



THURBER ENGINEERING LTD.



**PRELIMINARY
FOUNDATION INVESTIGATION REPORT
BADESDAWA RIVER BRIDGE REPLACEMENT
NORT ROAD (FORMELY HIGHWAY 808),
DISTRICT OF KENORA, ONTARIO
G.W.P 6623-17-00, SITE NO. 41S-102**

GEOCRES No.: 52P-4

Report

to

Hatch

Date: May 3, 2017
File: 15697

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GEOGRES No.: 52P-4

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation conducted at the site of the existing bridge carrying Nort Road over Badesdawa River, also known as Mud River, in the Unsurveyed Territory, District of Kenora, Ontario.

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 was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Hatch, under the Ministry of Transportation Ontario (MTO) Agreement Number 6018-E-0018-010.

2. SITE DESCRIPTION

The existing bridge is located on Nort Road (formerly Highway 808), approximately 54.7 km north of Pickle Lake Road, in the Unsurveyed Territory, District of Kenora. At the structure site, Nort Road is a gravel surface road running generally in the southwest-northeast direction.

The existing bridge is a 33.8 m in length and 6 m in width single span, single lane steel Bailey bridge. The superstructure is supported by timber crib /gabion abutments. Badesdawa River flows from southeast to northwest at the bridge location and joins Otokwin River some distance northwest of the bridge. In the vicinity of the existing bridge, the river banks are between 4 m and 5 m in height. The land on both sides of the river is densely vegetated with trees, shrubs and grass.

In the river channel, five rows of timber piles (bents) cut-off above the river water level indicate presence of an old bridge that existed on the same alignment. Erosion of the river banks, including oversteepening of the front slopes at the abutments was evident. Loss of ground with part of timber cribs exposed was observed.

Based on published geological information, the site is located in the Beren River Subprovince of the Superior Province. The general area of the project is covered by glaciolacustrine and glaciomarine deep water deposits of silts and clays. The silts and clays are underlain by the Neo- to Mesozoic massive to foliated granodiorite and granite bedrock.

3. INVESTIGATION PROCEDURES

The field investigation program for this project was carried out between October 18 and 20, 2016. The program consisted of drilling and sampling two (2) boreholes numbered 16-01 and 16-02, which were drilled at the east and west abutments to depths of 19.2 m and 19.5 m, respectively. The approximate locations of all completed boreholes are shown on the attached Borehole Locations and Soil Strata Drawing enclosed in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling operations. The ground surface elevations for the boreholes were derived from the Survey Plan B-514893-Nort-2, dated November 2016, provided to Thurber by Hatch.

Track-mounted CME 750 drill rig was used to drill the boreholes. The boreholes were advanced using hollow stem augers and NW casing. An NQ core barrel was used to obtain 3 m of rock core in each borehole. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures, as per ASTM D-1586-99.

The drilling and sampling operations were supervised on a full time basis by members 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.

Groundwater conditions in the open boreholes were observed throughout the drilling operations and in open boreholes after completion of drilling. The groundwater level observations may not be representative of the site conditions, as water was used during bedrock coring operations. The boreholes were backfilled in general accordance with MOE Regulation 903 (amended by Ontario Reg. 372). Completion details of the boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole Number	Borehole Depth/ Base Elev. (m)	Completion Details
East Abutment	16-01	19.2 / 314.9	Bentonite holeplug to surface.
West Abutment	16-02	19.5 / 315.0	Bentonite holeplug to surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and hydrometer). All laboratory tests were carried out to MTO and / or ASTM Standards, as appropriate. The results of the geotechnical laboratory program are summarized on the Record of Borehole sheets included in Appendix A and on figures presented in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the below ground position of the steel structure, a sample of the native silty clay and a sample of surface water from the river upstream of the bridge, were collected. The samples were submitted to SGS Laboratories in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate. The results of the analytical testing are summarized in Section 6 below and the Certificates of the Analysis are enclosed in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. The factual data presented on the Record of Borehole sheets takes precedence over this general description and should be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In summary, the embankment fill at this site overlies a layer of silty clay, which in turn is underlain by a cohesionless deposit grading with depth from sand to sand and silt. The overburden at this site is underlain by a granite bedrock at a depth of 16.2 to 16.5 m (Elev. 318.0).

Water level in Badesdawa River was indicated on the Survey Plan drawing at Elev. 330.73 in September 2016.

5.1 Embankment Fill

Embankment fill material consisting of brown sand and gravel with trace to some silt was encountered extending from ground surface in both boreholes. The fill thickness was 0.8 m and 2.2 m in Borehole 16-01 and 16-02 with the underside of the fill between Elev. 333.4 and Elev. 332.3, respectively.

SPT 'N' values obtained within the fill in Borehole 16-01 was 37 blows per 0.3 m of penetration, indicating a dense relative density and, the values ranged from 5 to 7 blows per 0.3 m of penetration in Borehole 16-02, indicating a loose relative density. Moisture contents between 3% and 8% were measured in the fill. Field vane shear tests measured undrained shear strength ranging from 45 kPa to 58 kPa. Vane tests measured that the sensitivity of the silty clay ranged from 1.4 to 2.4 indicating that the silty clay has low sensitivity.

