THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION REPORT
DEAD HORSE CREEK CONCRETE ARCH REHABILITATION
HIGHWAY 17, WALSH TOWNSHIP
DISTRICT OF THUNDER BAY, ONTARIO
LATITUDE: 48.817896º, LONGITUDE: -86.686889º

G.W.P. No. 6811-14-00, SITE No. 48E-21/C

GEOCRES Number: 42D-51

Report

to

HATCH

Date: August 31, 2018
File: 15595

103, 2010 Winston Park Drive, Oakville, ON L6H 5R7 T: 905 829 8666 F: 905 829 1166
thurber.ca

THURBER

TABLE OF CONTENTS

APPENDICES

THURBER

FOUNDATION INVESTIGATION REPORT
DEAD HORSE CREEK CONCRETE ARCH REHABILITATION
HIGHWAY 17, WALSH TOWNSHIP
DISTRICT OF THUNDER BAY, ONTARIO

G.W.P. No. 6811-14-00, SITE No. 48E-21/C

GEOCRES Number: 42D-51

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed rehabilitation of Dead Horse Creek concrete arch culvert on Highway 17, located in the Walsh Township, District of Thunder Bay, Ontario.

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

Thurber was retained by Hatch to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0008.

2. SITE DESCRIPTION

The site is located on Highway 17, approximately 42 km east of Terrace Bay, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata Drawings in Appendix D.

Highway 17 runs in an east-west direction in the general area along the northern shoreline of Lake Superior. The culvert is oriented at a slight skew (about 9°) to the centreline of the highway. The culvert carries Dead Horse Creek flow in an southerly direction towards Lake Superior.

The historical culvert drawings dated March 1953 and Ontario Structural Inspection Manual (OSIM) prepared by MTO for a site inspection conducted on July 17, 2013, indicate that the existing structure is a 37.8 m long, 9.8 m wide and 4.6 m high single span concrete arch culvert founded on strip footings. The clear span between two strip footings is approximately 9.1 m. The grade level of Highway 17 at the existing culvert is at an approximate Elevation of 237.6 m. The upstream and downstream water levels in the creek were measured at Elevation 229.31 m and 228.31 m, respectively, in October 2015, as shown on the preliminary structural GA drawings provided by Hatch.

The lands surrounding the Dead Horse Creek Culvert site predominantly consist of heavily forested areas with occasional lakes. Local topography is generally of medium to high relief with jagged, rugged, cliffed and knobby terrains. Photographs of the culvert and surrounding area are presented in Appendix C.

Based on the published geological information, the subsurface soils at the site generally consist of exposed bedrock or a thin veneer of till overlying bedrock. Bedrock geology map of the area shows that the bedrock consists of mafic to intermediate metavolcanics rocks.

3. INVESTIGATION PROCEDURES

The borehole investigation and field testing program for this project was carried out between August 18 and August 28, 2017 and consisted of drilling and sampling six (6) boreholes, designated as Boreholes 17-28 to 17-33. Boreholes 17-28 was drilled at the inlet of the culvert at the streambed elevation and extended to a depth of 4.9 m (Elevation 223.7). Boreholes 17-29 to 17-33 were drilled on the roadway surface or from the embankment side slope and extended to depths between 3.0 m and 4.9 m (Elevations 231.9 and 234.8). Bedrock was proved by NQ or HQ coring in Boreholes 17-28, 17-29, 17-30, and 17-33.

Boreholes 17-31 to 17-33 were drilled through the asphalt pavement, to the east of the existing culvert, at approximately 10 m, 20 m and 30 m distance, respectively. These three boreholes were advanced to investigate the extent of and assess the need for frost taper leading to the culvert.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the

boreholes were derived from cross-sections and topographic drawings provided by Hatch. The coordinate system MTM NAD 83, Zone 14 was used for the approximate locations of the boreholes shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

All boreholes except 17-28 were drilled using a rubber track mounted drill rig equipped with continuous flight hollow and solid stem augers. Borehole 17-28 was advanced by coring using a portable electric powered Hilti coring machine. Soil samples were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Dynamic Cone Penetration Test (DCPT) was conducted in Borehole 17-31 starting at a depth of 3.0 m and extending to cone tip refusal at a depth of 3.7 m (Elevation 234.1).

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

All rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined on site and further inspected and confirmed in the laboratory.

Upon completion of drilling operations, the boreholes were backfilled in general accordance with Ontario Regulation 903 as amended by Regulation 128/03. Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
17-28	4.9 / 223.7	Borehole backfilled with bentonite holeplug to surface.
17-29	4.9 / 232.8	Borehole backfilled with bentonite holeplug and cuttings to 0.9 m, concrete to 0.2 m, then asphalt patch to surface.
17-30	4.0 / 231.9	Borehole backfilled with bentonite holeplug and cuttings to surface.

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
17-31	3.7 / 234.1	Borehole backfilled with cuttings to 0.6 m, concrete to 0.2 m, then asphalt patch to surface.
17-32	3.7 / 234.1	Borehole backfilled with bentonite holeplug and cuttings to 0.6 m, concrete to 0.2 m, then asphalt patch to surface
17-33	3.0 / 234.8	Borehole backfilled with bentonite holeplug and cuttings to 0.6 m, concrete to 0.1 m, then asphalt patch to surface

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer). The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact rock cores in the laboratory to assist in evaluation of the unconfined compressive strength of the bedrock. Results of the point load tests are included in Appendix B and on the Record of Borehole sheets in Appendix A.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structural members, a surface water sample was collected from the creek upstream of the culvert. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in this report and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets 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 and should be used for interpretation of site

conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered below the existing embankment fill typically consisted of cobbles and boulders, or sandy silt overlying bedrock at a shallow depth. Bedrock outcrops are visible in the surrounding area. Descriptions of the individual strata are presented below.

