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REPORT ON

Geotechnical Investigation
Proposed Residential Development
Riverside South Development (Phase 8)
Ottawa, Ontario

Submitted to:
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REPORT

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development to be located within the Riverside South Community (Phase 8) in Ottawa, Ontario.

The purpose of this geotechnical investigation was to supplement the existing subsurface information and determine the general soil and groundwater conditions across the site by means of 16 boreholes. Based on an interpretation of the factual information obtained, along with existing data available for the site, engineering guidelines are provided on the geotechnical design aspects of the project, including construction considerations which could affect design decisions.

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

2.0 DESCRIPTION OF PROJECT AND SITE

Plans are being prepared to develop a proposed residential subdivision within the Riverside South Community (Phase 8) in Ottawa, Ontario (see Site Plan, Figure 1).

The site is located south of Earl Armstrong Road, between Spratt Road and Canyon Walk Drive. The subject site is irregular in shape and measures approximately 1,250 by 420 metres in size.

It is understood that the development will consist of a conventional subdivision with a mix of single family homes and townhouses, as well as access roads and services within the subdivision.

The site topography is relatively flat with a gentle downward slope from east to west (i.e., towards the river). The majority of the site is currently undeveloped, consisting of former agricultural land or forested areas.

Golder Associates previously completed two geotechnical investigations within or in close proximity to the site. The results of those investigations are provided in the following reports:

1) Report to Totten Sims Hubicki Associates by Golder Associates Ltd. titled "Geotechnical Considerations for Earl Armstrong Road Widening, Former River Road to Limebank Road, Ottawa, Ontario", dated January 2008 (Project No. 06-1120-290).

2) Report to the Riverside South Development Corporation by Golder Associates Ltd. titled "Preliminary Geotechnical Investigation, Proposed Residential Development, Riverside South Community Development, Phases 6 to 9" dated September 2009 (Project No. 09-1121-0120).

Based on a review of these previous geotechnical investigations and the published geological mapping, the subsurface conditions at the site likely consist of surficial deposits of layered silty clay, clayey silt, sandy silt and silty sand overlying silty clay and glacial till, which in turn are underlain by bedrock. Based on published geological maps, the bedrock surface is expected to be at depths ranging from about 5 to 25 metres (sloping downward from south to north across the site) and to consist of March formation sandstone.

3.0 PROCEDURE

The field work for this investigation was carried out between January 5 and 15, 2015. At that time, 16 boreholes (numbered 14-1 to 14-16, inclusive) were put down at the approximate locations shown on the Site Plan, Figure 1.

The boreholes were advanced using a track-mounted continuous flight hollow-stem auger drill rig, supplied and operated by Marathon Drilling Ltd. of Ottawa, Ontario. The boreholes were generally advanced to depths of about 5.9 to 9.8 metres below the existing ground surface. Below about 7.6 and 6.1 metres depth, boreholes 14-5 and 14-14 were advanced without sampling, using a dynamic cone penetration test (DCPT), to depths of about 9.8 and 10.4 metres, respectively, below the existing ground surface.

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

Standpipe piezometers were sealed into boreholes 14-1, 14-4, 14-8, 14-11, 14-14, and 14-16 to allow subsequent measurement of the groundwater level across the site. The groundwater levels in these standpipe piezometers were measured on January 27, 2015.

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

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

Soil samples from boreholes 14-3 and 14-14 were submitted to EXOVA Environmental Ontario Ltd. for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

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

4.0 SUBSURFACE CONDITIONS

4.1 General

Information on the subsurface conditions is provided as follows:

- Record of Borehole Sheets for the current investigation are provided in Appendix A, which also show the results of the laboratory testing.
- Record of Borehole Sheets from relevant boreholes from the previous investigations by Golder Associates are provided in Appendix B.
- The results of the basic chemical analysis carried out on soil samples from boreholes 14-3 and 14-14 are provided in Appendix C.

The subsurface conditions on the site generally consist of topsoil, underlain by layered silty clay, clayey silt and silty sand, overlying compressible silty clay, followed by glacial till.

The following sections present a more detailed overview of the subsurface conditions on this site, with a focus on the boreholes advanced for the current investigation.

4.2 Topsoil and Fill

Topsoil exists at ground surface at all of the borehole locations, with the exception of borehole 14-2 where the topsoil had been stripped. The topsoil varies in thickness from about 220 to 300 millimetres.

A layer of topsoil fill and soil was encountered at borehole 14-9 with a total thickness of about 0.6 metres. The soil fill consists of silty clay with organic matter and cobbles.

4.3 Weathered Silty Clay to Clay

The topsoil and fill are typically underlain by a deposit of silty clay to clay which has been weathered to a grey brown colour. The weathered deposit extends to depths of about 0.6 to 3.1 metres below the existing ground surface.

Standard penetration tests carried out within this material gave SPT N values of about 2 to 10 blows per 0.3 metres of penetration. The results of two in situ vane tests carried out in the weathered silty clay to clay measured undrained shear strength values of about 92 and greater than 96 kilopascals. The results of the in situ testing indicate a stiff to very stiff consistency.

The results of one Atterberg limit test carried out on a sample of the weathered deposit gave a plasticity index value of about 43 percent and a liquid limit value of about 74 percent, indicating a soil of high plasticity.

The measured natural water contents of two samples of the weathered silty clay were about 32 and 43 percent.

About 0.4 metres of intermixed clayey silt, silty clay, and silty sand were encountered above the weathered deposit at borehole 14-3. Similarly, about 0.7 metres of clayey silt and silty clay overlie the weathered deposit at borehole 14-15.

A discontinuous layer of sand was encountered below the weathered deposit at borehole 14-15. The sand has a thickness of about 0.3 metres and extends down to a depth of about 2.2 metres below the existing ground surface.

4.4 Layered Silty Sand and Clayey Silt

A deposit of layered silty sand and clayey silt was encountered below the topsoil and/or weathered deposit in all of the boreholes with the exception of 14-8 and 14-15. The layered silty sand and clayey silt has a thickness that ranges from about 0.5 to 2.1 metres and extends down to depths of about 1.4 to 4.0 metres below the ground surface. This deposit generally contains silty clay layers. In boreholes 14-7, 14-9, 14-12, and 14-13 this deposit grades to a clayey silt and silty clay with silty sand layers.

Standard penetration tests carried out within this deposit gave SPT N values of about 1 to 7 blows per 0.3 metres of penetration, indicating a very loose to loose state of packing.

The results of one Atterberg limit test carried out on a sample of the clayey silt and silty clay from borehole 14-12 gave a plasticity index value of about 23 percent and a liquid limit value of 39 percent, indicating a soil of intermediate plasticity.

The measured natural water contents of four samples of this deposit ranged from about 28 to 41 percent.

4.5 Unweathered Silty Clay to Clay

The layered silty sand and clayey silt are underlain by a deposit of silty clay to clay (hereafter referred to as silty clay). The silty clay deposit is unweathered and typically grey in colour. The unweathered deposit extends to, or was proven/inferred to, depths ranging from 4.4 to 9.1 metres below the ground surface. The silty clay was fully penetrated in boreholes 14-1, 14-5, 14-8, 14-12, and 14-13, which are located generally within the central-south part of the site. The deposit is apparently thicker beneath the east, west, and north parts of the site.

The results of in situ vane testing in the deposit measured undrained shear strength values generally ranging from about 29 to greater than 96 kilopascals, indicating a firm to very stiff consistency, with the shear strength generally increasing with depth. Within the shallower/weaker portions of the deposit the undrained shear strength is more typically in the range of 30 to 50 kilopascals (i.e., firm).

The results of two Atterberg limit tests carried out on samples of the unweathered silty gave plasticity index values of about 20 and 36 percent and liquid limit values of about 34 and 57 percent, indicating a soil of intermediate to high plasticity.