The results of grain size distribution analysis carried out on a fill sample are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 in Appendix B. The results of the grain size distribution analysis are summarized below:

Soil Particle	Percentage (%)
Gravel	46
Sand	43
Silt & Clay	11

5.2 Silty Clay

A deposit of brown to grey silty clay was encountered below the fill in both boreholes. The silty clay contained trace to some sand, trace gravel and occasional silt seams. The deposit was 4.8 m and 6.5 m thick and extended to depths of 5.6 m (Elev. 328.5) in Borehole 16-01 and 8.7 m (Elev. 325.8) in Borehole 18-02.

SPT 'N' values obtained within the silty clay ranged from 2 to 11 blows per 0.3 m of penetration, indicating a soft to stiff consistency, however, the SPT 'N' values typically ranged from 4 to 7 blows per 0.3 m of penetration, indicating a firm consistency. Field vane shear tests measured undrained shear strength ranging from 45 kPa to 58 kPa, indicating a firm to stiff consistency. Vane tests measured that the sensitivity of the silty clay ranged from 1.4 to 2.4 indicating that the silty clay has low sensitivity.

The results of grain distributions analyses carried out on representative samples of the deposit are presented on the Record of Borehole sheets in Appendix A and on Figure B2 in Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 18
Silt	65 to 77
Clay	17 to 33

Moisture contents between 12% and 50% were measured in the silty clay.

5.3 Sand

Underlying the silty clay is a layer of sand with trace silt and trace gravel. Traces of organic matter, namely fragments of decayed wood, were noted in the upper 0.5 m zone of sand in Borehole 16-01. The sand layer varied in thickness from 6.3 m in Borehole 16-01 to 1.5 m in Borehole 16-02. The underside of the sand was encountered between depths of 11.9 m (Elev. 322.2) and 10.2 m (Elev.324.3) in Boreholes 16-01 and 16-02, respectively.

SPT N-values measured in the sand typically ranged from 7 to 24 blows per 0.3 m penetration, indicating a loose compact relative density. The sand was very loose with a SPT N-value of 3 in the upper zone of Borehole 16-01, immediately beneath the silty clay. The results of grain size analysis conducted on a sample of the sand are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figures B3 of Appendix B. The results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	1
Sand	96
Silt and Clay	3

The measured water contents of sand samples ranged from 12% to 17%.

5.4 Sand and Silt

Underlying the sand was a layer of sand and silt with trace clay and trace gravel. The layer was 4.3 m and 6.3 m in thickness with the underside at depths of 16.2 m and 16.5 m, both at Elev.318.0.

SPT 'N' values obtained in the sand and silt ranged from 11 to 24 blows per 0.3 m penetration, indicating a compact relative density.

Samples of the sand and silt were subjected to the grain size distribution testing; the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figure B4 of Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	46 to 63
Silt	35 to 50
Clay	2 to 4

Measured moisture contents ranged from 11% to 18%.

5.5 Bedrock

Granite bedrock was encountered below the sand and silt in both boreholes and proved by coring. Depths and elevations to the top of bedrock at the borehole locations are summarized in Table below. The top of bedrock may vary across the site and between and beyond the borehole locations.

Table 5.1 – Depths and Elevations of Top of Bedrock

Foundation Element	Borehole	Top of Bedrock	
		Depth (m)	Elevation (m)
East Abutment	16-01	16.2	318.0
West Abutment	16-02	16.5	318.0

The bedrock was described as slightly weathered to fresh, grey and strong.

Total Core Recovery (TCR) in the bedrock ranged from 96% to 100%. The RQD values ranged from 70% to 98%, which indicated a fair to excellent rock quality.

The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core run, varied from 0 to 4. A 300 mm clay seam was noted at 16.8 m depth (Elev. 317.7) in Borehole 16-02.

5.6 Groundwater Conditions

Where possible, water levels were monitored in the open boreholes during drilling operations. Water was introduced into boreholes during bedrock coring, and therefore water levels recorded

upon completion of drilling may not reflect natural groundwater levels. The water levels observed upon completion of drilling are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16-01	October 20, 2016	Dry	-	Open Borehole
16-02	October 19, 2016	3.7	330.8	Open Borehole upon completion of drilling

The recorded levels are very short-term readings and seasonal fluctuations of the groundwater and river level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The Survey Plan provided by Hatch indicated water level in Badesdawa River at Elev. 330.73 in September 2016.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty clay and a sample of surface water from Badesdawa River were submitted to SGS Canada for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are summarized in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			BH 16-01, SS4 (7.5'-9.5')	Badesdawa River Water
pH	-	-	6.68 – 7.49	7.89
Redox Potential	mV	mV	91	235
Sulphide	%	mg/L	< 0.02	0.006
Chloride	µg/g	mg/L	2.5	0.30
Sulphate	µg/g	mg/L	11	0.37
Electrical Conductivity	µS/cm	µS/cm	32	91
Resistivity	Ohms.cm	Ohms.cm	31000	11000

7. MISCELLANEOUS

Borehole locations were established in the field by Thurber Engineering Ltd. The northing and easting coordinates and ground surface elevations were obtained from measurements taken in the field relative to the Survey Plans provided by Hatch.

Thurber obtained subsurface utility clearances prior to drilling. RPM Drilling Inc. of Thunder Bay, 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. Troy MacKinnon of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. 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 were carried out by Ms. Anna Piascik, P.Eng. and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Mark Farrant, P.Eng.
Geotechnical Engineer



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



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
 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.

EXPLANATION OF ROCK LOGGING TERMS


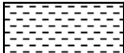



ROCK WEATHERING CLASSIFICATION

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.

