THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
CULVERT REPLACEMENT, 22+283 HAVILLAND
HIGHWAY 17 NEAR GOULAIS RIVER
SAULT STE MARIE AREA
G.W.P. 545-00-00

GEOCRES Number: 41K-98

Report

to

WSP Canada Inc.

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September 19, 2016
19-5308-95

THURBER

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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, 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 7.1 kilometres north of the intersection of Highway 552 and Highway 17 in the Township of Havilland. A 1.05 m diameter by 61.7 m long corrugated steel pipe culvert (CSP) is present at the site and covered with approximately 10 m of fill. The culvert conveys water from west to east, towards the nearby Stokely Creek. The invert elevation is 239.2 m at the east end and 245.7 m at the west end.

The grade of the existing Highway 17 in the vicinity of the culvert is at 253.8 m geodetic. The culvert is located within a fill section The embankment is constructed with side slopes approximately 1.9 horizontal to 1 vertical (1.9H:1V) and 1.8 horizontal to 1 vertical (1.8H:1V),

corresponding to the east and west slopes respectively. The embankment fill height is approximately 12.6 m at the east side and approximately 9.9 m at the west side.

The existing roadway cross-section includes three 3.5 m wide lanes (two lanes in the southbound direction), a 2.2 m wide northbound paved shoulder, a 1.0 m wide southbound paved shoulder and 0.5 m rounding on both sides. Three cable guide rail is present on the northbound side of the highway. The AADT is reported to be 2650. The highway profile slopes down to the north at approximately 5.1%. Although the site is in a tangent section a curve begins less than 200 m to the south.

The site is located in a rural area with forests, swamps, creeks. The local topography is 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

This borehole investigation and field testing program was carried out between January 24 and 28, 2016. The program consisted of drilling and sampling four boreholes (numbered 15-17, 15-18, 15-19, and 15-20) to depths ranging from 2.6 to 21.9 m. Of these boreholes, one was located near the culvert inlet (15-20), one located near the culvert outlet (15-17), and two (15-18 and 15-19) were located through the embankment on opposite sides of the road near the culvert.

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. 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 with 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.

One soil sample was submitted to Paracel Laboratories Ltd. (Ottawa) for analysis of pH, resistivity, and soluble sulphate and chloride. The results of the chemical testing can be found 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 embankment fill overlying clay and sandy silt layers underlain by silty sand with gravel till. Bedrock was not encountered in any of the four boreholes. More detailed descriptions of the individual strata are presented below.

5.2 Sand with Gravel Fill

A layer of asphalt 80 mm in thickness was encountered at ground surface in Borehole 15-19 which was drilled through the paved shoulder of the roadway.

Sand fill with gravel extended to a depth of 0.9 m and 2.3 m below surface (elevations 251.1 m and 253.2 m) in Boreholes 15-19 and 15-18 respectively.

The moisture content of the granular fill ranged from 3% to 13%. 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 Silty Sand Embankment Fill

Silty sand fill was encountered below the sand with gravel fill in Boreholes 15-18 and 15-19. The thickness of the silty sand fill ranged from 7.6 m to 11.7 m. The base of the silty sand fill was encountered at elevations ranging of 241.5 m and 243.5 m.

The embankment fill was observed to be silty sand to sand with silt some gravel including occasional cobbles, while the lower portion in Borehole 15-18 was a mixture of silt, sand and clay which was cohesive in nature.

Silty sand fill was also noted in the inlet and outlet boreholes with a thickness of 1.2 m and 1.8 m and a base elevation of 238.9 m and 245.5 m.

The SPT N-value for the silty sand embankment fill ranged from 7 to 33 blows per 0.3 m penetration, indicating a loose to dense state. The SPT N-value for the silty sand fill found at the inlet and outlet ranged from 2 to 7 blows per 0.3m, indicating a very loose to loose state. The water contents of the recovered silty sand embankment fill samples ranged between 10% and 22%. The colour of the silty sand fill is brown.

The SPT N-value for the silty, sandy clay fill in Borehole 15-18 ranged from 3 to 7 blows per 0.3 m penetration, indicating firm state. The water content of the silty, sandy clay fill samples ranged between 33% and 46%. The colour of the silty, sandy clay fill is reddish brown.

The results of grain size analyses conducted on five samples of the embankment fill are presented on Fig. No 1 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Silty Sand Fill	
Gravel	1 to 4
Sand	52 to 91
Silt and Clay	8 to 46
Silty, Sandy Clay Fill	
Gravel	0
Sand	42
Silt	31
Clay	27

Atterberg limit testing was carried out on one sample of the silty, sandy clay fill. The liquid limit was 33% and the plasticity index was 21%. The sample can be classified as clay of low plasticity (CL). The results are presented on Fig. No 6 in Appendix C and summarized in the table below.

Test	%
Plastic Limit	12
Liquid Limit	33
Plasticity Index	21

5.4 Topsoil

Topsoil 25 mm in thickness, was encountered in one borehole (15-20) drilled at the inlet. The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating quantities or quality.

A sandy silt fill with organics was observed over the fill in Borehole 15-17. It was 300 mm thick and had a moisture content of 21%.

5.5 Sand with Silt and Gravel

A native soil deposit likely the original creek bed ranging from sand with silt and gravel to gravel with silt and sand was encountered in three boreholes (Boreholes 15-17, 15-19, and 15-20). This soil was found just below the embankment fill. This layer, where encountered was observed to range from 1.1 m to 1.5 m in thickness with base elevation ranging from 237.5 m to 244.4 m. The upper portion of this deposit in Borehole 15-19 contained wood. This layer contained occasional to frequent cobbles.

The SPT N-value for this deposit was 6 to greater than 100 blows per 0.3 m penetration, indicating a loose to very dense state. The high N-values are likely due to the presence of cobbles within this layer. The water contents of the recovered samples typically ranged between 8% and 17%, although one sample containing wood returned a moisture content of 43%. The colour of this deposit is brown.

