

**FOUNDATION INVESTIGATION REPORT  
BLIND CREEK WEST CULVERT – EBL  
HIGHWAY 11/17 - FOUR LANING  
FROM 0.36 km EAST OF HIGHWAY 527 EASTERLY 12.6 km  
TO 1 km WEST OF MACKENZIE STATION ROAD  
G.W.P. 623-89-00, SITE 48C-350/C1**

**Geocres Number: 52A-160**

**Report to**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the location of the Blind Creek West culvert under existing Highway 11/17 in the Township of MacGregor, District of Thunder Bay. Replacement of the existing culvert is planned as part of the proposed Highway 11/17 four-laning project extending from 0.36 km east of Highway 527 to 1 km west of MacKenzie Station Road. The existing Highway 11/17 will become the new eastbound lanes of the four-lane divided highway.

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 sections, laboratory test results and written descriptions 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 McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-0017.

**2 SITE DESCRIPTION**

The proposed Blind Creek West culvert is located approximately 11 km east of Thunder Bay, Ontario and approximately 6.8 km east of Highway 527. The new culvert will be situated at the location of the existing culvert under the existing Highway 11/17 alignment. The existing roadway embankment is approximately 1.5 to 3.5 m in height.

The existing culvert comprises twin 1.4 m diameter corrugated steel pipes (CSP) with lengths of 34.7 and 33.8 m. The invert level of the existing culverts ranges from approximate elevation 232.5 at the inlet (north end) to elevation 230.8 at the outlet (south end). The CSPs are suspended

approximately 300mm above the water level at the outlet, and bedrock is exposed along the sides of the adjacent plunge pool.

Lands surrounding the culvert site consist of forested areas with bedrock outcrops. Cobbles and boulders line the creek channel.

Photographs in Appendix C show the general nature of the site.

The site lies near the border of the Superior and Southern Geological Provinces of the Canadian Shield. According to bedrock geology maps produced by the Ontario Geological Survey, the culvert site is underlain by mafic to intermediate metavolcanic rocks consisting of basaltic and andesitic flows, tuffs, breccias, chert, iron formation, minor metasedimentary and intrusive rock, and related migmatites. Locally, the overburden generally consists of deposits of silty sand to sand and gravel with cobbles and boulders.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for this project were carried out between October 20 and 22, 2011 and consisted of drilling and sampling six boreholes identified as BCWE-1 to BCWE-6.

Boreholes BCWE-1 and BCWE-4 were located near the proposed culvert inlet, Boreholes BCWE-2 and BCWE-5 were located on the existing highway embankment, and Boreholes BCWE-3 and BCWE-6 were located near the culvert outlet. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata drawing included in Appendix D.

Boreholes BCWE-1, BCWE-2, BCWE-4 and BCWE-5 located at the north and central part of the culvert were advanced to depths of 9.0 m to 10.7 m (elevations 225.9 to 224.0), including rock coring. Borehole BCWE-3 located at the culvert outlet was completed by manual excavation to expose the bedrock surface at 60 mm depth (Elev. 232.6), and Borehole BCWE-6 was documented by visual examination of the embankment slope surface and exposed bedrock at the toe.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling. Clearing and access preparation were required prior to commencement of the borehole drilling. Silt fencing was installed between the drill area and the creek to prevent migration of core water sediment into the adjacent creek.

A track mounted CME 45 drill rig was used at this site and a combination of hollow-stem augers, casing and NQ coring techniques were used to advance the boreholes. Overburden samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the 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 samples and rock cores for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes upon completion of the drilling operations. The completion details of the boreholes are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

<b>Borehole</b>	<b>Borehole Depth/ Elevation (m)</b>	<b>Completion Details</b>
BCWE-1	10.7 / 224.0	Backfilled with holeplug to 3.6 m, then auger cuttings to surface.
BCWE-2	9.1 / 225.9	Backfilled with bentonite holeplug to 3.0 m, then sand and gravel to surface.
BCWE-3	0.1 / 232.6	Filled in with gravel.
BCWE-4	9.0 / 224.2	Backfilled with bentonite holeplug to 1.5 m, then cuttings to surface.
BCWE-5	9.2 / 225.4	Backfilled with holeplug to 3.0 m, then auger cuttings to surface.
BCWE-6	1.4 / 232.1	Visual inspection only.

#### **4 LABORATORY TESTING**

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis. The results of these tests are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Point load tests were carried out on selected samples of intact bedrock upon arrival at the laboratory to evaluate the unconfined compressive strength (UCS) of the bedrock. The UCS values of the rock assessed from the point load data are reported on the borehole logs.

#### **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. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the subsurface stratigraphy encountered at the site consisted of sand and gravel embankment fill overlying native deposits of silty sand to sand and gravel, which in turn were underlain by cobbles and boulders. Cobbles and boulders were also encountered at the fill/native soil interface and within the native deposits. Bedrock was encountered below the layer of cobbles

and boulders. The bedrock is exposed at the ground surface at the culvert outlet. More detailed descriptions of the individual strata are presented below.

### **5.1 Topsoil**

A 25 mm thick veneer of topsoil was encountered at the ground surface in Borehole BCWE-4.

