

**FOUNDATION INVESTIGATION REPORT
ELBOW CREEK BRIDGE REPLACEMENT
HIGHWAY 599
KENORA DISTRICT, ONTARIO**

G.W.P. 6109-10-00, SITE NO. 41S-76

Geocres Number: 52G-11

Report to:

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Bridge Final FIDR.docx

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Elbow Creek Bridge along Highway 599, in the 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 and cross-sections, 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 WSP Canada Inc., under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0012.

2 SITE DESCRIPTION

The existing Elbow Creek Bridge is located on Highway 599 approximately 70 km north (by road) from the intersection of Highways 17 and 599 at Ignace, approximately 120 km east of Dryden and 160 km west of Lake Nipigon.

Elbow Creek flows from the east to the west, connecting Sturgeon Lake to Elva Lake. The creek channel is approximately 7 m wide and 1 m deep at the site. The surrounding lands are undeveloped and heavily wooded. The banks of the creek and the base of the existing highway embankment are lined with numerous cobbles and boulders.

Photographs in Appendix C show the general nature of the site and the existing bridge.

The site lies within the physiographic region known as the Wabigoon Subprovince of the Superior Province of the Canadian Shield. The site is underlain by glacial deposits of sand, gravelly sand and gravel, or a thin layer of drift overlying Neo to Mesoarchean mafic to intermediate meta-volcanic rocks.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out in two phases, between August 23 and September 9, 2011 and between May 5 and June 2, 2014. The field testing consisted of drilling and sampling ten boreholes, identified as Boreholes ECB-01 to ECB-06 and ECB-09 to ECB-12, and excavating one test pit, identified as Test Pit ECB-07. The second phase of the investigation was conducted in order to collect additional subsurface information to support various configurations for the replacement bridge structure. The approximate locations of the boreholes and test pit are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Boreholes ECB-01 to ECB-04 and ECB-09 to ECB-12 were drilled near the proposed abutments and were terminated at depths of 6.1 m to 15.0 m, including coring 2.9 to 3.3 m into bedrock. Test Pit ECB-07 was excavated near the west end of the proposed south abutment and was terminated at a depth of 1.1 m upon bedrock. Boreholes ECB-05 and ECB-06 were drilled to depths of 11.3 m and 4.6 m at the north and south approaches, respectively. A proposed Borehole ECB-08 at the west end of the north abutment was not drilled due to access constraints.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by WSP Canada Inc.

Truck and track-mounted CME 75 drill rigs were used to advance the boreholes using a combination of hollow stem augers, NW casing/wash boring techniques, and NQ coring. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A Caterpillar 420 backhoe was used to excavate the test pit.

NQ coring techniques were used to recover 2.9 to 3.3 m long core samples from the bedrock in Boreholes ECB-01 to ECB-04 and ECB-09 to ECB-12. All rock cores were logged and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined.

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 transporting to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Groundwater conditions observed after completion of drilling were not representative of site conditions as water was used during wash boring and coring operations. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after drilling. The piezometers were subsequently

decommissioned and the boreholes without piezometers were backfilled in general accordance with MOE Regulation 903. Completion details of the piezometers and boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Boreholes	Piezometer Tip Depth/ Elevation (m)	Completion Details
North Approach	ECB-05	None installed	Borehole backfilled with holeplug from 11.3 m to 2.1 m, sand and gravel to 1.0 m, concrete to 0.1 m then asphalt to surface.
North Abutment	ECB-01	15.0/ 393.6	Sand from 15.0 m to 12.9 m, holeplug from 12.9 m to 3.0 m, sand and gravel from 3.0 m to 0.15 m then asphalt to surface.
	ECB-04	None installed	Borehole backfilled with holeplug from 14.6 m to 0.30 m, concrete to 0.10 m then asphalt to surface.
	ECB-10	None installed	Borehole backfilled with holeplug to 0.1 m, then asphalt to surface.
	EBC-12	None installed	Borehole backfilled with holeplug and cuttings from 12.7 m to surface.
South Abutment	ECB-02	None installed	Borehole backfilled with holeplug from 5.8 m to 0.9 m, sand and gravel to 0.10 m then asphalt to surface.
	ECB-03	7.1/ 401.4	Sand from 7.1 m to 4.9 m, holeplug to 4.9 m to 0.15 m then asphalt to surface.
	ECB-07	None installed	Test pit backfilled to surface.
	ECB-09	None installed	Borehole backfilled with holeplug to 0.1 m, then asphalt to surface.
	ECB-11	None installed	Borehole backfilled with holeplug and cuttings from 7.4 m to surface.
South Approach	ECB-06	None installed	Borehole backfilled with holeplug from 4.6 m to 1.0 m, sand and gravel to 0.1 m then asphalt to surface.

4 LABORATORY TESTING

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

Bedrock core samples were subjected to geotechnical logging. Point load tests were carried out on selected samples of intact rock in the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The average UCS values of the intact rock assessed from the point load test data are reported on the borehole logs in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole and Test Pit 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. However, the factual data presented in the Record of Borehole and Test Pit sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole and test pit locations.

The soil stratigraphy below the existing highway embankment typically comprises a native cohesionless deposit ranging from gravelly sand to silty sand over metamorphic bedrock. Both the embankment fill and native soils contain cobbles and boulders. More detailed descriptions of the individual strata are presented below.

5.1 Asphalt

Asphalt was encountered in all the boreholes drilled from the existing Highway 599 roadway. The asphalt was between 150 and 250 mm thick.

5.2 Topsoil

A topsoil layer ranging from 50 to 225 mm thick was encountered at the ground surface in Boreholes ECB-11 and ECB-12 and in Test Pit ECB-07.

5.3 Sand and Gravel Fill

The existing highway embankment fill beneath the asphalt typically comprised a brown gravelly sand to sand and gravel fill with trace to some silt and cobbles and boulders. The embankment fill has a total thickness of 2.7 to 3.8 m in boreholes advanced from the top of embankment, with a lower boundary at depths of 3.0 to 4.0 m (Elev. 405.6 to 404.5).

SPT ‘N’ values recorded in the fill ranged from 5 to 84 blows per 0.3 m penetration and typically from 11 to 49, indicating a compact to dense relative density. SPT ‘N’ values of 50 blows for

0.05 to 0.125 m of penetration were recorded in Boreholes ECB-09 and ECB-10, indicating the presence of cobbles and boulders. Coring was required to penetrate the cobbles and boulders within the lower portion of the fill in Boreholes ECB-01 to ECB-05. Measured moisture contents of the fill ranged from 4% to 17%.

The results of grain size analysis tests 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 B1 of Appendix B.

Gravel %	23 to 58
Sand %	39 to 67
Silt & Clay %	3 to 13

5.4 Sand Fill

A layer of brown sand fill was encountered below the topsoil in Boreholes ECB-11 and ECB-12, which were drilled on the east side of the highway embankment. The sand contained trace to some silt, trace gravel and occasional cobbles and boulders. The sand fill ranged from 0.6 m to 2.1 m thick, with lower boundary depths of 0.7 to 2.2 m (Elev. 406.9 to 405.6).

SPT 'N' values of 8 and 10 blows for 0.3 m of penetration were recorded in the sand fill in Borehole ECB-11, indicating a loose to compact relative density. The moisture content ranged from 14% to 26%.

5.5 Peat

A 0.5 m thick layer of compressed peat was encountered beneath the sand fill in Borehole ECB-12. The base of the peat was at 1.2 m depth (Elev. 406.4). An SPT 'N' value of 43 blows for 0.3 m of penetration was recorded in the peat, which is attributed to the presence of cobbles within the organic material. The moisture content of the compressed peat was 17%.

5.6 Sand and Gravel to Gravelly Sand

A native deposit of grey sand and gravel to gravelly sand containing trace to some silt, trace clay and occasional cobbles and boulders was encountered below the embankment fill in Boreholes ECB-01, ECB-04, ECB-05, ECB-06, ECB-09, ECB-10, and below the topsoil in Test Pit ECB-07. The layer was interrupted by a silty sand layer in Boreholes ECB-01, ECB-04 and ECB-05.

