



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT, 23+049 HAVILLAND
HIGHWAY 17 NEAR GOULAIS RIVER
SAULT STE MARIE AREA
G.W.P. 545-00-00**

GEOCREC Number: 41K-99

Report

to

WSP Canada Inc.

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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 borehole location plan, stratigraphic profiles, 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 6.3 kilometres north of the intersection of Highway 552 and Highway 17 in the Township of Havilland. A 1.05 m diameter by 50.6 m long corrugated steel pipe culvert (CSP) is present at the site and covered with approximately 10 m of fill. The culvert conveys water under Highway 17 from west to east. The invert elevation is 253.2 m at the east end and 255.8 m at the west end.

The grade of the existing Highway 17 in the vicinity of the culvert is at 264.3 m geodetic.

The culvert is located within a fill section. The embankment is constructed with side slopes approximately 1.6 horizontal to 1 vertical (1.6H:1V). The west side slope at the crossing was noted to be rock lined with boulder sized particles. The embankment fill height is approximately 10.8 m at the east side and approximately 9.0 m at the west side. The existing roadway cross-section includes three 3.5 m lanes (two lanes in the southbound direction), a 2.2 m northbound paved shoulder, a 1.0 m southbound paved shoulder and 0.5 m rounding on both sides. Three

cable guide rail is present on both sides of the highway. The AADT is reported to be 2650. The highway has a slight curve at the site with a profile sloping down to the south at 1.7%.

The site is located in a rural area of rolling topography with forests, swamps and creeks. 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

This borehole investigation and field testing program was carried out between January 7 and January 17, 2016. The program consisted of drilling and sampling eight boreholes (numbered 15-21, 15-22, 15-23, 15-24, 15-25, 15-26, 15-27, and 15-28) to depths ranging from 4.2 to 18.7 m. Of these boreholes, one was located near the culvert outlet (15-21), one located near the culvert inlet (15-24), two (15-22 and 15-23) were located through the embankment on opposite sides of the road near the culvert, and four were drilled for potential widening/detour at the toe of slope at approximately 50 m spacing north and south of the culvert alignment on both sides of the highway (15-25, 15-26, 15-27, and 15-28).

Prior to the start of drilling, the borehole locations were established in the field and utility clearances were obtained. 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, as well as the detour boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). In-situ shear vane testing was performed in cohesive soils with an MTO N-sized vane.

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 or where required asphalt patch.

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 at the culvert consist of granular and clayey embankment fill overlying sand and silt, and gravelly deposits. The subsurface conditions found 50 m north and south of the culvert site was generally found to include a sandy silt over a clay layer overlying a silty sand layer. Bedrock was not encountered in any of the eight boreholes. More detailed descriptions of the individual strata are presented below.

5.2 Granular Fill

A layer of asphalt 60 to 90 mm in thickness was encountered at ground surface in Boreholes 15-22 and 15-23 which were drilled through the roadway.

A 0.3 m thick sand with gravel and recycled asphalt product (RAP) fill likely placed as part of a past pavement rehabilitation was found immediately below the asphalt. Sand with silt and gravel with occasional cobbles extended to a depth of 2.3 m and 1.5 m below surface (elevations 262.0 m and 263.1 m) in Boreholes 15-22 and 15-23 respectively.

The moisture content of the granular fill ranged from 3% to 9%. The results of grain size analysis conducted on one sample of the granular material are presented on Fig. No 1 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	39
Sand	50
Silt and Clay	11

The ground was frozen at the time of the field investigation thus the relative density of this layer could not be determined reliably.

5.3 Embankment Fill

Embankment fill was encountered below the granular fill in Boreholes 15-22 and 15-23. The thickness of the embankment fill ranged from 7.5 m to 8.5 m. The base of the embankment fill was encountered at elevations ranging from 253.5 m to 255.6 m.

The upper portions of the fill were observed to range from sand with silt and gravel to sandy silt while the lower portion was sandy clay. Trace to some organics were noted in the embankment fill. In Borehole 15-22 a 0.9 m thick layer of sand fill with gravel and occasional cobbles was found below the sandy clay fill.

The SPT N-value for the sand and silt embankment fill ranged from 3 to 42 blows per 0.3 m penetration, indicating a very loose to dense state. The water contents of the recovered sand and silt fill samples ranged between 6% and 35%. The colour of the sand and silt fill is brown to reddish brown.

The SPT N-value for the sandy clay fill ranged from 5 to 16 blows per 0.3 m penetration, indicating a firm to very stiff state. The water contents of the recovered sandy clay embankment fill samples ranged between 17% and 36%. The colour of the sandy clay fill is brown to reddish brown.

The SPT N-value for the lower sand with gravel, occasional cobbles found in Borehole 15-22 was 73 blows per 0.3 m penetration, indicating a very dense state. Sample recovery was poor thus water content and grain size analysis could not be conducted. Field observations describe this material as moist with a brown colour.

The results of grain size analyses conducted on five samples of the embankment fill are presented on Fig. No 2 and Fig. No 3 in Appendix C. The results are summarized in the following table.

Soil Particles	%
<u>Silty Sand Fill</u>	
Gravel	9 to 35
Sand	53 to 66
Silt and Clay	12 to 38
<u>Sandy Clay Fill</u>	
Gravel	3 and 5
Sand	30 and 34
Silt	44 and 37
Clay	23 and 24

Atterberg limit testing was carried out on two samples of the sandy clay fill. The samples can be classified as clay of low plasticity (CL). The results are presented on Fig. No 8 in Appendix C and summarized in the table below.

Test	%
Plastic Limit	18 and 16
Liquid Limit	26 and 27
Plasticity Index	8 and 11

5.4 Topsoil

Topsoil, 25 mm to 75 mm in thickness, was encountered in all off-road boreholes. 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 Sandy Silt

A soil deposit generally described as sandy silt was encountered in Boreholes 15-25, 15-26, 15-27, and 15-28 just below the base of the embankment fill, and just below the topsoil. This layer was observed to range from 0.5 m to 1.7 m in thickness with the elevation of the base of the unit ranging from 261.8 m to 263.9 m.

The SPT N-value for this deposit was 4 to 21 blows per 0.3 m penetration, indicating a very loose to compact state. The water contents of the recovered samples ranged between 14% and 22%. The colour of this deposit is brown.

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

Soil Particles	%
Gravel	0 and 2
Sand	24 and 47
Silt	65 and 48
Clay	11 and 3

5.6 Clay

Clay was encountered underlying the sandy silt deposit in all four widening boreholes (15-25, 15-26, 15-27, and 15-28). Where encountered, the thickness ranged from 0.2 m to 2.9 m. The elevation of the underside of this clay ranged from at 258.9 m to 263.7 m. This deposit contained occasional to frequent silt, sand and gravel seams. A 0.6 m thick silty sand layer was found within the deposit in Borehole 15-26.

