November 9, 2018

FOUNDATION INVESTIGATION AND DESIGN REPORT

STRUCTURAL BUNDLE - 11 STRUCTURES ON HIGHWAYS 129, 532 AND 556
HIGHWAY 532 - ATKINSON CREEK CULVERT NO. 1 REPLACEMENT, 9.7 KM NORTH OF HIGHWAY 556 (SITE NO. 38S-290C)
GAUDETTE TOWNSHIP, ALGOMA DISTRICT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5378-11-00 ; WP 5261-13-02

Submitted to:
AECOM
189 Wyld Street, Suite 103
North Bay, Ontario
P1B 1Z2

Report No.: 1670846 ; GEOCRES No. 41K110
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REPORT

Golder Associates

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FOUNDATION INVESTIGATION REPORT
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the detail design of the replacement of a culvert on Highway 532 (Site No. 38S-290C) in the Gaudette Township, Algoma District, Ontario.

The purpose of the field investigation is to establish the subsurface conditions at the location of the proposed replacement culvert by methods of borehole drilling, in-situ testing and laboratory testing on selected soil samples.

This report summarizes the factual results of field and laboratory work (including field investigation procedures, borehole stratigraphy, and geotechnical and analytical laboratory test results) as well as a description of the interpreted soil and groundwater conditions at the Atkinson Creek culvert site.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Request for Proposal dated May 2016 (Agreement No. 5016-E-0029). Golder's proposal for foundation engineering services is contained in Section 17.8 of AECOM's Technical Proposal for this assignment.

2.0 PROJECT AND SITE DESCRIPTION

2.1 Project Description

The existing culvert at the site conveys the Atkinson Creek under Highway 532 in a northeast to southwest direction. The culvert was constructed in 1978 and there are no records of the culvert being rehabilitated since that time. It is understood that the existing culvert underwent a structural assessment in 2015 and was identified as being in fair structural condition with minor deterioration of several elements, and more significant deterioration of the structural steel coatings. The culvert is to be replaced with a new reinforced concrete box culvert.

2.2 Site Description

The site of the proposed culvert replacement is located about 9.7 km north of Highway 556 in the Gaudette Township, Algoma District, Ontario.

The existing culvert consists of a single cell, Structural Plate Corrugated Steel Pipe (SPCSP) culvert with an approximately 3.67 m diameter and measuring about 30.9 m in length. The culvert is shown on Drawing 1.

The Atkinson Creek at the location of the culvert is between approximately 6 m and 7 m wide and flows in a generally northeast to southwest direction where it crosses below Highway 532. The downstream end of the Atkinson Creek flows into the Achigan Creek about 260 m southwest of the culvert. The Achigan Creek in turn flows into the Goulais River about 5.6 km south of the culvert (i.e., immediately south of Searchmont).

Highway 532 at the location of the culvert consists of an approximately 5.5 m high earth fill embankment that carries one lane of traffic in each direction. Although the highway is oriented in a generally northwest to southeast direction at the culvert, for the purposes of this report the highway is defined as running in a north-south direction. The travelled portion of the highway consists of an asphalt surface which is at approximately Elevation 251.6 m in the vicinity of the existing culvert.

Entrances to residential dwellings are located on the east side of Highway 532, approximately 80 m south and 105 m north of the culvert, as well as on the west side of Highway 532, approximately 90 m north of the culvert. Overhead electrical transmission lines run along the highway on the east side of Highway 532 (i.e., immediately west of the inlet).

The topography of the area in the immediate vicinity of the culvert is relatively flat to undulating, particularly on the west side of Highway 532, given that the site is located within the Achigan Creek valley. However, the natural ground surface rises significantly further east and west of the culvert – an indicator of the high relief and rugged topography in this area. The natural ground surface in the immediate vicinity of the inlets and outlets of the existing culvert varies between about Elevations 246.5 m and 248.0 m. The site is relatively heavily vegetated with grasses and shrubs, as well as deciduous and coniferous trees.

3.0 FIELD INVESTIGATION PROCEDURES

The fieldwork at the site of the existing culvert was carried out on September 6 and 8, 2017, during which time three boreholes (designated as Boreholes ACC2-01 to ACC2-03) were advanced near the existing culvert. Boreholes ACC2-01 and ACC2-03 were advanced near the outlet and inlet of the existing culvert, respectively. Borehole ACC2-02 was advanced through the Highway 532 embankment on the northbound lane (south of the existing culvert).

The subsurface soil conditions encountered in the boreholes are shown in detail on the Records of Boreholes in Appendix A. Lists of abbreviations and symbols are also provided in Appendix A to assist in the interpretation of the borehole records. The locations of the as-drilled boreholes are shown in plan on Drawing 1.

The boreholes were advanced using portable drilling equipment and a drill rig. Boreholes ACC2-01 and ACC2-03 were advanced using portable drilling equipment set up on land near the inlet and outlet of the existing culvert. The portable drilling equipment was supplied and operated by Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario. These two boreholes were advanced through the overburden using 'BW' casing with wash boring techniques. Borehole ACC2-02 was advanced using a CME-75 truck-mounted drill rig supplied and operated by Landcore Drilling Inc. of Chelmsford, Ontario. This borehole was advanced using 210 mm outer diameter, continuous-flight, hollow-stem augers; however, rock coring using a 'NQ' double-tube rock core barrel was used to penetrate through a gravelly fill layer with cobbles encountered below the embankment fill.

In the two boreholes advanced near the inlet and outlet of the existing culvert, the soil samples were generally obtained continuously immediately below the existing ground surface followed by sampling at intervals of depth of about 1.5 m; while in the borehole advanced on Highway 532, the soil samples were obtained at intervals of depth of about 0.75 m and 1.5 m. All soil samples were collected using a 50 mm outer diameter, split-spoon sampler driven by a manual hammer (within Boreholes ACC2-01 and ACC2-03 advanced using the portable drilling equipment) or an automatic hammer (within Borehole ACC2-02 advanced using the truck-mounted drill rig) in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*). Field vane shear tests were carried out in the cohesive soils for assessment of undrained shear strengths (ASTM D2573, *Standard Test Method for Field Vane Shear Strength Test in Cohesive Soil*) using the MTO Standard 'N'-size vane in the borehole advanced with the drill rig, and 'B'-size vane in the smaller diameter boreholes advanced by portable equipment. Dynamic Cone Penetration Tests (DCPTs) were also carried out in all boreholes following the soil sampling operation.

The boreholes, including the DCPTs, were advanced to depths ranging between about 12.8 m and 19.2 m below existing ground surface.

All three boreholes were backfilled upon completion of drilling in accordance with Ontario Regulation 903 (Wells) (as amended).

Prior to commencement of field work, Golder arranged for the clearance of underground utilities/services. The field work was observed on a full-time basis by a member of Golder's engineering staff who monitored the drilling and sampling operations, and logged the boreholes in the field. The soil samples were transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual/tactile examination and geotechnical laboratory testing.

Geotechnical index testing (i.e., water content, organic content, Atterberg limits and grain size distribution) was carried out on selected soil samples. The results of the geotechnical laboratory testing are summarized on the borehole records in Appendix A and the results of the geotechnical testing are provided in Appendix B. All of the laboratory tests were carried out in accordance with MTO Laboratory and/or ASTM Standards, as appropriate.

A soil sample was also collected from Boreholes ACC2-03 (advanced near the inlet of the existing culvert) for corrosivity testing. The selected soil sample was submitted, under chain-of-custody procedures, to Maxxam Analytics of Mississauga, Ontario (a Standards Council of Canada accredited laboratory) for analysis of a suite of corrosivity parameters including pH, sulphate, sulphide, chloride and resistivity/conductivity.

Temporary benchmarks were established and surveyed near the existing Atkinson Creek culvert by Callon Dietz Inc. prior to the drilling crews mobilizing to site. Upon completion of drilling operations, borehole offsets and corresponding ground surface elevation differences were recorded and tied-in to the surveyed benchmark locations to determine the as-drilled borehole locations and ground surface elevations. The borehole survey information, including northing and easting coordinates (presented in the MTM NAD83 Zone 13 and latitude/longitude coordinate systems) and the ground surface elevations (referenced to Geodetic datum), are provided on the borehole records in Appendix A, presented on Drawing 1, and summarized below.

Borehole No.	Approximate Location	Coordinates (MTM NAD83 Zone 13)		Ground Surface Elevation	Borehole Depth [3]
		Northing (Latitude)	Easting (Longitude)		
ACC2-01 [1]	Outlet of existing culvert; west of Highway 532	5186427.3 m (46.817360°)	297960.3 m (-84.089639°)	247.8 m	12.8 m
ACC2-02 [2]	Northbound lane of Highway 532; south of existing culvert	5186446.5 m (46.817533°)	297968.1 m (-84.089537°)	251.6 m	19.2 m
ACC2-03 [1]	Inlet of existing culvert; east of Highway 532	5186463.0 m (46.817681°)	297966.3 m (-84.089561°)	248.0 m	13.1 m

Notes:
1. Boreholes ACC2-01 and ACC2-03 were advanced using portable drilling equipment set up on land near the outlet and inlet of the existing culvert.
2. Borehole ACC2-02 was advanced using a truck-mounted drill rig through the Highway 532 embankment.
3. The borehole depth includes the DCPT carried out at the bottom of each open borehole.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)[1] mapping, the Atkinson Creek culvert site is located at the edge of a valley train consisting primarily of gravelly and sandy soils which "are mainly confined to the larger river valleys and usually occur as flat, terraced landforms" (McQuay, 1980). The granular deposits are variable in thickness and are generally underlain by varved silt and clay to glacial till and bedrock. The valley train is bordered by bedrock knobs.

Based on geological mapping developed by the Ontario Ministry of Northern Development and Mines (MNDM)[2], the site is underlain by bedrock from the gneissic tonalite suite of rocks comprised of tonalite to granodiorite (foliated to gneissic) with minor supracrustal inclusions.

4.2 Overview of Local Subsurface Conditions

The subsurface soil and groundwater conditions encountered in the boreholes advanced at this site, together with the results of the in-situ and geotechnical/analytical laboratory testing, are presented on the Records of Boreholes (provided in Appendix A) and the laboratory test figures/sheets (provided in Appendices B and C). The results of the in-situ field tests (i.e., SPT 'N'-values and field vane undrained shear strengths) as presented on the borehole records are uncorrected, and the 'N'-values are based on SPT sampling procedures carried out with a manual hammer at the locations of Boreholes ACC2-01 to ACC2-03 and an automatic hammer at the location of Borehole ACC2-02.

The stratigraphic boundaries shown on the borehole records and on the soil strata profile (i.e., Drawing 1) are inferred from observations of drilling progress, generally non-continuous sampling, and in-situ testing and therefore, represent transitions between soil types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the Atkinson Creek culvert site consist of a granular embankment fill (associated with Highway 532) or a surficial granular deposit comprised of sandy silt to silt and sand underlain by an extensive deposit of clayey silt. The cohesive deposit is underlain by a deposit of silt.

Detailed descriptions of the subsurface conditions encountered in the boreholes at this site are provided in the following subsections.

4.2.1 Asphalt

An approximately 130 mm thick layer of asphalt was encountered in Borehole ACC2-02 which was advanced through the Highway 532 embankment on the northbound lane (south of the existing culvert). The top of the asphalt layer is at about Elevation 251.6 m.

4.2.2 Sand to Gravelly Sand to Sand and Gravel to Gravel (Fill)

An approximately 5.5 m thick layer of granular fill associated with the Highway 532 embankment was encountered below the layer of asphalt in Borehole ACC2-02. The embankment fill is comprised predominantly of sand, trace

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1 Ontario Ministry of Natural Resources and Forestry. Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 41KNE, Study Number 91.

2 Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2544.

to some gravel, trace to some silt to gravelly sand, trace to some silt, but becomes coarser at a depth of about 3.7 m below existing ground surface, where it is comprised of sand and gravel to gravel, trace to some silt with cobbles and rock fragments. An approximately 1.2 m thick layer of granular fill comprised of gravelly sand, some silt, trace clay was also encountered immediately at the ground surface in Borehole ACC2-01 which was advanced near the outlet of the existing culvert and next to the toe of the highway embankment. The top of the granular fill layer encountered in Boreholes ACC2-01 and ACC2-02 is at about Elevation 247.8 m and Elevation 251.5 m, respectively.

The SPT 'N'-values measured within the upper portion of the embankment fill range from 9 blows to 14 blows per 0.3 m of penetration, indicating a loose to compact state of compactness. A SPT 'N'-value measured within the gravel portion of the fill is 36 blows per 0.3 m of penetration, indicating a dense state of compactness. A SPT 'N'-value measured within the sand and gravel portion of the fill (i.e., at the base of the fill) is 12 blows per 0.3 m of penetration, indicating a compact state of compactness. However, the latter SPT 'N'-value is likely unrepresentative of the material's state of compactness as a result of coring immediately above the split-spoon sample. Two SPT 'N'-values measured within the granular fill encountered at the ground surface in Borehole ACC2-01 are 8 blows per 0.3 m of penetration, indicating a loose state of compactness.

The water content measured on two samples of the sand to gravelly sand portion of the embankment fill is approximately 6% and 7%. The water content measured on the gravel portion of the embankment fill is approximately 2%. The water content measured on sample of the granular fill recovered near the outlet of the existing culvert is approximately 17%.

The results of a grain size distribution tests carried out on two samples of the granular fill are shown on Figure B1 in Appendix B.

A consolidated drained direct shear test was also carried out on samples of the sand to gravelly sand fill recovered from Borehole ACC2-02. The results are presented on Figure B2.

4.2.3 Sandy Silt to Silt and Sand

A deposit of organic silt and sand was encountered below the surficial layer of fill in Borehole ACC2-01 advanced near the outlet of the existing culvert, and a deposit of sandy silt to silt and sand was encountered immediately at the ground surface in Borehole ACC2-03 advanced near the inlet of the existing culvert. The deposit contains rootlets, wood fragments, and organics. The top of this deposit in Borehole ACC2-01 is at about Elevation 246.6 m and its thickness is about 1.9 m; while in Borehole ACC2-03, the top of this deposit is at about Elevation 248.0 m and its overall thickness is about 2.2 m.

The SPT 'N'-values measured within this deposit range between 0 blows (i.e., designated as "WH" on the borehole record, which indicates that the split-spoon sampler was penetrated for 0.3 m under the self-weight of the hammer) and 4 blows per 0.3 m of penetration, indicating a very loose and loose state of compactness.

The water content measured on three samples of the silt and sand portion of the deposit ranges between approximately 37% and 60%. An organic content test carried out on a sample recovered from Borehole ACC2-01 is 5.8% (by weight).

The results of grain size distribution tests carried out on two samples of the silt and sand portion of the deposit are shown on Figure B3 in Appendix B.

An Atterberg limits test carried out on a sample of the silt and sand deposit recovered from Borehole ACC2-01 measured a liquid limit of about 30%, a plastic limit of about 26%, and a corresponding plasticity index of about 4%. The results of this Atterberg limits test are shown on the plasticity chart on Figure B4 in Appendix B, and indicate that the material is classified as an organic silt of slight plasticity. An Atterberg limits test was also carried out on a sample of the silt and sand deposit recovered from Borehole ACC2-03 and the results indicate that the material is non-plastic.

4.2.4 Clayey Sit

An extensive cohesive deposit comprised of clayey silt, trace to some sand, was encountered below the silt and sand deposit in Boreholes ACC2-01 and ACC2-03 and below the sand and gravel fill in Borehole ACC2-02. The top of the cohesive deposit ranges between about Elevations 246.0 m and 244.8 m and its thickness ranges from about 7.1 m to 9.2 m.

The SPT ‘N’-values measured within the clayey silt deposit range between 1 blow and 8 blows per 0.3 m of penetration. In-situ vane tests carried out within this deposit in Boreholes ACC2-02 and ACC2-03 measured (uncorrected) undrained shear strength ranging from about 46 kPa to greater than 96 kPa. The measured undrained shear strengths below the Highway 532 embankment are generally greater than 96 kPa, while the measured undrained shear strength range between about 46 kPa and 75 kPa near the inlet of the existing culvert. An in-situ vane test was also attempted at a depth of about 5.2 m below ground surface in the borehole advanced near the outlet of the existing culvert; however, it was not possible to turn the vane, indicative of the material’s very stiff to hard consistency. The sensitivity (defined as the quotient between the undisturbed shear strength and the remoulded shear strength) ranges between about 2 and 11, but typically varies from 2 to 7. The in-situ field vanes tests results indicate that the deposit has a predominantly firm to very stiff consistency.

The water content measured on nine samples of this deposit ranges between about 33% and 50%, and on average is about 39%.

