



November 9, 2018

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**STRUCTURAL BUNDLE - 11 STRUCTURES ON HIGHWAYS 129, 532  
AND 556**  
**HIGHWAY 532 - ATKINSON CREEK CULVERT NO. 2 REPLACEMENT,  
10.5 KM NORTH OF HIGHWAY 556 (SITE NO. 38S-291C)**  
**LAT. 46.822333° ; LONG. -84.093152°**  
**GAUDETTE TOWNSHIP, ALGOMA DISTRICT, ONTARIO**  
**MINISTRY OF TRANSPORTATION, ONTARIO**  
**GWP 5378-11-00 ; WP 5261-13-03**

**Submitted to:**  
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**Lat. 46.822333°, Long. -84.093152°**

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REPORT





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# PART A

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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-291C) in 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 No. 2 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 an easterly 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 10.5 km north of Highway 556 in Gaudette Township, Algoma District, Ontario.

The existing culvert consists of a single cell, Structural Plate Corrugated Steel Pipe (SPCSP) culvert with an approximately 3.36 m diameter and measuring about 31 m in length. The culvert is shown on Drawing 1.

The Atkinson Creek near the inlet and outlet of the existing culvert is approximately 6 m wide and 9 m wide, respectively, and flows in an easterly direction where it crosses below Highway 532. About 870 m downstream (southeast) of the culvert, Atkinson Creek flows into the Achigan Creek. The Achigan Creek in turn flows into the Goulais River about 6.3 km south of the culvert (i.e., immediately south of Searchmont).

Highway 532 at the location of the culvert consists of an approximately 4.7 m high earth fill embankment that carries one lane of traffic in each direction. The travelled portion of the highway consists of a thin bituminous treatment surface which is at approximately Elevation 251.9 m in the vicinity of the existing culvert.

Residences are located within 120 m south and 150 m north of the existing culvert. Multiple dwellings are also located along Station Road which extends west of Highway 532 about 175 m south of the existing culvert. Overhead electrical transmission lines run along the highway on the west side of Highway 532 (i.e., immediately west of the travelled portion of the highway).

The topography of the area in the immediate vicinity of the culvert is relatively flat to undulating. However, the natural ground surface rises significantly further north, 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 247.5 m and 249.0 m. The site is relatively heavily vegetated with grasses and shrubs, as well as deciduous and coniferous trees.

### **3.0 FIELD INVESTIGATION PROCEDURES**

The field work at the site of the existing culvert was carried out between August 27 and 29 as well as between September 7 and 9, 2017, during which time three boreholes (designated as Boreholes ACC1-01 to ACC1-03) were advanced near the existing culvert. Boreholes ACC2-01 and ACC2-03 were advanced near the inlet and outlet of the existing culvert, respectively. Borehole ACC2-02 was advanced through the Highway 532 embankment on the northbound lane (north of the existing culvert).

The subsurface soil conditions encountered in the boreholes are shown in detail on the borehole and drillhole records in Appendix A. Lists of abbreviations and symbols as well as lithological and geotechnical rock description terminology are also provided in Appendix A to assist in the interpretation of the borehole and drillhole records. The locations of the as-drilled boreholes are shown in plan on Drawing 1.

The boreholes were advanced using both portable drilling equipment and a truck-mounted 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-55 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 an 'NQ' double-tube rock core barrel was used to penetrate through a gravelly fill layer with cobbles encountered near the bottom portion of the embankment fill and a deposit of sand with cobbles encountered near the bottom of the borehole. The 'NQ' rock core barrel was also utilized to recover bedrock core samples from Borehole ACC1-02. Bedrock quality and discontinuity data were recorded in the field based on visual inspection of the recovered bedrock core extracted from the core barrel. Photographs of the recovered bedrock core samples are provided in Appendix A.

In the two portable 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; 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 ACC1-01 and ACC1-03 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 borehole advanced by portable equipment near the outlet of the existing borehole.

The boreholes were advanced to depths ranging between about 8.2 m and 14.3 m below existing ground surface. In Borehole ACC1-02 the bedrock was cored for a length of about 2.8 m. Borehole ACC1-01 was terminated within the overburden upon encountering casing refusal.





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. Geotechnical index testing (i.e., water content, organic content, Atterberg limits and grain size distribution) was carried out on selected soil samples, in accordance with MTO Laboratory and/or ASTM Standards, as appropriate. 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

Classification of the rock mass quality of the bedrock cores with respect to the Rock Quality Designation (RQD) is described based on Table 3.10 of the Canadian Foundation Engineering Manual (CFEM, 2006). The degree of weathering of the bedrock samples (e.g., fresh – W1) and the strength classification of the intact rock mass based off field identification (e.g., strong to very strong – R4 to R5) are described in accordance with Table B.3 and Table B.6, respectively, of the International Society for Rock Mechanics (ISRM, 1985) standard classification system.

A soil sample was also collected from Boreholes ACC1-03 (advanced near the outlet 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
		Northing (Latitude)	Easting (Longitude)		
ACC1-01 <sup>1</sup>	Inlet of existing culvert; west of Highway 532	5186987.3 m (46.822395°)	297677.1 m (-84.093359°)	249.1 m	8.2 m
ACC1-02 <sup>2</sup>	Northbound lane of Highway 532; north of existing culvert	5186983.8 m (46.822363°)	297695.0 m (-84.093124°)	251.9 m	14.3 m <sup>3</sup>
ACC1-03 <sup>1</sup>	Outlet of existing culvert; east of Highway 532	5186975.3 m (46.822287°)	297707.4 m (-84.092961°)	249.0 m	11.3 m

Notes:

1. Boreholes ACC1-01 and ACC1-03 were advanced using portable drilling equipment set up on land near the inlet and outlet of the existing culvert, respectively.
2. Borehole ACC2-02 was advanced using a truck-mounted drill rig through the Highway 532 embankment.
3. The borehole depth includes the cored bedrock.





## **4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **4.1 Regional Geology**

Based on Northern Ontario Engineering Geology Terrain (NOEGTS)<sup>1</sup> 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)<sup>2</sup>, 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 borehole records (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 ACC1-01 to ACC1-03 and an automatic hammer at the location of Borehole ACC1-02.

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 granular embankment fill (associated with Highway 532) or a surficial granular deposit comprised of silt to sandy silt to sand, underlain by a deposit of clayey silt with a low plasticity which transitions into a non-plastic silt. The silt deposit is underlain by a deposit of sand to gravelly sand. Detailed descriptions of the subsurface conditions encountered in the boreholes at this site are provided in the following subsections.

#### **4.2.1 Surface Treatment**

An approximately 13 mm thick layer of bituminous surface treatment was encountered in Borehole ACC1-02 which was advanced through the Highway 532 embankment on the northbound lane, north of the existing culvert. The top of this thin layer of surface treatment is at about Elevation 251.9 m.

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

An approximately 5.5 m thick layer of granular fill associated with the Highway 532 embankment was encountered below the thin layer of surface treatment in Borehole ACC1-02. The upper portion of the embankment fill is comprised predominantly of gravelly sand, trace to some silt, but becomes coarser at a depth of about 3.0 m below

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

<sup>2</sup> Ontario Ministry of Northern Development and Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2544.



existing ground surface, where it is comprised of sand and gravel, trace to some silt, with cobbles. A portion of the sand and gravel fill was cored with a rock core barrel to advance the borehole through a zone of cobbles. The top of the granular fill layer encountered in Borehole ACC1-02 is at about Elevation 251.9 m (i.e., immediately below the surface treatment).

The SPT 'N'-values measured within the embankment fill generally range from 7 blows to 13 blows per 0.3 m of penetration, indicating a loose to compact state of compactness. One SPT 'N'-value of 3 blows per 0.3 m of penetration was measured within the sand and gravel portion of the fill (i.e., at the base of the fill), indicating a very loose state of compactness; however, this 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.

The water content measured on two samples of the gravelly sand portion of the embankment fill is 3% and 4%; the water content measured on a sample of the sand and gravel portion of the embankment fill, which was noted to be wet, is 10%.

The results of 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 fill recovered from Borehole ACC1-02. The results are presented on Figure B2.

#### **4.2.3 Silt to Sandy Silt to Sand**

An upper deposit of silt to sandy silt to sand was encountered at the ground surface in Boreholes ACC1-01 and ACC1-03 advanced near the inlet and outlet of the existing culvert, respectively. The deposit contains organics and wood fragments in places. The top of this deposit in Borehole ACC1-01 is at about Elevation 249.1 m and its overall thickness is about 1.8 m; while in Borehole ACC1-03, the top of this deposit is at about Elevation 249.0 m and its thickness is about 0.6 m.

The SPT 'N'-values measured within this deposit range between 2 blows and 4 blows per 0.3 m of penetration, indicating a very loose to loose state of compactness.

The water content measured on four samples of the granular deposit ranges between approximately 14% and 36%. The lower water content of 14% was measured on a sample of the coarser portion of the granular deposit (i.e., the sand recovered from Borehole ACC1-01).

An Atterberg limits test carried out on a sample of the silt portion of the granular deposit recovered from Borehole ACC1-01 measured a liquid limit of about 25%, a plastic limit of about 22%, and a corresponding plasticity index of about 3%. The results of this Atterberg limits test are shown on the plasticity chart on Figure B3 in Appendix B, and indicate that the material is classified as a silt of slight plasticity.

#### **4.2.4 Varved Silty Clay and Clayey Silt**

A varved cohesive deposit comprised of dark brown silty clay laminae and light brown clayey silt laminae was encountered below the sandy silt deposit in Borehole ACC1-03 advanced near the outlet of the existing culvert. The top of this deposit at about Elevation 248.4 m and its thickness is about 1.9 m.

The SPT 'N'-values measured within the varved deposit are 3 blows and 6 blows per 0.3 m of penetration. In-situ vane tests carried out within the bottom portion of the deposit measured (uncorrected) undrained shear strengths of about 37 kPa and 41 kPa. The sensitivity (defined as the quotient between the undisturbed shear strength and



the remoulded shear strength) is about 4 and 5. The in-situ field vanes tests results indicate that the deposit has a predominantly firm consistency.

The results of a grain size distribution test carried out on a sample of the varved cohesive deposit are shown on Figure B4 in Appendix B.

An Atterberg limits test was carried out on a sample of the varved cohesive deposit. The test measured a liquid limit of about 46%, a plastic limit of about 20%, and a corresponding plasticity index of about 26%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B5 in Appendix B and indicate that the material (i.e., the dark brown laminae) can be classified as a silty clay of intermediate plasticity. It was difficult to test the clayey silt laminae which were much thinner than the silty clay laminae. The water content measured on a sample of the deposit is about 52%, near or above the liquid limit for the silty clay laminae.

#### **4.2.5 Clayey Sit**

A cohesive deposit comprised of clayey silt was encountered below the upper granular deposit in Borehole ACC1-01 at the culvert inlet, below the sand and gravel fill in Borehole ACC1-02, and below the varved silty clay and clayey silt deposit in Borehole ACC1-03 at the culvert outlet. The top of the cohesive deposit ranges between about Elevations 247.3 m and 246.4 m and its thickness ranges from about 2.3 m to 6.2 m.

The SPT 'N'-values measured within the clayey silt deposit range between 1 blow and 5 blows per 0.3 m of penetration. A single in-situ vane test carried out within this deposit in Borehole ACC1-02 measured an (uncorrected) undrained shear strength of about 62 kPa. The limited number of in-situ vane tests is attributed to the highly silty nature of the cohesive deposit. The sensitivity (defined as the quotient between the undisturbed shear strength and the remoulded shear strength) is about 11. The in-situ field vanes tests results indicate that the deposit has a predominantly stiff consistency, but considering the limited vane testing, the consistency is considered to range from firm to stiff.

The results of grain size distribution tests carried out on four samples of the clayey silt deposit are shown on Figure B6 in Appendix B.

Atterberg limits tests were carried out on four samples of the clayey silt deposit. The tests measured liquid limits between about 21% and 25%, plastic limits between about 17% and 19%, and plasticity indices from just over 4% to 6%. The results of the Atterberg limits tests are shown on the plasticity chart on Figure B7 in Appendix B and indicate that the material can be classified as a clayey silt of low plasticity. An Atterberg limits test was also carried out on a silt seam encountered in Borehole ACC1-03 at a depth of about 6.4 m below existing ground surface. The test measured a liquid limit of about 26%, a plastic limit of about 22%, and a corresponding plasticity index of 4%. The results of this Atterberg limits test are shown on the plasticity chart on Figure B8 in Appendix B and indicate that the material can be classified as a silt of slight plasticity. The water content measured on seven samples of the clayey silt deposit ranges between about 26% and 41%, and on average is about 35%, which is generally above the liquid limit for the material. A water content measured on a silt seam recovered from Borehole ACC1-03 is about 37%.

#### **4.2.6 Silt**

A deposit of silt was encountered below the clayey silt deposit in all boreholes. The top of this deposit is at about Elevation 245.0 m near the west (inlet) end of the culvert and it dips down towards the east end of the culvert to about Elevation 240.3 m. The silt deposit is thicker near the inlet and outlet of the existing culvert (i.e., about 3.1 m



and 2.5 m thick, respectively) and is about 1.1 m thick below the Highway 532 embankment as encountered in Borehole ACC1-02.