5.1 Asphalt

Approximately 100 to 175 mm thick asphalt was encountered in Boreholes 17-29, 17-31, 17-32 and 17-33.

5.2 Embankment Fill

Embankment fill consisting of sandy gravel to gravelly sand with trace to some silt and clay and occasional cobbles, was encountered below the asphalt in Boreholes 17-29, 17-31, 17-32 and 17-33 and from the ground surface in Borehole 17-30. The thickness of the embankment fill, where fully penetrated, ranged from 0.9 m to 2.8 m and extended to depths of 0.9 m to 3.0 (Elevations 234.8 to 235.7).

SPT ‘N’ values recorded in the fill ranged from 3 to 102 blows for 0.3 m penetration, indicating a very loose to very dense relative density. Measured moisture contents ranged from 1 to 19 percent.

The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets included in Appendix A and are summarized in the following table. The results are also presented on Figure B1 in Appendix B.

Soil Particle	Percentage (%)
Gravel	19 to 59
Sand	30 to 73
Silt & Clay	7 to 11

5.3 Silt

A layer of silt, containing some sand, trace clay and gravel, was encountered at a depth of 3.0 m (Elevation 234.8) in Borehole 17-32. Borehole 17-32 was terminated in the silt layer at a depth of 3.7 m (Elevation 234.1).

One SPT 'N' value recorded in the silt was 67 blows for 0.3 m penetration, indicating a very dense relative density. The measured moisture content in the silt was 18 percent.

The results of a grain size distribution analysis conducted on the sample of the silt is presented on the Record of Borehole sheets included in Appendix A and is summarized in the following table. The results are also presented on Figure B2 in Appendix B.

Soil Particle	Percentage (%)
Gravel	4
Sand	15
Silt	75
Clay	6

5.4 Cobbles and Boulders

Cobbles and boulders were encountered in Borehole 17-28 from the ground surface. The layer of cobbles and boulders extended to the bedrock surface at a depth of 1.8 m (Elevation 226.8).

Samples of the cobbles and boulders were obtained through coring.

5.5 Bedrock

Schist bedrock was encountered and cored in Boreholes 17-28, 17-29, 17-30 and 17-33. The bedrock was grey to black in colour with vertical to steeply dipping foliation. Occasional mechanical breaks were noted throughout the bedrock cores. The bedrock is generally described as slightly to moderately weathered. The table below summarizes depths and elevations to the top of bedrock.

Table 5.1 – Depths and Elevations of Top of Bedrock

Borehole	Top of Bedrock	
	Depth (m)	Elevation (m)
17-28	1.8	226.8
17-29	2.0	235.7
17-30	0.9	235.0
17-33	2.1	235.7

Total Core Recovery (TCR) in the bedrock ranged from 55% to 100% with Solid Core Recovery (SCR) typically ranging from 0% to 100%. The Rock Quality Designation (RQD) determined from the recovered cores generally ranged from 0% to 100%, indicating very poor to excellent rock quality. The lower bound values of RQD were typically recorded near the bedrock surface.

Average unconfined compressive strengths (UCS) of the intact rock cores typically ranged between 72 MPa and 153 MPa, indicating strong to very strong strength. The UCS values are correlated from the point load tests (PLT) results presented in Appendix B. UCS values correlated from tests performed normal to the foliations are typically much higher than those correlated from tests performed parallel or subparallel to the foliations.

5.6 Groundwater Conditions

When possible, groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. However, water was used in Boreholes 17-29, 17-30, and 17-33 for the coring operations and thus the actual groundwater levels could not be observed. Borehole 17-28 was drilled within the creek from the streambed. The groundwater levels measured in the open boreholes are summarized in the table below.

THURBER

Table 5.2 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
17-28	August 28, 2017	-	228.8	Creek level at time of drilling
17-29	August 19, 2017	-	-	Water added to borehole for coring
17-30	August 18, 2017	-	-	Water added to borehole for coring
17-31	August 19, 2017	Dry	-	Open borehole
17-32	August 19, 2017	Dry	-	Open borehole
17-33	August 18, 2017	-	-	Water added to borehole for coring

The upstream and downstream water levels of Dead Horse Creek were measured at Elevation 229.31 m and 228.31 m, respectively, in October 2015, as shown on drawings provided by Hatch.

The above groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. The groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the creek water was submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in the table below. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Water)	Creek Water (Upstream)
Sulphide	mg/L	<0.006
Chloride	mg/L	0.91
Sulphate	mg/L	1.7
pH	No unit	7.50
Electrical Conductivity	µS/cm	81
Resistivity	Ohms.cm	12300
Redox Potential	mV	182

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay and OGS Inc of Almonte, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Mr. John Zoldy of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, B.A.Sc. of Thurber.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc.

Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT and Mr. Keli Shi, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER

Thurber Engineering Ltd.

Cory Zanatta, P.Eng.
Geotechnical Engineer

Keli Shi, P.Eng.
Geotechnical Engineer

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

THURBER

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

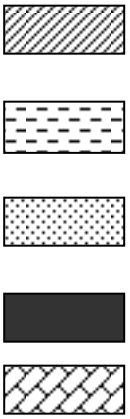
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and 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. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
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 structure are preserved.