The SPT N-value in the clay deposit was 4 to 14 blows per 0.3 m penetration. In conjunction with measured field vane shear strengths ranging from 91 to greater than 106 kPa, the clay was found to have a typically stiff to very stiff consistency. The sensitivity ranged from 3 to 5. The

colour of the clay is brown to reddish brown. The water content of the recovered clay samples ranged from 32% to 53%; the silty sand layer in 15-26 had a water content of 22%.

The results of grain size analysis conducted on two samples of the clay are presented on Fig. No 5 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	0 and 14
Sand	13 and 23
Silt	49 and 33
Clay	38 and 30

Atterberg limit testing was carried out on two samples of the clay. This soil can be classified as clay of low (CL) to intermediate plasticity (CI). The results are presented on Fig. No 8 in Appendix C and summarized in the table below.

Test	%
Plastic Limit	15 and 16
Liquid Limit	31 and 38
Plasticity Index	16 and 22

5.7 Silty Sand

A native soil deposit ranging from silty sand to sand with silt and gravel was encountered in all boreholes. This soil was found just below the topsoil in the inlet and outlet holes, and beneath the base of the embankment fill in the roadway holes. In all four widening boreholes this layer was found below the native clay layer. All boreholes were terminated in this layer at elevation ranging from 245.6 m to 256.9 m. This layer was at least 4.0 m to 6.8 m in thickness. A 0.3 m thick gravel layer was noted within the unit in Borehole 15-21. A similar layer 1.2 m thick was noted at the base of the hole in Borehole 15-22.

The SPT N-value for this deposit was 2 to greater than 100 blows per 0.3 m penetration, indicating a very loose to very dense state. The deposit is generally dense. The water contents of the recovered samples ranged between 4% and 25%. The colour of this deposit is brown to reddish brown.

Grain size analyses conducted on six samples of the soil are presented on Fig. No 6 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	6 to 30
Sand	32 to 77
Silt and Clay	7 to 59

A grain size analysis conducted on two samples of the gravel layer found in Borehole 15-21 and 15-22 are presented on Fig. No 7 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	46 and 44
Sand	40 and 43
Silt and Clay	14 and 13

5.8 Groundwater Conditions

Groundwater was observed in Boreholes 15-21, 15-26, 15-27 and 15-28. The results are summarized in the following table.

Borehole	Depth of observed water (m)	Elevation of observed water (m)
15-21	0.9	253.8
15-26	0.9	262.7
15-27	0.5	262.9
15-28	0.5	262.2

A 25 mm inside diameter PVC piezometer was installed in Borehole 15-24. The piezometer was recorded as dry to 4.16 m on January 11, 2016 and February 19, 2016; corresponding to an elevation of 253.2 m. The piezometer was decommissioned on February 19, 2016.

The water level at the inlet was at an elevation of 255.9 m on January 11, 2016. The water level at the outlet was at an elevation of 254.2 m on January 14, 2016. The groundwater level in the area of the culvert is expected to reflect the water level in the ditches.

These observations are short-term readings and seasonal fluctuations of the groundwater level are to be expected, and must be taken into consideration. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

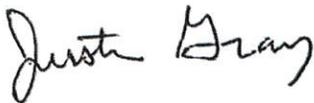
6 MISCELLANEOUS

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 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.



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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

CONT No
WP No

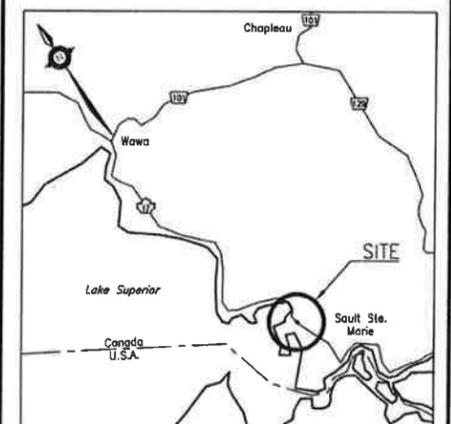
HIGHWAY 17
23+049
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

WSP



SHEET

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

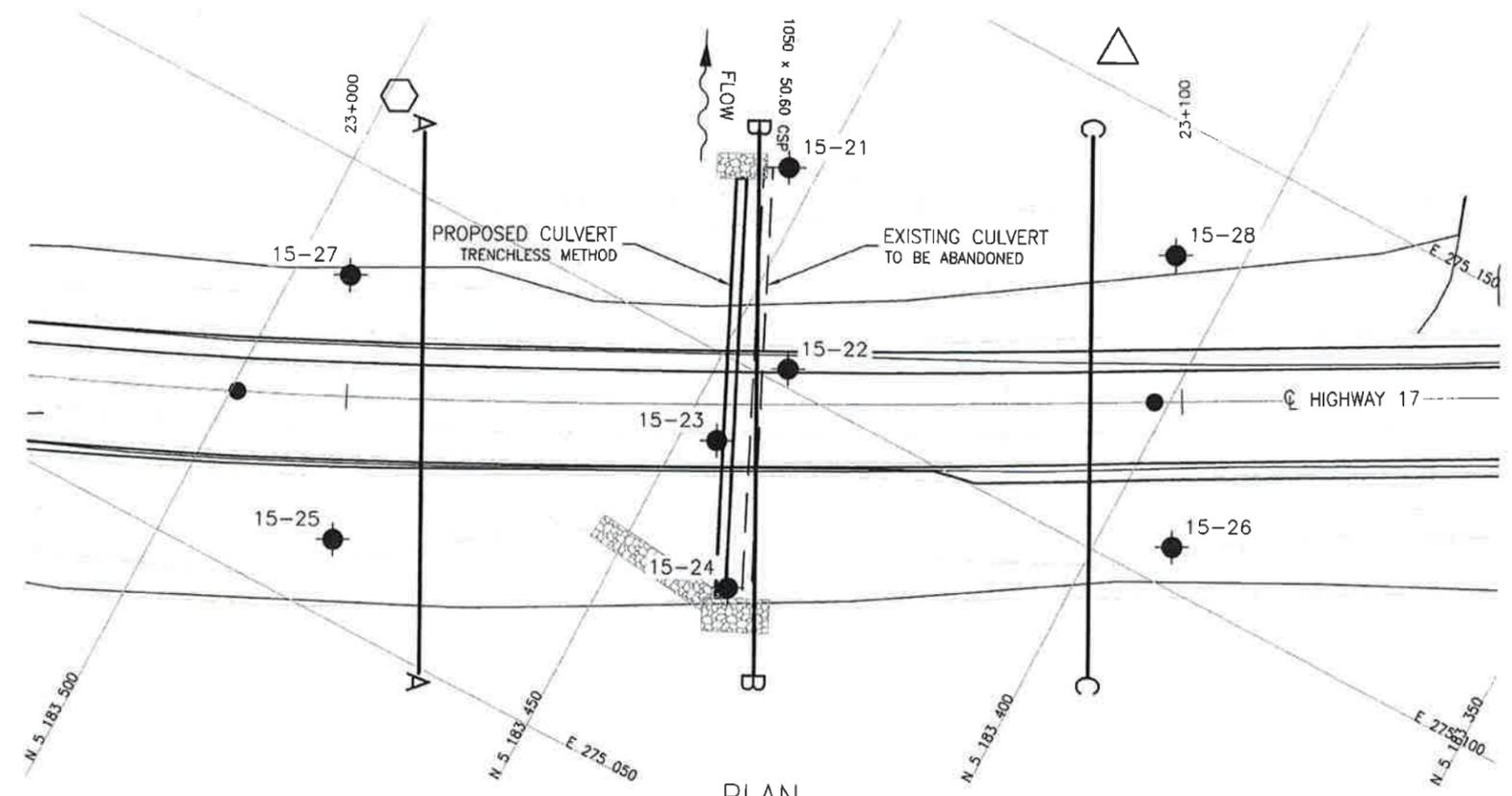
- ◆ Borehole
- ⊕ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- ▽ Water Level
- ⊕ Head Artesian Water
- ⊕ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
15-21	254.7	5 183 453.4	275 123.3
15-22	264.3	5 183 442.2	275 102.0
15-23	264.6	5 183 445.7	275 090.5
15-24	257.3	5 183 436.3	275 075.6
15-25	264.5	5 183 480.9	275 058.7
15-26	263.6	5 183 391.6	275 104.6
15-27	263.4	5 183 493.8	275 087.5
15-28	262.7	5 183 407.5	275 135.6

