



THURBER ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION REPORT
McLEAN'S CREEK CULVERT REPLACEMENT
HIGHWAY 17, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 48.839562°, LONGITUDE: -87.442991°**

G.W.P. 6809-14-00, W.P. 6809-14-01, SITE NO. 48C-178C

GEOCRES Number: 42D-059

Report

to

HATCH

Date: January 15, 2020
File: 15595



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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 McLean's Creek Culvert on Highway 17, located west of Selim, in the District of Thunder Bay, Ontario. Thurber previously completed a preliminary foundation investigation at the culvert site in 2018.

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

Thurber carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6016 -E-0008.

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

- Preliminary Foundation Investigation and Design Report, McLean's Creek Culvert Replacement, Highway 17, Unsurveyed Territory, Thunder Bay District, Ontario, GEOCRES Number 42D-53, prepared by Thurber Engineering Ltd.

The borehole logs from the preliminary investigation are included in this report.

2. SITE DESCRIPTION

The site is located along Highway 17, approximately 3 km west of the Selim area. The existing culvert allows McLean's Creek to flow south into Lake Superior. Highway 17 generally runs in an east-west direction at the culvert site.

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Based on the Ontario Structure Inspection Manual (OSIM) prepared by MTO on November 20, 2014 the existing culvert is a cast in place concrete box culvert that is 6.1 m wide, 2.8 m high and 36.7 m long. The culvert barrel is in fair condition with severe erosion along the bottom 0.3 m of both side walls and light scaling on the bottom 0.9 m of the side walls. There are several cracks in the walls that are up to 0.9 m in length as well as a crack at the midspan of the culvert with rust stains on both the walls and soffit. Delamination has also occurred along the soffit at the outlet of the culvert.

The estimated culvert invert is at approximate Elevation 186.6 m at the inlet (north) and 186.2 m at the outlet (south). The existing road grade at the culvert location is at approximate Elev. 192.0 m, and there is approximately 2.5 m of fill above the culvert. The elevation of the water flowing through the culvert in November of 2013 was recorded at approximately 187.5 m upstream of the inlet and 185.8 m downstream of the outlet.

The area on either side of the creek near the inlet and outlet of the culvert is vegetated with grass, shrubs and small trees. Rainbow Falls provincial park is located southwest of the culvert, with the entrance to the park approximately 80 m to the west of the culvert outlet. Photographs in Appendix D show the culvert and the surrounding area.

The site lies within the physiographic region known as the Wawa Subprovince of the Superior Province of the Canadian Shield. Based on Ontario Geological Survey (OGS) Map 2518, titled "Surficial Geology of Northern Ontario", dated 1987, the site is located in an area of "bare bedrock with thin glacial sediment cover". Based on OGS Map 2545, titled "Bedrock Geology of Ontario", dated 1991, the bedrock is of the Archean age and consists of intrusive rocks, mainly massive to foliated granodiorite and granite.

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between June 23 and July 26, 2018, and consisted of drilling and sampling three (3) boreholes, designated as Boreholes 18-25 to 18-27, to depths of between 4.4 m to 15.8 m below the existing ground surface. Borehole 18-25 was drilled within the paved portion of Highway 17, approximately 16 m east of the existing culvert near the east end of the proposed roadway protection. Boreholes 18-26 and 18-27 were drilled near the inlet and outlet of the proposed culvert alignment to address cofferdam construction.

The previous preliminary investigation for this project was carried out between July 24 and 26, 2017, during which time four boreholes denoted as Boreholes 17-38 to 17-41 were drilled at



selected locations at the culvert site to depths of between 2.7 m to 15.8 m.

The Record of Borehole sheets for the boreholes from the current and previous preliminary investigation 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 C.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from topographic drawings provided to Thurber by Hatch. The borehole drilled from the Highway platform from the current investigation was drilled using a truck-mounted drill rig using wash boring drilling techniques, Boreholes 18-26 and 18-27 were drilled using a portable Hilti drill and tripod equipment using wash boring techniques. 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).

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

The boreholes were backfilled in general accordance with Ontario Regulation 903, as amended. A piezometer was installed in Borehole 17-38 drilled during the preliminary investigation.

Completion details of the boreholes are summarized in Table 3.1 below.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-25	15.8/175.9	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 3.0 m, bentonite holeplug to 0.3 m, sand to 0.2 m, then asphalt to surface.
18-26	9.8/178.0	None Installed	Borehole backfilled with bentonite holeplug to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-27	4.4/182.5	None Installed	Borehole backfilled with bentonite holeplug to surface.
17-38	15.8/174.7	15.2/175.3	Sand from 15.8 m to 11.6 m, then bentonite holeplug to surface
17-38A (DCPT)	6.0/184.5	None Installed	Borehole backfilled with bentonite holeplug to surface
17-39	15.8/176.0	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface
17-39A (DCPT)	9.2/182.6	None Installed	Borehole backfilled with bentonite holeplug to surface
17-40	14.8/174.1	None Installed	Borehole backfilled with bentonite holeplug to surface
17-41	2.7/188.9	None Installed	Borehole backfilled with bentonite holeplug and cuttings to 0.2 m, then asphalt to surface

4. LABORATORY TESTING

The 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 (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Point load tests were conducted on rock cores. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented 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, a sample of the fill, and a sample of the surface water from the creek upstream of the existing culvert were



collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. 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 must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes consisted of asphalt and sand and gravel fill overlying varying thicknesses of sand and silt layers, which were in turn underlain by silty clay and bedrock. Descriptions of the individual strata are presented below.

5.1 Surficial Boulders / Sand and Gravel / Topsoil

The creek bed and the creek banks near the proposed cofferdam locations were observed to contain boulders, as shown on Photos 4 to 6 in Appendix D. At Borehole 18-26, a 0.3 m thick boulder was encountered at the ground surface, which was underlain by topsoil with some gravel to a depth of 0.5 m (Elevation 187.2 m). At Borehole 18-27, a layer of sand and gravel with trace cobbles and trace organics was encountered at the ground surface and extended to a depth of 0.9 m (Elevation 186.0 m).

The surficial deposits were compact, based on SPT 'N' values of 16 to 27 blows per 0.3 m of penetration, with 70 blows per 0.2 m of penetration also recorded in Borehole 18-27, which is likely due to the presence of cobbles in the soil. The measured moisture content of the surficial materials ranged from 10 percent for the sand and gravel to 80 percent for the topsoil with some gravel.

The results of a grain size distribution analysis carried out on a sample of the sand and gravel are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 in Appendix B. The results of the grain size distribution analysis are summarized below:



Soil Particle	Percentage (%)
Gravel	43
Sand	52
Silt and Clay	5

5.2 Asphalt

Boreholes 17-39, 17-41, and 18-25 were drilled through the paved portions of Highway 17 and encountered a 150 to 200 mm thick layer of asphalt. Borehole 17-38 was drilled on the east side of the culvert inlet near the base of the existing highway embankment and encountered 75 mm of asphalt, that may have been part of a former road bed.

5.3 Sand and Gravel Fill

Sand and gravel fill ranging to gravelly sand fill, and containing trace silt, was encountered below the asphalt in Boreholes 17-38, 17-39, 17-41, and 18-25, and at the ground surface in Borehole 17-40. The sand and gravel to gravelly sand fill had a thickness of between 2.8 m and 5.0 m and extended to depths of approximately 2.8 m to 5.2 m (Elevation 188.7 m to 186.1 m). Borehole 17-41 was terminated within the fill at a depth of 2.7 m (Elevation 188.9 m).

SPT 'N' values within the sand and gravel to gravelly sand fill ranged from 2 blows per 0.3 m of penetration to 50 blows for 0.15 m of penetration, indicating a very loose to very dense relative density. Moisture contents between 1 percent and 21 percent were measured in the cohesionless fill.

The results of grain size distribution analyses carried out on selected samples of the sand and gravel fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 in Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	19 to 49
Sand	46 to 75
Silt and Clay	3 to 7



5.4 Silty Sand to Sand and Silt

Silty sand to sand and silt, containing trace clay and trace gravel was encountered in Boreholes 17-38 to 17-40 and 18-25 to 18-27 at depths of between 0.6 m to 5.5 m (Elevations 186.0 m to 187.4 m). The silty sand to sand and silt layer was between 0.9 m to 7.4 m thick and extended to depths of between 1.8 m and 11.2 m (Elevations 185.1 m to 178.7 m).

SPT 'N' values within the deposit ranged from 5 to 102 blows per 0.3 m of penetration, indicating a loose to very dense condition. Measured moisture contents within the deposit varied between 14 percent and 22 percent.

The DCPTs 17-38A and 17-39A were terminated within this deposit at depths of 6.0 m and 9.2 m (Elevation 184.5 m and 182.6 m) respectively upon refusal of 100 blows per 0.3 m of penetration.