Natural water contents ranging from about 33 to 69 percent were measured in the unweathered silty clay.

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

Borehole/ Sample No.	Sample Depth/ Elevation (m)	σ_{v0}' (kPa)	σ_p' (kPa)	C_c	C_r	e_0	OCR
14-3 / 6	5.1 / 86.2	50	125	0.70	0.014	1.31	2.5
14-9 / 6	5.0 / 86.2	50	130	0.45	0.010	1.06	2.6

Notes:
σ_p' - Apparent preconsolidation pressure
σ_{v0}' - Computed existing vertical effective stress
C_c - Compression index
e_0 - Initial void ratio
OCR - Overconsolidation ratio
C_r - Recompression index

4.6 Clayey Silt to Silty Clay

A thin layer of clayey silt and/or silty clay was encountered below the silty clay in boreholes 14-10, 14-12, and 14-14. The clayey silt and silty clay was encountered at depths between about 4.4 to 6.1 metres below the existing ground surface and was proven/inferred to depths ranging from about 4.9 to 7.0 metres.

The measured natural water content of one sample of the clayey silt was about 39 percent.

4.7 Glacial Till

A deposit of glacial till was encountered beneath the silty clay at boreholes 14-1, 14-5, 14-8, 14-10, 14-12, 14-13, and 14-14. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand or sandy silt. The glacial till was encountered at depths ranging from about 4.9 to 9.1 metres below the existing ground surface and proven to extend to depths ranging from about 6.1 to 10.4 metres below the existing ground surface. The till surface was found to be shallowest beneath the central-south portions of the site.

Standard penetration tests carried out within the glacial till gave SPT N values typically ranging from about 14 to 52 blows per 0.3 metres of penetration, indicating a generally compact to very dense state of packing.

The measured natural water content of one sample of the glacial till was about 10 percent.

4.8 Groundwater

The groundwater levels sealed in boreholes 14-1, 14-4, 14-8, 14-11, 14-14, and 14-16 were measured on January 27, 2015. The observed groundwater levels are summarized in the table below:

Borehole Number	Ground Surface Elevation (m)	Water Level Depth (m)	Water Level Elevation (m)
14-1	91.18	1.17	90.01
14-4	91.91	0.94	90.39
14-8	92.21	1.91	90.30
14-11	91.55	1.32	90.23
14-14	92.03	0.82	91.21
14-16	91.99	1.22	90.77

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

5.0 DISCUSSION

5.1 General

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

5.2 Site Grading

Based on the subsurface conditions encountered and the soil strengths determined within the boreholes, the site has been divided into two assessment areas, Area A and Area B, as shown on the Site Plan, Figure 1. The subsurface conditions in Areas A and B generally consist of topsoil underlain by weathered silty clay, layered clayey silt and silty sand, overlying a deposit of unweathered and compressible sensitive silty clay, followed by glacial till.

The "softer" unweathered silty clay deposits in Areas A and B have limited capacity to accept additional load from the weight of grade raise fill and from the foundations of houses without undergoing consolidation settlements. Therefore, for these areas, to leave sufficient remaining capacity for the silty clay to support house foundations, with reasonable footing sizes, the thicknesses of grade raise fill will need to be limited.

The following table provides the maximum grade raises which are permitted for each of the assessment areas indicated on Figure 1. These grade raise limitations have been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that strip footings up to 0.6 metres in size can be designed using an allowable bearing pressure of at least 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code.

Assessment Zone	Maximum Permissible Grade Raise (metres)
A	2.1
B	1.9

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

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

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

5.3 Foundations

It is considered that the proposed residences may be supported on spread footings founded on or within the weathered silty clay or layered clayey silt and silty sand.

As discussed in the preceding section, the silty clay has a limited capacity to accept the combined load from site grading fill and foundation loads. The allowable bearing pressures for spread footing foundations are therefore based on limiting the stress increases on the unweathered firm, compressible, grey silty clay at depth to an acceptable level so that foundation settlements do not become excessive.

Four important parameters in calculating the stress increase on the unweathered silty clay are:

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

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

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

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

Further, the provided maximum allowable bearing pressure for footing foundations supported by the silty clay corresponds to settlement resulting from consolidation of this deposit. Consolidation of the silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the above allowable bearing pressure should be the full dead load plus <u>sustained</u> live load.

Any existing ditches that may underlie future houses (such as the ditch located on the east side of Area B), will need to be filled. The following guidelines are provided in regards to filling of the ditches beneath future houses:

- The ditch should be made dry and cleaned of all organic or disturbed soil prior to filling.
- Filling to the underside of footing elevation should be carried out using crushed clear stone having a unit weight not exceeding about 17.5 kilonewtons per cubic metre (i.e., similar to the native soil). The use of clear stone is recommended so as to avoid possible settlements associated with the use of heavier material.
- The engineered fill should be placed to occupy the full house footprint and the full zone of influence/support for the foundations. That zone is considered to extend down and out from the outside edge of the perimeter foundations at a slope of 1H:1V (horizontal:vertical).

- The engineered fill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable vibratory compaction equipment.
- To avoid settlements resulting from loss of soil into the voids in the clear stone, it should be fully encapsulated in a geotextile. The geotextile should be placed on the bottom and sides of the ditch, as well as over the top of the clear stone.
- A Class II non-woven geotextile should be used, with a Filtration Opening Size (FOS) not exceeding 150 microns, in accordance with Ontario Provincial Standard Specifications (OPSS) 1860.
- Footings founded on or within properly placed engineered fill (as described above) can also be designed using a maximum allowable bearing pressure of 75 kilopascals.

5.4 Frost Protection

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

5.5 Seismic Design

The seismic design provisions of the 2012 Ontario Building Code (OBC) depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or bedrock below founding level. The OBC also permits the Site Class to be specified based solely on the stratigraphy and in situ testing data, rather than from direct measurement of the shear wave velocity. Based on this methodology, and based on the available information it is considered that a Site Class of E would be applicable to the design of structures in both Areas A and B. It should be noted that the seismic Site Class is not directly applicable to structures designed in accordance with Part 9 of the OBC (i.e., conventional housing); however this assessment is provided to address City of Ottawa requirements that relate to housing on Site Class E sites. It should also be noted that a more favourable Site Class value could potentially be assigned for houses in Areas A and B. Based on previous shear wave velocity testing in the Phase 9 site to the west of Phase 8, it is considered reasonably likely that a Site Class of at least D might feasibly be assigned to much of the site on the basis of such testing (particularly where the glacial till is shallower).

5.6 Basement Excavations

Excavations for basements will be through the topsoil, weathered silty clay and layered clayey silt and silty sand. No unusual problems are anticipated with excavating the overburden soils using conventional hydraulic excavating equipment.

Side slopes in the overburden materials should be stable in the short term at 1 horizontal to 1 vertical in accordance with the *Occupational Health and Safety Act* (OHSA) of Ontario for Type 3 soils.

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

Based on the *present* groundwater levels, excavations deeper than about 0.8 metres may, in some areas, extend below the groundwater level. 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.

5.7 Basement and Garage Floor Slabs

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

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

The backfill material inside the garage should have a unit weight no greater than 19.5 kilonewtons per cubic metre (i.e., uniform fine sand or clear crushed stone). The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of OPSS Granular A compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment.

5.8 Basement Wall and Foundation Wall Backfill

The soils at this site are frost susceptible and should not be used as backfill directly against exterior, unheated, or well insulated foundation elements. To avoid problems with frost adhesion and heaving, a bond break such as Platon system sheeting should be placed against the foundation walls.

Drainage of the wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in 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 made through the topsoil, layered clays, silts, and sand, as well as potentially the glacial till. No unusual problems are anticipated with excavating the overburden using conventional hydraulic excavating equipment. However, it should be expected that boulders will be encountered within the glacial till (for deeper trenches). Boulders larger than 0.3 metres in size should be removed from the excavation side slopes.