### **5.2 Sand and Gravel Fill**

Sand and gravel fill was encountered in Boreholes BCWE-1, BCWE-2 and BCWE-5 drilled on the existing roadway embankment, and below the topsoil veneer in Borehole BCWE-4. Sand and gravel fill was visually documented at the location of Borehole BCWE-6 on the embankment side slope. The sand and gravel fill was brown and contained trace silt and clay and occasional cobbles.

The thickness of the sand and gravel fill ranged from 1.4 m to 3.1 m, with the base of the fill at elevations 232.8 to 231.7.

SPT N-values recorded in the fill typically ranged from 28 to 56 blows for 0.3 m penetration, indicating a compact to very dense relative density. SPT 'N' values of 50 blows per 0.1 m and 100 blows for no penetration were obtained on probable cobbles in Boreholes BCWE-2 and BCWE-5.

The moisture content of samples of the sand and gravel fill ranged from 3% to 12%.

Selected samples of the sand and gravel fill underwent laboratory gradation analysis. The results of these tests are summarized on the Record of Borehole sheets in Appendix A and the grain size distribution curves are plotted on Figure B1, Appendix B. The results of the three gradation analyses are as follows.

Gravel%	37 to 76
Sand%	22 to 56
Silt and Clay%	2 to 7

### **5.3 Cobbles and Boulders**

Rock coring equipment was required to advance the boreholes through a layer of cobbles and boulders below the sand and gravel fill in Boreholes BCWE-1, BCWE-2, BCWE-4 and BCWE-5. The cobbles and boulders either form the base of the embankment fill or represent native materials lining the original stream channel.

The layer of cobbles and boulders was 0.7 m to 1.2 m thick, with the lower boundary encountered at depths of 2.3 m to 4.2 m (elevation 231.7 to 230.8).

#### **5.4 Sand and Gravel**

Native sand and gravel was encountered below the cobbles and boulders in Boreholes BCWE-2 and BCWE-4. The sand and gravel was brown and contained trace silt and clay as well as cobbles and boulders.

The sand and gravel layer was 1.1 m thick in Borehole BCWE-2 and 3.0 m thick in Borehole BCWE-4. The base of the sand and gravel layer was encountered at a depth of 5.3 m in both boreholes (elevations 229.7 and 227.9).

SPT N-values recorded in the native sand and gravel ranged from 26 blows for 0.3 m penetration to 50 blows for 0.05 m penetration, indicating a compact to very dense relative density. SPT N-values recorded for penetration less than 0.3 m can be attributed to the presence of cobbles and boulders.

One sample of the native sand and gravel was selected for laboratory grain size analysis. The results of this test are summarized below and plotted on Figure B2, Appendix B.

Gravel%	56
Sand%	41
Silt and Clay%	3

A thin layer (100mm) of gravel containing some sand was encountered overlying bedrock at Borehole BCWE-3.

#### **5.5 Sand**

Orange brown sand with some silt and trace of gravel was encountered beneath the cobbles and boulders in Borehole BCWE-1. The sand layer was 1.5 m thick with a lower boundary at 4.5 m depth (elevation 230.2).

A SPT 'N' value of 22 blows for 0.3 m penetration was recorded in the sand, indicating a compact condition. A moisture content of 19% was measured

#### **5.6 Silty Sand**

Native silty sand was encountered beneath the sand layer in Borehole BCWE-1 and below the cobbles and boulders in Borehole BCWE-5. The silty sand was grey and contained trace to some gravel and trace clay. A gravelly zone with cobbles was encountered within the silty sand in Borehole BCWE-5 at a depth of 4.6 m.

The silty sand was 2.2 m thick in both boreholes. The base of the silty sand was encountered at depths of 6.7 m and 5.2 m (elevations 228.0 and 229.4) in Boreholes BCWE-1 and BCWE-5, respectively.

SPT N-values recorded in the native silty sand ranged from 35 blows for 0.3 m penetration to 50 blows for 0.075 m penetration, indicating a dense to very dense relative density.

The moisture content of samples of the silty sand ranged from 7% to 15%.

One sample of the silty sand underwent laboratory gradation analysis, the results of which are summarized below and are plotted on Figure B3, Appendix B.

Gravel%	10
Sand%	52
Silt%	29
Clay%	9

### 5.7 Cobbles and Boulders

A layer of cobbles and boulders was encountered overlying bedrock in Boreholes BCWE-1, BCWE-2, BCWE-4 and BCWE-5. The thickness of the layer of cobbles and boulders ranged from 0.2 m to 0.8 m, with the base of the layer encountered at depths of 5.5 m to 7.4 m (elevations 228.9 and 227.3).

### 5.8 Bedrock

Bedrock was encountered in all boreholes. The depths to bedrock proven by coring, manual excavation or visual assessment are summarized in Table 5.1. The bedrock surface rises to the south and outcrops at the culvert outlet.

**Table 5.1 – Depth to Bedrock at Borehole Locations**

<b>Borehole</b>	<b>Depth to Bedrock (m)</b>	<b>Top of Bedrock Elevation (m)</b>	<b>Proving Method</b>
BCWE-1	7.4	227.3	Cored
BCWE-2	6.1	228.9	Cored
BCWE-3	0.1	232.6	Manual excavation
BCWE-4	5.5	227.7	Cored
BCWE-5	5.8	228.8	Cored
BCWE-6	1.4	232.1	Visual inspection

The bedrock recovered from the cores was described as intermediate metavolcanic rock with occasional quartz veins. The bedrock is grey in colour with white bands.