The sand and gravel deposit has uninterrupted thickness ranging from 0.5 to 8.5 m. Where interrupted by silty sand layer, the combined thickness of sand and gravel layers ranged from 4.7 to 5.5 m. The lower boundary of the sand and gravel deposit varied in depth from 0.7 to 11.9 m (Elev. 404.6 to 396.6).

SPT 'N' values obtained in the deposit ranged from 9 to 60 blows for 0.3 m penetration indicating a loose to very dense relative density. SPT 'N' values of 50 blows for 0.3 m penetration and 63 blows for 0.2 m penetration were recorded in Boreholes ECB-04 and ECB-10 due to the presence of cobbles. Coring was required to penetrate the cobbles and boulders in the upper 0.6 m in ECB-05 and in the lower 2.1 m in ECB-10. Measured moisture contents ranged from 6% to 22%.

Selected samples of sand and gravel underwent laboratory grain size analysis 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 Figures B2 and B3 of Appendix B.

Gravel %	20 to 60
Sand %	34 to 76
Silt & Clay %	2 to 23

5.7 Silty Sand

A deposit of silty sand with trace to some gravel, trace clay and occasional cobbles and boulders was encountered within and below the sand and gravel deposit in Boreholes ECB-01, ECB-04 and ECB-05 and Test Pit ECB-07, below the sand fill in ECB-11 and below the peat in ECB-12. Borehole ECB-05 was terminated within the silty sand at 11.3 m depth (Elev. 397.3). In Boreholes ECB-01 and ECB-04, the combined thickness of silty sand layers ranged from 3.5 to 3.8 m. In Boreholes ECB-11, ECB-12 and Test Pit ECB-07, the silty sand layer varied from 0.4 m to 8.3 m thick. The lower boundary of the silty sand deposit varied from depths of 1.1 m to 12.0 m (Elev. 404.2 to Elev. 396.6).

SPT 'N' values recorded in the silty sand were between 7 blows for 0.3 m of penetration and 50 blows for 0.15 m of penetration and typically between 20 and 66, indicating a compact to very dense relative density. Coring was required to penetrate the cobbles and boulders within this deposit in ECB-01. Moisture contents ranged between 8% and 16%.

Three samples of the silty sand underwent laboratory grain size analysis 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.

Gravel %	9 to 21
Sand %	54 to 57
Silt & Clay %	25 to 34

5.8 Bedrock

Bedrock was encountered below the fill in Boreholes ECB-02 and ECB-03, below the silty sand in Boreholes ECB-01, ECB-04, ECB-11 and ECB-12 and in Test Pit ECB-07, and below the sand and gravel in Boreholes ECB-06, ECB-09 and ECB-10. Bedrock was proven by recovery of 2.9 m to 3.2 m long rock core samples in eight of the boreholes. In Test Pit ECB-07, the bedrock surface was exposed by open excavation.

The depth to bedrock varied significantly between the south and north abutment. The depths and elevations of the bedrock surface are summarized in Table 5.1.

Table 5.1 – Depths and Elevations of Bedrock

Abutment/ Approach	Borehole	Top of Bedrock	
		Depth (m)	Elevation
North	ECB-01	12.0	396.6
	ECB-04	11.6	397.0
	ECB-10	11.9	396.6
	ECB-12	9.5	398.1
South	ECB-02	3.0	405.5
	ECB-03	3.9	404.6
	ECB-06*	4.6	403.9
	ECB-07**	1.1	404.2
	ECB-09	4.7	403.8
	ECB-11	4.2	403.6

* Refusal on probable bedrock

** Bedrock exposed by test pit excavation

The bedrock recovered in the core samples was described as metamorphic breccia. Total Core Recovery (TCR) in the bedrock was generally 100% and locally 80% to 96% in two core runs. The Rock Quality Designation (RQD) was between 76% and 100%, indicating good to excellent rock quality with the exception of one run near the bedrock surface (Borehole ECB-01) with an RQD of 68%, indicating a fair rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m core, was typically less than 5 and locally greater than 10 near the bedrock surface.

The unconfined compressive strength of the intact rock interpreted from point load tests conducted on selected cores ranged from 57 MPa to 294 MPa (average per core run), indicating a strong to extremely strong rock.

5.9 Water Levels

Where possible, water levels were monitored in the open boreholes during drilling operations. Wash boring and rock coring methods were used to advance the boreholes and therefore water levels recorded during or upon completion of drilling may not reflect natural groundwater levels. Standpipe piezometers were installed in two boreholes to monitor the groundwater level after completion. The water levels observed in the open boreholes upon completion and measured in the piezometers are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
ECB-01	August 25, 2011	3.4	405.2	Open borehole
	September 16, 2011	4.1	404.5	In piezometer
	December 1, 2011	3.8	404.8	In piezometer
	October 28, 2012	4.2	404.4	In piezometer
ECB-02	August 29, 2011	3.0	405.5	Open borehole
ECB-03	August 30, 2011	3.1	405.4	Open borehole
	September 16, 2011	3.9	404.6	In piezometer
	December 1, 2011	3.8	404.7	In piezometer
	October 28, 2012	4.4	404.1	In piezometer
ECB-04	September 9, 2011	3.0	405.6	Open borehole
ECB-05	August 28, 2011	3.6	405.0	Open borehole
ECB-06	August 29, 2011	3.0	405.5	Open borehole
ECB-07	June 2, 2014	0.7	404.6	Open test pit

The preliminary GA drawing provided by WSP Canada Inc. indicates a water level at Elev. 404.8 in the Elbow Creek on May 10, 2011. In general, the groundwater level is expected to be at or slightly above the water level in the creek.

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

6 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. with direction from WSP Canada Inc. The coordinates and the ground surface elevations for the boreholes were established based on topographic survey information provided by WSP Canada Inc.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied truck and track-mounted CME-75 drill rigs and conducted the drilling, sampling and in-site testing operations for the boreholes. Perron Contracting of Sioux Lookout, Ontario supplied a 420 Cat backhoe and conducted the test pit excavation. The drilling and test pitting operations were supervised by Mr. Jason Mei, Mr. George Azzopardi, Ms. Eckie Siu, and Mr. Stephane Loranger of Thurber.

Overall supervision of the field program, interpretation of the data, and preparation of the report were carried out by Mr. Mark Farrant P.Eng.

The report was reviewed by Mr. Murray Anderson, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Review Principal



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.

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


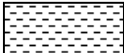



ROCK WEATHERING CLASSIFICATION

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.

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.

RECORD OF BOREHOLE No ECB-01

1 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 945.6 E 631 983.6 ORIGINATED BY JM
HWY 599 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.08.23 - 2011.08.25 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
408.6	GROUND SURFACE																		
0.0 408.3	ASPHALT: (250mm)																		
0.3	SAND and GRAVEL, trace to some silt, occasional cobbles and boulders Dense Brown Moist to Wet (FILL) Cobble (150mm) at 0.5m Cored cobbly material from 1.4m to 2.8m																		
			1	SS	37														
405.6																			
3.0	SAND and GRAVEL, trace silt, occasional cobbles and boulders Dense to Very Dense Grey Wet		2	SS	33														
			3	SS	60														

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ECB-01

2 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 945.6 E 631 983.6 ORIGINATED BY JM
HWY 599 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.08.23 - 2011.08.25 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
Continued From Previous Page						20 40 60 80 100						WATER CONTENT (%) 20 40 60						
	Boulder (225mm) at 10.4m																	
397.9																		
10.7	Silty SAND , trace gravel Very Dense Grey Wet		6	SS	50/ 0.150													
396.6																		
12.0	BEDROCK METAMORPHIC BRECCIA , grey, slightly weathered to fresh, very strong to extremely strong Vertical breaks at 12.1m and 12.2m Horizontal breaks at 12.2m, 12.5m, 13.5m, 13.9m and 14.1m		1	RUN														



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RECORD OF BOREHOLE No ECB-02