In accordance with the OHSA of Ontario, the overburden soils would generally be classified as Type 3 soils and side slopes in the overburden in the short term may be sloped at 1 horizontal to 1 vertical. Alternatively, excavations within the overburden could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation.

Some groundwater inflow into the excavations could be expected. However, it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the excavations provided suitably sized pumps are used.

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

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding material should, in all cases, extend to the spring line of the pipe and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density. The use of crushed clear stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or sandy soils on the trench walls could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

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

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

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

Where the trench will be covered with hard surfaced areas, the type of native material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility.

Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density using suitable compaction equipment.

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

5.10 Pavement Design

In preparation for pavement construction, all topsoil, fill (if containing organic matter); disturbed or otherwise deleterious materials should be removed from the roadway areas.

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

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

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

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

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

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

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

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

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

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

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

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

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

Based on previous experience with the construction of roadways on other phases of the Riverside South Community, there is considered to be a high likelihood for portions of the roadways to require both a geotextile and additional granular subbase, unless the pavement construction is carried out during optimal weather conditions. A significant contingency in the construction budget should be carried for such measures.

5.11 Pools, Decks and Additions

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

5.11.1 Above Ground and In Ground Pools

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

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

5.11.2 Decks

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

- The deck will be attached to the house; and/or,
- The deck will be heavily loaded and require spread footing or drilled pier foundations (i.e., where the deck will be designed in accordance with Part 9 of the OBC and require a building permit).

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5.11.3 Additions

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

5.12 Corrosion and Cement Type

Samples of soil from boreholes 14-3 and 14-14 were submitted to EXOVA Environmental Ontario for basic chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried concrete elements. The results of this testing are provided in Appendix C. The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a moderate to elevated potential for corrosion of exposed ferrous metal, which should be considered in the design of substructures.

5.13 Trees

The clay soils on this site are potentially sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from clay soil, the clay undergoes shrinkage which can result in settlement of adjacent structures. Some restrictions could therefore need to be imposed on the planting of trees of higher water demand in close proximity to the foundations of houses or other structures founded at shallow depth. The required set-backs can be evaluated once further details are available on the site grading design.

6.0 ADDITIONAL CONSIDERATIONS

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

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soil having adequate bearing capacity has been reached and that the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill as well as sewer bedding and backfill should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction point of view.

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

It should also be noted that no oedometer consolidation tests were carried out on the Shelby tube samples retrieved for this investigation; if the permissible grade raises specified in Section 5.2 cannot be accommodated, consolidation testing could be considered to further refine the grading recommendations.

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

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

7.0 CLOSURE

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

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
S. A. TRICKEY
100104579
PROVINCE OF ONTARIO

Susan Trickey, P.Eng.
Geotechnical Engineer

Mike Cunningham, P.Eng.
Principal, Geotechnical Engineer

WAM/SAT/MIC/sg/ob
n:\active\2014\1121 - geotechnical\1418804 rsdc phase 8 ottawa\report\1418804 rpt-001_rev 1 july 2015.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

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

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

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

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

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

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

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

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

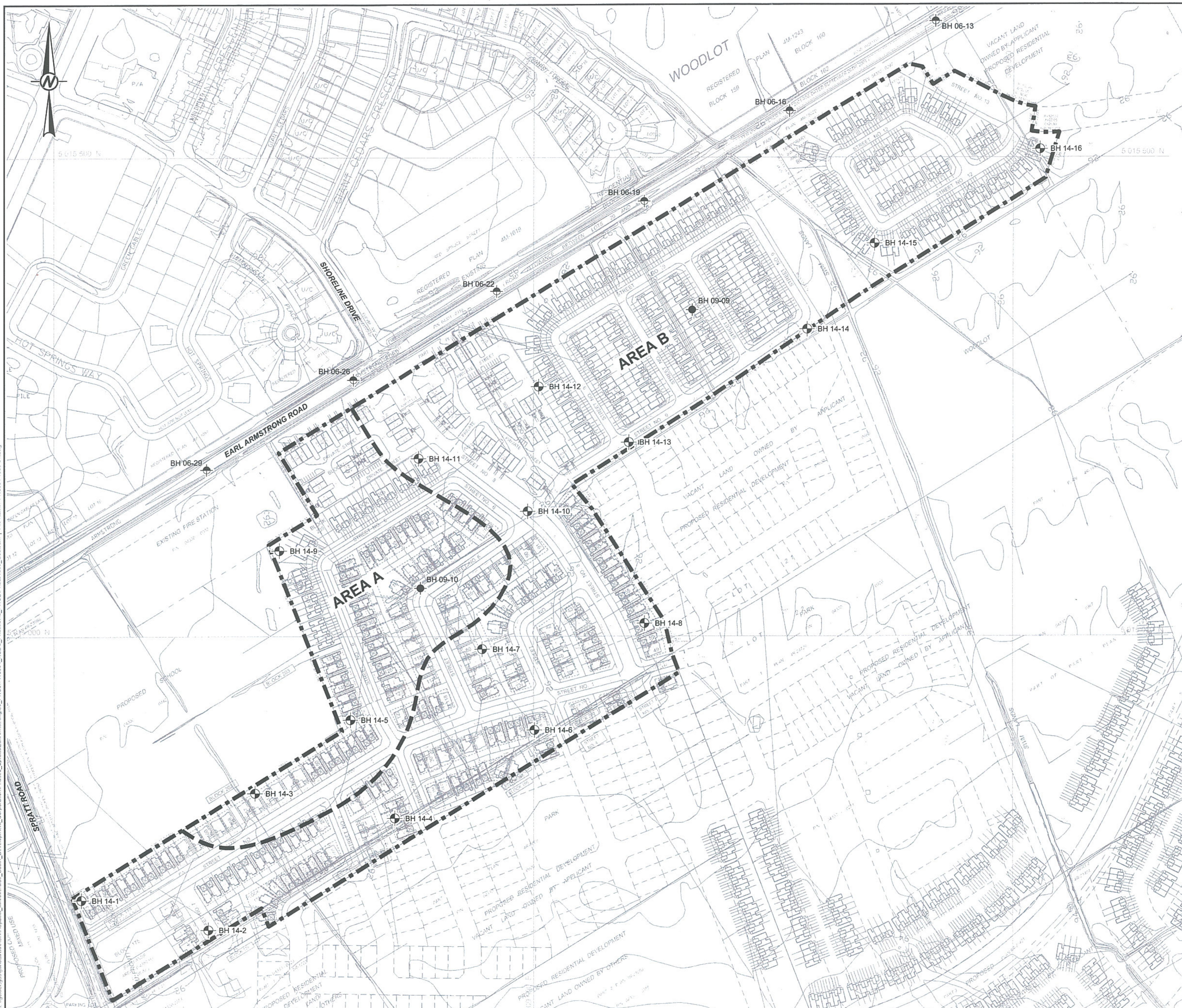
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