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

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 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-28 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 893.0 E 327 819.0 ORIGINATED BY JZ

HWY 17 BOREHOLE TYPE Coring COMPILED BY AN

DATUM Geodetic DATE 2017.08.28 - 2017.08.28 CHECKED BY CZ

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 (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
228.6	GROUND SURFACE										
0.0	**COBBLES** and **BOULDERS**, some sand and gravel		1	GS							
			1	RUN			228				
226.8							227				RUN #2 TCR=100% SCR=82% RQD=75% UCS=133MPa (Average)
1.8	**BEDROCK (SCHIST)**, moderately to slightly weathered, vertical foliation, grey										
	Vertical fracture (25mm) at 1.8m, 2.2m, 2.4m and 2.9m		2	RUN			226				
	Horizontal fracture (25mm) at 1.9m, 2.2m, 2.3m and 2.7m										RUN #3 TCR=94% SCR=94% RQD=94% UCS=123MPa (Average)
	Horizontal fracture (25mm) at 2.9m, 3.5m, 4.2m, 4.5m and 4.6m		3	RUN			225				
223.7			4	RUN			224				RUN #4 TCR=100% SCR=100% RQD=100% UCS=110MPa (Average)
4.9	END OF BOREHOLE AT 4.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.										

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

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

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

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 12/11/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-29 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 877.6 E 327 797.3 ORIGINATED BY TY

HWY 17 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2017.08.19 - 2017.08.19 CHECKED BY CZ

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
237.7	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	**SAND** and **GRAVEL**, some silt and clay Very Dense Brown Moist (FILL)		1	SS	102		237		○		40 49 11 (SI+CL)
			2	SS	73		236		○		
235.7	Occasional cobbles										
2.0	**BEDROCK (SCHIST)**, slightly to moderately weathered, vertical foliation, grey		1	RUN			235				RUN #1 TCR=100% SCR=0% RQD=0%
			2	RUN			234				RUN #2 TCR=100% SCR=27% RQD=7% UCS=128MPa (Average)
			3	RUN			233				RUN #3 TCR=100% SCR=89% RQD=89% UCS=72MPa (Average)
232.8											
4.9	END OF BOREHOLE AT 4.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.9m, CONCRETE TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 12/11/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-30 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 864.5 E 327 786.0 ORIGINATED BY TY

HWY 17 BOREHOLE TYPE Solid Stem Augers/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2017.08.18 - 2017.08.18 CHECKED BY CZ

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.9	GROUND SURFACE										
0.0	Sandy **GRAVEL**, some silt and clay Compact Moist (FILL)		1	SS	14				○		59 30 11 (SI+CL)
235.0							235				RUN #1 TCR=100% SCR=0% RQD=0% UCS=153MPa (Average)
0.9	**BEDROCK (SCHIST)**, slightly weathered, vertical foliation, grey to black		1	RUN							RUN #2 TCR=100% SCR=37% RQD=39% UCS=9MPa (Average)
			2	RUN			234				
			3	RUN							RUN #3 TCR=100% SCR=50% RQD=50%
			4	RUN			233				RUN #4 TCR=75% SCR=62% RQD=20% UCS=148MPa (Average)
231.9							232				
4.0	END OF BOREHOLE AT 4.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

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

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 12/11/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-31 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 874.7 E 327 826.5 ORIGINATED BY TY

HWY 17 BOREHOLE TYPE Solid Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2017.08.19 - 2017.08.19 CHECKED BY CZ

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
237.8	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	Gravelly **SAND**, some silt and clay Brown Moist (FILL)		1	GS			237		○		33 56 11 (SI+CL)
	Occasional cobbles		2	GS					○		
							236				
			1	SS	3				○		
234.8							235				
3.0	End of sampling and start DCPT										
234.1											
3.7	END OF BOREHOLE AT 3.7m UPON DCPT REFUSAL. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT PATCH TO SURFACE.										

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

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

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 12/11/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-32 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 873.5 E 327 836.4 ORIGINATED BY TY

HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.08.19 - 2017.08.19 CHECKED BY CZ

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.8	GROUND SURFACE										
0.0	**ASPHALT:** (175mm)										
0.2 / 237.2	**SAND** and **GRAVEL**, trace silt and clay Brown Moist (FILL)		1	GS					○		
0.6	Gravelly **SAND**, trace to some silt and clay Brown Moist (FILL)		2	GS			237 236		○		19 73 8 (SI+CL)
234.8							235				
3.0 / 234.1	**SILT**, some sand, trace gravel and clay Very Dense Brown Wet		1	SS	67				○		4 15 75 6
3.7	END OF BOREHOLE AT 3.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT COLD PATCH TO SURFACE.										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-33 1 OF 1 METRIC

W.P. 6806-14-01 LOCATION Dead Horse Concrete Arch N 5 408 872.1 E 327 846.3 ORIGINATED BY TY

HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.08.18 - 2017.08.18 CHECKED BY CZ

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.8	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND** and **GRAVEL**, trace silt and clay Brown Moist (FILL)		1	GS			237		○		38 55 7 (SI+CL)
			2	GS					○		
							236				
235.7											
2.1	**BEDROCK (SCHIST)**, moderately weathered, vertical foliation, grey		1	RUN			235				RUN #1 TCR=55% SCR=17% RQD=0% UCS=99MPa (Average)
234.8											
3.0	END OF BOREHOLE AT 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 12/11/17

