



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT, 11+730 FENWICK
HIGHWAY 17 NEAR GOULAIS RIVER
SAULT STE MARIE AREA
G.W.P. 545-00-00**

GEOCRES Number: 41K-100

Report

to

WSP Canada Inc.

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September 19, 2016
19-5308-95



TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	General.....	3
5.2	Granular Fill.....	3
5.3	Embankment Fill.....	4
5.4	Topsoil.....	4
5.5	Silt to Sandy Silt	4
5.6	Silty Sand	5
5.7	Groundwater Conditions	6
6	MISCELLANEOUS.....	7

APPENDICES

APPENDIX A	Borehole Locations and Soil Strata Drawings
APPENDIX B	Record of Borehole Sheets
APPENDIX C	Laboratory Test Results
APPENDIX D	Selected Photographs of Culvert Location

**FOUNDATION INVESTIGATION REPORT
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for replacement of a culvert under Highway 17 near Goulais River, Ontario.

No previous foundation investigation information was available for the subject culvert.

The purpose of this investigation was to obtain subsurface information at the site and, based on the data obtained, to provide a model of the subsurface conditions including a borehole location plan and stratigraphic profile, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under MTO Agreement Number 5014-E-0008.

2 SITE DESCRIPTION

The culvert site is located on Highway 17, approximately 3.8 kilometres north of the intersection of Highway 552 and Highway 17 in the Township of Fenwick. A 750 mm diameter by 43.0 m long corrugated steel pipe culvert (CSP) is present at the site and covered with approximately 5 m of fill. The culvert conveys storm water under Highway 17 from west to east. The invert elevation is 255.4 m at the east end or left and 258.3 m at the west end or right.

The grade of the existing Highway 17 in the vicinity of the culvert is at 262.8 m geodetic. The profile slopes down to the south. The culvert is located on a curve within a fill section. The embankment is constructed with side slopes approximately 3 horizontal to 1 vertical (3H:1V) and 2 horizontal to 1 vertical (2H:1V) corresponding to the west and east slopes, respectively.

The embankment fill height is approximately 4.5 m at the west side and approximately 7.4 m at the east side.

The road includes a single 3.5 m wide lane in each direction, a 3.0 m wide gravel shoulder on the west side and a 2.0 m wide paved shoulder on the east. A guide rail is present on the east side. The site is located in a rural area with forests, swamps, and creeks. The local topography rolling with undulating hills and valleys. Selected photographs of the culvert site are attached in Appendix D.

The surficial geology of the area is typical of the Wisconsin glaciation. Soil cover consists primarily of glaciolacustrine (clay, silt, and sand) deposits underlain by glacial till.

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out between January 18 and January 19, 2016. The program consisted of drilling and sampling four boreholes (numbered 15-29, 15-30, 15-31, and 15-32) to depths ranging from 11.0 to 18.9 m. Of these boreholes, one was located near the culvert inlet (15-32), one located near the culvert outlet (15-29), and two (15-30 and 15-31) were located through the embankment on opposite sides of the road near the culvert.

Prior to the start of drilling, utility locates were obtained. Buried utilities were noted in close proximity to both the inlet and outlet at this site, borehole locations were established in the field accordingly. The co-ordinates and elevations of the as-drilled boreholes were subsequently determined by Thurber based on elevation data provided by WSP.

A truck-mounted drill rig equipped with hollow stem augers was used to drill and sample the boreholes on the roadway, and a portable tripod drill rig was used to drill and sample the culvert inlet and outlet boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Results of the field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

The boreholes were backfilled with soil cuttings mixed with bentonite and topped to surface with the existing granular material and asphalt patch where required.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification and to Natural Moisture Content determination. Selected soil samples were subjected to Grain Size Distribution analyses (sieve and hydrometer) and Atterberg Limit testing. The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the Figures in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert replacement alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes consist of granular and sandy silt embankment fill overlying a silt layer underlain by a silty sand deposit. Bedrock was not encountered in any of the four boreholes. More detailed descriptions of the individual strata are presented below.

5.2 Granular Fill

Boreholes 15-30 and 15-31 were drilled through the shoulders of the roadway; paved shoulders were noted in the northbound direction with an asphalt thickness of 60 mm.

Sand with gravel fill extended to a depth of 0.8 m to 1.5 m below the road surface. A lower layer described as silty sand with gravel fill extended to a depth of 1.5 m to 2.3 m below the road surface. The base of the granular fill was encountered at elevations ranging from 260.7 to 261.1 m.

The moisture content of the upper granular fill ranged from 4% to 7%, while the lower granular fill was 9% to 13%. Gradation testing on one sample of the granular fill indicated 21% gravel, 68% sand and 11% fines (Figure 1 Appendix C). The ground was frozen at the time of the field investigation thus the relative density of the granular fill could not be determined reliably.

5.3 Embankment Fill

Embankment fill was encountered below the granular fill in Boreholes 15-30 and 15-31. The thickness of the embankment fill ranged from 2.4 to 3.1 m. A 1.2 m layer of silty sand fill was also encountered at the surface of Borehole 15-29. The base of the embankment fill was encountered at elevations ranging from 255.0 to 258.4 m.

The embankment fill was observed to be silty sand to sandy silt.

In Boreholes 15-30 and 15-31, the SPT N-values for the embankment fill ranged from 11 to 22 blows per 0.3 m penetration, indicating a compact state. The water content of the fill samples ranged between 12% and 16%. The SPT N-values for the fill found at the outlet ranged from 3 to 6 blows per 0.3 m penetration, indicating a loose state. The water content of the recovered outlet fill samples ranged between 16% and 23%. The colour of the embankment fill is brown.

The results of grain size analyses conducted on three samples of the fill are presented on Fig. No 2 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	5 to 10
Sand	34 to 53
Silt	37 to 53
Clay	5 to 8

5.4 Topsoil

Topsoil, 25 to 75 mm in thickness was encountered at the inlet and outlet boreholes (15-29 and 15-32). The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating quantities or quality.

