



THURBER ENGINEERING LTD.

**FINAL
FOUNDATION INVESTIGATION REPORT
CULVERT REHABILITATION, STRUCTURE NO. 40-117/C
HIGHWAY 35 MINERS BAY CULVERT, LUTTERWORTH TOWNSHIP
AGREEMENT NO. 5015-E-0043**

G.W.P. 5087-11-00

Geocres No.: 31D-691

Report to:

McIntosh Perry Consulting Engineers Limited

Latitude: 44.819854
Longitude: -78.775411

June 2018
Thurber File: 16284

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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 rehabilitation of the Miners Bay culvert crossing of Highway 35. The culvert is located approximately 3.5 km north of Halliburton Road 2 (Deep Bay Road) within Lutterworth Township. Thurber Engineering Limited (Thurber) carried out the investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Agreement No. 5015-E-0043.

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 online Geocres Library.

2 SITE DESCRIPTION

Highway 35 is a north-south highway although at the location of the culvert the true alignment of Highway 35 is east-west. Based on the overall alignment of the highway, the highway will be described as north-south and the culvert will be described as oriented east (inlet) to west (outlet). The culvert is described within the RFP is an open footing culvert with a total length of 24 m. The east section of the culvert is noted to be a reinforced concrete rigid frame open footing culvert constructed in 1969; the length is 17 m, the span is 3.0 m and the height is 2.75 m. The east middle section of the culvert is noted to be a reinforced concrete non-rigid frame open footing culvert of unknown age. The west middle section is noted to be a stone masonry wall section with reinforced concrete top slab. The west end of the culvert is noted to be a reinforced concrete non-rigid frame open footing culvert with walls and top slab of different construction. The span for the three western sections is approximately 3.0 metres, the height is 3.1 m and the length is approximately 7 metres. Wingwalls are present at both ends of the culvert on the north and south sides of the culvert. The stream bed elevations at the culvert inlet and outlet are approximately 272.4 m and 271.2 m respectively. It was observed that the culvert is not in a straight alignment between the inlet and outlet.

FINAL

At the location of the culvert, Highway 35 is a two-lane highway with paved shoulders and a concrete curb at the west edge of pavement. Based on the RFP, there is approximately 0.6 m to 1.0 m of fill on the culvert with the centerline of Highway 35 having approximate elevation 276.2 m at the culvert. The embankment is retained by wingwalls at both culvert ends. Erosion was noted adjacent to the north east wingwall along Clear Lake Road at the time of the field investigation. Steel guiderails are present on both sides of the highway at the culvert. The land adjacent to the east side of the highway is developed with houses and the Miner's Bay Lodge. The west side of the highway is vegetated with trees and partially developed with houses. Bedrock outcrops are noted within close proximity to the culvert. Traffic volumes are understood to be 3150 AADT (2013).

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

Thurber contacted Ontario One Call in advance of the field investigation to obtain utility locate clearances in the vicinity of the proposed boreholes.

The site investigation and field testing program was carried out on May 8th, 2017 for the on-road drilling and August 10th, 2017 for the off-road drilling. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and are summarized in Table 3-1. The site is within MTM Zone 10.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Borehole Termination Depth below Existing Ground Surface (m)
17-1	North of culvert – southbound lane	4 964 686.0	362 106.3	276.3	7.1
17-2	South of culvert – northbound lane	4 964 681.2	362 098.3	276.2	7.3
17-3	East end – culvert inlet	4 964 670.8	362 101.9	272.4	0.4
17-4	West end – culvert outlet	4 964 695.8	362 094.4	271.2	0.3

The drilling was carried out using portable equipment for off road boreholes 17-3 and 17-4, and a truck mounted drill rig equipped with NW casing for the on-road boreholes 17-1 and 17-2. The subsurface stratigraphy encountered in the boreholes was recorded in the field by Thurber personnel. Split spoon samples were collected at regular depth intervals in the boreholes during the completion of Standard Penetration Tests (SPT). Bedrock was cored and collected using NQ coring equipment in on-road boreholes 17-1 and 17-2. All soil and

rock core samples recovered from the boreholes were transported to Thurber's Ottawa geotechnical laboratory for further examination and testing.

All boreholes were backfilled with a low-permeability mixture of auger cuttings and bentonite pellets in accordance with Ontario MOE Regulation 903. Boreholes advanced within paved areas were capped with granular fill followed by 80 mm of cold patch asphalt to reinstate the travelling surface.

The approximate as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber in August 2017.

3.1 Laboratory Testing

Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples in accordance with the current MTO standards. Grain size distribution analyses testing was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were determined. Chemical analysis for determination of pH, conductivity, resistivity, soluble sulphate and chloride concentrations was carried out on one soil sample.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 Overview / 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 is presented on Drawing No. 1 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. It must be recognized that soil and groundwater conditions may vary between and beyond sampled locations.

