conditions, in advance of the basement excavations being made.

Consideration should be given at the time of tendering for the basement excavation work to carrying out a few test excavations across the site in the presence of the bidders so that the actual excavating conditions and rate of groundwater inflow can be assessed.

Where the groundwater level is lowered below the floor of the excavation in advance of construction, excavation side slopes should be stable in the short term at 1 horizontal to 1 vertical. Excavation side slopes below groundwater level in the overburden soils will slough to a somewhat flatter inclination. In accordance with the Occupational Health and Safety Act of Ontario, these excavation side slopes would likely need to be cut back at 3 horizontal to 1 vertical (i.e., Type 4 soils). If required, near vertical trench walls in the bedrock should stand unsupported for the construction period.

As previously discussed in Section 5.2, to prevent expansion of the shale and/or reaction with the concrete, the shale must be protected from exposure to oxygen both in the long term as well as temporarily during construction. When exposed during construction, the shale must be covered as soon as practical following exposure with a 50 millimetre thick concrete mud slab. Where the excavation floor will be within 0.5 metres above the bedrock surface, protection measures will also be required and the excavation will need to be deepened to expose the bedrock, and a mud slab placed.

The concrete mud slab should be made with sulphate resistant cement (Type HS or equivalent). Construction planning should ensure the shale is not left exposed and uncovered overnight.

5.6 Basement Floor Slabs

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

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

Where the footing level is below the natural groundwater level and supported on the soil (rather than the bedrock), there would be the potential for loss of ground and settlement of structures due to soil particles from the subgrade soils migrating into the underslab clear stone fill resulting from groundwater inflow into the underslab drainage system. Therefore, where that is the case, the clear stone should be separated from the subgrade soils with a Class II non-woven geotextile, in accordance with OPSS 1860, having a Filtration Opening Size (FOS) not exceeding 100 microns.

5.7 Frost Protection

The native soils at this site are frost susceptible. The shale bedrock may also be frost susceptible, if/where it is highly weathered, or contains soil-filled seams. For frost protection purposes, all exterior footings or interior footings in unheated areas should be provided with a minimum of 1.5 metres of earth cover. Isolated, exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover.

5.8 Basement Walls and Wall Backfill

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

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

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

5.9 Site Servicing

Excavations for the installation of site services will be through the overburden soils and, at least on some portions of the site, into bedrock. Based on the observed groundwater conditions, it is expected that many of these excavations will be below the groundwater level.

Significant groundwater inflow should be expected from the dolomitic limestone bedrock which is present on the west portion of the site, and also from the sandier portions of the overburden. Lesser groundwater inflow is expected from the silt, glacial till, and shale bedrock.

Based on previous investigation work completed in the area of this site, including the investigation for the sanitary sewer along the south site boundary, the dolomitic limestone is expected to have a hydraulic conductivity in the range of 10^{-3} to 10^{-1} centimetres per second, which is very high. Therefore, significant groundwater inflows are expected for excavations extending into this bedrock formation. The flow will be primarily from the upper several metres, where the bedrock is typically quite fractured. Therefore, where excavations are expected to extend into the dolomitic limestone bedrock, the pumping requirements will be significant. Pre-pumping from sumps in the bedrock for a period of a few weeks might be a feasible method to lowering the groundwater in advance of excavation. This method of groundwater control was required and successfully used on other nearby sites.

The rate of groundwater inflow from the sandier overburden materials will likely also be significant, resulting in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes. Based on past experience on adjacent sites, some pre-drainage of the sandier overburden will likely be required, but which may also occur in conjunction with pre-drainage of the bedrock. The drainage could also be carried out by constructing several sumps and pre-pumping from the sandier overburden carried out in advance of excavation.

The hydraulic conductivities of the silty soils, glacial till and shale bedrock are expected to be in the range of 10^{-6} to 10^{-4} centimetres per second. Groundwater inflow into the trenches in these materials could initially be significant, but should diminish with time and continued pumping, and it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps and using suitably sized and multiple pumps within the excavations.

Where the trench will be entirely within the glacial till but with the surface of the underlying bedrock at only shallow depth below the trench floor, there could be a risk basal heaving of the trench floor; basal heaving occurs where the weight of the soil cover is less than the piezometric pressure in the underlying bedrock. Such basal heaving could result in disturbance of the pipe subgrade. However, the groundwater control operations for the westerly sections of sewer, which will likely be installed in bedrock, will involve pumping from the bedrock, and the zone of influence of that pumping may extend beneath the adjacent sections of pipe as well. If that is the case, and if the rate of pumping is sufficient, it is possible that this pumping could sufficiently lower the groundwater level in the bedrock such that basal heaving would not occur.

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 excavation, and the time of year at which the excavation is made. The expected level of pumping would require that a Category 3 Permit-To-Take-Water (PTTW) be obtained from the Provincial Ministry of the Environment (MOE).

As discussed above, significant volumes of water will be pumped from the excavations. Water pumped from the excavations will likely be discharged (possibly via ditches) to the storm water management pond which is located south of this site, north of Blais Road. The dewatering or excavation contractor should be made responsible for obtaining the necessary permits for discharge and ensuring compliance with the applicable sewer use by-law.

Excavations within the layered sand, sandy silt, silty sand, and silt, and glacial till below the water table should be carried out within a protective trench box. The stand-up time for exposed side slopes will be extremely short and the subgrade will be disturbed if left exposed for any length of time. Construction of the site services should be planned to be carried out in short sections which can be fully completed in a minimal amount of time.

The contractor should prepare a groundwater management plan for review and approval.

Bedrock removal could be accomplished using mechanical methods (such as hoe ramming), at least for shallow depths of excavation. Deeper excavations will likely require drill and blast procedures. Near vertical trench walls in the bedrock should stand unsupported for the construction period, at least for moderate depths (i.e., less than about 3 metres).

It should also be noted that the bedrock surface elevation and quality may be very irregular in the area of the fault that defines the transition between the dolomitic limestone and the shale.

Blasting should be controlled to limit the peak particle velocities at all adjacent structures or services (e.g., the existing storm sewer at the south portion of the site) 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.

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface occurs, it may be necessary to place a sub-bedding layer consisting of 300 millimetres of compacted OPSS Granular B Type II beneath the Granular A. 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 standard Proctor maximum dry density. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or surrounding soil 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 standard Proctor maximum dry density.

It is should be generally acceptable to re-use the excavated overburden soils as trench backfill. However, some of the overburden materials (such as the sandy silts) may be too wet to compact. Where that is the case, the wet materials should be wasted (and drier materials imported) or these materials should be placed only in the lower portions of the trench, recognizing that some future settlement of the roadways may occur and 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 within the lower portions 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 loading. The rock fill should be limited to a maximum of 300 millimetres in size.

In areas where the trench will be covered with hard surfaced materials, the type of material placed within the frost zone (between finished grade and two 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 standard Proctor maximum dry density. It should be noted that some of the excavated materials will be quite wet and difficult to compact. These materials would best be placed in the lower portions of the trenches to minimize the post-construction settlements of the backfill.

5.10 Pavement Design

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

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

Transition from bedrock to earth subgrade (if this condition is encountered) should be carried out in accordance with the OPSD 205 series. The transition depth “t” should be taken as 1.8 metres.

The surface of the subgrade or fill should be crowned to promote drainage of the pavement granular structure. Perforated pipe subdrains should be provided at subgrade level extending from the catch basins for a distance of at least 3 metres in four orthogonal directions or longitudinally where parallel to a curb.

The pavement structure for local roads which will not experience bus or truck traffic (other than school bus and garbage collection) should be:

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

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

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

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the materials standard Proctor maximum dry density using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 9 of OPSS 310.

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

Superpave 12.5 mm Surface Course – 40 millimetres

Superpave 19 mm Base Course – 50 millimetres

The pavement design should be based on a Traffic Category of Level B on local roads and Level C on collector roads. The asphalt cement should be PG 58-34.

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. Given that the roadway subgrade in some locations could consist of relatively wet trench backfill, it should be planned to include a significant contingency for such works.

5.11 Corrosion and Cement Type

Samples of soil from boreholes 13-6 and 13-11 were submitted to Exova Laboratories Ltd. for chemical analysis related to potential corrosion of exposed buried ferrous elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix C.

The results indicate a high potential for corrosion of exposed ferrous metal.

The results also indicate that Type GU cement should be acceptable for substructures. However, as previously mentioned, oxidation of pyrite in the shale bedrock beneath this site could produce ferrous sulphate and sulphuric acid.

5.12 Pools, Decks and Additions

5.12.1 Above Ground and In Ground Pools

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

5.12.2 Decks

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

5.12.3 Additions

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

5.13 Re-use of Shale Bedrock

As previously discussed, the shale bedrock on this site has the potential to swell once exposed to air (i.e., once allowed to dry); this swelling could be detrimental to the performance of overlying grade dependent structures. Therefore, given the potential swelling nature of the shale bedrock, this material should not be used for roadway subgrade fill, garage backfill, or foundation wall backfill, unless the swelling potential and characteristics are assessed (by means of laboratory testing) and found acceptable.

5.14 Trees

When trees draw water from clayey soils, the soil can experience shrinkage which can result in settlement of adjacent structures.

The soils at this site are generally non-clayey in nature, in which case no restrictions would apply to the planting of trees adjacent to proposed structures.

Some clayey silt was encountered beneath the east part of the site, however, this soil is considered to be have a low shrinkage-potential, and the grading will also likely be such that the deposit would be quite deep and therefore below the expected depth of root penetration. In this regard, restrictions on the planting of trees (from a geotechnical perspective) are also not expected to be necessary in this area. However, this assessment should be reviewed once the site grading is known.

5.15 Community Park Facilities

A future city park is proposed to be located at the southeast corner of the proposed development. One borehole, 13-2, was advanced within the park limits to assess the subsurface conditions in this area. Based on the results of the investigation, the subsurface conditions underlying the park are consistent with the rest of the development in that part of the site. Therefore, no special considerations are anticipated for the construction of standard park facilities, such as pathways, playgrounds, park shelters, parking lots, sports fields, and/or basketball courts.

This recommendation is preliminary and is provided for planning purposes only. Additional geotechnical information will be required at the detailed design stage.

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 view point.

The test pits from the previous investigations were loosely backfilled upon completion of excavating and therefore constitute zones of disturbance. The locations of the test pits appear to be outside of foundation areas. However, should the development layout change such that the test pits will be located within the areas of influence/support of future buildings, then those test pits will need to be repaired at the time of construction.

At the time of the writing of this report, only conceptual details for the proposed development were available. Golder Associates should be retained to review the final drawings and specifications for this project prior to tendering to ensure that the guidelines in this report have been adequately interpreted.

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.

A large trunk sewer exists on the southern portion of the site. The construction of that sewer was carried out mostly within a trench box; this limits the excavation size. However, it is possible that the excavation may have extended within the footprint of the houses. If this is the case, some of the backfill material will need to be subexcavated and replaced with engineered fill. Further guidance will be required if this condition is encountered.

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.

