



THURBER ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION AND DESIGN REPORT
ROSSMERE CREEK CULVERT REPLACEMENT
HIGHWAY 11, HAGEY TOWNSHIP
DISTRICT OF THUNDER BAY, ONTARIO
G.W.P. No. 6804-14-00, W.P. No. 6804-14-01
SITE No. 48W-192/C
LATITUDE: 48.635823°, LONGITUDE: -90.185649°**

GEOCRES Number: 52B-36

Report

to

WSP Canada Inc.

Date: October 31, 2018
File: 22155



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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 detailed design of the proposed Rossmere Creek Culvert replacement. The Rossmere Creek culvert is located on Highway 11, west of Shebandowan, in Hagey Township, District of Thunder Bay, Ontario. Thurber previously conducted a preliminary foundation investigation at the culvert site in 2017.

The purpose of this investigation was to explore the subsurface conditions at the culvert site 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 WSP Canada Inc. (WSP) to carry out this detailed foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0035.

The preliminary investigation previously conducted by Thurber is described in the following report:

- Preliminary Foundation Investigation and Design Report, Rossmere Creek Culvert Replacement, Highway 11, Site No. 48W-192/C, Hagey Township, District of Thunder Bay Ontario, GEOCRES Number 52B-32, dated October 2, 2017, prepared by Thurber Engineering Ltd.

The Borehole Logs from the preliminary investigation are included in this report.

2. SITE DESCRIPTION

The site is located on Highway 11, approximately 2.9 km west of the intersection of Highway 586



and Highway 11 in Hagey Township, 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 Rossmere Creek to flow in a southerly direction and drain into Rossmere Bay, part of Middle Shebandowan Lake.

The Ontario Structural Inspection Manual (Inspection Form) prepared by MTO on December 16 2015 indicates that the existing structure is a 25 m long, three span (1.4 m, 1.4 m, 1.0 m) open footing, timber structure culvert with an unknown construction date. The culvert invert is at approximately Elevation 449.3 m at the inlet (north end) and 449.2 m at the outlet (south end), and the culvert height is approximately 1.2 m. The existing road grade of Highway 11 at the culvert location is approximately Elev. 452.2 m, which indicates approximately 1.8 m of fill above the culvert. The Rossmere water level (ice level) was measured by Thurber at Elevation 450.2 m on March 27, 2017, and was measured by others at 450.0 m in August, 2015. At the time of the field investigations the culvert was flowing mostly full, with the top of the ice elevation just below the crest of the culvert. No information is available to indicate whether the culvert is founded on footings or timber piles.

The lands surrounding Rossmere Creek 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 and consists of organic terrain. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on published geological information, the subsurface soils at the site generally consist of organic deposits of peat with nearby ground moraine deposits of silty to sand till. Bedrock in the area has been identified as mafic to intermediate metavolcanic bedrock, comprised of basaltic and andesitic flows.

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between March 7 and April 23, 2018, and consisted of drilling and sampling six (6) boreholes, designated as Boreholes 18-01 to 18-06, to depths ranging from 9.8 m to 15.5 m below the existing ground surface. Boreholes 18-01 to 18-04 were drilled near the inlet and outlet of the existing culverts near the locations of the the proposed cofferdams, and Boreholes 18-05 and 18-06 were drilled through the paved section



of Highway 11 for the proposed roadway protection systems and diversion pipe.

The previous preliminary investigation was carried out between March 25 and 27, 2017 and consisted of drilling and sampling a total of seven (7) boreholes, designated as Boreholes 17-15 to 17-21, to depths ranging from 3.7 m to 15.3 m below the existing ground surface.

The Record of Borehole sheets for the boreholes from the current and previous investigations are included in Appendix A. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from cross sections and topographic drawings provided to Thurber by WSP. The boreholes from the current investigation were drilled using a truck mounted drill rig with hollow stem augers and wash boring techniques for Boreholes 18-05 and 18-06, and a portable Hilti drill and tripod equipment using wash boring techniques for Boreholes 18-01 to 18-04. 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 Boreholes 18-05 and 18-06 adjacent to the original borehole to cone refusal depth of approximately 14.1 m and 15.5 m, respectively.

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.

Piezometers were installed as part of the current investigation in Boreholes 18-02, 18-03 and 18-06, and water level readings were taken throughout the investigation. The piezometers were decommissioned at the completion of the field investigation. The boreholes were backfilled in general accordance with Ontario Regulation 903, as amended. A piezometer was also installed in Borehole 17-18 drilled during the preliminary investigation. Caving was noted in a number of boreholes in the silt and silty sand soils.

Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-01	9.8 / 440.3	None installed	Borehole caved to 5.2 m then backfilled with bentonite holeplug and cuttings to surface.
18-02	9.9 / 440.1	3.7 / 446.3	Borehole caved to 3.7 m, then backfilled with sand to 1.5 m, then bentonite holeplug to surface
18-03	9.8 / 440.2	5.8 / 444.2	Borehole caved to 5.8 m, then backfilled with sand to 3.4 m, then bentonite holeplug to surface
18-04	9.8 / 440.3	None installed	Borehole caved to 5.4 m then backfilled with bentonite holeplug and cuttings to surface.
18-05	15.2 / 436.9	None installed	Borehole caved to 10.4 m then backfilled with bentonite holeplug and cuttings to 0.6 m, concrete to 0.3 m, then asphalt to surface.
18-06	15.5 / 436.7	15.2 / 437.0	Sand from 15.5 m to 11.6 m, bentonite holeplug to 11 m, bentonite holeplug and cuttings to 0.6 m, concrete to 0.3 m, then asphalt to surface.
17-15	12.8 / 437.6	None installed	Borehole backfilled with bentonite holeplug and cuttings to surface.
17-16	15.3 / 436.9	None installed	Borehole backfilled with bentonite holeplug cuttings and concrete to surface.
17-17	15.3 / 436.8	None installed	Borehole backfilled with bentonite holeplug cuttings and concrete to surface.
17-18	12.8 / 437.4	12.2 / 438	Sand from 12.8 m to 10.7 m, and bentonite holeplug cuttings and concrete to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
17-19	3.7 / 448.4	None installed	Borehole backfilled with bentonite holeplug and concrete to surface.
17-20	3.7 / 448.4	None installed	Borehole backfilled with bentonite holeplug and concrete to surface.
17-21	3.7 / 448.4	None installed	Borehole backfilled with bentonite holeplug and concrete to surface.

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, during the previous investigation, two samples 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 Appendix A and the soil stratigraphy drawings included in Appendix D. 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.

In general, the subsurface conditions encountered in the boreholes below the existing



embankment fill typically consist of peat, underlain by silty clay, and deposits of silt and sand. Auger refusal and cone refusal occurred in Boreholes 17-17 and 17-16 beneath the sand deposits on probable bedrock at Elevations 437.6 m and 436.9 m. DCPT refusals were also encountered in Boreholes 18-05 and 18-06 at Elevations ranging from 438.0 m to 436.7 m. Descriptions of the individual strata are presented below.

5.1 Asphalt

The boreholes that were drilled through the paved portion of Highway 11 (Boreholes 18-05, 18-06, 17-16, 17-17, 17-19, 17-20, and 17-21) encountered approximately 75 mm to 350 mm of asphalt at the ground surface, which extended to Elevation 451.7 m to 452.1 m.

5.2 Embankment Fill

Embankment fill was encountered in all boreholes drilled on Highway 11 (Boreholes 18-05, 18-06, 17-16, 17-17, 17-19, 17-20, and 17-21) beneath the asphalt. The fill consisted of sand, gravelly, sand, and silty sand and contained trace to some silt, trace to some gravel, and occasional cobbles and boulders, particularly in the upper portions of the fill. The embankment fill typically extended to depths of approximately 2.1 m to 3.1 m below existing road surface elevation (Elevation 449.1 m to 450.0 m).

SPT 'N' values in the fill ranged from 5 to 46 blows for 0.3 m penetration, indicating a loose to very dense relative density. Higher blow counts of more than 50 blows for 0.05 m were also recorded in the embankment fill, however these high blow counts are likely a result of cobbles or boulders within the fill as well as frozen material. Measured moisture contents ranged from 2 to 22%.

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

Soil Particle	Percentage
Gravel	0 to 25
Sand	60 to 70
Silt and Clay	10 to 40



5.3 Peat

Peat was encountered beneath the embankment fill in all boreholes on Highway 11 and at the ground surface in the boreholes at the inlet and outlet of the existing culvert. The peat is described as black to dark brown in colour and contains trace to some silt and sand, and some roots and rootlets.

The peat ranged in thickness from 0.4 m to 2.4 m where fully penetrated. Beneath the road embankment, the peat, where fully penetrated, extended to depths of between 3.5 m and 4.3 m below existing road surface (Elevations 447.8 m to 448.7 m). At the inlet and outlet, the peat extended to depths of between 1.4 m and 2.4 m below existing ground surface (Elevations 447.7 m and 448.8 m). In Boreholes 17-19 to 17-21 the peat extended to the maximum depth drilled of 3.7 m below existing road surface (Elevation 448.4 m).

SPT 'N' values recorded in the peat ranged between 1 to 6 blows for 0.3 m penetration, indicating a very soft to firm consistency. The blow counts in the peat under the highway embankment are higher than the blow counts in the peat beyond the toe of the embankment. Higher blow counts of 16 and 40 were recorded near the ground surface in the peat but were likely a result of frozen material. Measured moisture contents in the peat ranged from 61% to 617%. The uncompressed peat beyond the toe of the embankment generally has a higher water content.

5.4 Silty Clay to Clay

Silty clay changing to clay, with some silt, trace to some sand and brown in colour was encountered beneath the peat deposits in all boreholes where the peat was fully penetrated. The silty clay to clay, where fully penetrated, was approximately 1.4 m to 5.6 m thick and extended to depths of between 3.5 m and 8.1 m below the existing ground surface (Elevations 446.6 m and 443.1 m).

A lower layer of silty clay to clay was encountered in Boreholes 18-03 and 18-05 at a depth of 7.5 m and 11.0 m (Elevation 442.5 m and 441.1 m), respectively. The lower silty clay to clay was approximately 1.6 m and 1.2 m thick, extending to depths of approximately 9.1 m and 12.2 m (Elevations 440.9 m and 439.9 m), respectively.

SPT 'N' values recorded in the silty clay to clay ranged from 0 to 19 blows for 0.3 m penetration. In-situ vane shear tests were conducted in the silty clay to clay and measured undrained shear strengths of between 57 kPa and 106 kPa. The results of the SPTs and vane shear tests indicate



the silty clay is soft to very stiff. The sensitivity of the silty clay to clay was measured to range between 2 and 6, indicating low sensitivity to sensitive. Measured moisture contents in the silty clay ranged from 23% to 84%.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B2 and B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	0 to 20
Silt	14 to 35
Clay	45 to 83

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B7 of Appendix B. The results are summarized as follows:

Soil Property	Percentage
Liquid Limit	41 to 79
Plastic Limit	18 to 30
Plasticity Index	23 to 52

The results of the Atterberg Limits testing indicate that the silty clay has an intermediate to high plasticity with group symbol CI to CH.

5.5 Silt

Silt, containing trace sand and clay, was encountered in Boreholes 17-15 to 17-18, 18-01, 18-04 and 18-06 at depths of between 5.6 m and 8.7 m (Elevations 446.6 m to 441.5 m). Where fully penetrated the silt layer was approximately 1.5 m to 6.1 m thick and extended to depths of between 10.2 m and 11.9 m (Elevations 441.9 m and 438.7 m). Boreholes 18-01 and 18-04 were terminated within the silt layer at depths of 9.8 m (Elevation 440.3 m).

SPT 'N' values recorded in the silt ranged from 6 to 71 blows for 0.3 m penetration, indicating a loose to very dense relative density. Measure moisture contents in the silt ranged from 10% to 34%.



The results of grain size analyses conducted on samples of the silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	0 to 5
Silt	89 to 94
Clay	4 to 7

5.6 Silty Sand to Sandy Silt

Silty sand to sandy silt, containing trace to some gravel, trace to some silt, trace clay and brown to grey in colour, was encountered in Boreholes 17-15, 17-18, and 18-01 to 18-05 at depths of between 4.7 m and 11.7 m (Elevations 445.3 m and 438.7 m). Where fully penetrated the silty sand to sandy silt was approximately 1.8 m to 2.9 m thick and extended to depths of between 7.6 m and 11.0 m (Elevations 442.5 m and 441.1 m). Boreholes 17-15, 17-18, 18-02, and 18-03 were terminated in the silty sand to sandy silt layers at depths of between 9.8 m and 12.8 m (Elevations 440.2 m and 437.4 m).

SPT 'N' values recorded in the silty sand to sandy silt ranged from 8 to 66 blows for 0.3 m penetration, indicating a loose to very dense relative density. Measure moisture contents ranged from 9 to 27 percent.

The results of grain size analyses conducted on samples of the silty sand to sandy silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0 to 18
Sand	28 to 68
Silt	21 to 67
Clay	2 to 5

5.7 Sand

Sand, containing trace to some gravel, trace to some silt, trace clay, and occasional cobbles was encountered in Boreholes 17-16, 17-17, 18-05, and 18-06 at depths of between 10.2 m and 12.2



m (Elevations 441.9m and 439.9 m). These boreholes were terminated within the sand layer at depths of between 15.2 m and 15.5 m (Elevations 436.9 m and 436.7 m). A separate sand layer was encountered in Borehole 18-02 at a depth of approximately 3.5 m (Elevation 446.5 m) and was approximately 1.2 m thick, extending to a depth of 4.7 m (Elevation 445.3 m).

