



**THURBER** ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT  
LYON CREEK CULVERT NO. 2 REPLACEMENT  
HIGHWAY 602  
DISTRICT OF RAINY RIVER  
TOWNSHIP OF LASH, ONTARIO**

**G.W.P. No. 6324-14-00, W.P. No. 6342-14-01, SITE No. 45-264/C**

**GEOCRES Number: 52C-52**

**Report**

**to**

**HATCH**

Date: January 13, 2017  
File: 13004

## TABLE OF CONTENTS

1.	INTRODUCTION .....	1
2.	SITE DESCRIPTION .....	2
3.	INVESTIGATION PROCEDURES .....	3
4.	LABORATORY TESTING .....	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS .....	5
5.1	Pavement Structure .....	5
5.2	Silty Clay Fill .....	6
5.3	Topsoil .....	6
5.4	Organic Soil .....	7
5.5	Silty Clay .....	7
5.6	Groundwater Conditions .....	8
6.	CORROSIVITY AND SULPHATE TEST RESULTS .....	9
7.	MISCELLANEOUS .....	10

## APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Geotechnical and Analytical Laboratory Test Results
Appendix C	Site Photographs
Appendix D	Borehole Locations and Soil Strata Drawing
Appendix E	Factual Data from 2015 Golder Preliminary Foundation Report

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**GEOCRES NUMBER: 52C-52**

## **1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Lyon Creek Culvert No. 2 on Highway 602, located south of Emo, in the Township of Lash, in the District of Rainy River, Ontario.

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

Thurber was retained by Hatch Ltd. (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-003.

In the preparation of this report and in addition to the borehole drilled under the current assignment, reference has been made to information on subsurface conditions contained in an earlier preliminary foundation report and a structural design report. The titles of these reports are listed as follows:

- Preliminary Foundation Investigation and Design Report, Lyon Creek Culvert No. 2, Highway 602, District of Rainy River, Township of Lash, prepared by Golder Associates (Golder), dated October 30, 2015; G.W.P. 6342-14-00. (Reference 1). The information presented in this report was reviewed and incorporated in the current report, as appropriate.

- Structural Design Report, Lyon Creek Culvert No. 2, Site No. 45-264C, Highway 602, prepared by Hatch Mott MacDonald and dated December 2015. (Reference 2).

Reference should be made to the Golder report for a written description of the subsurface conditions, borehole location plan, stratigraphic profile and laboratory test results. The Record of Borehole sheets from the Golder report are attached in Appendix E. The subsurface information, including the Record of Borehole sheets and the Borehole Locations and Soil Strata drawings, from both the current investigation and the Golder preliminary Foundation Investigation and Design Report (FIDR) should be included in the contract documents. It should be noted that Golder is solely responsible for the accuracy and quality of the subsurface information provided in the preliminary FIDR.

## **2. SITE DESCRIPTION**

The site is located on Highway 602, approximately 2.6 km south of the junction of Highway 602 and Highway 11 near Emo, within the Township of Lash, in the District of Rainy River, Ontario. The culvert allows Lyon Creek to flow in a south-westerly direction under Highway 602. Highway 602 generally runs in an overall north-south direction, and northwest-southeast direction at the culvert site.

The Structural Design Report (SDR) provided to Thurber by Hatch indicates that the existing structure is a 17 m long, 5.5 m wide, open footing concrete culvert with an unknown construction date. The highway embankment is approximately 4 m high, and there is approximately 1.6 m of fill above the culvert. A Biennial Inspection on November 29, 2013 and a 2015 Ontario Structure Inspection Manual (OSIM) report indicate that the components of the structure are in generally poor condition with up to 50 mm cracking at the centreline of the footing walls and soffit, corroded rebar, efflorescence, and delamination.

The grade level of Highway 602 at the existing culvert is at an approximate Elevation of 343.1 m. The culvert invert is at approximate Elevation 339.3 m. The creek water level was measured at Elevation 339.8 m by others in June, 2014 and the highest water level at Elevation 340.4 m was measured by Golder in February, 2015.

The lands surrounding Lyon Creek and the culvert at the site predominantly consist of agricultural lands with a few forested areas. Lyon Creek discharges into Rainy River approximately 1.3 km south west of the culvert. Rainy River runs in a generally north-south direction near the site. The lands surrounding the site are relatively flat with elevations between 344 m and 346 m.

Selected photographs of the culvert area are included in Appendix C for reference.

Based on published geological information, the culvert lies within an area of glaciolacustrine fine-grained deposits of silt and clay, undifferentiated silty clay to silt till deposits and recent organic deposits of peat, muck and marl. Bedrock at the site is identified as consisting of various metasedimentary rock types.

### **3. INVESTIGATION PROCEDURES**

The borehole investigation and field testing program for this project was carried out on July 23 and 24, 2016, and consisted of drilling and sampling four (4) boreholes, designated as Boreholes 16-07 to 16-10. All boreholes were located in the paved section of the Highway 602 northbound lane. Borehole 16-07 was located approximately 10 m north of the centreline of the existing culvert, near the alignment of the proposed creek diversion pipe. Boreholes 16-08 to 16-10 were located on the south side of the existing culvert and drilled at 10 m intervals to assess the existence and extent of any frost taper near the culvert.

Borehole 16-07 was advanced to a depth of approximately 11.3 m (Elevation 331.8 m) below the existing road surface and boreholes 16-08 to 16-10 were advanced to approximately 3.7 m (Elevation 339.4 m) below existing road surface. A Dynamic Cone Penetration Test (DCPT) was carried out in Borehole 16-07 below the sampled portion of the borehole to a cone refusal depth of 23.5 m (Elevation 319.6 m), below the existing grade.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were derived from cross sections and topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 16 was used for the boreholes.

A rubber track mounted CME 55 drill rig was used to advance the boreholes using hollow stem augers. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing using an MTO "N" size vane was carried out in cohesive soils.

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

Groundwater conditions were observed in the open boreholes throughout the drilling operations and upon completion of drilling. The boreholes were backfilled in general accordance with Ontario Regulation 903.

Completion details of the boreholes are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

Borehole Number	Sampled Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
16-07	11.3 / 331.8	None installed	Borehole backfilled with bentonite holeplug and auger cuttings, to 0.1 m, then surface patched with asphalt.
16-08	3.7 / 339.4	None installed	Borehole backfilled with auger cuttings, to 0.1 m, then surface patched with asphalt.
16-09	3.7 / 339.4	None installed	Borehole backfilled with auger cuttings, to 0.1 m, then surface patched with asphalt.
16-10	3.7 / 339.4	None installed	Borehole backfilled with auger cuttings, to 0.1 m, then surface patched with asphalt.

The previous investigation conducted by Golder included four (4) boreholes, numbered LY-1 to LY-4. Boreholes LY-1 and LY-4 were advanced at the toe of the slope near the culvert inlet and outlet to depths of approximately 7.5 m (Elevations 333.4 and 333.0 m), and Boreholes LY-2 and LY-3 were advanced from the existing highway platform to depths of approximately 11.6 m (Elevation 331.5 m). The approximate locations of the Golder boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D, and on the 2015 Golder report's Borehole Locations and Soil Strata Drawing included in Appendix E.

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

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) and plasticity testing (Atterberg Limits) where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing native soil, and a

sample of the surface water from the creek upstream of the existing culvert were collected. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix B.

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

Reference is made to the Record of Borehole sheets included in Appendices A and E. Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and on the “Borehole Locations and Soil Strata” drawings included in Appendices D and E. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

The borehole logs from the previous Golder investigation are presented in Appendix E and are generally consistent with the results of the current investigation.

In general, the subsurface conditions encountered in the boreholes from the current and previous investigation consisted of asphalt pavement overlying granular fill and silty clay to sandy silt embankment fill, underlain by a layer of organic soil and a deposit of native silty clay. Descriptions of the individual strata are presented below.

### **5.1 Pavement Structure**

Borehole 16-07 to 16-10, LY-2 and LY-3 were drilled from the paved platform of Highway 602. The pavement structure consisted of approximately 40 mm to 50 mm of asphalt over approximately 450 mm to 850 mm of granular base material, consisting of gravelly sand to sand and gravel with trace to some silt.

The moisture content measured in samples of the granular base material ranged from 3% to 5%.

The results of grain size distribution analyses tests conducted on selected samples of the granular base material are presented on the Record of Borehole sheets included in Appendix A, and are summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Percentage (%)
Gravel	22 to 35
Sand	46 to 66
Silt and Clay	12 to 19

## 5.2 Silty Clay Fill

Embankment fill was encountered beneath the road structure in Boreholes 16-07 to 16-10, LY-2 and LY-3 and extended to depths from 1.5 m to 2.3 m below the ground surface (Base Elev. 340.8 m to 341.6 m). The thickness of the embankment fill ranged from 0.6 m to 1.8 m. The fill generally consisted of grey silty clay containing trace to some sand and trace gravel. Locally in Borehole LY-2, the fill consisted of grey sandy silt with trace clay. Occasional wood fragments were also observed in the embankment fill.

The fill was typically stiff in consistency, with SPT 'N' values ranging from 9 to 12 blows for 0.3 m penetration. Higher SPT 'N' values ranging from 19 to 95 blows per 0.3 m of penetration were noted in the frozen fill in Boreholes LY-2 and LY-3. The measured moisture content of the fill ranged from 13% to 31%.

The results of grain size distribution analyses conducted on a selected sample of the silty clay fill are presented on the Record of Borehole sheets included in Appendix E and are summarized in the following table.

Soil Particle	Percentage (%)
	Cohesive Fill
Gravel	1
Sand	7
Silt	56
Clay	36

## 5.3 Topsoil

Topsoil was identified at the ground surface in Borehole LY-1. The topsoil thickness was 75 mm.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.



## 5.4 Organic Soil

Organic soils were encountered beneath the embankment fill in Boreholes LY-2 and LY-3 and at the surface in Borehole LY-4. The organic soils generally consisted of black to brown organic clay or organic silt containing trace to some sand and trace gravel. The organic layers were 0.6 m to 1.5 m thick.