Core recovery was typically high, between 93% and 100%. Lower core recovery values of 49% and 57% were obtained in the initial core run in Boreholes BCWE-1 and BCWE-5, advanced partially in the cobbles and boulders overlying the bedrock. RQD values typically ranged from 83% to 100%, indicating good to excellent rock quality. Lower RQD values of 23% to 58% were measured in Run #1 of Boreholes BCWE-1, BCWE-4

and BCWE-5, reflecting the presence of cobbles and boulders in the initial run. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally less than 5 with occasional values over 5.

The unconfined compressive strength of the rock, estimated from the results of point load tests conducted on the rock core samples, typically ranged from 75 to 135 MPa, indicating a strong to very strong intact rock. Individual values of 21 MPa (weak) and 195 MPa (very strong) were obtained in Boreholes BCWE-4 and BCWE-1, respectively. The results are summarized on the Record of Borehole sheets in Appendix A (as average per run).

## 5.9 Water Levels

Water levels measured in the open boreholes upon completion of the drilling operations are summarized in Table 5.2. Water was added to the boreholes during coring operations and therefore the measured water levels may not be indicative of stabilized groundwater conditions at the site.

**Table 5.2 – Water Level Measurements**

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
BCWE-1	Oct. 20, 2011	1.1	233.6	Upon completion
BCWE-2	Oct. 21, 2011	2.1	232.9	Upon completion
BCWE-4	Oct. 22, 2011	0.8	232.4	Upon completion
BCWE-5	Oct. 20, 2011	1.3	233.3	Upon completion

The water level in the creek at the time of the fieldwork was in the order of 0.1 m above the culvert invert level. Based on this observation and the culvert invert levels shown on the preliminary design drawings, the creek water level is estimated to be between elevation 232.6 at the inlet and 230.9 at the outlet. These water levels are consistent with water levels of 232.6 and 231.1 shown on preliminary plan plates (June 2010). The water falls approximately 0.3 m upon exiting the CSPs.

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

## 6 MISCELLANEOUS

The borehole locations were selected by Thurber Engineering Ltd. and staked in the field by McCormick Rankin Corporation (MRC). The co-ordinates and ground surface elevations at the boreholes were surveyed by MRC. Where boreholes required relocation from the staked location, field measurements were recorded and the surveyed coordinates and elevations adjusted accordingly.

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

Eastern Ontario Diamond Drilling Ltd. from Hawkesbury, Ontario supplied a track mounted CME 45 drill rig and conducted the drilling, sampling and in-situ testing operations.

The field program was supervised on a full time basis by Ms. Eckie Siu of Thurber.

Routine laboratory testing was carried out by Thurber Engineering Ltd.

Overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng. Interpretation of the data and preparation of this report were carried out by Ms. Lindsey Blaine, E.I.T. and Ms. Mei T. Cheong, M.Phil.

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

### Thurber Engineering Ltd

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## **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 <sup>(1)</sup> '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

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


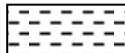



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	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

<u>TERMS</u>	
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.

RECORD OF BOREHOLE No BCWE-1

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 467.1 E 375 003.6 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.20 - 2011.10.20 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
234.7							20 40 60 80 100									
							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE				WATER CONTENT (%)					
							20 40 60 80 100	w <sub>p</sub> w      w <sub>L</sub>								
0.0	<b>SAND</b> and <b>GRAVEL</b> , trace silt and clay Dense to Compact Brown Damp (FILL)		1	GS												
			1	SS	49											
	Moist to Wet Occasional cobbles		2	SS	28											
232.4																
2.3	Cored through <b>COBBLES</b> and <b>BOULDERS</b>															
231.7																
3.0	<b>SAND</b> , fine grained, some silt, trace gravel Compact Orange Brown Wet		3	SS	22											
230.2																
4.5	Silty <b>SAND</b> , trace gravel Very Dense Grey Wet		4	SS	50/ 0.075											
228.0																
6.7	Cored through <b>COBBLES</b> and <b>BOULDERS</b>		1	RUN												
227.3																
7.4	<b>BEDROCK</b> , metavolcanic, grey with white bands, occasional quartz interbeds  Occasional mechanical breaks  Sub-vertical fracture (25mm) at 9.1m, 9.4m, 9.5m, 9.9m: 75mm at 8.0m		2	RUN												

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BCWE-1

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 467.1 E 375 003.6 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.20 - 2011.10.20 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20 40 60 80 100									
	<b>BEDROCK</b> , metavolcanic, grey with white bands, occasional mechanical breaks							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
224.0								20 40 60 80 100									
10.7	END OF BOREHOLE AT 10.7m. WATER LEVEL AT 1.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 3.6m, THEN AUGER CUTTINGS TO SURFACE.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BCWE-2

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 463.3 E 375 020.7 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LRB

