



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT
CHOWDER CREEK EAST CULVERT REPLACEMENT
HIGHWAY 11, SITE No. 48E-084/C
DISTRICT OF THUNDER BAY
ONTARIO
G.W.P. No. 6310-14-00, W.P. No. 6312-14-01
GEOCRES Number: 42F-41**

Report

to

HATCH

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Chowder Creek East Culvert on Highway 11, located east of Longlac, in Unsurveyed Territory in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by Hatch Ltd. (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-04.

A previous foundation investigation carried out at this site was documented in the report titled "*Preliminary Foundation Investigation and Design Report, Chowder Creek East Culvert, Highway 11, District of Thunder Bay, Unsurveyed Territory, Ministry of Transportation, Ontario, G.W.P. 6312-14-00*" Geocres No. 42F-35, prepared by Golder Associates, dated September 8, 2015. Reference should be made to that report for a written description of the subsurface conditions, borehole location plan, stratigraphic profile, record of borehole sheets and laboratory test results obtained during the preliminary stage of the design. It should be noted that Golder is solely responsible for the subsurface information provided in the Preliminary Foundation Report. The Record of Borehole sheets and Borehole Locations and Soil Strata drawing from the Golder's report have been enclosed in Appendix E of this report for reference, and the subsurface information presented in that report was incorporated in the current report, as appropriate. The

borehole logs and stratigraphic profile from the Golder Report should be included in the tender documents.

2. SITE DESCRIPTION

The site is located on Highway 11, approximately 40.4 km east of the intersection of Highway 625 and Highway 11 in unsurveyed territory in the District of Thunder Bay, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and soil Strata Drawings in Appendix D.

Highway 11 runs in a general east-west direction with the culvert perpendicular to the centreline of the highway. The culvert allows Chowder Creek to flow in a southerly direction and drain into Inman Lake which subsequently drains into Chowder Lake.

The Structural Design Report provided to Thurber by Hatch indicates that the existing structure is a 26 m long, two cell (2.1 m, 2.1 m) timber box culvert with an unknown construction date. A Biennial Inspection on August 22, 2012 indicates that the structure generally is in fair to poor condition. The grade level of Highway 11 at the existing culvert is at an approximate Elevation of 280.7 m. The culvert invert is at approximately Elevation 278.02 m at the inlet (north end) and 277.74 m at the outlet (south end). The Chowder Creek water level was measured at Elevation 278.6 m and Elevation 278.0 m by others on November 8, 2008 and March 24, 2015, respectively.

The lands surrounding Chowder Creek East and the culvert at the site predominantly consist of heavily forested areas with occasional marsh lands and lakes. Local topography is generally of low relief swampy terrain with bedrock outcrops visible along Highway 11 approximately 400 m west of the site. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils in at the site generally consist of organic terrain deposits of mainly peat/marsh bordering with areas of undulating rolling bedrock knobs. Bedrock in the area has been identified as mafic to intermediate metavolcanic bedrock of Archean era, comprised of massive granodiorite to granite rocks.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out on August 10 and 11, 2016, and consisted of drilling and sampling six (6) boreholes, designated as Borehole 16-16, 16-17, 16-17B and 16-18 to 16-20. All boreholes were located in the paved section of Highway 11 in the east bound lane with the exception of borehole 16-17 and 16-17B which were

located near the outlet. Borehole 16-16 was located approximately 13 m east of the centreline of the existing culvert near the alignment of the proposed stream diversion pipe. Boreholes 16-18 to 16-20 were located west of the existing culvert structure and distributed at 10 m intervals to assess the existence and extents of any frost taper near the culvert.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were derived from cross sections and topographic drawings provided to Thurber by Hatch. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings included in Appendix D.

Boreholes were drilled using a rubber track mounted CME 55 drill rig equipped with continuous flight, hollow and solid stem augers. Boreholes were advanced to depths of between approximately 2.1 m and 14.3 m below existing ground surface elevation. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone Penetration Test (DCPT) was carried out at 16-17 approximately 1 m west of the original auger hole to cone refusal depth of approximately 11.9 m.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and in the open boreholes upon completion of drilling. The boreholes were backfilled in general accordance with Ontario Regulation 903.

Completion details of the borehole are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-16	14.3 / 266.4	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-17	11.9 / 266.9	Borehole backfilled with bentonite holeplug and cuttings to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
16-17B	8.2 / 272.1	Borehole backfilled with bentonite holeplug and cuttings to 1.5 m depth then gravel to surface.
16-18	3.7 / 277.2	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-19	3.7 / 277.2	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.
16-20	2.1 / 278.9	Borehole backfilled with bentonite holeplug and cuttings and surface reinstated with asphalt.

The previous investigation, Geocres No. 42F-35, included four (4) boreholes, numbered CH-1 to CH-4. Boreholes CH-1 and CH-4 were advanced at the toe of the embankment slope near the culvert inlet/outlet to depths of approximately 5.9 m and 9.8 m, respectively, and boreholes CH-2 and CH-3 were advanced from the existing highway platform to depths of approximately 11.0 m and 10.0 m respectively. The MTM NAD83 northing and easting coordinates, ground surface elevations referenced to Geodetic datum and borehole depths at each borehole location for Golder boreholes are presented below in Table 3.2. The approximate locations of the Golder boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix E.

4. LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) and plasticity testing (Atterberg Limits) where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native soil, and a sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendices A and E. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and should be used for interpretation of site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

The borehole logs from the previous Golder investigation are presented in Appendix E and are generally consistent with the results of the current investigation.

In general, the subsurface conditions encountered in the boreholes drilled through the highway platform from the current and previous investigation contain embankment fill, of which the upper portion contains gravelly sand to sand and gravel beneath the asphalt surface and the lower portion of the embankment fill contains sand to silt and sand. Beneath the embankment fill, peat was encountered, followed by silty sand and silt to silt and sand. A sand to sand and gravel deposit was encountered below the silt and sand deposit. Descriptions of the individual strata are presented below.

5.1 Asphalt

The boreholes that were drilled through the paved portion of Highway 11 indicate that the pavement structure consists of approximately 125 mm to 150 mm of asphalt.

5.2 Embankment Fill

Embankment fill was encountered below the asphalt or ground surface in all Boreholes except in CH-1, and generally ranged in composition from gravelly sand to sand and gravel in the upper portions and sand to sand and silt, trace clay, trace gravel and trace organics in the lower part of the fill.

5.2.1 Gravelly Sand to Sand and Gravel Fill

The gravelly sand to sand and gravel fill was approximately 0.5 to 2.3 m thick with the base of the fill ranging between 0.6 to 2.3 m below the existing road surface (Elev. 278.1 to 280.3).

The relative density of the fill ranged from loose to compact with SPT 'N' values of 9 to 18 blows for 0.3 m penetration of the sampler. Measured moisture contents ranged from 2% to 4%.

The results of grain size distribution analyses conducted on a sample of the fill are presented on the Record of Borehole sheets included in Appendix A and summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Percentage (%)
Gravel	36
Sand	55
Silt and Clay	9

5.2.2 Sand to Sand and Silt Fill

The sand to sand and silt fill was approximately 0.6 m to 4.0 m thick with the base of the fill ranging between 0.6 m and 4.1 m below the existing road surface (Elev. 276.6 to Elev. 278.2).

The relative density of the fill ranged from very loose to compact with SPT 'N' values of 0 to 24 blows for 0.3 m penetration of the sampler. Higher SPT 'N' values ranging from 32 to 64 blows per 0.3 m penetration were noted in frozen fill in Boreholes CH-2 and CH-3.

Measured moisture contents ranged from 5% to 26%. A high moisture content of 48% was recorded near ground surface in CH-4 which contained trace organics.

The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendices A and E and are summarized in the following table. The results from the Thurber boreholes are also presented on Figure B2 in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 16
Sand	45 to 86
Silt and Clay	12 to 55

5.3 Peat

Peat was encountered in boreholes 16-16, 16-17, 16-17B, and CH-2 to CH-4 beneath the fill and in Borehole CH-1 at the surface. The peat ranged in thickness from 0.7 m to 4.3 m and extended to depths of approximately 0.7 m to 6.1 m below ground surface (Elev. 273.9 to Elev. 278.5). The peat contains occasional silt seams. The peat is generally very loose to loose with SPT 'N' values of 0 to 5 blows for 0.3 m penetration. Measured moisture contents in the peat ranged from 39% to 349%.

5.4 Silty Sand

A layer of silty sand was encountered beneath the peat deposits in boreholes CH-1 and CH-2. The silty sand generally contains trace organics, and is grey. The silty sand layer ranged in thickness from 0.6 m to 0.7 m and extended to depths of between 1.4 m to 5.6 m (Elev. 275.1 to Elev. 277.8). The silty sand is typically compact with an SPT 'N' value of 15 blows for 0.3 m penetration.

5.5 Upper Silt to Silt and Sand

Silt to silt and sand were encountered in all boreholes typically beneath the peat deposits or silty sand layer. The silt to silt and sand generally contains trace to some clay, trace gravel, occasional cobbles and is brown to grey. Peat seams were encountered at approximately 7.9 m below ground surface in borehole 16-16, and organic lenses were encountered in boreholes 16-18 and 16-19 at depths between 1.8 m and 3.0 m below ground surface, respectively.

Where fully penetrated, the upper silt to silt and sand layer was approximately 3.1 m to 5.2 m thick and extended to depths of between 4.5 m and 10.5 m (Elev. 268.8 to Elev. 274.7). The formation is typically very loose to loose with SPT 'N' values of 0 to 13 blows for 0.3 m penetration of the sampler. Higher SPT 'N' values of 30 and 49 blows for 0.3 m penetration of the sampler were recorded in boreholes CH-1 and 16-16, respectively, indicative of inferred cobbles. Measure moisture contents in the silt to silt and sand ranged from 11% to 26%

The results of grain size analyses conducted on samples of the upper silt to silt and sand are provided on the Record of Borehole sheets in Appendices A and E and are summarized in the following table. The results from the Thurber boreholes are also presented on Figures B3 and B4 of Appendix B.

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 56
Silt	36 to 90
Clay	5 to 19

5.6 Silty Sand to Sand and Gravel

Silty sand to sand and gravel was encountered in boreholes 16-16, 16-17, and CH-1 to CH-4. In borehole 16-16 the sand layer was encountered beneath the upper silt to silt and sand layer and extended from approximately 10.5 m to 11.0 m below existing ground surface (Elev. 270.2 to Elev. 269.7). In boreholes 16-17, and CH-1 to CH-4, the silty sand to sand and gravel layer was encountered at a depth of approximately 4.5 m to 10.1 m below ground surface (Elev. 274.7 to Elev. 268.8) and extended to the borehole termination depth. The silty sand to sand and gravel layer contains some gravel, trace silt and occasional cobbles.

The silty sand to sand and gravel is compact to very dense with SPT-N values of 14 to 103 blows for 0.3 m penetration. Measured moisture contents ranged from 9% to 18%.

The results of grain size analyses conducted on samples of the silty sand to sand and gravel are provided on the Record of Borehole sheets in Appendices A and E and are summarized in the following table. The results from the Thurber borehole are also presented on Figure B5 of Appendix B.

Soil Particle	Percentage (%)
Gravel	4 to 37
Sand	59 to 70
Silt and Clay	4 to 28

5.7 Lower Silt to Sandy Silt

A deposit of silt to sandy silt was encountered in borehole 16-16 below the sand layer at a depth of 11.0 m below existing ground surface elevation (Elev. 269.7). The deposit extended to the maximum depth drilled of 14.3 m. The silt to sandy silt typically contained some clay and was grey in colour.

The silt to sandy silt was very dense with SPT 'N' values of 57 to 75 blows for 0.3 m penetration. Measured moisture contents ranged from 12% to 17%.

