



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
BLACKBIRD CREEK CULVERT REPLACEMENT
HIGHWAY 17, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 48.845825°, LONGITUDE: -87.037083**

G.W.P. 6808-14-00, W.P. 6808-14-01, SITE No. 48E-052C

GEOCRES Number: 42D-50

Report

to

HATCH

Date: September 7, 2018
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 proposed replacement of the Blackbird Creek Culvert on Highway 17, located east of the township of Terrace Bay, in the District of Thunder Bay, Ontario. Thurber carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0008.

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.

2. SITE DESCRIPTION

The site is located along Highway 17, approximately 9 km east of the township of Terrace Bay, Ontario. The culvert allows Blackbird Creek to flow from the southeast to the northeast under Highway 17. Highway 17 generally runs in a northeast-southwest direction at the culvert site with the culvert running perpendicular to the roadway.

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, 1.8 m high and 30.6 m long. The culvert barrel is in overall poor condition with light to medium erosion along the bottom 0.7 m of both side walls. The side wall erosion is severe in some locations. There is a 750 mm long crack near the inlet on the west wall. Medium scaling and cracking were observed in the soffit, and severe scaling was observed on the southeast wall. The water level in the creek on June 7, 2016 was reported at approximate Elevation 205.6 m upstream of the inlet and 204.6 m downstream of the outlet.



The grade level of Highway 17 at the existing culvert is at an elevation of 209 m. The invert elevation (southeast) is approximately 204.4 m, and the outlet elevation (northwest) is approximately 204.2 m. The height of fill above the existing culvert is approximately 3 m.

The area on either side of the creek near the inlet and outlet of the culvert is vegetated with tall grass and trees, and the overall surrounding area is densely forested. There are also pine trees and grass growing on top of the culvert at the inlet and 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 field investigation for this project was carried out between August 20 and September 17, 2017, during which time four boreholes denoted as Boreholes 17-34 to 17-37 were drilled at selected locations at the culvert site. Boreholes 17-35 and 17-37 were located within the westbound lane of Highway 17 on either side of the culvert. Borehole 17-36 was located near the inlet of the culvert and 17-34 was located near the outlet. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing provided in Appendix C.

A track-mounted CME 55 drill rig was used to drill Boreholes 17-35 to 17-37 and a Hilti DD 250 E portable drill was used to drill Borehole 17-34. The boreholes were advanced using hollow stem and solid stem augers and wash boring techniques to depths between 2.1 m and 18.9 m. In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT). In locations where soft clay was observed, field vane shear tests were performed to measure the undrained shear strength of the soil. A dynamic cone penetration test (DCPT) was conducted at Borehole 17-36 from a depth of 13.4 m to 15.8 m. The results of the boreholes and DCPT are presented on the Record of Borehole sheets in Appendix A.

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.

Groundwater conditions were observed in the open boreholes throughout the drilling operations and in a standpipe piezometer that was installed in Borehole 17-36. The standpipe piezometer consisted of a 25 mm diameter PVC pipe, with a 3 m long slotted screen installed to a depth of 11.2 m. The boreholes in which no standpipe piezometers were installed were backfilled in general accordance with Ontario Regulation 903, as amended by Regulation 128/03. The piezometer was decommissioned upon completion of the drilling investigation at the site.

Details of the piezometer installations and borehole completion are summarized as follows:

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
17-34	15.3/190.1	None Installed	Bentonite holeplug and cuttings to surface and covered with gravel
17-35	18.9/190.1	None Installed	Cuttings to 0.9 m, then dry cement to 0.1 m and asphalt to surface
17-36	15.8/190.1	11.2/194.7	Sand to 7.9 m, then bentonite holeplug and cuttings to surface
17-37	2.1/206.9	None Installed	Cuttings to 0.75 m, then concrete to 0.15 m and 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. 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.



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, topsoil and fill overlying varying thicknesses of silty sand, which was in turn underlain by silty clay and lower silty sand and sand layers. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 17-35 and 17-37 were drilled through the westbound lane of Highway 17 and encountered a 140 to 150 mm thick layer of asphalt.

5.2 Fill

Fill material was encountered below the asphalt in Boreholes 17-35 and 17-37. The fill consisted of sand and gravel to gravelly sand, underlain by sand and silt fill. The fill layer was 2.9 m thick at Borehole 17-35 and extended to an Elevation of 205.9 m. Borehole 17-37 was terminated within the fill layer at a depth of 2.1 m (Elevation 206.9 m).

5.2.1 Sand and Gravel to Gravelly Sand Fill

A 1.2 m and 1.4 m thick layer of sand and gravel to gravelly sand was encountered in Boreholes 17-35 and 17-37 respectively.

SPT 'N' values within the sand and gravel to gravelly sand fill ranged from 64 to 80 blows per 0.3 m of penetration, indicating a very dense relative density. Moisture contents between 4 percent and 7 percent were measured in the granular 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 of Appendix B. The results of the grain size distribution analyses are summarized below:



Soil Particle	Percentage (%)
Gravel	22 to 42
Sand	50 to 59
Silt	15
Clay	4
Silt and Clay	8

5.2.2 Sand and Silt Fill

A 1.7 m thick layer of sand and silt fill was encountered below the sand and gravel fill in Borehole 17-35. Borehole 17-37 was terminated in the sand and silt fill at an elevation of 206.9 m.

SPT 'N' values within the sand and silt fill ranged from 10 to 26 blows per 0.3 m of penetration, indicating a compact relative density. Moisture contents between 14 percent and 19 percent were measured in the fill.

The results of grain size distribution analyses carried out on a selected sample of the sand and silt fill 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
Sand	34
Silt	63
Clay	3

5.3 Topsoil

Boreholes 17-34 and 17-36, which were drilled near the existing outlet and inlet of the culvert, encountered a surficial layer of topsoil that contained some sand, silt and roots. The topsoil layer was 0.6 m thick and extended to approximate Elevation 204.8 m to 205.3 m. A 2.5 m thick buried topsoil layer was encountered below the fill in Borehole 17-35 from a depth of 3.1 m to 5.6 m (base Elevation 203.4 m). The buried topsoil was mixed with inorganic soil and was sandy with occasional silt pockets, rootlets and wood fragments.