The SPT 'N'-values measured within the silt deposit generally range between 7 blows and 22 blows per 0.3 m of penetration, indicating a generally loose to compact state of compactness; one higher SPT 'N'-value of 43 blows per 0.3 m of penetration may reflect the transition to denser soil at the base of the deposit in Borehole ACC1-03.

The water content measured on four samples of the silt deposit recovered from Boreholes ACC1-01 and ACC1-03 ranges between approximately 16% and 28%.

The results of grain size distribution tests carried out on two samples of the silt deposit are shown on Figure B9 in Appendix B.

Atterberg limits tests were carried out on two samples of the silt deposit recovered from Boreholes ACC1-01 and ACC1-03. The results of the Atterberg limits tests indicate that the material can be classified as a non-plastic silt.

#### **4.2.7 Sand to Gravelly Sand**

A granular deposit of sand to gravelly sand was encountered below the silt deposit in all boreholes. Cobbles were encountered within the sand deposit in Borehole ACC1-02. A rock core barrel was used to penetrate through the cobbly zone between approximately Elevations 242.2 m and 241.0 m in this borehole. The top of this deposit ranges between about Elevations 242.2 m and 237.8 m. The sand deposit was fully penetrated in Borehole ACC1-02 and is approximately 1.7 m thick. Boreholes ACC1-01 and ACC1-03 were terminated with the gravelly sand deposit at depths of about 8.2 m, corresponding to Elevation 240.9 m (upon encountering practical refusal to casing advancement), and 11.3 m, corresponding to Elevation 237.7 m, below the existing ground surface, respectively.

The SPT 'N'-values measured within the granular deposit range between 29 blows and 52 blows per 0.3 m of penetration, indicating a compact to very dense state of compactness.

The water content measured on three samples of the sand to gravelly sand deposit ranges between approximately 8% and 9%.

#### **4.2.8 Granite and Basalt (Bedrock)**

Bedrock was encountered below the lower deposit of sand in Borehole ACC1-02 advanced through the Highway 532 embankment. The top of the bedrock was encountered at a depth of about 11.5 m below existing ground surface, corresponding to Elevation 240.4 m. Borehole ACC1-01, advanced near the inlet of the proposed culvert, was terminated upon encountering practical refusal to casing advancement on inferred bedrock at a depth of about 8.2 m below existing ground surface, corresponding to Elevation 240.9 m.

Based on a review of the cored bedrock samples, the bedrock consists of granite and basalt. The upper 2.5 m of the bedrock is described as fresh, massive, pink, medium to coarse grained, faintly porous, very strong granite. The lower 0.3 m of bedrock is described as fresh, massive, black, fine grained, faintly porous, strong basalt. The bedrock details are presented on the drillhole record in Appendix B. A photograph of the bedrock core is shown on Figure B10 in Appendix B.

The Total Core Recovery (TCR) measured on the rock core samples ranges between about 88% and 100%, and the Solid Core Recovery (SCR) ranges between about 38% and 80%. The Rock Quality Designation (RQD) measured on the rock core samples ranges from about 75% to 100%, indicating a rock mass of good to excellent



quality as per Table 3.10 of CFEM (2006). An RQD value of 75% was measured within the upper 1.3 m of bedrock in Borehole ACC1-02 (Run 1), while RQD values of 100% were measured within the lower portion of bedrock (Runs 2 and 3), as shown on the drillhole record in Appendix A.

### 4.3 Groundwater Conditions

The water level was measured at the ground surface (corresponding to Elevation 249.1 m) and 0.8 m (corresponding to Elevation 248.2 m) below existing ground surface upon removal of drilling casing in Boreholes ACC1-01 and ACC1-03 (advanced near the inlet and outlet 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 ACC1-02 (advanced through the Highway 532 embankment) was measured upon completion of drilling at a depth of about 3.0 m below existing ground surface, corresponding to Elevation 248.9 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 248.0 m, which is similar to the 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 ACC1-03 (advanced near the outlet 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 <sub>4</sub> ) Content (ppm or μg/g)
ACC1-03 <sup>1</sup>	SA 2	0.9	247.1	Varved Silty Clay and Clayey Silt	15,000	69	6.2	24	64

Notes:

1. 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 0.52 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

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# PART B

FOUNDATION INVESTIGATION REPORT  
STRUCTURAL BUNDLE – 11 STRUCTURES ON HIGHWAYS 129, 532 AND  
556  
HIGHWAY 532 – ATKINSON CREEK CULVERT NO. 2 REPLACEMENT,  
10.5 KM NORTH OF HIGHWAY 556 (SITE NO. 38S-291C)  
GAUDETTE TOWNSHIP, ALGOMA DISTRICT, ONTARIO  
MINISTRY OF TRANSPORTATION, ONTARIO  
GWP 5378-11-00; WP 5261-13-03



## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the replacement of the Atkinson Creek Culvert No. 2 under Highway 532 (Site No. 38S-291C). 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 3.36 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 247.33 m and 247.15 m, respectively.

It is 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 two 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,  $\Psi$ , and geotechnical resistance factors,  $\phi_{gu}$  and  $\phi_{gs}$ , 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 247.0 m to 246.85 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.

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)	<ul style="list-style-type: none"><li>■ West portion of culvert/ culvert inlet: 0.3 m of compacted Granular 'A' material over generally firm to stiff clayey silt overlying loose to compact silt</li><li>■ Central portion of culvert: 0.3 m of compacted Granular 'A' material over loose to compact sand and gravel fill overlying stiff clayey silt</li><li>■ East portion of culvert/culvert outlet: 0.3 m of compacted Granular 'A' material over firm varved silty clay and clayey silt overlying firm to stiff clayey silt</li></ul>	150 kPa	80 kPa

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, shall be calculated in accordance with Section 6.10.5 of the CHBDC (2014). The unfactored coefficient of friction ( $\tan \delta$ ) and effective cohesion (where applicable) between the various interface materials is summarized below.

Interface Materials	Unfactored Coefficient of Friction ( $\tan \delta$ )	Effective Cohesion, $c'$
Precast concrete box culvert on Granular 'A' material	0.55	0 kPa
Granular 'A' material on existing sand and gravel fill (central portion of culvert)	0.67	0 kPa
Granular 'A' material on varved silty clay (east portion of culvert)	0.47 (long-term)	40 kPa (short-term)



Interface Materials	Unfactored Coefficient of Friction ( $\tan \delta$ )	Effective Cohesion, $c'$
Granular 'A' material on clayey silt (west portion of culvert)	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 <sup>1</sup>	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 5.7 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 gradation 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  $\mu\text{m}$ . 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 (based on the interpreted stratigraphy shown on Drawing 1), 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 <sup>3</sup>	0.41	0.26
New Granular 'B' Type II	21 kN/m <sup>3</sup>	0.41	0.26
Loose to Compact Gravelly Sand to Sand and Gravel (Fill)	22 kN/m <sup>3</sup>	0.44	0.28
Very Loose to Loose Silt to Sandy Silt to Sand	19 kN/m <sup>3</sup>	0.53	0.36
Firm Varved Silty Clay and Clayey Silt	18 kN/m <sup>3</sup>	0.58	0.41

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 platform widening is required along Highway 532 as part of the Atkinson Creek Culvert No. 2 replacement construction. Based on the cross-sections of the Highway 532 embankment provided by AECOM, the west and east 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) and 2H:1V, respectively, 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 2H:1V and 4.5H: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 10+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,  $\Psi$ , and the geotechnical resistance factor,  $\phi_{gu}$  (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 and varved silty clay/clayey silt deposits 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.



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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 ( $\phi'$ ) 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, $\gamma$	Effective Friction Angle, $\phi'$	Undrained Shear Strength, $s_u$
New Granular 'A' or Granular 'B' Type II	Hwy 532: ~251.9 m	Hwy 532: ~5.5 m	21 kN/m <sup>3</sup>	36°	--
Silt to Sandy Silt to Sand	East: ~249.0 m West: ~249.1 m	East: ~0.6 m West: ~1.8 m	19 kN/m <sup>3</sup>	28°	--
Varved Silty Clay and Clayey Silt	East: ~248.2 m	East: ~1.9 m	18 kN/m <sup>3</sup>	25°	40 kPa
Clayey Silt	247.3 m to 246.4 m	2.3 m to 6.2 m	18 kN/m <sup>3</sup>	28°	60 kPa
Silt	245.0 m to 240.3 m	1.1 m to 2.5 m	18 kN/m <sup>3</sup>	30°	--
Sand to Gravelly Sand	242.2 m to 237.8 m	~1.7 m (based on Borehole ACC1-02)	21 kN/m <sup>3</sup>	36°	--

For the purpose of the stability analyses, the groundwater level was assumed to be at the creek surface (i.e., at Elevation 248.0 m, as surveyed in June 2017).

### 6.5.2 Results of Analysis

The global 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 to sandy silt to sand (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 Factors of Safety associated with deep-seated, global failure surfaces of the slopes that would impact the operation of the highway are summarized below and shown on Figures 1 and 2.

Location	Inclination of Side Slope	Factor of Safety	
		Short-Term/Temporary Condition	Long-Term/Permanent Condition
East Side of Hwy 532	1.5H:1V	2.4	1.7
West Side of Hwy 532	2.0H:1V	1.3	1.3

The Factors of Safety associated with both the temporary/short-term and permanent/long-term conditions along the west side of the highway embankment are the same given that the potential failure surfaces associated with



the minimums Factors of Safety are confined within the embankment fill and do not extend into the underlying native deposit.

In order to satisfy a minimum Factor of Safety equal to or greater than 1.5 for the long-term/permanent along the west side of the highway embankment, it is recommended that the embankment side slopes should be covered with a minimum 1.0 m thick layer (measured perpendicular to the face of the slope and extending from the toe of the slope to Elevation 250.6 m) 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. Although a rip-rap layer is not necessarily required along the face of the slope on the east side of the embankment, a minimum 0.5 m thick layer should be included to protect the side slope from erosion.

## **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 246.5 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. As such, the temporary excavation will extend through the existing highway embankment fill as well as deposits of silt to sandy silt to sand, and varved silty clay and clayey silt.

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) and the firm varved silty clay and clayey silt encountered near the outlet of the existing culvert are classified as a Type 3 soils according to OHSA. The soils below the groundwater table/creek water level (i.e., bottom portion of the embankment fill – sand and 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 0.6 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., 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.

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). 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, $\gamma$	Internal Angle of Friction, $\phi'$	Undrained Shear Strength, $s_u$	Lateral Earth Pressure Coefficients <sup>1</sup>		
				$K_p$ (Passive) <sup>2</sup>	$K_o$ (At-Rest)	$K_a$ (Active)
Gravelly Sand to Sand and Gravel (Fill)	22 kN/m <sup>3</sup>	34°	--	3.54	0.44	0.28
Silt to Sandy Silt to Sand	19 kN/m <sup>3</sup>	28°	--	2.77	0.53	0.36
Varved Silty Clay and Clayey Silt	18 kN/m <sup>3</sup>	25°	40 kPa <sup>3</sup>	2.46	0.58	0.41
Clayey Silt	18 kN/m <sup>3</sup>	28°	60 kPa <sup>3</sup>	2.77	0.53	0.36
Silt	18 kN/m <sup>3</sup>	30°	--	3.00	0.50	0.33
Sand to Gravelly Sand	21 kN/m <sup>3</sup>	36°	--	3.85	0.41	0.26

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 ( $\phi'$ ) and undrained ( $s_u$ ) cases should be made to establish the more conservative earth pressure condition for design.
4. Bedrock was encountered at about Elevation 240.4 m in Borehole ACC1-02 (below the lower sand deposit) and practical refusal to casing advancement was encountered at about Elevation 240.9 m in Borehole ACC1-01 (within the lower gravelly sand deposit near the inlet of the existing culvert).