Grain size analyses conducted on three samples of the soil are presented on Fig. No 2 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	28 to 53
Sand	37 to 64
Silt and Clay	7 to 10

5.6 Clay (CH) to Silty Clay

A native clay deposit was encountered in two boreholes (15-18 and 15-19). In Borehole 15-18 the clay was of high plasticity, while the soil in Borehole 15-19 was a silty clay. This soil was found just below the embankment fill in Borehole 15-18 and below the silty sand and gravel in Borehole 15-19. This layer was observed to range from 4.7 m to 5.4 m in thickness with the elevation of the base of the unit ranging from 236.6 m to 236.8 m.

The SPT N-values for the clay of high plasticity ranged from 3 to 4 blows per 0.3 m penetration. In-situ shear vane test results indicated undrained shear strengths ranging from 64 kPa to 90 kPa; indicating a stiff consistency. The water content of the clay of high plasticity ranged between 34% and 66%. The colour of this material is reddish brown.

The SPT N-values measured within the silty clay ranged from 12 to 39 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. The moisture content of the silty clay samples ranged from 13% to 24%. The colour of this material was brown to reddish brown.

Grain size analyses conducted on two samples of the soil are presented on Fig. No 3 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Clay (CH)	
Gravel	0
Sand	7
Silt	24
Clay	69
Silty Clay	
Gravel	0
Sand	6
Silt	81
Clay	13

Atterberg limit testing was carried out on a sample of each clay type.

The clay in Borehole 15-18 had a liquid limit was 72% and the plasticity index was 50%. The sample can be classified as clay of high plasticity (CH).

The silty clay in Borehole 15-19 had a liquid limit was 23% and the plasticity index was 6%. The sample can be classified as silty clay to clayey silt (CL-ML).

The results are presented on Fig. No 6 in Appendix C and summarized in the table below.

	Clay (CH)	Silty Clay
Test	**%**	**%**
Plastic Limit	22	17
Liquid Limit	72	23
Plasticity Index	50	6

5.7 Silt

A deposit ranging from silt with sand to sandy silt with gravel was encountered below the clay in Boreholes 15-18 and 15-19. This layer was observed to range from 1.5 m to 2.0 m in thickness with the base elevation ranging from 235.3 m to 234.6 m. A similar material was observed in Borehole 15-20 to be 2.1 m thick and extending to elevation 242.3 m

SPT N-values measured within this silt material ranged from 26 to greater than 100 blows per 0.3 m penetration, indicating a compact to very dense state. The colour of this deposit was brown to brownish grey.

The moisture content of the samples tested ranged from 10% to 27%. Two samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Fig. No 4 in Appendix C.

Soil Particles	%
Gravel	0 and 22
Sand	5 and 28
Silt	40 and 90
Clay	5 and 10

The material can be classified as silt (ML).

5.8 Silty Sand with Gravel (Till)

A silty sand with gravel till was encountered below the silt in 15-18 and 15-19. Both Borehole 15-18 and Borehole 15-19 were terminated within this layer at elevations of 233.8 m and 231.5 m and 3.1 m, respectively. The top elevation of the unit ranged from 235.3 m and to 234.6 m.

SPT N-values measured within this glacial till layer material ranged from 43 to greater than 100 blows per 0.3 m penetration, indicating a dense to very dense state. The colour of this deposit was brown.

The moisture content of the samples tested ranged from 6% to 12%. Two samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Fig. No 5 in Appendix C.

Soil Particles	%
Gravel	17 and 22
Sand	35 and 57
Silt and Clay	48 and 21

5.9 Groundwater Conditions

Groundwater was not observed in any of the boreholes. However, Boreholes 15-18 and 15-20 exhibited cave at depths of 9.8 m and 1.5 m (elevations 244.3 m and 245.8 m), respectively upon completion of drilling. The water level in the culvert at the inlet was observed to be at elevation 245.9 m on January 27, 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 will affect water levels.

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.

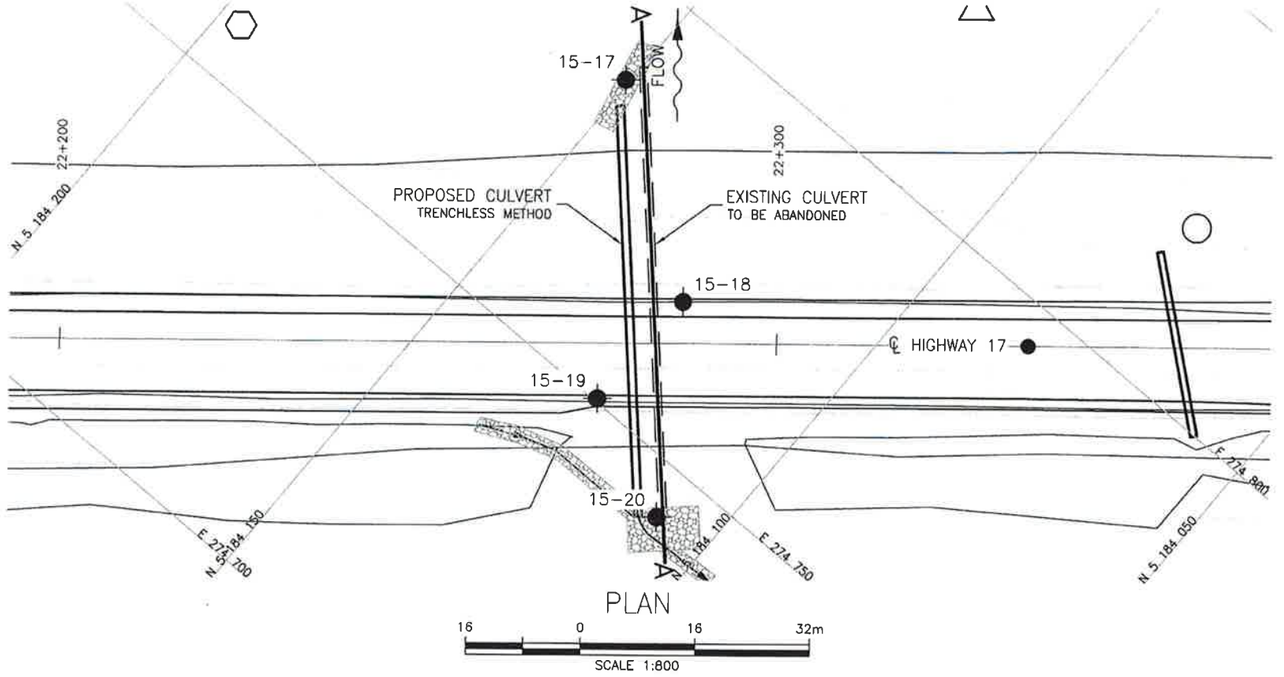
Fred J. Griffiths, P.Eng.
Senior Associate, Senior Foundations Engineer

