



**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**for**

**LITTLE PITOPIKO RIVER CULVERT REPLACEMENT**

**SITE NO. 39W-133/C**

**HIGHWAY 11 - STA. 24+200**

**TOWNSHIP OF McMILLAN, DISTRICT OF NEW LISKEARD**

**HEARST, ONTARIO**

**ASSIGNMENT NO. 5015-E-0009**

**GWP 5047-07-00**

**WP 5370-11-01**

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PML Ref.: 16TF013A  
Index No.: 090FIR and 091FDR  
GEOCRES No.: 42F-048  
May 24, 2017



**PART A – FOUNDATION INVESTIGATION REPORT**

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**PART A – FOUNDATION INVESTIGATION REPORT**

Little Pitopiko River Culvert Replacement

Site No. 39W-133/C

Highway 11 - Station 24+200

Township Of McMillan, District of New Liskeard

Hearst, Ontario

Assignment No. 5015-E-0009, GWP 5047-07-00, WP 5370-11-01

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**1. INTRODUCTION**

GHD Ltd. (GHD) has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation of Ontario (MTO) to conduct the geotechnical investigation for the replacement or rehabilitation of thirteen (13) structures located on Highway 11 and three (3) on Highway 583, near Hearst, Ontario. This foundation investigation work is part of an assignment (Assignment No: 5015-E-0009) to prepare detail designs for 15 culverts and the Fraser River Bridge. The assignment involves five contracts carried out under four different General Work Plans (GWPs).

This report gives the results of the foundation investigation carried out for the culvert replacement (MTO Site No. 39W-133/C), located at the crossing of Little Pitopiko River and Highway 11, about 76 km west of Hearst, Sta. 24+200, in the Township of McMillan, District of New Liskeard.

The purpose of the foundation investigation is to identify the subsurface conditions expected to influence the selection and design of the replacement structure at the proposed location.

**2. SITE DESCRIPTION**

Highway 11 in this area is a two-lane road and provides rural arterial road services for communities in the region. The highway at the culvert location consists of approximately 3.5 m wide lanes and about 2 m wide shoulders. The topography surrounding the culvert is generally flat, and consists of dense vegetation with black spruce trees and thick brush. Based on the survey information, the grade of the highway at the center of the culvert is approximately El. 258 m.

The Request for Quotation (RFQ) dated June 2011 reveals that the existing culvert was constructed in 1958 as a triple-cell rectangular wood structure. The span of the two barrels on the west is about 2.1 m, while the barrel on the east is 1.7 m wide. The length of the culvert is 27.0 m with approximately 2.5 m high fill above the crown. The culvert has no record of rehabilitation.

The approach embankment at the culvert location is about 4.1 m high. The slopes of the embankments on both sides of the road were covered with grass and small shrubs. The Little Pitopiko River flows from south to north and empty into the Shekak River located downstream.



Refer to the Photographs P1 to P4 provided in Appendix A, for general site and culvert conditions.

### 3. **FIELD INVESTIGATION PROCEDURES**

The fieldwork for the foundation investigation consisted of four (4) boreholes drilled on August 7 and 8, 2016. Two of the boreholes were drilled at the shoulders of the west and east approaches of the highway. The other two boreholes were located near the southeast and northwest ends of the existing culvert. All boreholes were terminated at depths ranging from 7.2 m to 11.0 m (El. 248.7 m to El. 246.8 m). The location of boreholes, termination depths and elevations are provided in Table 3. In addition, the borehole locations are shown on Drawing 133/C-1.

**Table 3 - Location and Depth of Boreholes**

<b>BOREHOLE NO.</b>	<b>LOCATION</b>	<b>DEPTH (m)</b>	<b>ELEVATION (m)</b>
16-133-01	Southwest Approach, Road Shoulder	11	247.0
16-133-02	Northeast Approach, Road Shoulder	9.5	248.7
16-133-03	SE Culvert End, Near Embankment Toe	8.0	246.8
16-133-04	NW Culvert End, Near Embankment Toe	7.2	247.7

Boreholes were advanced using CME 55 track-mounted drilling rig equipped with continuous flight 200 mm diameter hollow stem augers. The equipment used for drilling was owned and operated by Landcore Drilling (Landcore) of Chelmsford, Ontario, a specialist drilling contractor, worked under the full time supervision of an experienced PML field technician.

Representative soil samples from boreholes were obtained at selected intervals using a split-spoon sampler. Sampling was in accordance with the Standard Penetration Test (SPT) procedures described in the ASTM D1586. The drill rig was equipped with a 63.5 kg (140 lb) cathead automatic hammer calibrated to fall freely through 760 mm (30 in.).

Soil samples were visually identified as they were retrieved and stored in moisture-proof bags.



The groundwater conditions at borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in the open boreholes. Upon completion of drilling, the boreholes were backfilled with drill cuttings and sealed with a bentonite/cement mixture in accordance with the MTO guidelines and Ministry of Environment (MOE) Reg. 903 for borehole abandonment.

Callon Dietz Inc. of London, Ontario was contracted by PML to carry out the survey of the as-drilled borehole locations and elevations. Co-ordinates were provided in MTM NAD 83 northings and eastings. All elevations reported in this report are referred to the Geodetic datum.

#### **4. LABORATORY TEST PROCEDURES**

All the soil samples were transported to PML laboratory, located in Toronto for detailed visual examination and laboratory testing. The laboratory tests included the following:

- Natural Moisture Content Determination (33)
- Atterberg Limit Tests (9)
- Grain Size Distribution (6)

Laboratory tests were performed on representative samples of each stratigraphic layers encountered. With the exception of hydrometer test (LS-702), all laboratory tests were conducted in accordance with MTO procedures, which follow American Society for Testing Materials (ASTM) standards.

All of the laboratory test results are provided on individual Record of Borehole Sheets provided in Appendix B. Results of the grain size distribution test are presented on Figures 133-GS-1 and 133-GS-2, and Atterberg limit tests are provided on Figures 133-PC-1 and 133-PC-2.

Chemical tests were carried out on two representative samples by AGAT Laboratories located in Mississauga, Ontario to determine the corrosivity characteristics of soils at the site. These tests included determination of sulphate and chloride contents, pH value and resistivity. Detail results of chemical analyses provided by AGAT Laboratories are presented in Appendix C.

#### **5. SITE GEOLOGY**

The project site is located within the southern part of the Canadian Shield. Maps published by Ontario Geological Survey suggests that the subsurface conditions at the site consist of glacial till



and overlying clay and silt deposits. The till may contain lenses of clay, silt, sand, gravel, and occasional cobbles and boulders. According to a preliminary report prepared by Evans (1941) on the geology of the Trans-Canada Highway between Longlac and Hearst, the bedrock in the area is composed of pegmatitic granite (granitic-gneiss) with distinct light and dark bands. The granitic-gneiss belongs to the migmatitic metasedimentary-metavolcanic complex of the region.

## **6. SUBSURFACE CONDITIONS**

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets provided in Appendix B. The borehole locations and stratigraphic profile sections are shown on Drawing 133/C-1. The boundaries between soil strata have been established at borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and may vary from location to location.

In summary, the subsurface consists of alluvial deposits and silty sand fill (granular fill), followed by sandy silt till to the maximum depth of investigation. For classification purposes, the soils encountered at the site can be classified into the following four layers.

- a) Alluvium
- b) Silty Sand to Sandy Silt, Trace Gravel, Trace Clay (Granular Fill)
- c) Sandy Silt, Some Sand, Trace to Some Gravel (Till)

### **6.1 Alluvium**

A layer of alluvium consisting of organic silt mixed with trace of gravel, wood pieces, rootlets, and topsoil was encountered below the ground surface in Boreholes 16-133-03 and 16-133-04. The thickness of this layer is about 2.2 m in both boreholes. A 300 mm thick peat was also encountered in Borehole 16-133-03 at a depth of about 1 m (El. 253.8 m) within the alluvium.

The moisture content of samples from the alluvium was in the range of 9.5% to 17.8 %.

The SPT “N”-values ranged from 2 to 9 blows/300 mm, indicating a “loose” state of compaction.



## **6.2 Silty Sand to Sandy Silt, Trace Gravel, Trace Clay (Granular Fill)**

Granular fill consisting of silty sand to sandy silt material was encountered below the surface in Boreholes 16-133-01 and 16-133-02 drilled on the approach embankments. The thickness of this fill ranged from 4.5 m to 5.3 m, extending to El. 253.5 m and El. 252.9 m.

