December 7, 2016

GEOTECHNICAL DESIGN REPORT

Geotechnical Investigation and Design for Proposed Replacement and Rehabilitation of the Sewer Infrastructure at Pukaskwa National Park, Heron Bay, Ontario

Submitted to:
PARSONS
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REPORT

Report Number: 1545167

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1.0 INTRODUCTION

This report presents the results of geotechnical explorations, testing and engineering carried out for the proposed sewer infrastructure replacement and rehabilitation at the Pukaskwa National Park, near Heron Bay, Ontario (Park). The geotechnical engineering components of the project include the removal and replacement and/or new installation of approximately 3.5 km of sanitary force mains and gravity sewers. In addition, one existing pump station is proposed for replacement. The location of the site is shown on the Borehole Location Plans attached as Figures 1 to 3.

The purpose of the work was to evaluate the existing subsurface soil and shallow ground water condition at the site by advancing 21 boreholes to depths ranging from 5 m to 8 m and provide geotechnical design recommendations for the removal and replacement and/or installation of the sanitary force mains, gravity sewers and a sanitary pump station (SPS).

The project scope also includes reconstruction and rehabilitation of the Park's access roads which has been addressed in a separate report, “Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park” submitted on December 7, 2016.

Golder Associates Ltd. (Golder) submitted the scope of work and cost estimate for this work to Parsons in a proposal dated November 17, 2015 (P1545167). Authorization to proceed was provided by Mr. Jan Wieczorek of Parsons, in an email dated December 22, 2015, and in the signed agreement dated February 1, 2016.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen (18) months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid. In addition, this report should be read in conjunction with the attached "Important Information and Limitations of This Report" included in Appendix A. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 SITE DESCRIPTION

Pukaskwa National Park, in located near Heron Bay, Ontario on the north shore of Lake Superior. The footprint of the Park is approximately 1,800 square kilometres and is located approximately 315 km from Thunder Bay, Ontario. The Park contains two car accessible campgrounds, a day-use area and a visitor centre. The Park is serviced by approximately 3 km of paved roads and 2 km of unpaved roads as well as site servicing infrastructure including sanitary sewers, water and electrical lines.

The Ontario Geologic Society's (OGS) 1979 Northern Ontario Engineering Geology Terrain Study 60 for the Heron Bay Area (NTS 42D/NE) indicates that Pukaskwa Road and the various campground access roads lie within two different surficial geologic areas within the District of Thunder Bay. According to the OGS study, the northern portion of the site consisting of Pukaskwa Road near the Pic River is within a glaciolacustrine plain, primarily consisting of sandy and silty sediments. The glaciolacustrine plain has low relief and is characterized as dissected and gullied with mixed drainage conditions (both wet and dry). The southern portion of the site, consisting of Pukaskwa Road approximately 800 to 900 m south of Pic River and the campground access roads, is within a surficial geologic area characterized with rock knobs consisting of either exposed bedrock or bedrock overlain by a thin veneer of glacial till. The area has higher relief and is characterized as jagged, rugged and cliffed. Based on the OGS digital data set for the Bedrock Geology of Ontario (MRD 126 – Revision 1), the bedrock at the site generally consists of felsic to intermediate metavolcanic rocks including tuffs and breccias with minor metasedimentary and intrusive rock.

3.0 PROJECT UNDERSTANDING

As noted above, the purpose of this report is to provide geotechnical information and design recommendations for the removal and replacement and/or new installation of the sanitary sewer infrastructure at the Park. The initial scope of work for the rehabilitation of the sanitary sewer infrastructure was presented as four options by Parson’s in their “Schematic Design Report”, submitted in draft to Parks Canada on June 27, 2016. Golder understands that Option B was pursued, with some modifications made to the sanitary sewer infrastructure rehabilitation plan in August 2016 at the design review meeting. Based on Golder’s review of Parson’s “Schematic Design Report”, “Schematic Design Drawings” which accompanied the report, and the results of the design review meeting the following table outlines Golder’s understanding of the scope for the rehabilitation of the sanitary sewer infrastructure at the Park.

Type	New Construction or Remove and Replace	Diameter (mm)	Approximate Length (m)	Location
Gravity Sewer	New Construction	200	110	North Campground
Gravity Sewer	Remove and Replace	200	630	Entrance Road (Manhole 15 to Pump Station # 2)
Gravity Sewer	New Construction	200	190	From Pump Station # 2 to RV Dump Station
Forcemain	New Construction	100	1550	Southern Campground and Entrance Road (from Pump Station # 1 to Pump Station # 2)
Forcemain	Remove and Replace	100	420	From Pump Station # 2 to just north of Administration Building Entrance
Forcemain	Remove and Replace	100	550	From just North of Administration Building to Lagoon

The new gravity sewers and forcemain will be buried below the frost depth which is considered 2.2 m below ground surface at the Park. In addition to the rehabilitation of the linear infrastructure, Golder understands that the existing pump station within the southern campground (designated in the “Schematic Design Report” as Pump Station # 1) will be replaced. The founding elevation of the new pump station is assumed to be similar to that of the existing station, which based on the “Schematic Design Drawings” has an invert of about elevation 182.2 m or about 2.7 m below existing ground surface.

4.0 SCOPE OF WORK

To provide the necessary geotechnical information required to complete the rehabilitation of the sanitary sewer infrastructure at the Park, Golder proposed to complete geotechnical drilling and testing along the alignment for the proposed sewer infrastructure improvements and at the SPS location. Following field work, a laboratory testing program was undertaken to further classify the subsurface material encountered. The methods and results of field and laboratory testing programs along with interpretation of the results and design recommendations are presented in this report.

For details regarding Golder's previous work at the site, please refer to the report titled "Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park" submitted in final on December 7, 2016.

4.1 Field Work

Field work was carried out from September 8, 2016 to September 11, 2016. Twenty (20) boreholes were advanced along the alignment of the proposed sewer infrastructure improvements to depths ranging from 0.6 m to 5.2 m. Boreholes BH16-08 to BH16-13 encountered auger refusal at depths ranging from 0.6 to 2.6 on inferred rock fill or bedrock. One (1) borehole was advanced at the location of the SPS replacement to a depth of 7.3 m and a dynamic cone penetration test (DCPT) was completed from 7.3 to 7.9 m. The location of the boreholes are shown on the Borehole Location Plan, attached to this report as Figures 1 to 3. The location of the boreholes drilled as part of Golder's previous work are also shown on Figures 1 to 3.

Prior to completion of the field work, Golder completed underground utility clearances of the proposed borehole locations through Ontario One Call and a private utility locate sub-contractor. Golder completed a site specific health and safety plan as well as a traffic management plan.

Field work was monitored by members of Golder's technical staff, who located the boreholes, arranged for the clearance of the underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined the recovered soil samples. The samples were classified in the field, placed in appropriate containers, labelled and transported to Golder's geotechnical laboratory where the samples underwent further visual examination and laboratory testing. Classification testing (water content and grain size distribution) was carried out on selected samples. Record of Borehole sheets for the boreholes advanced as part of this assignment are provided following the text of this report.

All boreholes were drilled using a truck-mounted drill rig supplied and operated by Landcore Drilling under the full time supervision of a member of Golder's engineering staff. The boreholes were advanced using 150 mm outside diameter (O.D.) solid stem augers or 150 mm O.D. hollow stem augers. Standard Penetration Tests (SPTs) were completed at regular intervals of depth in general accordance with American Society for Testing and Materials standard ASTM D1586 and a DCPT was completed in one borehole. Boreholes were terminated once the target depth was reached (5.2 m for those advanced for linear infrastructure and 7.9 m at pump station location) or if auger refusal was encountered.

Groundwater conditions and water levels in the open boreholes were observed during and upon completion of drilling operations. All boreholes were backfilled with cuttings and bentonite in accordance with Ontario Regulation 903 (as amended) and the road surface was reinstated using cold asphalt patch, where holes were advanced through paved surfaces.

Upon completion of drilling the locations of the boreholes were recorded using a hand-held Global Positioning System (GPS) device (accurate to ± 3 m). The borehole coordinates were subsequently plotted on the site topographic plan, provided by Parson's via email on July 22, 2016, to obtain the borehole elevations. The following table outlines the borehole coordinates and elevations and termination depth.

Borehole	Surface Elevation (masl)	Termination Depth (m)	UTM Zone 16 (NAD 83)	
			Easting (m)	Northing (m)
BH16-01	186.0	5.2	552992	5384380
BH16-02	190.5	5.2	552827	5384172
BH16-03	189.6	5.2	552669	5383987
BH16-04	190.8	5.2	552626	5383805
BH16-05	189.7	5.2	552459	5383764
BH16-06	189.8	5.2	552446	5383522
BH16-07	192.1	5.2	552519	5383286
BH16-08	199.0	2.6	552638	5383073
BH16-09	200.3	1.9	552667	5382828
BH16-10	198.0	1.1	552727	5382727
BH16-11	195.3	0.9	552728	5382608
BH16-12	194.0	0.6	552675	5382490
BH16-13	189.1	1.1	552590	5382398
BH16-14	186.0	4.6	552507	5382370
BH16-15	185.5	5.2	552432	5382364
BH16-16	185.6	5.2	552342	5382384
BH16-17	185.6	5.2	552271	5382383
BH16-18	185.6	5.2	552070	5382346
BH16-19	185.8	5.2	551984	5382327
BH16-20	185.2	5.2	552089	5382289
BH16-21	184.9	7.9*	552101	5382236

*Borehole drilling extended to 7.3 m below ground surface in BH16-21, a DCPT was carried out to 7.9 m below ground surface.

4.2 Laboratory Testing Program

The soil samples obtained were brought to our Barrie Laboratory to undergo further visual inspection and classification testing. The table below outlines the completed Laboratory Testing Program.

Laboratory Test	Number Competed
Moisture Content	104
Particle Size Analysis (Sieve only)	12
Particle Size Analysis (Sieve and Hydrometer)	1
Atterberg Limits	1

5.0 SUBSURFACE CONDITIONS

The, subgrade soil and shallow groundwater conditions encountered in the boreholes, as well as the results of the field and the geotechnical laboratory testing, are shown in detail on the Record of Borehole sheets (BH16-01 to BH16-21) and on Figures B1 through B6 following the text of this report. Method of Soil Classification and Symbols and Terms Used on the Records of Pavement Boreholes sheets are provided to assist in the interpretation of the logs.

It should be noted that the boundaries between the strata on the borehole logs have been inferred from drilling observations and non-continuous samples, represent a transition from one soil type to another and should not be inferred to represent an exact plane of geological change. Further, conditions will vary between and beyond the boreholes.

Underlying the road structure, the subsurface soil conditions generally consist of sand with traces of gravel and silt. Shallow bedrock or rock fill was inferred based on auger refusal in a localized section of the entrance road. An isolated granular deposit of silt and a cohesive deposit of clayey silt to silty clay was encountered in Borehole BH16-08. The subsurface soil conditions encountered during Golder's previous investigation were predominantly sand and silty sand.

Relevant information from Golder's previous investigation has been included in the sections below. For more detailed information refer to Golder's report titled "Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park" submitted on December 7, 2016.

5.1 Soil Conditions

5.1.1 Asphalt and Fill

All boreholes were advanced through existing paved or unpaved roads or parking areas. Where boreholes were advanced through paved roads the asphalt thickness ranged from 40 to 70 mm. The underlying fill was characterized as gravelly silty sand. The results of one particle size analysis carried out on a sample of the gravelly silty sand is attached in Appendix B as Figure B4. Eighteen water content tests were conducted on samples of the gravelly silty sand which resulted in water contents ranging from 3 per cent to 15%with an average of 55. Two SPT tests completed on the gravelly silty sand fill resulted in N-values of 21 and 40 blows for 0.3 m of penetration, indicting a compact to dense material. The gravelly silty sand fill was encountered immediately underlying the asphalt and extended to depths ranging from 0.6 m to 1.5 m below ground surface (mbgs). Boreholes BH16-11, BH16-12, and BH16-13 were terminated within the gravelly silty sand fill layer due to auger refusal on inferred bedrock or rock fill.

Where boreholes were advanced through unpaved roads and parking areas fill material ranging from sand to silty sand was encountered at surface. The fill was brown in colour and contained trace to some gravel and occasionally traces of fibrous organics. The results of one particle size analysis completed on a sample of sand fill is attached in Appendix B as Figure B1. Seven water content tests were completed on samples of the silty sand and sand fill which resulted in water contents ranging from 5 to 7% with an average of 6%. Two SPT tests completed on the silty sand and sand fill resulted in N-values of 7 and 25 blows for 0.3 m of penetration, indicting a loose to compact material. The silty sand and sand fill was encountered at surface and extended to depths ranging from 0.7 m to 1.5 mbgs.

A 100 mm thick layer of black organic silt was noted within the sand fill at Borehole BH16-02. One water content test on the organic silt resulted in a water content of 38%.

Further details regarding the pavement structure for paved and unpaved roads is available in Golder's report titled "Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park" submitted in December 7, 2016.

5.1.2 Sand

The predominant subsurface soil type encountered during the investigation was characterized as poorly graded sand with trace to some silt and gravel. Near surface the sand is brown in colour but generally becomes grey with depth. The results of ten particle size analysis conducted on samples of the sand are attached in Appendix B as Figures B2 and B3. Seventy-four (74) water content tests were completed on samples of the sand and which resulted in water contents ranging from 4% to 30% with an average of 18%. Eighty-six (86) SPT tests completed in the sand resulted in N-values of 1 to 27 blows for 0.3 m of penetration with an average of 13 blows for 0.3 m of penetration, indicting a very loose to compact material. The sand was encountered below the fill material in all boreholes and extended to depths ranging from 1.8 m to 7.3 mbgs. Borehole BH16-01 through to BH16-07, BH16-09, BH16-10, and BH16-14 to BH16-21 were terminated within the sand deposit.

5.1.3 Silt

An approximately 0.4 m thick layer of grey silt was encountered in Borehole BH16-08, underlying the sand. One water content test on the silt layer resulted in a natural water content of 13%.

5.1.4 Silty Clay to Clayey Silt

An approximately 0.6 m thick layer of grey silty clay to clayey silt was encountered in Borehole BH16-08 underlying the silt. Borehole BH16-08 was terminated in the stratum at a depth of 2.6 mbgs. One particle size analysis and the Atterberg Limits of a sample of silty clay to clayey silt are attached in Appendix B as Figures B5 and B6, respectively. One water content test conducted on a sample of silty clay to clayey silt resulted in a value of 27%.

5.1.5 Inferred Bedrock and Rock Fill

The presence of bedrock and rock fill has been inferred through observation of drilling progress. Rock coring to confirm the presence of bedrock or rock fill was not completed as part of this investigation. Bedrock was inferred to be encountered in six (6) boreholes advanced as part of the investigation, while rock fill was inferred to be encountered in one (1) borehole advanced as part of the investigation. The following table outlines the boreholes where bedrock or rock fill was inferred to be encountered, the depth it was encountered, and the elevation. Select boreholes from Golder's previous investigation are also included in this table.

Borehole	Bedrock or Rock Fill	Depth (mbgs)	Elevation (m)
BH16-08	Bedrock	2.6	196.4
BH16-09	Bedrock	1.9	198.4
BH16-10	Bedrock	1.1	196.9
BH16-11	Bedrock	0.9	194.4
BH16-12	Rockfill	0.6	193.4
BH16-13	Bedrock	1.1	188.0

Borehole	Bedrock or Rock Fill	Depth (mbgs)	Elevation (m)
BH16-14	Bedrock	4.6	181.4
BH11*	Bedrock	0.5	194.5
BH12*	Bedrock	0.4	192.5
BH13*	Bedrock	0.4	185.3
BH14*	Bedrock	0.2	185.5
BH15*	Bedrock	0.6	185.8

*Boreholes advanced as part of Golder's previous investigation. For further details see "Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park" submitted on December 7, 2016.

5.2 Groundwater Conditions

Groundwater conditions and water levels in the open boreholes were observed during and upon completion of drilling operations. The following table presents the water levels that were measured in the open boreholes upon completion of drilling. Select boreholes from Golder's previous investigation are also included in this table.