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

Appendix A

Borehole Locations and Soil Strata Drawings

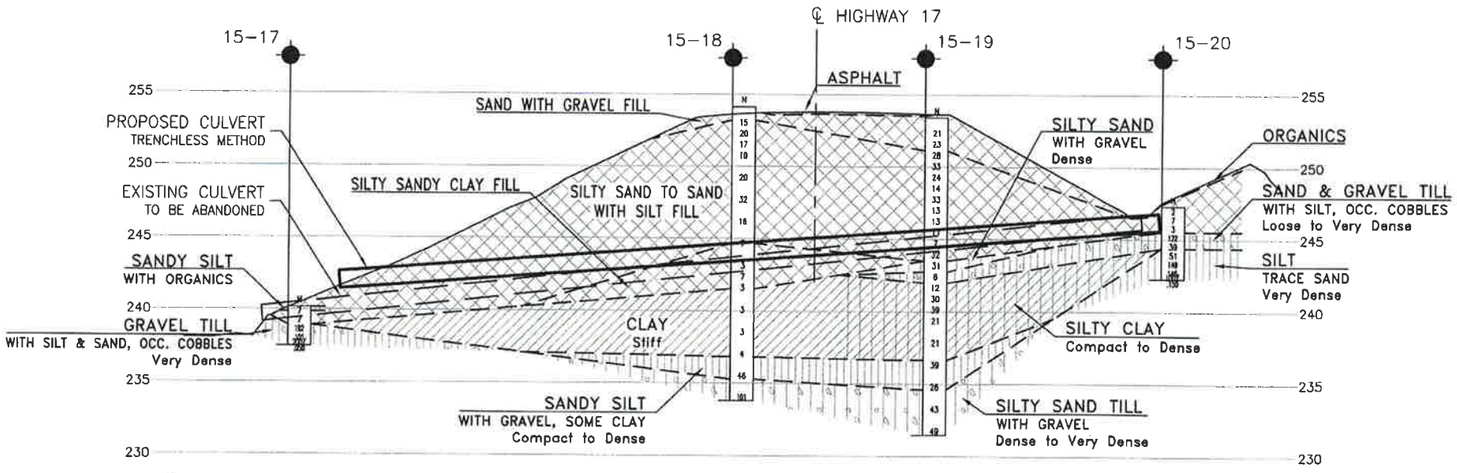
19-5308-95



PLAN

16 0 16 32m

SCALE 1:600



SECTION ALONG A-A

8 0 8 16m

SCALE 1:400

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
F. J. GRIFFITHS
Sept 14/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Sep 14/16
PROVINCE OF ONTARIO

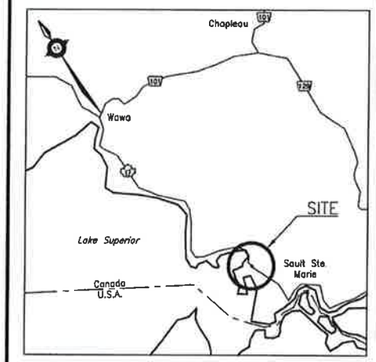
CONT No
WP No

HIGHWAY 17
22+283
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

WSP

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
15-17	240.1	5 184 150.6	274 786.7
15-18	254.1	5 184 124.5	274 768.3
15-19	253.4	5 184 125.0	274 750.4
15-20	247.3	5 184 108.0	274 743.1

-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-98

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	JG	CHK –	CODE	LOAD	DATE SEP 2016
DRAWN	MFA	CHK JG	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\18\5308\95\tec6885-PlanAProfile(Culvert 57).dwg
PLOTDATE: 9/7/2016 3:18 PM

MINISTRY OF TRANSPORTATION, ONTARIO

Appendix B

Record of Borehole Sheets

19-5308-95

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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.

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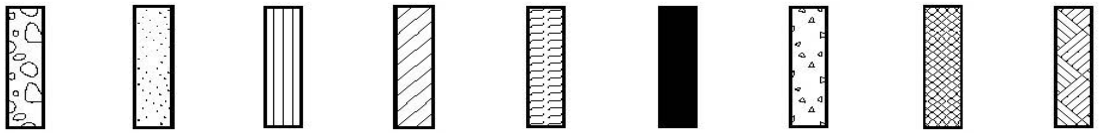
STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



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

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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

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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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-17 1 OF 1 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 150.6 E 274 786.7 ORIGINATED BY CAM

HWY 17 BOREHOLE TYPE Portable COMPILED BY SML

DATUM Geodetic DATE 2016.01.24 - 2016.01.24 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
240.1											
0.0 / 239.8	Sandy silt with organics **FILL**		1	SS	7		240				
0.3	Silty sand Loose Brown Moist to Wet **FILL**		2	SS	7						
238.9	some clay						239				
1.2	**GRAVEL** with silt and sand, occasional cobbles Very Dense Brown Wet		3	SS	192						
			4	SS	101		238				53 37 8 2
237.5			5	SS	200/ 50 mm						
2.6	End of Borehole at 2.63 m Borehole Open Upon Completion Borehole Dry Upon Completion										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-18 1 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 124.5 E 274 768.3 ORIGINATED BY JAG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML