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 and the lower sand deposit (if sheet piles extend below a depth of about 9.8 m, corresponding to approximately Elevation 242.2 m). 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 to sandy silt to 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<sup>3</sup>/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, 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 overall project 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 order to reduce dewatering and temporary shoring requirements, the bottom portion of the granular pad (i.e., below the base of the 0.3 m thick bedding) could be constructed in wet conditions by end-dumping the granular material comprised of Granular 'B' Type II material. The overlying 0.3 m thick bedding layer 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 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 ACC1-03 (advanced near the outlet 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 15,000 ohm-cm. These results indicate “non-corrosive” soils (i.e., resistivity above 10,000 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 0.0024%, 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 6.2, 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

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MTO Foundations Designated Contact, Principal

TZ/LCC/tz

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<https://golderassociates.sharepoint.com/sites/14262g/deliverables/04-final fidr/atkinson creek culvert no. 2/1670846-10-rpt-rev0-atkinson creek culvert no. 2 fidr-20181109.docx>



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- McQuay, D.F. 1980. Sault Ste. Marie Area (NTS 41K/NE), District of Algoma; Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 91, 21p. Accompanied by Maps 5012 and 5013, Scale 1:100000.
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- Ontario Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2544.
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### **ASTM International:**

- ASTM D1586                      Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- ASTM D2573                      Standard Test Method for Field Vane Shear Strength Test in Cohesive Soil

### **Canadian Standards Association (CSA):**

- 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 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

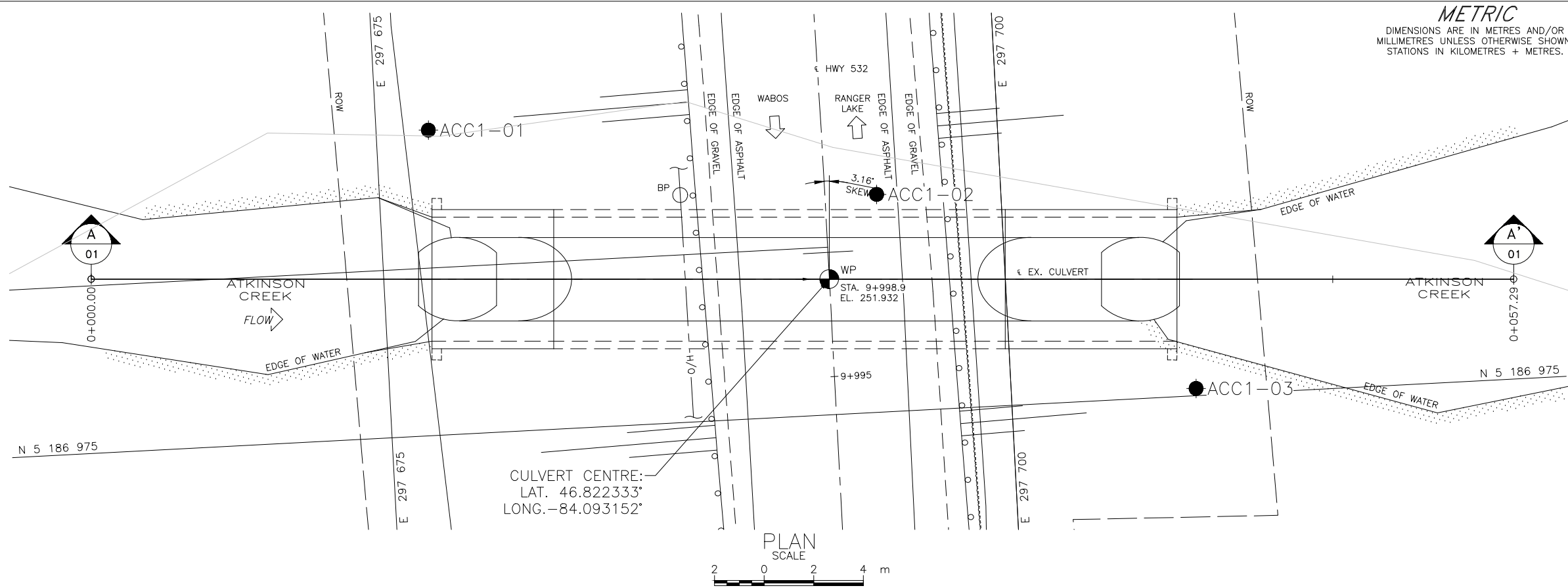
**Ontario Regulations:**

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

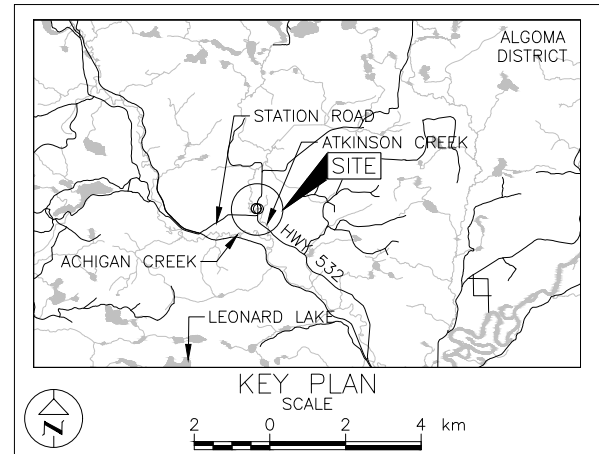




**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No.5261-13-03

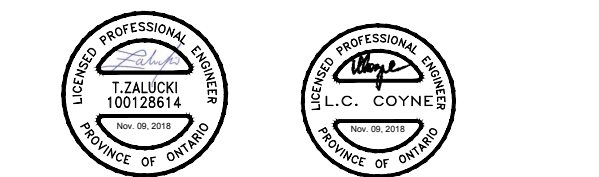
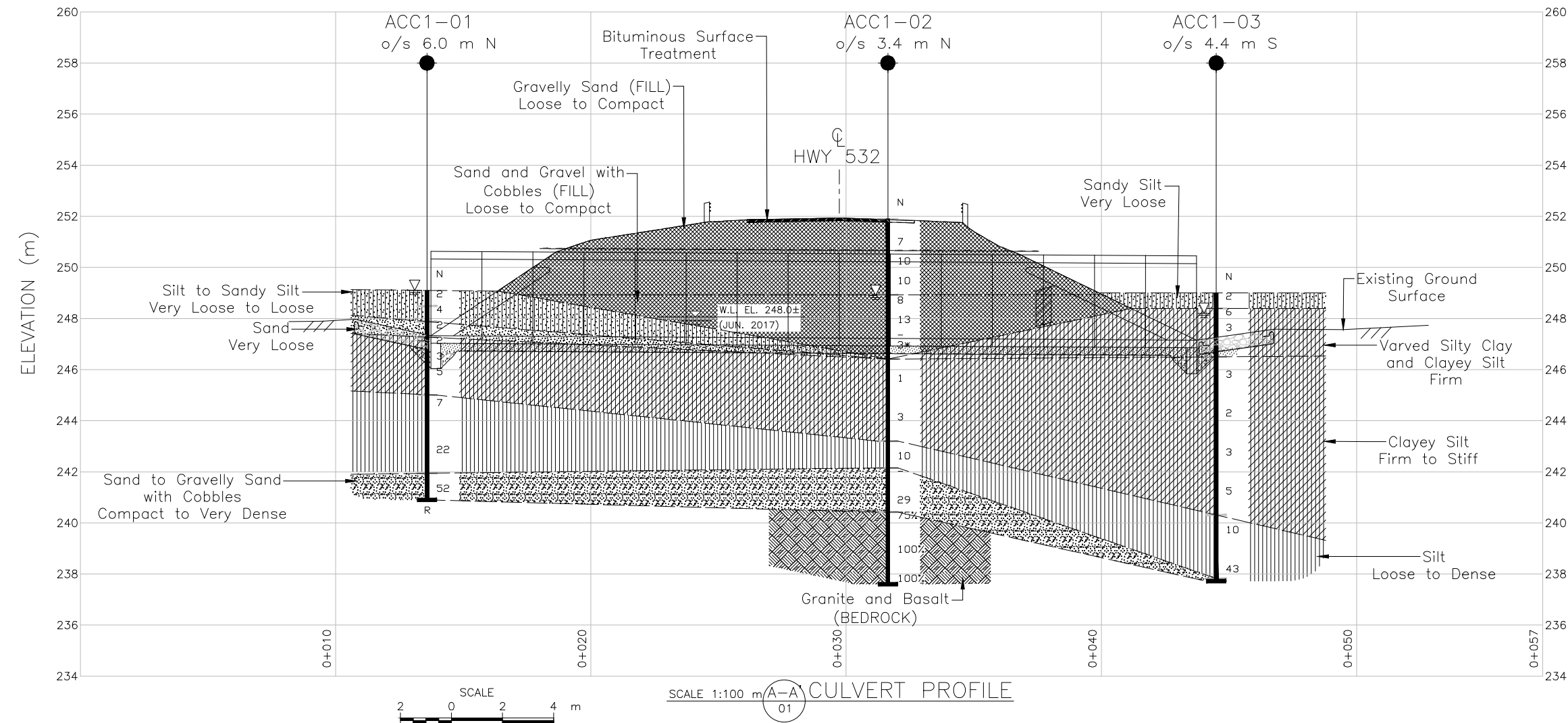
HIGHWAY 532  
ATKINSON CREEK CULVERT NO. 2  
BOREHOLE LOCATIONS AND SOIL  
STRATA



LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- WL upon completion of drilling
- R Refusal

BOREHOLE CO-ORDINATES (MTM NAD83 ZONE 13)			
No.	ELEVATION	NORTHING	EASTING
ACC1-01	249.1	5186987.3	297677.1
ACC1-02	251.9	5186983.8	297695.0
ACC1-03	249.0	5186975.3	297707.4



**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-P70.dwg", received June 7, 2018.

NO.	DATE	BY	REVISION
Geocres No. 41K-111			
HWY. 532	PROJECT NO. 1670846		DIST. ALGOMA
SUBM'D. AK	CHKD. TZ	DATE: 11/8/2018	SITE: 38S-291C
DRAWN: SMD	CHKD. LCC	APPD. LCC	DWG. 01

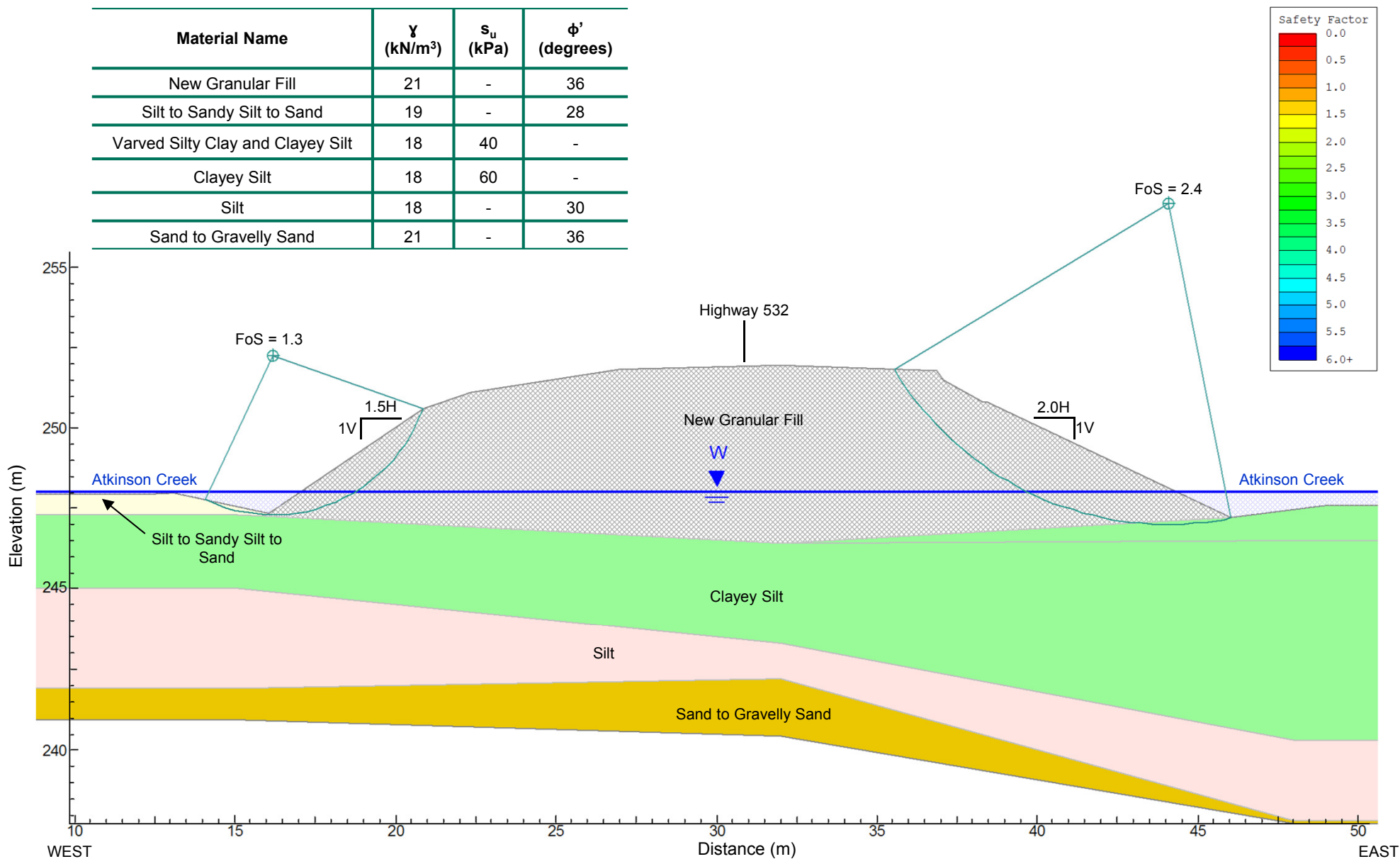


# FIGURES



# Highway 532 – Atkinson Creek Culvert No. 2 Replacement Global Slope Stability (Temporary/Short-Term Condition) Highway Embankment at Station 10+000