The stratigraphy encountered in the boreholes through the embankment near the culvert is generally characterized by the asphalt pavement structure underlain by granular fill embankment overlying bedrock.

4.2 Asphalt

Boreholes 17-1 and 17-2 were drilled through the existing Highway 35 lanes and encountered asphalt with a thickness of 80 mm.

4.3 Embankment Fill

Below the asphalt, within on-road Boreholes 17-1 and 17-2, was a layer of cohesionless embankment fill consisting of sand with silt and gravel to gravel with sand. Cobbles and boulders were noted within the embankment fill. The underside of the embankment fill was at a depth of 3.6 to 4.0 m (elev. 272.7 to 272.2 m) below the existing roadway surface.

SPT tests conducted in the fill gave N-values typically ranging from 11 to 88 blows indicating a relative density of compact to very dense. The higher N-values could be indicative of the presence of cobbles and boulders. Moisture contents ranged from 2 to 16%.

Gradation analyses were completed on three samples of the embankment 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.

Table 4-1: Gradation Results for Embankment Fill

Soil Particle	Percentage (%)	
	Sand with silt and gravel	Gravel with sand
Gravel	27 - 36	62
Sand	54 - 67	32
Silt and Clay	6 - 10	6

4.4 Sand with Gravel to Gravel with Sand

A sand with gravel to gravel with sand layer was encountered from the surface of off-road Boreholes 17-3 and 17-4. Frequent cobbles and boulders were noted within the creek bed in close proximity to both boreholes and may have been reflected in SPT N-values exceeding 100 blows per 0.3 m. The thickness of this layer ranged from 0.3 to 0.4 m and was underlain by inferred bedrock at elevation 270.9 m to 272.0 m.

The recorded moisture contents ranged from 9 to 14%.

A gradation analysis was completed on a sample of the sand with gravel layer. The grain size distribution curve is included in Figure C2 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Table 4-2: Gradation Results for Sand with Gravel

Soil Particle	Percentage (%)
Gravel	40
Sand	52
Silt and Clay	8

4.5 Bedrock

Bedrock was encountered below the fill in both of the on-road boreholes and was proven with coring techniques. The bedrock transitioned from quartzite to granite in both boreholes. The inlet and outlet boreholes were terminated on SPT refusal on inferred bedrock. The bedrock and inferred bedrock surface ranges from elevation 270.9 to 272.7 m and is summarized in the table below:

Table 4-3: Summary of Bedrock Elevation

Location	Borehole No.	Depth Below Existing Ground Surface (m)	Top of Bedrock Elevation (m)
North of culvert – southbound lane	17-1	3.6	272.7
South of culvert – northbound lane	17-2	4.0	272.2
East end – culvert inlet	17-3	0.4	272.0 ^(*)
West end – culvert outlet	17-4	0.3	270.9 ^(*)

^(*) – Inferred by SPT refusal

The Total Core Recovery (TCR) was 100%, the Solid Core Recovery (SCR) ranged from 92 to 100% and the Rock Quality Designation (RQD) ranged from 75 to 100%. Based on the RQD values the bedrock is classified as good to excellent quality. The granite bedrock is estimated to be strong to very strong.

4.6 Groundwater

The groundwater level was not measured in the embankment boreholes since water was introduced in the hole for coring operations. The water level in the creek was observed at 272.7 m and 271.2 m at the culvert inlet and outlet respectively on August 10th, 2017. It is expected that, based on the shallow bedrock surface encountered at this site, the groundwater level will largely be controlled by the water level in the creek. It should be noted that significant differences in the creek water level and flow rates were noted between the May and August field investigations. As the creek bed is bedrock, it should be expected that relatively quick changes in water level could occur.

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 events.

4.7 Analytical Testing

One sample of the native soil was submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are provided in Appendix C and are summarized in the table below:

Table 4-4: Analytical Results Summary

Borehole	Sample	Depth (m)	Sulphate (µg/g)	pH	Resistivity (Ohm-cm)	Conductivity (µS/cm)	Chloride (µg/g)
17-3	SS1	0 – 0.4	23	7.85	4550	220	8

