

**FOUNDATION INVESTIGATION REPORT  
BLIND CREEK WEST CULVERT – WBL  
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/C2**

**Geocres Number: 52A-163**

**Report to**

**McCormick Rankin Corporation**

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July 31, 2012  
File: 19-1351-182

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of the Blind Creek West culvert under the new westbound lanes of Highway 11/17 in the Township of MacGregor, District of Thunder Bay. The new 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 approximately 80 m north of the existing Highway 11/17 alignment.

Blind Creek West flows from north to south at the proposed culvert location. Lands surrounding the culvert site consist of forested areas. Cobbles and boulders were observed within the creek channel and at ground surface at various locations across the site.

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 located near a boundary between mafic to intermediate metavolcanic bedrock and metasedimentary bedrock. Bedrock samples collected during the field investigation confirm that the site is underlain by intermediate metavolcanic rock. Locally, the bedrock is overlain by deposits of sand and gravel, silty sand and sand.

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

The site investigation and field testing for this project were carried out between November 1 and 6, 2011. Six boreholes, identified as BCWW-1 to BCWW-6, were drilled and sampled at the site.

Boreholes BCWW-1 and BCWW-4 were located near the proposed culvert inlet, Boreholes BCWW-2 and BCWW-5 were located at the centreline of the proposed WBL, and Boreholes BCWW-3 and BCWW-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.

The boreholes were advanced to depths of 6.8 m to 10.7 m (elevations 230.6 to 225.6). Bedrock was proven by coring 3.4 m to 3.8 m into bedrock in all boreholes.

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 during and upon completion of the drilling operations. Groundwater conditions observed after completion of coring were not representative of site conditions as water was introduced into the borehole during coring. A standpipe piezometer was installed in Borehole BCWW-5 for subsequent monitoring of groundwater levels. The completion details of the piezometers and boreholes are summarized in Table 3.1. The piezometer was decommissioned in general accordance with MOE Regulation 903 in late July 2012.



**Table 3.1 – Piezometer and Borehole Completion Details**

<b>Borehole</b>	<b>Borehole Depth/ Elevation (m)</b>	<b>Completion Details</b>
BCWW-1	-	Backfilled with bentonite holeplug to 4.5 m, then auger cuttings to surface .
BCWW-2	-	Backfilled with bentonite holeplug to 5.5 m, then auger cuttings to surface.
BCWW-3	-	Backfilled with bentonite holeplug and auger cuttings to surface.
BCWW-4	-	Backfilled with bentonite holeplug and auger cuttings to surface.
BCWW-5	4.3 / 232.4	Bentonite holeplug from 7.7 m to 4.3 m. Piezometer installed at 4.3 m. Filter sand from 4.3 m to 1.5 m, then bentonite holeplug to surface.
BCWW-6	-	Backfilled with bentonite holeplug and auger cuttings to surface.

#### **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 topsoil overlying a layer of gravelly sand, underlain by various cohesionless deposits of sand and gravel, sand to silty sand, and silt. Cobbles and boulders were encountered within these deposits. Bedrock was encountered below the cohesionless deposits. More detailed descriptions of the individual strata are presented below.

### **5.1 Topsoil**

Topsoil was encountered at the surface in all boreholes. The topsoil is dark brown to black and typically described as silty with some sand. The topsoil thickness varied from 200 mm to 400 mm.

### **5.2 Gravelly Sand**

A layer of gravelly sand was encountered below the topsoil in all boreholes. The gravelly sand is brown, locally dark brown or grey, and contains trace to some silt, and cobbles and boulders. The use of coring methods was required to advance Boreholes BCWW-1 and BCWW-2 through the cobbles and boulders within the gravelly sand.

The gravelly sand layer was 0.3 m to 2.9 m thick. The base of this layer was encountered at depths of 0.6 m to 3.1 m (elevations 236.1 to 234.3).