The results of grain size analysis conducted on a sample of the sandy silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B6 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	32
Silt	50
Clay	18

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the open borehole are summarized in Table 5.1 below. Groundwater levels reported in the Golder report are also included.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-16	August 11, 2016	2.1	278.6	Open borehole
16-17	August 11, 2016	0.9	277.9	Open borehole
16-17B	August 11, 2016	2.3	278.1	Open borehole
16-18	August 10, 2016	2.4	278.4	Open borehole
CH-2	March 23, 2015	4.0	276.7	Geocres No. 42F-35
CH-3	March 24, 2015	2.6	278.1	Geocres No. 42F-35
CH-4	March 25, 2015	1.7	277.0	Geocres No. 42F-35

A water level measurement near the outlet of the culvert was reported at Elevation 278.6 m on November 4, 2008 on the drawings provided by Hatch and Elevation 278.0 m on March 24, 2015 on Golder's Soil Strata drawing. The groundwater level should be assumed to reflect the local creek water level. The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silt from Borehole 16-16, and a sample of the creek water were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-16, SS#7, 7.6 m – 8.2 m	Chowder Creek East
			(Silt)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	µg/g	mg/L	9.1	1.4
Sulphate	µg/g	mg/L	19	0.22
pH	No unit	No unit	7.86 to 8.89	7.96
Electrical Conductivity	µS/cm	µS/cm	78	240
Resistivity	Ohms.cm	Ohms.cm	12800	4170
Redox Potential	mV	mV	207	215

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Tim Sivak of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, B.A.Sc., EIT. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for design of the proposed Chowder Creek East Culvert Replacement. The structure is located on Highway 11, approximately 40.4 km east of the intersection of Highway 11 and Highway 625 and, approximately 55 km east of Longlac, in the District of Thunder Bay Unsurveyed Territory, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The design-build or construction contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

A preliminary foundation design for the Chowder Creek East Replacement culvert was documented in the report titled "*Preliminary Foundation Investigation and Design Report, Chowder Creek East Culvert – Site No. 48E-84/C, Highway 11, District of Thunder Bay, Unsurveyed Territory, Ministry of Transportation, Ontario*", Geocres No. 42F-35, prepared by Golder Associates, dated September 8, 2015. The subsurface information presented in this report has been reviewed and incorporated, as appropriate.

Information on the existing culvert site was obtained from the MTO Terms of Reference and the Structural Design Report (SDR) titled "Chowder Creek East (Chowder Creek) Timber Culvert, Site

No. 48E-84/C, Highway 11", prepared by Hatch, dated December 2015. The SDR provided discussion on the existing structure, discussion of alternatives for the proposed culvert replacement, and recommendations for the preferred alternative.

As indicated in SDR, the existing timber box culvert (unknown date of construction) is 26 m long, and has two 2.1 m span cells. A Biennial Inspection on August 22, 2012 indicated that the structure was in poor to fair condition. The Chowder Creek flows in a southerly direction and drains into Inman Lake which subsequently drains into Chowder Lake. The Preliminary General Arrangement Drawing indicates grade of Highway 11 at the existing culvert at approximate Elevation of 280.7, and the culvert invert at approximate Elevation 280.0 resulting in approximate 0.7 m of soil cover above the culvert. The water level in the Chowder Creek was at Elevation 278.6 m on November 4, 2008.

9. CULVERT DESIGN

9.1 Culvert Replacement Options

The following options for the replacement culvert were presented and evaluated in the Structural Design Report (SRD):

- Option 1 – Precast Concrete Closed Box Culvert
- Option 2 – Precast Open Footing Culvert
- Option 3 – Multiple Round Corrugated Steel Pipes.

As described in the SDR, Option 3 was selected for detail design as the preferred structure alternative based on the evaluation that it would satisfy all of the design criteria and would result in favorable aquatic environment while minimizing disruption to the existing channel. Option 3 could offer relatively lightweight structure for delivery to the site and installation, and would require the least amount of on-site construction time in comparing with other options. The proposed structure would consist of two 30 m long and 2.7 m diameter round aluminized or polymer laminated corrugated steel pipes. The invert of the CSPs would be located at Elev. 277.3 on the upstream (north) and Elev. 277.1 on the downstream (south) side.

The SDR also identified Option 1 (concrete closed box) as a viable culvert replacement alternative with some advantages over Option 3; however, resulting in higher costs. The required opening size of 4.8 m by 2.1 m was assessed for a box culvert. The invert of the concrete box culvert would be located at Elev. 278.0 on the upstream (north) and Elev. 277.7 on the downstream (south) side.

Preliminary General Arrangement (GA) drawings for both CSP and concrete closed box options were included in the SDR. The alignment of the replacement culvert and the finished road grade level appears to remain unchanged. Construction staging, installation of a temporary roadway protection and a 1.5 m diameter temporary stream diversion pipe (CSP) would be required to accommodate construction. As indicated in the SDR, no wingwalls/headwalls will be required at this culvert. A cut-off wall is proposed to minimize the loss of fines from beneath the culverts. Both viable culvert options are presented in this report.

The 100% design drawings provided by Hatch show replacement of peat below the culvert with rock fill inside a vertical sheet pile enclosure. Further discussion on peat replacement is provided in Section 12.

The discussions and recommendations are based on information provided by Hatch and on the factual data obtained during the course of the current investigation. In addition, the existing subsurface information collected during the preliminary investigation and documented in the Geocres Report No. 42F-35 (enclosed in Appendix E) has been reviewed and incorporated in this report. The subsurface information, including Record of Borehole sheets and the Borehole Locations and Soil Strata drawings from both current and preliminary investigations (Geocres Report No.42F-35) should be included in the Contract Documents.

9.2 Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the boreholes advanced during the preliminary and current investigations consisted of pavement structure and granular embankment fill overlying a deposit of peat, which in turn is underlain by cohesionless deposits ranging in composition from silt to sand with a sand and gravel layer encountered at depths. All boreholes were terminated in the native cohesionless deposit between 2.1 m and 14.3 m depth (between Elev. 278.9 and Elev. 266.4). A layer of peat was encountered beneath the embankment fill in all boreholes drilled near the culvert. The thickness of peat ranged from 0.7 m to 0.9 m at the northern part of the culvert footprint, and then increasing southerly to as much as 4.3 m. The greatest thickness of peat was encountered in the area near the south part of the culvert. In Borehole 16-17 and CH-3 located within the southern half of the existing culvert, the base of the peat was at a depth of 4.9 m (Elev. 273.9) and 5.6 m (Elev. 275.1), respectively.

The water level in the Chowder Creek was measured at Elevation 278.6 m and Elevation 278.0 m on November 4, 2008 and March 24, 2015, respectively.

9.3 Foundation Design

9.3.1 Corrugated Steel Pipe Culvert

Replacement of the culvert with multiple CSPs on the same alignment as the existing culvert is identified on the SDR as the preferred option for this site. The multiple pipes are required to accommodate the hydraulic requirements. The proposed invert level of the CSP culverts will be located at Elev. 277.3 on the upstream (north) and Elev. 277.1 on the downstream (south) side. At the level of the proposed invert, a native silty sand and silt will be encountered at the northern end of the culvert footprint. Then, towards the center of the culvert footprint, the invert will intersect peat and embankment fill and will be located near the base of the embankment fill, as indicated by Boreholes 16-17, 16-17B, CH-2 to CH-4. The southern part of the culvert base/footprint will intersect the peat deposit. Beneath the embankment fill, a layer of peat varying in thickness from 0.7 m to 4.3 m was encountered in the boreholes.

If this alternative is selected, the CSPs should be placed on a minimum 300 mm thick layer of bedding material. All the peat encountered at and below the culvert subgrade must be removed and replaced by compacted granular fill or rock fill up to the underside of the bedding material within a sheet pile enclosure, as described in Sections 12.1 and 12.2. Culvert subgrade preparation and placement and compaction of the granular fill replacing the peat must be carried out in the dry, unless rock fill is utilized as described in Section 12.1.2. The granular fill or rock fill below the culvert must be placed on native silt and sand deposits. Adequate preparation of the subgrade will be essential for performance of the culvert.

9.3.2 Concrete Box Culvert

A concrete box replacement culvert with the opening 4.8 m by 2.1 m was presented in the SDR as a viable alternative for this site. The culvert invert at approximate Elev. 278.0 m at the inlet (north end) and Elev. 277.7 m at the outlet (south end) were shown in the SDR. The subsoils at the invert level will be located within the embankment fill material and will intersect the peat deposit within the northern and southern parts of the footprint. As noted above, the embankment fill is underlain by a peat deposit varying in thickness from 0.7 m to 4.3 m.

In order to provide a competent foundation subgrade, the peat deposit must be excavated and replaced with compacted granular fill or rock fill, as described in Section 12.1. The culvert should then be placed on a 300 mm thick layer of bedding material and a levelling course, as discussed in Section 12.2 of this report.

The following geotechnical capacities could be used for design of a box culvert founded at or below Elev. 278.0 m on the compacted granular fill or rock fill used to replace the peat:

- Factored Geotechnical Resistance at ULS of 150 kPa
- Geotechnical Resistance at SLS (less than 25 mm settlement) of 100 kPa.

The above values of the geotechnical resistance and reaction were based on the outside box culvert width of 5.2 m.

The consequence factor of 1 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing, and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per CHBDC 2014, Sec. 6.9.

The ULS resistance and settlement are dependent on the footing/culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design should be reduced in accordance with the CHBDC 2014, Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces / sliding resistance between the concrete and the underlying Granular A or B Type II bedding material should be calculated assuming an ultimate coefficient of friction of 0.45.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

9.4 Settlement and Stability

Embankment grade raise or widening was not indicated in the SDR as part of the culvert replacement. It is recommended that the underlying peat deposit be excavated and replaced with compacted granular fill or rock fill. Therefore, changes in the loading conditions on the foundation soils consisting of native silts and sands are expected to be small. If the peat below the culvert footprint is completely removed and replaced with granular fill or rock fill, the post construction

settlements after culvert construction and embankment reconstruction at this site is estimated to be less than 25 mm.

In order to minimize settlement of the peat outside of the replacement culvert footprint, it is recommended that the granular fill or rock fill be placed within a sheet pile enclosure below the culvert. This will allow for a vertical excavation of peat. A sloped excavation in the peat would result in placement of heavier granular fill or rock fill above the remaining peat, which would cause settlement of the embankment outside of the culvert footprint.

Considering the subsurface conditions and the embankment height up to 3.0 m above the surrounding ground, the granular fill embankment will be stable at side slopes inclined at 2 horizontal to 1 vertical, or flatter.

9.5 Frost Depth

The depth of frost penetration at this site is approximately 2.5 m, as per OPSD 3090.100. The pipe and box culvert options do not require frost cover/protection.

The frost taper investigation in Boreholes 16-18 to 16-20 indicated the presence of 1.2 to 3.0 m of granular fill overlying native sand and silt to at least 30 m west of the centreline of the existing culvert. Borehole 16-16 also included granular fill to a depth of 4.1 m, extending at least 13 m east of the centreline of the existing culvert. It is not known whether the granular fill material was intentionally placed as a frost taper, or as road embankment fill and base material above the native silt.

The native silt underlying the fill is frost susceptible. As the frost penetration line is below the top of culvert, frost treatment/taper for the culvert will be required as per OPSD 803.031 for a CSP culvert or OPSD 803.010 for a box culvert.

10. LATERAL EARTH PRESSURES

A triangular distribution of lateral earth pressures acting on the culvert walls may be assumed for design. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2014, but are generally given by the expression:

$$p_h = K (\gamma h + q)$$

where p_h = horizontal pressure on the wall at depth h (kPa)

K	=	earth pressure coefficient (see table below)
γ	=	unit weight of retained soil (see table below)
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 10.1 below.

Table 10.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ$; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I (modified) $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive	3.7	-	3.3	-

Note: Submerged unit weight should be used below the groundwater level/high creek level.

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 1.7 m for Granular B Type I, or at a depth of 2.0 m for Granular A or B Type II.

11. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2014, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site includes a very loose to compact silts and sands. This would correspond to a Seismic Site Class E in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground

acceleration, PGA, for a 2% in 50 year probability of exceedance at this site is 0.034 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 11.1 may be used:

Table 11.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I (modified) $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.33
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.51	0.55

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

The saturated silts and sands should be considered as prone to liquefaction; however, in view of the low potential for seismic activity in the area, liquefaction is not considered to be a major concern at this site.

12. CULVERT CONSTRUCTION CONSIDERATIONS

12.1 Peat Replacement and Subgrade Preparation

Performance of the replacement culvert will depend on the preparation of the subgrade. The borehole information indicates a variable thickness of peat deposit within the culvert footprint area and east of the culvert along the stream diversion pipe alignment. Approximately 0.7 m of peat was encountered at the north part of the culvert and as much as 4.3 m of peat was encountered at the south end of the culvert.

