REPORT

Geotechnical Investigation

Proposed Residential Development
Pathways at Findlay Creek – Phase 3 (Block 60)
4800 Bank Street, Ottawa, ON

Submitted to:

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1.0 INTRODUCTION

This report provides geotechnical design guidance for a proposed residential development to be located on Pathway Phase 3 (Block 60) at 4800 Bank Street in Ottawa, Ontario. The previous investigation report titled: "*Geotechnical Investigation, Proposed Residential Development, Remer and Idone Lands, Ottawa, Ontario, report number 13-1121-0083 (1046), dated January 2017*", which was issued for the entire residential subdivision on the Remer and Idone Lands, was used to prepare this geotechnical report for the proposed development at Block 60.

The purpose of the subsurface investigations was to determine the general soil, bedrock, and groundwater conditions across the site by means of seven boreholes and three augerholes advanced during previous investigations for the larger development area. Based on an interpretation of the factual information, obtained from the existing subsurface information available for the site from previous investigations, engineering recommendations are provided on the geotechnical design aspects of the proposed development, including construction considerations that 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 residential housings on Pathway Phase 3 (Block 60) at 4800 Bank Street in Ottawa, Ontario (see Key Map on Figure 1).

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

- The site is Block 60 on plan of subdivision of Part of Lots 21 and 22 Concession 4 (Rideau Front) in Township of Gloucester (Ottawa), and measures approximately 135 m by 65 m in plan area.
- The site is currently bordered by vacant lands; however, future developments will be constructed to the east and south of the proposed development site.
- The site is proposed to be developed into conventional residential houses with basements (numbered Blocks 1 to 8, inclusive) and an associated access road.

The approximate locations of the relevant boreholes and augerholes from the previous investigations that were referenced in this report are shown on the Site Plan, Figure 1.

Based on the results of those previous investigations, as well as a review of the published geological mapping, the subsurface conditions across this site are expected to predominantly consist of variable deposits of sand and silt, underlain by bouldery glacial till, over bedrock. The bedrock surface is expected to vary at depths of about 3 to 6 m below the existing ground surface. Published geological mapping indicates that the bedrock in the area consists of interbedded sandstone and dolomite of the March Formation; however, based on site investigations it is known that the bedrock consists of Oxford formation dolomite.

3.0 SUBSURFACE CONDITIONS

3.1 General

Information on the subsurface conditions is provided as follows:

- Record of borehole and augerhole sheets of the previous investigations by Golder (1988, 2013 and 2017) are provided in Appendix A.
- Record of borehole sheets of the previous investigation by Jacques Whitford Limited (now Stantec) (1990) are provided in Appendix B.

In general, the subsurface conditions at this site consist of topsoil, over variable thickness of sand and silt deposits underlain by glacial till, over dolostone bedrock.

The following sections present a more detailed overview of the subsurface conditions encountered in the boreholes and augerholes advanced on and in the area of the site during the previous investigations. It is assumed in the sections below that the site has not been altered since those investigations were completed (i.e., no stripping, excavation or filling has been carried out on the site).

3.2 Topsoil

Topsoil or peat existed at the ground surface at all borehole and auger hole locations. The thickness of the topsoil or peat ranged from about 0.2 to 0.9 m.

3.3 Sand and Silt

The topsoil and peat is generally underlain by variable deposits of sand and silt at all boreholes and auger holes. These deposits predominantly consist of sand, silty sand to sandy silt and silt, with varying amounts of gravel, cobbles and boulders, and clay particles. These deposits were not penetrated at the test hole locations, with the exception of boreholes 13-30A and 13-32 but were proven to extend to depths ranging between about 0.9 and 6.7 m beneath the existing ground surface prior to encountering sampling refusal.

At boreholes 13-30 and 13-32, the sand and silt deposits extend to depths of 1.8 and 3.4 m, respectively.

SPT “N” values in the sand and silt deposits ranged widely, from 2 to >50 blows per 0.3 m of penetration, indicating a very loose to very dense state of packing.

3.4 Glacial Till

Glacial till exists beneath the sand and silt deposits in boreholes 13-30A and 13-32. The glacial till generally consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand to sandy silt. The glacial till was not penetrated at the test holes but was proven to extend to depths of about 3.2 and 7.7 m, respectively beneath the existing ground surface prior to encountering refusal to sampling or being terminated.

SPT “N” values obtained in borehole 13-30A were reported to vary between 22 and greater than 50 blows per 0.3 m of penetration, indicating a compact to very dense state of packing. The high “N” value likely reflects the presence of cobbles or boulders within the deposit.

3.5 Refusal

Practical refusal to sampling was encountered in boreholes 13-28, 13-30, 13-30A and 90-3 at depths varying between about 0.9 to 6.3 m below the existing ground surface. Refusal likely indicates the presence of cobbles or boulders within the sand and silt deposits or glacial till, and not bedrock surface.

Borehole 13-32 was advanced through the large cobbles or boulders, from a depth of about 6.1 to 7.7 m, using rotary diamond drilling techniques while retrieving NQ sized core.

3.6 Groundwater

The measured groundwater level in the standpipe piezometers installed in boreholes 13-26 and 13-32, and seepage depths in auger holes AH217, AH218 and HAH16-18 were between 0.2 m below the surface and near the existing ground surface (i.e., elevations 95.5 to 96.1 metres above sea level, masl). Groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

3.7 Corrosion Testing

Six samples of soils were submitted to EXOVA laboratories for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements, as part of the previous investigation carried out for the subdivision. The results of the testing are provided in Appendix C and are summarized below.

Borehole Number/ Sample Number	Sample Depth (m)	Chloride (%)	SO_4 (%)	pH	Resistivity (Ohm-cm)
13-4 / Sa 2	0.8 – 1.4	0.019	<0.01	7.3	3,450
13-6 / Sa 6	3.8 – 4.4	<0.002	<0.01	8.0	8,330
13-13 / Sa 5	3.1 – 3.7	<0.002	<0.01	7.9	9,090
13-16 / Sa 2	1.5 – 2.1	0.004	<0.01	8.0	9,090
13-23 / Sa 7	3.6 – 4.2	0.003	0.03	8.1	5,560
13-31 / Sa 7	3.7 – 4.3	0.003	0.02	8.2	7,690

4.0 DISCUSSION AND CONSTRUCTION CONSIDERATIONS

4.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the available information described herein and project requirements. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the factual information for construction, and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, safety, and equipment capabilities.