DATUM Geodetic DATE 2016.01.27 - 2016.01.28 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.1											
0.0	Sand with gravel Compact Brown Moist **FILL**		1	AS			254		○		
253.2											
0.9	Silty sand to sand with silt some gravel, occasional cobbles Compact to Dense Brown Moist to wet **FILL**		2	SS	15		253		○		
			3	SS	20				○		
			4	SS	17		252		○		2 52 46 (SI+CL)
			5	SS	10		251		○		
			6	SS	20		250		○		
			7	SS	32		249		○		
	wet		8	SS	16		248		○		
	some clay						247				
244.7			9	SS	7		246		○		
9.4	Silty, Sandy Clay Reddish brown Firm						245				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-18 2 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 124.5 E 274 768.3 ORIGINATED BY JAG
HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML
DATUM Geodetic DATE 2016.01.27 - 2016.01.28 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	FILL						244				
			10	SS	3						0 42 31 27
							243				
			11	SS	7						
							242				
241.5			12	SS	3						
12.6	**CLAY (CH)** Stiff Reddish Brown Moist							4.0			
			13	SS	3		241				
							240	4.3 4.0			
			14	SS	3		239				0 7 24 69
								3.5			
							238	3.8			
			15	SS	4		237				
236.8											
17.3	Sandy **SILT** with gravel some clay Dense Brownish Grey Moist						236				
			16	SS	46						22 28 40 10
235.3											
18.8	**SILTY SAND** with gravel Very Dense Brown **TILL**						235				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-18 3 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 124.5 E 274 768.3 ORIGINATED BY JAG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML

DATUM Geodetic DATE 2016.01.27 - 2016.01.28 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
233.8			17	SS	101		234				
20.3	End of Borehole at 20.33 m Borehole Open to 9.76 m Upon Completion										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-19 1 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 125.0 E 274 750.4 ORIGINATED BY JAG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML

DATUM Geodetic DATE 2016.01.25 - 2016.01.26 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
253.4											
0.0	**ASPHALT** (80 mm)										
0.1	Sand with gravel Compact Brown Moist **FILL**		1	SS	21		253		○		
			2	SS	23		252		○		
251.1											
2.3	Silty sand to sand with silt Loose to Dense Brown Moist **FILL**		3	SS	28		251		○		
			4	SS	33		250		○		4 72 24 (SI+CL)
			5	SS	24		249		○		
	occasional clay layer trace gravel		6	SS	14				○ ○		
			7	SS	33		248		○		
			8	SS	13		247		○		
			9	SS	13		246		○		
			10	SS	11				○		1 91 8 (SI+CL)
			11	SS	7		245		○ ○		
			12	SS	32		244		○		
243.5											

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-19 2 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 125.0 E 274 750.4 ORIGINATED BY JAG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML

DATUM Geodetic DATE 2016.01.25 - 2016.01.26 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page											
9.9	**SILTY SAND** with gravel, occassional wood Dense Brown		13	SS	31		243			○		
242.7	Wet											
10.7	**SAND and GRAVEL** with silt occasional cobbles Loose Brown		14	SS	6					○		45 48 7 (SI+CL)
242.0	Wet						242					
11.4	**SILTY CLAY** Stiff to Hard Brown to Reddish Brown		15	SS	12					○		
			16	SS	30		241			⊣⊢		0 6 81 13
			17	SS	39					○		
			18	SS	21		240			○		
							239					
			19	SS	21		238			○		
236.6							237					
16.8	**SILT** with sand some clay to Sandy **SILT** Dense to Compact Brown		20	SS	39					○		
	Wet						236					
			21	SS	26		235			○		
234.6												
18.8	**SILTY SAND** with gravel Dense Brown **TILL**						234					

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-19 3 OF 3 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 125.0 E 274 750.4 ORIGINATED BY JAG

HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SML

DATUM Geodetic DATE 2016.01.25 - 2016.01.26 CHECKED BY FJG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	SILTY SAND with gravel Dense Brown **TILL**		22	SS	43		233		○		22 57 21 (SI+CL)
231.5			23	SS	49		232		○		17 35 44 4
21.9	End of Borehole at 21.95 m Borehole Open to 9.8 m Upon Completion Borehole Dry Upon Completion										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 15-20 1 OF 1 METRIC

GWP# 545-00-00 LOCATION Culvert 22+283, Highway 17 Goulais River N 5 184 108.0 E 274 743.1 ORIGINATED BY CAM

HWY 17 BOREHOLE TYPE Portable / Casing COMPILED BY SML

DATUM Geodetic DATE 2016.01.27 - 2016.01.27 CHECKED BY FJG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
247.3											
0.0 / 0.0	**TOPSOIL** (25 mm)										
	Silty sand Very Loose to Loose Brown Moist to Wet **FILL**		1	SS	2		247				
			2	SS	7						2 78 20 (SI+CL)
			3	SS	3		246				
245.5											
1.8	**SAND** with silt and gravel, occasional cobbles Very Dense to Dense Brown Wet		4	SS	122						
			5	SS	39		245				28 64 8 (SI+CL)
244.4											
2.9	**SILT** trace sand Very Dense Brown Moist		6	SS	51		244				0 5 90 5
			7	SS	149						
			8	SS	146		243				
242.3			9	SS	100/150 mm						
5.0	End of Borehole at 2.89 m Borehole Open to 1.5m Upon Completion										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\overset{20}{15\text{-}\oplus\text{-}5}$ (%) STRAIN AT FAILURE