5 MISCELLANEOUS

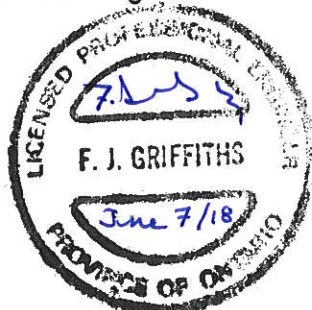
Borehole locations were selected by Thurber relative to the existing culvert alignment and the existing site features. The as-drilled locations and ground surface elevations for the on-road and off-road boreholes were surveyed by Thurber.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario and Forage M3 Drilling also of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out 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. Christopher Murray, P.Eng., 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 was carried out by Mr. Christopher Murray, M.Sc., P.Eng. and Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Christopher Murray, M.Sc., P.Eng.
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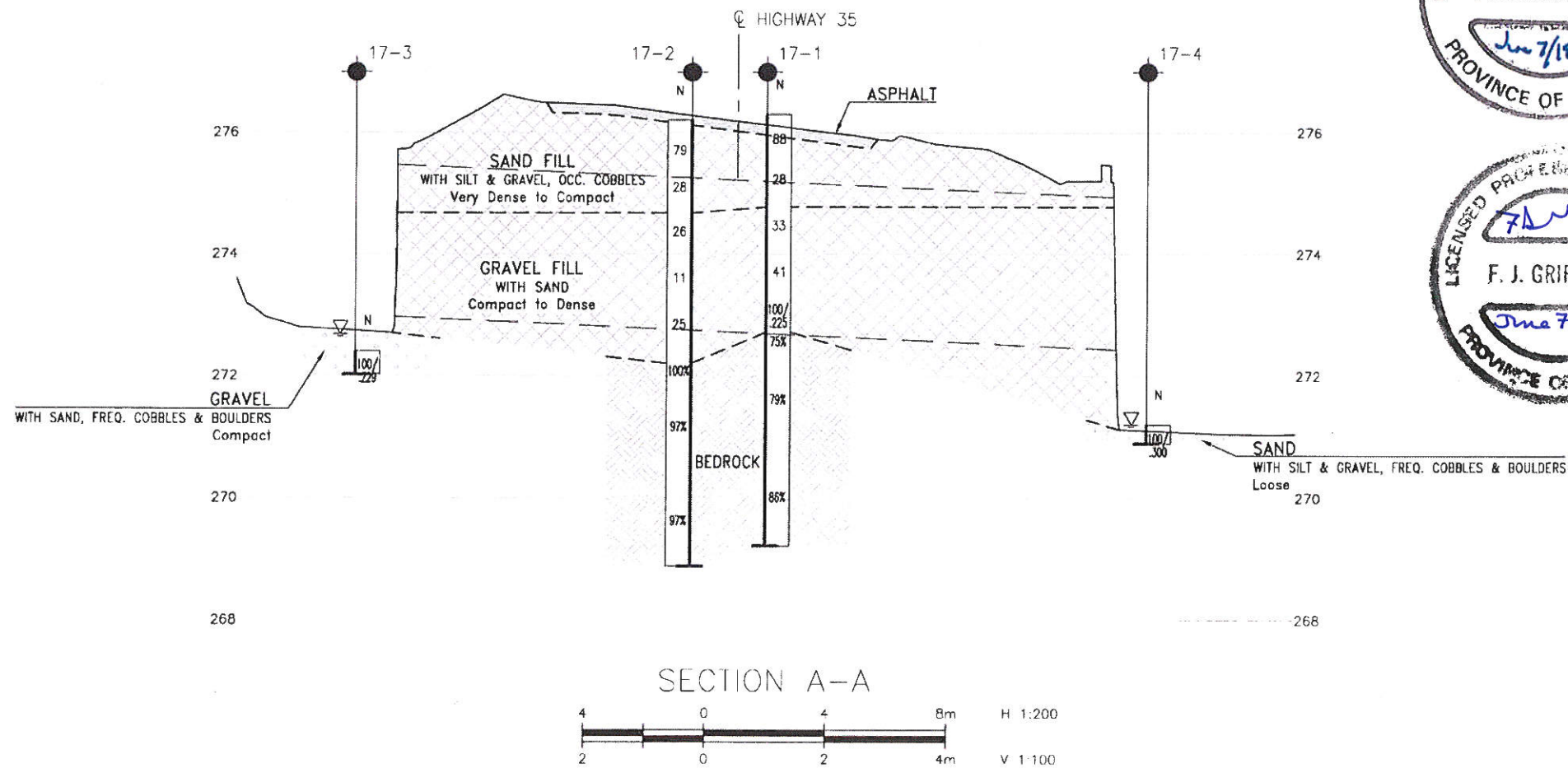
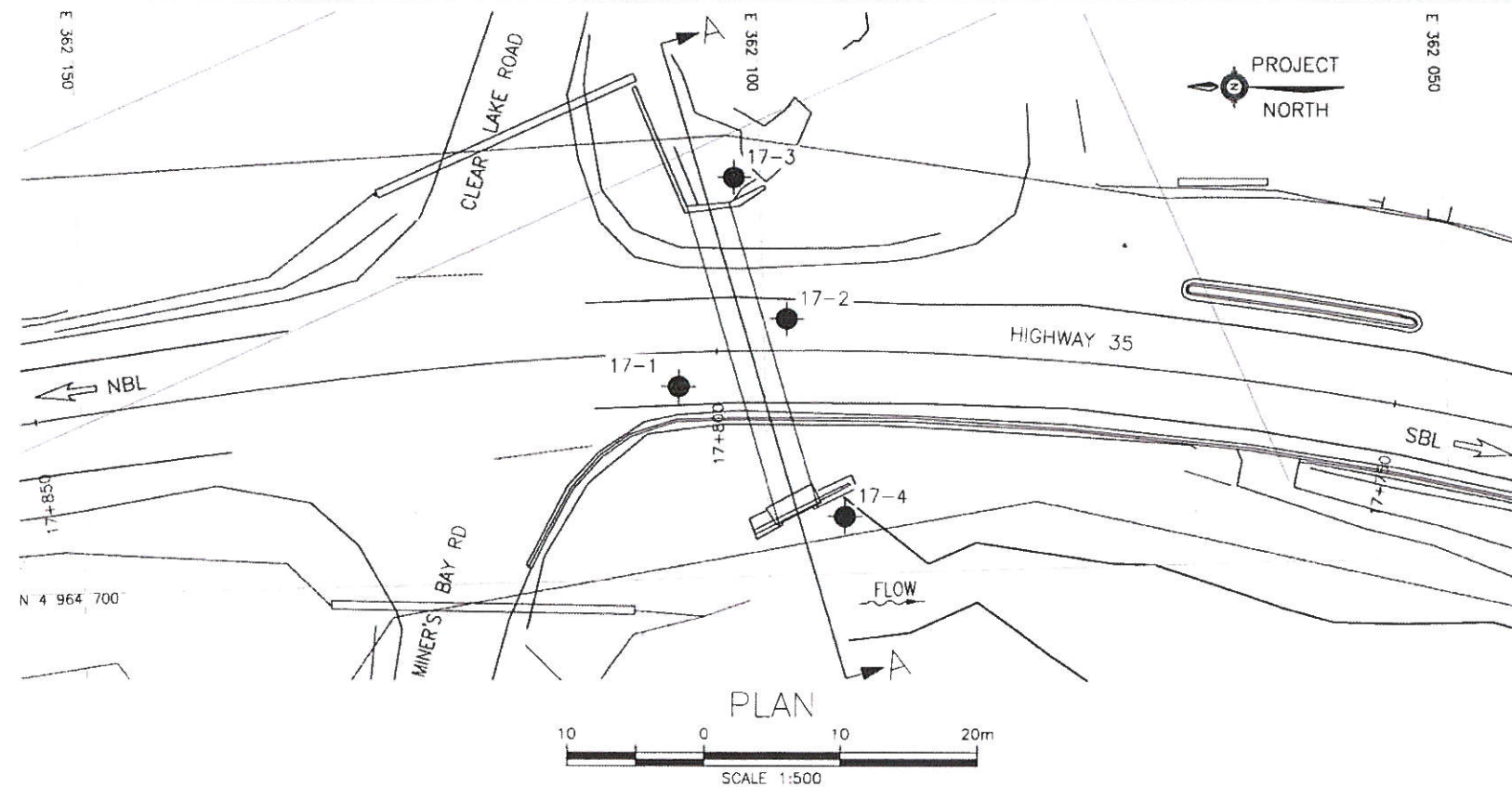