Reference should be made to the "*Important Information and Limitations of This Report*" which follows the text but forms an integral part of this document.

4.2 Site Grading

In general, the subsurface conditions at this site consist of topsoil, overlying variable thicknesses of silt and sand, followed by glacial till, which is in turn underlain by bedrock. The depth to sampling refusal varied from about 0.9 to 6.3 m below the existing ground surface.

From a foundation design perspective, no practical restrictions apply to the thickness of grade raise fill that may be placed within the proposed development. However, grade raises in excess of 4 m should be reviewed and approved by a geotechnical professional.

For predictable performance of the structures, roadways, and site services, preparation for filling of the site should include stripping the existing topsoil and peat. The organic soil is not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no structures, roadways or services, the existing topsoil or peat may be left in place provided settlement of the ground surface following filling can be tolerated.

Groundwater level or seepage was generally encountered near the existing ground surface (from elevations 95.5 to 96.1 masl). Considerable groundwater flow should be expected for excavations that extend below the groundwater level. Therefore, consideration should be given to setting the grading to limit the required depths of excavation (particularly for basements) since groundwater management requirements and costs increase with excavation depth below the groundwater level. It would be preferred from a geotechnical perspective to limit the depths of excavations to no more than about 1.0 m below the existing ground surface. Ongoing significant groundwater inflow to the basement drainage system would also ideally be avoided.

4.3 Material Reuse

The native soils encountered at this site are not considered to be generally suitable for reuse as structural or engineered fill. Within foundation areas, imported granular material placed and compacted to provide engineered fill should be used, where required.

The silt and sand deposits and glacial till may be suitable for use as controlled fill beneath pavement areas, provided they are not too wet to place and compact. Glacial till encountered below the groundwater may be too wet to feasibly be used as controlled fill. These materials could, however, be reused in non-structural areas (i.e., landscaping).

4.4 Foundations

The native undisturbed, inorganic overburden soils encountered at the site are considered suitable for supporting the conventional residential houses (with basements). Topsoil and fill (if encountered) would not be considered suitable to support the building foundations and therefore must be removed from underneath the building footings and slabs.

For frost protection purposes, exterior footings for buildings should be founded at least 1.5 m below finished exterior grade. Isolated footings in unheated areas should be provided with at least 1.8 m of soil for frost protection (see Section 4.7 below). Any subexcavation below underside of the footing elevations should be removed and replaced with engineered fill. The engineered fill should consist of Ontario Provincial Standard Specification (OPSS) Granular B Type II, placed in maximum 300 mm thick lifts, and compacted to at least 95% of the material's Standard Proctor Maximum Dry Density (SPMDD) using suitable vibratory compaction equipment. The engineered fill material must be placed within the full zone of influence of the building foundations. The zone of influence is considered to extend out and down from the edge of the perimeter footings at a slope of 1 horizontal to 1 vertical (1H:1V).

Strip and pad footing foundations may be designed using a maximum allowable bearing pressure (i.e., Serviceability Limit States, SLS, bearing resistance) of 75 kPa. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code (OBC). The Ultimate Limit States bearing resistance may be taken as 150 kPa, for footings up to 1.0 m in width, if needed for design.

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

The overburden materials on this site, in particular the glacial till deposit, contain cobbles and boulders. Any cobbles or boulders in footing areas that are loosened by the excavation process should be removed (and not pushed back into place) and the cavity filled with lean concrete. Otherwise, recompression of the disturbed soils could lead to larger than expected post-construction settlements.

There may be portions of the site where the shallow sand and silt deposits will be exposed at footing/subgrade level. Prior to construction of footings or the placement of engineered fill within these areas, the surface of the native sandy and silty materials should be proof rolled to provide surficial densification of any loose or disturbed material.

4.5 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 m of soil and/or bedrock below founding level. Based on the 2012 OBC methodology, this site can be assigned a Site Class of D.

More favourable Site Class values could potentially be assigned for portions of the site if shear wave velocity testing were carried out.

4.6 Liquefaction Considerations

The upper portions of the silt and sand deposits below the groundwater level are generally loose and are considered to be potentially liquefiable under seismic loading. These deposits are not homogenous across the site and it is expected that the liquefiable zones within the soil mass will be localized to some areas of the site and post-seismic event settlements will likely be small.

With regards to the proposed conventional residential housing at this site (e.g., two storey residential buildings with basements), the structures can be considered to have a fundamental period of vibration of less than or equal to 0.5 seconds. In such a case, the liquefaction can be considered to have very minimal negative impact on the performance of the structures. As such, this will not affect the proposed Site Class D for this site.

If the fundamental period of vibration of the structures is greater than 0.5 seconds (e.g., commercial buildings), then additional seismic assessment will be required.

4.7 Frost Protection

The native subgrade soils on this site are considered to be highly frost susceptible. Therefore, all exterior perimeter foundation elements or foundation elements in unheated areas should be provided with a minimum of 1.5 m of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces that are cleared of snow cover during winter months should be provided with a minimum of 1.8 m of earth cover. Insulation could be provided as an alternative to earth cover for frost protection. Further details can be provided, if required.

4.8 Foundation and Basement Excavations

Excavations for basements and foundations will be made into the silts and sands.

No unusual problems are anticipated in excavating the overburden materials using conventional hydraulic excavating equipment, recognizing that boulders may be encountered in the sands and silts and will likely be encountered in the glacial till (should excavations into the till be required). Boulders larger than 0.3 m in size should be removed from the excavation side slopes, for worker safety.

In accordance with the Occupational Health and Safety Act (OHSA) of Ontario, the overburden materials above the groundwater table (or where the groundwater level is lowered below the floor of the excavation) would generally be classified as a Type 3 soil and therefore, the side slopes should be stable in the short term at 1 horizontal to 1 vertical. Below the water table, side slopes of 3 horizontal to 1 vertical (Type 4 soil in accordance with the OHSA) will be required to prevent sloughing of the sandier soils.

