

**FOUNDATION INVESTIGATION AND DESIGN REPORTS  
PROPOSED PICNIC LAKE CREEK CULVERT REPLACEMENT  
HIGHWAY 17 WEST OF HIGHWAY 631, WHITE RIVER, ONTARIO  
WP 5080-09-01 SITE NO. 38C-054/C  
G.W.P. 5270-08-00  
MTO GEOCRE NO. 42C-27**

Prepared for:

**MCINTOSH PERRY CONSULTING ENGINEERS**

By:

**SPL CONSULTANTS LIMITED**

Project: 750-1001 (Picnic Lake Creek)  
January 2014



**SPL Consultants Limited**  
Geotechnical Environmental Materials Hydrogeology

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**PART A**  
**FOUNDATION INVESTIGATION REPORT**  
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## **1. INTRODUCTION**

SPL Consultants Limited (SPL) was retained by McIntosh Perry Consulting Engineers to conduct a foundation investigation as part of the proposed culvert replacement at Picnic Lake Creek on Highway 17 approximately 1.5 km west of Highway 631 near White River, Ontario.

The terms of reference (TOR) for this investigation are outlined in the Request for Quotation (RFQ) issued by the Ministry of Transportation (MTO) under Agreement No. 5010-E-0001 dated April 2010 and SPL's subsequent proposal No. P10.06.018 dated June 2010. At the time of the initial foundation investigation (in July 2011) the proposed culvert was to be shifted slightly to the east. Subsequent to the initial foundation investigation the design was altered such that the new culvert would be lengthened and constructed in approximately the same location as the existing culvert.

The purpose of the foundation investigation was to obtain subsurface information at the site by means of exploratory boreholes. This report presents the findings of the foundation investigation carried out at the site, as well as general comments and recommendations for the design and construction of the proposed culvert replacement.

As part of this project a geotechnical (pavement) investigation was also carried out at the site concurrent with the foundation investigation. The results of the pavement investigation are presented under separate cover.

## **2. SITE DESCRIPTION**

The site is located on Highway 17 approximately 2 km west of Highway 631, near White River, Ontario (see Drawing No. 1). The existing culvert is a Structural Plate Corrugated Steel Pipe Arch (SPCSPA) structure with a width of 4.674 m, a height of 2.819 m and an overall length of 19.82 m. The depth of cover over top of the existing culvert is approximately 1 m.

The elevation of the natural ground in the general vicinity of the culvert crossing is approximately 368.5 m to 371 m. The elevation of the highway (top of pavement) at the crossing is approximately 373.5 m (the embankment is approximately between 3 m to 5 m high at the crossing).

## **3. INVESTIGATION PROCEDURES**

The foundation investigation was carried out in July 2011 and November 2013. The scope of work for this assignment included a desk study, field investigations, laboratory testing, analysis and preparation of this report.

### **3.1 Desktop Study**

Surficial geology comprises glacial till and glaciofluvial outwash deposits. These deposits generally would be expected to include silt, sand and gravel deposits, as well as potentially cobble and boulders.

Bedrock geology maps of the general area indicate the bedrock to be foliated to gneissic tonalite and granodiorite. Metasedimentary rocks of Paragneiss and Migmatites also exist in the vicinity of the Picnic Lake Creek crossing.

### **3.2 Field Investigation**

Field investigations were carried out on July 11 and 12, 2011 and on November 26 and 27, 2013. The investigations included drilling a total of 6 boreholes at the crossing location (BH11-1 through BH11-4, BH13-1 and BH13-2). As mentioned previously, additional shallow boreholes were advanced at the same time for the geotechnical (pavement) portion of the work; the results of these boreholes are submitted with the geotechnical (pavement) investigation report under separate cover.

The boreholes drilled in July 2011 were advanced using a truck-mounted drill rig supplied and operated by Groundworks Drilling of Etobicoke, ON. The boreholes were drilled using hollow-stem auger drilling as well as Dynamic Cone Penetration Testing (DCPT) to the depth of 12.8 m below the existing ground surface. In November 2013, additional boreholes were advanced using hand portable drilling equipment supplied and operated by OGS Inc. of Almonte, ON. These boreholes were drilled to depths ranging from 6.1 to 8.2 m below the existing ground surface. During drilling, sampling and in-situ testing [including Standard Penetration (SPT) Testing and DCPT testing] were carried out.

Standpipe piezometers were installed in Boreholes BH11-1 and BH11-4 to allow for measurement of groundwater levels at the site. All boreholes were backfilled and sealed with bentonite at the ground surface. All boreholes were abandoned in accordance with Ontario Regulation 903.

Borehole locations are shown in Drawing Nos. 2A and 2B. Borehole logs are included in Appendix A of this report.

### **3.3 Laboratory Testing**

During drilling and in-situ testing, disturbed soil samples were obtained for further examination and classification. A laboratory testing program, including determination of natural water content, grain size distribution (sieve and hydrometer) and chemical analyses was carried out on selected representative soil samples.

The results of natural water content tests are included on the relevant borehole logs in Appendix A. The results of determination of grain size distribution are summarized on the individual borehole logs, and are also presented in Drawing Nos. 3 through 5.

Chemical testing to determine sulphate content, chloride content, pH and soil resistivity was also carried out on selected soil samples obtained during drilling. The results of these tests are included in Appendix B.

## **4. SUBSURFACE CONDITIONS**

The subsurface conditions at the site are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at each of the borehole locations are included in the individual borehole logs in Appendix A.

### **4.1 Soil Conditions**

#### **4.1.1 Asphalt**

Boreholes BH11-1 through BH11-4 were drilled on the shoulder of the existing highway. Boreholes BH11-2 through BH11-4 encountered a layer of asphalt approximately 50 mm thick.

#### **4.1.2 Topsoil**

Boreholes BH13-1 and BH13-2 were drilled near the inlet/outlet of the proposed culvert and encountered a topsoil layer 150 mm to 175 mm thick, respectively.

#### **4.1.3 Granular Fill**

The asphalt in boreholes BH11-1 through BH11-4 is underlain by granular fill, which forms the pavement structure of the highway, as well as the existing highway embankment. Fill material was also encountered in borehole BH13-2.

The granular fill ranged from silty sand to sand and gravel. Cobbles and boulders were also encountered within the granular fill. Grain size curves for selected samples of the granular fill are presented in Drawing No. 3.

A summary of the grain size distribution of these samples is also presented in Table 1 below. It should be noted that these grain size distribution tests were carried out on samples obtained through SPT testing, which does not recover coarse gravel, cobble and boulder sized particles. Because of this it is expected that the grain size distributions shown on Drawing No. 3 may be finer than portions of the materials in the field.

**Table 1 – Results of Grain Size Analyses for Fill Material**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
BH11-1	SS4	0	65	28	7
BH11-3	SS2	5	88	4	3
BH13-2	SS1	13	77	10	

The density of the fill material (as interpreted based on SPT “N” values) typically ranged from loose to very dense, with localized areas being very loose to loose. In coarser granular materials SPT “N” values can be influenced by the size of particles. Very high “N” values often reflect the presence of cobbles and boulders, rather than a very high density of the soil matrix itself.

In the boreholes drilled on the shoulder of the existing road (BH11-1 through BH11-4), the fill material extended to a depth ranging from 2.9 m to 5.3 m below the existing road surface. This corresponds to elevations of 370.3 m to 368.2 m. In borehole BH13-2, drilled south of the existing road, the fill extended to a depth of 1.1 m below the existing ground surface. This corresponds to an elevation of 370.2 m.

#### 4.1.4 Peat and Organic Soil

At Borehole BH11 -4 the granular fill is underlain by an approximately 1.4 m thick layer of peat (from a depth of 2.9 m to 4.3 m below the road surface). This suggests that portions of the original ground surface may not have been completely stripped prior to construction of the road embankment.

Underlying the granular fill in borehole BH13-2 is a layer of organic clayey silt mixed with roots and organic material. This layer has an approximate thickness of 0.7 m (again suggesting that the original ground may not have been completely stripped).

#### 4.1.5 Native Silt and Sand

In three of the four boreholes drilled near the culvert (BH11-1, BH13-1 and BH13-2) a layer consisting of a mix of silt and sand was encountered. In Boreholes BH11-2 and BH11-3, drilled on the existing road, the layer underlies the granular fill and has a thickness ranging from 2 m to 2.4 m. In borehole BH13-2, drilled south of the existing culvert, this layer underlies a layer of organic clayey silt has a thickness of 1.9 m. In borehole BH13-1, drilled north of the existing culvert, this layer underlies the topsoil and has a thickness of 2.9 m.