SPT 'N' values within the topsoil ranged from 4 to 9 blows per 0.3 m of penetration, indicating a very loose to loose consistency. The moisture content of the topsoil ranged from 11 percent to 65%.

5.4 Upper Silty Sand

An upper silty sand layer with some clay and occasional wood fragments was encountered in Boreholes 17-34 and 17-36 at Elevations 203.9 and 205.3 m respectively. The thickness of the silty sand layer was 2.6 m at Borehole 17-34 and 0.8 m at Borehole 17-36. The silty sand layer extended to elevations of 201.3 (17-34) and 204.5 m (17-36).

The SPT 'N' values for the silty sand ranged from 3 to 6 blows per 0.3 m penetration indicated a very loose to loose relative density. The silty sand had a measured moisture content ranging from 35 percent to 46 percent.

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

Soil Particle	Percentage (%)
Gravel	0
Sand	58
Silt	29
Clay	13

5.5 Silty Clay

An upper layer of silty clay with some sand to sandy was encountered below the topsoil in Boreholes 17-34 and 17-35 and extended to depths of 1.5 m (Elevation 203.9 m) and 7.2 m (Elevation 201.8 m) respectively. The thickness of the upper silty clay layer ranged for 0.9 m to 1.6 m. A layer of silty clay with trace to some sand was encountered below the upper silty sand deposit in Boreholes 17-34 to 17-36. The depth to the top of the silty clay layer ranged from 1.4 to 7.2 m (204.5 to 201.3). The thickness of the silty clay layer ranged from 6.8 to 8.8 m, and extended to depths of 10.2 to 14.0 m (Elevation 195.7 to 192.9 m).

SPT 'N' values ranging from 0 (weight of hammer) to 5 blows per 0.3 m penetration were recorded. In situ field vane tests measured undrained shear strengths ranging from 7 to 30 kPa (typically 10 to 30 kPa). Therefore, the silty clay is considered to generally have a very soft to firm



consistency. The sensitivity of the clay was measured to range between 1.1 and 3.5, indicating low to medium sensitivity. The silty clay had a measured moisture content ranging from 15 percent to 62 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 Figure B4 and B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	22 to 75
Clay	25 to 78

The results of Atterberg Limits testing are summarized below:

Index Property	Percentage (%)
Plastic Limit	17 to 25
Liquid Limit	28 to 74
Plasticity Index	10 to 49

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

5.6 Lower Silty Sand

A lower layer silty sand with trace gravel underlaid the silty clay layer in Boreholes 17-34, 17-35 and 17-36. The silty sand layer extended to depths ranging from 12.0 m to 17.1 m (Elevation 193.9 to 190.6 m) and had a thickness ranging from 1.8 m to 3.1 m.

SPT 'N' values within the silty sand deposit ranged from 0 (weight of hammer) to 18 blows per 0.3 m of penetration, indicating a very loose to compact relative density. Measured moisture contents within the silty sand deposit varied between 15 percent and 19 percent.

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



Soil Particle	Percentage (%)
Gravel	1
Sand	75
Silt and Clay	24

5.7 Sand

A sand layer with trace to some gravel and some silt was encountered below the lower silty sand layer in Boreholes 17-34 to 17-36 at depths ranging from 12.0 m to 17.1 m (Elevation 193.9 to 190.6 m). All three boreholes were terminated in the sand layer at depths ranging from 13.4 m to 18.9 (Elevation 192.5 to 190.1 m).

SPT 'N' values within the sand deposit ranged from 6 to over 100 blows per 0.3 m of penetration, indicating a loose to very dense relative density. Measured moisture contents within the sand deposit varied between 11 percent and 19 percent.

The results of grain size distribution analyses testing carried out on a selected sample of the sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B5 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	4
Sand	87
Silt and Clay	9

5.8 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 17-36 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	
17-34	August 17, 2017	Dry	Dry	Open Borehole
17-35	August 20, 2017	3.7	205.3	Open borehole
17-36	August 28, 2017	0.6	205.3	Standpipe piezometer
17-37	August 20, 2017	Dry	Dry	Open borehole

The creek water level on June 7, 2016, was reported to be Elevation 205.6 m upstream of the inlet and 204.6 m downstream of the outlet.

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

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty sand from Borehole 17-36 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	
			17-36, SS#2, 0.8 m – 1.4 m	Blackbird Creek
			(Silty Sand)	(Creek Water)
Sulphide	mg/L	mg/L	<0.02	0.08
Chloride	mg/L	mg/L	340	110
Sulphate	mg/L	mg/L	10	180
pH	No unit	No unit	7.99	7.78
Electrical Conductivity	µS/cm	µS/cm	397	1180
Resistivity	Ohms.cm	Ohms.cm	2520	847
Redox Potential	mV	mV	137	224



7. MISCELLANEOUS


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

RPM Drilling Ltd. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment to complete Boreholes 17-35 to 17-37 and Ohlmann Geotechnical Services (OGS) of Almonte, Ontario supplied and operated the drilling, sampling and in-situ testing equipment to complete Borehole 17-34. The field investigation was supervised on a full-time basis by Mr. Ty Tonus-Burman of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, EIT 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 Dr. Nancy Berg, EIT 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.


Sept 7, 2018
Nancy Berg, Ph.D.
Geotechnical EIT



Mark Farrant, P.Eng.
Geotechnical Engineer

Client: Hatch

File No.: 15595

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P.K. Chatterji, P.Eng., Ph.D.

