



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT  
SLATE RIVER TRIBUTARY CULVERT REPLACEMENT  
HIGHWAY 61  
TOWNSHIP OF BLAKE, THUNDER BAY DISTRICT  
G.W.P. 6305-14-00; SITE NO. 48W-195/C**

**GEOCRES No. 52A-222**

**Report**

to

**Hatch**

Date: October 25, 2016  
File: 10088



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**GEOGRES No. 52A-222**

**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted for the proposed replacement of the Slate River Tributary Culvert on Highway 61, located in the Township of Blake, Thunder Bay District.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Hatch, under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0017.

A preliminary foundation investigation carried out at this site for the replacement culvert was documented in the report titled "Foundation Investigation and Preliminary Design Report, Slate River Tributary Culvert Replacement, Highway 61, Township of Blake, Thunder Bay District", prepared by DST Consulting Engineers Inc. (DST), dated November 17, 2015; Geocres No. 52A-194. The information presented in the above report was reviewed and incorporated in the current report, as appropriate.



## **2. SITE DESCRIPTION**

The culvert site is located on Highway 61 approximately 1.8 km north of Highway 608 in the Township of Blake, Thunder Bay District, Ontario. A tributary of the Slate River flows from west to east at the culvert location.

According to MTO Plan E-441-61-4 for the crossing at Slate River Tributary and Highway 61 (Site No. 48W-195/C), the existing culvert is a cast in place box structure with a width of 7.0 m and a height of 2.1 m. The total length of the culvert is 25.5 m with approximately 2 m of fill above the culvert.

Residential and agricultural properties are present in the vicinity of the culvert site. Naturally low-lying, swampy areas are present near the inlet and outlet of the culvert, with vegetation consisting of tall grass and shrubs with occasional trees. Local topography is of low relief with no evident bedrock outcrops. Photographs of the culvert and surrounding area are presented in Appendix C.

The site lies within the physiographical region known as the Animikie Basin of the Southern Province, which is characterized by sedimentary rock of the Rove Formation. According to Ontario Geological Survey (OGS) data, the bedrock at this site generally consists of black shale, siltstone and greywacke. The bedrock is overlain by glaciolacustrine and quiet basin deposits of the Pleistocene age consisting of silts and clays with minor sands.

## **3. INVESTIGATION PROCEDURES**

The current site investigation and field testing for this project were carried out between March 18 and 22, 2016. A total of three boreholes, denoted as SL-1 to SL-3, were advanced to depths ranging from 9.8 m to 15.8 m below the existing grade. A Dynamic Cone Penetration Test (DCPT) was carried out below the sampled portion of Boreholes SL-1 to a cone refusal depth of 22.4 m below the existing grade (Elev. 204.2). Details of the borehole depths and completion are summarized in Table 3.1 below.

The locations of the boreholes from the previous and current investigation are shown on the attached Borehole Locations and Soil Strata Drawing included in Appendix D.



**Table 3.1 – Borehole Completion Details**

<b>Borehole</b>	<b>Drilling Depth / Base of Hole Elevation (m)</b>	<b>Completion Details</b>
SL-1	15.8 / 210.8	Borehole backfilled with bentonite holeplug from 15.8 m to 0.1 m then asphalt cold patch to surface.
SL-2	9.8 / 214.3	Borehole backfilled with bentonite holeplug from 9.8 m to the ground surface.
SL-3	9.8 / 214.3	Borehole backfilled with bentonite holeplug from 9.8 m to the ground surface.

Borehole SL-1 was advanced using a CME 750 buggy ATV drill rig in combination with hollow stem augers to advance the borehole to the target depth. Boreholes SL-2 and SL-3 were advanced to the target depth using a tripod drilling rig in combination with NW casing/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). Field vane shear testing using an MTO “N” size vane was carried out in very soft to soft cohesive soils.

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

Groundwater conditions in the open boreholes were observed during and upon completion of the drilling operations.

#### **4. LABORATORY TESTING**

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were also subjected to gradation analysis and Atterberg Limits testing, and the results of this testing program are summarized on the Record of Borehole sheets in Appendix A and shown on the figures included in Appendix B.

#### **5. DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A stratigraphic profile is presented on the “Borehole Locations and Soil Strata” drawing in Appendix D. An overall description of the stratigraphy is given in the following



paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The borehole logs from the previous foundation investigation (Geocres 52A-194) are presented in Appendix E and are generally consistent with the results of the current investigation.

The subsurface stratigraphy encountered below the existing embankment fill at the site generally consists of an upper firm silty clay deposit with organic matter underlain by a lower stiff silty clay. The boreholes at the culvert inlet and outlet were advanced from the surface of the water in swampy areas adjacent to the river tributary. At the culvert inlet, the upper silty clay was encountered from the swamp bed surface. At the culvert outlet, the lower silty clay is overlain by sand fill which was encountered from the swamp bed surface. More detailed descriptions of the individual strata are presented below.

## **5.1 Asphalt**

Borehole SL-1 was advanced from the top of the road embankment and encountered 125 mm of asphalt.

## **5.2 Sand to Gravelly Sand Fill**

Granular embankment fill was encountered below the asphalt in Borehole SL-1 and below 0.6 m of water in Borehole SL-3 near the culvert outlet. The fill consists of sand, trace gravel to gravelly, and trace to some silt. Occasional cobbles were encountered in the fill. Organic materials were observed intermixed in the fill in Borehole SL-2, indicating that displacement or subexcavation of organic materials below the water level may have occurred during highway construction.