The grain size distributions of selected samples of the silt and sand obtained during the ground investigation are presented in Drawing No. 5 and are summarized in Table 2 below.

**Table 2 – Results of Grain Size Analyses for Silt and Sand**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
BH11-2	SS5	6	91	2	1
BH11-2	SS6	0	8	84	8
BH11-3	SS7	0	10	82	8
BH13-1	SS4	0	44	52	4
BH13-2	SS-6	0	62	35	3

The consistency of native silt and sand layer (as interpreted on SPT “N” values and DCPT resistance values) was found to be very loose to compact.

#### 4.1.6 Silty Sand and Sandy Silt Till

All of the above mentioned layers (granular fill, peat, organic soil and native silt and sand) are underlain by a deposit of silty sand and sandy silt till. The till layer extended to the depth of drilling in all of the boreholes advanced at the site.

The till deposits is a heterogeneous mix of primarily sandy silt to silty sand with a trace of gravel and clay. Cobbles and boulders may also exist within the till deposit, and should be anticipated during construction. The grain size distribution of a number of samples of the till are presented in Drawing No. 4, and are summarized in Table 3 below.

**Table 3 – Results of Grain Size Analyses for Silty Sand and Sandy Silt Till**

Borehole No.	Sample No.	Grain Size Distribution			
		% Gravel	% Sand	% Silt	% Clay
BH11-1	SS8	2	24	59	15
BH11-1	SS10	1	51	42	6
BH11-4	SS6	7	60	28	5
BH13-1	SS7	1	26	66	7
BH13-1	SS11	17	42	38	4
BH13-2	SS8	0	1	93	6

The consistency of the till (as interpreted based on SPT “N” and DCPT resistance values) was found to range from compact to very dense. SPT “N” values and DCPT resistance values are presented on the borehole logs included in Appendix A.

#### 4.1.7 Bedrock

Bedrock was not encountered in any of the boreholes drilled as part of this investigation.

## 4.2 Groundwater Conditions

Groundwater was encountered in all of the boreholes drilled below the elevation of the existing creek. This elevation was noted to be approximately 370 m in July 2011 as well as in November 2013. Standpipe piezometers were installed in BH11-1 and BH11-4. In July 2011, the groundwater level at the site was measured one day after completion of drilling and found to be at approximately 370.4 m elevation in both piezometers.

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations as well as fluctuations in response to major weather events, and in particular for this site, in response to changes in the level of the creek. If construction is carried out at a time when the creek level is higher than the level in July 2011, a corresponding increase in groundwater levels should be anticipated.

## 4.3 Summary

A summary of the soil and groundwater conditions encountered at the Picnic Lake Creek crossing location is presented in Table 4 below.

**Table 4 – Simplified Stratigraphy and Groundwater Elevations**

Borehole No.	Ground Surface Elevation	Simplified Stratigraphy (Depth)					Measured Groundwater Elevation
		Topsoil	Granular Fill	Peat/Organic Soil	Silt and Sand	Silty Sand & Sandy Silt Till	
BH11-1	373.5	---	0.0– 5.3 m	---	---	5.3 – 12.8 m	El. 370.4 m
BH11-2	373.1	---	0.0 – 3.1 m	---	3.1 – 5.5 m	5.5 – 12.8 m	--
BH11-3	373.9	---	0.0 – 5.3 m	---	5.3 – 7.3 m	7.3 – 12.8 m	--
BH11-4	373.2	---	0.0 – 2.9 m	2.9 – 4.3 m	---	4.3 – 12.8 m	El. 370.4 m
BH13-1	370.8	0.0 – 0.2	---	---	0.2 – 3.1	3.1 – 8.2	---
BH13-2	371.3	0.0 – 0.2	0.2 – 1.1	1.1 – 1.8	1.8 – 3.7	3.7 – 6.7	---

## 5. CLOSURE

The field investigations in July 2011 were supervised by Mr. Naeem Ehsan, P.Eng. The field investigations in November 2013 were supervised by Mr. Daniel Wall, E.I.T. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., who is the project manager and SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., who is the project quality control auditor, provided independent review and quality control.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

### SPL CONSULTANTS LIMITED

Chris Hendry, M.Eng., P.Eng.



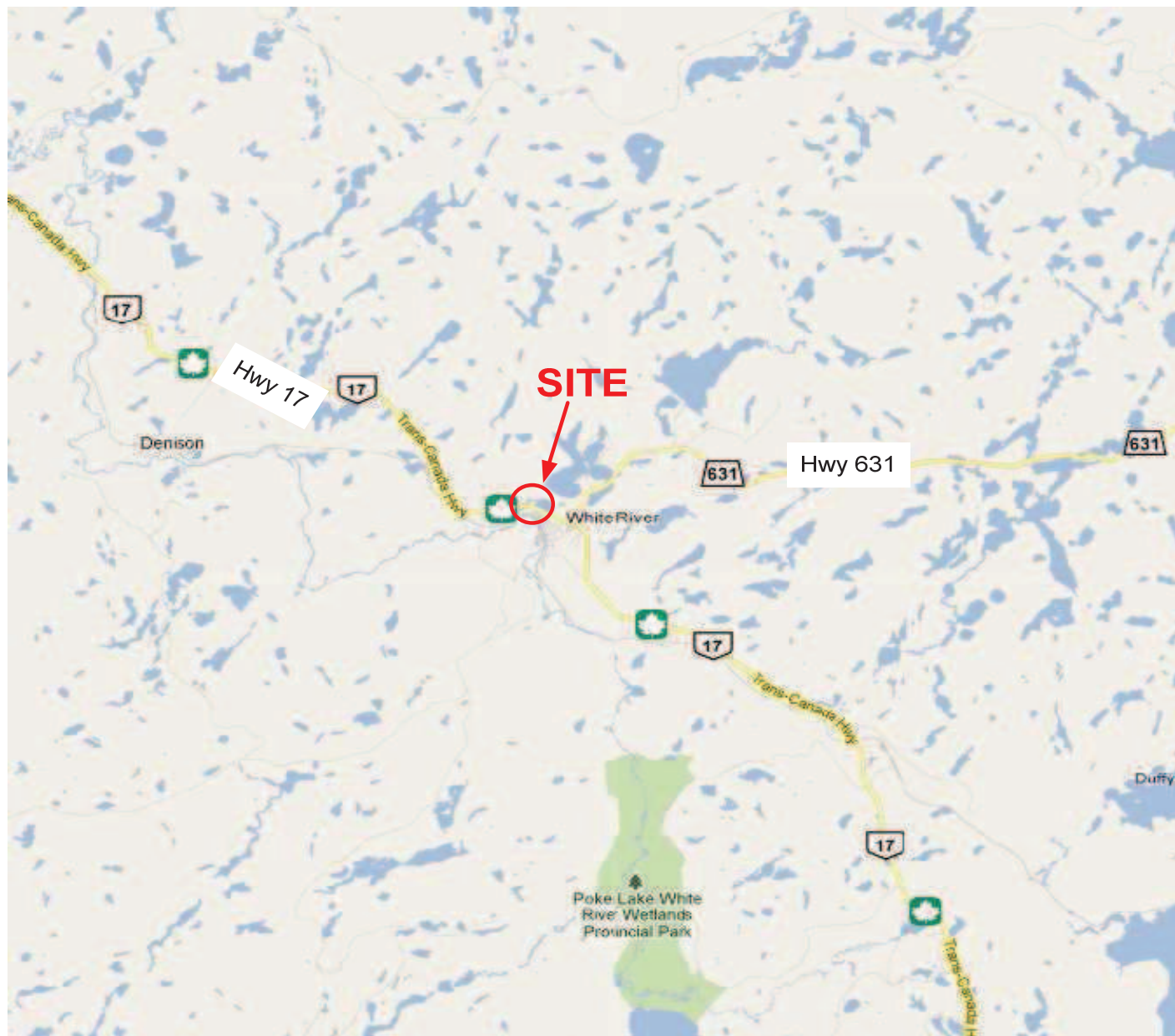
Fanyu Zhu, Ph.D., P.Eng.






Shaheen Ahmad, M.A.Sc., P.Eng.