1 OF 1

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 927.8 E 631 975.4 ORIGINATED BY JM
HWY 599 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.08.28 - 2011.08.29 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L														
408.5	GROUND SURFACE							20	40	60	80	100														
0.0	ASPHALT: (150mm)							20	40	60	80	100														
0.2	SAND and GRAVEL, trace silt, occasional cobbles and boulders Dense to Compact Brown Moist (FILL) Cored cobbly material from 2.1m to 3.0m		1	SS	42	▽																				
			2	SS	49																					
			3	SS	11																					
405.5	BEDROCK METAMORPHIC BRECCIA, grey, fresh, strong to very strong Sub-vertical breaks (50mm) at 3.9m Horizontal breaks at 3.3m, 4.3m, 4.7m and 5.0m		1	RUN																						
2			RUN																							
402.4	END OF BOREHOLE AT 6.1m. BOREHOLE OPEN TO 5.8m AND WATER LEVEL AT 3.0m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 5.8m TO 0.9m, SAND AND GRAVEL FROM 0.9m TO 0.1m, THEN ASPHALT TO SURFACE.																									
6.1																										

ONTMT4S 0840.GPJ 2012TEMPLATE(MTO).GDT 9/30/14

METRIC

SOIL PROFILE			SAMPLES														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES												
408.5	GROUND SURFACE																
0.0	ASPHALT: (150mm)																
0.2	Gravelly SAND, some silt, occasional cobbles and boulders Dense to Compact Brown Moist (FILL) Cored cobbly material from 0.8m to 2.2m		1	SS	37												
	Boulder (275mm) at 2.9m																
	Boulder (300mm) at 3.3m																
404.6	Cobble (175mm) at 3.6m		2	SS	23												
3.9	BEDROCK METAMORPHIC BRECCIA, grey, slightly weathered to fresh, very strong		1	RUN													
	Horizontal breaks at 3.9m, 4.1m, 4.3m, 4.7m, 4.9m, 5.6m, 6.1m, 6.8m and 6.9m																
	Sub-vertical breaks at: 75mm at 4.7m 100mm at 5.2m 150mm at 6.4m 50mm at 6.7m 50mm at 6.9m 100mm at 7.0m		2	RUN													
401.4	END OF BOREHOLE AT 7.1m. BOREHOLE OPEN TO 7.1m AND WATER LEVEL AT 3.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
7.1																	
<div>WATER LEVEL READINGS:</div> <table><tr><th>DATE</th><th>DEPTH (m)</th><th>ELEV. (m)</th></tr><tr><td>Sep.16/11</td><td>3.9</td><td>404.6</td></tr><tr><td>Dec.01/11</td><td>3.8</td><td>404.7</td></tr><tr><td>Oct.28/12</td><td>4.4</td><td>404.1</td></tr></table>						DATE	DEPTH (m)	ELEV. (m)	Sep.16/11	3.9	404.6	Dec.01/11	3.8	404.7	Oct.28/12	4.4	404.1
DATE	DEPTH (m)	ELEV. (m)															
Sep.16/11	3.9	404.6															
Dec.01/11	3.8	404.7															
Oct.28/12	4.4	404.1															

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No ECB-04

1 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 944.4 E 631 986.2 ORIGINATED BY JM/GA
 HWY 599 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2011.08.31 - 2011.09.09 CHECKED BY RPR/LT

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					
408.6	GROUND SURFACE												
0.0	ASPHALT: (200mm)												
0.2	SAND and GRAVEL , trace to some silt, occasional cobbles and boulders Dense Brown Moist (FILL) Cored cobbly material from 0.8m to 3.0m		1	SS	40								
405.6													
3.0	SAND and GRAVEL to Gravelly SAND , trace silt, occasional cobbles and boulders Very Dense to Compact Grey Wet		2	SS	50/ 0.150								
			3	SS	12								
402.5													
6.1	Silty SAND , trace gravel, trace clay Very Dense to Dense Grey Wet Boulder (0.6m) at 6.4m		4	SS	66								
			5	SS	41								
399.6													
9.0	SAND and GRAVEL , trace silt Dense Grey Wet		6	SS	45								

Continued Next Page

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

RECORD OF BOREHOLE No ECB-04

2 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 944.4 E 631 986.2 ORIGINATED BY JM/GA
HWY 599 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2011.08.31 - 2011.09.09 CHECKED BY RPR/LT

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								PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%) W P W W L					
	Continued From Previous Page																				
397.9							398														
10.7	Silty SAND , trace gravel Dense Grey Wet		7	SS	46																
397.0							397														
11.6	BEDROCK METAMORPHIC BRECCIA , grey, fresh, coarse grained, very strong Sub-horizontal joints at 11.9m Horizontal joints at 11.6m, 11.7m and 12.5m		1	RUN			396														
			2	RUN			395														
394.0							394														
14.6	END OF BOREHOLE AT 14.6m. BOREHOLE OPEN TO 14.6m AND WATER LEVEL AT 3.0m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 14.6m TO 0.3m, CONCRETE FROM 0.3m TO 0.1m, THEN ASPHALT TO SURFACE.																				

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ECB-05

1 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 950.9 E 631 986.4 ORIGINATED BY JM
HWY 599 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.08.27 - 2011.08.28 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL
408.6	GROUND SURFACE							20	40	60	80	100							
0.0	ASPHALT: (150mm)							20	40	60	80	100							
0.2	SAND and GRAVEL, trace to some silt, occasional cobbles and boulders Compact to Dense Brown Moist (FILL) Cored cobbly material from 1.4m to 3.6m		1	SS	24		408							○					
			2	SS	35									○					
							407												
							406												
405.6							405												
3.0	SAND and GRAVEL, to some gravel Compact Dark Brown Wet		3	SS	17									○					
							404							○					
404.0	Silty SAND, some gravel, trace clay Compact Grey Wet Boulder (0.5m) at 5.5m		4	SS	16									○					
							403												
			5	SS	22		402							○					
							401												
401.0														○					
7.6	SAND and GRAVEL, trace silt Dense to Loose Grey Wet		6	SS	42		400							○					
			7	SS	9		399							○					

Continued Next Page

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

RECORD OF BOREHOLE No ECB-05

2 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 950.9 E 631 986.4 ORIGINATED BY JM
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.08.27 - 2011.08.28 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	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									
	Continued From Previous Page																
397.9		◇ ◇ ◇ ◇ ◇															
10.7	Silty SAND , some gravel Very Dense Grey		8	SS	51											21 54 25 (SI+CL)	
397.3	Wet																
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 10.2m AND WATER LEVEL AT 3.6m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 10.3m TO 2.1m, SAND AND GRAVEL FROM 2.1m TO 1.0m, CONCRETE FROM 1.0m TO 0.1m, THEN ASPHALT TO SURFACE.																

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RECORD OF BOREHOLE No ECB-06

1 OF 1

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 921.2 E 631 975.3 ORIGINATED BY JM
 HWY 599 BOREHOLE TYPE Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.08.29 - 2011.08.29 CHECKED BY RPR/LT

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)							
								20 40 60 80 100				w _P w w _L							
408.5	GROUND SURFACE																		
0.0	ASPHALT: (150mm)																		
0.2	SAND and GRAVEL, trace silt Compact to Dense Brown Moist (FILL)		1	SS	29	∇	408												
			2	SS	26		407												
			3	SS	33		406												
			4	SS	5		405												
							404												
405.5	Loose																		
3.0	Gravelly SAND, some silt Dense to Very Dense Grey Wet		5	SS	30		405												
403.9							404												
4.6	END OF BOREHOLE AT 4.6m UPON REFUSAL ON PROBABLE BEDROCK. BOREHOLE OPEN TO 4.6m AND WATER LEVEL AT 3.0m. BOREHOLE BACKFILLED WITH HOLEPLUG FROM 4.6m TO 1.0m, SAND AND GRAVEL FROM 1.0m TO 0.1m, THEN ASPHALT TO SURFACE.																		