Review Principal, Designated MTO Contact

Date: September 7, 2018

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION



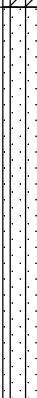

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

RECORD OF BOREHOLE No 17-34

1 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 964.3 E 302 071.6 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE BW Casing COMPILED BY MP
 DATUM Geodetic DATE 2017.09.17 - 2017.09.17 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 (%) GR SA SI CL			
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							
205.4	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL , silt, some sand, roots Loose Dark Brown Moist		1	SS	6		205													
204.8																				
0.6	Silty CLAY , some sand, rootlets Soft Brown Moist		2	SS	3		204													
203.9																				
1.5	Silty SAND , some clay, occasional wood fragments Loose to Very Loose Brown Moist		3	SS	5		203													
			4	SS	6		202													
			5	SS	3		201													
201.3																				
4.1	Silty CLAY , trace to some sand Firm to Very Soft Grey Moist to Wet (CI)		6	SS	5		200													
							199													
							198													
			7	SS	0		197													
							196													

Continued Next Page

+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 17-35

1 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 958.4 E 302 086.0 ORIGINATED BY TY
HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2017.08.20 - 2017.08.20 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 (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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+³, ×³: Numbers refer to
Sensitivity


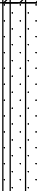
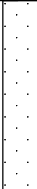
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-35

2 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 958.4 E 302 086.0 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.08.20 - 2017.08.20 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L WATER CONTENT (%)					
	Continued From Previous Page							20	40	60	80	100	20	40	60		GR	SA	SI	CL
195.0	Silty CLAY , trace sand Very Soft Grey Wet (CL)						198	1.5									0	0	70	30
			10	SS	0		197													
							196													
14.0	Silty SAND , trace to some clay, trace gravel Loose Grey Wet						195													
			11	SS	8		194													
							193													
191.9	SAND , some gravel, some silt Compact Grey Wet						192													
17.1							191													
190.1			12	SS	22															
18.9	END OF BOREHOLE AT 18.9m. BOREHOLE OPEN TO 6.0m AND WATER LEVEL AT 3.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.1m, THEN COLD PATCH																			

Continued Next Page

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

RECORD OF BOREHOLE No 17-35

3 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 958.4 E 302 086.0 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.08.20 - 2017.08.20 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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page ASPHALT TO THE SURFACE.																

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/24/17

METRIC

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-36

2 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 932.8 E 302 095.1 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2017.08.22 - 2017.08.22 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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
195.7																	
10.2	Silty SAND Very Loose Grey Wet		7	SS	0												
193.9																	
12.0	SAND , some silt, trace gravel Loose Grey Wet		8	SS	6												
192.5																	
13.4	End of sampling and start DCPT at 13.4m																
190.1																	
15.8	END OF DCPT AT 15.8m. BOREHOLE OPEN TO 11.3m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.08.26 0.6 205.3																

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/8/17

RECORD OF BOREHOLE No 17-37

1 OF 1

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 939.3 E 302 076.6 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.08.20 - 2017.08.20 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									
209.0	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (140mm)																
0.1	Gravelly SAND , some silt, trace clay Brown Dry (FILL)		1	GS			208								o		22 59 15 4
207.5																	
1.5	SAND and SILT Compact Brown Moist (FILL)		1	SS	15		207								o		
206.9																	
2.1	END OF BOREHOLE AT 2.13m. HOLE FILLED WITH CUTTINGS TO 0.6m, DRY CEMENT TO 0.2m, THEN COLD-PATCH ASPHALT TO THE SURFACE.																

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



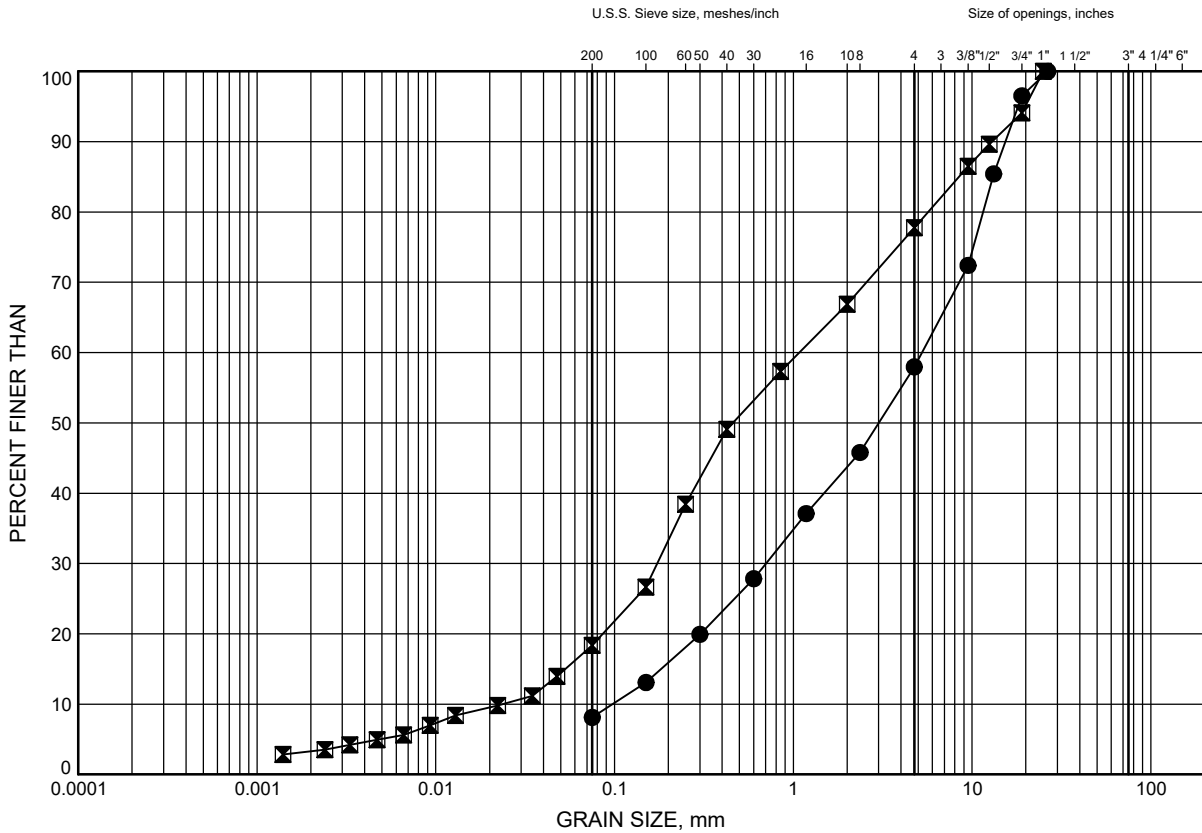
Appendix B

Laboratory Test Results

BlackBird Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND and GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-35	0.3	208.7
⊠	17-37	0.8	208.2