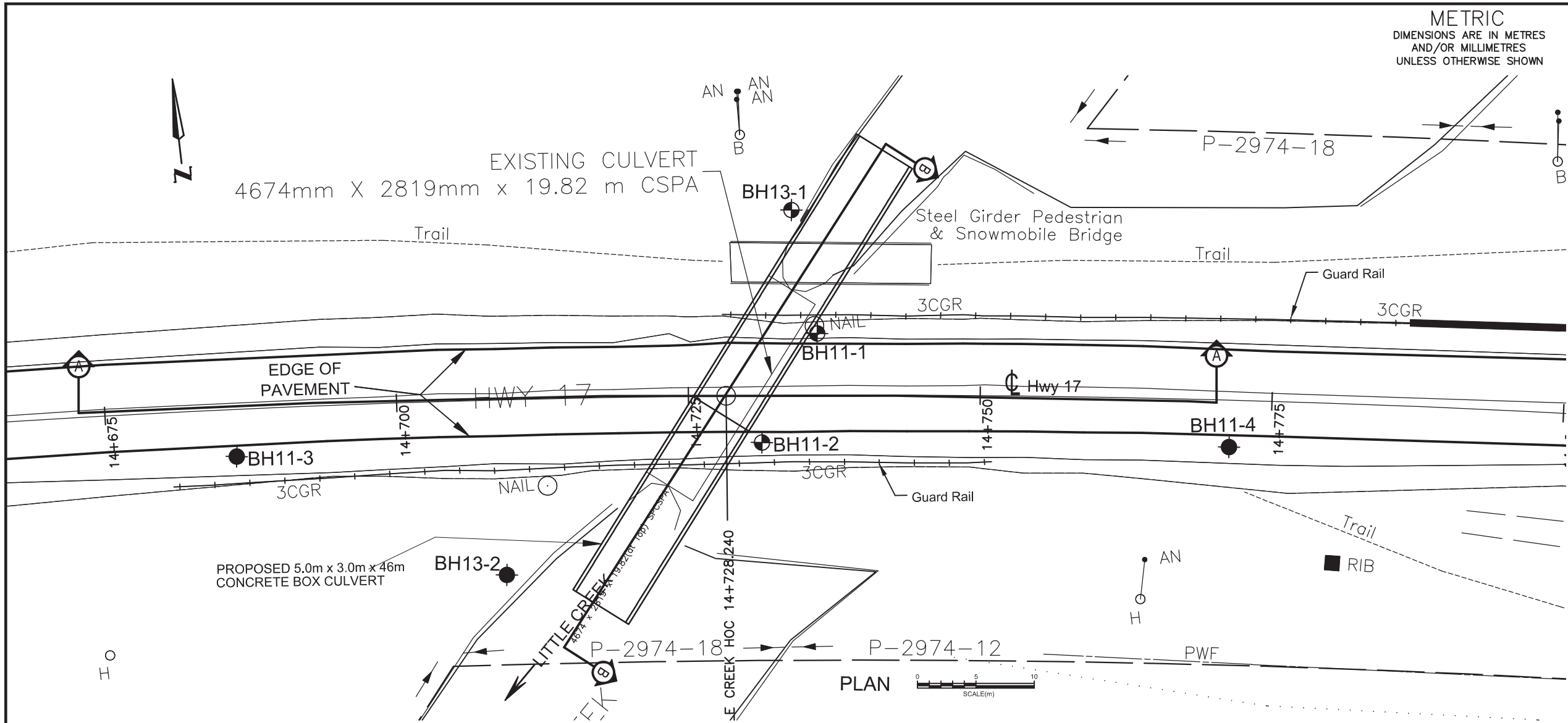
# Drawings



Client: McIntosh Perry Consulting Engineers		Title: SITE PLAN	
Project#:	750-1001	DWG #:	1
Drawn:	NT	Approved:	CH
Date:	AUG 15-2011	Scale:	N. T. S.
Size:	Letter	Rev:	0
		 <b>SPL Consultants Limited</b> Geotechnical Environmental Materials Hydrogeology	







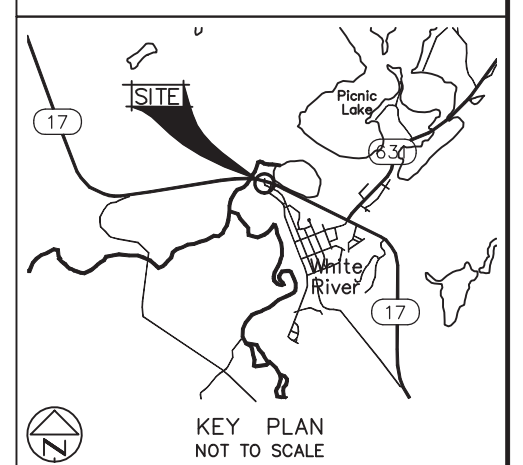
CONT No  
WP No 5080-09-01

PICNIC LAKE CREEK CULVERT  
HIGHWAY 17

BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
36A

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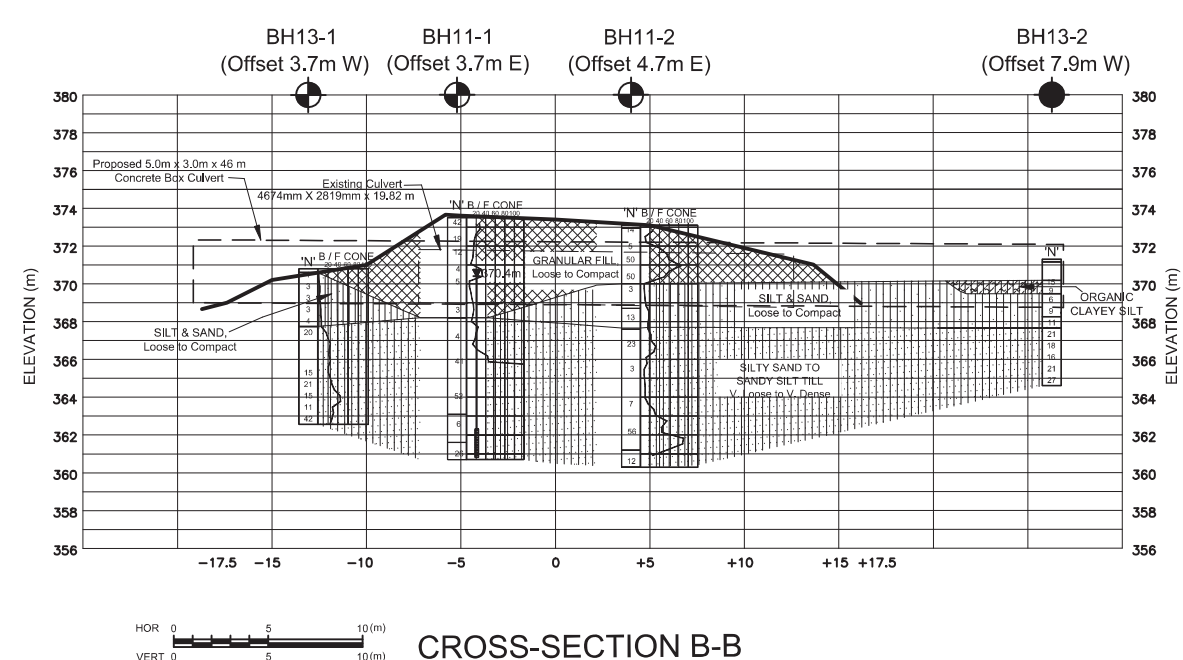
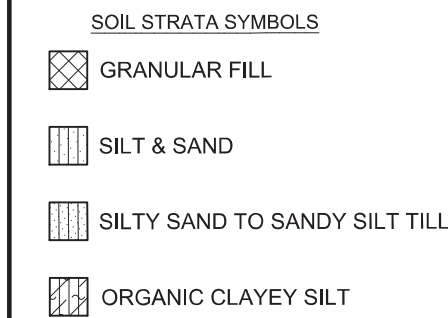
LEGEND

- ◆ Bore Hole
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- ↓ WL at time of investigation July 2011
- ↓ WL in Piezometer
- Piezometer

No	ELEVATION	STATION	OFFSET
BH11-1	373.5	14+735.9	5.3m N
BH11-2	373.1	14+731.5	4.0m S
BH11-3	373.9	14+686.1	4.0m S
BH11-4	373.2	14+771.4	4.0m S
BH13-1	370.8	14+733.9	15.9m N
BH13-2	371.3	14+709.1	15.0m S

— NOTES —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore holes the boundaries are assumed from geological evidence.