RECORD OF TEST PIT No ECB-07

1 OF 1

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 933.7 E 631 967.2 ORIGINATED BY SLL
 HWY 599 BOREHOLE TYPE Backhoe COMPILED BY MFA
 DATUM Geodetic DATE 2014.06.02 - 2014.06.02 CHECKED BY MEF

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							
405.3	GROUND SURFACE														
0.0	TOPSOIL, trace roots and rootlets: (225mm)														
0.2	Gravelly SAND, occasional cobbles		1	GS		405									
404.6	Brown Moist to Wet														
0.7	Silty SAND, trace gravel		2	GS											
404.2	Brown Moist														
1.1	END OF TEST PIT AT 1.1m UPON REFUSAL ON BEDROCK. WATER LEVEL AT 0.7m IN OPEN HOLE. TEST PIT BACKFILLED TO SURFACE.														






RECORD OF BOREHOLE No ECB-09

1 OF 1

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 928.4 E 631 978.8 ORIGINATED BY ES
HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2014.05.05 - 2014.05.05 CHECKED BY MEF

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					
								20 40 60 80 100					
408.5	GROUND SURFACE												
0.0	ASPHALT: (150mm)												
0.2	SAND and GRAVEL, trace to some silt, occasional cobbles Compact to Very Dense Brown Wet (FILL)		1	GS									
			1	SS	17								
			2	SS	23								
			3	SS	84								
			4	SS	50/ 0.125								
404.5													
4.0	Gravelly SAND, some silt, occasional cobbles												
403.8	Cobble												
4.7	BEDROCK METAMORPHIC BRECCIA, grey, strong to extremely strong Sub-vertical breaks (75mm) at 4.7m, 4.8m 100mm at 5.1m 125mm at 5.4m Sub-horizontal breaks at 4.9m, 5.1m, 5.5m Occasional quartz, very strong, grey Sub-vertical breaks (50mm) at 5.9m		1	RUN									
			2	RUN									
			3	RUN									
400.9													
7.6	END OF BOREHOLE AT 7.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m THEN ASPHALT TO SURFACE.												

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+³, ×³: Numbers refer to
Sensitivity

20
15
10







(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ECB-10

1 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 941.8 E 631 981.4 ORIGINATED BY ES
 HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.05.05 - 2014.05.05 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _P	W		W _L				
408.5	GROUND SURFACE																			
0.0	ASPHALT: (175mm)																			
0.2	SAND and GRAVEL, trace to some silt, occasional cobbles Compact to Very Dense Brown Wet (FILL)		1	GS																
			1	SS	13															
			2	SS	21															
406			3	SS	50/ 0.125															
			4	SS	50/ 0.050															
405.1																				
3.4	Gravelly SAND, trace to some silt, trace clay, occasional cobbles Compact to Very Dense Grey Wet																			
404			5	SS	29															
			6	SS	18															
402																				
			7	SS	63/ 0.200															
400																				
			8	SS	38															
	Cored from 9.8m to 11.9m																			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ECB-10

2 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 941.8 E 631 981.4 ORIGINATED BY ES
HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2014.05.05 - 2014.05.05 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page						20	40	60	80	100	20	40	60		GR SA SI CL				
396.6 11.9	Gravelly SAND , trace to some silt, trace clay, occasional cobbles and boulders		1	RUN		398										RUN #1 TCR=94%				
	Boulder from 9.8m to 10.1m Boulder from 10.3m to 11.0m		2	RUN		397										RUN #2 TCR=11%				
	BEDROCK METAMORPHIC BRECCIA , grey, very strong to extremely strong Sub-vertical fracture (50mm thick) at 12.0m 150mm at 12.3m 150mm at 12.5m 200mm at 12.7m Sub-horizontal fracture at 12.0m, 12.7m		3	RUN		396										RUN #3 TCR=100% SCR=100% RQD=100% UCS=190MPa (Average)				
			4	RUN		395											RUN #4 TCR=100% SCR=100% RQD=100% UCS=294MPa (Average)			
393.7 14.8	END OF BOREHOLE AT 14.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m THEN ASPHALT TO SURFACE.					394														

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

RECORD OF BOREHOLE No ECB-11

1 OF 1

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 924.8 E 631 985.5 ORIGINATED BY SLL
HWY 599 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY MFA
DATUM Geodetic DATE 2014.05.28 - 2014.05.29 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			W _P W W _L				
407.8	GROUND SURFACE															
0.9	TOPSOIL: (50mm) SAND , trace to some silt, trace gravel, occasional cobbles Compact to Loose Brown Moist (FILL)															
			1	SS	10		407									
			2	SS	8		406									
405.6																
2.2	Silty SAND , trace gravel Compact Brown to Grey Moist		3	SS	20		405									
			4	SS	23		404									
403.6																
4.2	BEDROCK: METAMORPHIC BRECCIA , grey, fresh, strong to very strong Sub-vertical joints at 4.57, 4.70, and 4.85 to 5.00m Sub-horizontal joints at 4.94, 5.00, and 5.23m Sub-vertical joints at 6.04 to 6.12, 6.91 to 6.93, and 7.14 to 7.21m Horizontal joints at 6.35 and 6.73m		1	RUN			403								RUN #1 TCR=100% SCR=100% RQD=100% UCS=236MPa (Average) RUN #2 TCR=100% SCR=100% RQD=96% UCS=84MPa (Average) RUN #3 TCR=100% SCR=100% RQD=100% UCS=149MPa (Average)	
			2	RUN			402									
			3	RUN			401									
400.4																
7.4	END OF BOREHOLE AT 7.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.															

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RECORD OF BOREHOLE No ECB-12

1 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 941.0 E 631 993.4 ORIGINATED BY SLL
 HWY 599 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
 DATUM Geodetic DATE 2014.05.29 - 2014.05.29 CHECKED BY MEF

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							
407.6	GROUND SURFACE							20	40	60	80	100			
0.0	TOPSOIL, with roots: (100mm)														
0.1	SAND, trace gravel, occasional cobbles and boulders (FILL)														
406.9							407								
0.7	PEAT, fibrous, occasional cobbles and boulders		1	SS	43										
406.4	Black Moist														
1.2	Silty SAND, trace gravel, occasional cobbles Loose to Dense Brown to Grey Moist		2	SS	22		406								
			3	SS	20		405								
	Grey Wet		4	SS	7		404								
							403								
			5	SS	20										
							402								
			6	SS	34		401								
							400								
			7	SS	49										
							399								
398.1	Very Dense Moist to Wet		8	SS	71/ 225										
9.5	BEDROCK: METAMORPHIC BRECCIA, grey, very strong Sub-vertical joints at 9.53 to 9.55, 9.58						398								

PLASTIC LIMIT

NATURAL MOISTURE CONTENT

LIQUID LIMIT

W P

W

W L

WATER CONTENT (%)

20

40

60

80

100

○ UNCONFINED

● QUICK TRIAXIAL

+ FIELD VANE

× LAB VANE

GR

SA

SI

CL

RUN #1

TCR=100%

SCR=100%

ROD=94%

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No ECB-12

2 OF 2

METRIC

W.P. 6109-10-01 LOCATION Elbow Creek Bridge N 5 525 941.0 E 631 993.4 ORIGINATED BY SLL
HWY 599 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY MFA
DATUM Geodetic DATE 2014.05.29 - 2014.05.29 CHECKED BY MEF