For excavations that need to be carried out below the groundwater level, some sloughing of excavation side slopes and/or disturbance of the base of the excavations can be anticipated. Pre-drainage of the site using ditching or pumping from sumps to lower the groundwater level to at least 0.5 m below the base of the excavations would assist in reducing the potential for side slope instability and subgrade disturbance. 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 mm thick layer of OPSS Granular A underlain by a non-woven geotextile, to protect the subgrade from construction traffic.

Consideration should be given at the time of tender of the basement excavation work to carrying out test excavations in the presence of bidders so that the actual excavation conditions and groundwater inflow can be assessed.

Under the new regulations, a Permit-To-Take-Water (PTTW) is required from the Ministry of the Environment, Conservation and Parks (MECP) if a volume of water greater than 400,000 litres per day is pumped from the excavations. If the volume of water to be pumped will be less than 400,000 litres per day, but more than 50,000 litres per day, the water taking will not require a PTTW, but will need to be registered in the Environmental Activity and Sector Registry (EASR) as a prescribed activity.

It is understood that a Category 3 Permit-To-Take-Water (PTTW) has been obtained from the MECP for the Pathways development and no further registration would be required.

4.9 Basement and Garage Floor Slabs

In preparation for the construction of the basement and garage floor slabs, all loose, wet, and disturbed materials as well as fill materials (if any) should be removed from beneath the floor slab. Provision should be made for at least 200 mm of 19 mm crushed clear stone to form the base of the basement floor slabs. Any engineered fill used to raise the grade to the underslab clear stone fill should be compacted to at least 95% of the material's SPMDD.

The recommended type of drainage system required (perimeter drains and/or underfloor drains; damp-proofing or water-proofing) depends upon the proposed basement founding elevations, soil types in the area and actual stabilized groundwater levels. As a general guideline, to prevent hydrostatic pressure build up beneath the basement floor slabs, it is suggested that the granular base for the floor slabs be positively drained. This can be achieved by providing a hydraulic link between the underfloor fill and exterior drainage system.

The groundwater level was observed to be near or slightly below the existing ground surface (or elevations 95.5 to 96.1 masl). From a constructability perspective, excavations below the groundwater level should ideally be limited/avoided. Raising of site grades in areas with a high water table would be beneficial in reducing the water control measures for foundation construction. Similarly, since significant and sustained groundwater inflow into the foundation drainage system would ideally be avoided, the founding depths should be set above the groundwater level.

However, if/where the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. In the extreme case, loss of fines into the clear stone could cause ground loss beneath the slab and plugging of the drainage system. Where a geotextile is required, it should consist of a Class II non-woven geotextile with a Filtration Opening Size (FOS) not exceeding about 100 microns, in accordance with OPSS 1860.

The garage backfill should be placed in maximum 300 mm thick lifts and be compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

The granular base for the garage floor slabs should consist of at least 150 mm of Granular A compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

4.10 Basement Walls 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, these foundation elements should either be backfilled with non-frost susceptible sand or sand and gravel conforming to the requirements for OPSS Granular B Type I or, alternatively, a bond break such as the Platon system sheeting could be placed against the foundation walls.

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

Basement walls made within open cut excavations, backfilled with granular material, and effectively drained as described above should be designed to resist lateral earth pressures calculated using a triangular distribution of the stress with a magnitude of:

$$\sigma_h(z) = K_o(\gamma z + q)$$

Where:

$\sigma_h(z)$ = Lateral earth pressure on the wall at depth z, kilopascals

K_o = At-rest earth pressure coefficient, use 0.5

γ = Unit weight of retained soil, 21.5 kN/m^3

z = Depth below top of wall, m

q = Uniform surcharge at ground surface behind the wall to account for traffic, equipment, or stockpiled soil (use 12 kPa as a minimum)

If Platon System sheeting or a similar water barrier product is used against the foundation walls, then hydrostatic groundwater pressures should also be considered in the calculation of the lateral earth pressures.

4.11 Site Servicing

Excavations for the installation of site services will be made through the topsoil, silt and sand deposits, glacial till and/or bedrock. Based on the anticipated groundwater levels at this site, the excavations for site servicing may extend below the groundwater level.

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

Excavation side slopes above the water table should be stable in short term at 1H:1V (i.e., for Type 3 soils per OSHA of Ontario). Excavation side slopes below groundwater level will need to be at 3H:1V (i.e., Type 4 soils).

The stand-up time for exposed side slopes will be extremely short and the subgrade will be disturbed if left exposed for any length of time. Construction of site services should be planned to be carried out in short sections, which can be fully completed in a minimal amount of time. The rate of groundwater inflow from the overburden could be significant. Based on past experience on the adjacent sites and particularly where the excavations are deeper and/or where the overburden is coarser, some pre-drainage of the overburden will be required. For example, several sumps could be constructed, and pre-pumping of the overburden groundwater carried out. if pumping from trench sumps cannot control the groundwater inflow into the excavation and prevent disturbance of the trench subgrade, it might be required to use several shallow wellpoints to achieve temporary groundwater lowering to install the servicing. This could be required using either open cut or a trench box.

Alternatively, excavations within the overburden soils could also be carried out within a fully braced steel trench box, which would minimize the width of the excavation. The use of a trench box will not, however, eliminate the potential for disturbance outside the trench box limits.

At least 150 mm 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% of the material’s SPMDD. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project, since fine particles from the sandy backfill materials or 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 mm above the top of pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 mm. The cover material should be compacted to at least 95% of the material’s SPMDD.

It should generally be possible to re-use the overburden soils as trench backfill. Material from below the water table may be re-used provided that it can be adequately placed and compacted.

Some of the overburden materials below the water table may be too wet to compact. Where that is the case, these materials should be wasted (and drier materials imported) or these materials should be placed only in the lower portions of the trench, recognizing that some future ground settlement over the trenches will likely occur. In that case, it would also be prudent to delay final paving for as long as practical and significant padding of the roadways may be required in these areas prior to final paving.

Boulders larger than 300 mm in diameter will also interfere with the backfill compaction and should be removed from the excavated material prior to re-use as backfill.

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 m depth) should match the soil exposed on the trench walls for frost heave compatibility. Trench backfill should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the material's SPMDD using suitable compaction equipment.

4.12 Pavement Design

In preparation for pavement construction, all topsoil should be removed from all pavement areas.

Sections requiring grade raising to the proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material (SSM). These materials should be placed in maximum 300 mm thick lifts and should be compacted to at least 95% of the materials' SPMDD using suitable compaction equipment.

