



THURBER ENGINEERING LTD.

**FINAL
FOUNDATION INVESTIGATION REPORT
HIGHWAY 11 MELOCHE CREEK CULVERT REPLACEMENT
10.1 KM SOUTH OF HIGHWAY 572 EAST, TOWNSHIP OF COOK
SITE NO.: 39E-222/C**

G.W.P. 5054-01-00

Geocres No.: 42A00-117

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 48.36789°
Longitude: -80.25409°

October 2018
Thurber File No.: 13058

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed culvert replacement at the Highway 11 crossing of Meloche Creek. The structure is located approximately 10.1 km south of Highway 572 East within the Township of Cook (approximate Sta. 12+670). Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Agreement No. 5015-E-0041.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. No previous foundation investigation information was available for the subject culvert site within the Geocres Library.

2 SITE DESCRIPTION

The existing structure is a single barrel reinforced concrete rigid frame culvert noted to be constructed in 1960. The culvert is reported to be 3.0 m wide by 1.8 m high and approximately 43 m long with a generally east to west alignment. The flow through the culvert is to the east.

At the location of the culvert (Linear Highway Referencing System Base Point: 17435, Offset: 10.1), Highway 11 is a two-lane highway with a rural cross-section and gravel shoulders. The Highway 11 embankment fill height is approximately 7.8 m with the road surface at approximate elevation of 316.5 m. The existing embankment side slopes are inclined at approximately 2H:1V. Wooden posts with steel cable guiderails are present on both sides of the highway in the area of the culvert. The land adjacent to the highway is undeveloped and densely vegetated with shrubs and trees. Traffic volumes are understood to be 3250 AADT (2012).

Select photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field testing program was carried out between October 12th and October 16th, 2016. Drilling consisted of advancing six boreholes identified as MC16-1 through MC16-6. The drilling was carried out using portable equipment for off road boreholes MC16-3 through MC16-6, and a rubber tired CME 550 drill rig for the on-road boreholes MC16-1 and MC16-2. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Borehole MC16-3 through MC16-6 which were drilled with portable equipment also utilized a full-weight hammer for SPT testing. The boreholes were sampled to refusal depths ranging from 2.3 to 8.4 m (elev. 308.6 to 302.3 m) below the existing ground surface. Coring was not completed as part of this assignment. Boreholes MC16-3 and MC16-4 were extended during Dynamic Cone Penetration Testing (DCPT).

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

A 19 mm diameter standpipe piezometer was installed in Borehole MC16-5 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the Record of Borehole sheet for Borehole MC16-5, provided in Appendix B. Following completion of the field investigation the remaining boreholes were backfilled in accordance with MOE requirements (O.Reg. 903). Boreholes MC16-1 and MC16-2 were capped with 150 mm of cold patch asphalt to reinstate the traveling surface.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets.

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analyses (hydrometer and/or sieve). The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. Two samples of soil recovered from within the boreholes were selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Locations and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented

on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, the site was found to be underlain by a pavement structure and granular and silt embankment fill overlying deposits of native, non-cohesive soils. A veneer of topsoil was present at the surface of the off-road boreholes over a thin layer of silty clay in two locations over sand and silty sand deposits. Bedrock was not encountered within the depth of investigation, although all boreholes terminated at SPT or DCPT refusal.

5.1 Embankment

5.1.1 Asphalt

Boreholes MC16-1 and MC16-2 were drilled through the existing Highway 11 embankment and encountered a layer of asphalt with a thickness of 180 mm.

5.1.2 Fill

Below the asphalt pavement within the on-road boreholes was a layer of non-cohesive fill varying in composition from gravel with sand to sand with silt and gravel to silt trace clay and organics. Cobbles were noted within the fill in MC16-02 between 2.3 and 6.1 m depth. The underside of the fill was 6.1 m (elev. 310.6 to 310.4 m) below the existing roadway surface. A buried layer of asphalt was observed at a depth of 1.0 m in Borehole MC16-2 and organics were present near a depth of 3.2 m in Borehole MC16-1.

The SPT tests conducted in the fill typically gave N-values ranging from 8 to 63 blows indicating a relative density of loose to very dense. SPT tests with results as high as 100 blows per 225 mm of penetration were recorded near the surface. Recorded moisture contents ranged from 6 to 21%.

Gradation analyses were completed on five samples of the granular fill layer. The grain size distribution curves for these samples are included in Figure C1 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B and indicate an SM to SP-SM material.

Soil Particle	Percentage (%)
Gravel	2 - 78
Sand	21 - 70
Silt and Clay	1 to 28

5.2 Silty Clay, Sandy (CL-ML)

A layer of native silty clay, sandy was encountered at ground surface in Boreholes MC16-03 and MC16-04 located near the inlet of the culvert. The layer was 0.6 m thick with an underside elevation of 309.5 to 309.1 m. SPT N-values ranged from weight of hammer to 7 blows, indicating a soft to stiff consistency. Moisture contents of the retained samples ranged from 20 to 47%. A single gradation analysis was completed and indicated a material with 38% sand, 49% silt and 13% clay. The results of the grain size analysis are illustrated on Figure C2 in Appendix C. An Atterberg Limit test, shown in Figure C5, was completed

on one sample and yielded a Liquid Limit of 24% and a Plastic Limit of 18%, indicating a CL-ML material.

5.3 Sand (SM to SP-SM)

A native deposit of sand varying in composition from sand with silt and gravel to silty sand with gravel to silty sand was observed at the ground surface in Boreholes MC16-05 and MC16-06 and underlying the soil layers noted above in the remaining boreholes. All boreholes were terminated in the sand layer (elev. 308.6 to 302.3 m) upon SPT and/or casing advancement refusal.

SPT tests gave N-values ranging from 1 to 67 blows. N-values of greater than 100 blows were observed near the base of the layer in all boreholes. The recorded moisture contents ranged from 9 to 23%.

Gradation analyses was completed on eight samples of the sand. The grain size distribution curves are included in Figure C3 and C4 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B and indicate an SM to SP-SM material.

Soil Particle	Percentage (%)	
Gravel	1 - 26	
Sand	53 - 91	
Silt	15 - 16	5 - 22
Clay	5 - 6	

5.4 Groundwater

The groundwater level was measured at 0.3 m (elev. 309.1 m) below the ground surface in the standpipe piezometer installed in Borehole MC16-05 on April 17, 2017. It is expected that the groundwater level will largely be controlled by the water level in Meloche Creek. The water level in the creek was near elevation 309.1 m during the time of the site investigation in October 2016. It should be noted that the groundwater level at the time of construction may be higher and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.5 Analytical Testing

Two samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below:



Borehole	Sample	Depth (m)	Sulphate (µg/g)	pH (-)	Resistivity (Ohm-cm)	Chloride (µg/g)
MC16-4	SS1	0 – 0.6	30	6.21	1370	328
MC16-6	SS3	1.5 – 2.1	7	6.35	17900	9

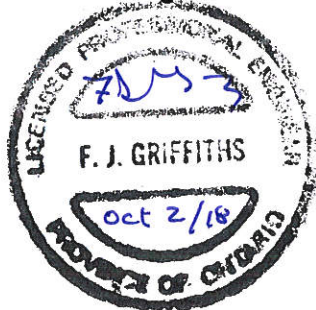
6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevations were measured by McIntosh Perry following completion of the field program.