Borehole	Groundwater Depth (mbgs)	Elevation (m)
BH16-01	1.6	184.4
BH16-02	1.8	188.7
BH16-03	1.1	188.5
BH16-04	1.6	189.2
BH16-05	1.7	188.0
BH16-06	1.4	188.4
BH16-07	3.1	189.0
BH16-08	1.6	197.4
BH16-09	Dry upon completion of drilling	
BH16-10	Dry upon completion of drilling	
BH16-11	Dry upon completion of drilling	
BH16-12	Dry upon completion of drilling	
BH16-13	Dry upon completion of drilling	
BH16-14	2.7	183.3
BH16-15	2.2	183.3
BH16-16	2.0	183.6
BH16-17	2.1	183.5
BH16-18	1.8	183.8
BH16-19	1.7	184.1
BH16-20	1.2	184.0
BH16-21	1.4	183.5
BH7*	1.2	188.6

Borehole	Groundwater Depth (mbgs)	Elevation (m)
BH9*	0.9	198.1
BH19*	1.3	185.5
BH20*	1.5	184.6
BH21*	1.2	-
BH22*	0.6	183.3
BH23*	1.5	183.2
BH24*	1.4	183.9
BH25*	1.3	184.1
BH28*	1.7	183.1

*Boreholes advanced as part of Golder's previous investigation. For further details see "Pavement Investigation and Design for Proposed Reconstruction and Rehabilitation of Pukaskwa National Park" submitted on December 7, 2016.

It should be noted that the groundwater levels presented, represent unstabilized levels and that groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

6.0 DISCUSSION

This section of the report provides engineering information for the geotechnical design aspects of the project, based on our interpretation of the borehole data and on our understanding of the project requirements. The information in this portion of the report is provided for the guidance of the design engineers and technicians. Where comments are made on construction, they are provided only in order to highlight aspects of construction which could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

It is understood that the project will include excavations for site servicing including:

- removal and replacement or new Installation of approximately 3.5 km of sanitary forcemains and gravity sewers by open cut; and,
- replacement of one Sanitary Pump Station (SPS).

It is understood that forcemains and gravity sewers will be placed below the frost penetration depth, which is considered to be 2.2 m for this site. The diameter of the proposed forcemains will be 100 mm and the diameter of the proposed gravity sewers will be 200 mm.

6.1 Excavations for Forcemains, Gravity Sewers and Pump Stations

Based on the results of this investigation, the founding soils for the services and SPS will primarily consist of compact to loose and locally very loose sand. Although cobbles and boulders were not noted in this investigation, Golder's previous field work noted occasional cobbles and boulders within the native soils. The native soil is generally considered to be suitable for supporting the pipes, provided the integrity of the base can be maintained during construction. Where very loose soil is expected at the founding depth such as in the vicinity of boreholes BH16-04, BH16-07, BH16-14, and BH16-15 some over-excavation and additional bedding material should be anticipated in the event that the native material at the excavation base is not considered suitable to support the buried services.

Based on the groundwater conditions encountered in the boreholes during drilling and considering the anticipated excavation depths, the services will generally be at or below the local water table at the site. Given the granular and relatively uniform nature of the native soil encountered at the site, the tendency for some boreholes to slough (cave) upon completion of the drilling and the relatively shallow groundwater table observed during drilling, excavations are expected to yield significant volumes of water. The native soils will readily flow upon exposure if not adequately dewatered in advance of excavation. Based on the observed groundwater and soil conditions during the investigation and the excavation depths groundwater control measures will require active dewatering such as closely-spaced (less than 5 m centre to centre) vacuum well points, eductors and/or submersible wells. Unless drawdown and radius of influence analyses completed as part of the final dewatering design demonstrate that dewatering systems installed on one side of the excavation are suitable, for the purposes of this report it is anticipated that dewatering systems would be required on both sides of the trench excavations. It is anticipated that a Permit to Take Water will be require for this construction work. It should be noted that in areas where bedrock is below but within 1 to 1.5 m of the base of the excavations, it may be difficult to achieve adequate dewatering of soils near the excavation base because of limitations associated with drawdown availability and spacing between dewatering point locations.

It is anticipated that the dewatered trench excavations will consist of conventional temporary open cuts with side slopes not steeper than 1 horizontal to 1 vertical. However, depending upon the construction procedures adopted by the contractor, actual groundwater seepage conditions, the success of the contractor’s groundwater control methods and weather conditions at the time of construction, some flattening and/or blanketing of the slopes may be required.

Care should be taken to direct surface runoff away from the open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. According to the Act, the native sand would be classified as Type 3 soil above the water table and a Type 4 soil below the water table. Excavations in Type 4 soil and excavations should be flattened to 3 horizontal to 1 vertical.

Although relatively deep excavations may not be required for the SPS installation, construction may still be carried out with a vertically sided shored excavation. Temporary excavation support for the SPS or other installations could consist of conventional “close sheeting” (timber frame sheets, braces and posts), pre-fabricated trench boxes and soldier piles and lagging wall systems provided that adjacent services or structures can tolerate some movement and that groundwater is adequately controlled. It should be noted that installation of conventional “close sheeting” and trench boxes typically require that excavation be made prior to or during installation of the supports. In particular, use of trench boxes requires that the excavation be carried to the full depth prior to installing the support system. Such excavation support systems, while designed for protection of the workers if properly installed, do not prevent or mitigate displacements of the surrounding ground, particularly if groundwater is not adequately controlled. For a soldier pile and lagging wall, the lagging boards should be installed as soon as space permits and with a lift height that does not exceed 1.2 m. The space behind any support lagging, timbers, sheets or pre-fabricated trench box systems should be immediately packed with granular material to minimize the potential for uncontrolled ground losses and uneven loads on the systems. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadways and utilities/structures. In addition, care must be taken during excavation to ensure that adequate support is provided for any existing structures (utility poles) or underground services located adjacent to the excavations.

It should be noted that trench boxes or any systems that require excavation prior to installation do not support either the ground behind the side walls of the excavations nor any adjacent utilities and structures and thus should not be utilized in areas where buried utilities or surface structures are present or where impacts to the adjacent roadway would then impact traffic flow.

6.1.1 Rock Excavation

In the vicinity of Boreholes BH16-08 to BH16-13 and BH11 to BH15 bedrock may be encountered above the excavation bottom, bedding and invert elevations for the forcemains and gravity sewers. In this instance, rock excavation will be required to install site services below the frost penetration depth.

As noted above, based on the OGS digital data set for the Bedrock Geology of Ontario (MRD 126 – Revision 1), the bedrock at the site generally consists of felsic to intermediate metavolcanic rocks including tuffs and breccias with minor metasedimentary and intrusive rock. During field work undertaken at the site, the rock could not be penetrated with conventional auger drilling techniques. Conventional excavation techniques will likely not be suitable for the excavation of the rock encountered at the site.

Golder understands that excavation of rock using explosives (e.g., blasting) may be prohibited at this site. Therefore mechanical means such as use of hoe rams, splitters or other systems will need to be used to excavate to the founding elevation. The method chosen will depend on the weathering condition and strength of the rock.

Although all boreholes where shallow bedrock was inferred were noted as dry, excavations in rock may still experience groundwater seepage through cracks or fissure in the rock. Groundwater seepage in rock excavations are expected to be handled with standard sumps and pumps. Temporary excavations in rock can be vertical.

6.2 Pipe Bedding, Cover and Trench Backfill

The bedding for the sanitary forcemains and gravity sewers should be compatible with the type and class of pipe, the surrounding subsoil and anticipated loading conditions. Granular bedding should consist of at least 150 mm of gravel meeting the specifications for OPSS.PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material) Granular A. Additional bedding (i.e., 450 mm in total) may be required if wet or loose materials are encountered in the bottom of the trenches. From the springline to 300 mm above the obvert of the pipe, sand cover meeting the specifications of OPSS.PROV 1004 (Material Specification for Aggregates – Miscellaneous) Winter Sand, should be used. All bedding and cover materials should be placed in maximum 150 mm loose lifts and should be uniformly compacted to at least 95 percent of standard Proctor maximum dry density. Clear stone bedding material should not be used in any case for pipe bedding or to stabilize the base.

Where the founding stratum is rock pipe, bedding should be as specified above. Loose or fractured rock should be removed from the base of the excavation to provide a uniform bearing stratum. Where a trench is excavated in rock to reach a specified installation depth, horizontal and vertical clearance between the pipe and the rock face should be at least 300 mm.

The excavated materials from the site will generally consist of sand. The majority of the native soils are generally near or wet of optimum water contents for compaction and may require some drying prior to reuse for trench backfill. Excavated native soils, if permitted to dry and protected from precipitation so that they can be placed at suitable water contents, could be reused as trench backfill provided they are free of significant amounts of topsoil, organics or other deleterious material, and are placed and compacted as outlined below. All topsoil and organic materials should be removed or used for landscaping purposes. All oversized cobbles and boulders (i.e., greater than 150 mm in size) should be removed from the backfill.

All trench backfill, from the top of the cover material to 1 m below subgrade elevation, should be placed in maximum 450 mm loose lifts and uniformly compacted to at least 95 percent of standard Proctor maximum dry density. From 1 m below subgrade to subgrade elevation, the materials should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 98 percent of standard Proctor maximum dry density.

Alternatively, if placement water contents at the time of construction are too high, or if there is a shortage of suitable in-situ material, then an approved imported sandy material which meets the requirements for OPSS.PROV 1010 Select Subgrade Material (SSM) could be used. It should be placed in loose lift thicknesses as indicated above and uniformly compacted to at least 95 percent of standard Proctor maximum dry density. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice.

Normal post-construction settlement of the compacted trench backfill should be anticipated, with the majority of such settlement taking place within about six months following the completion of trench backfilling operations. This settlement will be reflected at the ground surface and may require local repairs. If the services are placed below the roads and require pavement reconstruction, then settlement can be compensated for by placing additional granular material prior to asphalt paving. Alternatively, if the asphalt binder course is placed shortly following the completion of trench backfilling operations in this area, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding. In any event, it is recommended that the surface course asphalt should not be placed over the binder course asphalt for at least twelve months.

6.3 Sanitary Pumping Station

One Pumping Station (PS) is currently proposed for replacement (designated in the “Schematic Design Report” as PS# 1) in the vicinity of BH16-21. The founding elevation of the new SPS is assumed to be similar to that of the existing SPS, which based on the “Schematic Design Drawings” has an invert of about elevation 182.2 m or about 2.7 m below existing ground surface.

Borehole BH16-21 consisted of fill overlying compact to loose sand. The groundwater level was measured at 1.4 mbgs (Elev. 183.5 m) upon completion of drilling in the open borehole. It should be noted that these founding soils are susceptible to disturbance by construction activity especially during wet weather and care should be taken to preserve the integrity of the material as a bearing stratum. To protect the founding soils from softening and disturbance during construction, a granular blanket or working slab of lean concrete could be placed at the bottom of the excavations.

Based on the assumed founding elevation, the bottom of the SPS will be within the loose to compact sand stratum. The geotechnical bearing resistance at Serviceability Limit State (SLS) of 100 kPa to limit settlement to 25 mm and a factored bearing resistance at Ultimate Limit State (ULS) of 200 kPa are considered appropriate for preliminary design and should be re-assessed when the final footing type/size/elevation are known. It is likely that bearing resistances will not govern foundation design since pumping station construction will result in a net unloading of the ground (the removed ground may weigh more than the weight of the SPS, sewage and pumps). Design of the SPS should be checked for resistance to hydraulic uplift pressures when the SPS is drained for periodic maintenance. The project specifications should identify criteria for limiting uplift pressures on the SPS base by dewatering during construction until construction is complete and stability against buoyancy can be assured.

As noted above, excavation for the SPS will extend below groundwater levels. Given the granular and relatively uniform nature of the native soil encountered at the site, the excavation is expected to yield significant volumes of water. Groundwater control measures will require active dewatering such as closely-spaced (less than 5 m centre to centre) vacuum well points, eductors and/or submersible wells. Based on the depth of sand below the anticipated bottom of excavation elevation, it is anticipated that a suitable submersible pump well system installed to sufficient depths could achieve drawdown and radius of influence conditions such that wells could be located at a few selected points around the excavation perimeter. It is anticipated that a Permit to Take Water will be require for this construction work.

6.3.1 Lateral Earth Pressure

SPS walls must be designed to resist lateral earth pressures. The earth pressure “p” (kPa) acting on subsurface walls at any depth “h” (m) can be calculated using the following equation:

$$p = k\,(\gamma h + q)$$

Where: k = 0.5, the estimated earth pressure coefficient applicable to a rigid unyielding wall. For walls where some slight yielding for the wall is permissible, use 0.33.

γ = 21.5 kN/m^3 (estimated unit weight of compacted, drained sand and gravel or gravelly sand backfill).

q = surcharge load in kPa, if any, acting adjacent to the wall

The above equation assumes that the backfill material will be fully drained granular materials. At this site, however, it is expected that full drainage cannot be achieved and may not be practical. In this case, a buoyant unit weight of 11.5 kN/m^3 should be used in the above equation along with water pressures consistent with assuming the groundwater level to be at the ground surface.

6.3.2 Uplift Considerations

The SPS should be designed for uplift based on the stabilized groundwater level at the site. Resistance to uplift resulting from the friction between the backfill and concrete walls of the SPS should be calculated using a coefficient of friction of 0.35. If sufficient resistance with a suitable factor of safety cannot be achieved by using dead loads and sidewall friction, additional capacity can be achieved by extending the base of the SPS beyond the limits of the walls. Alternatively, grouted earth anchors could be installed to provide additional uplift capacity.

An uplift assessment should be carried out for the proposed PS. The factor of safety against uplift is estimated as:

$$Factor\ of\ Safey\ against\ Uplift = \frac{Weight\ of\ Concrete\ Walls/Base + Side\ Friction\ Resistance}{Uplift\ Forces\ due\ to\ Groundwater}$$

Only the weight of the SPS concrete walls and base should be considered in the assessment. The weight of all other proposed connected structures should be neglected. For this methodology, a minimum factor of safety against hydraulic uplift of about 1.3 should be used. If, however, resistance against uplift is based solely on gravity (weight of the structure), a factor of safety of 1.1 is considered appropriate. For design purposes, the groundwater levels should be assumed equal to the ground surface to account for full saturation of any backfill.

6.4 Frost Protection

The depth of frost penetration for this project should be taken as 2.2 m. To protect the forcemain and gravity sewers from freezing the obverts of the pipes should be below this depth. Based on Golder's review of Parson's "Schematic Design Drawings" we understand that all new and replaced linear sanitary services will be below the frost penetration depth.

7.0 MONITORING AND TESTING

The geotechnical and pavement aspects of the final design drawings and specifications should be reviewed by this office prior to tendering and construction, to confirm that the intent of this report has been met. During construction, sufficient in-situ materials testing should be carried out to confirm that the conditions exposed are consistent with those encountered in the boreholes and to monitor conformance to the pertinent project specifications.

8.0 CLOSURE

We trust that this report provides sufficient geotechnical and pavement engineering information to facilitate the design of this project. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact this office.