REVISIONS

Jan14/14	CH	Revised Final Report
Nov16/12	TJC	Final Revision
Feb16/12	TJC	Revision 1
DATE	BY	DESCRIPTION

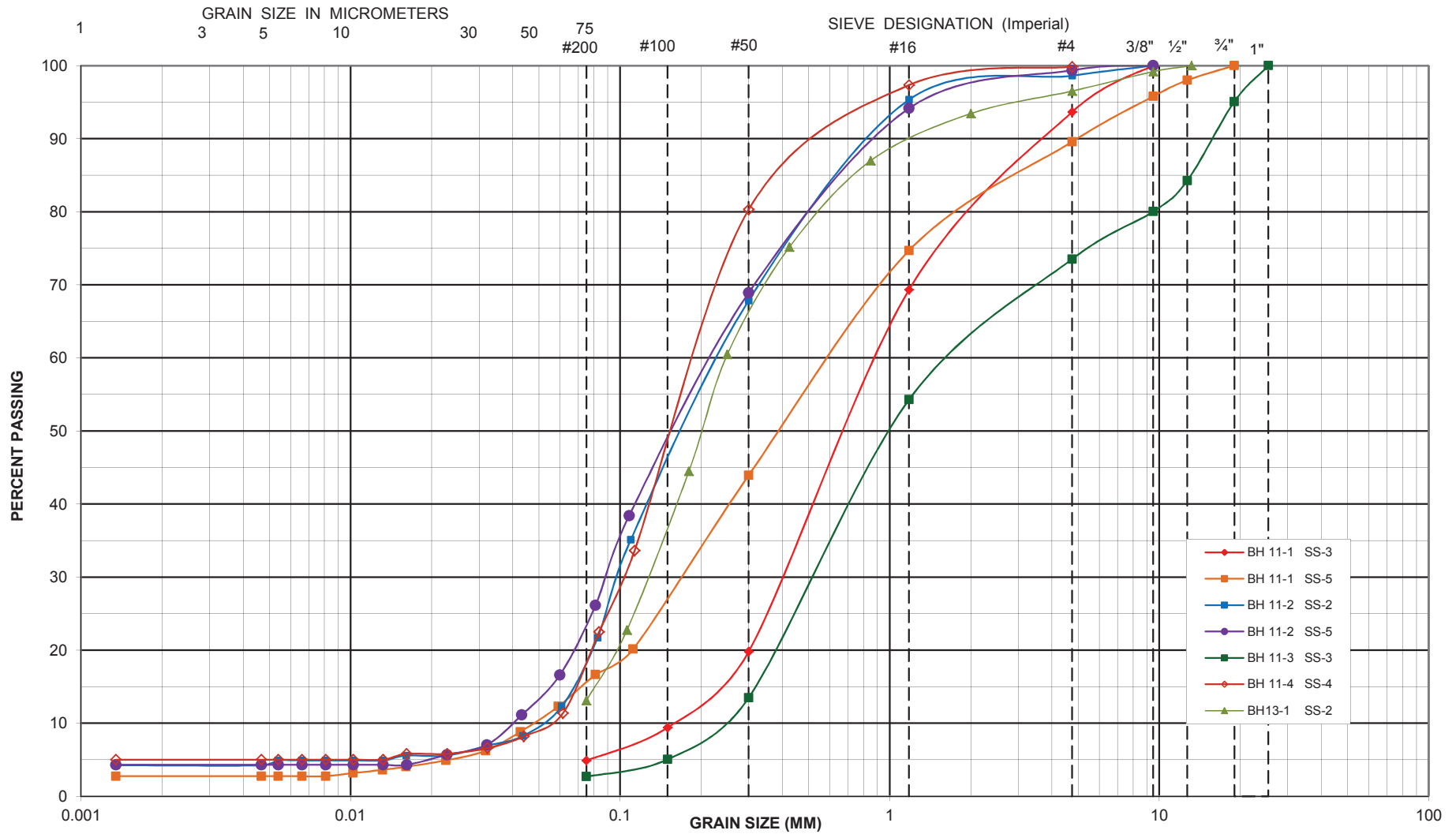
GEOCREs No 42C-27

HWY No 17	SUBM'D CH	CHECKED CH	DATE Jan14, 2014	DIST Algoma
DRAWN ZMO	CHECKED CH	APPROVED FZ		SITE 38C-054/C
				DWG 2B

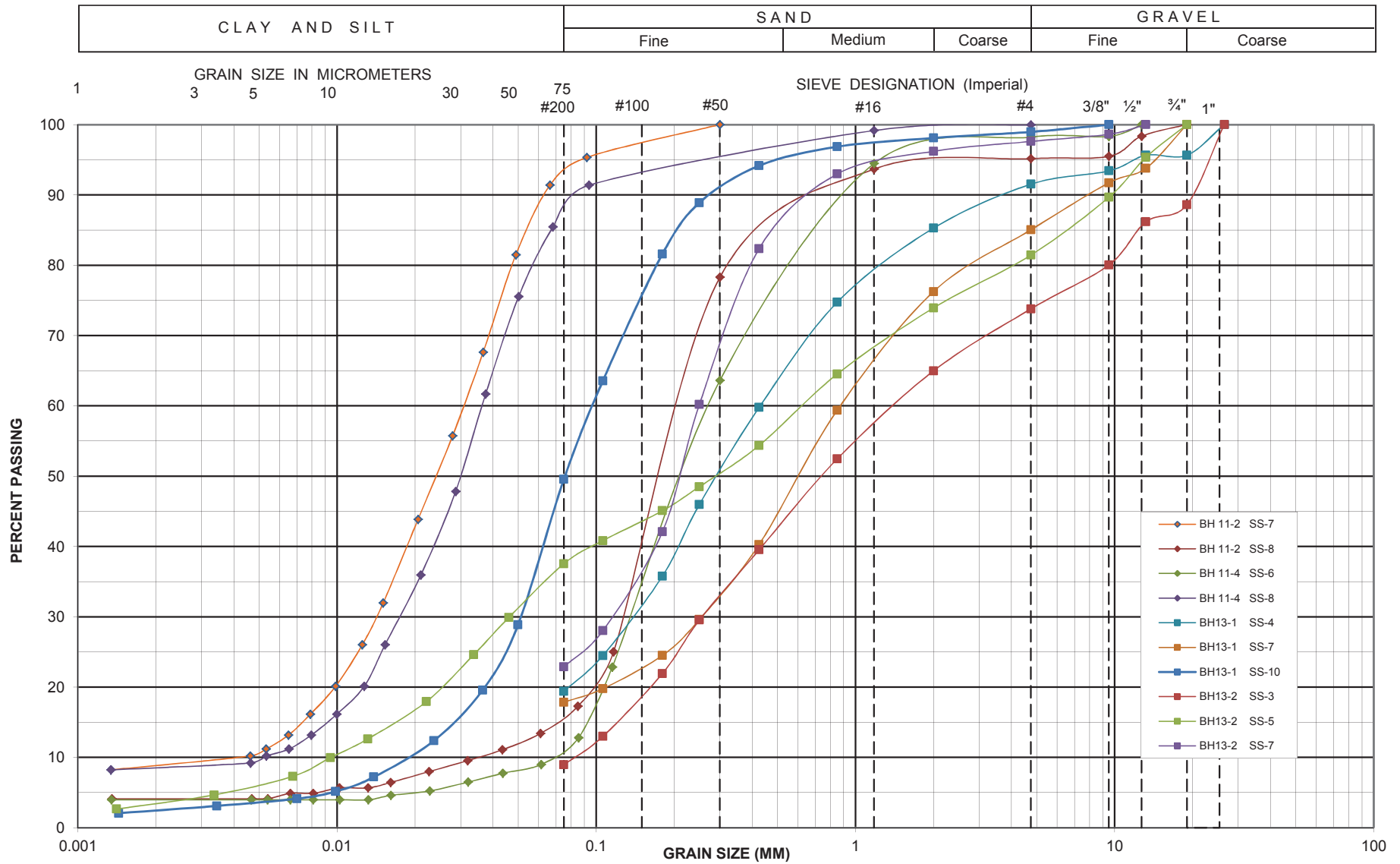


# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



# UNIFIED SOIL CLASSIFICATION SYSTEM



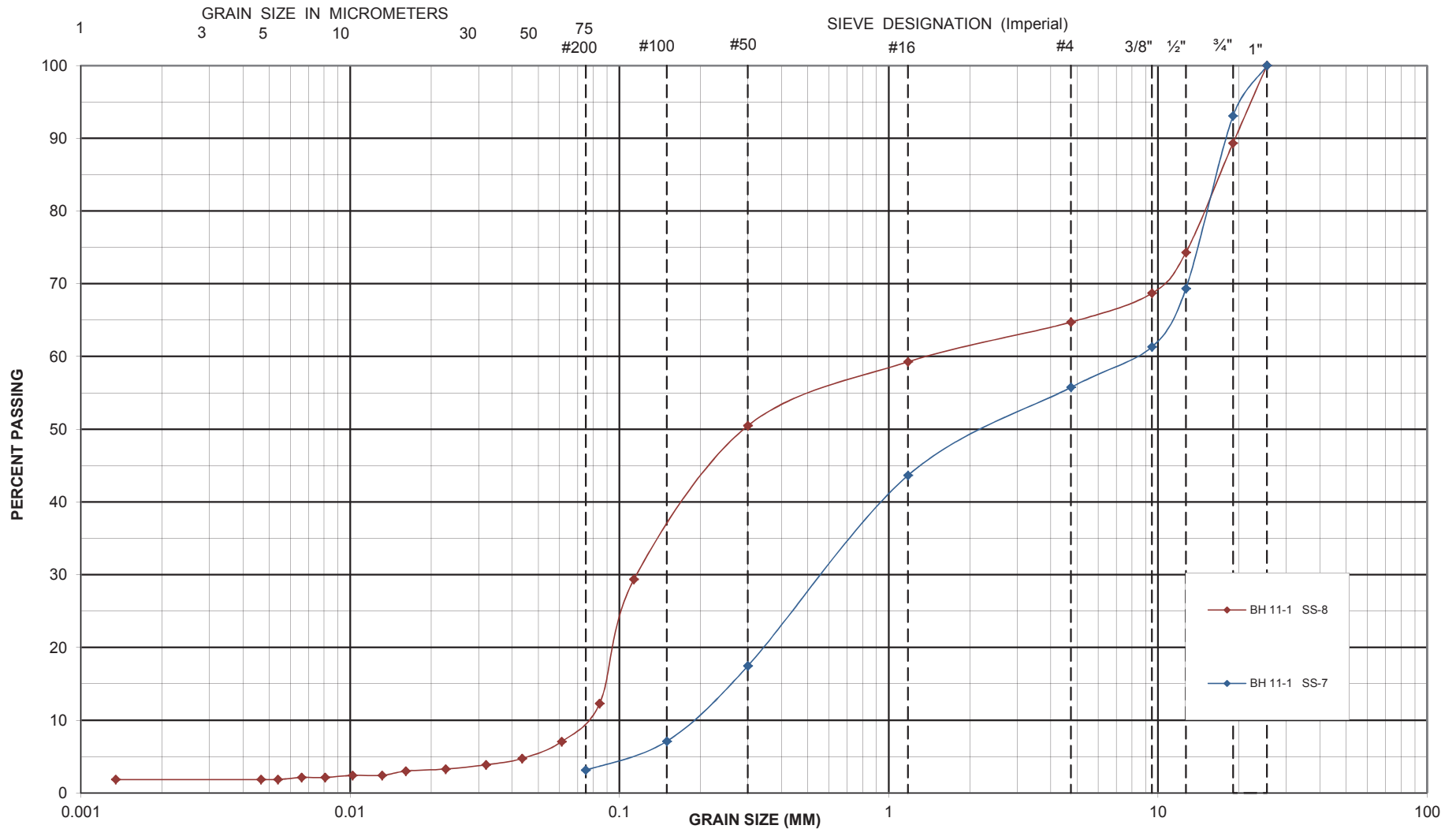
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**GRAIN SIZE DISTRIBUTION - SILT & SAND**  
Proposed Borden River Culvert Replacement

Drawing No. 4  
Project No. 750-1001  
Date : January 2014

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



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GRAIN SIZE DISTRIBUTION - SAND & GRAVEL  
Proposed Borden River Culvert Replacement

Drawing No. 5  
Project No. 750-1001  
Date : January 2014

# Appendix A

## Borehole Logs (Record of Borehole Sheets)

**RECORD OF BOREHOLE No BH 11-1**

1 OF 1

**METRIC**

W.P. 5077-09-01 LOCATION Borden River Culvert - See Borehole Location Plan, E, N ORIGINATED BY NE  
DIST Algoma HWY 101 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FL  
DATUM Geodetic DATE Jun/12/2011 CHECKED BY CH

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							WATER CONTENT (%)			
427.0							20	40	60	80	100							
426.0	ASPHALT: 50 mm																	
	Fill: SAND trace to some gravel, trace to some silt greyish brown, moist dense to compact. some gravel, dense trace gravel, compact		1	SS	48	Holeplug												
			2	SS	17		426											
			3	SS	16		425								6 89 (5)			
424.7	Fill: SAND trace to some gravel, some silt, trace clay greyish brown, moist to saturated loose to compact.		4	SS	6													
2.3			5	SS	5	Cutting									10 74 13 3			
						W. L. 423.4 m Jun 13, 2011	423								auger grinding at 3.7m			
	some gravel to gravelly, saturated		6	SS	26		422								spoon wet at 4.6m			
421.4	SAND & GRAVEL: trace silt and clay, brown, saturated compact to very dense.					Holeplug	421											
5.6			7	SS	10	Sand									44 53 (3)			
	inferred cobbles / boulder						420								auger very hard from 7.0m to 7.6m			
			8	SS	86/ 250mm	Screen/Sand									41 54 3 2			
419.0	End of Borehole						419								spoon bouncing			
8.0	Notes: 1. Auger refusal at 8.02m. 2. Water level at 4.6m during drilling 3. Water level at 4.1m upon completion. 4. 19mm dia. piezometer was installed to a depth of 8.02m. 5. Water level in piezometer Date Depth (m) Elevation (m) June 13, 2011 3.63 423.4																	

ON-MTO SPL-M-MTO-750-JUNE-BORDEN CREEK - AUGUST 2012.GPJ ON\_MOT.GDT 4/12/12