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

Appendix C

Laboratory Test Results

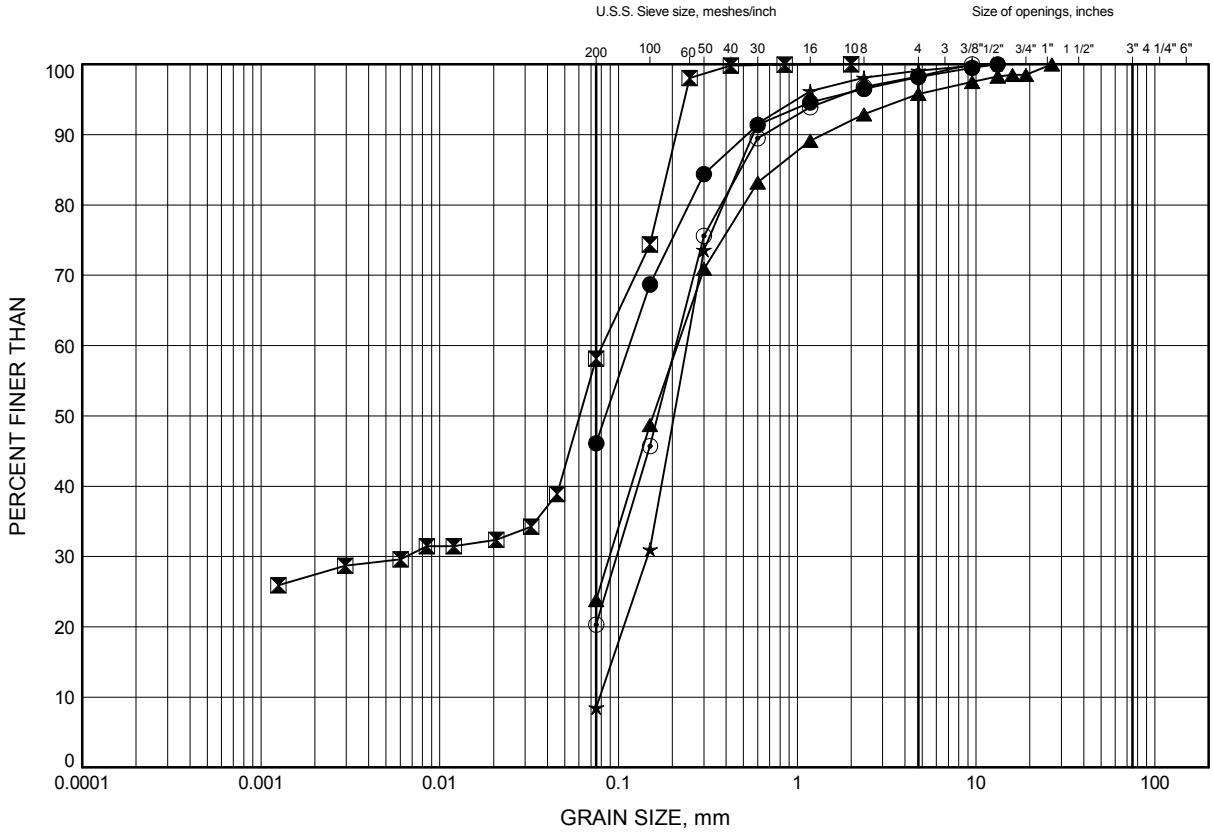
19-5308-95

Culvert 22+283, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 1

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-18	2.59	251.51
⊠	15-18	10.97	243.13
▲	15-19	3.35	250.05
★	15-19	7.92	245.48
⊙	15-20	0.91	246.38

Date March 2016

GWP# 545-00-00

THURBER

Prep'd JAG

Chkd. FJG

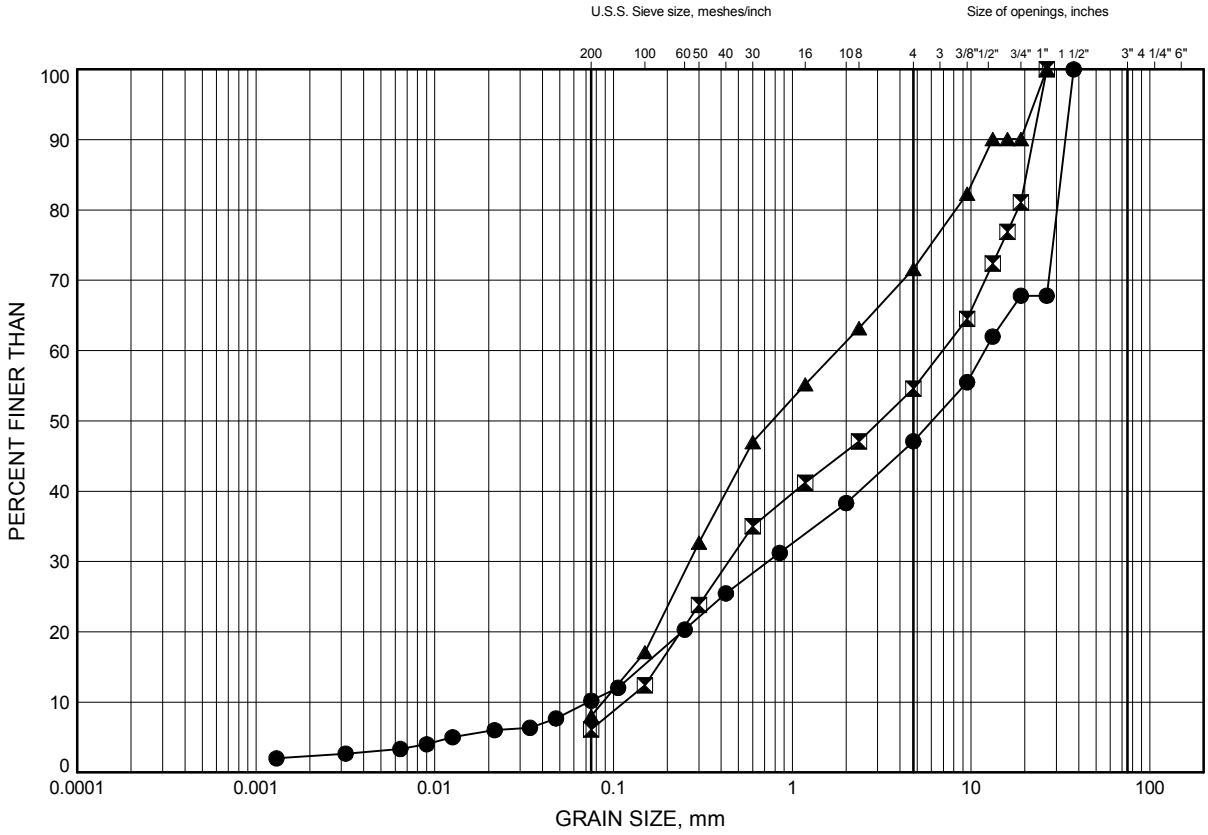
GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 23/3/16

Culvert 22+283, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 2

Gravel with Silt and Sand to Sand with Silt and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-17	2.13	238.00
⊠	15-19	10.97	242.43
▲	15-20	2.67	244.63