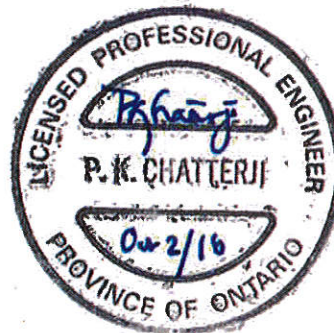
Landcore Drilling of Chelmsford, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning. The field investigation was supervised on a full-time basis by Mr. Jeff Morrison, E.I.T. and Mr. Sean O'Bryan, of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Dr. Fred Griffiths, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Stephen Peters, P.Eng.
Geotechnical Engineer



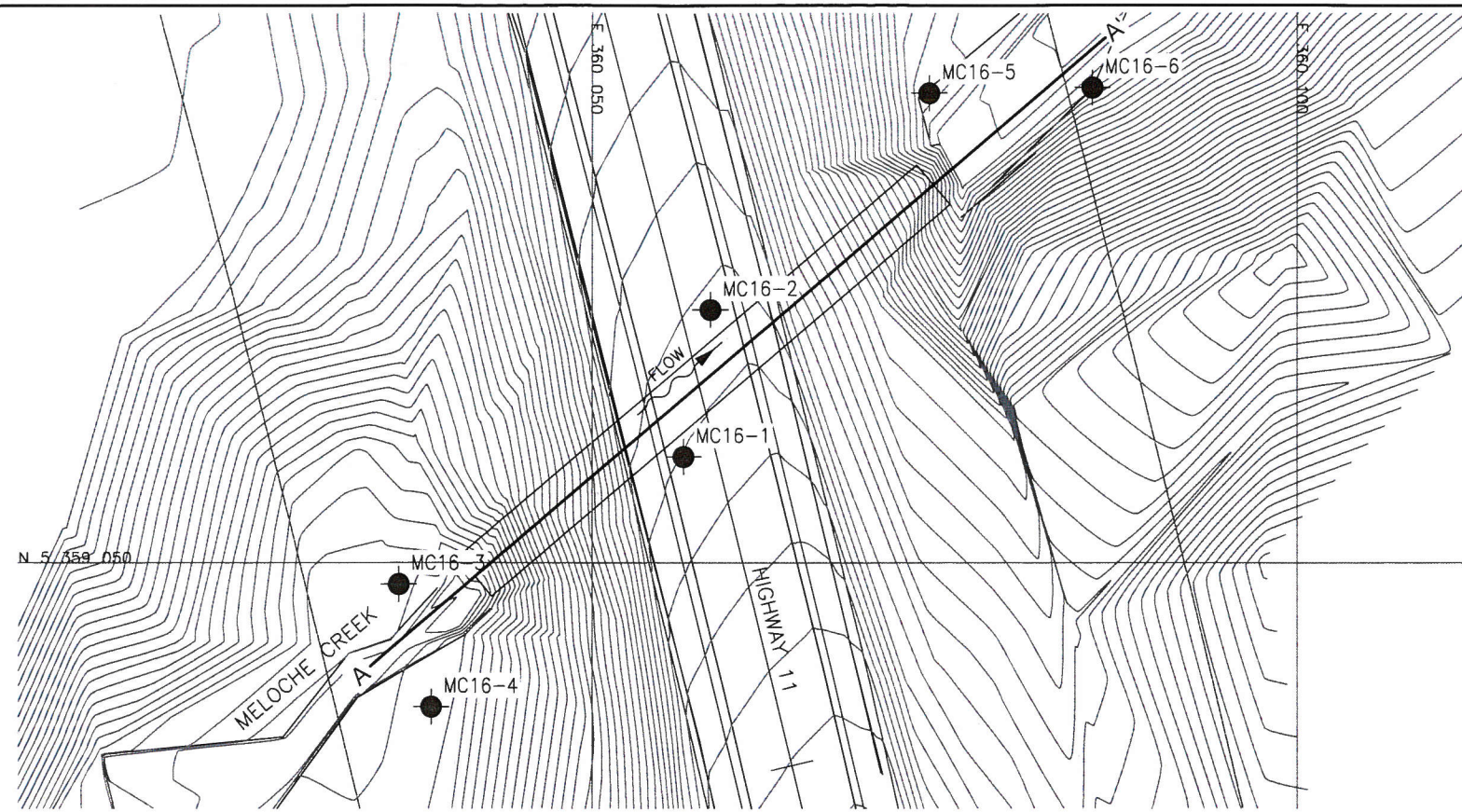
Dr. Fred Griffiths, P.Eng.
Senior Associate
Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.
Review Principal
Senior Geotechnical Engineer

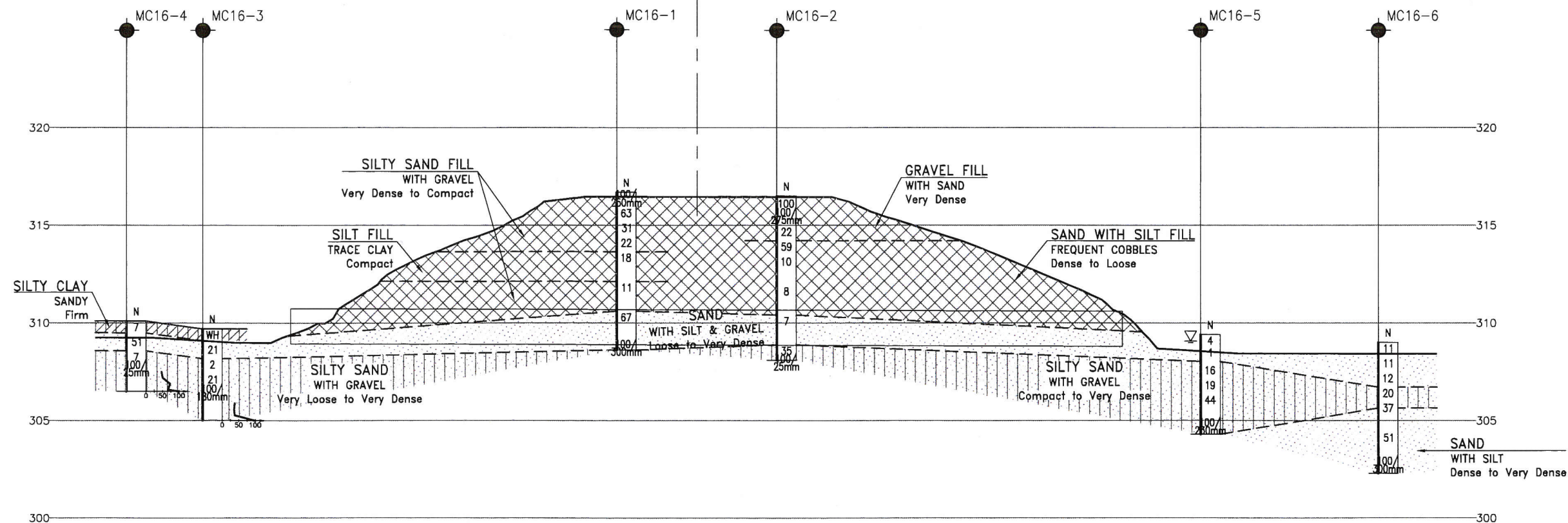
Appendix A.