**RECORD OF BOREHOLE No BH 11-2**

1 OF 1

**METRIC**

W.P. 5077-09-01 LOCATION Borden River Culvert - See Borehole Location Plan, E, N ORIGINATED BY NE  
DIST Algoma HWY 101 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FL  
DATUM Geodetic DATE Jun/13/2011 CHECKED BY CH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						w <sub>p</sub>	w	w <sub>L</sub>	GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)								
							20	40	60	80	100	10	20	30						
427.1																				
426.0	<b>ASPHALT:</b> 50 mm <b>Fill: SAND</b> some silt, trace gravel, trace clay greyish brown, moist compact to very loose.  contains asphalt pieces		1	SS	21							○						1 81 14 4		
			2	SS	13							○								
			3	SS	8							○								
			4	SS	3							○								
	very loose		5	SS	2							○						1 76 19 4		
423.0																				
4.1	<b>Fill: SAND &amp; GRAVEL</b> some silt, trace clay, with organics dark grey to black, saturated compact.		6	SS	12								○					wet spoon		
421.5																				
5.6	<b>SILT:</b> trace sand, trace clay light grey, saturated compact.		7	SS	15								○					0 7 84 9		
419.9																				
7.2	<b>SAND:</b> trace gravel, some silt, trace clay grey, saturated very loose to very dense.		8	SS	4								○					augering grinding at 7.5m		
																		5 80 11 4		
418.1																				
9.0	<b>End of Borehole</b> Notes: 1. Auger refusal at 9.0m. 2. Water level at 4.6m during drilling. 3. Water level at 5.93m upon completion.		9	SS	50/ 10mm							○								

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

ON-MTO SPL-M-MTO-750-JUNE-BORDEN CREEK - AUGUST 2012.GPJ ON\_MOT.GDT 4/12/12

**RECORD OF BOREHOLE No BH 11-3**

1 OF 1

**METRIC**

W.P. 5077-09-01 LOCATION Borden River Culvert - See Borehole Location Plan, E, N ORIGINATED BY NE  
DIST Algoma HWY 101 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FL  
DATUM Geodetic DATE Jun/12/2011 CHECKED BY CH

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									WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					LAB VANE							
427.6							20	40	60	80	100													
426.6	<b>ASPHALT:</b> 50 mm <b>Fill: GRAVELLY SAND</b> trace silt greyish brown, moist very dense to dense.		1	SS	52								○											
			2	SS	32								○											
426.1																								
1.5	<b>Fill: GRAVELLY SAND</b> trace silt brown to greyish brown, moist loose to compact.		3	SS	9								○					26	71	(3)				
			4	SS	5								○											
			5	SS	13								○											
423.9																								
3.7	<b>End of Borehole</b> Notes: 1. Auger refusal at 3.7m.																							