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

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

Pavement Component	Thickness (mm)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	400

The pavement structure for collector roadways and fire routes that will experience bus and/or truck traffic should consist of:

Pavement Component	Thickness (mm)
Asphaltic Concrete	120
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	450

If any of the roadways would be categorized as 'collector' roadways and/or will experience bus or truck traffic (other than school buses, garbage trucks, moving trucks, etc.), then additional pavement design recommendations will need to be provided.

The granular base and subbase materials should be uniformly compacted to at least 100% of the material's SPMDD using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 10 of OPSS 310. The composition of the asphaltic concrete pavement with 90 mm thickness should be as follows:

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

The composition of the asphaltic concrete pavement with 120 mm thickness should be as follows:

- Superpave 12.5 mm Surface Course – 50 mm
- Superpave 19.0 mm Base Course – 70 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.

The above pavement design is 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.

4.12.1 Pavement Structure Compaction

Adequate compaction of the granular roadway materials will be essential to the continued acceptable performance of the roadway. Compaction should be carried out in conformance with procedures outlined in OPSS 501 "Construction Specification for Compacting" with compacted densities of the various materials being in accordance with Subsection 501.08.02 Method A. The granular base and subbase material should be uniformly compacted to at least 100% of the material's SPMDD using suitable vibratory compaction equipment. Compaction of the asphaltic concrete should be carried out in accordance with OPSS 310, Table 10.

The placement and compaction of any engineered fill, as well as sewer and watermain bedding and backfill, should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction viewpoint. In addition, compaction testing and sampling of the asphaltic concrete used on site should be carried out to make sure that the materials used and level of compaction achieved during construction meet the project requirements.

4.13 Tree Planting Restrictions

Silty clay soils in the Ottawa area are highly sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the silty clay, the silty clay undergoes shrinkage which can result in settlement of adjacent structures.

Based on the results of the investigations, silty clay was not encountered within the referenced boreholes and auger hole locations. As such, no restrictions on the types or sizes of trees that may be planted or tree to foundation setback distances need to be considered for this development in accordance with the City's 2017 guidelines for Tree Planting in Sensitive Marine Clay Soils.

4.14 Corrosion and Cement Type

As part of the previous investigation for the entire residential subdivision on the Remer and Idone Lands (January 2017), six soil were submitted to EXOVA laboratories for basic chemical analysis related to elevated potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements. The results are considered applicable to the site of the Block 60 development, considering consistent subsurface and groundwater conditions across the subdivision. The results of the 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.

4.15 Impacts to Adjacent Properties or Infrastructure

Based on the information available to Golder at the time of this report, excavations for foundations or services at this site will not be within the zone of influence (defined within a line drawn from the existing underside of foundation or utility invert at an angle of 1 horizontal to 1 vertical) of existing structures or utilities. The planned excavations should therefore not have an impact on adjacent properties or utilities.

4.16 Pools, Decks and Additions

4.16.1 Above Ground and In Ground Pools

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

4.16.2 Decks

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

4.16.3 Additions

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

6.0 ADDITIONAL CONSIDERATIONS

The soils at this site are sensitive to disturbance from ponded water, construction traffic and frost. If construction is carried out during periods of sustained below freezing temperatures, all subgrade areas should be protected from freezing (e.g., by using insulated tarps and/or heating).

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soils having adequate bearing capacity have 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 viewpoint.

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

7.0 CLOSURE

We trust that this report meets your current requirements. If you have any questions, or if we may be of further assistance, please contact the undersigned.

Signature Page

Golder Associates Ltd.

Ali Ghirian, P.Eng.
Geotechnical Engineer

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

AG/WC/hdw

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https://golderassociates.sharepoint.com/sites/126333/project files/6 deliverables/geotech report for block 60 (20142688)/final/20142688-1148-001-r-rev0-pathway block 60 geotechnical investigation-jan 2021.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

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

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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.

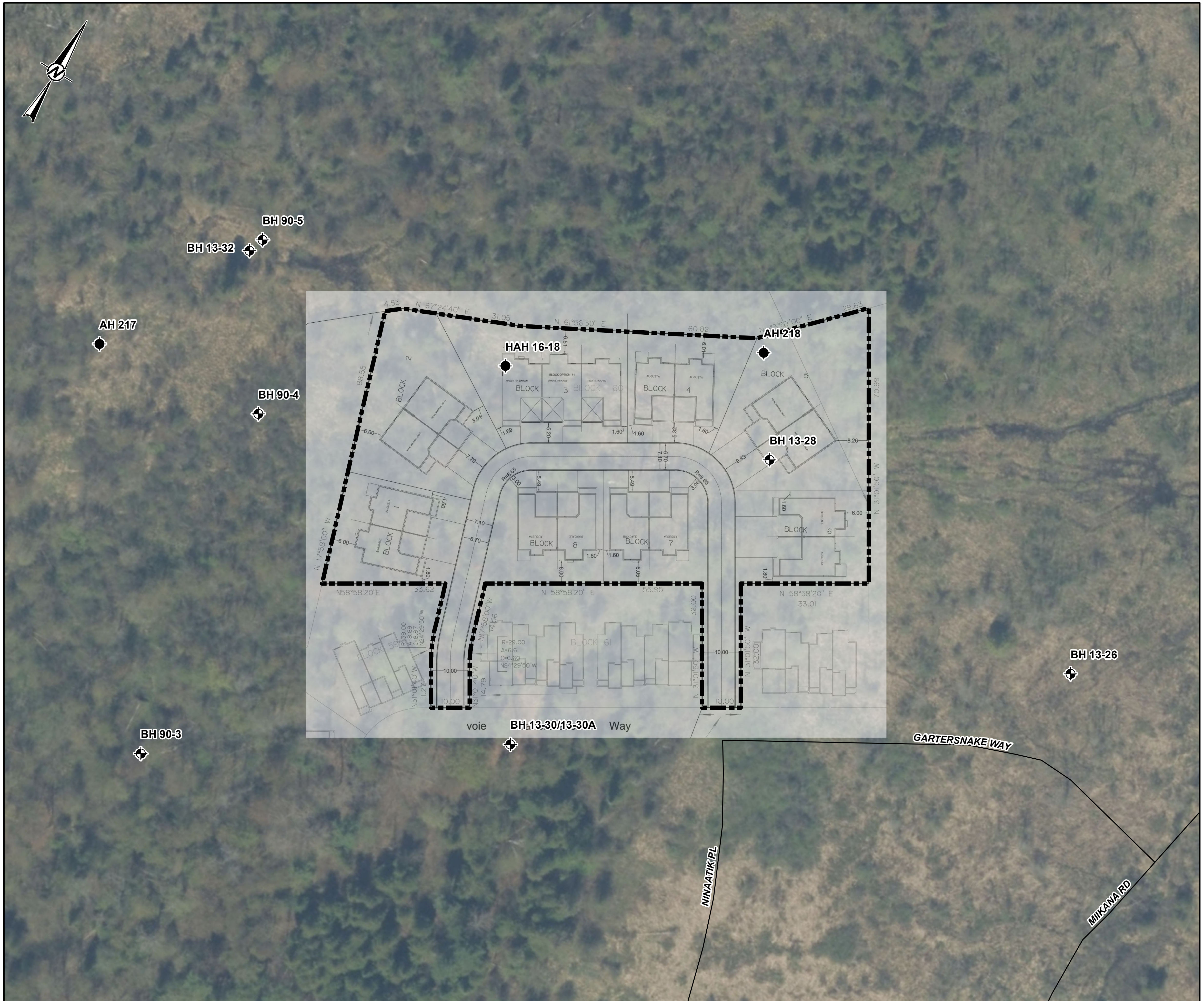
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater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