The results of grain size distribution tests carried out on six samples of the clayey silt deposit are shown on Figure B5 in Appendix B.

Atterberg limits tests were carried out on seven samples of the clayey silt deposit. The tests measured liquid limits between about 24% and 30%, plastic limits between about 18% and 21%, and plasticity indices between about 4% and 10%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B6 in Appendix B and indicate that the material can be classified as a clayey silt of low plasticity.

4.2.5 Silt

A deposit of silt, trace to some sand, was encountered below the clayey silt deposit in all boreholes. The top of this deposit ranges between about Elevations 237.8 m and 236.8 m. The thickness of the sampled portion of the silt deposit is greater than 1.1 m; all of the boreholes were terminated within the silt deposit. DCPTs were also carried out at the bottom of each open borehole (i.e., below the last collected soil sample). The DCPTs were terminated at elevations ranging between about 235.2 m and 232.4 m. The blow counts at these elevations generally range between 20 blows and 60 blows per 0.3 m of penetration.

The SPT ‘N’-values measured within the silt deposit range between 10 blows and 17 blows per 0.3 m of penetration, indicating a loose to compact state of compactness.

The water content measured on two samples of the silt deposit recovered from Boreholes ACC2-02 and ACC2-03 is approximately 28% and 31%, respectively.

4.3 Groundwater Conditions

The water level was measured at a depth of about 0.7 m (corresponding to Elevation 247.1 m) and 3.5 m (corresponding to Elevation 244.5 m) below existing ground surface upon removal of drilling casing in Boreholes ACC2-01 and ACC2-03 (advanced near the outlet and inlet of the existing culvert), respectively. The water levels are not necessarily considered representative of the groundwater level at the site due to introduction of drilling water to accommodate wash boring techniques. The water level measured inside the hollow-stem augers in Borehole ACC2-02 (advanced through the Highway 532 embankment) was measured upon completion of drilling at a depth of about 4.3 m below existing ground surface, corresponding to Elevation 247.3 m. Drilling water was also introduced at depth of about 4.4 m to core through a layer of cobbles and the measured water level may not be indicative of the groundwater level at the site.

Given the presence of the Atkinson Creek, the groundwater level is anticipated to be at or near the creek surface. The water level surveyed at the surface of the Atkinson Creek in June 2017 was at approximately Elevation 247.0 m, which is similar to the higher water levels described above.

The water level in the creek and the degree of saturation of the embankment fill (or the potential presence of a perched water table within the fill) is subject to seasonal fluctuations and precipitation events. Water levels in the creek and within the fill are expected to be higher during wet seasons and sustained periods of precipitation.

4.4 Analytical Testing of Soil

A soil sample was selected from Borehole ACC2-03 (advanced near the inlet of the existing culvert) and submitted to Maxxam Analytics Ontario for corrosivity testing. The analytical laboratory test results are provided on the Certificates of Analysis presented in Appendix C, and summarized below.

Borehole Designation	Sample No.	Average Approx. Sample Depth (m)	Average Approx. Sample Elevation (m)	Material Type	Resistivity (ohm·cm)	Conductivity (µohm/cm)	pH	Chloride (Cl) Content (ppm or µg/g)	Sulphate (SO_4) Content (ppm or µg/g)
ACC2-03 [1,2]	SA 2	0.9	247.1	Silt and Sand	4,100	246	5.1	130	22

Notes:
1. The borehole designation on the Certificates of Analysis was erroneously labelled as “ACCS-03”.
2. It is noted that corrosivity test results associated with soil samples recovered from boreholes that were advanced at other sites associated with this project are also presented on the Certificates of Analysis.

Sulphide concentration was also measured on the soil sample referenced above and is approximately 1.06 µg/g.

5.0 CLOSURE

The field work for this investigation was supervised by Ms. Amelia Jewison, B.A.Sc., and Ms. Katelyn Nero, B.A.Sc. The Foundation Investigation Report was prepared by Mr. Tomasz Zalucki, P.Eng., a geotechnical engineer with Golder. Ms. Lisa C. Coyne, P.Eng., a MTO Foundations Designated Contact and Principal of Golder, conducted an independent quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

Tomasz Zalucki, P.Eng.
Geotechnical Engineer

Lisa C. Coyne, P.Eng.
MTO Foundations Designated Contact, Principal

TZ/JPD/LCC/tz

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PART B

FOUNDATION DESIGN REPORT
STRUCTURAL BUNDLE – 11 STRUCTURES ON HIGHWAYS 129, 532 AND 556
HIGHWAY 532 – ATKINSON CREEK CULVERT NO. 1 REPLACEMENT, 9.7 KM NORTH OF HIGHWAY 556 (SITE NO. 38S-290C)
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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the replacement of the Atkinson Creek culvert under Highway 532 (Site No. 38S-290C). These recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the field investigation. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and carry out the design of the culvert foundations. The discussion and recommendations contained in the Foundation Design Report are intended for the use of MTO and its designers, and shall not be used or relied upon for any other purpose or by any other parties, including the construction or design-build contractor.

Contractors must make their own interpretation based on the factual data presented in the Foundation Investigation Report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project and for which special provisions may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

It is understood that the existing 3.67 m diameter, single cell, Structural Plate Corrugated Steel Pipe (SPCSP) culvert at Atkinson Creek will be replaced with a new precast concrete box culvert having a 5 m span and a 3 m rise (inside dimensions). The thickness of the side wall and top/base slab of the precast concrete box culvert are proposed to be 350 mm and 300 mm, respectively. The invert at the inlet and outlet of the new culvert is proposed at Elevations 246.3 m and 246.2 m, respectively.

It understood that a temporary dewatering system and temporary bypass piping will be designed and installed by the contractor to accommodate the removal of the existing SPCSP culvert and installation of the new precast concrete box culvert. A temporary protection system will also be designed and installed by the contractor along the centreline of Highway 532 to permit removal of the existing SPCSP culvert and installation of the new precast concrete box culvert in stages while maintaining traffic on Highway 532 during construction.

6.2 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the 2014 *Canadian Highway Bridge Design Code* (CHBDC 2014) and its *Commentary*, the proposed culvert is expected to carry low traffic volumes, but its performance will have potential impacts on other transportation corridors, hence having a “typical consequence level” associated with exceeding limits states design. In addition, given the project-specific foundation investigation carried out at this site (as presented in Foundation Investigation Report (i.e., Part A)), in comparison to the degree of site understanding in Section 6.5 of *CHBDC (2014)*, the level of confidence for design is considered to be a “typical degree of site and prediction model understanding.” Accordingly, the appropriate corresponding ULS and SLS consequence factor, Ψ, and geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.1 and 6.2 of the *CHBDC* have been used for design.

6.3 Replacement Culvert

6.3.1 Factored Geotechnical Resistances

A precast concrete box culvert founded at approximately Elevation 245.9 m will be constructed as part of the replacement strategy at the Atkinson Creek site. It is not necessary to found the proposed precast box culvert at or below the standard depth for frost protection purposes (i.e., 2.0 m in this area), as these type of culverts are generally tolerant of small magnitudes of movement related to freeze-thaw cycles. The factored ultimate and serviceability geotechnical resistances for the precast box culvert founded on a 0.3 m thick bedding layer placed on the properly prepared subgrade (or on a concrete working slab or granular pad, for subgrade protection, as discussed further in Sections 6.3.3 and 6.6.5) are summarized in the table below. It is noted that approximately 800 mm of sub-excavation will be required, to about Elevation 244.8 m, at and near the outlet at the west end of the culvert, as discussed further below.

Culvert Size	Founding Soils	Factored Ultimate Geotechnical Resistance	Factored Serviceability Geotechnical Resistance for 25 mm of Settlement
5.7 m wide by 3.6 m high (outside dimensions)	■ East portion of culvert: 0.3 m of compacted Granular 'A' material over generally firm to very stiff clayey silt ■ West portion of culvert/culvert outlet: 0.3 m of compacted Granular 'A' material over 0.8 m of compacted Granular 'B' Type II material (1) over generally firm to very stiff clayey silt	200 kPa	90 kPa

Note:

1. This includes 0.8 m of sub-excavation (beyond the base of the 0.3 m thick granular bedding and down to approximately Elevation 244.8 m) of the very loose to loose organic silt and sand, trace rootlets, wood fragments, and organics encountered near the outlet of the culvert. If the material is not fully sub-excavated the geotechnical resistances will be lower than indicated above and the immediate settlement is expected to be relatively large. Furthermore, on-going decomposition of the organics will result in long-term settlement of the culvert in areas where the material is not fully removed and backfilled properly.

The factored ultimate resistance presented above is based on loading applied concentrically to the top surface slab of the culvert. Where the load is not applied concentrically to the top surface slab of the culvert, inclination of the load should be taken into account in accordance with Section 6.10.4 and Section C6.10.4 of the CHBDC (2014) and its *Commentary*.

6.3.2 Resistance to Lateral Loads / Sliding Resistance

Resistance to lateral forces/sliding resistance between the precast concrete box culvert and the granular bedding, as well as between the granular bedding and the native subgrade soils (or granular material where sub-excavation of the very loose to loose organic silt and sand deposit is required), shall be calculated in accordance with Section 6.10.5 of the *CHBDC* (2014). The unfactored coefficient of friction (tan δ) and effective cohesion (where applicable) between the various interface materials is summarized below.

Interface Materials	Unfactored Coefficient of Friction (tan δ)	Effective Cohesion, c'
Precast concrete box culvert on Granular 'A' material	0.55	0 kPa
Granular 'A' material on Granular 'B' Type II material	0.70	0 kPa
Granular 'A' or Granular 'B' Type II material on clayey silt	0.50 (long-term)	60 kPa (short-term)

6.3.3 Culvert Bedding, Cover and Backfill

Culvert construction, including placement of bedding, cover and backfill should be in accordance with the relevant Ontario Provincial Standards for Roads and Public Works as summarized below.

Culvert Replacement Option	Ontario Provincial Standard Drawing: Bedding, Cover and Backfill	Ontario Provincial Standard Specification: Culvert Construction
Concrete Precast Box Culvert	OPSD 803.010 – Backfill and Cover for Concrete Culverts [1]	OPSS 422 – Precast Reinforced Concrete Box Culverts

Note:
1. OPSD 803.010 is applicable to concrete culverts with spans less than 3 m. However, the proposed 5.0 m wide precast box culvert should be constructed in general accordance with this specification.

The culvert bedding should be minimum 300 mm thick and consist of OPSS.PROV 1010 (*Aggregates*) Granular 'A' material, placed and compacted in-the-dry. In addition, a minimum 75 mm thick uncompacted levelling layer consisting of OPSS.PROV 1010 Granular 'A' material or concrete fine aggregate meeting the graduation requirements specified in OPSS.PROV 1002 (*Aggregates – Concrete*) should be provided as shown on OPSD 803.010 (*Backfill and Cover for Concrete Culverts*) for culvert construction.

The culvert bedding should be placed on properly prepared subgrade whether comprised of native soil or sub-excavation backfill. However, taking into consideration that the bedding will likely be placed on native fine-grained soils (i.e., clayey silt), it is recommended that a non-woven geotextile be placed between the subgrade soils and the bottom of the bedding. The geotextile should meet the specification for OPSS 1860 (*Geotextiles*) Class II and have a Filtration Opening Size (FOS) not greater than 212 µm. If the subgrade is expected to be disturbed due to construction traffic and/or ponded water and the bedding cannot be placed in a timely manner, a concrete working slab or thicker layer of granular fill will be required on the subgrade as outlined in Section 6.6.5; in this case, a non-woven geotextile layer would not be required.

The bedding, cover and backfill should be placed in lifts not exceeding 200 mm in loose thickness, and compacted to at least 95% of the Standard Proctor maximum dry density of the material as specified in OPSS.PROV 501 (*Compacting*). Backfill should be placed concurrently on both sides of the culvert walls, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm as per OPSS 422 (*Precast Reinforced Concrete Box Culverts*).

The backfill behind the culvert walls should consist of granular fill meeting the specifications for OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II material. The granular backfill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*).

Any reconstruction of the highway embankments along and over the culvert should be carried out in accordance with OPSD 208.010 (*Benching of Earth Slopes*) to integrate the new fill with the existing embankment fill along the cut faces.

Inspection and field density testing should be carried out during all engineering fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

6.4 Lateral Earth Pressures

The lateral earth pressures acting on the walls of the new precast concrete box culvert will depend on the type and method of placement of the backfill material, the nature of the soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the culvert walls. These design recommendations and parameters assume level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II should be used as backfill behind the walls and on top of the culvert for a thickness not less than 300 mm. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*).
- Surcharge loadings should be accounted for in the design as required.
- For restrained structures, granular fill should be placed in a zone with the width equal to at least 2.0 m behind the back of the wall (in accordance with Figure C6.20(a) of the *Commentary* to the *CHBDC, 2014*). For unrestrained structures, fill should be placed within a wedge-shaped zone defined by a line drawn at 1 horizontal to 1 vertical (1H:1V) extending up and back from the rear face of a footing or bottom of a structure (in accordance with Figure C6.20(b) of the *Commentary* to the CHBDC, 2014). The lateral pressures should be based on the proposed embankment fill/backfill and existing soils/fill, as and where applicable, and the following parameters (unfactored) may be used:

Fill Type	Soil Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
New Granular 'A'	22 kN/m^3	0.43	0.27
New Granular 'B' Type II	21 kN/m^3	0.43	0.27
Generally Compact Sand to Gravelly Sand to Sand and Gravel (Fill)	22 kN/m^3	0.44	0.28
Dense Gravel (Fill)	21 kN/m^3	0.43	0.27
Very Loose to Loose Sandy Silt to Silt and Sand	19 kN/m^3	0.53	0.36

If the culvert design does not allow lateral yielding of the culvert walls (e.g., a rigid box culvert), at-rest earth pressures should be assumed for the geotechnical design. Where the design does allow lateral yielding of the walls (for example, for headwalls or wingwalls adjacent to the ends of the box culvert), active earth pressures should be used in the geotechnical design of the wall structure. The movement required to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure for design, should be calculated in accordance with Section C6.12.1 and Table C6.6 of the *Commentary* to the *CHBDC, 2014*.

6.5 Highway Embankment

It is understood that neither a grade raise nor a platform widening is required along Highway 532 as part of the Atkinson Creek culvert replacement construction. Based on the cross-sections of the Highway 532 embankment (provided by AECOM), the side slopes of the embankment immediately adjacent to the new culvert are planned to be inclined at 1.5 horizontal to 1 vertical (1.5H:1V) in order to achieve the following:

i) Limit the length of the culvert to no more than 30 m;

ii) Avoid construction of headwalls and wingwalls; and

iii) Avoid additional efforts and potential issues with acquiring/occupying additional right-of-way.

Beyond the limits of the new culvert (i.e., about 10 m north and 10 m south of the new culvert), the highway embankment side slopes are generally flatter, inclined between approximately 2.1H:1V and 2.9H:1V; however, in places, portions of the side slopes are as steep as 1.5H:1V.

6.5.1 Global Slope Stability

The following sections present the method used to evaluate static global stability of the highway embankment adjacent to the Atkinson Creek culvert (i.e., near Station 14+990) as well as 10 m north of the culvert (i.e., near Station 15+000), the geotechnical soil/fill parameters used in the analyses, and results of the stability analyses.

6.5.1.1 Method of Analysis

Limit equilibrium slope stability analyses were performed using the commercially available program Slide (Version 6.0), developed by Rocscience Inc., employing the Morgenstern-Price method of analysis. For all analyses, the Factors of Safety of numerous potential failure surfaces were computed in order to establish the minimum Factor of Safety. The Factor of Safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. For the purpose of the stability analysis, the Factor of Safety is equal to the inverse of the product of the consequence factor, Ψ, and the geotechnical resistance factor, ϕ_{gu}. (i.e., $FoS = 1/(\Psi \cdot \phi_{gu})$). Accordingly, minimum Factors of Safety of 1.3 and 1.5 have been used for the design of the highway embankment slopes for the short-term/temporary and long-term/permanent conditions, respectively, as per Table 6.2 of CHBDC (2014).

6.5.1.2 Parameter Selection

For the native granular soils encountered at this site, effective stress parameters were estimated from empirical correlations based on the results of the in-situ Standard Penetration Tests (SPT). The correlations proposed by Peck et al. (1974) and U.S. Navy (1986) were employed and the results were adjusted using engineering judgment based on precedent experience in similar soil conditions. For the granular fills, the results of the laboratory drained direct shear test (see Figure B2 in Appendix B), modified to account for potential material variability, were used to select the effective stress parameters used in the stability analysis.