The thickness of the granular fill in the roadway embankment (Borehole SL-1) was 4.0 m, with the base at a depth of 4.1 m (Elev. 222.5). In Borehole SL-2, the fill was 3.5 m thick with a lower boundary at 4.1 m depth (Elev. 220.0).

SPT 'N' values recorded in the embankment fill decreased with depth from 77 to 2 blows per 0.3 m of penetration, indicating a very dense to very loose relative density. The 'N' value of 77 blows for 0.3 m penetration is probably indicative of frozen ground conditions however. In Borehole SL-2, 'N' values ranged from 1 to 8 blows per 0.3 m, indicating a very loose to loose condition. One value of 50 blows for 0.125 m of penetration was probably obtained on a cobble. Moisture contents ranged from 5 to 22%, locally up to 63% near the stream base in Borehole SL-2.



The results of grain size analysis conducted on the fill are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B1 of Appendix B. The results are summarized as follows:

Gravel %	12 to 21
Sand %	62 to 69
Silt & Clay %	17 to 19

### 5.3 Silty Clay with Organics

A layer of brown to dark brown silty clay with organics was encountered below 0.6 m of water in Borehole SL-2 near the culvert inlet and underlying the fill in Borehole SL-1. The upper silty clay layer contained some sand and organic matter. The thickness of the silty clay layer ranged from 1.5 m to 2.4 m, with a base depth of 3.0 and 5.6 m (Elev. 221.1 and 221.0).

SPT 'N' values recorded in the upper silty clay varied between 3 and 5 blows per 0.3 m of penetration, indicating a soft to firm consistency. Natural moisture contents ranged from 33 to 48%.

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

Gravel %	0
Sand %	20
Silt %	56
Clay %	24

### 5.4 Silty Clay

A deep deposit of silty clay described variously as grey, reddish brown and brown was encountered below the upper silty clay in Boreholes SL-1 and SL-2, and below the sand fill in Borehole SL-3. All boreholes were terminated in the lower silty clay at depths ranging from 9.8 to 15.8 m (Elev. 214.3 to 210.8).

SPT 'N' values recorded in the silty clay varied between 2 and 8 blows per 0.3 m of penetration. The vane shear tests (VST) measured in-situ undrained shear strengths ranging from 70 to 90 kPa, with one value greater than 100 kPa. Based on the SPT and VST data, the consistency



of the lower silty clay is typically stiff. Natural moisture contents ranged from 24 to 63%, with typical values between 39% and 48%.

The sensitivity of the lower silty clay, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 2 to 3, suggesting that the lower silty clay is of normal sensitivity.

The results of grain size analyses conducted on samples of the lower silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figures B3 and B4 of Appendix B. The results are summarized as follows:

Gravel %	0
Sand %	0
Silt %	25 to 50
Clay %	50 to 75

The results of Atterberg Limits tests conducted on samples of the lower silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Plasticity Index	17 to 45
Liquid Limit	39 to 75

The results of the Atterberg Limits testing indicate the layer to be of intermediate to high plasticity with group symbol CI to CH.

## **5.5 Groundwater Conditions**

The groundwater level in Borehole SL-1 was measured at a depth of 5.0 m (Elev. 221.6) upon completion of drilling.

Boreholes SL-2 and SL-3 were located at the toe of the embankment slope in areas covered by water. The depth of water at the borehole locations was approximately 0.6m.

The water level in the tributary of Slate River was shown on MTO Plan E-441-61-4 to be at Elev. 224.4 on June 13, 2014. The water level in the stream and groundwater levels are expected to fluctuate seasonally and subject to precipitation patterns, and may vary from the levels noted.





## 6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field and topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated a buggy ATV CME-750 hi-torque drill rig and portable tripod drill rig to carry out the drilling, sampling and in-situ testing operations for the boreholes at this site.

The drilling and sampling operations in the field were supervised on a full time basis by Ms. Eckie Siu of Thurber. Geotechnical lab testing was carried out by Thurber's MTO-approved laboratory. Overall supervision of the field program was conducted by Mr. Stephane Loranger, CET.

Ms. Deanna Pizycki, EIT, interpreted the data and prepared the report. The report was reviewed by Mr. Murray Anderson, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

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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 <sup>(1)</sup> '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 <sub>L</sub> < 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 <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 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 SL-1

1 OF 3

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 607.7 E 343 102.2 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Hollow Stem Augers/DCPT COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.18 - 2016.03.18 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20    40    60    80    100	○ UNCONFINED    + FIELD VANE	W <sub>P</sub> W      W <sub>L</sub>	20    40    60	GR    SA    SI    CL							
226.6	GROUND SURFACE																		
0.0	ASPHALT: (125mm)																		
0.1	SAND, trace gravel to gravelly, trace to some silt, occasional cobbles Very Loose to Very Dense Brown Moist to Wet (FILL)		1	GS															
			1	SS	77														
			2	SS	17														
			3	SS	6														
			4	SS	2														
222.5																			
4.1	Silty CLAY, some sand, some organics Firm Dark Brown Moist		5	SS	5														
221.0																			
5.6	Silty CLAY, trace sand Stiff Grey		6	SS	3														
			7	SS	3														
			8	SS	2														
		</																	

Continued Next Page

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

# RECORD OF BOREHOLE No SL-1

2 OF 3

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 607.7 E 343 102.2 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Hollow Stem Augers/DCPT COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.18 - 2016.03.18 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      LIQUID CONTENT      LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE	w   P                      w                      w   L					
								● QUICK TRIAXIAL      × LAB VANE						
	Continued From Previous Page							20   40   60   80   100	20   40   60					