Figure 1



Date: November 9, 2018

Project No: 1670846

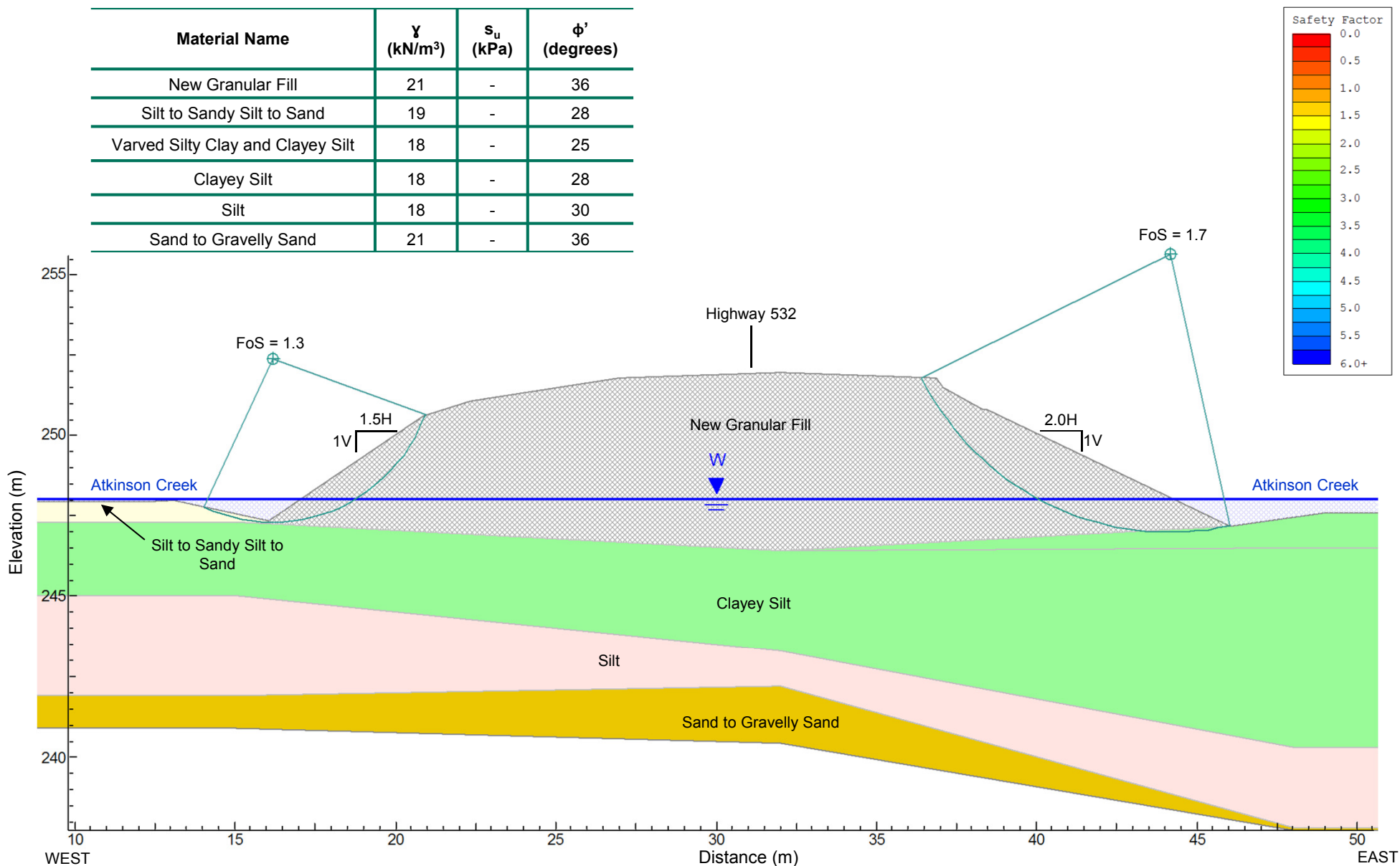
Analysis By: TZ Reviewed By: LCC





# Highway 532 – Atkinson Creek Culvert No. 2 Replacement Global Slope Stability (Permanent/Long-Term Condition) Highway Embankment at Station 10+000

Figure 2



Date: November 9, 2018

Project No: 1670846

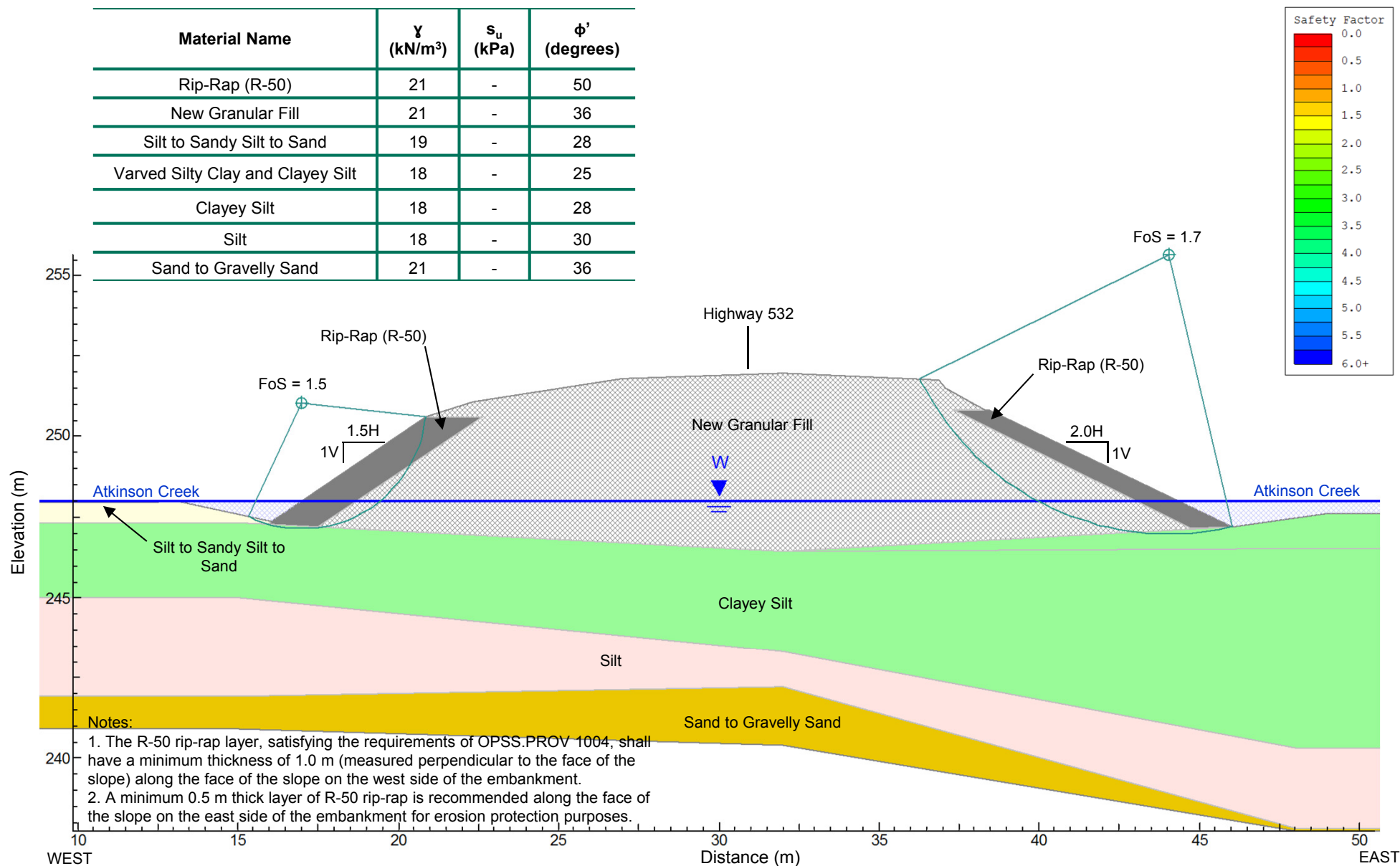
Analysis By: TZ Reviewed By: LCC





# Highway 532 – Atkinson Creek Culvert No. 2 Replacement Global Slope Stability (Permanent/Long-Term Condition) Highway Embankment at Station 10+000 (with Rip-Rap Slope Protection)

Figure 3





# APPENDIX A

## Borehole and Drillhole Records





## LIST OF SYMBOLS

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

### I. GENERAL

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	Poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

<b>(a)</b>	<b>Index Properties</b>
$\rho(\gamma)$	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
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

### (a) Index Properties (continued)

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

### (b) Hydraulic Properties

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

### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_{\alpha}$	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
$\sigma'_p$	pre-consolidation stress
OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$

### (d) Shear Strength

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

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

Notes: 1  
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



## 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, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> 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

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	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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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 <sub>4</sub>	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	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 With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

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

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

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

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

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

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

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

### GRAIN SIZE

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

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

### CORE CONDITION

#### Total Core Recovery (TCR)

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

#### Solid Core Recovery (SCR)

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

#### Rock Quality Designation (RQD)

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

### DISCONTINUITY DATA

#### Fracture Index

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

#### Dip with Respect to Core Axis

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

#### Description and Notes

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

#### Abbreviations

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

PROJECT 1670846		RECORD OF BOREHOLE No ACC1-01				SHEET 1 OF 1		METRIC								
W.P. 5261-13-03		LOCATION N 5186987.3; E 297677.1 MTM NAD 83 ZONE 13 (LAT. 46.822395; LONG. -84.093359)				ORIGINATED BY AJ										
DIST ALGOMA HWY 556		BOREHOLE TYPE Portable Equipment - Wash Boring; BW Casing				COMPILED BY AK										
DATUM Geodetic		DATE August 27 to 29, 2017				CHECKED BY TZ										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
249.1	GROUND SURFACE							20	40	60	80	100				
0.0	Sandy SILT, trace clay, trace wood fragments and organics		1	SS	2		249									
248.5	Very loose Brown Moist		2	SS	4		248									
0.6	SILT, some sand, trace gravel, trace clay, trace organics		3	SS	2											
247.9	Very loose to loose Brown Wet		4	SS	2		247									
1.2	SAND, some gravel, trace silt, trace organics		5	SS	3											
247.3	Very loose Brown Wet		6	SS	5		246									
1.8	CLAYEY SILT, trace to some sand, trace to some gravel															
	Firm to stiff Brown to grey Wet															
	- Grey below a depth of about 2.4 m															
245.0	SILT, trace sand, trace clay		7	SS	7		245									
4.1	Loose to compact Grey Wet						244									
							243									
			8	SS	22		242									
241.9	Gravelly sand, trace silt															
7.2	Very dense Grey Wet		9	SS	52		241									
240.9	CASING REFUSAL END OF BOREHOLE															
8.2	NOTES:  1. Borehole ACC1-01 was advanced near the inlet of the existing Atkinson Creek Culvert (on the west side of Highway 532).  2. The threaded portion of the steel NW casing sheared during borehole advancement. It was not possible to retrieve the casing despite multiple attempts. The casing was abandoned in the borehole between depths of about 6.1 m and 9.1 m below the existing ground surface.  3. Water level measured at ground surface (Elev. 249.1 m) upon completion of drilling prior to casing removal.															

GTA-MTO 001 \GOLDER\GDS\GAL\MISSISSAUGA\CLIENTS\IMTOS\SAULT\_STE\_MARIE\GPJ\_GAL-GTA.GDT 11/8/18

PROJECT		1670846		RECORD OF BOREHOLE		No ACC1-02		SHEET 1 OF 3		METRIC						
W.P.		5261-13-03		LOCATION		N 5186983.8; E 297695.0 MTM NAD 83 ZONE 13 (LAT. 46.822363; LONG. -84.093124)		ORIGINATED BY		AJ						
DIST		ALGOMA HWY 556		BOREHOLE TYPE		210 mm O.D. Hollow Stem Augers; NQ Rock Coring		COMPILED BY		AK						
DATUM		Geodetic		DATE		September 8 and 9, 2017		CHECKED BY		TZ						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
251.9	GROUND SURFACE															
0.0	Bituminous Surface Treatment (13 mm) Gravelly sand, trace to some silt (FILL) Loose to compact Brown Moist		1	SS	7											
			2	SS	10											
			3	SS	10											
248.9																
3.0	Sand and gravel, trace to some silt, with cobbles (FILL) Loose to compact Grey, black and red Wet		4	SS	8											28 63 9 0
			5	SS	13											
			-	RC	-											
			6	SS	3*											
246.4																
5.5	CLAYEY SILT, trace sand Stiff Grey Wet		7	SS	1											0 5 84 11
			8	SS	3											
243.2																
8.7	SILT, trace to some sand Loose to compact Grey Wet		9	SS	10											
242.2																
9.8	SAND, some gravel, trace silt, with cobbles Compact Grey Wet		-	RC	-											
			10	SS	29											
240.4																
11.5	GRANITE AND BASALT (BEDROCK)  Bedrock cored between depths of about 11.5 m and 14.3 m.  For bedrock coring details, refer to Record of Drillhole ACC1-02.		1	RC	REC 88%											RQD = 75%
			2	RC	REC 100%											RQD = 100%
			3	RC	REC 100%											RQD = 100%
237.6																
14.3	END OF BOREHOLE															

Continued Next Page

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

GTA-MTO 001 \GOLDER\GDS\GAL\MISSISSAUGA\CLIENTS\MTOS\SAULT\_STE\_MARIE02\_DATAGINT\SAULT\_STE\_MARIE.GPJ GAL-GTA.GDT 11/8/18

PROJECT <u>1670846</u>		<b>RECORD OF BOREHOLE No ACC1-02</b>				SHEET 2 OF 3		<b>METRIC</b>																
W.P. <u>5261-13-03</u>		LOCATION <u>N 5186983.8; E 297695.0 MTM NAD 83 ZONE 13 (LAT. 46.822363; LONG. -84.093124)</u>				ORIGINATED BY <u>AJ</u>																		
DIST <u>ALGOMA</u> HWY <u>556</u>		BOREHOLE TYPE <u>210 mm O.D. Hollow Stem Augers; NQ Rock Coring</u>				COMPILED BY <u>AK</u>																		
DATUM <u>Geodetic</u>		DATE <u>September 8 and 9, 2017</u>				CHECKED BY <u>TZ</u>																		
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa																
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60</span> <span>20 40 60</span> </div>												
	NOTES:  1. Borehole ACC1-02 was advanced on the northbound lane of Highway 532 to the north of the existing Atkinson Creek Culvert.  2. Water level measured at a depth of about 3.0 m below existing ground surface (Elev. 248.9 m) inside the augers upon completion of drilling.  * The low SPT 'N'-value is likely attributed to sample disturbance as a result of coring immediately above the split-spoon sample.																							