5.5 Silt to Sandy Silt

A native soil deposit ranging from silty trace sand to sandy silt was encountered in all boreholes. This soil was found below topsoil in 15-32 and below the embankment fill in 15-29, 15-30 and 15-31. This layer was observed to range from 0.6 m to 1.7 m in thickness with the base elevation ranging from 254.4m to 257.9 m.

The SPT N-value for this deposit was 5 to 22 blows per 0.3 m penetration, indicating a loose to compact state. The water contents of the recovered samples ranged between 19% and 36%. The colour of this deposit is brown. This layer in Borehole 15-29 contained some organics which accounted for the low SPT N-value of 5 blows per 0.3 m penetration and the high water content of 36%.

The results of grain size analysis conducted on four samples of the sandy silt are presented on Fig. No 3 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	0 to 5
Sand	5 to 47
Silt	49 to 93
Clay	1 to 4

Atterberg limit testing was carried out on two samples of the sandy silt. One sample was found to be non-plastic (Borehole 15-32 SS2), and one sample (Borehole 15-29 SS3) was classified as sandy silt (ML/OL). The results are presented on Fig. No 5 in Appendix C and summarized in the table below.

Test	%
Plastic Limit	NP and 28
Liquid Limit	NA and 33
Plasticity Index	NA and 5

5.6 Silty Sand

A native soil deposit typically ranging from silty sand to sandy silt was encountered in all boreholes. This soil was found just below the silt layer. All four boreholes were terminated within this deposit at elevations ranging from 244.1 m to 247.6 m.

The SPT N-value for this deposit was 11 to 73 blows per 0.3 m penetration, indicating a compact to very dense state. The water contents of the recovered samples ranged between 2% and 25%. The colour of this deposit is brown.

Grain size analyses conducted on nine samples of the soil are presented on Fig. No 4 and Fig. No 5 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	0 to 1
Sand	36 to 93
Silt and Clay	7 to 64

5.7 Groundwater Conditions

Groundwater was not observed in any of the boreholes during drilling and all four boreholes were dry upon completion of drilling. However, in Borehole 15-29 which was left open overnight following the completion of drilling the water level in was measured at elevation 255.9 m. At the time of investigation surface water was not present in the inlet of the culvert or associated ditches. Surface water at the outlet was observed at elevation 256.3 m on January 19, 2016.

Where surface water is present, the groundwater level should be assumed to coincide with the local surface or creek water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling.

Marathon Drilling Ltd. of Greely, Ontario, supplied and operated a truck-mounted CME 55 drill rig to carry out the drilling, sampling and in-situ testing operations on the existing highway platform. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drill rig.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Justin Gray E.I.T. and Mr. Chris Murray E.I.T. of Thurber. Laboratory testing was carried out by Stantec (Ottawa) in its MTO-approved laboratory.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Justin Gray E.I.T. and Dr. Fred Griffiths P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Justin A. Gray
Geotechnical E.I.T.