The results of grain size distribution analyses carried out on selected samples of the silty sand and sand and silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B2 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 7
Sand	44 to 77
Silt	25 to 48
Clay	3 to 10
Silt and Clay	21 to 23

5.5 Sand

Sand, with trace to some silt and trace gravel, was encountered in Boreholes 17-39, 18-25, and 18-26 at depths of between 7.3 m and 11.2 m (Elevations 181.9 m to 180.5 m). Where fully penetrated the sand layer was between 2.5 m and 4.9 m thick and extended to depths of between 13.7 m and 14.8 m (Elevations 178.0 m and 177.0 m). Borehole 18-26 was terminated in the sand at a depth of 9.8 m (Elevation 178.0 m).

SPT 'N' values within the deposit ranged from 2 blows per 0.3 m of penetration to 50 blows per 0.125 mm of penetration, indicating a very loose to very dense condition. Measured moisture contents within the deposit varied between 17 percent and 28 percent.



The results of grain size distribution analyses carried out on samples of the sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	88 to 96
Silt and Clay	4 to 12

5.6 Silt

Silt, containing some sand, some clay, and trace gravel was encountered in Borehole 17-38 at a depth of 10.1 m (Elevation 180.4 m). The silt was approximately 4.5 m thick and extended to a depth of 14.6 m (Elevation 175.9 m).

SPT 'N' values within the silt deposit ranged from 19 to 28 blows per 0.3 m of penetration, indicating a compact relative density. Measured moisture contents within the silt deposit varied between 19 percent and 23 percent.

The results of grain size distribution analyses carried out on a selected sample of the silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B4 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	11
Silt	75
Clay	14

5.7 Silty Clay

A 2.5 m thick upper layer of silty clay with trace sand was encountered below the fill in Borehole 18-25, which extended to a depth of 5.5 m (Elev. 186.2 m). A lower layer of silty clay with trace sand and gravel was also encountered in Boreholes 17-38 to 17-40, 18-25 and 18-27 below the sand and silt layers above the bedrock. Where fully penetrated, the lower silty clay layer was approximately 0.4 m to 1.1 m thick and extended to depths of 2.2 m to 11.3 m (Elevations 184.7 m to 177.6 m). Boreholes 17-38, 17-39, 18-25 were terminated within the silty clay layer at depths of 15.8 m (Elevation 176.0 m to 174.7 m).



In Borehole 18-25, artesian conditions were encountered within the upper silty clay layer at a depth of approximately 4.5 m (Elevation 187.4 m). The groundwater temporarily rose to approximately 0.6 m above ground surface (Elevation 192.3 m). After approximately 20 minutes the ground water level dissipated and upon completion of drilling no groundwater was observed in the open borehole.

SPT 'N' values of 6 to 31 blows per 0.3 m penetration indicated that the silty clay had a firm to hard consistency. The silty clay had a measured moisture content ranging from 20 to 36 percent.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendix A and on Figures B5 and B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 6
Silt	21 to 69
Clay	28 to 76

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	14 to 23
Liquid Limit	24 to 55

The results of the Atterberg Limits testing indicate the layer to be of low to high plasticity with group symbol CH in the upper layer and CL in the lower layer.

5.8 Bedrock

Bedrock was encountered below the silty clay in Boreholes 17-40 and 18-27 at depths of 11.3 m and 2.2 m (Elevation 177.6 m and 184.7 m), respectively. The bedrock was proven by coring in both boreholes to depths of 14.8 m and 4.4 m (Elevation 174.1 m and 182.5 m), respectively. In Borehole 17-40 the bedrock consisted of moderately weathered grey basalt underlain by slightly weathered reddish brown granite, while in Borehole 18-27 only slightly weathered granite was encountered. The total core recovery, solid core recovery and rock quality index values recorded for the three runs of rock that were sampled in each borehole are shown below.



Borehole	Run Number	Total Core Recovery (%)	Solid Core Recovery (%)	Rock Quality Index (%)
17-40	1	100	100	89
	2	77	37	20
	3	97	70	40
18-27	1	90	90	24
	2	100	100	100
	3	18	18	18

The RQD results indicate very poor to good rock quality. Average unconfined compressive strengths (UCS) of the rock ranged between 70 MPa and 238 MPa based on correlations with the point load tests, indicating the rock was strong to very strong. The point load test results are included in Appendix B.

5.9 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. A standpipe piezometer was installed in Borehole 17-38 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometer are summarized below.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-25	June 23, 2018	Dry	Dry	Open borehole. Artesian condition in upper silty clay
18-26	July 24, 2018	0.6	187.2	Open borehole
18-27	July 26, 2018	0.2	186.7	Open borehole
17-38	July 26, 2017	2.6	187.9	Standpipe piezometer
17-39	July 24, 2017	2.1	189.7	Open borehole
17-40	July 26, 2017	1.0	187.9	Open borehole
17-41	July 24, 2017	Dry	Dry	Open borehole

In Borehole 18-25, artesian pressure of approximately 0.6 m above the ground surface (Elevation 192.3 m) was encountered during drilling at a depth of approximately 4.5 m. The artesian pressure dissipated after approximately 20 minutes, and no groundwater was observed in the open borehole upon completion of drilling.



The creek water level in November 2013 was reported to be Elev. 187.5 m upstream of the inlet and 185.8 m downstream of the outlet and was measured at Elevation 187.5 m and 187.2 m (at the inlet and outlet respectively) during the preliminary investigation.

The groundwater levels above are short-term readings, and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

During the preliminary investigation, a sample of the sand and gravel fill from Borehole 17-39 and a sample of the creek water were submitted for analytical testing 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	
			17-39, 3.0 m – 3.7 m	McLean's Creek
			(Sand and Gravel Fill)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.006
Chloride	mg/L	mg/L	1500	0.39
Sulphate	mg/L	mg/L	37	2
pH	No unit	No unit	6.17	7.17
Electrical Conductivity	µS/cm	µS/cm	1520	33
Resistivity	Ohms.cm	Ohms.cm	656	30300
Redox Potential	mV	mV	276	198

7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

Downing Drilling of Hawkesbury, Ontario, and OGS Drilling of Almonte, Ontario, supplied and operated the drilling, sampling and in-situ testing equipment for the current field investigation. The



current field investigation was supervised on a full-time basis by Mr. Liam Steers and Mr. Ryan McCourt of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch. The coordinate system MTM NAD83 Zone 14 was used for these boreholes.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. 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.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level


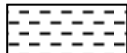



C_{pen} Shear Strength Determination by Pocket Penetrometer

- (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			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 18-25

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 342.1 E 272 301.3 ORIGINATED BY BRM
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.23 - 2018.06.23 LATITUDE 48.839590 LONGITUDE -87.442767 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									
191.7	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT (200mm)																
0.2	SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL)		1	SS	77		191										
			2	SS	77												
	Boulders from 1.5m to 2.3m		3	SS	66		190										
			4	SS	50/ 0.150		189										
188.7	Silty CLAY, trace sand Firm Brown Wet (CH)		5	SS	6		188										
3.0																	
	Artesian condition encountered at 4.5m						187										
	Water level rose to 0.6m above ground level, Dissipated after 20 minutes		6	SS	7												
186.2							186										
5.5	SAND and SILT, trace clay, trace gravel Compact to Very Dense Grey Moist to Wet		7	SS	20		185										
			8	SS	41		184										
							183										
	boulder at 9.1m		9	SS	50/ 0.125		182										

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

ELEV. DEPTH	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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES								
	Continued From Previous Page											kN/m ³	GR SA SI CL

Continued from Previous Page					
	SAND and SILT , trace clay, trace gravel Compact to Very Dense Grey Moist to Wet				
180.5		10	SS	50/ 0.100	
11.2	SAND , trace silt, Very Dense Grey Wet				
		11	SS	50/ 0.125	
178.0					
13.7	Silty CLAY , trace sand Stiff to Hard Grey Wet (CL)	12	SS	10	
175.9		13	SS	31	
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 3.0m, BENTONITE HOLEPLUG TO 0.3m, SAND TO 0.2m, THEN COLD PATCH ASPHALT TO SURFACE.				
	Artesian condition encountered at 4.5m and water level rose to 0.6m (Elevation 192.3) Water level dissipated after 20 minutes				