GTA-MTO 001 \GOLDER\GDS\GAL\MISSISSAUGA\CLIENTS\IMTO\SAULT\_STE\_MARIE\GPJ\_GAL-GTA.GDT 11/8/18



SHEET 3 OF 3

DATUM: Geodetic

DRILLING CONTRACTOR: Landcore Drilling

STA-RCK 026 \\GOLDER.GDS\GAL\MISSISSAUGA\SIM\CLIENTS\MTOSAULT STE MARIE\GPJ GAL-MISS.GDT 11/8/18

CHECKED: TZ

PROJECT		1670846		RECORD OF BOREHOLE		No ACC1-03		SHEET 1 OF 2		METRIC				
W.P.		5261-13-03		LOCATION		N 5186975.3; E 297707.4 MTM NAD 83 ZONE 13 (LAT. 46.822287; LONG. -84.092961)		ORIGINATED BY		KN				
DIST		ALGOMA HWY 556		BOREHOLE TYPE		Portable Equipment - Wash Boring; NW Casing		COMPILED BY		AK				
DATUM		Geodetic		DATE		September 7, 2017		CHECKED BY		TZ				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
249.0	GROUND SURFACE													
0.0	Sandy SILT, trace clay, trace wood fragments and organics		1	SS	2									
248.4	Very loose Brown Moist		2	SS	6									
0.6	Varved SILTY CLAY and CLAYEY SILT, trace sand		3	SS	3									
	Firm Brown Wet													
246.5	CLAYEY SILT, trace sand		4	SS	3									
2.5	Firm to stiff Grey Wet		5	SS	2									
	- Silt seam encountered at a depth of about 6.4 m		6	SS	3									
			7	SS	5									
240.3	SILT, trace clay		8	SS	10									
8.7	Compact to dense Grey Wet		9A	SS	43									
			9B											
237.8	Gravelly SAND, some silt, trace clay													
11.3	Dense Grey Wet													
	END OF BOREHOLE													
NOTES: 1. Borehole ACC1-03 was advanced near the outlet of the existing Atkinson Creek Culvert (on the east side of Highway 532). 2. Borehole caved to a depth of about 8.0 m below existing ground surface (Elev. 241.0 m) upon removal of casing.														

Continued Next Page

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

GTA-MTO 001 \GOLDER\GDS\GAL\MISSISSAUGA\CLIENTS\IMTOS\SAULT\_STE\_MARIE\GPJ\_GAL-GTA.GDT 11/8/18

PROJECT <u>1670846</u>		<b>RECORD OF BOREHOLE No ACC1-03</b>				SHEET 2 OF 2		<b>METRIC</b>													
W.P. <u>5261-13-03</u>		LOCATION <u>N 5186975.3; E 297707.4 MTM NAD 83 ZONE 13 (LAT. 46.822287; LONG. -84.092961)</u>				ORIGINATED BY <u>KN</u>															
DIST <u>ALGOMA</u> HWY <u>556</u>		BOREHOLE TYPE <u>Portable Equipment - Wash Boring; NW Casing</u>				COMPILED BY <u>AK</u>															
DATUM <u>Geodetic</u>		DATE <u>September 7, 2017</u>				CHECKED BY <u>TZ</u>															
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa													
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> <span>20 40 60 80 100</span> <span>20 40 60 80 100</span> </div> <div style="display: flex; justify-content: space-between;"> <span>○ UNCONFINED</span> <span>+ FIELD VANE</span> </div> <div style="display: flex; justify-content: space-between;"> <span>● QUICK TRIAXIAL</span> <span>× REMOULDED</span> </div>					<div style="display: flex; justify-content: space-between;"> <span>20 40 60</span> <span>20 40 60</span> </div>									
	3. Water level measured at a depth of about 0.8 m below existing ground surface (Elev. 248.2 m) upon removal of casing.																				

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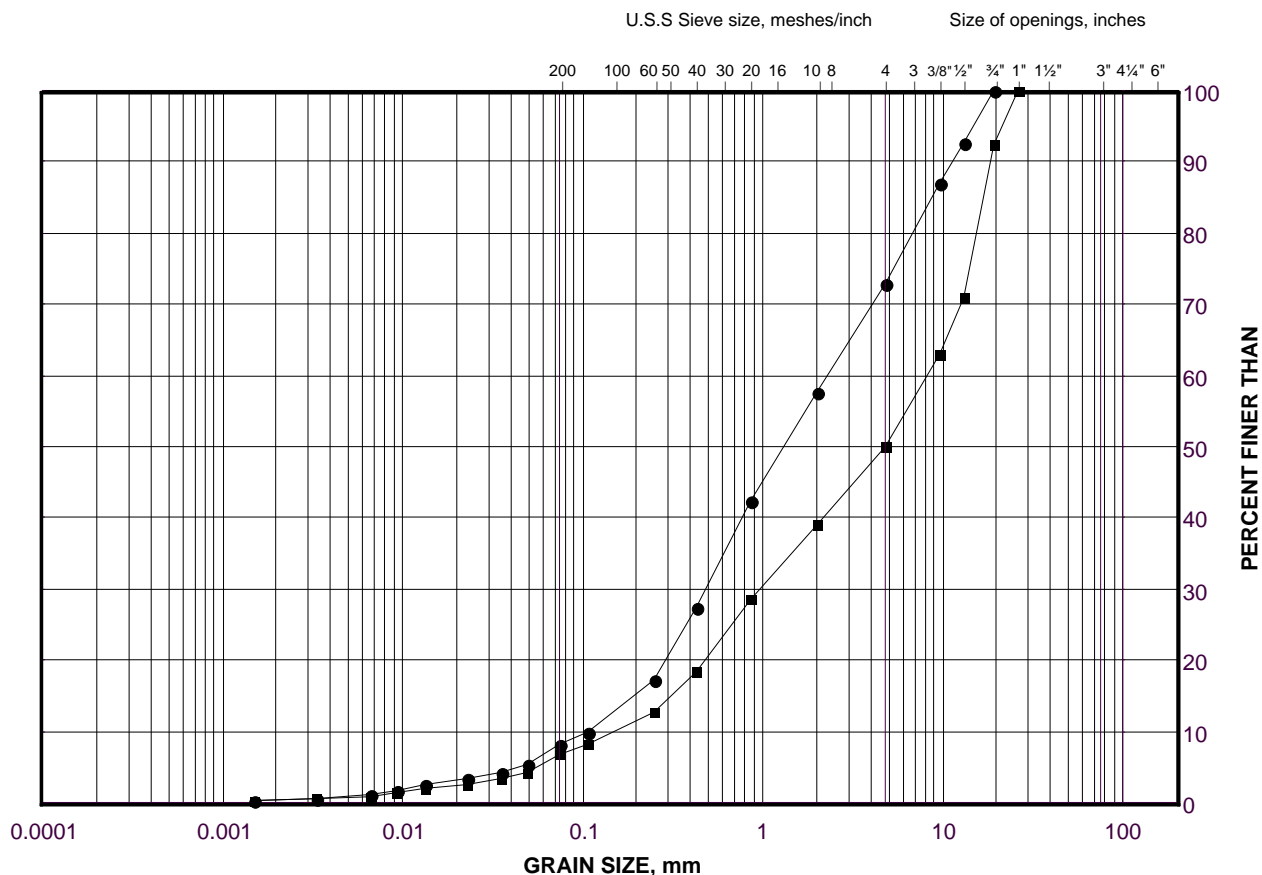
# APPENDIX B

## Geotechnical Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

Gravelly Sand to Sand and Gravel (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)
●	ACC1-02	3	249.3
■	ACC1-02	5	247.8

Project Number: 1670846

Checked By: TZ

**Golder Associates**

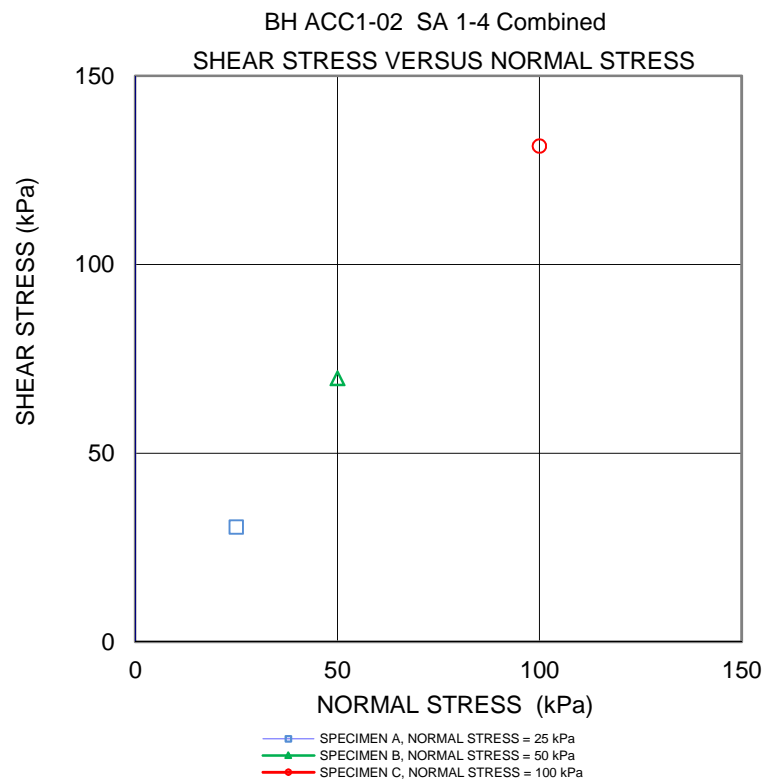
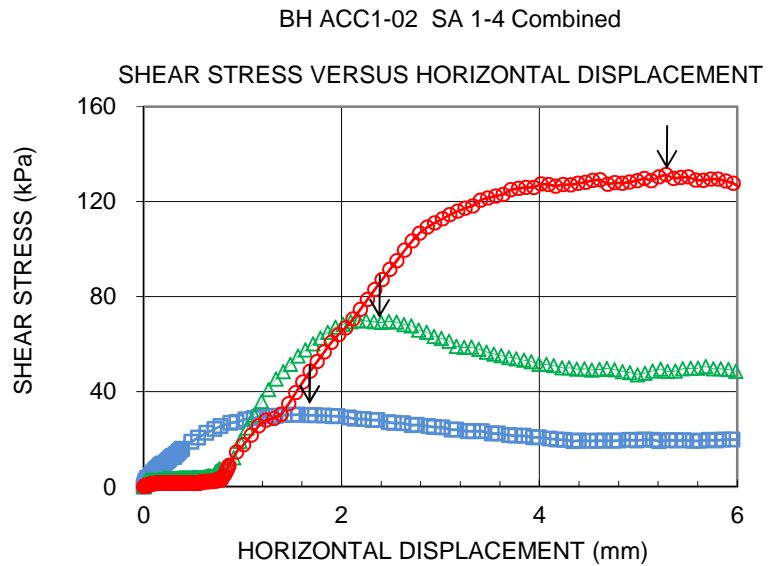
Date: 10-Jul-18

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 1 OF 3		FIGURE B2A		
TEST STAGE	A	B	C	
BOREHOLE NUMBER	ACC1-02			
SAMPLE	1-4 Combined			
SAMPLE DEPTH, (m)	-			
SAMPLE HEIGHT, (mm)	2.72	2.72	2.75	
SAMPLE LENGTH, (mm)	60.00	60.00	60.00	
WATER CONTENT, BEFORE TEST, (%)	10.43	10.43	10.43	
NORMAL (CONSOLIDATION) STRESS, (kPa)	25	50	100	
WATER CONTENT, AFTER TEST, (%)	12.55	13.05	12.67	
DISPLACEMENT RATE, mm/min	0.024	0.024	0.024	
TIME TO FAILURE, hours	1.1	1.5	3.7	
PEAK SHEAR STRESS <sup>1</sup> , (kPa)	30.3	69.8	131.4	
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.6	2.2	5.3	
DRY DENSITY, initial, Mg/m <sup>3</sup>	1.855	1.865	1.855	
WET DENSITY, initial, Mg/m <sup>3</sup>	2.048	2.06	2.049	
TEST NOTES:				
<div><div><sup>1</sup></div><div>In the absence of a peak, the shear stress reported is at 10% relative to horizontal displacement (ASTM D3080).</div></div>				
<div><div><sup>2</sup></div><div>Specimens compacted to a target density of 2.07 g/cm<sup>3</sup> at 10% moisture content; achieved 99% compaction</div></div>				
<div><div><sup>4</sup></div><div>Direct Shear Tests carried out under submerged conditions.</div></div>				
Date: 7/25/2018		Prepared By: LH		
Project No. 1670846		Checked By: TZ		
Golder Associates Ltd.				