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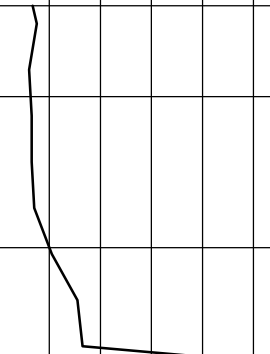
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SL-1

3 OF 3

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 607.7 E 343 102.2 ORIGINATED BY ES  
HWY 61 BOREHOLE TYPE Hollow Stem Augers/DCPT COMPILED BY MFA  
DATUM Geodetic DATE 2016.03.18 - 2016.03.18 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED     + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						
	Continued From Previous Page							20 40 60 80 100						
204.2														
22.4	END OF DCPT AT 22.4m UPON CONE REFUSAL. WATER LEVEL AT 5.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE.													

# RECORD OF BOREHOLE No SL-2

1 OF 2

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 594.0 E 343 085.6 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Tripod COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.21 - 2016.03.21 CHECKED BY DJP

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)								
								20   40   60   80   100			w <sub>P</sub> w                      w <sub>L</sub>								
224.1	GROUND SURFACE							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE											
0.0	<b>WATER</b>						224												
223.5																			
0.6	Silty <b>CLAY</b> , some sand, some organics (rootlets) Firm Brown Frozen (top 0.3m)		1	SS	3		223												
			2	SS	5														
			3	SS	3		222												
	becoming dark brown at 2.4m		4	SS	3														
221.1							221												
3.0	Silty <b>CLAY</b> , trace sand Stiff Reddish Brown		5	SS	5														
			6	SS	5		220												
			7	SS	8														
							219												
			8	SS	6		218												
							217												
	becoming grey at 7.8m		9	SS	5		216												
							215												
214.3			10	SS	4														
9.8	END OF BOREHOLE AT 9.8m.																		

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE



RECORD OF BOREHOLE No SL-2

2 OF 2

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 594.0 E 343 085.6 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Tripod COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.21 - 2016.03.21 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					W P W W L 20 40 60					
	Continued From Previous Page WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																

# RECORD OF BOREHOLE No SL-3

1 OF 2

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 610.6 E 343 112.0 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Tripod COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.22 - 2016.03.22 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS ▽*	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
224.1	GROUND SURFACE							20 40 60 80 100				
0.0	<b>WATER</b>						224					
223.5												
0.6	<b>SAND</b> , trace gravel to gravelly, some silt, with organics (rootlets, wood, peat) Very Loose to Loose Dark Grey Wet (FILL)		1	SS	1		223					
			2	SS	3							
			3	SS	4		222					
			4	SS	8							
	probable cobble		5	SS	50/0.125		221					12 69 15 4
			1	GS								
220.0							220					
4.1	Silty <b>CLAY</b> , trace sand Stiff Reddish Brown		2	GS								
			6	SS	5		219					0 0 48 52
	becoming brown at 6.1m		7	SS	5		218					
			8	SS	4		217					
							216					0 0 50 50
							215					
214.3			9	SS	5							
9.8	END OF BOREHOLE AT 9.8m.											

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No SL-3

2 OF 2

METRIC

GWP# 6305-14-00 LOCATION Slate River Tributary Culvert N 5 348 610.6 E 343 112.0 ORIGINATED BY ES  
 HWY 61 BOREHOLE TYPE Tripod COMPILED BY MFA  
 DATUM Geodetic DATE 2016.03.22 - 2016.03.22 CHECKED BY DJP

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
	Continued From Previous Page																
	WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																