THURBER

Appendix B

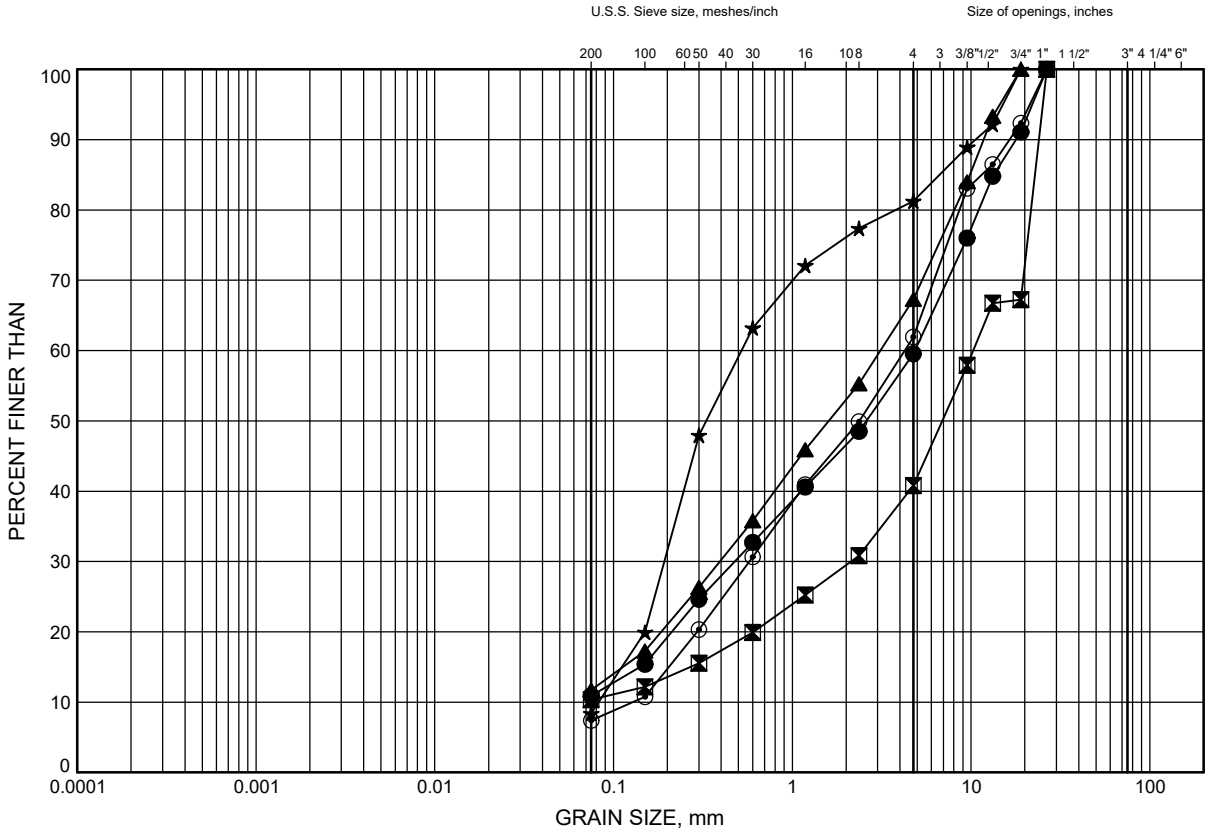
Geotechnical and Analytical Laboratory Test Results

Dead Horse Concrete Arch

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sandy GRAVEL to Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-29	0.3	237.4
⊠	17-30	0.3	235.6
▲	17-31	0.3	237.5
★	17-32	1.1	236.7
⊙	17-33	0.3	237.5

Date December 2017

W.P. 6806-14-01

THURBER

Prep'd AN

Chkd. CZ

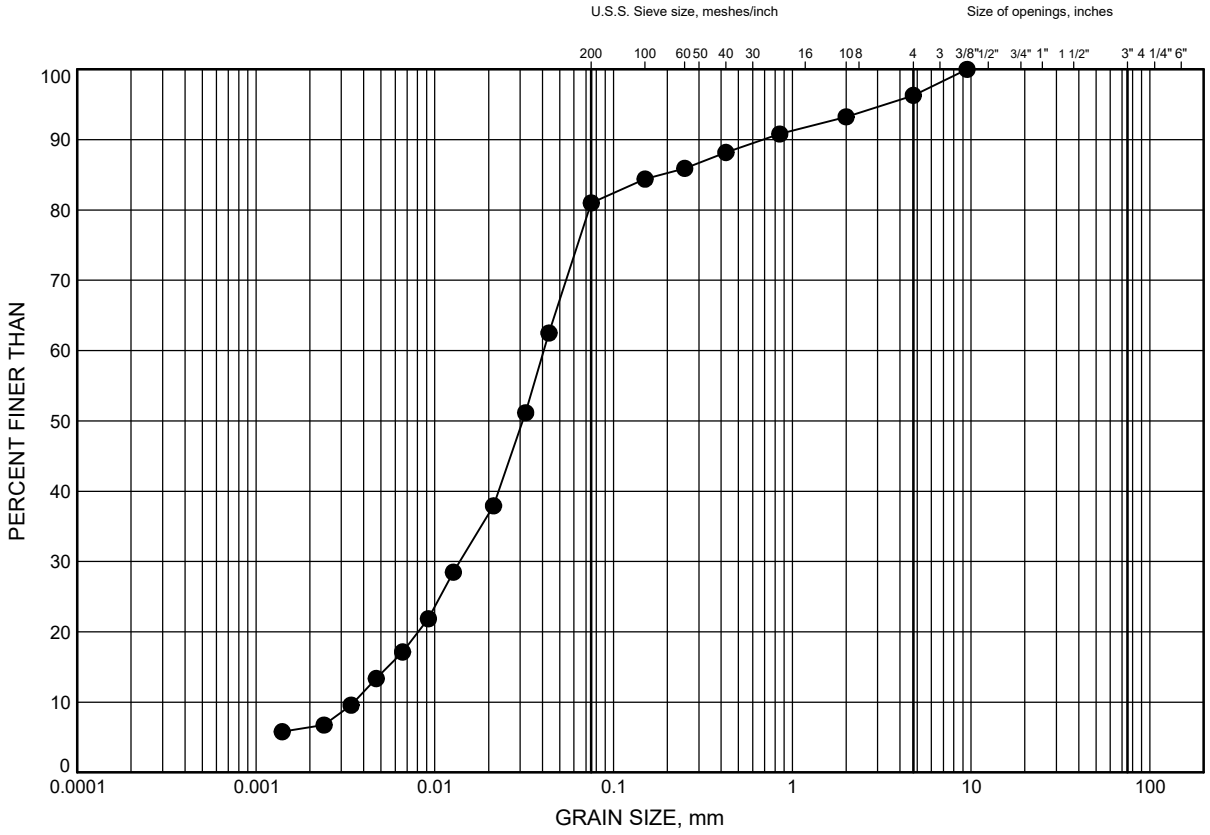
GRAIN SIZE DISTRIBUTION - THURBER MTO-15595.GPJ 12/11/17