SPT N-values recorded in the gravelly sand ranged from 26 blows for 0.3 m penetration to 100 blows/0.125 m, indicating a compact to very dense relative density. The higher 'N' values may be associated with the presence of cobbles and boulders. N-values of 6 to 16 blows for 0.3 m were obtained in tests commenced at the ground surface (partially in topsoil and partially in the gravelly sand), indicating a surficially loose to compact condition.

The moisture content of samples of the gravelly sand ranged from 8% to 28%, with the higher values possibly reflecting an organic content.

Two samples of the gravelly sand underwent laboratory gradation analysis. The results of this testing are presented on the Record of Borehole sheets in Appendix A and the grain size distribution curves are plotted on Figure B1, Appendix B. The results are as follows:

Gravel %	21 to 25
Sand %	55 to 71
Silt and Clay %	8 to 20

### **5.3 Sand and Silt**

A layer of sand and silt was encountered below the gravelly sand at 2.1 m depth (elevation 235.4) locally in Borehole BCWW-2. The sand and silt was brown and contained trace gravel and trace clay. The sand and silt layer was 0.8 m thick with a base at 2.9 m depth (elevation 234.6).

An SPT N-value of 31 blows for 0.3 m penetration was recorded in the sand and silt layer, indicating a dense condition. The moisture content of a sample was 16%.

A sample of the sand and silt underwent laboratory gradation analysis, the results of which are summarized below. The results of this test are also presented on the Record of Boreholes sheets in Appendix A and the grain size distribution curve for this sample is plotted on Figure B2, Appendix B.

Gravel %	7
Sand %	43
Silt %	46
Clay %	4

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

A layer of brown to grey sand and gravel with cobbles and boulders was encountered below the gravelly sand in Borehole BCWW-1 and below the sand and silt layer in Borehole BCWW-2. The sand and gravel layer contained some silt. Coring was required to advance the boreholes through the cobbles and boulders within the sand and gravel layer.

The sand and gravel layer was 3.8 m and 3.0 m thick in Boreholes BCWW-1 and BCWW-2, respectively. The base of this layer was encountered at depths of 5.3 m and 5.9 m (elevations 232.2 and 231.6).

SPT N-values recorded in the sand and gravel layer generally ranged from 38 blows for 0.3 m penetration to 100 blows/0.125 m penetration, indicating a dense to very dense relative density and/or the presence of cobbles and boulders. A lower N-value of 17 blows for 0.3 m was obtained near the base of this deposit in Borehole BCWW-1, indicating a compact condition.

The moisture content of samples of the sand and gravel layer ranged from 8% to 16%.

One sample of the sand and gravel underwent laboratory gradation analysis. The results of this testing are presented on the Record of Borehole sheets in Appendix A and the grain size distribution curve is plotted on Figure B3, Appendix B. The results are as follows:

Gravel %	59
Sand %	29
Silt and Clay %	12

#### **5.5 Silt**

A layer of brown to grey silt was encountered below the gravelly sand layer locally in Borehole BCWW-3. The silt contained trace sand and trace to some clay. The silt layer was 4.6 m thick with a lower boundary at 5.5 m depth (elevation 230.8).

SPT N-values recorded in the silt layer ranged from 7 to 21 blows for 0.3 m penetration, indicating a loose to compact relative density. The moisture content of samples of the silt ranged from 21% to 26%.

Two samples of the silt underwent laboratory gradation analysis, the results of which are summarized below. The results of this testing are also presented on the Record of Boreholes sheets in Appendix A and the grain size distribution curves are plotted on Figure B4, Appendix B.

Gravel %	0
Sand %	6 to 9
Silt %	80 to 88
Clay %	6 to 11

### 5.6 Silty Sand

A layer of silty sand was encountered below the silt in Borehole BCWW-3 and below the gravelly sand in Boreholes BCWW-4 to BCWW-6. The silty sand was brown to grey and contains trace to some gravel and trace clay. This unit became gravelly immediately above the underlying bedrock in Borehole BCWW-3.