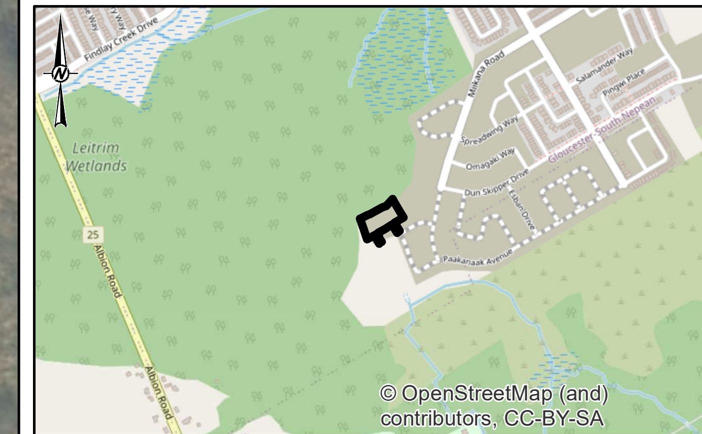
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and 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 1:25,000

LEGEND

- APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATIONS
- APPROXIMATE AUGER HOLE LOCATION, PREVIOUS INVESTIGATIONS
- ROADWAY
- APPROXIMATE SITE BOUNDARY

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - CITY OF OTTAWA.
2. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 10 20 40

1:1,000 METRES

CLIENT

LEITRIM SOUTH HOLDINGS LIMITED

PROJECT

PATHWAYS AT FINDLAY CREEK RESIDENTIAL DEVELOPMENT – PHASE 3 (BLOCK 60) 4800 BANK STREET, OTTAWA, ONTARIO

TITLE

SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2020-09-11
DESIGNED	----
PREPARED	JEM
REVIEWED	AG
APPROVED	WC

PROJECT NO.	CONTROL	REV.	FIGURE
20142688	0003	A	1

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

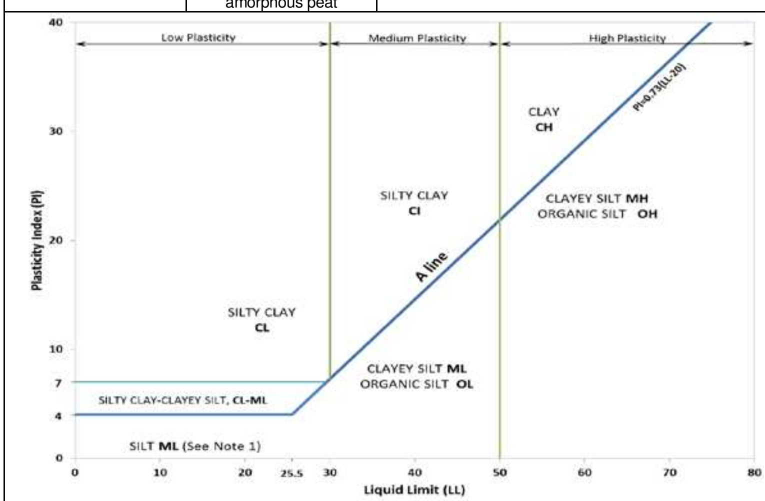
APPENDIX A

Method of Soil Classification and Terms Description Terminology Record of Boreholes and Auger holes – Previous Investigations by Golder

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF 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)
> 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.). Values reported are as recorded in the field and are uncorrected.

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

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

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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 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 the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

* 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 = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 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

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of rock material weathering.

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

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

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

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

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

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

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

GRAIN SIZE

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

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

CORE CONDITION

Total Core Recovery (TCR)
The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)
The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)
The percentage of solid drill core, greater than 100 mm length, as measured along the centerline axis of the core, relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid segments.

DISCONTINUITY DATA

Fracture Index
A count of the number of naturally occuring discontinuities (physical separations) in the rock core. Mechanically induced breaks caused by drilling are not included.

Dip with Respect to Core Axis
The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^o angle is horizontal.

Description and Notes
An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

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

RECORD OF BOREHOLE: 13-26

PROJECT: 13-1121-0083
SHEET 1 OF 1

LOCATION: See Site Plan
BORING DATE: October 17, 2013
DATUM: Geodetic

SAMPLER HAMMER, 32kg; DROP, 760mm
PENETRATION TEST HAMMER, 32kg; 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 (20, 40, 60, 80), nat V. + Q - ●, rem V. ⊕ U - ○ | HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-8}, 10^{-6}, 10^{-4}, 10^{-2}); WATER CONTENT PERCENT (20, 40, 60, 80), Wp ⊢—○W—⊣ Wl | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

Boring method: Portable Drill, NW Casing

Description	Elev. / Depth (m)
GROUND SURFACE	95.44
TOPSOIL	0.00
Loose to compact grey SILTY SAND to SANDY SILT	94.83 / 0.61
End of Borehole	89.95 / 5.49

Note:
Blow counts were corrected for half-weight hammer.