For the cohesive clayey silt deposit encountered at the site, total stress parameters were employed in the stability analyses for the short-term, undrained conditions (i.e., temporary conditions). The total stress parameters (i.e., average mobilized undrained shear strength, s_u) for the cohesive soils were assessed based on the results of in-situ field vane shear tests.

Effective stress parameters were also employed to evaluate the stability of the highway embankment based on the long-term, drained conditions (i.e., permanent conditions). The effective stress parameters (i.e., effective friction angle (ϕ') and effective cohesion (c')) for the cohesive deposit were estimated from empirical correlations based on the plasticity index. The correlations proposed by Mitchell (1993), Kulhawy and Mayne (1990), and Ladd et al. (1977) were employed and the results were adjusted using engineering judgment based on precedent experience in similar soil conditions.

The simplified stratigraphy together with the geotechnical parameters employed for the different soils types and fills encountered at the site, as well as new fills required to backfill the culvert, are summarized below.

Fill / Soil Type	Top Elevation	Thickness	Bulk Unit Weight, γ	Effective Friction Angle, ϕ'	Undrained Shear Strength, s_u
New Granular 'A' or Granular 'B' Type II	Hwy 532: 251.5 m	Hwy 532: 5.5 m	21 kN/m^3	36°	--
Sand to Gravelly Sand (Fill)	Hwy 532: 251.5 m West: 247.8 m	Hwy 532: 3.6 m West: 1.2 m	22 kN/m^3	34°	--
Gravel (Fill)	Hwy 532: ~ 247.9 m	~ 1.2 m	21 kN/m^3	36°	--
Sand and Gravel (Fill)	Hwy 532: ~ 246.7 m	~ 0.7 m	22 kN/m^3	34°	--
Sandy Silt to Silt and Sand	East: 248.0 m West: 246.6 m	East: 2.2 m West: 1.9 m	19 kN/m^3	28°	--
Clayey Silt	246.0 m to 244.8 m	7.1 m to 9.2 m	18 kN/m^3	28°	60 kPa
Silt	237.8 m to 236.8 m	> 1.1 m	18 kN/m^3	32°	--

For the purpose of the stability analyses, the groundwater level was assumed to be at the creek surface (i.e., at Elevation 247.0 m, as surveyed in June 2017).

6.5.2 Results of Analysis

The slope stability analyses of the highway embankment at the location of the new precast concrete box culvert are based on the assumption that the very loose to loose silt and sand to organic silt and sand deposit (or any other unsuitable soils) will be fully sub-excavated from the footprint of the new culvert and immediately next to culvert, and replaced with OPSS.PROV 1010 Granular 'A' or Granular 'B' Type II material compacted in accordance with OPSS.PROV 501 (*Compacting*). The stability analyses indicate that the 1.5H:1V side slopes of the highway embankment adjacent to the new culvert will have a Factor of Safety of 1.3 during the short-term/temporary and long-term/permanent conditions for deep-seated, global failure surfaces of the slopes that would impact the operation of the highway (refer to Figures 1 and 2). The Factors of Safety associated with both the temporary/short-term and permanent/long-term conditions are the same given that the potential failure surfaces associated with the minimum Factors of Safety are confined within the embankment fill and do not extend into the underlying clayey silt deposit.

In order to satisfy a minimum Factor of Safety equal to or greater than 1.5 for the long-term/permanent, it is recommended that the embankment side slopes should be covered (or blanketed) with a minimum 1.0 m thick layer (measured perpendicular to the face of the slope) of R-50 rip-rap (refer to Figure 3) in accordance with OPSS.PROV 1004 (*Aggregates – Miscellaneous*). The rip-rap particles should be angular (i.e., not rounded or sub-rounded) to offer an adequate Factor of Safety against surficial slope instability. In addition, it is recommended that a non-woven geotextile separator, satisfying the requirement of OPSS 1860 (*Geotextiles*), be placed along the side slopes between the rip-rap and the granular fill to prevent migration of fines into the rip-rap.

6.6 Construction Considerations

This section identifies key construction considerations that may impact the design and construction of the new precast concrete box culvert.

6.6.1 Temporary Open-Cut Excavations

It is expected that temporary excavations will generally extend down to approximately Elevation 245.9 m in order to facilitate removal of the existing SPCSP culvert and installation of a new precast concrete box culvert, including placement of granular bedding for the new culvert. However, where encountered, the very loose to loose silt and sand and organic silt and sand deposit must be excavated down to Elevation 244.8 m (based on Borehole ACC2-01 advanced near the outlet of the existing culvert) or deeper, where required. As such, the temporary excavation will extend through the existing highway embankment fill as well as deposits of sandy silt, to silt and sand, to organic silt and sand.

The founding subgrade should be inspected to ensure that any organic soils or other unsuitable materials have been removed in accordance with OPSS 422 (*Precast Reinforced Concrete Box Culverts*). Any sub-excavated areas should be backfilled with OPSS.PROV 1010 (*Aggregates*) Granular ‘B’ Type II material, and placed and compacted in accordance with OPSS.PROV 501 (*Compacting*).

All excavations must be carried out in accordance with Ontario Regulation 213 (*Ontario Occupation Health and Safety Act for Construction Projects*), as amended, and OPSS 902 (*Excavating and Backfilling – Structures*).

The existing embankment fill (assuming it is above the groundwater/perched water level) is classified as a Type 3 soil according to OHSA. The soils below the groundwater table/creek water level (i.e., bottom portion of the embankment fill – sand and gravel to gravel) and the deposits of sandy silt to silt and sand to organic silt and sand are classified as Type 4 soils; however, if dewatered, the majority of the fills can be classified as Type 3 soils, with the exception of the very loose to loose granular soils which would remain classified as Type 4 soils. Temporary excavations in Type 3 soils should be made with side slopes no steeper than 1H:1V. Temporary excavations in Type 4 soils should be made with side slopes no steeper than 3H:1V.

Cobbles were encountered within the lower portion the embankment fill. Consequently, construction equipment must be capable of excavating through these obstructions.

All temporary excavations should be observed by a qualified geotechnical engineer and reviewed during construction to confirm that the soil and groundwater conditions encountered are as anticipated in this document.

6.6.2 Temporary Cofferdams and Protection Systems

Temporary cofferdams near the inlet and outlet of the culvert and a temporary protection system along the centreline of Highway 532 in the vicinity of Atkinson Creek will be required to support the installation/construction of the new culvert and maintain traffic along the highway during excavation/construction operations, respectively.

Since the depth of water in the creek near the inlet and outlet of the culvert is relatively shallow (i.e., up to about 0.8 m, as measured by the design team surveyor in June 2017), it may be possible to construct the temporary cofferdams and divert the creek water using one of the following methods:

- Small inflatable bladder cofferdams;
- Water dams consisting of industrial grade, impermeable, composite fabrics formed into flexible tubes containing one or more chambers; or
- Multiple rows of large sand bags ("super-bags" or "bulk-bags") lined with an impermeable barrier.

Given the relatively constrained access to the site, the use of smaller, more modular or inflatable cofferdams may be preferred as these systems can be maneuvered by small equipment and/or by hand. However, the viability and effectiveness of such systems will depend on the creek water level at the time of construction as well as the available space between where the diversion structure(s)/temporary cofferdams will be located relative to the excavation for the new culvert. As noted in Section 6.6.1, the soils below the creek bed are considered Type 4 soils and as such, temporary unsupported excavations will have to be made with side slopes no steeper than 3H:1V. The spacing required to accommodate this slope, relative to the restrictions imposed by the right-of-way, will need to be considered when determining if an unsupported excavation using one of the above methods is practical or not.

If water levels in the creek are high, if the working area is restricted and/or if deeper sub-excavation is required to remove weak/softened soils (as encountered near the outlet of the existing culvert) before bedding placement, it may be necessary to install a proper groundwater cut-off system (e.g., an interlocking steel sheet piles) to avoid excavation instability, a "boiling" or "quick" condition that would loosen/soften any of the soils and/or cause disturbance of the foundation subgrade within the footprint of the excavation area. If required, a more robust/watertight cofferdam system for this site would consist of steel sheet piles driven to a suitable depth.

For the temporary protection system, consideration could be given to driven steel sheet piles or a soldier pile and lagging system whereby more rigid steel H-piles would be driven to a suitable depth and horizontal timber lagging installed between the H-piles as the excavation proceeds to retain the embankment fill. The latter system assumes that groundwater is not perched in the highway embankment fill and that the lower portion of the existing fill (i.e., below the creek water level) could be adequately retained and seepage would not be excessive, although this may not be the case given the presence of highly pervious fill (i.e., sand and gravel to gravel). Otherwise, mitigation measures would be required behind the lagging boards to address water seepage/inflow into the excavation that could otherwise cause migration of fine-grained soil particles through the lagging boards and result in potential subsidence of the highway surface).

The temporary cofferdams and protection systems at this site should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems)*. The temporary protection systems extending through the highway embankment should be designed in accordance with Performance Level 2. The lateral movement of the temporary cofferdam system should include an evaluation of base stability, soil squeezing stability and hydraulic uplift as defined in the *Canadian Foundation Engineering Manual* (CFEM, 2006). The contractor is responsible for the design and construction of all temporary cofferdams and protection systems.

For conceptual purposes, to aid the designer in assessing the approximate construction cost of protection systems for this site, the temporary cofferdams and protection systems may be designed using the parameters listed below.

Fill / Soil Type	Bulk Unit Weight, γ	Internal Angle of Friction, ϕ'	Undrained Shear Strength, s_u	Lateral Earth Pressure Coefficients [1]		
				K_p (Passive) [2]	K_o (At-Rest)	K_a (Active)
Sand to Gravelly Sand (Fill)	22 kN/m^3	34°	--	3.54	0.44	0.28
Gravel (Fill)	21 kN/m^3	36°	--	3.85	0.41	0.26
Sand and Gravel (Fill)	22 kN/m^3	34°	--	3.54	0.44	0.28
Sandy Silt to Silt and Sand	19 kN/m^3	28°	--	2.77	0.53	0.36
Clayey Silt	18 kN/m^3	28°	60 kPa [3]	2.77	0.53	0.36
Silt	18 kN/m^3	32°	--	3.25	0.47	0.31

Notes:

1. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients should be corrected accordingly.
2. The total passive resistance below the base of the excavation (i.e., within the sheet pile cofferdam or temporary protection system enclosure) may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.16 of the Canadian Highway Bridge Design Code (CHBDC, 2014) to account for the fact that a large strain would be required for mobilization of the full passive resistance.
3. For cohesive deposits, an assessment for both the drained (ϕ') and undrained (s_u) cases should be made to establish the more conservative earth pressure condition for design.

The installation of sheet piles for temporary cofferdams and roadway protection systems may be impeded by the presence of cobbles within the lower portion of the highway embankment. Given the presence of these obstructions, consideration should be given to protecting the tips of the sheet piles and/or the use of heavier sheet pile sections, assuming a sheet pile system is selected.

6.6.3 Control of Groundwater and Surface Water

The temporary excavations will extend through the lower portion of the existing granular embankment fill and the silt and sand to organic silt and sand deposit below the creek level. As such, some form of groundwater control will be required to allow for construction to be carried out in “dry” conditions.

The method and extent of groundwater control required will ultimately depend on the type of temporary cofferdams and protection systems selected by the contractor (described in Section 6.6.2). If temporary shoring is comprised of sheet pile cut-off walls, the requirements for groundwater control will be lessened. However, if temporary shoring is comprised of soldier pile and timber lagging (through the roadway embankment) and inflatable bladders, flexible tubes or sand bags (for cofferdams around the culvert inlet and outlet), the requirements for groundwater control could be more extensive. The contractor is responsible for the design and installation of all groundwater control measures giving due consideration to the type of temporary shoring selected as well as the requirements for maintaining the stability/integrity of the culvert foundation subgrade and for construction of the culvert and bedding in-the-dry. To address dewatering for this site, groundwater control measures should be carried out in accordance with OPSS.PROV 517 (*Dewatering*), as modified by the Non-Standard Special Provision FOUND0003

(*Dewatering of Structure Excavation*). A copy of the Non-Standard Special Provision FOUND0003 is provided in Appendix D. If construction water pumping volumes are anticipated to exceed 50 m^3/day, an Environmental Activity Section Registry (EASR) will be required as per the changes to the Environmental Protection Act by the Ontario Ministry of Environment and Climate Change (MOECC).

Surface water should be directed away from the excavation area(s) to prevent ponding of water that could result in disturbance and loosening/softening of the foundation subgrade

6.6.4 Obstructions

As described in Section 4.2.2, cobbles were encountered within the lower portion of the existing embankment fill. Consequently, construction equipment including equipment/tools used to install temporary cofferdam and protection systems should be capable of excavating through such obstructions. It is recommended that a Notice to Contractor be included in the contract documents to address obstructions (refer to Appendix D).

6.6.5 Subgrade Protection

The overburden soils exposed at the founding level, especially the clayey silt with a significant silt content, will be susceptible to disturbance from construction traffic and/or ponded water. To limit the effect of this disturbance, it is recommended that a concrete working slab be placed on the subgrade if the precast concrete box culvert and associated bedding cannot be placed within four hours after preparation, inspection and approval of the subgrade. The minimum thickness of the concrete working slab should be 100 mm and the concrete should have a 28-day compressive strength of not less than 20 MPa. A Non-Standard Special Provision to address this requirement is included in Appendix D.

As an alternative to construction of a concrete working slab, which could impact/extend the construction schedule, consideration can be given to constructing a minimum 0.6 m thick granular pad below the base of the precast concrete box culvert. In places, as a result of subexcavation of the very loose to loose silt and sand and organic silt and sand deposit encountered near the outlet of the existing culvert, the thickness of the granular fill will be greater than 0.6 m (refer to Section 6.6.1). However, in order to reduce dewatering and temporary shoring requirements, the bottom portion of the granular pad (i.e., below the minimum 0.6 m thickness) could be constructed in wet conditions by end-dumping Granular 'B' Type II material with no or nominal compactive effort, up to the final lift below the bedding. The upper 0.3 m of the granular pad (i.e., the bedding) should consist of Granular 'A' material as outlined in Section 6.3.3. The earth excavation for the granular pad and construction of the granular pad in wet conditions should be carried out simultaneously. A Non-Standard Special Provision to address the earth excavation and construction of the uncompacted portion of the granular pad in wet conditions is included in Appendix D.

6.6.6 Frost Tapers

Frost tapers, if required, should be constructed in general accordance with OPSD 803.010 (*Backfill and Cover for Concrete Culverts*) for the new precast concrete box culvert. Given that the embankment fill in the immediate proximity of the culvert is generally comprised of material with a low degree of frost susceptibility (i.e., sand, trace to some fines to gravelly sand to sand and gravel), and given that Highway 532 is a secondary highway, it is understood that frost tapers may not be required.

6.6.7 Erosion Protection

Provisions should be made for scour and erosion protection at the culvert location. In order to prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring, although the risk may not be very high given the predominantly cohesive founding soils), or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles, and potentially settlement of the overlying roadway surface), a clay seal or concrete cut-off wall should be provided at the upstream end of the culvert. If a clay seal is adopted, the clay material should meet the requirements of OPSS.PROV 1205 (*Clay Seal*), and the seal should be a minimum 1 m thick if constructed of natural clay or soil-bentonite mix and extend from a depth of 1 m below the scour level, to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and to a minimum vertical height equivalent to the high water level, including along the embankment slope. Alternatively, a 0.6 m thick clay blanket (if constructed of natural clay or a soil-bentonite mix) may be constructed, extending upstream three times the culvert height and along the adjacent slopes to a height corresponding to the high water level. A cut-off wall instead of clay seal can also be considered. Ultimately, the requirements for scour mitigation measures at the culvert inlet should be assessed by the hydraulics design engineer.

The requirements for and design of erosion protection measures for the inlet and outlet of the culverts should also be assessed by the hydraulics design engineer. As a minimum, rip-rap treatment for the outlet of the culvert should be consistent with the standard presented in OPSD 810.010 (*Rip-Rap Treatment for Sewer and Culvert Outlets*). Erosion protection for the inlet of the culvert should generally follow the standard presented in OPSD 810.010, with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, rip-rap should be provided over the full extent of the clay blanket, including the creek side slopes and fill slope over the culvert.

In order to reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection must be in accordance with OPSS.PROV 804 (*Seed and Cover*).

6.6.8 Analytical Testing of Construction Materials

The results of analytical tests carried out on a sample of the silt and sand deposit recovered from Borehole ACC2-03 (advanced near the inlet of the culvert) are presented in Section 4.4 and on the Certificates of Analysis in Appendix C.