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

**RECORD OF BOREHOLE No BH 11-4**

1 OF 1

**METRIC**

W.P. 5077-09-01 LOCATION Borden River Culvert - See Borehole Location Plan, E, N ORIGINATED BY NE  
DIST Algoma HWY 101 BOREHOLE TYPE Hollow Stem Augers COMPILED BY FL  
DATUM Geodetic DATE Jun/13/2011 CHECKED BY CH

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								
								20 40 60 80 100								
428.1																
428.0	ASPHALT: 60 mm															
428.0	Fill: SAND some gravel, trace silt greyish brown, moist dense.		1	SS	49											
427.3	Fill: SILTY SAND trace gravel, trace clay brown, moist compact.		2	SS	27											
426.6	Fill: SAND some silt, trace clay brown, moist compact to very loose.		3	SS	11											
	loose		4	SS	5										0 81 14 5	
	very loose		5	SS	3											
424.0	SAND trace silt, trace clay, trace gravel grey, saturated very loose.		6	SS	2										wet spoon 2 89 5 4	
422.6	SILT trace to some sand, trace clay grey, saturated loose to dense.		7	SS	39											
	some sand, loose		8	SS	7										0 13 79 8	
419.3	End of Borehole		9	SS	50/ 10mm										spoon bouncing	
8.9	Notes: 1. Auger refusal at 8.85 m. 2. Water level at 4.6m during drilling. 3. Water level at 6.0m upon completion															

ON-MTO SPL-M-MTO-750-JUNE-BORDEN CREEK - AUGUST 2012.GPJ ON\_MOT.GDT 4/12/12







**RECORD OF BOREHOLE No BH13-1**

1 OF 1

**METRIC**

W.P. 750-1101 LOCATION Borden River Culvert - See Borehole Location Plan ORIGINATED BY DW  
DIST Algoma HWY 101 BOREHOLE TYPE Portable drilling with continuous sampling and wash boring COMPILED BY DW  
DATUM Geodetic DATE Nov/22/2013 CHECKED BY CH

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												
					WATER CONTENT (%)															
					20 40 60 80 100					20 40 60										
423.7	<b>Topsoil - 120 mm</b> <b>Fill: Sand</b> brown, moist, wet, very loose to loose  - wet below 0.6 m		1A	SS	5		423													
423.6			1B	SS	5															
0.1			2	SS	3															
			3A	SS	9															
422.2			3B	SS	9				422											
1.5	<b>Silty Sand</b> dark brown, moist, loose		4	SS	25		421													
421.9			5	SS	24															
1.8			6	SS	31					420										
			7	SS	28															
			8	SS	18				419											
			9	SS	3															
418.2			<b>Sand and Silt</b> trace gravel, trace clay, brown, wet, loose to compact		10		SS			9	418									
5.5	11	SS			11	417														
	12	SS			16															
416.4	<b>End of Borehole</b> 1. Drilling ended at 7.3 m 2. Casing driven to 3.1 m, wash boring begins 3. Water level at 0.6 m during drilling																			
7.3																				

ON-MTO-LARGE SCALE SPL-M-MTO-750-BORDEN RIVER- NOV22 2013.GPJ ON\_MOT.GDT 10/1/14

**RECORD OF BOREHOLE No BH13-2**

1 OF 1

**METRIC**

W.P. 750-1101 LOCATION Borden River Culvert - See Borehole Location Plan ORIGINATED BY DW  
DIST Algoma HWY 101 BOREHOLE TYPE Portable drilling with continuous sampling and wash boring COMPILED BY DW  
DATUM Geodetic DATE Nov/23/2013 CHECKED BY CH

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			25	50	75	100	125					
423.7 0.0	<b>Topsoil - 190 mm</b>																
423.5 0.2	<b>Sand</b> some silt, some root fragments, trace gravel, brown, moist, loose to compact		1	SS	9		423										
			2	SS	20												
422.2 1.5	- wet below 1.2 m <b>Sand</b> some gravel, trace silt, brown, wet, compact		3	SS	22		422										26 65 (9)
			4	SS	15												
421.2 2.4	<b>Silty Sand</b> trace to some gravel, trace clay, brown, wet, loose		5	SS	7		421										19 44 34 3
	- very loose		6	SS	1												
	- loose		7	SS	5		420										2 75 (23)
419.2 4.5	<b>End of Borehole</b> Notes: 1. Sampler refusal at 4.25 m 2. DCPT refusal at 4.5 m 3. Casing driven to 3.1, wash boring begins 4. Water level at 1.2 m during drilling.		8	SS	50/ 0 mm												

# Appendix B

## Chemical Test Results

**CLIENT NAME: SPL BEATTY  
6221 HIGHWAY 7 WEST UNIT 16  
VAUGHAN, ON L4H0K8**

**ATTENTION TO: Naeem Ehsan**

**PROJECT NO: 750-1001**

**AGAT WORK ORDER: 11T507482**

**SOIL ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst**

**DATE REPORTED: Jul 14, 2011**

**PAGES (INCLUDING COVER): 4**

**VERSION\*: 1**

Should you require any information regarding this analysis please contact your client services representative at (905) 712 5100, or at 1-800-856-6261

**\*NOTES**

**All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.**



**AGAT** Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 11T507482

PROJECT NO: 750-1001

5835 COOPERS AVENUE  
MISSISSAUGA, ONTARIO  
CANADA L4Z 1Y2  
TEL (905)712-5100  
FAX (905)712-5122  
<http://www.agatlabs.com>

CLIENT NAME: SPL BEATTY

ATTENTION TO: Naeem Ehsan

### Inorganic Chemistry (soil)

DATE SAMPLED: Jun 12, 2011

DATE RECEIVED: Jul 06, 2011

DATE REPORTED: Jul 14, 2011

SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	BH11-MSC-4, S1(0-2) 2521422	BH11-MSC-2, S8(25) 2521424	BH11-BR-2, S1(0-2) 2521425	BH11-BR-4, S6(15) 2521426
Chloride (2:1)	µg/g		2	18	117	7	6
Sulphate (2:1)	µg/g		2	7	17	46	10
pH (2:1)	pH Units		N/A	10.09	8.31	5.90	9.15
Electrical Conductivity (2:1)	mS/cm		0.002	0.154	0.258	0.075	0.083
Resistivity (2:1)	ohm.cm		1	6490	3880	13300	12000

**Comments:** RDL - Reported Detection Limit; G / S - Guideline / Standard

**2521422-2521426** EC,pH,Chloride and Sulphate were determined on the extract obtained from the 2:1 extraction procedure (2 parts DI water: 1 part soil).

**Certified By:**

## Quality Assurance

CLIENT NAME: SPL BEATTY

AGAT WORK ORDER: 11T507482

PROJECT NO: 750-1001

ATTENTION TO: Naeem Ehsan

### Soil Analysis

RPT Date: Jul 14, 2011

RPT Date: Jul 14, 2011			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

#### Inorganic Chemistry (soil)

Chloride (2:1)	1	2521422	18	18	0.0%	< 2	99%	80%	120%	95%	80%	120%	97%	80%	120%
Sulphate (2:1)	1	2521422	7	7	0.0%	< 2	92%	80%	120%	97%	80%	120%	96%	80%	120%
pH (2:1)	1	2521422	10.09	10.00	0.9%	N/A	105%	90%	110%						
Electrical Conductivity (2:1)	1	2521422	0.154	0.148	4.0%	< 0.002	96%	90%	110%						

**Certified By:**



## Method Summary

CLIENT NAME: SPL BEATTY

AGAT WORK ORDER: 11T507482

PROJECT NO: 750-1001

ATTENTION TO: Naeem Ehsan

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
<b>Soil Analysis</b>			
Chloride (2:1)	INOR 1005	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR 1005	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Electrical Conductivity (2:1)	INOR 1036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR 1036		CALCULATION







**PART B**  
**FOUNDATION DESIGN REPORT**  
**PROPOSED PICNIC LAKE CREEK CULVERT REPLACEMENT**  
**HIGHWAY 17 WEST OF HIGHWAY 631, WHITE RIVER, ONTARIO**  
**WP 5080-09-01 SITE NO. 38C-054/C**  
**G.W.P. 5270-08-00**  
**MTO GEOCRES NO. 42C-27**

Prepared for:

**MCINTOSH PERRY CONSULTING ENGINEERS**

By:

**SPL CONSULTANTS LIMITED**

Project: 750-1001 (Picnic Lake Creek)  
January 2014



**SPL Consultants Limited**  
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## **6. DISCUSSION AND RECOMMENDATIONS**

### **6.1 General**

The proposed new culvert is a 5.0 m wide by 3.0 m high, closed bottom, concrete box culvert. The base of the new culvert will be installed at approximately 368.5 m elevation, slightly to the east of the existing culvert. The current design does not include any change to the final embankment height.