Drawings



PLAN
SCALE 1:500
10 0 10 20m

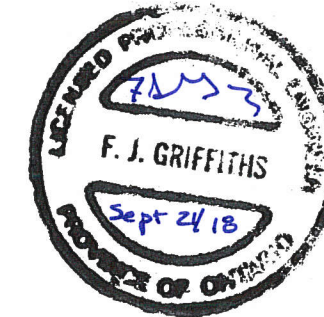
Q HIGHWAY 11



SECTION A-A'

SCALE 1:250
5 0 5 10m

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

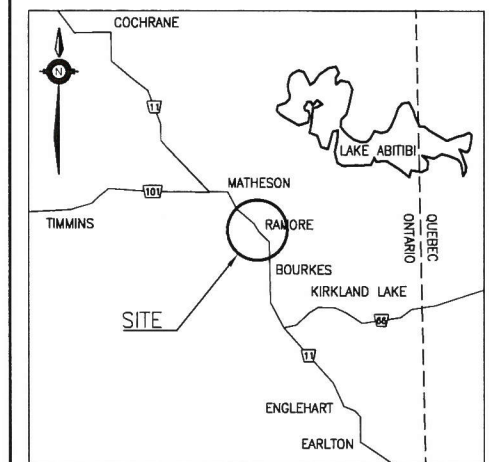


CONT No
GWP No 5054-01-00

HIGHWAY 11
MELOCHE CREEK CULVERT
REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH
PERRY MP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

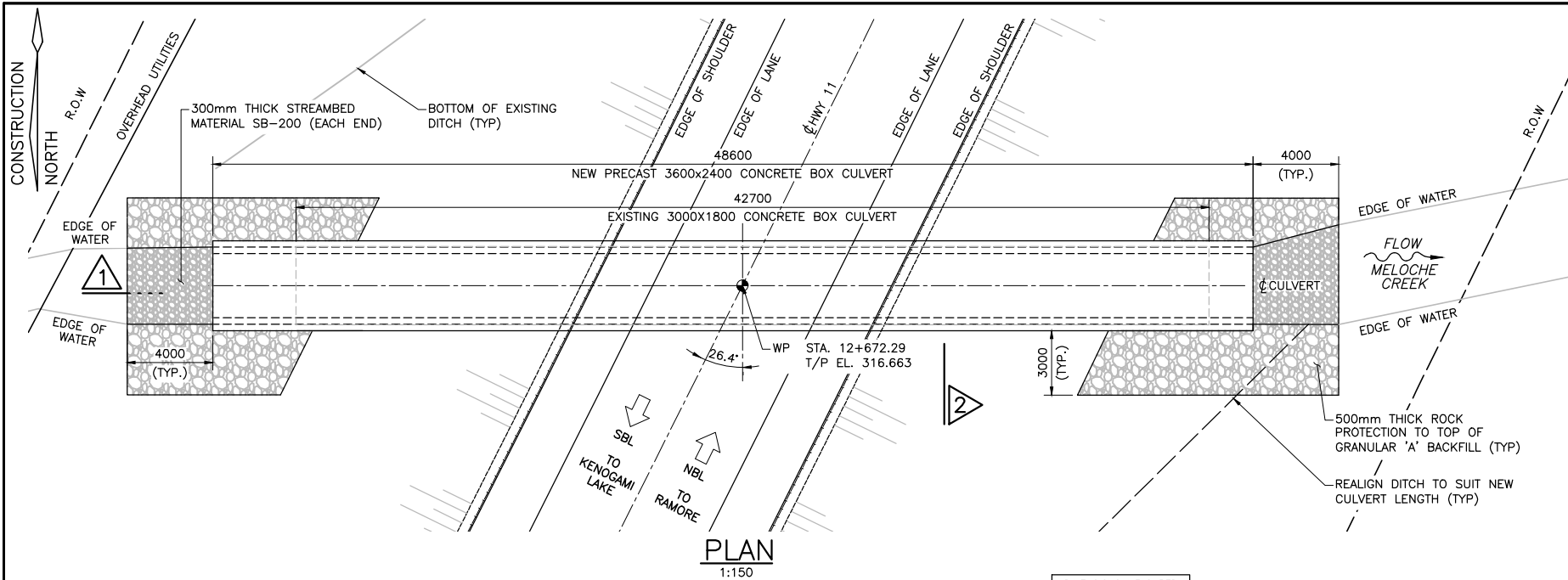
NO	ELEVATION	NORTHING	EASTING
MC16-1	316.7	5 359 057.5	360 056.5
MC16-2	316.5	5 359 067.9	360 058.4
MC16-3	309.7	5 359 048.5	360 036.3
MC16-4	310.1	5 359 039.8	360 038.6
MC16-5	309.4	5 359 083.2	360 073.9
MC16-6	309.0	5 359 083.6	360 085.5

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.

GEOCREs No. 42A00-117

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SBP	CHK FJG	CODE
DRAWN	AN	CHK SBP	SITE
LOAD	DATE	SEPT 2018	
STRUCT	DWG	1	



LEGEND:

- GRANULAR
- ROCK PROTECTION
- STREAMBED MATERIAL
- GUIDERAIL
- ROCK BAFFLES

LIST OF ABBREVIATIONS:

- | | | | |
|------|--------------------|------|--------------|
| CL | CENTRELINE | MIN. | MINIMUM |
| DWG. | DRAWINGS | STA. | STATION |
| EL. | ELEVATION (METERS) | W.L. | WATER LEVEL |
| EX. | EXISTING | TYP. | TYPICAL |
| U/S | UPSTREAM | D/S | DOWNSIDE |
| OG | ORIGINAL GROUND | ROW | RIGHT OF WAY |

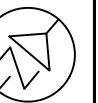
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT. No.
WP No. 5218-13-01

HIGHWAY 11
MELOCHE CREEK CULVERT
REPLACEMENT

GENERAL ARRANGEMENT

McINTOSH PERRY



SHEET

93

GENERAL NOTES:

- CLASS OF CONCRETE
PRECAST 40 MPa
- CLEAR COVER TO REINFORCING STEEL
PRECAST 50 ± 10mm
- REINFORCING NOTES
 - REINFORCING STEEL SHALL BE GRADE 400W.
 - UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS B.
 - BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUP AND TIES SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.
- GEOTEXTILE
 - NON-WOVEN, CLASS II, FOS 75 TO 150um. AND FREE OF FOLDS, TEARS AND WRINKLES.
- CONSTRUCTION NOTES
 - THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND SITE CONDITIONS BEFORE PROCEEDING WITH WORK AND REPORT ANY DISCREPANCIES TO THE CONTRACT ADMINISTRATOR BEFORE COMMENCING THE WORK.
 - THE CONTRACTOR SHALL CARRY OUT SITE SURVEYS TO DETERMINE THE EXISTING ELEVATIONS OF ASPHALT PRIOR TO REMOVALS.
 - THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN OF THE DEWATERING AND TEMPORARY FLOW PASSAGE SYSTEMS.
 - THE TEMPORARY FLOW CONTROL SHALL BE DESIGNED FOR A TWO (2) YEAR DESIGN STORM RETURN PERIOD OF 1.57 m³/s.
 - LENGTH OF PRECAST UNITS MAY BE MODIFIED AS PER MANUFACTURERS REQUIREMENTS. TOTAL LENGTH OF THE CULVERT SHALL NOT BE LESS THAN WHAT IS SHOWN AND MAXIMUM LENGTH OF CULVERT WILL BE WITHIN 300mm OF WHAT IS SHOWN.
 - BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN THE ELEVATION BE GREATER THAN 400mm.
 - THE CONTRACTOR SHALL SELECT EQUIPMENT, MATERIALS AND TYPES OF CONSTRUCTION TO SUIT CONSTRAINTS, SUCH AS THE TEMPORARY MODULAR BRIDGE.
 - ALL AREAS AFFECTED BY CONSTRUCTION ACTIVITIES SHALL BE FULLY REINSTATED TO PRE-CONSTRUCTION OR BETTER CONDITIONS TO THE SATISFACTION OF THE CONTRACT ADMINISTRATOR INCLUDING THE REINSTATEMENT OF ALL VEGETATION, PATHWAYS, FENCES, AND AREAS USED FOR SITE ACCESS.

5. FOUNDATION DESIGN

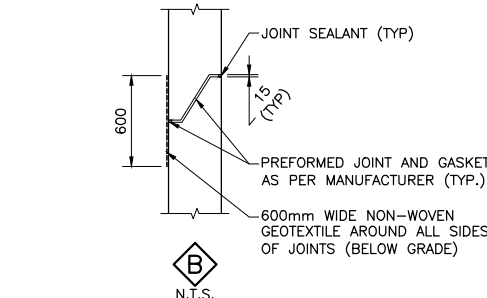
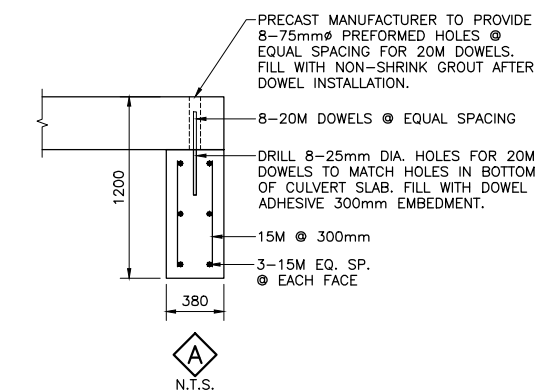
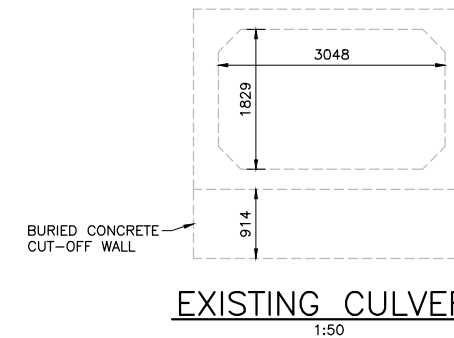
FACTORED GEOTECHNICAL RESISTANCE AT SLS 225 kPa
FACTORED GEOTECHNICAL RESISTANCE AT ULS 300 kPa

APPLICABLE STANDARD DRAWINGS:

- MTOD 3941.2100 - FIGURES IN CONCRETE SITE NUMBER AND LAYOUT

LIST OF DRAWINGS:

- GENERAL ARRANGEMENT
- BOREHOLE LOCATIONS AND SOIL STRATA CULVERT
- BOREHOLE LOCATIONS AND SOIL STRATA TMB
- CONSTRUCTION STAGING I
- CONSTRUCTION STAGING II
- MISCELLANEOUS DETAILS



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	REV	DESCRIPTION
DESIGN	LD	CHK	QI	CODE CHBDC-14
DRAWN	DS	CHK	LD	SITE 39E-0222/CO
				LOAD CL-625-ONT
				DATE SEP/18
				DWG 01

Appendix B.
Record of Borehole Sheets



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).

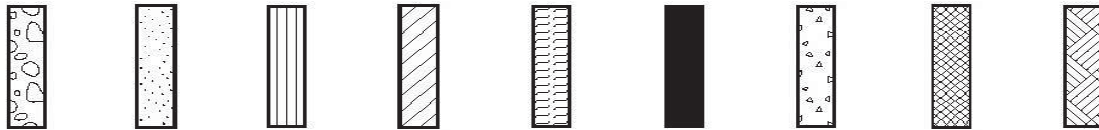
DYNAMIC CONE PENETRATION TEST (DCPT):

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

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.

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 (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 MC16-1

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.3677991°, Long: -80.2541546°
Meloeche Creek Culvert, MTM z12: N 5 359 057.5 E 360 056.5 ORIGINATED BY SOB
HWY 11 BOREHOLE TYPE NW Casing COMPILED BY JM
DATUM Geodetic DATE 2016.10.12 - 2016.10.12 CHECKED BY SP

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 (%)								
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L								
316.7															
0.0	180 mm ASPHALT Silty SAND with gravel Brown Very dense to compact FILL		1	SS	100/										
0.1						250mm									
			2	SS	63										
			3	SS	31										
			4	SS	22										
313.7															
3.0	SILT, trace clay and organics Grey Compact FILL		5	SS	18										
312.1															
4.6	Silty SAND some gravel Brown Compact FILL		6	SS	11										
310.6															
6.1	SAND with silt and gravel Brown Very dense		7	SS	67										
			8	SS	100/										
308.6															
8.1	End of Borehole														