W. Alex Meacoe

Alex Meacoe, EIT

Troy

Troy Skinner, P.Eng.
Associate

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

WAM/TMS/bg

n:\active\2013\1121 - geotechnical\13-1121-0186 claridge kellam lands bank st\report\13-1121-0186 rpt-001 geotechnical investigation november 2013.docx

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

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

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

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

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

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

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

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

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

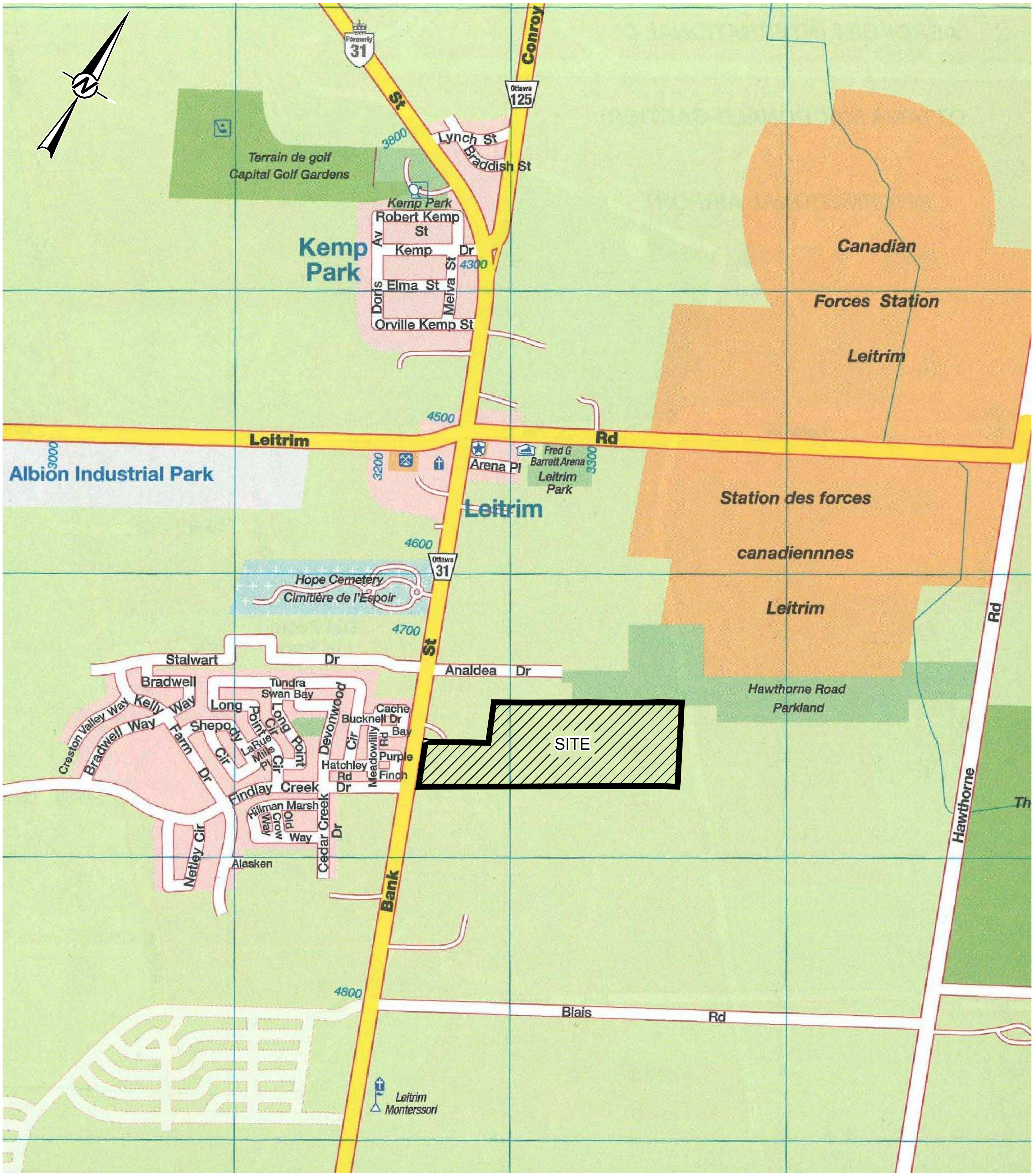
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

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

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

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

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



NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT No. 13-1121-0186

0 400 800 1,200

SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
OTTAWA, ONTARIO

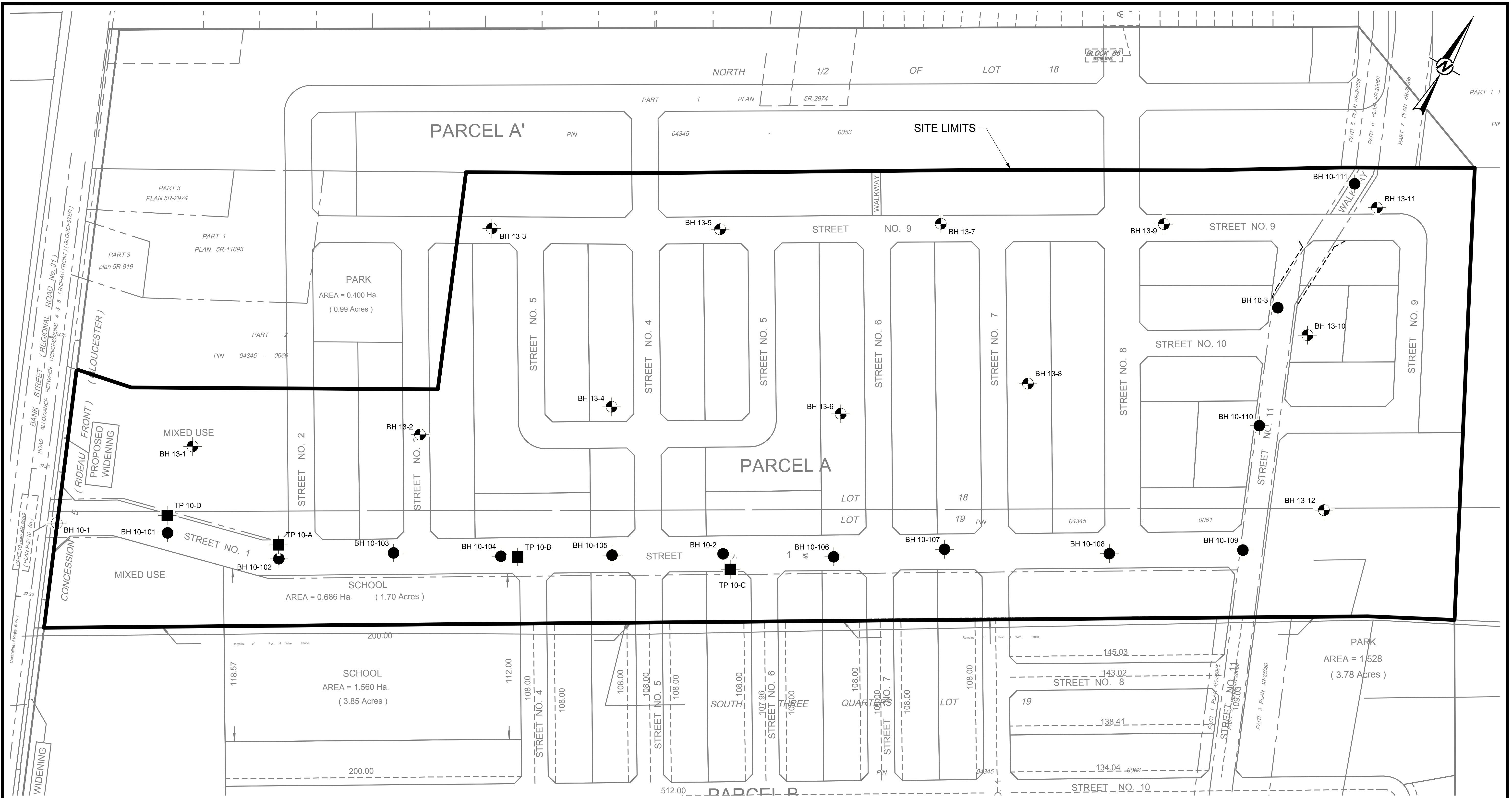
TITLE

KEY PLAN

Golder Associates

PROJECT No.		13-1121-0186	FILE No.	1311210186-01
DESIGN			SCALE	AS SHOWN
CADD	JM	2013-11-05	FIGURE	
CHECK	WAM	2013-11-05		1
REVIEW	TMS	2013-11-05		

N:\Active\2013\1121 - Geotechnical\13-1121-0186 Claridge Kellam Lands Bank St\Spatial IM\CAD\PRODUCTION\1311210186-01.dwg | Layout: ANSI_A_FIGURE_PORTRAIT | Modified: jmcconnell 11/06/2013 1:06 PM | Plotted: jmcconnell 11/06/2013



LEGEND

⊕	APPROXIMATE BOREHOLE LOCATION IN PLAN, CURRENT INVESTIGATION
■	APPROXIMATE TEST PIT LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD., REPORT No. 10-1121-0014
●	APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTGATION BY GOLDER ASSOCIATES LTD., REPORT No. 10-1121-0014

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT No. 13-1121-0186

REFERENCE

BASE PLAN SUPPLIED IN ELECTRONIC FORMAT BY CLARIDGE HOMES CORPORATION

0 50 100 150
SCALE METRES

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RVW

PROJECT
GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
OTTAWA, ONTARIO

TITLE

SITE PLAN

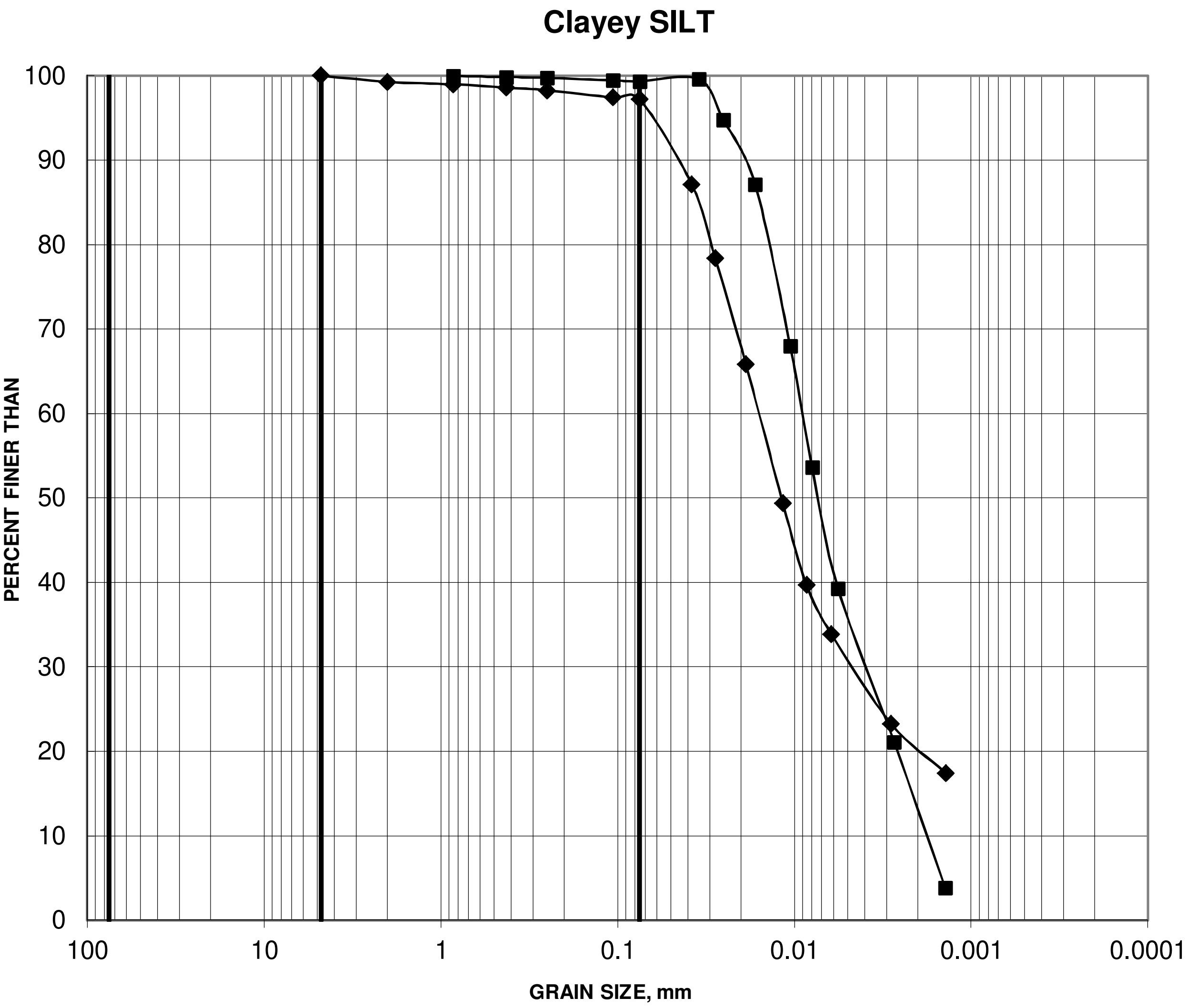
Golder Associates

PROJECT No.		13-1121-0186	FILE No.	1311210186-02
DESIGN			SCALE	AS SHOWN
CADD	JM	2013-11-05	FIGURE	
CHECK	WAM	2013-11-05		2
REVIEW	TMS	2013-11-05		