The peat must be subexcavated to expose the native silt to silt and sand deposit. The subexcavation should be carried out within a sheet pile enclosure to allow a vertical excavation, as indicated in Section 9.4. The sheet piles should remain in place following project completion. The excavation should be carried out in accordance with OPSS 209 (Embankments over Swamps and Compressible Soils). The subexcavated area should be backfilled with granular material

meeting the requirements of OPSS.PROV 1010 for Granular A or Granular B Type II placed in accordance with OPSS.PROV.206, and compacted as per OPSS.PROV 501, provided that the peat subexcavation and compaction and placement of the replacement granular fill is carried out in the dry as per OPSS 902, as described in Section 12.1.1. If full dewatering is not possible, the peat should be replaced with rock fill as described in Section 12.1.2.

12.1.1 Peat Removal with Full Dewatering

Prior to peat excavation, the following dewatering measures must be in place:

- Creek diversion
- Sheet pile cofferdam enclosure
- Pumping from inside the cofferdam using well points

The dewatering above must be effective to lower the groundwater level a minimum of 0.5 m below the base of the peat excavation and not to create basal instability in the native Silt to Sand and Silt below the peat. If this full dewatering option is employed, the peat may be removed to the top of native Silt to Sand and Silt and replaced with Granular A or Granular B Type II and compacted as per OPSS.PROV 501.

Following peat removal, a separation layer consisting of a non-woven geotextile should be placed between the native soils and the peat replacement materials such as Granular A or Granular B Type II. The geotextile should meet the specifications for OPSS 1860 Class II, and have a fabric opening size (FOS) not greater than 212 micro millimetres.

12.1.2 Peat Removal without Full Dewatering

Given the potential for deep peat excavation and replacement under the culvert footprint, groundwater flow and seepage of surface water through the embankment fill, backfilling in the wet conditions (below water level) could be considered. When backfilling is conducted in the wet, select rock fill should be used. The recommended gradation of the rock fill is as follows:

Sieve Size	Percent Passing (%)
150 mm	100
106 mm	50 – 100
75 mm	15 – 80
26.5 mm	0 – 15
0.075 mm	0 – 2

Following peat removal, a separation layer consisting of a non-woven geotextile should be placed between the native soils and rock fill. The geotextile should meet the specifications for OPSS 1860 Class II, and have a fabric opening size (FOS) not greater than 212 micro millimetres. The rock fill should be completely wrapped with the geotextile to minimize migration of fines into the rock fill.

Rock fill used to backfill subexcavated areas below the water table may be placed by end dumping. Granular fill must not be used to backfill excavations below the water table. The rock fill placement below the water level should follow OPSS.PROV 209 (Embankments over Swamps and Compressible Soils).

Rock fill placed above the water level should be placed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill above the water level must be compacted as per OPSS.PROV 206. Where granular fill or bedding material is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking shall be in accordance with OPSS.PROV 206. All granular fill must be compacted as per OPSS 501.

For this backfilling option under water, if the peat is not completely removed or the rock fill traps peat, there is a risk of additional settlement of the culvert.

12.2 Bedding and Backfilling

The bedding material should be placed on the prepared subgrade as soon as practical following inspection and approval. Placement of the bedding material should be carried out in the dry.

Considering the relatively high permeability of the embankment fill and the cohesionless native soils at this site, there is a potential for groundwater seepage and surface water flow at the subgrade and bedding level. In order to provide a uniform foundation subgrade, a 300 mm thick

layer of bedding material conforming to OPSS PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the proposed CSPs or box culvert.

Bedding placement should follow OPSD 802.014 (Flexible Pipe Embedment in Embankments) for CSP pipe culvert, and OPSD 803.010 (Backfill and Cover for Concrete Culverts) for box culvert. In addition, the surface prepared to support the box units should have a 75 mm minimum thickness top levelling course consisting of uncompacted Granular A, as per OPSS 422.

The bedding should be compacted in thin lifts as specified in OPSS.PROV 501 (Compaction).

A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils (including the native soils and the peat replacement materials such as Granular A, Granular B Type II or rockfill) and the underside of the bedding material. The geotextile should meet the specifications for OPSS 1860 Class II, and have a fabric opening size (FOS) not greater than 212 micro millimetres.

Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which has to be protected from disturbance during construction.

Backfill to the culvert should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010, 802.014 or 803.010, as appropriate. Backfilling for the culvert should be in accordance with OPSS PROV 421 for a CSP and OPSS 422 for a box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS PROV 501.

12.3 Excavation and Groundwater Control

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and native silt at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level. Surficial alluvial deposits and peat should be classified as Type 4 soils.

Excavation for culvert construction should be carried out in accordance with OPSS 902.

Excavations for culvert replacement will be carried out through the existing embankment fill and the underlying peat. The depth to base of peat will vary significantly along the culvert length and the excavation could be as deep as 5 to 6 m in the southern part of the culvert footprint.

Management of the excavated peat will have to be considered for this site and details specified in the Contract, as per OPSS 209. The options may include disposal of peat outside of the site or reuse within the Contract area (for flattening the side slopes, placement in the right-of-way, etc.).

Moreover, excavations for culvert replacement will be carried out below the creek water level indicated at Elev. 278.6, and diversion of the creek flow will be required. Given the relatively high permeability of the embankment fill materials and native silt, water inflow/seepage into the excavation should be anticipated from the embankment fill and the native silt. Depending on the time of construction, a combination of cofferdam enclosures and creek diversion along with the use of well points/relief wells within an enclosure will be required to maintain relatively dry excavations during the course of staged construction. The dewatering scheme must be effective to lower the groundwater level to at least 0.5 m below the final subgrade level to avoid base boiling in the native soils. Dewatering of all excavation should be carried out in accordance with OPSS. PROV 517.

The design of an effective dewatering system that may be required is the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist. Dewatering must remain operational and effective until the culvert is installed and backfilled. Suggesting wording for an NSSP in this regard is included in Appendix F.

13. STREAM DIVERSION PIPE

A 1500 mm diameter CSP stream diversion pipe to carry the creek waters is proposed in the Preliminary General Arrangement drawing. The diversion pipe is shown to be located approximately 11 m to the east of the centreline of the new culvert with the invert at approximate Elev. 277.3. Below the invert level, the subgrade will consist of some 0.6 m of loose sand and silt fill underlain by approximately 2 m of peat, as documented in Borehole 16-16.

The temporary CSP diversion pipe could be installed on the sand and silt fill subgrade, without peat excavation, and placed on a minimum 500 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per OPSD 802.010 (Flexible

pipe embedment and backfilling). The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. The prepared subgrade should be protected from disturbance during construction.

The stream diversion pipe could be installed within the temporary open cut excavations, or alternatively temporary roadway protection system could be utilized. The installation of the diversion pipe in open cut should follow OPSD 802.014 (Flexible Pipe Embedment in Embankment) and OPSS 421 (Pipe Culvert Installation in Open Cut). .

14. TEMPORARY PROTECTION SYSTEM

Temporary roadway protection system should be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2.

Interlocking sheet piles could be considered at this site. The soil parameters in Table 14.1 may be used for design of the temporary roadway protection system with horizontal backfill.

Table 14.1 –Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Fill	Native Sand/Sandy Silt	Native Silt
Bulk Unit Weight (γ)	21 kN/m ³	20 kN/m ³	20 kN/m ³
Submerged Unit Weight (γ_w)	11 kN/m ³	10 kN/m ³	10 kN/m ³
Coefficient of Active Earth Pressure (K_a)	0.33	0.33	0.35
Coefficient of Passive Earth Pressure (K_p)	3.0	3.0	2.9

Full hydrostatic pressure should be considered assuming a water level equal to the design high water level in the creek.

The design of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system.

15. EMBANKMENT RESTORATION

Provided that the embankment is reconstructed with side slopes inclined at not steeper than 2H:1V, the restored embankment slope should remain stable. As discussed in Section 9.4, if all the peat is removed from under the culvert footprint, settlement of the embankment in the order of 25 mm should be expected under the existing culvert footprint. For removal of peat and placement of rock fill under water, it may be difficult to completely remove all the peat. If some peat is left or the rock fill traps some peat, there is a risk of additional settlement of the culvert/embankment.

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS PROV 206 and OPSS PROV 209. The embankment material may consist of imported Granular A, Granular B Type II, or Granular B Type III material. Alternatively, the existing granular embankment fill may be reused above the culvert, provided it is unfrozen, free of organics, and at a moisture content that it is suitable for compaction.

Fill placement along the culvert should follow the requirements of OPSD 208.010 (Benching of Earth Slopes) to integrate the existing and new embankment fill.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel must be conducted at this site.

16. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures considering hydrologic and hydraulic factors should be carried out by specialists experienced in this field.

Typically, rock protection will be required over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS PROV 804.

A concrete cut-off wall and a clay seal should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in

accordance with OPSS PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

17. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soil and creek water from the current and preliminary investigations indicates the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete foundations from the surrounding native soil or surface water is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested.
- The potential for soil or surface water corrosion on metal is considered to be mild.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used.

18. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- A suitable dewatering / unwatering system must be employed to enable culvert construction in the dry and prevent base boiling, sloughing and instability of the excavation walls.
- Relatively deep peat excavation will be required. The Contractor should be prepared to acquire swamp excavating equipment
- Management of excavated peat will have to be considered during design (disposal versus re-use).
- The water level in the creek may fluctuate and be at higher elevation at the time of construction than indicated in the report.
- Cobbles or other buried obstructions may be encountered during excavation in the existing embankment fill and may interfere with installation of the temporary roadway protection system. Suggested wording for an NSSP on obstructions is included in Appendix F.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support).

Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor.

19. CLOSURE

Engineering analysis and preparation of this report was carried out by Ms. Anna Piascik, P.Eng. and Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 16-16

1 OF 2

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 872.7 E 393 820.5 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.11 - 2016.08.11 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
280.7	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (150mm)							20	40	60	80	100						
0.2	Gravelly SAND Compact Brown Moist (FILL)		1	GS			280											
280.0			1	SS	24													
0.7	SAND, some silt, trace gravel Compact Brown Moist (FILL)		2	SS	19		279											
278.5			3	SS	4		278											
2.2	SAND and SILT, trace clay, trace gravel Very Loose to Loose Grey Moist/Wet (FILL)		4	SS	3		277											
276.6			5	SS	1		276											
4.1	PEAT, trace sand Very Loose Brown Wet						275											
274.6			6	SS	4		274											
6.1	SILT, some clay, trace sand Very Loose to Dense Grey Moist to Wet						273											
	25mm peat seam at 7.9m		7	SS	0		272											
							271											
	Cobbles noted at 9.1m and 10.2m		8	SS	49													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-16

2 OF 2

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 872.7 E 393 820.5 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.11 - 2016.08.11 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																	
	Continued From Previous Page						20	40	60	80	100	20	40	60			
270.2	SAND , some gravel, trace silt, occasional cobbles Very Dense Brown Moist to Wet		9	SS	103		270						○				
10.5																	
269.7																	
11.0	SILT , some sand, trace clay Very Dense Grey Wet						269										
268.5																	
12.2	Sandy SILT , some clay Very Dense Grey Wet		10	SS	57		268						○				
							267										
			11	SS	75								○				
266.4																	
14.3																	
	END OF BOREHOLE AT 14.3m. WATER LEVEL AT 2.1m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.																