SPT 'N' values recorded in the sand ranged from 17 to 36 blows for 0.3 m penetration, indicating a compact to dense relative density. Measure moisture contents ranged from 2 to 21 percent.

The results of grain size analyses conducted on samples of the sand 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 to 18
Sand	58 to 98
Silt	14 to 19
Clay	2 to 5
Silt and Clay	2

5.8 Auger Refusal

Auger and/or split spoon refusal was encountered at a depth of 15.3 m (Elev 436.8 to 436.9 m) in Boreholes 17-16 and 17-17.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling and in the open boreholes upon completion, and piezometers were installed in Boreholes 17-18, 18-02, 18-03, and 18-06. The groundwater levels are high measured in the open boreholes and the piezometers are summarized in Table 5.1 below. The piezometers were decommissioned and sealed at the end of the field investigation.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-01	April 21, 2018	-	-	Borehole caved to 5 m depth
18-02	April 23, 2018	-0.1	450.1	In piezometer/artesian condition in sand



Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-03	April 21, 2018	-1.4	451.4	In piezometer/artesian condition in silty sand
	April 22, 2018	-1.4	451.4	
	April 23, 2018	-1.4	451.4	
18-04	April 17, 2018	0.0	450.1	Borehole caved to 5.4 m.
18-05	March 8, 2018	1.7	450.4	Borehole caved to 10.4 m.
18-06	March 9, 2018	1.7	450.5	In piezometer
17-15	March 27, 2017	0.2	450.2	Open borehole
17-16	March 27, 2017	3.0	449.2	Open borehole
17-17	March 26, 2017	3.0	449.1	Open borehole
17-18	March 27, 2017	0.2	450.0	In piezometer
17-19	March 25, 2017	3.0	449.1	Open borehole
17-20	March 25, 2017	3.0	449.1	Open borehole
17-21	March 25, 2017	3.0	449.1	Open borehole

During the previous investigation, the creek was frozen at the time and the top of ice level was recorded by Thurber at Elev. 450.2 m. The water level in the creek was also recorded by others, as shown on the topographic survey provided by WSP, and was 450.0 m in August, 2015. The groundwater level should be assumed to reflect the local creek water level. Artesian groundwater conditions were noted in Boreholes 18-02 and 18-03.

The above groundwater levels 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

Two samples of the native silty clay from Boreholes 17-16 and 17-17, 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		
			17-16 SS#5, 4.6 m – 5.2 m	17-17 SS#5, 4.6 m – 5.2 m	Rossmere Creek
			(Silty Clay)	(Silty Clay)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.02	0.014
Chloride	µg/g	mg/L	16	30	24
Sulphate	µg/g	mg/L	150	22	1.1
pH	No unit	No unit	8.98	8.64	6.35
Electrical Conductivity	µS/cm	µS/cm	127	160	115
Resistivity	Ohms.cm	Ohms.cm	7870	6250	8700
Redox Potential	mV	mV	286	210	197

7. MISCELLANEOUS

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

OGS Inc. of Almonte, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the current field investigation. The field investigation was supervised on a full time basis by Mr. Amir Fereidouni and Jilesh Patel 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, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



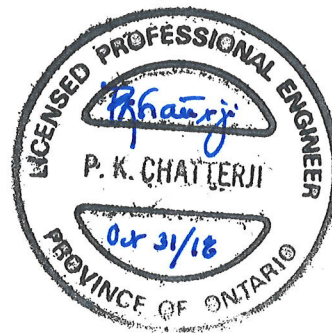
Thurber Engineering Ltd.



Cory Zanatta, P.Eng.
Geotechnical Engineer



Mark Farrant, P.Eng.
Geotechnical Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

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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 detailed foundation design recommendations for the proposed Rossmere Creek culvert replacement located on Highway 11 in Hagey Township, District of Thunder Bay, Ontario. This detailed foundation report should be read in conjunction with the Preliminary Foundation Report dated October 2, 2017.

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 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.

Information on the existing culvert site was obtained from the MTO Terms of Reference and the Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on December 16, 2015. The existing structure is a three-span open footing timber culvert. The culvert is approximately 3.8 m wide and 25 m long. The estimated culvert invert is at approximately Elev. 449.3 m at the inlet (north end) and 449.2 m at the outlet (south end). The existing road grade at the culvert location is approximately Elev. 452.2 m, which indicates approximately 1.8 m of fill above the culvert. At the time of the investigation the culvert was flowing nearly full. No information is available to indicate whether the culvert is founded on footings or timber piles.

The preliminary foundation report provided recommendations for both pipe culverts and box

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culverts. General Arrangement Drawings and discussions with WSP/MTO, indicate that twin Corrugated Steel Pipe (CSP) culverts are the preferred replacement option. The CSPs are to have a 2.7 m diameter each. The invert level of the new pipes (underside of the pipe) are approximately at Elevation 448.52 and 448.36 at the inlet and outlet, respectively.

The replacement culvert will be constructed along a new alignment, approximately 4 m west of the existing culvert alignment. No grade raise is proposed for the culvert replacement. No headwalls or wingwalls are proposed. A temporary creek diversion pipe would also be installed during construction, approximately 10 m east of the existing culvert.

9. CULVERT FOUNDATION DESIGN

In general, the subsurface conditions encountered in the boreholes drilled through the highway platform contain embankment fill, typically consisting of sand to sand and silt, underlain by a layer of peat, followed by silty clay, then silt and then sand. The water level was measured at approximately Elevation 450.0 m in the creek and Elevations 450.0 m to 451.4 m in the piezometers. Artesian groundwater condition with piezometric head of about 0.1 m to 1.4 m above ground level was encountered in Boreholes 18-02 and 18-03 at the inlet and outlet.

The founding soils encountered at the proposed invert level (Elevation 448.4m to 448.5 m) generally consist of peat underlain by soft to very stiff silty clay. There is approximately 1 m of fill over the proposed CSPs. Foundation design aspects for the replacement culvert include subgrade conditions and preparation, settlement of founding soils, lateral earth pressures, roadway protection system design, groundwater control, cofferdams, staged construction, and restoration of the roadway embankment.

The preliminary investigation report provided foundation recommendations for different types of culverts and these recommendations are not repeated here but may be used for detailed design.

9.1 Foundations

Replacement of the culvert with twin CSPs on an offset alignment 4 m to the west is being considered for this site. Since there is no grade raise proposed, it is anticipated that the subgrade soils within the culvert footprint will not be subjected to any significant additional loading due to the culvert replacement.

The twin CSPs should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements as per Ontario



Provincial Standard Drawing (OPSD) OPSD 802.010. All the peat encountered at and below the culvert subgrade must be removed and replaced by compacted granular fill up to the underside of the bedding material within a sheet pile enclosure, as described in Sections 12.1 and 12.2. Based on the general arrangement drawings, the underside of the bedding material will be at approximately Elevation 448.0 m. 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 firm silty clay deposits below the peat. Adequate preparation of the subgrade will be essential for performance of the culvert.

9.2 Settlement

Embankment grade raise or widening, is not proposed as part of the culvert replacement. It is recommended that the underlying peat deposit be completely excavated and replaced with compacted granular or rock fill. Therefore, changes in the loading conditions on the foundation soils consisting of native silty clay are expected to be small. If the peat below the culvert footprint is completely removed and replaced with granular or rock fill, the post construction settlements after culvert construction and embankment reconstruction at this site is estimated to be less than 30 to 40 mm. The settlement may be mitigated by designing an oversized culvert or designing a camber to accommodate the settlement.

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 along the highway alignment, which would cause settlement of the embankment outside of the culvert footprint.

It must be noted that any additional load imposed on the culvert replacement will induce immediate settlement and consolidation settlement of the cohesive soils (soft to very stiff silty clay) at this site.

9.3 Frost Cover

The depth of frost penetration at this site is approximately 2.3 m, as per OPSD 3090.100. The twin CSPs do not require frost cover/protection.

Boreholes 17-19 to 17-21 were drilled to investigate the presence of an existing frost taper. The boreholes found 2.1 to 2.4 m of granular and sand fill overlying peat deposits to at least 30 m east



of the centreline of the existing culvert. The majority of the granular fill is not frost susceptible, except for the sand and silt fill below a depth of 1.1 m to 1.5 m in Boreholes 17-16, 17-17 and 18-06 near the existing culvert, which has low frost susceptibility. 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 peat.

The peat soils and native silty clay soils underlying the fill are frost susceptible. As the frost penetration line is below the top of culvert, frost treatment/taper for the culvert should be provided as per OPSD 803.031 for the CSP culverts. Since the existing embankment material beyond the excavations for the existing culvert is not frost susceptible, a new frost taper does not appear to be warranted.

10. LATERAL EARTH PRESSURES

A triangular distribution of lateral earth pressures acting on any culvert walls or retaining walls, if employed, 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 $\phi = 32^\circ$; $\gamma = 21.2 \text{ kN/m}^3$	
	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 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 soft to very stiff silty clay overlying compact sand and silt soils. This would correspond to a Seismic Site Class D 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 0.040 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 $\phi = 32^\circ$, $\gamma = 21.2 \text{ kN/m}^3$	Existing Fill $\phi = 30^\circ$, $\gamma = 20 \text{ kN/m}^3$
Active (K_{AE})*	0.30	0.33	0.36
At Rest (K_{OE})**	0.52	0.57	0.60

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

** After Woods

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 within the culvert footprint area and east of the culvert along the stream diversion pipe alignment. Approximately 0.4 to 2.4 m of peat was encountered near the culvert location. The base elevation of the peat deposit ranges from 447.7 m to 448.8 m.

The peat must be fully subexcavated to expose the native silty clay subgrade. The subexcavation should be carried out within a sheet pile enclosure to allow a vertical excavation, as indicated in Section 9.2. No information was available to confirm whether the existing culvert is founded on footings or timber piles. If timber piles are encountered during the peat removal excavations, they should either be extracted (if short piles) or cut off (if long piles) in order to facilitate removal of the peat.

The sheet piles should be designed for the case where they are exposed or unsupported to the bottom of the peat excavation. The removal of peat within the sheet pile enclosure should extend for 1.5 m beyond the width of the replacement culvert and for the entire length of the culvert. The sheet piles should remain in place following project completion and should not be extracted. 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.

A separation layer consisting of a non-woven geotextile should be placed between the peat replacement materials, such as Granular A, Granular B Type II or rock fill, 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 prepared subgrade, which has to be protected from disturbance during construction.

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 (the sheet pile cofferdam should enclose the peat excavation area on all four sides)
- Pumping from inside the cofferdam using sumps/pumps

The dewatering above must be effective to lower the groundwater level a minimum of 0.5 m below the base of the sub-excavation so as not to create basal instability in the native silty clay below the peat. Artesian groundwater conditions were noted in Boreholes 18-02 and 18-03 at the inlet and outlet. The dewatering scheme must be able to control the artesian conditions and to prevent base boiling. After implementing effective dewatering, the peat may be removed to the top of native silty clay 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 clay 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 that removal and replacement of peat below the water table is required, and that groundwater flow, artesian conditions in the foundation soils, and seepage of surface water



through the embankment fill is expected, even with using a sheet pile cofferdam and pumping from inside the cofferdam, it may not be possible to fully dewater the excavation. For this situation where the excavation cannot be fully dewatered, backfilling in the wet conditions (below the remaining 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 clay 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 Culvert Backfill

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. 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 side walls and on the top 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 silts and sands at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level. Surficial alluvial deposits, peat, and silty clay 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 the base of peat may vary significantly along the culvert length.

Excavation for culvert replacement will be carried out below the creek water level indicated at Elev. 450.0 m, and diversion of the creek flow will be required. The groundwater table is high at this site and there is evidence of artesian conditions. Given the relatively high permeability of the embankment fill materials, water inflow/seepage into the excavation should be anticipated from the embankment fill. A combination of creek diversion and sheet pile cofferdam enclosures along with the use of sumps/pumps within an enclosure will be required to maintain relatively dry excavations during the course of staged construction. Recommendations for cofferdam design are provided in Sections 14 and 15 below. 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. Peat removal and dewatering will also be required for installation of the temporary diversion culvert in an open trench.



The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517 and SP517F01. A preconstruction survey is not required, thus Designer Fill-In ***** in SP FOUN0003 should be "N/A". Considering the conditions on site, a design Engineer and design-checking Engineer with a minimum of 5 years of experience in designing systems of similar nature and scope to the required work is required, and thus Designer Fill-In ***** in SP517F01 should be "Yes".

Dewatering must remain operational and effective during peat sub-excavation and backfilling. Suggesting wording for an NSSP in this regard is included in Appendix F.

13. STREAM DIVERSION PIPE

A stream diversion pipe consisting of a CSP will be used to facilitate construction of the twin CSP culvert replacement, as indicated on the General Arrangement drawings. The diversion pipe is shown to be located approximately 10 m to the east of the centreline of the existing culvert with the invert at approximate Elevation 449.42 m. The contractor is responsible for design of the diversion pipe, and the invert level will depend on the water level in the creek at the time of construction. Below the invert level, the subgrade will consist of at least 0.7 m of peat, but may extend deeper, as documented in Boreholes 17-19 to 17-21.