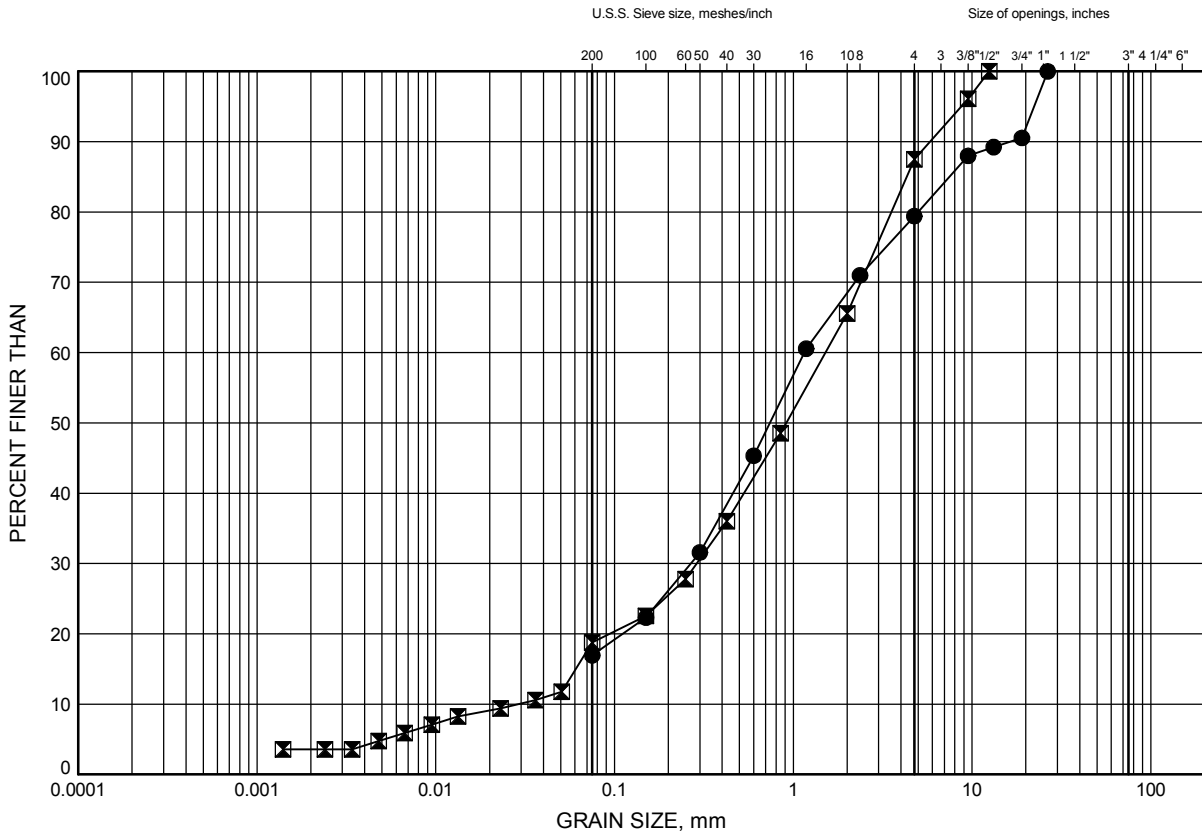
## **Appendix B**

### **Laboratory Test Results**

# Slate River Tributary Culvert GRAIN SIZE DISTRIBUTION

FIGURE B1

## Sand FILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL-1	1.07	225.53
◻	SL-3	2.74	221.36

Date July 2016  
GWP# 6305-14-00

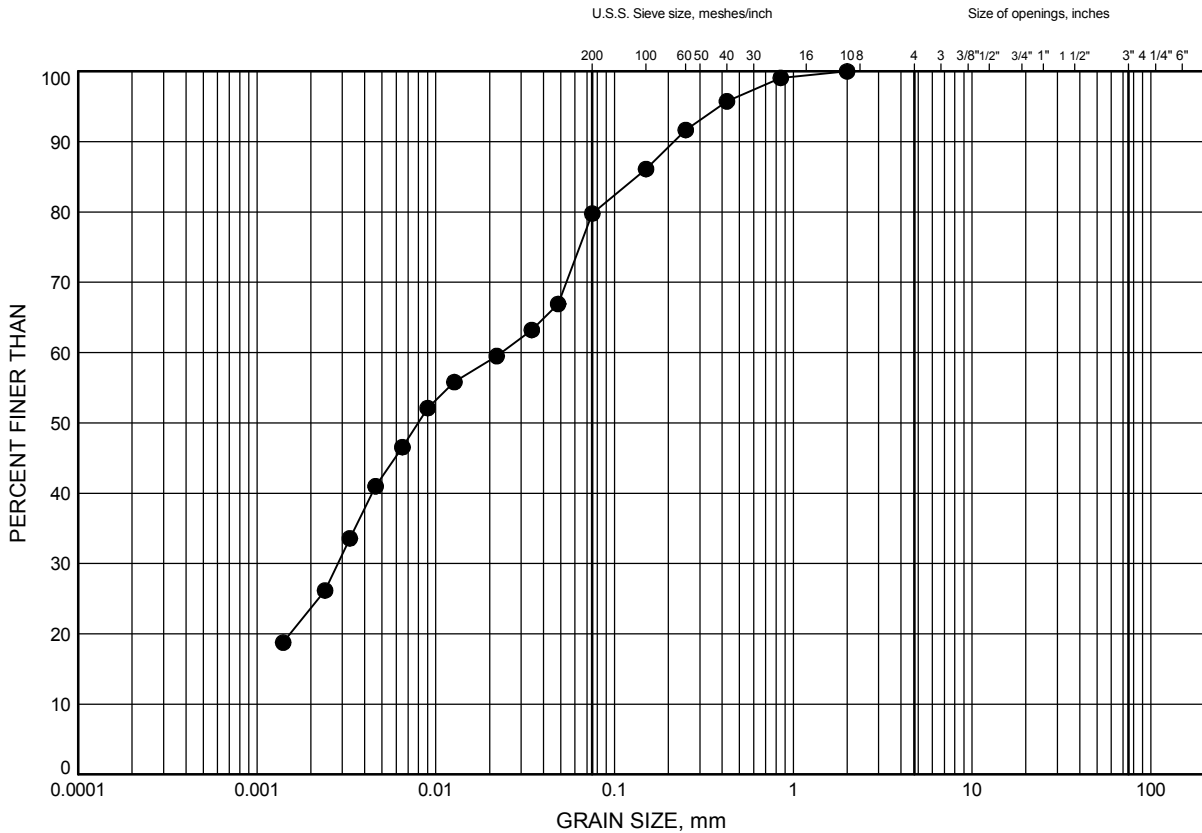


Prep'd MFA  
Chkd. DJP

# Slate River Tributary Culvert GRAIN SIZE DISTRIBUTION

FIGURE B2