DOUBLE LINE 13058 MELOECHE GPJ 2012TEMPLATE(MTO).GDT 14/9/18

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC16-2

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.3678925°, Long: -80.2541275°
Meloe Creek Culvert, MTM z12: N 5 359 067.9 E 360 058.4 ORIGINATED BY SOB
HWY 11 BOREHOLE TYPE NW Casing COMPILED BY JM
DATUM Geodetic DATE 2016.10.12 - 2016.10.12 CHECKED BY SP

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							WATER CONTENT (%)		
								<div><div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div></div>							<div><div>PLASTIC LIMIT W_P</div><div>NATURAL MOISTURE CONTENT W</div><div>LIQUID LIMIT W_L</div></div>		
316.5																	
0.0																	
0.1	ASPHALT (180mm)																
	GRAVEL with sand		1	SS	100		316							78 21 1 (SI+CL)			
	Brown																
	Very dense to compact		2	SS	100/												
	FILL				275mm		315										
	- asphalt layer at 1.0 m																
			3	SS	22												
314.2																	
2.3	SAND with silt and gravel, frequent cobbles		4	SS	59		314							44 50 6 (SI+CL)			
	Brown																
	Very dense to loose		5	SS	10		313										
	FILL																
							312							2 70 28 (SI+CL)			
			6	SS	8		311										
310.4																	
6.1	SAND with silt and gravel		7	SS	7		310										
	Brown																
	Loose						309										
308.9																	
7.6	Silty SAND (SM) with gravel		8	SS	35												
	Brown																
	Compact to very dense																
308.1			9	SS	100/												
8.4	End of Borehole				25mm												

+³, ×³: Numbers refer to
Sensitivity

20
15
10




(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC16-3

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.36772°, Long: -80.2544284° Meloche Creek Culvert, MTM z12: N 5 359 048.5 E 360 036.3 ORIGINATED BY JM
 HWY 11 BOREHOLE TYPE Portable w/ NW Casing COMPILED BY JM
 DATUM Geodetic DATE 2016.10.12 - 2016.10.12 CHECKED BY SP

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 (%)									
309.7								20	40	60	80	100		W P	W	W L	GR	SA	SI	CL	
0.0	Silty CLAY (CL-ML) , sandy Brown to grey Firm		1	SS	WH													0	38	49	13
309.1																					
0.6	SAND with silt and gravel Grey Compact		2	SS	21		309														
308.2																					
1.5	Silty SAND (SM) with Gravel Grey to brown Very loose to very dense		3	SS	2		308											26	53	15	6
306.5			5	SS	100/ 180mm		307														
3.2																					
305.0							306														
4.7	End of Borehole Note: DCPT data from approximately 1 m away																				




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

RECORD OF BOREHOLE No MC16-4

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.3676415°, Long: -80.2543985°
Meloch Creek Culvert, MTM z12: N 5 359 039.8 E 360 038.6 ORIGINATED BY JM
HWY 11 BOREHOLE TYPE Portable w/ NW Casing COMPILED BY JM
DATUM Geodetic DATE 2016.10.12 - 2016.10.12 CHECKED BY SP

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			W P W W L									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)									
310.1							20	40	60	80	100	20	40	60	GR	SA	SI	CL		
0.0	Silty CLAY (CL-ML) , sandy Brown Firm		1	SS	7		310							○						
309.5																				
0.6	SAND with silt and gravel, frequent cobbles Grey Very dense		2	SS	51		309							○						
308.6																				
1.5	Silty SAND (SM) with gravel Grey Loose to very dense		3	SS	7		308							○			18	60	16	6
307.8			4	SS	100/ 25mm															
2.3																				

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

RECORD OF BOREHOLE No MC16-5

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.3680285°, Long: -80.253916°
Meloch Creek Culvert, MTM z12: N 5 359 083.2 E 360 073.9 ORIGINATED BY JM
HWY 11 BOREHOLE TYPE Portable w/ NW Casing COMPILED BY JM
DATUM Geodetic DATE 2016.10.12 - 2016.10.12 CHECKED BY SP

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W P W W L WATER CONTENT (%)						
309.4																		
0.0	Sand (SM) with silt some gravel Loose to very loose Brown to grey		1	SS	4		309									12 76 12 (SI+CL)		
			2	SS	1		308											
308.0																		
1.4			Silty SAND (SM) with gravel Grey to brown Compact to very dense	3	SS		16	307										
				4	SS		19	306										
				5	SS		44	305										
304.3			6	SS	100/ 230mm										26 53 21 (SI+CL)			
5.1	End of Borehole DATE DEPTH (m) ELEV. (m) 2016.10.20 0.5 308.9 2017.04.17 0.3 309.1																	

DOUBLE LINE 13058 MELOCHE.GPJ 2012TEMPLATE(MTO).GDT 14/9/18

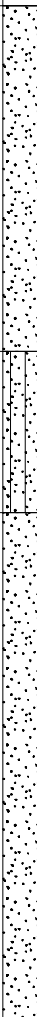



+³, ×³: Numbers refer to Sensitivity
20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No MC16-6

1 OF 1

METRIC

GWP# 5054-01-00 LOCATION Lat: 48.368031°, Long: -80.2537597° Meloche Creek Culvert, MTM z12: N 5 359 083.6 E 360 085.5 ORIGINATED BY JM
 HWY 11 BOREHOLE TYPE Portable w/ NW Casing COMPILED BY JM
 DATUM Geodetic DATE 2016.10.16 - 2016.10.16 CHECKED BY SP

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 (%)																			
309.0	SAND (SP) with silt trace gravel Grey Compact		1	SS	11		20	40	60	80	100	20	40	60		8	87	5 (SI+CL)														
0.0																																
					2														SS	11												
					3														SS	12												
306.7	Silty SAND with Gravel Grey Compact		4	SS	20		20	40	60	80	100	20	40	60		25	53	22 (SI+CL)														
2.3																																
305.6	SAND (SP) with silt Brown Compact to very dense		5	SS	37		20	40	60	80	100	20	40	60																		
3.4																																
					6														SS	51												
302.3	End of Borehole		7	SS	100/ 300mm		20	40	60	80	100	20	40	60		1	91	8 (SI+CL)														
6.7																																

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

Appendix C.