N:\Active\2013\1121 - Geotechnical\13-1121-0186 Claridge Kellam Lands Bank St\Spatial IM\CAD\PRODUCTION\1311210186-02.dwg | Layout: ANSI_B_FIGURE_LANDSCAPE | Modified: jmcconnell 11/06/2013 3:01 PM | Plotted: jmcconnell 11/06/2013

GRAIN SIZE DISTRIBUTION

FIGURE 3



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

Borehole	Sample	Depth (m)
■ 13-9	2	1.52-2.13
◆ 13-10	3A	2.29-2.59

Created by: CW
Checked by: CNM

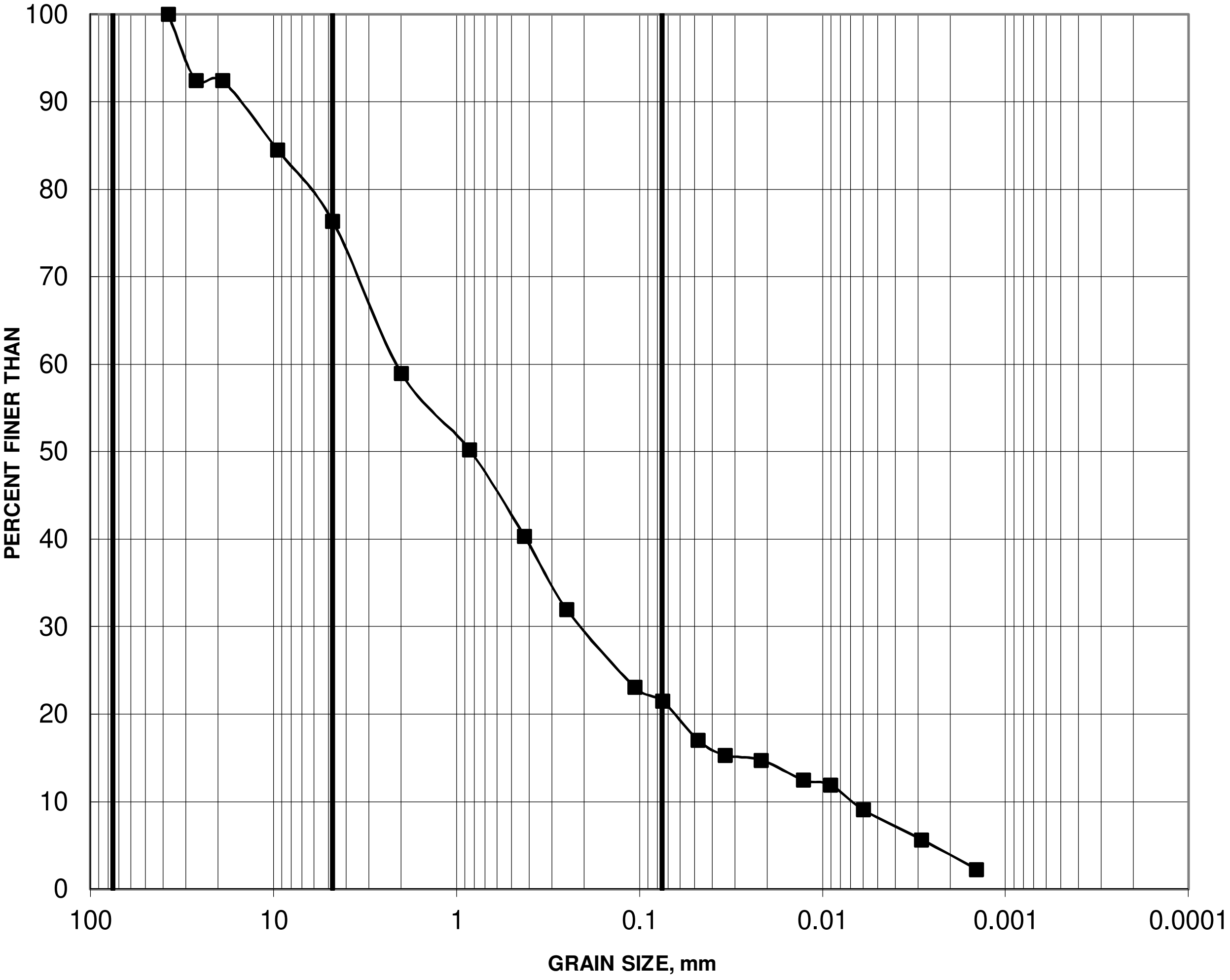
Project: 13-1121-0186

Golder Associates

GRAIN SIZE DISTRIBUTION

FIGURE 4

GLACIAL TILL



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

Borehole	Sample	Depth (m)
■ 13-1	3	2.29-2.90

Project: 13-1121-0186

Golder Associates

Created by: CW
Checked by: CNM

APPENDIX A

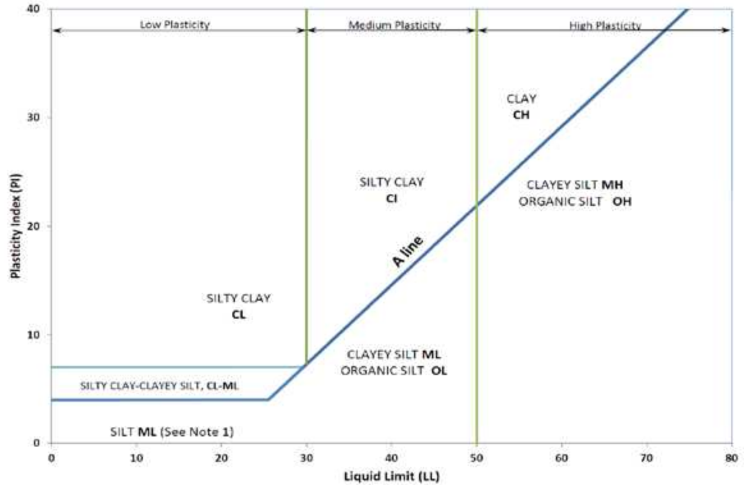
List of Abbreviations and Symbols
Lithological and Geotechnical Rock Description Terminology
Record of Borehole and Drillhole Sheets
Current Investigation

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(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 = $\tan\delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint
FLT	Fault
SH	Shear
VN	Vein
FR	Fracture
SY	Stylolite
BD	Bedding
FO	Foliation
CO	Contact
AXJ	Axial Joint
KV	Karstic Void
MB	Mechanical Break
PL	Planar
CU	Curved
UN	Undulating
IR	Irregular
K	Slickensided
PO	Polished
SM	Smooth
SR	Slightly Rough
RO	Rough
VR	Very Rough

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-1

SHEET 1 OF 1

LOCATION: N 5020559.0 ;E 375921.5

BORING DATE: Oct. 7, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: 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		96.38							
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.00							
		(SM) - SILTY SAND, some gravel; brown; non-cohesive, moist, loose to compact		96.15 0.23							
1					1	50 DO	8				
2					2	50 DO	27				
		(SM) SILTY SAND, some gravel; brown, with cobbles and boulders, (GLACIAL TILL); non-cohesive, moist, dense		94.09 2.29	3	50 DO	35		○	MH	
3					4	50 DO	35				
				92.42	5	50 DO	>50				
4		End of Borehole Auger Refusal		3.96							Borehole dry upon completion of drilling Oct. 7, 2013
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

MIS-BHS 001 1311210186.GPJ GAL-MIS.GDT 11/12/13 SL/JM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-2

SHEET 1 OF 1

LOCATION: N 5020642.9 ;E 376050.4

BORING DATE: Oct. 7 and 8, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

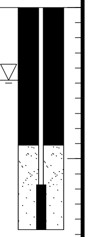
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	94.55					
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00					
		(ML) - SANDY SILT; grey brown; non-cohesive, moist	94.32 0.23					Bentonite Seal
1		(SM) - SILTY SAND, some gravel; grey brown; non-cohesive, moist, dense	93.71 0.84	1	50 DO	37		Silica Sand
		(SM) - SILTY SAND; grey, with shale fragments; non-cohesive, moist, dense	93.25 1.30					Standpipe
		End of Borehole Auger Refusal	1.47					
2								W.L. in Standpipe at Elev. 94.07 m on Oct. 23, 2013
3								
4								
5								
6								
7								
8								
9								
10								



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-3

SHEET 1 OF 1

LOCATION: N 5020787.5 ;E 376022.5

BORING DATE: Oct. 8, 2013

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	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	96.38							
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00							
		(CI) - SILTY CLAY; brown; cohesive, w>PL, very stiff	0.13							
1		(SM) - SILTY SAND; brown; non-cohesive, moist, loose	95.54 0.84	1	50 DO	6				
2		Weathered SHALE BEDROCK	94.86 1.52	2	50 DO	56				
				3	50 DO	>50				
3		End of Borehole Auger Refusal	93.81 2.57							Borehole dry upon completion of drilling Oct. 8, 2013
4										
5										
6										
7										
8										
9										
10										

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-4

SHEET 1 OF 1

LOCATION: N 5020723.9 ;E 376152.8

BORING DATE: Oct. 8, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: 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		92.37							
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.00							
		(SM) SILTY SAND, some gravel; brown, with cobbles and boulders, (GLACIAL TILL); non-cohesive, moist, compact		92.19 0.18							
1					1	50 DO	26		○		
					2	50 DO	>50				
		End of Borehole Auger Refusal		90.59 1.78							
2											Borehole dry upon completion of drilling Oct. 8, 2013
3											
4											
5											
6											
7											
8											
9											
10											

MIS-BHS 001 1311210186.GPJ GAL-MIS.GDT 11/12/13 SL/JM

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-5

SHEET 1 OF 2

LOCATION: N 5020864.4 ;E 376156.1

BORING DATE: Oct. 8, 15 and 16, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.08							
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.00							
		(SM) SILTY SAND, some gravel; brown, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense		0.15							
1					1	50 DO	17		○		
2					2	50 DO	68				
					3	50 DO	39				▽
3	Rotary Drill NQ Core	Moderately weathered, thinly bedded, black SHALE BEDROCK		90.01 3.07	C1	NQ RC	DD				
4					C2	NQ RC	DD				
		End of Borehole		88.66 4.42							W.L. in open hole at Elev. 90.64 m upon completion of drilling Oct. 16, 2013
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF DRILLHOLE: 13-5

SHEET 2 OF 2

LOCATION: N 5020864.4 ;E 376156.1

DRILLING DATE: Oct. 8, 15 and 16, 2013

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG:

DRILLING CONTRACTOR:

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

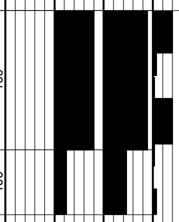
BD- Bedding
FO- Foliation
CO- Contact
OR- Orthogonal
CL - Cleavage