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
J. B. HAGAN
100171186
Dec 7/2016
PROVINCE OF ONTARIO

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DPM/JH/SJB/leb/plc

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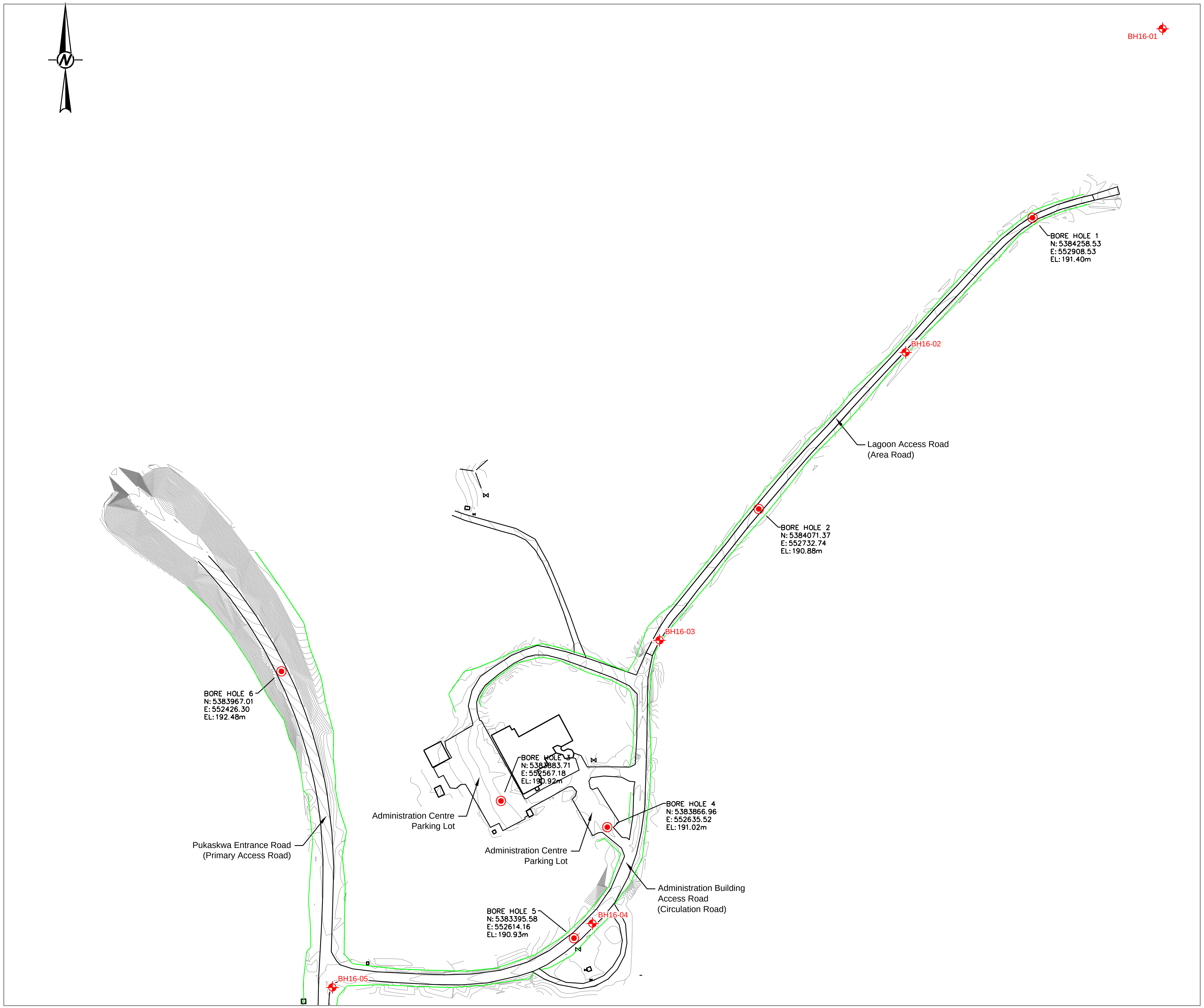
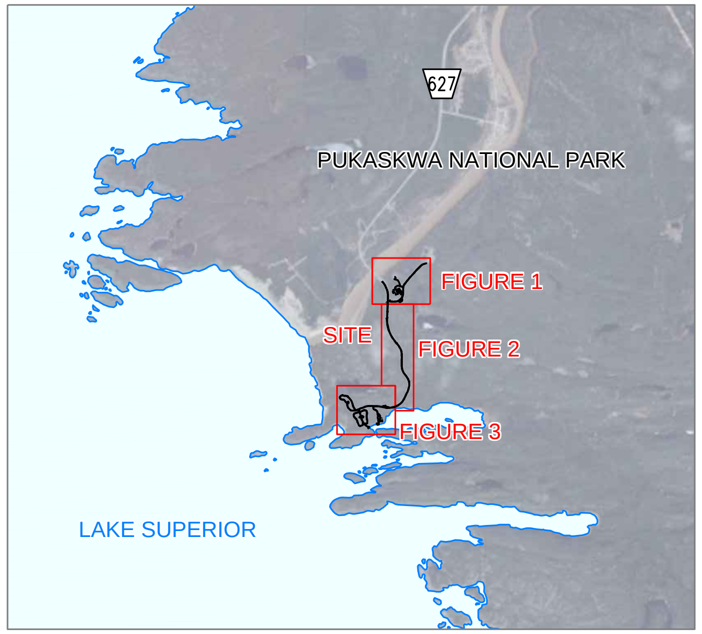
ATTACHMENTS

Figures 1 to 3
Record of Borehole Logs





REGIONAL LOCATION 1:100000 m

LEGEND

⌖ BOREHOLE LOCATION

◉ PAVEMENT BOREHOLE LOCATION

NOTES

1. DATUM UTM NAD 83 ZONE 16
2. MAPPING BASED ON CALLON DIETZ INC. ONTARIO LAND SURVEYORS (DRAWING NO. 16-20450 SHEET 1-3)

0 50 100 150m
1:2500

CLIENT
PARKS CANADA

PROJECT
ROAD RECONSTRUCTION
PUKASKWA NATIONAL PARK
HERON BAY, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-10-05
PREPARED	STB
DESIGN	
REVIEW	JBH
APPROVED	ALB

PROJECT No.	Phase	Rev.	Figure
1545167	-	AA	1

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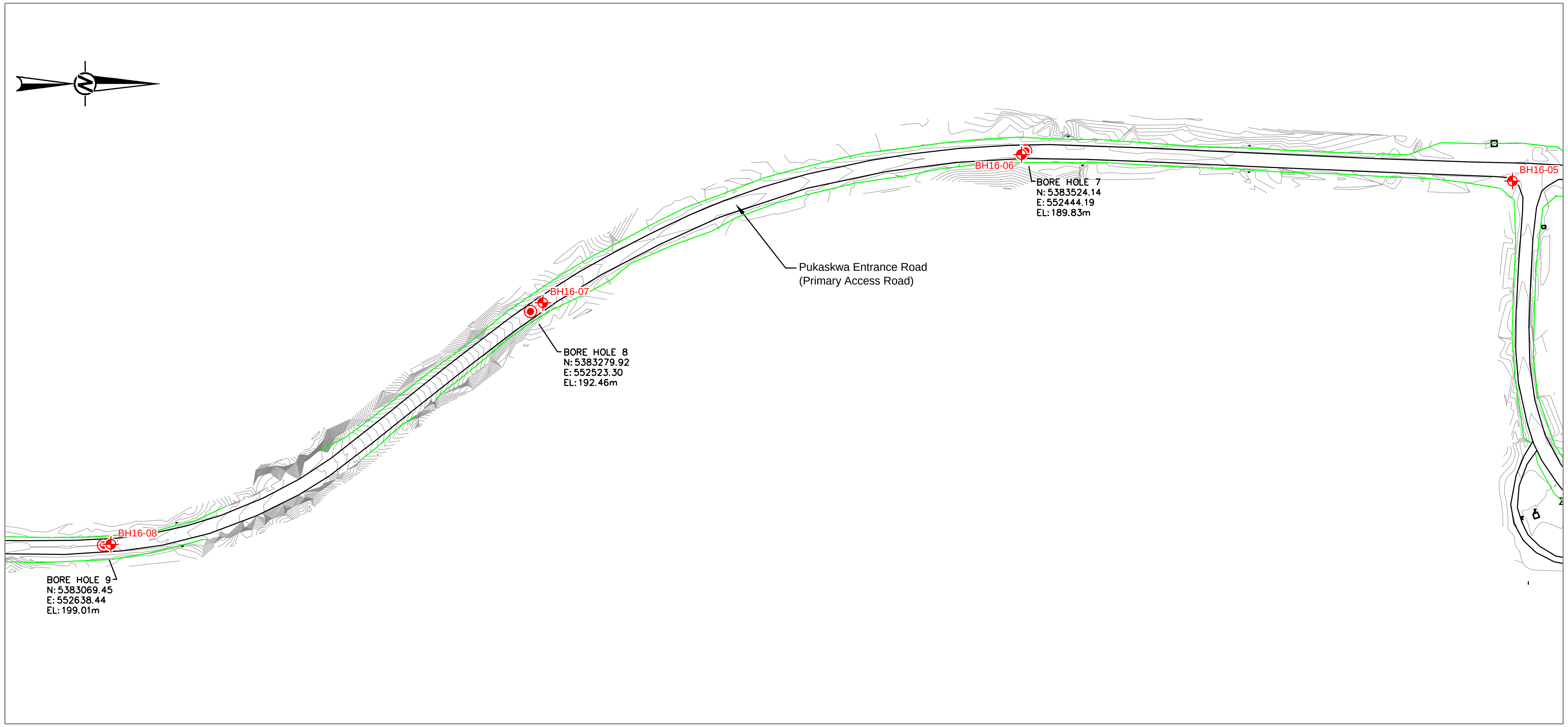
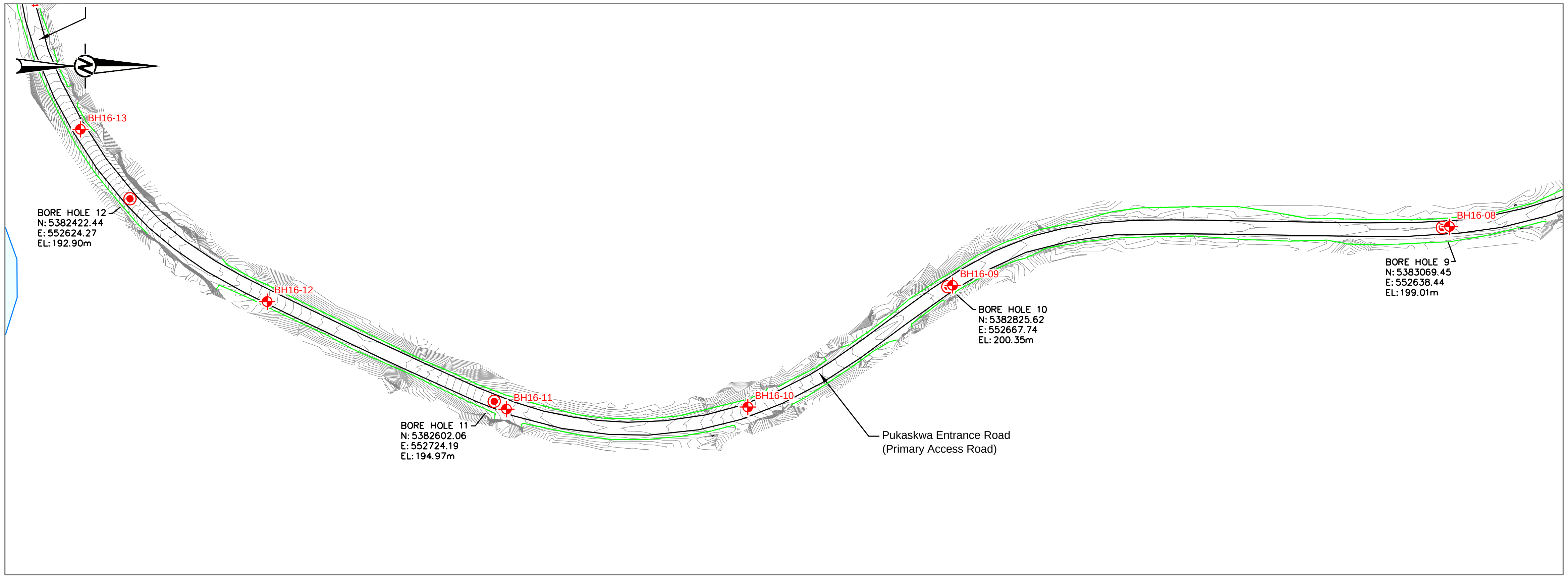
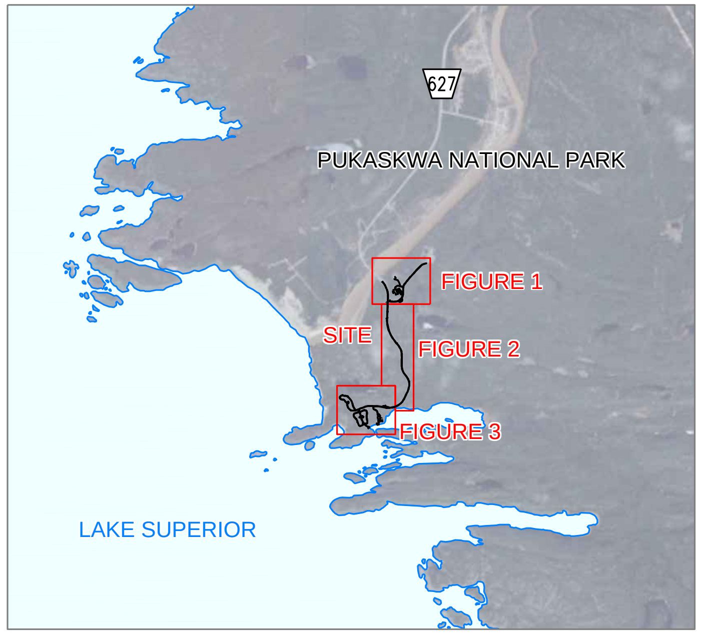
0 25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B







REGIONAL LOCATION 1:100000 m

LEGEND

⌖	BOREHOLE LOCATION
◉	PAVEMENT BOREHOLE LOCATION

NOTES

1. DATUM UTM NAD 83 ZONE 16
2. MAPPING BASED ON CALLON DIETZ INC. ONTARIO LAND SURVEYORS (DRAWING NO. 16-20450 SHEET 1-3)

0 50 100 150m
1:2500

CLIENT
PARKS CANADA

PROJECT
ROAD RECONSTRUCTION
PUKASKWA NATIONAL PARK
HERON BAY, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-10-05
PREPARED	STB
DESIGN	
REVIEW	JBH
APPROVED	ALB

PROJECT No.	Phase	Rev.	Figure
1545167	-	AA	2

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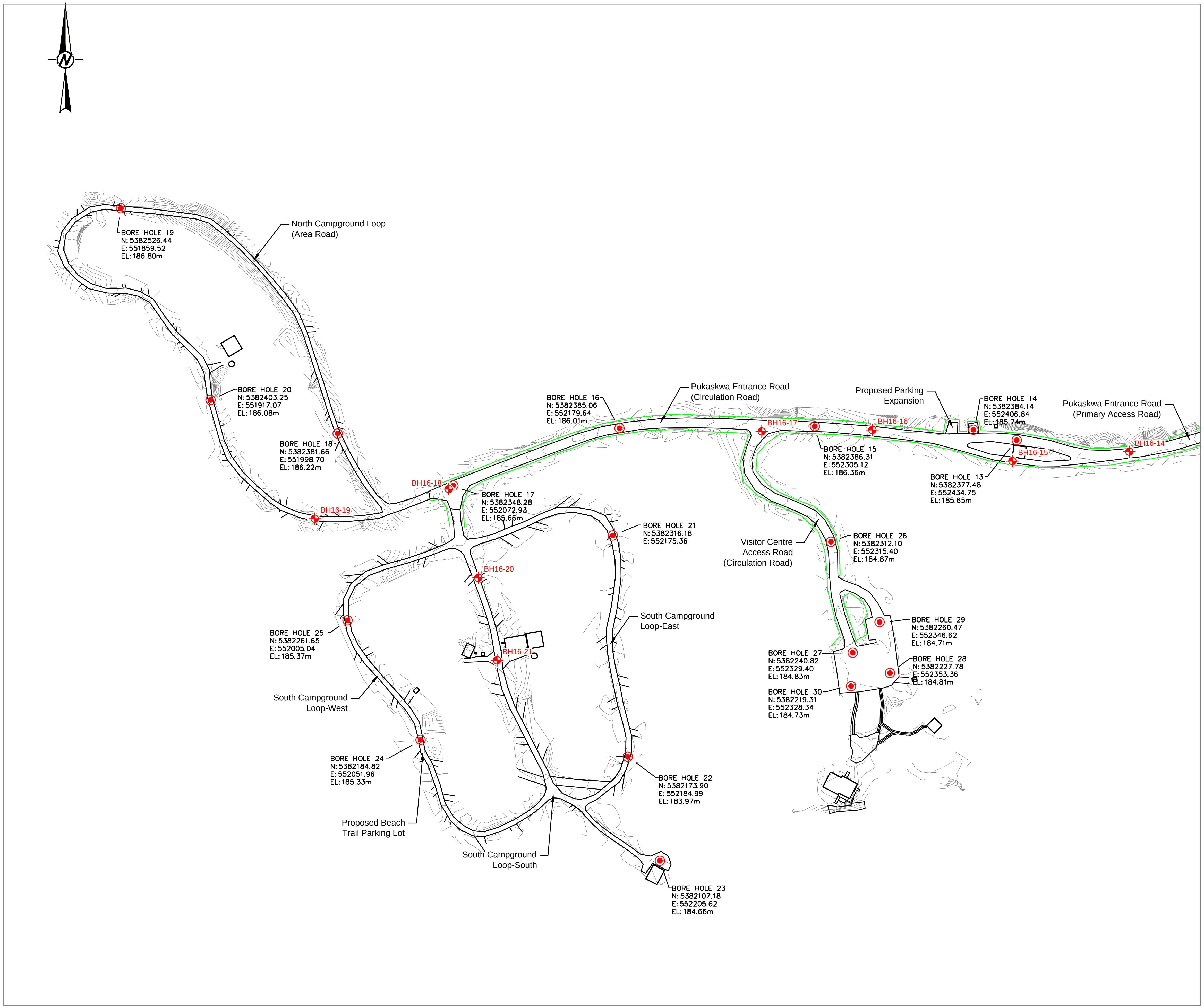