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	Approximate Uniaxial Compressive Strength (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

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 % 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.

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			

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

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RECORD OF BOREHOLE No 16-01

2 OF 3

METRIC

GWP# 6623-17-00 LOCATION Badesdawa River Bridge Replacement N 5 738 870.1 E 331 412.5 ORIGINATED BY TM
 HWY Nort Road (formerly Hwy 808) BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AM
 DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY AMP

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					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
								WATER CONTENT (%)					
	Continued From Previous Page						20 40 60 80 100		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
									W P	W	W L		
322.2	SAND and SILT , trace clay Compact Grey Moist		10	SS	7								
11.9			11	SS	11								
			12	SS	14								
			13	SS	14								
318.0	GRANITE , slightly weathered to fresh, strong, grey (BEDROCK)		1	RUN									
16.2													
			2	RUN									
314.9													
19.2	END OF BOREHOLE AT 19.2m. NO FREE STANDING WATER IN BOREHOLE. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO												

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S MTO-15697.GPJ 2015TEMPLATE(MTO).GDT 4/26/17

METRIC

ELEV DEPTH	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
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100			
	Continued From Previous Page										

[illegible]

RECORD OF BOREHOLE No 16-02

1 OF 3

METRIC

GWP# 6623-17-00 LOCATION Badesdawa River Bridge Replacement N 5 738 844.6 E 331 371.6 ORIGINATED BY TM
 HWY Nort Road (formerly Hwy 808) BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AM
 DATUM Geodetic DATE 2016.10.18 - 2016.10.19 CHECKED BY AMP

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					
334.5	GROUND SURFACE												
0.0	SAND and GRAVEL , trace silt Loose Brown Moist (FILL)		1	SS	7		334						No recovery
			2	SS	7		333						
			3	SS	5								
332.3													0 18 65 17
2.2	Silty CLAY , trace to some sand, trace gravel Firm to Stiff Brown Moist		4	SS	7		332						
			5	SS	5		331						
													0 0 67 33
			6	SS	6		330						
							329						
													0 0 67 33
			7	SS	6		328						
							327						
			8	SS	11								0 0 67 33
							326						
							325						
325.8													0 0 67 33
8.7	SAND , trace silt, trace gravel Compact Brown Moist		9	SS	24								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-02

2 OF 3

METRIC

GWP# 6623-17-00 LOCATION Badesdawa River Bridge Replacement N 5 738 844.6 E 331 371.6 ORIGINATED BY TM
 HWY Nort Road (formerly Hwy 808) BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AM
 DATUM Geodetic DATE 2016.10.18 - 2016.10.19 CHECKED BY AMP

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 (%)			
								20 40 60 80 100						20 40 60			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L			
Continued From Previous Page																	
324.3																	
10.2	SAND and SILT , trace clay, trace gravel Compact Grey Moist																
			10	SS	24												
			11	SS	14												
			12	SS	14												
										</							

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S MTO-15697.GPJ 2015TEMPLATE(MTO).GDT 4/26/17

RECORD OF BOREHOLE No 16-02

3 OF 3

METRIC

GWP# 6623-17-00 LOCATION Badesdawa River Bridge Replacement N 5 738 844.6 E 331 371.6 ORIGINATED BY TM
 HWY Nort Road (formerly Hwy 808) BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AM
 DATUM Geodetic DATE 2016.10.18 - 2016.10.19 CHECKED BY AMP

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	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page													
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.													