Date March 2016

GWP# 545-00-00

THURBER

Prep'd JAG

Chkd. FJG

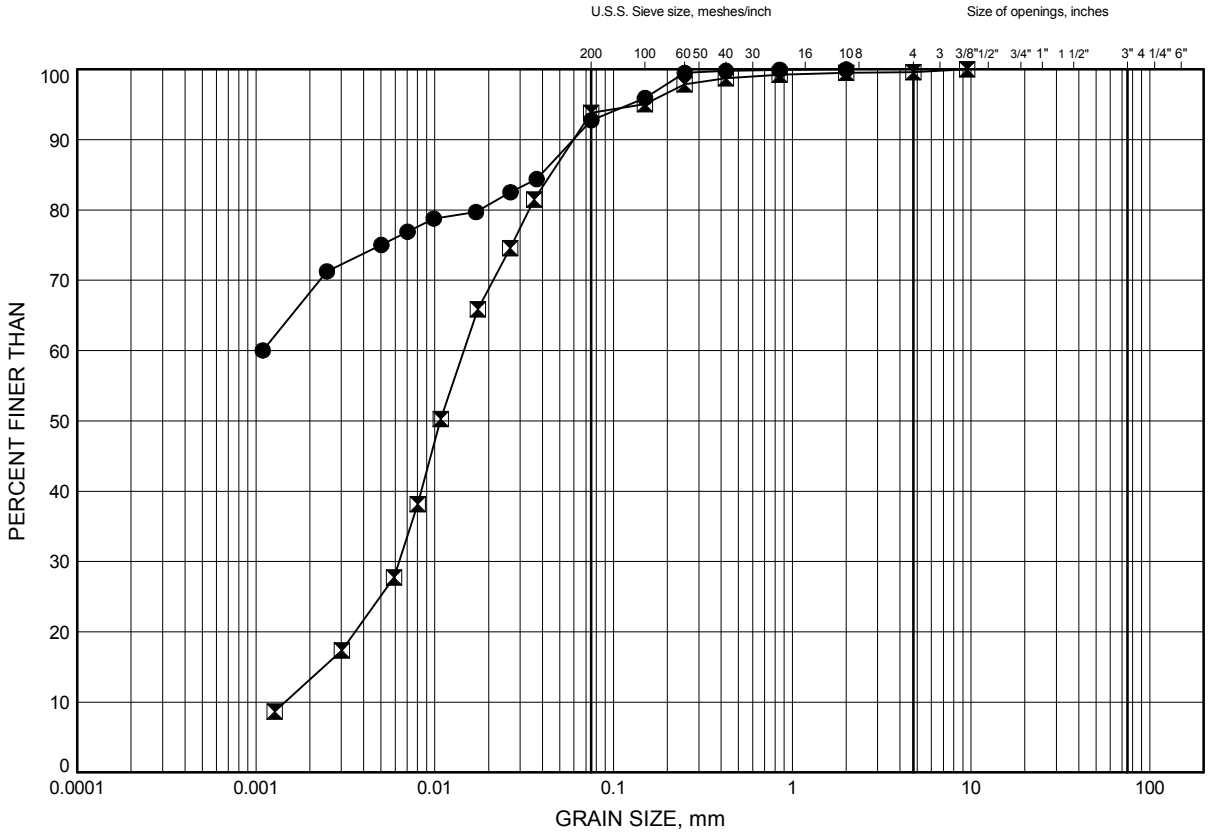
GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 23/3/16

Culvert 22+283, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 3

Clay to Silty Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-18	15.54	238.56
⧓	15-19	12.50	240.90

Date March 2016

GWP# 545-00-00

THURBER

Prep'd JAG

Chkd. FJG

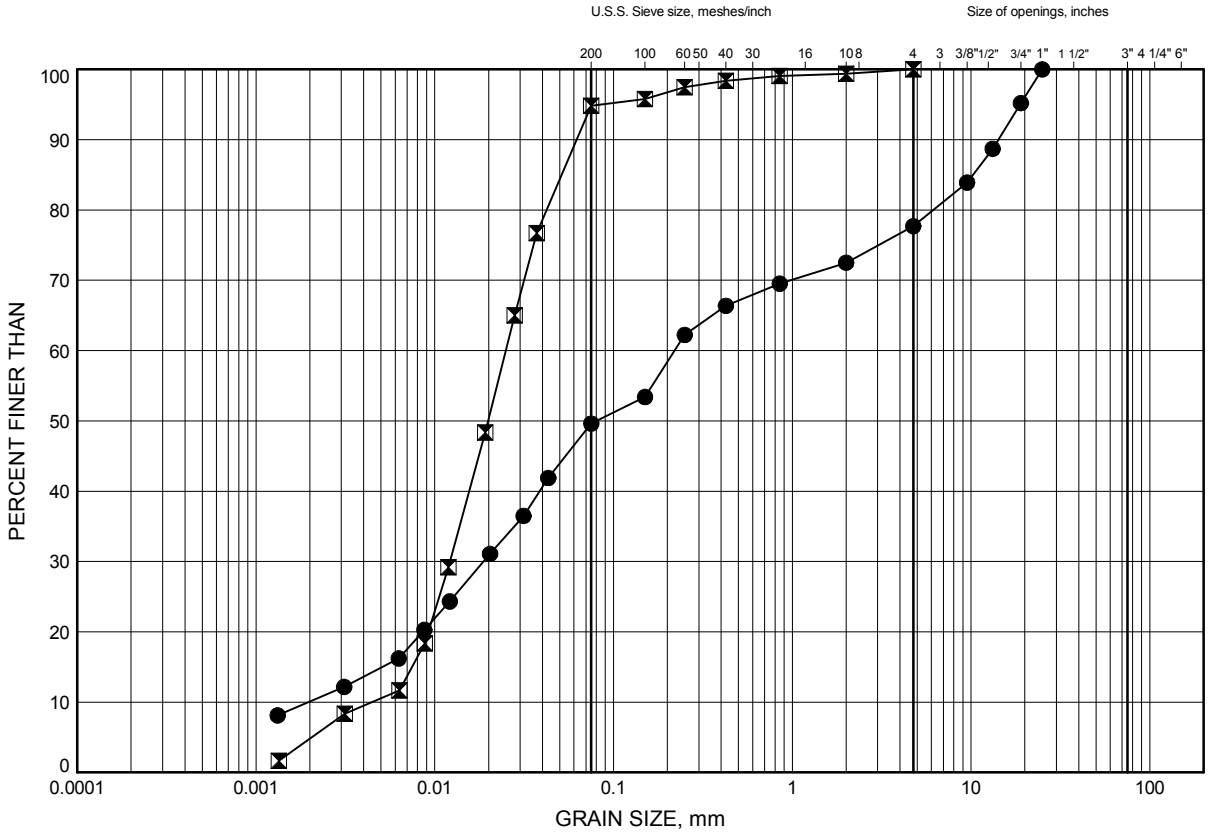
GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 23/3/16