The SPT “N”-values within the silty sand to sandy silt fill were in the range of 2 to 18 blows/300 mm, indicating a “very loose” to “compact” state of compaction.

The moisture content of samples from the silty sand to sandy silt fill was in the range of 3.8% to 24.5%. The sieve analysis performed on a sample taken at a depth of 3.5 m (El. 254.5 m) from Borehole 16-133-01, indicated that the fill is composed of 22% gravel, 67% sand, and 11% fines. In addition, the result of a grain size analysis of a sample from Borehole 16-133-02, taken at a depth of 2.9 m (El. 255.3 m), provided 2% gravel, 45% sand, and 43% silt and 10% clay. The grain size distribution curves are provided on Figure 133-GS-1, in Appendix B.

In Borehole 16-133-02, the fill below the depth of about 3.3 m (El. 254.9 m) consisted of silt materials. This silt was about 2.7 m thick (extending to El. 253.3 m). The SPT “N”-values within the silt was in the range of 2 to 4 blows/300 mm, indicating a “very loose” to “loose” state of compaction.

The moisture content of samples from the silt fill was in the range of 21.3% to 24.5%. Further, the liquid limit of a sample taken at a depth of 4.1 m (El. 254.1 m) was 16 and the plastic limit was 15, resulting in a plasticity index of 1. Based on the Atterberg limit values, the silt fill may, therefore, be classified as inorganic silt (ML) in the Unified Soil Classification System (USCS). The result is reported on the plasticity chart presented on Figure 133-PC-1, in Appendix B.

The silt fill was followed by a 400 mm thick organic deposit, consisting of silt and sand with wood pieces and rootlets to elevation 252.9 m.

## **6.3 Sandy Silt, Some Clay, Trace to Some Gravel (Till)**

The granular fill on the highway and the alluvial deposits near the inlet and outlet are underlain by sandy silt (till) deposit with varying proportions of sand and gravel. This till deposit was encountered below elevations ranging from El. 253.5 m to El. 252.7 m. This sandy silt till deposit was grey in color and moist and extends to the maximum depth of investigation of 11 m (El. 247 m).





The SPT “N”-values in the sandy silt till varied from 38 blows/300 mm to refusal, indicating dense to very dense condition of compaction.

The moisture content of the sandy silt till varied from 7.4% to 11.7%. The liquid limit of representative samples was found to be in the range of 16 to 18 and the corresponding plastic limit was between 12 and 13, resulting in a plasticity index of 4 to 5. Based on the results of the Atterberg limit tests, the soil may be classified as sandy silt of low plasticity (CL-ML) in the Unified Soil Classification System (USCS). The plasticity chart is provided on Figure 133-PC-1, in Appendix B.

The grain size analyses carried out on representative samples of the sandy silt till indicate 8% - 16% gravel, 30% - 32% sand, 43% - 48% silt and 11% - 14% clay. The grain size distribution curves are presented on Figure 133-GS-2, in Appendix B.

## 7. GROUNDWATER

Groundwater was encountered in all boreholes between El. 255 m and El. 253 m. During fieldwork, the amount of water in Little Pitopiko River was estimated to be about 1 m deep. The groundwater level may change due to seasonal fluctuation of precipitation or the water level in the river.

## 8. CHEMICAL TEST RESULTS

Chemical corrosivity tests were conducted on samples from the granular fill and the till, taken at a depth of 4.2 m (El. 254 m) and 5 m (El. 253 m) from Boreholes 16-133-04 and 16-133-03, respectively. A summary of test results are provided in Table 8. The test method are described in Appendix C.

**Table 8 - A Summary Of Chemical Corrosivity Test Results**

BOREHOLE NO.	SAMPLE NO	DEPTH / ELEVATION (m)	SOIL TYPE	SULPHATE (µg/g)	CHLORIDE (µg/g)	pH	RESISTIVITY (Ohm-cm)
16-133-02	SS3	4.2 / 254	Silt Fill	14	556	8.37	1010
16-133-01	SS4	5 / 253	Sandy Silt Till	8	139	8.65	2870



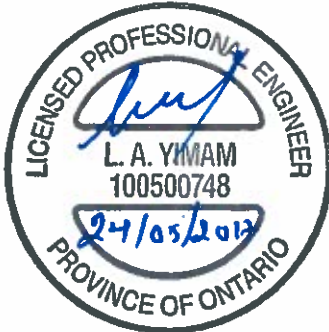
## 9. CLOSURE

The drilling work was supervised by Mr. Kyle Daly, BSc. PEng., under the direction of Mr. Lulseged Yimam, PhD. P.Eng. The drilling equipment was supplied and operated by Landcore Drilling Ltd. of Chelmsford, Ontario. The laboratory tests were conducted at the PML laboratory in Toronto. Chemical tests were carried out by AGAT Laboratories of Mississauga, Ontario. Surveying of borehole locations was performed by Callon Dietz Inc. of London, Ontario.

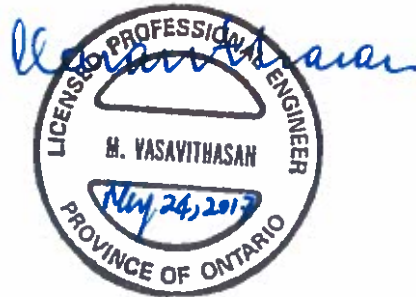
This report was prepared by Mr. L. Yimam, PhD, P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P. Eng. An independent review of the report was conducted by Mr. C. M. P. Nascimento, P. Eng., Project Manager and MTO Designated Principal Contact.

Yours very truly

Peto MacCallum Ltd.



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Part A – Foundation Investigation Report

Little Pitopiko River Culvert Replacement, Site No. 39W-133/C, Highway 11 - Sta. 24+200

Township of McMillan, Hearst, Ontario, GWP 5047-07-00, WP 5370-11-01, Index No.: 090FIR

PML Ref.: 16TF013A, May 24, 2017

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## **APPENDIX A**

Site Photographs



**Photograph P1:** View of the Inlet (South Side) of the Culvert, Looking East (July 26, 2016).





**Photograph P2:** View of the Outlet (North Side) of the Culvert (July 26, 2016).





**Photograph P3:** View of the Inlet (South Side) of the Culvert, Looking East (July 26, 2016).



## **APPENDIX B**

Borehole Location Plan and Soil Strata

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Curves – Figures 133-GS-1 and 133-GS-2

Plasticity Charts – Figures 133-PC-1 and 133-PC-2





## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**COMPOSITION:** SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 - 10	10 - 20	20 - 30	30 - 40	> 40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE
F V FIELD VANE	

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
$E$	kPa	MODULUS OF LINEAR DEFORMATION
$G$	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
$H$	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
$U$	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	$n$	1, %	POROSITY	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	$w$	1, %	WATER CONTENT	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	$S_r$	%	DEGREE OF SATURATION	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$w_L$	%	LIQUID LIMIT	$D$	mm	GRAIN DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_p$	%	PLASTIC LIMIT	$D_n$	mm	n PERCENT - DIAMETER
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_s$	%	SHRINKAGE LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	$h$	m	HYDRAULIC HEAD OR POTENTIAL
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	$q$	m <sup>3</sup> /s	RATE OF DISCHARGE
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	$v$	m/s	DISCHARGE VELOCITY
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	$i$	1	HYDRAULIC GRADIENT
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	$k$	m/s	HYDRAULIC CONDUCTIVITY
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	$j$	kN/m <sup>3</sup>	SEEPAGE FORCE
$e$	1, %	VOID RATIO						

**RECORD OF BOREHOLE No 16-133-01**

1 of 1

**METRIC**

G.W.P. 5047-07-00 LOCATION Co-ords: 5 515 252.5 N ; 254 871.7 E ORIGINATED BY K.D.  
DIST New Liskeard BOREHOLE TYPE Hollow Stem Augers, NW Casing and Wash Boring COMPILED BY L.Y.  
DATUM Geodetic HWY 11 DATE August 07, 2016 CHECKED BY M.V.