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

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

BR - Broken Rock

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



DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	COLOUR % RETURN FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3 m	DISCONTINUITY DATA B Angle	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec	Diametral Point Load Index (MPa)	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Continued from previous page		90.01																
	Rotary Drill NQ Core	Moderately weathered, thinly bedded, black SHALE BEDROCK		3.07	C1	100														
4					C2	100														
				88.66																
		End of Drillhole		4.42																W.L. in open hole at Elev. 90.64 m upon completion of drilling Oct. 16, 2013
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				

Hydraulic conductivity scale: 10^{-6} 10^{-5} 10^{-4} 10^{-3}; Point load scale: 2 4 6; B Angle: 0 90 180 270; Dip w.r.t. core axis: 0 30 60 90

DEPTH SCALE
1 : 50

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-6

SHEET 1 OF 1

LOCATION: N 5020797.4 ;E 376289.0

BORING DATE: Oct. 8, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	90.46						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00						
		(ML) - sandy CLAYEY SILT; brown; cohesive, w~PL, very stiff	90.18 0.28						
1				1	50 DO	5			
				2	50 DO	10			
2		(ML) - CLAYEY SILT; grey; cohesive, w>PL, stiff to very stiff	88.48 1.98						
				3	50 DO	4			∇
3		(SM) SILTY SAND, some gravel; grey, with cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, compact	87.57 2.89						
				4	50 DO	26	○		
4				5	50 DO	27			
		(SM) SILTY SAND, some gravel; grey, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, very dense	85.89 4.57	6	50 DO	>50			
5		End of Borehole Auger Refusal	85.41 5.05						W.L. in open hole at Elev. 88.02 m upon completion of drilling Oct. 8, 2013
6									
7									
8									
9									
10									

MIS-BHS 001 1311210186.GPJ GAL-MIS.GDT 11/12/13 SL/JM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-7

SHEET 1 OF 1

LOCATION: N 5020942.3 ;E 376283.2

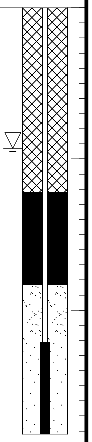
BORING DATE: Oct. 9, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.19							
0	Power Auger 200mm (Diam Hollow Stem)	TOPSOIL		0.00							
		(SM) SILTY SAND, some gravel; brown, with cobbles and boulders, (GLACIAL TILL); non-cohesive, moist, compact		0.15							Native Backfill
1					1	50 DO	21				
											Bentonite Seal
2					2	50 DO	35		○		
				90.12 2.07							Silica Sand
		(SM) SILTY SAND, some gravel; grey, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, dense			3	50 DO	>50				Standpipe
				89.37 2.82							
3		End of Borehole Auger Refusal									W.L. in Standpipe at Elev. 91.26 m on Oct. 23, 2013
4											
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-8

SHEET 1 OF 2

LOCATION: N 5020878.4 ;E 376388.2

BORING DATE: Oct. 9 and 11, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	HYDRAULIC CONDUCTIVITY	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.20						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00						
		(SP) - SAND, some gravel; grey brown; non-cohesive, moist, compact to dense	0.15						
1				1	50 DO	20			
2				2	50 DO	48	○		▽
		(SM) - SILTY SAND, some gravel; grey, with shale fragments, non-cohesive, wet, very dense	88.91 2.29	3	50 DO	81			
3	Washboring NW casing	(SM) - SILTY SAND, some gravel; grey, with cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, dense to very dense	88.33 2.87						
4				4	50 DO	>50			
5				5	50 DO	45			
				6	50 DO	99			
6	Rotary Drill NQ Core	Moderately weathered, thinly bedded, black SHALE BEDROCK	85.26 5.94	C1	NQ RC	DD			
7		End of Borehole	84.32 6.88						W.L. in open hole at Elev. 89.22 m upon completion of drilling Oct. 11, 2013
8									
9									
10									

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF DRILLHOLE: 13-8

SHEET 2 OF 2

LOCATION: N 5020878.4 ;E 376388.2

INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: Oct. 9 and 11, 2013

DRILL RIG:

DRILLING CONTRACTOR:

DATUM: Geodetic

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

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH COLOUR % RETURN	RECOVERY TOTAL CORE % 80 60 40 20	RECOVERY SOLID CORE % 80 60 40 20	R.Q.D. % 80 60 40 20	FRACT. INDEX PER 0.3 m 5 10 15 20	DISCONTINUITY DATA B Angle 0 90 180 270	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0 30 60 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jcon	Jr	Ja	HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}	Diametral Point Load Index (MPa) 2 4 6	RMC -Q' AVG.	NOTES WATER LEVELS INSTRUMENTATION
		Continued from previous page		85.26																
6	WB NW Rotary Drill NQ Core	Moderately weathered, thinly bedded, black SHALE BEDROCK		5.94 84.32	C1			■	■											
7		End of Drillhole		6.88																W.L. in open hole at Elev. 89.22 m upon completion of drilling Oct. 11, 2013
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-9

SHEET 1 OF 1

LOCATION: N 5021017.6 ;E 376413.7

BORING DATE: Oct. 9, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.30m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	90.39						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00						
		(SM) - SILTY SAND; brown; non-cohesive, wet	90.21 0.18						
1		(ML) - CLAYEY SILT; grey brown; non-cohesive, moist, very stiff	89.48 0.91	1	50 DO	18			
				2	50 DO	10	○	MH	
2		(SM) SILTY SAND, some gravel; grey, with cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, compact to dense	88.29 2.10						∇
				3	50 DO	39			
3				4	50 DO	26			
4				5	50 DO	36			
		(SM) SILTY SAND, some gravel; grey, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, very dense	85.82 4.57	6	50 DO	>50			
5				7	50 DO	>50			
		End of Borehole Auger Refusal	84.88 5.51						W.L. in open hole at Elev. 88.10 m upon completion of drilling Oct. 9, 2013
6									
7									
8									
9									
10									

DEPTH SCALE

1 : 50

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-10

SHEET 1 OF 1

LOCATION: N 5021001.3 ;E 376535.1

BORING DATE: Oct. 10, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

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

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		90.38						
0	Power Auger 200mm Diam (Hollow Stem)	TOPSOIL		0.00						
		(CI) - SILTY CLAY; grey brown; cohesive, w>PL, very stiff		0.10						
1		(ML) - CLAYEY SILT; grey brown; non-cohesive, moist to wet, very stiff		89.31 1.07	1	50 DO	10			
					2	50 DO	14			
2										∇
								○	MH	
		(SM) - SILTY SAND, some gravel; grey, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, compact to very dense		87.79 2.59	3	50 DO	17			
3					4	50 DO	22			
4					5	50 DO	61			
					6	50 DO	>50			
5		End of Borehole Auger Refusal		85.48 4.90						W.L. in open hole at Elev. 88.25 m upon completion of drilling Oct. 10, 2013
6										
7										
8										
9										
10										

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-11

SHEET 1 OF 1

LOCATION: N 5021099.3 ;E 376532.5

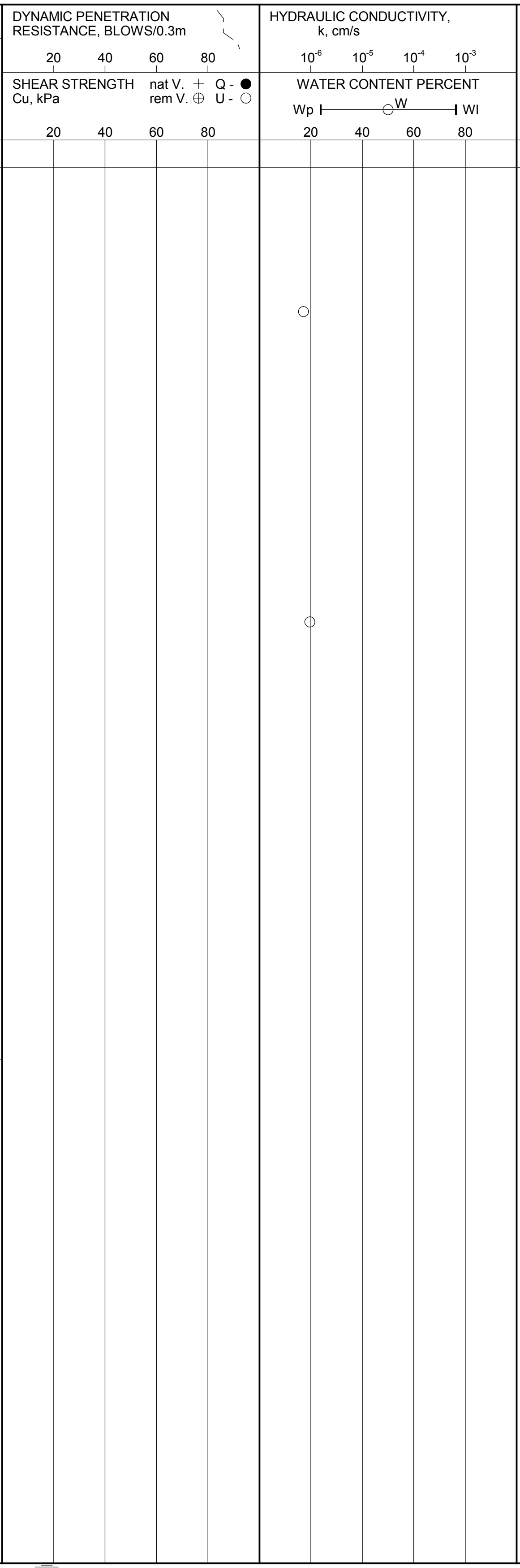
BORING DATE: Oct. 9, 2013

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/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	90.48					
Power Auger 200mm Diam (Hollow Stem)	TOPSOIL	0.00					
	(ML) - SANDY SILT; grey brown; non-cohesive, moist, loose to compact	0.15	1	50 DO	20		
			2	50 DO	4		
	(SM/ML) - SILTY SAND to SANDY SILT; grey; non-cohesive, wet, loose to compact	88.19 2.29	3	50 DO	12		▽
			4	50 DO	11		
			5	50 DO	6		
	(ML) - CLAYEY SILT, some sand; grey; non-cohesive, wet	85.91 4.57	6	50 DO	3		
	(SM) SILTY SAND, some gravel; grey, with shale fragments, cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, compact to dense	85.15 5.33	7	50 DO	14		
			8	50 DO	49		
	End of Borehole Auger Refusal	83.90 6.58					W.L. in open hole at Elev. 88.04 m upon completion of drilling Oct. 9, 2013



MIS-BHS 001 1311210186.GPJ GAL-MIS.GDT 11/12/13 SL/JM

DEPTH SCALE
1 : 50

LOGGED: DG

CHECKED: WAM

PROJECT: 13-1121-0186

RECORD OF BOREHOLE: 13-12

SHEET 1 OF 1

LOCATION: N 5020904.7 ;E 376603.9

BORING DATE: Oct. 9 and 10, 2013

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}

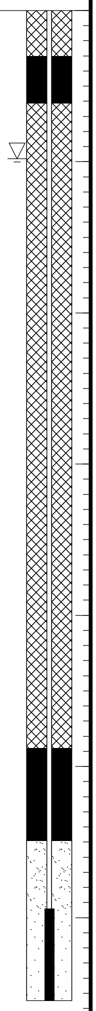
WATER CONTENT PERCENT Wp ⊢ W ○ ⊣ Wl 20 40 60 80

ADDITIONAL LAB. TESTING

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	89.99
	TOPSOIL	0.00
Power Auger 200mm Diam (Hollow Stem)	(SM) - SILTY SAND, very fine; brown; non-cohesive, wet	0.15
	(SP) SAND, some low plasticity fines; brown; non-cohesive, wet	89.46 0.53
	(SM/ML) SILTY SAND to sandy SILT; grey; non-cohesive, wet, compact	89.08 0.91
	(ML) - sandy SILT; grey; non-cohesive, wet, very loose	86.33 3.66
	(SM) SILTY SAND, some gravel; grey, with cobbles and boulders, (GLACIAL TILL); non-cohesive, wet, compact	85.72 4.27
	End of Borehole Auger Refusal	83.44 6.55