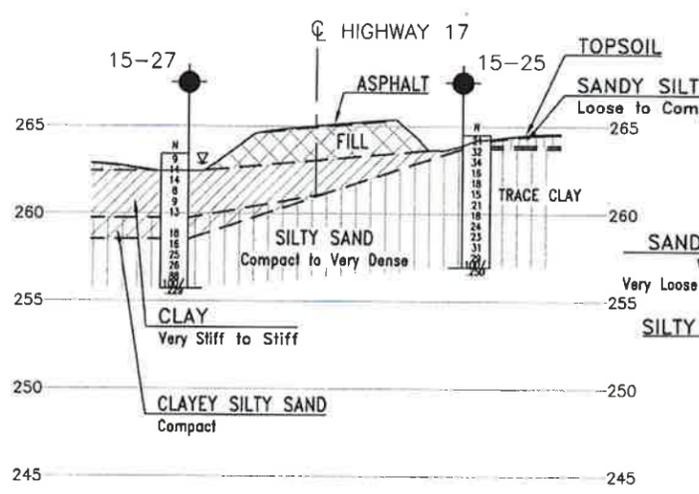
-NOTES-

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

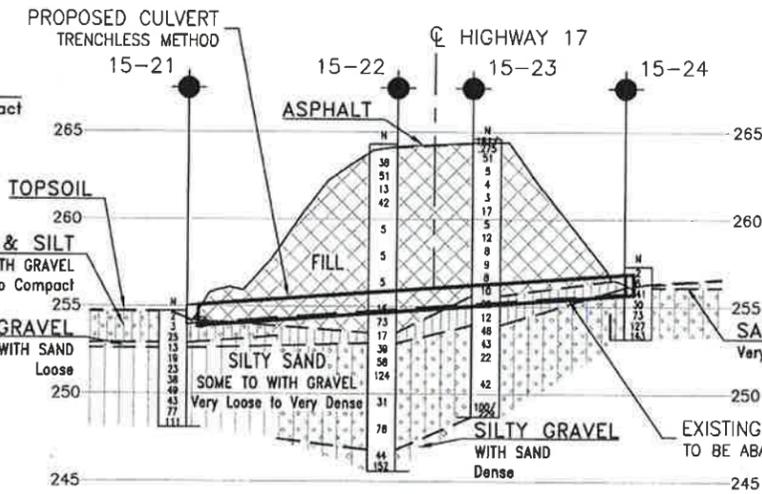
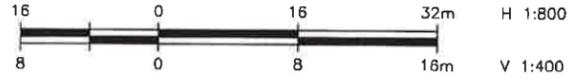
GEORES No. 41K-99



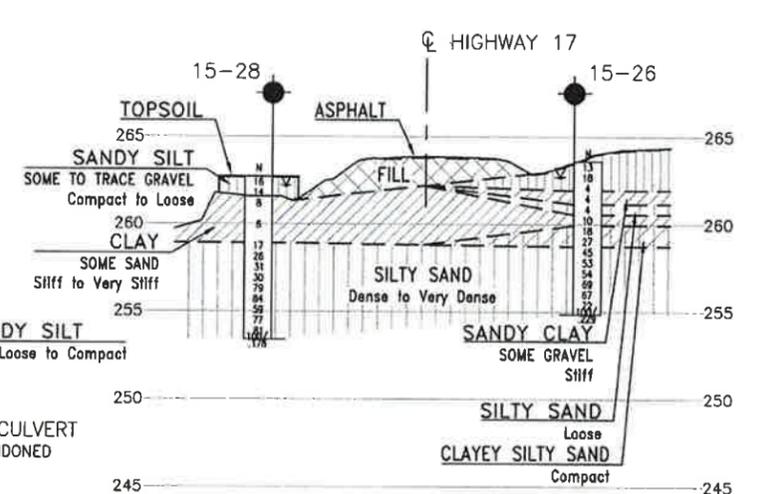
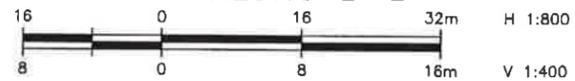
PLAN



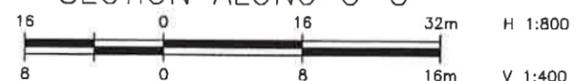
SECTION ALONG A-A



SECTION ALONG B-B



SECTION ALONG C-C



DATE	BY	DESCRIPTION
DESIGN	JG	CHK -
DRAWN	MFA	CHK JG
		SITE
		STRUCT
		DWG 1

FILENAME: K:\Drawing\19\3208\95\Lead995-PlanProfile-Culvert_80.dwg
PLOTDATE: 9/7/2016 4:03 PM