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED      + FIELD VANE												
								● QUICK TRIAXIAL      × LAB VANE												
258.0	Ground Surface						20	40	60	80	100					GR SA SI CL				
0.0	Silty sand to sandy silt trace to some gravel trace clay																			
	Compact      Brown      Moist to loose      to grey      to wet																			
	(FILL)		1	SS	18															
			2	SS	9															
			3	SS	9															
253.5	Sandy silt, some clay trace to some gravel																			
4.5	Dense to      Grey      Moist very dense		4	SS	55															
			5	SS	70															
			6	SS	48															
	(TILL)		7	SS	100/28cm															
			8	SS	100/23cm															
247.0	End of borehole		9	SS	100/20cm															
11.0	Samples 7, 8 & 9: Sampler bouncing																			

**RECORD OF BOREHOLE No 16-133-02**

1 of 1

**METRIC**

G.W.P. 5047-07-00 LOCATION Co-ords: 5 515 262.8 N ; 254 891.7 E ORIGINATED BY K.D.  
DIST New Liskeard BOREHOLE TYPE Hollow Stem Augers, NW Casing and Wash Boring COMPILED BY L.Y.  
DATUM Geodetic HWY 11 DATE August 08, 2016 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa										WATER CONTENT (%)	
							○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE								
258.2	Ground Surface						20	40	60	80	100					GR SA SI CL		
0.0	Silty sand to sandy silt trace to some clay trace gravel					▽*	258									2 45 43 10		
	Compact Grey Moist to loose		1	SS	7		257							○				
			2	SS	5		256							○				
	Silt trace sand, trace gravel		3	SS	2		255							○				
	Very loose Grey Moist to loose		4	SS	4		254							■ ○				
	(FILL)		5	SS	12		253							○				
	organic material, wood pieces rootlets						252							○ H			9 31 48 12	
252.9	Sandy silt, some clay trace to some gravel		6	SS	60		251							○				
5.3	Very dense Grey Moist		7	SS	53		250											
	(TILL)		8	SS	100/13cm	249							○					
					</													

**RECORD OF BOREHOLE No 16-133-03**

1 of 1

**METRIC**

G.W.P. 5047-07-00 LOCATION Co-ords: 5 515 243.4 N ; 254 882.5 E ORIGINATED BY K.D.  
DIST New Liskeard BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY L.Y.  
DATUM Geodetic HWY 11 DATE August 07, 2016 CHECKED BY M.V.

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/m³	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 (%)														
254.8	Ground Surface																		
0.0	Organic silt topsoil and rootlets inclusions		1	SS	4	▽*	254												
	Loose      Brown      Moist (ALLUVIUM)		2	SS	2												118		
			3	SS	9		253												
252.6	Sandy silt, some clay trace to some gravel		4	SS	42		252												
2.2	Hard      Grey      Moist		5	SS	50		251												
	(TILL)		6	SS	67		250												
			7	SS	90		249												
			8	SS	80		248												
			9	SS	100/25cm		247												
246.8	End of borehole																		
8.0	Samples 7, 8 & 9: Sampler bouncing																		
	*    2016   08   07																		
	▽    Water level observed during drilling																		

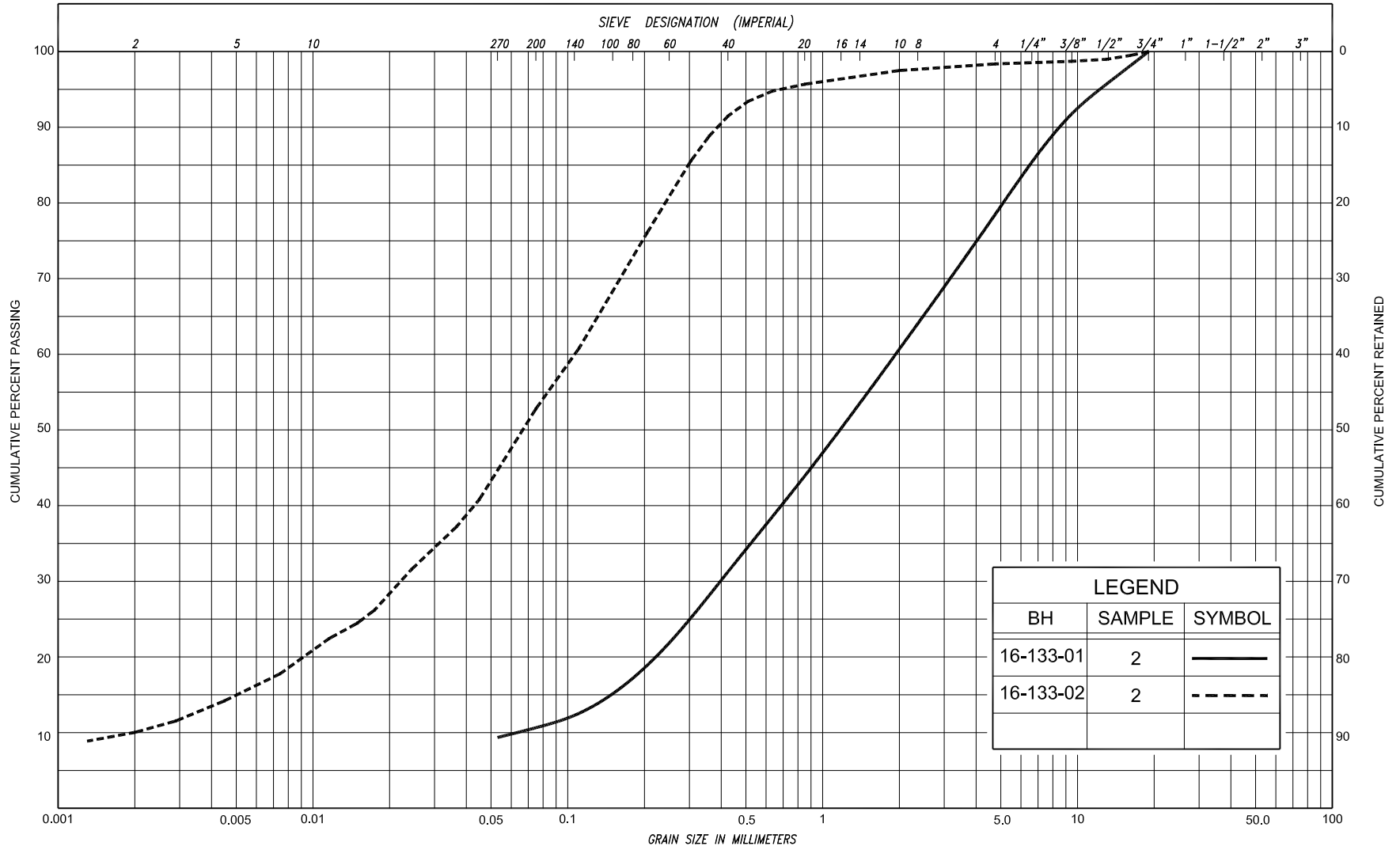
# RECORD OF BOREHOLE No 16-133-04

1 of 1

METRIC

G.W.P.	5047-07-00	LOCATION	Co-ords: 5 515 274.1 N ; 254 871.7 E	ORIGINATED BY	K.D.
DIST	New Liskeard	BOREHOLE TYPE	Hollow Stem Augers, NW Casing and Wash Boring	COMPILED BY	L.Y.
DATUM	Geodetic HWY 11	DATE	August 08, 2016	CHECKED BY	M.V.

[illegible]



SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED
				SAND									
CLAY	FINE	MEDIUM	COARSE	FINE		MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.
	SILT			SAND									
CLAY		SILT		V. FINE	FINE	MED.	COARSE	GRAVEL					U.S. BUREAU
				SAND									