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5 10
(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 16-17

2 OF 2

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 860.3 E 393 813.3 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2016.08.10 - 2016.08.11 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
268.8	Continued From Previous Page																
10.1	SAND and GRAVEL, trace silt Compact Brown Moist to Wet		10	SS	16											37 59 4 (SI+CL)	
266.9																	
11.9	END OF BOREHOLE AT 11.9m. WATER LEVEL AT 0.9m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No 16-17B

1 OF 1

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 868.6 E 393 802.3 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.11 - 2016.08.11 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
280.4	GROUND SURFACE							20	40	60	80	100	PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
0.0	SAND and GRAVEL , trace silt Loose to Compact Brown Moist (FILL)		1	SS	18		280										36 55 9 (SI+CL)
			2	SS	9		279										
			3	SS	10												
278.1																	
2.3	SAND , some silt, trace clay and gravel, trace organics Very Loose Grey Wet (FILL)		4	SS	0		278										9 66 19 6
			5	SS	2		277										No recovery
3.4	PEAT , trace silt Very Loose to Loose Brown Wet		6	SS	5		276										No recovery
			7	SS	3		275										
274.7																	
5.6	Sandy SILT , some clay Loose Grey Wet		8	SS	6		274										
							273										
			9	SS	3												0 23 58 19
272.1																	
8.2	END OF BOREHOLE AT 8.2m. WATER LEVEL AT 2.3m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPUG AND CUTTINGS TO 1.5m, THEN GRAVEL TO SURFACE.																

+³, ×³: Numbers refer to Sensitivity
 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-18

1 OF 1

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 872.5 E 393 794.5 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.10 - 2016.08.10 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
280.8	GROUND SURFACE							20 40 60 80 100						GR SA SI CL
0.0	ASPHALT: (140mm)		1	GS				○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
0.1	Gravelly SAND, trace silt							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L						
280.2	Compact							WATER CONTENT (%)						
0.6	Brown		2	GS				20 40 60 80 100						
	Moist (FILL)						280							5 68 27 (SI+CL)
	SAND, some silt to silty, trace gravel, trace clay													
	Brown													
	Moist (FILL)													
279.0							279							
1.8	SAND and SILT, trace clay, trace gravel, trace organics		3	GS										
	Very Loose													
	Brown													
	Moist													
	Thin black lenses of organic silt at 2.4m		4	GS			278							
			5	SS	2									0 56 36 8
277.2														
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL AT 2.4m BELOW SURFACE AFTER DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-19

1 OF 1

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 872.3 E 393 784.5 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.10 - 2016.08.10 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
280.9	GROUND SURFACE													
0.0	ASPHALT: (140mm)		1	GS										
0.1	Gravelly SAND, trace silt													
280.3	Compact													
0.6	Brown Moist (FILL)		2	GS										
	Silty SAND, trace to some gravel, trace clay													
	Brown Moist (FILL)		3	GS										16 45 32 7
			4	GS										
	Possible cobbles at 2.7m		5	GS										8 46 37 9
277.9														
3.0	SAND and SILT, trace gravel, trace clay, trace organics/rootlets, peat lenses (<20mm thick)		6	SS	6									
277.2	Loose Grey Moist													
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-20

1 OF 1

METRIC

W.P. 6312-14-01 LOCATION Chowder Creek Culvert N 5 518 872.2 E 393 774.5 ORIGINATED BY TS
 HWY 11 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.08.10 - 2016.08.10 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa														
281.0	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							<div><div>PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT</div><div>W_P W W_L</div></div>							
0.0	ASPHALT: (125mm)							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>							<div><div>204060</div><div>WATER CONTENT (%)</div></div>							
0.1	Gravelly SAND , some silt Compact Brown Dry (FILL)		1	GS			280															
			2	GS																		
279.8																						
1.2	SAND and SILT , trace to some clay Compact Brown Moist to Wet		3	GS															0 44 46 10			
278.9			4	GS			279												0 46 45 9			
2.1	END OF BOREHOLE AT 2.1m ON AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND PATCHED WITH ASPHALT AT SURFACE.																					

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

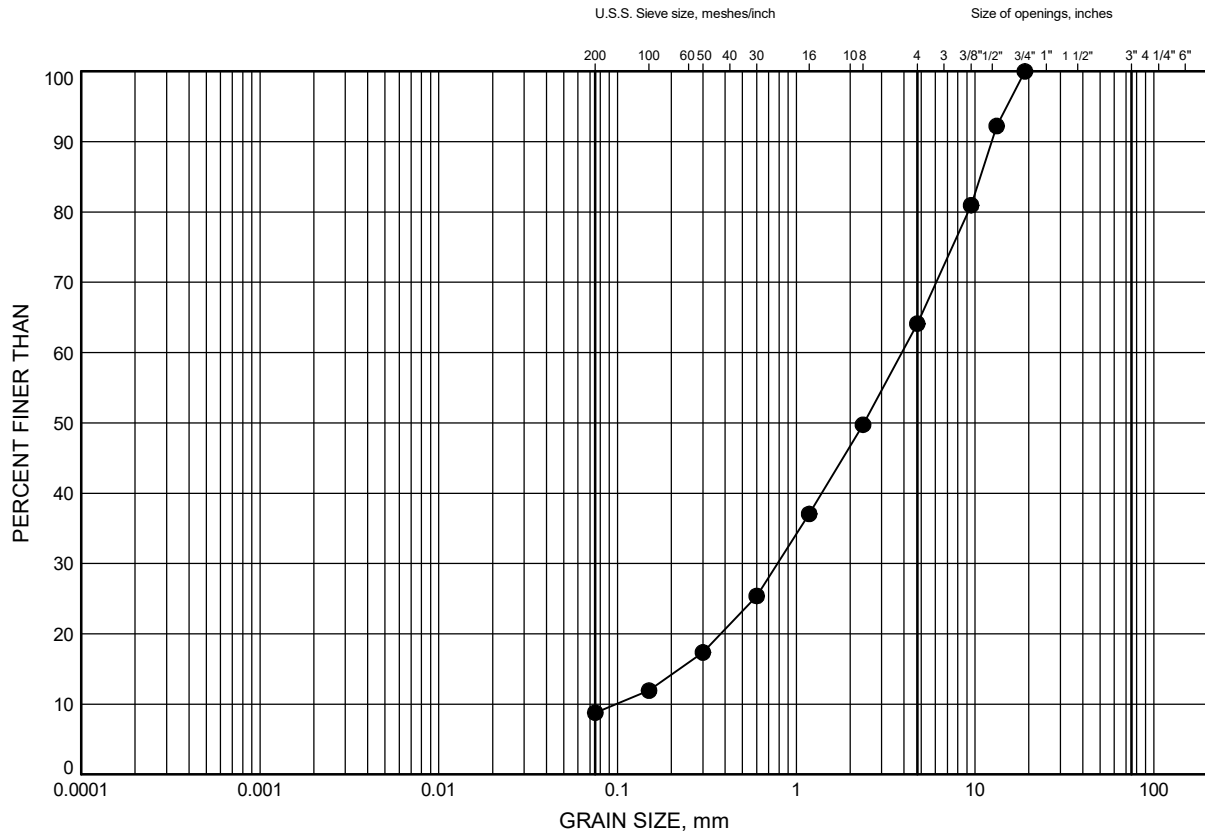
Appendix B

Geotechnical and Analytical Laboratory Test Results

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand and Gravel Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-17B	0.38	279.98

Date February 2017
W.P. 6312-14-01

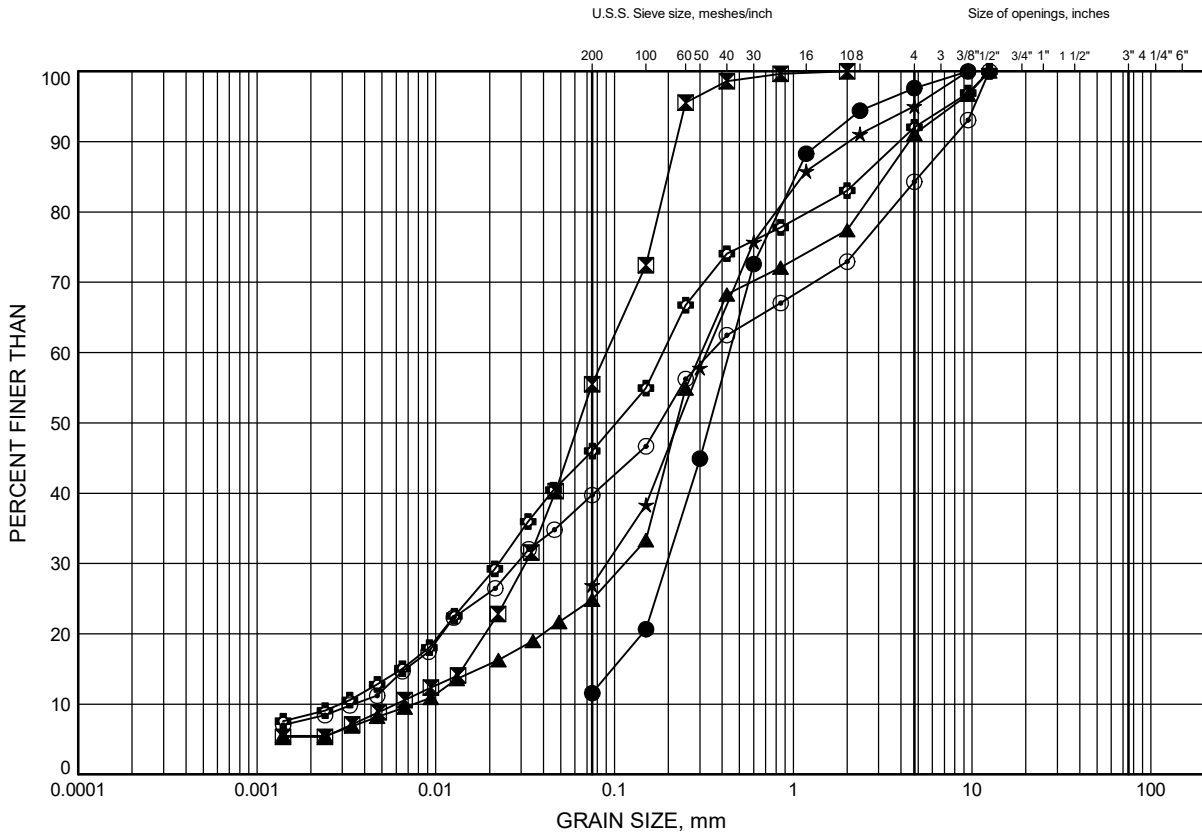


Prep'd MFA
Chkd. AMP

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand to Sand and Silt Fill



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-16	1.07	279.63
⊠	16-16	2.59	278.11
▲	16-17B	2.59	277.77
★	16-18	0.76	280.09
⊙	16-19	1.41	279.49
⊛	16-19	2.82	278.08

Date February 2017
W.P. 6312-14-01

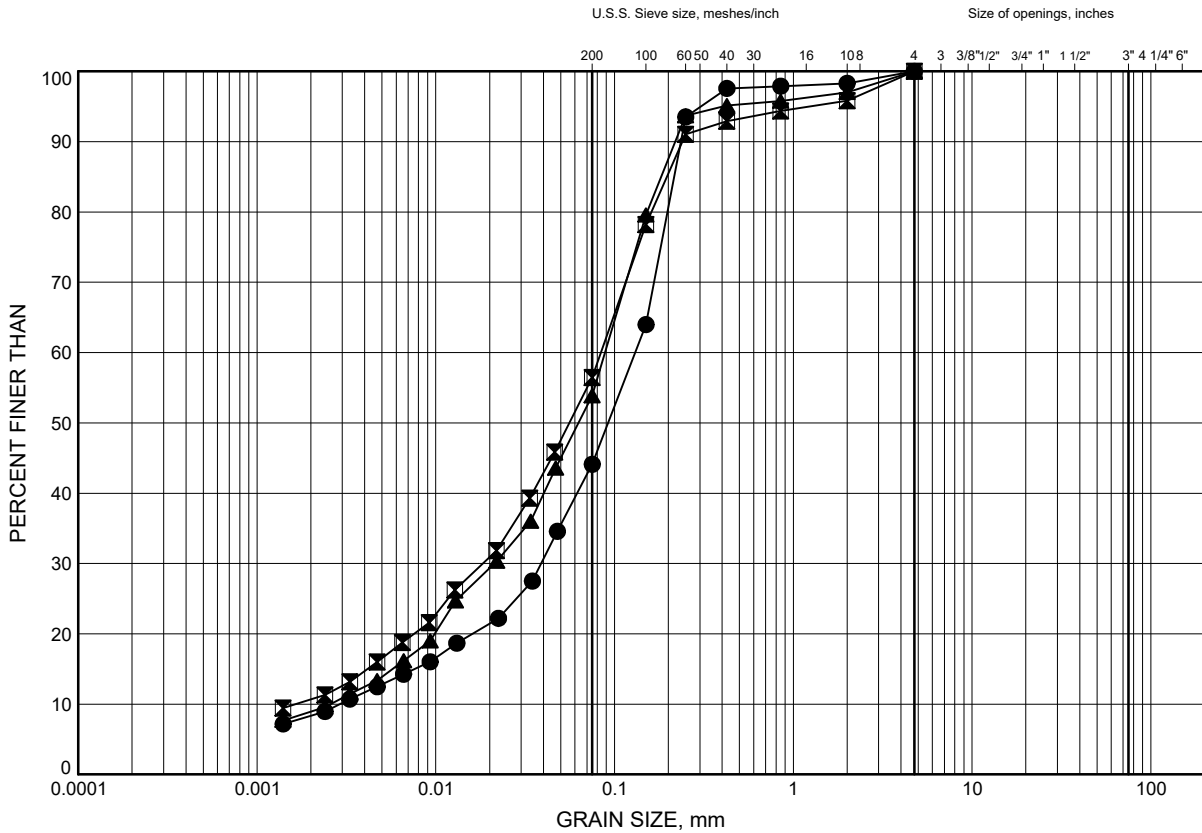


Prep'd MFA
Chkd. AMP

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Upper Sand and Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-18	3.35	277.49
⊠	16-20	1.30	279.66
▲	16-20	1.91	279.05