Date November 2017
W.P. 6808-14-01

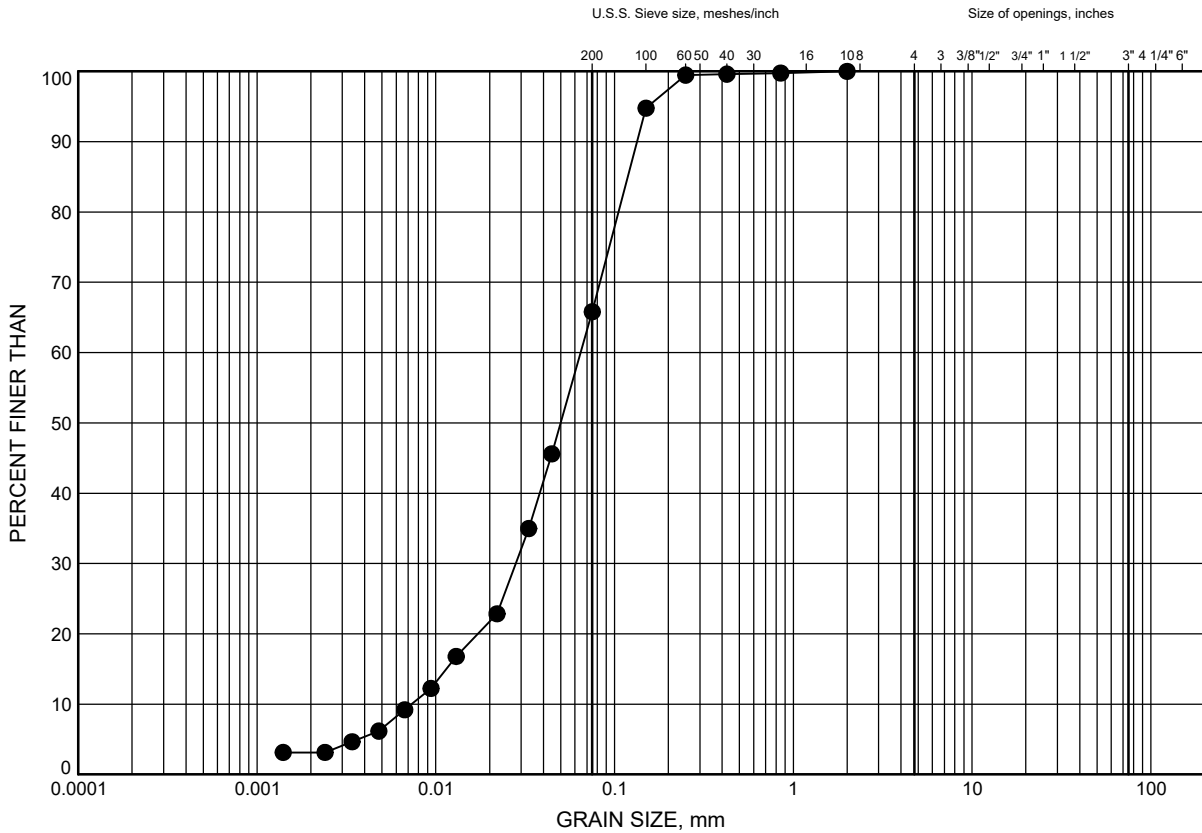


Prep'd AN
Chkd. MEF

BlackBird Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND and SILT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-35	2.6	206.4