The peat should be sub-excavated where encountered. The peat should then be replaced with 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, or clear stone if wet. The bedding material should be wrapped in geotextile. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The water level in Borehole 18-05 drilled along the diversion pipe is excepted to be at Elevation 450.4, hence dewatering will be required for installation of the diversion pipe. 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 a shored trench. 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. COFFERDAMS

Construction of cofferdams will be required to construct the culvert replacement in the dry. It is recommended that excavations be enclosed within a water tight enclosure. Due to the presence of 1.8 m to 2.4 m of peat at the inlet and outlet of the culvert, a sand bag cofferdam system may not be as effective where work is required below the creek level. Interlocking sheet piles are however considered to be feasible for cofferdam construction in this situation. The recommendations provided in Section 15 below for Temporary Protection Systems are also applicable to sheet piled cofferdams. The cofferdams should extend deep enough to penetrate a sufficient distance in the silty clay layer.

Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field.

15. TEMPORARY PROTECTION SYSTEM/ COFFERDAM SHEET PILES

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

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

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

Table 14.1 –Soil Parameters for Temporary Protection System/Cofferdam Design

Soil Parameter	Existing Fill	Native Silty Clay	Native Silt to Sand	Peat
Angle of Internal Friction (ϕ)	30°	24°	30°	20°
Bulk Unit Weight (γ)	20 kN/m ³	19 kN/m ³	20 kN/m ³	11 kN/m ³
Submerged Unit Weight (γ_w)	10 kN/m ³	9 kN/m ³	10 kN/m ³	1 kN/m ³
Coefficient of Active Earth Pressure (K_a)	0.33	0.42	0.33	0.49
Coefficient of Passive Earth Pressure (K_p)	3.0	2.4	3.0	-



The design of the temporary protection system and cofferdams are 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.

16. EMBANKMENT RESTORATION

Provided that the embankment is reconstructed with granular fill with side slopes inclined at not steeper than 2H:1V, the restored embankment slopes should remain stable. As discussed in Section 9.2, if all the peat is removed from under the culvert footprint, settlement of the embankment in the order of 30 to 40 mm should be expected under the existing culvert footprint. For underwater peat replacement with rock fill, it may be difficult to completely remove all of 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. The existing embankment fill should not be reused to restore the embankment.

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.

17. 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 and in accordance with OPSD 810.010, OPSS 511 and OPSS PROV 1004.

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 clay seal should be used to minimize the potential for erosion or piping around the culvert. The clay seal should be provided at the inlet and 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.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soil and creek water 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. However, the impact of road salt should be considered while selecting the class of concrete.
- The potential for soil or surface water corrosion on metal is considered to be mild. The impact of road salt on corrosion should be considered.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used.

19. CONSTRUCTION CONCERNS

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

- Peat excavation will be required. The Contractor should be prepared to have appropriate equipment for peat removal.
- 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.
- 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 E.
- 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.

20. CLOSURE

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

Thurber Engineering Ltd.

Cory Zanatta, P. Eng.
Geotechnical Engineer



Mark Farrant, P.Eng.
Geotechnical Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact





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 18-01

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 623.3 E 291 123.5 ORIGINATED BY JP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.04.20 - 2018.04.21 LATITUDE 48.63597332 LONGITUDE -90.18558004 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)						
								20 40 60 80 100				w _p w w _L						
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
450.1	GROUND SURFACE																	
0.0	PEAT , some silty sand, trace roots and rootlets Very Soft Dark Brown Wet		1	SS	2		450								240			
			2	SS	2		449											
			3	SS	2		448									617		
447.7			4	SS	4		447									520		
2.4	Silty CLAY , some sand Soft to Stiff Brown Wet to Moist (CI)		5	SS	6		447		4.0 +									
			6	SS	13		446											
							445											
444.3			7	SS	18		444											
5.8	Silty SAND , trace clay Compact Grey Wet						443											
442.5			8	SS	16		442											
7.6	SILT , trace sand and clay Compact Grey Wet						441											
440.3			9	SS	14													
9.8	END OF BOREHOLE AT 9.8m.																	

Continued Next Page

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

RECORD OF BOREHOLE No 18-01

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 623.3 E 291 123.5 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.04.20 - 2018.04.21 LATITUDE 48.63597332 LONGITUDE -90.18558004 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W P W W L	20 40 60				
	Continued From Previous Page													
	BOREHOLE CAVED TO 5.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No 18-02

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 620.2 E 291 114.1 ORIGINATED BY JP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.04.22 - 2018.04.23 LATITUDE 48.63594544 LONGITUDE -90.18570664 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W P W W L				WATER CONTENT (%)	
450.0	GROUND SURFACE							20 40 60 80 100							
0.0	PEAT , some silt and sand, trace roots and rootlets Very Soft Dark Brown Wet		1	SS	2								219	GR SA SI CL	
			2	SS	2										180
447.9			3	SS	2										452
2.1	Silty CLAY , some sand Firm to Stiff Brown Moist (CH)		4	SS	6								0 17 21 62		
446.5									6.0						
3.5	SAND , trace silt and clay Compact Grey Wet		5	SS	26								0 98 2 (SI+CL)		
445.3															
4.7	Sandy SILT , trace clay Loose to Compact Grey Wet		6	SS	8										
					7	SS	17								
					8	SS	14								
			9	SS	13								0 28 67 5		
440.1															

Continued Next Page

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

RECORD OF BOREHOLE No 18-02

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 620.2 E 291 114.1 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.04.22 - 2018.04.23 LATITUDE 48.63594544 LONGITUDE -90.18570664 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
9.9	<p>Continued From Previous Page</p> <p>END OF BOREHOLE AT 9.9m. BOREHOLE CAVED TO 3.7m. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.</p> <p>WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.04.23 -0.1 450.1</p>																

RECORD OF BOREHOLE No 18-03

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 588.6 E 291 126.3 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.04.19 - 2018.04.20 LATITUDE 48.63566145 LONGITUDE -90.18554083 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							
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL × LAB VANE					
450.0	GROUND SURFACE						20	40	60	80	100				
0.0	PEAT , some sand and silt, trace roots and rootlets Very Stiff to Soft Dark Brown Wet		1	SS	16								286	0 0 23 77	
			2	SS	2										273
448.2			3	SS	2								496		
1.8	Silty CLAY Very Stiff to Firm Brown Moist (CH)														
			4	SS	19										
			5	SS	7										
			6	SS	8										
444.8															
5.2	Silty SAND , trace gravel Very Dense Grey Moist														
			7	SS	66										
442.5															
7.5	CLAY , some silt Stiff Grey Wet		8	SS	13									0 0 17 83	
440.9															
9.1	Silty SAND , some gravel, trace clay Very Dense Grey Wet		9	SS	66										
440.2															
9.8	END OF BOREHOLE AT 9.8m.														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div><div>20406080100</div><div>SHEAR STRENGTH kPa</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT</div><div>w_pw_Lw</div><div>WATER CONTENT (%)</div><div>204060</div></div> <div>UNIT WEIGHT</div> <div>γ</div> <div>kN/m³</div> <div>REMARKS & GRAIN SIZE DISTRIBUTION (%)</div> <div>GRSA SICI CL</div>					
Continued From Previous Page					
BOREHOLE CAVED TO 5.8m. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.					
WATER LEVEL READINGS					
DATE DEPTH(m) ELEV.(m)					
2018.04.20 -1.0 451.0					
2018.04.21 -1.4 451.4					
2018.04.22 -1.4 451.4					
2018.04.23 -1.4 451.4					

RECORD OF BOREHOLE No 18-04

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 588.5 E 291 114.4 ORIGINATED BY JP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.04.17 - 2018.04.17 LATITUDE 48.6356603 LONGITUDE -90.18570202 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20	40	60					
450.1	GROUND SURFACE														
0.0	PEAT, some silt and sand, trace roots and rootlets Firm to Soft Brown Wet		1	SS	40										
			2	SS	5										
			3	SS	2										
448.1															
2.0	Silty CLAY, trace sand Soft to Stiff Brown Moist (CH)		4	SS	3										
			5	SS	11										
444.8			6	SS	6										
5.3	SILT and SAND, some gravel, trace clay Compact Grey Wet														
			7	SS	21										
442.5															
7.6	SILT, trace clay Very Dense to Compact Grey Wet		8	SS	71										
440.3			9	SS	16										
9.8	END OF BOREHOLE AT 9.8m.														

Continued Next Page

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

RECORD OF BOREHOLE No 18-04

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 588.5 E 291 114.4 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.04.17 - 2018.04.17 LATITUDE 48.6356603 LONGITUDE -90.18570202 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	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						
	Continued From Previous Page													
	BOREHOLE CAVED TO 5.4m AND WATER LEVEL AT SURFACE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No 18-05

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 606.2 E 291 134.1 ORIGINATED BY JP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY MP
DATUM Geodetic DATE 2018.03.07 - 2018.03.08 LATITUDE 48.63581993 LONGITUDE -90.18543484 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	20 40 60	GR SA SI CL			
452.1	GROUND SURFACE					▽	452						1 69 28 2	
0.0	ASPHALT: (350mm)						451							
451.7							450							
0.4	Silty SAND , trace to some gravel, trace clay, trace cobbles Very Dense Grey Frozen (FILL)		1	SS	50/ 0.050		449							
			2	SS	52/ 0.075		448							
			3	SS	5		447							
449.1							446							
3.0	PEAT , with silty sand, trace gravel Loose Brown Wet		4	SS	5		445							
448.4							444							
3.7	CLAY , some silt, trace sand Stiff to Soft Brown Moist (CH)		5	SS	8		443							
			6	SS	10									
			7	SS	4									
444.0														
8.1	Silty SAND , trace clay Grey Wet		8	SS	24									

Continued Next Page




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

RECORD OF BOREHOLE No 18-05

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 606.2 E 291 134.1 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2018.03.07 - 2018.03.08 LATITUDE 48.63581993 LONGITUDE -90.18543484 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		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		WATER CONTENT (%)			
								20 40 60 80 100	20 40 60				
Continued From Previous Page													
441.1	Silty CLAY , trace sand Very Stiff Grey Wet		9	SS	21		442						0 84 14 2
11.0							441						
439.9	SAND , some silt, trace clay, pieces of cobbles Compact Grey Wet		10	SS	23		440						
12.2							439						
					11	SS	19		438				
436.9	END OF BOREHOLE AT 15.2m. BOREHOLE CAVED TO 10.4m AND WATER LEVEL AT 1.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CUTTINGS AND CONCRETE, THEN ASPHALT TO SURFACE.						437						
15.2													

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

RECORD OF BOREHOLE No 18-06

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 603.0 E 291 113.3 ORIGINATED BY JP
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring/Dynamic Cone Penetration Test COMPILED BY MP
DATUM Geodetic DATE 2018.03.09 - 2018.03.09 LATITUDE 48.63579073 LONGITUDE -90.1857177 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				
452.2	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (300mm)							20 40 60 80 100				
451.9												
0.3	SAND, some gravel, some silt and clay Very Dense Brown Moist (FILL)		1	SS	90							17 67 16 (SI+CL)
451.1												
1.1	Silty SAND, trace gravel Very Dense to Compact Grey Frozen (FILL)		2	SS	51							
			3	SS	19							
449.1												
3.1			4	SS	6							
448.7	PEAT, with silty sand, trace gravel Loose Brown Wet											
3.5												
	Silty CLAY, trace sand Soft Brown Wet		5	SS	4							0 4 24 72
			6	SS	5							
444.9												
7.3	SILT, trace clay, trace sand Loose to Compact Grey Wet		7	SS	9							0 3 91 6
			8	SS	13							

Continued Next Page

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

RECORD OF BOREHOLE No 18-06

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83-15 N 5 388 603.0 E 291 113.3 ORIGINATED BY JP
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2018.03.09 - 2018.03.09 LATITUDE 48.63579073 LONGITUDE -90.1857177 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					WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE			● QUICK TRIAXIAL	×	LAB VANE
	Continued From Previous Page						20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L				
440.3	SAND, with cobbles, trace silt Compact to Dense Grey Wet		9	SS	20								0 0 94 6		
11.9			10	SS	25										
			11	SS	36										
			12	SS	29										
436.7															
15.5	END OF BOREHOLE AT 15.5m. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.														
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.03.09 1.7 450.5														




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

RECORD OF BOREHOLE No 17-15

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 618.3 E 291 128.0 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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			WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE				w _P w w _L							
						● QUICK TRIAXIAL × LAB VANE													
450.4	GROUND SURFACE							20	40	60	80	100							
0.0	PEAT , trace roots and rootlets Very Soft Dark Brown Wet		1	GS			450											163	
			1	SS	1		449												
448.7																			
1.7	Silty CLAY , some sand Very Soft to Stiff Brown Wet (CI)		2	SS	1		448												
			3	SS	4														
			4	SS	3		447												
			5	SS	10		446												
			6	SS	0		445												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-15

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 618.3 E 291 128.0 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY CZ

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						
								20 40 60 80 100						
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W P W W L WATER CONTENT (%)			
							20 40 60 80 100				20 40 60			
							440							
			9	SS	6									
							439							
438.7														
11.7	SAND and SILT, trace clay, trace gravel Very Dense Grey Wet													
			10	SS	60		438							8 36 52 4
437.6														
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL IN OPEN BOREHOLE AT APPROX. 0.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.													