Dr. P.K. Chatterji, P.Eng.
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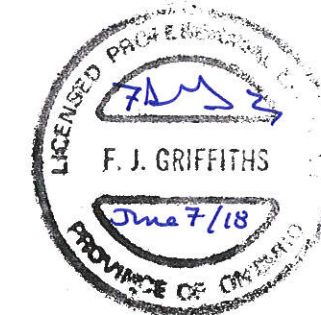
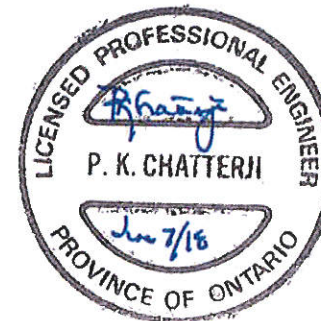
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Appendix A.

Borehole Location Plan and Stratigraphic Drawings



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

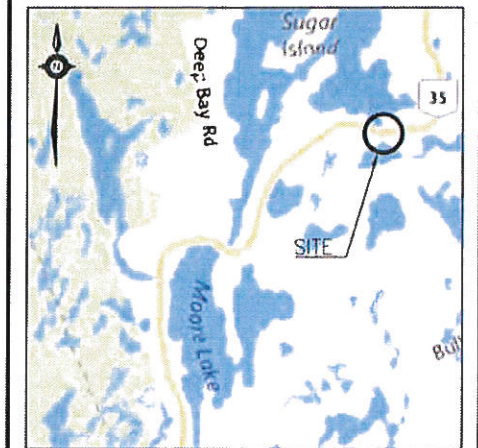


CONT No
GWP No 5087-11-00

HIGHWAY 35
MINER'S BAY
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

McINTOSH
PERRY

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
W	Water Level
W	Head Artesian Water
W	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-1	276.3	4 964 686.0	362 106.3
17-2	276.2	4 964 681.2	362 098.3
17-3	272.4	4 964 670.8	362 101.9
17-4	271.2	4 964 695.8	362 094.4

-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. 31D-691

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CM	CHK	CODE
DRAWN	MFA	CHK	SITE
			STRUCT
			DWG 1

CULVERT REHABILITATION, STRUCTURE NO. 40-117/C
HIGHWAY 35 MINERS BAY CULVERT, LUTTERWORTH TOWNSHIP

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).

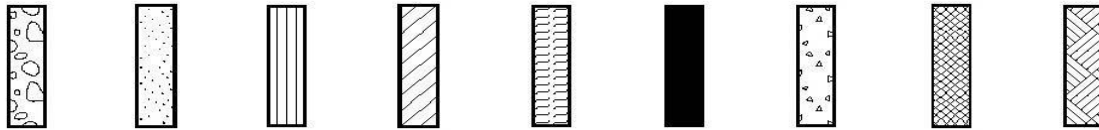
DYNAMIC CONE PENETRATION TEST (DCPT):

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 17-1

1 OF 1

METRIC

GWP# 5087-11-00 LOCATION Miner's Bay Culvert, MTM z12: N 4 964 686.0 E 362 106.3 ORIGINATED BY JM
 HWY 35 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY JM
 DATUM Geodetic DATE 2017.08.05 - 2017.08.05 CHECKED BY CM

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						
								20 40 60 80 100						
276.3														
0.0	80 mm ASPHALT													
0.2	SAND with Silt and Gravel, occasional Cobbles Very Dense to Compact Brown FILL		1	SS	88									
			2	SS	28									
274.8														
1.5	GRAVEL with Sand Dense Grey FILL		3	SS	33									
			4	SS	41									
	-100 mm Cobble at 2.9 m													
272.7			5	SS	100/ 225mm									
3.6	BEDROCK Quartzite to Granite Fresh to Slightly Weathered White to Grey		1	RUN										
			2	RUN										
			3	RUN										
269.2														
7.1	End of Borehole													

ONTMT4S 16284 MINER'S BAY CULVERT.GPJ 2012TEMPLATE(MTO).GDT 16/3/18

RECORD OF BOREHOLE No 17-2

1 OF 1

METRIC

GWP# 5087-11-00 LOCATION Miner's Bay Culvert, MTM z12: N 4 964 681.2 E 362 098.3 ORIGINATED BY JM
 HWY 35 BOREHOLE TYPE NW Casing / NQ Coring COMPILED BY JM
 DATUM Geodetic DATE 2017.08.05 - 2017.08.05 CHECKED BY CM

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								
276.2							20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
0.0	80 mm ASPHALT						20	40	60	80	100	WATER CONTENT (%)				
0.2	SAND with Silt and Gravel, occasional Cobbles Very Dense to Compact Brown FILL		1	SS	79											27 67 6 (SI+CL)
			2	SS	28											
274.7																
1.5	GRAVEL with Sand Compact Grey FILL -75 mm Cobble at 2.2 m		3	SS	26											62 32 6 (SI+CL)
			4	SS	11											
			5	SS	25											
	-200 mm Boulder at 3.7 m															
272.2																
4.0	BEDROCK Quartzite to Granite Fresh to Slightly Weathered White to Grey		1	RUN												RUN #1 TCR=100% SCR=100% RQD=100%
			2	RUN												
					3	RUN										

ONTMT4S 16284 MINER'S BAY CULVERT.GPJ 2012TEMPLATE(MTO).GDT 16/3/18

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

RECORD OF BOREHOLE No 17-3

1 OF 1

METRIC

GWP# 5087-11-00 LOCATION Miner's Bay Culvert, MTM z12: N 4 964 670.8 E 362 101.9 ORIGINATED BY CM
 HWY 35 BOREHOLE TYPE Portable COMPILED BY KE
 DATUM Geodetic DATE 2017.10.08 - 2017.10.08 CHECKED BY CM