NUMBER	TYPE	BLOWS/0.30m
1	GRAB	--
2	50 DO	28
3	50 DO	20
4	50 DO	23
5	50 DO	20
6	50 DO	4
7	50 DO	22
8	50 DO	20
9	50 DO	>50

PIEZOMETER OR STANDPIPE INSTALLATION



Native Backfill

Bentonite Seal

Native Backfill

Bentonite Seal

Silica Sand

Standpipe

W.L. in Standpipe at Elev. 89.01 m on Oct. 23, 2013

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: WAM

APPENDIX B

Borehole and Test Pit Records
Selected Laboratory Test Results
Previous Investigation by Golder Associates
Report 10-1121-0014

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
10-A	0.00 – 0.30	TOPSOIL
	0.30 – 2.20	Brown SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)
	2.20	Refusal on grey DOLOMITIC LIMESTONE BEDROCK
		Note 1: Test pit excavated just north of borehole 10-102. Note 2: Boulders and cobbles were encountered within the glacial till (maximum boulder dimension: about 0.7 metres x 1.5 metres). Note 3: Water seepage at about 1.7 metres depth. Note 4: A test pit was also excavated just to the south of borehole 10-102. Refusal encountered at about 1.6 metres depth on a probable large boulder.
10-B	0.00 – 0.30	TOPSOIL
	0.30 – 0.55	Brown CLAYEY SILT, some sand
	0.55 – 2.20	Brown fine to coarse SAND, trace to some silt
	2.20 – 2.70	Grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)
	2.70	Refusal on black weathered SHALE BEDROCK
		Note 1: Test pit excavated just east of borehole 10-104. Note 2: Water seepage at about 1.0 metres depth.

TABLE 1

RECORD OF TEST PITS

Test Pit Number (Elevation)	Depth (metres)	Description
10-C	0.00 – 0.05	TOPSOIL
	0.05 – 0.50	Brown SILT, trace to some sand
	0.50 – 3.20	Grey brown medium to coarse SAND, with gravel and cobbles
	3.20 – 4.50	Grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)
	4.50	Refusal on probable weathered SHALE BEDROCK
		Note 1: Test pit excavated just south of borehole 10-2. Note 2: Unable to excavate further due to water inflow and considerable sloughing of excavation side walls. Note 3: Water inflow at about 3.8 metres depth.
10-D	0.00 – 0.30	TOPSOIL
	0.30 – 1.70	Brown SILTY SAND
	1.70 – 1.90	Brown SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)
	1.90	Refusal on grey DOLOMITIC LIMESTONE BEDROCK
		Note 1: Test pit excavated just north of borehole 10-101. Note 2: Test pit dry upon completion

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-1

SHEET 1 OF 3

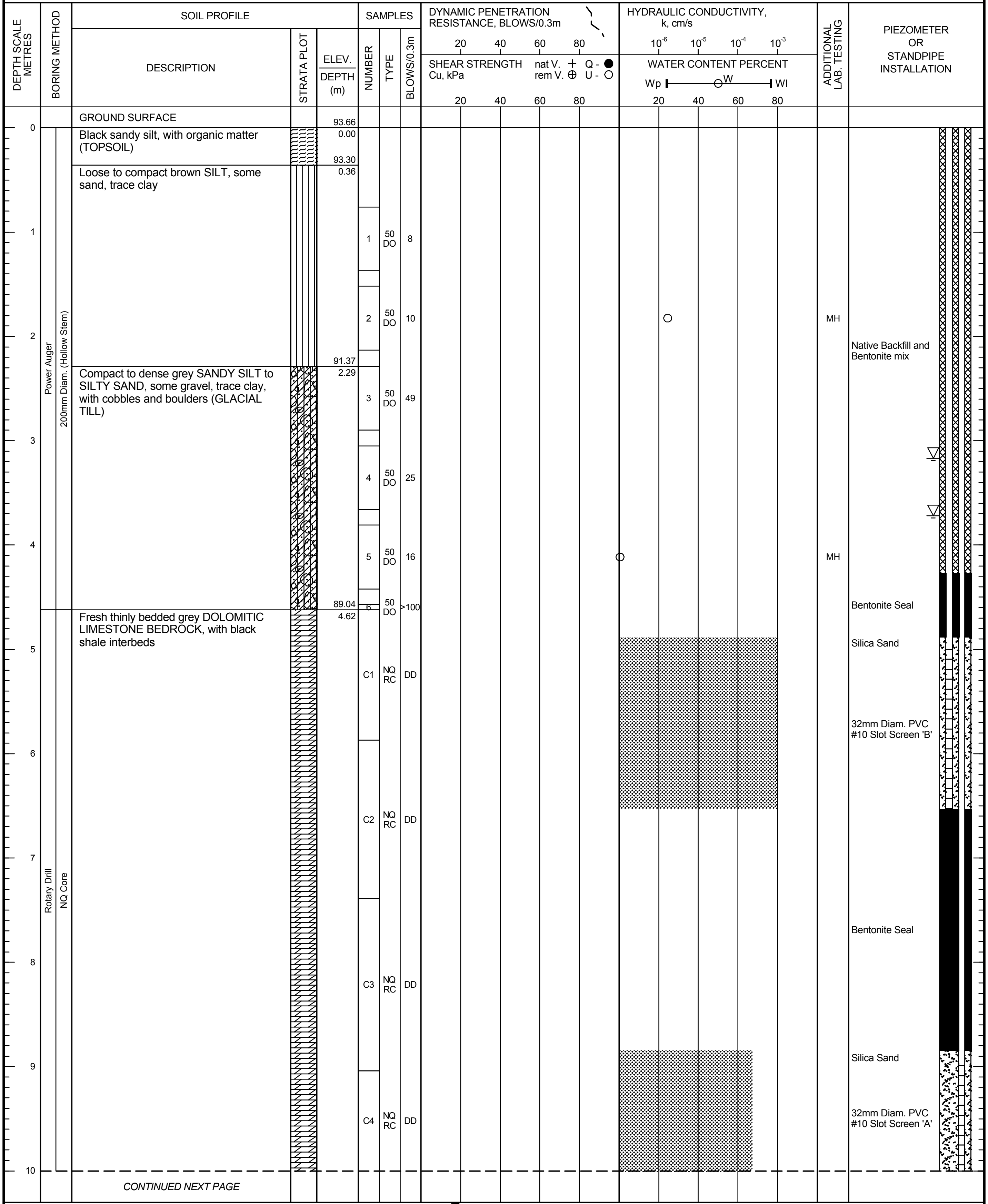
LOCATION: See Site Plan

BORING DATE: Jan. 26 & Sept. 16-17, 2010

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/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	93.66					
Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)	0.00					
	Loose to compact brown SILT, some sand, trace clay	93.30 0.36	1	50 DO	8		
			2	50 DO	10	MH	Native Backfill and Bentonite mix
	Compact to dense grey SANDY SILT to SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	91.37 2.29	3	50 DO	49		
			4	50 DO	25		
			5	50 DO	16	MH	
			6	50 DO	>100		Bentonite Seal
Rotary Drill NQ Core	Fresh thinly bedded grey DOLOMITIC LIMESTONE BEDROCK, with black shale interbeds	89.04 4.62					Silica Sand
			C1	NQ RC	DD		32mm Diam. PVC #10 Slot Screen 'B'
			C2	NQ RC	DD		
			C3	NQ RC	DD		Bentonite Seal
							Silica Sand
			C4	NQ RC	DD		32mm Diam. PVC #10 Slot Screen 'A'

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-1

SHEET 2 OF 3

LOCATION: See Site Plan

BORING DATE: Jan. 26 & Sept. 16-17, 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	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ├──○W──┤ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Rotary Drill NQ Core	Fresh thinly bedded grey DOLOMITIC LIMESTONE BEDROCK, with black shale interbeds	▨		C4	NQ RC	DD				
11			▨		C5	NQ RC	DD				32mm Diam. PVC #10 Slot Screen 'A'
12			▨	81.62 12.04							
		End of Borehole Note: Probable void or mud seam encountered between 8.1m and 8.7m depth.									W.L. in screen 'A' at Elev. 90.49m on Sept. 28, 2010
13											W.L. in screen 'B' at Elev. 89.94m on Feb. 16, 2010
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF DRILLHOLE: 10-1

SHEET 3 OF 3

LOCATION: See Site Plan

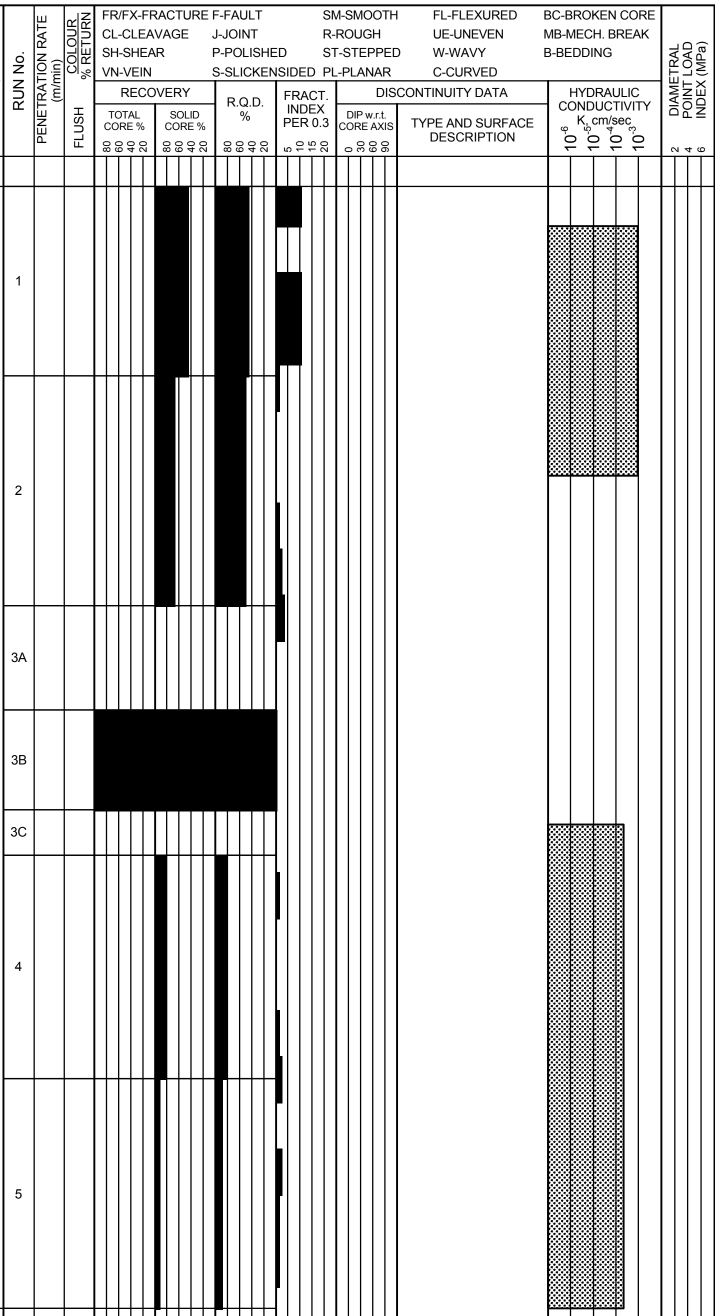
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: Jan. 26 & Sept. 16-17, 2010
DRILL RIG: CME 55
DRILLING CONTRACTOR: Marathon Drilling