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

RECORD OF BOREHOLE No 17-16

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 606.7 E 291 118.7 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY CZ

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				
452.2	GROUND SURFACE							20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
0.0 0.1	ASPHALT: (75mm)							20 40 60 80 100	WATER CONTENT (%)			
	SAND, some silt, trace gravel, occasional cobbles and boulders Compact Brown Moist (FILL)		1	GS					○ UNCONFINED	+ FIELD VANE		
			1	SS	100/				● QUICK TRIAXIAL	× LAB VANE		
			2	GS	0.025							
450.7												
1.5	SAND and SILT, trace clay Compact Brown Moist (FILL)		2	SS	14							
			3	SS	11							
449.2												
3.0	PEAT, trace sand, roots and rootlets Soft Dark Brown Wet		4	SS	4							
448.1												
4.1	Silty CLAY, trace sand Very Soft Brown Wet		5	SS	2							
446.6												
5.6	SILT, trace sand and clay Loose to Compact Grey Wet		6	SS	7							
			7	SS	11							
			8	SS	10							

Continued Next Page

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

RECORD OF BOREHOLE No 17-16

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 606.7 E 291 118.7 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY CZ

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
	Continued From Previous Page							20 40 60 80 100	20 40 60			
	Becoming dense		9	SS	34		442					
440.5												
11.7	SAND , some gravel, trace silt Dense to Compact Grey Wet		10	SS	36		440					
			11	SS	27		438					
436.9			12	SS	100		437					
15.3	END OF BOREHOLE AT 15.3m ON AUGER REFUSAL. WATER LEVEL IN OPEN BOREHOLE AT APPROX. 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CUTTINGS AND CONCRETE TO SURFACE. DYNAMIC CONE PENETRATION TEST CONDUCTED ADJACENT TO BOREHOLE.				0.025							

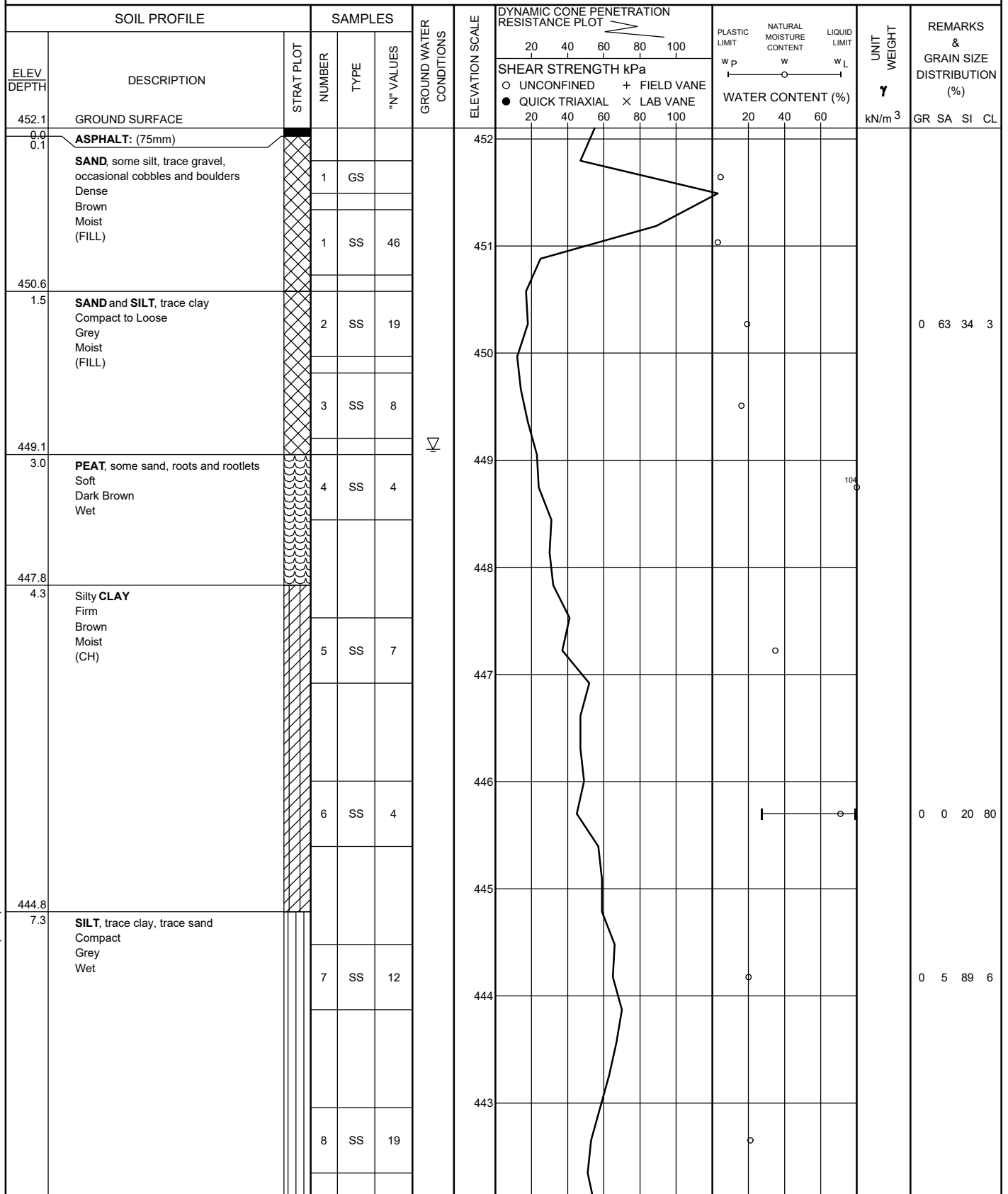
+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-17

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 602.7 E 291 128.2 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.26 CHECKED BY CZ



Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-17

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 602.7 E 291 128.2 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.26 CHECKED BY CZ

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								
441.9	Continued From Previous Page						442									
10.2	SAND, some silt, some gravel, trace clay Compact Grey Wet		9	SS	17		441									
							440									
			10	SS	29		439									
							438									
			11	SS	20		437									
436.8	END OF BOREHOLE AT 15.3m ON SPLIT SPOON REFUSAL WATER LEVEL IN OPEN BOREHOLE AT APPROX. 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CUTTINGS AND CONCRETE TO SURFACE. DYNAMIC CONE PENETRATION TEST CONDUCTED ADJACENT TO BOREHOLE.		12	SS	100/ 0.025											
15.3																






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

RECORD OF BOREHOLE No 17-18

1 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 592.6 E 291 119.4 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.25 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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			WATER CONTENT (%)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			w _P w w _L							
450.2	GROUND SURFACE							20	40	60	80	100						
0.0	PEAT, some roots and rootlets, trace sand Very Soft Dark Brown Wet		1	GS			450										305	
			1	SS	1		449										192	
448.8	Silty CLAY, trace sand Very Soft to Firm Brown Wet (CH)		2	SS	1		448											
			3	SS	1		447											
			4	SS	6		446											
			5	SS	4		445											
			6				444											
			7				443											
444.1	Silty SAND, some clay Compact Brown Wet		6	SS	18		442											
			7	SS	24		441											
441.5	SILT, trace sand, trace clay Compact Grey Wet		8	SS	16													

Continued Next Page

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

RECORD OF BOREHOLE No 17-18

2 OF 2

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 592.6 E 291 119.4 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.25 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	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								
								20 40 60 80 100								
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				w _P w w _L WATER CONTENT (%)					
440.0							440									
10.2	Silty SAND , trace gravel Compact Grey Wet		9	SS	17		439									
							438									
437.4			10	SS	17											
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL IN OPEN BOREHOLE AT 0.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.27 0.2 450.0 Decommissioned															

ONTMT4S MTO-15593.GPJ 2017TEMPLATE(MTO).GDT 10/3/17

RECORD OF BOREHOLE No 17-19

1 OF 1

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 605.8 E 291 136.1 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2107.03.25 - 2017.03.25 CHECKED BY CZ

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							
452.1	GROUND SURFACE						20 40 60 80 100								
0.0 0.1	ASPHALT: (75mm)														
	Gravelly SAND, some silt Brown Moist (FILL)		1	GS											25 65 10 (SI+CL)
450.0															
2.1	PEAT, some sand, trace roots and rootlets Soft Dark Brown Wet		2	GS										232	
448.4			1	SS	3									235	
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL IN OPEN BOREHOLE AT APPROX. 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CONCRETE TO SURFACE.														

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-20

1 OF 1

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 605.5 E 291 146.1 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.25 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%) w _P w w _L				
452.1	GROUND SURFACE							20	40	60	80	100			
0.0 0.1	ASPHALT: (75mm)						452								
	SAND , some silt, trace gravel Brown Moist (FILL)		1	GS											7 70 23 (SI+CL)
							451								
450.0							450								
2.1	PEAT , some sand, trace roots and rootlets Soft Dark Brown Wet		2	GS										275	
							449							195	
448.4			1	SS	3										
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL IN OPEN BOREHOLE AT APPROX. 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CONCRETE TO SURFACE.														

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-21

1 OF 1

METRIC

W.P. 6804-14-01 LOCATION Rossmere Creek Culvert, MTM NAD 83 Zone 15 N 5 388 605.1 E 291 156.1 ORIGINATED BY AHF
 HWY 11/17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.03.25 - 2017.03.25 CHECKED BY CZ

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L
452.1	GROUND SURFACE							20 40 60 80 100					
0.0 0.1	ASPHALT: (75mm)						452						
	SAND, some silt, some gravel Brown Moist (FILL)		1	GS									15 68 17 (SI+CL)
							451						
							450						
449.7	PEAT, some roots and rootlets, trace sand Dark Brown Wet		2	GS									
2.4	Firm						449						
			1	SS	5								
448.4													
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL IN OPEN BOREHOLE AT APPROX. 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CONCRETE TO SURFACE.												