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 15-21

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 453.4 E 275 123.3 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.01.13 - 2016.01.14 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 (%)
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 (%)								
						PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	W _p	W	W _L			
254.7	TOPSOIL (25 mm)													
0.0	SILTY SAND with gravel to sandy SILT Very Loose to compact Brown Wet		1	SS	2									
			2	SS	3									
			3	SS	25									
252.9														
1.8	GRAVEL , silty with sand													
252.6	Loose Brown Wet		4	SS	13								46 40 14 (SI+CL)	
2.1	SILTY SAND Compact to Very Dense Brown Wet to Moist		5	SS	19									
			6	SS	23									
			7	SS	38									
			8	SS	49									
			9	SS	43									
			10	SS	77									
	some gravel		11	SS	111									
248.1														
6.7	End of Borehole at 6.65 m Groundwater at 0.9 m Cave at 1.3 m upon completion													

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-22

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 442.2 E 275 102.0 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.09.01 - 2016.09.01 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							
264.3															
0.0	ASPHALT , (60 mm)														
264.0	Sand with gravel with RAP FILL		1	AS											
0.3	Sand with silt and gravel, occasional cobbles Dense to Very Dense Brown Moist FILL		2	SS	38										
			3	SS	51									39 50 11 (SI+CL)	
262.0															
2.3	Silty Sand with gravel to sandy silt trace organics Loose to dense Brown to Reddish Brown Moist to Wet FILL		4	SS	13										
			5	SS	42									18 66 16 (SI+CL)	
			6	SS	5										
258.2															
6.1	Sandy clay trace gravel trace organics firm to very stiff Reddish Brown Wet FILL		7	SS	5										
			8	SS	5									3 30 44 23	
			9	SS	16										
254.4															

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

Continued Next Page

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

RECORD OF BOREHOLE No 15-22

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 442.2 E 275 102.0 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.09.01 - 2016.09.01 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	GR SA SI CL
9.9	Sand with gravel occasional cobbles Very Dense Brown Moist FILL		10	SS	73									
253.5														
10.8	Sandy SILT Compact Brown Moist		11	SS	17						○			
252.9														
11.4	SAND with silt and gravel to SILTY SAND Dense to very dense Reddish Brown Moist		12	SS	39						○			
			13	SS	58						○			16 77 7 (SI+CL)
			14	SS	124						○			
			15	SS	31						○			6 45 47 2
			16	SS	78						○			
246.8														
17.5	GRAVEL, silty with sand Dense to very dense Brown		17	SS	44						○			
			18	SS	152						○			44 43 13 (SI+CL)
245.6														
18.7	End of Borehole at 18.7 m Borehole Dry Upon Completion Cave at 12.0 m Upon Completion													

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

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

RECORD OF BOREHOLE No 15-23

1 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 445.7 E 275 090.5 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.07.01 - 2016.07.01 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
264.6															
0.0	ASPHALT (90 mm)														
0.1															
264.3	Sand with gravel and RAP FILL		1	SS	181/ 275mm										
0.3	Sand with silt and gravel, occasional cobble Very Dense Brown Dry FILL		2	SS	51										
263.1															
1.5	Silty sand to Sand with silt and gravel Very loose to compact Brown Moist to wet FILL		3	SS	5										
			4	SS	4										
			5	SS	3										
	with organics		6	SS	17										
			7	SS	5									9 53 33 5	
			8	SS	12										
			9	SS	8									35 53 12 (SI+CL)	
257.8															
6.9	Sandy clay to silty sand occasional clay layers Stiff Brown Moist FILL		10	SS	9										
			11	SS	8										
			12	SS	10									5 34 37 24	
255.6															
9.0	Sandy SILT Compact Brown Wet		13	SS	29										

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 15-23

2 OF 2

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 445.7 E 275 090.5 ORIGINATED BY JAG
 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
 DATUM Geodetic DATE 2016.07.01 - 2016.07.01 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page						20	40	60	80	100						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
							20	40	60	80	100	20	40	60			
254.0	Sandy SILT Compact Brown Wet		14	SS	12							○				9 32 52 7	
10.7	SAND with silt and gravel Compact to very dense Brown Moist		15	SS	46							○					
			16	SS	43							○				30 58 12 (SI+CL)	
			17	SS	22							○					
			18	SS	42							○				23 65 12 (SI+CL)	
			19	SS	100/ 229mm							○					
248.7																	
15.9	End of Borehole at 15.9 m due to auger refusal Borehole dry upon completion Borehole open upon completion																

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-24

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 436.3 E 275 075.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable / Casing COMPILED BY SML
 DATUM Geodetic DATE 2016.08.01 - 2016.11.01 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									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
257.3																	
0.0	TOPSOIL (50 mm)																
	Sandy SILT with organics Very loose to loose Brown Wet		1	SS	2												
			2	SS	6												
256.1																	
1.2	SILTY SAND with gravel Compact to very dense Brown Wet		3	SS	141												
			4	SS	30												
			5	SS	73											26 56 18 (SI+CL)	
			6	SS	127												
			7	SS	143												
253.2																	
4.2	End of Borehole at 4.16 m Borehole dry upon completion Borehole open upon completion																

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-25

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 480.9 E 275 058.7 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.11.01 - 2016.11.01 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								
264.5														
0.0	TOPSOIL (50 mm)													
0.1	Sandy SILT Compact Brown		1	SS	21									
263.9														
260.0	CLAY Very Stiff Reddish Brown		2	SS	32									
0.8	SILTY SAND Compact to very dense Brown to reddish brown Moist		3	SS	34									
			4	SS	16									
			5	SS	18									
	trace clay		6	SS	15									
			7	SS	21									
			8	SS	18									
			9	SS	24									
			10	SS	23									
			11	SS	31									
			12	SS	29									
			13	SS	100									
256.9														
7.6	End of Borehole at 7.57 m Borehole dry upon completion Borehole open upon completion					250 mm								

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

RECORD OF BOREHOLE No 15-26

1 OF 1

METRIC

GWP# 545-00-00 LOCATION Culvert 23+049, Highway 17 Goulais River N 5 183 391.6 E 275 104.6 ORIGINATED BY CAM
 HWY 17 BOREHOLE TYPE Portable COMPILED BY SML
 DATUM Geodetic DATE 2016.12.01 - 2016.12.01 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			20	40	60						80
263.6	TOPSOIL (25 mm) Sandy SILT Compact to loose Brown Moist to wet		1	SS	13	▽										
			2	SS	18											0 24 65 11
262.0			3	SS	4											
1.7	CLAY (Cl) , sandy some gravel Firm Brown occasional sand seams		4	SS	4											14 23 33 30
261.2			5	SS	4											
260.6	SILTY SAND occasional clay seams Loose Brown Wet		6	SS	10											
3.0	CLAY occasional sand seams Stiff Brown		7	SS	18											
260.0			8	SS	27											
3.7	SILTY SAND , clayey Compact Brown Moist		9	SS	45											
			10	SS	53											
258.8			11	SS	54											
4.9	SILTY SAND Dense to very dense Brown Moist		12	SS	69											
			13	SS	67											
			14	SS	72											
254.9			15	SS	100/											
8.8	End of Borehole at 8.76 m Groundwater at 0.9 m upon completion Borehole open upon completion				229m											