Fred J. Griffiths, P.Eng.
Senior Associate, Senior Foundations Engineer

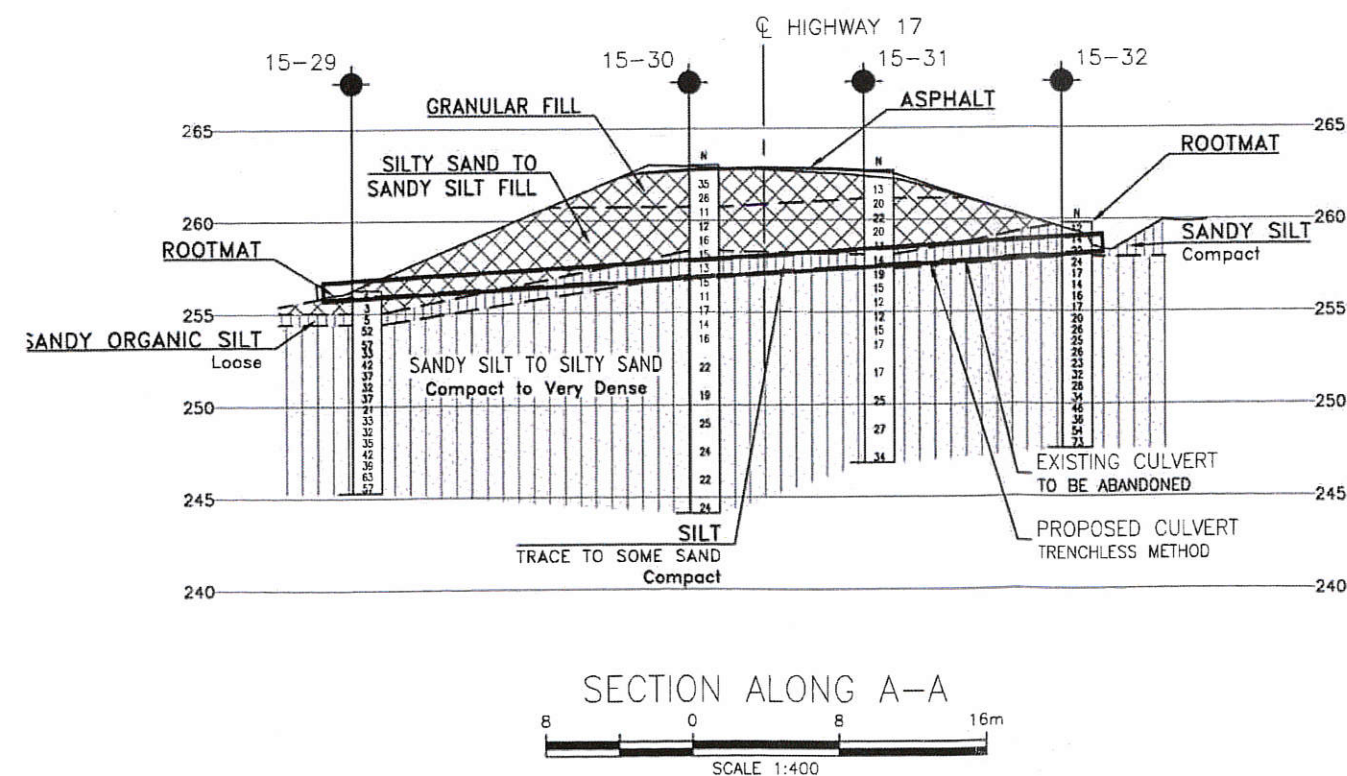
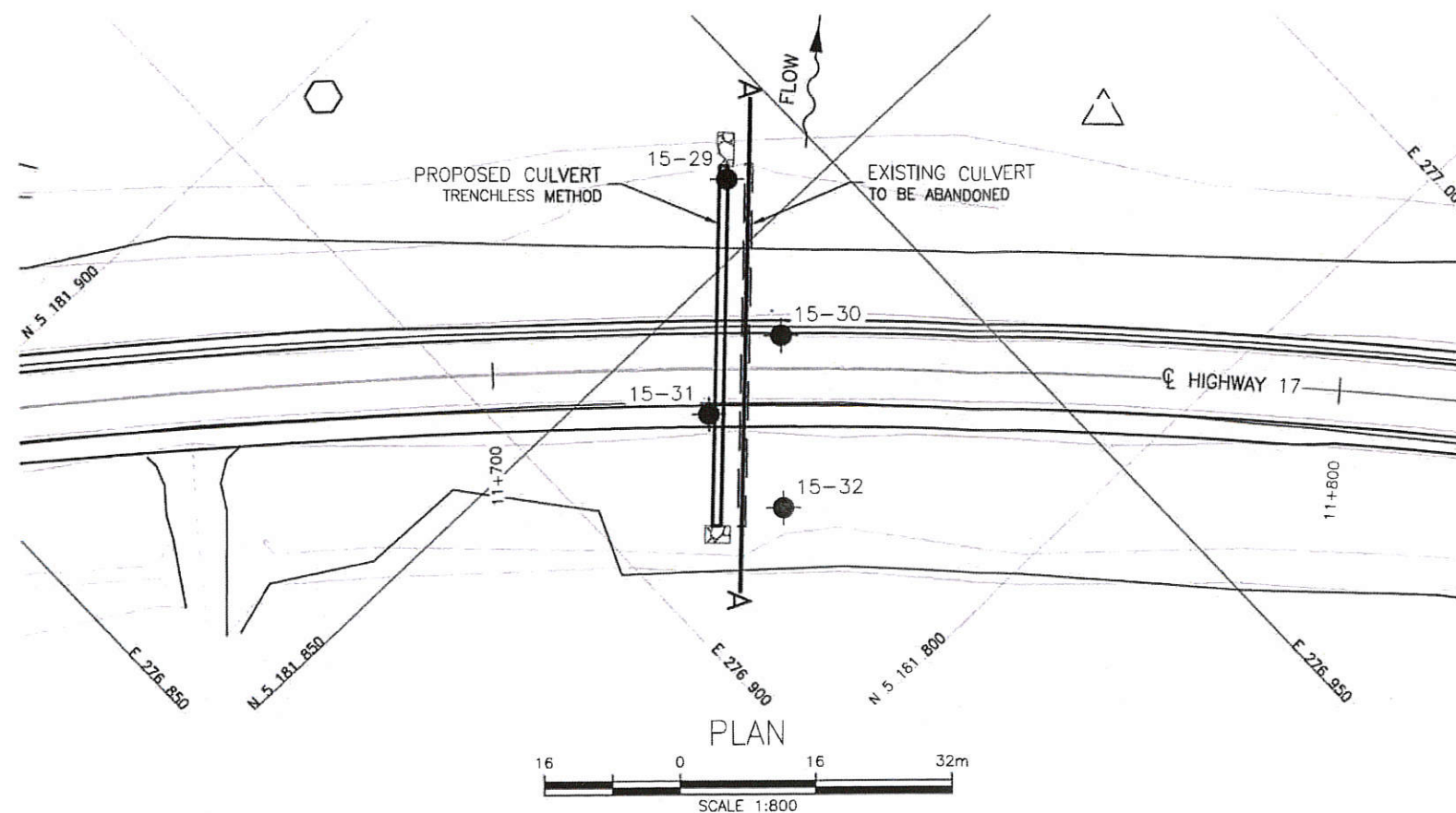


P. K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

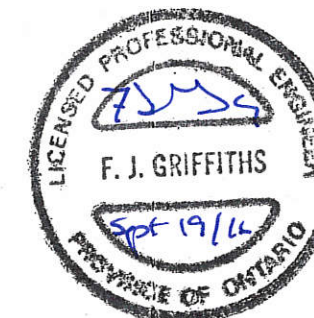
Appendix A

Borehole Locations and Soil Strata Drawings

19-5308-95



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

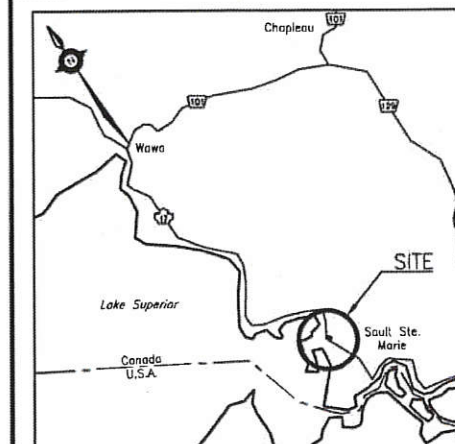


S	CONT No
	WP No






HIGHWAY 17
11+730
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN
LEGEND

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

[illegible]

-NOTES-

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

GEOCRES No. 41K-100

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	JG	CHK -	CODE	LOAD	DATE	SEP 2016			
DRAWN	MFA	CHK JG	SITE	STRUCT	DWG 1				