+³, ×³: Numbers refer to
Sensitivity

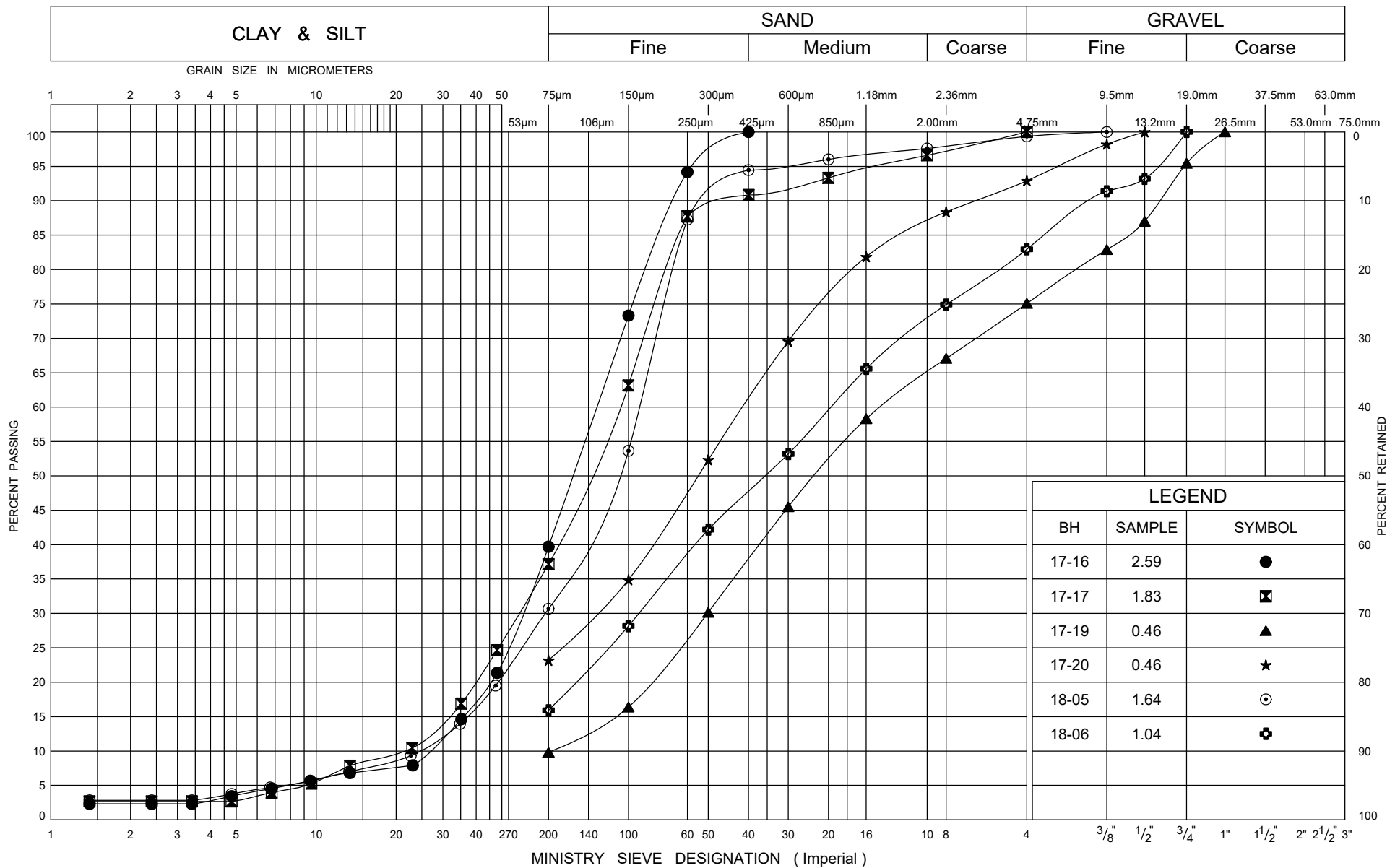
20
15
10

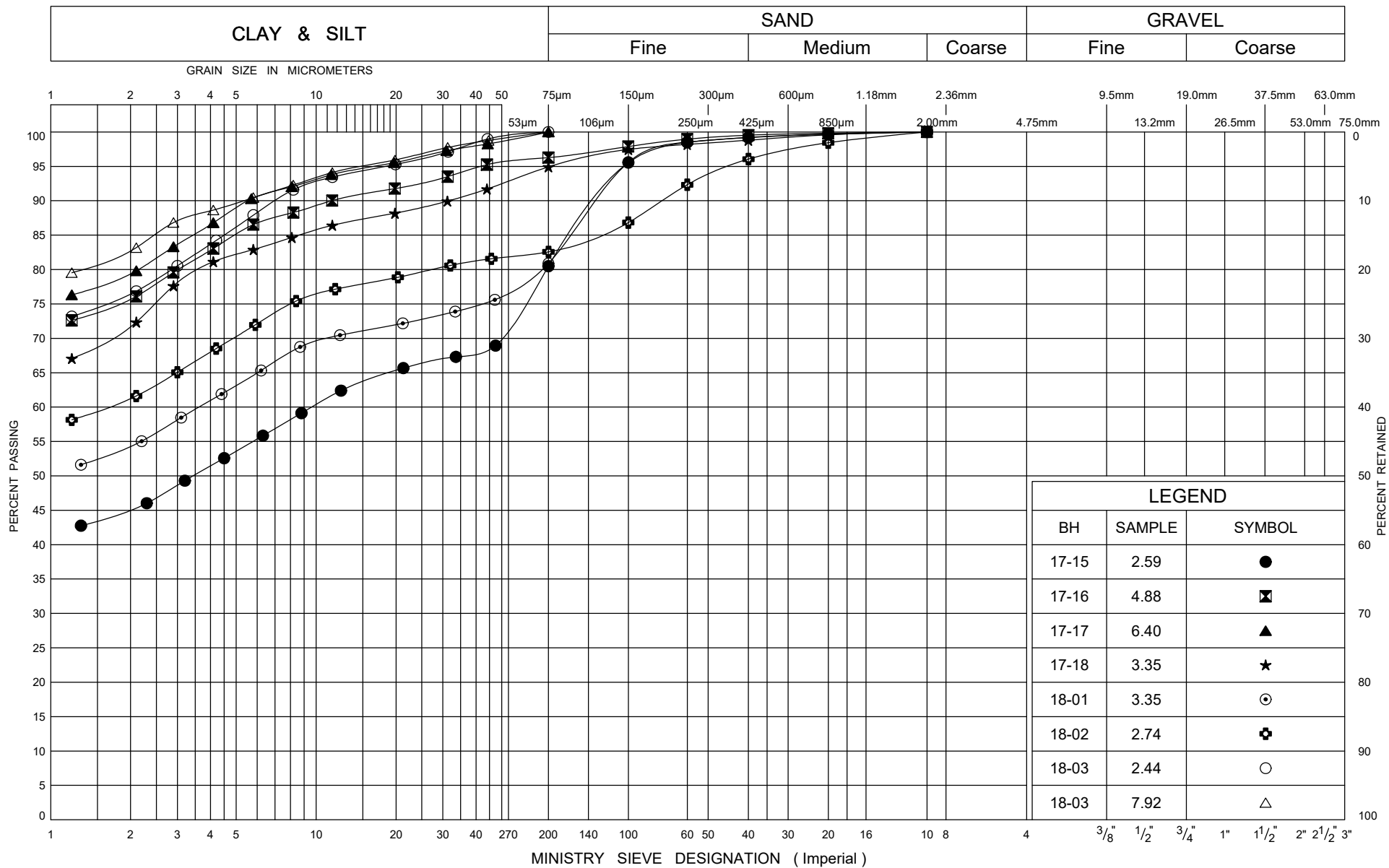
(%) STRAIN AT FAILURE

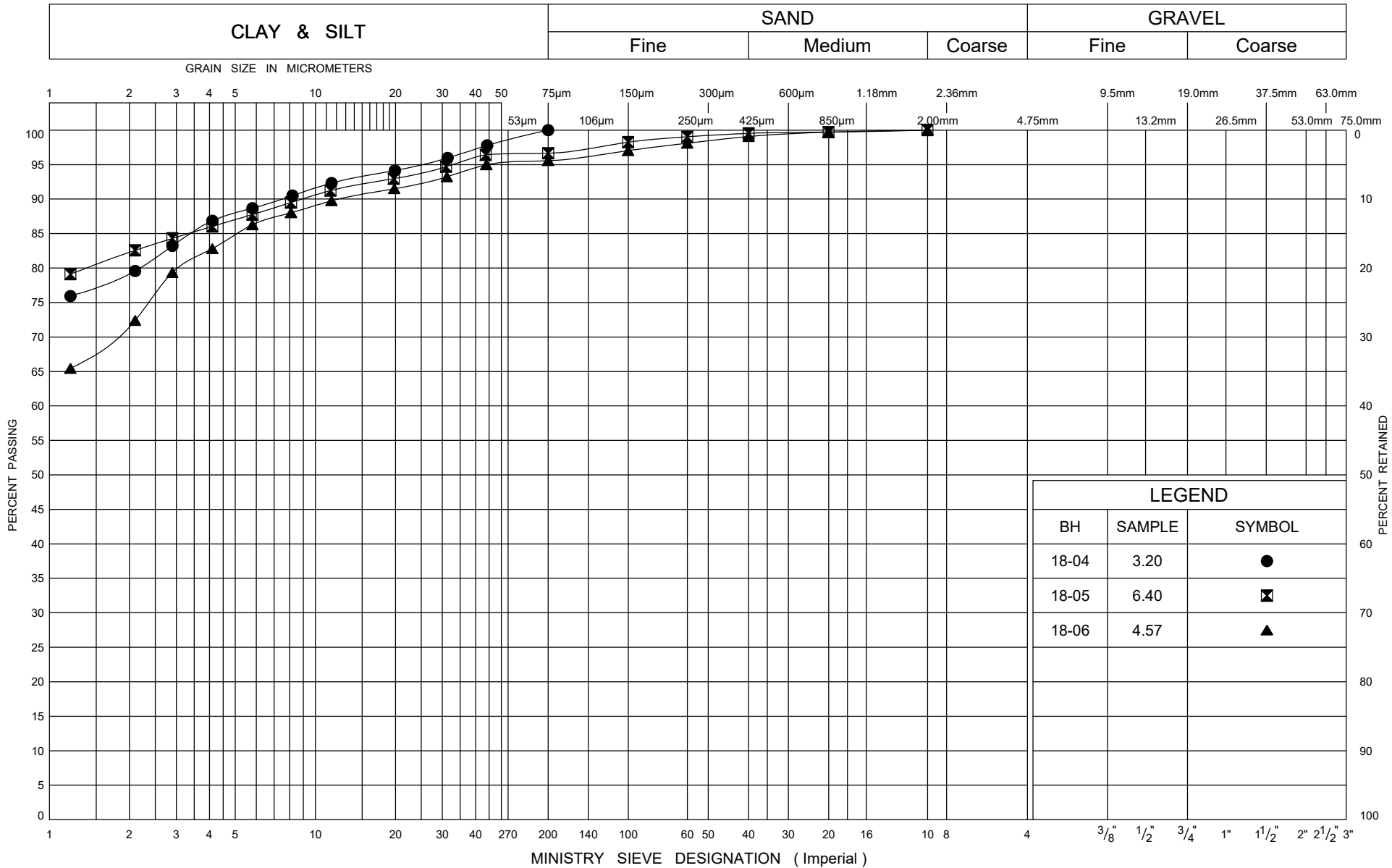


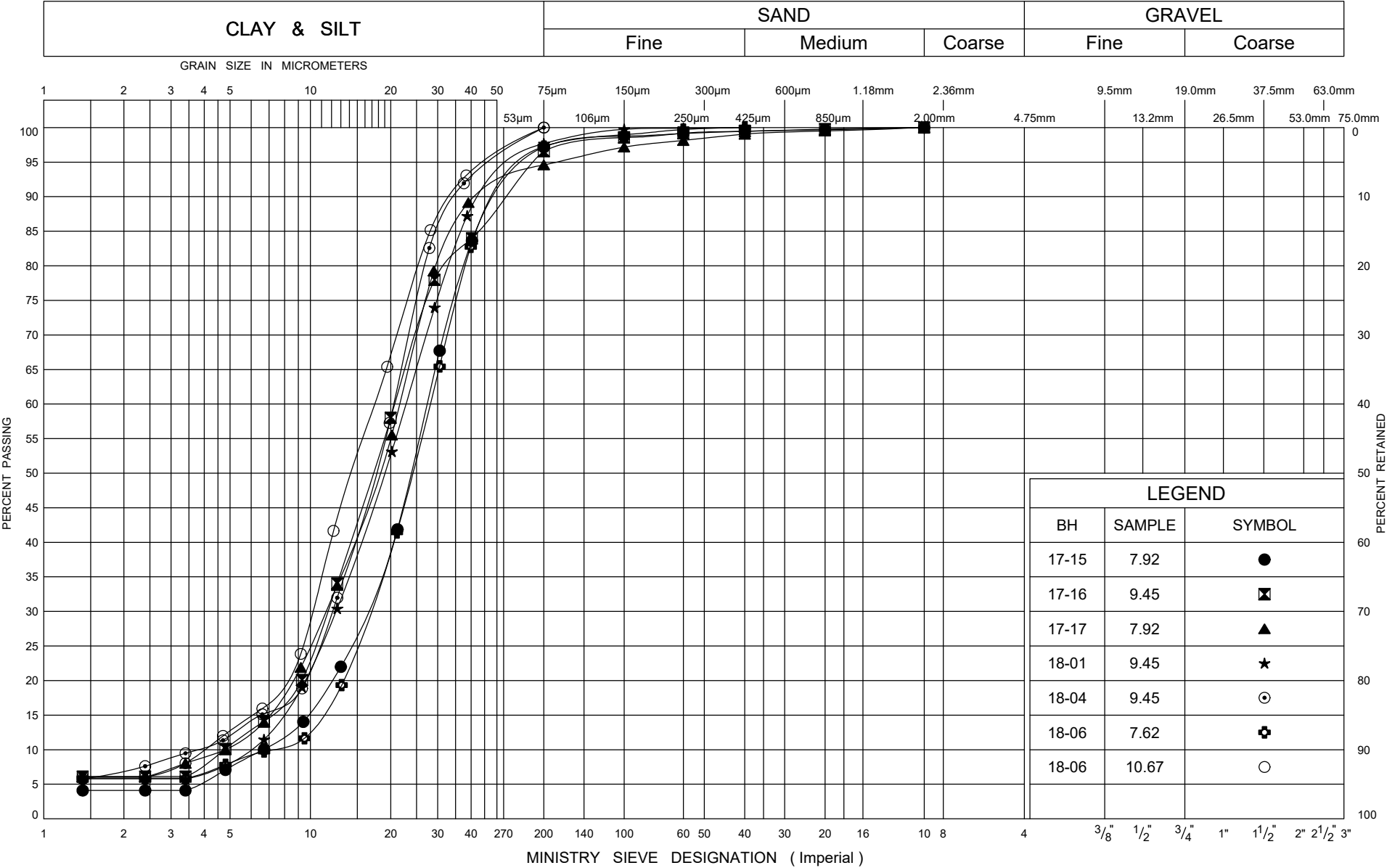
Appendix B

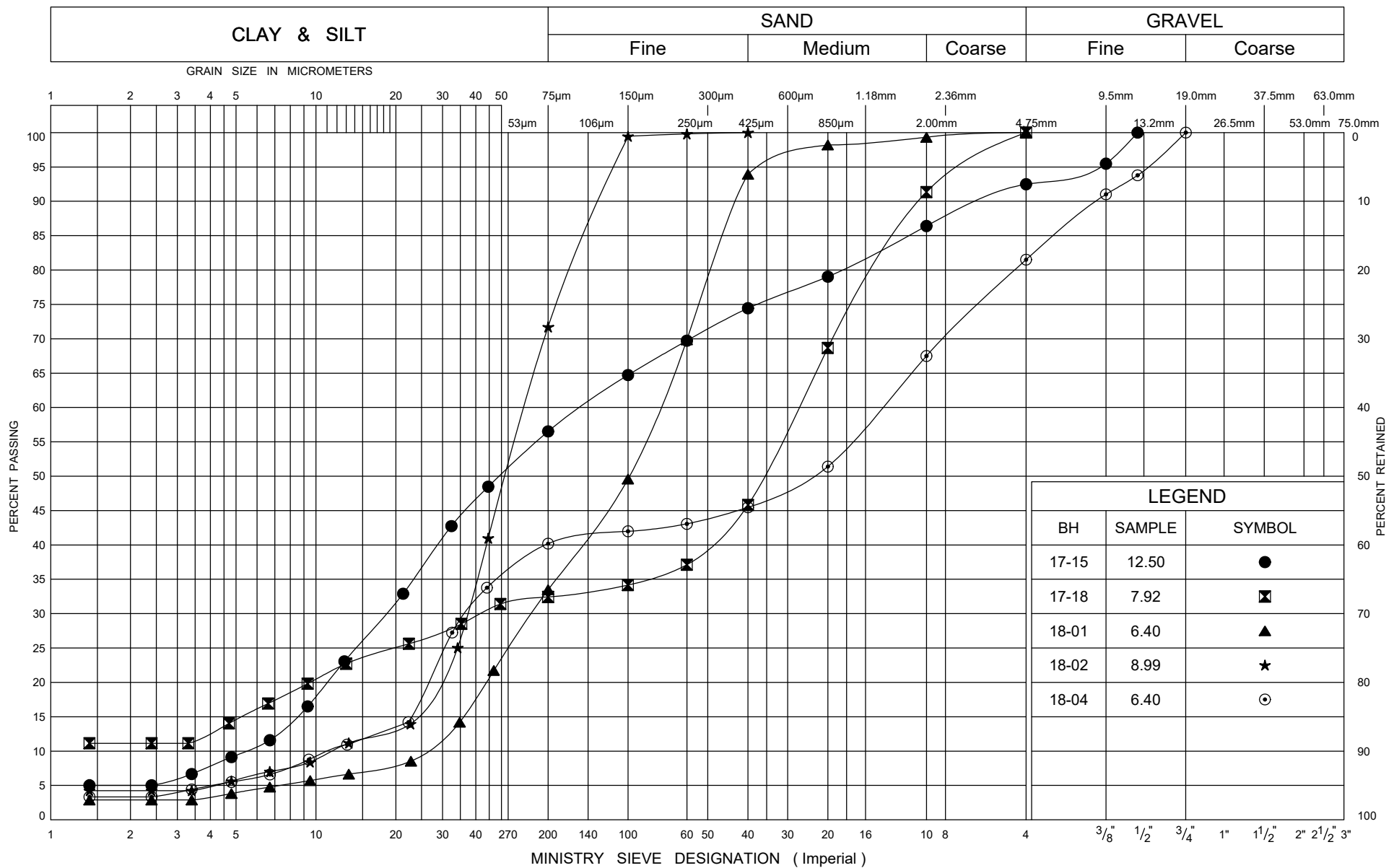
Geotechnical and Analytical Laboratory Test Results

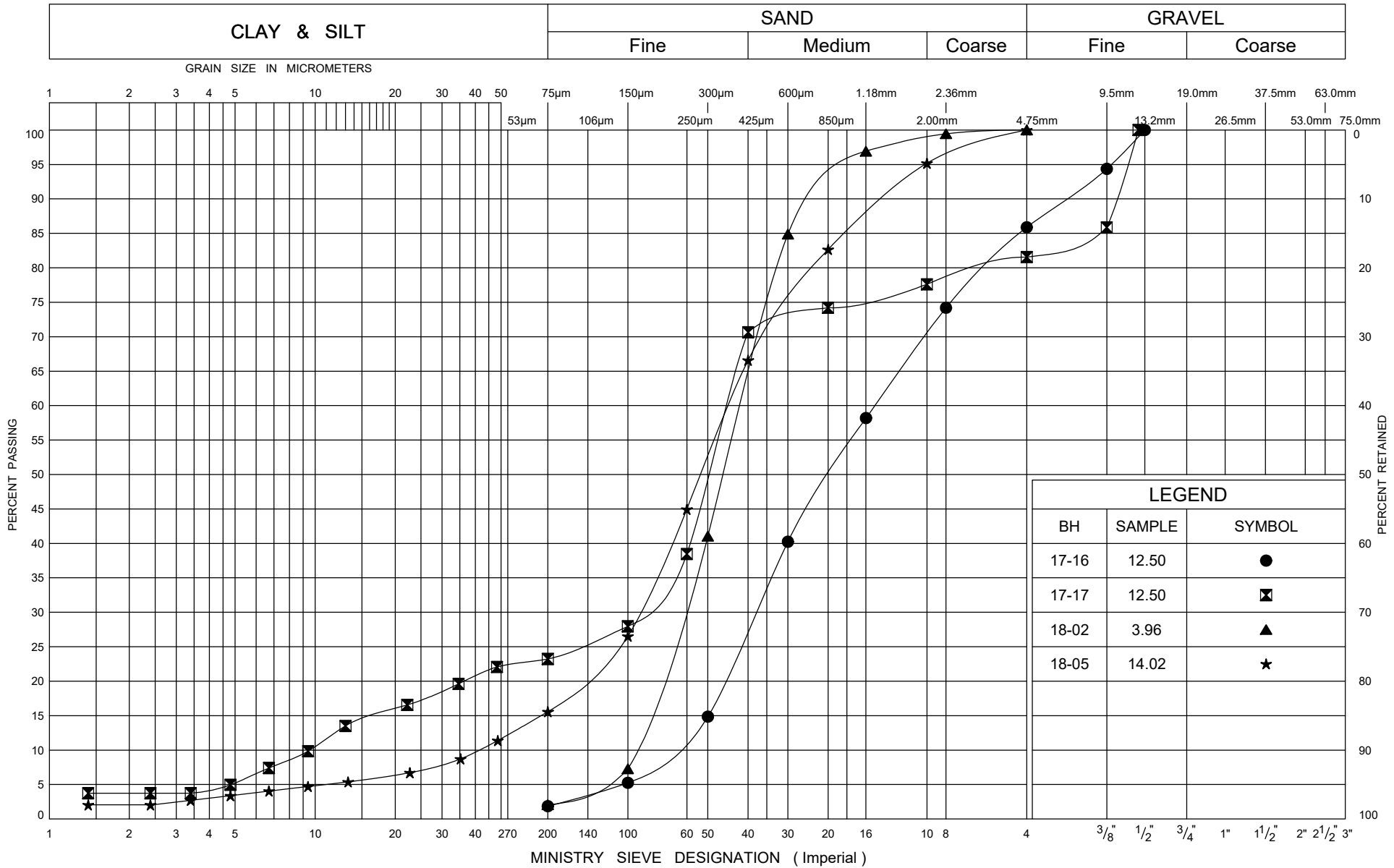


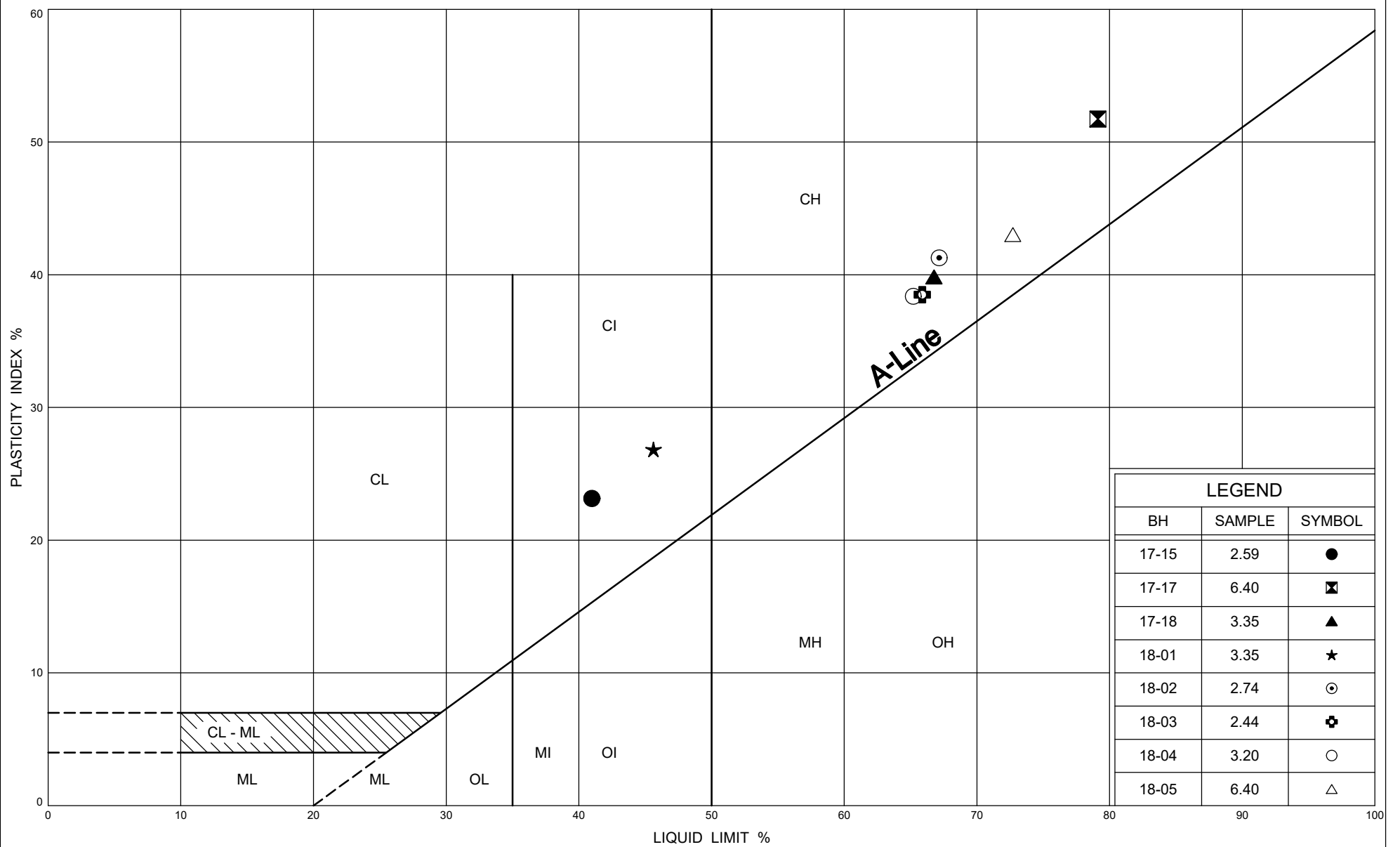












Ministry of
Transportation

PLASTICITY CHART

Silty CLAY

FIG No B7

W P 6804-14-01

Rossmere Creek Culvert



SGS Canada Inc.

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

Thurber Engineering Ltd

Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

Project : 17840/17792

02-June-2017

Date Rec. : 10 May 2017

LR Report: CA14294-MAY17

Reference: 17840/17792 Cory Zanatta

Copy: #2

CERTIFICATE OF ANALYSIS

Final Report - Reissue

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Rossmere Creek
Sample Date & Time						25-Apr-17
Temperature Upon Receipt [°C]	---	---	--	--	---	9.0
pH [no unit]	11-May-17	10:30	15-May-17	10:54	0.05	6.35
Conductivity [µS/cm]	11-May-17	10:41	15-May-17	10:51	2	115
Resistivity (calculated) [ohms.cm]	---	---	---	---	---	8700
Redox Potential [mV]	11-May-17	13:57	15-May-17	10:32	---	197
Chloride [mg/L]	15-May-17	18:20	16-May-17	13:24	0.04	24
Sulphate [mg/L]	15-May-17	18:20	16-May-17	13:24	0.04	1.1
Sulphide [mg/L]	11-May-17	12:10	12-May-17	16:01	0.006	0.014



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 17840/17792

LR Report : CA14294-MAY17

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: yes

Custody Seal Present: no

Deanna Edwards, B.Sc, C.Chem

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 : 17840/17792

LR Report : CA14294-MAY17

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



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Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 17840/17792

LR Report : CA14294-MAY17