RECORD OF BOREHOLE No 18-26

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 363.8 E 272 278.5 ORIGINATED BY LS
DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.07.23 - 2018.07.24 LATITUDE 48.839784 LONGITUDE -87.443080 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 (%)						
187.8	GROUND SURFACE							20	40	60	80	100		W _p	W	W _L		
0.0	BOULDER																	
187.5			1	SS	16													
0.3	TOPSOIL, some rootlets, some gravel																	
187.2	Compact Brown Moist		2	SS	15													
0.6	Silty SAND, trace gravel, occasional cobbles Compact to Very Dense Brown to Grey Wet		3	SS	11													
			4	SS	61													7 70 23 (SH+CL)
			5	SS	65													
			6	SS	102													
			7	SS	42													2 77 21 (SH+CL)
			8	SS	100													
			9	SS	88													
180.5	SAND, some silt, trace gravel Very Dense Grey Wet		10	SS	70													0 88 12 (SH+CL)
178.0	END OF BOREHOLE AT 9.8m.																	
9.8																		

Continued Next Page

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

RECORD OF BOREHOLE No 18-26

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 363.8 E 272 278.5 ORIGINATED BY LS
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
 DATUM Geodetic DATE 2018.07.23 - 2018.07.24 LATITUDE 48.839784 LONGITUDE -87.443080 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
	BOREHOLE OPEN TO 0.6m AND WATER LEVEL AT 0.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No 18-27

1 OF 1

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 316.3 E 272 275.6 ORIGINATED BY LS
DIST Thunder Bay HWY 17 BOREHOLE TYPE Wash Boring COMPILED BY MP
DATUM Geodetic DATE 2018.07.25 - 2018.07.26 LATITUDE 48.839357 LONGITUDE -87.443115 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							
186.9	GROUND SURFACE							<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>20406080100</div>							
0.0	SAND and GRAVEL , trace cobbles, trace organics, trace silt Compact Brown Moist		1	SS	27										
186.0			2	SS	70/ 0.200								○		43 52 5 (SI+CL)
0.9	Silty SAND , trace gravel, ocasional cobbles Compact Brown Wet														
185.1			3	SS	18								○		
1.8	Silty CLAY		4	SS	11								○		
184.7	Stiff Grey Wet														
2.2	Spoon refusal at 2.2m		1	RUN											
	BEDROCK (GRANITE) , slightly weathered, pink sub vertical fracture (125mm) at 2.3m mechanical fracture (200mm) at 2.3m vertical fracture (200mm) at 2.4m sub horizontal fracture (50mm) at 2.7m		2	RUN											
184															
183			3	RUN											
182.5															
4.4	END OF BOREHOLE AT 4.4m. WATER LEVEL AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.														

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-38

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 354.2 E 272 288.6 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.25 - 2017.07.25 LATITUDE 48.839698 LONGITUDE -87.442941 CHECKED BY NLB

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE									
190.5	GROUND SURFACE																			
0.0	ASPHALT: (75mm) Gravelly SAND to SAND and GRAVEL , trace silt, occasional cobbles Very Loose to Loose Dark Brown Moist to Wet (FILL)		1	AS												19 75 6 (SI+CL)				
0.1			1	SS	2															
			2	SS	7															
			3	SS	5													36 60 4 (SI+CL)		
187.4	Silty SAND , trace gravel, trace clay Loose to Very Dense Grey Wet		4	SS	9															
3.1																				
			5	SS	35												0 72 25 3			
			6	SS	53															
			7	SS	26															
			8	SS	43															

Continued Next Page

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

RECORD OF BOREHOLE No 17-38

2 OF 2

METRIC

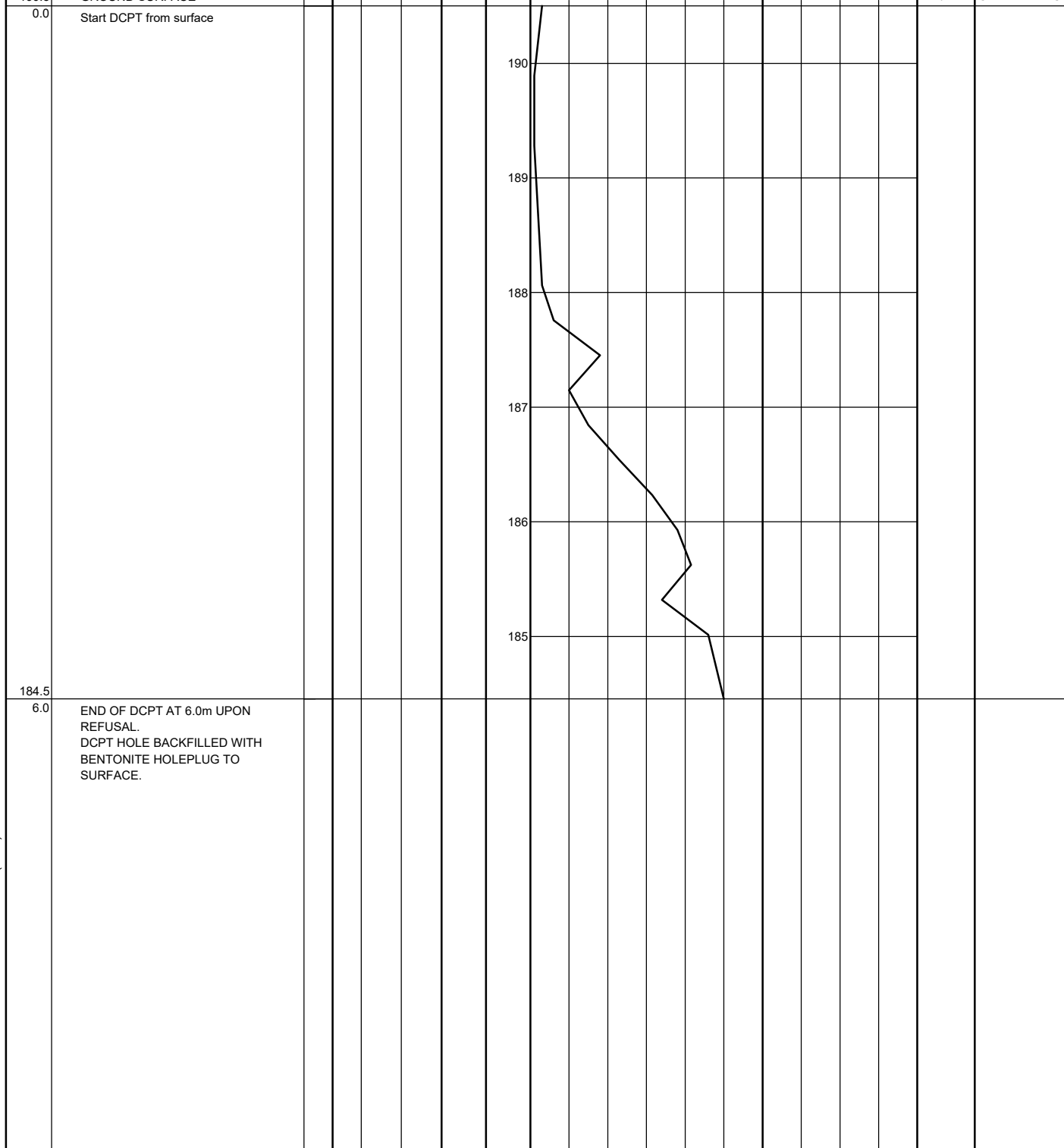
W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 354.2 E 272 288.6 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.25 - 2017.07.25 LATITUDE 48.839698 LONGITUDE -87.442941 CHECKED BY NLB

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							WATER CONTENT (%)			GR	SA	SI	CL
								<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div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ONTMT452 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 8/29/19

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100		W _P W W _L				
								SHEAR STRENGTH kPa		WATER CONTENT (%)				
190.5	GROUND SURFACE							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								20 40 60 80 100	20 40 60					



ONTMT4S2 MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 8/29/19

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-39

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 336.2 E 272 274.3 ORIGINATED BY JZ
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid & Hollow Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839536 LONGITUDE -87.443135 CHECKED BY NLB

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				GR	SA	SI	CL	
191.8	GROUND SURFACE																				
0.0	ASPHALT: (150mm)																				
0.2	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	AS																	
			1	SS	23																
			2	SS	29																
			3	SS	22																
			4	SS	25																
	Dark Brown Wet																				
			5	SS	26																
186.6																					
5.2	SAND and SILT, trace clay, trace gravel Compact Grey Wet																				
			6	SS	28																
			7	SS	14																
			8	SS	14																
181.9																					

Continued Next Page




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

RECORD OF BOREHOLE No 17-39

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 336.2 E 272 274.3 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid & Hollow Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839536 LONGITUDE -87.443135 CHECKED BY NLB

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									WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE														
	Continued From Previous Page							20	40	60	80	100						GR	SA	SI	CL	
9.9	SAND , trace to some silt, trace gravel Very Loose to Dense Grey Saturated						181															
			9	SS	2										○					0	96	4 (SI+CL)
							180															
			10	SS	41		179															
	No recovery						178															
			11	SS	40																	
177.0							177															
14.8	Silty CLAY , trace sand, trace gravel Very Stiff Grey Moist (CL)																					
			12	SS	15															0	0	69 31
176.0							176															
15.8	END OF BOREHOLE AT 15.8m. WATER LEVEL AT 2.1m FROM SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.																					