ONTMT4S MTO-15697.GPJ 2015TEMPLATE(MTO).GDT 4/26/17



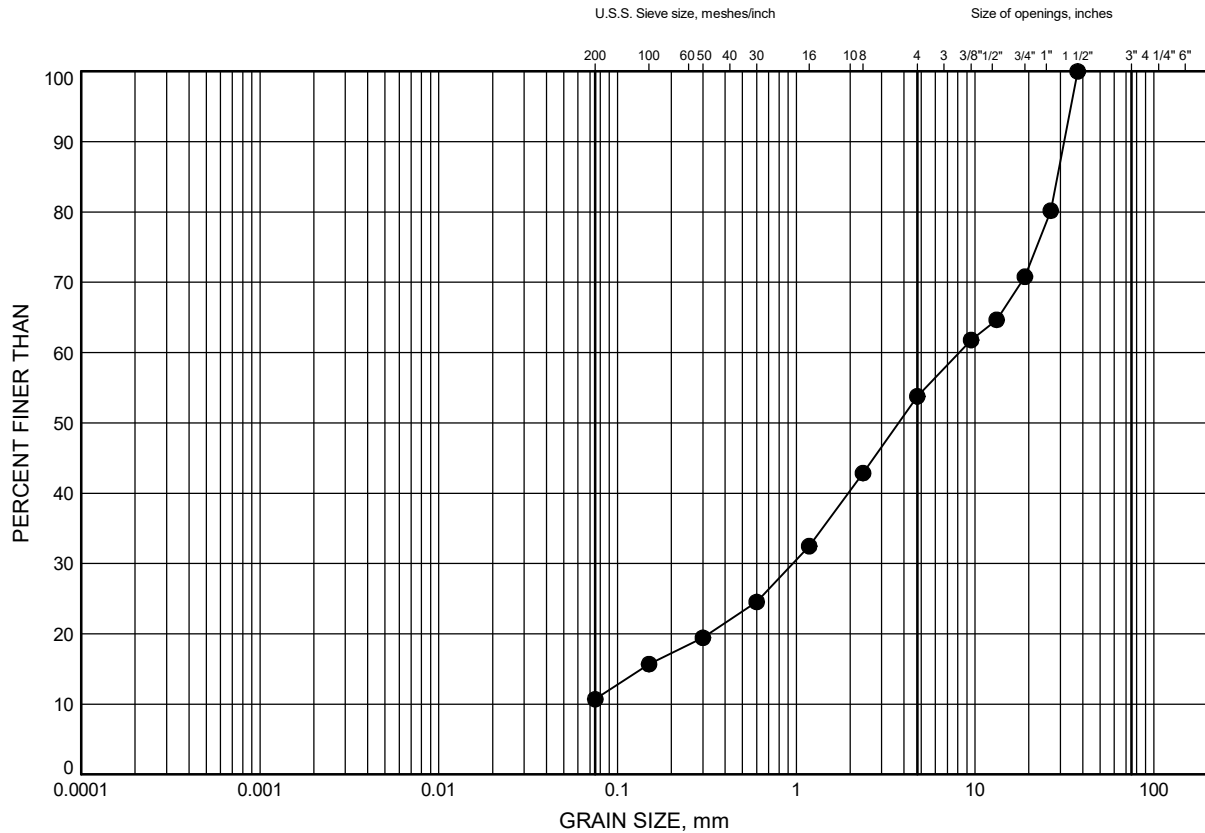
Appendix B

Geotechnical and Analytical Laboratory Test Results

Badesdawa River Bridge Replacement GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND and GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	0.30	333.83

Date April 2017
GWP# 6623-17-00

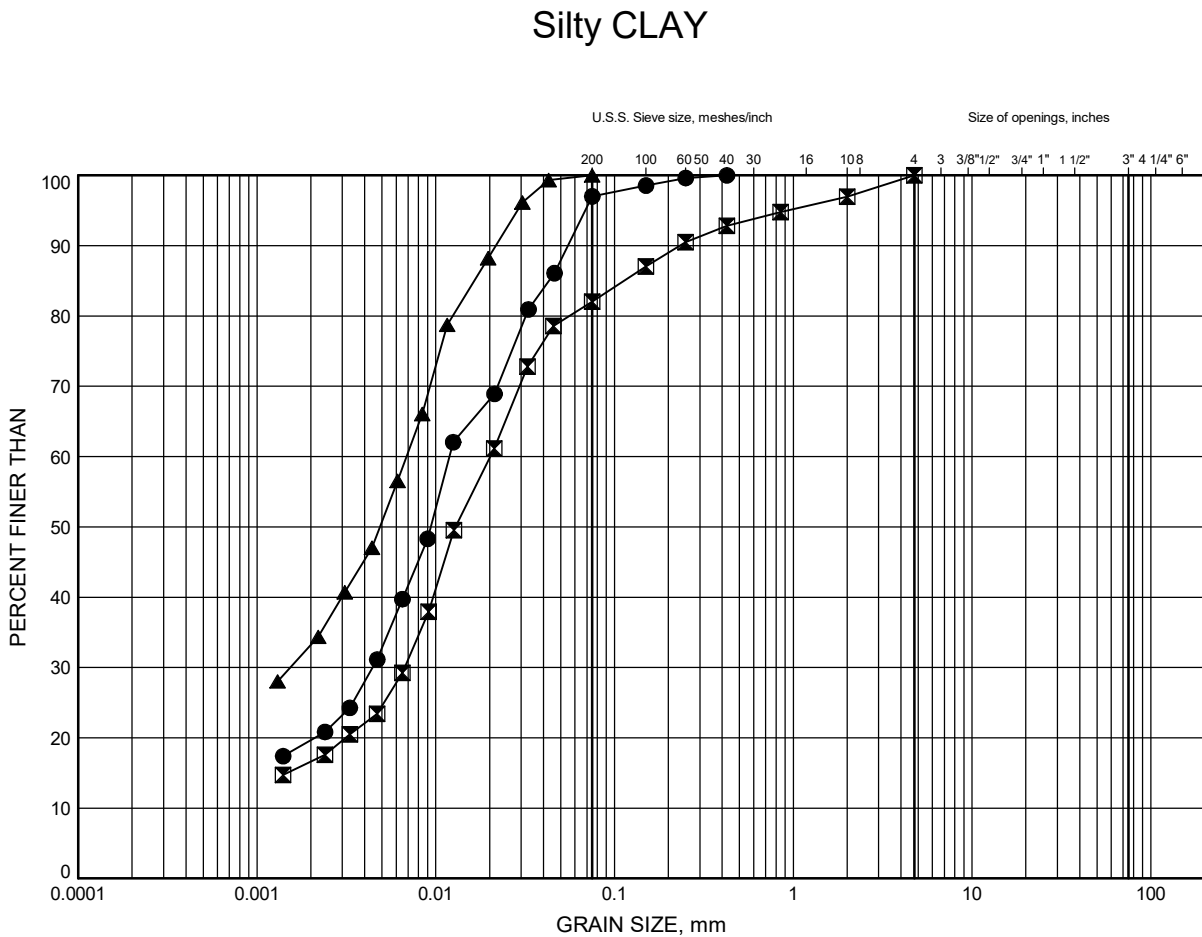


Prep'd MFA
Chkd. KS

Badesdawa River Bridge Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	2.59	331.54
⊠	16-02	2.59	331.90
▲	16-02	6.40	328.09