FILENAME: H:\Drafting\19\5308\95\led0895-Plan&Profile(Culvert 67+70).dwg

Appendix B

Record of Borehole Sheets

19-5308-95



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

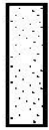


STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel



Sand



Silt



Clay



Organics



Asphalt



Concrete



Fill



Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No 15-29

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 857.1 E 276 939.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.19 - 2016.01.19 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20 40 60 80 100				w _p w w _L							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
256.2																			
0.0																			

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

RECORD OF BOREHOLE No 15-29

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 857.1 E 276 939.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.19 - 2016.01.19 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page		17	SS	63												
			18	SS	57												
245.3																	
11.0	End of Borehole at 11 m Borehole Open Upon Completion Borehole Dry Upon Completion on 2016.01.19 Water in Open Borehole at 0.3 m on 2016.01.20																

ONTMT4S 19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-30

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 839.3 E 276 931.5 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.19 - 2016.01.19 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
								20	40	60	80	100	W _P	W	W _L					
								○ UNCONFINED												
263.0																				
0.0																				
0.1	ASPHALT (60 mm)																			
	SAND with gravel Dense Brown Moist FILL		1	AS								○								
			2	SS	35							○								
261.5																				
1.5	SAND with silt and gravel Compact Brown Moist FILL		3	SS	26							○					21	68		
260.7																		11 (SI+CL)		
2.3	SANDY SILT Some Gravel Compact Brown Moist FILL		4	SS	11							○								
			5	SS	12							○					10	34		
258.9												○						48		
4.1	SILTY SAND Compact Brown Moist FILL		6	SS	16							○						8		
258.4												○								
4.7	SILT some sand Compact Brown Wet		7	SS	15							○					0	13		
			8	SS	13							○						85		
257.0																		2		
6.0	SILTY SAND to SAND with silt Compact Brown Moist		9	SS	15							○								
			10	SS	11							○								
			11	SS	17							○					0	71		
			12	SS	14							○						29 (SI+CL)		
			13	SS	16							○								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-30

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 839.3 E 276 931.5 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.19 - 2016.01.19 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20 40 60 80 100	W _p W W _L											
Continued From Previous Page									○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
244.1 18.9			14	SS	22		252													
							251													
			15	SS	19		250													
			16	SS	25		249													
							248													
			17	SS	24		247													
			18	SS	22		246													
			19	SS	24		245													
	End of Borehole at 18.9 m Borehole Open Upon Completion Borehole Dry Upon Completion																			

ONTMT4S 19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-31

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 838.4 E 276 918.9 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.18 - 2016.01.18 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _P	W	W _L		
262.7																	
0.0	SAND with gravel FILL		1	AS													
261.9							262										
0.8	SILTY SAND with gravel Compact Brown Moist FILL		2	SS	13												
261.1																	
1.5	SANDY SILT trace gravel Compact Brown Moist FILL		3	SS	20		261										
			4	SS	22		260										
			5	SS	20		259										
258.9																	
3.8	SILTY SAND Compact Brown Moist FILL		6	SS	11		258										
258.1																	
4.6	SILT trace sand Compact Brown Wet		7	SS	14		257										
257.3																	
5.3	SILTY SAND to SAND with silt Compact to Dense Brown Wet to Dry		8	SS	19		256										
			9	SS	15		255										
			10	SS	12		254										
			11	SS	12		253										
			12	SS	15												
			13	SS	17												

Continued Next Page

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

RECORD OF BOREHOLE No 15-31

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 838.4 E 276 918.9 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.01.18 - 2016.01.18 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page							20	40	60	80	100	20	40	60					
							252													
			14	SS	17								○							
							251													
			15	SS	25		250						○							
							249													
			16	SS	27								○				0 93 7 (SI+CL)			
							248													
			17	SS	34		247						○							
246.8																				
15.8	End of Borehole at 15.85 m Borehole Open Upon Completion Borehole Dry Upon Completion																			

0 93 7
(SI+CL)

RECORD OF BOREHOLE No 15-32

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 824.3 E 276 917.7 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.18 - 2016.01.18 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
						WATER CONTENT (%)													
						20 40 60													
259.8																			
0.0	ROOTMAT (75 mm) SANDY SILT Compact Brown Moist		1	SS	12														
0.1			2	SS	14														
			3	SS	22														
257.9																			
1.8	SILTY SAND Compact to Very Dense Brown Moist		4	SS	24														
			5	SS	17														
			6	SS	14														
			7	SS	16														
			8	SS	17														
			9	SS	20														
			10	SS	26														
			11	SS	25														
			12	SS	26														
			13	SS	23														
			14	SS	32														
			15	SS	28														
			16	SS	34														

Continued Next Page

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

RECORD OF BOREHOLE No 15-32

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 11+730, Highway 17 Goulais River N 5 181 824.3 E 276 917.7 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.18 - 2016.01.18 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
	Continued From Previous Page		17	SS	46													
			18	SS	36		249											
			19	SS	54													
247.6			20	SS	73		248											0 86 14 (SI+CL)
12.2	End of Borehole at 12.19 m Borehole Open Upon Completion Borehole Dry Upon Completion																	