Number	Type	Blows/0.30m
1	50 DO	1
2	50 DO	6
3	50 DO	9
4	50 DO	8
5	50 DO	13
6	50 DO	8
7	50 DO	10
8	50 DO	11
9	50 DO	25

Piezometer or standpipe installation:

- Bentonite Seal
- Silica Sand
- 38 mm Diam. PVC #10 Slot Screen 'B'
- Bentonite Seal
- Silica Sand
- 32 mm Diam. PVC #10 Slot Screen 'A'
- Silica Sand

WL in Screen 'A' at Elev. 95.42 m on November 7, 2013

WL in Screen 'B' at Elev. 95.46 m on November 7, 2013

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DWM
CHECKED: PAS

PROJECT: 13-1121-0083

RECORD OF BOREHOLE: 13-28

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 4, 2013

DATUM: Geodetic

SAMPLER HAMMER, 32kg; DROP, 760mm

PENETRATION TEST HAMMER, 32kg; 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^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		95.62							
0	Portable Drill, NW Casing	TOPSOIL		0.00	1	50 DO	2				
		Loose brown SILTY SAND		95.01 0.61	2	50 DO	6				
1		Loose to compact grey SILTY SAND		94.40 1.22	3	50 DO	10				
2		Very dense dark brown SANDY SILT		93.79 1.83	4	50 DO	>50				
		End of Borehole Spoon Refusal Note: Blow counts were corrected for half-weight hammer.		93.44 2.18							
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: ALB

CHECKED: PAS

PROJECT: 13-1121-0083

RECORD OF BOREHOLE: 13-30

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 9, 2013

DATUM: Geodetic

SAMPLER HAMMER, 32kg; DROP, 760mm

PENETRATION TEST HAMMER, 32kg; 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^{-8}, 10^{-6}, 10^{-4}, 10^{-2}); WATER CONTENT PERCENT Wp —○W— Wl (20, 40, 60, 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Portable Drill, NW Casing	TOPSOIL		0.00							
		Stiff brown CLAYEY SILT, some sand, trace gravel, with rootlets		0.15	1	50 DO	5				
		Brown SILTY SAND, some gravel		0.61	2	50 DO	>50				
1		End of Borehole Spoon Refusal		0.91							

Notes:
1. Ground surface elevation unable to be determined due to heavy tree cover.
2. Borehole was terminated and relocated to BH 13-30A due to shallow refusal.
3. Blow counts were corrected for half-weight hammer.

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: PAS

PROJECT: 13-1121-0083

RECORD OF BOREHOLE: 13-30A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 9, 2013

DATUM: Geodetic

SAMPLER HAMMER, 32kg; DROP, 760mm

PENETRATION TEST HAMMER, 32kg; 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^{-8} 10^{-6} 10^{-4} 10^{-2}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE									
0	Portable Drill, NW Casing	TOPSOIL		0.00							
		Very loose brown SANDY SILT, some clay		0.15	1	50 DO	2				
1		Compact brown SILTY SAND, trace clay		0.61	2	50 DO	15				
		Loose to compact grey brown SILTY SAND, trace gravel		1.22	3	50 DO	10				
2		Compact to very dense grey fine to medium SAND, some silt, trace gravel, with cobbles and boulders (GLACIAL TILL)		1.83	4	50 DO	22				
					5	50 DO	42				
3					6	50 DO	>50				
		End of Borehole Spoon Refusal Notes: 1. Borehole 13-30A was relocated approximately 1.5 m from borehole 13-30 due to shallow refusal. 2. Blow counts were corrected for half-weight hammer.		3.20							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DWM

CHECKED: PAS

PROJECT: 13-1121-0083

RECORD OF BOREHOLE: 13-32

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: October 10 & 11, 2013

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	96.12				
0	Wash Boring, NW Casing	TOPSOIL	0.00				Bentonite Seal
		Inferred brown SILTY fine SAND	95.51 / 0.61				Silica Sand
		Inferred grey SILTY fine SAND	94.60 / 1.52				38 mm Diam. PVC #10 Slot Screen 'B'; Silica Sand
		Inferred grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	92.69 / 3.43				Bentonite Seal; Peltonite; Silica Sand
				C1	NQ RC	DD	32 mm Diam. PVC #10 Slot Screen 'A'
				C2	NQ RC	DD	Silica Sand
		End of Borehole	88.42 / 7.70				

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^{-8} 10^{-6} 10^{-4} 10^{-2}

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

ADDITIONAL LAB. TESTING

STRATA PLOT

Note:
Soil stratigraphy from 0 m to 6.12 m inferred from casing advancement cuttings and resistance.

WL in Screen 'A' at Elev. 96.02 m on Nov. 7, 2013

WL in Screen 'B' at Elev. 96.00 m on Nov. 7, 2013

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: DWM

CHECKED: PAS

TABLE 1 (Continued)

RECORD OF TEST PITS AND HAND AUGERHOLES

Hand Augerhole Number (Elevation m)	Depth (m)	Description
HAH 16-18	0.00 – 0.60	(PT) PEAT; dark brown, fibrous; moist to wet
	0.60 – 1.55	(SM) SILTY SAND, fine; grey; non-cohesive, wet
	1.55 – 2.20	(ML/SM) SILT and SAND; grey; non-cohesive, wet
	2.20	End of Hand Augerhole – Side walls sloughing

Note: Water level at 0.2 metres depth upon completion.