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE						
235.0								20 40 60 80 100						
0.0	<b>SAND and GRAVEL</b> , trace silt and clay Very Dense to Compact Brown Damp (FILL)		1	GS			235							
			1	SS	56		234							
	Occasional cobbles Moist		2	SS	31									
	Wet		3	SS	50/ 0.100		233							
231.9								232						
3.1	Cored through <b>COBBLES</b> and <b>BOULDERS</b>													
230.8							231							
4.2	<b>SAND and GRAVEL</b> , with cobbles and boulders, trace silt and clay Compact Brown Wet		4	SS	26		230							
229.7														
5.3	Cored through <b>COBBLES</b> and <b>BOULDERS</b>						229							
228.9														
6.1	<b>BEDROCK</b> , metavolcanic, occasional quartz interbeds, grey with white bands, occasional vertical and mechanical bands Sub-vertical fracture (25mm to 100mm) at 6.4m, 6.6m, 6.8m, 7.0m and 7.1m Sub-horizontal fracture at 6.9m  Sub-vertical fracture (25mm to 75mm) at 8.2m, 8.3m, 8.8m 125mm at 8.4m		1	RUN			228							
				2	RUN			227						
225.9							226							
9.1	END OF BOREHOLE AT 9.1m. WATER LEVEL AT 2.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 3.0m, THEN SAND AND GRAVEL TO													

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BCWE-2

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 463.3 E 375 020.7 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LRB

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w <sub>p</sub>	w	w <sub>L</sub>		
	Continued From Previous Page SURFACE.																

ONTMT4S 1182.GPJ 12/14/11

RECORD OF BOREHOLE No BCWE-3

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 374 459.7 E 375 036.8 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Manual Excavation & Visual Inspection COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LRB

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
232.7 0.0 0.1	GRAVEL, some sand, mixed with organics Brown (60mm)  END OF BOREHOLE AT 0.06m ON BEDROCK.												

## METRIC

[illegible]

ONTMT4S 1182.GPJ 6/5/12



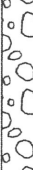
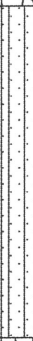


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BCWE-5

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 473.9 E 375 018.8 Blind Creek West EBL ORIGINATED BY ES  
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.20 - 2011.10.20 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
234.6							20 40 60 80 100	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub>									
							UNCONFINED + FIELD VANE QUICK TRIAXIAL X LAB VANE										
							WATER CONTENT (%)										
							20 40 60										
0.0	SAND and GRAVEL Dense Brown Damp (FILL)		1	GS													
			1	SS	42												
	No recovery		2	SS	160 0.0												
232.8																	
1.8	Cored through COBBLES and BOULDERS																
231.6																	
3.0	Silty SAND, some gravel, trace clay Dense Grey Moist																
			3	SS	35												
	Becoming gravelly, occasional cobbles Wet		4	SS	40												
229.4																	
5.2	Cored through COBBLES and BOULDERS		1	RUN													
228.8																	
5.8	BEDROCK, metavolcanic, grey with white bands, quartz interbeds																
	Sub-vertical fractures (50mm) at 6.6m, 7.3m, 7.4m		2	RUN													
	Highly broken zone (75mm) at 7.6m																
	Sub-vertical fractures (25mm to 50mm) at 8.3m, 8.5m, 8.6m, 8.7m, 9.1m		3	RUN													
225.4																	
9.2	END OF BOREHOLE AT 9.2m. WATER LEVEL AT 1.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 3.0m,																

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BCWE-5

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 473.9 E 375 018.8 Blind Creek West EBL ORIGINATED BY ES  
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.20 - 2011.10.20 CHECKED BY LRB

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		W <sub>p</sub>	W		
	Continued From Previous Page						20 40 60 80 100						
	THEN AUGER CUTTINGS TO SURFACE.						20 40 60 80 100						

RECORD OF BOREHOLE No BCWE-6

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 374 469.3 E 375 039.0 Blind Creek West EBL ORIGINATED BY ES  
 HWY 11/17 BOREHOLE TYPE Visual Inspection of Embankment Slope Surface COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
233.5														
0.0	SAND and GRAVEL, some cobbles and boulders Brown (FILL)						233							
232.1														
1.4	BEDROCK EXPOSED AT TOP OF EMBANKMENT SLOPE ADJACENT TO BOREHOLE LOCATION.													