The depths to the base of the organic soils was 3.7 m and 3.8 m (Base Elev. 339.4 and 339.3 m) in Boreholes LY-2 and LY-3, and 0.6 m (Base Elev. 339.9 m) in Borehole LY-4.

The organic soils were typically firm to stiff, with SPT 'N' values of 7 to 9 blows for 0.3 m penetration. A higher SPT 'N' value of 12 blows per 0.3 m penetration was also recorded in the frozen surficial organic silt in Borehole LY-4. The measured moisture content in the organic soils ranged from 32% to 38%.

The results of grain size distribution analyses and Atterberg Limits tests conducted on a selected sample of the organic clay are presented on the Record of Borehole sheets included in Appendix E and are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	19
Silt	44
Clay	37
Soil Property	Percentage (%)
Liquid Limit	53
Plasticity Limit	29

The results of the Atterberg Limits testing indicate the organic soil to be of high plasticity with a group symbol of CH.

## 5.5 Silty Clay

Native silty clay with trace to some sand and trace gravel was encountered beneath the embankment fill or organic soils in Boreholes 16-07 to 16-10 and LY-2 to LY-3 at depths of 1.5 m to 3.8 m (Elev. 339.3 to 341.6 m) below the existing road surface. In Boreholes LY-1 and LY-4, drilled at the culvert inlet and outlet, the silty clay was encountered at 0.1 m to 0.6 m depth (Elev. 340.8 and 339.9 m) respectively. All of the boreholes were terminated within the silty clay at

depths ranging from 3.7 m to 11.6 m (Elev. 331.5 to 339.4 m). A DCPT was conducted from the bottom of Borehole 16-07, until reaching refusal of 100 blows per 0.3 m of penetration at a depth of 23.5 m (Elev. 319.6 m).

SPT 'N' values recorded in the silty clay ranged from 4 to 9 blows for 0.3 m penetration, with the exception of an SPT 'N' value of 23 blows per 0.3 m penetration, recorded near the frozen ground surface in Borehole LY-1. Vane shear tests (VST) conducted in the silty clay measured in-situ undrained shear strengths ranging from 55 kPa to greater than 100 kPa. Based on the SPT and VST data, the consistency of the silty clay is typically firm to very stiff. Natural moisture contents ranged from 18% to 38%.

The results of grain size distribution analyses and Atterberg Limits tests conducted on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendices A and E, and are summarized in the following table. The results from the grain size distribution analyses and Atterberg Limits from Boreholes 16-07 to 16-10 are presented on Figures B2 and B3 in Appendix B.

<b>Soil Particle</b>	<b>Percentage (%)</b>
Gravel	0 to 4
Sand	0 to 39
Silt	29 to 41
Clay	23 to 61
<b>Soil Property</b>	<b>Percentage (%)</b>
Liquid Limit	33 to 61
Plasticity Limit	13 to 25

The results of the Atterberg Limits tests indicate that the silty clay typically ranges from medium to high plasticity with group symbols of CI to CH, however one sample from Borehole 16-10 revealed a low plasticity, with a group symbol of CL.

## 5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the current investigation and reported in the Golder report are summarized in Table 5.1 below.

**Table 5.1 – Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-07	July 24, 2016	10.1	333.0	Open borehole
16-08	July 23, 2016	Dry	-	Open borehole
16-09	July 23, 2016	Dry	-	Open borehole
16-10	July 23, 2016	Dry	-	Open borehole
LY-1	March 15, 2015	Dry	-	Reported by Golder
LY-2	February 13, 2015	Dry	-	Reported by Golder
LY-3	February 13, 2015	Dry	-	Reported by Golder
LY-4	March 15, 2015	Dry	-	Reported by Golder

A water level measurement near the outlet of the creek was reported on the drawings provided by Hatch, which indicate a creek level at Elevation 339.74 m on June 17, 2014. The creek level when frozen, was reported by Golder at Elevation 340.1 on February 13, 2015. The groundwater level should be assumed to reflect the local creek water level.

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

## **6. CORROSIVITY AND SULPHATE TEST RESULTS**

A sample of the native silty clay from Borehole 16-07, and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

**Table 6.1 – Analytical Test Results**

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-07, SS#3B, 2.3 m – 2.9 m	Lyon Creek Culvert
			(Silty Clay)	(Creek Water)
Sulphide	%	mg/L	<0.02	<0.02
Chloride	µg/g	mg/L	33	30
Sulphate	µg/g	mg/L	17	<10
pH	No unit	No unit	7.83 to 8.72	7.71
Electrical Conductivity	µS/cm	µS/cm	98	195
Resistivity	Ohms.cm	MOhms.cm	10200	513
Redox Potential	mV	mV	246	290

## 7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Omar Ali of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT and Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Mr. Keli Shi, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Mr. Cory Zanatta, EIT  
Geotechnical Engineer-In-Training

Keli Shi, P.Eng.  
Geotechnical Engineer

P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact



## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

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

# UNIFIED SOILS CLASSIFICATION

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



# RECORD OF BOREHOLE No 16-07

1 OF 3

METRIC

W.P. 6342-14-01 LOCATION Lyon Creek, Culvert No. 2 Replacement N 5 386 723.9 E 245 165.2 ORIGINATED BY OA  
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.07.24 - 2016.07.24 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20    40    60    80    100	W <sub>P</sub> W                      W <sub>L</sub>	WATER CONTENT (%)			20    40    60	GR   SA   SI   CL					
343.1	GROUND SURFACE																		
0.0	<b>ASPHALT:</b> (50mm)																		
	Gravelly <b>SAND</b> , some silt and clay		1	GS													28	58	14
	Brown																		(SI+CL)
	Moist																		
342.3	(FILL)																		
0.8	Silty <b>CLAY</b> , some sand to sandy, trace gravel		1	SS	9														
	Firm to Stiff																		
	Grey																		
	Moist																		
	(FILL)		2	SS	12														
340.8																			
2.3	Silty <b>CLAY</b> , trace to some sand, trace gravel		3	SS	6														
	Stiff to Very Stiff																		
	Brown																		
	Moist																		
	Grey below 3.0m		4	SS	9														
			5	SS	5														
			6	SS	7														
			7	SS	7														
			8	SS	8														
							</												

Continued Next Page

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

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No 16-07

3 OF 3

METRIC

W.P. 6342-14-01 LOCATION Lyon Creek, Culvert No. 2 Replacement N 5 386 723.9 E 245 165.2 ORIGINATED BY OA  
 HWY 602 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.07.24 - 2016.07.24 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W <sub>p</sub>	W	W <sub>L</sub>			
	Continued From Previous Page						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60						
319.6							323							
							322							
							321							
							320							
23.5	END OF BOREHOLE AT 23.5m UPON DYNAMIC CONE REFUSAL. WATER LEVEL AT 10.1m IN OPEN BOREHOLE UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.1m, THEN SURFACE PATCHED WITH ASPHALT.													

# RECORD OF BOREHOLE No 16-08

1 OF 1

METRIC

W.P. 6342-14-01 LOCATION Lyon Creek, Culvert No. 2 Replacement N 5 386 709.6 E 245 185.7 ORIGINATED BY OA  
 HWY 602 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.07.23 - 2016.07.23 CHECKED BY MEF

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							
343.1	GROUND SURFACE							20 40 60 80 100							
0.0	ASPHALT: (50mm)		1	GS			343								
342.3	SAND and GRAVEL, some silt and clay Brown Moist (FILL)		2	GS											35 46 19 (SI+CL)
0.8	Silty CLAY, some gravel, trace sand Grey Moist (FILL)		3	GS			342								
341.6	Silty CLAY, trace sand, trace gravel Grey Moist		4	GS			341								0 0 39 61
1.5	Firm		1	SS	4		340								
339.4	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.1m, THEN SURFACE PATCHED WITH ASPHALT.														
3.7															

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

## METRIC

SOIL PROFILE									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT  NATURAL MOISTURE CONTENT  LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
					ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W <sub>P</sub> W W <sub>L</sub> WATER CONTENT (%)	kN/m <sup>3</sup>	GR SA SI CL
343.1 0.0	GROUND SURFACE								
	ASPHALT: (50mm)								
	Gravelly SAND, some silt and clay Brown Moist (FILL)		1 GS					22 66 12 (SI+CL)	
342.2 0.9	Silty CLAY, some sand, some gravel Grey Moist (FILL)		2 GS						
			3 GS						
341.6 1.5	Silty CLAY, some sand to sandy, trace gravel Brown Moist		4 GS						
	Firm		1 SS 5					0 25 40 35	
339.4 3.7	END OF BOREHOLE AT 3.7m. WATER NOT OBSERVED UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.1m, THEN SURFACE PATCHED WITH ASPHALT.								

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

# RECORD OF BOREHOLE No 16-10

1 OF 1

METRIC

W.P. 6342-14-01 LOCATION Lyon Creek, Culvert No. 2 Replacement N 5 386 698.1 E 245 202.1 ORIGINATED BY OA  
 HWY 602 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.07.23 - 2016.07.23 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
343.1	GROUND SURFACE							20 40 60 80 100		W <sub>P</sub> W      W <sub>L</sub>				
0.0	ASPHALT: (50mm)							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE						
	SAND and GRAVEL, some silt and clay Brown Moist		1	GS			343				○			32 54 14 (SI+CL)
342.2	(FILL)		2	GS							○			
0.9	Silty CLAY, trace sand to sandy, some gravel Grey Moist		3	GS			342				○			
341.6	(FILL)													
1.5	Silty CLAY, trace to some sand, trace gravel Brown Moist		4	SS			341							
	Firm		1	SS	5		340				○			
339.4											○			2 24 40 34
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO 0.1m, THEN SURFACE PATCHED WITH ASPHALT.													