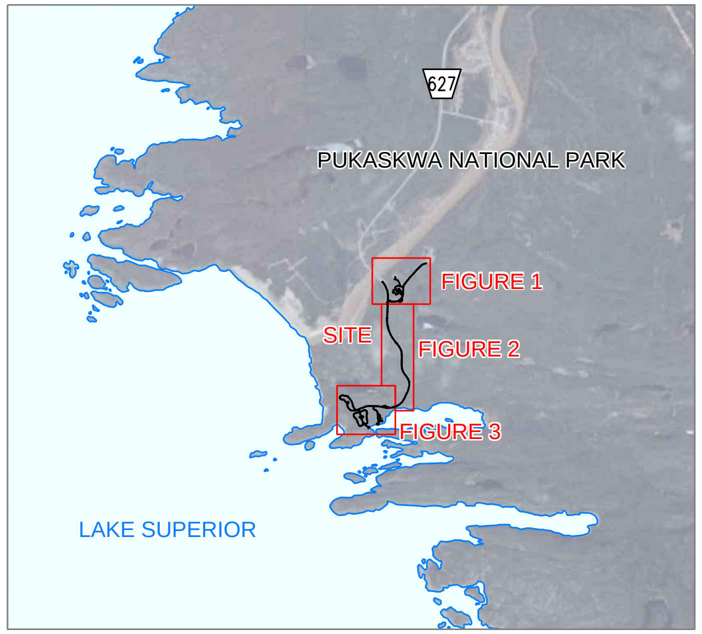

REGIONAL LOCATION 1:100000 m

LEGEND

⊕	BOREHOLE LOCATION
◎	PAVEMENT BOREHOLE LOCATION

NOTES

1. DATUM UTM NAD 83 ZONE 16
2. MAPPING BASED ON CALLON DIETZ INC. ONTARIO LAND SURVEYORS (DRAWING NO. 16-20450 SHEET 1-3)

0 50 100 150m
1:2500

CLIENT
PARKS CANADA

PROJECT
ROAD RECONSTRUCTION
PUKASKWA NATIONAL PARK
HERON BAY, ONTARIO

TITLE
BOREHOLE LOCATION PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-10-05
PREPARED	STB
DESIGN	
REVIEW	JBH
APPROVED	ALB

PROJECT No.	Phase	Rev.	Figure
1545167	-	AA	3

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25 mm

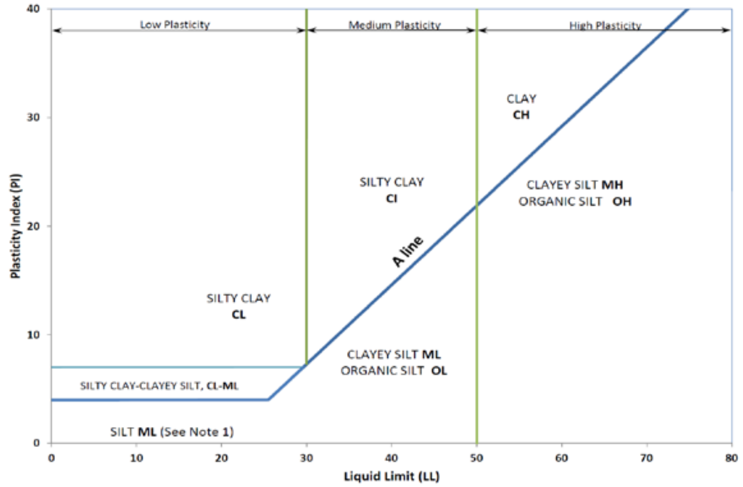
0

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(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

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

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-01

SHEET 1 OF 1

LOCATION: N 5384380.00; E 552992.00

BORING DATE: September 11, 2016

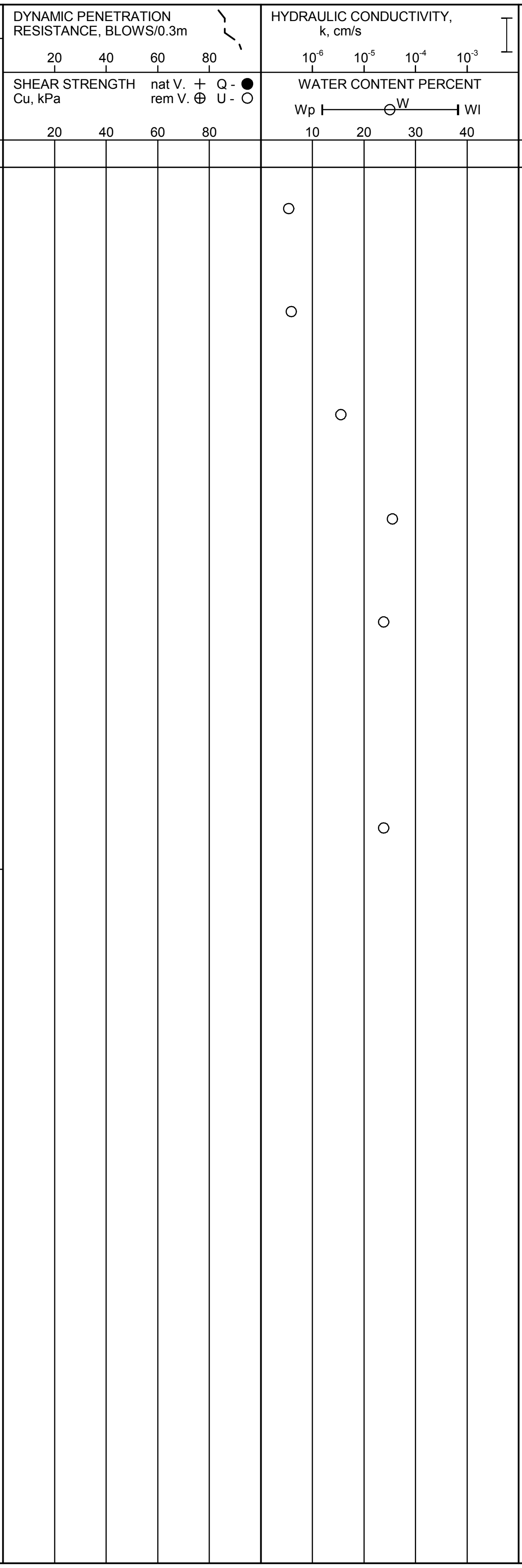
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

DESCRIPTION (SOIL PROFILE)	ELEV. / DEPTH (m)
GROUND SURFACE	186.00
FILL-(SP) SAND, some silt; brown, contains rootlets; moist, compact	0.00
(SP) SAND, some silt; brown; moist, compact grey below 3.1 mbgs	184.55 1.45
End of Borehole	180.82 5.18

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	AS		
2	SS	25	M
3	SS	25	M
4	SS	9	
5	SS	10	
6	SS	15	



PIEZOMETER OR STANDPIPE INSTALLATION

NOTE:

1. Groundwater measured at a depth of 1.6 m below existing grade (Elev. 184.4 masl) upon completion of drilling September 11, 2016.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-02

SHEET 1 OF 1

LOCATION: N 5384172.00; E 552827.00

BORING DATE: September 11, 2016

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

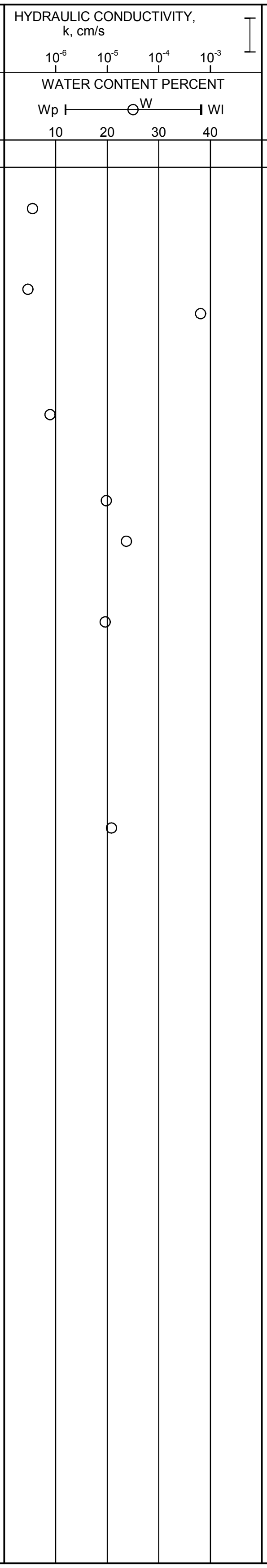
BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	190.50
FILL-(SP) SAND, some silt, trace gravel; brown; moist, loose	0.00
ORGANIC SILT, black, containing rootlets from 1.0 to 1.1 mbgs	189.05 1.45
(SP) SAND, trace to some silt; brown; moist, very loose to compact	185.32 5.18
End of Borehole	

NUMBER	TYPE	BLOWS/0.3m
1	AS	
2A		
2B	SS	7
3	SS	2
4A	SS	11
4B		
5	SS	27
6	SS	17

NOTE:

1. Groundwater measured at a depth of 1.8 m below existing grade (Elev. 188.7 masl) upon completion of drilling September 11, 2016.



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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5383987.00; E 552669.00

RECORD OF BOREHOLE: BH16-03

BORING DATE: September 11, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

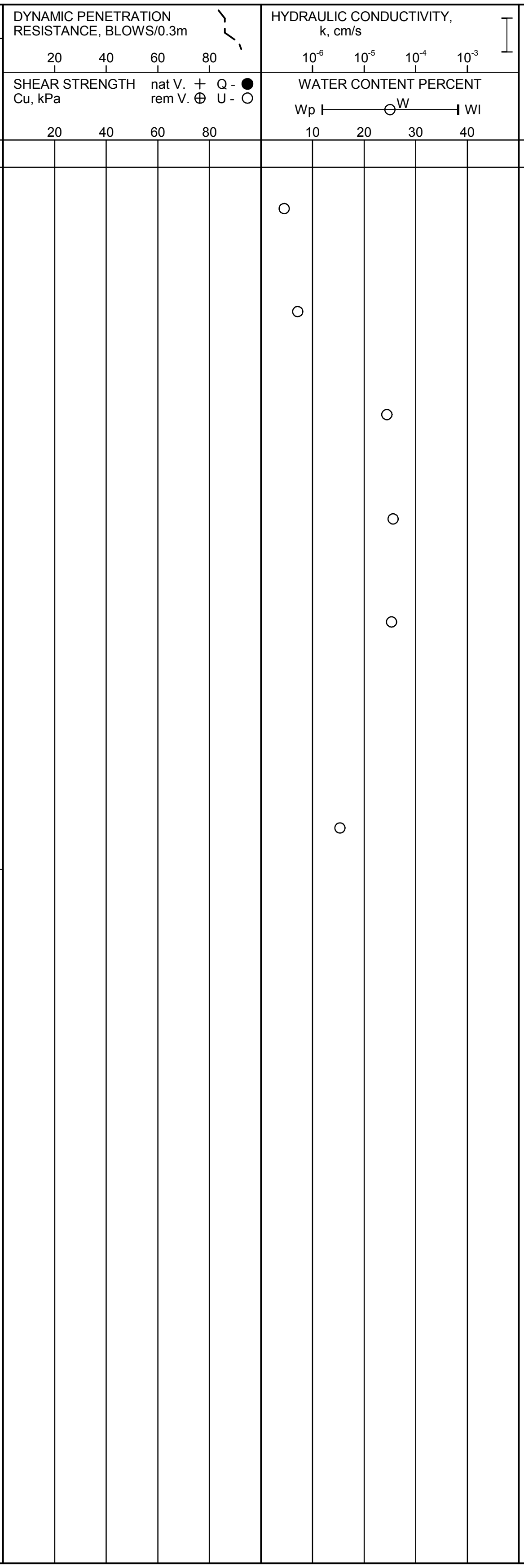
BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)
GROUND SURFACE		189.60
FILL-(SP) SAND, some silt, trace gravel; brown; moist	▩	0.00
(SP) SAND, trace gravel, trace to some silt; brown, containing silt pockets; moist to wet, loose to compact	⁘	188.91 0.69
End of Borehole		184.42 5.18

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	AS	
2	SS	7
3	SS	8
4	SS	8
5	SS	8
6	SS	17

NOTE:

1. Groundwater measured at a depth of 1.1 m below existing grade (Elev. 188.5 masl) upon completion of drilling September 11, 2016.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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

DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5383805.00; E 552626.00

RECORD OF BOREHOLE: BH16-04

BORING DATE: September 11, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

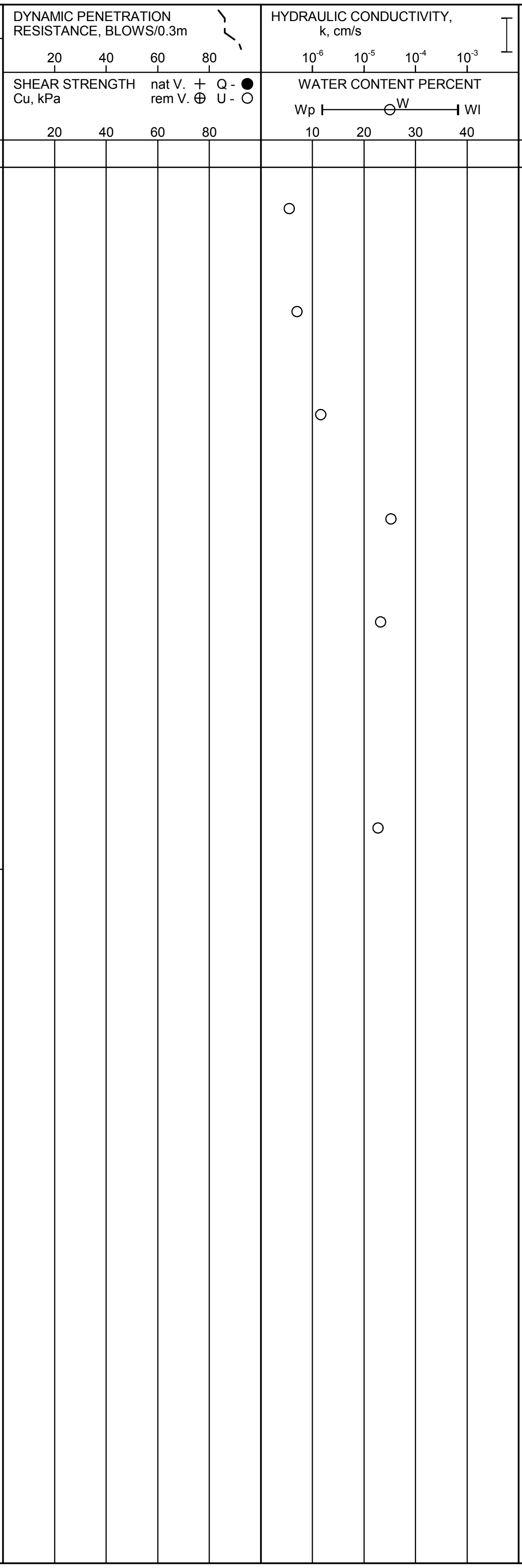
BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
	GROUND SURFACE	190.80
0	ASPHALT	0.00
	FILL-(SM) gravelly SILTY SAND; brown; moist	0.07
	(SP) SAND, trace gravel, trace to some silt; brown; moist to wet, very loose to compact	190.11 0.69
5.18	End of Borehole	185.62 5.18

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	AS	
2	SS	22
3	SS	4
4	SS	0
5	SS	3
6	SS	24

NOTE:

1. Groundwater measured at a depth of 1.6 m below existing grade (Elev. 189.2 masl) upon completion of drilling September 11, 2016.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