Dead Horse Concrete Arch

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-32	3.4	234.4

GRAIN SIZE DISTRIBUTION - THURBER MTO-15595.GPJ 12/11/17

Date December 2017

W.P. 6806-14-01

THURBER

Prep'd AN

Chkd. CZ

FINAL REPORT

CA12892-JUL17 R

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA12892-JUL17 R

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Deanna Edwards, B.Sc, C.Chem
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7.	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Mark Farrant	Telephone	705-652-2000
Telephone	905-829-8666 x 228	Facsimile	705-652-6365
Facsimile		Email	deanna.edwards@sgs.com
Email	mfarrant@thurber.ca	SGS Reference	CA12892-JUL17
Project		Received	07/28/2017
Order Number		Approved	01/23/2018
Samples	Water (2)	Report Number	CA12892-JUL17 R
		Date Reported	01/23/2018

COMMENTS

Temperature of Sample upon Receipt: 23 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project:
Project Manager: Mark Farrant
Samplers: John Zoldy

PACKAGE: **REG153 - 1.3 Other (ORP)** (WATER)

Sample Number	7
Sample Name	15545 Dead Horse Creek
Sample Matrix	Water
Sample Date	26/07/2017

Parameter	Units	RL		Result
1.3 Other (ORP)				
pH	units	0.05		7.50

PACKAGE: **REG153 - Corrosivity Index** (WATER)

Sample Number	7
Sample Name	15545 Dead Horse Creek
Sample Matrix	Water
Sample Date	26/07/2017

Parameter	Units	RL		Result
Corrosivity Index				
Resistivity (calculated)	ohms.cm	-9999		12300

PACKAGE: **REG153 - Metals and Inorganics** (WATER)

Sample Number	7
Sample Name	15545 Dead Horse Creek
Sample Matrix	Water
Sample Date	26/07/2017

Parameter	Units	RL		Result
Metals and Inorganics				
Conductivity	µS/cm	2		81
Chloride	mg/L	0.04		0.91
Sulphate	mg/L	0.04		1.7

Client: Thurber Engineering Ltd.
Project:
Project Manager: Mark Farrant
Samplers: John Zoldy

PACKAGE: **REG153 - UNDEFINED** (WATER)

Sample Number	7
Sample Name	15545 Dead Horse Creek
Sample Matrix	Water
Sample Date	26/07/2017

Parameter	Units	RL		Result
UNDEFINED				
Redox Potential	mV	-		182
Sulphide	mg/L	0.006		< 0.006

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0425-JUL17	mg/L	0.04	<0.04	11	20	97	80	120	99	75	125
Sulphate	DIO0425-JUL17	mg/L	0.04	<0.04	0	20	99	80	120	98	75	125
Chloride	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	99	80	120	111	75	125
Sulphate	DIO0438-JUL17	mg/L	0.04	<0.04	1	20	94	80	120	103	75	125

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0430-JUL17	µS/cm	2	< 2	0	10	100	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0431-JUL17	no unit	0.05	NA	0		100			NA		

Redox Potential

Method: SM 2580 I

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Redox Potential	EWL0428-JUL17	mV	no	NA	5	20	109	80	120	NA		

Sulphide by SFA

Method: SM 4500 I Internal ref.: ME-CA-IENVISFA-LAK-AN-008

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	SKA0007-AUG17	mg/L	0.006	<0.006	ND	20	98	80	120	102	75	125

QC SUMMARY

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

-- End of Analytical Report --

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	15595	**Date Drilled:**	Aug 28/17
Client:	HATCH	**Date Tested:**	Sep 6/17
Project Name:	Replace 9 Culverts	**Tester:**	JZ
Core Size:	AW +EW **BH No :** 17-28	**Reviewed by:**	WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
2	2	1.9	D	19.4	48.0	225.0	7.9	188.5	Schist	Very Strong
3	2	2.2	A	2.0	50.0	56.3	0.6	13.5	Schist	Weak
4	2	2.4	D	20.8	37.0	210.0	12.6	301.9	Schist	Extremely Strong
5	2	2.7	A	3.0	37.0	54.5	1.1	27.1	Schist	Medium Strong
6	3	3.0	D	14.2	37.0	230.0	8.6	205.8	Schist	Very Strong
7	3	3.2	A	1.2	37.0	61.4	0.4	9.8	Schist	Weak
8	3	3.9	A	3.0	37.0	62.7	1.0	23.8	Schist	Weak
9	3	4.4	D	17.5	37.0	243.0	10.6	254.0	Schist	Extremely Strong
10	4	4.6	A	4.6	37.0	72.7	1.4	32.7	Schist	Medium Strong
11	4	4.8	D	12.9	37.0	244.0	7.8	187.2	Schist	Very Strong
12										
13										
14					**RUN #2 AVERAGE =**			132.7		Very Strong
15					**RUN #3 AVERAGE =**			123.3		Very Strong
16					**RUN #4 AVERAGE =**			109.9		Very Strong
17										
18										
19										
20										
21										
22										