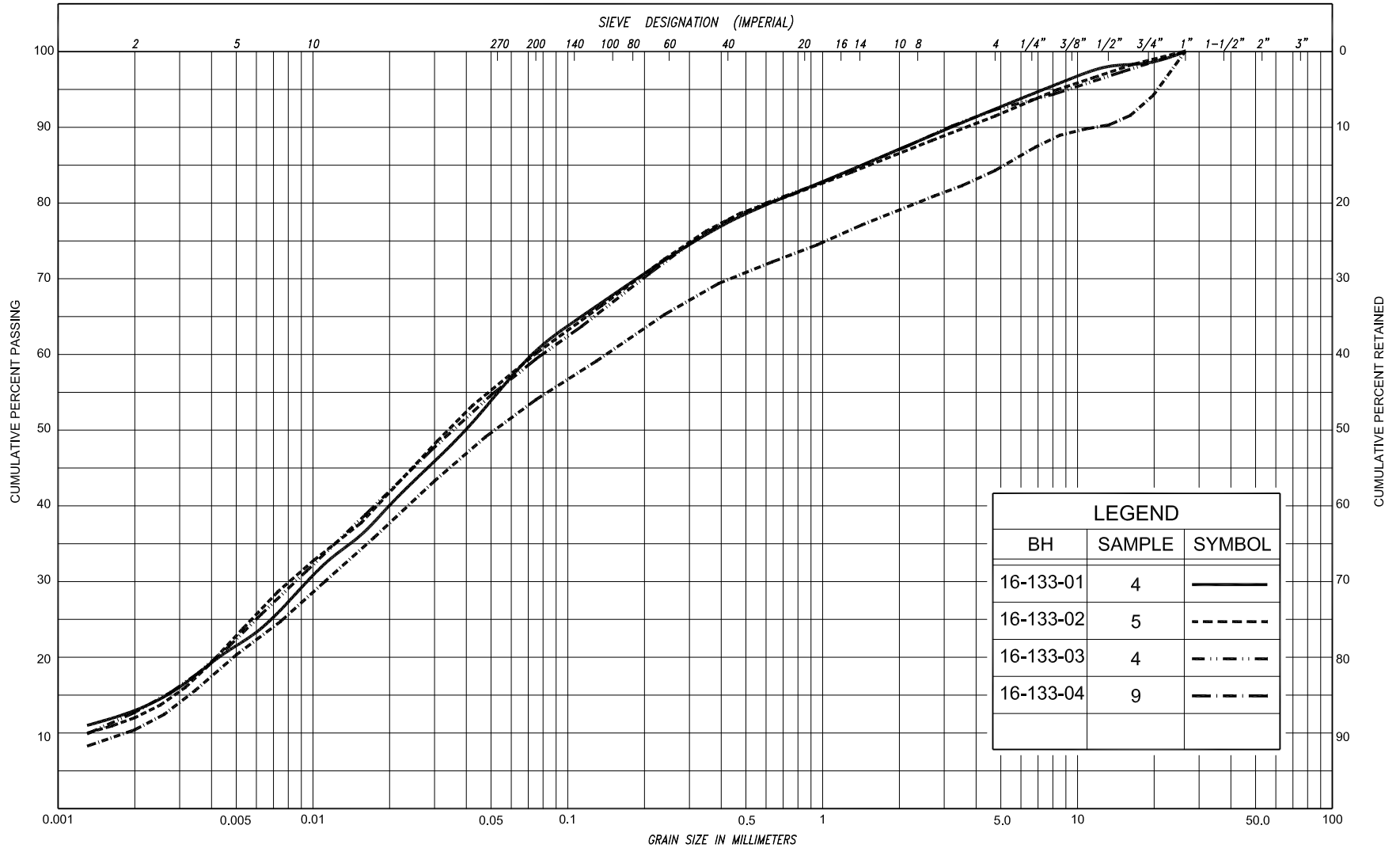


# GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT, trace to some gravel (FILL)

FIG No. 133-GS-1

HWY 11

G.W.P. 5047-07-00



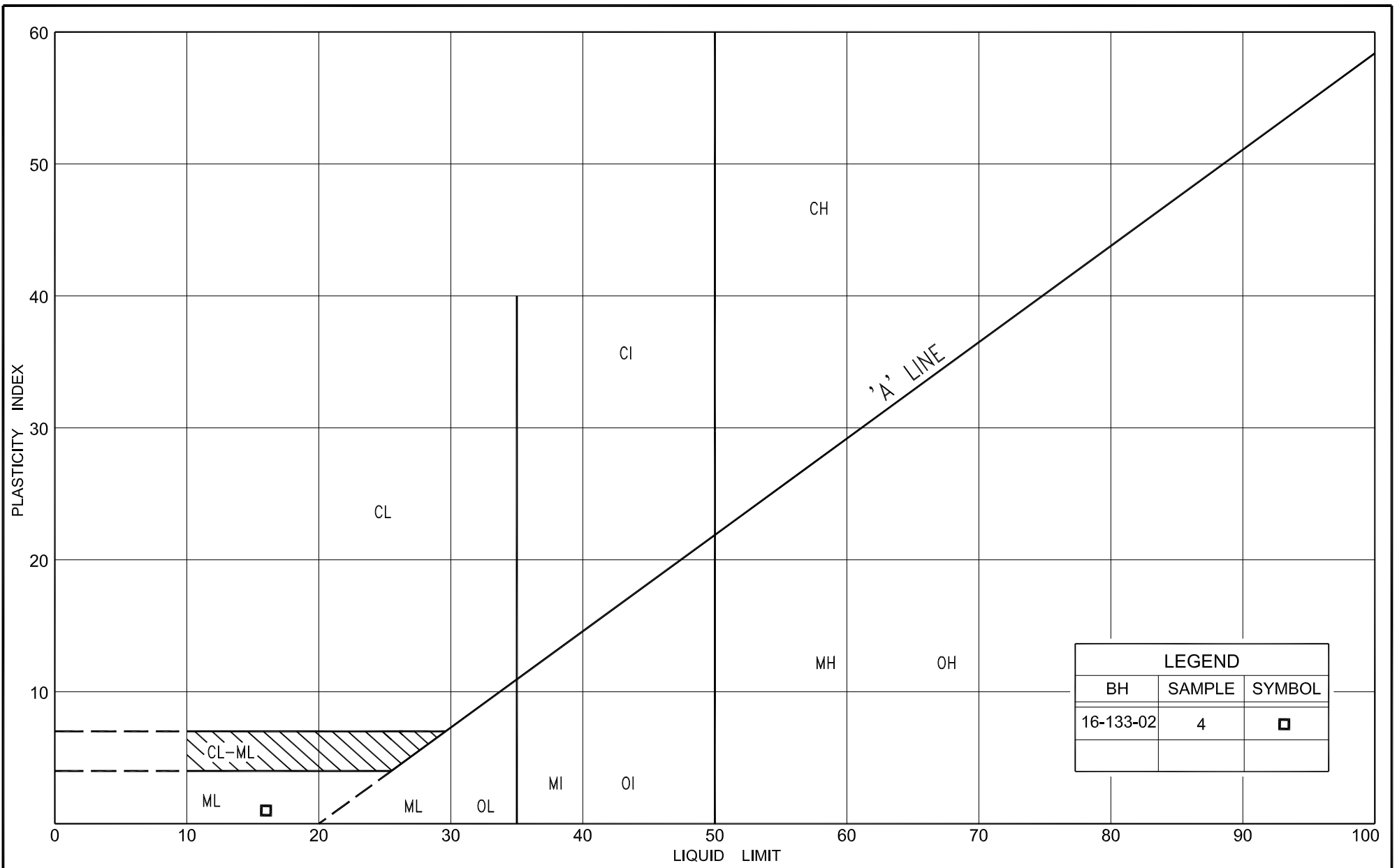
SILT & CLAY				FINE		MEDIUM		COARSE	GRAVEL			COBBLES	UNIFIED			
				SAND												
CLAY	FINE		MEDIUM	COARSE	FINE		MEDIUM	COARSE		GRAVEL			COBBLES	M.I.T.		
	SILT										GRAVEL					
CLAY		SILT		V. FINE	FINE	MED.	COARSE								U.S. BUREAU	
				SAND												



## GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand, trace to some gravel

FIG No. 133-GS-2  
 HWY 11  
 G.W.P. 5047-07-00



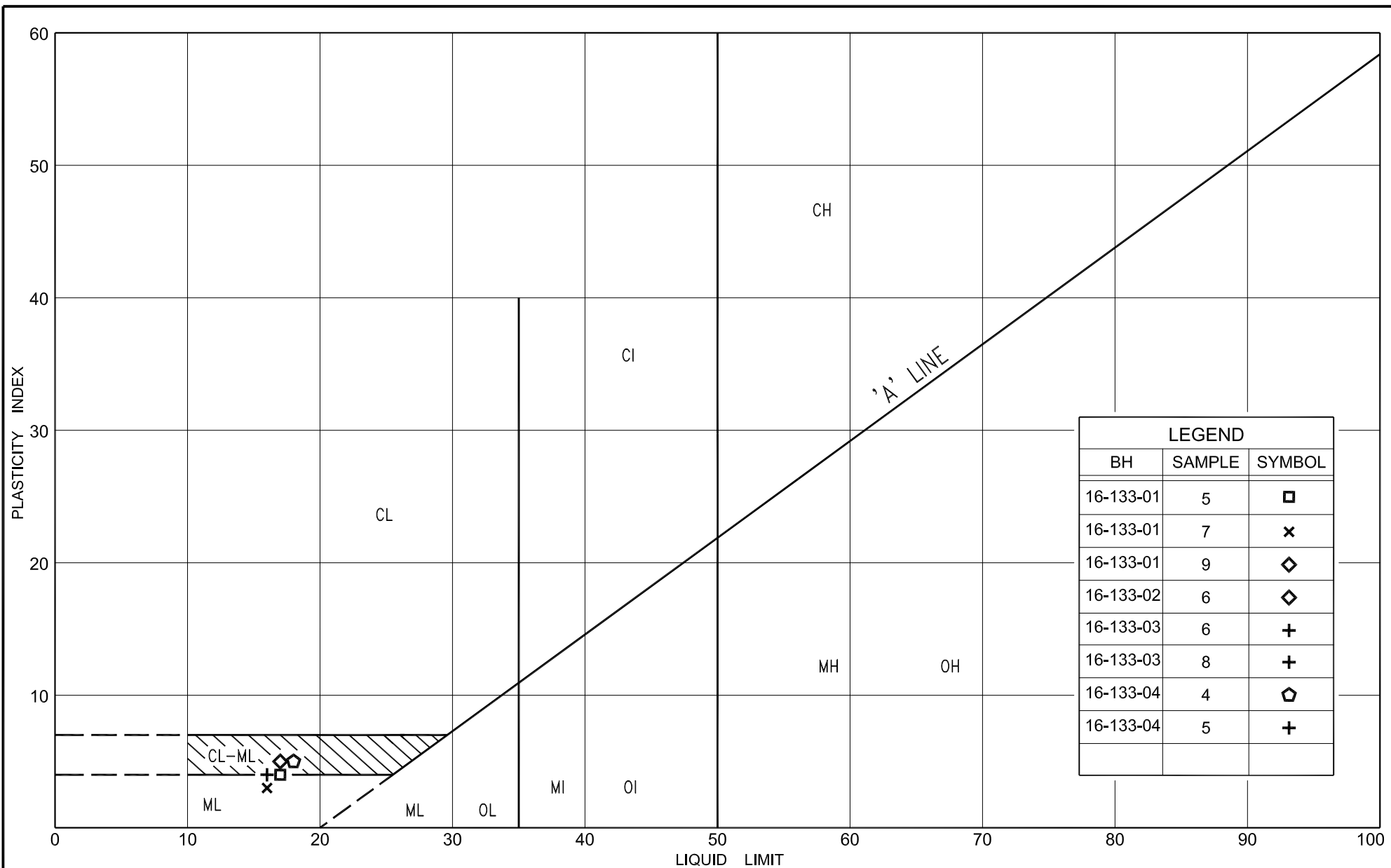
# PLASTICITY CHART SILT, trace sand (ML) (FILL)

FIG No. 133-PC-1

HWY 11

G.W.P. 5047-07-00





**PLASTICITY CHART**  
 SANDY SILT, some clay, trace to some gravel (CL-ML)  
 (TILL)

FIG No. 133-PC-2

HWY 11

G.W.P. 5047-07-00



## **APPENDIX C**

### Results of Chemical Corrosivity Tests



**AGAT** Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 16T131831

PROJECT: 16TF013A

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

CLIENT NAME: PETO MACCALLUM LIMITED

SAMPLING SITE:

ATTENTION TO: Lul Yimam

SAMPLED BY: Kyle Daly

### Corrosivity Package

DATE RECEIVED: 2016-08-29

DATE REPORTED: 2016-09-07

				BH16-004-02	BH16-008-03	BH16-112-04	BH16-131-04	BH16-133-02
SAMPLE DESCRIPTION:				SS7	SS7	SS4A	SS4	SS3
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Parameter	Unit	G / S	RDL	7813058	7813065	7813066	7813067	7813068
Chloride (2:1)	µg/g		2	16	7	159	44	559
Sulphate (2:1)	µg/g		2	62	47	43	3	14
pH (2:1)	pH Units		NA	8.44	8.56	8.07	8.61	8.37
Electrical Conductivity (2:1)	mS/cm		0.005	0.216	0.167	0.441	0.179	0.986
Resistivity (2:1)	ohm.cm		1	4630	5990	2270	5590	1010
Redox Potential (2:1)	mV		5	258	249	261	243	254

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

**7813058-7813068** EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:

*Amanjot Bhela*

## Quality Assurance

CLIENT NAME: PETO MACCALLUM LIMITED

PROJECT: 16TF013A

SAMPLING SITE:

AGAT WORK ORDER: 16T131831

ATTENTION TO: Lui Yimam

SAMPLED BY: Kyle Daly

### Soil Analysis

RPT Date: Sep 07, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

#### Corrosivity Package

Chloride (2:1)	7813068	7813068	559	551	1.4%	< 2	91%	80%	120%	102%	80%	120%	104%	70%	130%
Sulphate (2:1)	7813068	7813068	14	14	0.0%	< 2	96%	80%	120%	102%	80%	120%	101%	70%	130%
pH (2:1)	7813068	7813068	8.37	8.29	1.0%	NA	101%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	7813068	7813068	0.986	0.986	0.0%	< 0.005	100%	90%	110%	NA			NA		
Redox Potential (2:1)	7813068	7813068	254	254	0.0%	< 5	103%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

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

Certified By:



## Method Summary

CLIENT NAME: PETO MACCALLUM LIMITED

AGAT WORK ORDER: 16T131831

PROJECT: 16TF013A

ATTENTION TO: Lui Yimam

SAMPLING SITE:

SAMPLED BY: Kyle Daly

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
<b>Soil Analysis</b>			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	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-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE



**AGAT** Laboratories

## Certificate of Analysis

AGAT WORK ORDER: 16T165347

PROJECT: 16TF013A

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

CLIENT NAME: PETO MACCALLUM LIMITED

SAMPLING SITE: Hearst, Ontario

ATTENTION TO: Lul Yimam

SAMPLED BY: Kyle Daly

### Corrosivity Package

DATE RECEIVED: 2016-11-29

DATE REPORTED: 2016-12-06

SAMPLE DESCRIPTION: 16-133-1,SS4

SAMPLE TYPE: Soil

DATE SAMPLED: 2016-08-07

Parameter	Unit	G / S	RDL	8051428
Chloride (2:1)	µg/g		2	139
Sulphate (2:1)	µg/g		2	8
pH (2:1)	pH Units		NA	8.65
Electrical Conductivity (2:1)	mS/cm		0.005	0.348
Resistivity (2:1)	ohm.cm		1	2870
Redox Potential (2:1)	mV		5	292

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

8051428 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:





## Quality Assurance

CLIENT NAME: PETO MACCALLUM LIMITED

PROJECT: 16TF013A

SAMPLING SITE: Hearst, Ontario

AGAT WORK ORDER: 16T165347

ATTENTION TO: LuI Yimam

SAMPLED BY: Kyle Daly

### Soil Analysis

RPT Date: Dec 06, 2016			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	
								Lower	Upper		Lower	Upper

#### Corrosivity Package

Chloride (2:1)	8048321		45	45	0.6%	< 2	99%	80%	120%	101%	80%	120%	102%	70%	130%
Sulphate (2:1)	8048321		31	32	2.8%	< 2	96%	80%	120%	102%	80%	120%	102%	70%	130%
pH (2:1)	8051428	8051428	8.65	8.59	0.7%	NA	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	8050228		0.208	0.208	0.0%	< 0.005	99%	90%	110%	NA			NA		
Redox Potential (2:1)	8051428	8051428	292	290	0.8%	< 5	101%	70%	130%	NA			NA		

Comments: NA signifies Not Applicable.