Date April 2017
GWP# 6623-17-00

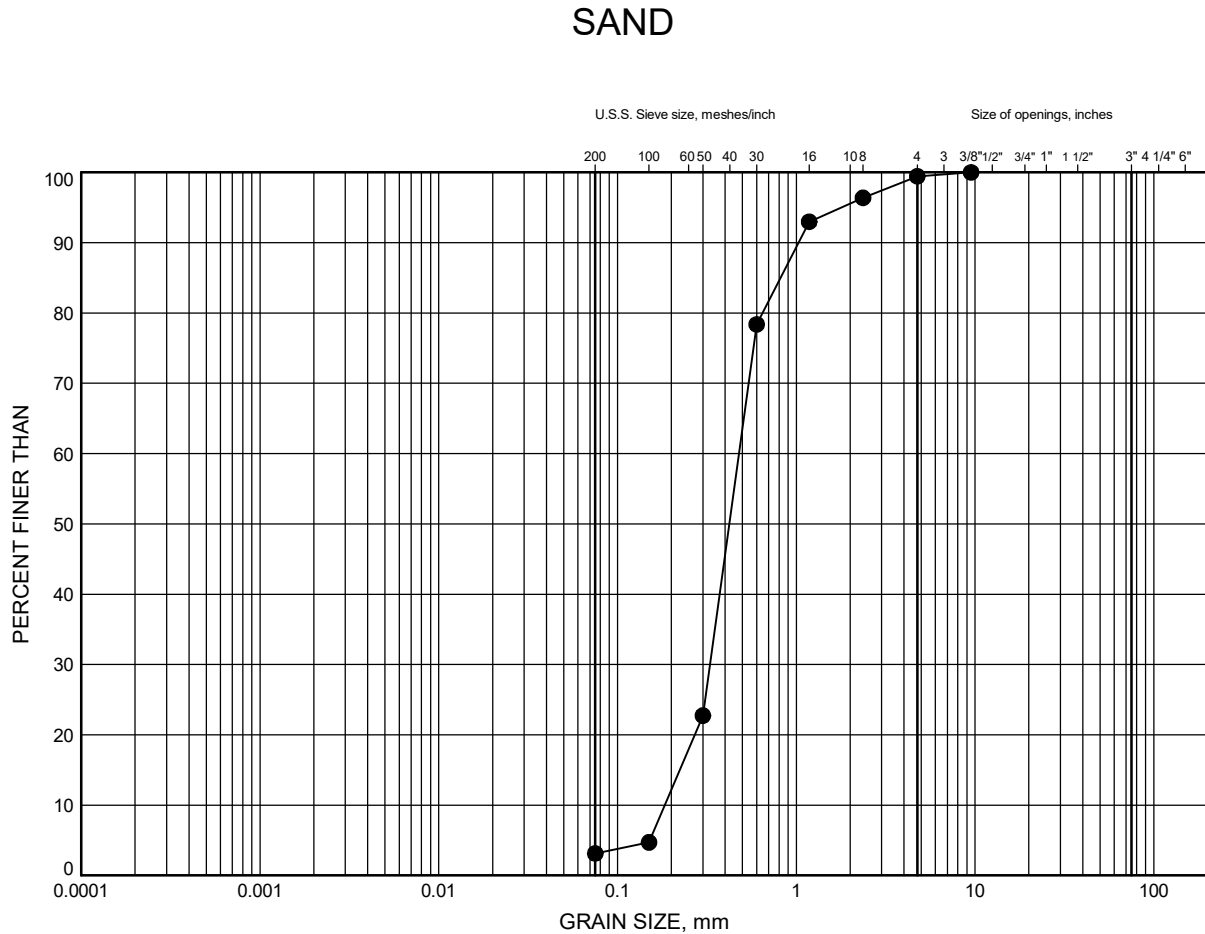


Prep'd MFA
Chkd. KS

Badesdawa River Bridge Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	7.92	326.21