Date November 2017
W.P. 6808-14-01

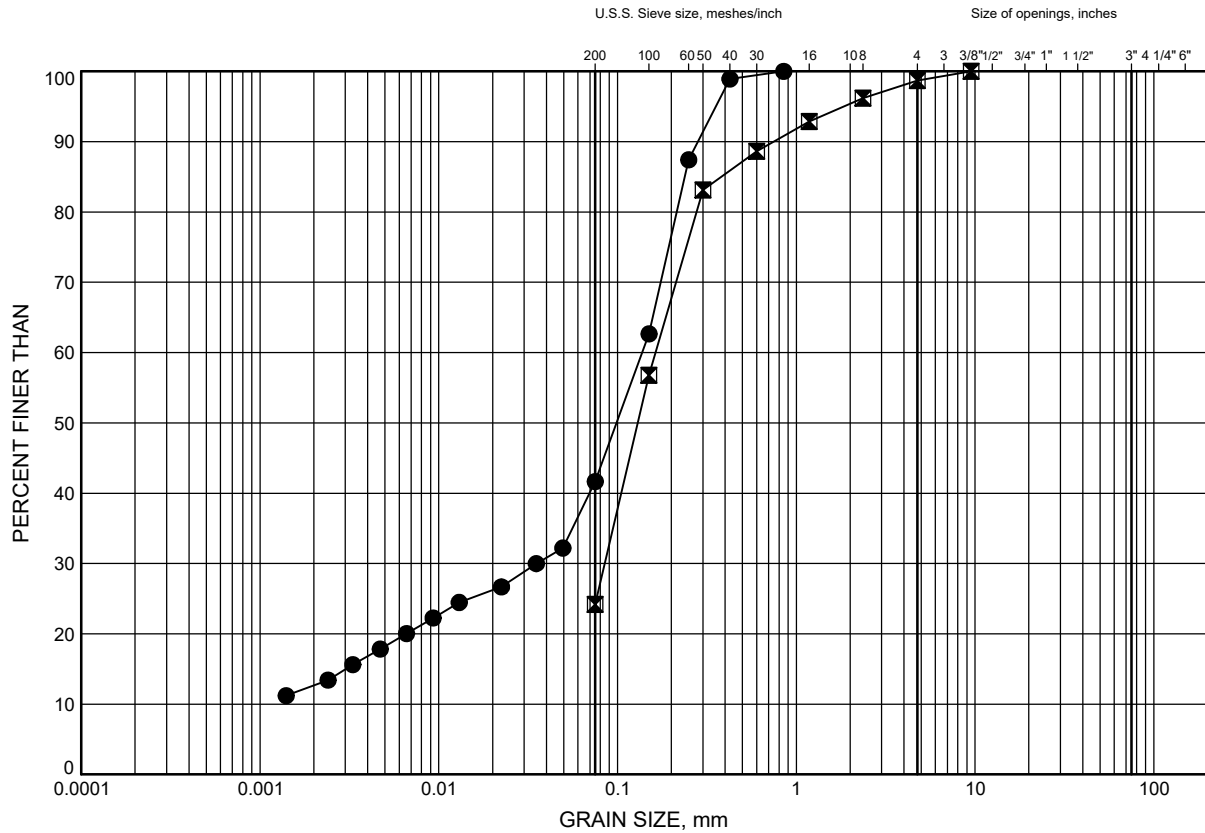


Prep'd AN
Chkd. MEF

BlackBird Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-34	1.8	203.6
⊠	17-34	14.0	191.4

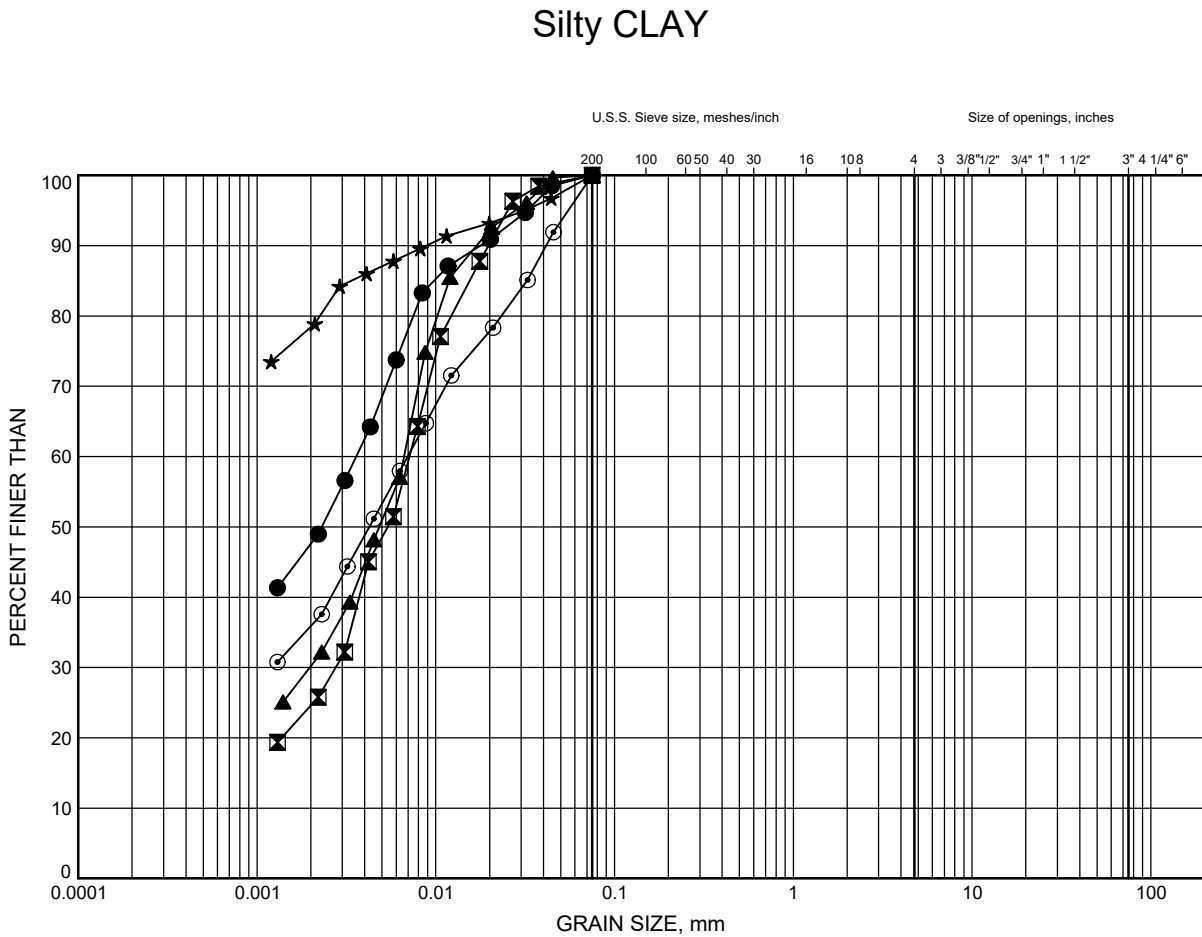
Date November 2017
W.P. 6808-14-01



Prep'd AN
Chkd. MEF

BlackBird Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-34	7.9	197.5
⊠	17-35	7.9	201.1
▲	17-35	12.5	196.5
★	17-36	1.8	204.1
⊙	17-36	6.4	199.5