Certified By: \_\_\_\_\_



## Method Summary

CLIENT NAME: PETO MACCALLUM LIMITED

AGAT WORK ORDER: 16T165347

PROJECT: 16TF013A

ATTENTION TO: Lui Yimam

SAMPLING SITE: Hearst, Ontario

SAMPLED BY: Kyle Daly

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	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-93-6036	McKeague 4.12, SM 2510 B	EC METER
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B, SSA #5 Part 3	CALCULATION
Redox Potential (2:1)		McKeague 4.12 & SM 2510 B	REDOX POTENTIAL ELECTRODE





**PART B – FOUNDATION DESIGN REPORT**

**for**

**LITTLE PITOPIKO RIVER CULVERT REPLACEMENT**

**SITE NO. 39W-133/C**

**HIGHWAY 11 - STA. 24+200**

**TOWNSHIP OF McMILLAN, DISTRICT OF NEW LISKEARD**

**HEARST, ONTARIO**

**ASSIGNMENT NO. 5015-E-0009**

**GWP 5047-07-00**

**WP 5370-11-01**

PETO MacCALLUM LTD.  
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**Distribution:**

- 3 cc: GHD Ltd. for distribution to MTO  
Project Manager + 1 digital copy (pdf)
- 1 cc: GHD Ltd. for distribution to MTO  
Foundations Section + 1 digital copy (pdf)
- 1 cc: GHD Ltd. + 1 digital copy (pdf)
- 1 cc: PML Toronto
- 1 cc: PML Kitchener

PML Ref.: 16TF013A  
Index No.: 091FDR  
GEOCRES No.: 42F-048  
May 24, 2017



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APPENDIX D – List of Ontario Provincial Standard Documents Relevant to the Project and  
 Non-Standard Specific Provison (NSSP)

**PART B – FOUNDATION DESIGN REPORT**

Little Pitopiko River Culvert Replacement

Site No. 39W-133/C

Highway 11 - Station 24+200

Township Of McMillan, District of New Liskeard

Hearst, Ontario

Assignment No. 5015-E-0009, GWP 5047-07-00, WP 5370-11-01

---

**10. INTRODUCTION**

This report provides foundation design recommendations based on the interpretation of the geotechnical data presented in the factual report (Part A) to assist the design team in the selection of a suitable type of foundation for the culvert replacement at the crossing of Highway 11 and Little Pitopiko River, approximately at Sta. 24+200, in the Township of McMillan, District of New Liskeard.

This foundation design report with the interpretation and recommendations are intended for the use of GHD Ltd. (GHD) on behalf of the Ministry of Transportation of Ontario (MTO), and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data provided in the foundation investigation report (Part A). Where comments are made in this report on construction, they are provided only to highlight aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual data, as it may affect equipment selection, proposed construction methods, and scheduling.

**11. PROJECT DESCRIPTION**

**11.1 General**

The discussions and recommendations presented in this report are based on the data obtained from the geotechnical investigation carried out by PML, and the information given in the General Arrangement (GA) drawing provided by GHD, dated April, 2017. The list of Ontario Provincial Standard Specifications (OPSSs) and Ontario Provincial Standard Drawings (OPSDs) cited in this report is provided in Appendix D.



## **11.2 Existing Culvert**

The existing structure is a triple cell rectangular timber culvert. According to the Request for Quotation (RFQ), the two barrels on the west have a width of 2.1 m each, and the east barrel is about 1.7 m wide. The height of the culvert is 1.6 m and the length is 27.0 m. The fill above the deck is about 2.5 m high. The culvert was constructed in 1958 and has no record of rehabilitation.

According to the Ontario Structure Inspection Manual (2015), the condition of the existing culvert is fair. Generally, timber staining, molding, splitting and cracking was observed along the walls and the soffit. The culvert deck appeared to be slightly curved on the south side.

The embankment slopes on both sides of the culvert are well vegetated with brush and trees, and the embankments appear in good condition with no sign of sloughing or erosion of slopes.

The foundation details of the existing timber culvert are not available. However, considering the width of the culvert and the fill height above the deck, the load imposed by the each cell of the existing culvert at the founding level may not exceed 120 to 140 kN per meter length of the culvert.

## **11.3 Proposed Culvert**

The existing timber culvert will be replaced by a 6.0 m span, 2.0 m high and 32 m long precast concrete box structure. The fill height above the replacement culvert will be about 2.3 m.

According to the GA drawing, there will be no grade raise or widening of road resulting from the culvert replacement, and the finished grade of the highway will remain at about El. 258 m.

The proposed culvert invert at inlet and outlet will be at El. 253.9 m and 253.8 m, respectively.

## **11.4 Foundation Conditions**

In summary, the subsurface at the road shoulder consists of 4.5 m to 5.3 m thick silty sand to sandy silt fill, followed by dense to very dense sandy silt till deposit. The till deposit was encountered below El. 253.5 m to El. 252.9 m, and extends to the full depth of investigation of El. 247 m.

At the inlet and outlet, the till was overlain by a layer of alluvium consisting of organic silt and trace gravel, wood pieces, rootlets, and topsoil inclusions.



Groundwater was encountered in all boreholes between El. 255 m and El. 253 m. The groundwater level at the site is thought to be influenced by the flow condition of the Little Pitopiko River. It may also fluctuate due to the influence of seasonal changes of precipitation.

## **12. CULVERT REPLACEMENT OPTIONS**

The feasibility of the following three options for replacing the existing culvert along the same vertical alignment are discussed in this report.

- Precast concrete box culvert
- Cast-in-place (CIP) concrete box culvert
- Three sided open footing precast concrete culvert

A discussion on these options are provided below in the order of preference. A comparison of the technical advantages and disadvantages for the replacement culvert are provided in Table 12.

### **12.1 Option 1: Precast Concrete Box Culvert**

Based on the comparison provided in Table 12, the use of precast concrete box culvert founded on the sandy silt till deposit, below El. 253.5 m, is feasible and recommended for the replacement structure. Recommendations for the design of the preferred option are provided in Section 12.4.

### **12.2 Option 2: Cast-In-Place Reinforced Concrete Box Culvert**

The sandy silt till deposit is capable of providing adequate geotechnical resistance to support a cast-in place (CIP) reinforced concrete box culvert. The CIP concrete box culvert may be designed using a geotechnical resistance of 300 kPa at factored Ultimate Limit State (ULS) and 200 kPa at Serviceability Limit State (SLS) if the structure is founded on the undisturbed sandy silt till. A cut-off wall may be required to prevent washout or undermining of the subgrade.

However, if this option is considered, construction under about 2.0 m of groundwater will impose greater difficulties, and a dewatering scheme should be used to provide a working platform for form work and placing concrete. The dewatering to construct the culvert in dry conditions will be a major concern. In view of construction difficulties, this option is not preferred.



**Table 12 - Comparison of Alternate Culvert Options**

<b>OPTION 1: PRECAST CONCRETE BOX CULVERT</b>	<b>OPTION 2: CAST IN-PLACE CONCRETE BOX CULVERT</b>	<b>OPTION 3: THREE-SIDED PRECAST OPEN CULVERT</b>
<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. High degree of quality and uniformity, design flexibility, superior strength and durability</li> <li>2. Reduced weather dependency during installation</li> <li>3. Reduced impact on traffic interruption;</li> <li>4. Ease of construction and installation in wet conditions is possible</li> <li>5. Better at accommodating differential settlements than cast-in-place culverts</li> </ol>	<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. Reduces uneven settlement</li> <li>2. Reduces water leakage and deterioration of culvert</li> <li>3. Ability to withstand differential settlements;</li> <li>4. Longer life span of the structure</li> <li>5. Degradation of subgrade can be avoided by placing lean concrete</li> </ol>	<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. High degree of quality and uniformity, design flexibility, superior strength and durability</li> <li>2. Generally allows for natural streambed to remain intact;</li> <li>3. Less accumulation of sediments in the upstream of channel</li> <li>4. Reduced weather dependency during installation</li> <li>5. Easier construction and installation than cast-in-place culvert</li> </ol>
<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Natural stream bed will not remain intact;</li> <li>2. Cause sediment accumulation in the upstream of the channel;</li> <li>3. Possibility for degradation of subgrade.</li> </ol>	<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Natural stream bed will not remain intact;</li> <li>2. Cause sediments accumulation in the upstream of the channel;</li> <li>3. Weather dependent during construction;</li> <li>4. Major dewatering scheme is required to construct the floor slab under 1 m high water.</li> </ol>	<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Potential for scour;</li> <li>2. Probability of uneven or differential settlements is high;</li> <li>3. Limited ability to withstand differential settlements.</li> </ol>
<b>Cost of Construction:</b> Total Cost \$ 14,000/m	<b>Cost of Construction:</b> Total Cost \$ 15,000/m	<b>Cost of Construction:</b> Total Cost \$ 14,500/m
<b>Recommended</b>	<b>Technically Feasible but Not Recommended</b>	<b>Technically Not Feasible and Not Recommended</b>



### **12.3 Option 3: Three-Sided Open Footing Precast Concrete Culvert**

The sandy silt till at the founding level may be susceptible to scour. Section C1.9.11.1 of the CHBDC, 2014 suggests avoiding the use of open footing on material susceptible to scour. The till may provide adequate geotechnical resistance required to support three-sided open footings, but placing the culvert may involve some excavation and dewatering to obtain the preferred dry condition. For these reasons, this option is not recommended.