## Upper Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL-2	2.74	221.36

Date July 2016  
GWP# 6305-14-00

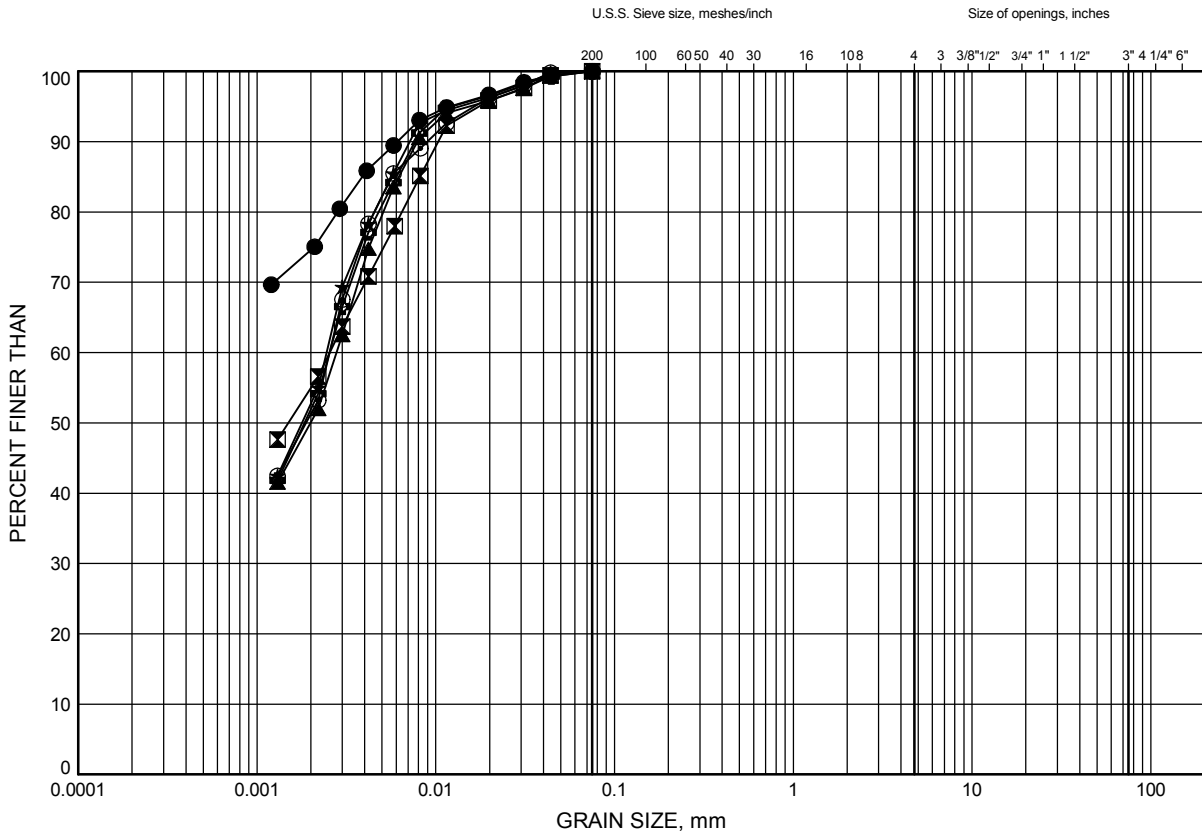


Prep'd MFA  
Chkd. DJP

# Slate River Tributary Culvert GRAIN SIZE DISTRIBUTION

FIGURE B3

## Lower Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL-1	6.40	220.20
⊠	SL-1	10.97	215.63
▲	SL-1	15.54	211.06
★	SL-2	4.88	219.22
⊙	SL-2	7.92	216.18
⊕	SL-3	4.88	219.22