Culvert 22+283, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 4

Sandy Silt to Silt with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-18	18.59	235.51
⧓	15-20	3.35	243.94

Date March 2016

GWP# 545-00-00

THURBER

Prep'd JAG

Chkd. FJG

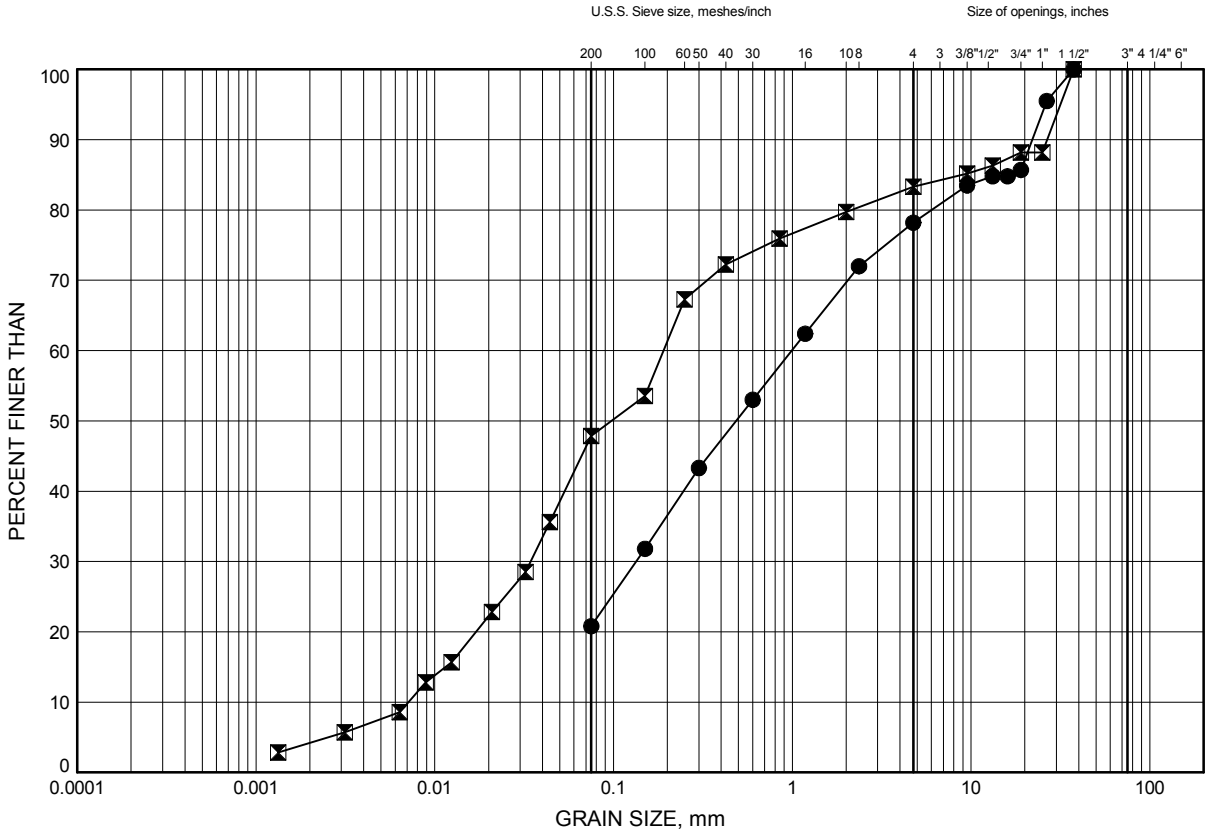
GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 23/3/16

Culvert 22+283, Highway 17 Goulais River

GRAIN SIZE DISTRIBUTION

FIGURE 5

Silty Sand (Till)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-19	20.12	233.28
⧓	15-19	21.64	231.76