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD		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: DIO0256-MAY17												
Chloride	0.04	mg/L	<0.04		2	20	97	80	120	100	75	125
Sulphate	0.04	mg/L	<0.04		0	20	96	80	120	89	75	125
Anions by IC - QCBatchID: DIO0269-MAY17												
Chloride	0.04	mg/L	<0.04		0	20	100	80	120	119	75	125
Sulphate	0.04	mg/L	<0.04		0	20	97	80	120	102	75	125
Conductivity - QCBatchID: EWL0183-MAY17												
Conductivity	2	µS/cm	< 2		0	10	99	90	110	NA		
pH - QCBatchID: EWL0182-MAY17												
pH	0.05	no unit	NA		1		100			NA		
Redox Potential - QCBatchID: EWL0192-MAY17												
Redox Potential	no	mV	NA		0	20	103	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0095-MAY17												
Sulphide	0.006	mg/L	<0.006		ND	20	80	80	120	NV	75	125
Sulphide by SFA - QCBatchID: SKA0105-MAY17												
Sulphide	0.006	mg/L	0.009		ND	20	96	80	120	125	75	125



SGS Canada Inc.

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

Thurber Engineering Ltd

Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

Project : 15593

08-May-2017

Date Rec. : 02 May 2017

LR Report: CA14060-MAY17

Reference: 15593 Cory Zanatta

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	9: 17-16 SS5	10: 17-17 SS5
Sample Date & Time					26-Mar-17	26-Mar-17
Temperature Upon Receipt [°C]	---	---	---	---	6.0	6.0
Corrosivity Index [none]	08-May-17	14:35	08-May-17	14:35	5.0	5.0
Soil Redox Potential [mV]	03-May-17	16:33	04-May-17	14:12	286	210
Sulphide [%]	05-May-17	13:47	05-May-17	15:54	< 0.02	< 0.02
% Moisture (wet wt) [%]	04-May-17	13:57	04-May-17	14:37	31.6	30.3
pH [no unit]	03-May-17	15:41	05-May-17	09:17	8.98	8.64
Chloride [µg/g]	05-May-17	17:42	08-May-17	14:40	16	30
Sulphate [µg/g]	05-May-17	17:42	08-May-17	14:40	150	22
Conductivity [uS/cm]	03-May-17	15:41	05-May-17	09:17	127	160
Resistivity (calculated) [Ohms.cm]	03-May-17	15:41	08-May-17	14:21	7870	6250

Temperature of Sample upon Receipt: 12 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

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.