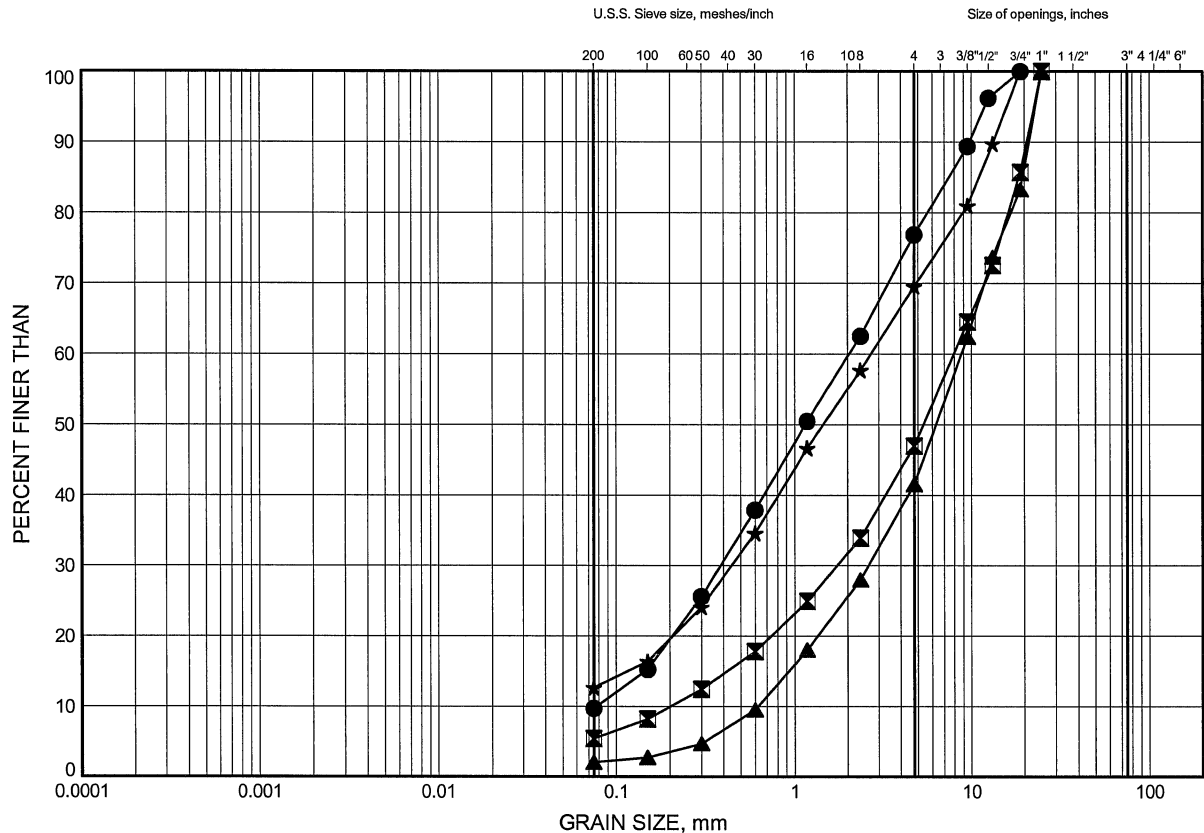
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page							20	40	60	80	100						
394.9	to 9.61, 10.13 to 10.19, 10.39 to 10.42, and 10.52 to 10.55m Horizontal joint at 10.31m		1	RUN													GR SA SI CL	
	2		RUN														RUN #2 TCR=100% SCR=98% RQD=81% UCS=201MPa (Average)	
	Horizontal joints at 10.82, 10.88, 11.00, and 11.62m																	
	Sub-vertical joints at 10.88 to 11.00, and 11.73 to 11.76m																	
			3	RUN													RUN #3 TCR=100% SCR=100% RQD=100% UCS=146MPa (Average)	
394.9																		
12.7	END OF BOREHOLE AT 12.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	

Appendix B
Laboratory Test Results

Elbow Creek Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND & 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)
●	ECB-03	0.38	408.12
■	ECB-06	1.07	407.43
▲	ECB-09	1.07	407.43
★	ECB-09	2.51	405.99

Date September 2014

W.P. 6109-10-01



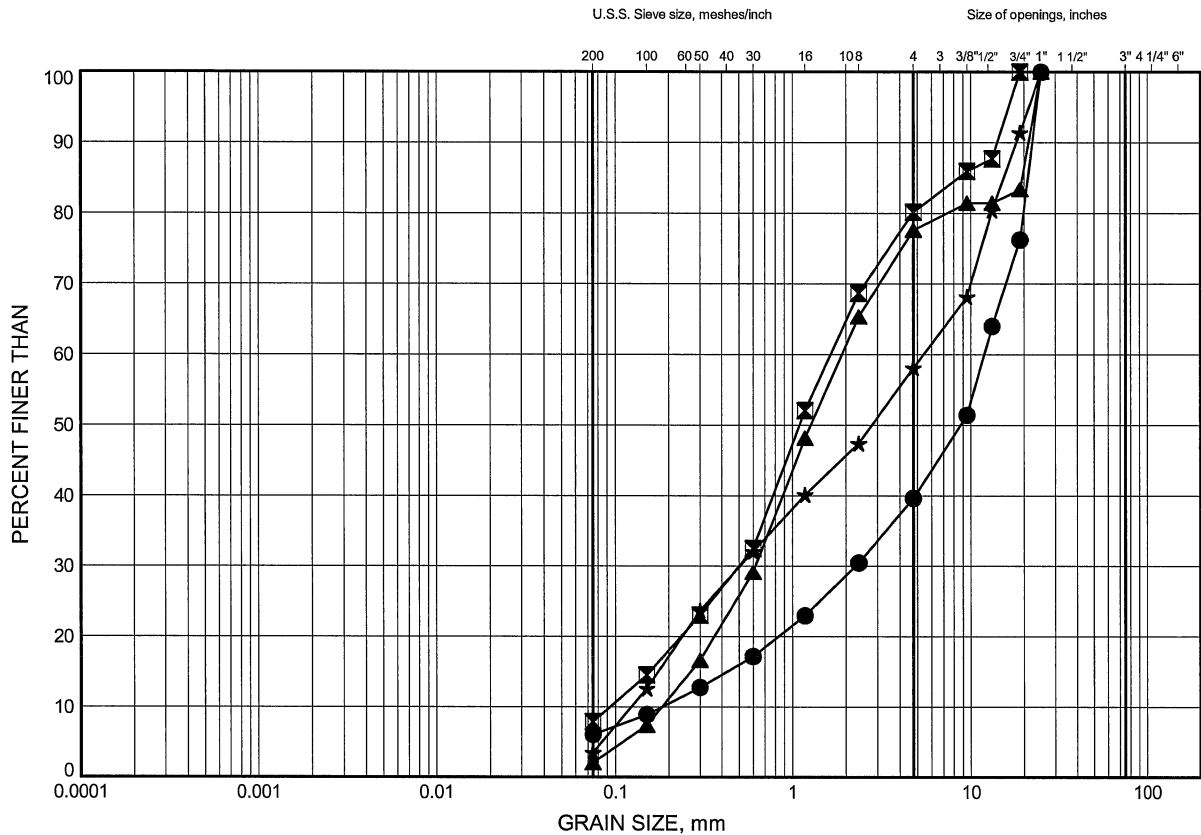
Prep'd AN

Chkd. MRA

Elbow Creek Bridge GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND & GRAVEL TO GRAVELLY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ECB-01	3.35	405.25
⊠	ECB-01	9.45	399.15
▲	ECB-04	4.88	403.72
★	ECB-05	9.45	399.15

Date ..September 2014.....

W.P. ..6109-10-01.....