The thickness of the silty sand ranged from 0.3 m to 2.9 m, with the lower boundary encountered at depths of 2.1 m to 7.2 m (elevations 234.6 to 229.1).

SPT N-values recorded in the native silty sand typically ranged from 39 to 61 blows for 0.3 m penetration, indicating a dense to very dense relative density. An N-value of 14 blows per 0.3 m (compact) was obtained in the upper part of this layer in Borehole BCWW-5. A higher N-value of 50 blows for 0.15 m penetration was recorded in Borehole BCWW-4 just above the bedrock surface.

The moisture content of samples of the silty sand ranged from 10% to 18%.

Four samples of the silty sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and are plotted on Figure B5, Appendix B.

Gravel %	5 to 19
Sand %	54 to 55
Silt %	23 to 35
Clay %	4 to 5

## 5.7 Sand

A layer of sand containing trace gravel and some silt was encountered below the silty sand in Boreholes BCWW-5 and BCWW-6. The sand layer was 2.2 m and 1.5 m thick with a lower boundary at depths of 4.3 m and 5.5 m (elevations 232.4 and 230.2). This unit became gravelly immediately above the underlying bedrock in Borehole BCWW-6.

SPT N-values of 4 and 17 blows for 0.3 m penetration were recorded in the sand in Borehole BCWW-5, indicating a loose to compact relative density. An N-value of 100 blows per 0.3 m (very dense) was obtained in Borehole BCWW-6.

The moisture content of samples of the sand ranged from 10% to 14%.

A sample of the sand underwent laboratory gradation analysis, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and are plotted on Figure B6, Appendix B.

Gravel %	8
Sand %	76
Silt and Clay %	16

## 5.8 Bedrock

Bedrock was proven below the sand and gravel, silty sand and sand by coring in all boreholes. The depths to bedrock are summarized in Table 5.1.

**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>Method</b>
BCWW-1	5.3	232.2	Cored
BCWW-2	5.9	231.6	Cored
BCWW-3	7.2	229.1	Cored
BCWW-4	3.4	234.0	Cored
BCWW-5	4.3	232.4	Cored
BCWW-6	5.5	230.2	Cored

The bedrock recovered in the cores was described as greenish grey metavolcanic bedrock. Zones of highly fractured rock (rubble zones) were noted in Boreholes BCWW-1, BCWW-2 and BCWW-5.

Total core recovery typically ranged from 86% to 100%. One run in Boreholes BCWW-2 yielded a lower core recovery of 56% in a highly fractured rock zone.

RQD values recorded for the bedrock core varied widely. RQD values typically ranged from 52% to 100%, indicating fair to excellent rock quality. Four values ranged from 14%

to 47%, indicating a very poor to poor rock quality, and an RQD value of 0% (very poor quality) was recorded in the initial two core runs from Borehole BCWW-2. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, varied from 0 to 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 118 to 197 MPa, indicating a very strong intact rock. Strengths of 32 to 88 MPa were measured on three samples, indicating a medium strong to strong rock. The results are summarized on the Record of Borehole sheets in Appendix A (as average per run).

### 5.9 Water Levels

Groundwater was observed at depths of 0.9 to 1.7 m in the boreholes during drilling. Water was added to the boreholes during coring operations and therefore water levels were not recorded upon completion. A standpipe piezometer was installed in Borehole BCWW-5 following completion of drilling.

The ground water depths and levels measured in the piezometer and in the open boreholes during drilling are summarized in Table 5.2.

**Table 5.2 – Water Level Measurements**

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
BCWW-1	Nov. 03, 2011	1.7	235.8	During drilling
BCWW-2	Nov. 02, 2011	1.5	236.0	During drilling
BCWW-3	Nov. 01, 2011	1.5	234.8	During drilling
BCWW-4	Nov. 06, 2011	1.4	236.0	During drilling
BCWW-5	Nov. 06, 2011	0.9	235.8	During drilling Piezometer
	Jan. 30, 2012	2.0	234.7	
BCWW-6	Nov. 05, 2011	0.9	234.8	During drilling

The water depth in the creek at the time of the fieldwork was variable but generally in the order of 0.15 m. Based on this observation and the creek invert levels shown on the preliminary design drawings, the creek water level is estimated to be near elevation 236.