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PROJECT: 1545167

LOCATION: N 5383764.00; E 552459.00

RECORD OF BOREHOLE: BH16-05

BORING DATE: September 11, 2016

SHEET 1 OF 1

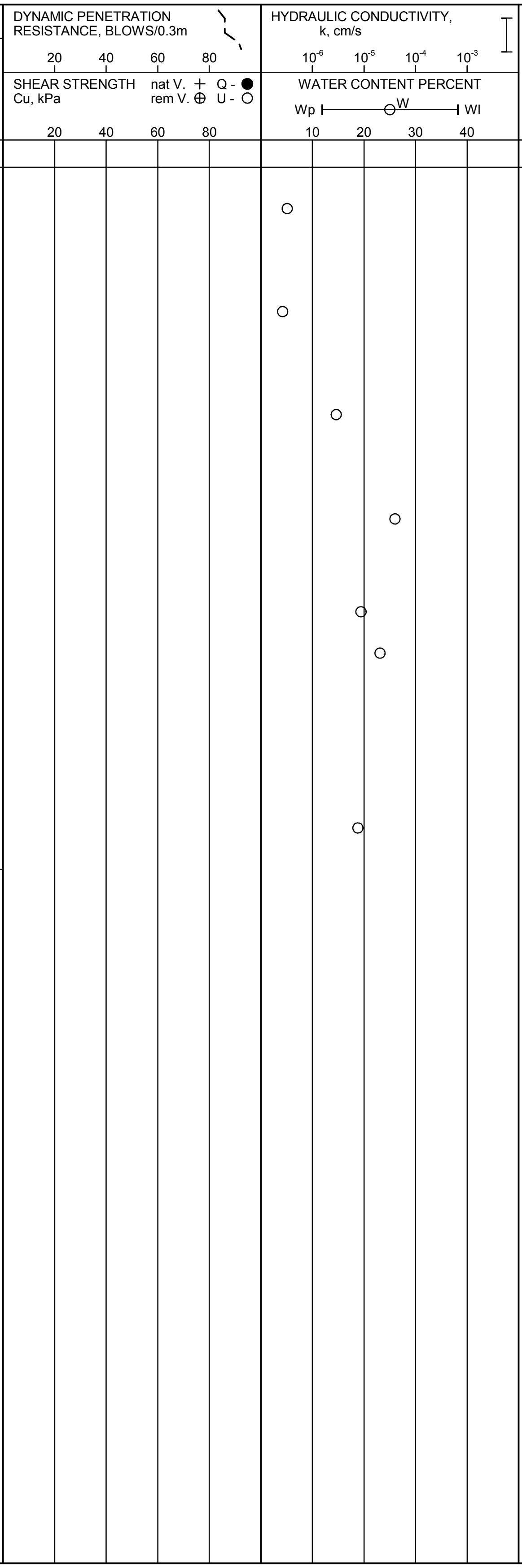
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	189.70					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT	0.00					
		FILL-(SM) SILTY SAND, some gravel; brown; moist	0.05	1	AS			
		(SP) SAND, trace to some silt; brown; moist to wet, compact	189.01 0.69					
1				2	SS	15		
2				3	SS	10		
		grey below 2.3 mbgs		4	SS	13	M	
3				5A	SS	15		
		SILTY SAND; grey; wet, compact from 3.5 to 4.1 mbgs		5B				
4								
		trace gravel below 4.6 mbgs						
5				6	SS	20	M	
		End of Borehole	184.52 5.18					

NOTE:

1. Groundwater measured at a depth of 1.7 m below existing grade (Elev. 188.0 masl) upon completion of drilling September 11, 2016.



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5383522.00; E 552446.00

RECORD OF BOREHOLE: BH16-06

BORING DATE: September 11, 2016

SHEET 1 OF 1

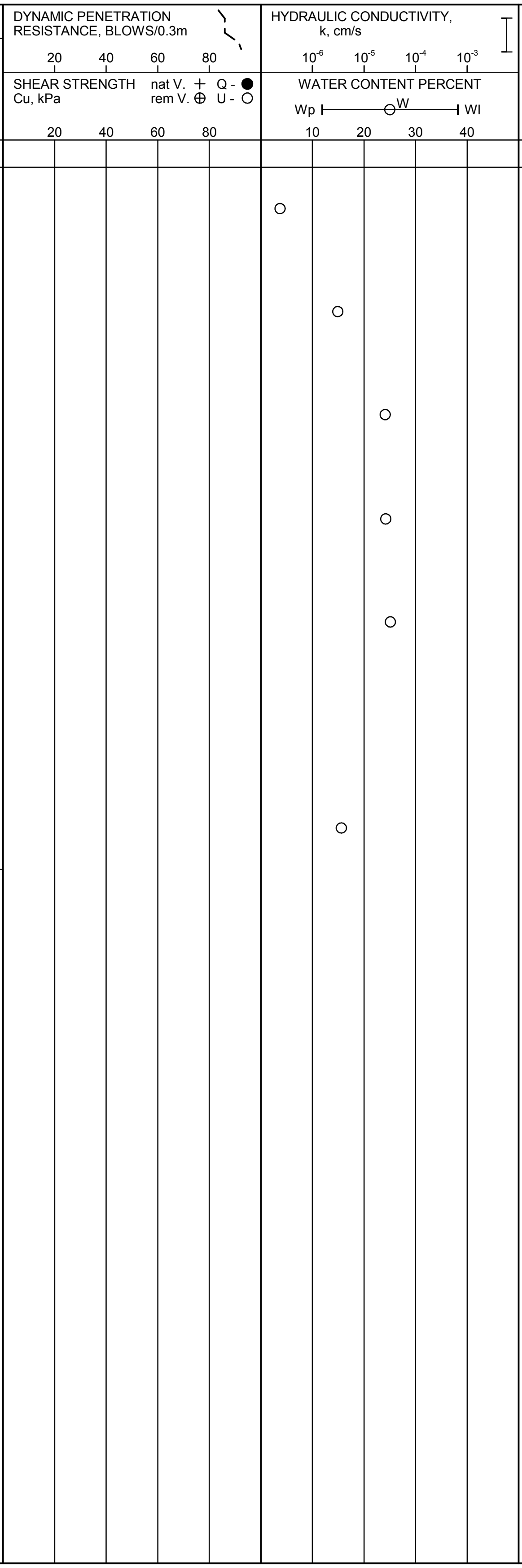
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		189.80					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT		0.00					
		FILL-(SM) gravelly SILTY SAND; brown; moist, compact		0.05	1	AS			
1					2	SS	21		
		(SP) SAND, trace gravel, some silt; brown to grey, containing silty sand pockets; wet, loose to compact		188.35 1.45	3	SS	10		
2					4	SS	9		
3					5	SS	13		
4									
5					6	SS	17		
		End of Borehole		184.62 5.18					

NOTE:

1. Groundwater measured at a depth of 1.4 m below existing grade (Elev. 188.4 masl) upon completion of drilling September 11, 2016.



6, 7, 8, 9, 10

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5383286.00; E 552519.00

RECORD OF BOREHOLE: BH16-07

BORING DATE: September 11, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

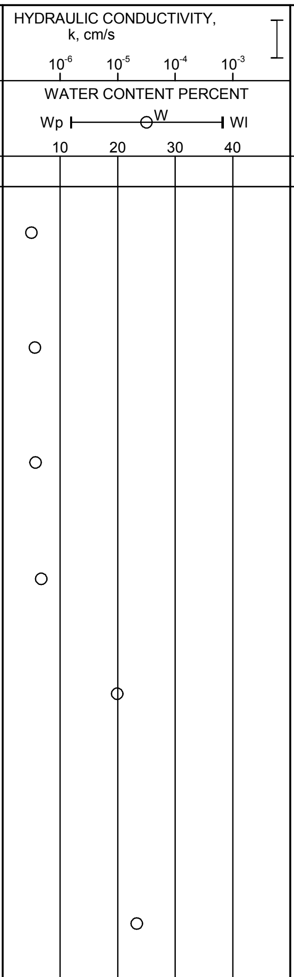
BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	192.10
ASPHALT	0.00
FILL-(SM) gravelly SILTY SAND; brown, containing rock fragments; moist, dense	0.05
(SP) SAND, trace gravel, trace to some silt; brown; moist to wet, very loose to compact	190.65 1.45
End of Borehole	186.92 5.18

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	AS	
2	SS	40
3	SS	18
4	SS	3
5	SS	2
6	SS	9

NOTE:

1. Groundwater measured at a depth of 3.1 m below existing grade (Elev. 189.0 masl) upon completion of drilling September 11, 2016.



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

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

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5383073.00; E 552638.00

RECORD OF BOREHOLE: BH16-08

BORING DATE: September 10, 2016

SHEET 1 OF 1

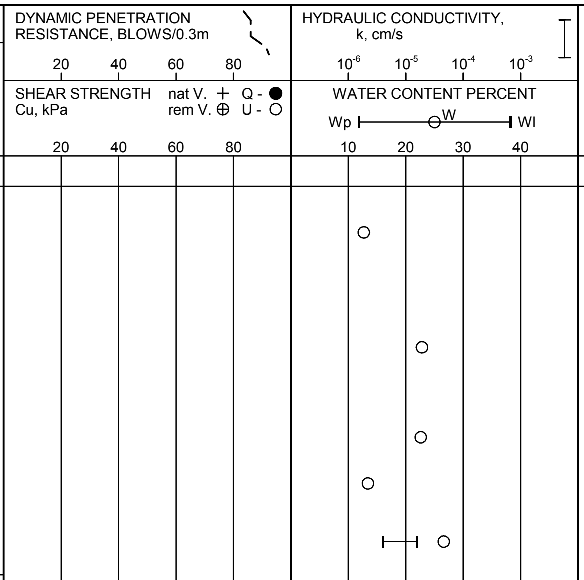
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		199.00					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT		0.00					
		FILL-(SM) gravelly SILTY SAND; brown; moist		0.05	1	AS			
1		(SP) SAND, trace gravel, trace silt; grey to brown; moist to wet, loose to compact		198.31 0.69	2	SS	20		
					3A	SS	8		
2		(ML) SILT, trace sand; grey, containing rootlets; moist, loose		197.20 1.80	3B				
		(CL-ML) SILTY CLAY to CLAYEY SILT, trace sand; grey; w>PL, hard		196.79 2.21	4	SS	50/ 127 mm	MH	
		End of Borehole Inferred Bedrock		196.43 2.57					

NOTE:

1. Groundwater measured at a depth of 1.6 m below existing grade (Elev. 197.4 masl) upon completion of drilling September 10, 2016.



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-09

SHEET 1 OF 1

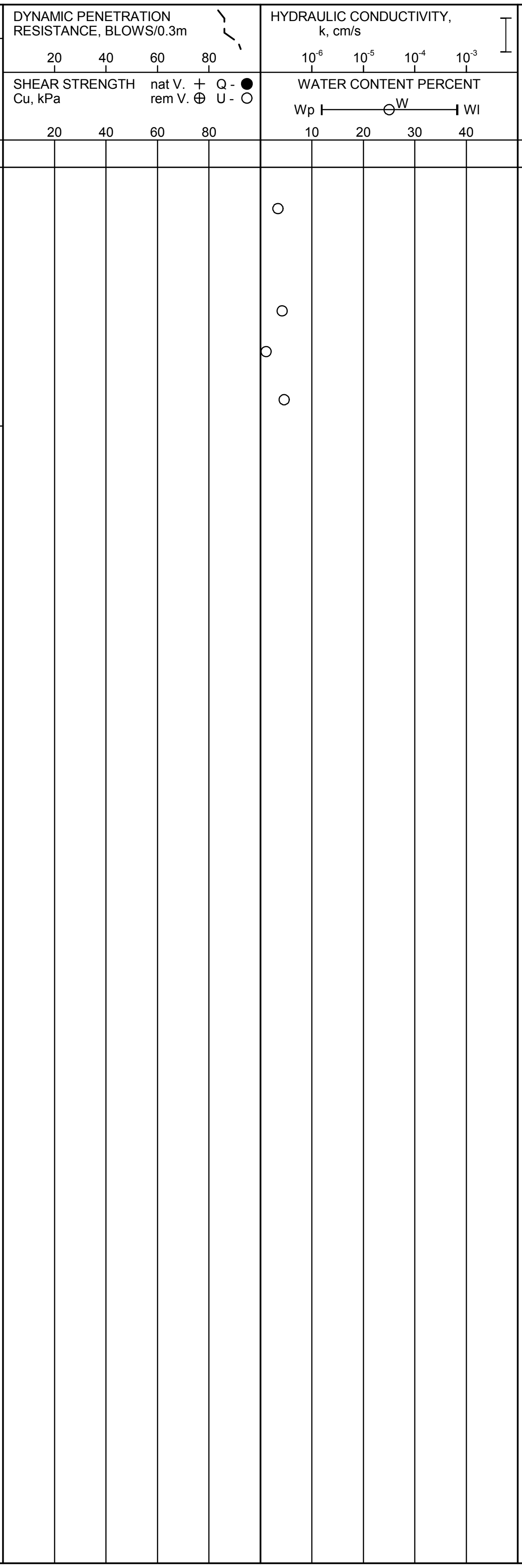
LOCATION: N 5382828.00; E 552667.00

BORING DATE: September 9, 2016

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		200.30					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT		0.00					
		FILL-(SM) gravelly SILTY SAND; brown; moist		0.05	1	AS			
		(SP) SAND, some gravel, some silt; brown, containing crushed rock fragments; moist, very dense		199.61 0.69					
1					2A	SS	52		
					2B				
					3	SS	64/ 229 mm		
2		End of Borehole Inferred Bedrock		198.39 1.91					
		NOTE:							
		1. Borehole dry upon completion of drilling September 9, 2016.							
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

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PROJECT: 1545167

LOCATION: N 5382727.00; E 552727.00

RECORD OF BOREHOLE: BH16-10

BORING DATE: September 9, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		198.00							
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT		0.00							
		FILL-(SM) SILTY SAND, some gravel; brown; moist		0.07	1	AS			○		
		(SP) SAND, trace silt, trace gravel; brown; moist, very hard		197.31 0.69	2	SS	61/ 178 mm		○		
1		End of Borehole Inferred Bedrock		196.91 1.09							
		NOTE: 1. Borehole dry upon completion of drilling September 9, 2016.									
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5382608.00; E 552728.00

RECORD OF BOREHOLE: BH16-11

BORING DATE: September 9, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		195.30							
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT	■	0.00							
		FILL-(SM) gravelly SILTY SAND; brown, containing rock fragments; moist, very dense	▨	0.05	1	AS			○		
				194.41	2	SS	50/ 127 mm		○		
1		End of Borehole Inferred Bedrock NOTE: 1. Borehole dry upon completion of drilling September 9, 2016.		0.89							
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5382490.00; E 552675.00

RECORD OF BOREHOLE: BH16-12

BORING DATE: September 9, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	SOIL PROFILE STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20, 40, 60, 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		194.00							
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT	■	0.00 0.05							
		FILL-(SM) gravelly SILTY SAND; brown; moist	▨								
		Supsected Rock Fill	▨	193.39							
		End of Borehole Probable Rock Fill		0.61							
		NOTE:									
1		1. Borehole dry upon completion of drilling September 9, 2016.									
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-13

SHEET 1 OF 1

LOCATION: N 5382398.00; E 552590.00

BORING DATE: September 9, 2016

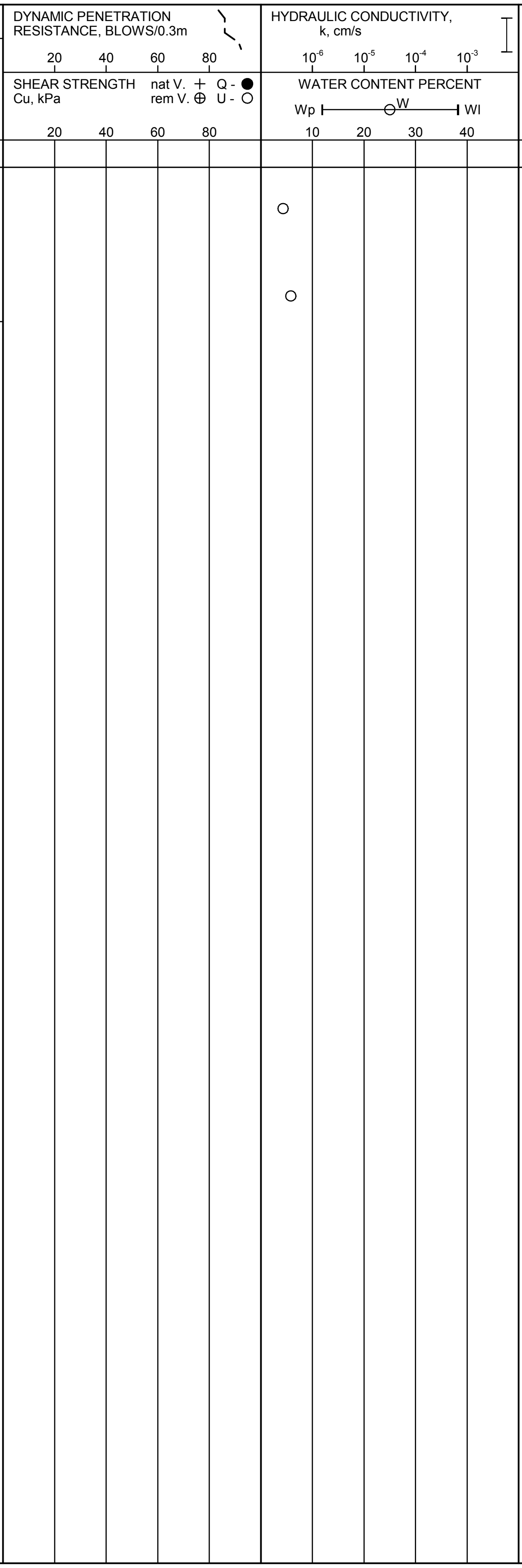
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		189.10					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT	■	0.00					
		FILL-(SM) gravelly SILTY SAND; brown, containing crushed rock fragments; moist, very dense	▨	0.04	1	AS			
1					2	SS	84/ 229 mm		
				187.96 1.14					
		End of Borehole Inferred Bedrock							