Appendix C

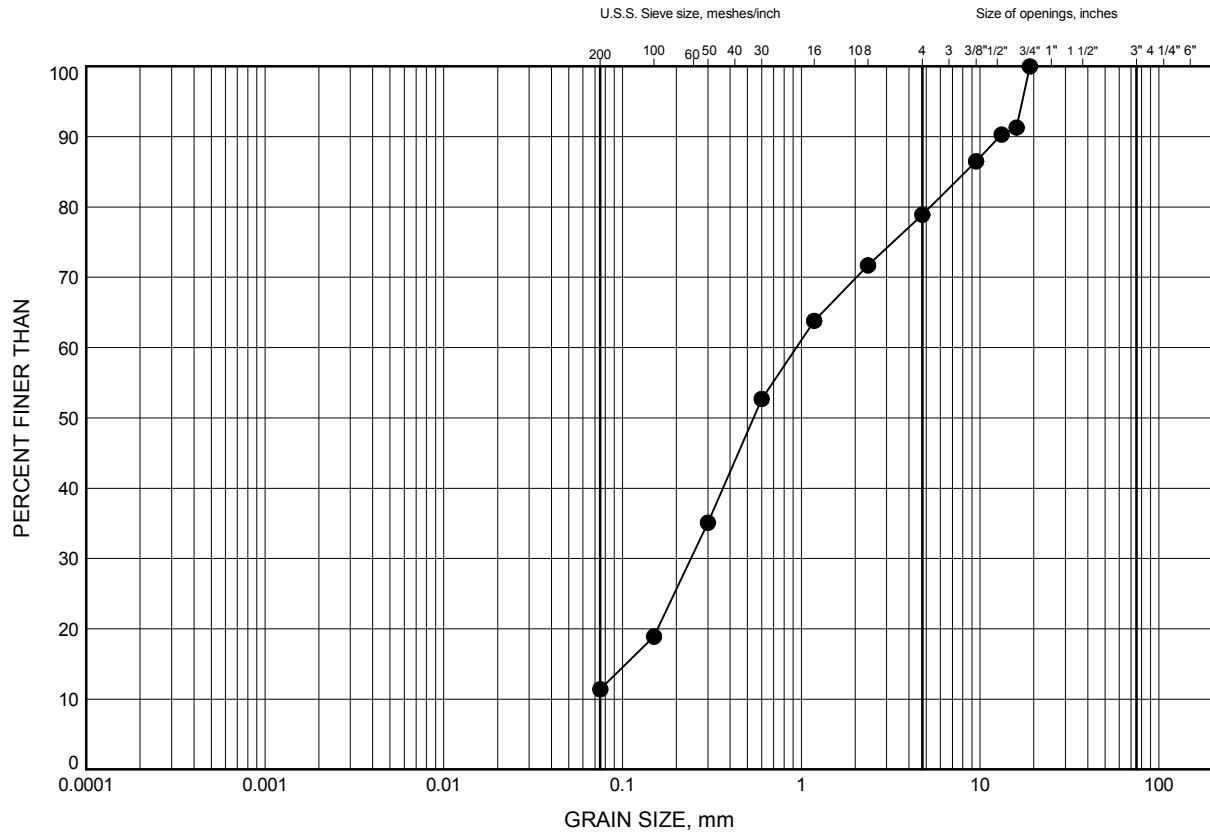
Laboratory Test Results

19-5308-95

Culvert 11+730, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-30	1.83	261.19

Date . March 2016.....
 GWP# . 545-00-00.....



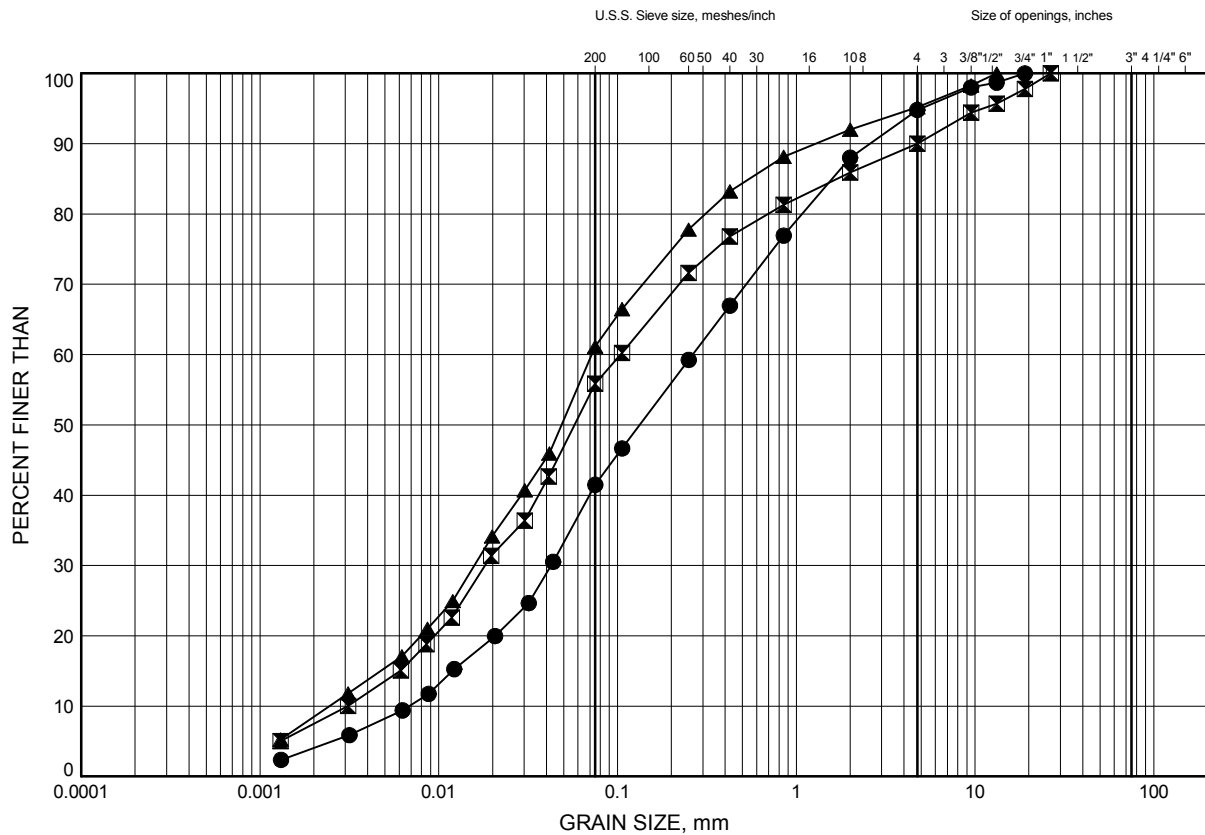
Prep'dJAG.....
 Chkd.FJG.....