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 Mr. Ryan Kromer, E.I.T. 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. R. Palomeque Reyna, P.Eng.

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

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


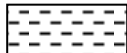



 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (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 BCWW-1

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 374 511.8 E 374 906.1 Blind Creek West WBL ORIGINATED BY RK  
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.11.03 - 2011.11.03 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	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										
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				WATER CONTENT (%)							
							20 40 60 80 100				20 40 60							
237.5																		
0.0	<b>TOPSOIL</b> , some sand Dark Brown to Black Moist (300mm)		1	SS	9		237											
237.2																		
0.3																		
	Gravelly <b>SAND</b> , trace silt and clay, some cobbles and boulders Loose to Very Dense Brown Moist to Wet	2	SS	100/ 0.125														
236.0	Auger grinding, cored through cobbles and boulder from 0.9m to 1.5m	3	SS	100/ 0.125				236										
1.5	<b>SAND</b> and <b>GRAVEL</b> , some silt and clay, with cobbles and boulders Very Dense to Dense Brown Wet Cored through cobbles and boulders from 1.5m to 2.3m																	
			4	SS	38		235											
			Cored through cobbles and boulders from 3.0m to 4.5m Grey	5	SS	43		234										
				6	SS	17		233										
232.2																		
5.3	<b>BEDROCK</b> , metavolcanic, greenish grey Rubble zone from 5.3m to 5.6m      Mechanical breaks from 7.4m to 7.6m		1	RUN			232											

ONTMT4S 1182.GPJ 6/28/12

RECORD OF BOREHOLE No BCWW-2

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 495.5 E 374 912.7 Blind Creek West WBL ORIGINATED BY RK  
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.11.02 - 2011.11.02 CHECKED BY RPR

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			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
237.5												
0.0												
237.2												
0.3	TOPSOIL, some sand, occasional rootlets Black to Dark Brown Moist (300mm)		1	SS	9		237					
	Gravelly SAND, trace silt and clay, some cobbles and boulders, Loose to Very Dense Brown Moist to Wet Cored through cobbles and boulders from 0.3m to 2.1m		2	SS	64		236					
235.4												
2.1	SAND and SILT, trace gravel, trace clay Dense Brown Wet		3	SS	31		235					7 43 46 4
234.6												
2.9	SAND and GRAVEL, some silt and clay, cobbles and boulders Very Dense Brown Wet Cored through cobbles and boulders from 3.0m to 5.9m  Frequent boulders and cobbles at 4.5m		4	SS	100/ 0.125		234					
			5	SS	50/ 0.125		233					
							232					
231.6												
5.9	BEDROCK, metavolcanic, greenish grey, occasional vertical joints  Rubble zone from 6.4m to 7.8m  Fresh		1	RUN			231					RUN #1 TCR=86% SCR=0% RQD=0%
			2	RUN			230					RUN #2 TCR=56% SCR=0% RQD=0%
			3	RUN			229					RUN #3 TCR=92% SCR=77% RQD=52% UCS=32MPa (Average)
228.2												
9.3	END OF BOREHOLE AT 9.3m. WATER OBSERVED AT 1.5m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 5.5m, THEN											

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 BCWW-2

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 495.5 E 374 912.7 Blind Creek West WBL ORIGINATED BY RK  
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.02 - 2011.11.02 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			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	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued From Previous Page HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																

# RECORD OF BOREHOLE No BCWW-3

1 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 478.1 E 374 920.1 Blind Creek West WBL ORIGINATED BY RK  
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.01 - 2011.11.01 CHECKED BY RPR