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	15595	**Date Drilled:**	Aug 18-19/17
Client:	HATCH	**Date Tested:**	Sep 8/17
Project Name:	Replace 9 Culverts	**Tester:**	JZ
Core Size:	NQ **BH No :** 17-29	**Reviewed by:**	WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	2	2.7	D	22.5	47.0	243.0	9.4	225.8	Schist	Very Strong
2	2	2.8	A	4.7	47.0	66.2	1.2	29.8	Schist	Medium Strong
3	3	4.4	A	4.9	47.0	66.7	1.3	31.2	Schist	Medium Strong
4	3	4.8	D	11.2	47.0	256.0	4.7	112.6	Schist	Very Strong
5										
6										
7					**RUN #2 AVERAGE =**			127.8		Very Strong
8					**RUN #3 AVERAGE =**			71.9		Strong
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	15595	**Date Drilled:**	Aug 18/17
Client:	HATCH	**Date Tested:**	Sep 6/17
Project Name:	Replace 9 Culverts	**Tester:**	JZ
Core Size:	NQ **BH No :** 17-30	**Reviewed by:**	WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	1.3	D	15.3	47.0	164.0	6.4	152.9	Schist	Very Strong
2	2	2.0	D	1.5	47.0	134.0	0.6	15.2	Schist	Weak
3	2	2.3	A	0.4	47.0	54.3	0.1	2.8	Schist	Very Weak
4	4	2.9	A	17.9	47.0	63.5	4.9	117.9	Schist	Very Strong
5	4	3.4	D	17.8	47.0	120.0	7.4	178.1	Schist	Very Strong
6										
7										
8					**RUN#1 AVERAGE =**			152.9		Very Strong
9					**RUN#2 AVERAGE =**			9.0		Weak
10					**RUN#4 AVERAGE =**			148.0		Very Strong
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	15595	**Date Drilled:**	Aug 18-19/17
Client:	HATCH	**Date Tested:**	Sep 8/17
Project Name:	Replace 9 Culverts	**Tester:**	JZ
Core Size:	NQ **BH No :** 17-33	**Reviewed by:**	WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	2.3	D	9.9	47.0	93.3	4.1	98.8	Schist	Strong
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER

Appendix C

Selected Site Photographs

Photo 1: Highway 17 at Dead Horse Creek Culvert looking west (Taken: June 27, 2017)

Photo 2: Highway 17 at Dead Horse Creek Culvert looking east (Taken: June 27, 2017)

Photo 3: Dead Horse Creek Culvert inlet (Taken: August 27, 2017)

Photo 4: Dead Horse Creek Culvert outlet (Taken: August 27, 2017)

Photo 5: Voids beneath east footing near north end (Taken: August 27, 2017)

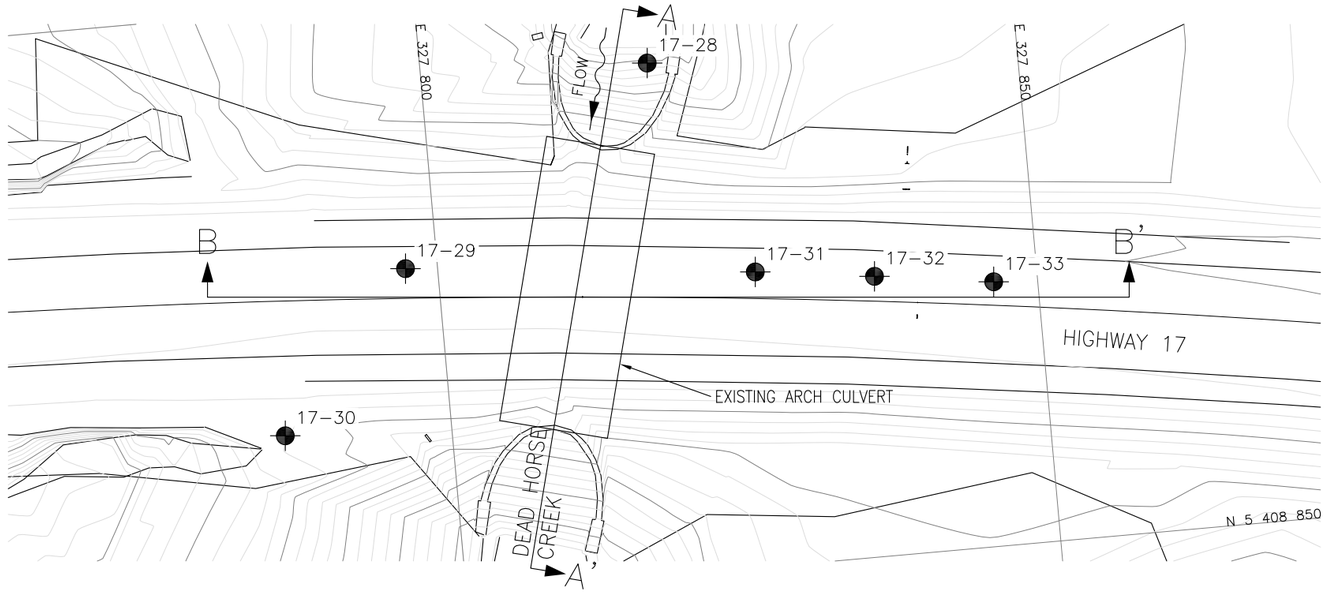
Photo 6: Voids beneath east footing near south end (Taken: August 27, 2017)