The analytical test results of the soil sample were compared to Table 7.1 (Relative Effect of Resistivity on Corrosion Potential/Aggressiveness (from NCHRP 1978)), as presented in the Federal Highway Administration/National Highway Institute Publication No. FHWA-NHI-14-007 (Federal Highway Administration, 2015), to assess the relative level of corrosion potential on buried steel in contact with soil. The resistivity value measured on the soil sample is 4,100 ohm·cm. These results indicate “moderately corrosive” soils (i.e., resistivity between 2,000 ohm·cm and 5,000 ohm·cm).

Given that the existing culvert will be replaced with a new precast concrete box culvert, the analytical test results were also compared to CSA A23.1 Table 3 (*Additional requirements for concrete subjected to sulphate attack*) to assess the potential severity of sulphate attack on concrete during its service life. The sulphate concentration measured on the soil samples was about 0.0022%, which is below the moderate degree of exposure (i.e., below the class S-3 exposure limits). Based on the one soil sample tested, the effects of sulphates from the silt and sand deposit in contact with the concrete structure may not need to be considered. However, if the proposed structure is expected to be exposed to de-icing salt or other solutions, consideration should be given by the designer to designing the concrete structure for a “C” type exposure class as defined by CSA A23.1 Table 1.

It is also noted that the measured pH level was about 5.1, suggesting that the native soils are acidic (i.e., pH less than 7).

Ultimately, it is the designer’s decision to determine the appropriate exposure class and to ensure that all aspects of CSA A23.1 Section 4.1.1 (*Durability Requirements*) are satisfied.

7.0 CLOSURE

The Foundation Design Report was prepared by Mr. Tomasz Zalucki, P.Eng., a geotechnical engineer with Golder. Ms. Lisa C. Coyne, P.Eng., a MTO Foundations Designated Contact and Principal of Golder, conducted an independent technical and quality control review of the report.

Report Signature Page

GOLDER ASSOCIATES LTD.

Tomasz Zalucki, P.Eng.
Geotechnical Engineer

Lisa C. Coyne, P.Eng.
MTO Foundations Designated Contact, Principal

TZ/JPD/LCC/tz

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CAN/CSA A23.1-14	Concrete Materials and Methods of Concrete Construction

Commercial Software:

Slide (Version 6.0) by Rocscience Inc.

Ontario Occupational Health and Safety Act:

Ontario Regulation 213 Construction Projects (as amended)

Ontario Provincial Standard Specifications (OPSS), Construction:

OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cut
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling – Structures

Ontario Provincial Standard Specifications (OPSS), Materials:

OPSS.PROV 1002	Material Specification for Aggregates – Concrete
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS.PROV 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1205	Material Specification for Clay Seal
OPSS 1860	Material Specification for Geotextiles

Ontario Provincial Standard Drawings (OPSD):

OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m
OPSD 810.010	General Rip-Rap Treatment for Sewer and Culvert Outlets

Ontario Regulations:

R.R.O 1990, Regulation 903	Wells, under Ontario Water Resources Act, R.S.O. 1990, c. O.40

DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

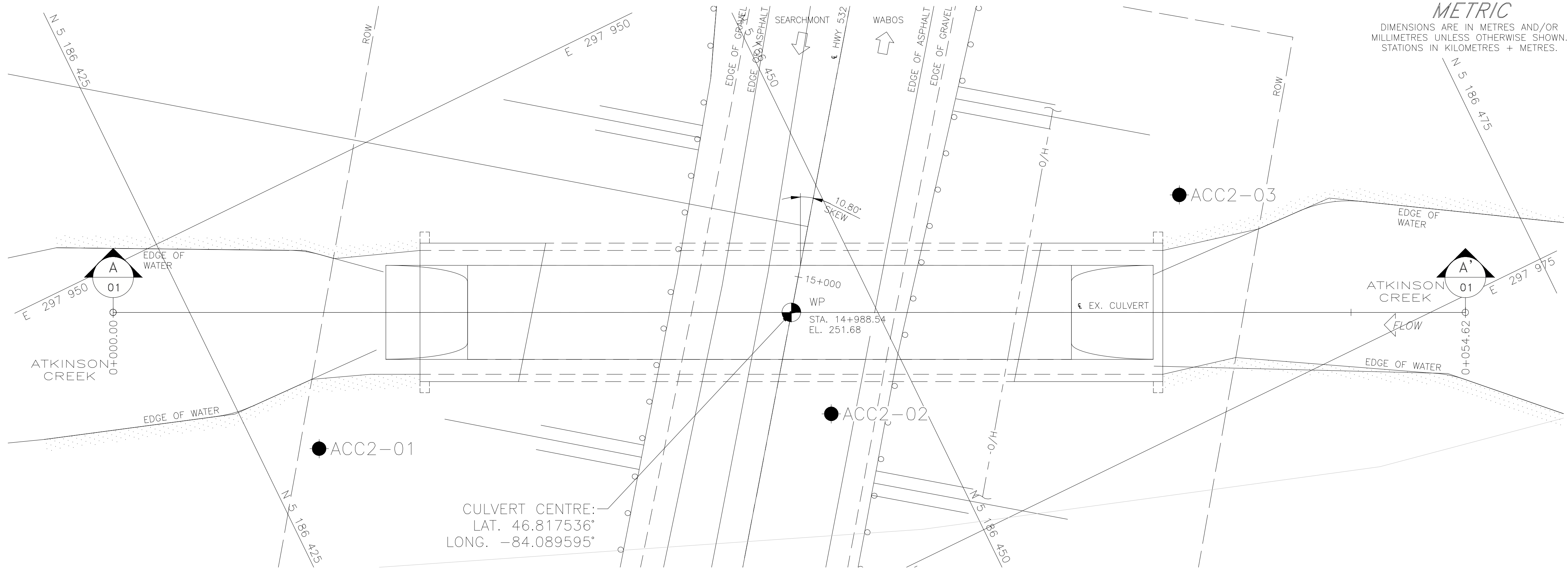
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5261-13-02

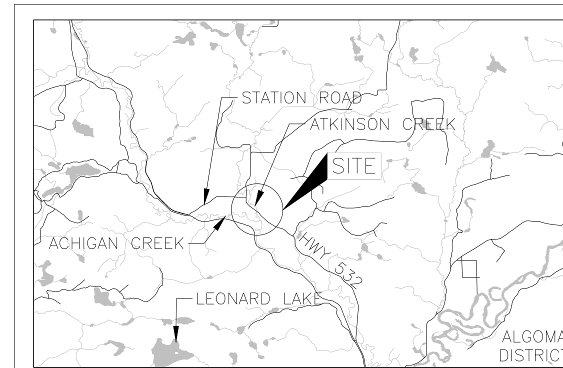
HIGHWAY 532
ATKINSON CREEK CULVERT NO. 1
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

GOLDER



PLAN

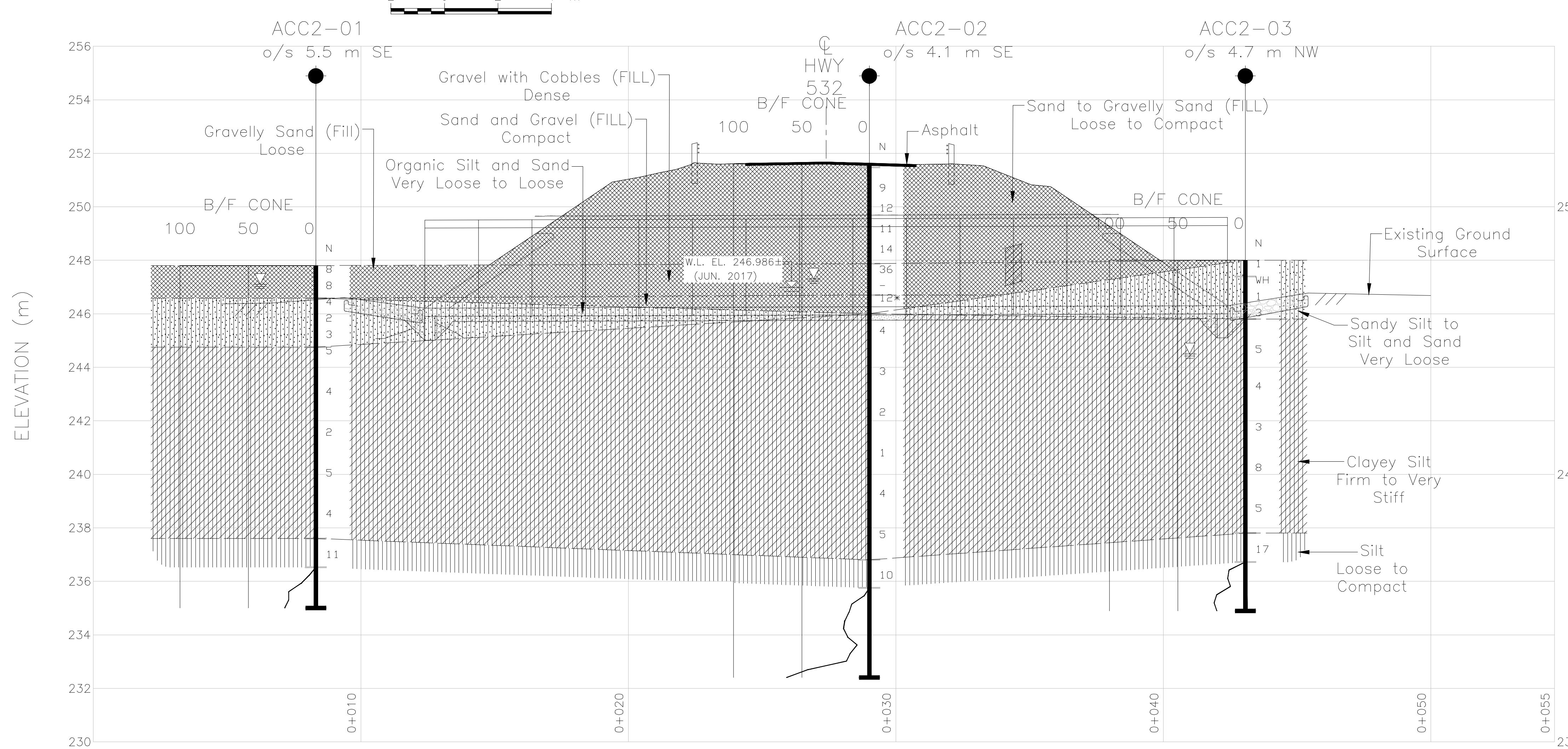


KEY PLAN
SCALE
2 0 2 4 km

LEGEND

●	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 13)			
No.	ELEVATION	NORTHING	EASTING
ACC2-01	247.8	5186427.3	297960.3
ACC2-02	251.6	5186446.5	297968.1
ACC2-03	248.0	5186463.0	297966.3



SCALE 1:100 m A-A 01 CULVERT PROFILE

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by AECOM, drawing file no. "60546679-P60.dwg", received June 7, 2018.

NO.	DATE	BY	REVISION

Geocres No. 41K-110

HWY. 532	PROJECT NO. 1670846		DIST. ALGOMA
SUBM'D. AK	CHKD. TZ	DATE: 11/8/2018	SITE: 38S-290C
DRAWN: SMD	CHKD. LCC	APPD. LCC	DWG. 01

LICENSED PROFESSIONAL ENGINEER T. ZALUCKI 100128614 Nov. 09, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Nov. 09, 2018 PROVINCE OF ONTARIO

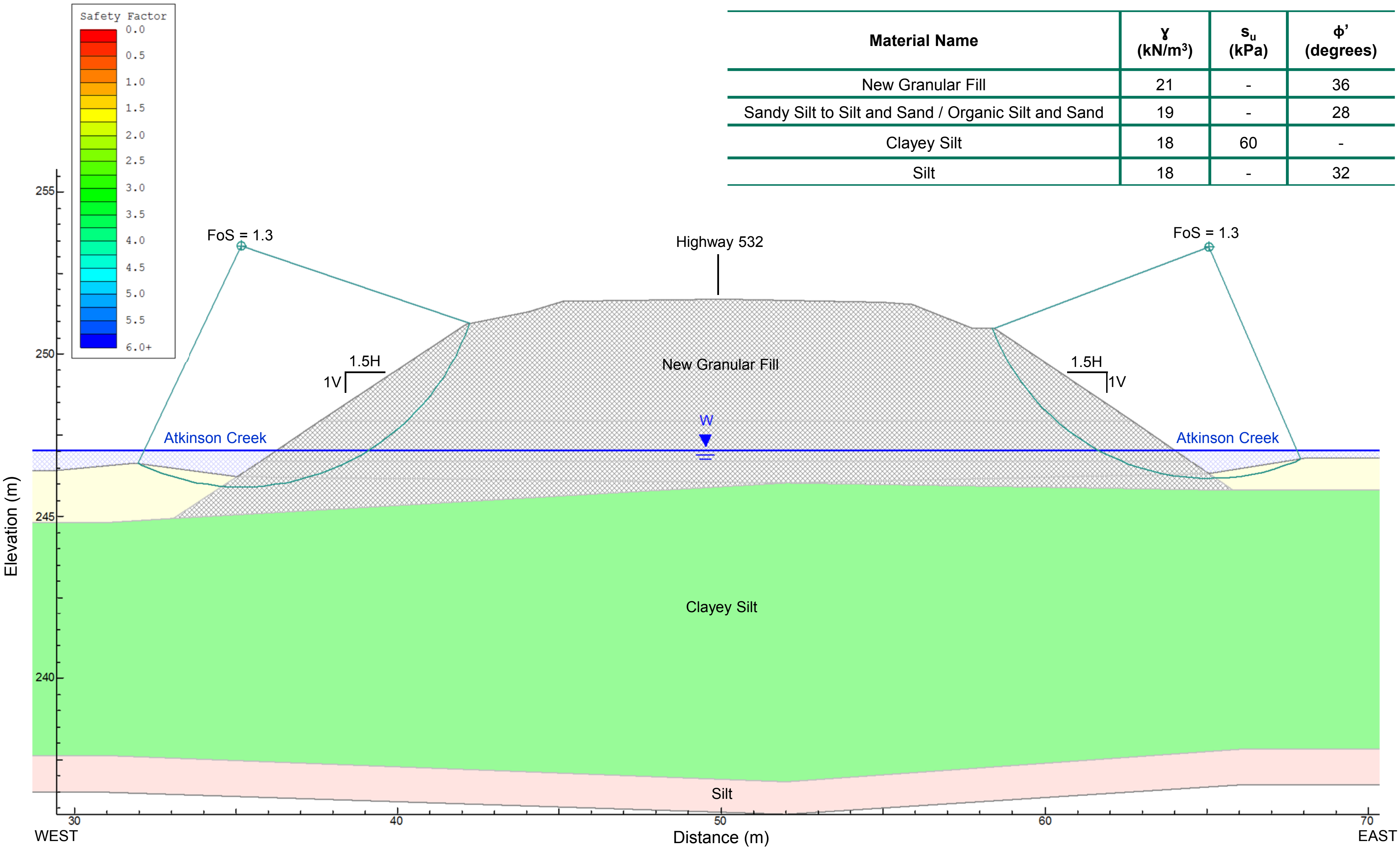
PLOT DATE: November 8, 2018

FIGURES

Highway 532 – Atkinson Creek Culvert No. 1 Replacement
Global Slope Stability (Temporary/Short-Term Condition)
Highway Embankment at Station 14+990

Figure 1

Material Name	γ (kN/m³)	s_u (kPa)	φ' (degrees)
New Granular Fill	21	-	36
Sandy Silt to Silt and Sand / Organic Silt and Sand	19	-	28
Clayey Silt	18	60	-
Silt	18	-	32