Date July 2016  
GWP# 6305-14-00

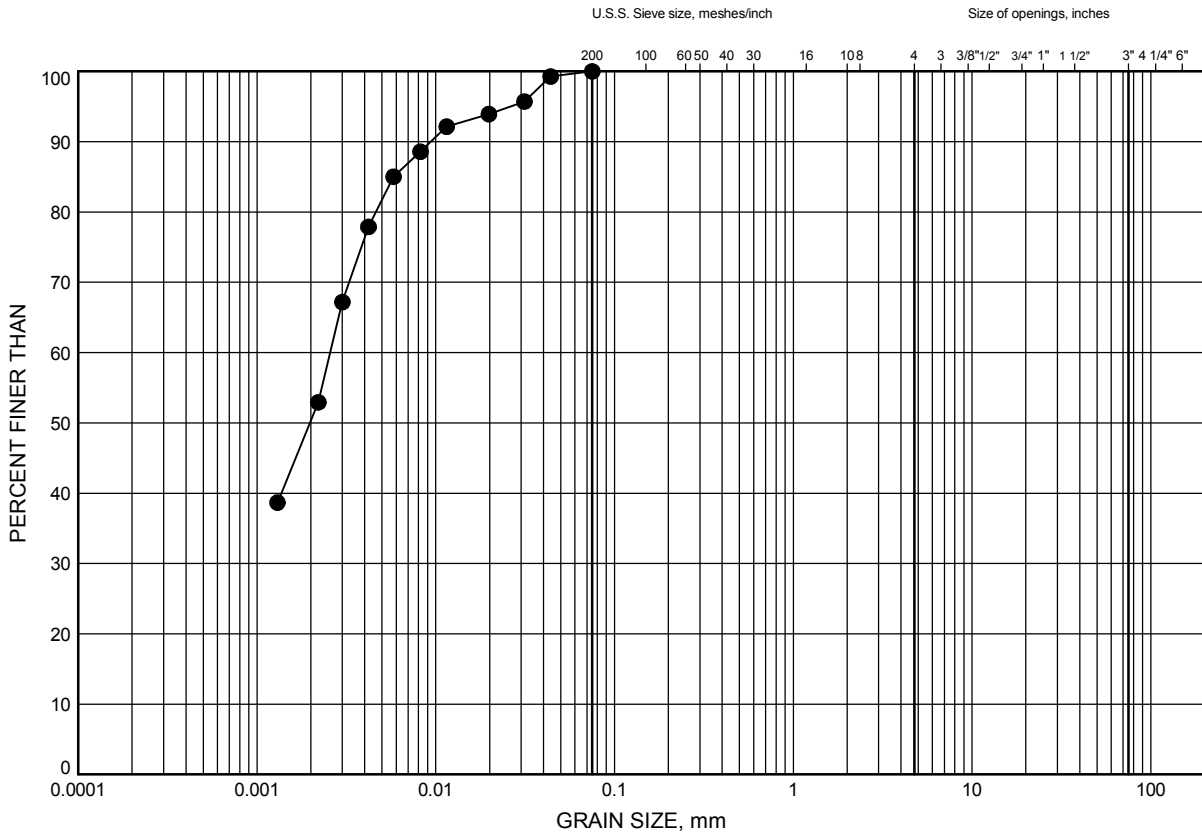


Prep'd MFA  
Chkd. DJP

# Slate River Tributary Culvert GRAIN SIZE DISTRIBUTION

FIGURE B4

## Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL-3	7.92	216.18

Date July 2016  
GWP# 6305-14-00



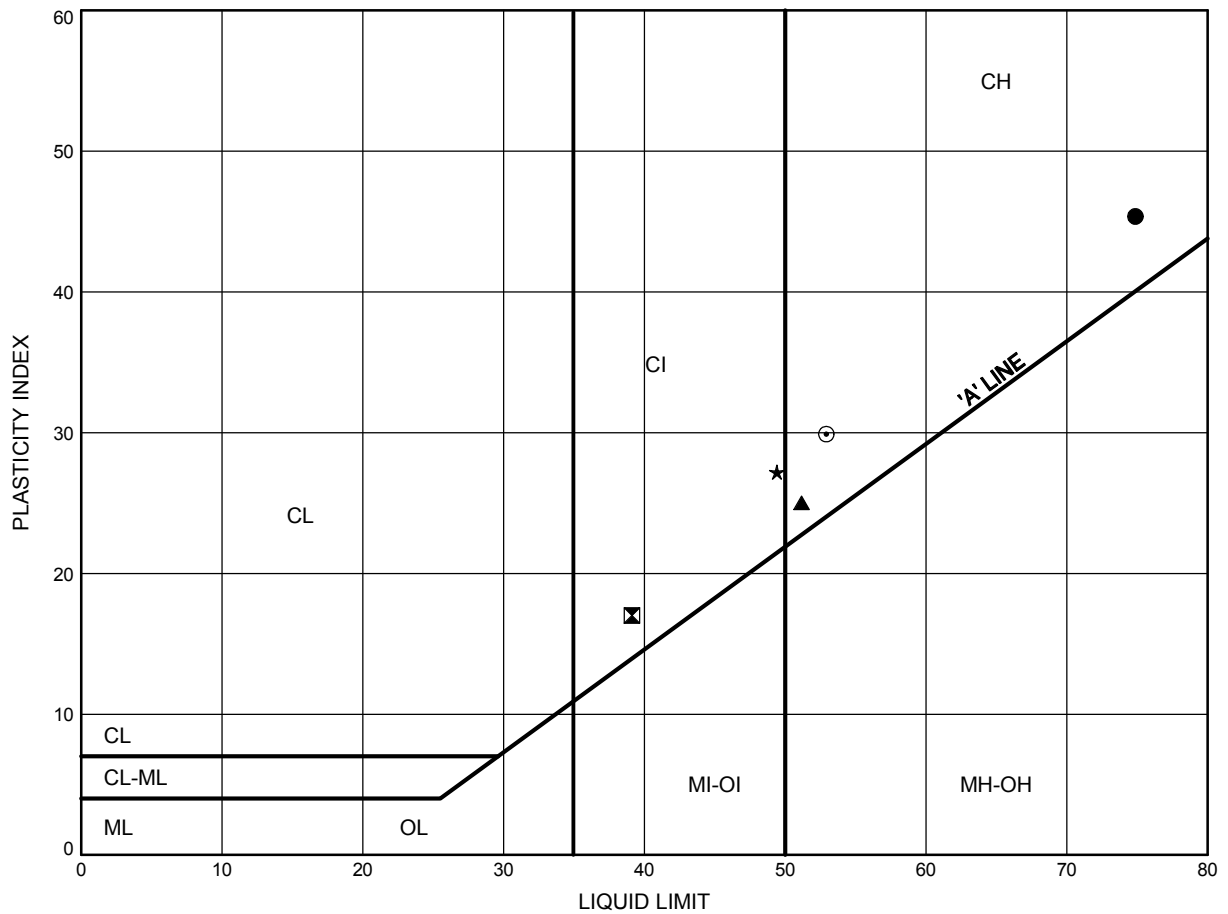
Prep'd MFA  
Chkd. DJP



Slate River Tributary Culvert  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B5

Silty CLAY



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SL-1	6.40	220.20
⊠	SL-1	15.54	211.06
▲	SL-2	4.88	219.22
★	SL-3	4.88	219.22
⊙	SL-3	7.92	216.18