Sample No.	Depth (m)
No samples taken	

Augerhole Number	Depth (metres)	Soil Description
AH 217	0.0 - 0.61	Black **PEAT**
	0.61 - 1.52	Grey **SILTY** Fine **SAND**
	1.52	End of Augerhole Water at Ground Surface
AH 218	0.0 - 0.91	Black **PEAT**
	0.91 - 1.52	Grey **SILTY** Fine **SAND**
	1.52	End of Augerhole Water at Ground Surface

APPENDIX B

Record of Boreholes – Previous Investigation by Jacques Whitford Limited (now Stantec)

JACQUES, WHITFORD LIMITED

BOREHOLE RECORD 90-3

CLIENT: Ship & Krakow Architects

LOCATION: Leitrim, Ontario

DATES: BORING 90-06-26

WATER LEVEL

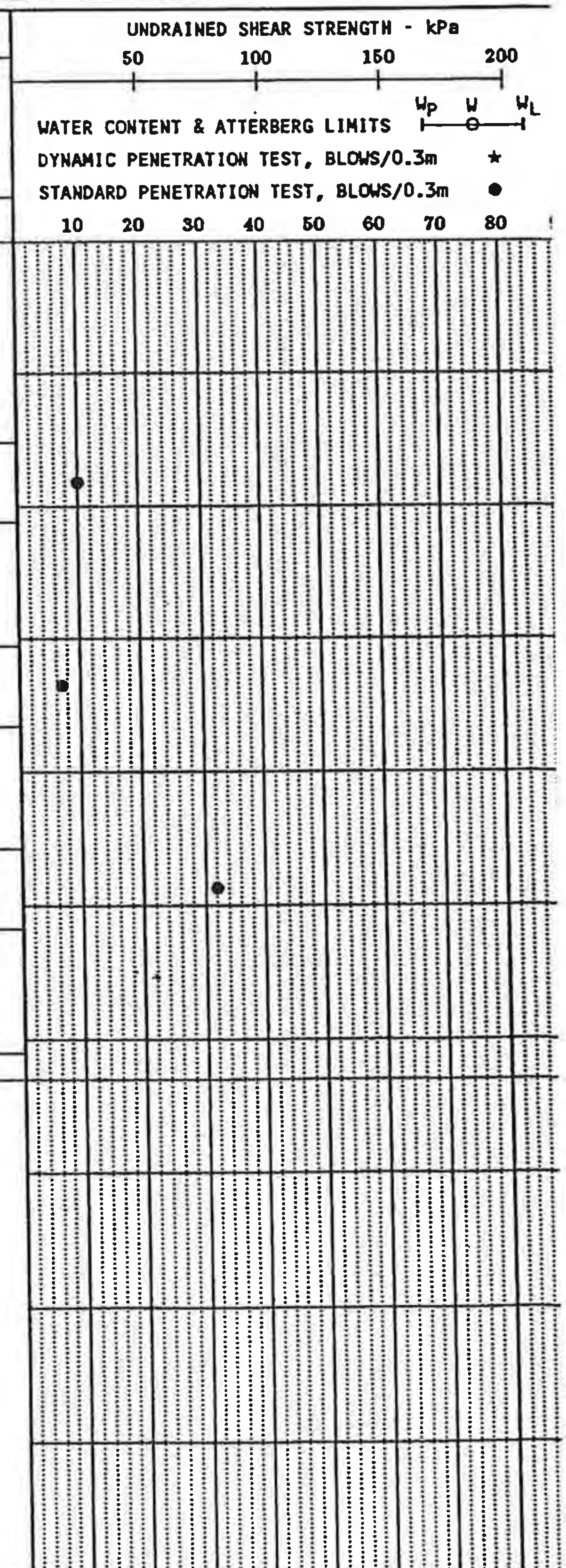
PROJECT No. 30067

BOREHOLE No. 90-3

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
0	96.60	Ground Surface						
0–0.6	96.0	Black PEAT						
0.6–5.6	91.0	Loose to compact, grey, medium, SAND, trace to some silt, trace gravel			SS	1	320	10
					SS	2	230	7
					SS	3	450	32
5.6–6.3	90.3	Compact, greyish brown, SILT and SAND, some gravel and pebbles			SS	4	-	*
6.3		End of Borehole						