DATUM: Geodetic

FR/FX-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	NOTES WATER LEVELS INSTRUMENTATION
		BEDROCK SURFACE			
5	Rotary Drill NQ Core	Fresh thinly bedded grey DOLOMITIC LIMESTONE BEDROCK, with black shale interbeds		89.04 4.62	Bentonite Seal Silica Sand
6					32mm Diam. PVC #10 Slot Screen 'B'
7					
8					Bentonite Seal
9					Silica Sand
10					
11					32mm Diam. PVC #10 Slot Screen 'A'
12		End of Borehole Note: Probable void or mud seam encountered between 8.1m and 8.7m depth.		81.62 12.04	W.L. in screen 'A' at Elev. 90.49m on Sept. 28, 2010 W.L. in screen 'B' at Elev. 89.94m on Feb. 16, 2010
13					
14					



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.
CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Jan. 26-27, 2010

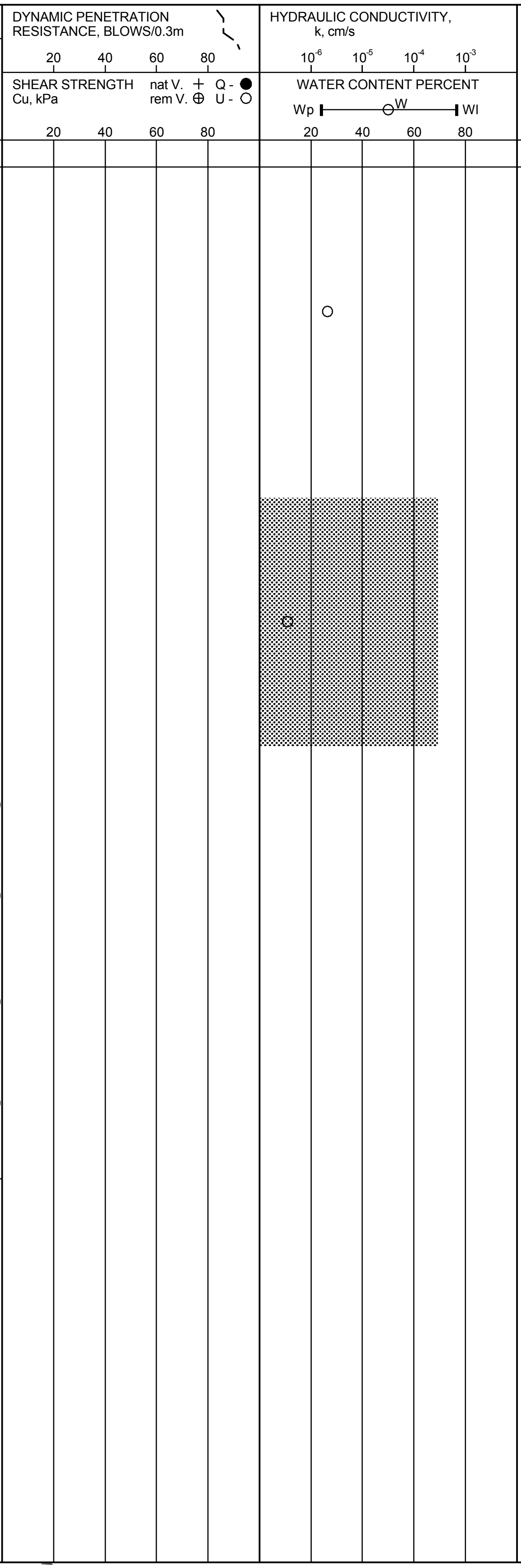
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

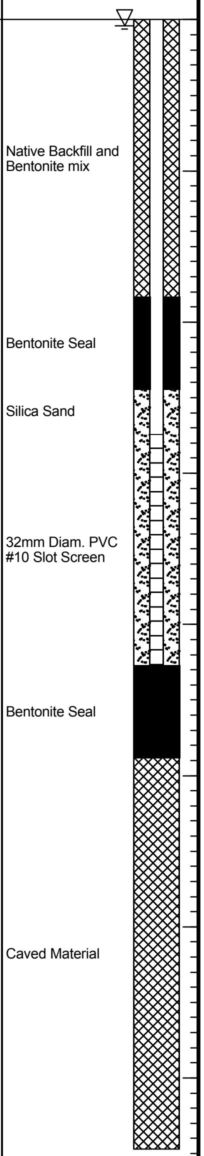
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	90.45				
Black sandy silt, with organic matter (TOPSOIL)	0.00				
Loose grey brown SILT, some sand, trace clay	90.15 0.30	1	50 DO	4	
Compact brown fine SAND, trace silt	88.93 1.52	2	50 DO	15	
Compact grey fine SAND, some silt	88.16 2.29	3	50 DO	15	
Compact to very dense grey SILTY SAND, some gravel and shale fragments, trace clay, with cobbles and boulders (GLACIAL TILL)	87.40 3.05	4 5 6	50 DO 50 DO 50 DO	13 18 >100	MH
Highly weathered to weathered black SHALE BEDROCK	85.60 4.85	7 8 9	50 DO 50 DO 50 DO	>100 >100 >100	
End of Borehole	82.98 7.47				



PIEZOMETER OR STANDPIPE INSTALLATION



W.L. in screen at Elev. 90.41m on Mar. 29, 2010

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

MIS-BHS 001 1011210014-1000.GPJ GAL-MIS.GDT 12/8/10 JM

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Jan. 27, 2010

DATUM: Geodetic

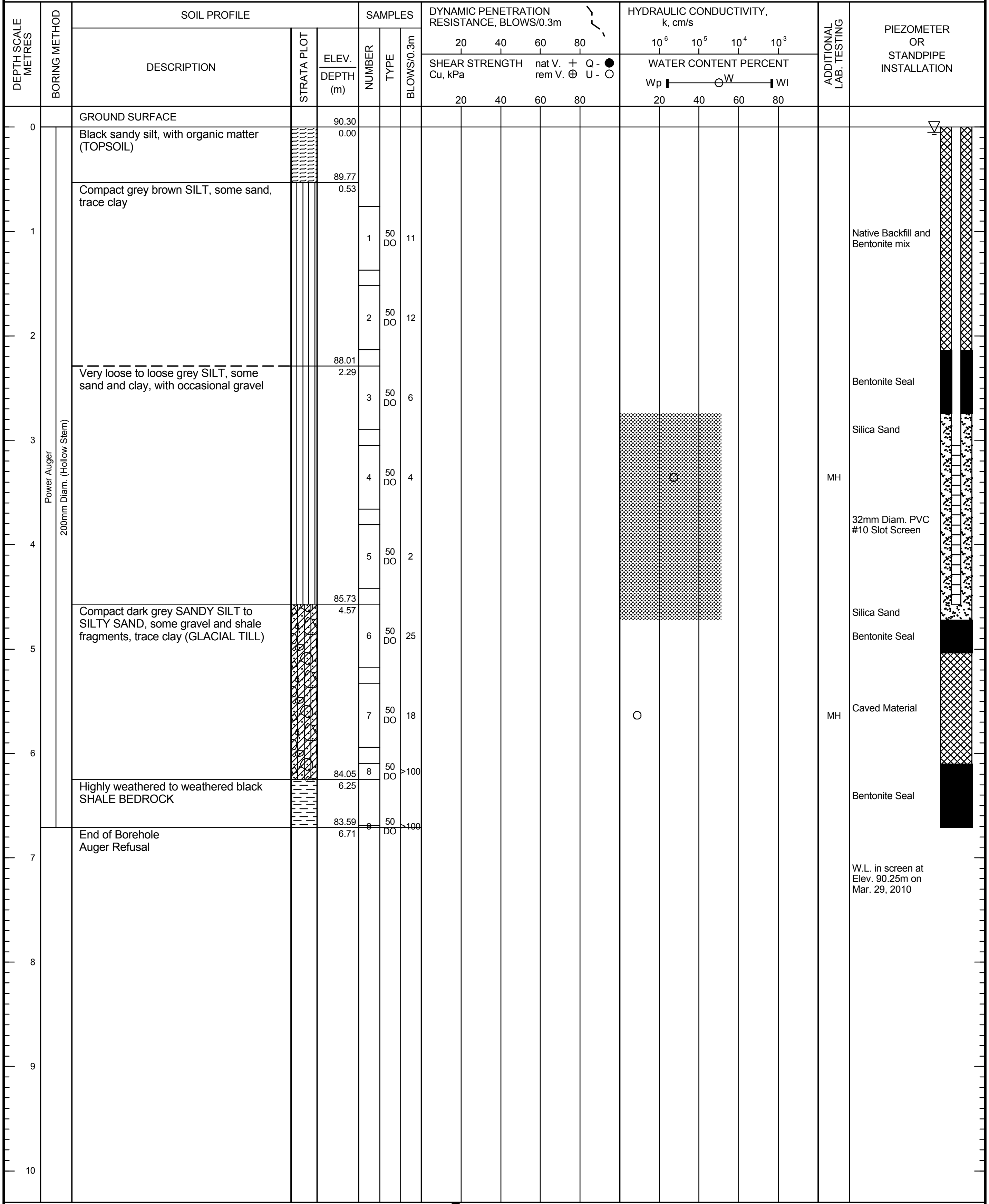
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.30
Black sandy silt, with organic matter (TOPSOIL)	0.00
Compact grey brown SILT, some sand, trace clay	89.77 0.53
Very loose to loose grey SILT, some sand and clay, with occasional gravel	88.01 2.29
Compact dark grey SANDY SILT to SILTY SAND, some gravel and shale fragments, trace clay (GLACIAL TILL)	85.73 4.57
Highly weathered to weathered black SHALE BEDROCK	84.05 6.25
End of Borehole Auger Refusal	83.59 6.71

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	11	
2	50 DO	12	
3	50 DO	6	
4	50 DO	4	MH
5	50 DO	2	
6	50 DO	25	
7	50 DO	18	MH
8	50 DO	>100	
9	50 DO	>100	



PIEZOMETER OR STANDPIPE INSTALLATION:

Native Backfill and Bentonite mix

Bentonite Seal

Silica Sand

32mm Diam. PVC #10 Slot Screen

Silica Sand

Bentonite Seal

Caved Material

Bentonite Seal

W.L. in screen at Elev. 90.25m on Mar. 29, 2010

DEPTH SCALE

1 : 50

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-101

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 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				
		GROUND SURFACE		94.24							
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)		0.00							
1		Brown SANDY SILT		93.96 0.28	1	GRAB					
2		SILTY SAND, with cobbles and boulders (GLACIAL TILL)		92.79 1.45							
3		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		91.75 2.49							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

MIS-BHS 001 1011210014-1000.GPJ GAL-MIS.GDT 12/8/10 JM

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-102

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 17, 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	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.30							
0	Power Auger 200mm Diam. (Hollow Stem)	Dark brown sandy silt, with organic matter (TOPSOIL)		0.00							
		Dense brown SANDY SILT, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		94.00 0.30	1	GRAB					
1											
2					2	50 DO	33				
				91.73							
		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		2.57							
3											Borehole dry upon completion of drilling
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-103

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 17, 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

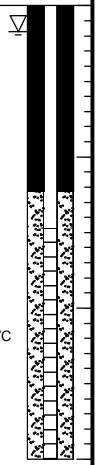
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

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

ADDITIONAL LAB. TESTING

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	93.49			
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)	0.00			
		Compact to very dense SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	93.11 0.38			
1				1	50 DO	13
				2	50 DO	>50
2		Highly weathered to weathered black SHALE BEDROCK	91.36 2.13	3	50 DO	>50
				4	50 DO	>50
3		End of Borehole Auger Refusal	90.49 3.00			
4						
5						
6						
7						
8						
9						
10						

PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

50mm Diam. PVC
#10 Slot Screen

W.L. in screen at
Elev. 93.32m on
Sept. 28, 2010

MIS-BHS 001 1011210014-1000.GPJ GAL-MIS.GDT 12/8/10 JM

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.
CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-104