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

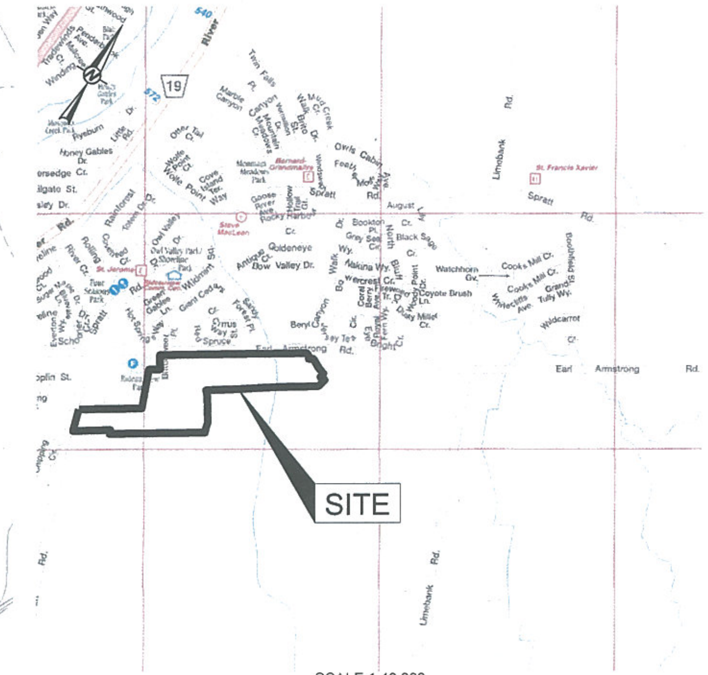
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and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

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

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



KEY MAP



SCALE 1:40,000

LEGEND

- APPROXIMATE BOREHOLE LOCATION IN PLAN, PRESENT INVESTIGATION
- APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD. REPORT N o. 09-1121-0120
- APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATION BY GOLDER ASSOCIATES LTD. REPORT N o. 06-1120-290
- APPROXIMATE LIMIT OF PHASE 8 DEVELOPMENT
- ASSESSMENT AREA

NOTES

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. LETTER REPORT No. 1418804

REFERENCE

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

CLIENT
RIVERSIDE SOUTH DEVELOPMENT CORPORATION

PROJECT
GEOTECHNICAL INVESTIGATION
RIVERSIDE SOUTH DEVELOPMENT (PHASE 8)
PROPOSED RESIDENTIAL DEVELOPMENT - OTTAWA, ONTARIO

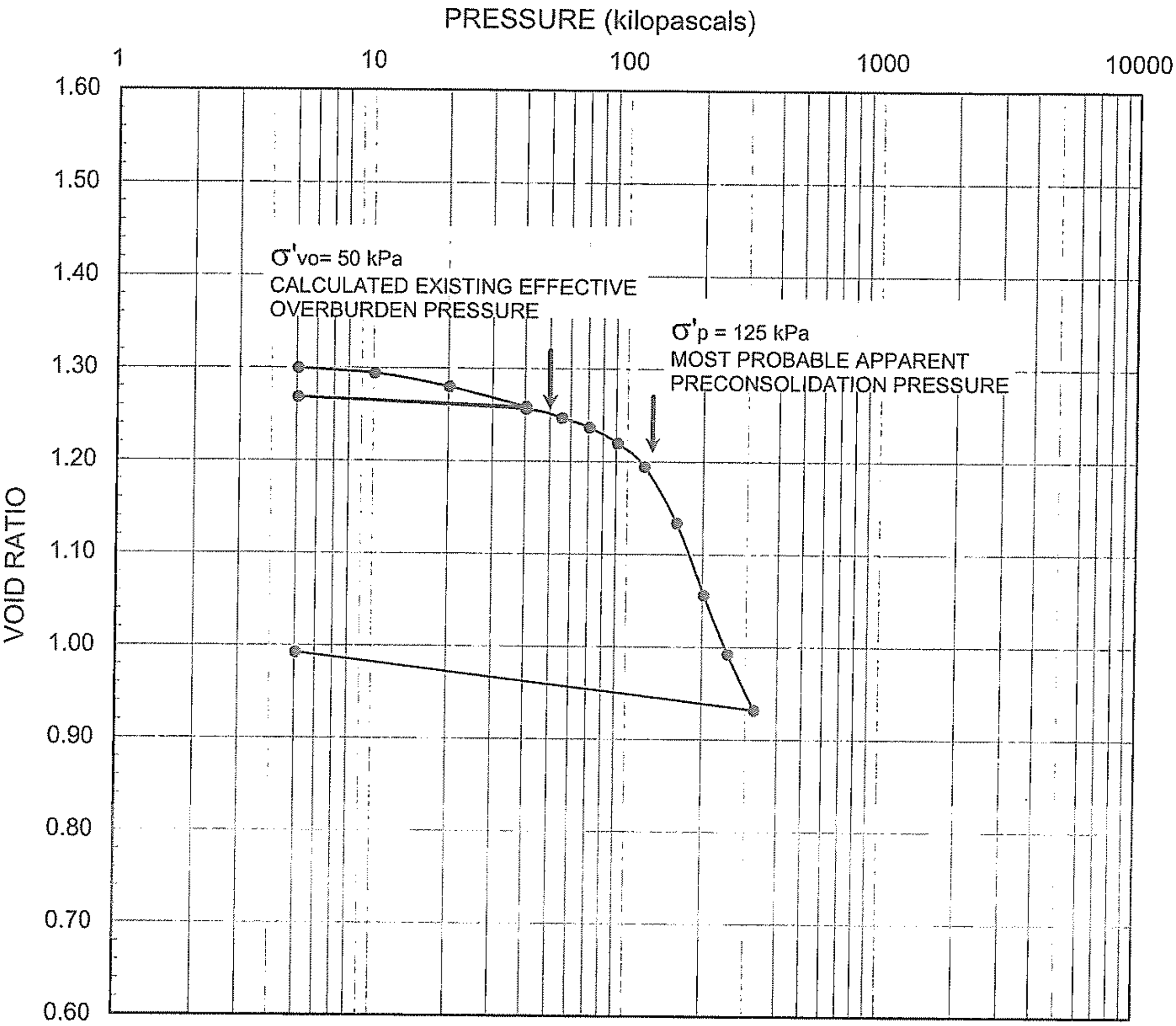
TITLE
SITE PLAN

CONSULTANT: Golder Associates

YYYY-MM-DD	2015-02-26
PREPARED	JM
DESIGN	----
REVIEW	SAT
APPROVED	MIC

PROJECT No.	PHASE	Rev.	FIGURE
1418804	1000	A	1

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



LEGEND

Borehole: 14-3	w_i = 48%	S_o = 101%	γ = 17.3 kN/m³
Sample: 6	w_f = 37%	e_o = 1.31	G_s = 2.76
Depth (m): 5.1	w_l = 34%	C_c = 0.70	
Elevation (m): 86.2	w_p = 17%	C_r = 0.014	