ONTMT4S_19-5308-95.GPJ 2012TEMPLATE(MTO).GDT 9/15/16

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

Appendix C

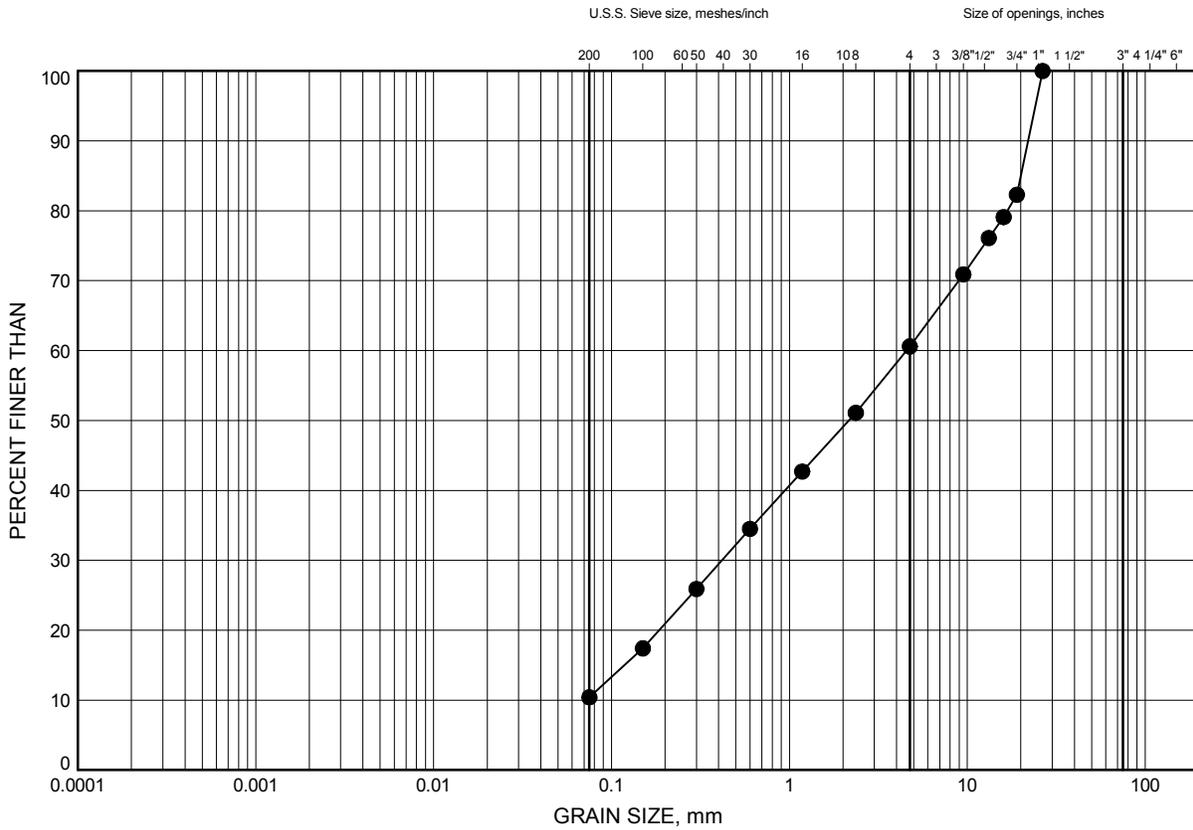
Laboratory Test Results

19-5308-95

Culvert 23+049, 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)
●	15-22	1.83	262.48

Date May 2016
 GWP# 545-00-00



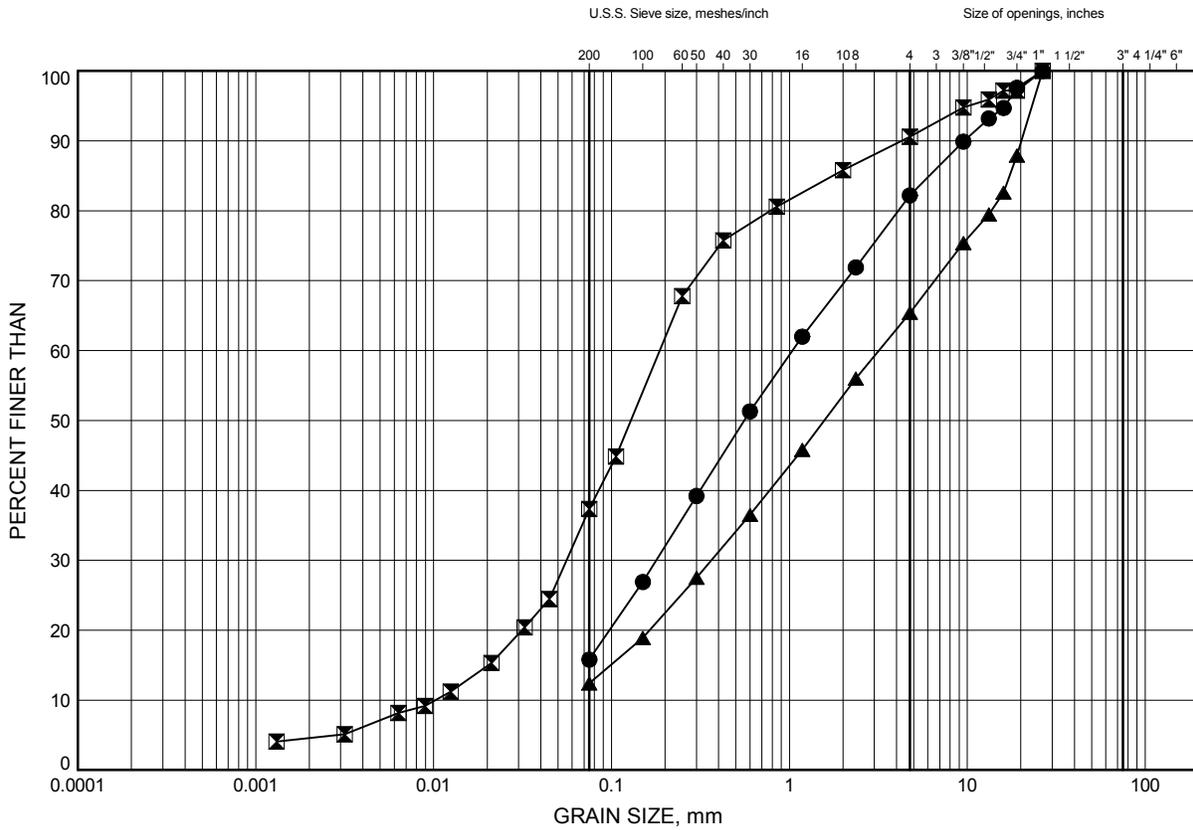
Prep'd JAG
 Chkd. FJG

GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 16/5/16

Culvert 23+049, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 2

Non-Cohesive Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-22	3.35	260.96
⊠	15-23	4.88	259.75
▲	15-23	6.40	258.23