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 20, 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

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	92.04			
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)	0.00			
		Grey brown CLAYEY SILT	91.74 0.30			
1		Loose brown fine to medium SAND, trace silt	91.38 0.66	1	50 DO	3
2		Compact grey fine SAND, trace silt	90.36 1.68	2	50 DO	24
		Grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	89.97 2.07			
3		Probable highly weathered to weathered Shale Bedrock	88.84 3.20			
4		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling	87.93 4.11			
5						
6						
7						
8						
9						
10						

∇

W.L. in borehole at 0.6m depth below ground surface upon completion of drilling

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-105

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 20, 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	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		92.51							
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)		0.00							
		Compact brown fine to medium SAND, some gravel, trace silt		92.15 0.36							
1					1	50 DO	24				
		Brown to dark grey SANDY SILT, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)		90.99 1.52	2	50 DO	28				
2											
3											∇
4											
		Probable highly weathered to weathered Shale Bedrock		87.79 4.72							
5											
		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		87.18 5.33							W.L. in borehole at 3.1m depth below ground surface upon completion of drilling
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.G.
CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-106

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 20, 2010

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	90.13							
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)	0.00							
		Stiff grey brown CLAYEY SILT, trace sand	89.77 0.36	1	50 DO	2				
		Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	87.54 2.59	2	50 DO	21				∇
5		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling	85.18 4.95							W.L. in borehole at 2.6m depth below ground surface upon completion of drilling
6										
7										
8										
9										
10										

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-107

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 20, 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	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		89.62							
0	Power Auger 200mm Diam. (Hollow Stem)	Black silty clay, with organic matter (TOPSOIL)		0.00							
		Brown to grey brown CLAYEY SILT, trace sand		89.26 0.36	1	GRAB					∇
1											
					2	50 DO	5				
2											
		Stiff grey CLAYEY SILT		87.33 2.29	3	50 DO	3				
3		Grey SILTY SAND, with cobbles and boulders (GLACIAL TILL)		86.75 2.87							
4											
		Probable highly weathered to weathered Shale Bedrock		84.82 4.80							
5		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		4.93							W.L. in borehole at 0.6m depth below ground surface upon completion of drilling
6											
7											
8											
9											
10											

MIS-BHS 001 1011210014-1000.GPJ GAL-MIS.GDT 12/8/10 JM

DEPTH SCALE

1 : 50

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-108

SHEET 1 OF 1

LOCATION: See Site Plan

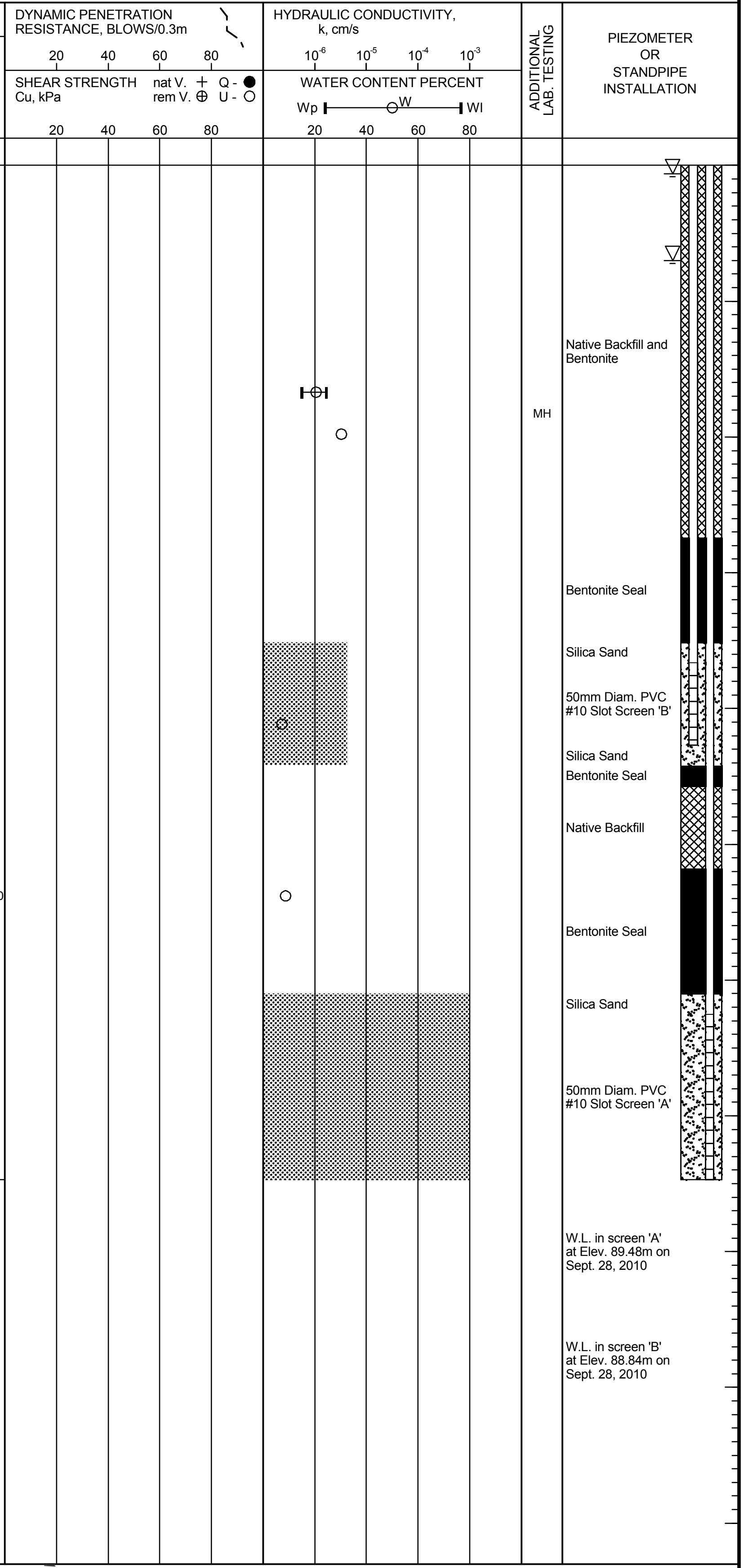
BORING DATE: Sept. 21-22, 2010

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	ADDITIONAL LAB. TESTING
		GROUND SURFACE	89.54				
0	Power Auger 200mm Diam. (Hollow Stem)	Dark brown silty clay, with organic matter (TOPSOIL)	0.00				
		Very stiff grey brown CLAYEY SILT, trace sand	89.34 0.20				
1				1	50 DO	9	
2		Stiff grey CLAYEY SILT, trace sand	87.71 1.83	2	50 DO	6	MH
				3	50 DO	3	
3		Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	86.19 3.35	4	50 DO	8	
4				5	50 DO	13	
		Highly weathered to weathered black SHALE BEDROCK	84.97 4.57	6	50 DO	18	
5				7	50 DO	>100	
6							
7		End of Borehole Auger Refusal	82.07 7.47				
8							
9							
10							



Native Backfill and Bentonite

Bentonite Seal

Silica Sand

50mm Diam. PVC #10 Slot Screen 'B'

Silica Sand

Bentonite Seal

Native Backfill

Bentonite Seal

Silica Sand

50mm Diam. PVC #10 Slot Screen 'A'

W.L. in screen 'A' at Elev. 89.48m on Sept. 28, 2010

W.L. in screen 'B' at Elev. 88.84m on Sept. 28, 2010

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-109

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 23, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	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		89.60							
Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)		0.00 89.37							
	Very stiff to stiff grey brown to grey CLAYEY SILT, occasional sand seam, trace gravel		0.23	1	GRAB					
				2	50 DO	5				
			86.45							
	SILTY SAND, with cobbles and boulders (GLACIAL TILL)		3.15							
			83.76							
	End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		5.84							

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-110

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 22, 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	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		90.06							
0	Power Auger 200mm Diam. (Hollow Stem)	Black sandy silt, with organic matter (TOPSOIL)		0.00							
		Very stiff brown to grey brown CLAYEY SILT, trace sand and gravel		89.88 0.18							
					1	GRAB					
1											∇
					2	50 DO	21				
2											
3											
		SANDY SILT, with cobbles and boulders (GLACIAL TILL)		86.71 3.35							
4											
5											
6											
		Probable highly weathered to weathered Shale Bedrock		83.35 6.71							
7											
		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		82.74 7.32							
8											W.L. in borehole at 1.2m depth below ground surface upon completion of drilling
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.G.

CHECKED: ________

PROJECT: 10-1121-0014

RECORD OF BOREHOLE: 10-111

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Sept. 23, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

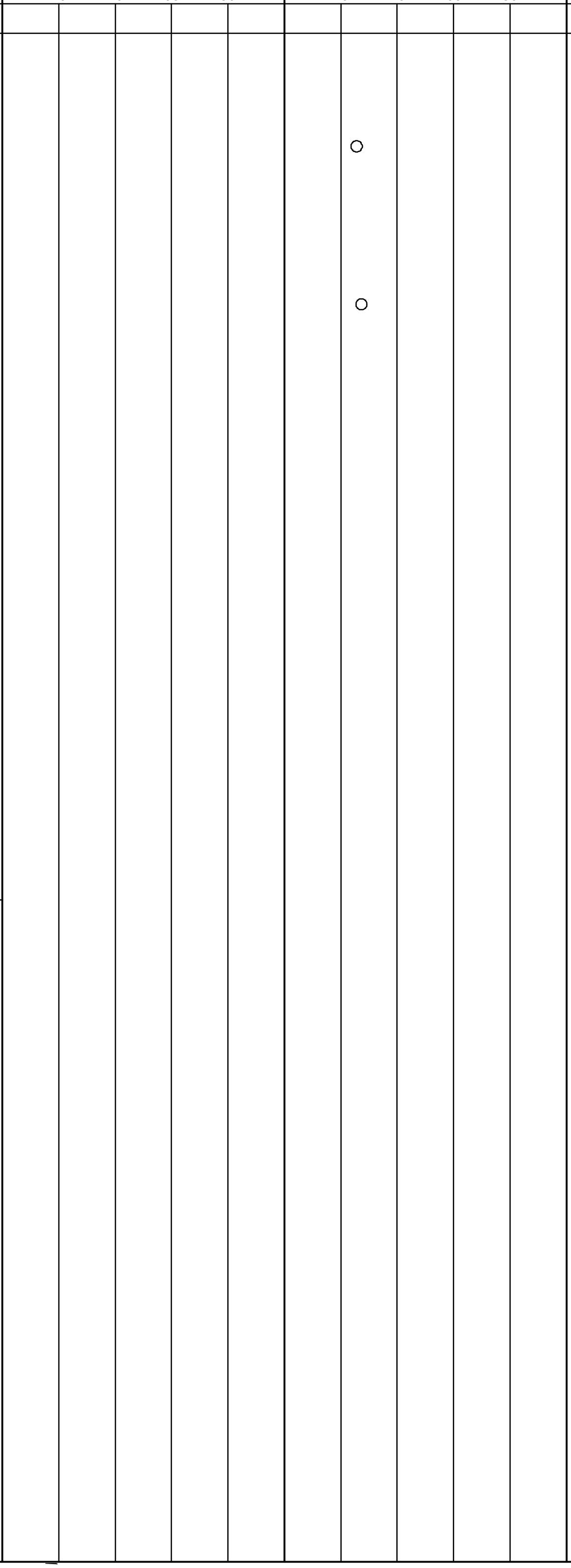
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		
		GROUND SURFACE		90.34					
0	Power Auger 200mm Diam. (Hollow Stem)	Dark grey silty clay, with organic matter (TOPSOIL)		0.00					
		Stiff brown to grey brown CLAYEY SILT, trace gravel, occasional sand seam		90.11 0.23	1	GRAB			
1									∇
2					2	50 DO	6		
4		SILTY SAND, with cobbles and boulders (GLACIAL TILL)		86.23 4.11					
5		Probable highly weathered to weathered Shale Bedrock		84.85 5.49					
6		End of Borehole Auger Refusal Note: Soil stratigraphy inferred from limited sampling		84.50 5.84					W.L. in borehole at 1.1m depth below ground surface upon completion of drilling