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									
272.4																	
0.0																	
272.0	GRAVEL with Sand Frequent Cobbles and Boulders Compact Brown		1	SS	100/ 229mm												
0.4	End of Borehole on Probable Bedrock Water 0.28 m above G.S. (Elev. 272.7 m) on 8/10/2017																


ONTMT4S 16284 MINER'S BAY CULVERT.GPJ 2012TEMPLATE(MTO).GDT 8/6/18

RECORD OF BOREHOLE No 17-4

1 OF 1

METRIC

GWP# 5087-11-00 LOCATION Miner's Bay Culvert, MTM z12: N 4 964 695.8 E 362 094.4 ORIGINATED BY CM
 HWY 35 BOREHOLE TYPE Portable COMPILED BY KE
 DATUM Geodetic DATE 2017.10.08 - 2017.10.08 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								W P	W	W L	WATER CONTENT (%)	GR
271.2								20	40	60	80	100								
0.0								20	40	60	80	100								
270.9	SAND with Silt and Gravel Frequent Cobbles and Boulders Loose Brown		1	SS	100/ 300mm		271							o				40	52	8 (SI+CL)
0.3	End of Borehole on Probable Bedrock Water at G.S. (Elev. 271.2 m) on 8/10/2017																			

ONTMT4S 16284 MINER'S BAY CULVERT.GPJ 2012TEMPLATE(MTO).GDT 16/3/18

Appendix C.