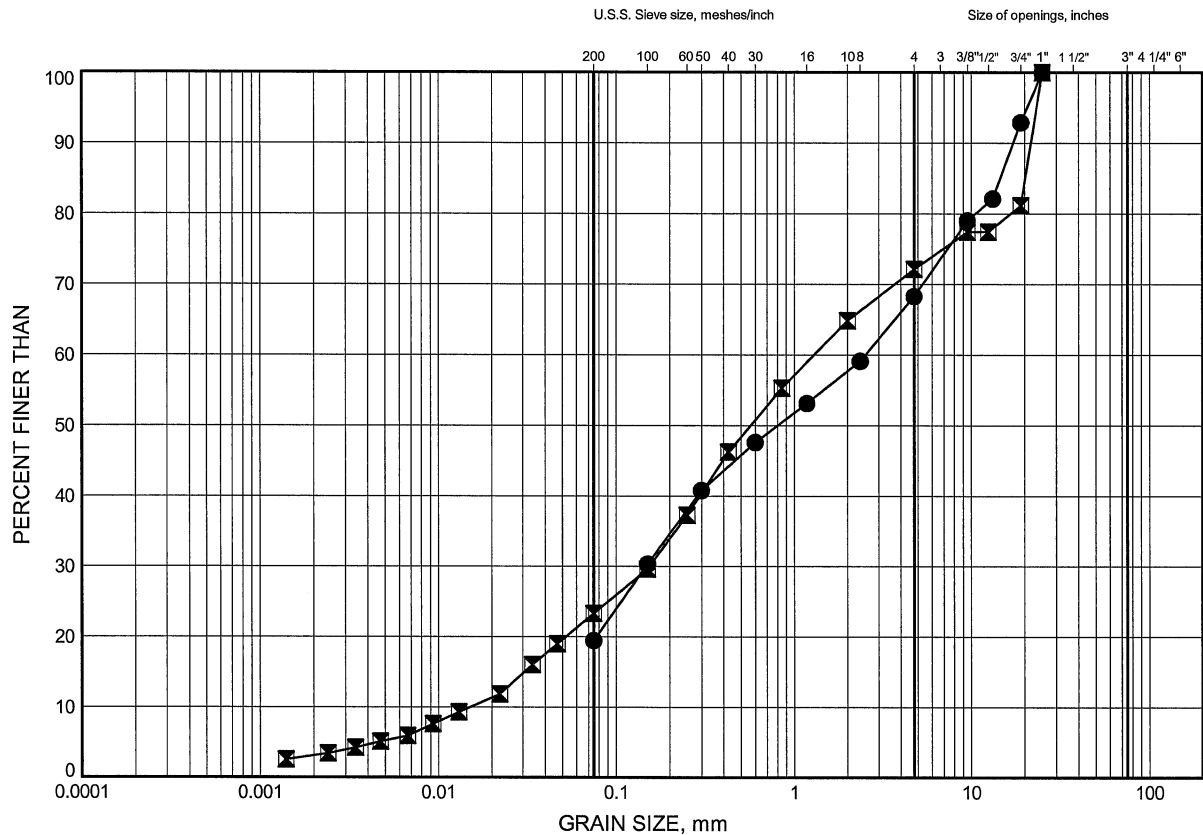
Prep'dAN.....

Chkd.MRA.....

Elbow Creek Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3

GRAVELLY SAND, Some Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	ECB-06	3.35	405.15
■	ECB-10	4.88	403.62