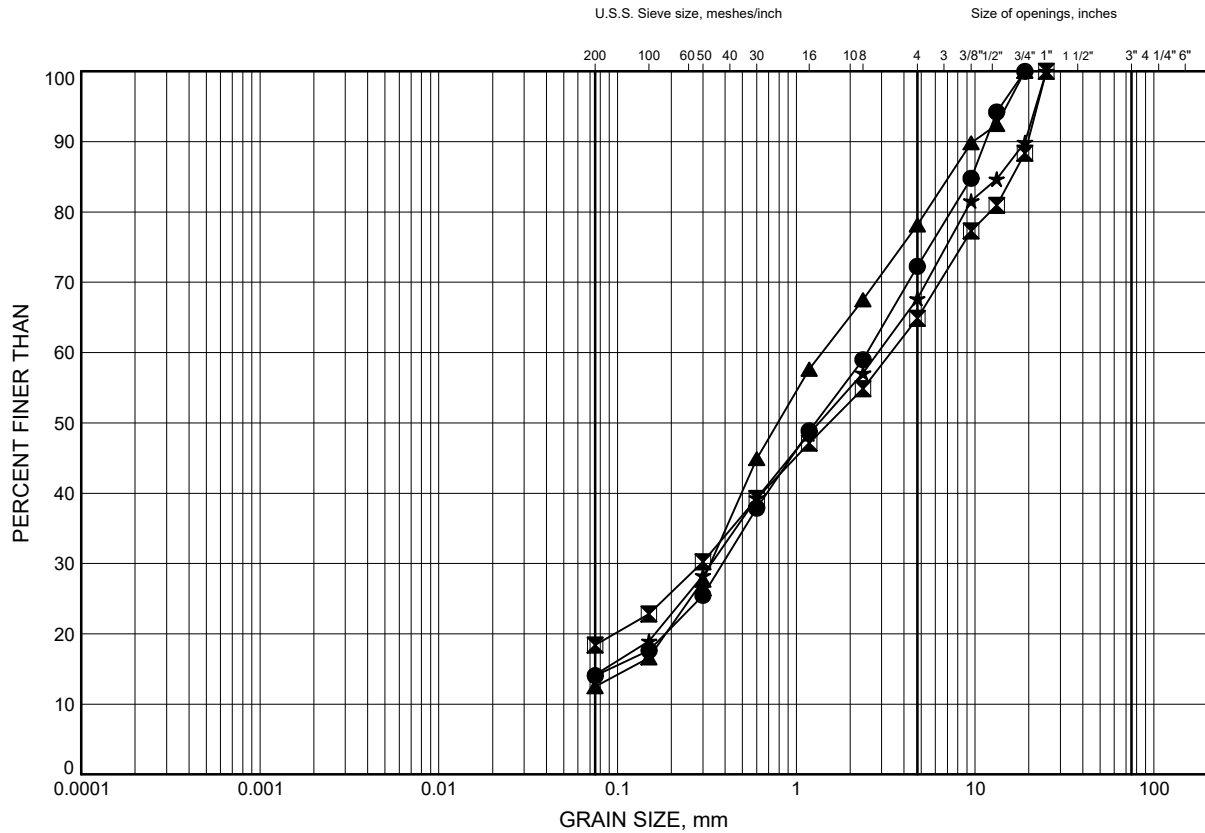
## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**

Lyon Creek, Culvert No. 2 Replacement  
**GRAIN SIZE DISTRIBUTION**

FIGURE B1

**Gravelly SAND FILL/SAND and GRAVEL FILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	0.30	342.80
⊠	16-08	0.76	342.34
▲	16-09	0.30	342.80
★	16-10	0.76	342.34

Date ..October 2016.....  
W.P. ..6342-14-01.....

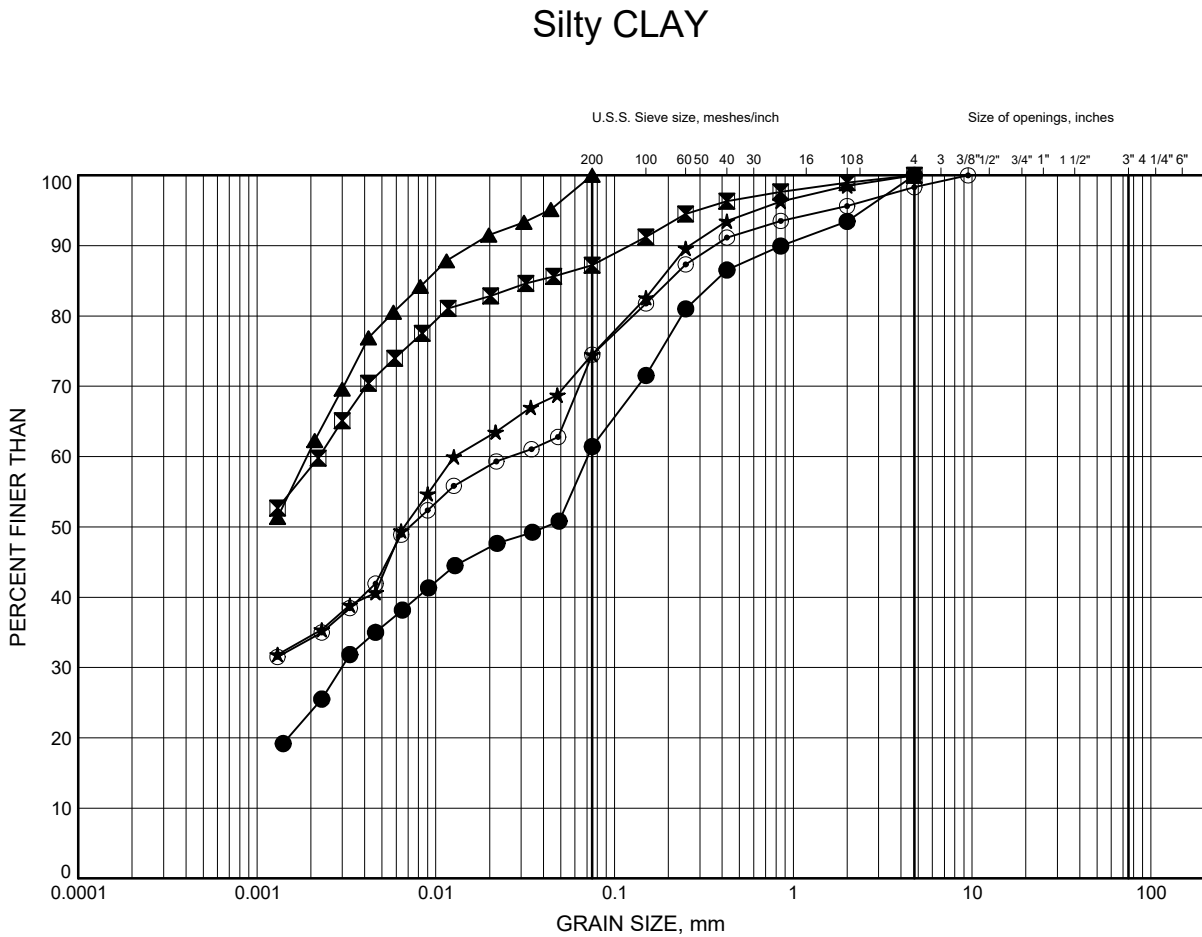


Prep'd .....AN.....  
Chkd. ....RPR.....



Lyon Creek, Culvert No. 2 Replacement  
GRAIN SIZE DISTRIBUTION

FIGURE B2



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	2.44	340.66
⊠	16-07	7.92	335.18
▲	16-08	2.29	340.81
★	16-09	3.35	339.75
⊙	16-10	3.35	339.75

Date ..October 2016.....  
W.P. ..6342-14-01.....

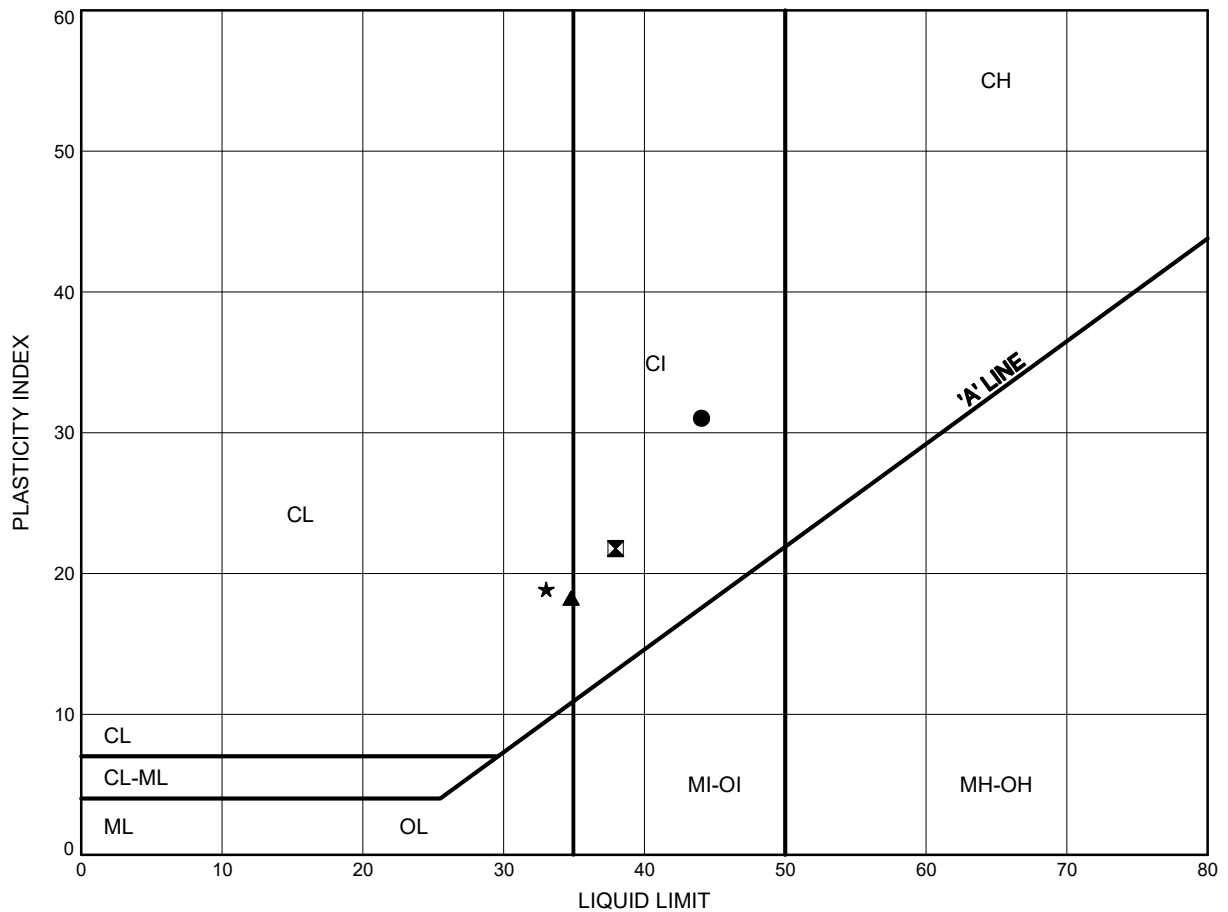


Prep'd .....AN.....  
Chkd. ....RPR.....