The subsurface conditions encountered in the boreholes drilled at the site include a layer of granular fill which forms the road structure, the embankment and backfill around the existing culvert. In the boreholes drilled on the existing roadway (BH11-1 through BH11-4) this layer ranges in thickness from 2.9 m to 5.3 m. A layer of fill approximately 0.9 m was also found underlying topsoil in Borehole BH13-2. The fill layer is underlain by a layer of silt and sand below the south end of the culvert and to the west of the crossing (BH11-2, BH11-3 and BH13-2). In Borehole BH13-1, drilled north of the culvert, the silt and sand layer is also underlying topsoil. In one area (BH11-4 located approximately 50 m east of the culvert) the granular fill is underlain by a layer of organic material (peat). Beneath these strata the entire site is underlain by a deposit of compact to dense silty sand and sandy silt till.

Groundwater levels at the site were found to be at an elevation of approximately 370.4 m, which is roughly coincident with the level of the creek at the time of the measurements.

Based on the borehole information at the proposed culvert location, the new culvert and bedding will be founded on loose to compact silt and sand as well as loose to dense silty sand and sandy silt till. These strata are expected to be adequate to support the proposed culvert.

### **6.2 Frost Protection**

The depth of frost penetration for the Picnic Lake Creek site is 2.4 m. The existing fill embankment is a combination of sandy silt, silty sand and sand and gravel. The fill within the frost depth typically has a low susceptibility to frost heave and therefore frost tapers are not required for the new construction.

### **6.3 Seismic Performance**

The site is located in an area of relatively low seismic activity. The Peak Horizontal Ground Acceleration (PHA) for an earthquake with a 10% chance of exceedance in 50 years (475 year return period event) is 0.011 g. Based on the Canadian Highway Bridge Design Code (CHBDC) this corresponds to a Seismic Performance Zone 1 (assuming the crossing would be classified as an Emergency Route Bridge), and Zonal Acceleration Ratio of  $A = 0$  (CHBDC Section 4.4).

For the purposes of assessing the effects of site conditions under seismic conditions, the site may be assumed to be Soil Profile Type II, which corresponds to a Site Coefficient  $S = 1.2$  (CHBDC Section 4.4.6).

## **6.4 Foundation Design**

### **6.4.1 Foundation Options**

MTO has selected a closed-bottom, pre-cast concrete box culvert as the preferred replacement option. The sub-surface conditions at the site are considered to be adequate for the founding of the preferred replacement structure (pre-cast box culvert) on normal foundations (granular bedding placed over native granular soils or existing granular fill).

Deep foundations are technically feasible, but are not required as conventional shallow foundations will provide sufficient bearing resistance and settlement performance for the proposed culvert.

### **6.4.2 Bearing Resistance**

For the new 5 m wide culvert, founded on undisturbed native soils at an elevation of approximately 368.5 m, the unfactored geotechnical bearing resistance at Ultimate Limit State (ULS) can be taken as 400 kPa. A resistance factor of 0.5 should be applied to this value, yielding a factored bearing resistance of 200 kPa. This value is for a concentrically loaded foundation. Eccentric loads (if present) should be accounted for by considering an effective bearing area as outlined in Section 6.7 of the CHBDC.

The geotechnical resistance at the Serviceability Limit State (SLS) can be taken as 100 kPa. Provided that the subgrade is not disturbed during construction the total and differential settlements associated with the above SLS resistance values are expected to be less than 25 mm and 20 mm, respectively. It is expected that for this level of settlement the new culvert will not require a camber.

### **6.4.3 Sliding Resistance**

For the purposes of evaluating the sliding resistance (Section 6.7.5 of the CHBDC) of either the native soils or the granular fill below the foundation the effective cohesion,  $c'$ , should be assumed to be zero. The effective friction angle ( $\phi'$ ) for the silty, sandy till soils may be assumed to be 30°. These values are unfactored values. A resistance factor of 0.8 should be applied to the resulting resistance to obtain the factored sliding resistance as per the CHBDC.

## **6.5 Bedding, Cover and Backfill**

Bedding, Cover and Backfill details for the new culverts should be generally as per MTOD 803.021. Bedding for the new culverts may consist of either:

- 500 mm of compacted Granular A or Granular B Type II; or
- 300 mm of compacted Granular A or Granular B Type II placed over a lean concrete working slab.

If constructed properly, either bedding treatment is considered adequate from a foundations perspective.

A 75 mm levelling course of additional Granular A or fine aggregate should also be provided between the bedding and the culvert. In order to minimize the potential for piping and undermining of the culvert foundations the bedding and levelling course should be wrapped in a non-woven geotextile which meets the requirements of OPSS 1860.

Cover for the new culverts should be a minimum of 300 mm thick as per MTOD 803.021 and may include either Granular A or Granular B with a maximum particle size of 150 mm (as per OPSS 902).

Granular Backfill may consist of either imported Granular A or B material, or salvageable portions of the existing soils (Granular A or B is preferred for fills below the water table as well as immediately below the pavement structure). Portions of the fill which forms the embankment may meet the requirements of OPSS 1010 for Granular B Type I. Other portions of the existing fill embankment may meet the requirements of OPSS 1010 for SSM. The excavated soils should be reviewed as exposed and suitable portions stockpiled for re-use as backfill (if a cost-effective stockpile location is available). Material from below the water table, as well as the native silty till, is unlikely to be suitable for re-use as backfill and there will be a net import of granular fill required for construction. All backfill should be free from frozen or other deleterious material and should have a maximum particle size of 150 mm as per OPSS 902.

All bedding, cover and backfill should be placed in accordance with OPSS 206, and compacted in accordance with OPSS 501 and OPSS 902.

Heavy vibratory equipment should not be used behind the culvert and retaining walls within the restricted zone as outlined in OPSS 501 and OPSS 902.

## 6.6 Earth Pressures

Computation of earth pressures acting against culvert walls and retaining structures should be in accordance with the Canadian Highway Bridge Design Code (CHBDC). For design purposes, the following properties can be assumed for the backfill:

### Compacted Granular 'A' or Granular 'B' Type II

Angle of Internal Friction ( $\phi$ ) = 35 degrees (unfactored)

Unit Weight = 22 kN/m<sup>3</sup>

Coefficients of Lateral Earth Pressure:

Earth Pressure Coefficient	Level Backfill	Sloping Backfill 3H:1V	Sloping Backfill 2H:1V
$K_a$	0.27	0.34	0.40
$K_b$	0.35	0.44	0.50
$K_0$	0.43	0.56	0.62
$K^*$	0.45	0.60	0.66

### Compacted Granular 'B' Type I

Angle of Internal Friction ( $\phi$ ) = 32 degrees (unfactored)

Unit Weight = 21 kN/m<sup>3</sup>

Coefficients of Lateral Earth Pressure:

Earth Pressure Coefficient	Level Backfill	Sloping Backfill 3H:1V	Sloping Backfill 2H:1V
$K_a$	0.30	0.38	0.47
$K_b$	0.38	0.48	0.57
$K_0$	0.47	0.61	0.69
$K^*$	0.51	0.67	0.76

Notes:

$K_a$  is the coefficient of active earth pressure;

$K_b$  is the coefficient of active earth pressure for an unrestrained structure including compaction efforts;

$K_0$  is the coefficient of earth pressure at rest;

$K^*$  is the coefficient of earth pressure at rest for a fully restrained structure including compaction efforts.

The above values assume that the backfill behind the structure is free-draining granular fill, and that proper drainage is provided.

The appropriate earth pressure coefficient for design will depend upon whether the retaining structure is restrained or some movement can occur such that the active earth pressure state can develop. The effect of compaction should also be taken into account when selecting the appropriate earth pressure coefficients. The use of heavy vibratory equipment behind the culvert and retaining walls should be limited as per OPSS 501 and 902.

According to the method outlined in the CHBDC and Commentaries Section 4.6.4, for a Zonal Acceleration Ratio of  $A = 0$  the earth pressure under the design seismic event is equal to the earth pressure under static conditions (the horizontal seismic coefficient,  $k_h$  is 0.5 or 1.5 times the Zonal Acceleration Ratio, and for the very small design earthquake  $A = 0$ ).

## 6.7 Embankment Widening

It is understood that the existing roadway embankment may be widened to the south to facilitate a detour around the construction site. Based on the elevations of the existing road and the native soils it is expected that this widening would likely be on the order of 3 m to 4 m in height. Based on the conditions encountered in the boreholes, foundation failures are not anticipated for the proposed

embankment widening with normal (2H:1V or flatter) slopes, assuming that all organic or unsuitable materials (such as the layer of peat encountered in the area around BH11-4 if encountered in other locations) are removed prior to placing the embankment fills.