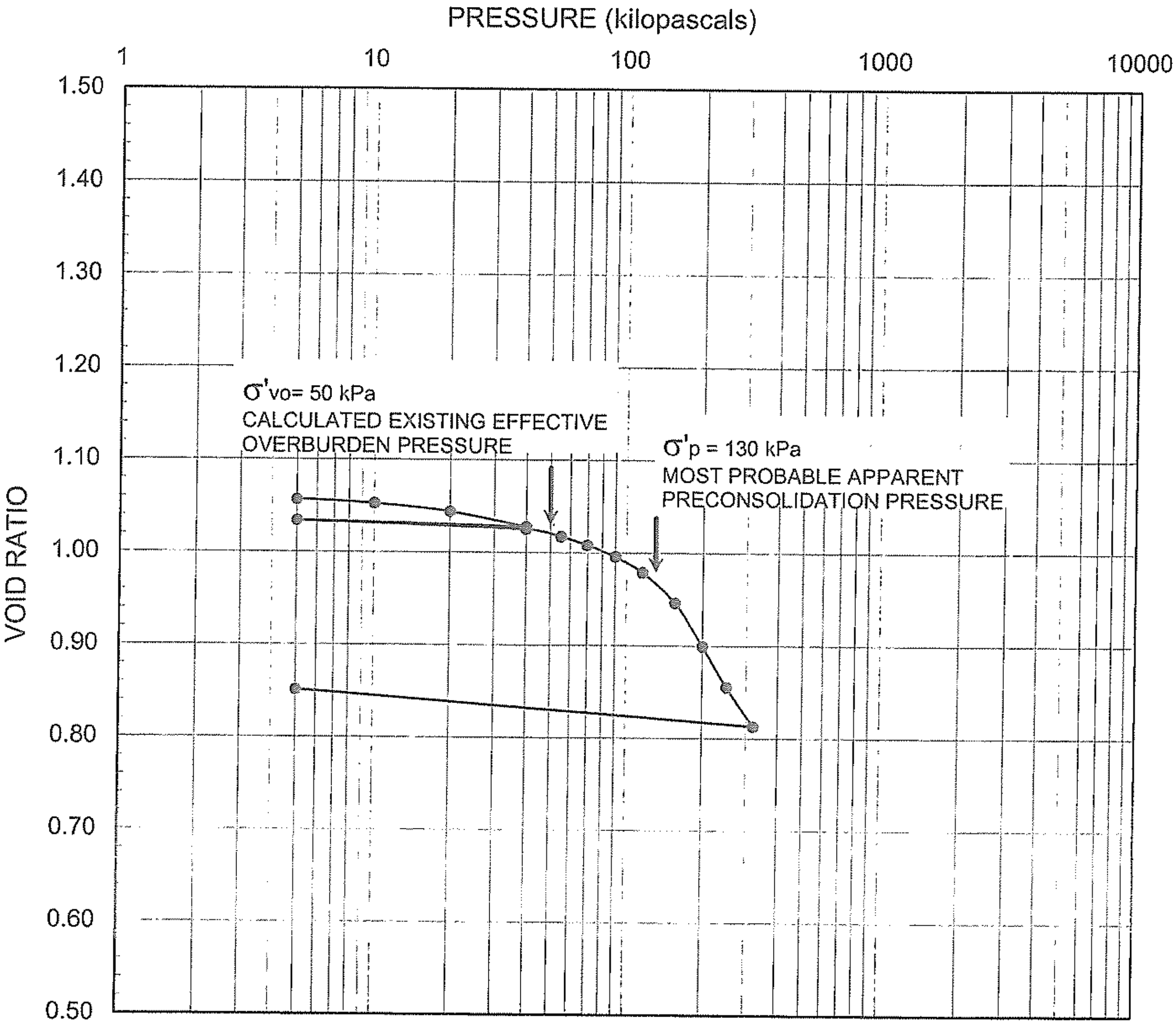
Golder Associates

SCALE	AS SHOWN
DATE	06/24/15
CADD	N/A
ENTERED	MI - KM
CHECK	CNM
REVIEW	SAT
FILE No.	Consolidation summary
PROJECT No.	1418804
REV.	1

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 2



LEGEND

Borehole:	14-9	w_i = 38%	S_o = 99%	γ = 18.1 kN/m³
Sample:	6	w_f = 31%	e_o = 1.06	G_s = 2.76
Depth (m):	5.0	w_l = 36%	C_c = 0.45	
Elevation (m):	86.2	w_p = 18%	C_r = 0.010	

Golder Associates

SCALE	AS SHOWN
DATE	06/24/15
CADD	N/A
ENTERED	MI - KM
CHECK	CNM
REVIEW	SAT
FILE No.	Consolidation summary
PROJECT No.	1418804
REV.	1

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 3

APPENDIX A

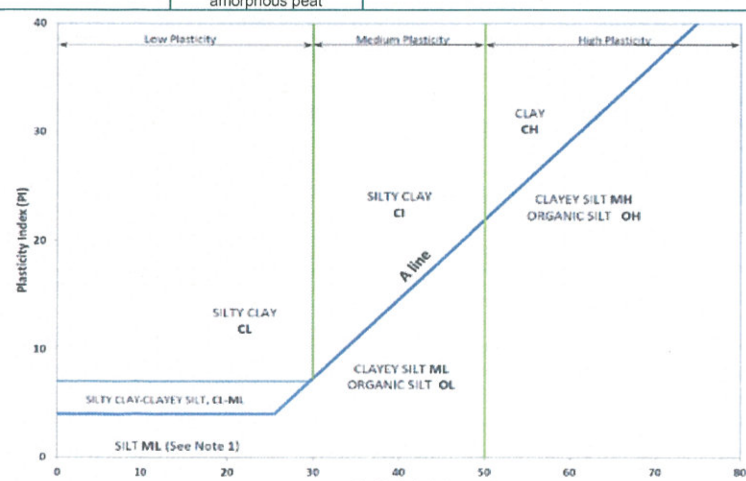
Method of Soil Classification
Abbreviations and Terms Used on Records of Boreholes and Test Pits
List of Symbols
Record of Borehole Sheets

METHOD OF SOIL CLASSIFICATION

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

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

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators: Dilatancy	Field Indicators: Dry Strength	Field Indicators: Shine Test	Field Indicators: Thread Diameter	Field Indicators: Toughness (of 3 mm thread)	Organic Content	USCS Group Symbol	Primary Name
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.

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ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

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

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

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Golder Associates

PROJECT: 1418804

RECORD OF BOREHOLE: 14-1

LOCATION: See Site Plan

BORING DATE: January 6, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.18 / 0.00
TOPSOIL	90.88 / 0.30
(CI/CH) SILTY CLAY; grey brown, with clayey silt seams (WEATHERED CRUST); cohesive, w>PL, very stiff	89.66 / 1.52
(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains grey brown silty clay layers; non-cohesive, wet, very loose	88.28 / 2.90
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm to stiff	82.65 / 8.53
(ML) sandy SILT, some gravel; grey (GLACIAL TILL); non-cohesive, wet, loose	81.43 / 9.75
End of Borehole	

SAMPLES

NUMBER	TYPE	BLOWS/0.30m
1	SS	15
2	SS	6
3	SS	2
4	SS	1
5	SS	1
6	SS	WH
7	SS	1
8	SS	1
9	SS	5

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION:
- Native Backfill
- Bentonite Seal
- Silica Sand
- Standpipe
- WL in Standpipe at Elev. 90.01 m on Jan. 27, 2015

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

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

RECORD OF BOREHOLE: 14-2

PROJECT: 1418804
SHEET 1 OF 1

LOCATION: See Site Plan
BORING DATE: January 6, 2015
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
0		GROUND SURFACE		91.28							
	Power Auger 200 mm Diam. (Hollow Stem)	(CI/CH) SILTY CLAY to CLAY; red brown and grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff		0.00	1	SS	6				
1		(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose		90.43 0.85	2	SS	4				∇
					3	SS	2				
2		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand and clayey silt layers; cohesive, w>PL, firm		89.30 1.98	4	SS	1				
3		(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm		88.38 2.90	5	TP	PM				
4								⊕ + / +			
5					6	SS	PM				
								⊕ + / ⊕ + / +			
6		End of Borehole		85.34 5.94							WL in open borehole at 1.22 m depth below ground surface upon completion of drilling
7											
8											
9											
10											

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DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: WAM

RECORD OF BOREHOLE: 14-3

PROJECT: 1418804 | SHEET 1 OF 1

LOCATION: See Site Plan | BORING DATE: January 5, 2015 | DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm | PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.28					
0	Power Auger, 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00	1	GRAB	-		
		(ML, CI/CH and SM) Intermixed CLAYEY SILT, SILTY CLAY and SILTY SAND; grey brown; cohesive, w>PL	91.06 / 0.22					
1		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers; (WEATHERED CRUST), cohesive, w>PL, very stiff	90.67 / 0.61	2	SS	7		
2		(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay seams; non-cohesive, wet, very loose	89.85 / 1.43	3	SS	2		∇
				4	SS	1		
3		(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm	88.38 / 2.90	5	SS	WH		
5				6	TP	WR	C	
7				7	SS	WR		
		End of Borehole	83.66 / 7.62					WL in open borehole at 1.52 m 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