Date March 2016

GWP# 545-00-00

THURBER

Prep'd JAG

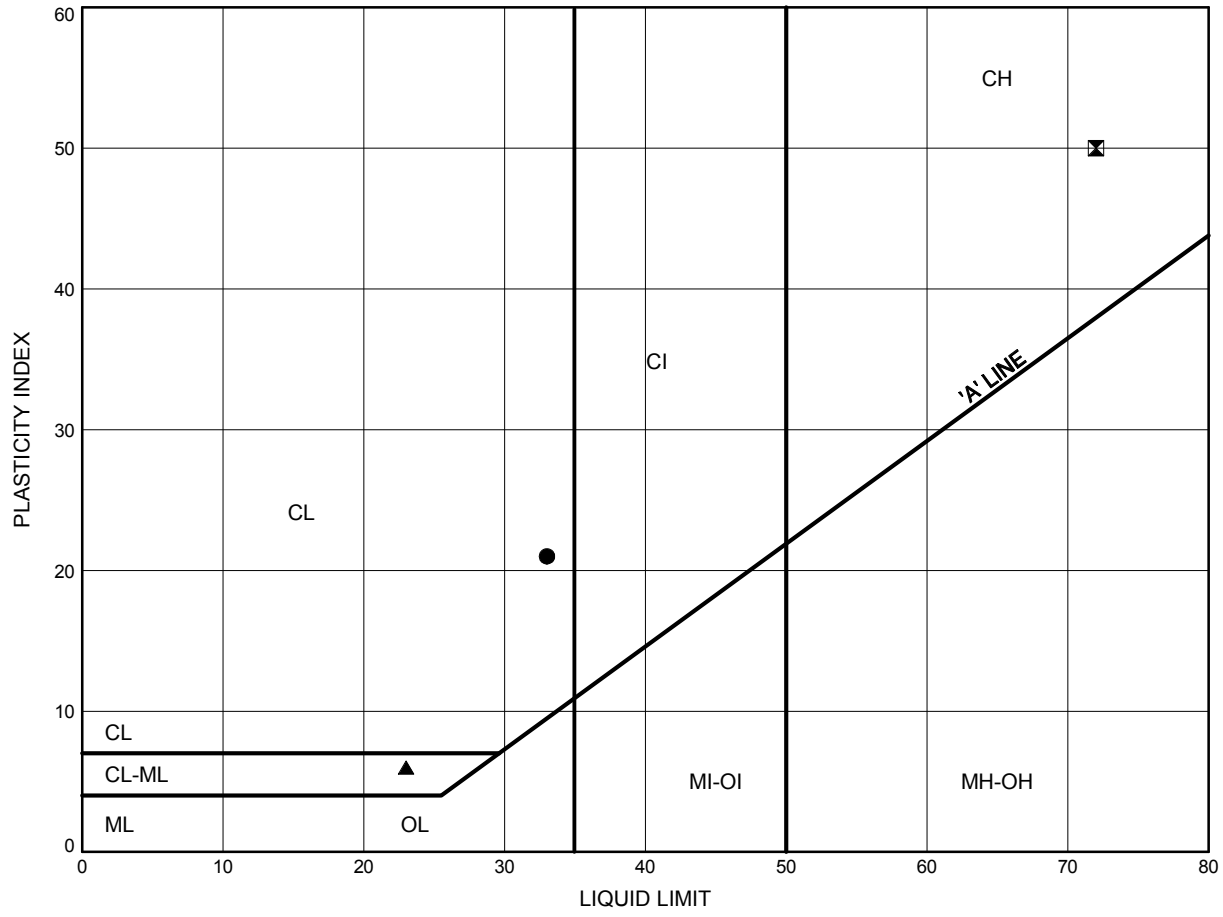
Chkd. FJG

GRAIN SIZE DISTRIBUTION - THURBER 19-5308-95.GPJ 23/3/16

Culvert 22+283, Highway 17 Goulais River

ATTERBERG LIMITS TEST RESULTS

FIGURE 6



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	15-18	10.97	243.13
⊠	15-18	15.54	238.56
▲	15-19	12.50	240.90

Date May 2016

GWP# 545-00-00

THURBER

Prep'd JAG

Chkd. FJG

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

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Certificate of Analysis

Thurber Engineering Ltd.

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

Client PO:
Project: 19-5308-95
Custody: 27345

Report Date: 10-Feb-2016
Order Date: 4-Feb-2016

Order #: 1606277

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

Paracel ID	Client ID
1606277-01	BH15-17 SS2 (2'-4')

Approved By:

Tim McCooeye
Senior Advisor

Certificate of Analysis

Report Date: 10-Feb-2016

Client: **Thurber Engineering Ltd.**

Order Date:4-Feb-2016

Client PO:

Project Description: 19-5308-95

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	9-Feb-16	9-Feb-16
Conductivity	MOE E3138 - probe @25 °C, water ext	9-Feb-16	9-Feb-16
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	5-Feb-16	5-Feb-16
Resistivity	EPA 120.1 - probe, water extraction	9-Feb-16	9-Feb-16
Solids, %	Gravimetric, calculation	8-Feb-16	8-Feb-16

Certificate of Analysis

Report Date: 10-Feb-2016

Client: **Thurber Engineering Ltd.**

Order Date:4-Feb-2016

Client PO:

Project Description: 19-5308-95

	Client ID:	BH15-17 SS2 (2'-4')	-	-	-
	Sample Date:	24-Jan-16	-	-	-
	Sample ID:	1606277-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	77.9	-	-	-
General Inorganics					
Conductivity	5 uS/cm	128	-	-	-
pH	0.05 pH Units	5.39	-	-	-
Resistivity	0.10 Ohm.m	78.4	-	-	-
Anions					
Chloride	5 ug/g dry	22	-	-	-
Sulphate	5 ug/g dry	19	-	-	-

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						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
General Inorganics									
pH	7.94	0.05	pH Units	7.90			0.5	10	
Resistivity	41.1	0.10	Ohm.m	42.9			4.2	20	
Physical Characteristics									
% Solids	91.5	0.1	% by Wt.	91.4			0.2	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	9.9		mg/L	ND	99.1	78-113			
Sulphate	9.92		mg/L	ND	99.2	78-111			

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 – inlet of culvert**

Photo 2: **East side – outlet of culvert**

Photo 3: **Looking west towards culvert inlet.**

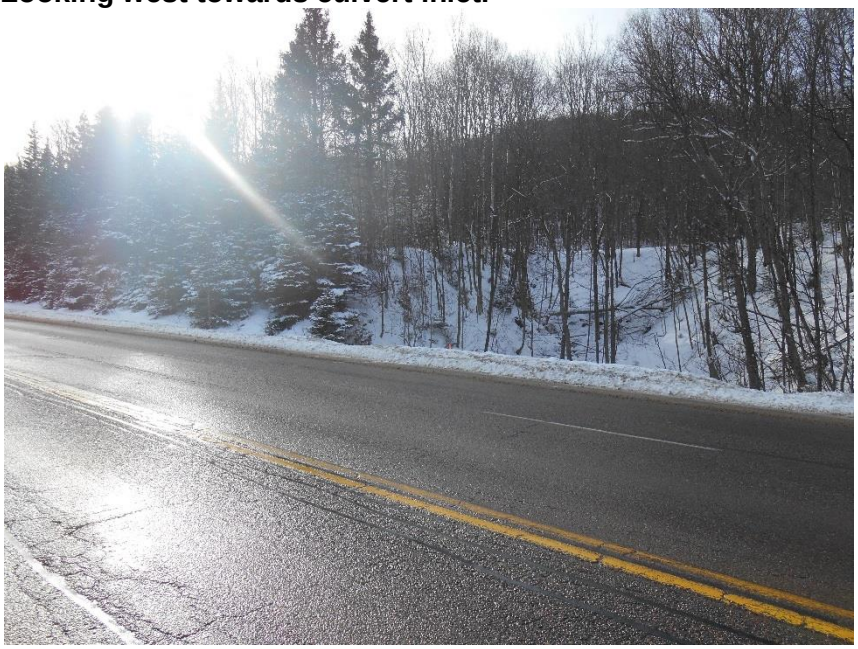

Photo 4: **Looking east towards culvert outlet.**

Photo 5: **Looking north towards culvert crossing.**