Date February 2017
W.P. 6312-14-01

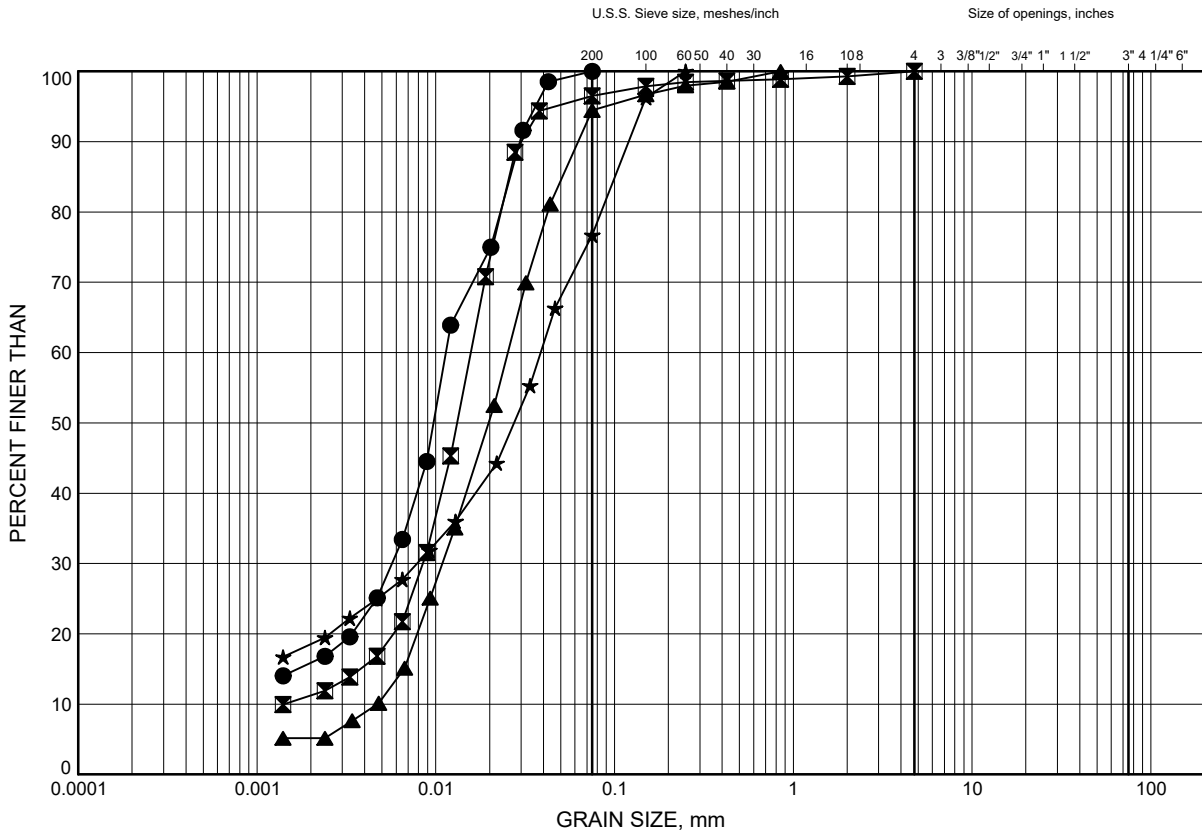


Prep'd AN
Chkd. AMP

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

Upper Silt to Sandy Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-16	6.40	274.30
⊠	16-16	9.45	271.25
▲	16-17	6.40	272.42
★	16-17B	7.92	272.44

Date February 2017
W.P. 6312-14-01

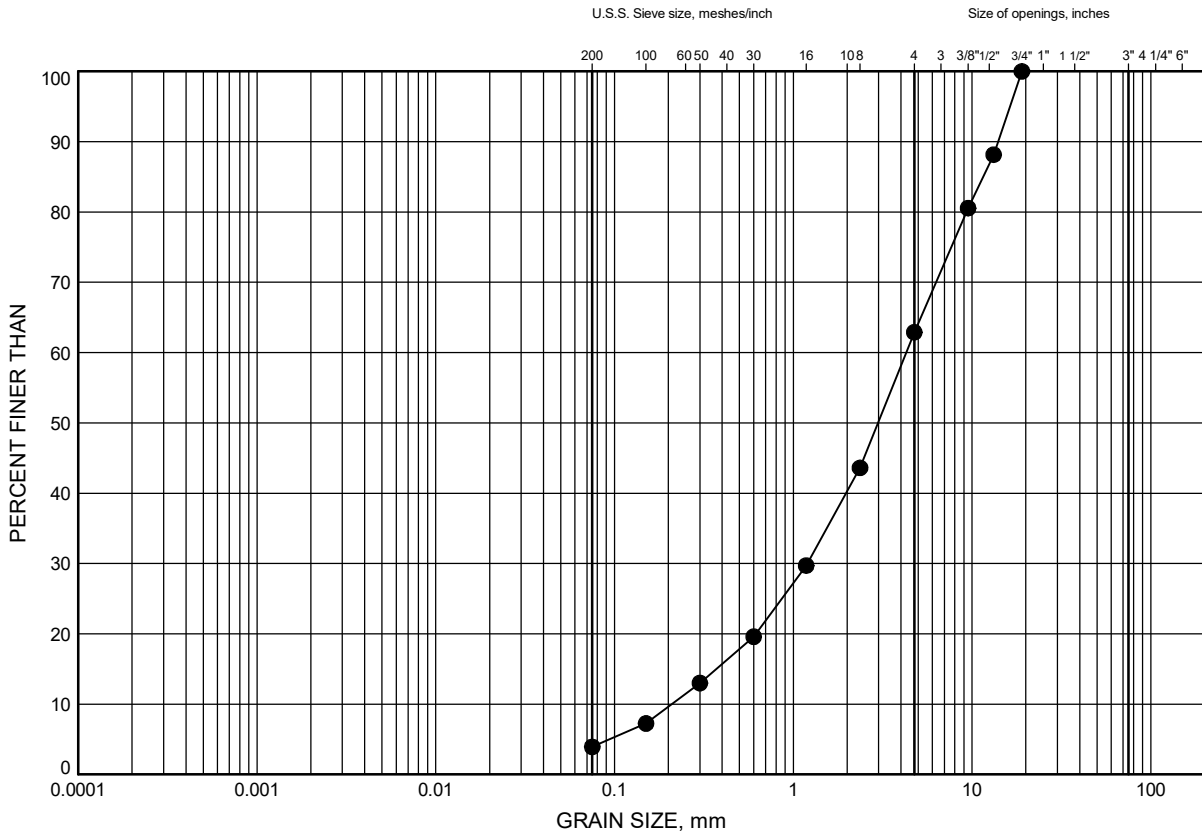


Prep'd AN
Chkd. AMP

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B5

Sand and Gravel



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-17	11.28	267.55

Date February 2017
W.P. 6312-14-01

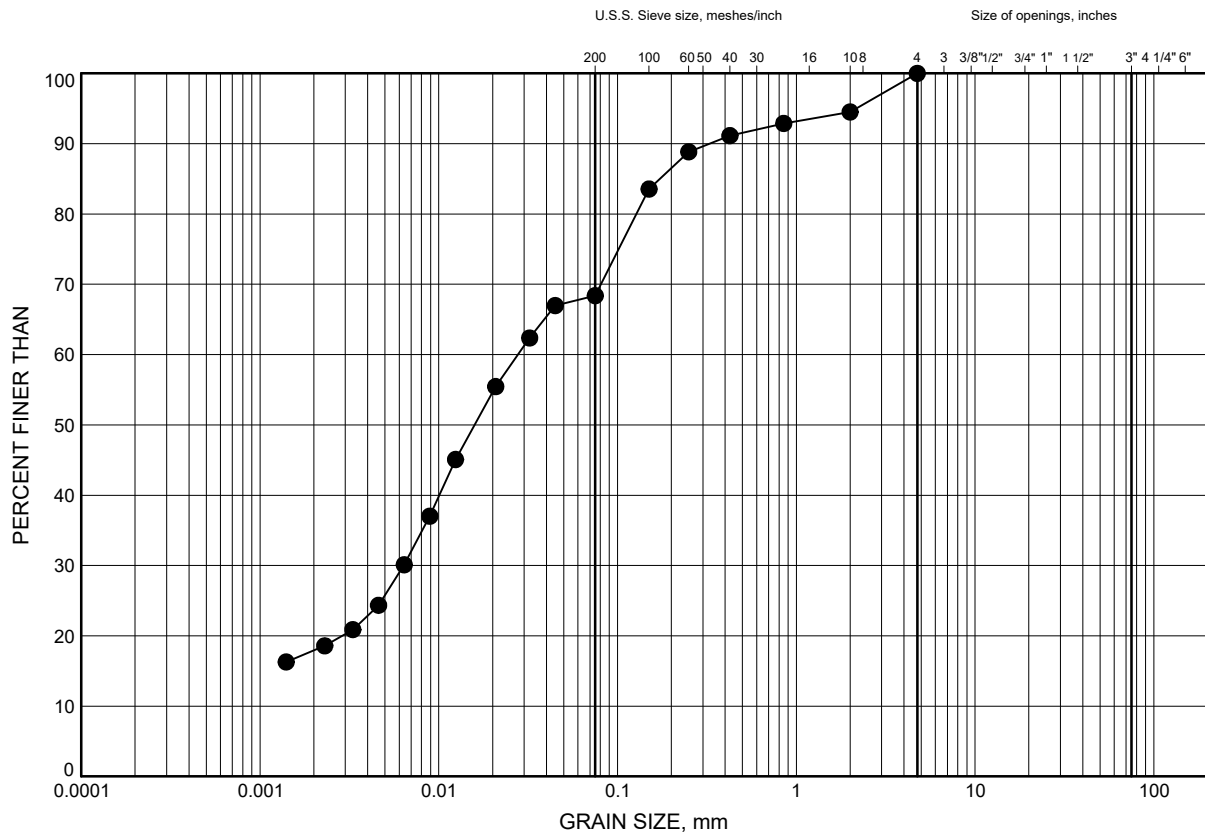


Prep'd MFA
Chkd. AMP

Chowder Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B6

Lower Sandy Silt



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-16	14.02	266.68

Date February 2017
W.P. 6312-14-01



Prep'd AN
Chkd. AMP

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662**29-August-2016****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 25 August 2016
LR Report: CA15493-AUG16
Reference: 13662 Mark Farrant