* Split spoon refusal



△ Pocket Penetrometer Test

□ Field Vane Test

JACQUES, WHITFORD LIMITED

BOREHOLE RECORD

90-4

CLIENT: Ship & Krakow Architects

LOCATION: Leitrim, Ontario

DATES: BORING 90-06-27

WATER LEVEL

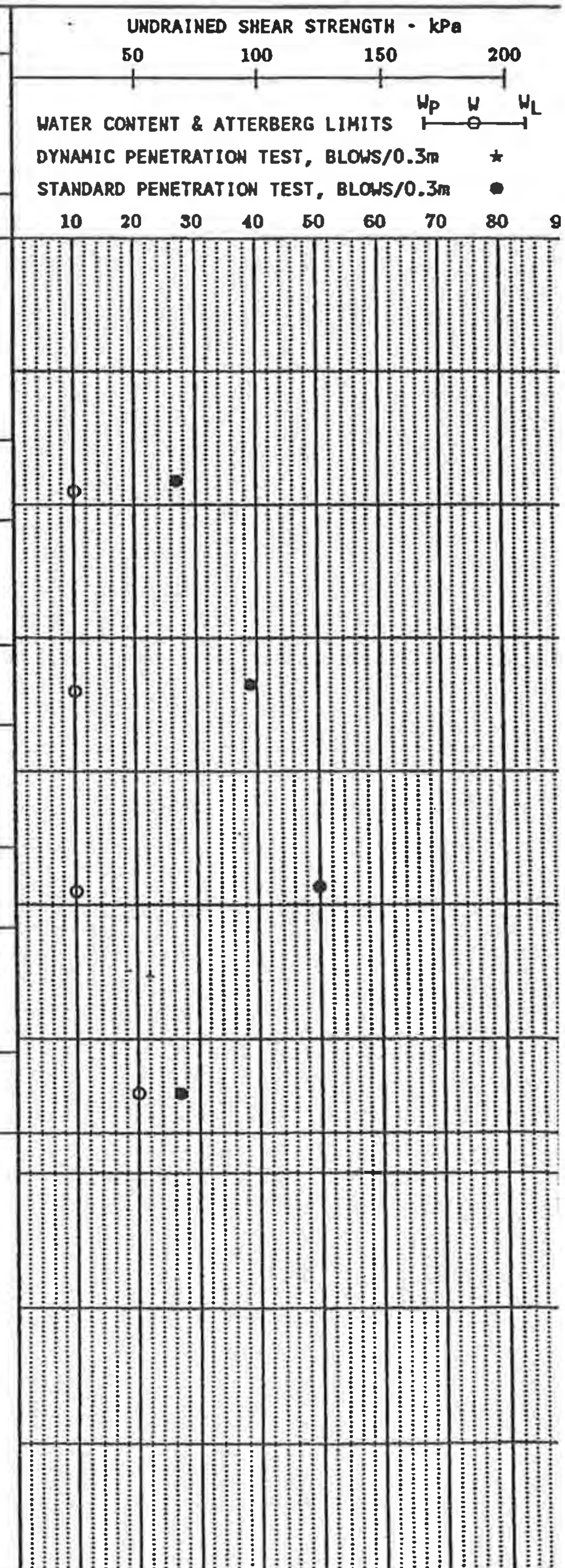
PROJECT No. 30067

BOREHOLE No. 90-4

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
	96.20	Ground Surface						
0		Black PEAT						
	95.6							
1–6		Compact to dense, grey, (fine becoming coarse at depth), SAND, trace silt, some gravel						
~1.8					SS	1	230	27
~3.3					SS	2	350	39
~4.8					SS	3	380	50
~6.4					SS	4	100	27
	89.5	End of Borehole						

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



△ Pocket Penetrometer Test

□ Field Vane Test

JACQUES, WHITFORD LIMITED

BOREHOLE RECORD

90-5

CLIENT: Ship & Krakow Architects

LOCATION: Leitrim, Ontario

DATES: BORING 90-06-27

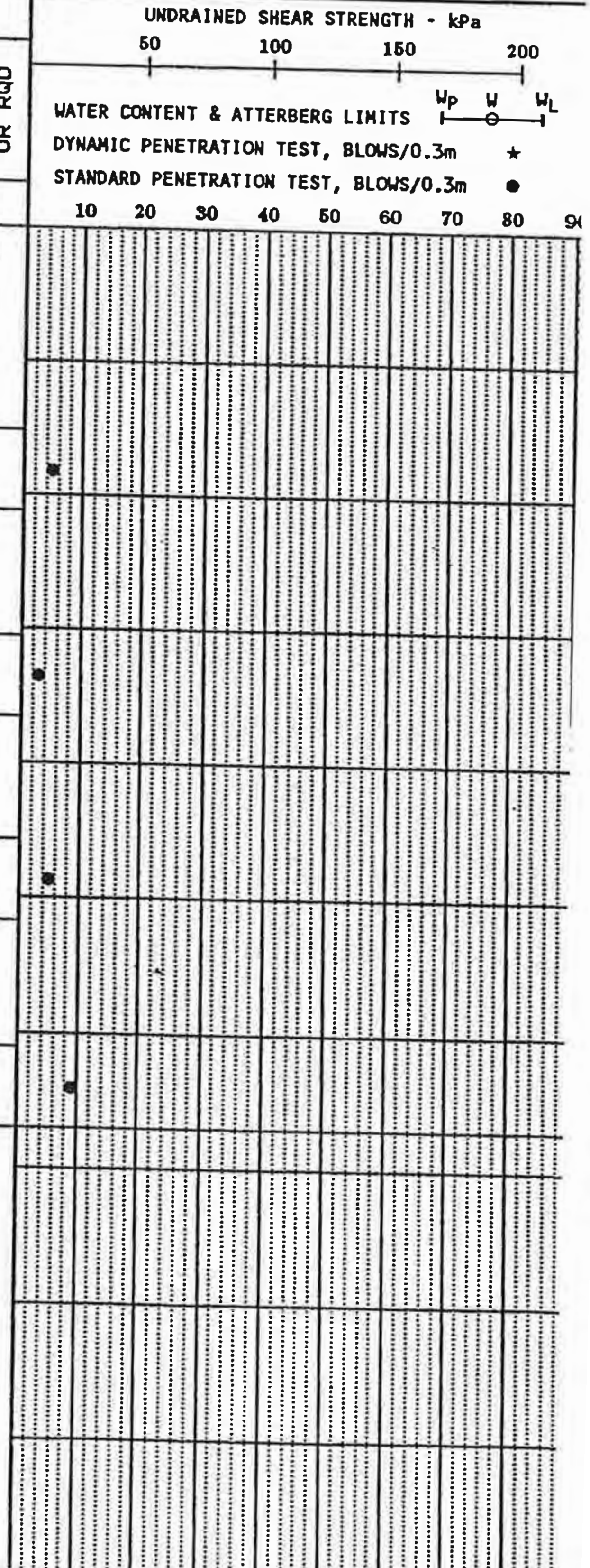
WATER LEVEL:

PROJECT No. 30067

BOREHOLE No. 90-5

DATUM: Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	96.10	Ground Surface						
		Black PEAT						
	95.5	Loose, grey, fine to medium, SAND and SILT, trace gravel and small pebbles at depth						
~2					SS	1	240	5
~3.5					SS	2	400	3
~5					SS	3	300	5
~6.5	89.4				SS	4	420	9
~6.7		End of Borehole						



△ Pocket Penetrometer Test

□ Field Vane Test

APPENDIX C

Results of Chemical Testing – Previous Investigation by Golder

Certificate of Analysis

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

Report Number:	1323883
Date Submitted:	2013-10-28
Date Reported:	2014-01-30
Project:	13-1121-0083
COC #:	779818

Group	Analyte	MRL	Units	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. Guideline	1068678 Soil 2013-10-01 13-4 SA#2	1068679 Soil 2013-09-29 13-6 SA#6	1068680 Soil 2013-09-27 13-13 SA#5	1068681 Soil 2013-10-03 13-16 SA#2
Agri. - Soil	Electrical Conductivity	0.05	mS/cm		0.29	0.12	0.11	0.11
	pH	2.0			7.3	8.0	7.9	8.0
General Chemistry	Cl	0.002	%		0.019	<0.002	<0.002	0.004
	Resistivity	1	ohm-cm		3450	8330	9090	9090
	SO4	0.01	%		<0.01	<0.01	<0.01	<0.01

Group	Analyte	MRL	Units	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D. Guideline	1068682 Soil 2013-10-04 13-23 SA#7	1068683 Soil 2013-10-09 13-31 SA#7
Agri. - Soil	Electrical Conductivity	0.05	mS/cm		0.18	0.13
	pH	2.0			8.1	8.2
General Chemistry	Cl	0.002	%		0.003	0.003
	Resistivity	1	ohm-cm		5560	7690
	SO4	0.01	%		0.03	0.02

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

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

GOLDER

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