Date September 2014
W.P. 6109-10-01

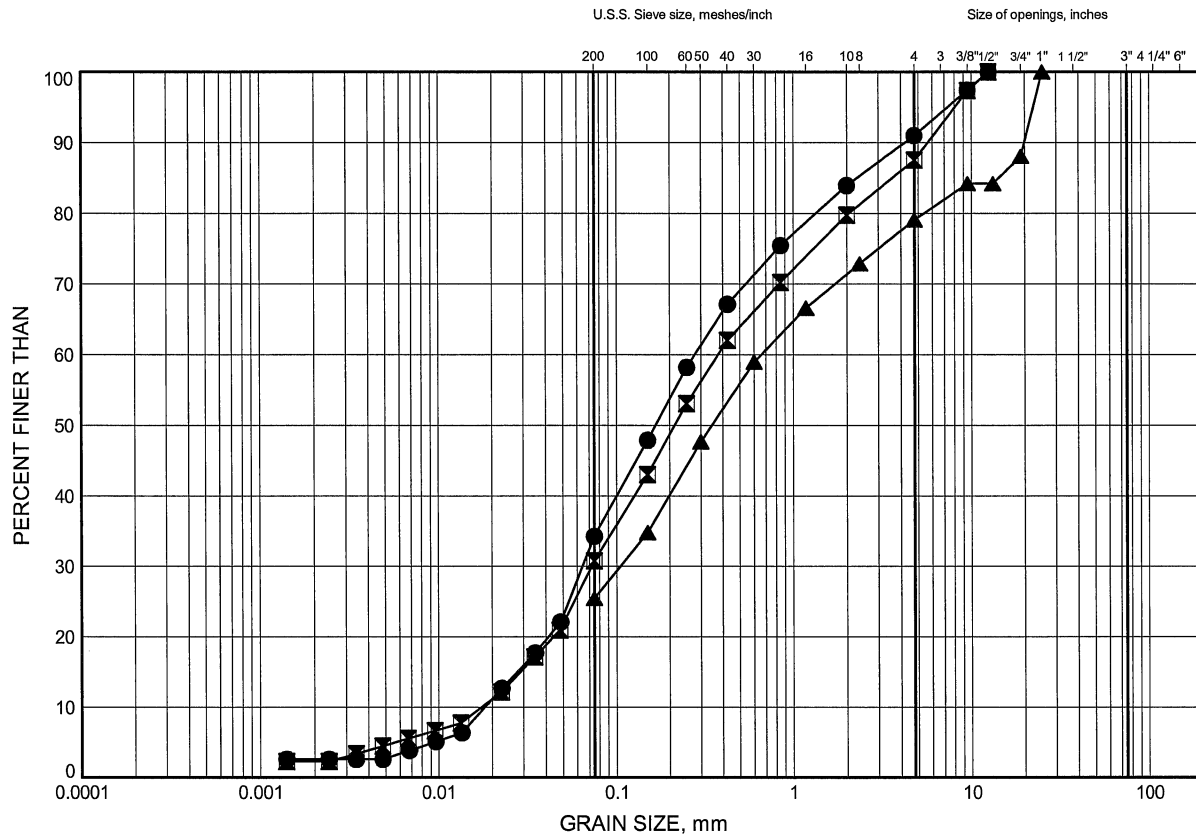


Prep'd AN
Chkd. MRA

Elbow Creek Bridge GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY SAND



Appendix C
Site Photographs



Photograph 1 – Elbow Creek Bridge looking south



Photograph 2 – Looking north at north abutment, east side of bridge

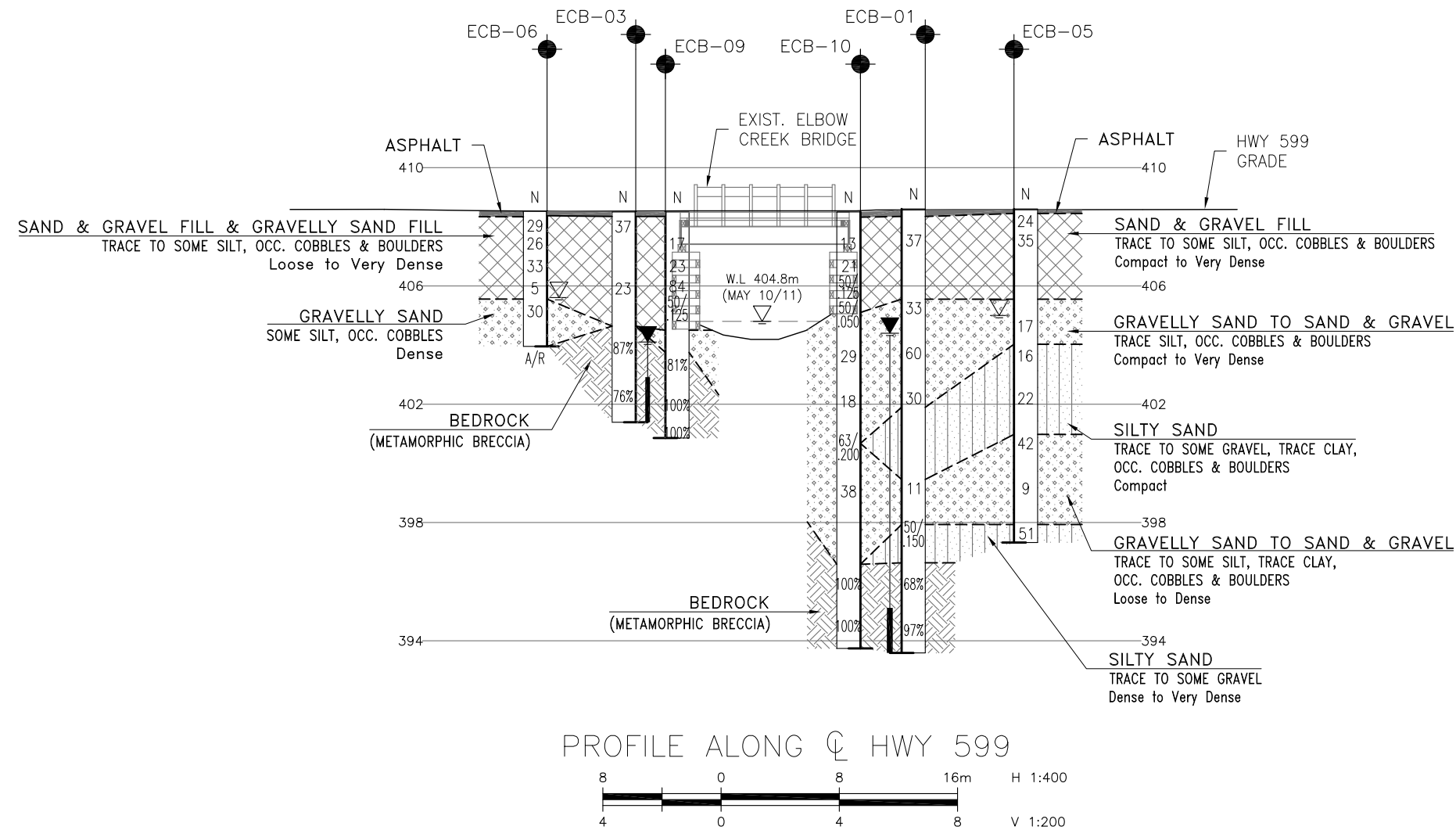
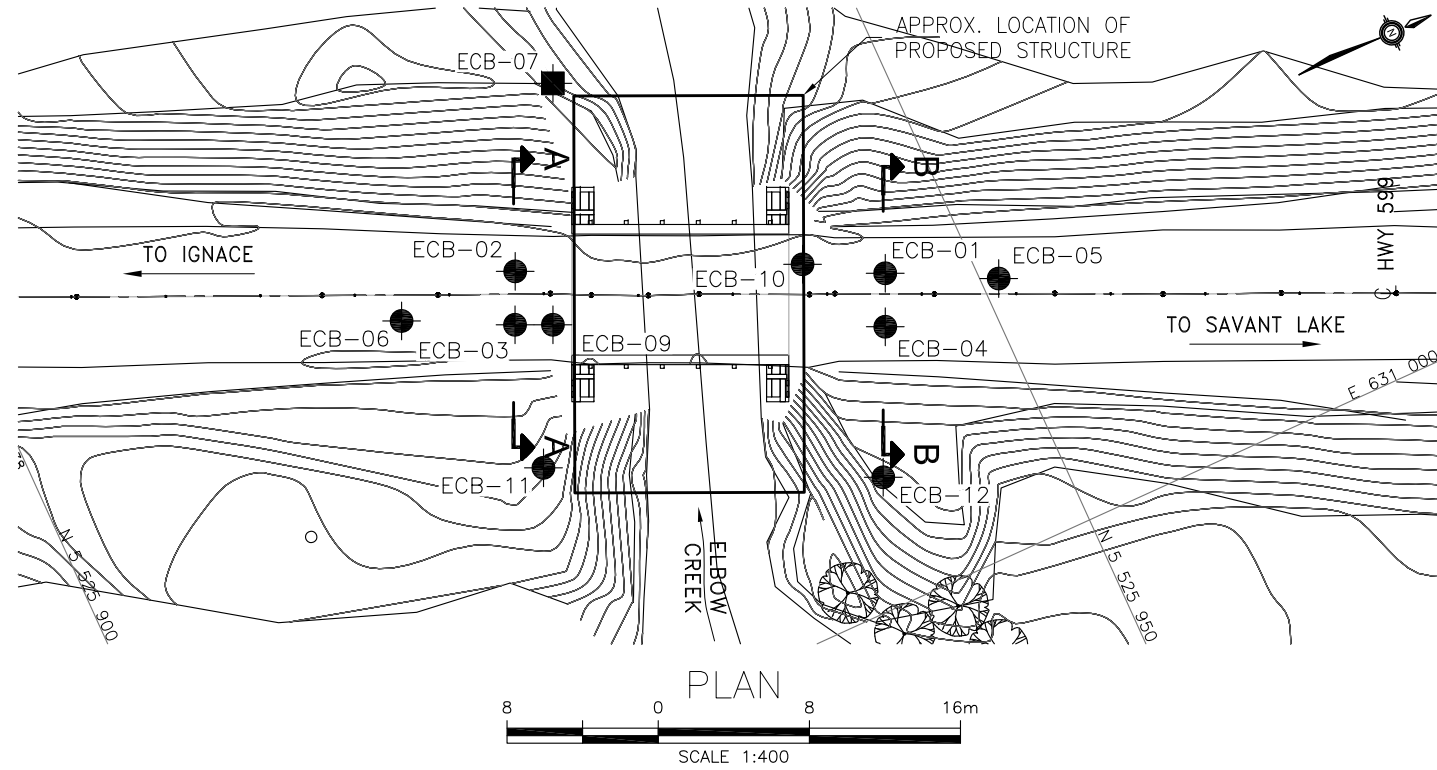


Photograph 3 – North abutment



Photograph 4 – South abutment and approach, east side

Appendix D
Borehole Locations and Soil Strata Drawings



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



CONT No 2014-6019
WP No 6109-10-01

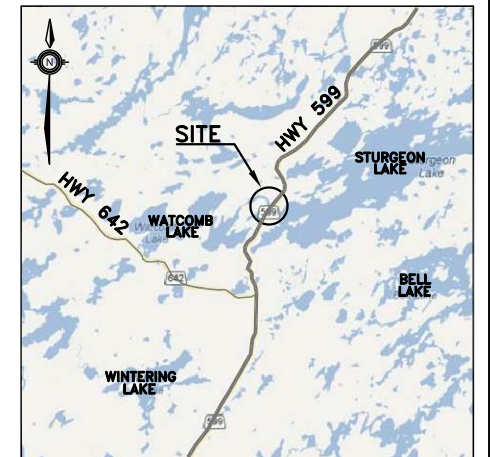
ELBOW CREEK BRIDGE
REPLACEMENT
HIGHWAY 599
BOREHOLE LOCATIONS AND SOIL STRATA



1200 PREMIER WAY, THUNDER BAY (ONTARIO) CANADA, P7B 6A3
TEL: 807 625-0700 | FAX: 807 623-4811 | WWW.WSPORC.COM







THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Test Pit
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level During Drilling
	Water Level In Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
ECB-01	408.6	5 525 945.6	631 983.6
ECB-02	408.5	5 525 927.8	631 975.4
ECB-03	408.5	5 525 926.6	631 978.0
ECB-04	408.6	5 525 944.4	631 986.2
ECB-05	408.6	5 525 950.9	631 986.4
ECB-06	408.5	5 525 921.2	631 975.3
ECB-07	405.3	5 525 933.7	631 967.2
ECB-09	408.5	5 525 928.4	631 978.8
ECB-10	408.5	5 525 941.8	631 981.4
ECB-11	407.8	5 525 924.8	631 985.5
ECB-12	407.6	5 525 941.0	631 993.4

-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. 52G-11

[illegible]