ONTMT4S 1182.GPJ 6/5/12

+ 3, X 3: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

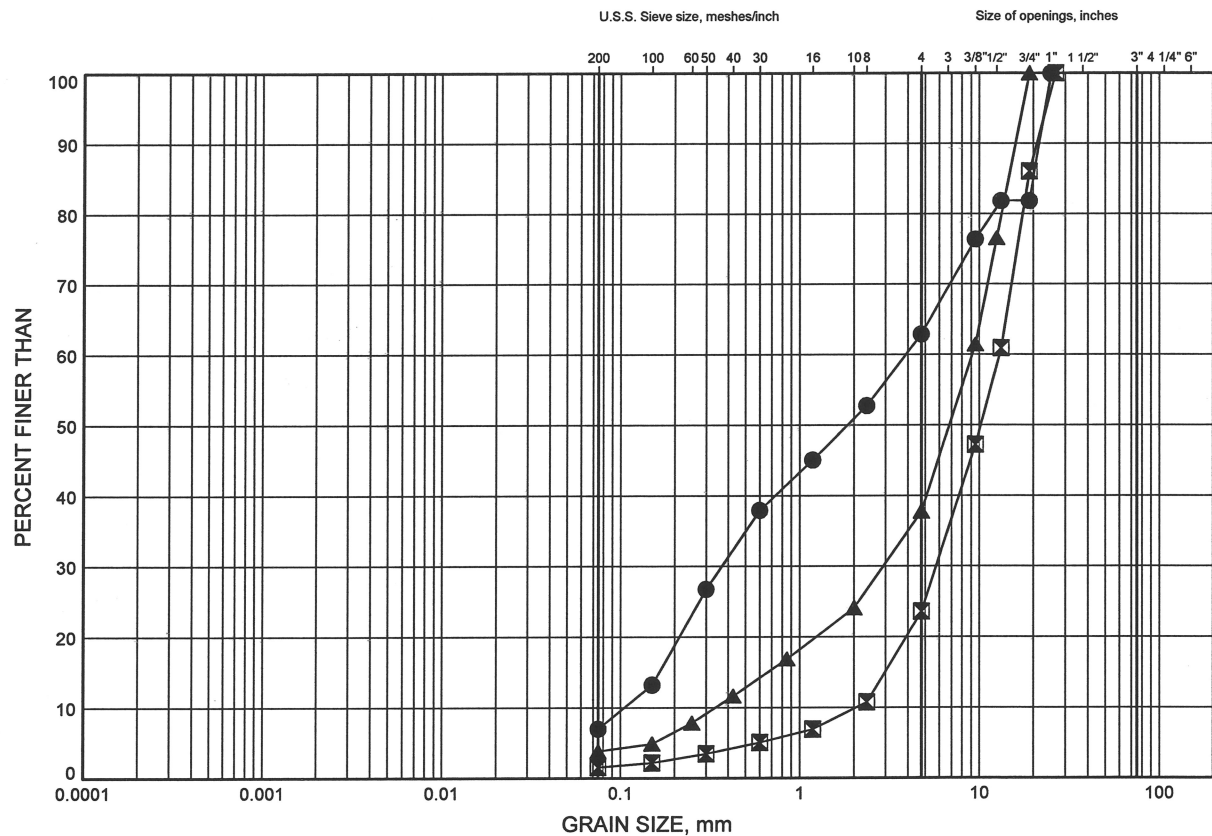
## **Appendix B**

### **Laboratory Test Results**

# Hwy 17 - Hwy 527 easterly 12.6km GRAIN SIZE DISTRIBUTION

FIGURE B1

## SAND & GRAVEL FILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWE-1	1.83	232.83
⊠	BCWE-2	2.44	232.54
▲	BCWE-4	1.07	232.12

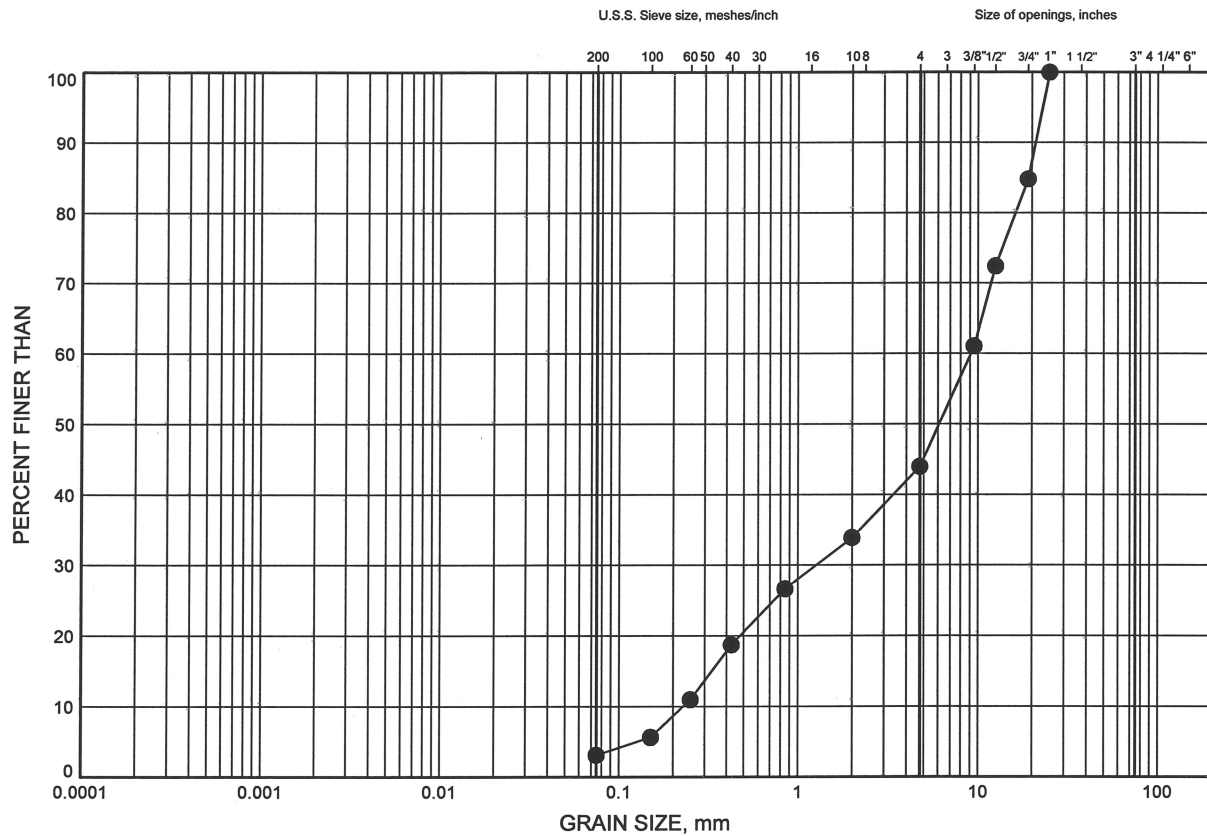


W.P.# 623-89-00.....  
Prepared By AN.....  
Checked By LRB.....