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					WATER CONTENT (%)							
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE					w <sub>P</sub> w      w <sub>L</sub>							
236.3							20	40	60	80	100	20	40	60		GR	SA	SI	CL	
0.0	TOPSOIL, occasional rootlets and wood fragments Dark Brown Moist (300mm)		1	SS	6		236													
236.0																				
0.3																				
235.4	Gravelly SAND, some silt Loose to Compact Brown Damp  SILT, trace sand, trace to some clay Compact to Loose Brown Moist to Wet		2	SS	12		235													
0.9																				
								234												
			4	SS	7															
								233												
			5	SS	8															
	Grey						232													
			6	SS	13															
							231													
230.8																				
5.5	Silty SAND, trace to some gravel, trace clay Dense Brown Wet  Gravelly		7	SS	39		230													
229.1			1	RUN																
7.2	BEDROCK, metavolcanic, greenish grey, occasional horizontal breaks		2	RUN			229													
					3	RUN		228												
							227													
			4	RUN																

Continued Next Page

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

RECORD OF BOREHOLE No BCWW-3

2 OF 2

METRIC

W.P. 623-89-00 LOCATION N 5 374 478.1 E 374 920.1 Blind Creek West WBL ORIGINATED BY RK  
 HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.01 - 2011.11.01 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						W <sub>P</sub>	W
	Continued From Previous Page																		
225.6	<b>BEDROCK</b> , metavolcanic, greenish grey, occasional horizontal breaks  Mechanical break from 10.5m to 10.6m						226												
10.7	END OF BOREHOLE AT 10.7m. WATER OBSERVED AT 1.5m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																		



# RECORD OF BOREHOLE No BCWW-4

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 374 518.1 E 374 923.5 Blind Creek West WBL ORIGINATED BY RK  
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.11.06 - 2011.11.06 CHECKED BY RPR

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					WATER CONTENT (%)											
237.4								20	40	60	80	100		W <sub>P</sub>	W	W <sub>L</sub>		GR	SA	SI	CL			
0.0	<b>TOPSOIL</b> , silty, some sand, occasional rootlets Dark Brown Moist (200mm)  Gravelly <b>SAND</b> , some silt, trace clay Loose to Compact Brown Moist to Wet  Very Dense Grey  Compact		1	SS	8		237								o									
0.2																	o							
									236									o						
									235									o						
									234									o						
234.3																								
3.1	Silty <b>SAND</b> , some gravel, trace clay Very Dense Grey Wet  <b>BEDROCK</b> , metavolcanic, greenish grey, occasional horizontal breaks		5	SS	50/ 0.150		234								o									
234.0																								
3.4									233															
									232															
									231															
230.6																								
6.8	END OF BOREHOLE AT 6.8m. WATER OBSERVED AT 1.4m DURING DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																							

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

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>P</sub>	W	W <sub>L</sub>		
236.7	<b>TOPSOIL</b> , silty, some sand, occasional rootlets Black Moist (300mm) Gravelly <b>SAND</b> , some silt Compact Brown Moist Silty <b>SAND</b> , trace clay, trace gravel Compact to Dense Grey Wet		1	SS	16											GR SA SI C	
236.4																	
0.3																	
236.1																	
0.6																	
234.6	<b>SAND</b> , some silt, trace gravel Loose to Compact Grey Wet		2	SS	14												
232.4	<b>BEDROCK</b> , metavolcanic, greenish grey, occasional horizontal breaks Rubble zone (125mm) at 4.3m		3	SS	35												
2.1																	
4.3	Rubble zone (125mm) at 4.3m																
230	Rubble zone (75mm) at 7.5m		4	SS	4												
229.0	END OF BOREHOLE AT 7.7m. WATER LEVEL AT 0.9m BEFORE CORING STARTED. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) Jan. 30/12      2.0      234.7		5	SS	17												
7.7																	

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

# RECORD OF BOREHOLE No BCWW-6

1 OF 1

METRIC

W.P. 623-89-00 LOCATION N 5 374 485.1 E 374 939.5 Blind Creek West WBL ORIGINATED BY RK  
HWY 11/17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.11.05 - 0201.11.05 CHECKED BY RPR