NOTE:

1. Borehole dry upon completion of drilling September 9, 2016.



DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

LOCATION: N 5382370.00; E 552507.00

RECORD OF BOREHOLE: BH16-14

BORING DATE: September 9, 2016

SHEET 1 OF 1

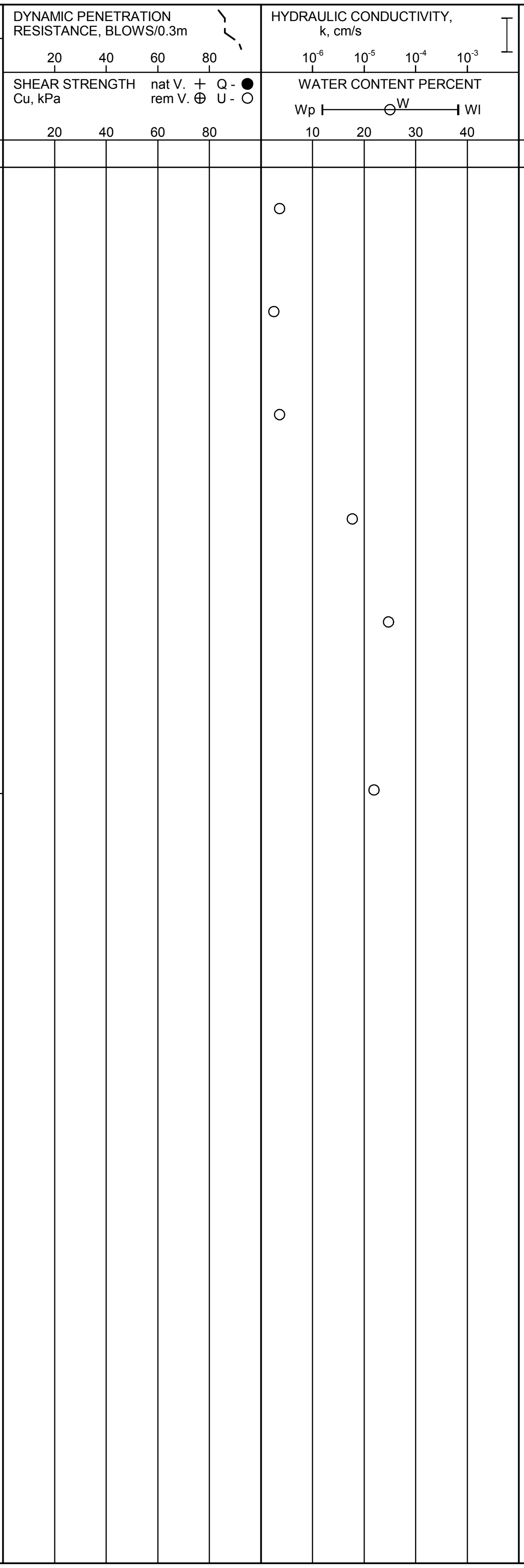
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	186.00					
0	Truck Mount CME 75 6" O.D. Auger	ASPHALT	0.00 0.05					
		FILL-(SM) gravelly SILTY SAND; brown; moist		1	AS			
		(SP) SAND, trace to some silt, trace gravel; brown; moist, very loose to compact	185.31 0.69					
1				2	SS	19		
2				3	SS	19	M	
		wet below 2.5 mbgs		4	SS	4		
3				5	SS	4		
4				6	SS	50/ 51 mm		
		End of Borehole Inferred Bedrock	181.38 4.62					
5								
6								
7								
8								
9								
10								

NOTE:

1. Groundwater measured at a depth of 2.7 m below existing grade (Elev. 183.3 masl) upon completion of drilling September 9, 2016.



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-15

SHEET 1 OF 1

LOCATION: N 5382364.00; E 552432.00

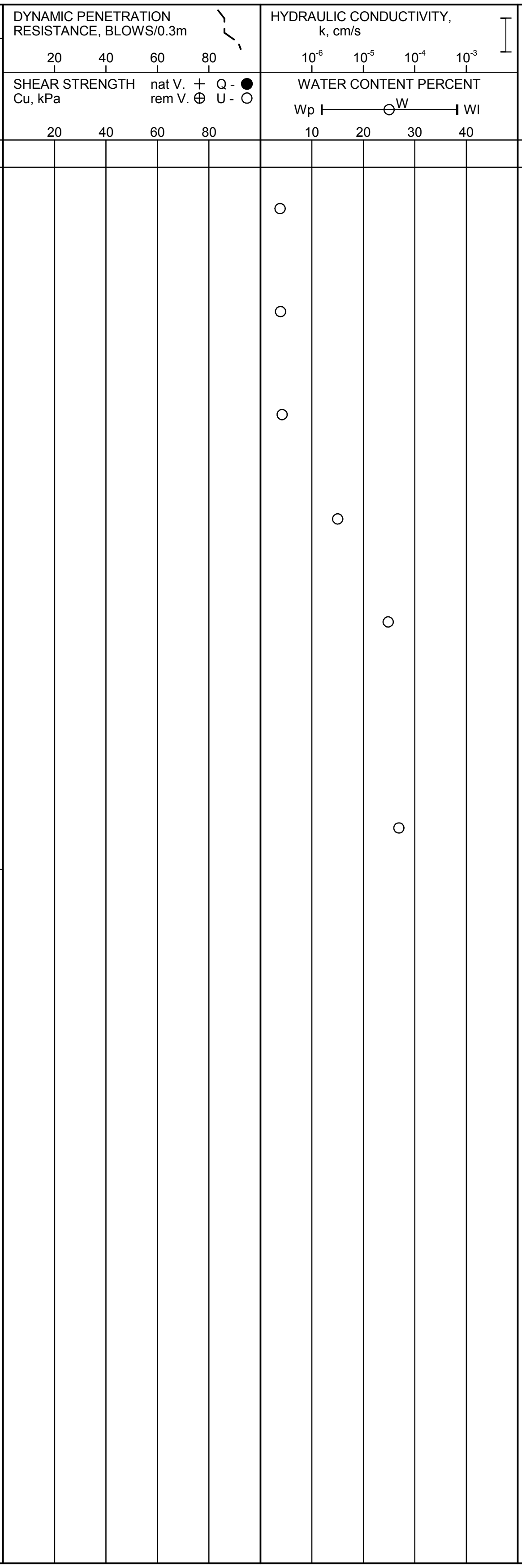
BORING DATE: September 9, 2016

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
	GROUND SURFACE	185.50				
0	ASPHALT	0.00 0.06				
	FILL-(SM) gravelly SILTY SAND; brown; moist		1	AS		
		184.81 0.69				
1	(SP) SAND, trace gravel, trace to some silt; brown; moist, very loose to compact		2	SS	9	
2			3	SS	6	
	wet below 2.3 mbgs		4	SS	15	M
3			5	SS	4	
4						
5	Fibrous ORGANICS 10mm thick at 5.0 mbgs		6	SS	3	
		180.32 5.18				
	End of Borehole					



PIEZOMETER OR STANDPIPE INSTALLATION

NOTE:

1. Groundwater measured at a depth of 2.2 m below existing grade (Elev. 183.3 masl) upon completion of drilling September 9, 2016.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167
LOCATION: N 5382384.00; E 552342.00

RECORD OF BOREHOLE: BH16-16

BORING DATE: September 9, 2016

SHEET 1 OF 1
DATUM: Geodetic

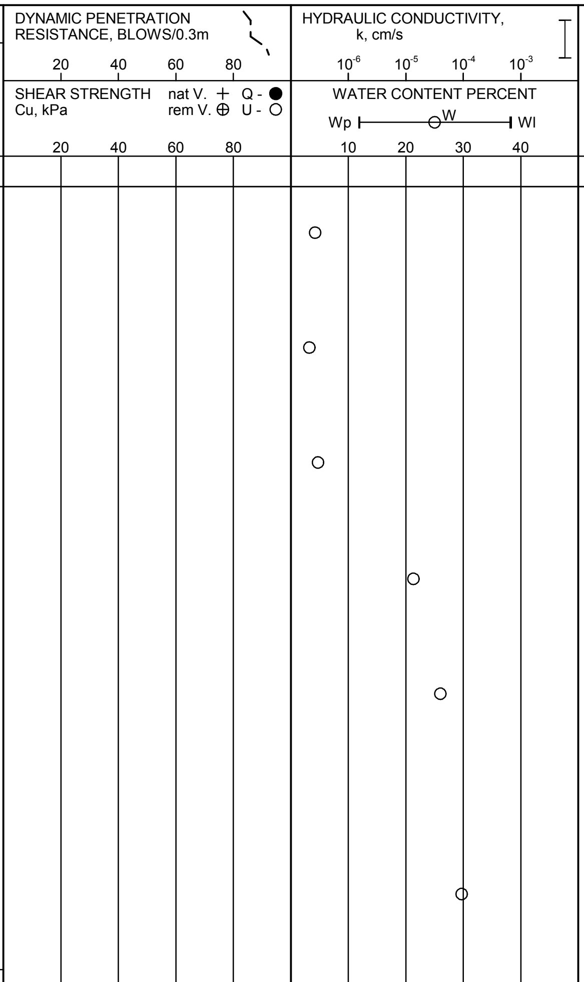
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: Truck Mount CME 75, 6" O.D. Auger

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	185.60			
ASPHALT	0.00			
FILL-(SM) gravelly SILTY SAND; brown; moist	0.04	1	AS	
(SP) SAND, trace to some silt, trace gravel; brown; moist, very loose to compact	184.91 0.69	2	SS	18
		3	SS	9
wet below 2.3 mbgs		4	SS	19
grey below 3.0 mbgs		5	SS	7
Fibrous ORGANICS from 4.9 to 5.0 mbgs		6A 6B	SS	4
End of Borehole	180.42 5.18			

NOTE:

1. Groundwater measured at a depth of 2.0 m below existing grade (Elev. 183.6 masl) upon completion of drilling September 9, 2016.



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

LOGGED: AK
CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-17

SHEET 1 OF 1

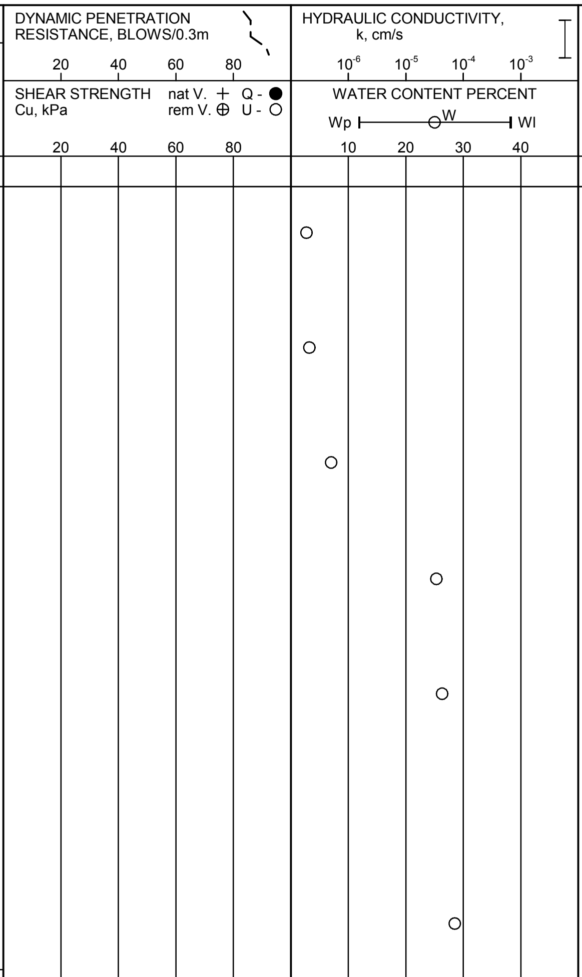
LOCATION: N 5382383.00; E 552271.00

BORING DATE: September 8, 2016

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		185.60					
0	Truck Mount CME 75 Solid Stem 6" O.D. Auger	ASPHALT		0.00					
		(SM) gravelly SILTY SAND; brown; moist		0.05	1	AS			
		(SP) SAND, trace gravel, trace to some silt; brown; moist, loose to compact		184.91 0.69					
1					2	SS	9		
2					3	SS	10		
		wet below 2.3 mbgs			4	SS	11		
3					5	SS	8		
4									
5					6	SS	5		
		End of Borehole		180.42 5.18					
6									
7									
8									
9									
10									



NOTE:

1. Groundwater measured at a depth of 2.1 m below existing grade (Elev. 183.5 masl) upon completion of drilling September 8, 2016.

GTA-BHS 001 S:\CLIENTS\PARKS_CANADA\PUKASKWA_NATIONAL_PARK\02_DATA\GINT\1545167-BG-0001.GPJ GAL-MIS.GDT 10-7-16 STB

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167
LOCATION: N 5382346.00; E 552070.00

RECORD OF BOREHOLE: BH16-18

BORING DATE: September 8, 2016

SHEET 1 OF 1
DATUM: Geodetic

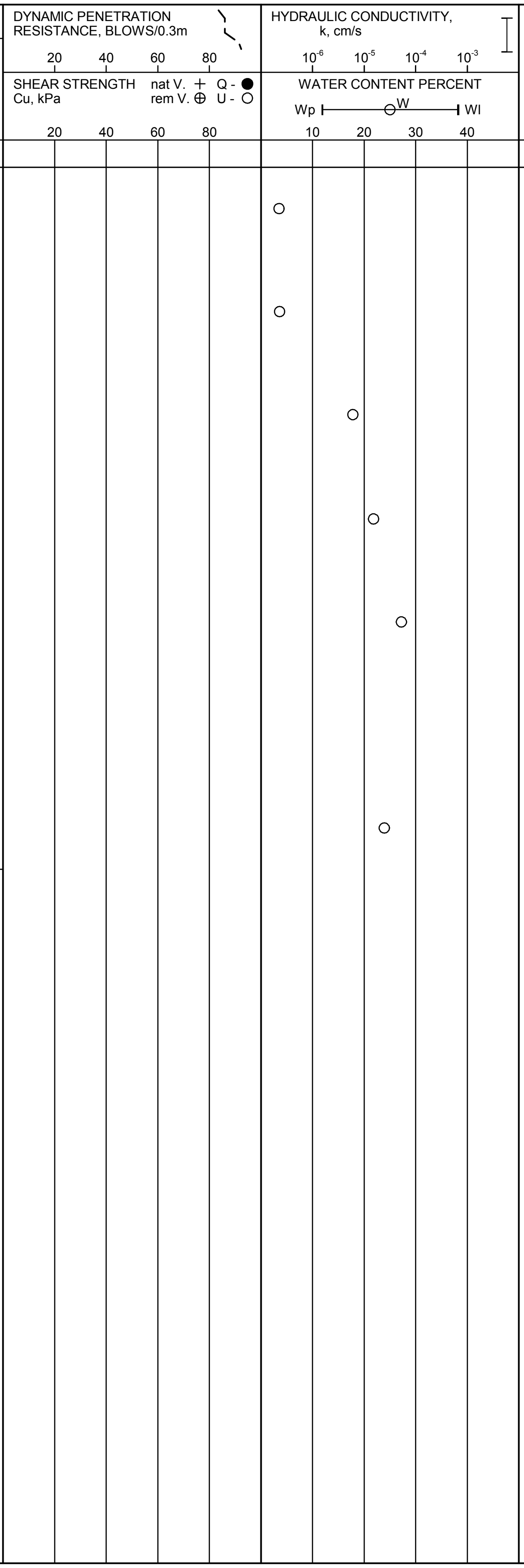
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: Truck Mount CME 75; Solid Stem 6" O.D. Auger

DEPTH SCALE METRES	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
	GROUND SURFACE		185.60				
0	ASPHALT		0.00				
	FILL-(SM) gravelly SILTY SAND; brown; moist		0.05	1	AS		
	(SP) SAND, trace to some silt, trace gravel; brown; moist, loose to compact		184.91 0.69	2	SS	14	
				3	SS	8	M
	wet below 2.3 mbgs			4	SS	13	
				5	SS	22	
	grey below 4.1 mbgs						
				6	SS	20	
	End of Borehole		180.42 5.18				

NOTE:

1. Groundwater measured at a depth of 1.8 m below existing grade (Elev. 183.8 masl) upon completion of drilling September 8, 2016.