THURBER

Appendix D

Borehole Locations and Soil Strata Drawings

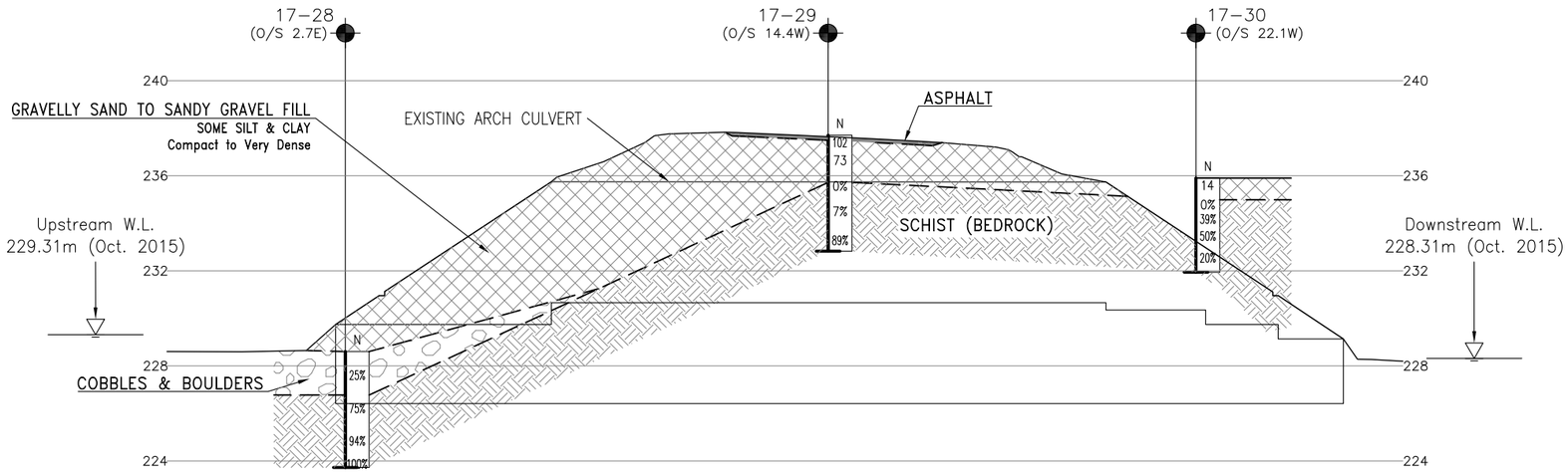
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

10 0 10 20m

SCALE 1:500



SECTION A–A'

5 0 5 10m

SCALE 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Aug 31/18
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C. W. ZANATTA
100215469
Aug 31/18
PROVINCE OF ONTARIO

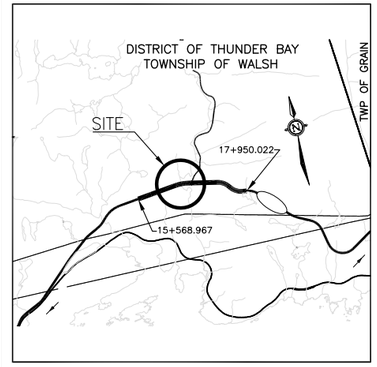
CONT No 6016-E-0012
WP No 6806-14-01

HIGHWAY 17
DEAD HORSE CREEK CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 4

HATCH

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
17-28	228.6	5 408 893.0	327 819.0
17-29	237.7	5 408 877.6	327 797.3
17-30	235.9	5 408 864.5	327 786.0
17-31	237.8	5 408 874.7	327 826.5
17-32	237.8	5 408 873.5	327 836.4
17-33	237.8	5 408 872.1	327 846.3

-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.