Lyon Creek, Culvert No. 2 Replacement  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B3

Silty CLAY



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	7.92	335.18
⊠	16-08	2.29	340.81
▲	16-09	3.35	339.75
★	16-10	3.35	339.75

Date ..October 2016.....  
W.P. ..6342-14-01.....



Prep'd .....AN.....  
Chkd. ....RPR.....

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13004****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive, Oakville  
, L6H 5R7  
Phone: 905-829-8666 x 228, Fax:

**09-August-2016**


**Date Rec. :** 03 August 2016  
**LR Report:** CA14113-AUG16  
**Reference:** 13004

**Copy: #1**

## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	7: BH-16-07 SS3B, 8'4"-9'6"
Sample Date & Time					24-Jul-16
Temperature Upon Receipt [°C]	---	---	---	---	24.2
Corrosivity Index [none]	09-Aug-16	13:32	09-Aug-16	14:29	1
pH [no unit]	08-Aug-16	11:40	09-Aug-16	09:32	7.83
Soil Redox Potential [mV]	08-Aug-16	18:47	09-Aug-16	08:27	246
Sulphide [%]	08-Aug-16	10:07	09-Aug-16	09:35	< 0.02
% Moisture (wet wt) [%]	05-Aug-16	07:02	05-Aug-16	09:08	14.2
pH [no unit]	04-Aug-16	09:56	04-Aug-16	15:49	8.72
Chloride [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	33
Sulphate [µg/g]	05-Aug-16	18:51	09-Aug-16	09:15	17
Conductivity [uS/cm]	04-Aug-16	09:56	04-Aug-16	15:49	98
Resistivity (calculated) [Ohms.cm]	09-Aug-16	13:31	09-Aug-16	14:29	10200

  
**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13004**

**LR Report : CA14113-AUG16**

Temperature of Samples upon receipt 24 degrees C  
No cooling agent present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13004**LR Report :** CA14113-AUG16

## Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1918
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13004

**LR Report :** CA14113-AUG16

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
							RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)
					%	Low				High	Low	
Anions by IC - QCBatchID: DIO0053-AUG16												
Chloride	0.4	µg/g	<0.4		0	20	109	80	120	111	75	125
Sulphate	0.4	µg/g	<0.4		3	20	101	80	120	101	75	125
Carbon/Sulphur - QCBatchID: ECS0007-AUG16												
Sulphide	0.02	%	<0.02		NV	20	113	80	120			
Conductivity - QCBatchID: EWL0045-AUG16												
Conductivity	2	uS/cm	2		1	10	99	90	110	NA		
pH - QCBatchID: EWL0045-AUG16												
pH	0.05	no unit	NA		0		100			NA		

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13004****02-August-2016****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive, Oakville  
, L6H 5R7  
Phone: 905-829-8666 x 228, Fax:

**Date Rec. :** 27 July 2016  
**LR Report:** CA15442-JUL16  
**Reference:** 13004

**Copy: #1**

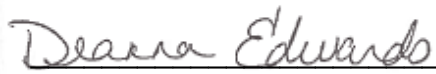
## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	6: Lyon Creek Culvert
Sample Date & Time					N/A
Temperature Upon Receipt [°C]	---	---	---	---	21.0
Corrosivity Index [none]	02-Aug-16	13:33	02-Aug-16	13:33	16
pH [no unit]	27-Jul-16	06:49	28-Jul-16	15:17	7.71
Redox Potential [mV]	27-Jul-16	13:39	02-Aug-16	10:54	290
Sulphide [mg/L]	29-Jul-16	13:00	29-Jul-16	12:19	< 0.02
Chloride [mg/L]	27-Jul-16	11:45	28-Jul-16	10:10	30
Sulphate [mg/L]	27-Jul-16	12:42	29-Jul-16	14:35	< 10
Conductivity [uS/cm]	27-Jul-16	06:49	28-Jul-16	15:17	195
Resistivity (calculated) [MOhms.cm]	02-Aug-16	13:27	02-Aug-16	13:27	513

Temperature of Samples upon receipt 15 degrees C  
No cooling agent present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

  
**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13004****LR Report : CA15442-JUL16**

### Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by discrete analyzer	ME-CA-[ENV]EWL-LAK-AN-026	US EPA 325.2
Anions by discrete analyzer	ME-CA-[ENV]EWL-LAK-AN-026	US EPA 375.4
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500





**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13004

**LR Report :** CA15442-JUL16

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD		LCS / Spike Blank			Matrix Spike / Reference Material		
					Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)		
							%	Low		High	Low	High
Anions by discrete analyzer - QCBatchID: DIO0458-JUL16												
Chloride	1	mg/L	<1		1	20	96	80	120	91	75	125
Sulphate	1	mg/L	1		1	20	93	80	120	109	75	125
Conductivity - QCBatchID: EWL0410-JUL16												
Conductivity	2	uS/cm	< 2		0	10	98	90	110	NA		
pH - QCBatchID: EWL0385-JUL16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0394-JUL16												
Redox Potential	no	mV	NA		1	20	107	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0211-JUL16												
Sulphide	0.02	mg/L	<0.02		0	20	92	80	120	NV	75	125