SGS Canada Inc.

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Lakefield - Ontario - K0L 2H0

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

Project : 15593

LR Report : CA14060-MAY17

Method Descriptions

Parameter	SGS Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013
pH	ME-CA-[ENV]EWL-LAK-AN-001

Deanna Edwards, B.Sc, C.Chem

Project Specialist

Environmental Services, Analytical



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 15593

LR Report : CA14060-MAY17

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: DIO0108-MAY17												
Chloride	0.4	µg/g	<0.4		3	20	101	80	120	105	75	125
Sulphate	0.4	µg/g	<0.4		2	20	97	80	120	87	75	125
Carbon/Sulphur - QCBatchID: ECS0006-MAY17												
Sulphide	0.02	%	<0.02		ND	20	113	80	120			
Conductivity - QCBatchID: EWL0047-MAY17												
Conductivity	2	uS/cm	< 2		2	10	93	90	110	NA		
pH - QCBatchID: EWL0047-MAY17												
pH	0.05	no unit	NA		0		100			NA		



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Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

Project : 17840/17792

02-June-2017

Date Rec. : 10 May 2017

LR Report: CA14294-MAY17

Reference: 17840/17792 Cory Zanatta

Copy: #2

CERTIFICATE OF ANALYSIS

Final Report - Reissue

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Rossmere Creek
Sample Date & Time						25-Apr-17
Temperature Upon Receipt [°C]	---	---	--	--	---	9.0
pH [no unit]	11-May-17	10:30	15-May-17	10:54	0.05	6.35
Conductivity [µS/cm]	11-May-17	10:41	15-May-17	10:51	2	115
Resistivity (calculated) [ohms.cm]	---	---	---	---	---	8700
Redox Potential [mV]	11-May-17	13:57	15-May-17	10:32	---	197
Chloride [mg/L]	15-May-17	18:20	16-May-17	13:24	0.04	24
Sulphate [mg/L]	15-May-17	18:20	16-May-17	13:24	0.04	1.1
Sulphide [mg/L]	11-May-17	12:10	12-May-17	16:01	0.006	0.014



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Lakefield - Ontario - KOL 2H0

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

Project : 17840/17792

LR Report : CA14294-MAY17

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: yes

Custody Seal Present: no

Deanna Edwards, B.Sc, C.Chem

Project Specialist

Environmental Services, Analytical



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 17840/17792

LR Report : CA14294-MAY17

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



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P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
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Project : 17840/17792

LR Report : CA14294-MAY17

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD		LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
					%	Low		High			Low	High
Anions by IC - QCBatchID: DIO0256-MAY17												
Chloride	0.04	mg/L	<0.04		2	20	97	80	120	100	75	125
Sulphate	0.04	mg/L	<0.04		0	20	96	80	120	89	75	125
Anions by IC - QCBatchID: DIO0269-MAY17												
Chloride	0.04	mg/L	<0.04		0	20	100	80	120	119	75	125
Sulphate	0.04	mg/L	<0.04		0	20	97	80	120	102	75	125
Conductivity - QCBatchID: EWL0183-MAY17												
Conductivity	2	µS/cm	< 2		0	10	99	90	110	NA		
pH - QCBatchID: EWL0182-MAY17												
pH	0.05	no unit	NA		1		100			NA		
Redox Potential - QCBatchID: EWL0192-MAY17												
Redox Potential	no	mV	NA		0	20	103	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0095-MAY17												
Sulphide	0.006	mg/L	<0.006		ND	20	80	80	120	NV	75	125
Sulphide by SFA - QCBatchID: SKA0105-MAY17												
Sulphide	0.006	mg/L	0.009		ND	20	96	80	120	125	75	125



Appendix C

Selected Site Photographs



Photo 1: View looking east along the south embankment of Highway 11



Photo 2: View looking west along Highway 11



Photo 3: South Side of Rossmere Creek Culvert



Photo 4: North Side of Rossmere Creek Culvert



Photo 5: Rossmere Creek Culvert Upstream



Photo 5: Rossmere Creek Culvert Downstream



Photo 6: Rossmere Creek looking south downstream.

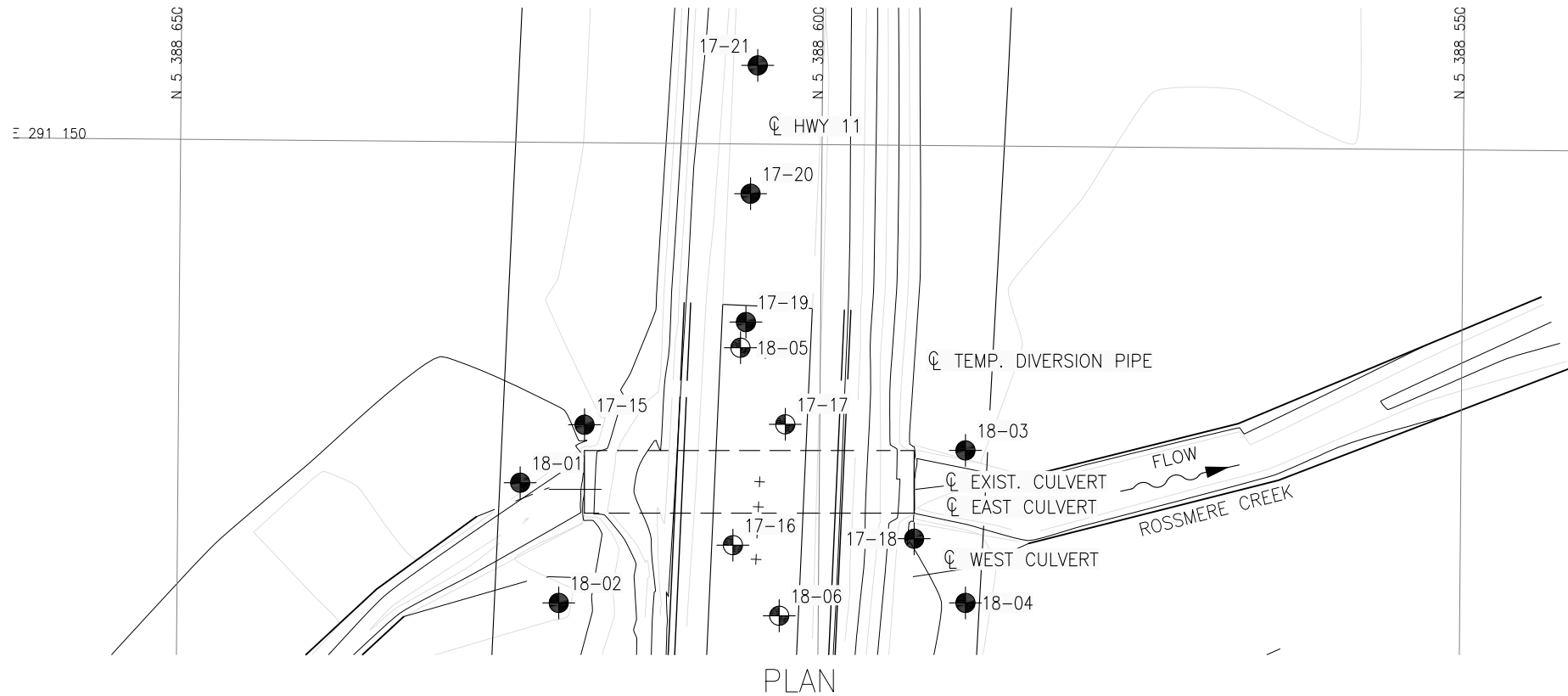


Photo 6: Rossmere Creek looking north west upstream.



Appendix D

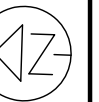
Borehole Locations and Soil Strata Drawing



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

CONT No 6016-E-0012
WP No 6804-14-01

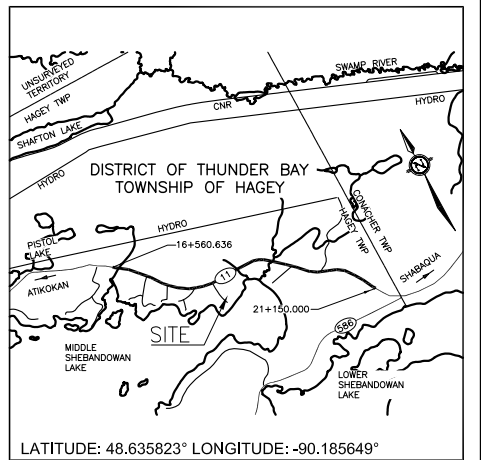
HIGHWAY 11
ROSSMERE CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
9



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

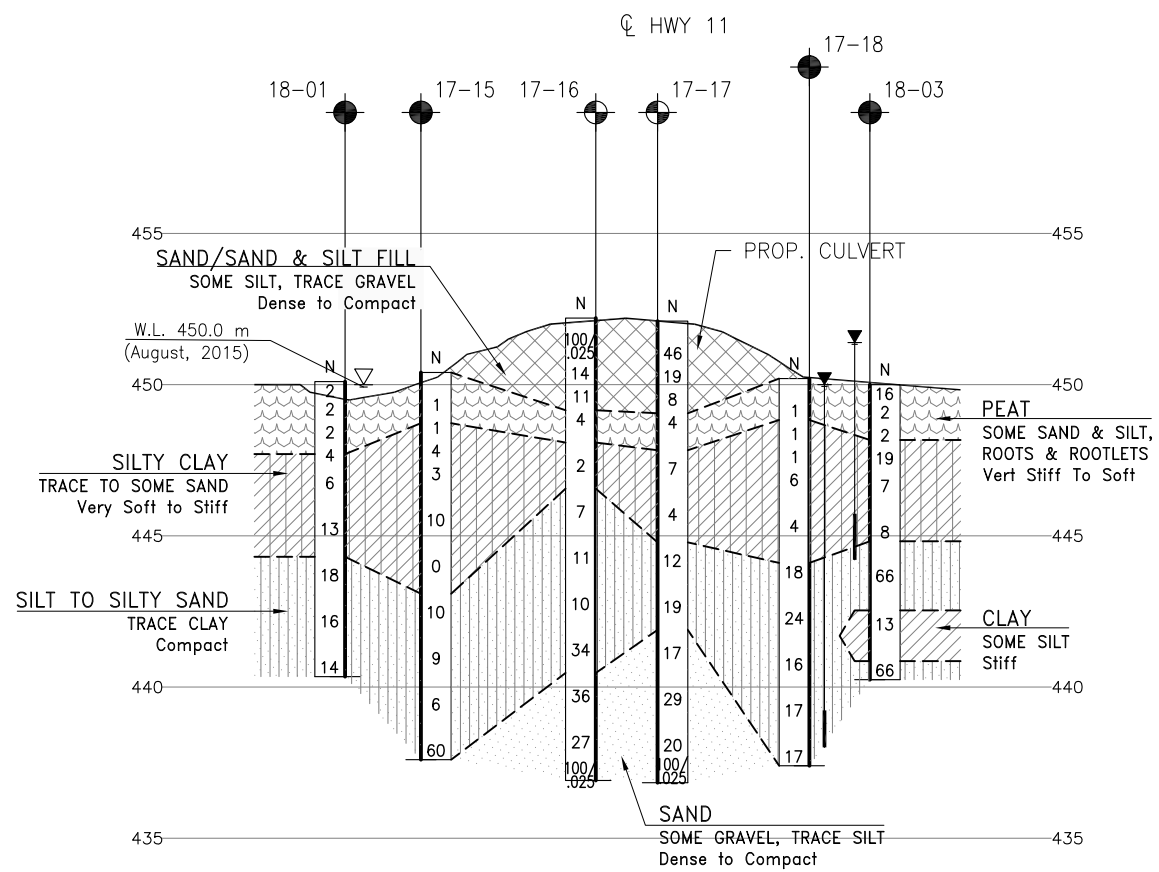
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-15	450.4	5 388 618.3	291 128.0
17-16	452.2	5 388 606.7	291 118.7
17-17	452.1	5 388 602.7	291 128.2
17-18	450.2	5 388 592.6	291 119.4
17-19	452.1	5 388 605.8	291 136.1
17-20	452.1	5 388 605.5	291 146.1
17-21	452.1	5 388 605.1	291 156.1
18-01	450.1	5 388 623.3	291 123.5
18-02	450.0	5 388 620.2	291 114.1
18-03	450.0	5 388 588.6	291 126.3
18-04	450.1	5 388 588.5	291 114.4
18-05	452.1	5 388 606.2	291 134.1
18-06	452.2	5 388 603.0	291 113.3

-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.
- Coordinate system is MTM NAD 83 Zone 15

GEOCRES No. 52B-36



PROFILE ALONG ϕ EXIST. CULVERT



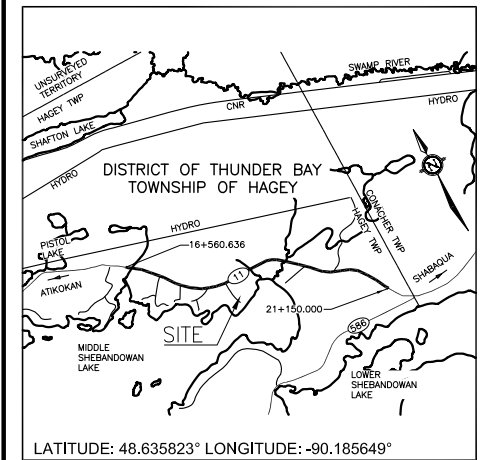
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CZ	CHK MEF	CODE
DRAWN	AN	CHK CZ	SITE 48W-192/C
			STRUCT
			DWG 1
			DATE MAY 2018