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-40

1 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 323.6 E 272 294.2 ORIGINATED BY JZ
DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
DATUM Geodetic DATE 2017.07.26 - 2017.07.26 LATITUDE 48.839423 LONGITUDE -87.442863 CHECKED BY NLB

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				GR	SA	SI	CL
188.9	GROUND SURFACE																		
0.0	SAND and GRAVEL , trace silt, occasional cobbles, trace organics Dense to Compact Brown Moist (FILL)		1	AS			188							○				49 48 3 (SI+CL)	
	No recovery		1	SS	40		187								○				
			2	SS	17		187												
	Grey Wet		3	SS	16		187								○				
186.1							186												
2.8	SAND and SILT , trace clay, trace gravel Loose to Very Dense Grey Wet		4	SS	5		186							○				4 47 43 6	
							185												
			5	SS	8		184							○					
							184												
			6	SS	54		183							○					
							182												
			7	SS	52		181							○					
							180												
		8	SS	60		180								○			0 52 38 10		
							179												

Continued Next Page

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

RECORD OF BOREHOLE No 17-40

2 OF 2

METRIC

W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 323.6 E 272 294.2 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2017.07.26 - 2017.07.26 LATITUDE 48.839423 LONGITUDE -87.442863 CHECKED BY NLB

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			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT					
								20 40 60 80 100			W P W W L					
	Continued From Previous Page															
178.7																
10.2	Silty CLAY , trace sand, trace gravel Very Stiff Grey Wet		9	SS	19		178									
177.6																
11.3	BEDROCK (BASALT), moderately weathered, very strong to strong, grey		1	RUN			177									
			2	RUN			176									
	Becoming granite, slightly weathered, very strong, reddish brown		3	RUN			175									
174.1																
14.8	END OF BOREHOLE AT 14.8m. WATER LEVEL AT 1.0m FROM SURFACE AT COMPLETION. BOREHOLE CAVED TO 4.6m AND BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.															

RECORD OF BOREHOLE No 17-41

1 OF 1

METRIC

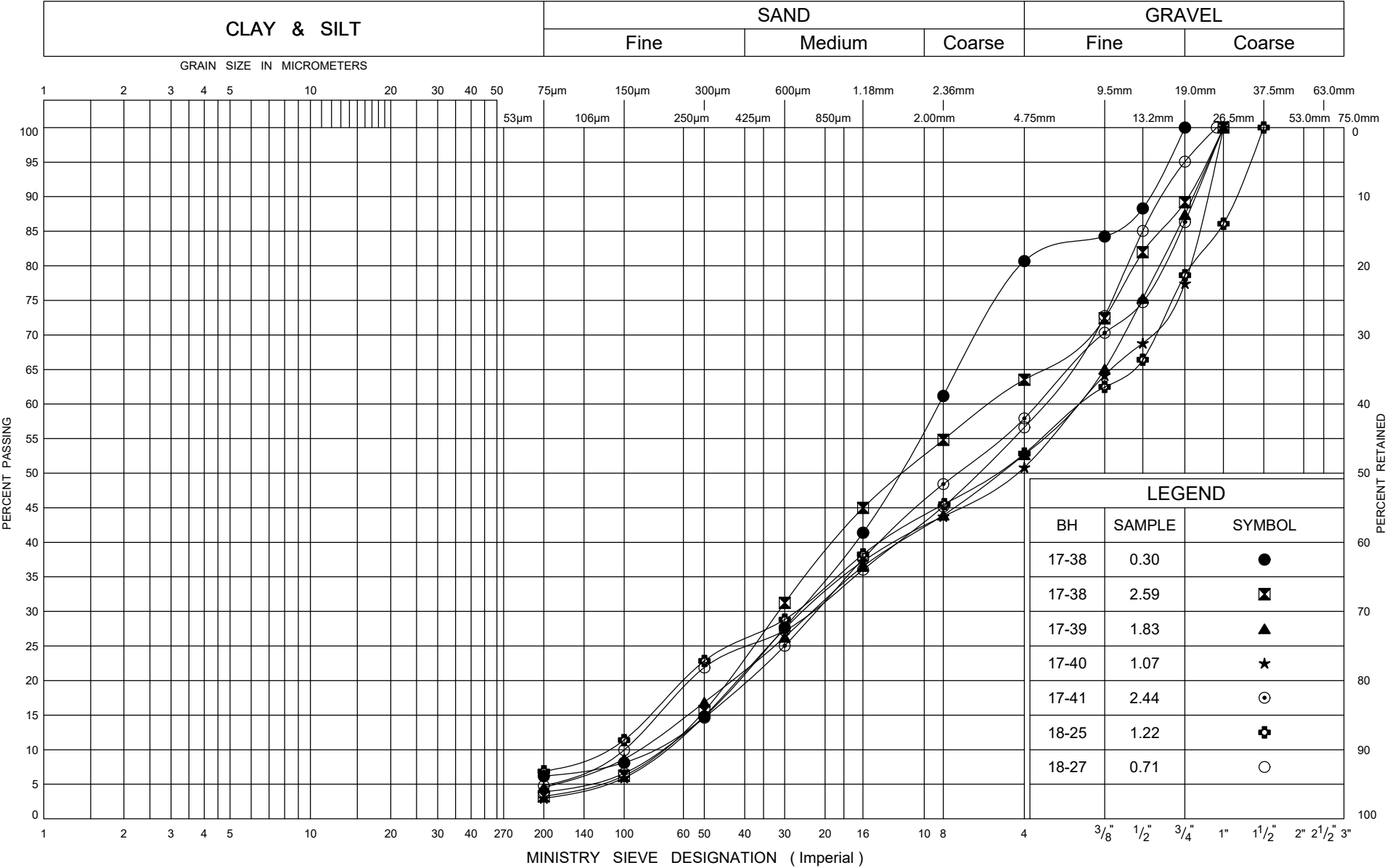
W.P. 6809-14-01 LOCATION McLean's Creek Culvert, MTM NAD 83 Zone 14 N 5 411 335.2 E 272 289.9 ORIGINATED BY JZ
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.07.24 - 2017.07.24 LATITUDE 48.839527 LONGITUDE -87.442922 CHECKED BY NLB

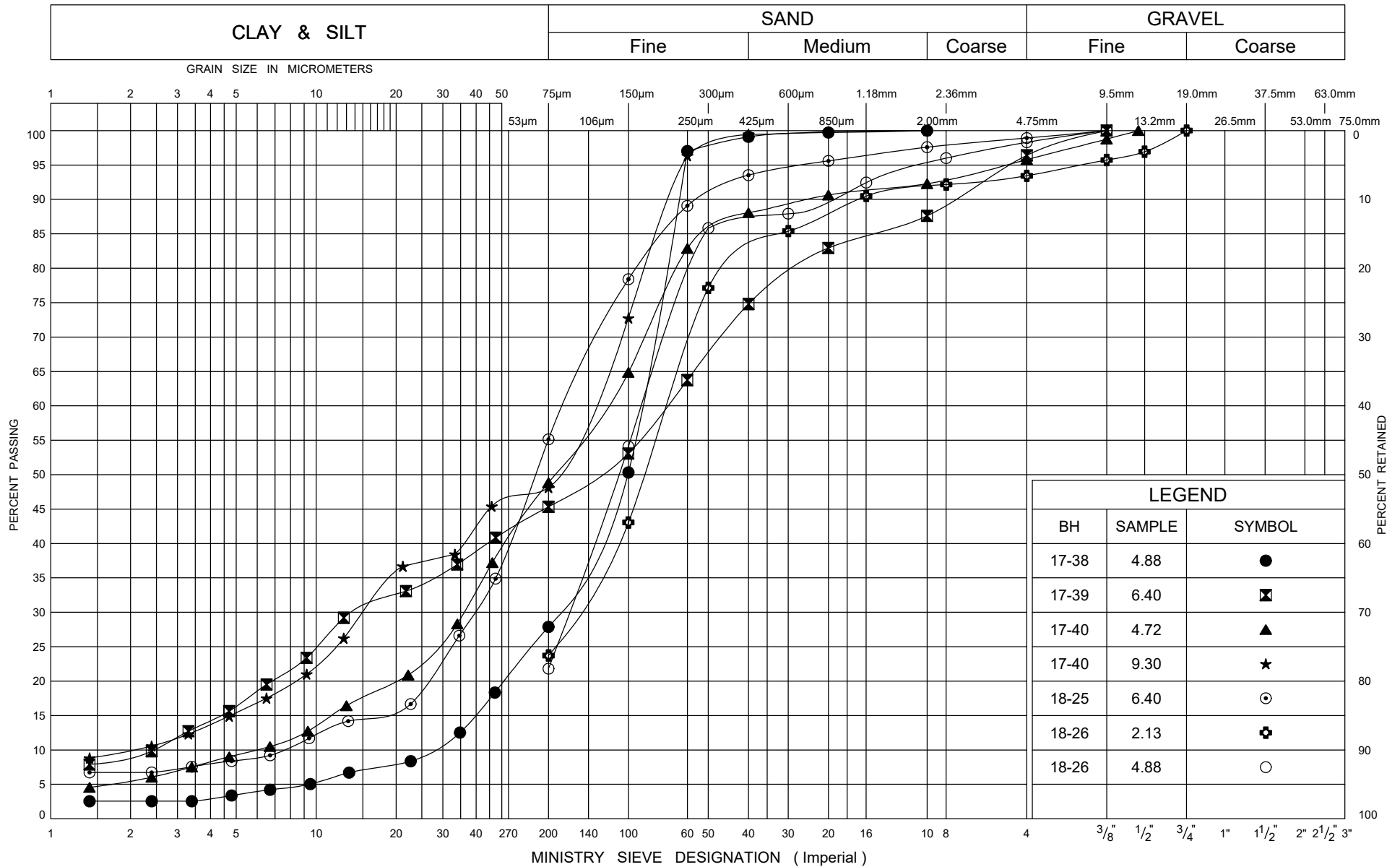
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
191.6	GROUND SURFACE							20 40 60 80 100						GR SA SI CL
0.0	ASPHALT: (150mm)							20 40 60 80 100						
0.2	SAND and GRAVEL, trace silt Brown Moist (FILL)		1	AS			191							
							190							
188.9	Loose		1	SS	5		189						42 54 4 (SI+CL)	
2.7	END OF BOREHOLE AT 2.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.													