Date: November 9, 2018
Project No: 1670846

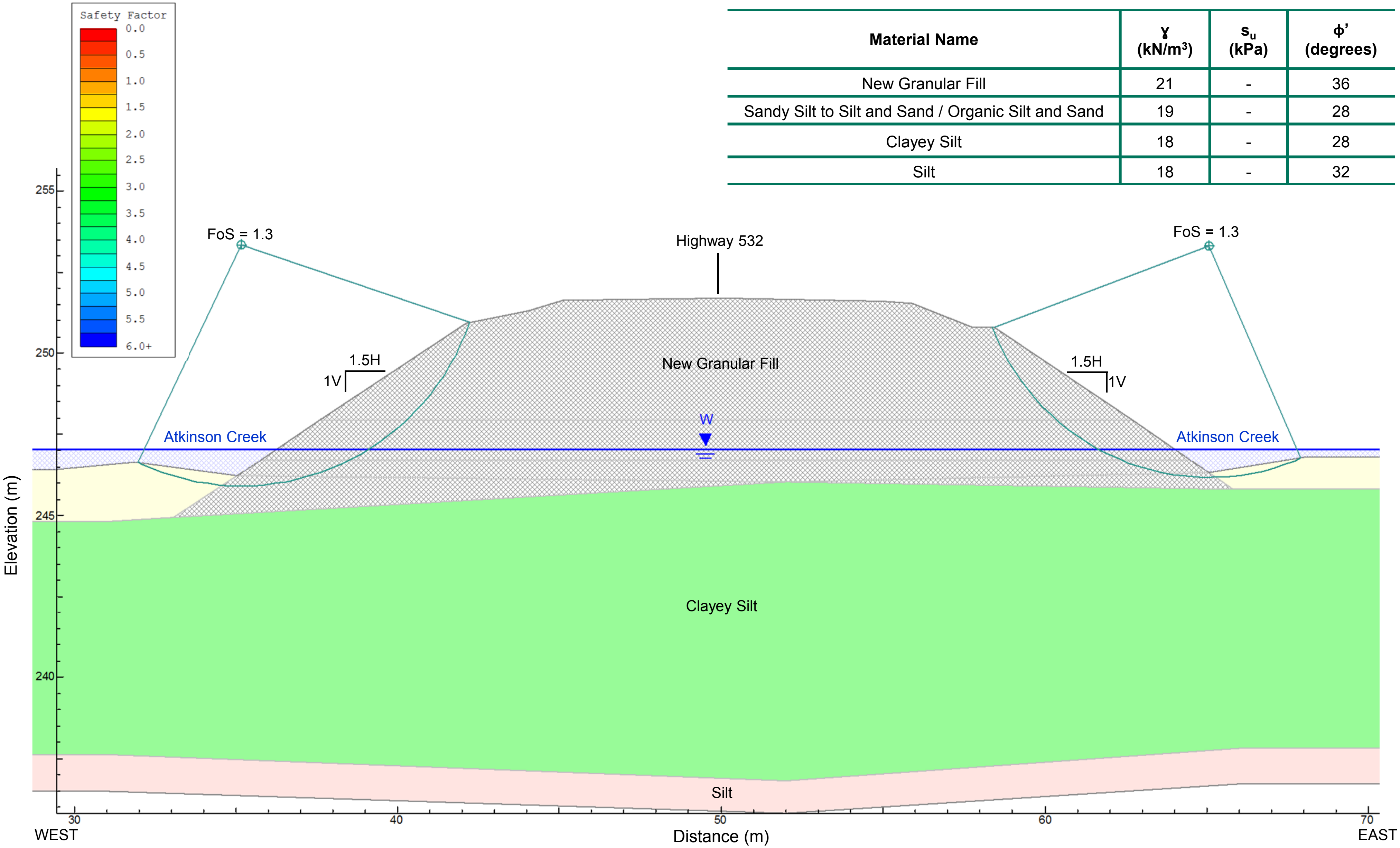
Analysis By: TZ **Reviewed By:** LCC

Golder Associates

Highway 532 – Atkinson Creek Culvert No. 1 Replacement
Global Slope Stability (Permanent/Long-Term Condition)
Highway Embankment at Station 14+990

Figure 2

Material Name	γ (kN/m³)	s_u (kPa)	ϕ' (degrees)
New Granular Fill	21	-	36
Sandy Silt to Silt and Sand / Organic Silt and Sand	19	-	28
Clayey Silt	18	-	28
Silt	18	-	32



Date: November 9, 2018

Project No: 1670846

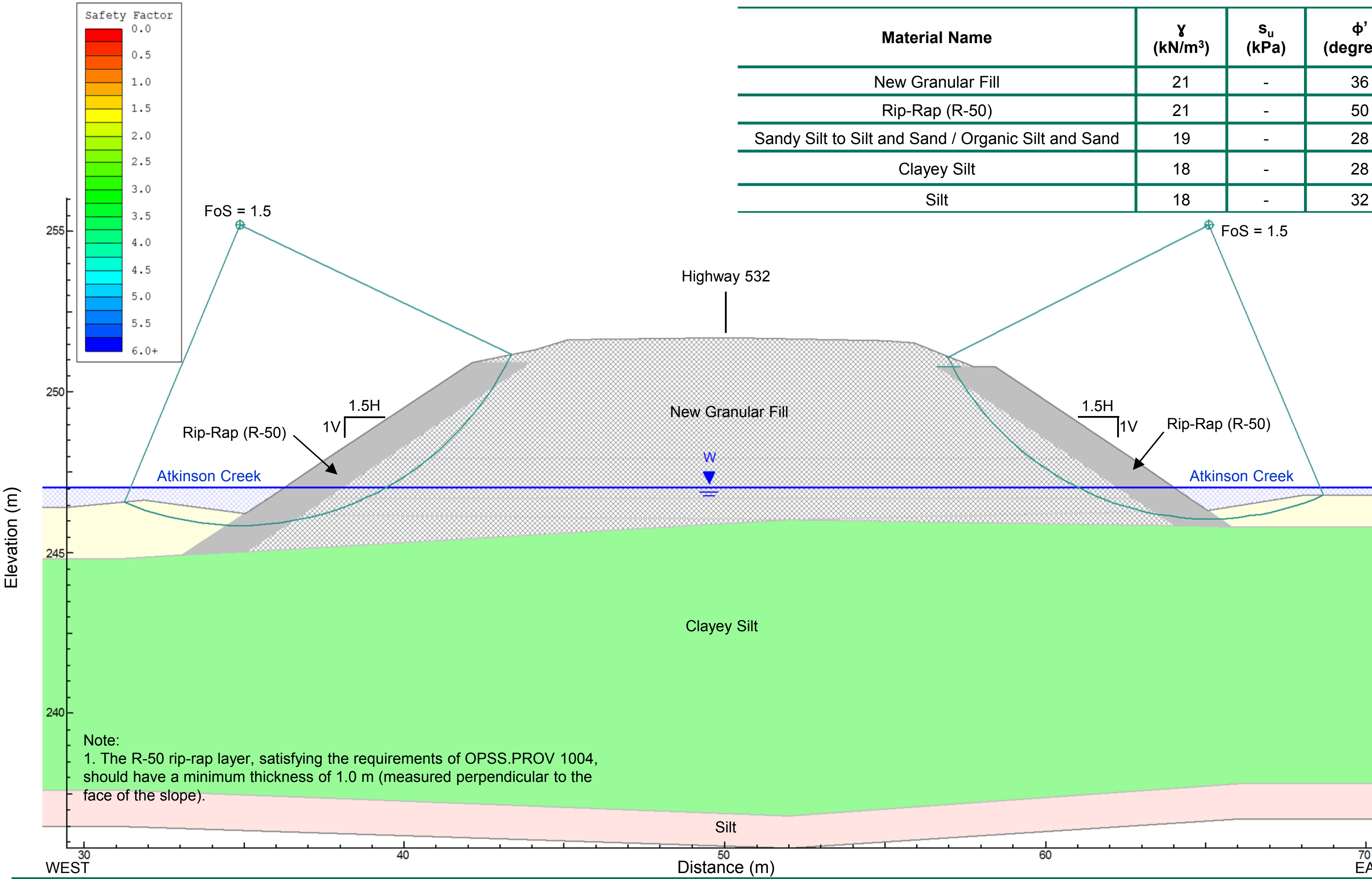
Analysis By: TZ **Reviewed By:** LCC

Golder Associates

Highway 532 – Atkinson Creek Culvert No. 1 Replacement
Global Slope Stability (Permanent/Long-Term Condition)
Highway Embankment at Station 14+990 (with Rip-Rap Slope Protection)

Figure 3

Material Name	ɣ (kN/m³)	s_u (kPa)	ϕ' (degrees)
New Granular Fill	21	-	36
Rip-Rap (R-50)	21	-	50
Sandy Silt to Silt and Sand / Organic Silt and Sand	19	-	28
Clayey Silt	18	-	28
Silt	18	-	32



Note:
1. The R-50 rip-rap layer, satisfying the requirements of OPSS.PROV 1004, should have a minimum thickness of 1.0 m (measured perpendicular to the face of the slope).

Date: November 9, 2018

Project No: 1670846

Analysis By: TZ **Reviewed By:** LCC

Golder Associates

APPENDIX A

Borehole Records

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
FoS	factor of safety

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. 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.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; 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, 60º 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

Piezo-Cone Penetration Test (CPT)

A 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 (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
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, G_s)
DS	direct shear test
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	field vane (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

GOLDER

RECORD OF BOREHOLE No ACC2-01

SHEET 1 OF 2

METRIC

PROJECT 1670846

W.P. 5261-13-03

LOCATION N 5186427.3; E 297960.3 MTM NAD 83 ZONE 13 (LAT. 46.817360; LONG. -84.089639)

ORIGINATED BY KN

DIST ALGOMA HWY 556

BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing

COMPILED BY SE

DATUM Geodetic

DATE September 6, 2017

CHECKED BY TZ

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Soil Profile

ELEV / DEPTH	DESCRIPTION
247.8	GROUND SURFACE
0.0	Gravelly sand, some silt, trace clay (FILL) Loose Brown Moist
246.6 / 1.2	ORGANIC SILT and SAND, trace clay, trace rootlets, wood fragments and organics Very loose to loose Brown Moist to wet
244.8 / 3.1	CLAYEY SILT, trace to some sand Firm to very stiff Grey Wet - Unable to turn a vane at a depth of about 5.2 m
237.6 / 10.2	SILT, trace to some sand Compact Grey Wet
236.5 / 11.3	END OF BOREHOLE Dynamic Core Penetration Test (DCPT)
235.0 / 12.8	END OF DCPT

NOTES:

1. Borehole ACC2-01 was advanced near the outlet of the existing Atkinson Creek Culvert (West side of Highway 532).

Samples

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT / REMARKS	GR	SA	SI	CL
1	SS	8		24	56	19	1
2	SS	8					
3	SS	4					
4	SS	2		0	52	45	3
5	SS	3	OC=5.8%				
6	SS	5					
7	SS	4					
8	SS	2		0	7	77	16
9	SS	5					
10	SS	4		0	4	87	9
11	SS	11					

Elevation scale: 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236, 235

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No ACC2-01 SHEET 2 OF 2 METRIC

PROJECT 1670846			
W.P. 5261-13-03	LOCATION N 5186427.3; E 297960.3 MTM NAD 83 ZONE 13 (LAT. 46.817360; LONG. -84.089639)	ORIGINATED BY KN
DIST ALGOMA HWY 556	BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing	COMPILED BY SE
DATUM Geodetic	DATE September 6, 2017	CHECKED BY TZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	2. Borehole caved to a depth of about 7.9 m below existing ground surface (Elev. 239.9 m) upon removal of casing. 3. Water level measured at a depth of about 0.7 m below exisitng ground surface (Elev. 247.1 m) upon removal of casing.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No ACC2-02 SHEET 1 OF 2 METRIC

PROJECT 1670846
W.P. 5261-13-03
LOCATION N 5186446.5; E 297968.1 MTM NAD 83 ZONE 13 (LAT. 46.817533; LONG. -84.089537)
ORIGINATED BY AJ
DIST ALGOMA HWY 556
BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; NQ Coring
COMPILED BY AK
DATUM Geodetic
DATE September 8, 2018
CHECKED BY TZ

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
251.6	GROUND SURFACE
0.0	ASPHALT (130 mm)
0.1	Sand, trace to some gravel, trace to some silt to gravelly sand, trace to some silt (FILL) Loose to compact Brown Moist
247.9 / 3.7	Gravel, trace to some sand, with cobbles and rock fragments (FILL) Dense Grey, black and red Wet
246.7 / 4.9	Sand and gravel (FILL) Compact Grey, black and red Wet
246.0 / 5.6	CLAYEY SILT, trace to some sand Stiff to very stiff Grey Wet
236.8 / 14.8	

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES	Shear strength (field vane, kPa)	Water content	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	9			
2	SS	12		○	
3	SS	11		○	10 81 9 0
4	SS	14			
5	SS	36		○	
-	RC	-			
6	SS	12*			
7	SS	4		H ○	0 6 87 7
8	SS	3		○	
			>96 (+)		
9	SS	2		H ○	
			11 (+)		
10	SS	1			
			>96 (+)		
11	SS	4		H ○	0 13 80 7
			>96 (+)		
12	SS	5			

Ground water level symbol (▽) at approx. elev. 247.4.

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (251 to 237); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No ACC2-02

SHEET 2 OF 2 **METRIC**

PROJECT 1670846

W.P. 5261-13-03

LOCATION N 5186446.5; E 297968.1 MTM NAD 83 ZONE 13 (LAT. 46.817533; LONG. -84.089537)

ORIGINATED BY AJ

DIST ALGOMA HWY 556

BOREHOLE TYPE 210 mm O.D. Hollow Stem Augers; NQ Coring

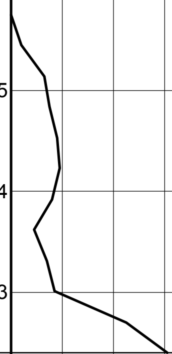
COMPILED BY AK

DATUM Geodetic

DATE September 8, 2018

CHECKED BY TZ

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
235.8	SILT, trace to some sand Loose to compact Grey Wet		13	SS	10		236		○		
15.9	END OF BOREHOLE Dynamic Core Penetration Test (DCPT)						235 234 233				
232.4 19.2	END OF DCPT										



Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60)

NOTES:

1. Borehole ACC2-02 was advanced on the northbound lane of Highway 532 to the south of the existing Atkinson Creek Culvert.

2. Water level measured at a depth of about 4.3 m below existing ground surface (Elev. 247.3 m) inside the augers upon completion of drilling.

3. Borehole caved to a depth of about 2.7 m below existing ground surface (Elev. 248.9 m) upon removal of augers.

* The SPT 'N'-value is likely unrepresentative of the material's state of compactness as a result of coring immediately above the split-spoon sample.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

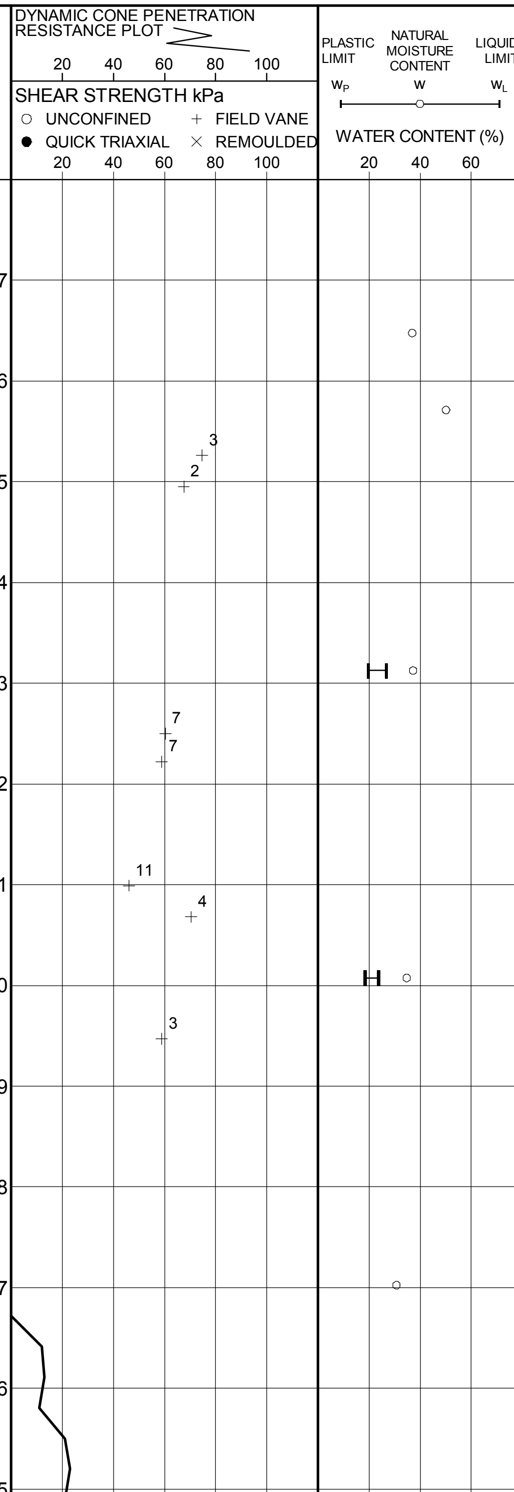
GOLDER

RECORD OF BOREHOLE No ACC2-03 SHEET 1 OF 2 METRIC

PROJECT 1670846
W.P. 5261-13-03
LOCATION N 5186463.0; E 297966.3 MTM NAD 83 ZONE 13 (LAT. 46.817681; LONG. -84.089561)
ORIGINATED BY KN
DIST ALGOMA HWY 556
BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing
COMPILED BY AK
DATUM Geodetic
DATE September 6, 2017
CHECKED BY TZ

SOIL PROFILE / SAMPLES

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
248.0	GROUND SURFACE									
0.0	Sandy SILT, trace clay, trace organics Very loose Brown Moist	1	SS	1						
247.4 0.6	SILT and SAND, trace to some clay, trace rootlets, wood fragments and organics Very loose Brown Moist to wet	2	SS	WH						
		3	SS	1		Non-Plastic	0	46	49	5
		4A 4B	SS	3						
245.8 2.2	CLAYEY SILT, trace to some sand Firm to very stiff Grey Wet	5	SS	5	▽					
		6	SS	4			0	5	84	11
		7	SS	3						
		8	SS	8			0	8	84	8
		9	SS	5						
237.8 10.2	SILT, trace to some sand Compact Grey Wet	10	SS	17						
236.7 11.3	END OF BOREHOLE Dynamic Core Penetration Test (DCPT)									
234.9 13.1	END OF DCPT NOTES: 1. Borehole ACC2-03 was advanced near the inlet of the existing Atkinson Creek Culvert (East side of Highway 532).									



Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

GOLDER

Foundation Design

PROJECT 1670846	RECORD OF BOREHOLE No ACC2-03	SHEET 2 OF 2	METRIC
W.P. 5261-13-03	LOCATION N 5186463.0; E 297966.3 MTM NAD 83 ZONE 13 (LAT. 46.817681; LONG. -84.089561)		ORIGINATED BY KN
DIST ALGOMA HWY 556	BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing		COMPILED BY AK
DATUM Geodetic	DATE September 6, 2017		CHECKED BY TZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100	PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	2. Borehole caved to a depth of about 9.1 m below existing ground surface (Elev. 238.9 m) upon removal of casing. 3. Water level measured at a depth of about 3.5 m below ground surface (Elev. 244.5 m) upon removal of casing.										

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

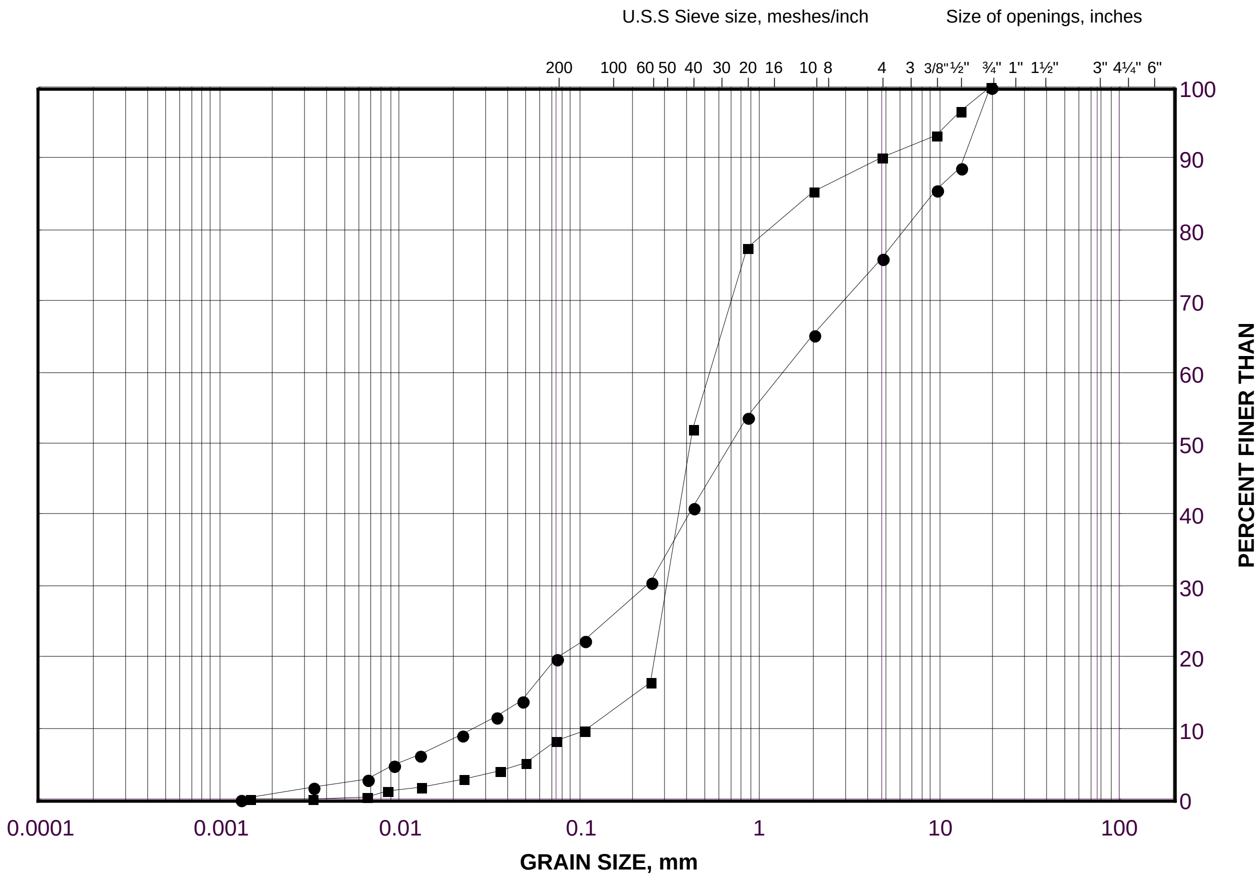
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sand to Gravelly Sand (Fill)

FIGURE B1



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	ACC2-01	1	247.5
■	ACC2-02	3	249.0

Project Number: 1670846

Checked By: TZ

Golder Associates

Date: 03-Jul-18

CONSOLIDATED DRAINED DIRECT SHEAR TEST
SHEET 1 OF 3

FIGURE B2A

TEST STAGE	A	B	C
BOREHOLE NUMBER		ACC2-02	
SAMPLE		1,2,4	
SAMPLE DEPTH, (m)		-	
SAMPLE HEIGHT, (mm)	27.40	27.20	27.50
SAMPLE LENGTH, (mm)	60.00	60.00	60.00
WATER CONTENT, BEFORE TEST, (%)	7.41	7.41	7.41
NORMAL (CONSOLIDATION) STRESS, (kPa)	25	50	100
WATER CONTENT, AFTER TEST, (%)	17.20	16.26	15.31
DISPLACEMENT RATE, mm/min	0.024	0.024	0.024
TIME TO FAILURE, hours	0.9	3.9	4.0
PEAK SHEAR STRESS[1], (kPa)	22.9	50.1	98.1
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.3	5.6	5.7
DRY DENSITY, initial, Mg/m^3	1.731	1.763	1.734
WET DENSITY, initial, Mg/m^3	1.859	1.894	1.862

TEST NOTES:

[1] In the absence of a peak, the shear stress reported is at 10% of relative horizontal displacement (ASTM D3080).

[3] Specimens compacted to a target density of 1.87 g/cm^3 at 7% moisture content; achieved 99% compaction.

[4] Direct Shear Tests carried out under submerged conditions.

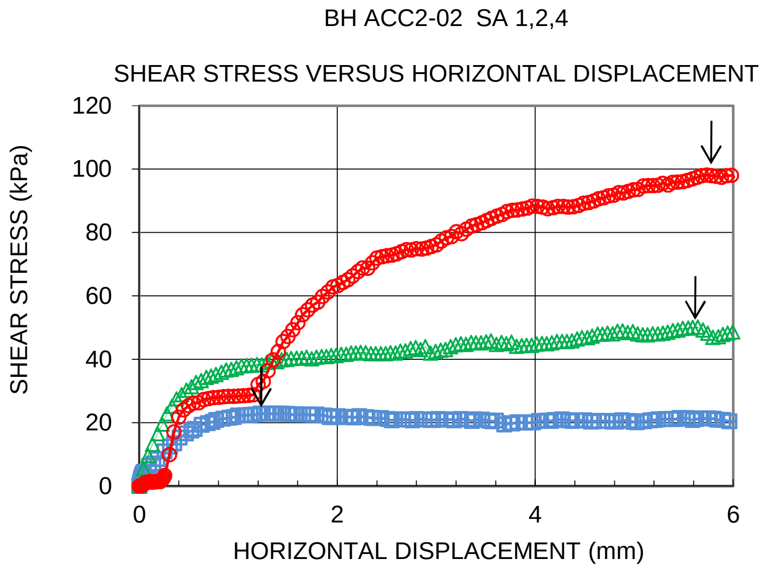
Date: 7/25/2018
Project No. 1670846

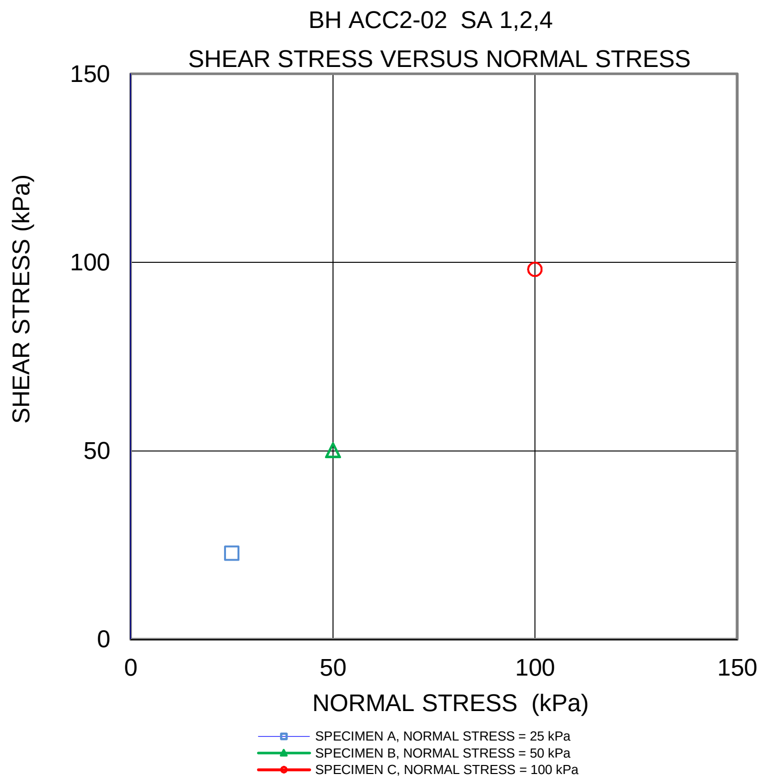
Golder Associates Ltd.

Prepared By: LH
Checked By: TZ

CONSOLIDATED DRAINED DIRECT SHEAR TEST
SHEET 2 OF 3

FIGURE B2B





Date: 7/25/2018

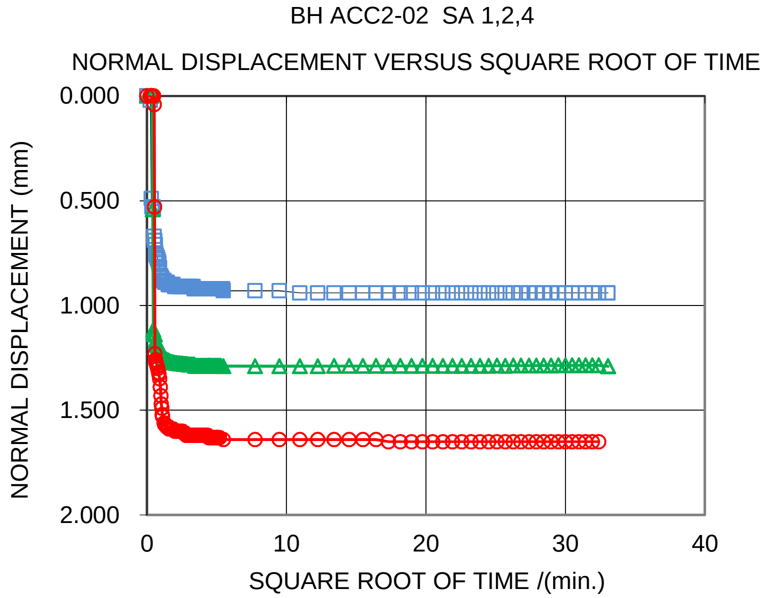
Project No. 1670846

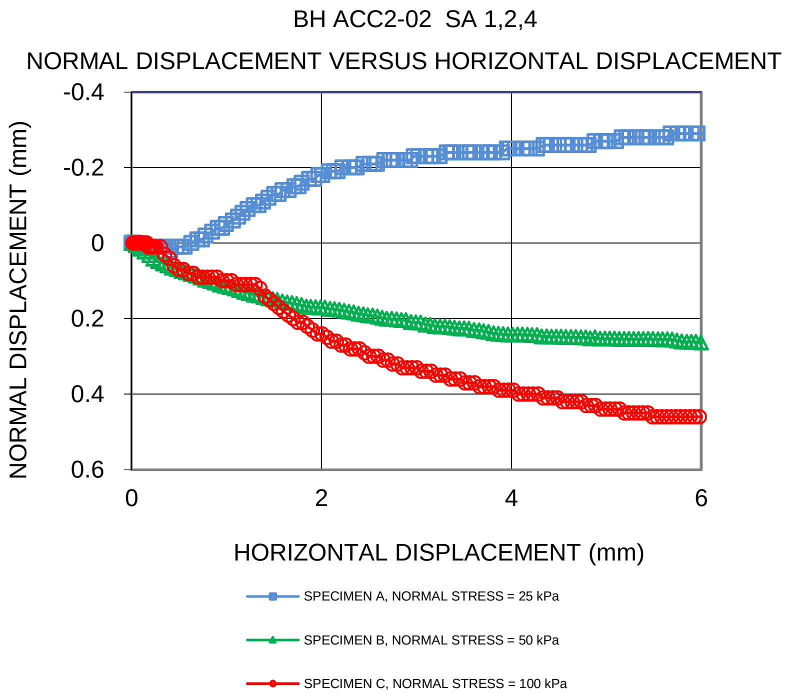
Golder Associates Ltd.

Prepared By: LH

Checked By: TZ

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 3 OF 3	FIGURE B2C



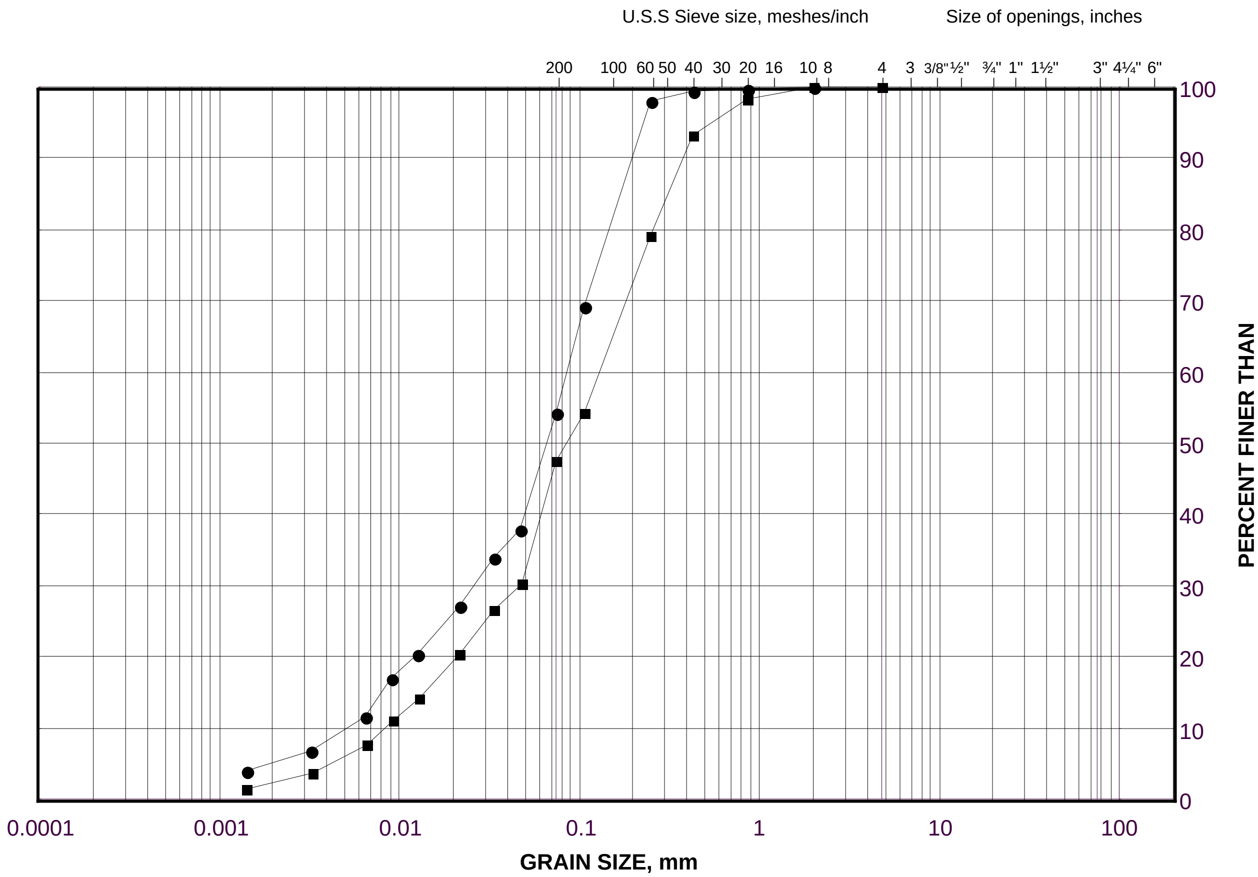


Date: 7/25/2018
Project No. 1670846

Golder Associates Ltd.