## **Appendix C**

### **Site Photographs**



**Photo 1: Lyon Creek Culvert No. 2, looking northwest**



**Photo 2: Lyon Creek Culvert No. 2, looking southeast**





**Photo 3: Lyon Creek Culvert No. 2, south embankment, looking north**





**Photo 4: Lyon Creek Culvert No. 2 outlet, looking north**





**Photo 5: Lyon Creek Culvert No. 2, north embankment, looking south**





**Photo 6: Lyon Creek Culvert No. 2 inlet, looking south**

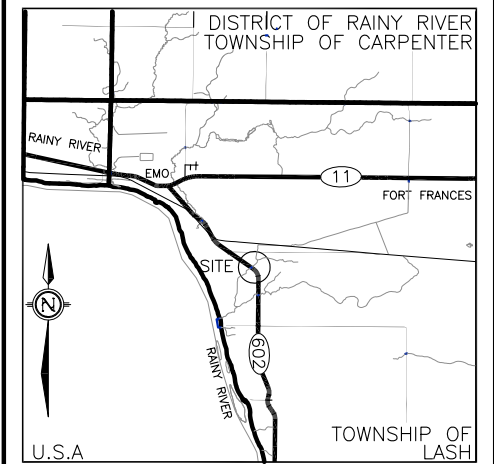


## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**






SHEET  
32

# HATCH



## KEYPLAN

### LEGEND

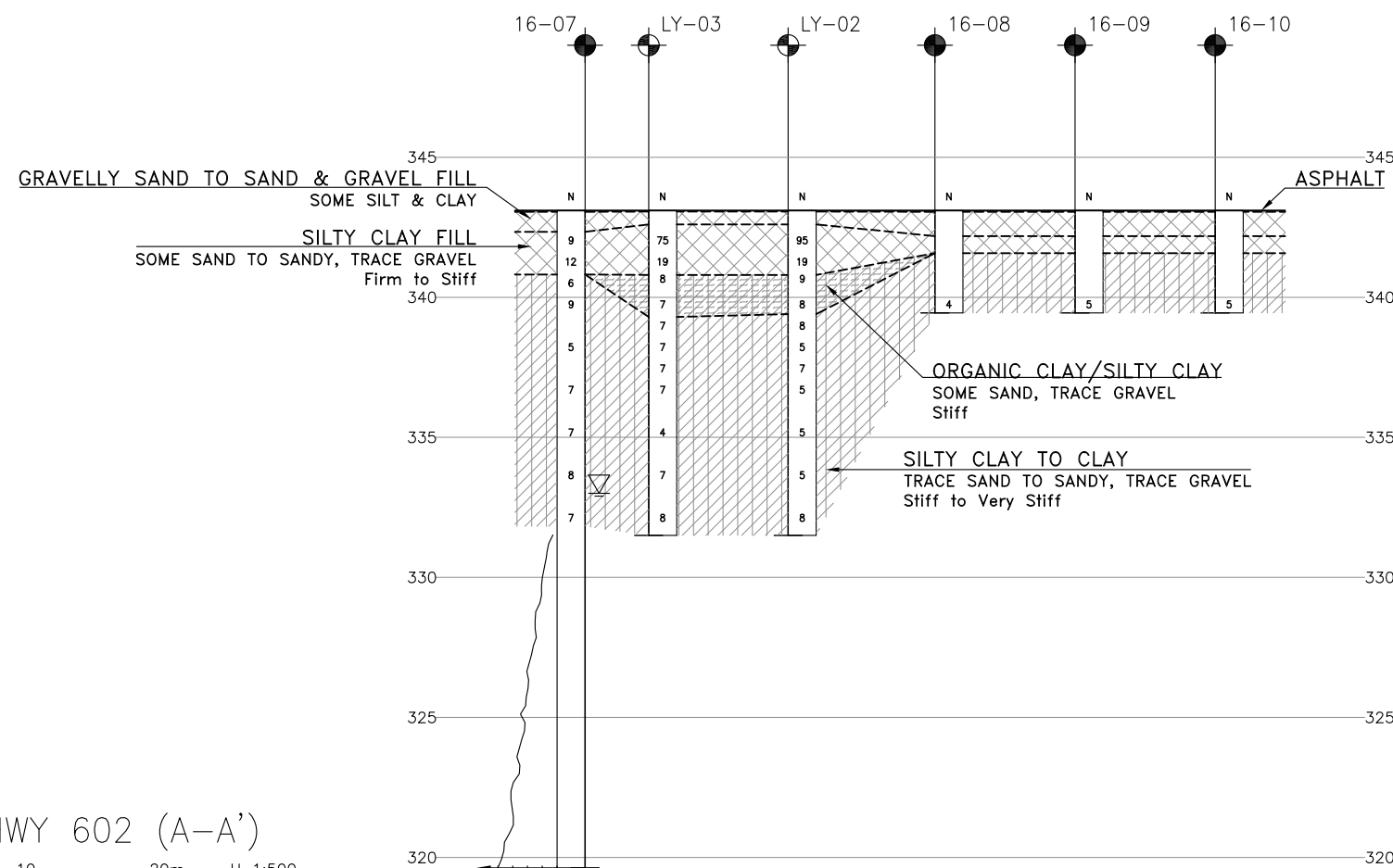
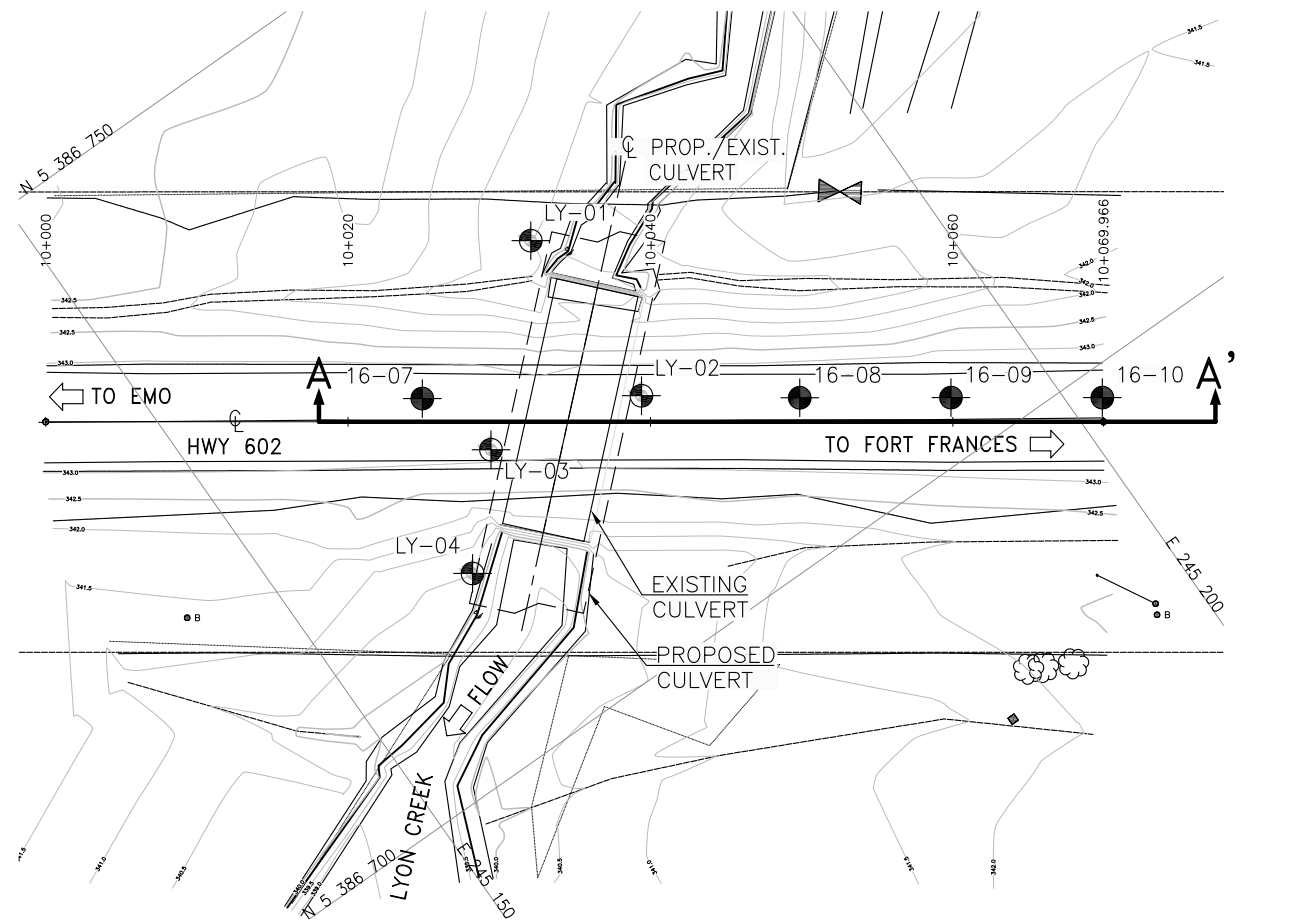
	Borehole (Current Investigation)
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-07	343.1	5 386 723.9	245 165.2
16-08	343.1	5 386 709.6	245 185.7
16-09	343.1	5 386 703.8	245 193.9
16-10	343.1	5 386 698.1	245 202.1
LY-01	340.9	5 386 728.3	245 177.1
LY-02	343.1	5 386 715.7	245 177.2
LY-03	343.1	5 386 718.5	245 167.0
LY-04	340.5	5 386 712.5	245 161.3

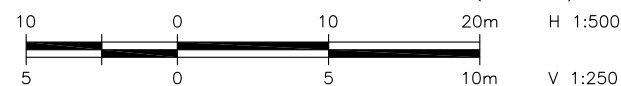
-NOTES-

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

**GEOCRES No. 52C-52**



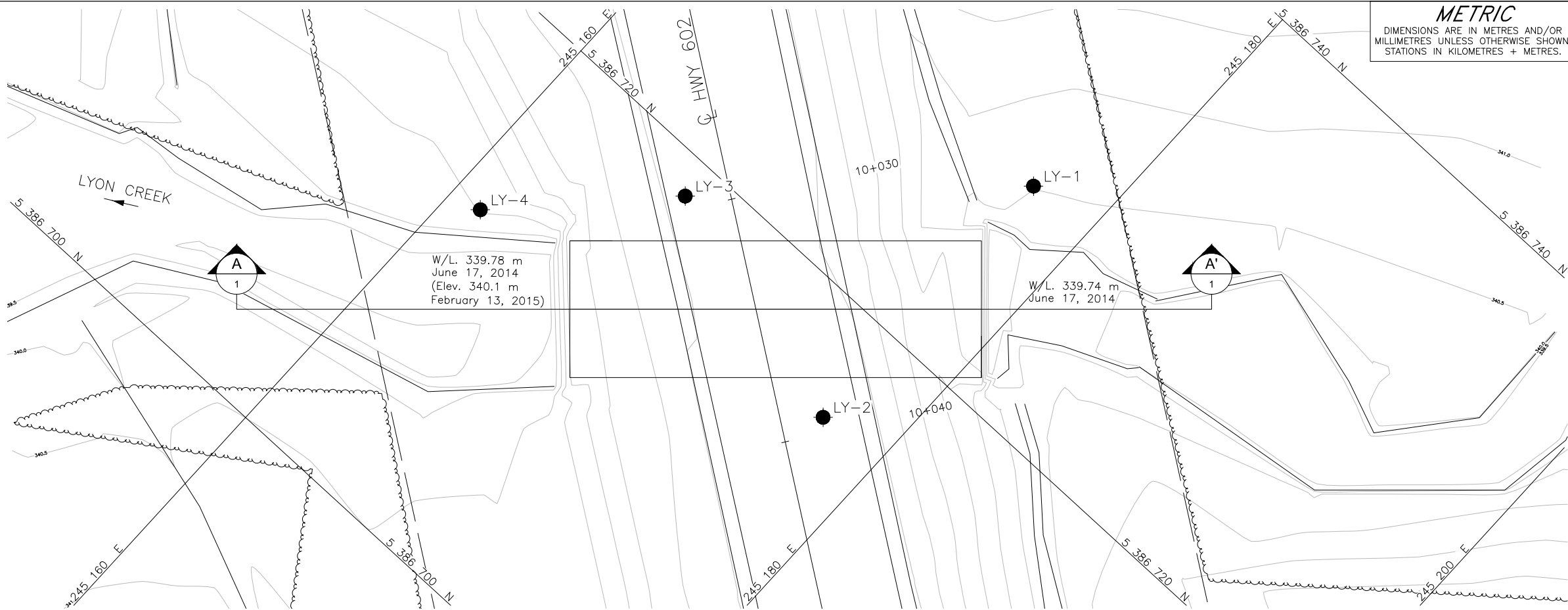
PROFILE ALONG C HWY 602 (A-A')