**CONSOLIDATED DRAINED DIRECT SHEAR TEST**  
**SHEET 2 OF 3**

**FIGURE B2B**



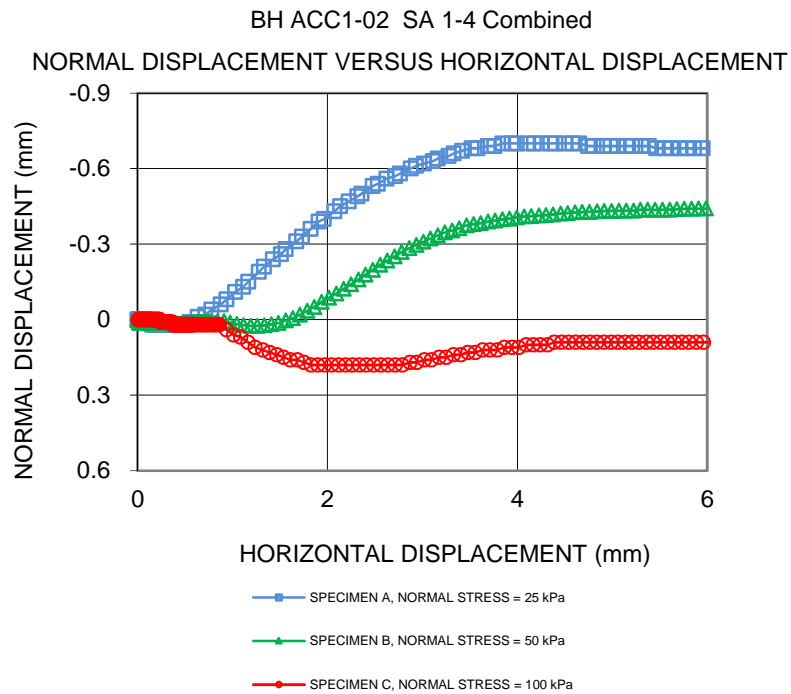
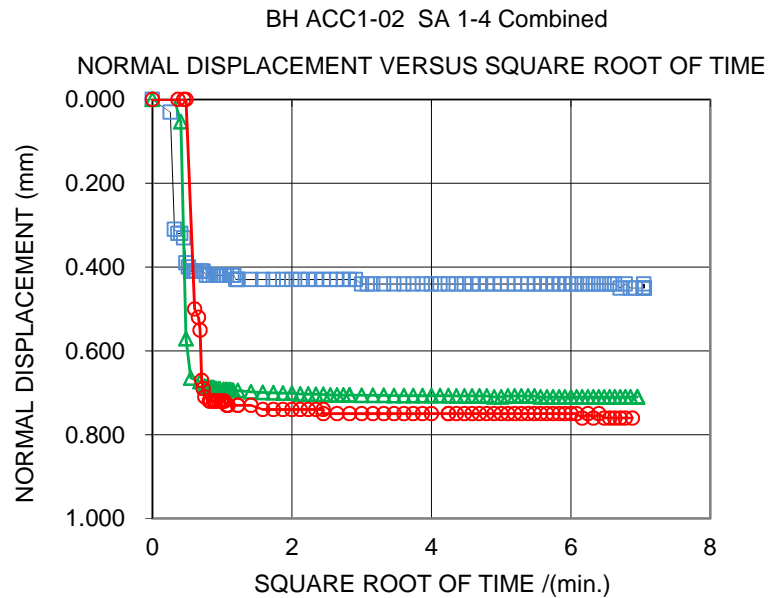
Date: 7/25/2018  
Project No. 1670846