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: BH-16, SS#7, 25'-27'
Sample Date & Time					24-Aug-16
Temperature Upon Receipt [°C]	---	---	---	---	16.0
Corrosivity Index [none]	---	---	29-Aug-16	15:32	1
pH [no unit]	27-Aug-16	10:28	29-Aug-16	15:29	7.86
Soil Redox Potential [mV]	26-Aug-16	13:46	29-Aug-16	11:43	207
Sulphide [%]	26-Aug-16	14:07	26-Aug-16	14:13	< 0.02
% Moisture (wet wt) [%]	25-Aug-16	15:23	25-Aug-16	15:23	13.8
pH [no unit]	26-Aug-16	08:44	29-Aug-16	11:36	8.89
Chloride [µg/g]	25-Aug-16	19:10	29-Aug-16	13:38	9.1
Sulphate [µg/g]	25-Aug-16	19:10	29-Aug-16	13:38	19
Conductivity [µS/cm]	26-Aug-16	08:44	29-Aug-16	12:11	78
Resistivity (calculated) [Ohms.cm]	---	---	29-Aug-16	14:39	12800

Temperature of Samples upon receipt 28.3 degrees C
No cooling agent present
Custody Seal not present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662**Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive
Oakville, ON
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Phone: 905-829-8666 x 228
Fax:

17-November-2016

Date Rec. : 16 August 2016
LR Report: CA15286-AUG16
Reference: 13662 Mark Farrant

Copy: #1


CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	7: Chowder Creek
Sample Date & Time						12-Aug-16
Temperature Upon Receipt [°C]	---	---	--	--	---	4.0
Corrosivity Index [none]	23-Aug-16	16:05	23-Aug-16	16:05		3
pH [no unit]	16-Aug-16	11:00	16-Aug-16	14:58	0.05	7.96
Conductivity [µS/cm]	16-Aug-16	11:00	16-Aug-16	14:58	2	240
Resistivity (calculated) [Ohms.cm]	16-Aug-16	11:00	24-Aug-16	09:08	---	4170
Redox Potential [mV]	16-Aug-16	14:10	17-Aug-16	11:15	---	215
Chloride [mg/L]	16-Aug-16	13:23	19-Aug-16	16:55	0.04	1.4
Sulphate [mg/L]	16-Aug-16	13:23	19-Aug-16	16:55	0.04	0.22
Sulphide [mg/L]	17-Aug-16	13:02	18-Aug-16	15:07	0.006	< 0.006

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500


Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

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Phone: 705-652-2000 FAX: 705-652-6365

Project : 13662

LR Report : CA15286-AUG16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0220-AUG16												
Chloride	0.04	mg/L	<0.04		NV	20	101	80	120	NV	75	125
Sulphate	0.04	mg/L	<0.04		3	20	100	80	120	97	75	125
Conductivity - QCBatchID: EWL0226-AUG16												
Conductivity	2	µS/cm	4.44		6	10	99	90	110	NA		
pH - QCBatchID: EWL0226-AUG16												
pH	0.05	no unit	NA		1		101			NA		
Redox Potential - QCBatchID: EWL0230-AUG16												
Redox Potential	no	mV	NA		3	20	106	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0139-AUG16												
Sulphide	0.006	mg/L	<0.006		100	20	101	80	120	104	75	125

Appendix C

Selected Site Photographs



Photo 1: Chowder Creek Culvert, south side looking west



Photo 2: Chowder Creek Culvert, north side looking east



Photo 3: Chowder Creek Culvert, north side looking west



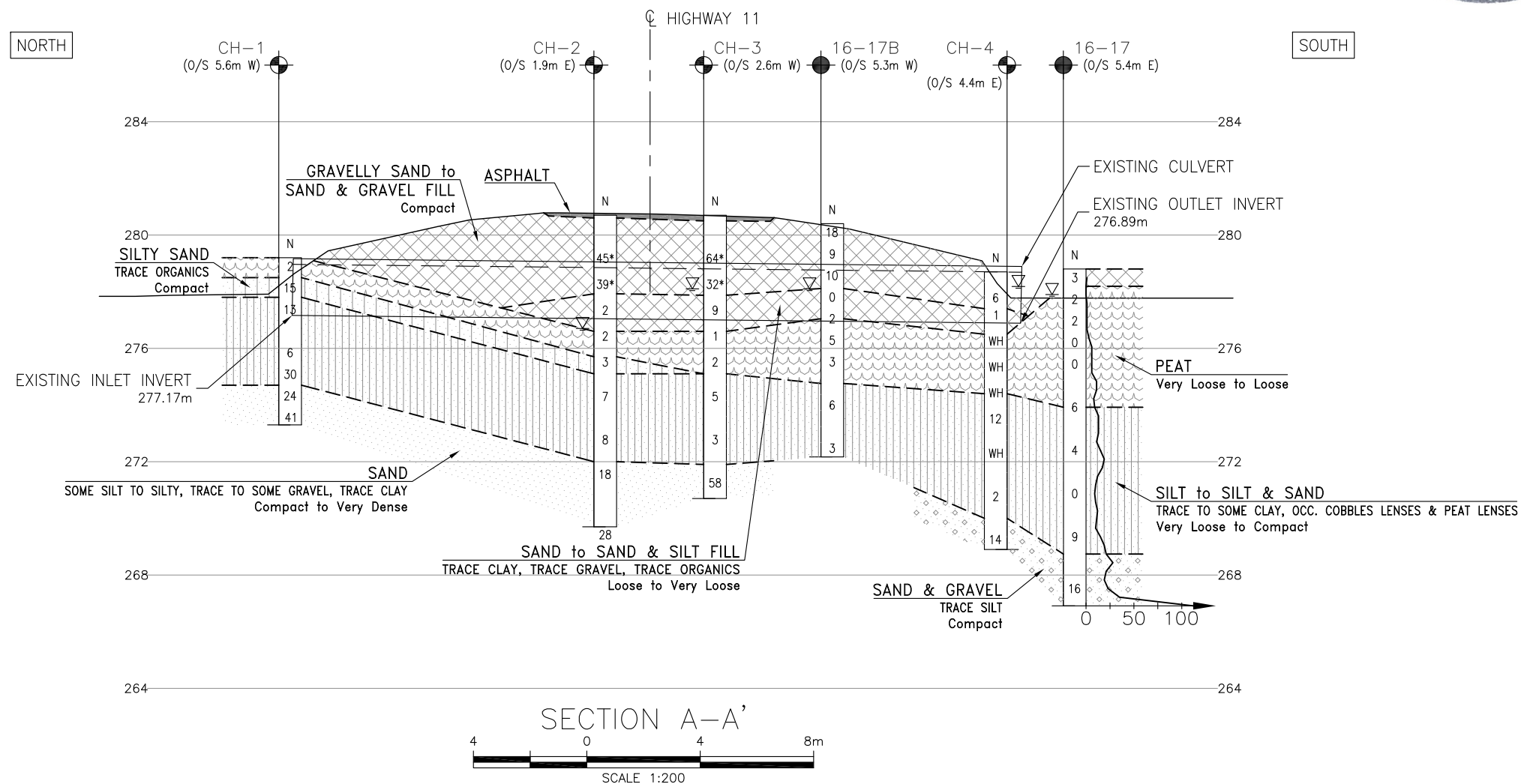
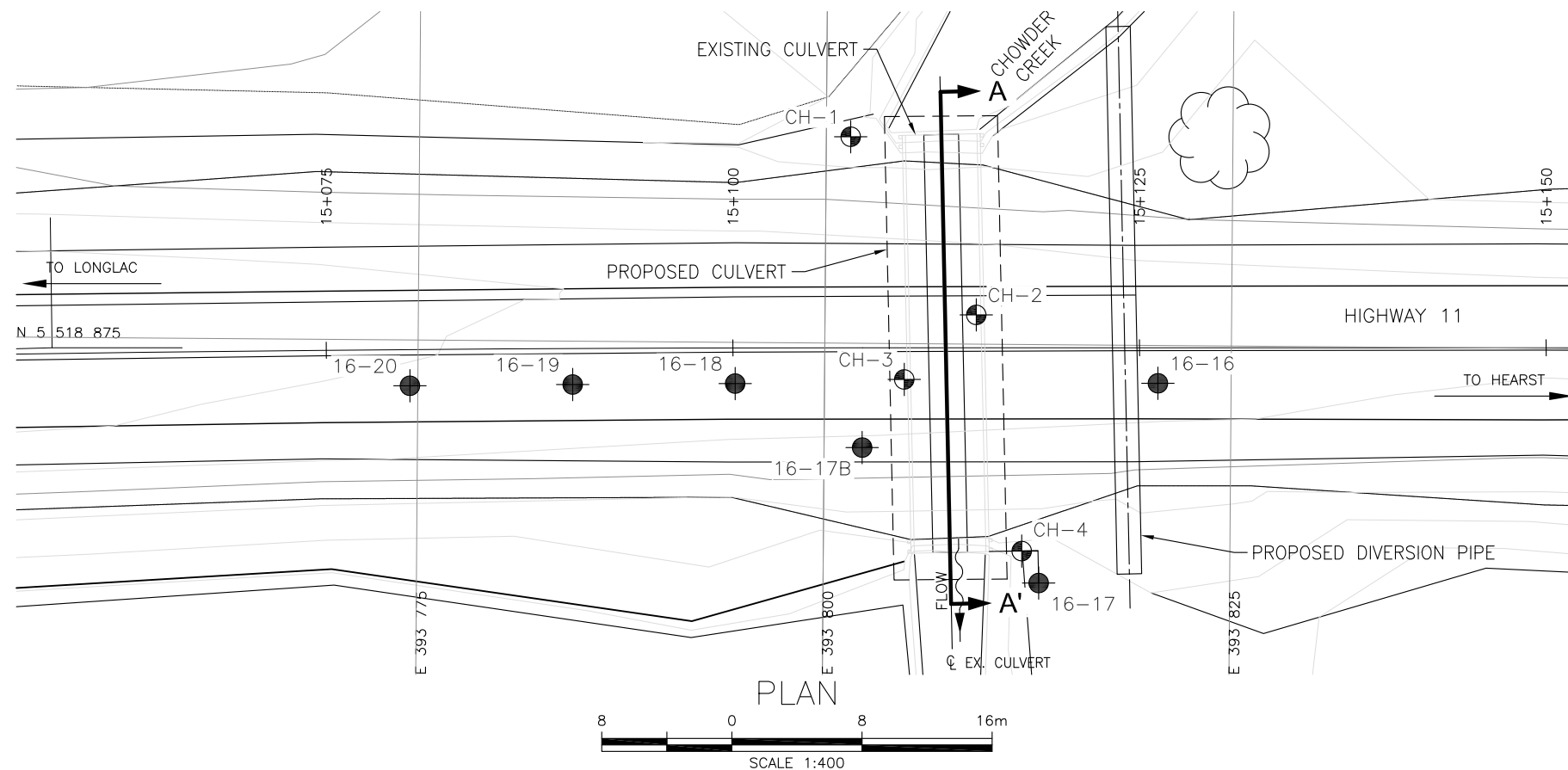
Photo 4: Chowder Creek Culvert, inlet (north side)



Photo 5: Chowder Creek Culvert, outlet (south side)

Appendix D

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

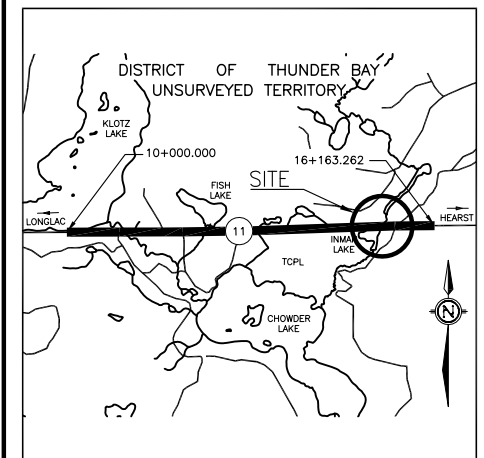


CONT No 2017-6001
WP No 6312-14-01

HIGHWAY 11
CHOWDER CREEK EAST
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA






SHEET
9

HATCH



KEYPLAN

LEGEND

	Borehole (by Thurber)
	Borehole (by Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