Appendix B

Laboratory Test Results





Ministry of
Transportation

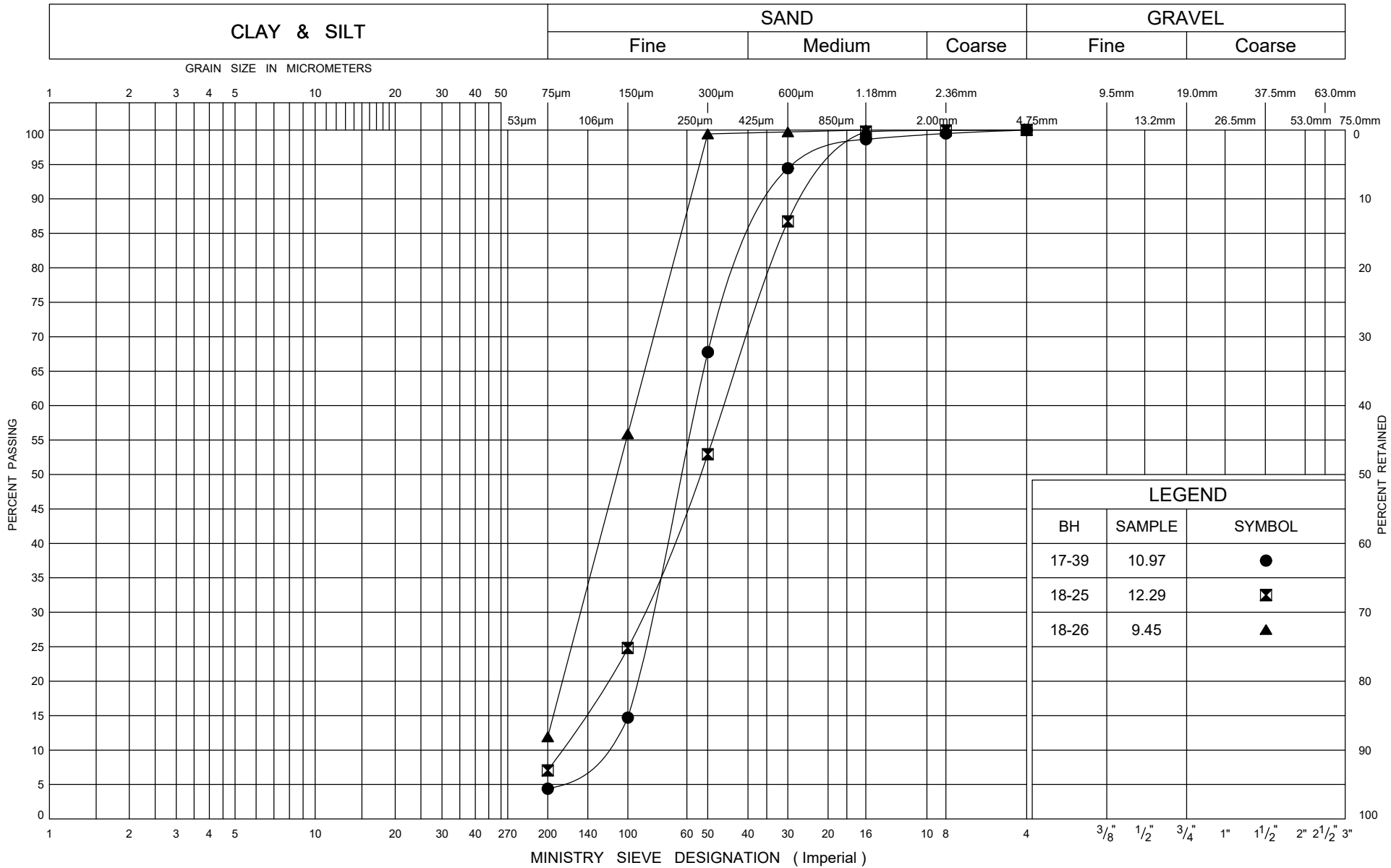
GRAIN SIZE DISTRIBUTION

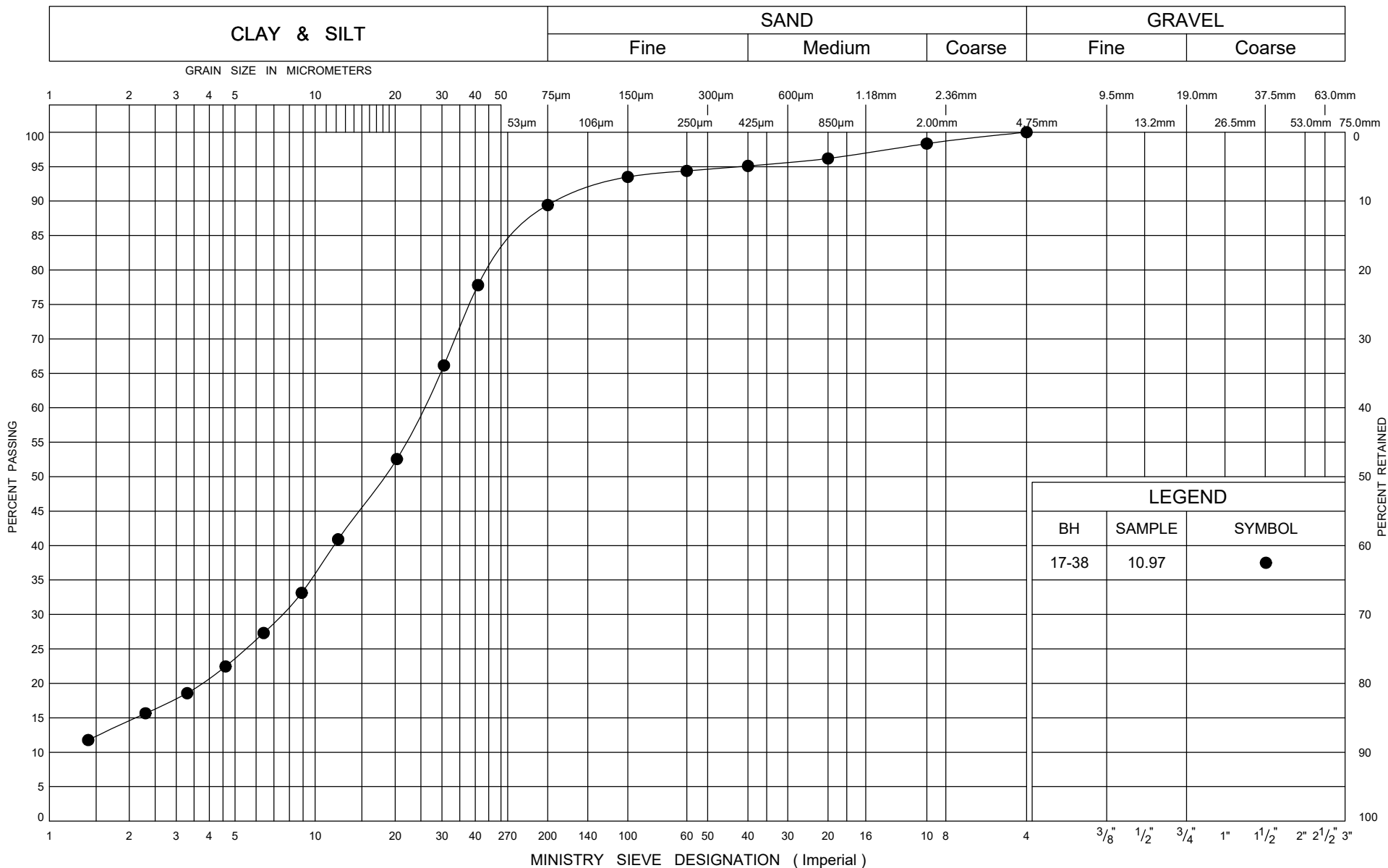
Silty SAND to SAND and SILT

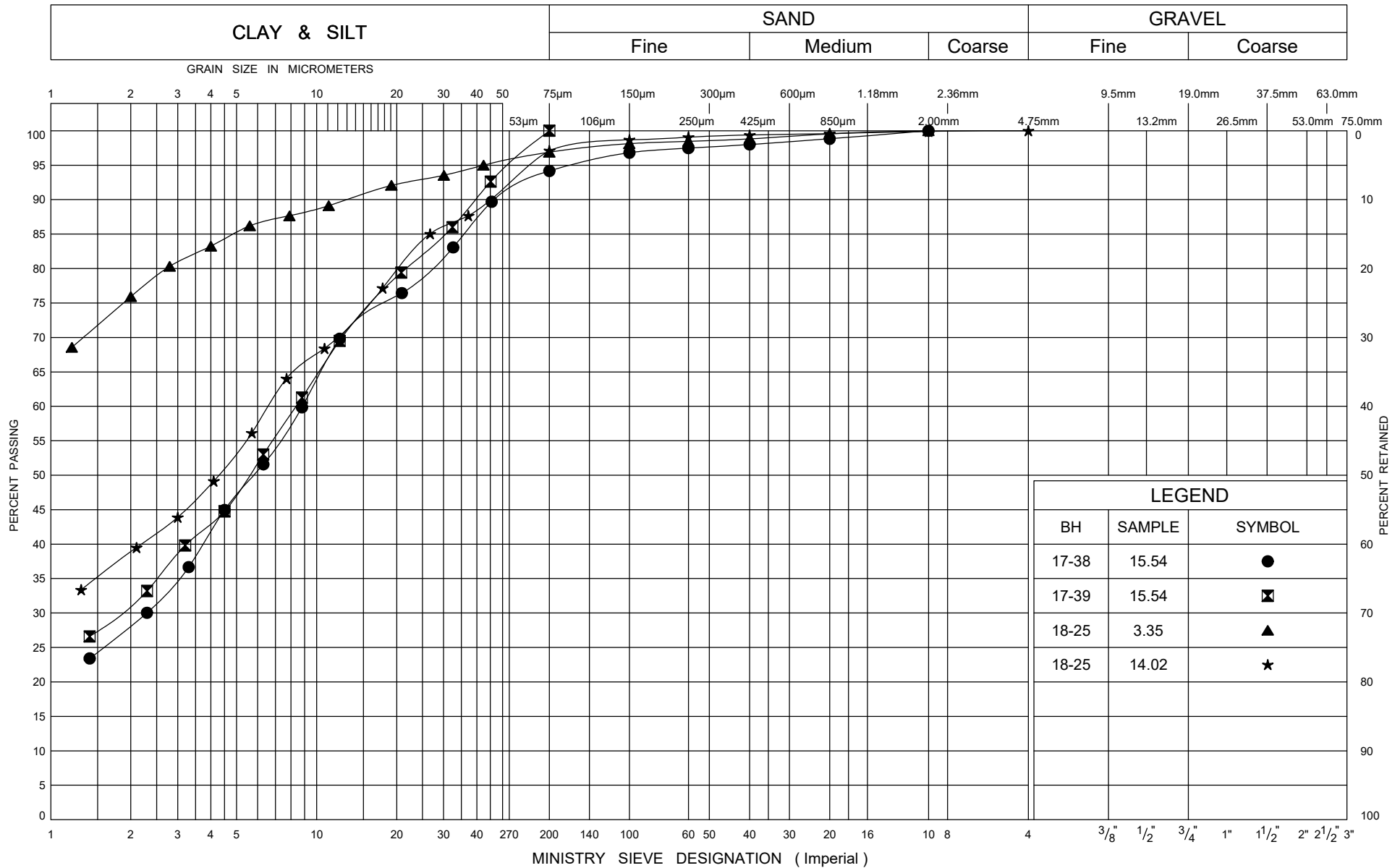
FIG No B2

W P 6809-14-01