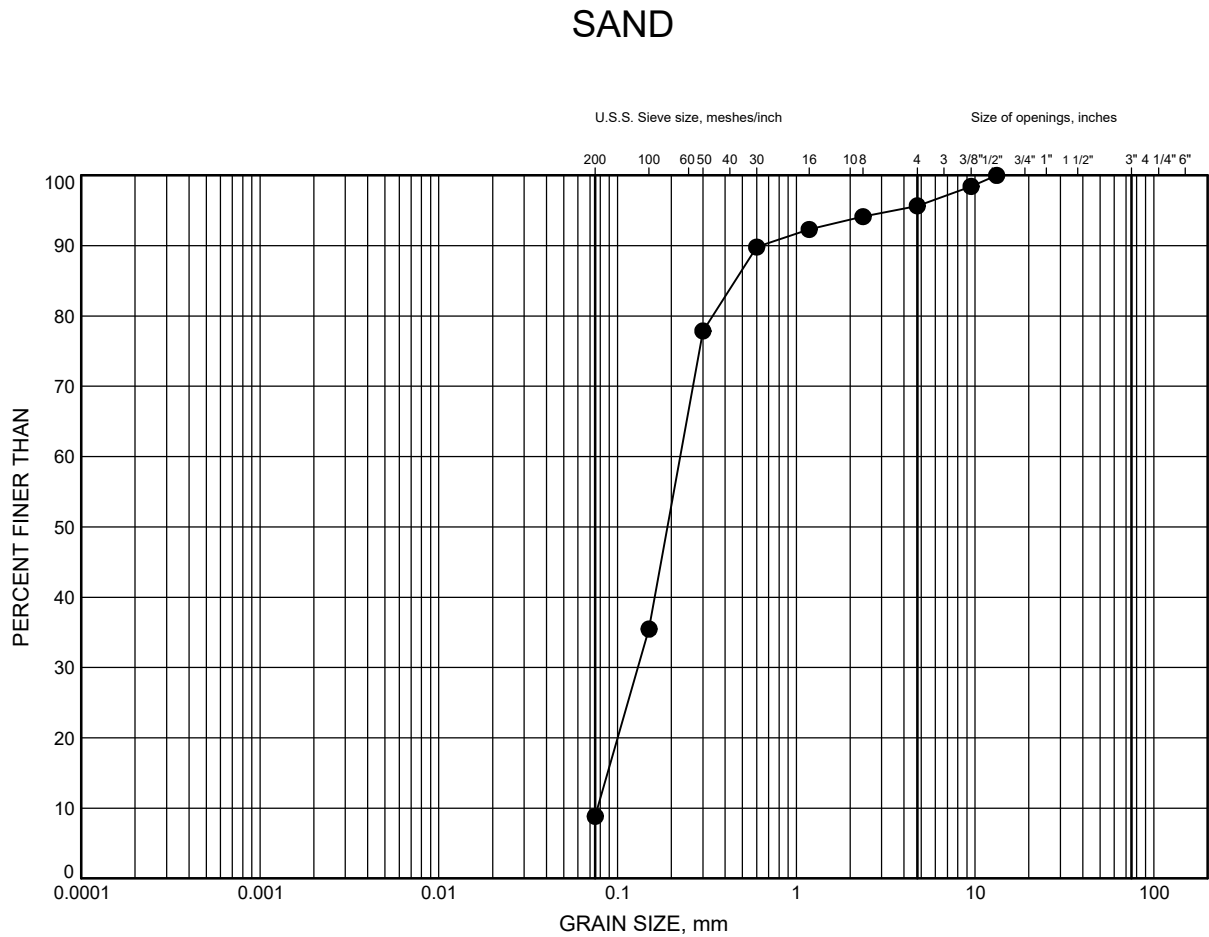
Date November 2017
W.P. 6808-14-01



Prep'd AN
Chkd. MEF

BlackBird Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-36	13.1	192.8

Date November 2017
W.P. 6808-14-01

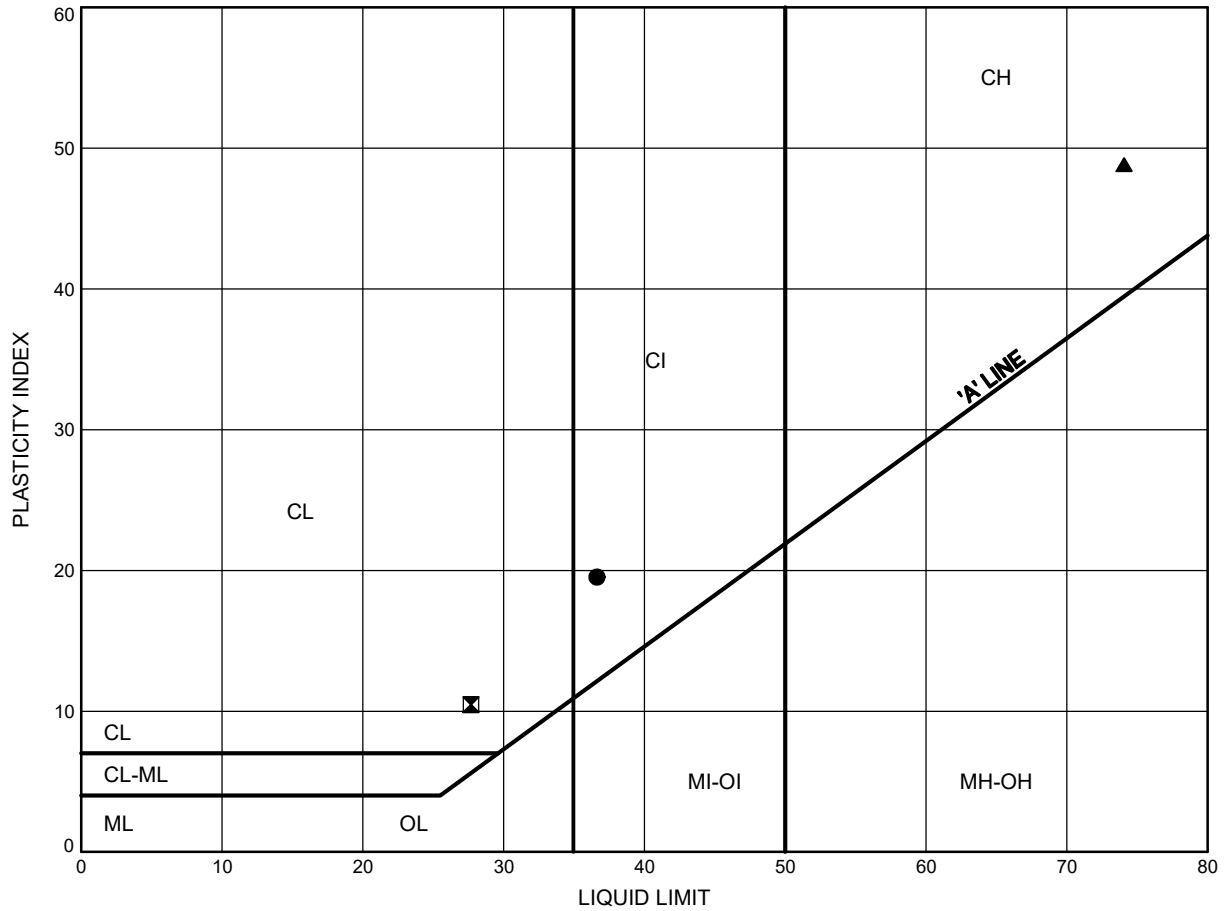


Prep'd AN
Chkd. MEF

BlackBird Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-34	7.9	197.5
⊠	17-35	12.5	196.5
▲	17-36	1.8	204.1

Date November 2017
 W.P. 6808-14-01



Prep'd AN
 Chkd. MEF

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-36, SS#2, 2.5'-
4.5'

Sample Date/Time 22-Aug-17

Moisture	%	27.9
pH	no unit	7.99
Corrosivity Index	none	2.0
Soil Redox Potential	mV	137
Sulphide	mg/L	<0.02
Chloride	mg/L	340.0
Sulphate	mg/L	10
Conductivity	uS/cm	397
Resistivity (calculated)	ohms.cm	2520

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

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(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.



Client
SGS LIMS Number
Analysis Package:

Attention: Cory Zanatta
Project#: 15595, North Superior Lake Region
Thurber Engineering Ltd.
CA15829-AUG17
Corrosivity (Solution)

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

Sample ID	Unit	Blackbird Creek
Sample Date/Time		21-Aug-17
Moisture	%	NA
pH	no unit	7.78
Corrosivity Index	none	NA
Redox Potential	mV	224
Sulphide	mg/L	0.076
Chloride	mg/L	110
Sulphate	mg/L	180
Conductivity	uS/cm	1180
Resistivity (calculated)	ohms.cm	847