All unsuitable materials should be removed and the approved embankment subgrade should be proof-rolled. The construction of the new embankment widening may require temporary dewatering or groundwater control as discussed in Section 6.8 below.

The sides of the existing embankment should be benched prior to placing fill material for the embankment widening, as per OPSD 208.01; benching is required when existing slopes are steeper than 3H:1V. Fill material should be placed and compacted in accordance with OPSS 206 and 501. Borrow material for the proposed embankment widening should consist of select suitable inorganic earth, free of objectionable inclusions such as cobbles, boulders, frozen material, organic soils, etc. the majority of the existing fill material is expected to be suitable for this purpose provided that any material from below the water table is properly dried prior to placement and compaction. Borrow material for the proposed embankment should be approved prior to installation from both a geotechnical and environmental standpoint.

Based on the subsurface conditions present, it is expected that the settlement at the surface of the embankment will be less than 50 mm (including settlement of the fill itself as well as the underlying soils) most of which will occur within approximately 6 weeks of construction (assuming granular fill is used for the embankment). These estimated settlements are typical of this type of construction and considered within acceptable limits.

All embankment construction (including review of exposed subgrade, approval of fill materials, etc.) should be carried out under the review and supervision of a qualified person.

## **6.8 Erosion Protection**

The native soils at the site are expected to be susceptible to erosion. Erosion and scour protection (such as rip rap treatment similar to OPSD 810.919) will be required at the culvert inlet and outlet. The sizing of the erosion protection should be carried out by a specialist who is familiar with the site hydraulics and the findings of this investigation.

The current design includes upstream and downstream cut-off walls on the new culvert. These walls should extend to below the base of the bedding and levelling course to prevent flow of water below the walls through the permeable bedding layer. It is also recommended that the bedding and levelling course be enclosed in a non-woven geotextile (OPSS 1860) in order to reduce the potential for piping and erosion of the culvert bedding.

## **6.9 Construction Considerations**

### Construction Dewatering

The groundwater level at the site was found to be approximately equal to the level of the water in the creek at the time of the investigation. The groundwater level is expected to be sensitive to changes in the water level in the creek, and for this reason it is recommended that, if possible, construction be carried out in a dry period when the creek would be expected to be at its lowest level.

It will also be necessary to install a temporary by-pass to divert the existing water course and maintain sufficiently dry conditions for construction.

The culvert replacement will require excavations below the water table, and even with these measures, dewatering will be required to stabilize the native soils, to maintain a dry working area and to minimize disturbance of the native soils during construction. Depending upon the creek level and groundwater conditions at the time of construction, closely spaced filtered sumps may be used for excavations which extend only a short distance below the groundwater table (say 0.5 m or so). The groundwater level at the time of the investigation in July 2011 was found to be 370.4 m. Excavation will be required to an elevation of 367.9 to install the culvert, bedding and levelling course. At this depth the excavation will likely require an active dewatering system including well points and/or deep wells. In addition to the above-ground diversion (coffer dam and diversion of the existing water course around the site), an underground impervious barrier (such as a sheet pile wall; the choice of protection systems and groundwater control will ultimately be the responsibility of the contractor) may also need to be constructed to control groundwater flows into the excavation.

### Temporary Excavations

All excavations should be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). Part III of Ontario Regulation 213/91 deals with excavations. In addition, the following Ontario Provincial Standard Specifications (OPSS) also deal with temporary excavations:

OPSS 539 – Construction Specification for Temporary Protection Systems

OPSS 902 – Construction Specification for Excavating and Backfilling - Structures

The soils at the site include granular fill in the pavement structure and embankment, underlain by loose to compact native granular soil. Both granular fill and granular native soils can be classified as Type 3 soil above the water table and Type 4 soil below the water table.

Temporary excavations above the water table are likely feasible using sloped excavations in the granular fill. Excavations below the water table will require some form of protection system and temporary support. It is also noted that the staging will require excavation in close proximity to the travelled lanes of the highway, which will preclude the use of sloped excavations in some areas (as there is not sufficient space).



If temporary shoring is required it would generally consist of soldier piles and timber lagging or interlocking sheet piles. It should be noted that cobbles and boulders were encountered during the investigation (particularly in the fill material, though cobbles and boulders are known to exist within glacial till and should be anticipated during construction). This should be considered when selecting shoring systems and installation methods.

#### Foundation Excavations

The bearing capacities provided in Section 6.4 above assume that the culvert is bearing on native soils and that the subgrade is not excessively disturbed during construction. Given the fact that the foundations for the proposed structure will be below the groundwater table in loose to compact sand and silt, it will require careful construction control to achieve this condition. Installation and operation of an adequate dewatering system, as discussed above, will be critical to the construction of the foundations.

A lean concrete working slab (mud slab) on foundation bearing surfaces can also be included in the design. If used, the working slab should be placed immediately after excavation and inspection (before placement of bedding and levelling layers) to minimize foundation disturbance. If excavation conditions are found to be better than anticipated then the requirement for the lean concrete slab may be waved at the discretion of the QVE and CA. All excavated surfaces should be kept free of frost, water, etc. during the course of construction.

All excavated surfaces should be inspected prior to foundation construction by a qualified individual who is familiar with the findings of this investigation and the design and construction of similar structures.

#### **6.10 Corrosion and Cement Type**

Two soil samples were submitted to AGAT for testing related to soil corrosivity and potential exposure of concrete elements to sulphate attack. The results of these tests are included in Appendix B.

The test results indicate that the sulphate content of the native soils is relatively low, and sulphate-resistant Portland cement is not required.

Soil resistivity test results indicate that there is a moderate potential for corrosion of buried steel elements. Appropriate care should be taken in designing the corrosion protection system for any buried steel structures.

## 7. CLOSURE

The field investigations in July 2011 were supervised by Mr. Naeem Ehsan, P.Eng. The field investigations in November 2013 were supervised by Mr. Daniel Wall, E.I.T. This report was prepared by Mr. Chris Hendry, P.Eng. Mr. Fanyu Zhu, P.Eng., who is the project manager and SPL's designated MTO contact and Mr. Shaheen Ahmad, P.Eng., who is the project quality control auditor, provided independent review and quality control.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

### SPL CONSULTANTS LIMITED

Chris Hendry, M.Eng., P.Eng.



Fanyu Zhu, Ph.D., P.Eng.



Shaheen Ahmad, M.A.Sc., P.Eng.

## 8. REFERENCES

The following section provides a general list of references, as well as a list of Ontario Provincial Standard Specifications which are expected to be relevant to the Foundations portion of the proposed work.

### General References

CAN/CSA-S6-06 Canadian Highway Bridge Design Code, 2011

Canadian Foundation Engineering Manual, 2006. 4<sup>th</sup> Edition. Canadian Geotechnical Society

### Relevant Ontario Provincial Standard Specifications

OPSS NO.	TITLE
128	Supply of Pre-Qualified Materials and Products
182	Environmental Protection for Construction in Waterbodies and on Waterbody banks.
201	Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders
206	Grading
401	Trenching, Backfilling, and Compacting
404	Support Systems
501	Compacting
504	Preservation, Protection and Reconstruction of Existing Facilities
506	Dust Suppressants
510	Removals
511	Rip-Rap, Rock Protection, and Granular Sheeting
514	Trenching, Backfilling, and Compacting
518	Control of Water from Dewatering Operations
539	Temporary Protection Systems
805	Temporary Erosion and Sediment Control Measures
902	Excavating and Backfilling – Structures
1001	Aggregates - General
1010	Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
1860	Geotextiles

Relevant CEED Special Provisions

Provision No.	Title
100S60	Amendment to MTO General Conditions of Contract, April 2010 – use of unlicensed vehicles...
104S04	Amendment to OPSS 401, November 2010
105S21	Amendment to OPSS 501, November 2010
110S13	Amendment to OPSS 1010, April 2004
199S55	Record Drawings for Structures and Foundations
511S01	Rip Rap
539S02	Protection System – Amendment to OPSS 512, April 2011
805F01	Light-Duty Sediment Barriers, etc.

Relevant OPSD's

OPSD No.	Title
810.010	Rip-Rap Treatment for Sewer and Culvert Inlets
810.020	Rip-Rap Treatment for Ditch Inlets
3090.100	Foundation, Frost Penetration Depths for Northern Ontario

Relevant MTOD's

MTOD No.	Title
803.021	Bedding and Backfill for Precast Concrete Box Culverts