### **12.4 Recommendations for Preferred Option**

The GA drawing indicates the proposed precast concrete box culvert will be placed at El. 253.5 m. The bedding is, therefore, expected to be on dense to very dense sandy silt till capable of providing adequate geotechnical resistance. Bedding for the precast concrete box culvert should be in accordance with OPSS 422.07.08, and may consist of 300 mm thick granular material, including the 75 mm leveling course required by OPSS 422. Bedding should be as specified in OPSS 422.05.13, and should also be placed in accordance with OPSS 422.07.07.

As required by Clauses 1.9.5.6 and 1.9.11.6.5 of the Canadian Highway Bridge Design Code (CHBDC, 2014), cut-off walls should be provided at both ends of the proposed precast concrete box culvert replacement. Cut-off walls should be in accordance with OPSD 812.010 or made of precast concrete with similar dimensions to prevent washout of granular bedding. The cut-off walls should be extended to a minimum of 1.2 m below the invert elevation.

A factored geotechnical resistance at ULS of 300 kPa and at SLS of 200 kPa should be used for the design of the proposed precast concrete box culvert. The geotechnical resistance at SLS is higher than the load currently imposed by the existing culvert. Therefore, there will be no net increase in the load conditions to induce significant settlement.

If the proposed culvert is placed beyond the existing foundation limit, site preparation may cause disturbance to the founding surface. In addition, the sandy silt till at the founding level will be susceptible to disturbance from construction traffic and any ponded water. In order to limit the degradation of the founding soil, it is recommended that the granular bedding be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade.



### **13. LATERAL EARTH PRESSURE**

The earth pressure for concrete structures should be computed as per Clause 6.12.2 (b) of CHBDC, 2014. Sufficient movement of the structure wall may not be permitted for all options discussed above and “at rest” conditions may be assumed to compute earth pressure. The earth pressure calculation should include maximum water level expected in the Little Pitopiko River.

The lateral earth and water pressure,  $p$  (kPa), may be computed using the equivalent fluid pressures presented in Section 6.12 of the CHBDC, 2014, or by employing the following equation assuming a triangular pressure distribution.

$$p = K (\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2 + C_p + C_s$$

Where,

$P$  = Lateral earth pressure (kPa)

$K$  = Lateral earth pressure coefficient

$\gamma$  = Unit weight of backfill material above design water level (kN/m<sup>3</sup>)

$\gamma'$  = Unit weight of submerged backfill ( $\gamma - \gamma_w$ ) material below design water level (kN/m<sup>3</sup>)

$\gamma_w$  = Unit weight of water (9.8 kN/m<sup>3</sup>)

$h_1$  = Depth below final grade above design water level (m)

$h_2$  = Depth below design water level (m)

$q$  = Surcharge load (kPa)

$C_p$  = Compaction pressure, kPa (refer to Clause 6.12.3 of CHBDC, 2014)

$C_s$  = Earth pressure from seismic events, kPa (refer to Clause 4.6.5 of CHBDC, 2014)

Granular ‘A’ or ‘B’ should be utilized as backfill material and should be carried out in accordance with the requirements specified in the OPSS 902. Table 14 provided the recommended earth pressure coefficients for granular backfill.





**Table 14 - Earth Pressure Coefficients**

<b>GEOTECHNICAL PARAMETER</b>	<b>OPSS GRANULAR A and GRANULAR B TYPE II</b>
Angle of Internal Friction, degrees	35°
Unit Weight ( $\gamma$ ), kN/m <sup>3</sup>	22.5
Coefficient of Active Earth Pressure ( $K_a$ )	0.27
Coefficient of Earth Pressure at Rest ( $K_o$ )	0.43
Coefficient of Passive Earth Pressure ( $K_p$ )	3.69

#### **14. APPROACH EMBANKMENT**

The height of the existing approach fill is approximately 4.1 m above the river bed. As stated earlier, it is understood there will be no increase in the profile grade of the highway. Based on the GA drawing, there will also be no significant change in the slope of the embankment. The assessment of the existing slope during site investigation indicated the embankment is performing well with no signs of instability, such as cracking or ravelling. Hence no major instability problems are anticipated for the replacement embankment constructed with 2H:1V side slopes.

The embankment fill may consist of suitable earth or granular fill. The fill below water table should consist of well compacted granular material, preferably Granular B Type II. Any unstable or organic deposits at the base of the embankment should be removed before placing the fill.

Rip-rap should be provided on both the upstream and downstream sides of the river to protect the toe of the embankments and to prevent erosion of the river bed in the proximity of the culvert. Rip-rap shall be placed in accordance with OPSD 810.010 and provided to a minimum height of 1.0 m above the high flood level expected in the Little Pitopiko River.

#### **15. BACKFILL AND COVER MATERIAL**

Backfill materials shall meet the requirements of Group I or Group II specified in OPSS 422.05.14, and placed according to the procedures described in Section 422.07.11. It shall be placed in layers not exceeding 200 mm in thickness before compaction and compacted in accordance with OPSS 501. Backfill on each side of the box culvert shall be completed simultaneously and at no



time, the levels on each side of the culvert exceed more than 400 mm. Restrictions on compaction near the culvert shall be as specified in OPSS 902.07.06.02.

Cover material required at the site, as in the case of backfill, should meet the requirements of OPSS 422.05.14 and placed in accordance with OPSS 422.07.12.

## **16. FOUNDATION FROST DEPTH**

In accordance with OPSD 3090.100, a minimum of 2.6 m earth cover is required to protect cast-in-place open footing culverts against the frost penetration in the area where the site is located.

Frost tapers within any granular backfill should be constructed in accordance with OPSD 3101.150.

## **17. SEISMIC CONSIDERATIONS**

The Spectral and Peak Ground Accelerations ( $S_a(0.2)$  and PGA) for the project site, based on the Town of Hearst, Ontario, and for the 2% in 50 year probability of exceedance, is 0.060 and 0.035, respectively (National Building Code of Canada, 2015). The Reference Peak Ground Acceleration ( $PGA_{ref}$ ) based on these  $S_a(0.2)$  and PGA values is 0.028. The soil at the site for seismic design purposes is classified as Type D in accordance with Clause 4.4.3.2 of CHBDC, 2014.

## **18. CONSTRUCTION CONSIDERATIONS**

### **18.1 Staged Construction**

It is understood that no detour is planned for the diversion of traffic during the construction. The construction of replacement precast concrete box culvert will be carried out in two stages by allowing the traffic to use one side of the highway with the aid of a temporary traffic signal. This will require a properly designed roadway protection system along the centerline of the road.

The sandy silt till below about El. 253.0 m will impose difficulty to drive sheet piles to adequate depth of embedment. Hence, sheet piles may have to be equipped with driving shoe to penetrate through dense to very dense glacial till. Alternatively, the use of soldier piles with timber lagging supported by anchors or struts may be considered to construct a shoring system. The soldier piles may be lowered in pre-augured holes and filled with non-shrinkable grout. Care should be taken to



prevent the loss of granular fill through voids while placing the timber lagging. However, it should be noted that the use of soldier piles will be costly for a culvert construction.

The Non-Standard Special Provision (NSSP) provided in the Appendix D should be included in the contract document to alert the contractor.

Alternatively, a two-lane detour or a single lane detour with temporary traffic signals and a river bypass system may be utilized to maintain the traffic on highway. If this option is considered, an additional foundation investigation may be required.

Temporary shoring or roadway protection system shall be designed and constructed to meet a Performance Level of 2 according to OPSS 539. The soil parameters given in Table 18.1 may be used for the design of the roadway protection system.

**Table 18.1 – Soil Parameters**

ELEVATION (m)		SOIL TYPE	SOIL PARAMETERS		
FROM	TO		FRICTION ANGLE ( $\phi^\circ$ )	UNIT WEIGHT ( $\gamma$ ) kN/m <sup>3</sup>	C <sub>u</sub> , (kPa)
258	253.5	Silty Sand to Sandy Silt Fill	30	18	-
253.5	247	Dense to Very Dense Sandy Silt Till, Some Clay and Trace to Some Gravel	32	20	-

**Note:** Submerged unit weight should be used below water level.

## 18.2 Excavation

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects. The protection system for excavations should follow OPSS 539, Construction Specification for Temporary Protection Systems, and OPSS 902, Construction Specifications for Excavating and Backfilling – Structures.