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

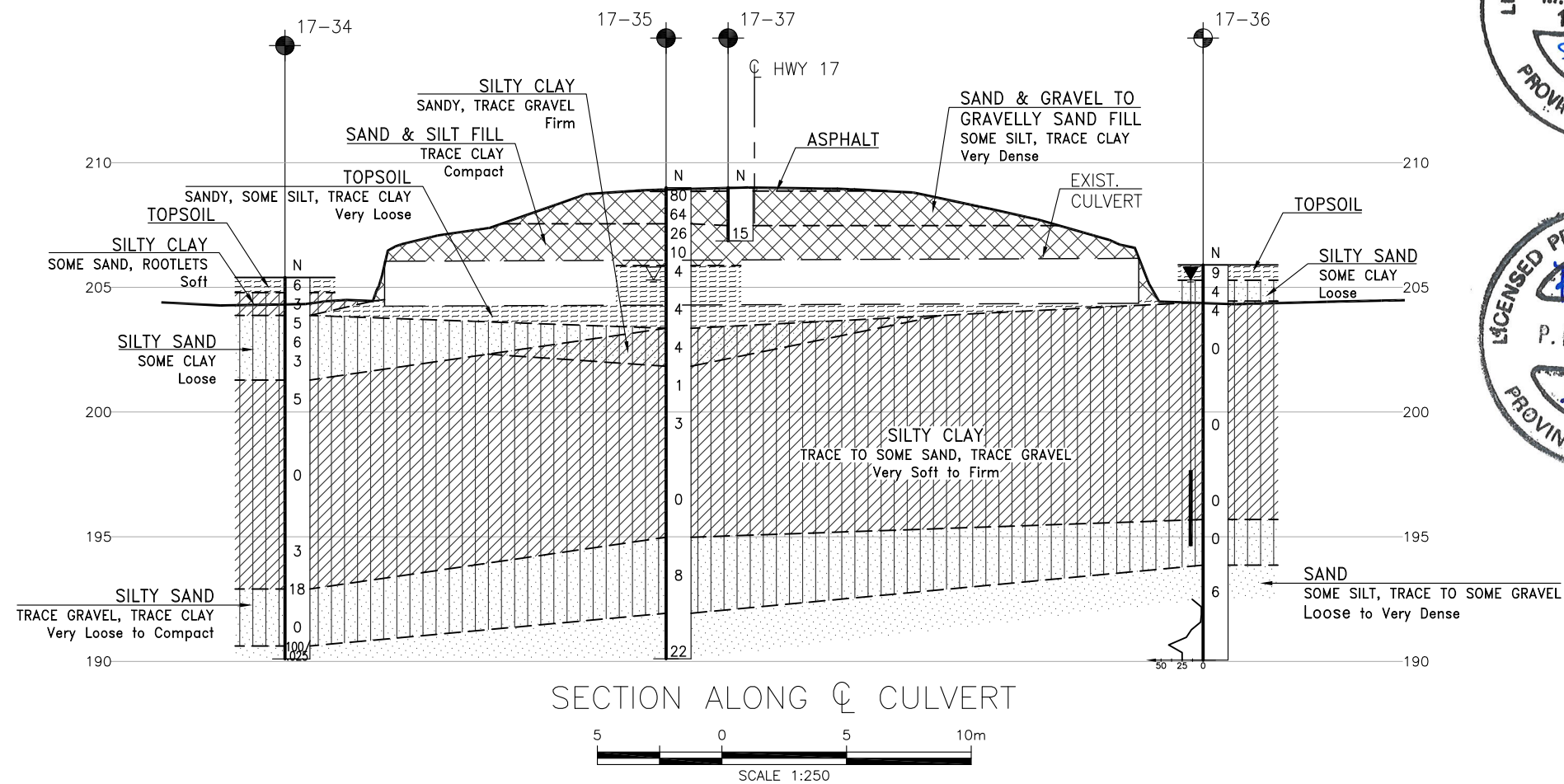
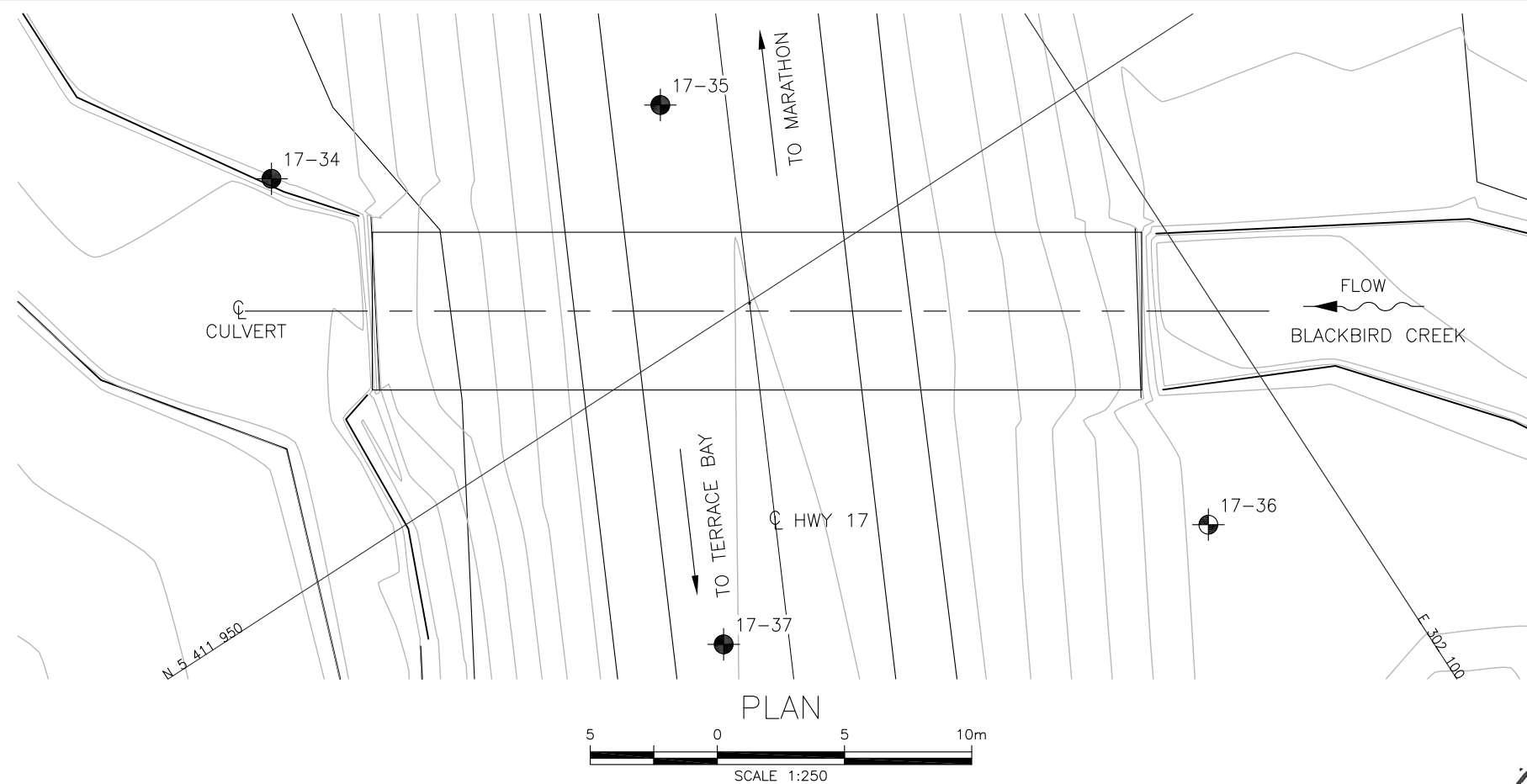
Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

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(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.



Appendix C

Borehole Locations and Soil Strata Drawing



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

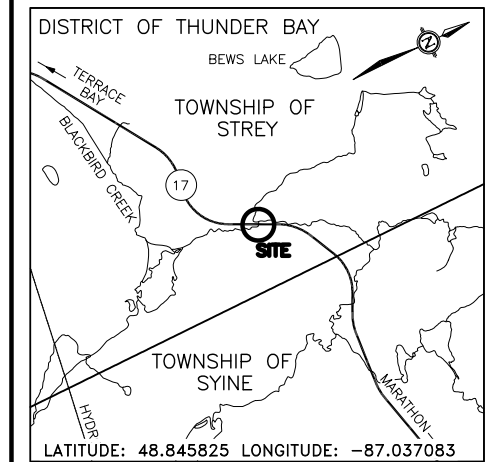
CONT No
WP No 6808-14-01

HIGHWAY 17
BLACKBIRD 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

[illegible]

-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. 52D-50

[illegible]



Appendix D

Site Photographs



Photo 1: Road approach looking south. Photo taken May 16, 2017.



Photo 2: Road approach looking north. Photo taken October, 2015.



Photo 3: East embankment looking north (inlet). Photo taken June 27, 2017.



Photo 4: East embankment looking south (inlet). Photo taken June 27, 2017.



Photo 5: West embankment looking south (outlet). Photo taken June 27, 2017.



Photo 6: Culvert outlet looking south. Photo taken May 16, 2017.



Photo 7: Culvert inlet looking west. Photo taken May 16, 2017.