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DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

PROJECT: 1418804

RECORD OF BOREHOLE: 14-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 5, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	91.91				
	TOPSOIL	0.00				
	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	91.66 / 0.25				
1			1	SS	7	
	(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose	90.63 / 1.28				
2			2	SS	3	Native Backfill
			3	SS	1	
3	(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm	89.01 / 2.90				
			4	SS	WH	
4						Bentonite Seal
						Silica Sand
5			5	SS	PM	Standpipe
						Cave
6	End of Borehole	85.81 / 6.10				
						WL in Standpipe at Elev. 90.97 m on Jan. 27, 2015

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa: nat V. +, rem V. ⊕, Q - ●, U - ○ (20, 40, 60, 80)

HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20, 40, 60, 80)

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

RECORD OF BOREHOLE: 14-5

PROJECT: 1418804
SHEET 1 OF 1

LOCATION: See Site Plan
BORING DATE: January 6-7, 2015
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Column headings: 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

Boring method: Power Auger, 200 mm Diam. (Hollow Stem) (0 to about 7.6 m); DCPT (about 7.6 m to 9.75 m)

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.52
TOPSOIL	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains clayey silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff	91.30 / 0.22
(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose	90.15 / 1.37
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm	88.78 / 2.74
(CI/CH) SILTY CLAY to CLAY; grey, with black mottling; cohesive, w>PL, firm to stiff	87.86 / 3.66
Probable Glacial Till; loose	82.38 / 9.14
Probable Glacial Till; very dense	82.07 / 9.45
End of Borehole	81.77 / 9.75

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

∇ (water level at 1.37 m)

WL in open borehole at 1.37 m depth below ground surface upon completion of drilling

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: WAM

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PROJECT: 1418804

RECORD OF BOREHOLE: 14-6

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 9, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Columns: 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

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

Description	Elev. / Depth (m)
GROUND SURFACE	92.03
TOPSOIL	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains clayey silt layers (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	91.73 / 0.30
(ML-SM) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose	90.96 / 1.07
(CI/CH) SILTY CLAY to CLAY; grey brown, contains clayey silt and silty sand layers; cohesive, w>PL	89.90 / 2.13
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	89.13 / 2.90
End of Borehole	84.41 / 7.62

Number	Type	Blows/0.30m
1	SS	6
2	SS	2
3	SS	1
4	SS	WH
5	SS	PM
6	SS	PM

WL in open borehole at 0.75 m depth below ground surface upon completion of drilling

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

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RECORD OF BOREHOLE: 14-7

PROJECT: 1418804

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 12, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.64				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	91.34 0.30	1	SS	7	∇
		(ML-CL/CI) CLAYEY SILT and SILTY CLAY; grey brown, contains silty sand layers; cohesive, w>PL, stiff to firm	90.27 1.37	2	SS	2	
		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	88.99 2.65	3	SS	1	
				4	SS	PM	
				5	TP	PM	
				6	SS	PM	
		End of Borehole	84.02 7.62				WL in open borehole at 1.22 m 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)

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

MIS-BHS 001 1418804.GPJ GAL-MIS.GDT 05/04/15 JM

RECORD OF BOREHOLE: 14-8

PROJECT: 1418804 — SHEET 1 OF 1

LOCATION: See Site Plan — BORING DATE: January 9, 2015 — DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm — PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa / NOTES	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	92.21					
TOPSOIL	0.00					
(CI/CH) SILTY CLAY to CLAY; grey brown, contains clayey silt and silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	91.96 / 0.25	1	SS	5		
		2	SS	2	>96 +	WL (approx. 1.9 m)
						Native Backfill
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	89.16 / 3.05	3	TP	PH		
(CI/CH) SILTY CLAY to CLAY, trace gravel; grey, contains clayey silt layers; cohesive, w>PL, stiff to very stiff	87.79 / 4.42	4	SS	2	>96 +	
(ML) sandy SILT, some gravel; grey, contains cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to dense	86.76 / 5.45	5	SS	16		Bentonite Seal
		6	SS	35		Silica Sand
		7	SS	19		Standpipe; Cave
End of Borehole	84.74 / 7.47					WL in Standpipe at Elev. 90.30 m on Jan. 27, 2015

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● ; rem V. ⊕ U - ○ : 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT: Wp — W — Wl : 20 40 60 80
ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH
CHECKED: WAM

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PROJECT: 1418804

RECORD OF BOREHOLE: 14-9

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 7, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
0	GROUND SURFACE	91.18				
	TOPSOIL/FILL	0.00				
	FILL - (CL/CI) SILTY CLAY; brown, contains organic matter and cobbles; cohesive, w>PL	90.88 / 0.30	1	SS	5	
1	(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	90.57 / 0.61	2	SS	10	
			3	SS	3	
2	(SM-ML) SILTY SAND and CLAYEY SILT; grey brown; non-cohesive, wet, very loose	89.35 / 1.83				
	(CI-ML) CLAYEY SILT and SILTY CLAY; grey brown, contains sand layers; cohesive, w>PL	88.89 / 2.29	4	SS	1	
3	(CI/CH) SILTY CLAY to CLAY, contains silty sand layers; grey; cohesive, w>PL, firm	88.28 / 2.90	5	SS	WH	
4	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	87.22 / 3.96				
5			6	TP	PM	C
7			7	SS	PM	
8			8	SS	PM	
9	End of Borehole	82.04 / 9.14				
10						

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

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

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

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

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

MIS-BHS 001 1418804.GPJ GAL-MIS.GDT 06/25/15 JM

RECORD OF BOREHOLE: 14-10

PROJECT: 1418804 — SHEET 1 OF 1

LOCATION: See Site Plan — BORING DATE: January 12, 2015 — DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm — PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	92.06					
TOPSOIL	0.00					
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL	91.76 / 0.30	1	SS	14		
(SM-ML) SILTY SAND and CLAYEY SILT; grey brown; non-cohesive, wet, loose to very loose	91.39 / 0.67	2	SS	7		∇
		3	SS	1		
		4	SS	4		
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	89.32 / 2.74	5	SS	WH		
					⊕ ; + ; +	
		6	SS	WH		
					⊕ ; +	
(ML-CI) CLAYEY SILT and SILTY CLAY, trace gravel; grey; cohesive, w>PL, very stiff	86.42 / 5.64				>96 +	
(ML) sandy SILT, some gravel; grey, contains cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact to dense	85.66 / 6.40	7	SS	15		
		8	SS	37		
End of Borehole	84.74 / 7.32					WL in open borehole at 0.76 m depth below ground surface upon completion of drilling

Column headings: DEPTH SCALE METRES (0–10); BORING METHOD; SOIL PROFILE; STRATA PLOT; 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

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

RECORD OF BOREHOLE: 14-11

PROJECT: 1418804 | SHEET 1 OF 1

LOCATION: See Site Plan | BORING DATE: January 12, 2015 | DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm | PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	91.55				
0	TOPSOIL	0.00				
	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff	91.30 / 0.25				
1			1	SS	9	
	(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose	90.25 / 1.30				
2			2	SS	3	
			3	SS	1	Native Backfill
3	(CI/CH) SILTY CLAY to CLAY; grey, contains sand layers; cohesive, w>PL, firm to stiff	88.65 / 2.90				
			4	SS	WH	
4						
5			5	TP	PH	Bentonite Seal
6						Silica Sand
			6	SS	WH	Standpipe
7						Cave
	End of Borehole	83.93 / 7.62				
8						WL in Standpipe at Elev. 90.23 m on Jan. 27, 2015
9						
10						

Chart columns: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa — nat V. + Q - ●, rem V. ⊕ U - ○ (20, 40, 60, 80); HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20, 40, 60, 80); ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