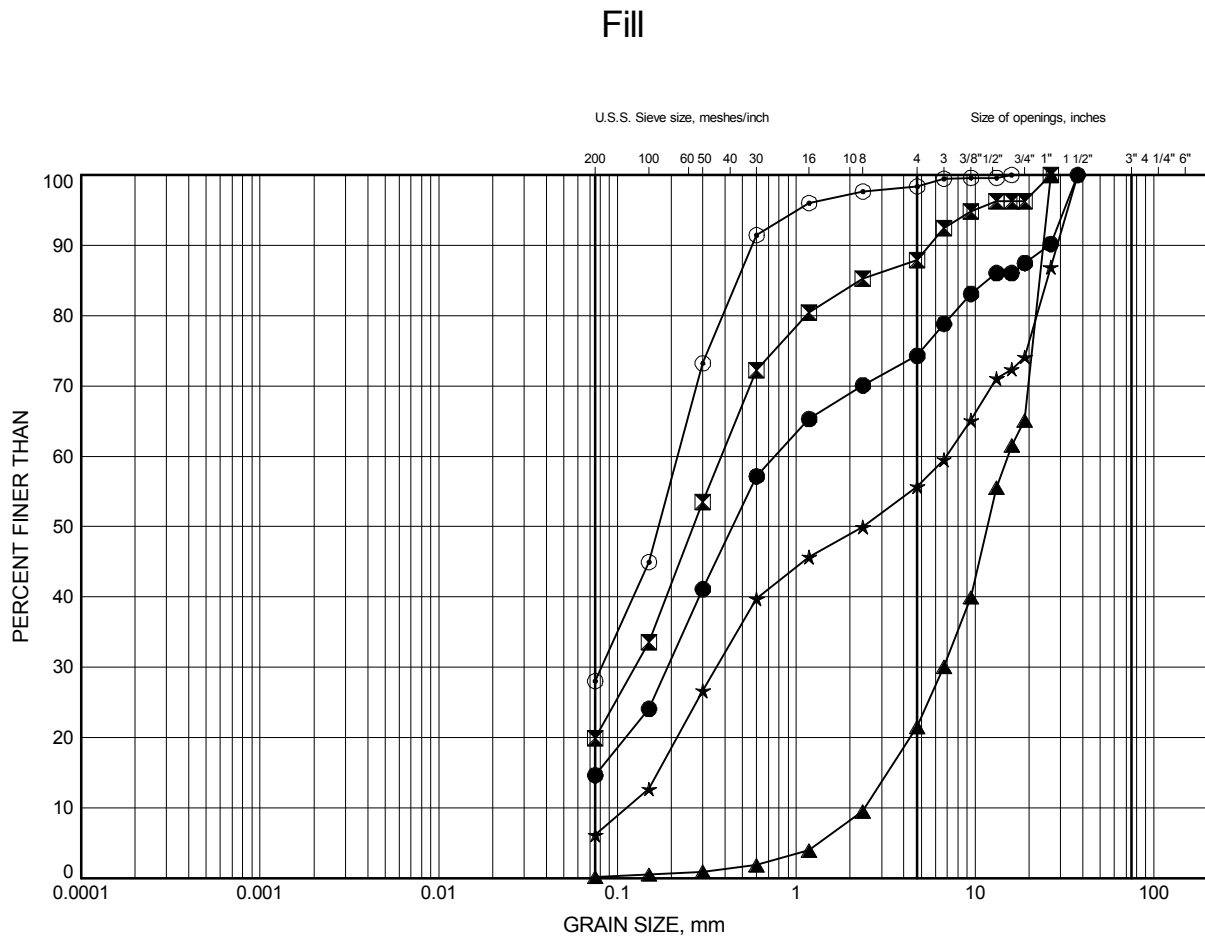
Laboratory Testing

Appendix C.1
Particle Size Analysis Figures

Meloche Creek Culvert

GRAIN SIZE DISTRIBUTION

FIGURE C1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC16-1	1.83	314.87
⊠	MC16-1	4.88	311.82
▲	MC16-2	0.91	315.59
★	MC16-2	2.59	313.91
⊙	MC16-2	4.88	311.62