Date July 2016  
 GWP# 6305-14-00



Prep'd MFA  
 Chkd. DJP



## **Appendix C**

### **Selected Site Photographs**



**Photograph 1: Drilling Borehole SL-1, Looking South**



**Photograph 2: Culvert Inlet, Looking Northwest**





**Photograph 3: Culvert Outlet, Looking Southeast**



**Photograph 4: Looking Northeast from Culvert**



## **Appendix D**

### **Borehole Locations and Soil Strata Drawings**



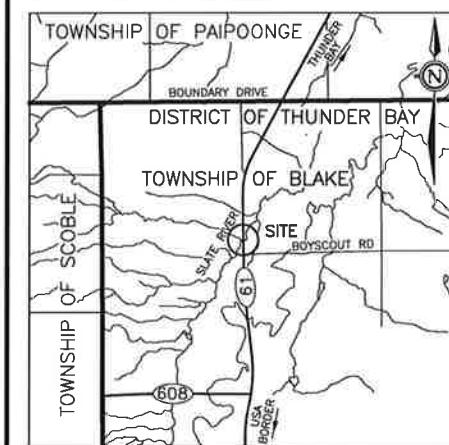


SHEET  
17



A circular professional engineer seal from the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "P. K. CHATTERJI" is printed. Handwritten in blue ink are the signature "P. K. Chatterji" above the name, the license number "90768" below it, and the date "Oct 26/16" at the very bottom.

A circular professional seal for a Licensed Professional Engineer in the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "M. R. ANDERSON" is printed. Above the name is a blue ink signature. Below the name is the license number "26916" written in blue ink.

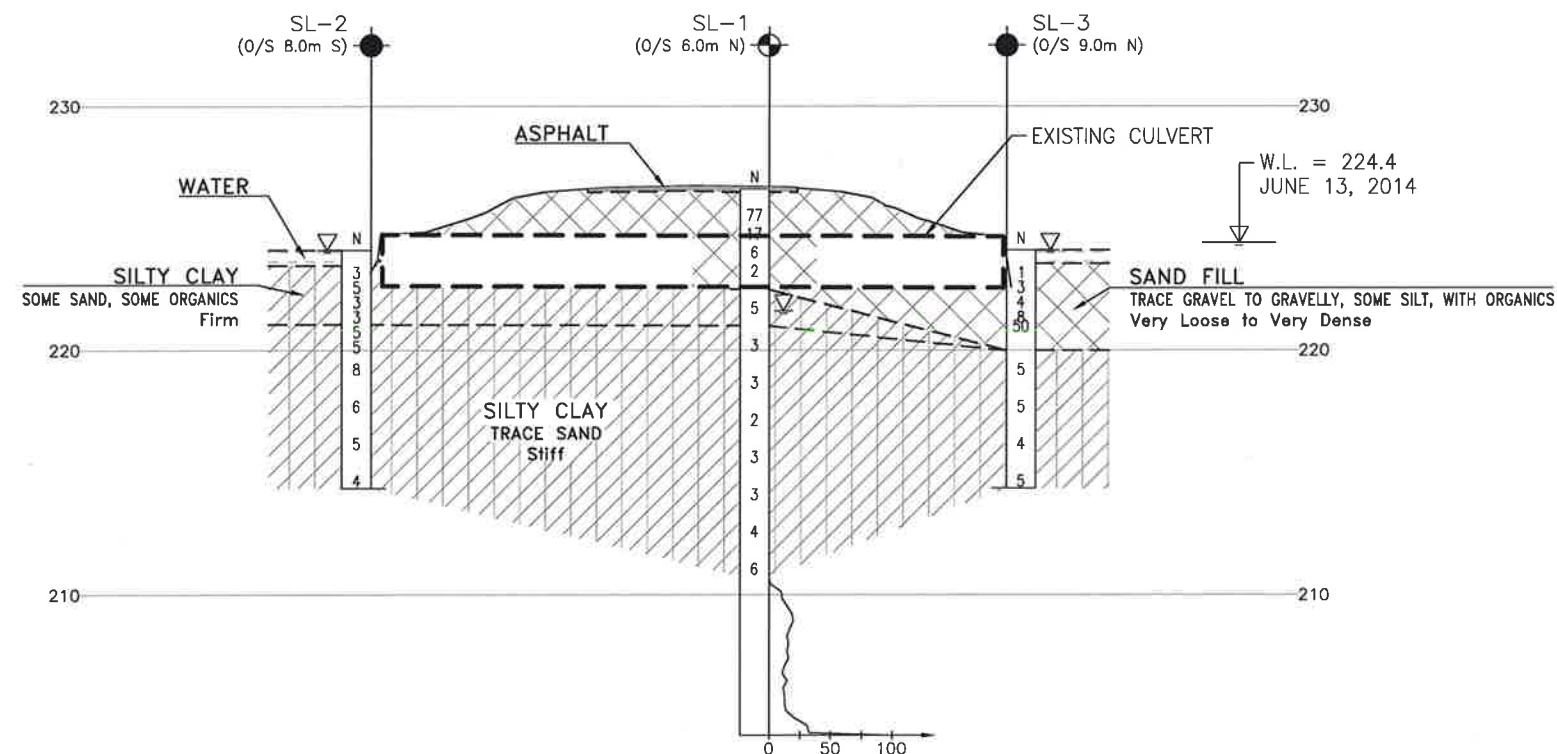


### LEGEND

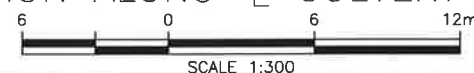
- | NO   | ELEVATION | NORTHING    | EASTING   |
|------|-----------|-------------|-----------|
| BH1  | 226.6     | 5 348 598.7 | 343 104.0 |
| BH2  | 226.3     | 5 348 608.5 | 343 093.7 |
| BH3  | 223.8     | 5 348 613.8 | 343 112.7 |
| BH4  | 223.9     | 5 348 607.3 | 343 082.3 |
| BH5  | 223.9     | 5 348 600.3 | 343 082.4 |
| SL-1 | 226.6     | 5 348 607.7 | 343 102.2 |
| SL-2 | 224.1     | 5 348 594.0 | 343 085.6 |
| SL-3 | 224.1     | 5 348 610.6 | 343 112.0 |

- 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.