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



CONT No 2014-6019
WP No 6109-10-01

ELBOW CREEK BRIDGE
REPLACEMENT
HIGHWAY 599
BOREHOLE LOCATIONS AND SOIL STRATA

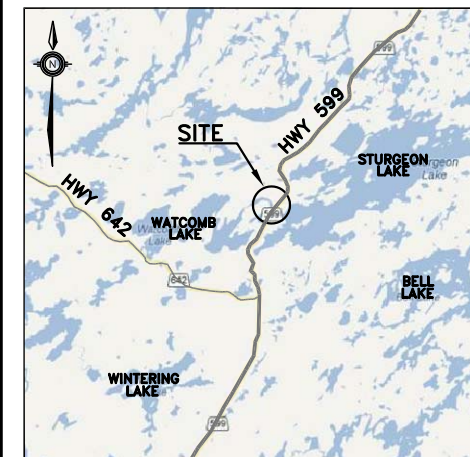
SHEET
17



1280 PREMIER WAY, THUNDER BAY, ONTARIO, CANADA, P7S 6A5
TEL: 807 625-0776 (FAX: 807 625-4461) WWW.WSPGROUP.COM



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

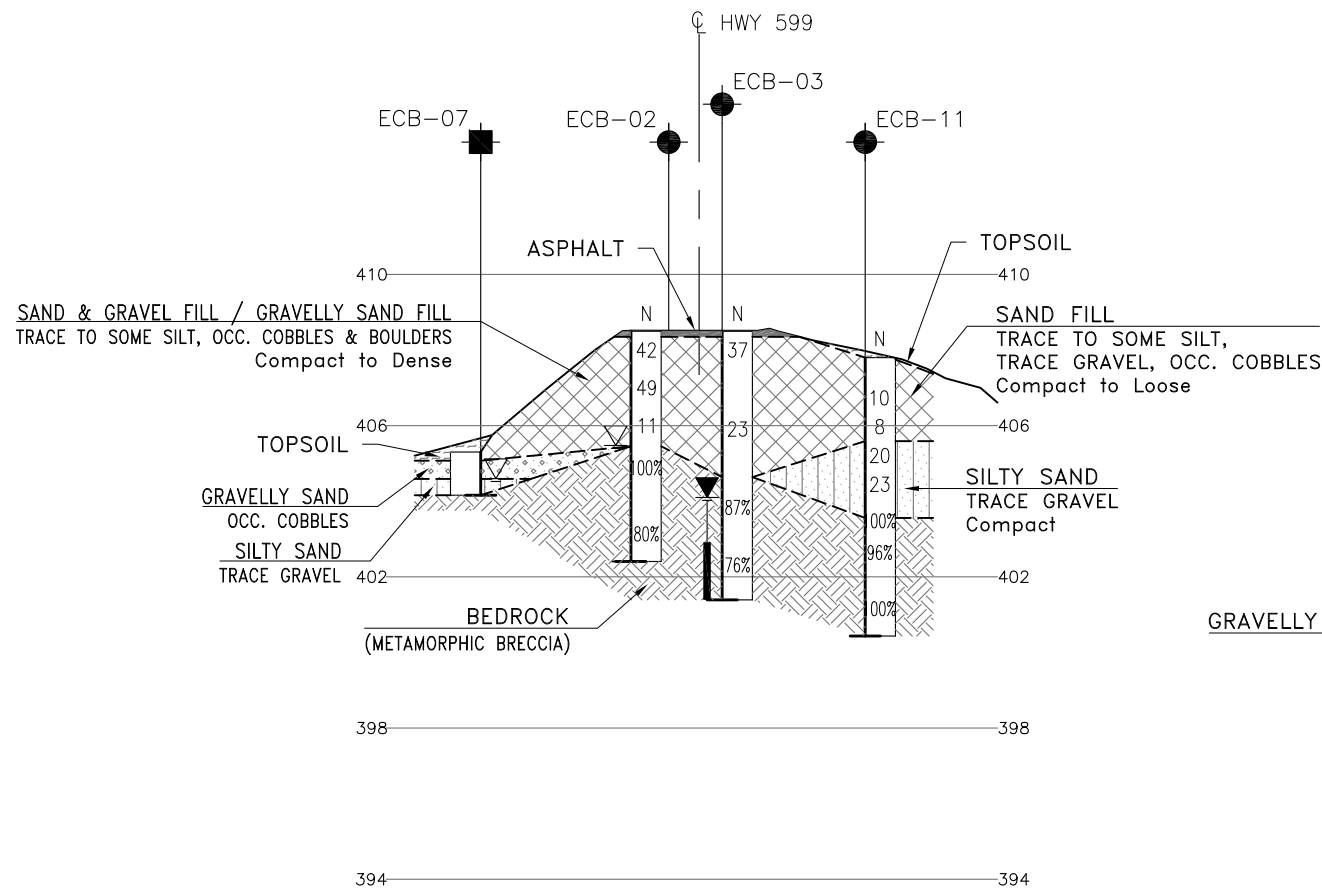
- Borehole
- Test Pit
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level During Drilling
- Water Level In Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
ECB-01	408.6	5 525 945.6	631 983.6
ECB-02	408.5	5 525 927.8	631 975.4
ECB-03	408.5	5 525 926.6	631 978.0
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ECB-07	405.3	5 525 933.7	631 967.2
ECB-09	408.5	5 525 928.4	631 978.8
ECB-10	408.5	5 525 941.8	631 981.4
ECB-11	407.8	5 525 924.8	631 985.5
ECB-12	407.6	5 525 941.0	631 993.4

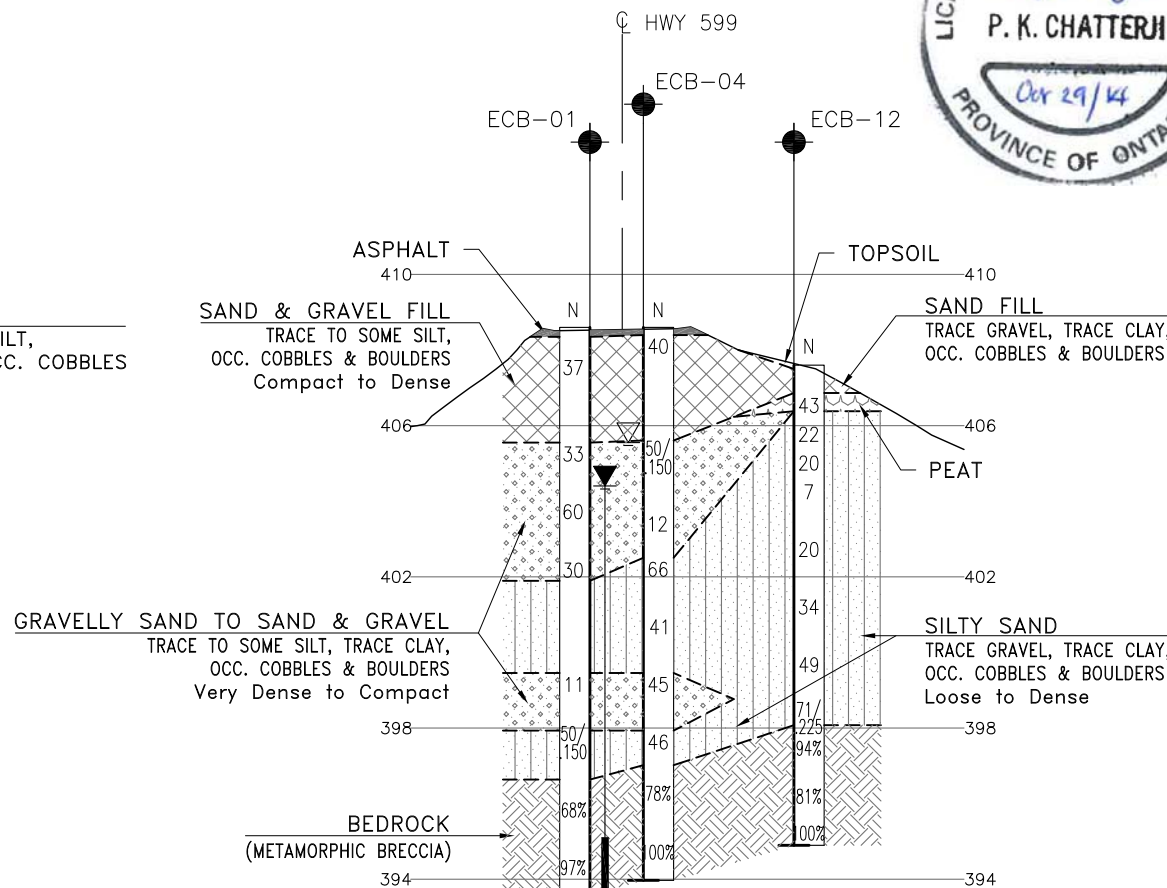
-NOTES-

- 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. 52G-11



PROFILE ALONG A-A



PROFILE ALONG B-B



H 1:400
V 1:200

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK MRA	CODE LOAD DATE OCT 2014
DRAWN	AN	CHK MEF	SITE 41S-76 STRUCT DWG 3