Date April 2017
GWP# 6623-17-00



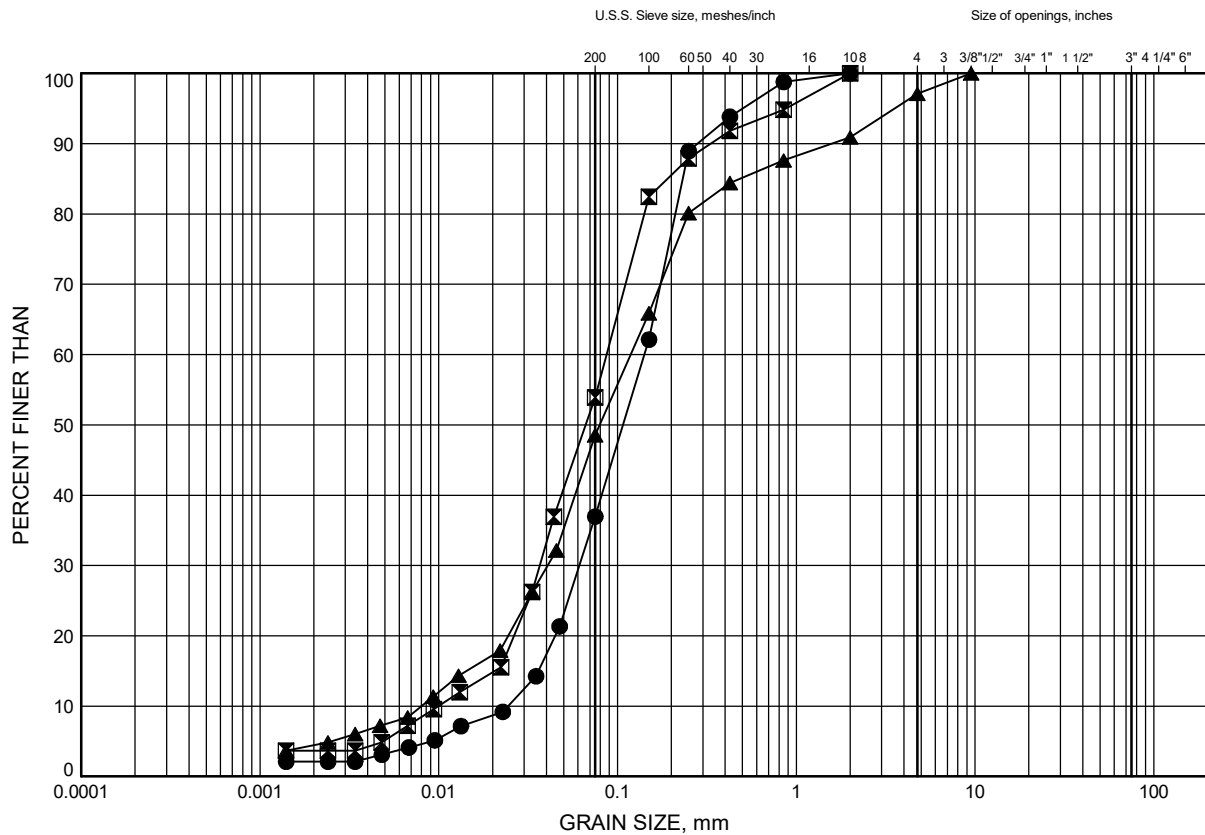
Prep'd MFA
Chkd. KS

Badesdawa River Bridge Replacement

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND and SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	12.50	321.64
⊠	16-02	10.97	323.51
▲	16-02	14.02	320.47

Date April 2017
GWP# 6623-17-00



Prep'd MFA
Chkd. KS

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697**12-April-2017****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 08 November 2016
LR Report: CA14154-NOV16
Reference: 15697 Mark Farrant

Copy: #1

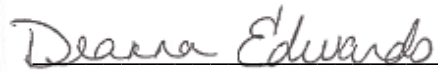
CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: BH 16-01, SS4, 7'6"-9'-6"
Sample Date & Time					07-Nov-16
Corrosivity Index [none]	14-Nov-16	15:51	14-Nov-16	15:51	3.5
pH [no unit]	09-Nov-16	07:57	09-Nov-16	14:38	6.68
Soil Redox Potential [mV]	09-Nov-16	17:17	10-Nov-16	11:05	91
Sulphide [%]	14-Nov-16	14:06	14-Nov-16	15:47	< 0.02
% Moisture (wet wt) [%]	09-Nov-16	12:51	10-Nov-16	15:59	25.0
pH [no unit]	10-Nov-16	09:02	11-Nov-16	11:51	7.49
Chloride [µg/g]	11-Nov-16	20:14	14-Nov-16	08:21	2.5
Sulphate [µg/g]	11-Nov-16	20:14	14-Nov-16	08:21	11
Conductivity [uS/cm]	10-Nov-16	09:02	11-Nov-16	11:51	32
Resistivity (calculated) [Ohms.cm]	14-Nov-16	15:49	14-Nov-16	15:49	31000

Temperature of Samples upon receipt 15 degrees C
No cooling agent present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.


Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

**SGS Canada Inc.**

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Lakefield - Ontario - K0L 2H0

Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697**LR Report :** CA14154-NOV16

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1915-07A
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013	
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500



SGS Canada Inc.

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Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697

LR Report : CA14154-NOV16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0187-NOV16												
Chloride	0.4	µg/g	<0.4		2	20	100	80	120	103	75	125
Sulphate	0.4	µg/g	<0.4		0	20	99	80	120	95	75	125
Carbon/Sulphur - QCBatchID: ECS0018-NOV16												
Sulphide	0.02	%	<0.02		NV	20	119	80	120			
Conductivity - QCBatchID: EWL0172-NOV16												
Conductivity	2	uS/cm	< 2		ND	10	99	90	110	NA		
pH - QCBatchID: ARD0035-NOV16												
pH	0.05	no unit			0	20	100	80	120			

**SGS Canada Inc.**

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Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697

12-April-2017

Thurber Engineering Ltd.

Attn : Mark Farrant

103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 228
Fax:

Date Rec. : 27 October 2016
LR Report: CA15613-OCT16
Reference: Project: 15697 Mark Farrant


Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Mud River Bridge
Sample Date & Time						20-Oct-16 08:20
Temperature Upon Receipt [°C]	---	---	--	--	---	20.0
pH [no unit]	28-Oct-16	07:54	31-Oct-16	08:53	0.05	7.89
Conductivity [µS/cm]	28-Oct-16	07:54	31-Oct-16	08:53	2	91
Resistivity (calculated) [Ohms.cm]	02-Nov-16	16:22	02-Nov-16	16:23	---	11000
Redox Potential [mV]	27-Oct-16	16:41	28-Oct-16	09:22	---	235
Chloride [mg/L]	01-Nov-16	01:42	02-Nov-16	11:15	0.04	0.30
Sulphate [mg/L]	01-Nov-16	01:42	02-Nov-16	11:15	0.04	0.37
Sulphide [mg/L]	28-Oct-16	15:13	28-Oct-16	16:45	0.006	0.006
Corrosivity Index [none]	02-Nov-16	16:25	02-Nov-16	16:25		2

Temperature of Sample upon receipt 20 degrees C
Cooling agent present
Custody Seal not Present


Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - K0L 2H0
Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697**LR Report :** CA15613-OCT16

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500



SGS Canada Inc.