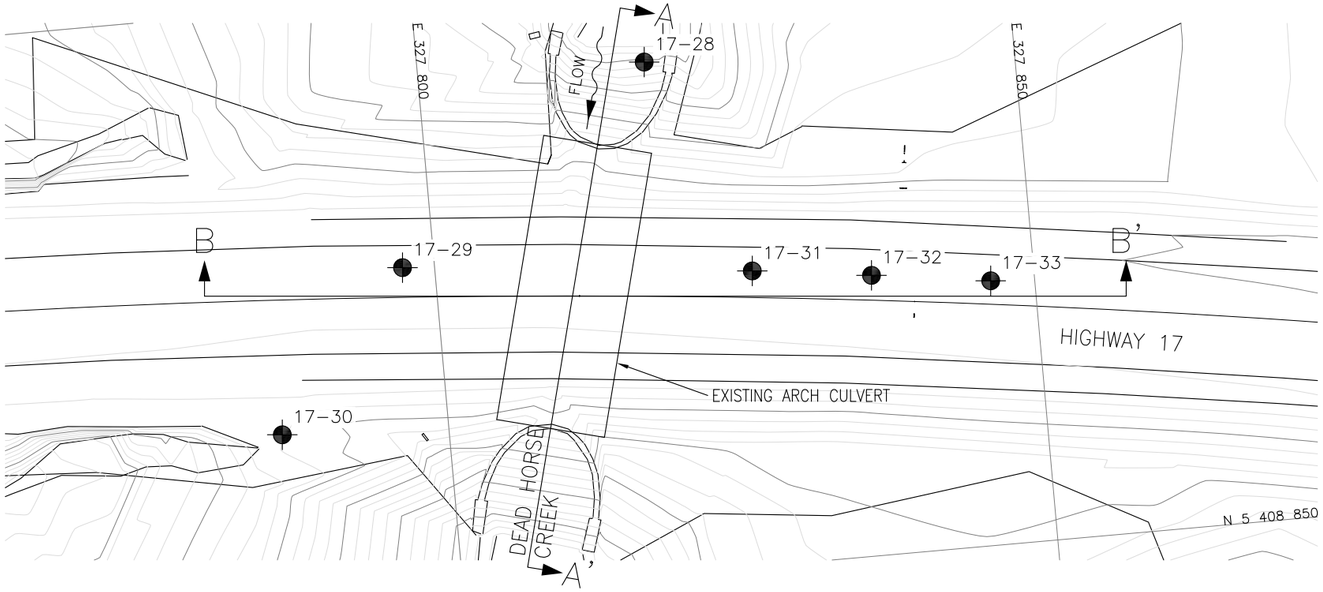
GEOCRES No. 42D-51

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CZ	CHK PKC	CODE	LOAD	DATE AUG 2018
DRAWN	MFA	CHK CZ	SITE 48E-21/C	STRUCT	DWG 2

FILENAME: H:\Drafting\15000\15595\TED-15595-Dh1.dwg
PLOTDATE: 8/31/2018 11:56 AM

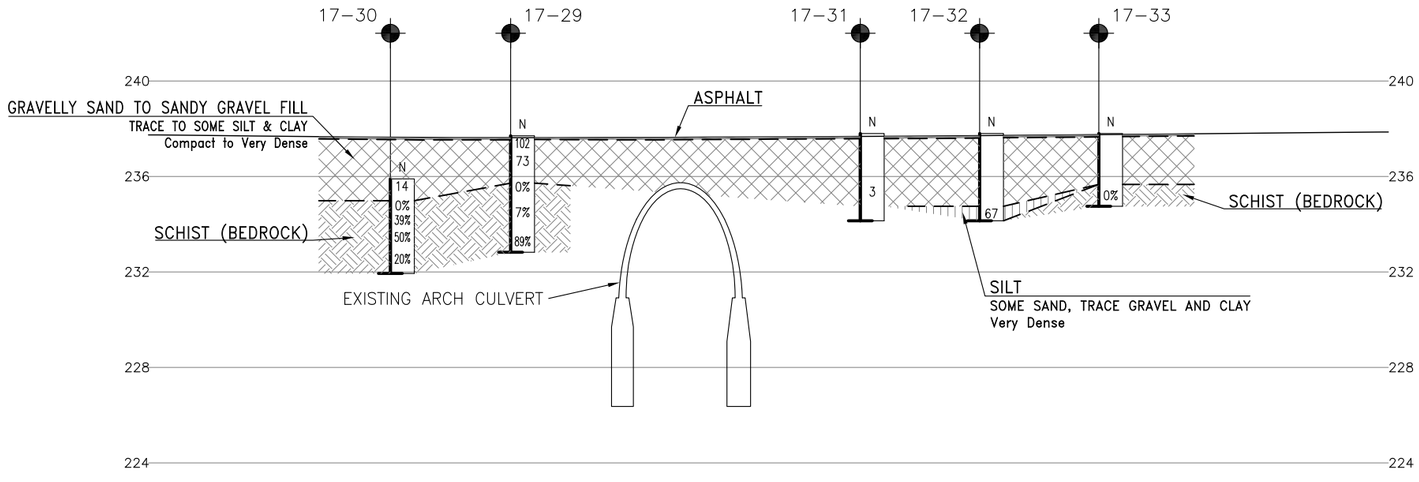
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

10 0 10 20m

SCALE 1:500



PROFILE B–B'

10 0 10 20m H 1:500

5 0 5 10m V 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Aug 31/18
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C. W. ZANATTA
100215469
Aug 31/18
PROVINCE OF ONTARIO

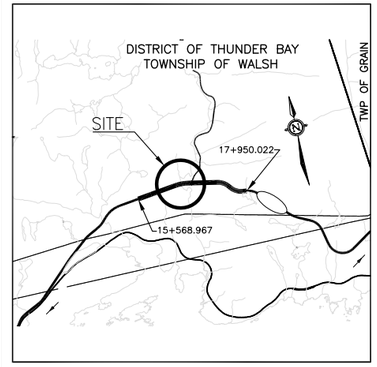
CONT No 6016-E-0012
WP No 6806-14-01

HIGHWAY 17
DEAD HORSE CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 5

HATCH

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
17-28	228.6	5 408 893.0	327 819.0
17-29	237.7	5 408 877.6	327 797.3
17-30	235.9	5 408 864.5	327 786.0
17-31	237.8	5 408 874.7	327 826.5
17-32	237.8	5 408 873.5	327 836.4
17-33	237.8	5 408 872.1	327 846.3

-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. 42D-51

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CZ	CHK	PKC	CODE	LOAD	DATE	AUG 2018
DRAWN	MFA	CHK	CZ	SITE 48E-21/C	STRUCT	DWG	3

FILENAME: H:\Drafting\15000\15595\TED-15595-Dh1.dwg
PLOTDATE: 8/31/2018 11:59 AM