**Golder Associates Ltd.**

Prepared By: LH  
Checked By: TZ

**CONSOLIDATED DRAINED DIRECT SHEAR TEST**  
**SHEET 3 OF 3**

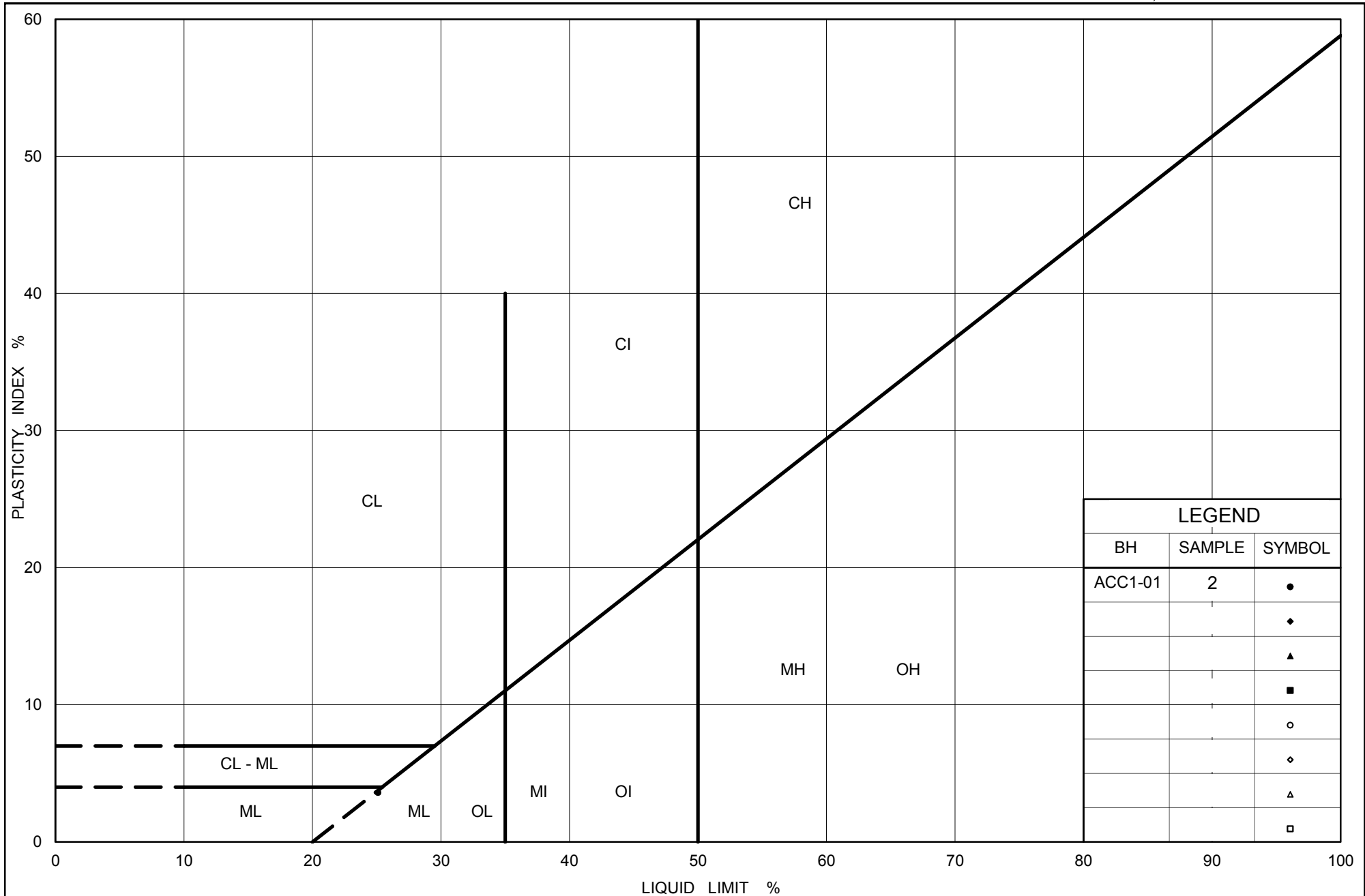
**FIGURE B2C**



Date: 7/25/2018  
Project No. 1670846

**Golder Associates Ltd.**

Prepared By: LH  
Checked By: TZ



Ministry of Transportation

Ontario

# PLASTICITY CHART Silt of Slight Plasticity

Figure No. B3

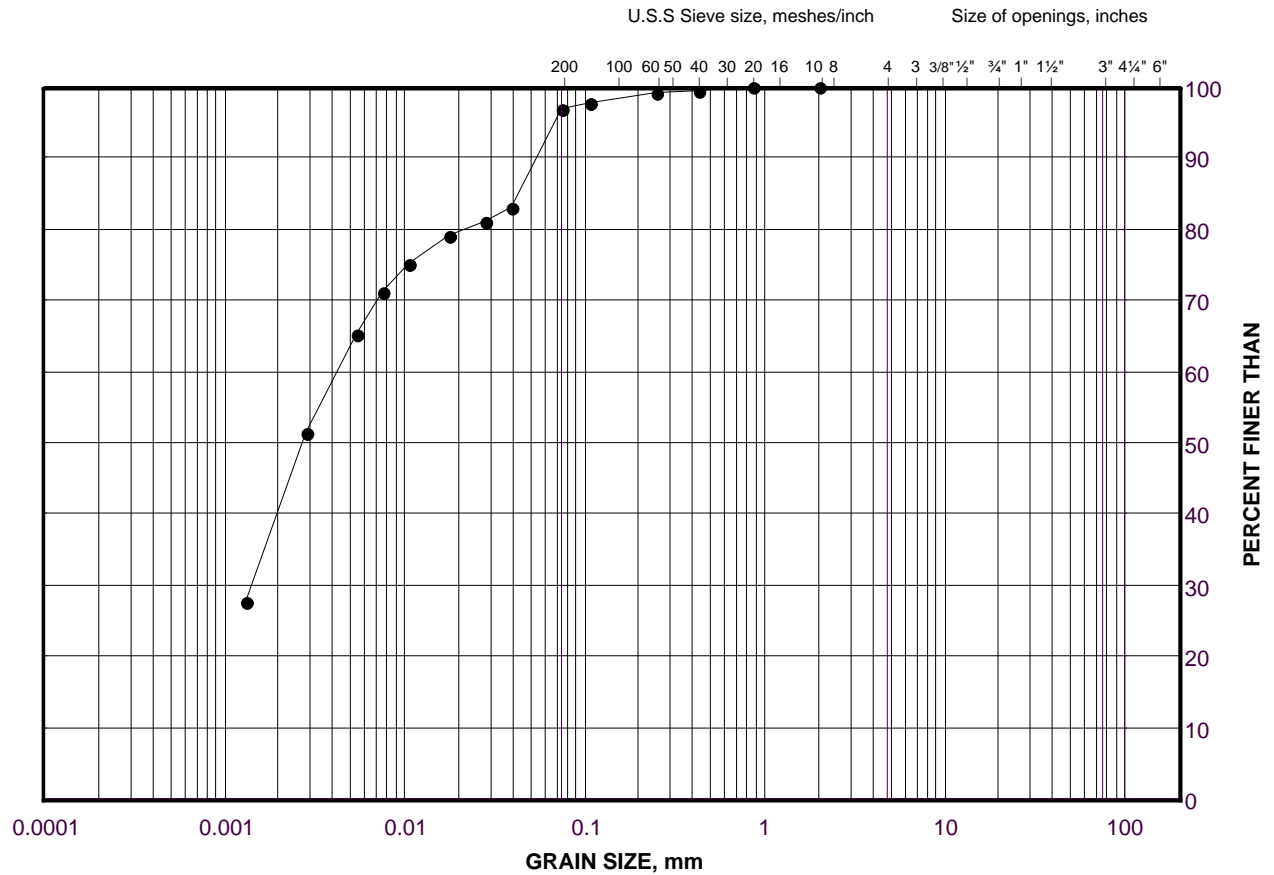
Project No. 1670846

Checked By: TZ

# GRAIN SIZE DISTRIBUTION

Varved Silty Clay and Clayey Silt

FIGURE B4



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

## LEGEND

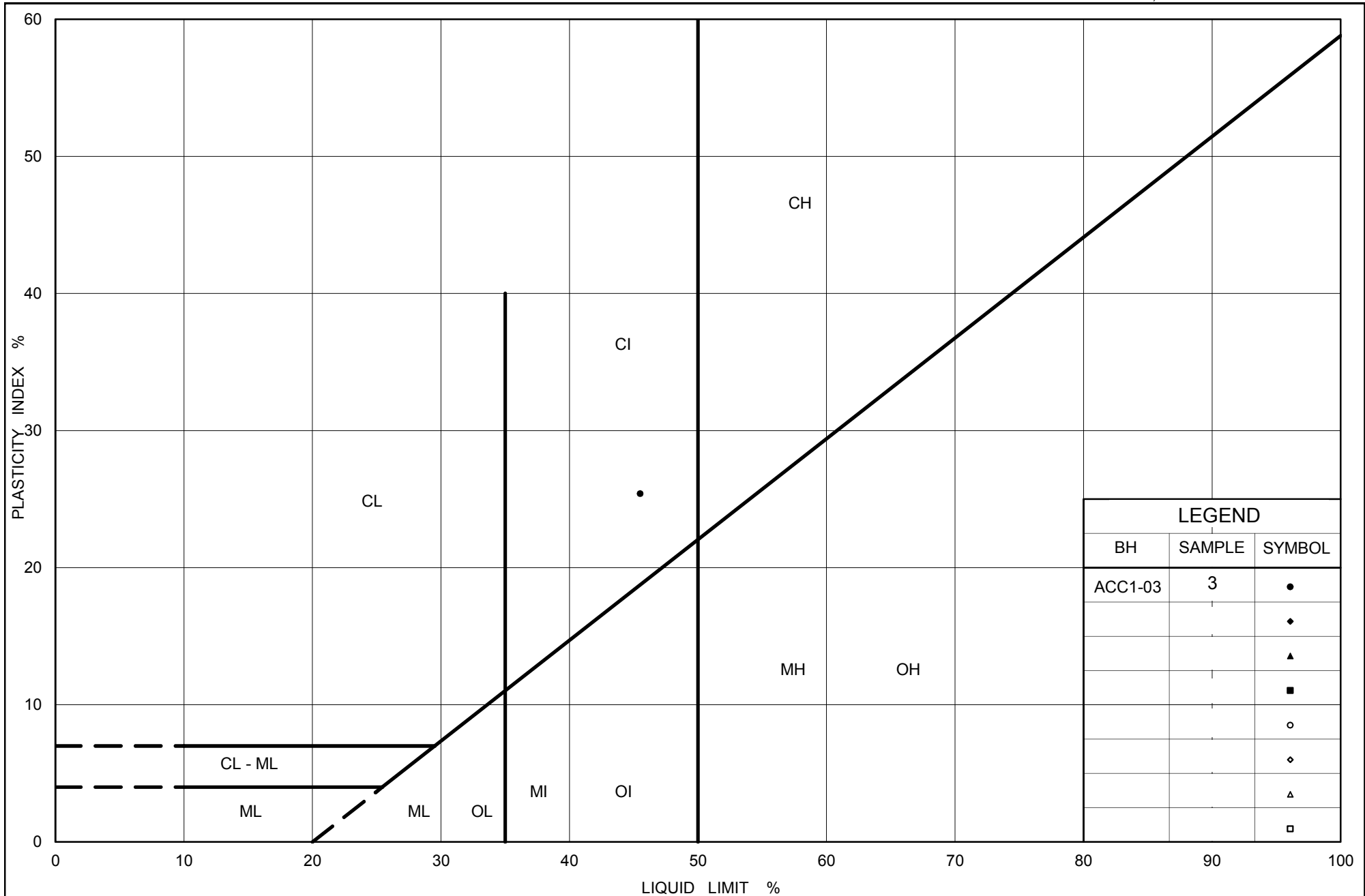
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
•	ACC1-03	3	247.5

Project Number: 1670846

Checked By: TZ

**Golder Associates**

Date: 03-Jul-18



Ministry of Transportation

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## PLASTICITY CHART

### Silty Clay Laminae

Figure No. B5

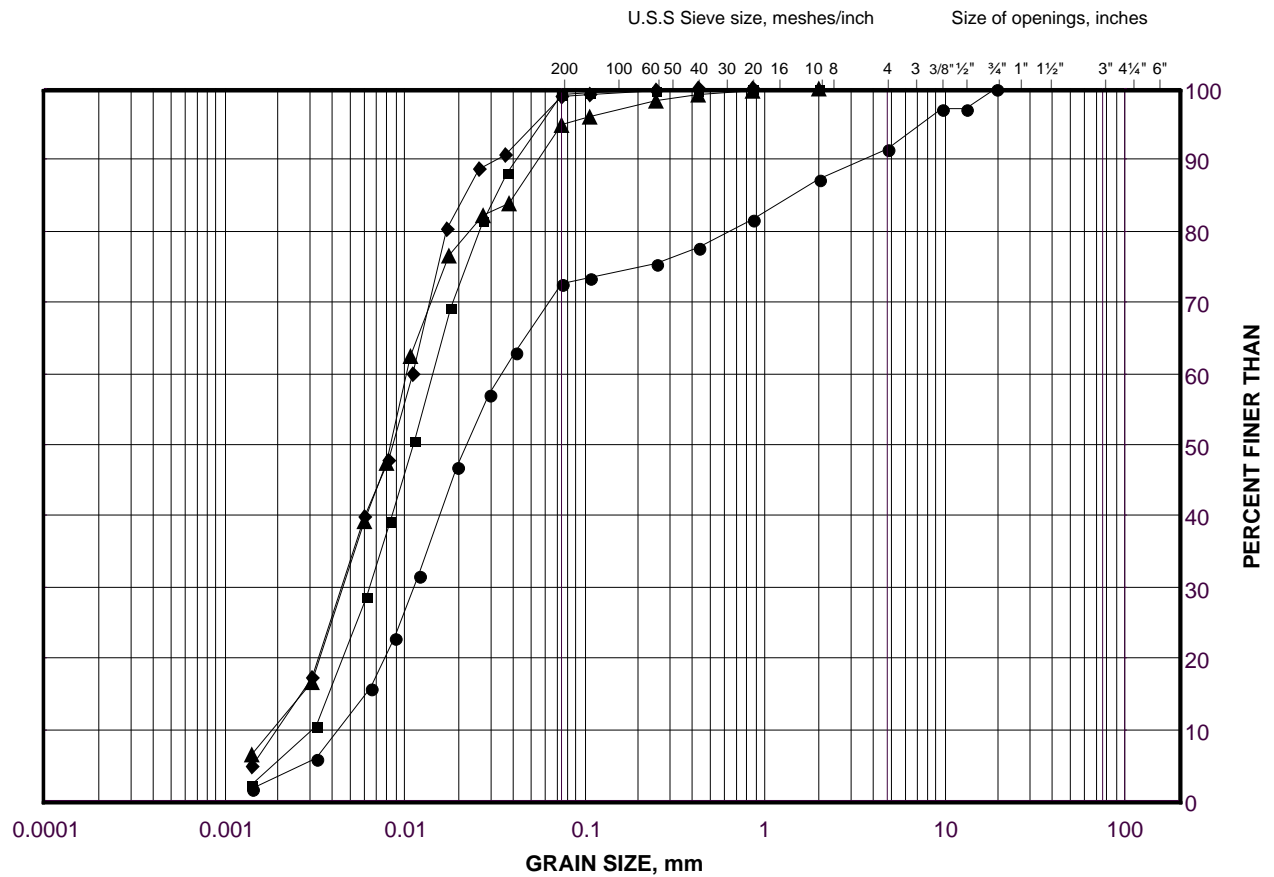
Project No. 1670846

Checked By: TZ

# GRAIN SIZE DISTRIBUTION

Clayey Silt

FIGURE B6



## LEGEND

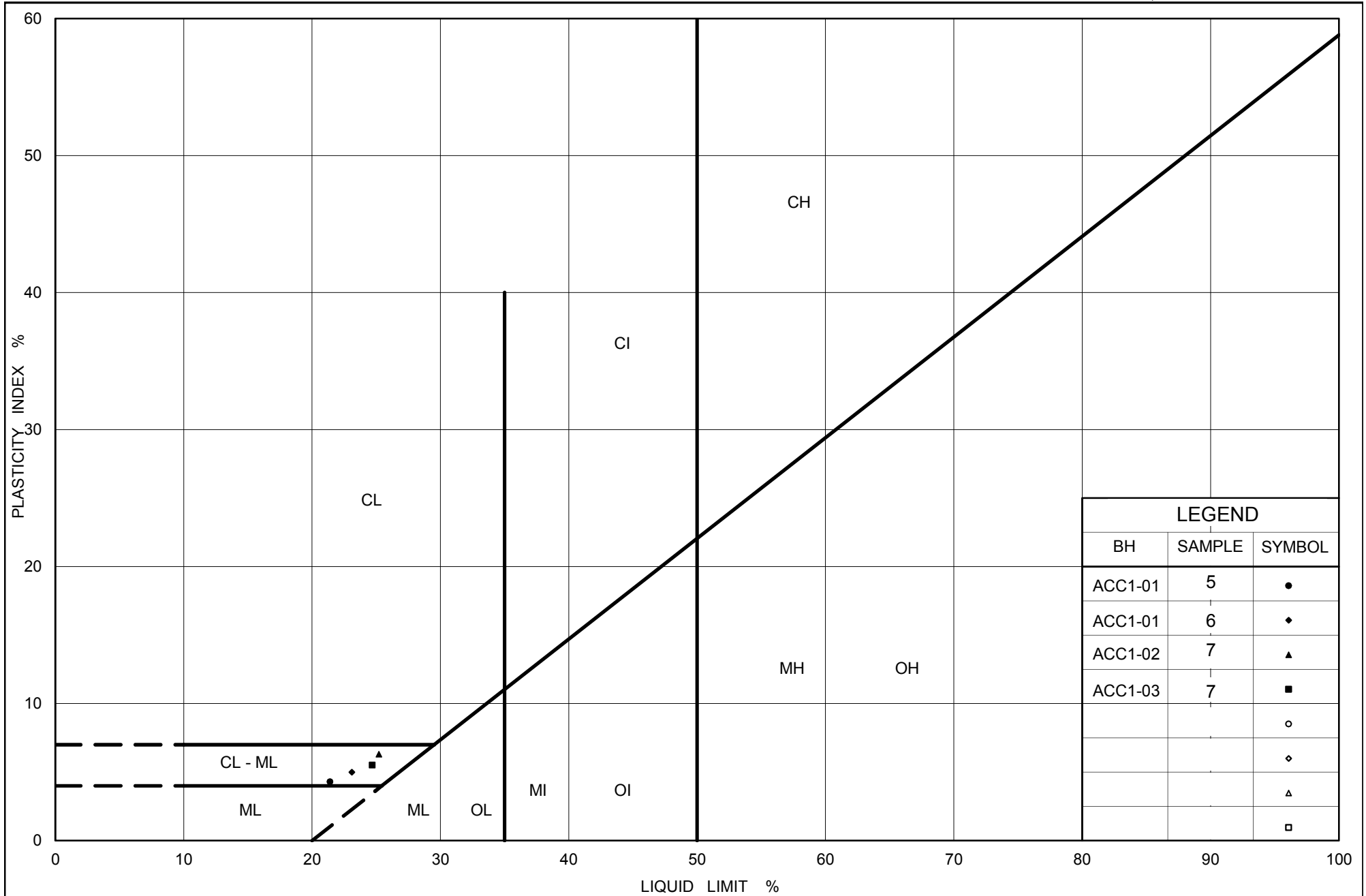
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	ACC1-01	5	246.4
■	ACC1-01	6	245.8
◆	ACC1-03	7	241.1
▲	ACC1-02	7	245.5