Prepared By: LH
Checked By: TZ

GRAIN SIZE DISTRIBUTION Silt and Sand to Organic Silt and Sand	FIGURE B3



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	ACC2-03	3	246.5
■	ACC2-01	4	245.7

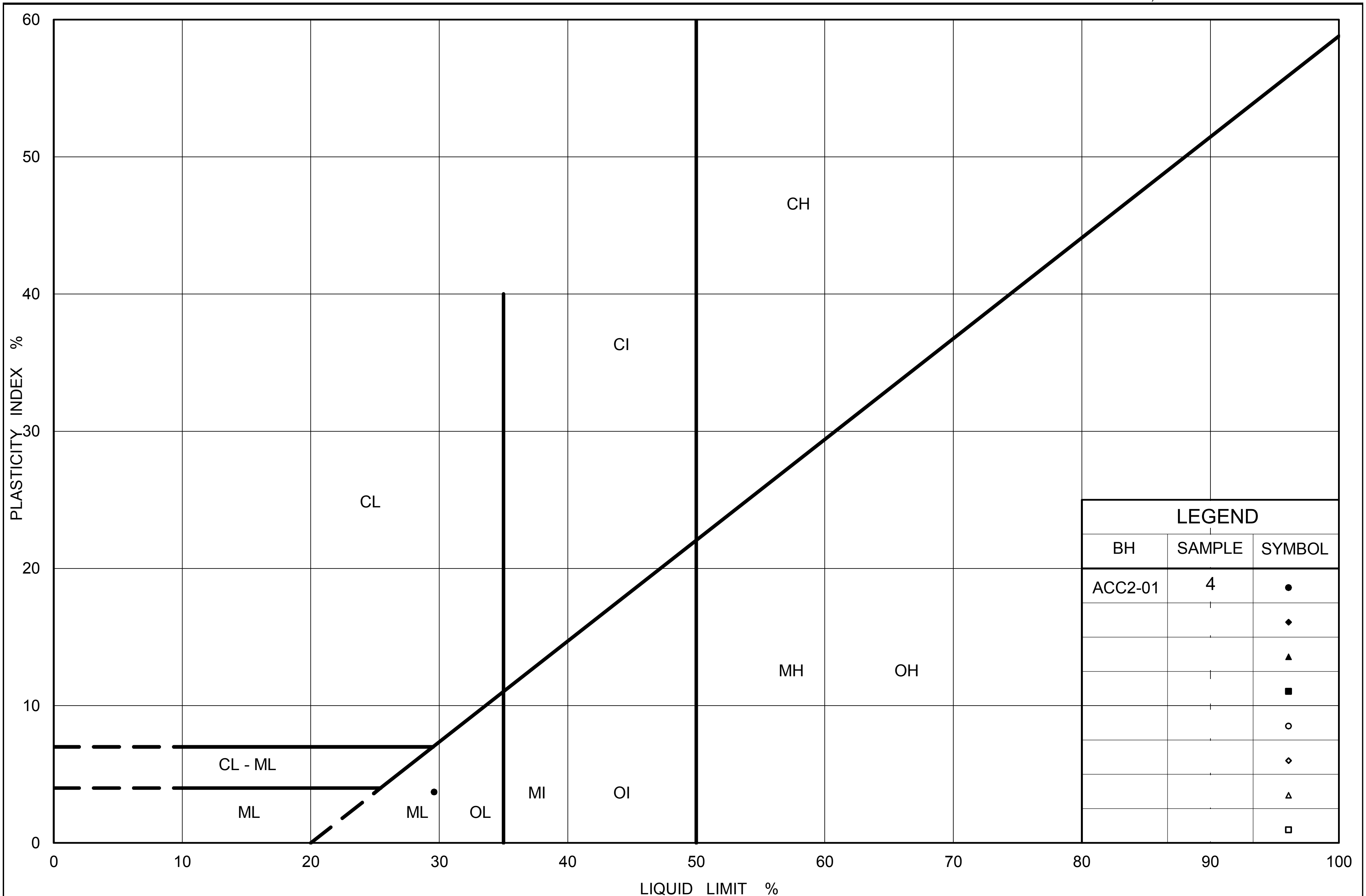
Project Number: 1670846

Checked By: TZ

Golder Associates

Date: 03-Jul-18

Oct 75, FF-S-21

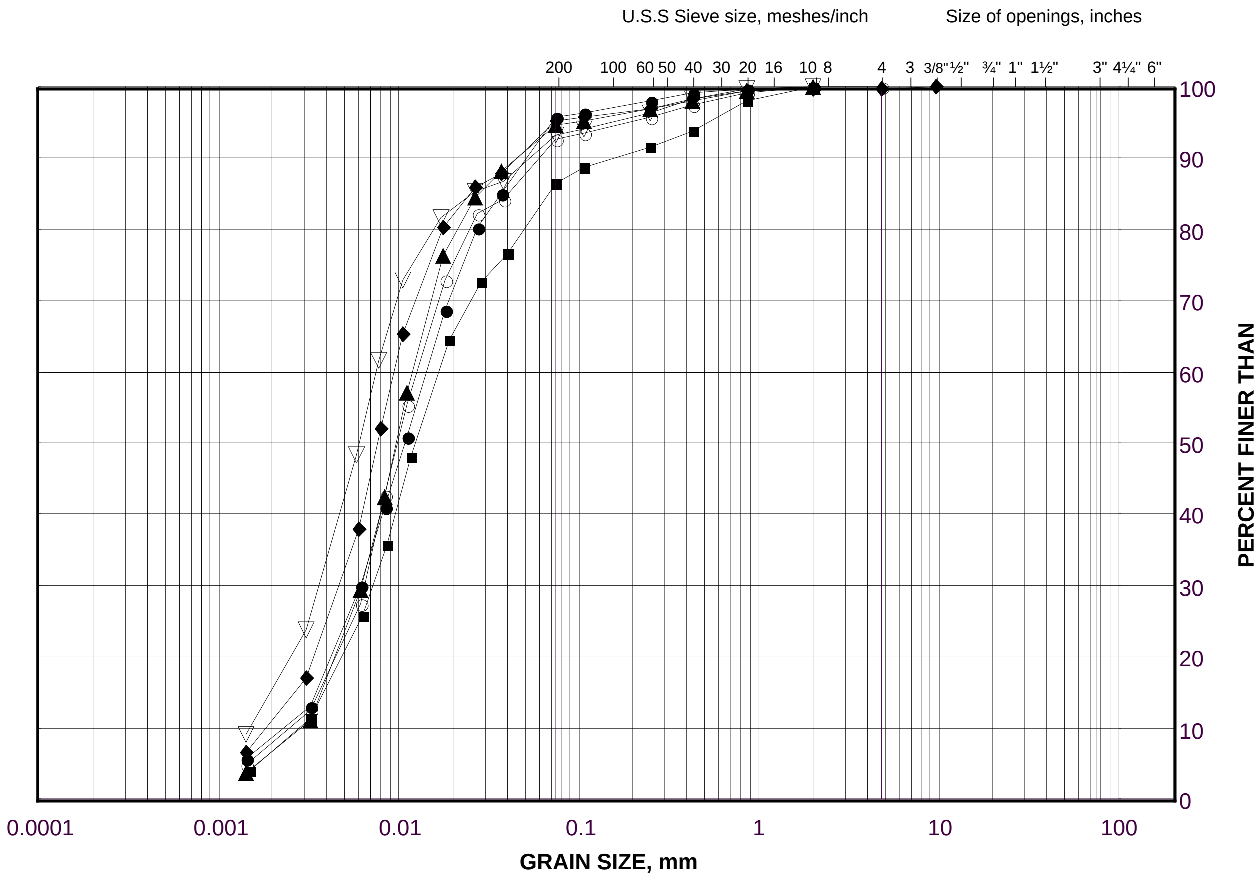


Ministry of Transportation Ontario	PLASTICITY CHART Organic Silt	Figure No. B4 Project No. 1670846 Checked By: TZ

GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B5



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

LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	ACC2-01	10	238.4
■	ACC2-02	11	239.1
◆	ACC2-03	6	243.1
▲	ACC2-02	7	245.2
▽	ACC2-01	8	241.4
❍	ACC2-03	8	240.1

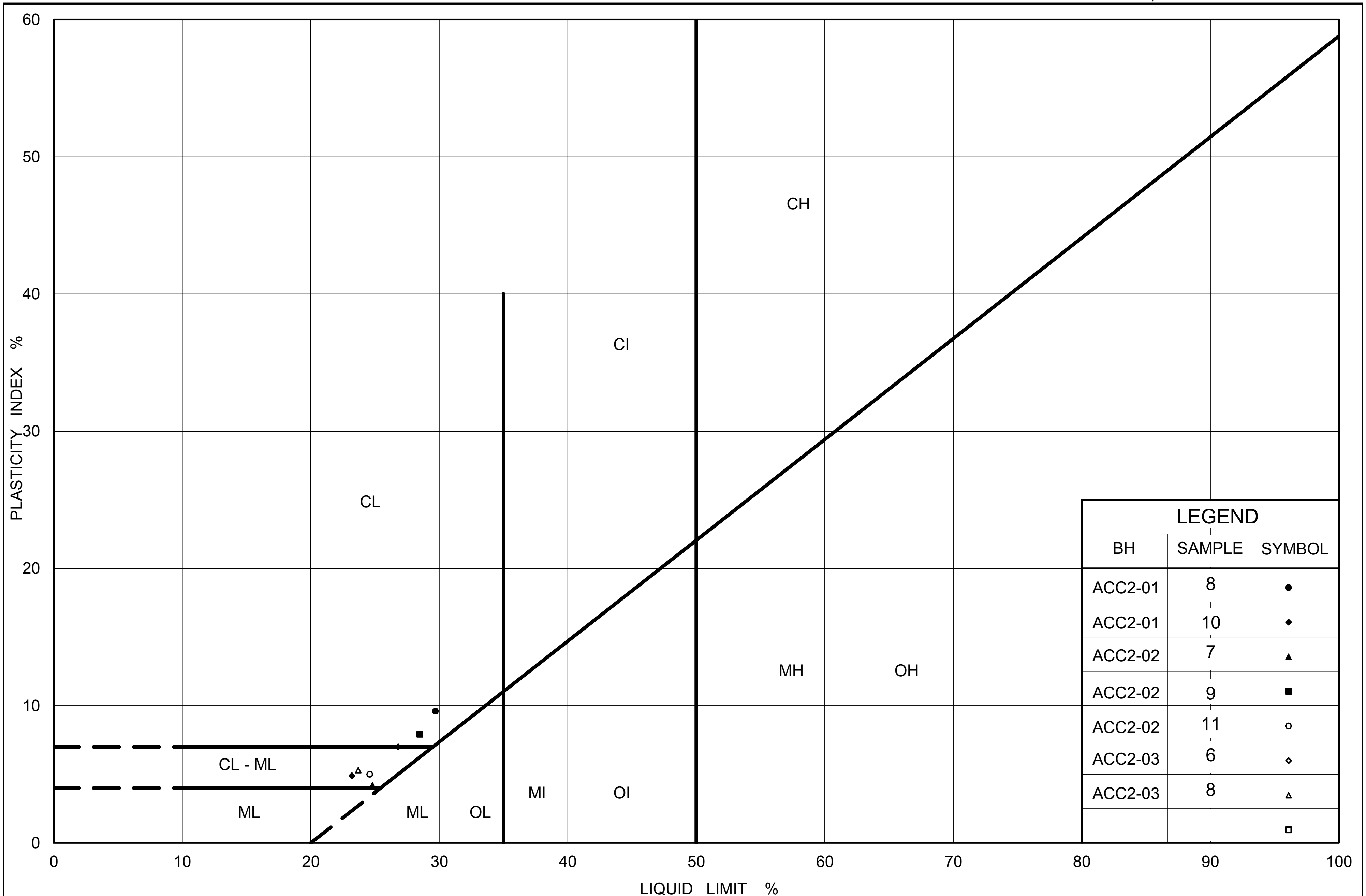
Project Number: 1670846

Checked By: TZ

Golder Associates

Date: 03-Jul-18

Oct 75, FF-S-21



LEGEND

BH	SAMPLE	SYMBOL
ACC2-01	8	●
ACC2-01	10	◆
ACC2-02	7	▲
ACC2-02	9	■
ACC2-02	11	○
ACC2-03	6	◇
ACC2-03	8	△
		□

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B6

Project No. 1670846

Checked By: TZ

APPENDIX C

Analytical Laboratory Test Results

Your Project #: MB7J9789
Site Location: 1670846
Your C.O.C. #: B7J9789-M058-01-01

Attention:EMA GITEJ

MAXXAM ANALYTICS
CAMPOBELLO
6740 CAMPOBELLO ROAD
MISSISSAUGA, ON
CANADA L5N 2L8

Report Date: 2017/09/18
Report #: R2445858
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B780085
Received: 2017/09/16, 12:10

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Moisture	8	2017/09/18	2017/09/18	BBY8SOP-00017	BCMOE BCLM Dec2000 m
Sulphide in Soil	8	2017/09/18	2017/09/18	BBY6SOP-00006	SM 22 4500 S2- D m

Remarks:

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All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

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Success Through Science®

Your Project #: MB7J9789
Site Location: 1670846
Your C.O.C. #: B7J9789-M058-01-01

Attention:EMA GITEJ

MAXXAM ANALYTICS
CAMPOBELLO
6740 CAMPOBELLO ROAD
MISSISSAUGA, ON
CANADA L5N 2L8

Report Date: 2017/09/18
Report #: R2445858
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B780085
Received: 2017/09/16, 12:10

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Letitia Prefontaine, B.Sc., Senior Project Manager
Email: LPrefontaine@maxxam.ca
Phone# (604)639-2616
==
This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		RZ2662	RZ2662	RZ2663		RZ2664		
Sampling Date		2017/08/23	2017/08/23	2017/09/07		2017/09/06		
COC Number		B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01		B7J9789-M058-01-01		
	UNITS	ACB-03 SA4	ACB-03 SA4 Lab-Dup	ACC1-03 SA2	RDL	ACCS-03 SA2	RDL	QC Batch
MISCELLANEOUS								
Sulphide	ug/g	0.69 (1)	<0.50	0.52	0.50	1.06 (2)	0.55	8761700

RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
(1) Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.
(2) RDL raised due to high sample moisture content.

Maxxam ID		RZ2665	RZ2666		RZ2667		
Sampling Date		2017/07/16	2017/07/11		2017/08/23		
COC Number		B7J9789-M058-01-01	B7J9789-M058-01-01		B7J9789-M058-01-01		
	UNITS	MRB-04 SA3	MRB-03 SA5	RDL	DCC-01 SA2	RDL	QC Batch
MISCELLANEOUS							
Sulphide	ug/g	<0.50	0.52	0.50	0.68 (1)	0.55	8761700

RDL = Reportable Detection Limit
(1) RDL raised due to high sample moisture content.