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

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

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

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



DEPTH SCALE

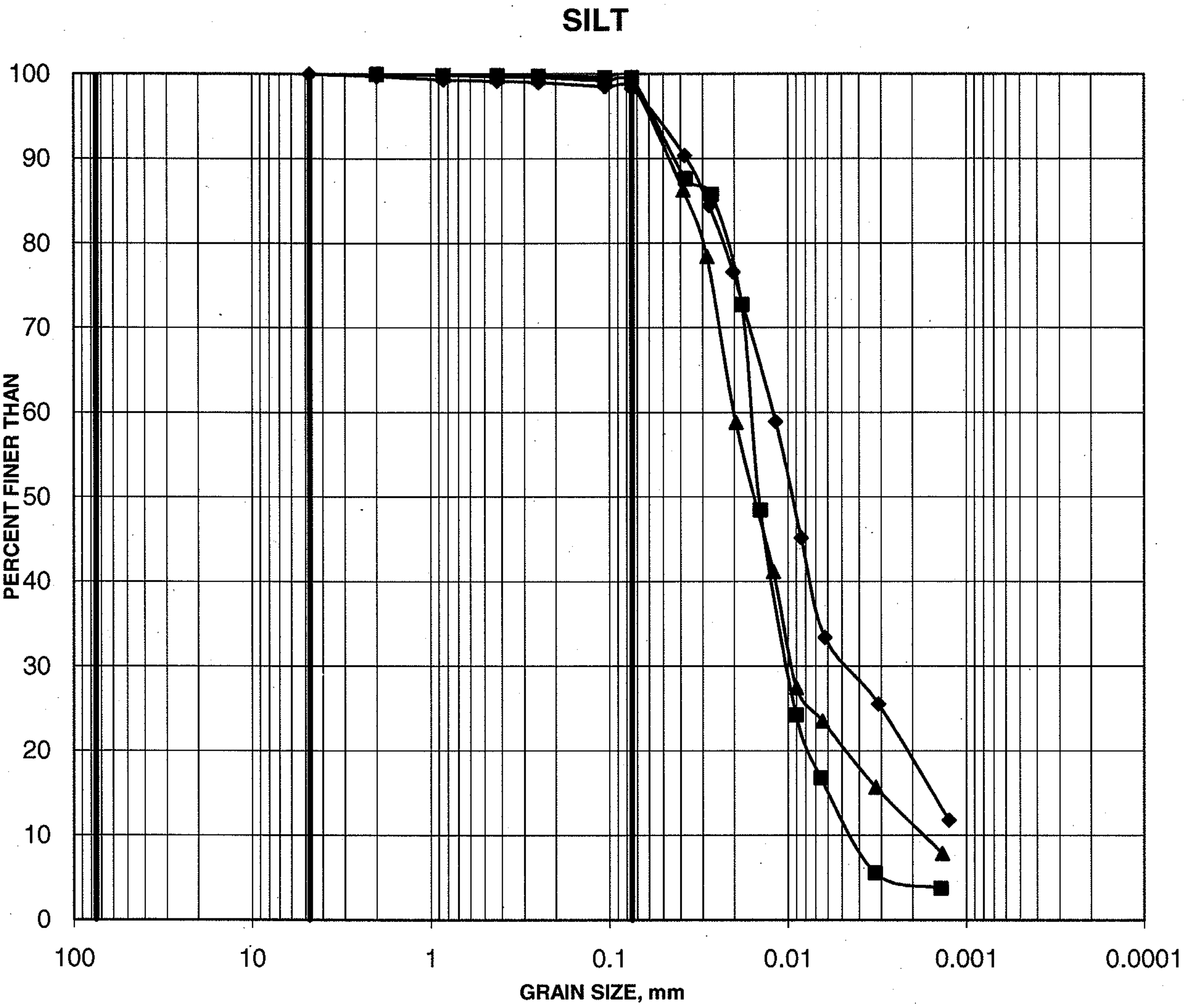
1 : 50

LOGGED: D.G.

CHECKED: ________

GRAIN SIZE DISTRIBUTION

FIGURE 3



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

Borehole	Sample	Depth (m)
■ 10-1	2	1.52-2.13
▲ 10-3	4	3.05-3.66
◆ 10-108	2B	1.83-2.13

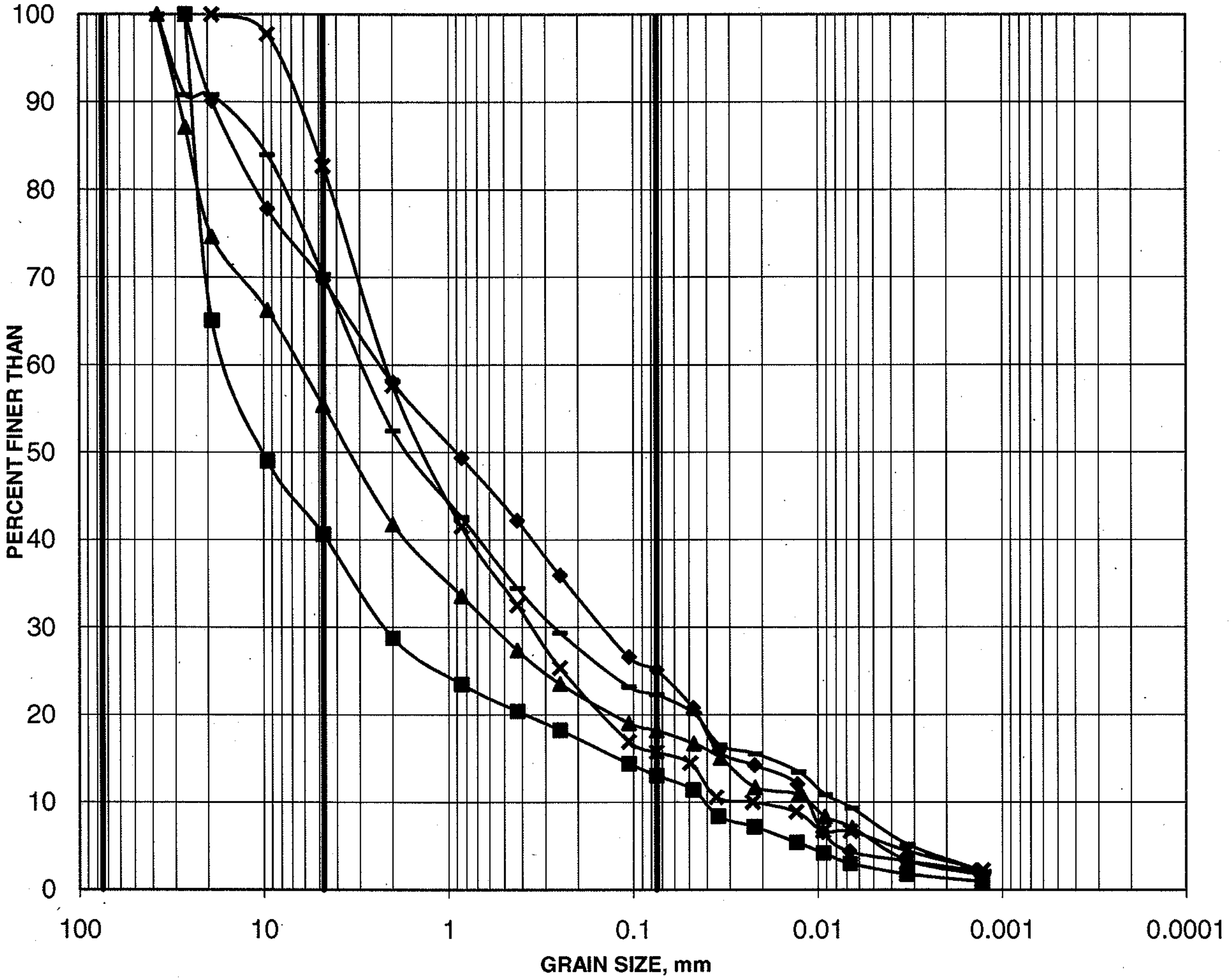
Project: 10-1121-0014

Golder Associates

Created by: MI
Checked by: CNM

GRAIN SIZE DISTRIBUTION

FIGURE 4



GLACIAL TILL

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

Borehole	Sample	Depth (m)
■ 10-1	5	3.81-4.42
× 10-2	4	3.05-3.66
▲ 10-3	7	5.34-5.95
– 10-4	4	3.05-3.66
◆ 10-113	2	1.52-2.13

Project: 10-1121-0014

Golder Associates

Created by: MI
Checked by: CNM

Golder Associates Ltd.
32 Steacie Drive
Kanata, Ontario
K2K 2A9

UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE

Project: Leitrim Sewer

Project No.: 10-1121-0014

Date: October 19, 2010

Location(s):

Bore Hole No.	Depth (m)	Date Tested	Core Size	Diameter (mm)	Density (kg/m³)	Compressive Strength (MPa)
10-1	9.09-9.19	Oct 19/10	NQ	47.5	2760	166.0

REMARKS : - Compressive Strength Corrected for L/D Ratio.
- Cores tested in vertical direction.

TESTING WAS CARRIED OUT IN GENERAL ACCORDANCE WITH ASTM D7012 - Method C

SIGNED:
C.N.Mangione P.Eng.

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Golder Associates
Attn : Kim Lesage

32 Steacie Drive, Kanata
Canada, K2K 2A9
Phone: 613 592 9600, Fax:613 592-9601

Thursday, October 21, 2010

Date Rec. : 07 October 2010
LR Report : **CA02364-OCT10**
Client Ref : Ref No 10-1121-0014

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	**SiO2** **%**	**Al2O3** **%**	**Fe2O3** **%**	**MgO** **%**	**CaO** **%**	**Na2O** **%**	**K2O** **%**	**TiO2** **%**	**P2O5** **%**	**MnO** **%**	**Cr2O3** **%**	**V2O5** **%**	**LOI** **%**	**Sum** **%**
1: BH10-1 Dolomitic Lomestone	12.8	3.36	1.36	17.0	25.0	0.04	1.59	0.11	0.04	0.06	0.01	< 0.01	38.3	99.6

Control Quality Analysis

Debbie Waldon

Debbie Waldon
Project Coordinator,
Minerals Services, Analytical

OnLine LIMS

APPENDIX C

Results of Basic Chemical Analysis
Exova Laboratories Report Number 1323738

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
32 Steacie Drive
Kanata, ON
K2K 2A9
Attention: Mr. Alex Meacoe
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1323738
Date Submitted: 2013-10-25
Date Reported: 2013-10-30
Project: 13-1121-0186
COC #: 779771

				Lab I.D.	1068207	1068208
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2013-10-08	2013-10-08
				Sample I.D.	BH 13-6 SA#2A	BH 13-11 SA#2
Group	**Analyte**	**MRL**	**Units**	**Guideline**		
Agri. - Soil	Electrical Conductivity	0.05	mS/cm		0.43	0.20
	pH	2.0			7.3	7.4
General Chemistry	Cl	0.002	%		0.017	0.005
	Resistivity	1	ohm-cm		2330	5000
	SO4	0.01	%		<0.01	<0.01

Guideline = *** = Guideline Exceedence**
** = Analysis completed at Mississauga, Ontario.
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

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

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

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
32 Steacie Drive
Kanata, Ontario, K2K 2A9
Canada
T: +1 (613) 592 9600