Project Number: 1670846

Checked By: TZ

**Golder Associates**

Date: 03-Jul-18



Ministry of Transportation

Ontario

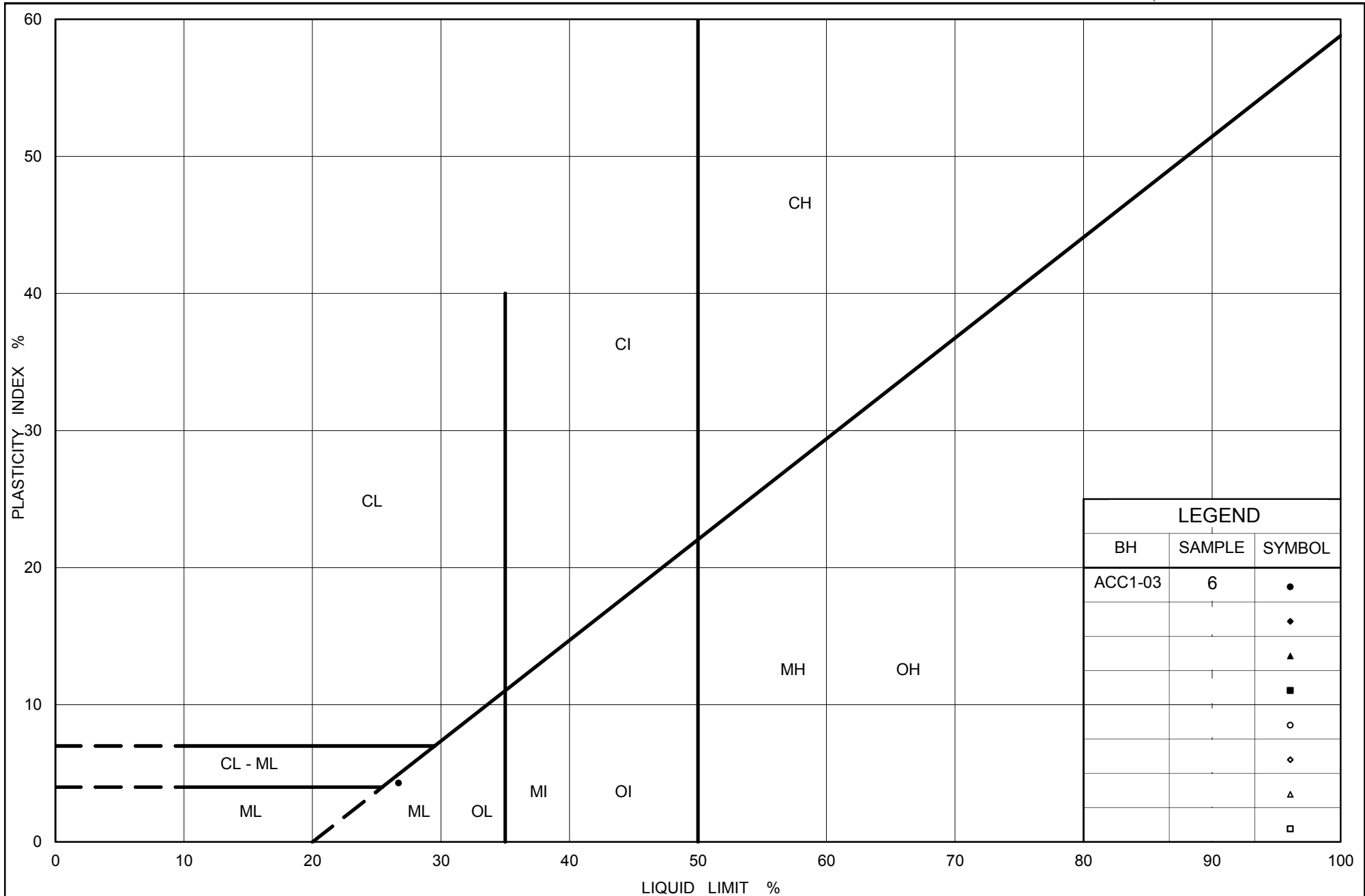
# PLASTICITY CHART Clayey Silt

Figure No. B7

Project No. 1670846

Checked By: TZ





Ministry of Transportation

Ontario

# PLASTICITY CHART Silt of Slight Plasticity (Seam)

Figure No. B8

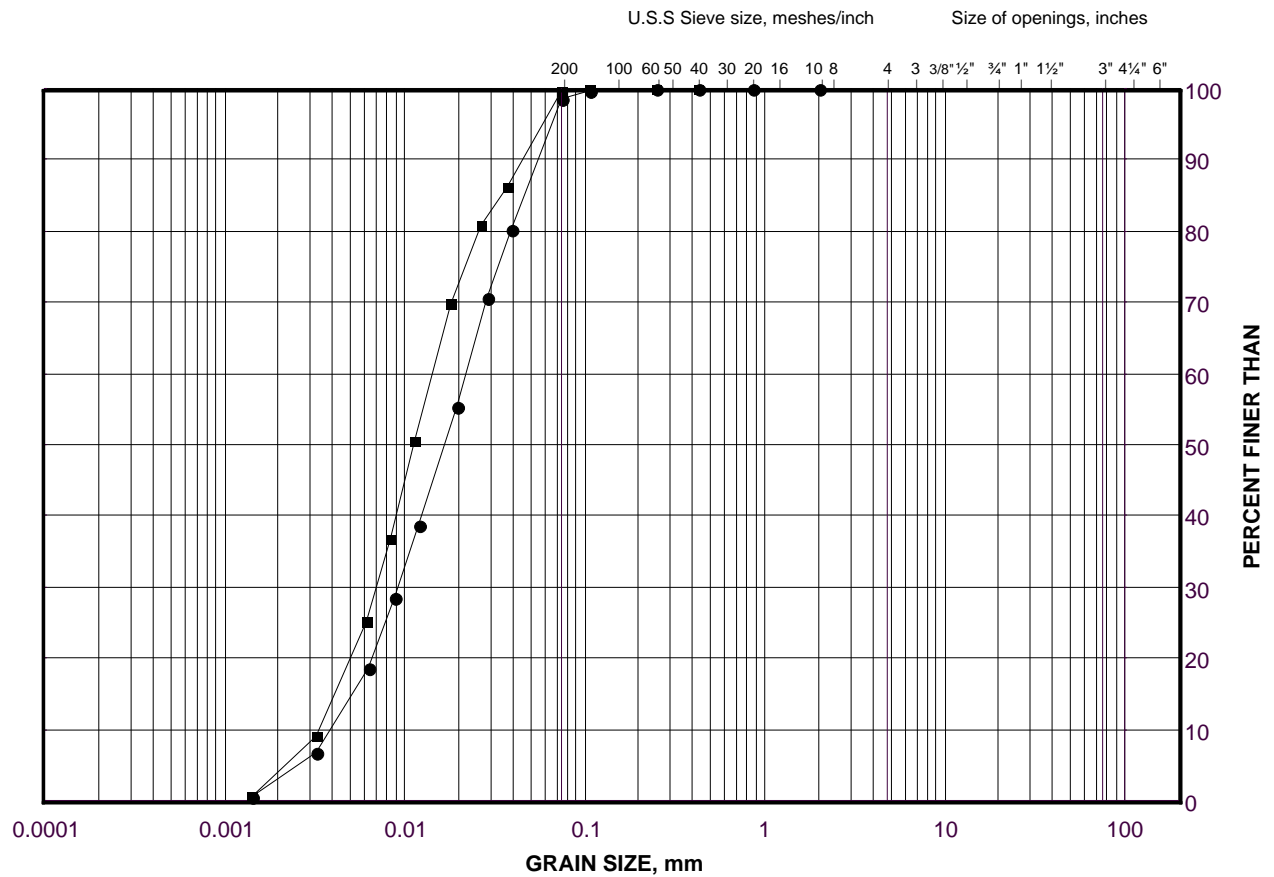
Project No. 1670846

Checked By: TZ

# GRAIN SIZE DISTRIBUTION

Silt

FIGURE B9



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

## LEGEND

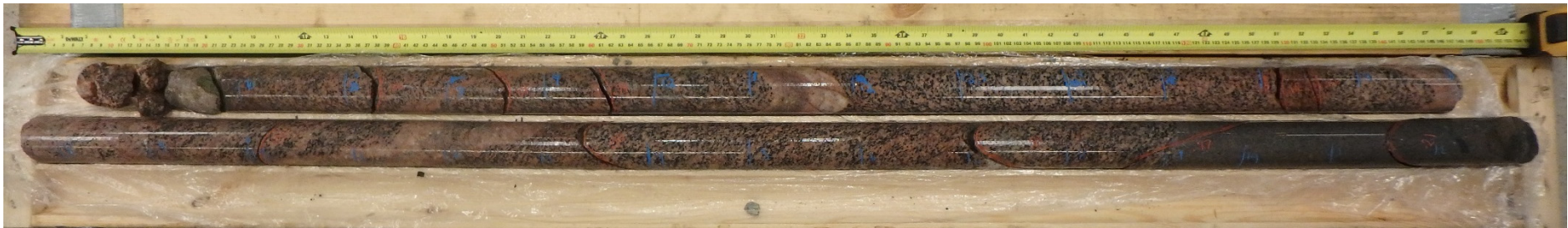
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	ACC1-01	7	244.6
■	ACC1-03	8	239.6

Project Number: 1670846

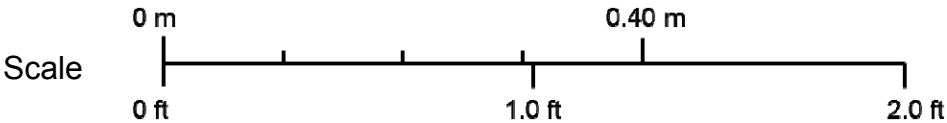
Checked By: TZ


**Golder Associates**

Date: 03-Jul-18



**Borehole ACC1-02:** Elevation 240.42 m to Elevation 237.60 m (End of Borehole)



PROJECT Highway 532 – Atkinson Creek Culvert No. 2 Replacement, 10.5 km North of Highway 556 (Site No. 38S-291C) Gaudette Township, Algoma District, Ontario				
TITLE BEDROCK CORE PHOTOGRAPH – BOREHOLE ACC1-02				
	PROJECT No. 1670846		FILE No. ----	
	DESIGN	TZ	20180710	SCALE NTS VER. 1.
	CADD	--		FIGURE B10
	CHECK			
	REVIEW	LCC	20180713	



# 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	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
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:**

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.

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
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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
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RDL = Reportable Detection Limit



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

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

### PHYSICAL TESTING (SOIL)

<b>Maxxam ID</b>		RZ2662	RZ2663	RZ2664	RZ2665		
<b>Sampling Date</b>		2017/08/23	2017/09/07	2017/09/06	2017/07/16		
<b>COC Number</b>		B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01		
	<b>UNITS</b>	<b>ACB-03 SA4</b>	<b>ACC1-03 SA2</b>	<b>ACCS-03 SA2</b>	<b>MRB-04 SA3</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Physical Properties</b>							
Moisture	%	24	22	28	8.2	0.30	8761682
RDL = Reportable Detection Limit							

<b>Maxxam ID</b>		RZ2666	RZ2667	RZ2668	RZ2669		
<b>Sampling Date</b>		2017/07/11	2017/08/23	2017/07/29	2017/08/02		
<b>COC Number</b>		B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01	B7J9789-M058-01-01		
	<b>UNITS</b>	<b>MRB-03 SA5</b>	<b>DCC-01 SA2</b>	<b>MCC-03 SA1</b>	<b>WRC-01 SA3</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Physical Properties</b>							
Moisture	%	13	32	14	17	0.30	8761682
RDL = Reportable Detection Limit							

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

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

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.**

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

## QUALITY ASSURANCE REPORT

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

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD	
			% 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  $\leq 2 \times \text{RDL}$ ).

(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]

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 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.

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	Date		Date		Laboratory Method	Reference
	Quantity	Extracted	Analyzed			
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 CaCl <sub>2</sub> 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

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.



### RESULTS OF ANALYSES OF SOIL

<b>Maxxam ID</b>		FCS510	FCS510	FCS511	FCS512	FCS513	FCS514		
<b>Sampling Date</b>		2017/08/23	2017/08/23	2017/09/07	2017/09/06	2017/07/16	2017/07/11		
<b>COC Number</b>		628368-01-01	628368-01-01	628368-01-01	628368-01-01	628368-01-01	628368-01-01		
	<b>UNITS</b>	<b>ACB-03 SA4</b>	<b>ACB-03 SA4 Lab-Dup</b>	<b>ACC1-03 SA2</b>	<b>ACCS-03 SA2</b>	<b>MRB-04 SA3</b>	<b>MRB-03 SA5</b>	<b>RDL</b>	<b>QC Batch</b>

<b>Calculated Parameters</b>									
Resistivity	ohm-cm	7300		15000	4100	5900	2400		5165355
<b>Inorganics</b>									
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									

<b>Maxxam ID</b>		FCS515	FCS516	FCS517		
<b>Sampling Date</b>		2017/08/23	2017/07/29	2017/08/02		
<b>COC Number</b>		628368-01-01	628368-01-01	628368-01-01		
	<b>UNITS</b>	<b>DCC-01 SA2</b>	<b>MCC-03 SA1</b>	<b>WRC-01 SA3</b>	<b>RDL</b>	<b>QC Batch</b>
<b>Calculated Parameters</b>						
Resistivity	ohm-cm	2200	24000	43000		5165355
<b>Inorganics</b>						
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						

## 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

## 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

## 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

### GENERAL COMMENTS

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

Package 1	5.7°C
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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.**

## QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		SPIKED BLANK		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5165977	Available (CaCl <sub>2</sub> ) 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 (SO <sub>4</sub> )	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).

### VALIDATION SIGNATURE PAGE

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

*Cristina Carriere*

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Cristina Carriere, Scientific Service Specialist

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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.

13-Sep-17 11:39

Ema Gitej



**B7J9789**

KES ENV-689



Page of

little Order #:




Project Manager:

Erna Gittel


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

Emaj Gitej




B7J9789

KES ENV-689



C#528368-01-01

bottle Order #:



628358

Project Manager:

Emaj Gitej

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

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required

**Please provide advance notice for rush projects**

<b>Regulation 153 (2011)</b>						<b>Other Regulations</b>		<b>Special Instructions</b>	Filtered (please circle) <b>Pesticides / Hg / Cr/VI</b>  SQ4 (20+ extracts)  Acidity/Resistivity  EXTRACT  Masscan (C)
<input type="checkbox"/> Table 1	<input type="checkbox"/> Res/Park	<input type="checkbox"/> Medium/Fine	<input type="checkbox"/> CCME	<input type="checkbox"/> Sanitary Sewer Bylaw					
<input type="checkbox"/> Table 2	<input type="checkbox"/> Ind/Comm	<input type="checkbox"/> Coarse	<input type="checkbox"/> Reg 558	<input type="checkbox"/> Storm Sewer Bylaw					
<input type="checkbox"/> Table 3	<input type="checkbox"/> Agri/Other	<input type="checkbox"/> For RSC	<input type="checkbox"/> MISA	Municipality _____					
<input type="checkbox"/> Table _____			<input type="checkbox"/> PWQO						
			<input type="checkbox"/> Other _____						
<div style="float: right;"> <p><b>Regular (Standard) TAT:</b>            (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 &gt; 5 days - contact your Project Manager for details.</p> <p><b>Job Specific Rush TAT (if applies to entire submission)</b>            Date Required: _____ Time Required: _____</p> </div>									

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

[illegible]

RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time	# jars used and not submitted	Laboratory Use Only				
Darcy Hansen		12/09/13	10am	USA MUN SEC		2013/09/13	11:39		Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
										5/5/7	Present Intact	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

\* 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](http://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/MP-CONTENT/UPLOADS/ONTARIO-COC.PDF](http://MAXXAM.CA/MP-CONTENT/UPLOADS/ONTARIO-COC.PDF)

SAMPLES MUST BE KEPT COOL (  $< 10^{\circ}\text{C}$  ) FROM TIME OF SAMPLING  
UNTIL DELIVERY TO MAXXAM

White: Maxxa      Yellow: Client





# **APPENDIX D**

## **Notice to Contractor and Non-Standard Special Provisions**

## **DEWATERING STRUCTURE EXCAVATIONS - Item No.**

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Special Provision No. FOUND0003

March 8, 2018

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### **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.**

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Notice to Contractor

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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.**

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Non-Standard Special Provision

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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.**

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### Non-Standard Special Provision

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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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