Date September 2018

GWP# 5054-01-00



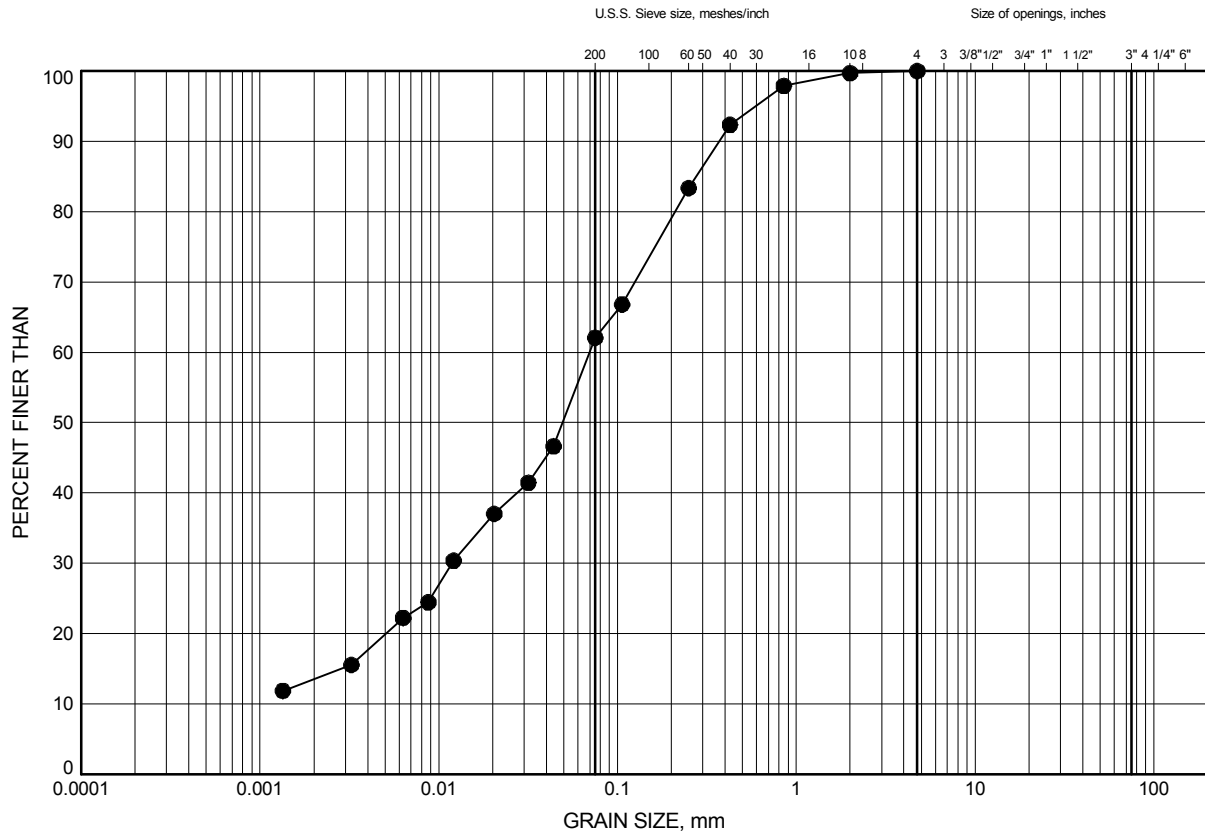
Prep'd CM

Chkd. SP

Meloche Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC16-3	0.30	309.40

Date September 2018
GWP# 5054-01-00

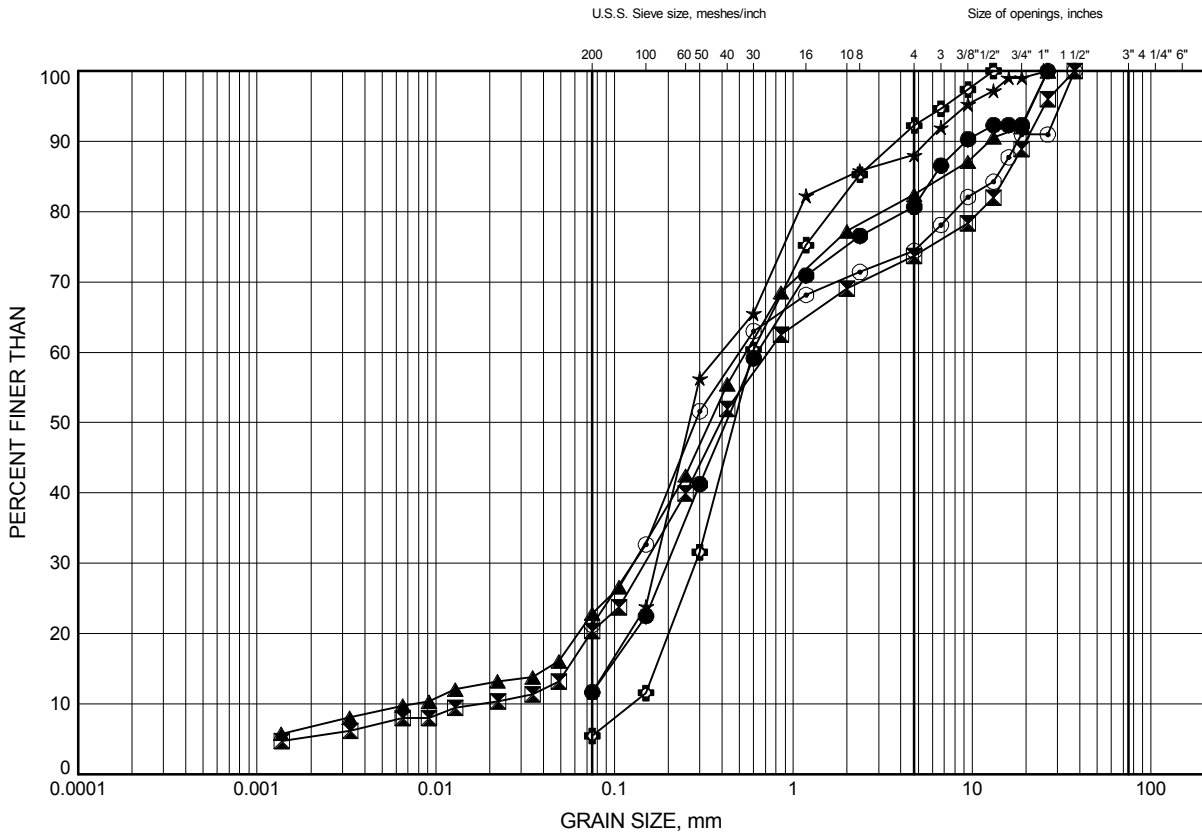


Prep'd CM
Chkd. SP

Meloche Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty SAND to SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC16-1	6.40	310.30
⊠	MC16-3	1.83	307.87
▲	MC16-4	1.83	308.27
★	MC16-5	0.91	308.49
⊙	MC16-5	3.35	306.05
⊕	MC16-6	0.30	308.70

Date September 2018

GWP# 5054-01-00



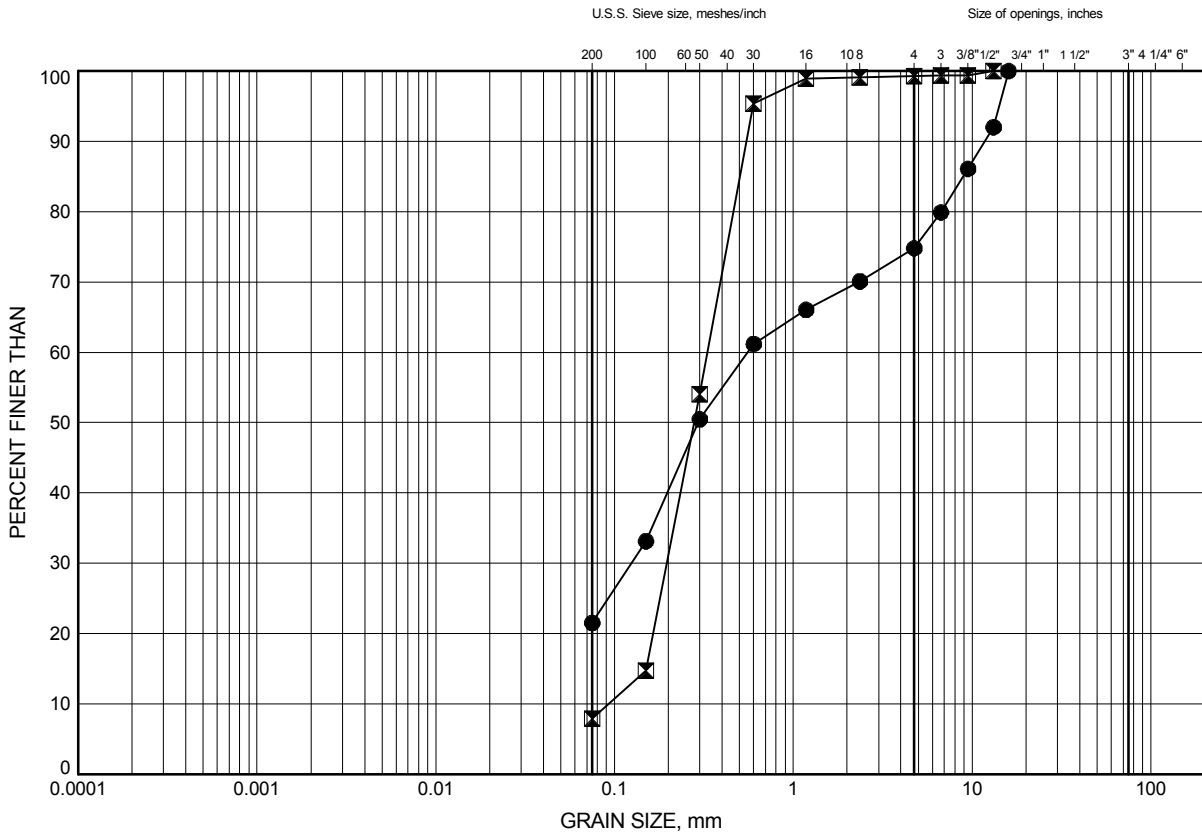
Prep'd CM

Chkd. SP

Meloche Creek Culvert GRAIN SIZE DISTRIBUTION

FIGURE C4

Silty SAND to SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC16-6	3.20	305.80
⊠	MC16-6	6.40	302.60