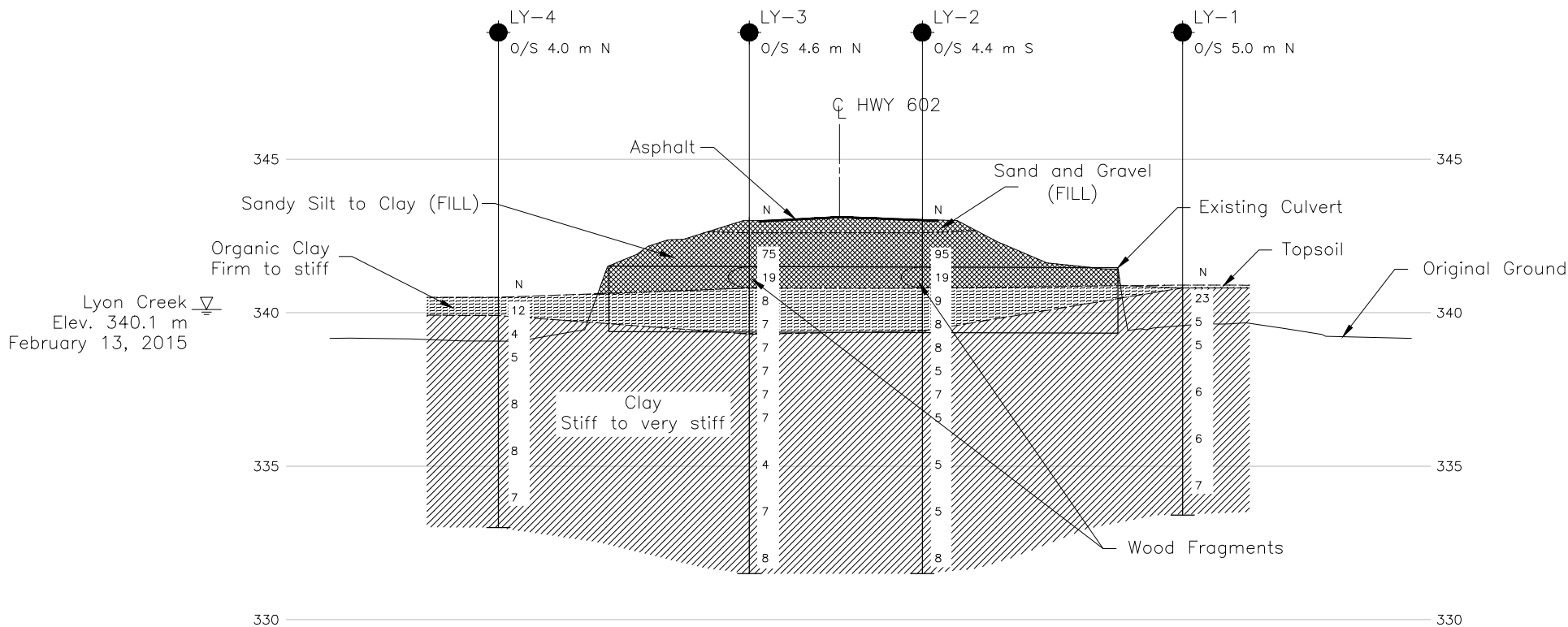
REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	MEF	CHK	MEF	CODE	LOAD	DATE	JAN 2017			
DRAWN	AN	CHK		SITE	STRUCT	DWG	2			

## **Appendix E**

### **Factual Data from 2015 Golder Foundation Investigation Report**



PLAN  
SCALE

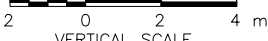


PROFILE  
A-A' 1

HORIZONTAL SCALE



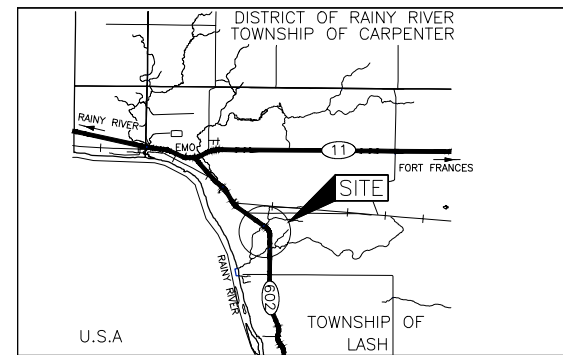
VERTICAL SCALE



**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No. .  
GWP No. 6342-14-00

HIGHWAY 602  
LYON CREEK CULVERT NO. 2 STA 10+035  
BOREHOLE LOCATION PLAN AND  
SOIL STRATA



KEY PLAN  
1:50,000 m

### LEGEND

- Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ▽ WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
LY-1	340.9	5386728.3	245177.1
LY-2	343.1	5386715.7	245177.2
LY-3	343.1	5386718.5	245167.0
LY-4	340.5	5386712.5	245161.3

### NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

### REFERENCE

Base plans provided in digital format by MTO, drawing file no. E7256022, dated JUN 2014, received JAN 27, 2015.

NO.	DATE	BY	REVISION
Geocres No. 52C-44			
HWY. 602	PROJECT No. 1411523		DIST. .
SUBM'D. AC	CHKD. .	DATE: 10/26/2015	SITE: 45-264/C
DRAWN: TB	CHKD. DAM	APPD. JMAC	DWG. 1



PROJECT 1411523			RECORD OF BOREHOLE No LY-1			1 OF 1 METRIC											
G.W.P. 6342-14-00			LOCATION N 5386728.3; E 245177.1			ORIGINATED BY MR											
DIST _____ HWY 602			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY TB											
DATUM GEODETIC			DATE March 15, 2015			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%) W <sub>p</sub> W W <sub>L</sub>			γ	GR SA SI CL
340.9	GROUND SURFACE							20 40 60 80 100									
0.0	TOPSOIL (75 mm)																
0.1	CLAY, trace to some sand, trace gravel Stiff to very stiff Brown to grey Frozen* to wet  Trace organics in the upper 1.5 m.		1	SS	23*		340										
			2	SS	5												
			3	SS	5		339										
			4	SS	6		338										
			5	SS	6		337										
			6	SS	7		336										
							335										
							334										
333.4	END OF BOREHOLE																
7.5	Note: 1. Borehole dry upon completion of drilling.																


SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/10/15 DATA INPUT:

PROJECT 1411523			RECORD OF BOREHOLE No LY-2			1 OF 1 METRIC											
G.W.P. 6342-14-00			LOCATION N 5386715.7; E 245177.2			ORIGINATED BY DM											
DIST _____ HWY 602			BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers			COMPILED BY TB											
DATUM GEODETIC			DATE February 13, 2015			CHECKED BY DAM											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> — W — W <sub>L</sub> WATER CONTENT (%)			γ kN/m <sup>3</sup>	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	20 40 60								
343.1	GROUND SURFACE																
0.0	ASPHALT (40 mm)						343										
342.6	Sand and gravel, trace silt (FILL)																
0.5	Brown Frozen																
	Sandy silt, trace clay, wood fragments (FILL)		1	SS	95		342										
	Grey Frozen		2	SS	19												
340.8							341										
2.3	ORGANIC CLAY, some sand		3	SS	9												
	Stiff																
	Black		4	SS	8		340										
	Moist																
339.4																	
3.7	CLAY, some sand, trace gravel		5	SS	8		339										
	Very stiff		6	SS	5												
	Grey																
	Moist		7	SS	7		338										
			8	SS	5		337										
							336										
			9	SS	5												
							335										
			10	SS	5		334										
							333										
			11	SS	8		332										
331.5																	
11.6	END OF BOREHOLE																
	Note: 1. Borehole dry upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/10/15 DATA INPUT:

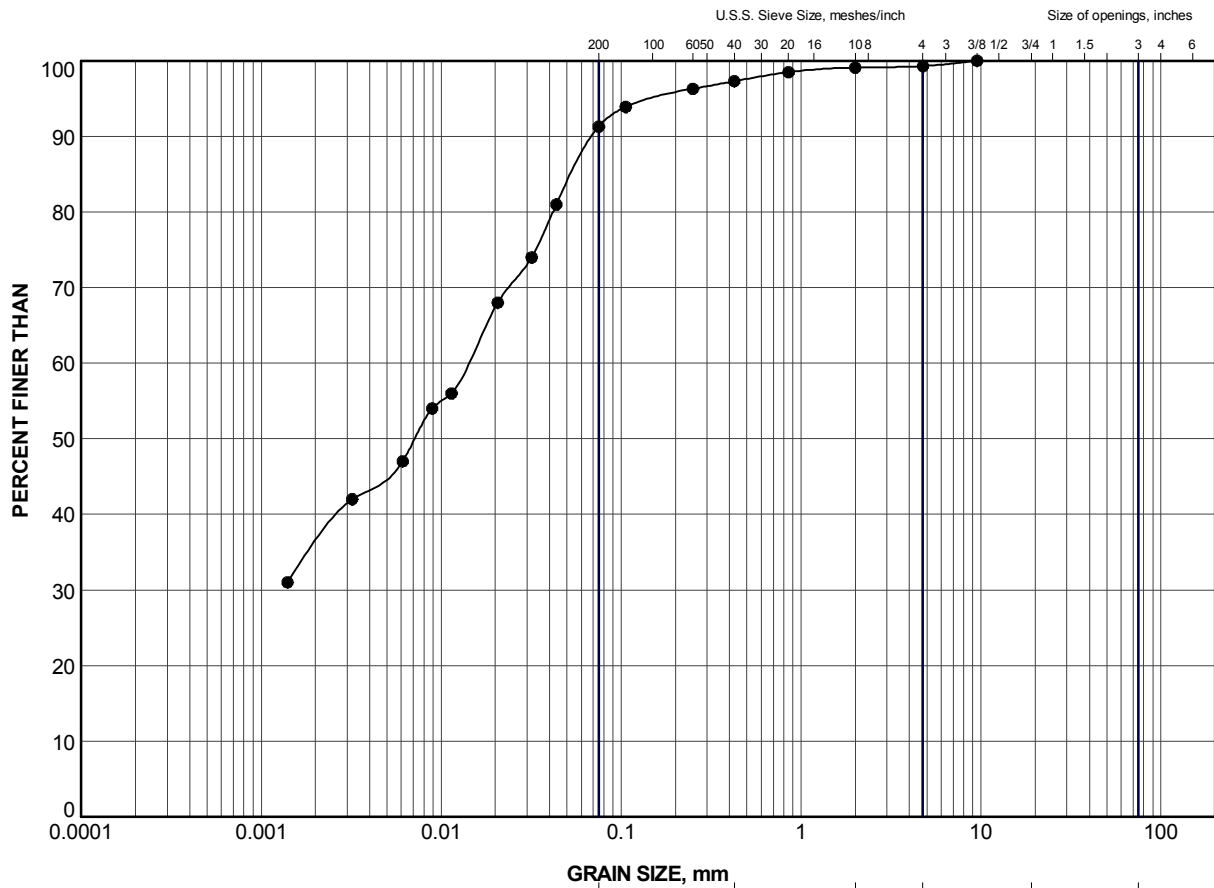
PROJECT 1411523		RECORD OF BOREHOLE No LY-3				1 OF 1 METRIC								
G.W.P. 6342-14-00		LOCATION N 5386718.5; E 245167.0				ORIGINATED BY DM								
DIST _____ HWY 602		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY TB								
DATUM GEODETIC		DATE February 13, 2015				CHECKED BY DAM								
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						
343.1	GROUND SURFACE							20 40 60 80 100	20 40 60					
0.0	ASPHALT (40 mm)						343							
342.6	Sand and gravel, trace silt (FILL)						342							1 7 56 36
0.5	Brown Frozen													
	Clay, trace to some sand, trace gravel, wood fragments (FILL)		1	SS	75									
	Black to grey Frozen		2	SS	19									
340.8							341							
2.3	ORGANIC CLAY, some sand													
	Firm to stiff		3	SS	8									
	Black to brown		4	SS	7		340							
	Moist													
339.3														
3.8	CLAY, some sand, trace gravel		5	SS	7		339							
	Very stiff		6	SS	7									
	Brown to grey		7	SS	7		338							1 12 41 46
	Wet		8	SS	7									
							337							
							336							
			9	SS	4		335							0 13 38 49
							334							
			10	SS	7									
							333							
			11	SS	8		332							
331.5														
11.6	END OF BOREHOLE													
	Note:													
	1. Borehole dry upon completion of drilling.													