McLean's Creek Culvert







Ministry of
Transportation

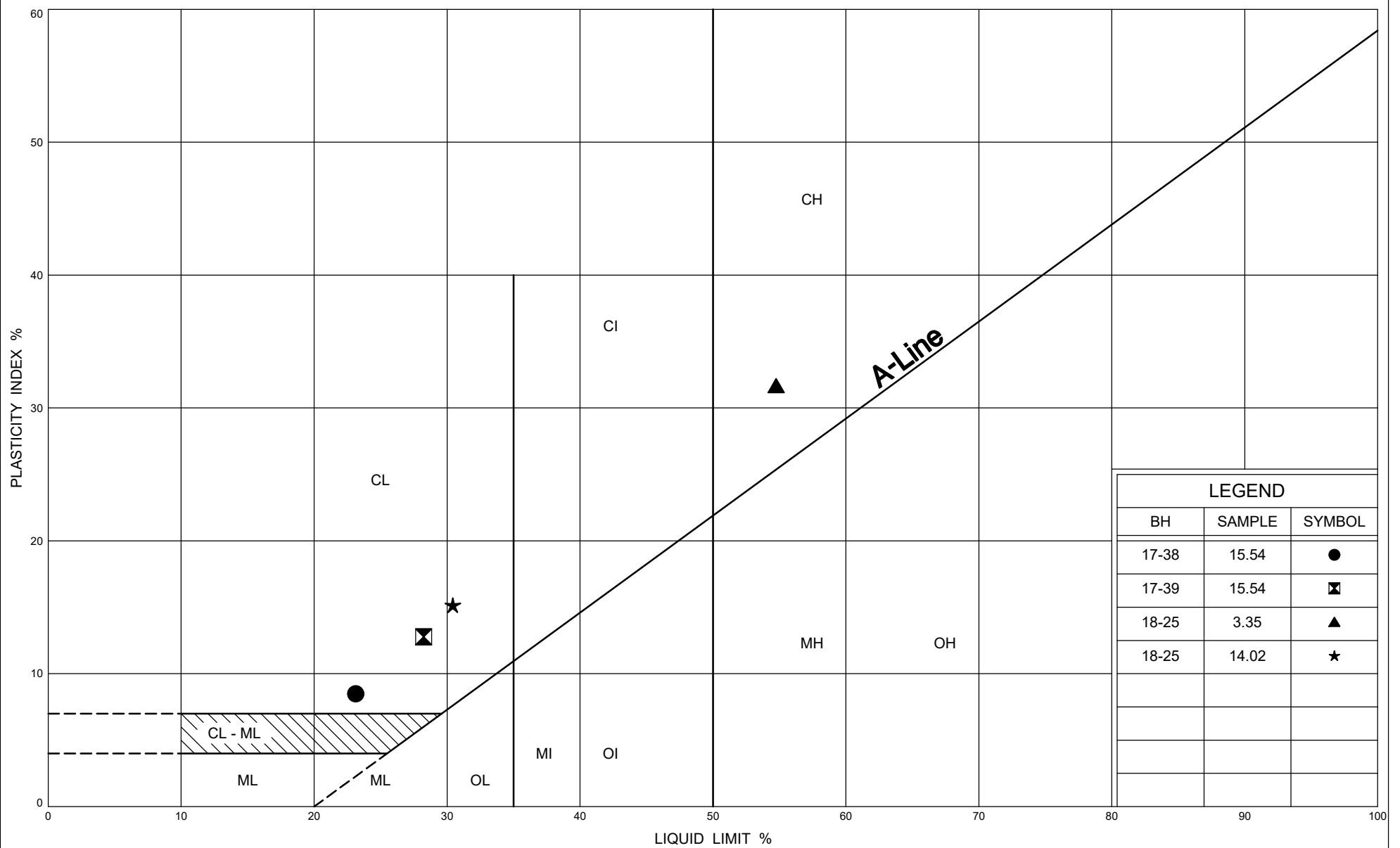
GRAIN SIZE DISTRIBUTION

Silty CLAY

FIG No B5

W P 6809-14-01

McLean's Creek Culvert





ASTM D5731-08

Date Drilled:	July 26/18
Date Tested:	August 17/18
Tester:	BS
Reviewed by:	MEF

[illegible]