Laboratory Testing

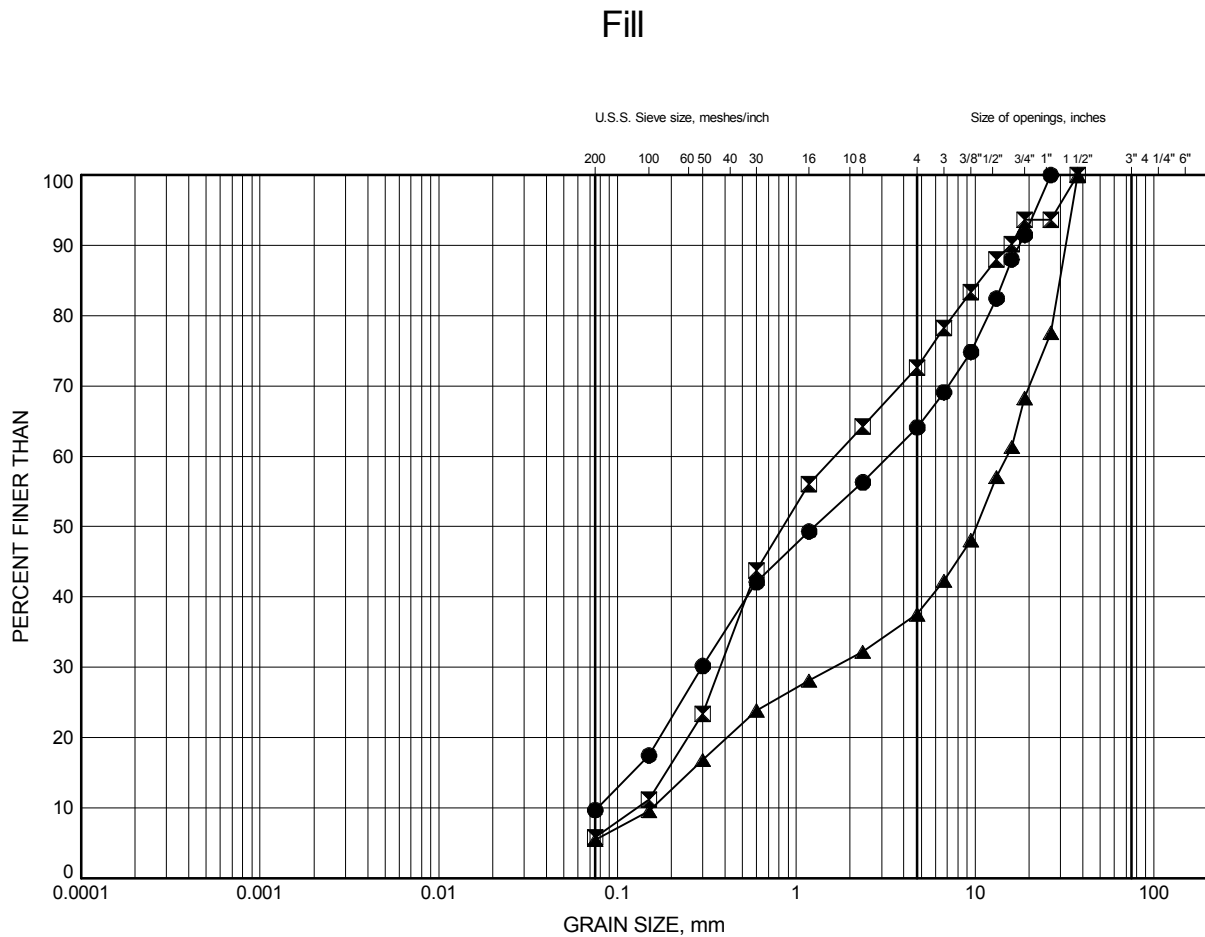
Appendix C.1

Particle Size Analysis Figures

Hwy's 35 and 523, 5 Structures

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)
●	17-1	1.07	275.23
⊠	17-2	1.09	275.13
▲	17-2	1.83	274.40

Date ..October 2017.....
 GWP# ..5087-11-00.....



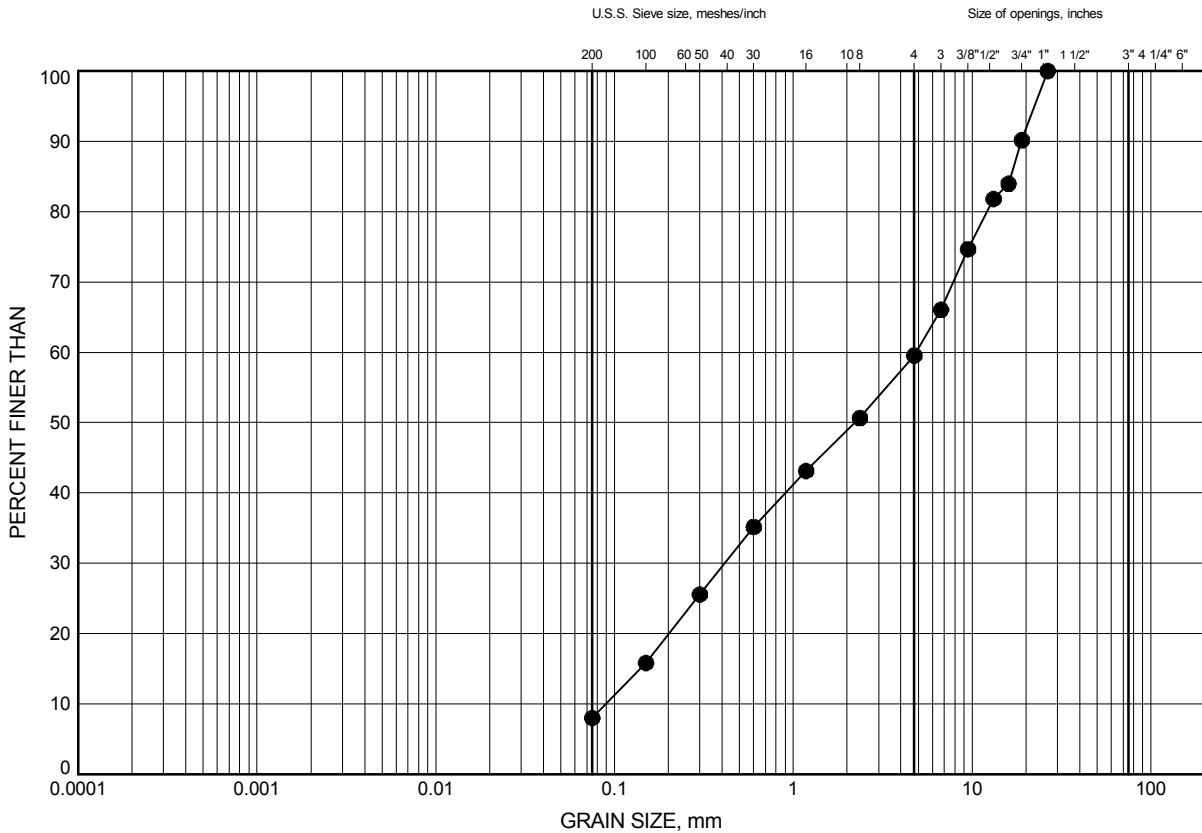
Prep'dCM.....
 Chkd.SP.....

Hwy's 35 and 523, 5 Structures

GRAIN SIZE DISTRIBUTION

FIGURE C2

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)
●	17-4	0.15	271.06

Date ..October 2017.....
GWP# ..5087-11-00.....