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

LOGGED: AK
CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-19

SHEET 1 OF 1

LOCATION: N 5382327.00; E 551984.00

BORING DATE: September 8, 2016

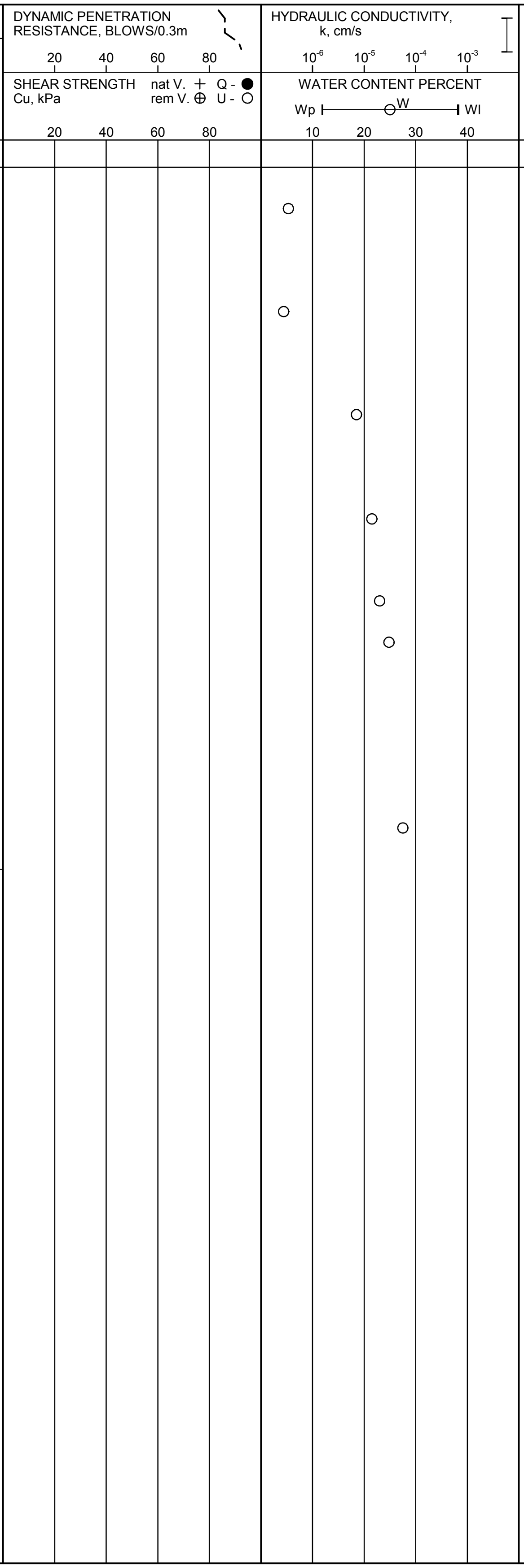
DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		185.80					
0	Truck Mount CME 75 Solid Stem 6" O.D. Auger	FILL-(SM) SILTY SAND, trace gravel; brown; moist	▩	0.00	1	AS			
		(SP) SAND, trace gravel, trace to some silt; brown; moist to wet, loose to compact		185.11 0.69	2	SS	12		
1					3	SS	6		
2					4	SS	11		
3					5A 5B	SS	18		
		grey below 3.4 mbgs							
4									
5					6	SS	13	M	
		End of Borehole		180.62 5.18					

NOTE:

1. Groundwater measured at a depth of 1.7 m below existing grade (Elev. 184.1 masl) upon completion of drilling September 8, 2016.



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

GTA-BHS 001 S:\CLIENTS\PARKS_CANADA\PUKASKWA_NATIONAL_PARK\02_DATA\GINT\1545167-BG-0001.GPJ GAL-MIS.GDT 10-7-16 STB

PROJECT: 1545167

LOCATION: N 5382289.00; E 552089.00

RECORD OF BOREHOLE: BH16-20

BORING DATE: September 8, 2016

SHEET 1 OF 1

DATUM: Geodetic

SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20, 40, 60, 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp ├──○W──┤ Wl (10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		185.20							
0	Truck Mount CME 75 Solid Stem 6" O.D. Auger	FILL-(SM) SILTY SAND, trace gravel; brown; moist		0.00	1	AS					
		(SP) SAND, trace gravel, trace to some silt; brown; moist to wet, compact		184.51 0.69							
1					2	SS	11				
					3	SS	11				
2					4	SS	11				
3		grey at 3.3 mbgs			5A 5B	SS	19				
4											
5					6	SS	21				
		End of Borehole		180.02 5.18							
6											
7											
8											
9											
10											

NOTE:

1. Groundwater measured at a depth of 1.2 m below existing grade (Elev. 184.0 masl) upon completion of drilling September 8, 2016.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: AK

CHECKED: DM

PROJECT: 1545167

RECORD OF BOREHOLE: BH16-21

SHEET 1 OF 1

LOCATION: N 5382236.00; E 552101.00

BORING DATE: September 8, 2016

DATUM: Geodetic

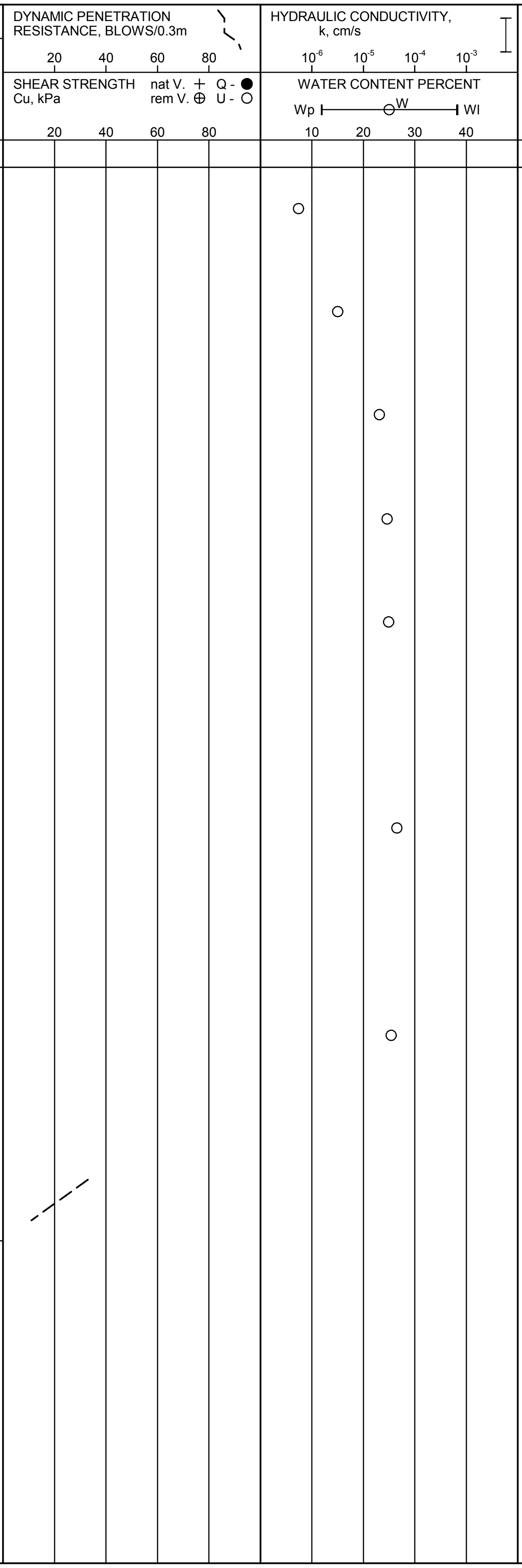
SPT/DCPT HAMMER: MASS, 64kg; DROP, 760mm

BORING METHOD: Truck Mount CME 75; Hollow Stem 8" O.D. 4 1/4" I.D. Auger

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	184.90					
0	FILL-(SM) SILTY SAND, some gravel; brown; moist	0.00	1	AS			
	(SP) SAND, trace to some silt; brown; moist, loose to compact	184.21 0.69					
1			2	SS	19		
	wet below 1.5 mbgs						
2			3	SS	8		
	grey below 2.2 mbgs						
			4	SS	22	M	
3			5	SS	17		
4							
5			6	SS	13		
6			7	SS	9	M	
7	End of Borehole Start of DCPT	177.60 7.30					
8	End of DCPT	176.98 7.92					

NOTE:

1. Groundwater measured at a depth of 1.4 m below existing grade (Elev. 183.5 masl) upon completion of drilling September 8, 2016.



DEPTH SCALE

1 : 50

LOGGED: AK

CHECKED: DM

APPENDIX A

Important Information and Limitations of This Report

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. 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 can not 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 upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. 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 can not 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 can not 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 Ground water 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.

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.

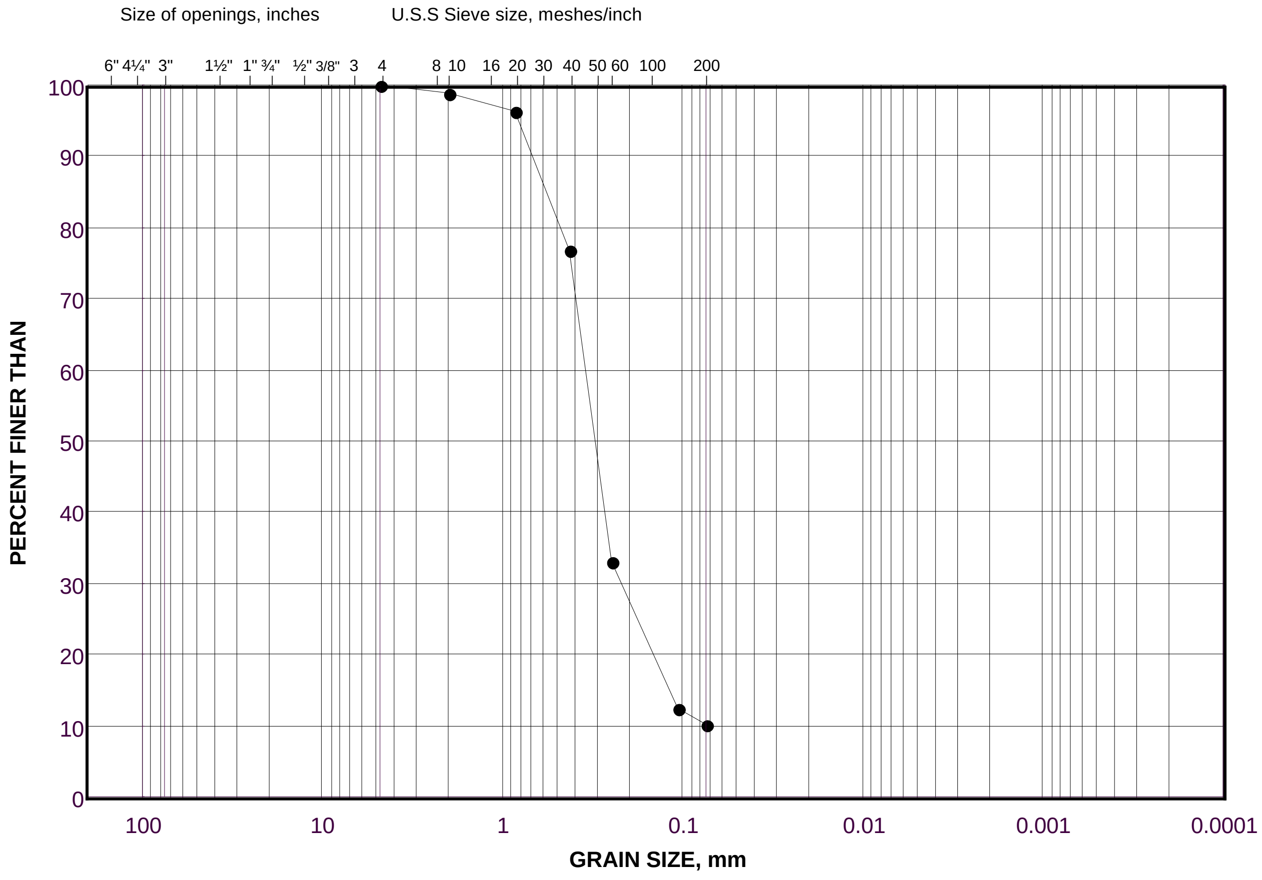
APPENDIX B

Figures B1 to B6

GRAIN SIZE DISTRIBUTION

FILL - (SP) SAND

FIGURE B1



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	BH16-01	SS2	0.76 - 1.37

Project Number: 1545167

Checked By: DPM

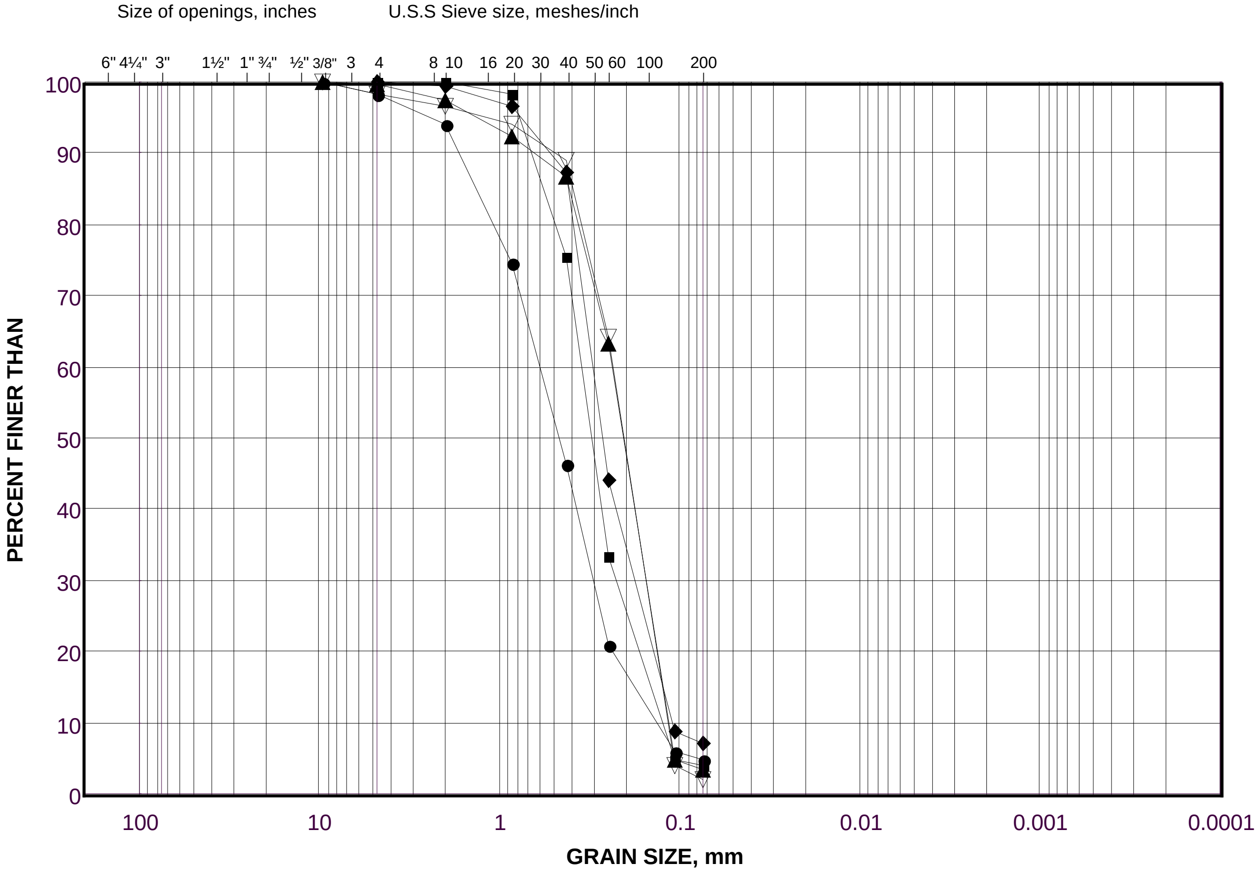
Golder Associates

Date: 05-Oct-16

GRAIN SIZE DISTRIBUTION

(SP) SAND

FIGURE B2



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	BH16-03	SS2	0.76 - 1.37
■	BH16-14	SS3	1.52 - 2.13
◆	BH16-01	SS3	1.52 - 2.13
▲	BH16-05	SS4	2.29 - 2.90
▽	BH16-05	SS6	4.57 - 5.18