ASTM D5731-08

Date Drilled:	July 26/17
Date Tested:	Aug 23/17
Tester:	ISP
Reviewed by:	MEF

[illegible]

Certificate of Analysis

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Client
SGS LIMS Number
Analysis Package:

Attention: Mark Farrant
Project#: 15595
Thurber Engineering Ltd.
CA14253-SEP17
Corrosivity (Soil)

Sample ID	Unit	BH-39, SS#5, 10'-12'
Sample Date/Time		24-Jul-17
Moisture	%	9.9
pH	no unit	6.17
Corrosivity Index	none	11.0
Soil Redox Potential	mV	276
Sulphide	mg/L	<0.02
Chloride	mg/L	1500
Sulphate	mg/L	37
Conductivity	uS/cm	1520
Resistivity (calculated)	ohms.cm	656

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

Data reported represents the sample submitted to SGS. Reproduction of this analytical report in full or in part is prohibited without prior written approval. Please refer to SGS General Conditions of Services located at http://www.sgs.com/terms_and_conditions_service.htm.
(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



FINAL REPORT

CA12892-JUL17 R

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

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

Contact Mark Farrant

Telephone 905-829-8666 x 228

Facsimile

Email mfarrant@thurber.ca

Project

Order Number

Samples Water (2)

LABORATORY DETAILS

Project Specialist Deanna Edwards, B.Sc, C.Chem

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email deanna.edwards@sgs.com

SGS Reference CA12892-JUL17

Received 07/28/2017

Approved 01/23/2018

Report Number CA12892-JUL17 R

Date Reported 01/23/2018

COMMENTS

Temperature of Sample upon Receipt: 23 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem





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Legend..... 8

Annexes..... 9-10



FINAL REPORT

CA12892-JUL17 R

Client: Thurber Engineering Ltd.

Project:

Project Manager: Mark Farrant

Samplers: John Zoldy

PACKAGE: REG153 - 1.3 Other (ORP) (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
1.3 Other (ORP)			
pH	units	0.05	7.17

PACKAGE: REG153 - Corrosivity Index (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
Corrosivity Index			
Resistivity (calculated)	ohms.cm	-9999	30300

PACKAGE: REG153 - Metals and Inorganics (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
Metals and Inorganics			
Conductivity	µS/cm	2	33
Chloride	mg/L	0.04	0.39
Sulphate	mg/L	0.04	2.0



FINAL REPORT

CA12892-JUL17 R

Client: Thurber Engineering Ltd.

Project:

Project Manager: Mark Farrant

Samplers: John Zoldy

PACKAGE: REG153 - UNDEFINED (WATER)

Sample Number 6
Sample Name 15595 McLeans
Creek
Sample Matrix Water
Sample Date 26/07/2017

Parameter	Units	RL	Result
UNDEFINED			
Redox Potential	mV	-	198
Sulphide	mg/L	0.006	< 0.006



FINAL REPORT

CA12892-JUL17 R

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0425-JUL17	mg/L	0.04	<0.04	11	20	97	80	120	99	75	125
Sulphate	DIO0425-JUL17	mg/L	0.04	<0.04	0	20	99	80	120	98	75	125
Chloride	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	99	80	120	111	75	125
Sulphate	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	94	80	120	103	75	125

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0430-JUL17	µS/cm	2	< 2	0	10	100	90	110	NA		



FINAL REPORT

CA12892-JUL17 R

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0431-JUL17	no unit	0.05	NA	0		100			NA		

Redox Potential
Method: SM 2580 |

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Redox Potential	EWL0428-JUL17	mV	no	NA	5	20	109	80	120	NA		

Sulphide by SFA
Method: SM 4500 | Internal ref.: ME-CA-IENVISFA-LAK-AN-008

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	SKA0007-AUG17	mg/L	0.006	<0.006	ND	20	98	80	120	102	75	125

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

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

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

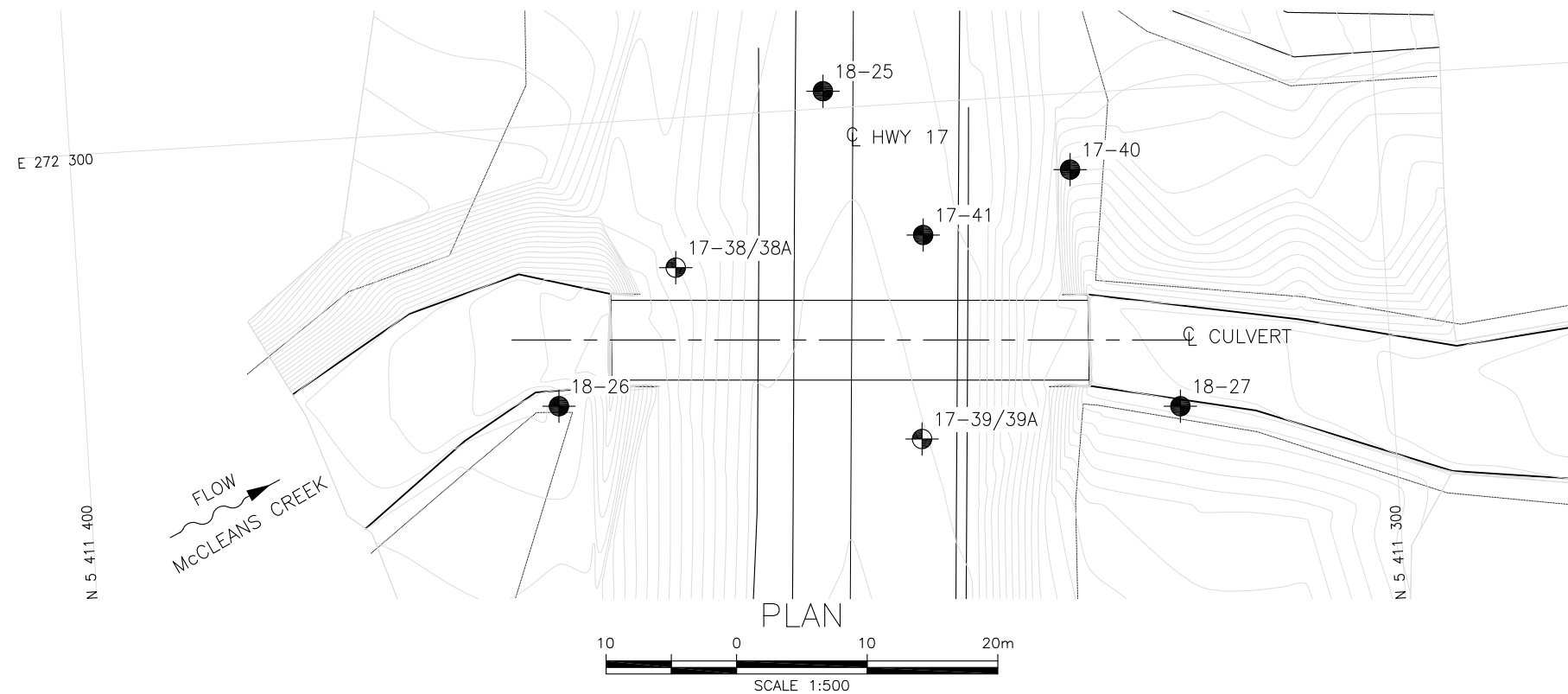
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-- End of Analytical Report --

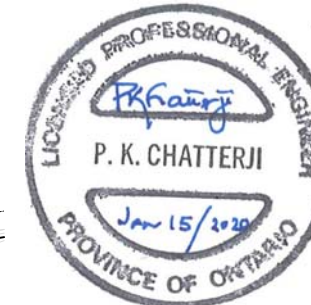


Appendix C

Borehole Locations and Soil Strata Drawing



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



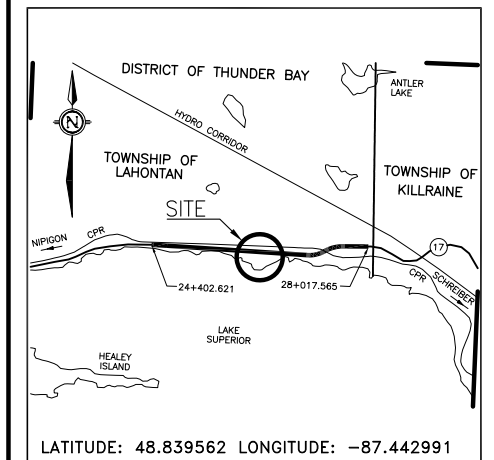
CONT No
WP No 6809-14-01

HIGHWAY 17
MCLEAN'S CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH








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
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