# Hwy 17 - Hwy 527 easterly 12.6km GRAIN SIZE DISTRIBUTION

FIGURE B2

## SAND & GRAVEL



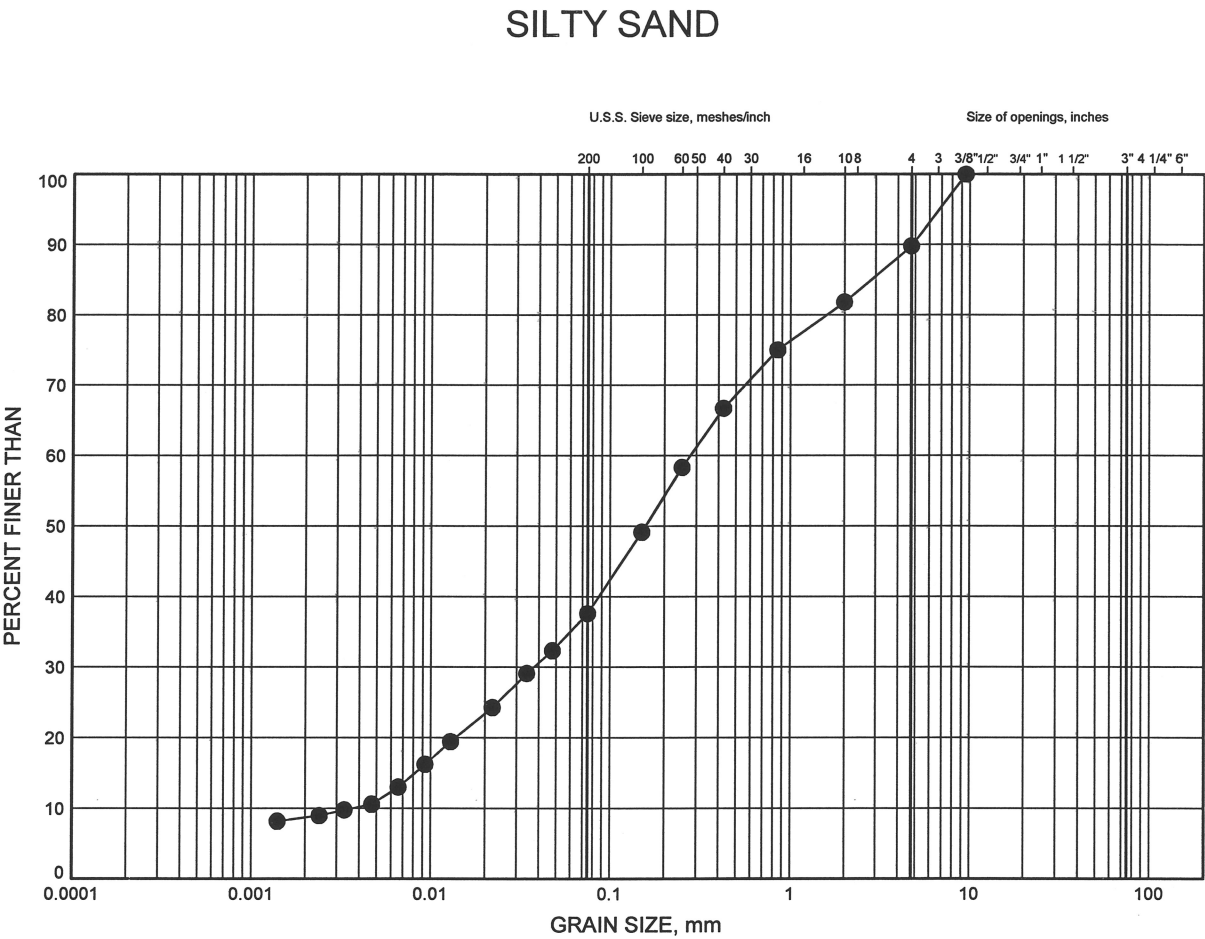
SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWE-2	4.88	230.10

Hwy 17 - Hwy 527 easterly 12.6km  
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)
●	BCWE-5	3.96	230.60

GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 12/1/11

W.P.# 623-89-00  
Prepared By AN  
Checked By LRB



## **Appendix C**

### **Site Photographs**



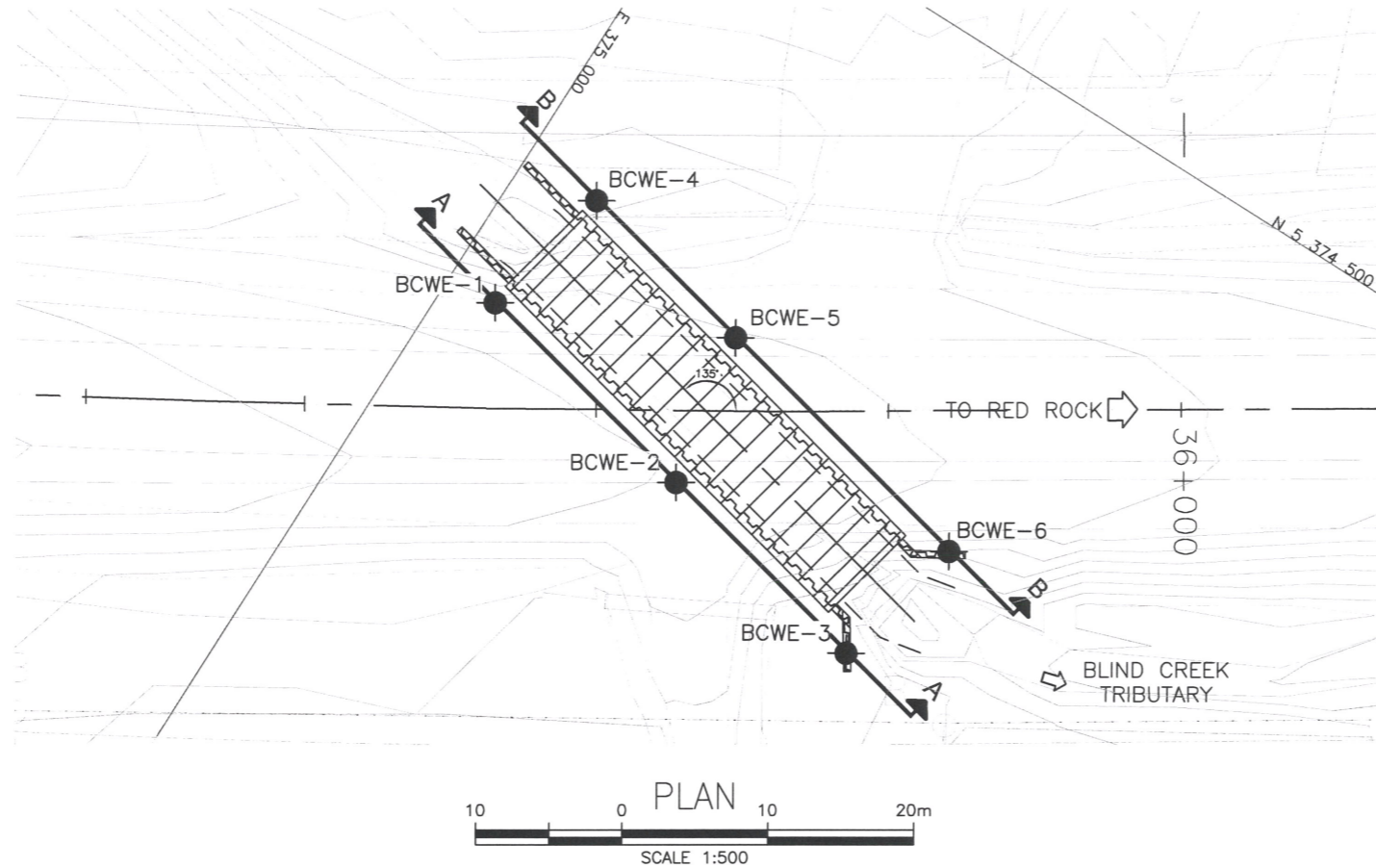
**Photograph 1 – Blind Creek West EBL Culvert Inlet**



**Photograph 2 – Blind Creek West EBL Culvert Outlet**

## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**



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



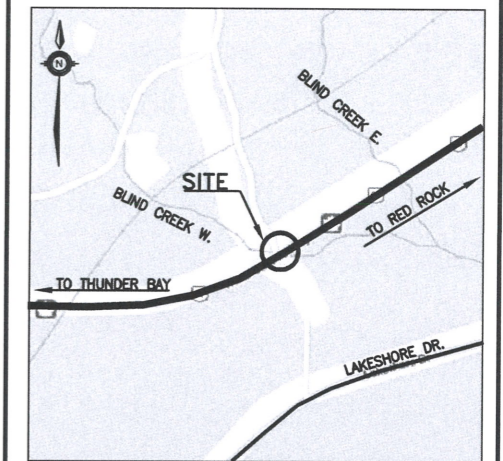
CONT No 2012-6010  
WP No 623-89-00

HIGHWAY 11/17  
BLIND CREEK WEST EBL  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA

**Hatch Mott MacDonald**

**THURBER ENGINEERING LTD.**

SHEET  
240



**KEYPLAN  
LEGEND**

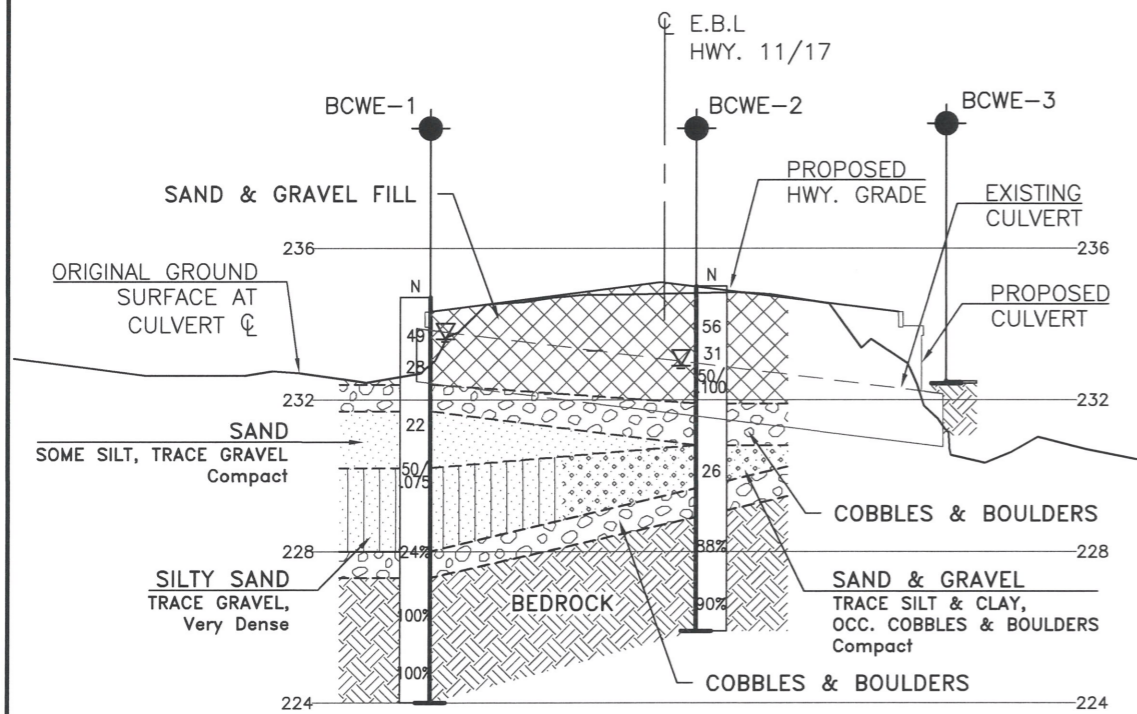
●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊕	Head Artesian Water
⊕	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BCWE-1	234.7	5 374 467.1	375 003.6
BCWE-2	235.0	5 374 463.3	375 020.7
BCWE-3	232.7	5 374 459.7	375 036.8
BCWE-4	233.2	5 374 476.8	375 005.7
BCWE-5	234.6	5 374 473.9	375 018.8
BCWE-6	233.5	5 374 469.3	375 039.0

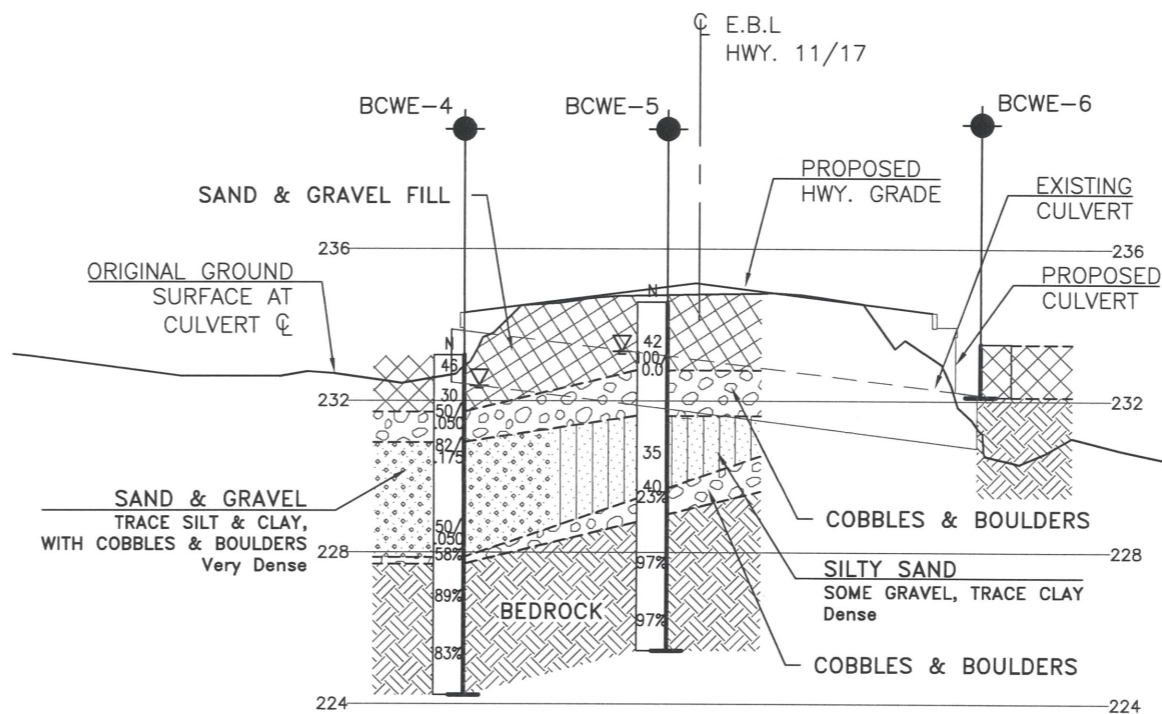
**-NOTES-**

- 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.

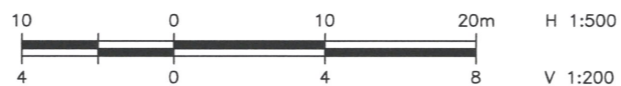
**GEOCRES No. 52A-160**



SECTION A-A



SECTION B-B



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK	LRB
DRAWN	AN	CHK	LRB
CODE	CAN/CSA	S6-06	LOAD CL-625-ONT
SITE	48C-350/C1	STRUCT	DWG 2
DATE	JULY	2012	