REVISIONS							
	DATE	BY	DESCRIPTION				
	DESIGN	DJP	CHK	AMP	CODE	LOAD	DATE OCT 201
	DRAWN	MFA	CHK	DJP	SITE	STRUCT	DWG 2



SECTION ALONG CULVERT A-A'



6	
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## **Appendix E**

**Borehole Data from Preliminary Foundation Report  
Geocres No. 52A-194**

# RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Slate River Tributary Culvert STA 23+370 RT 5.1 m ORIGINATED BY PR  
DIST Thunder Bay HWY 61 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 08 27 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED	+ FIELD VANE	□ QUICK TRIAXIAL					
101.4	GROUND SURFACE						20	40	60	80	100				
100.4	ASPHALT		AS1	AS			50	100	150	200	250	20	40	60	
100.3	FILL-SAND & CRUSHED GRAVEL-Trace silt		SS2	SS	5										
	FILL-SAND-some gravel, trace silt, BROWN L S C M AC		SS3	SS	10										
			SS4	SS	2										
			SS5	SS	5										
			SS6	SS	7										
96.8	CLAY-Silty, GREY S		SS7	SS	4										
4.6			SS8	SS	4										
			SS9	SS	1										
			SS10	SS	3										
90.6															
10.8	END OF BOREHOLE														

ON MOT-HIGH VANES GS-TB-019500 SLATE RIVER GPJ DST\_MIN.GDT 11/24/14

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Slate River Tributary Culvert STA 23+380 LT 5.0 m ORIGINATED BY PR  
DIST Thunder Bay HWY 61 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 08 27 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
101.1	GROUND SURFACE													
100.1	ASPHALT		AS1	AS			101							
100.3	FILL-SAND & CRUSHED GRAVEL-Trace silt													
	FILL-SAND-some gravel, trace silt, BROWN L S C M AC		SS2	SS	21		100							30 55 (15)
			SS3	SS	8		99							
			SS4	SS	4		98							
			SS5	SS	5		97							
			SS6	SS	8		96							
			SS7	SS	7		95							
95.8	CLAY-Silty, GREY S		SS8	SS	4		94							
5.3			SS9	SS	5		93							
			SS10	SS	4		92							
			SS11	SS	2		91							
90.3														
10.8	END OF BOREHOLE													

ON MOT-HIGH VANES GS-TB-019500 SLATE RIVER GPJ DST\_MIN GDT 11/24/14

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

# RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Slate River Tributary Culvert STA 23+385 RT 14.0 m ORIGINATED BY PR  
DIST Thunder Bay HWY 61 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 09 05 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100							
98.6	GROUND SURFACE														
98.5	TOPSOIL		SS1	SS	1										
98.0	SAND-organics, BLACK silty clay														
0.6	SILT-sandy, some clay, Very Loose		SS2	SS	3										
			SS3	SS	1										
96.3															
2.3	CLAY-Silty, GREY/REDISH silty clay		SS4	SS	3										
	-Trace Organics														
			SS5	SS	2										
			SS6	SS	8										
			SS7	SS	3										
			SS8	SS	3										
92.6	END OF BOREHOLE														
6.0															

NR = NO RECOVERY +<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 3

# RECORD OF BOREHOLE No BH4

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Slate River Tributary Culvert STA 23+379 LT 16.5 m ORIGINATED BY PR  
DIST Thunder Bay HWY 61 BOREHOLE TYPE Hand Auger Hole COMPILED BY DB  
DATUM Local DATE 2014 09 05 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
98.7	GROUND SURFACE																
	WATER and ORGANICS																
97.2																	
96.9	SAND-some gravel																
1.8	CLAY-silty																
94.7																	
4.0	END OF BOREHOLE																

ON\_MOT-HIGH VANES GS-TB-019500 SLATE RIVER.GPJ DST\_MIN.GDT 11/24/14

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 4

# RECORD OF BOREHOLE No BH5

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Slate River Tributary Culvert STA 23+372 LT 16.5 m ORIGINATED BY PR  
DIST Thunder Bay HWY 61 BOREHOLE TYPE Hand Auger Hole COMPILED BY DB  
DATUM Local DATE 2014 09 05 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE □ QUICK TRIAXIAL × LAB VANE									
98.7	GROUND SURFACE																
	WATER and ORGANICS																
97.6																	
97.3	SAND-some gravel																
1.4	CLAY-silty																
95.1																	
3.6	END OF BOREHOLE																

ON\_MOT-HIGH VANES GS-TB-019500 SLATE RIVER.GPJ DST\_MIN.GDT 11/24/14

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

A:\Veg\109-7B-010000 Thunder Bay Refresher - 8013-E-0021 Alignment & 400-1900 Slate River\CAD\2010\0000\Updated Drawings