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PROJECT: 1418804

RECORD OF BOREHOLE: 14-12

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 13, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa	WATER CONTENT PERCENT	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	91.90						
0	TOPSOIL	0.00						
	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL	91.65 / 0.25	1	GRAB	-			
1	(SM-ML) SILTY SAND and CLAYEY SILT; grey brown; non-cohesive, moist, loose	91.29 / 0.61	2	SS	5			∇
2	(ML-CI) CLAYEY SILT and SILTY CLAY; grey brown, contains silty sand layers; cohesive, w>PL, firm	90.47 / 1.43	3	SS	1			
	(CI/CH) SILTY CLAY to CLAY; grey brown; cohesive, w>PL, stiff	89.46 / 2.44	4	SS	2			
3–4	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	88.85 / 3.05	5	SS	1			
	(ML) CLAYEY SILT; grey; cohesive, w>PL, very stiff	87.48 / 4.42						
5	(ML) sandy SILT, some gravel; grey, contains cobbles/boulders (GLACIAL TILL); non-cohesive, wet, compact	87.02 / 4.88	6	SS	6			
			7	SS	14			
6	End of Borehole	85.80 / 6.10						WL in open borehole at 1.22 m depth below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

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PROJECT: 1418804

RECORD OF BOREHOLE: 14-13

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 13, 2015

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		92.04							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		(ML-SM) CLAYEY SILT and SILTY SAND; grey brown; non-cohesive, moist, loose		91.74 0.30	1	SS	8				
1					2	SS	4				
		(ML-CI) CLAYEY SILT and SILTY CLAY; grey brown; cohesive, w>PL, stiff		90.67 1.37	3	SS	2				
2		(CI/CH) SILTY CLAY to CLAY; grey brown; cohesive, w>PL, stiff to firm		89.91 2.13	4	SS	2				
3					5	SS	1				
4		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to very stiff		88.38 3.66				⊕ + +			
5					6	SS	5				
					7	SS	2				
6		(ML) sandy SILT, some gravel; grey, contains cobbles/boulders (GLACIAL TILL); non-cohesive, wet, dense		86.10 5.94	8	SS	39				
7					9	SS	52				
		End of Borehole		84.73 7.31							
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

PROJECT: 1418804

RECORD OF BOREHOLE: 14-14

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: January 15, 2015

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 / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - O)	HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT PERCENT (Wp W Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		92.03							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		(CI/CH) SILTY CLAY to CLAY; grey brown, contains clayey silt layers (WEATHERED CRUST); cohesive, wet, very stiff		91.73 0.30	1	SS	9				
1					2	SS	5				
		(SM-ML) SILTY SAND and CLAYEY SILT; grey brown, contains silty clay layers; non-cohesive, wet, very loose		90.66 1.37	3	SS	2				Native Backfill
					4	SS	1				
3		(CI/CH) SILTY CLAY to CLAY; grey, contains sand layers; cohesive, w>PL, firm to stiff		89.29 2.74	5	SS	WH				
4								⊕ + ⊕ +			
5					6	SS	WH				Bentonite Seal
								⊕ + +			Standpipe
6	DCPT	Probable Silty Clay and Clayey Silt; grey		85.93 6.10				>96 +			WL in Standpipe at Elev. 91.21 m on Jan. 27, 2015
7		Probable Glacial Till; loose to compact		85.02 7.01							
10											

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

PROJECT: 1418804

RECORD OF BOREHOLE: 14-14

LOCATION: See Site Plan

BORING DATE: January 15, 2015

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	DCPT	Probable Glacial Till; loose to compact		81.67							
		End of Borehole		10.36							
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

MIS-BHS 001 1418804.GPJ GAL-MIS.GDT 05/04/15 JM

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: WAM

PROJECT: 1418804

RECORD OF BOREHOLE: 14-15

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 15, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.84			
TOPSOIL	0.00			
(ML-CI) CLAYEY SILT and SILTY CLAY; grey brown; cohesive, w>PL, very stiff	91.59 / 0.25	1	SS	4
(CI/CH) SILTY CLAY to CLAY; red brown to grey brown, contains clayey silt and silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	90.88 / 0.96	2	SS	7
		3	SS	3
(SW) SAND; grey brown, contains clayey silt layers; non-cohesive, wet, loose	89.95 / 1.89			
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand layers; cohesive, w>PL, firm to stiff	89.65 / 2.19	4	SS	1
		5	SS	PM
		6	SS	WH
		7	SS	PM
End of Borehole	84.22 / 7.62			

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

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

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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

WL in open borehole at 1.31 m depth below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

PROJECT: 1418804

RECORD OF BOREHOLE: 14-16

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: January 15, 2015

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	91.99				
	TOPSOIL	0.00				
	(CI/CH) SILTY CLAY to CLAY; grey brown and red brown, contains clayey silt and silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	91.69 0.30				
1			1	SS	7	
	(SM-ML) SILTY SAND and CLAYEY SILT; grey brown; non-cohesive, wet, very loose	90.28 1.71	2	SS	3	
2			3	SS	2	
3	(CI/CH) SILTY CLAY to CLAY; grey, contains clayey silt layers; cohesive, w>PL, firm to stiff	88.94 3.05	4	SS	WH	Native Backfill
4						
5			5	TP	PM	
6			6	SS	PM	Standpipe
7						Cave
	End of Borehole	84.37 7.62				
8						WL in Standpipe at Elev. 90.77 m on Jan. 27, 2015
9						
10						

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

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

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: WAM

APPENDIX B

Record of Borehole Sheets
(Previous Investigations by Golder Associates Ltd.)

PROJECT: 06-1120-290

RECORD OF BOREHOLE: BH 06-13

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec. 12, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.30m
GROUND SURFACE	92.59			
ASPHALTIC CONCRETE	0.00			
Grey crushed stone (BASE)	0.17			
Brown sand and gravel (SUBBASE)	92.09 / 0.50			
Very stiff grey brown SILTY CLAY (Weathered Crust)	91.67 / 0.93	1	50 DO	11
Grey brown layered SILTY CLAY, SANDY SILT and SILTY SAND	91.07 / 1.52	2	50 DO	9
		3	50 DO	4
		4	50 DO	2
Firm to stiff grey SILTY CLAY	88.02 / 4.57	5	50 DO	WH
		6	50 DO	WH
End of Borehole	84.97 / 7.62			

Column headings: 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

Water level in open hole at elev. 88.02m upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: D.V.

CHECKED: S.A.T.

PROJECT: 06-1120-290

RECORD OF BOREHOLE: BH 06-16

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec. 5, 2006

DATUM: Local

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		92.16							
0	Power Auger, 200mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE		0.00							
		Grey crushed stone (BASE)		0.15							
		Brown sand and gravel (SUBBASE)		91.66 0.50							
1		Very stiff red brown to grey brown SILTY CLAY (Weathered Crust)		91.16 1.00	1	50 DO	8				
					2	50 DO	10				
2		Grey brown layered SILTY CLAY, SANDY SILT and SILTY SAND		90.03 2.13							▽
					3	50 DO	2				
3		Firm grey brown SILTY CLAY		89.11 3.05	4	50 DO	2				
		Firm grey SILTY CLAY		88.50 3.66							
5					5	50 DO	WH				
		End of Borehole		86.37 5.79							
6											Water level in open hole at elev. 89.72m upon completion of drilling
7											
8											
9											
10											

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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.V.

CHECKED: S.A.T.