Culvert 11+730, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 2

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-29	0.91	255.33
⊠	15-30	3.35	259.67
▲	15-31	1.83	260.84

Date March 2016
GWP# 545-00-00

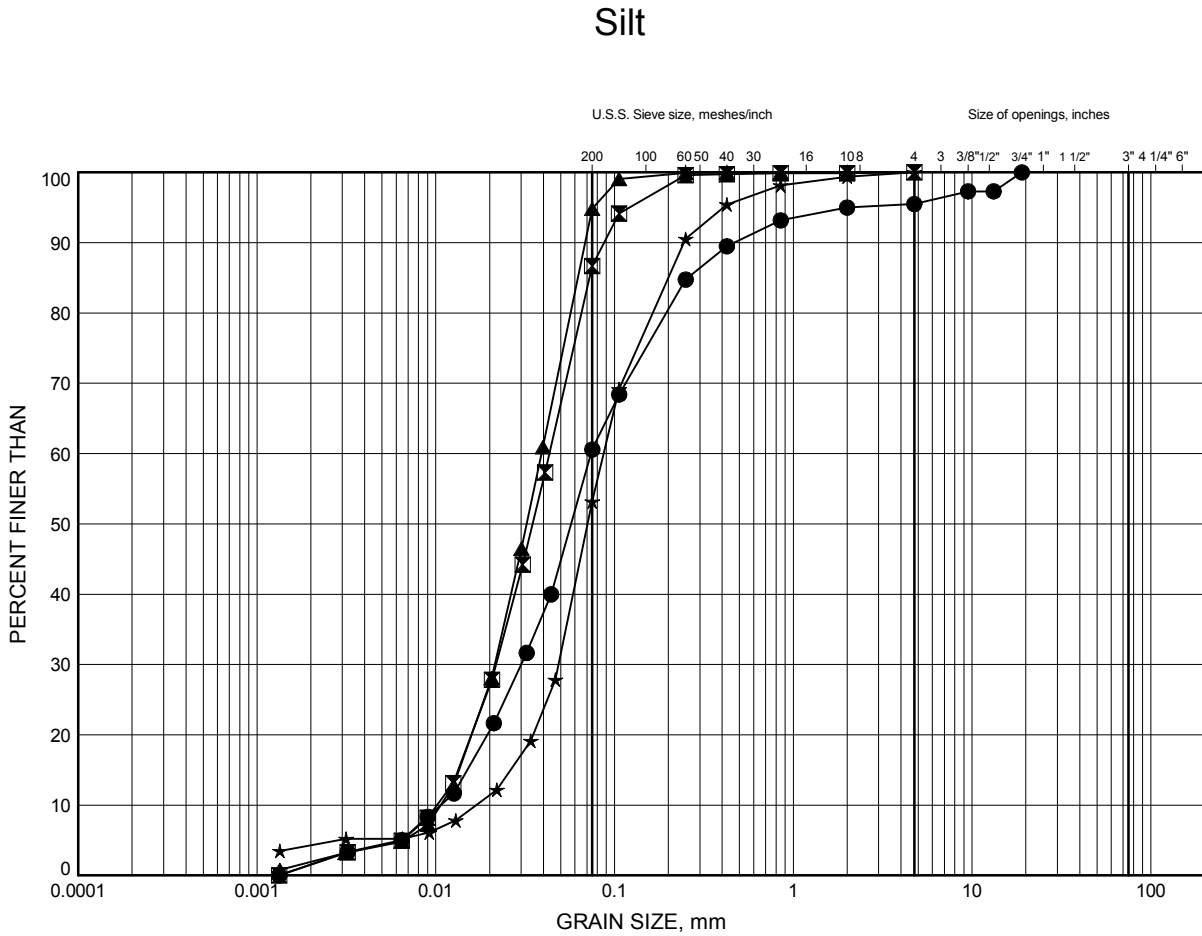


Prep'd JAG
Chkd. FJG

Culvert 11+730, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-29	1.52	254.72
⊠	15-30	4.88	258.14
▲	15-31	4.88	257.79
★	15-32	0.91	258.86