Project Number: 1545167

Checked By: DPM

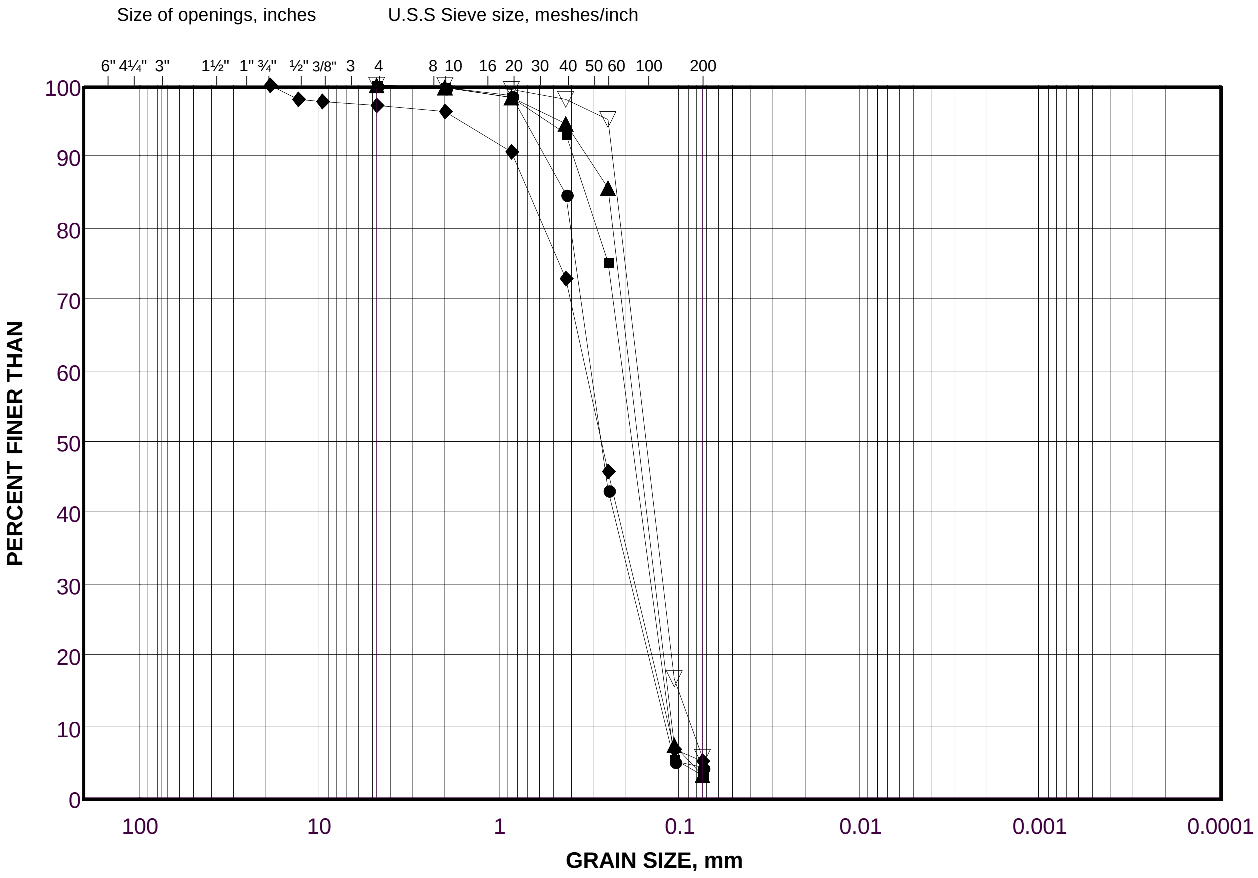
Golder Associates

Date: 05-Oct-16

GRAIN SIZE DISTRIBUTION

(SP) SAND

FIGURE B3



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	BH16-18	SS3	1.52 - 2.13
■	BH16-21	SS4	2.29 - 2.90
◆	BH16-15	SS4	2.29 - 2.90
▲	BH16-19	SS6	4.57 - 5.18
▽	BH16-21	SS7	6.10 - 6.71

Project Number: 1545167

Checked By: DPM

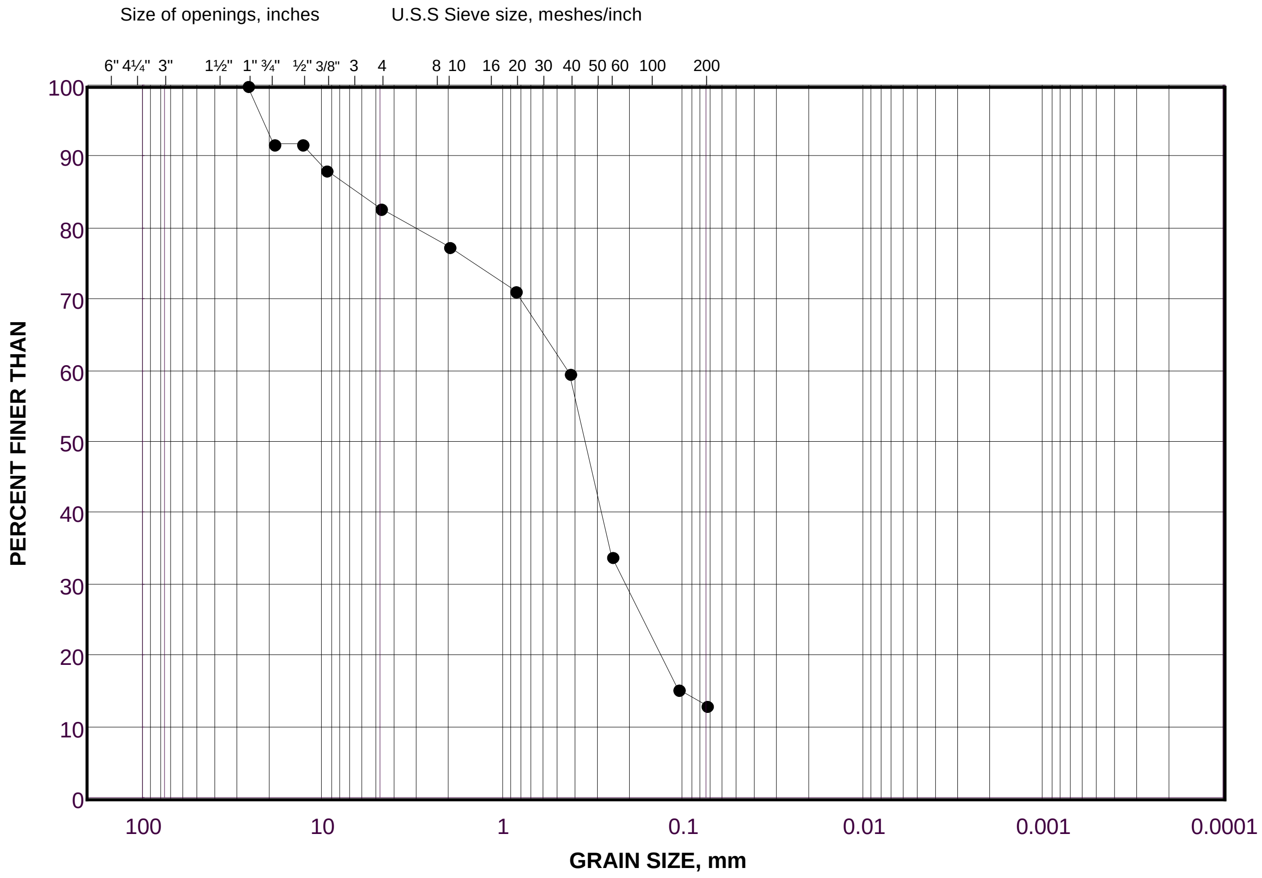
Golder Associates

Date: 05-Oct-16

GRAIN SIZE DISTRIBUTION

FILL - (SM) gravelly SILTY SAND

FIGURE B4



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	BH16-07	SS2	0.76 - 1.37

Project Number: 1545167

Checked By: DPM

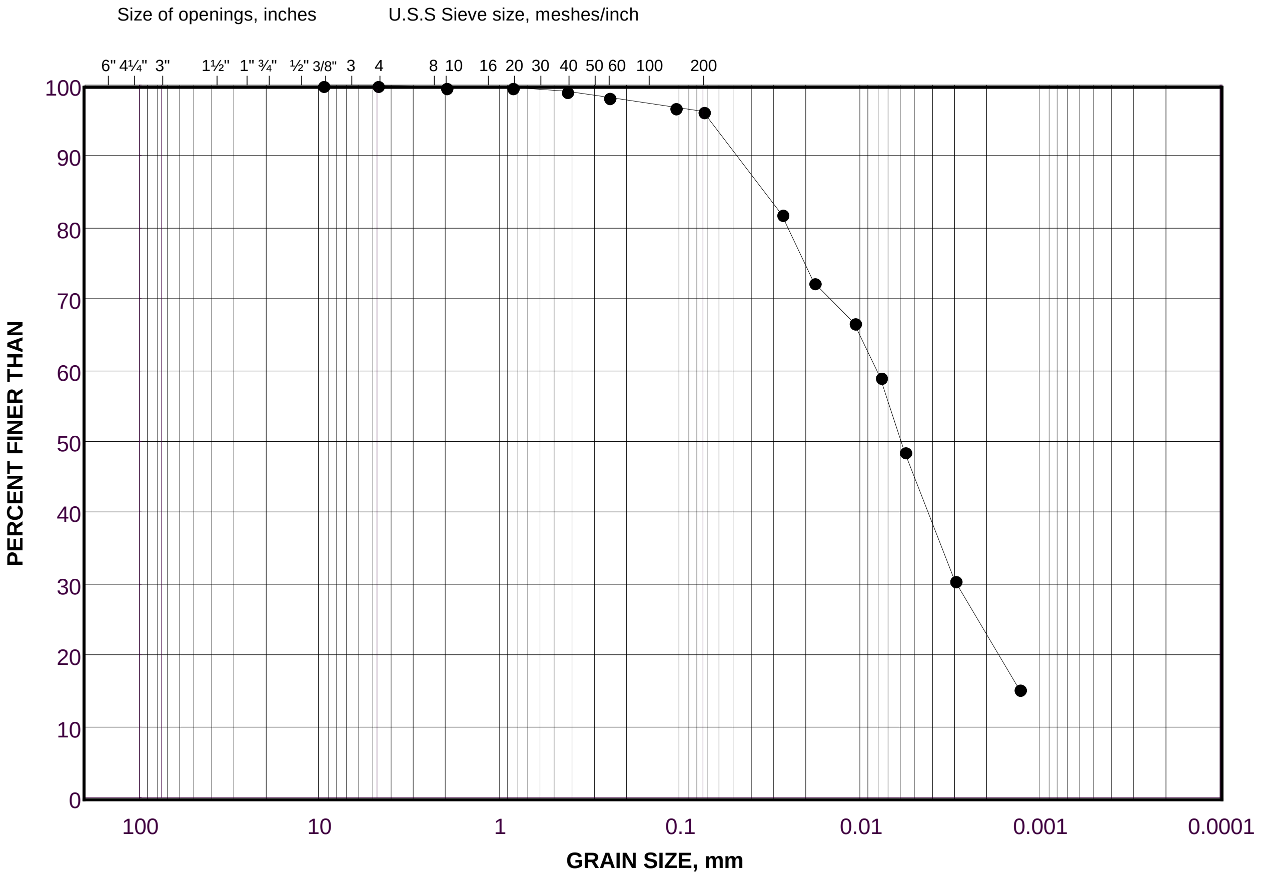
Golder Associates

Date: 05-Oct-16

GRAIN SIZE DISTRIBUTION

(CL-ML) SILTY CLAY to CLAYEY SILT

FIGURE B5



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	**GRAVEL SIZE**		**SAND SIZE**			**FINE GRAINED**

LEGEND

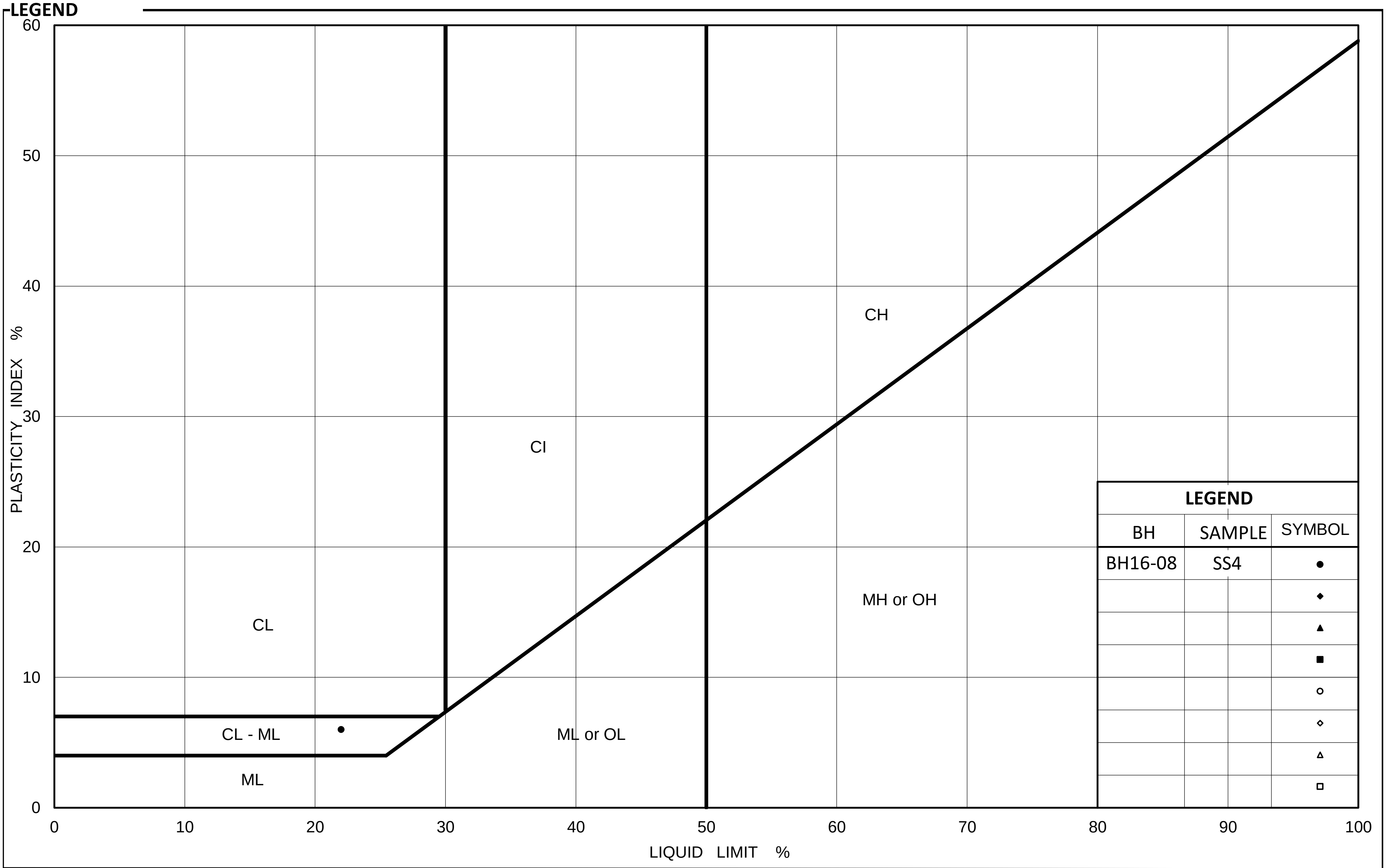
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	BH16-08	SS4	2.29 - 2.90

Project Number: 1545167

Checked By: DPM

Golder Associates

Date: 05-Oct-16



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PLASTICITY CHART
(CL-ML) SILTY CLAY to CLAYEY SILT

Figure No.	B6
Project No.	1545167
Checked By:	DPM

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

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