Date September 2018
GWP# 5054-01-00

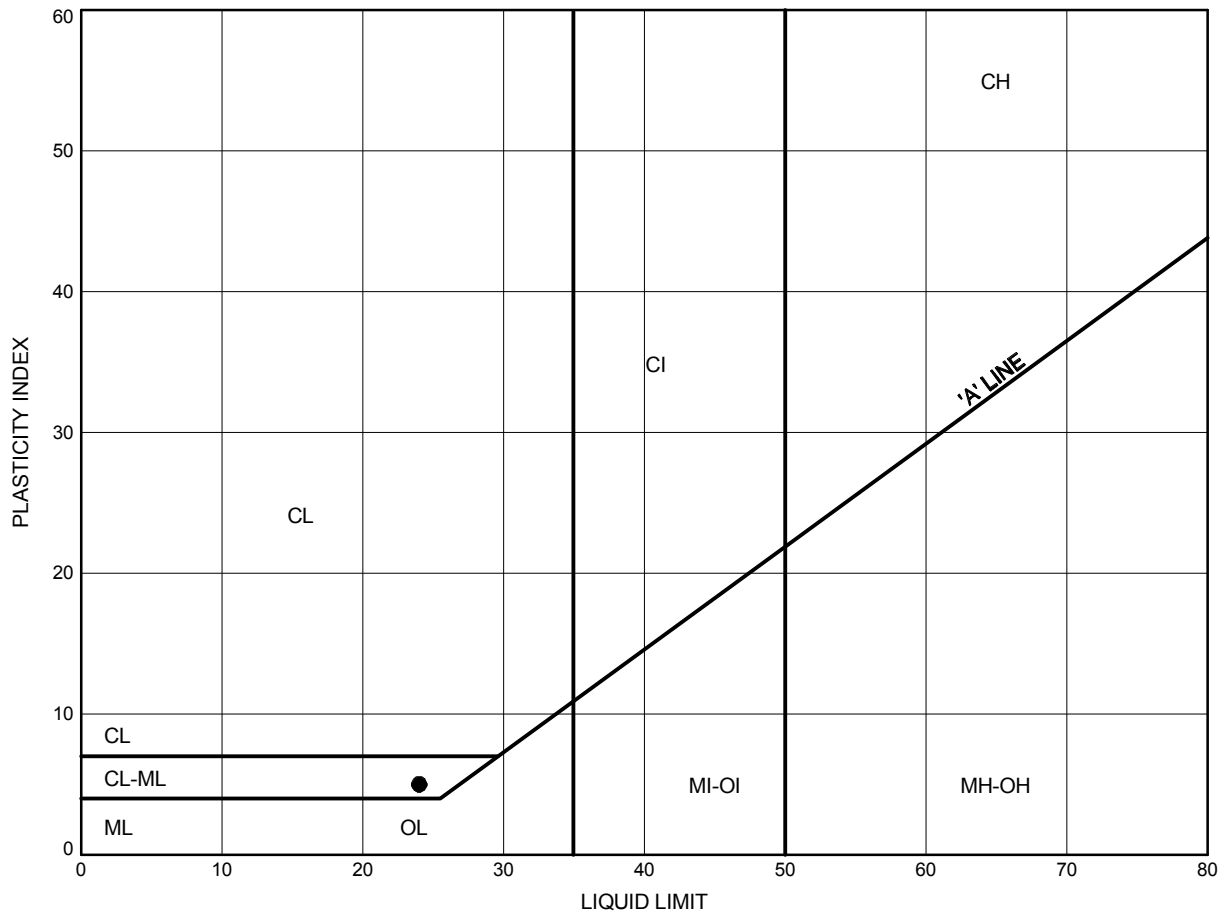


Prep'd CM
Chkd. SP

Meloche Creek Culvert
ATTERBERG LIMITS TEST RESULTS

FIGURE C5

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MC16-3	0.30	309.40

Date ..September 2018.....
 GWP# ..5054-01-00.....



Prep'dCM.....
 Chkd.SP.....

Appendix C.2
Analytical Testing Results

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO:

Report Date: 02-Nov-2016

Order Date: 28-Oct-2016

Project Description: 13058

		Client ID:	C2-3 SS1 0'-2'	C2-4 SS3 5'-7'	C6-3 SS2 2'-6'-4'6	C6-4 SS3A 5'-6'
		Sample Date:	18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
		Sample ID:	1644497-01	1644497-02	1644497-03	1644497-04
		MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics						
% Solids	0.1 % by Wt.		74.7	79.6	76.7	74.5
General Inorganics						
Conductivity	5 uS/cm		357	494	795	344
pH	0.05 pH Units		7.59	7.52	7.54	7.60
Resistivity	0.10 Ohm.m		28.0	20.2	12.6	29.1
Anions						
Chloride	5 ug/g dry		49	236	314	67
Sulphate	5 ug/g dry		11	8	21	14
		Client ID:	C7-3 SS2 2'-6'-4'6	C7-4 SS3 5'-7'	MC16-4 SS1 0'-2'	MC16-6 SS3 5'-7'
		Sample Date:	18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
		Sample ID:	1644497-05	1644497-06	1644497-07	1644497-08
		MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics						
% Solids	0.1 % by Wt.		64.7	72.9	65.0	88.2
General Inorganics						
Conductivity	5 uS/cm		226	616	729	56
pH	0.05 pH Units		7.52	7.62	6.21	6.35
Resistivity	0.10 Ohm.m		44.3	16.2	13.7	179
Anions						
Chloride	5 ug/g dry		11	187	328	9
Sulphate	5 ug/g dry		19	21	30	7
		Client ID:	C28-3 SS2 2'-6'-4'6	C28-4 SS1 0'-2'	C34-3 SS3 5'-7'	C34-4 SS1 0'-2'
		Sample Date:	18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
		Sample ID:	1644497-09	1644497-10	1644497-11	1644497-12
		MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics						
% Solids	0.1 % by Wt.		71.3	70.8	79.9	91.9
General Inorganics						
Conductivity	5 uS/cm		765	999	233	208
pH	0.05 pH Units		7.47	7.60	7.65	6.95
Resistivity	0.10 Ohm.m		13.1	10.0	42.8	48.2
Anions						
Chloride	5 ug/g dry		343	493	13	18
Sulphate	5 ug/g dry		15	21	36	24

Appendix D.
Site Photographs

HIGHWAY 11 MELOCHE CREEK CULVERT REPLACEMENT
10.1 KM SOUTH OF HIGHWAY 572 EAST, TOWNSHIP OF COOK



Photo 1. Looking north along Highway 11.



Photo 2. Looking south along Highway 11.