Date March 2016
GWP# 545-00-00

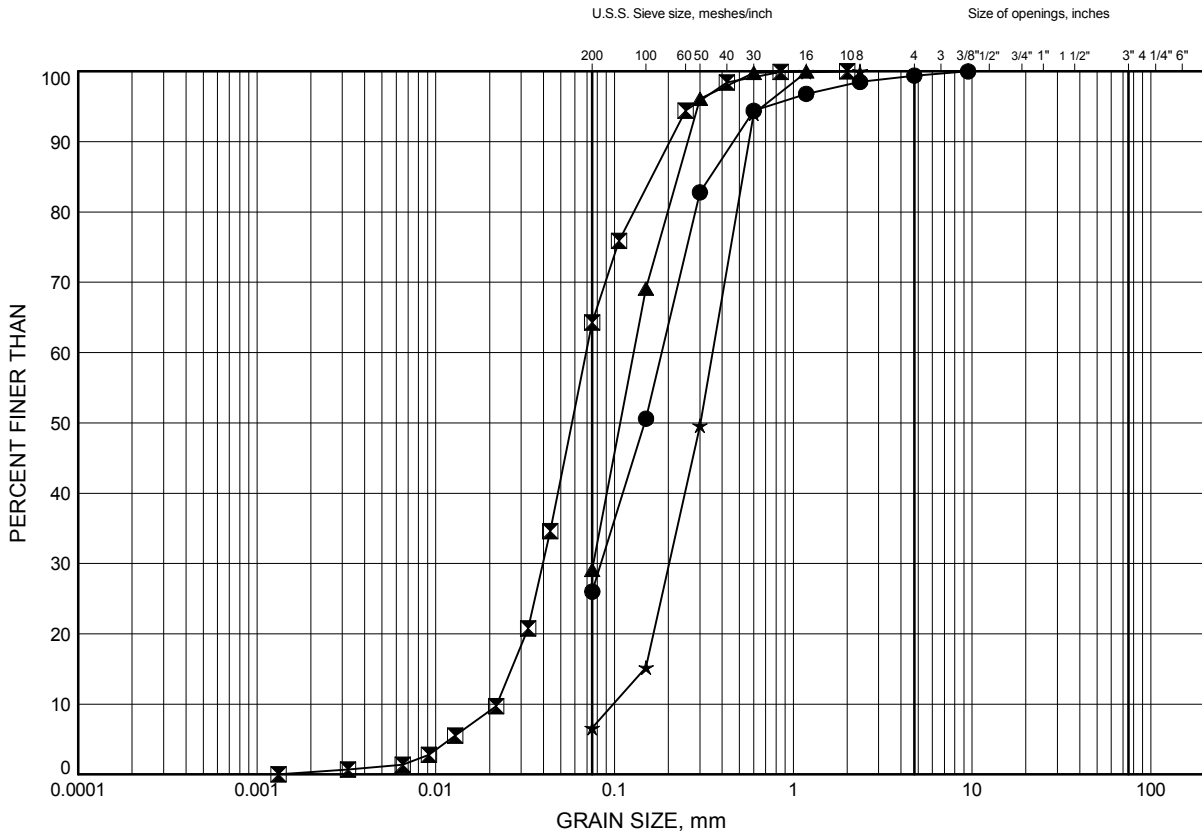


Prep'd JAG
Chkd. FJG

Culvert 11+730, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 4

Silty Sand, Sandy Silt, and Sand with Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-29	3.35	252.89
⊠	15-29	7.62	248.62
▲	15-30	7.92	255.10
★	15-30	15.54	247.48

Date March 2016
 GWP# 545-00-00

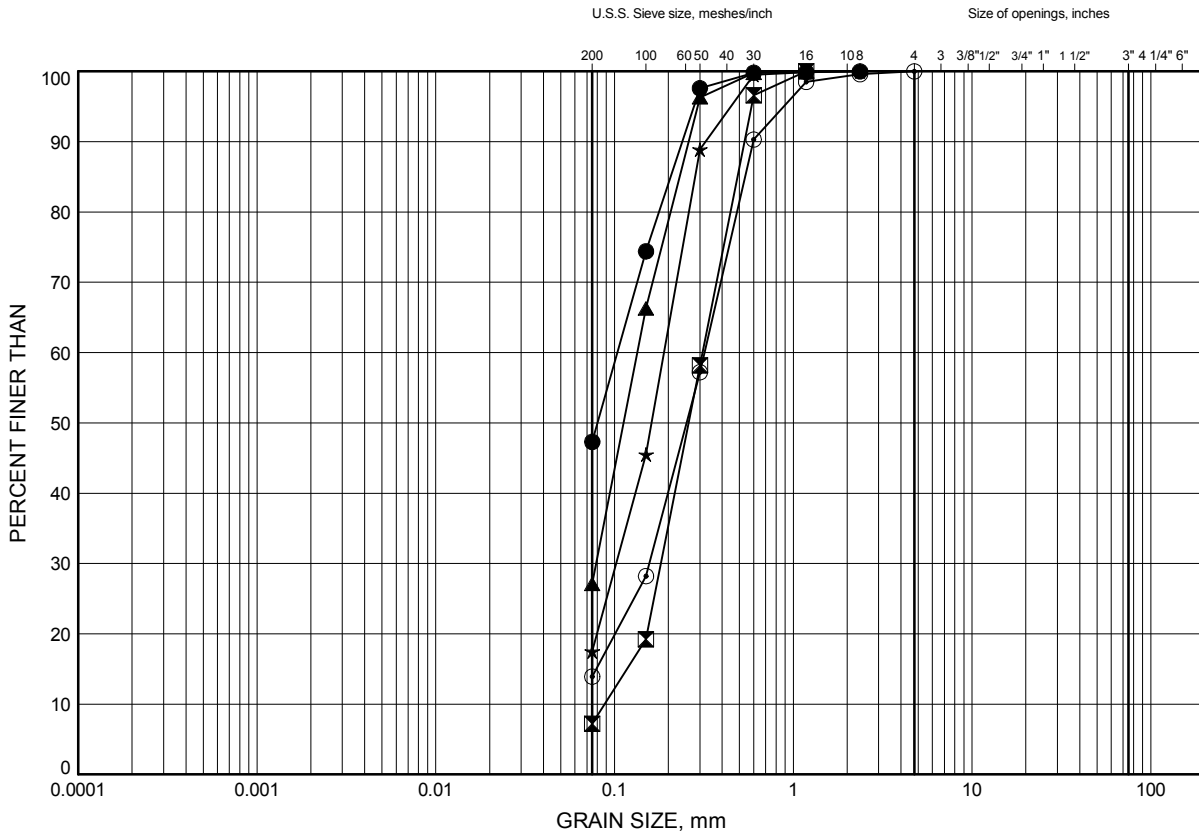


Prep'd JAG
 Chkd. FJG

Culvert 11+730, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 5

Silty Sand, and Sand with Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-31	6.40	256.27
⊠	15-31	14.02	248.65
▲	15-32	3.96	255.81
★	15-32	6.40	253.37
⊙	15-32	11.28	248.50