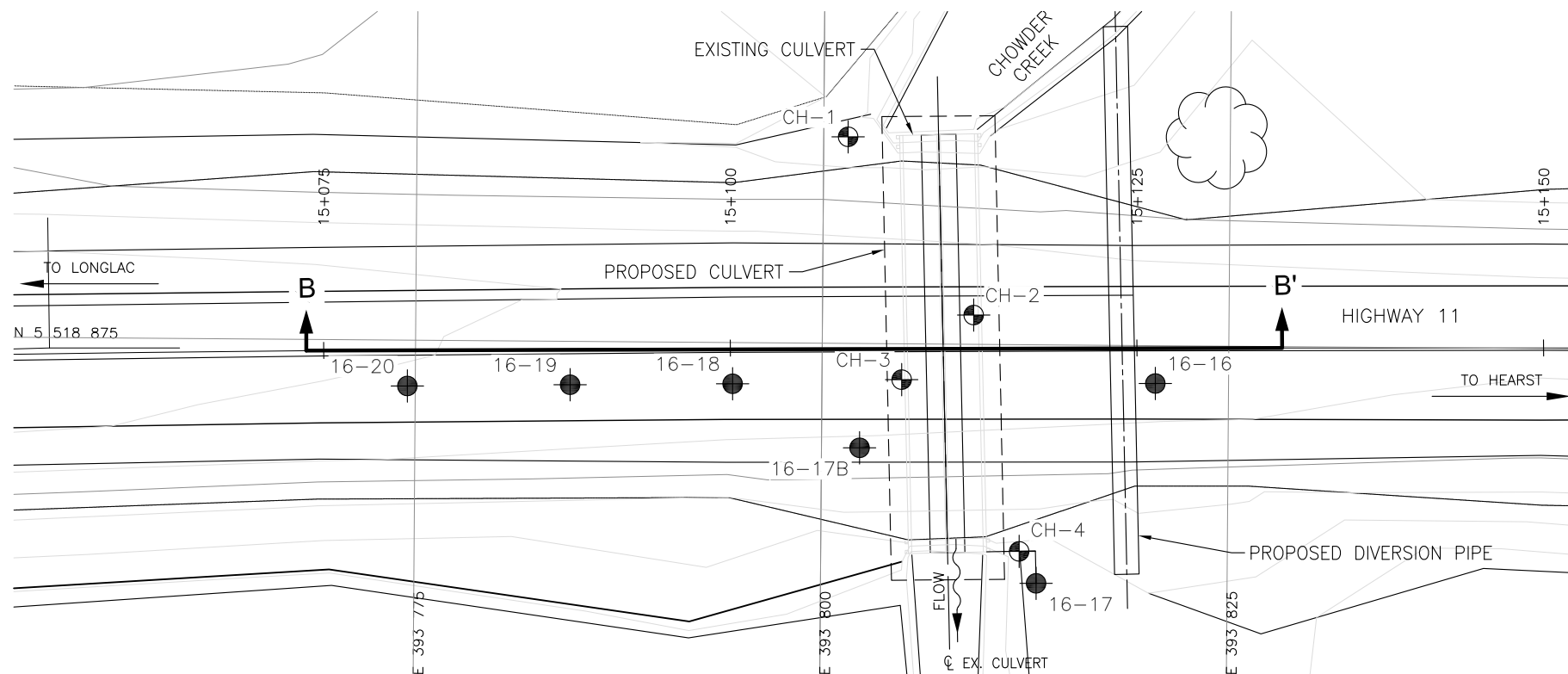
NO	ELEVATION	NORTHING	EASTING
16-16	280.7	5 518 872.7	393 820.5
16-17	278.8	5 518 860.3	393 813.3
16-17B	280.4	5 518 868.6	393 802.3
16-18	280.8	5 518 872.5	393 794.5
16-19	280.9	5 518 872.3	393 784.5
16-20	281.0	5 518 872.2	393 774.5
CH-1	279.2	5 518 887.7	393 801.5
CH-2	280.7	5 518 876.8	393 809.3
CH-3	280.7	5 518 872.8	393 804.9
CH-4	278.7	5 518 862.3	393 812.2

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) MTM Zone 14 co-ordinate system used to obtain borehole Northings and Eastings.
- 4) Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 42F-41

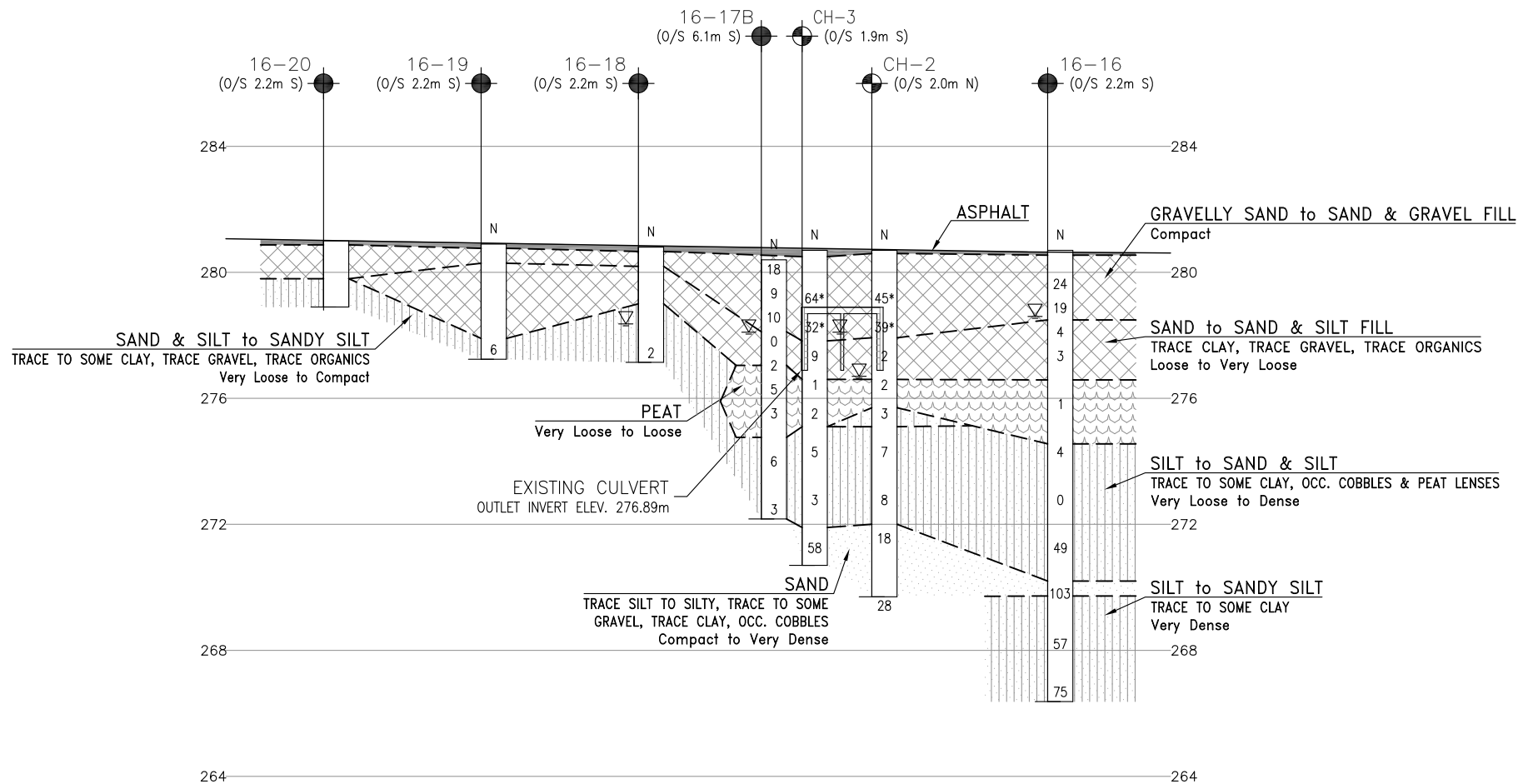
[illegible]



PLAN



SCALE 1:400



PROFILE B-B'



H 1:400

V 1:200

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



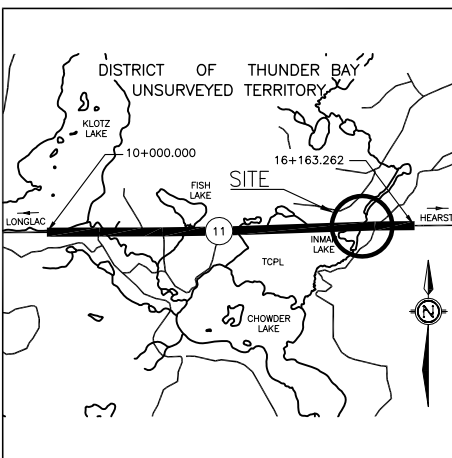
CONT No 2017-6001
WP No 6312-14-01

HIGHWAY 11
CHOWDER CREEK EAST
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
10

HATCH



KEYPLAN

LEGEND

●	Borehole (by Thurber)
⊙	Borehole (by Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊕	Head Artesian Water
⊖	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-16	280.7	5 518 872.7	393 820.5
16-17	278.8	5 518 860.3	393 813.3
16-17B	280.4	5 518 868.6	393 802.3
16-18	280.8	5 518 872.5	393 794.5
16-19	280.9	5 518 872.3	393 784.5
16-20	281.0	5 518 872.2	393 774.5
CH-1	279.2	5 518 887.7	393 801.5
CH-2	280.7	5 518 876.8	393 809.3
CH-3	280.7	5 518 872.8	393 804.9
CH-4	278.7	5 518 862.3	393 812.2

-NOTES-

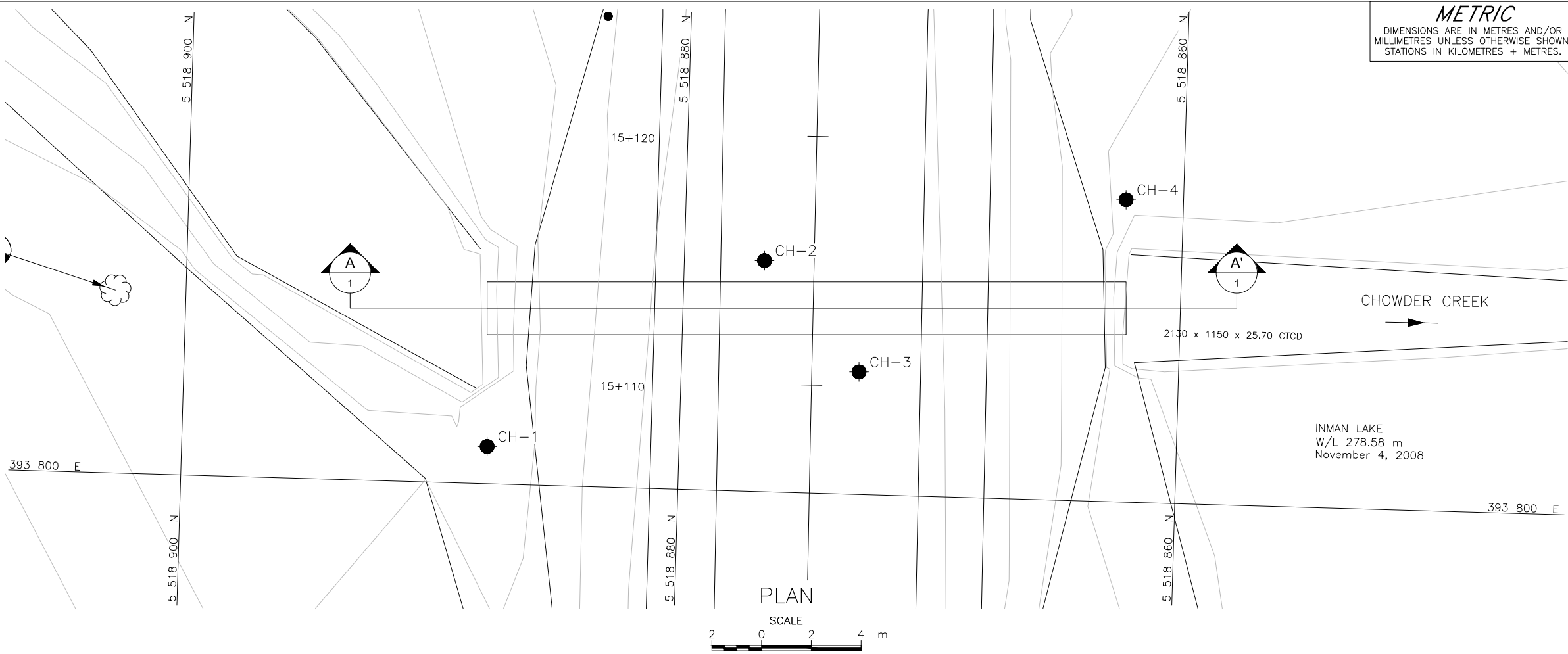
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- MTM Zone 14 co-ordinate system used to obtain borehole Northings and Eastings.
- Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 42F-41