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/10/15 DATA INPUT:

PROJECT 1411523		<b>RECORD OF BOREHOLE No LY-4</b>				1 OF 1 <b>METRIC</b>											
G.W.P. 6342-14-00		LOCATION N 5386712.5; E 245161.3				ORIGINATED BY MR											
DIST _____ HWY 602		BOREHOLE TYPE 108 mm I. D. Hollow Stem Augers				COMPILED BY TB											
DATUM GEODETIC		DATE March 15, 2015				CHECKED BY DAM											
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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
340.5	GROUND SURFACE							20	40	60	80	100					
0.0	ORGANIC SILT, trace sand, trace gravel Brown Frozen		1	SS	12		340										
339.9																	
0.6	CLAY, trace to some sand, trace gravel Stiff to very stiff Brown to grey Wet		2	SS	4		339										
			3	SS	5		338										
							337										
			4	SS	8		336										
			5	SS	8		335										
			6	SS	7		334										
333.0	END OF BOREHOLE						333										
7.5	Note:  1. Borehole dry upon completion of drilling.																

SUD-MTO 001 1411523.GPJ GAL-MISS.GDT 28/10/15 DATA INPUT:




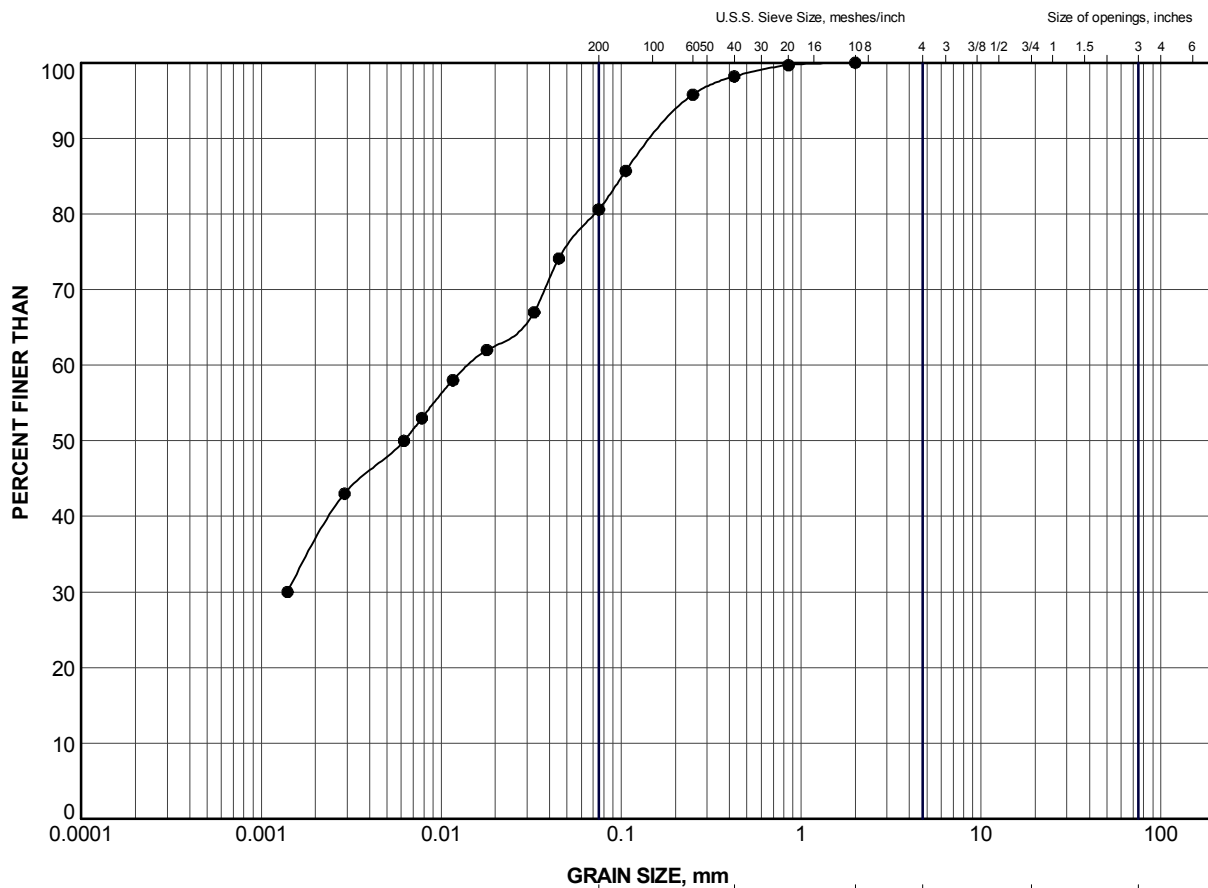


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LY-3	1	342.0


PROJECT					
HIGHWAY 602 LYON CREEK CULVERT NO. 2 STA 10+035					
TITLE					
GRAIN SIZE DISTRIBUTION CLAY (FILL)					
PROJECT No.		1411523		FILE No. 1411523.GPJ	
DRAWN	TB	May 2015	SCALE	N/A	REV.
CHECK	DAM	May 2015			
APPR	JMAC	May 2015			
 <b>Golder Associates</b> SUDBURY, ONTARIO			<b>FIGURE B1</b>		



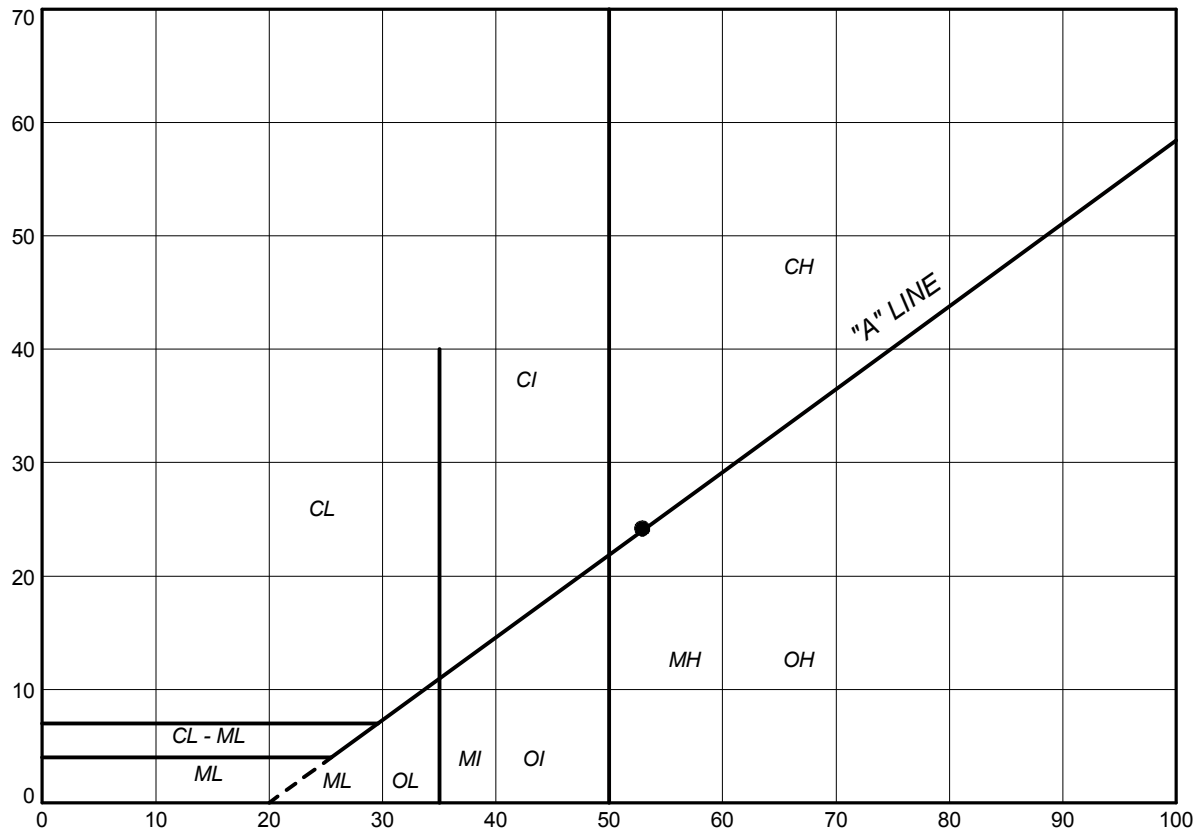
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LY-2	3	340.5