Date May 2016
 GWP# 545-00-00

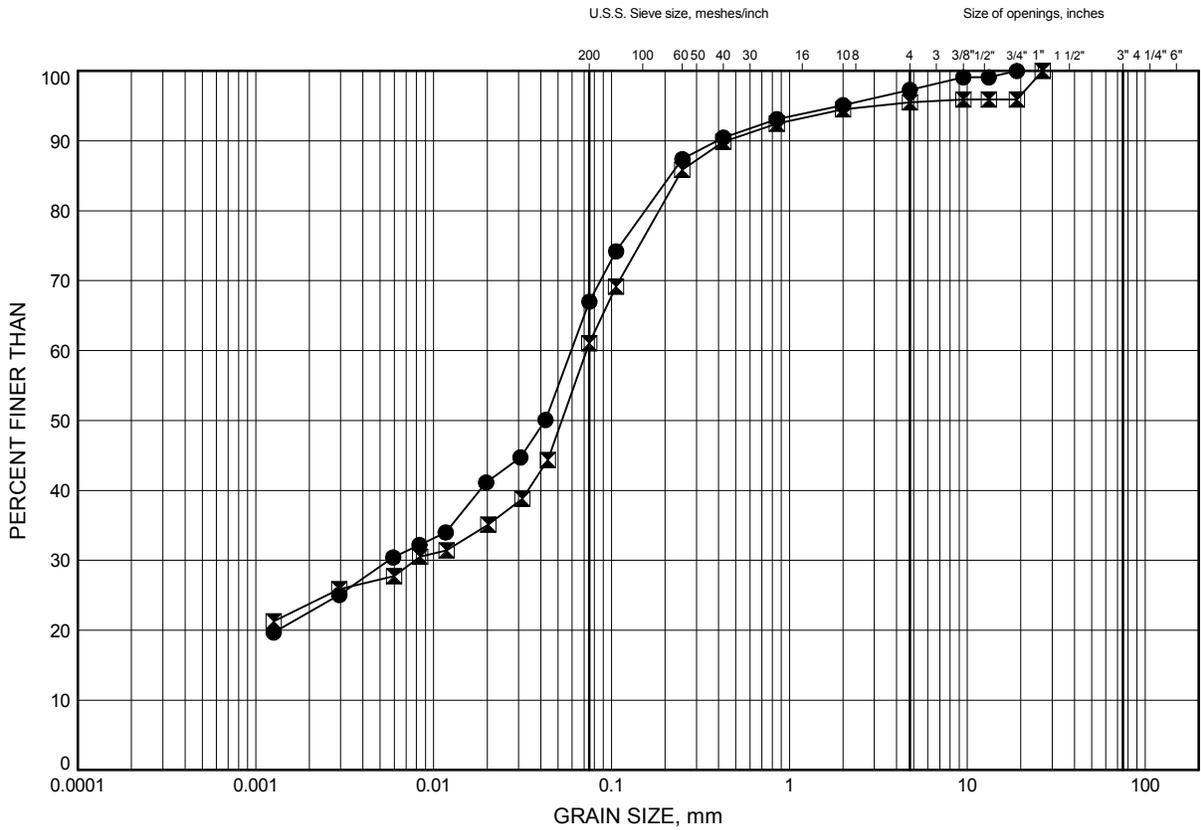


Prep'd JAG
 Chkd. FJG

Culvert 23+049, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 3

Cohesive Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-22	7.92	256.39
☒	15-23	8.69	255.94

GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 16/5/16

Date May 2016
 GWP# 545-00-00

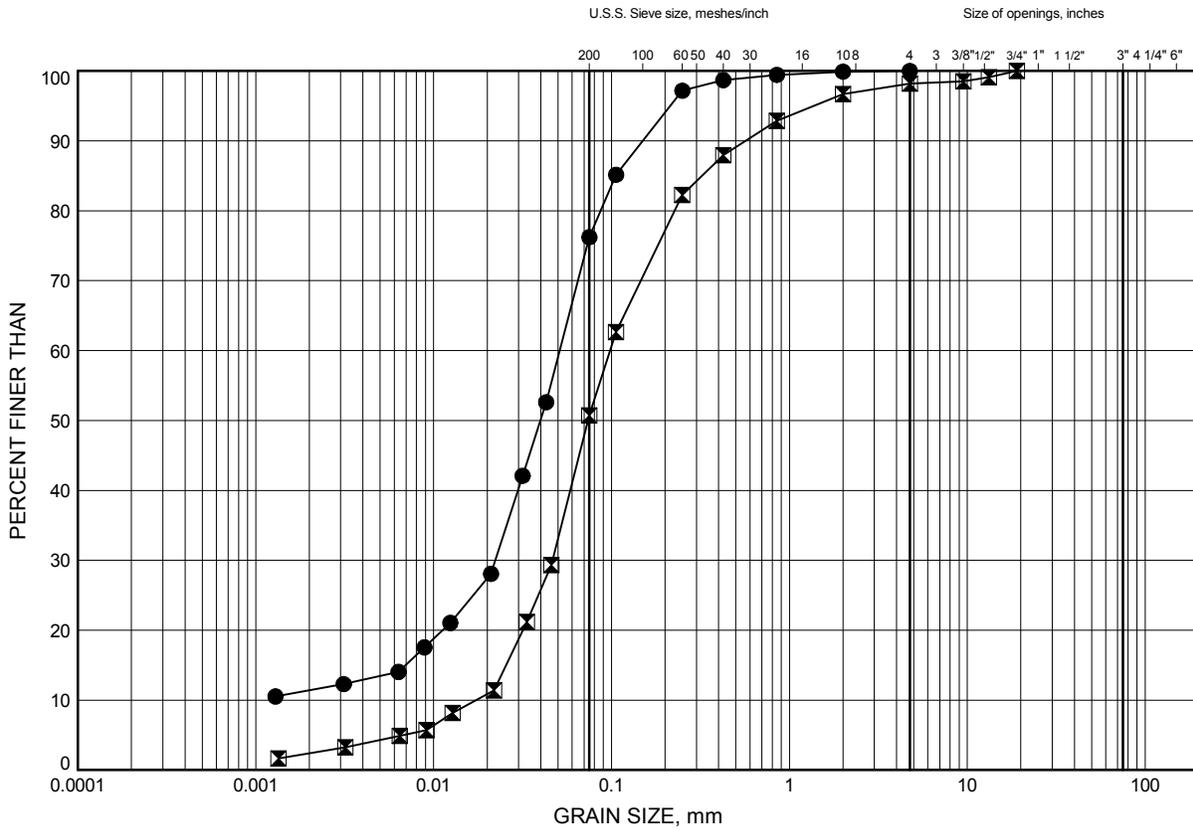


Prep'd JAG
 Chkd. FJG

Culvert 23+049, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 4

Sandy Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-26	0.91	262.73
⊠	15-27	0.34	263.07

GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 16/5/16

Date May 2016
 GWP# 545-00-00

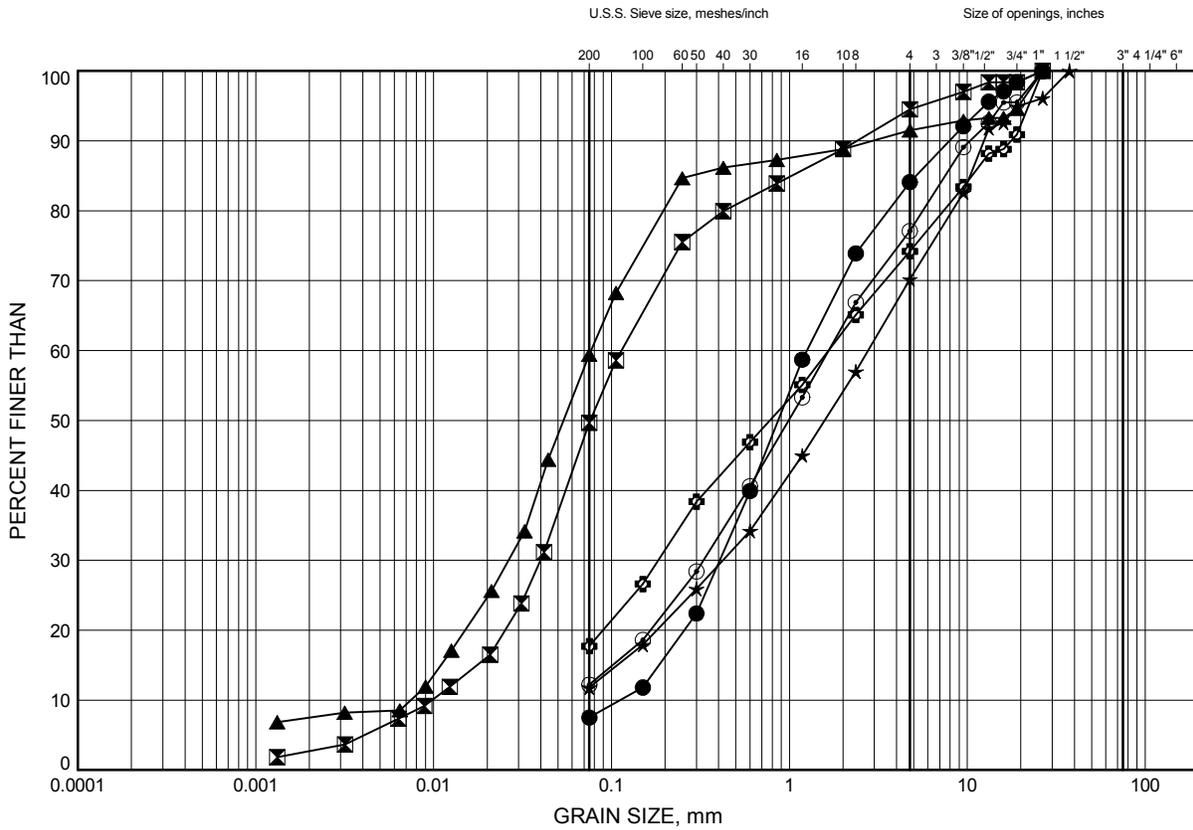


Prep'd JAG
 Chkd. FJG

Culvert 23+049, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 6

Sand with Silt and Gravel to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-22	12.50	251.81
⊠	15-22	14.78	249.53
▲	15-23	10.21	254.42
★	15-23	11.73	252.89
⊙	15-23	14.02	250.61
⊕	15-24	2.74	254.58