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

Appendix C.2
Rock Core Photographs

Borehole 17-1
Runs 1 and 2 (of 3)
Elevation 272.7 m to 270.8 m



Borehole 17-1
Run 3 (of 3)
Elevation 270.8 m to 269.2 m



Borehole 17-2
Runs 1 and 2 (of 3)
Elevation 272.2 m to 270.4 m



Borehole 17-2
Run 3 (of 3)
Elevation 270.4 m to 268.9 m



Appendix C.3
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Stephen Peters

Client PO: 16284
Project: Hwy 35/523
Custody: 38404

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017

Order #: 1734260

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

Parcel ID	Client ID
1734260-01	Black Creek 17-3 SS#2 7.83-9.83'
1734260-02	Black Creek 17-5 SS#3 10.17-12.17'
1734260-03	Miner's Bay 17-3 SS#1 0-1.25'
1734260-04	Bark Lake 17-3 SS#3 10-12'
1734260-05	Bark Lake 17-6 SS#2 15-17'

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16284

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017
Project Description: Hwy 35/523

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	25-Aug-17	25-Aug-17
Conductivity	MOE E3138 - probe @25 °C, water ext	29-Aug-17	29-Aug-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	28-Aug-17	28-Aug-17
Resistivity	EPA 120.1 - probe, water extraction	29-Aug-17	29-Aug-17
Solids, %	Gravimetric, calculation	26-Aug-17	26-Aug-17

Certificate of Analysis
 Client: Thurber Engineering Ltd.
 Client PO: 16284

Report Date: 29-Aug-2017
 Order Date: 23-Aug-2017
 Project Description: Hwy 35/523

		Client ID:	Black Creek 17-3 SS#2 7.83-9.83'	Black Creek 17-5 SS#3 10.17-12.17	Miner's Bay 17-3 SS#1 0-1.25'	Bark Lake 17-3 SS#3 10-12'
		Sample Date:	14-Aug-17	16-Aug-17	10-Aug-17	08-Aug-17
		Sample ID:	1734260-01	1734260-02	1734260-03	1734260-04
		MDL/Units	Soil	Soil	Soil	Soil
Physical Characteristics						
% Solids	0.1 % by Wt.		73.7	76.1	91.0	70.4
General Inorganics						
Conductivity	5 uS/cm		99	176	220	217
pH	0.05 pH Units		8.33	8.05	7.85	4.91
Resistivity	0.10 Ohm.m		101	56.8	45.5	46.1
Anions						
Chloride	5 ug/g dry		11	51	8	6
Sulphate	5 ug/g dry		23	25	23	176
		Client ID:	Bark Lake 17-6 SS#2 15-17'	-	-	-
		Sample Date:	09-Aug-17	-	-	-
		Sample ID:	1734260-05	-	-	-
		MDL/Units	Soil	-	-	-
Physical Characteristics						
% Solids	0.1 % by Wt.		88.8	-	-	-
General Inorganics						
Conductivity	5 uS/cm		63	-	-	-
pH	0.05 pH Units		5.70	-	-	-
Resistivity	0.10 Ohm.m		158	-	-	-
Anions						
Chloride	5 ug/g dry		7	-	-	-
Sulphate	5 ug/g dry		26	-	-	-

Certificate of Analysis
Client: **Thurber Engineering Ltd.**
Client PO: **16284**

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017
Project Description: **Hwy 35/523**

Method Quality Control: Blank

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

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16284

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017
Project Description: Hwy 35/523

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	10.5	5	ug/g dry	10.7			1.3	20	
Sulphate	22.3	5	ug/g dry	23.3			4.4	20	
General Inorganics									
Conductivity	844	5	uS/cm	841			0.4	6.2	
pH	8.36	0.05	pH Units	8.45			1.1	10	
Resistivity	11.8	0.10	Ohm.m	11.9			0.4	20	
Physical Characteristics									
% Solids	87.3	0.1	% by Wt.	87.2			0.0	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16284

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017
Project Description: Hwy 35/523

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	101	5	ug/g	10.7	90.4	78-113			
Sulphate	119	5	ug/g	23.3	96.2	78-111			

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16284

Report Date: 29-Aug-2017
Order Date: 23-Aug-2017
Project Description: Hwy 35/523

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.

Site Photographs

CULVERT REHABILITATION, STRUCTURE NO. 40-117/C
HIGHWAY 35 MINERS BAY CULVERT, LUTTERWORTH TOWNSHIP



Photo 1. Looking upstream from culvert inlet, note erosion at north wingwall



Photo 2. Looking northward from culvert site along Hwy 35

Photographs taken August 17, 2017

CULVERT REHABILITATION, STRUCTURE NO. 40-117/C
HIGHWAY 35 MINERS BAY CULVERT, LUTTERWORTH TOWNSHIP



Photo 3. Looking southward from culvert site along Hwy 35



Photo 4. Looking northward at culvert outlet and wingwalls

Photographs taken August 17, 2017