PROJECT					
HIGHWAY 602 LYON CREEK CULVERT NO. 2 STA 10+035					
TITLE					
GRAIN SIZE DISTRIBUTION ORGANIC CLAY					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	May 2015	SCALE	N/A	REV.
CHECK	DAM	May 2015			
APPR	JMAC	May 2015			
			<b>FIGURE B2</b>		

PLASTICITY INDEX (Percent)



LIQUID LIMIT (Percent)

**SOIL TYPE**  
 C = Clay  
 M = Silt  
 O = Organic

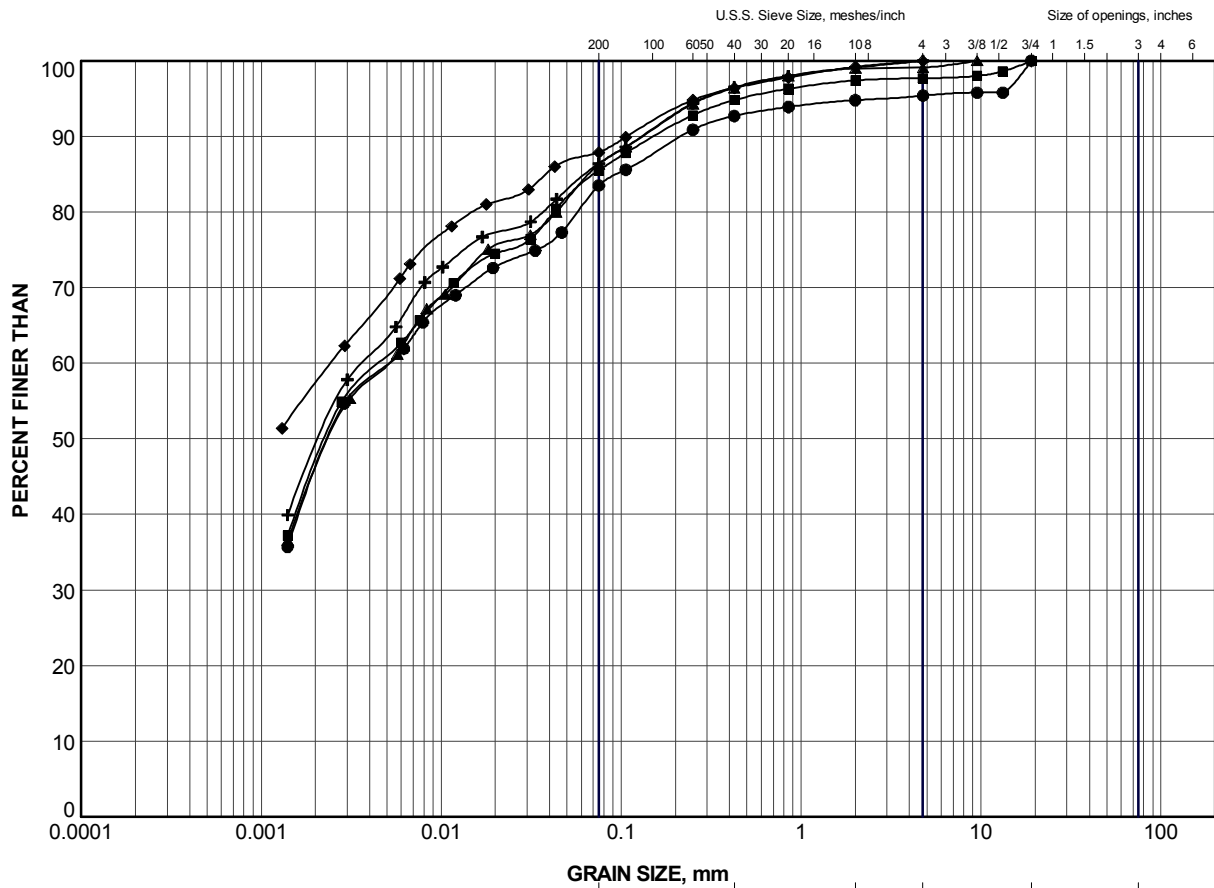
**PLASTICITY**  
 L = Low  
 I = Intermediate  
 H = High

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	LY-2	3	52.9	28.7	24.2

PROJECT					
HIGHWAY 602 LYON CREEK CULVERT NO. 2 STA 10+035					
TITLE					
PLASTICITY CHART ORGANIC CLAY					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	May 2015	SCALE	N/A	REV.
CHECK	DAM	May 2015	FIGURE B3		
APPR	JMAC	May 2015			




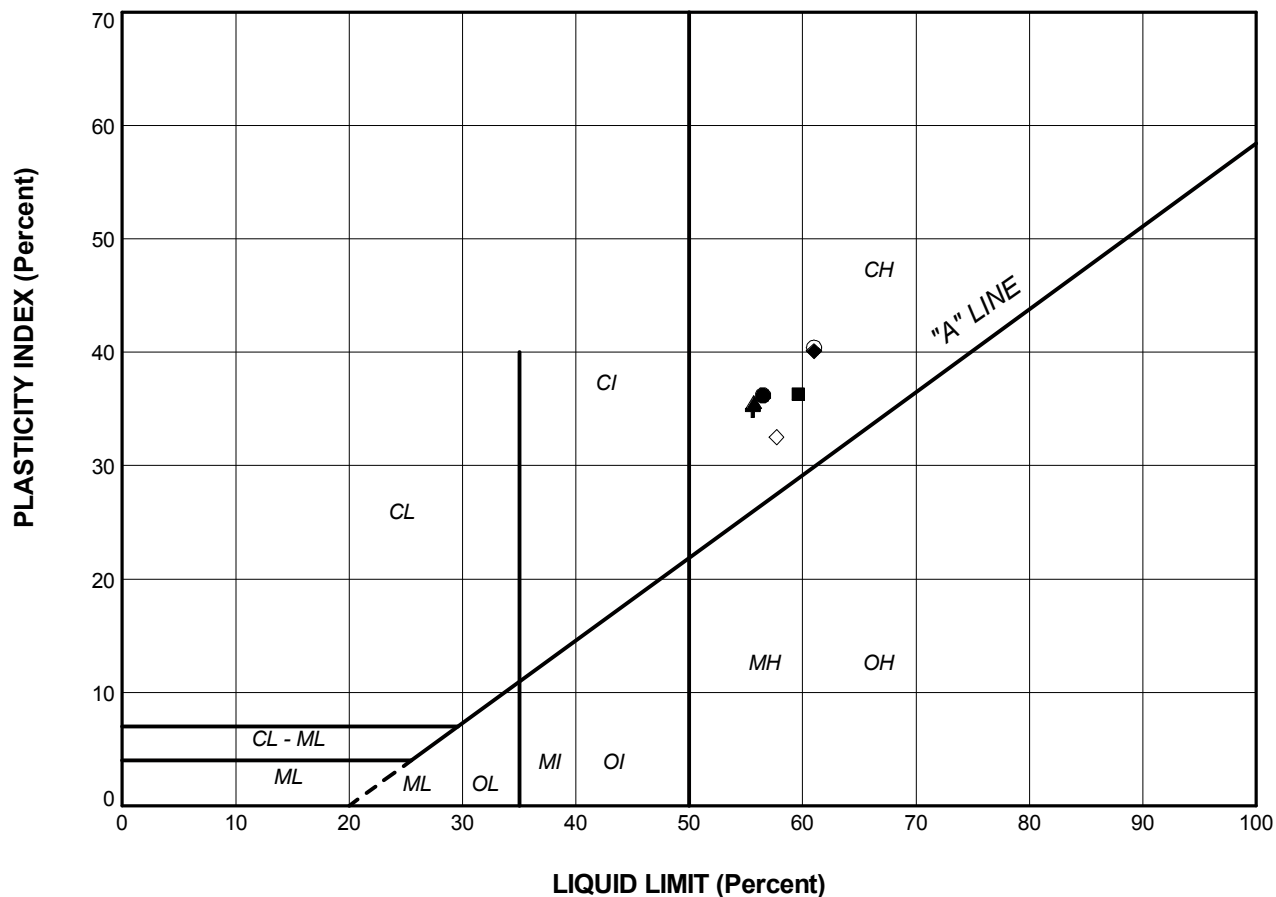


CLAY AND SILT		SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
		fine	medium	coarse	fine	coarse	
		SAND SIZE			GRAVEL SIZE		

### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	LY-2	5	339.0
■	LY-2	8	336.7
▲	LY-3	6	338.2
+	LY-3	9	335.2
◆	LY-4	5	335.6

PROJECT					HIGHWAY 602 LYON CREEK CULVERT NO. 2 STA 10+035				
TITLE					GRAIN SIZE DISTRIBUTION CLAY				
PROJECT No.			1411523		FILE No.			1411523.GPJ	
DRAWN	TB	May 2015	SCALE	N/A	REV.				
CHECK	DAM	May 2015							
APPR	JMAC	May 2015							
 <b>Golder Associates</b> SUDBURY, ONTARIO					<b>FIGURE B4</b>				



PROJECT					
HIGHWAY 602 LYON CREEK CULVERT NO. 2 STA 10+035					
TITLE					
PLASTICITY CHART CLAY					
PROJECT No. 1411523			FILE No. 1411523.GPJ		
DRAWN	TB	May 2015	SCALE	N/A	REV.
CHECK	DAM	May 2015	FIGURE B5		
APPR	JMAC	May 2015			