Date May 2016
 GWP# 545-00-00

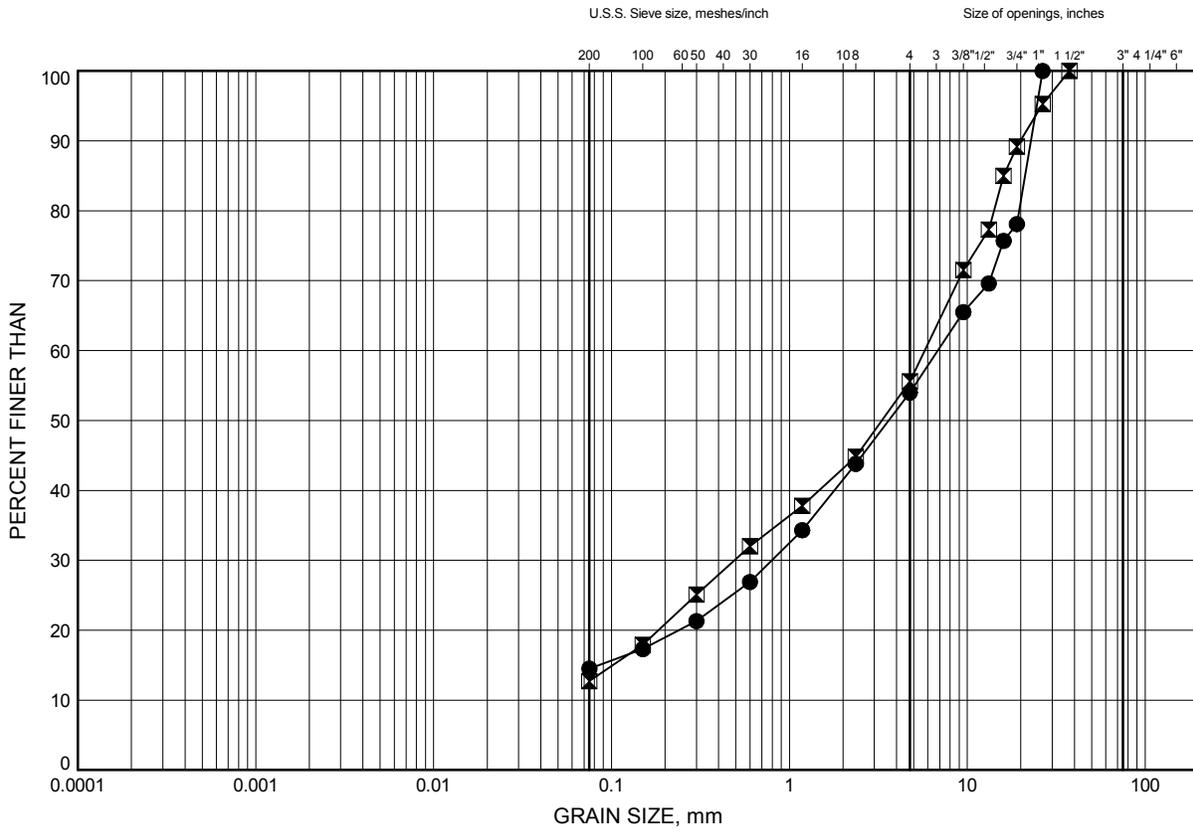


Prep'd JAG
 Chkd. FJG

Culvert 23+049, Highway 17 Goulais River
GRAIN SIZE DISTRIBUTION

FIGURE 7

Gravel, Silty with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-21	2.13	252.62
⊠	15-22	18.44	245.87

GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 16/5/16

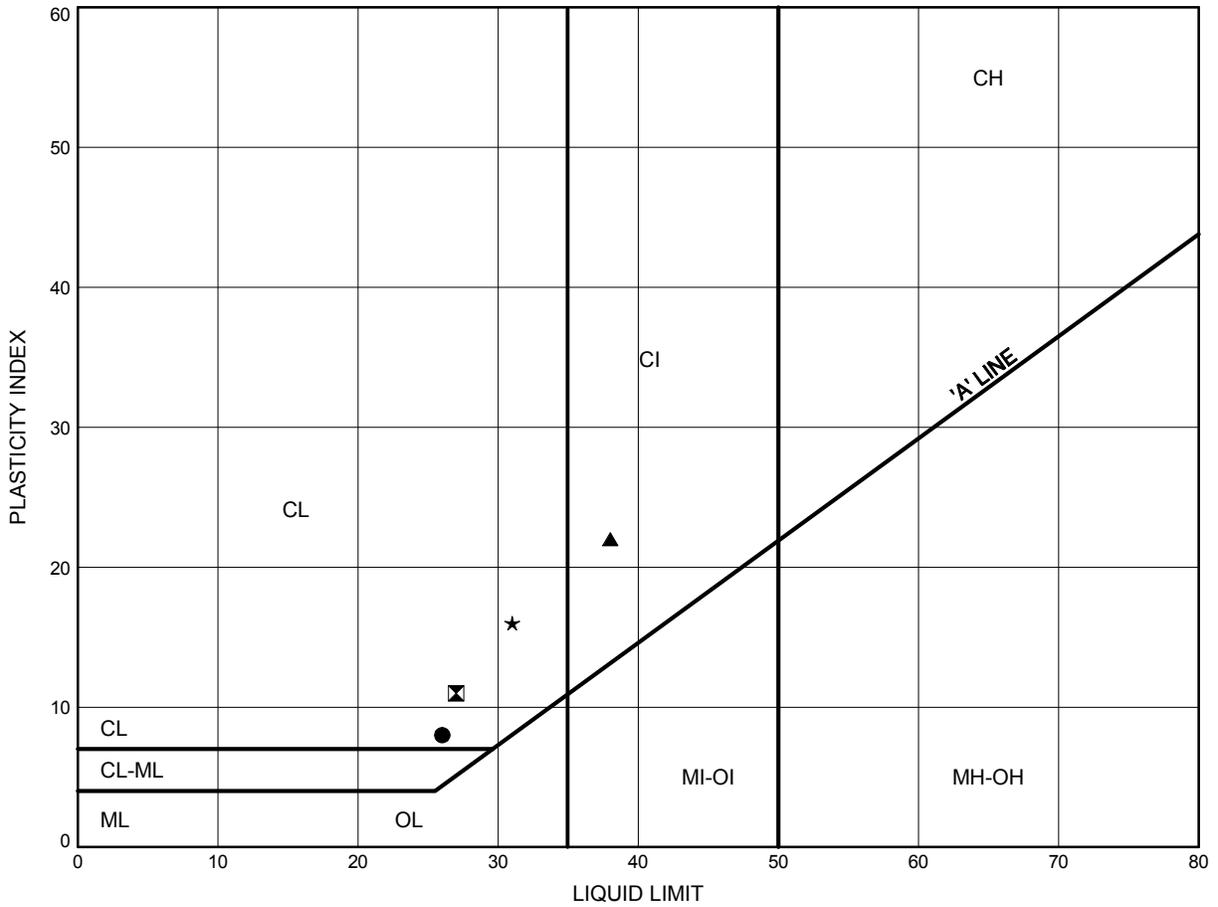
Date May 2016
 GWP# 545-00-00



Prep'd JAG
 Chkd. FJG

Culvert 23+049, Highway 17 Goulais River
ATTERBERG LIMITS TEST RESULTS

FIGURE 8



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-22	7.92	256.39
⊠	15-23	8.69	255.94
▲	15-26	2.13	261.52
★	15-28	2.74	259.98

THURBALT 19-5308-95.GPJ 16/5/16

Date May 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:

Parcel 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

Report Date: 04-Feb-2016

 Client: **Thurber Engineering Ltd.**

Order Date: 29-Jan-2016

Client PO:

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

Report Date: 04-Feb-2016

 Client: **Thurber Engineering Ltd.**

Order Date: 29-Jan-2016

Client PO:

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

Report Date: 04-Feb-2016

 Client: **Thurber Engineering Ltd.**

Order Date: 29-Jan-2016

Client PO:

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

Report Date: 04-Feb-2016

 Client: **Thurber Engineering Ltd.**

Order Date: 29-Jan-2016

Client PO:

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

Report Date: 04-Feb-2016

Client: **Thurber Engineering Ltd.**

Order Date: 29-Jan-2016

Client PO:

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 – looking toward end of culvert



Photo 3: Looking north at culvert crossing and west side slope.



Photo 4: Looking north towards culvert crossing.



Photo 5: Looking north at east slope.