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																</
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Appendix E

**Record of Borehole Sheets and Borehole Location and Soil Strata Drawing
Geocres No 42F-35**

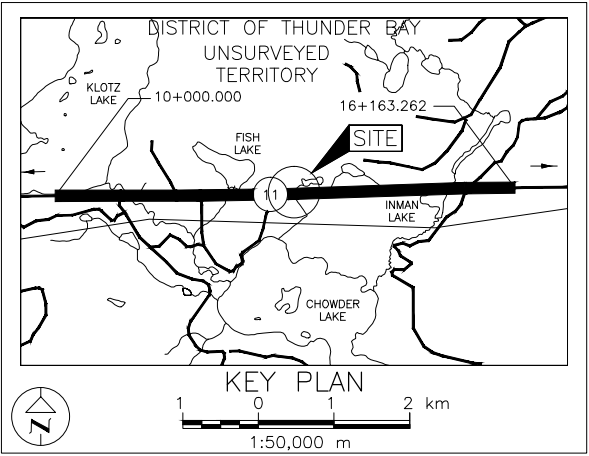


METRIC
DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
GWP No. 6312-14-00

HIGHWAY 11
CHOWDER CREEK CULVERT STA 15+113
BOREHOLE LOCATIONS AND SOIL
STRATA

SHEET



LEGEND

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

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
CH-1	279.2	551887.7	393801.5
CH-2	280.7	551887.6	393809.3
CH-3	280.7	551887.2	393804.9
CH-4	278.7	551886.3	393812.2

NOTES

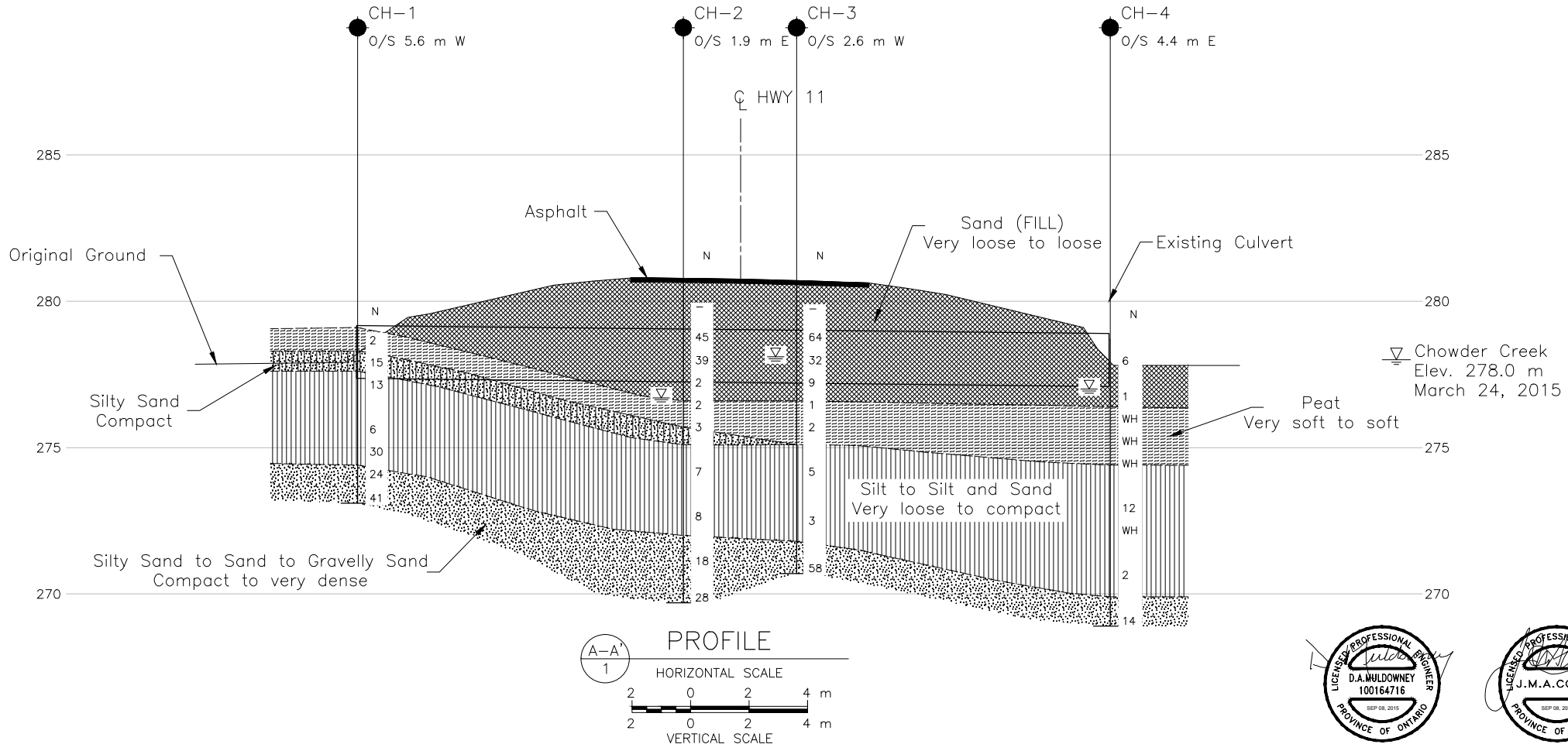
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

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

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by MTO, drawing file no. BC494854113, received FEB 20, 2015.



Chowder Creek
Elev. 278.0 m
March 24, 2015



NO.	DATE	BY	REVISION
1	8/26/2015	JJL	1

Geocres No. 42F-35

HWY. 11	PROJECT NO. 1411523	DIST. .
SUBM'D. AC	CHKD. .	DATE: 8/26/2015
DRAWN: JJL	CHKD. DAM	APPD. JMAC
		SITE: 48E-84/C
		DWG. 1

PROJECT 1411523		RECORD OF BOREHOLE No CH-1				1 OF 1 METRIC											
G.W.P. 6312-14-00		LOCATION N 5518887.7; E 393801.5				ORIGINATED BY NJ											
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY AC											
DATUM GEODETIC		DATE March 27, 2015				CHECKED BY DAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
279.2	GROUND SURFACE																
0.0	PEAT, some sand Very soft Black Moist		1	SS	2												
278.5																	
0.7	Silty SAND Compact Grey Moist to wet		2	SS	15												
277.8																	
1.4	SILT, trace to some clay, trace sand Loose to compact Grey Wet		3	SS	13												
	Augers grinding from 3.0 m to 3.8 m depth on inferred cobbles.		4	SS	6												
			5	SS	30												
274.7																	
4.5	SAND, some silt, some gravel, trace clay Compact to dense Grey Wet		6	SS	24												
			7	SS	41												
273.3																	
5.9	END OF BOREHOLE Note: 1. Water level not obtained.																



SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No CH-2			1 OF 1 METRIC											
G.W.P. 6312-14-00			LOCATION N 5518876.8; E 393809.3			ORIGINATED BY NJ											
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC											
DATUM GEODETIC			DATE March 23, 2015			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m ³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60	W _p W W _L							
280.7	GROUND SURFACE																
0.0	ASPHALT (140 mm)																
0.1	Sand, trace to some gravel, trace to some silt (FILL) Very loose Brown Frozen* to wet		1	AS	-		280										
			2	SS	45*		279										
			3	SS	39*		278										9 78 (13)
			4	SS	2		277										
276.6	PEAT Very soft to soft Black Wet		A 5 B	SS	2		276										
275.7	Silty SAND, trace organics Grey Wet		A 6 B	SS	3		275										
275.1	SILT, some sand, trace to some clay Loose Grey Wet						274										
272.0	Silty SAND, trace gravel Compact Grey Wet		7	SS	7		273										
			8	SS	8		272										
			9	SS	18		271										
			10	SS	28		270										4 68 (28)
269.7	END OF BOREHOLE																
11.0	Note: 1. Water level at a depth of 4.0 m below ground surface (Elev. 276.7 m) upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No CH-3			1 OF 1 METRIC											
G.W.P. 6312-14-00			LOCATION N 5518872.8; E 393804.9			ORIGINATED BY NJ											
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC											
DATUM GEODETIC			DATE March 24, 2015			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W _p W W _L WATER CONTENT (%)			γ	GR SA SI CL
280.7	GROUND SURFACE							20 40 60 80 100									
0.0	ASPHALT (150 mm)																
0.2	Sand, trace to some gravel, trace to some silt (FILL) Loose Brown Frozen* to wet		1	AS	-		280										
			2	SS	64*		279										
			3	SS	32*		278									5 83 (12)	
			4	SS	9		277										
276.6	PEAT Very soft Black Wet		A 5 B	SS	1		276										
			6	SS	2												
275.1	SILT, trace sand, trace clay Very loose to loose Grey Wet						275										
			7	SS	5		274									NP 0 4 90 6	
							273										
			8	SS	3		272										
271.9	SAND, some silt, trace to some gravel, trace clay Very dense Grey Wet		A 9 B	SS	58		271									11 70 15 4	
270.7	Augers grinding from 8.8 m to 9.1 m depth on inferred cobbles. END OF BOREHOLE																
10.0	Note: 1. Water level at a depth of 2.6 m below ground surface (Elev. 278.1 m) upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No CH-4			1 OF 1 METRIC												
G.W.P. 6312-14-00			LOCATION N 5518862.3; E 393812.2			ORIGINATED BY NJ												
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY AC												
DATUM GEODETIC			DATE March 25, 2015			CHECKED BY DAM												
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ	GR SA SI CL	
							20 40 60 80 100	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × REMOULDED	W _p	W	W _L	20 40 60	kN/m ³				
278.7 0.0	GROUND SURFACE Sand, some gravel (FILL) Very loose to loose Brown to black Moist to wet Trace organics in the upper 0.8 m.		1	SS	6		278											
			2	SS	1		277											
276.5 2.2	PEAT Very soft Black Moist to wet		3	SS	WH		276											
		4	SS	WH	275													
274.4 4.3	SILT and SAND, trace to some clay, trace gravel Very loose to compact Grey Wet	A 5 B	SS	WH	274													
		6	SS	12	273													
		7	SS	WH	272													
		8	SS	2	271													
270.0 8.7	Gravelly SAND, trace to some silt Compact Grey Wet							270										
268.9 9.8	END OF BOREHOLE Note: 1. Water level at a depth of 1.7 m below ground surface (Elev. 277.0 m) upon completion of drilling.						269											

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 03/09/15 DATA INPUT:

Appendix F

List of Specifications and Suggested Wording for NSSP

List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206
- OPSS PROV 209
- OPSS.PROV 421
- OPSS PROV 422
- OPSS PROV 501
- OPSS.PROV 517
- OPSS PROV 539
- OPSS PROV 804
- OPSS PROV 902
- OPSS PROV 1010
- OPSS PROV 1205
- OPSS 1860
- OPSD 208.010
- OPSD 802.010
- OPSD 802.014
- OPSD 803.010
- OPSD 803.031
- OPSD 3090.100

2. Suggested Wording for NSSP

- Suggested Text for NSSP on "Obstructions"

"Excavations and installation of cofferdams and roadway protection systems could encounter obstructions such as cobbles and boulders embedded in the fill and native soils, or shallow bedrock. Such obstructions may impede excavation progress and/or sheetpile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths."

- Suggested Text for NSSP on "Groundwater and Dewatering"

"The Contractor is notified that the site has high groundwater levels and that these levels may be higher than the water levels shown in the Foundation Investigation Report prepared for this site. While reference should be made to that report for a description of the encountered conditions, the Contractor must satisfy himself regarding the groundwater levels likely to prevail at the time of construction and be prepared to implement dewatering procedures.

The Contractor is further notified that failure to implement dewatering in advance of excavating below the groundwater table may result in sloughing and boiling of the soil in the excavation and a loss in stability and bearing resistance.

Design and provision of an effective dewatering system is the responsibility of the Contractor. Subgrade preparation, culvert construction and backfilling must be carried out in the dry. "