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Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

Project : 15697

LR Report : CA15613-OCT16

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
					RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0011-NOV16												
Chloride	0.04	mg/L	<0.04		1	20	104	80	120	107	75	125
Sulphate	0.04	mg/L	<0.04		3	20	99	80	120	95	75	125
Conductivity - QCBatchID: EWL0454-OCT16												
Conductivity	2	µS/cm	2		0	10	98	90	110	NA		
pH - QCBatchID: EWL0454-OCT16												
pH	0.05	no unit	NA		1		100			NA		
Redox Potential - QCBatchID: EWL0448-OCT16												
Redox Potential	no	mV	NA		5	20	101	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0251-OCT16												
Sulphide	0.006	mg/L	<0.006		ND	20	94	80	120	90	75	125



Photograph B1 – Rock core sample from Borehole 16-01



Photograph B2 – Rock core sample from Borehole 16-02



Appendix C

Selected Site Photographs



Photograph 1 – Badesdawa River Bridge; Looking Southwest



Photograph 2 – Badesdawa River Bridge; Looking Northeast

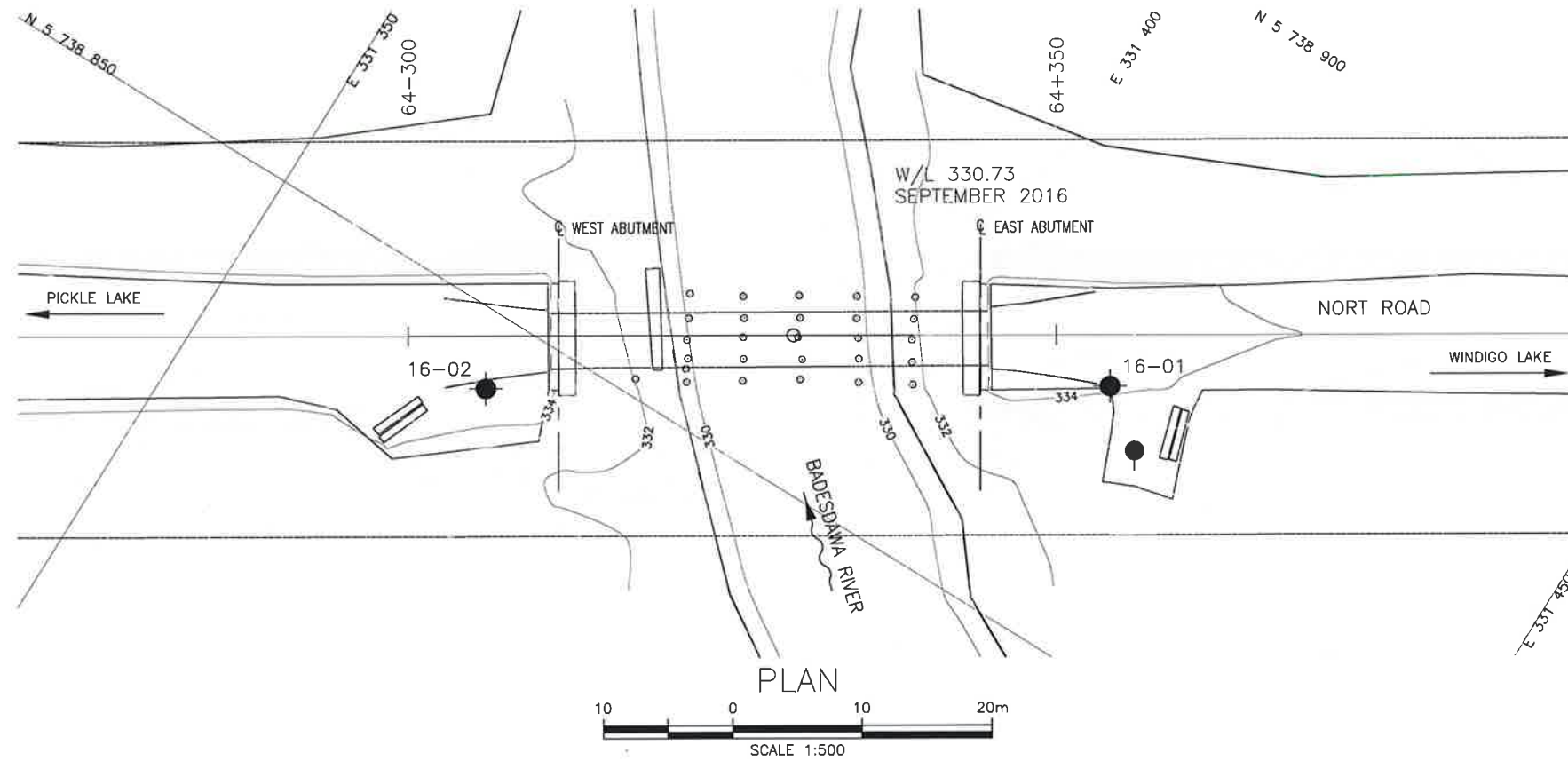


Photograph 3 – Badesdawa River Bridge; Looking East



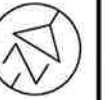
Appendix D

Borehole Locations and Soil Strata Drawing



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

CONT No
GWP No 6623-17-00



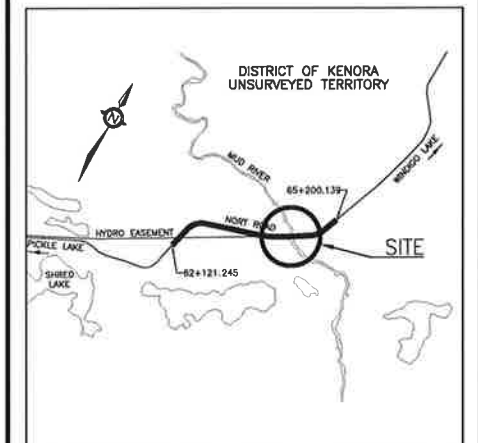
NORT ROAD
BADESDAWA RIVER
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET |

HATCH








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

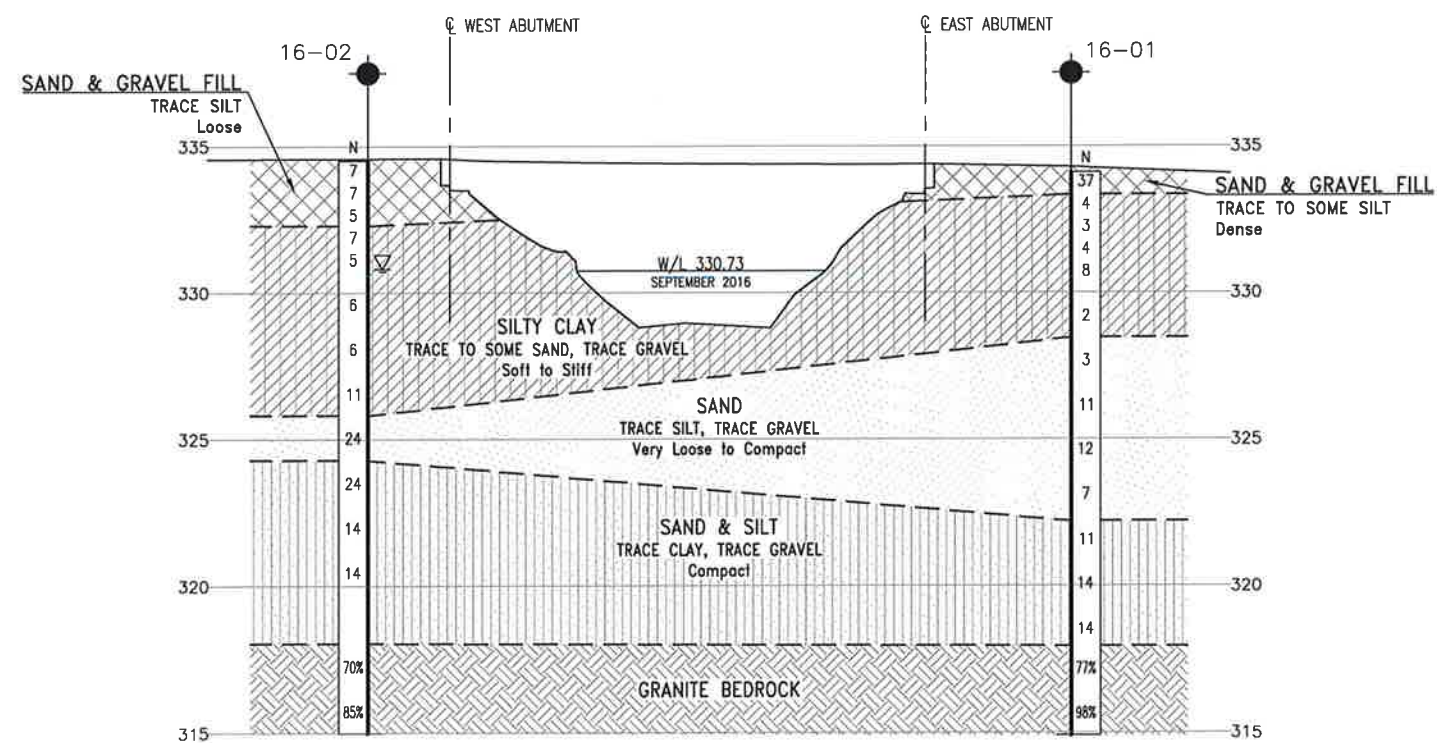
- | | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation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

NO	ELEVATION	NORTHING	EASTING
16-01	334.1	5 738 870.1	331 412.5
16-02	334.5	5 738 844.6	331 371.6

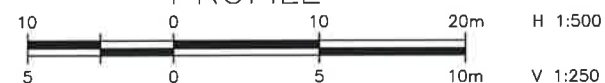
-NOTES-

- 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.
- 3) MTM Zone 15 coordinate system used to obtain Borehole Northings and Eastings.

GEOCRES No. 52P-4



PROFILE



REVISIONS								
	DATE	BY						
	DESIGN	AMP	CHK	PKC	CODE	LOAD	DATE	MAY 2017
	DRAWN	MFA	CHK	AMP	SITE 41S-102	ISTRUCT	DWG	1