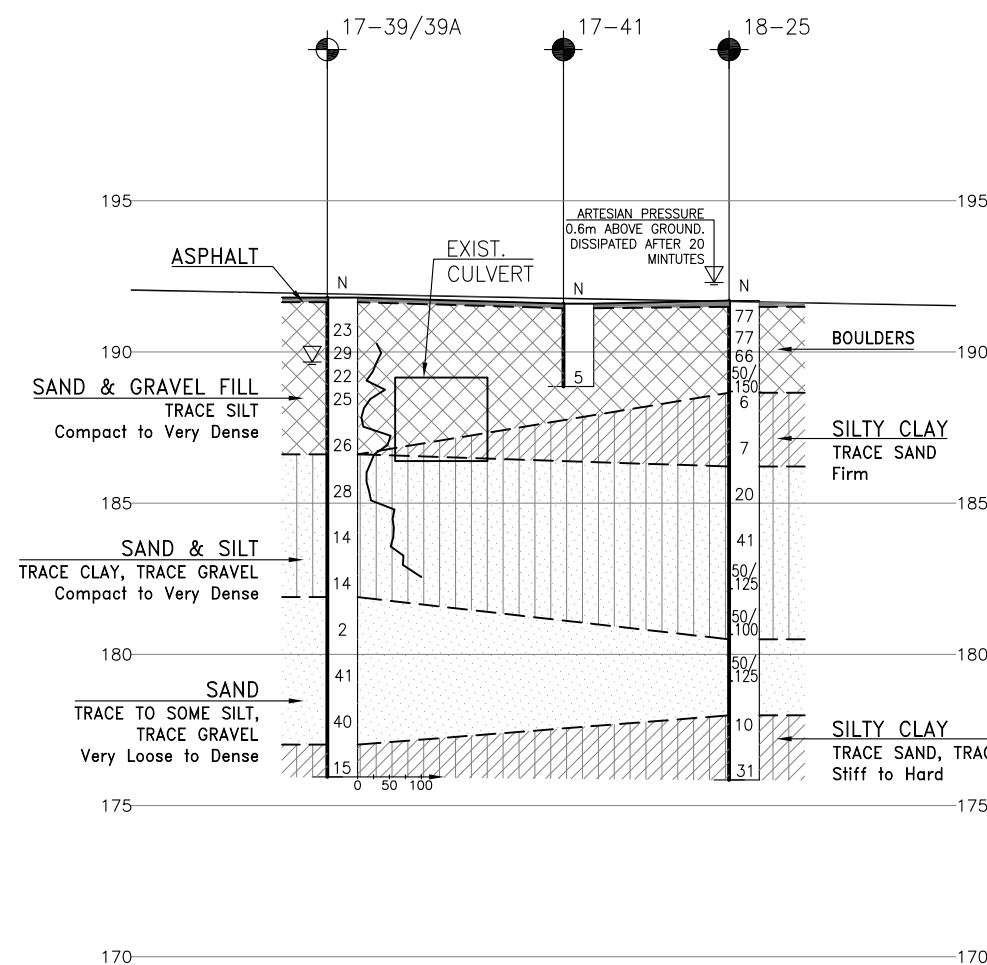
NO	ELEVATION	NORTHING	EASTING
17-38/38A	190.5	5 411 354.2	272 288.6
17-39/39A	191.8	5 411 336.2	272 274.3
17-40	188.9	5 411 323.6	272 294.2
17-41	191.6	5 411 335.2	272 289.9
18-25	191.6	5 411 342.1	272 301.3
18-26	187.8	5 411 363.8	272 278.5
18-27	186.6	5 411 316.3	272 275.6

-NOTES-

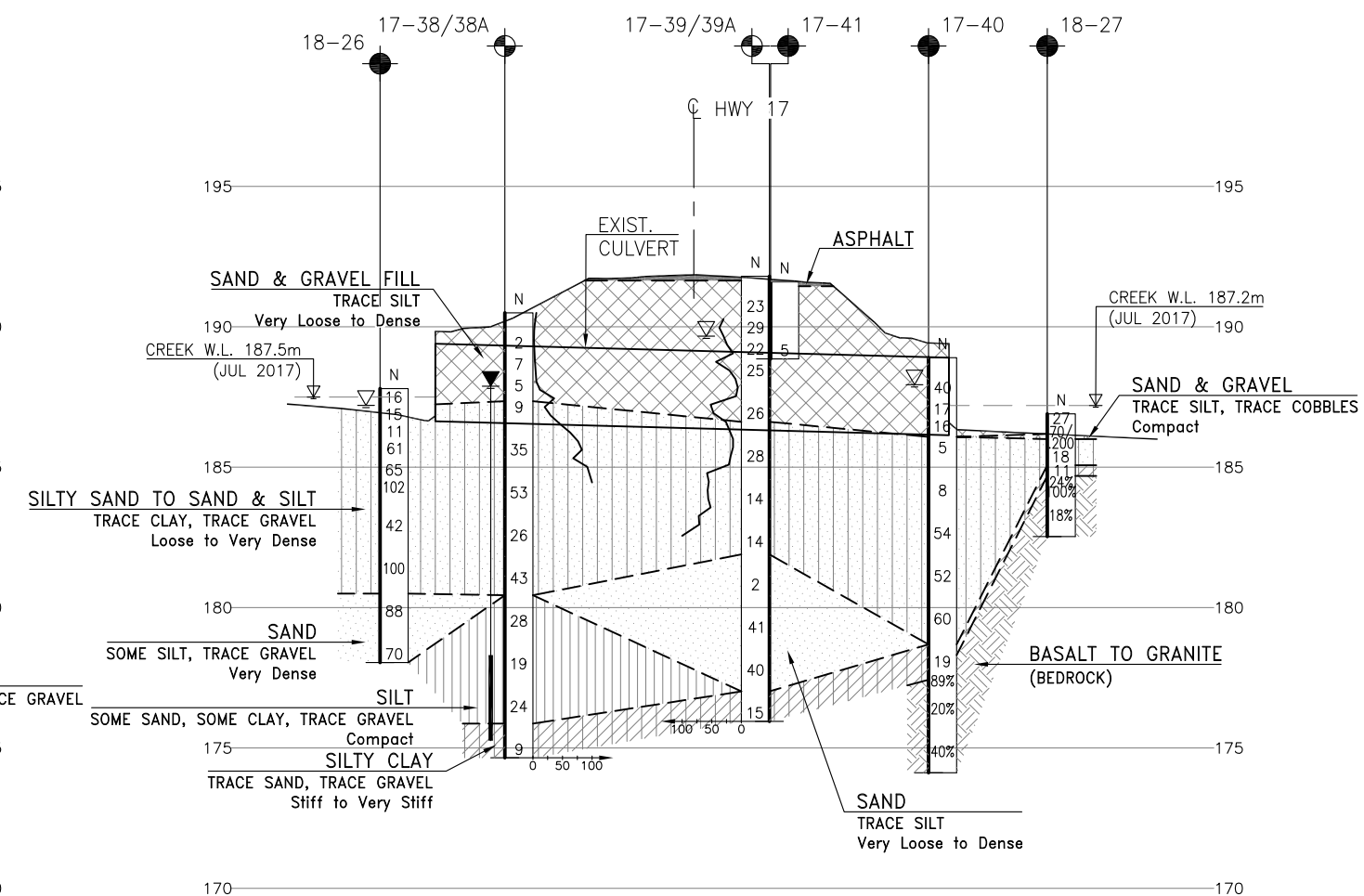
- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 14

GEOCRES No. 42D-059

SECTION ALONG C HWY 17



SECTION ALONG CULVERT



H 1:500

V 1:250

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	CZ	CHK	MEF	CODE	LOAD	DATE	JAN 2020			
DRAWN	AN	CHK	CZ	SITE 48C-178C	STRUCT	DWG	1			



Appendix D

Site Photographs



Photo 1: Road approach looking east (May 18, 2017)



Photo 2: Road approach looking west (May 18, 2017)



Photo 3: Culvert Inlet looking south (July 24, 2017)



Photo 4: Boulders near Culvert Inlet looking north (July 23, 2018)



Photo 5: Culvert outlet looking north, showing delamination of soffit and scaling and spalling of lower wall (June 14, 2013)



Photo 6: Boulders in creek bed near Culvert Outlet looking south (July 25, 2018)



Photo 7: Looking east at north side of road (inlet) (July 24, 2017)



Photo 8: Looking west at north side of road (inlet) (July 24, 2017)



Photo 9: Looking east on south side of road (outlet) (July 26, 2017)



Photo 10: Looking west on south side of road (outlet) (July 26, 2017)