Date March 2016
 GWP# 545-00-00

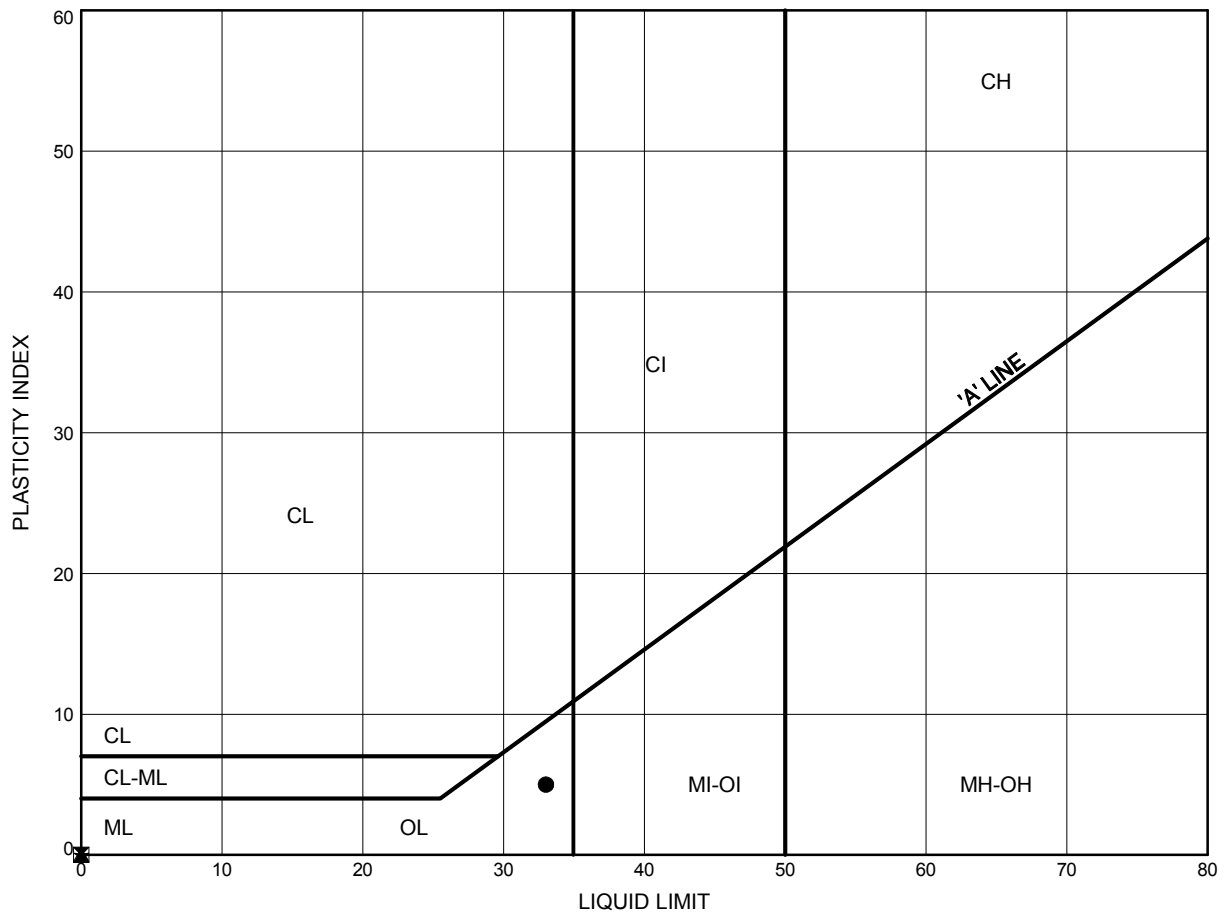


Prep'd JAG
 Chkd. FJG

Culvert 11+730, Highway 17 Goulais River

ATTERBERG LIMITS TEST RESULTS

FIGURE 6



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-29	1.52	254.72
☒	15-30	3.35	259.67
▲	15-31	1.83	260.84
★	15-32	0.91	258.86

Date March 2016

GWP# 545-00-00



Prep'd JAG

Chkd. FJG

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Shawn Lapain

Client PO:
Project: 19-5308-95
Custody: 27346

Report Date: 4-Feb-2016
Order Date: 29-Jan-2016

Order #: 1605367

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1605367-01	BH15-23 SS11 (25'-27')
1605367-02	BH15-3 SS8 (20'-22')
1605367-03	BH15-32 SS3 (4'-6')
1605367-04	BH15-33 GS3 (2.5'-3.5')

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95****Analysis Summary Table**

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	3-Feb-16	3-Feb-16
Conductivity	MOE E3138 - probe @25 °C, water ext	2-Feb-16	3-Feb-16
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	1-Feb-16	1-Feb-16
Resistivity	EPA 120.1 - probe, water extraction	2-Feb-16	2-Feb-16
Solids, %	Gravimetric, calculation	30-Jan-16	30-Jan-16

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: 19-5308-95

Client ID:	BH15-23 SS11 (25'-27')	BH15-3 SS8 (20'-22')	BH15-32 SS3 (4'-6')	BH15-33 GS3 (2.5'-3.5')
Sample Date:	07-Jan-16	18-Jan-16	18-Jan-16	21-Jan-16
Sample ID:	1605367-01	1605367-02	1605367-03	1605367-04
MDL/Units	Soil	Soil	Soil	Soil

Physical Characteristics

% Solids	0.1 % by Wt.	85.0	84.7	79.0	85.3
----------	--------------	------	------	------	------

General Inorganics

Conductivity	5 uS/cm	1400	138	114	108
pH	0.05 pH Units	6.14	6.11	5.34	5.70
Resistivity	0.10 Ohm.m	7.17	72.4	87.8	92.3

Anions

Chloride	5 ug/g dry	747	73	61	14
Sulphate	5 ug/g dry	22	11	11	17

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	8.7	5	ug/g dry	8.4			2.5	20	
Sulphate	298	5	ug/g dry	335			11.5	20	
General Inorganics									
Conductivity	749	5	uS/cm	758			1.3	6.2	
pH	7.76	0.05	pH Units	7.79			0.4	10	
Physical Characteristics									
% Solids	77.8	0.1	% by Wt.	78.6			1.0	25	

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: **19-5308-95**

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.3		mg/L	0.8	94.3	78-113			
Sulphate	41.8		mg/L	33.5	83.3	78-111			

Certificate of Analysis

Client: **Thurber Engineering Ltd.**

Client PO:

Report Date: 04-Feb-2016

Order Date: 29-Jan-2016

Project Description: 19-5308-95

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable

ND: Not Detected

MDL: Method Detection Limit

Source Result: Data used as source for matrix and duplicate samples

%REC: Percent recovery.

RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.

Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Appendix D

Selected Photographs

19-5308-95

Photo 1: West side – end of culvert



Photo 2: East side – end of culvert



Photo 3: Looking south towards culvert crossing.



Photo 4: Looking north towards culvert crossing.



Photo 5: Looking south at northbound slope.