PROJECT: 06-1120-290

RECORD OF BOREHOLE: BH 06-19

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec. 5, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕)
		GROUND SURFACE	92.54				
0	Power Auger, 200mm Diam. (Hollow Stem)	ASPHALTIC CONCRETE	0.00				
		Brown sand and gravel (BASE/SUBBASE)	0.15				
		Very stiff grey brown SILTY CLAY (Weathered Crust)	91.84 / 0.70				
1				1	50 DO	10	
		Grey brown layered SILTY CLAY, SANDY SILT and SILTY SAND	91.02 / 1.52				
2				2	50 DO	5	
				3	50 DO	3	
3		Stiff grey brown SILTY CLAY	89.49 / 3.05				
				4	50 DO	2	
		Stiff to very stiff grey SILTY CLAY	88.88 / 3.66				
4							⊕ ~17; + ~64
							⊕ ~16; + ~36
5				5	50 DO	4	
		Loose to compact grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)	87.21 / 5.33	6	50 DO	10	
6		End of Borehole	86.60 / 5.94				

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: D.V.

CHECKED: S.A.T.

RECORD OF BOREHOLE: BH 06-22

PROJECT: 06-1120-290
LOCATION: See Site Plan
BORING DATE: Dec. 4, 2006
SHEET 1 OF 1
DATUM: Local
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	WATER CONTENT PERCENT / SHEAR STRENGTH	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	92.45					
ASPHALTIC CONCRETE	0.00					Flush mount casing set in asphaltic concrete seal
Grey crushed stone (BASE)	0.08					Bentonite Seal
Brown fine sand and gravel (SUBBASE)	92.13 0.33					
Very stiff grey brown SILTY CLAY with occasional grey fine sand and grey sandy silt interbeds (Weathered Crust)	91.64 0.81	1	50 DO	15	w ≈ 20	Native Backfill
		2	50 DO	9	w ≈ 37	
		3	50 DO	5	w ≈ 32	Bentonite Seal
Grey brown layered SILTY CLAY, SANDY SILT and SILTY SAND	89.55 2.90	4	50 DO	5	w ≈ 28	Native Backfill
		5A				
Firm to stiff grey SILTY CLAY	88.41 4.04	5B	50 DO	2	w ≈ 58	Silica Sand
		6	50 DO	WH	w ≈ 60	Standpipe
					Shear: rem V. ≈ 9, nat V. ≈ 44	Native Backfill
					Shear: rem V. ≈ 12, nat V. ≈ 54	
End of Borehole	86.66 5.79					

Water level in standpipe at elev. 91.04m on Dec. 27, 2006

Legend: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; HYDRAULIC CONDUCTIVITY, k, cm/s; SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○; WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl; ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: H.E.C.
CHECKED: T.M.S.

RECORD OF BOREHOLE: BH 06-26

PROJECT: 06-1120-290
LOCATION: See Site Plan
SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: Dec. 8, 2006

DATUM: Local
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m
0	GROUND SURFACE	91.99			
	ASPHALTIC CONCRETE	0.00			
	Grey crushed stone (BASE)	0.08			
	Brown sand and gravel (SUBBASE)	91.64 0.35			
	Very stiff grey brown to red brown SILTY CLAY (Weathered Crust)	91.19 0.80			
1			1	50 DO	13
2			2	50 DO	11
	Grey brown layered SILTY CLAY, SANDY SILT and SILTY SAND	89.70 2.29	3	50 DO	4
3			4	50 DO	4
	Firm to stiff grey brown SILTY CLAY	87.42 4.57	5	50 DO	WH
6			6	50 DO	WH
	End of Borehole	84.37 7.62			

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

Water level in open hole at elev. 88.94m upon completion of drilling

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: D.V.
CHECKED: T.M.S.

PROJECT: 06-1120-290

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 06-29

BORING DATE: Dec. 13, 2006

SHEET 1 OF 1

DATUM: Local

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.63			
ASPHALTIC CONCRETE	0.04			
Grey crushed stone (BASE)	91.23 / 0.40			
Brown sand and gravel (SUBBASE)	90.93 / 0.70			
Grey brown silty clay, trace to some sand (FILL)	90.41 / 1.22			
Very stiff grey brown SILTY CLAY (Weathered Crust)		1	50 DO	14
		2	50 DO	11
Grey brown to grey layered SILTY CLAY, SANDY SILT and SILTY SAND	89.04 / 2.59	3	50 DO	5
		4	50 DO	WH
Firm grey SILTY CLAY with occasional fine sand seams	87.67 / 3.96			
		5	50 DO	WH
End of Borehole	85.84 / 5.79			

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: Water level in open hole at elev. 87.06 m upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: D.V.

CHECKED: T.M.S.

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PROJECT: 09-1121-0120

RECORD OF BOREHOLE: 09-10

LOCATION: See Site Plan

BORING DATE: Aug. 13, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

Description	Elev. / Depth (m)	Sample Number	Type	Blows/0.30m	Piezometer or Standpipe Installation
GROUND SURFACE	90.50				
Dark brown clayey silt, some sand and organic matter (TOPSOIL)	0.00				Native Backfill
Stiff grey brown SILTY CLAY, trace to some sand, occasional sand seam (Weathered Crust)	90.17 / 0.33	1	50 DO	9	Bentonite Seal
Loose grey brown SANDY SILT to SILTY SAND, trace to some clay	89.13 / 1.37	2	50 DO	2	
Firm grey SILTY CLAY, trace gravel, sand and shells, occasional sand seam	88.37 / 2.13	3	50 DO	WH	Native Backfill
		4	50 DO	PM	Bentonite Seal
		5	50 DO	PM	Standpipe
					Cave
End of Borehole	83.18 / 7.32				W.L. in standpipe at Elev. 89.64m on Sept. 8, 2009

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

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

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: ________

PROJECT: 09-1121-0120

RECORD OF BOREHOLE: 09-9

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Aug. 13, 2009

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	SHEAR STRENGTH / WATER CONTENT	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	91.99					
	Dark brown silty clay, some sand and organic matter (TOPSOIL)	0.00					Bentonite Seal
	Grey brown SILTY CLAY, some sand (Weathered Crust)	91.69 / 0.30					
	Loose brown SANDY SILT, some clay	91.43 / 0.56					
1			1	50 DO	5		
	Stiff grey brown CLAYEY SILT, some sand, with fine sand seams with depth (Weathered Crust)	90.47 / 1.52	2	50 DO	4		
2							Native Backfill
			3	50 DO	3	W ○	
3	Grey CLAYEY SILT, trace sand, occasional sand and gravel seams with depth	88.94 / 3.05	4	50 DO	1	W ○	
4						nat V. +	
							Bentonite Seal
5			5	50 DO	5		Silica Sand
							Standpipe
			6	50 DO	7	W ○	Silica Sand
							Bentonite Seal
6	Compact to loose grey SANDY SILT, some gravel, trace clay, occasional cobbles and boulders (GLACIAL TILL)	85.89 / 6.10	7	50 DO	11		
7			8	50 DO	>50		Cave
8			9	50 DO	7		
	End of Borehole	83.76 / 8.23					
9							W.L. in standpipe at Elev. 89.87m on Sept. 8, 2009
10							

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

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

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

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

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: R.I./J.C.

CHECKED: ________

APPENDIX C

Results of Chemical Analysis, EXOVA Environmental Ontario Report No. 1503893

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

EXOVA

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Alex Meacoe
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1503893
Date Submitted: 2015-03-13
Date Reported: 2015-03-20
Project: 1418804
COC #: 794683

Group	Analyte	MRL	Units	Guideline		
				Lab I.D.	1164065	1164066
				Sample Matrix	Soil	Soil
				Sample Type		
				Sampling Date	2015-01-05	2015-01-15
				Sample I.D.	BH 14-3 SA2/5-7'	BH 14-14 SA3/5-7'
Agri. - Soil	pH	2.0			7.8	7.9
General Chemistry	Cl	0.002	%		<0.002	<0.002
	Electrical Conductivity	0.05	mS/cm		0.63	0.12
	Resistivity	1	ohm-cm		1590	8330
	SO4	0.01	%		0.01	0.01

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

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

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