Excavation of the soils at the structure location should be feasible using conventional excavation equipment. All excavated surfaces should be kept free of frost and water during the period of construction. Runoff should be directed away from open excavations and should not be allowed to flow across slope faces. Excavated material shall not be stockpiled on top of the excavation.

Based on the record of boreholes, the excavations for the construction of replacement culvert will be advanced through existing embankment fill material. For OHSA classification purposes, the fill materials should be classified as Type 3 soils and the sandy silty till material should be considered as Type 2 soils. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation.

### **18.3 Groundwater Control**

The groundwater level at the site varied between El. 255 m and El. 253 m and excavation to the founding level may have to be carried out under 2 m high water level. Groundwater levels are subject to seasonal fluctuations. The groundwater level should be lowered to a minimum of 0.5 m below the proposed founding levels to allow construction in-the-dry and place bedding materials.

The Little Pitopiko River may have to be temporarily diverted and a cofferdam may be required to maintain a dry work environment. A cofferdam consisting of sand bags and clay puddle may be constructed by damming the upstream and downstream of the culvert. Dewatering may be carried out by pumping from the sumps located along the periphery of the cofferdam.

If restrictions are imposed on placing clay puddle in the river, the culvert replacement may have to be constructed under the prevailing water level. If the construction is carried out under water, the backfill material shall consist of Granular B Type II containing particle sizes not finer than 75 µm. Construction in-the-wet can be done by excavating without dewatering, overbuilding the levelling course/bedding and compacting, then trimming to the required top of bedding elevation.

For the construction in the dry, the contractor should be responsible for selection, performance and detailed design of the dewatering system including the cofferdam. The dewatering system should be designed to conform to the requirement of OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation) and OPSS 518 (Construction Specification



for Control of Water from Dewatering Operations). In addition to these standard specifications, Non-Standard Specific Provisions (NSSP) provided in Appendix D, should also be followed.

In accordance with the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment is required if the dewatering discharge is greater than 50,000 L/day. The expected daily flows at the culvert location should be assessed to determine if this permit will be necessary. It may be prudent to obtain the PTTW to avoid delays should the PTTW become necessary during construction.

In addition, construction site dewatering involving between 50,000 L/day (13,208 gal/day) and 400,000 L/day (105,668 gal/day) will require registration in the Environmental Activity and Sector Registry (EASR) under water taking EASR Regulation 63/16.

## **19. EROSION CONTROL**

Generally, the measures provided in the OPSD 800 series (inlet/outlet treatment, headwalls, cut-off walls etc.) need to be considered to prevent the effect of erosion after the culvert is replaced.

Further, inlet and outlet protection in accordance with OPSS 511 (Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting), OPSS. PROV 1004 (Material Specification for Aggregates) and OPSD 810.010 (General Rip-Rap Layout Sewer and Culvert Outlets) is recommended to prevent erosion adjacent to the culvert as well as scour.

Clay seals at the inlet shall be in conformance with OPSS 1205 (Material Specification for Clay Seal) and extend over the area defined under rock protection.

Where embankments are composed of earth, they should be covered with topsoil or suitable excess earth material from swamps or muskeg areas and seeded in accordance with OPSS 802 (Construction Specification for Topsoil) and OPSS 804 (Construction Specification for Topsoil) as soon as grading is completed to prevent erosion and material degradation.



## **20. SOIL CORROSIVITY**

Representative samples of the silty sand and sandy silt fill and sandy silt till were tested for soil corrosivity and potential exposure of concrete to sulphate attack. A summary of the chemical test results are provided in Table 8 of Part A of this report. As shown in this table, the sulphate contents of both samples are relatively low (14 µg/g and 8µg/g), and the values suggest that potential for sulphate attack will be mild. According to Clause 4.1.1.6 of the Canadian Standards Association (CSA) standard A23.1-14, soluble sulphate concentrations less than 0.1% (1000 µg/g) generally indicate a low degree of sulphate attack when concrete is in contact with soil or groundwater.

However, the chloride content provided in Table 8 (556 µg/g and 139 µg/g) suggests the presence a corrosive environment for buried metal or reinforcing steel. The chloride concentration in the sandy silt till (139 µg/g or 139 ppm) is less than 250 ppm, and this indicates the potential for a strong corrosive environment. For corrosive environment to steel, it is generally recognised that the chloride concentration should be below 250 µg/g (250 ppm).

Further, a resistivity value of less than 2000 ohm-cm is generally considered corrosive for soil in contact with steel. The resistivity values provided in Table 8 for the till (2870 ohm-cm) is slightly higher than 2000 ohm-cm, and indicates a moderately corrosive environment for buried metal.

The pH value in Table 8 (8.65) is within the normal range expected for soil pH.

Generally, no sulphate attack is expected from selected backfill materials. However, it may be advisable to test backfill material for corrosion potential if it is imported from unknown sources.



## 21. CLOSURE

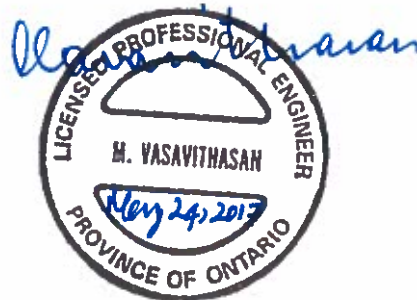
This report was prepared by Mr. L. Yimam, PhD. P.Eng., and reviewed by Mr. M. Vasavithasan, M.Sc. Eng., P. Eng.. An independent review of the report was conducted by Mr. C. M. P. Nascimento, P. Eng., Project Manager and MTO Designated Principal Contact.

Yours very truly

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## **APPENDIX D**

List of Ontario Provincial Standard Documents Relevant to the Project  
and Non-Standard Specific Provision (NSSP)





### LIST OF STANDARD SPECIFICATIONS RELEVANT TO THE REPORT

DOCUMENTS	TITLE
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS 501	Construction Specification for Compacting
OPSS 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS 517	Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 518	Construction Specification for Control of Water from Dewatering Operations
OPSS 539	Construction Specification For Temporary Protection Systems
OPSS 802	Construction Specification for Topsoil
OPSS 804	Construction Specification for Seed and Cover
OPSS 902	Excavation and Backfilling of Structures
OPSS 1205	Material Specification for Clay Seal
OPSS.PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSD 800 Series	Inlet/Outlet Treatment, Headwalls, Cut off Wall, etc.
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 812.010	Cut off Wall for Structural Plate Pipe Arch and Circular CSP
OPSD 3090.100	Foundation Frost Depth for Northern Ontario
OPSD 3101.150	Walls Abutment, Backfill Minimum Granular Requirement



## **NON-STANDARD SPECIAL PROVISIONS (NSSP)**

### **NSSP 1 – Surface Water Control and Dewatering (Addition to OPSS 518)**

The contractor shall take measures for necessary surface water diversions and drainage and to lower the prevailing groundwater level a minimum of 0.5 m below the base of the excavations for work in-the-dry in the overburden materials.

The fill and sandy till expected within the depth of excavation consist of significant amount of sand and are relatively pervious. The presence of some clay both in the fill and till means the permeability of these soils varies from low to medium depending on the percentage of fines. Generally, in view of the relatively pervious subsoil conditions, the dewatering design and the implementation should prevent unsafe conditions, such as sloughing and boiling under unbalanced groundwater conditions. In addition to designing and implementing measures for surface water control and dewatering, the contractor is also advised that damming of the drain and diversion of the flow by pumping through temporary conduits for construction staging will likely be required at this site.

### **NSSP 2 – Excavations and Slope Stability (Addition to OPSS 902 and OPSS 539)**

The contractor is advised that the subsoils at this site require careful design for excavation including fill slope geometries and shoring schemes for the removal of part of the existing timber culverts and to maintain the stability of the culvert that will be left in place for diversion of traffic. The Contractor is also advised to restrict the stockpiling of material and the placement of heavy equipment near slope crests in order to prevent slope instabilities. The analyses and discussions in the Foundation Design Report are provided for conceptual illustration of the issue. The contractor is responsible for carrying out slope stability analyses and design of excavation and slope geometries and temporary roadway protection schemes and shoring schemes required for their operations.

### **NSSP 3 – Settlement Management (Addition to OPSS 902)**

The contractor is advised that their design and construction should minimize additional loading on foundation soil over existing levels as increases in loading over existing levels will cause related settlements that may be excessive.