Maxxam ID		RZ2668	RZ2669		
Sampling Date		2017/07/29	2017/08/02		
COC Number		B7J9789-M058-01-01	B7J9789-M058-01-01		
	UNITS	MCC-03 SA1	WRC-01 SA3	RDL	QC Batch
MISCELLANEOUS					
Sulphide	ug/g	0.78	0.57	0.50	8761700

RDL = Reportable Detection Limit

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Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

PHYSICAL TESTING (SOIL)

Maxxam ID		RZ2662	RZ2663	RZ2664	RZ2665		
Sampling Date		2017/08/23	2017/09/07	2017/09/06	2017/07/16		
COC Number		B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01		
	UNITS	**ACB-03 SA4**	**ACC1-03 SA2**	**ACCS-03 SA2**	**MRB-04 SA3**	**RDL**	**QC Batch**
Physical Properties							
Moisture	%	24	22	28	8.2	0.30	8761682
RDL = Reportable Detection Limit							

Maxxam ID		RZ2666	RZ2667	RZ2668	RZ2669		
Sampling Date		2017/07/11	2017/08/23	2017/07/29	2017/08/02		
COC Number		B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01		
	UNITS	**MRB-03 SA5**	**DCC-01 SA2**	**MCC-03 SA1**	**WRC-01 SA3**	**RDL**	**QC Batch**
Physical Properties							
Moisture	%	13	32	14	17	0.30	8761682
RDL = Reportable Detection Limit							

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Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

TEST SUMMARY

Maxxam ID: RZ2662
Sample ID: ACB-03 SA4
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2662 Dup
Sample ID: ACB-03 SA4
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2663
Sample ID: ACC1-03 SA2
Matrix: Soil

Collected: 2017/09/07
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2664
Sample ID: ACCS-03 SA2
Matrix: Soil

Collected: 2017/09/06
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2665
Sample ID: MRB-04 SA3
Matrix: Soil

Collected: 2017/07/16
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2666
Sample ID: MRB-03 SA5
Matrix: Soil

Collected: 2017/07/11
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

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Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

TEST SUMMARY

Maxxam ID: RZ2667
Sample ID: DCC-01 SA2
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2668
Sample ID: MCC-03 SA1
Matrix: Soil

Collected: 2017/07/29
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

Maxxam ID: RZ2669
Sample ID: WRC-01 SA3
Matrix: Soil

Collected: 2017/08/02
Shipped:
Received: 2017/09/16

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Moisture	BAL/BAL	8761682	2017/09/18	2017/09/18	Lolita Obusan
Sulphide in Soil	SPEC/COL	8761700	2017/09/18	2017/09/18	Prabhleen Sodhi

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Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	9.0°C
Package 2	6.0°C

Sample RZ2662 [ACB-03 SA4] : Sample was extracted past method specified hold time for Moisture. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2663 [ACC1-03 SA2] : Sample analyzed past method specified hold time for Sulphide in Soil. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2664 [ACCS-03 SA2] : Sample analyzed past method specified hold time for Sulphide in Soil. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2665 [MRB-04 SA3] : Sample was extracted past method specified hold time for Moisture. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2666 [MRB-03 SA5] : Sample was extracted past method specified hold time for Moisture. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2667 [DCC-01 SA2] : Sample was extracted past method specified hold time for Moisture. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil.

Sample RZ2668 [MCC-03 SA1] : Sample was extracted past method specified hold time for Moisture. {Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.} Sample received past method specified hold time for Moisture. Sample analyzed past method specified hold time for Sulphide in Soil. Sample received past method specified hold time for Sulphide in Soil

Results relate only to the items tested.

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Maxxam Job #: B780085
Report Date: 2017/09/18

QUALITY ASSURANCE REPORT

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
8761682	Moisture	2017/09/18					<0.30	%	0 (1)	20
8761700	Sulphide	2017/09/18	39 (2,3)	75 - 125	84	75 - 125	<0.50	ug/g	NC (4)	30

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Duplicate Parent ID

(2) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(3) Matrix Spike Parent ID [RZ2662-01]

(4) Duplicate Parent ID [RZ2662-01]

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Maxxam Job #: B780085
Report Date: 2017/09/18

MAXXAM ANALYTICS
Client Project #: MB7J9789
Site Location: 1670846
Sampler Initials: DH

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Ph.D., P.Chem., Scientific Specialist

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Maxxam
A Bureau Veritas Group Company

Your Project #: 1670846
Your C.O.C. #: 628368-01-01

Attention:Darcy Hansen

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2017/09/20
Report #: R4722990
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7J9789
Received: 2017/09/13, 11:39

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	8	N/A	2017/09/18	CAM SOP-00463	EPA 325.2 m
Conductivity	8	N/A	2017/09/18	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	8	2017/09/15	2017/09/15	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	8	2017/09/14	2017/09/18	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	8	N/A	2017/09/18	CAM SOP-00464	EPA 375.4 m
Sulphide (from Campobello) (1)	8	N/A	N/A		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Campo to Burnaby Subcontract

Maxxam
A Bureau Veritas Group Company

Your Project #: 1670846
Your C.O.C. #: 628368-01-01

Attention:Darcy Hansen

Golder Associates Ltd
Mississauga - Standing Offer
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2017/09/20
Report #: R4722990
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7J9789
Received: 2017/09/13, 11:39

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B7J9789
Report Date: 2017/09/20

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: DH

RESULTS OF ANALYSES OF SOIL

Maxxam ID		FCS510	FCS510	FCS511	FCS512	FCS513	FCS514		
Sampling Date		2017/08/23	2017/08/23	2017/09/07	2017/09/06	2017/07/16	2017/07/11		
COC Number		628368-01-01	628368-01-01	628368-01-01	628368-01-01	628368-01-01	628368-01-01		
	UNITS	**ACB-03 SA4**	**ACB-03 SA4 Lab-Dup**	**ACC1-03 SA2**	**ACCS-03 SA2**	**MRB-04 SA3**	**MRB-03 SA5**	**RDL**	**QC Batch**
Calculated Parameters									
Resistivity	ohm-cm	7300		15000	4100	5900	2400		5165355
Inorganics									
Soluble (20:1) Chloride (Cl)	ug/g	55	58	24	130	58	260	20	5167700
Conductivity	umho/cm	137	133	69	246	169	424	2	5167946
Available (CaCl2) pH	pH	6.48		6.20	5.13	5.62	5.77		5165977
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	64	22	29	<20	20	5167702

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam ID		FCS515	FCS516	FCS517		
Sampling Date		2017/08/23	2017/07/29	2017/08/02		
COC Number		628368-01-01	628368-01-01	628368-01-01		
	UNITS	**DCC-01 SA2**	**MCC-03 SA1**	**WRC-01 SA3**	**RDL**	**QC Batch**
Calculated Parameters						
Resistivity	ohm-cm	2200	24000	43000		5165355
Inorganics						
Soluble (20:1) Chloride (Cl)	ug/g	190	<20	<20	20	5167700
Conductivity	umho/cm	450	41	23	2	5167946
Available (CaCl2) pH	pH	8.18	6.90	6.62		5165977
Soluble (20:1) Sulphate (SO4)	ug/g	<20	<20	24	20	5167702

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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TEST SUMMARY

Maxxam ID: FCS510
Sample ID: ACB-03 SA4
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS510 Dup
Sample ID: ACB-03 SA4
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine

Maxxam ID: FCS511
Sample ID: ACC1-03 SA2
Matrix: Soil

Collected: 2017/09/07
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS512
Sample ID: ACCS-03 SA2
Matrix: Soil

Collected: 2017/09/06
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS513
Sample ID: MRB-04 SA3
Matrix: Soil

Collected: 2017/07/16
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine

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Maxxam Job #: B7J9789
Report Date: 2017/09/20

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: DH

TEST SUMMARY

Maxxam ID: FCS513
Sample ID: MRB-04 SA3
Matrix: Soil

Collected: 2017/07/16
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS514
Sample ID: MRB-03 SA5
Matrix: Soil

Collected: 2017/07/11
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS515
Sample ID: DCC-01 SA2
Matrix: Soil

Collected: 2017/08/23
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

Maxxam ID: FCS516
Sample ID: MCC-03 SA1
Matrix: Soil

Collected: 2017/07/29
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

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Maxxam Job #: B7J9789
Report Date: 2017/09/20

Golder Associates Ltd
Client Project #: 1670846
Sampler Initials: DH

TEST SUMMARY

Maxxam ID: FCS517
Sample ID: WRC-01 SA3
Matrix: Soil

Collected: 2017/08/02
Shipped:
Received: 2017/09/13

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5167700	N/A	2017/09/18	Deonarine Ramnarine
Conductivity	AT	5167946	N/A	2017/09/18	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5165977	2017/09/15	2017/09/15	Tahir Ahmed
Resistivity of Soil		5165355	2017/09/18	2017/09/18	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5167702	N/A	2017/09/18	Deonarine Ramnarine
Sulphide (from Campobello)	SPEC	5170216	N/A	2017/09/19	Lims Auto Schedule Runner

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	5.7°C

Custody seal was present and intact.

Sample FCS513 [MRB-04 SA3] : Sample submitted and analyzed past the recommended hold time for pH, Chloride, Sulphate and Conductivity/Resistivity analysis.

Sample FCS514 [MRB-03 SA5] : Sample submitted and analyzed past the recommended hold time for pH, Chloride, Sulphate and Conductivity/Resistivity analysis.

Sample FCS517 [WRC-01 SA3] : Sample submitted and analyzed past the recommended hold time for pH, Chloride, Sulphate and Conductivity/Resistivity analysis.

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5165977	Available (CaCl2) pH	2017/09/15			99	97 - 103			0.11	N/A
5167700	Soluble (20:1) Chloride (Cl)	2017/09/18	NC	70 - 130	104	70 - 130	<20	ug/g	5.5	35
5167702	Soluble (20:1) Sulphate (SO4)	2017/09/18	124	70 - 130	107	70 - 130	<20	ug/g	NC	35
5167946	Conductivity	2017/09/18			101	90 - 110	<2	umho/cm	3.2	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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13-Sep-17 11:39
Ema Gitej
B7J9789
KES ENV-689

Page of

Bottle Order #: 628368
Project Manager: Ema Gitej
C#628368-01-01

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:	
Company Name:	#1326 Golder Associates Ltd	Company Name:		Quotation #:	B70916
Attention:	Accounts Payable	Attention:	Darcy Hansen	P.O. #:	
Address:	6925 Century Ave Suite 100 Mississauga ON L5N 7K2	Address:		Project:	~~[illegible]~~ 1670846
				Project Name:	
Tel:	(905) 567-4444 x Fax: (905) 567-6561 x	Tel:	(905) 567-4444 x2064 Fax:	Site #:	
Email:	AP_CustomerService@golder.com	Email:	Darcy_Hansen@golder.com	Sampled By:	

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ____ ☐ PWQO ☐ Other ____

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? ____

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☐
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ____ Time Required: ____ ☐
Rush Confirmation Number: ____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Chloride & SO4 (20:1 extract)	Conductivity/Resistivity	pH CaCl2 EXTRACT	Sulphide (Maxxam BC)						# of Bottles	Comments
1		ACB-03 SA4	Aug 23, 2017	–			✓	✓	✓	✓						2	
2		ACC1-03 SA2	Sept 7, 2017	–			✓	✓	✓	✓						2	
3		ACC2-03 SA2	Sept 6, 2017	–			✓	✓	✓	✓						2	
4		MRB-04 SA3	Jul 16, 2017	–			✓	✓	✓	✓						2	
5		MRB-03 SA5	Jul 11, 2017	–			✓	✓	✓	✓						2	
6		PCC-01 SA2	Aug 23, 2017	–			✓	✓	✓	✓						2	
7		MCC-03 SA1	Jul 29 2017	–			✓	✓	✓	✓						2	
8		WRC-01 SA3	Aug 2, 2017	–			✓	✓	✓	✓						2	
9																	
10																	

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
[signature] / Darcy Hansen	17/09/13	10am	[signature] USA MUNSTER	2017/09/13	11:39	

Laboratory Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	5 5 7	Present	✓	
		Intact		✓

White: Maxxam Yellow: Client

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Maxxam Analytics International Corporation o/a Maxxam Analytics

APPENDIX D

Notice to Contractor and Non-Standard Special Provisions

<u>DEWATERING STRUCTURE EXCAVATIONS</u> - Item No.

Special Provision No. FOUND0003 March 8, 2018

Amendment to OPSS 902, November 2010

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

902.02 REFERENCES

Section 902.02 of OPSS 902 is amended by the addition of the following:

Ontario Provincial Standard Specifications, Construction

OPSS 517	Dewatering
OPSS 805	Temporary Erosion and Sediment Control Measures

902.03 DEFINITIONS

Section 903.03 of OPSS 902 is amended by the addition of the following:

Automatic Transfer Switch means as defined in OPSS 517.

Cofferdam means as defined in OPSS 539.

Cut-Off Wall means as defined in OPSS 517.

Design Storm Return Period means as defined in OPSS 517.

Dewatering System means as defined in OPSS 517.

Groundwater Control System means as defined in OPSS 517.

Plug means as defined in OPSS 517.

Sediment means as defined in OPSS 517.

Sediment Control Measure means as defined in OPSS 517.

Temporary Flow Passage System means as defined in OPSS 517.

Unwatering means as defined in OPSS 517.

Vegetated Discharge Area means as defined in OPSS 517.

Waterbody means as defined in OPSS 517.

Watercourse means as defined in OPSS 517.

902.04 DESIGN AND SUBMISSION REQUIREMENTS

902.04.01 Design Requirements

902.04.01.01 Dewatering

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a two-year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

902.04.02 Submission Requirements

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

902.04.02.01 Working Drawings

Working Drawings for the dewatering system shall be according to OPSS 517.

902.04.02.02 Preconstruction Survey

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of 100 metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website https://www.ontario.ca/environment-and-energy/map-well-records or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

902.04.02.03 Milestone Inspections

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

902.07 CONSTRUCTION

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

902.07.04 Dewatering Structure Excavation

902.07.04.01 General

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

902.07.04.02 Discharge of Water

The discharge of water shall be according to OPSS 517.

902.07.04.03 Monitoring

Monitoring shall be according to OPSS 517.

902.07.04.04 System Amendments

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

902.07.04.05 Removal

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.

** Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item **only** on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.

OBSTRUCTIONS – Item No.

Notice to Contractor

The Contactor is advised of the presence of cobbles encountered within the existing embankment fill.

Consideration of the presence of the cobbles shall be made in the selection of appropriate equipment/tools and procedures for excavations and during installation of temporary cofferdams and roadway protection systems.

WORKING SLAB – Item No.

Non-Standard Special Provision

The subgrade soils within the footprint of the proposed culvert may be susceptible to disturbance and loosening/softening from construction traffic and ponded water.

If the precast concrete box culvert is not placed on the prepared subgrade within four hours of its inspection and approval, a concrete working slab of 20 MPa compressive strength at 28-days with minimum thickness of 100 mm, shall be placed on the foundation subgrade. A minimum 75 mm thick uncompacted levelling pad consisting of Granular ‘A’ material (OPSS.PROV 1010) or concrete fine aggregate (meeting the grading requirements specified in OPSS.PROV 1002) shall be provided on top of the concrete working slab to support the precast concrete box culvert.

EARTH EXCAVATION AND GRANULAR PAD CONSTRUCTION– Item No.

Non-Standard Special Provision

Where a concrete working slab is not adopted to protect the culvert subgrade from disturbance, the Contractor shall construct a minimum 0.6 m thick granular pad below the base of the precast concrete box culvert. In places, as a result of subexcavation of the very loose to loose silt and sand and organic silt and sand deposit encountered near the outlet of the existing culvert, the temporary excavations, and hence the thickness of the granular pad, will be greater than 0.6 m.

The excavation for and construction of the granular pad first lift (0.5 m thick or less) below water shall be carried out simultaneously as specified herein.

The subexcavation within the culvert footprint shall be carried out in strips with width of no more than 3 m, extending along the length of the culvert footprint. Each strip excavation shall be backfilled as outlined below before excavation of the subsequent adjacent strip commences. For the first segment of excavation, once the removal of the overburden material has been completed, the construction of the granular pad in wet conditions shall commence immediately in general accordance with the following procedure:

- The granular pad, together with backfill of any subexcavation, shall be constructed of Granular 'B' Type II material meeting the specification outlined in OPSS.PROV 1010 (Aggregates).
- For backfill of the subexcavation below the water level, construction of the granular pad shall be carried out in lifts of not more than 0.5 m in thickness. The surface of each such lift shall be compacted/tamped by the bucket of a backhoe/excavator of at least 35,000 kg operating weight with a minimum of two passes to cover the entire surface of the lift.
- The surface of the final lift to or immediately below the water surface (i.e., below the bedding) shall be compacted by a track bulldozer of minimum 8,000 kg operating weight for a minimum of twelve passes (six forward and six backward), overlapping successively across the granular pad.
- The portion of the granular pad above water (i.e., the bedding placed in dry conditions) shall be constructed in accordance with the requirements of OPSS 902 and OPSS.PROV 501.

The Contractor shall be responsible for maintaining the stability of the excavation and the integrity of the granular pad constructed in wet conditions as the work is carried out.

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For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
6925 Century Avenue, Suite #100
Mississauga, Ontario, L5N 7K2
Canada
T: +1 (905) 567 4444