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

CONT No 6016-E-0012
WP No 6804-14-01

HIGHWAY 11
ROSSMERE CREEK
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
10



KEYPLAN

LEGEND

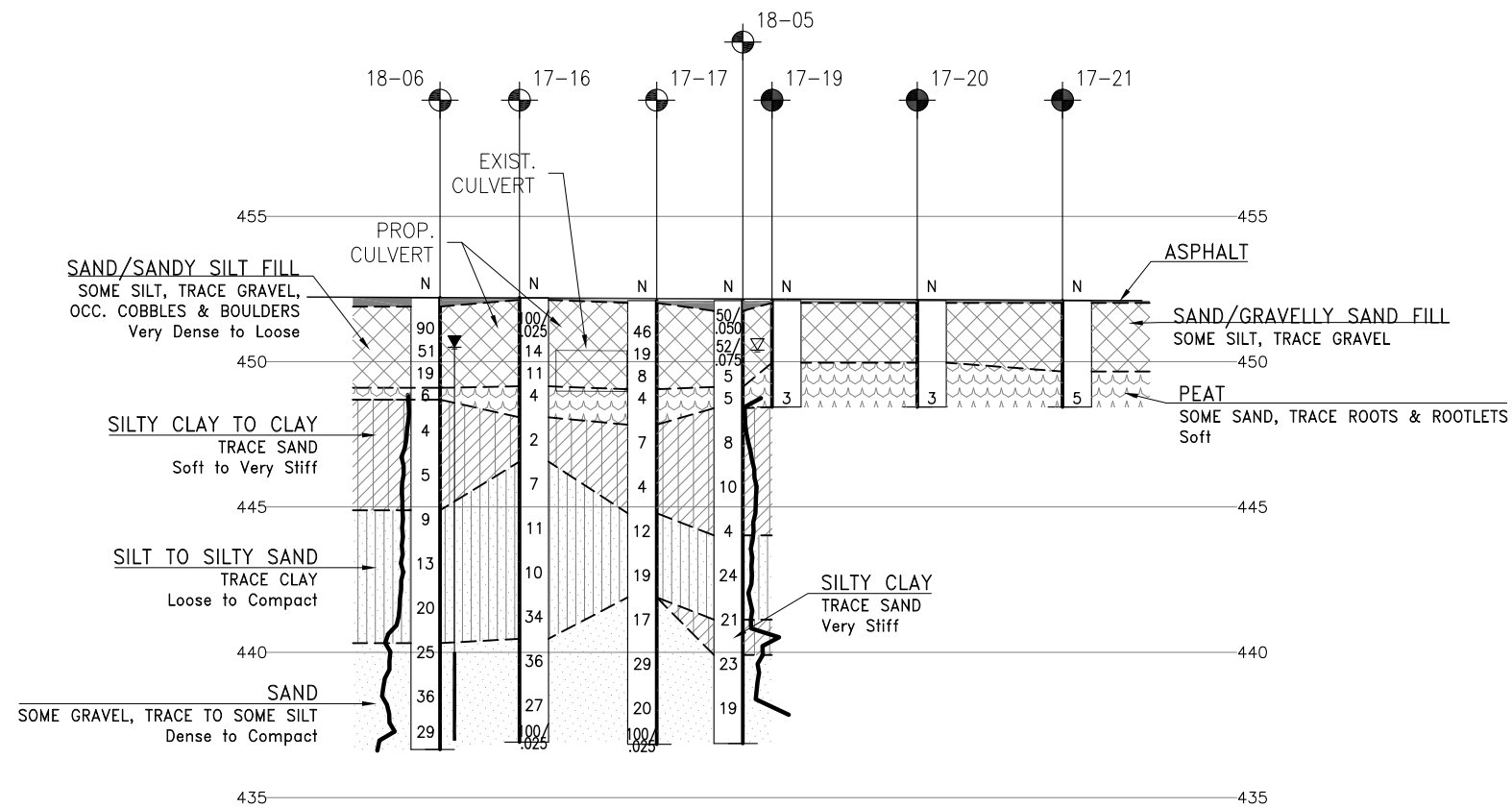
●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⬇	Head Artesian Water
⬆	Piezometer
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-15	450.4	5 388 618.3	291 128.0
17-16	452.2	5 388 606.7	291 118.7
17-17	452.1	5 388 602.7	291 128.2
17-18	450.2	5 388 592.6	291 119.4
17-19	452.1	5 388 605.8	291 136.1
17-20	452.1	5 388 605.5	291 146.1
17-21	452.1	5 388 605.1	291 156.1
18-01	450.1	5 388 623.3	291 123.5
18-02	450.0	5 388 620.2	291 114.1
18-03	450.0	5 388 588.6	291 126.3
18-04	450.1	5 388 588.5	291 114.4
18-05	452.1	5 388 606.2	291 134.1
18-06	452.2	5 388 603.0	291 113.3

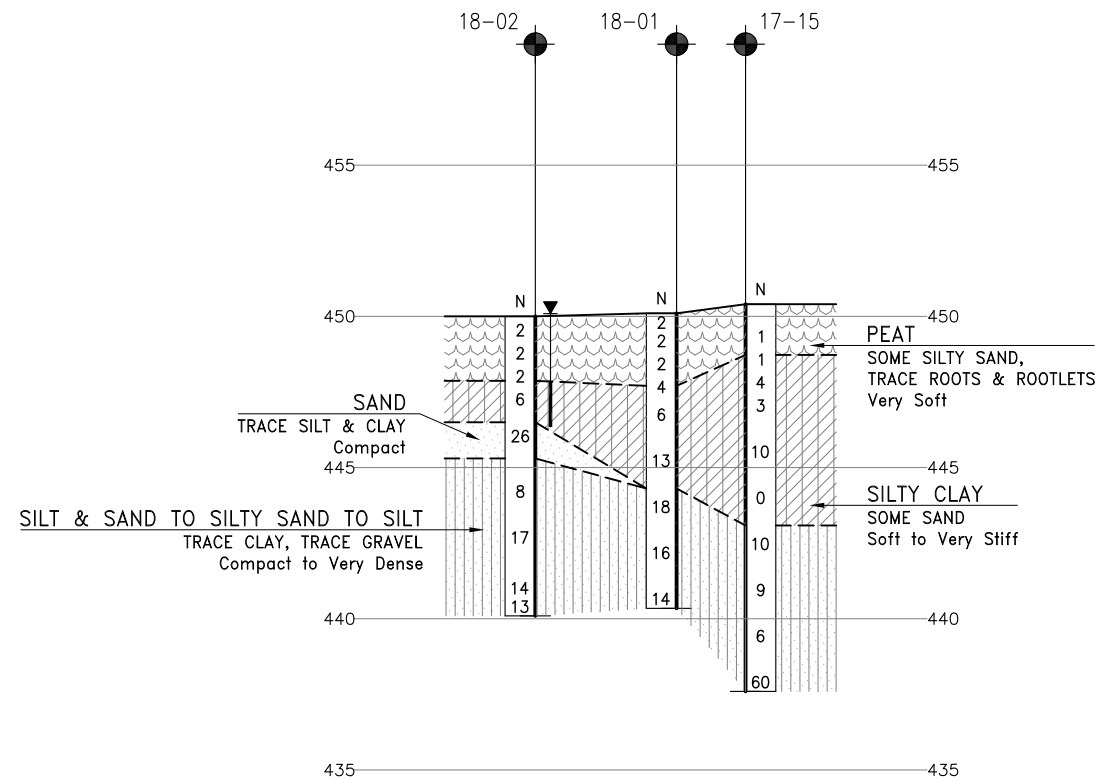
-NOTES-

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- Coordinate system is MTM NAD 83 Zone 15

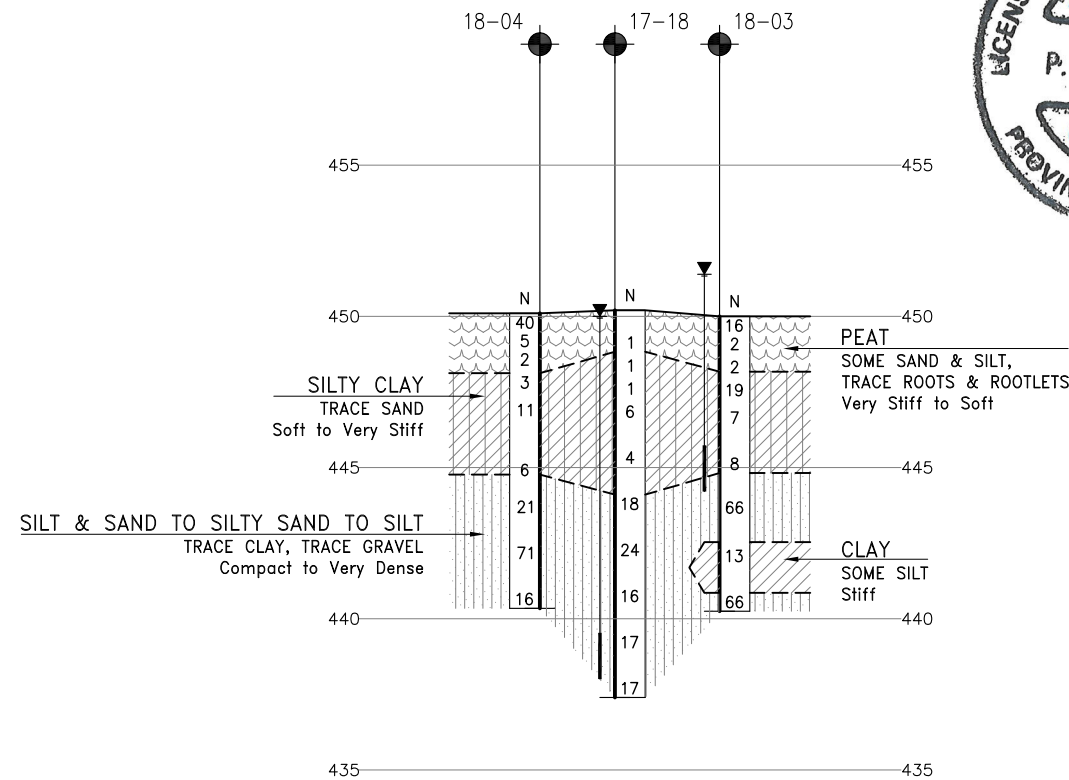
GEOCRES No. 52B-36



PROFILE ALONG ⊕ HWY 11



SECTION A-A'



SECTION B-B'

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CZ	CHK MEF	CODE
DRAWN	AN	CHK CZ	SITE
			LOAD
			STRUCT
			DWG 2
			DATE MAY 2018



Appendix E

List of Specifications and Suggested Wording for NSSP



1. List of OPSS and OPSD Documents Relevant to this Project

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 209 (Construction Specification for Embankments over Swamps and Compressible Soils)
- OPSS.PROV 421 (Construction Specification for Pipe Culvert Installation in Open Cut)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation)
- SP 517F01 Amendment to OPSS 517 (Design Storm Return Period and Preconstruction Survey Distance)
- 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)
- 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 511 (Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting)
- OPSS 1860 (Material Specification for Geotextiles)
- OPSD 802.010 (Flexible Pipe Embedment and Backfill, Earth Excavation)
- OPSD 802.014 (Flexible Pipe Embedment in Embankment, Original Ground: Earth or Rock)
- OPSD 803.010 (Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3.0 m)



- OPSD 803.031 (Frost Treatment – Pipe Culverts, Frost Penetration Line Between Top of Pipe and Bedding Grade)
- OPSD 810.010 (General Rip-Rap Layout for Sewer and Culvert Outlets)
- OPSD 3090.100 (Foundation Frost Penetration Depths for Northern Ontario)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)

2. Suggested Wording for NSSP on Peat Removal and Dewatering

The contractor is alerted that peat removal at this site is proposed to be carried out within a sheet pile enclosure. The design of these sheet piles is the responsibility of the contractor and it should be recognized that as peat is excavated the free-standing height of sheet piles will gradually increase. These sheet piles shall not be extracted but shall be left in place as per OPSS 539.

The ground water table at this site is high and artesian conditions were noted at the inlet and outlet of the culvert. Dewatering will be required to install the new culverts and the diversion pipe in the dry. The design of an effective dewatering system is the responsibility of the contractor. The dewatering system must be effective to lower the groundwater table at a minimum of 0.5 m below the final subgrade level to avoid basal heave and base boiling. The dewatering system is to be designed in accordance with SP FOUN0003, OPSS.PROV. 517 and SP517F01. A preconstruction survey is not required. A dewatering engineer with a minimum of 5 years of experience in designing dewatering systems shall be retained by the contractor for design of an effective dewatering system.

3. Suggested Wording for NSSP on Obstructions

Excavations and installation of cofferdams and roadway protection systems may encounter obstructions such as cobbles and boulders embedded in the fill and native soils. Such obstructions may impede excavation progress and/or sheet pile installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths. Vibrating equipment is not permitted for installation of sheet piles.