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				WATER CONTENT (%)				GR	SA	SI	CL	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE												
235.7							20	40	60	80	100									
0.0	<b>TOPSOIL</b> , silty, occasional rootlets Black Moist (400mm)		1	SS	6															
235.3																				
0.4																				
234.6	Gravelly <b>SAND</b> Loose to Dense Brown to Dark Brown Moist to Wet		2	SS	31															
1.1																				
	Silty <b>SAND</b> , some gravel, trace clay Compact to Very Dense Brown to Grey Wet		3	SS	61															
231.7																				
4.0	<b>SAND</b> , medium, trace gravel, some silt Very Dense Grey Wet		6	SS	100															
230.2	Gravelly		1	RUN																
5.5	<b>BEDROCK</b> , metavolcanic, greenish grey, occasional horizontal breaks		2	RUN																
			3	RUN																

ONTM/T4S 1182.GPJ 6/28/12

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

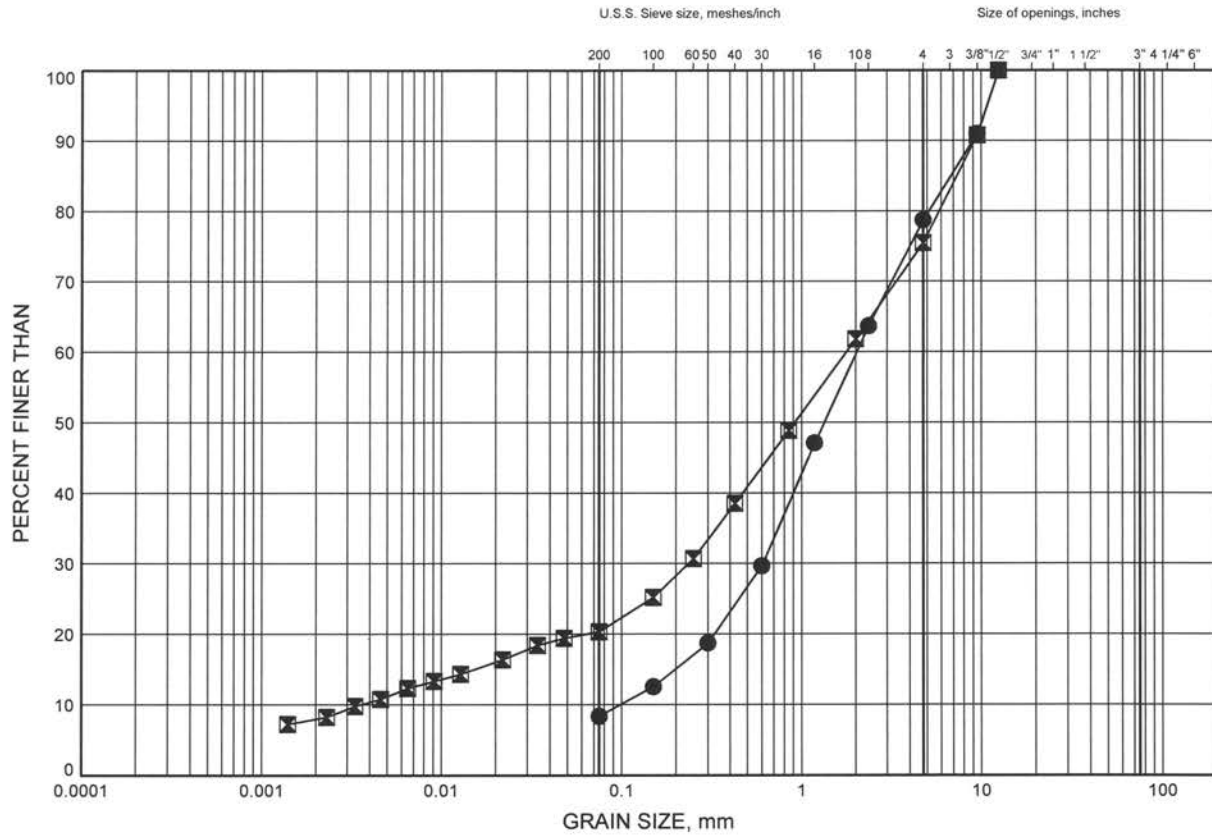
## **Appendix B**

### **Laboratory Test Results**

# Blind Creek West - WBL GRAIN SIZE DISTRIBUTION

FIGURE B1

## GRAVELLY SAND



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

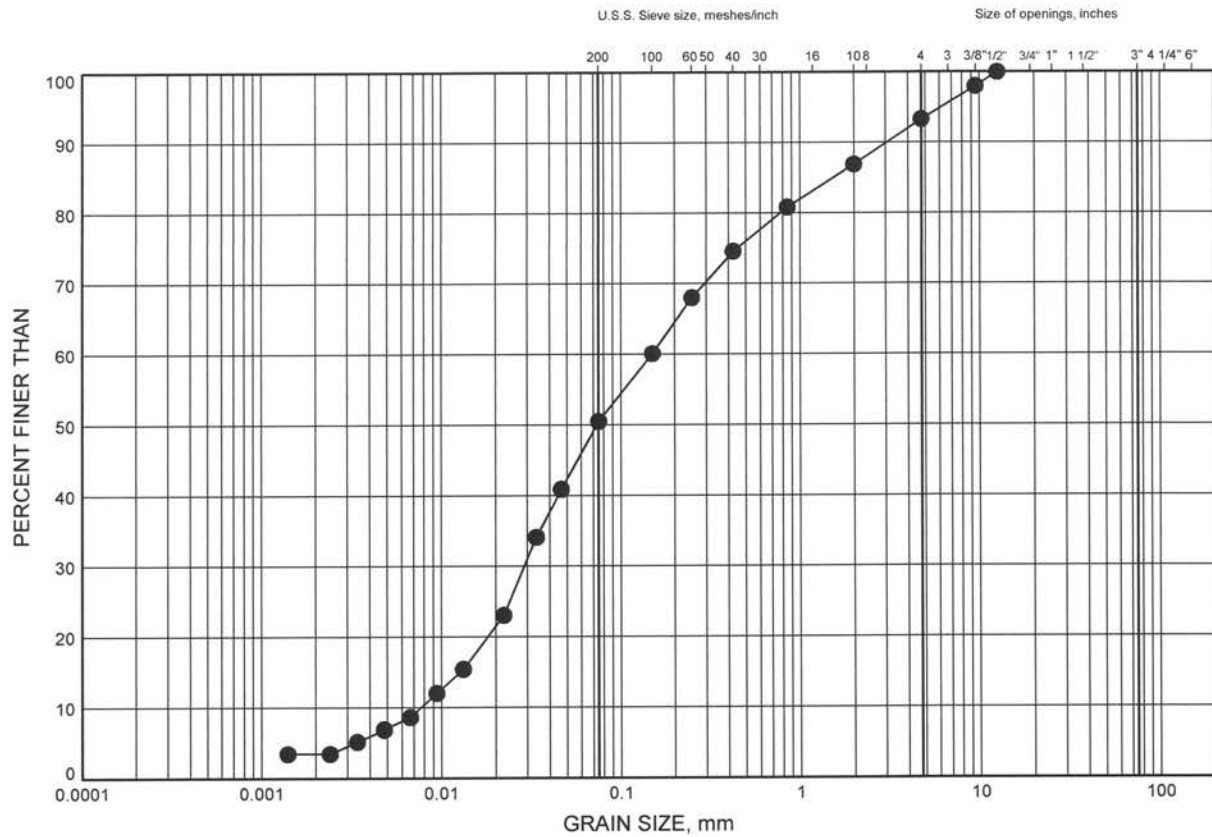
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-1	1.07	236.43
■	BCWW-4	1.83	235.57

# Blind Creek West - WBL GRAIN SIZE DISTRIBUTION

FIGURE B2

## SAND & SILT



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

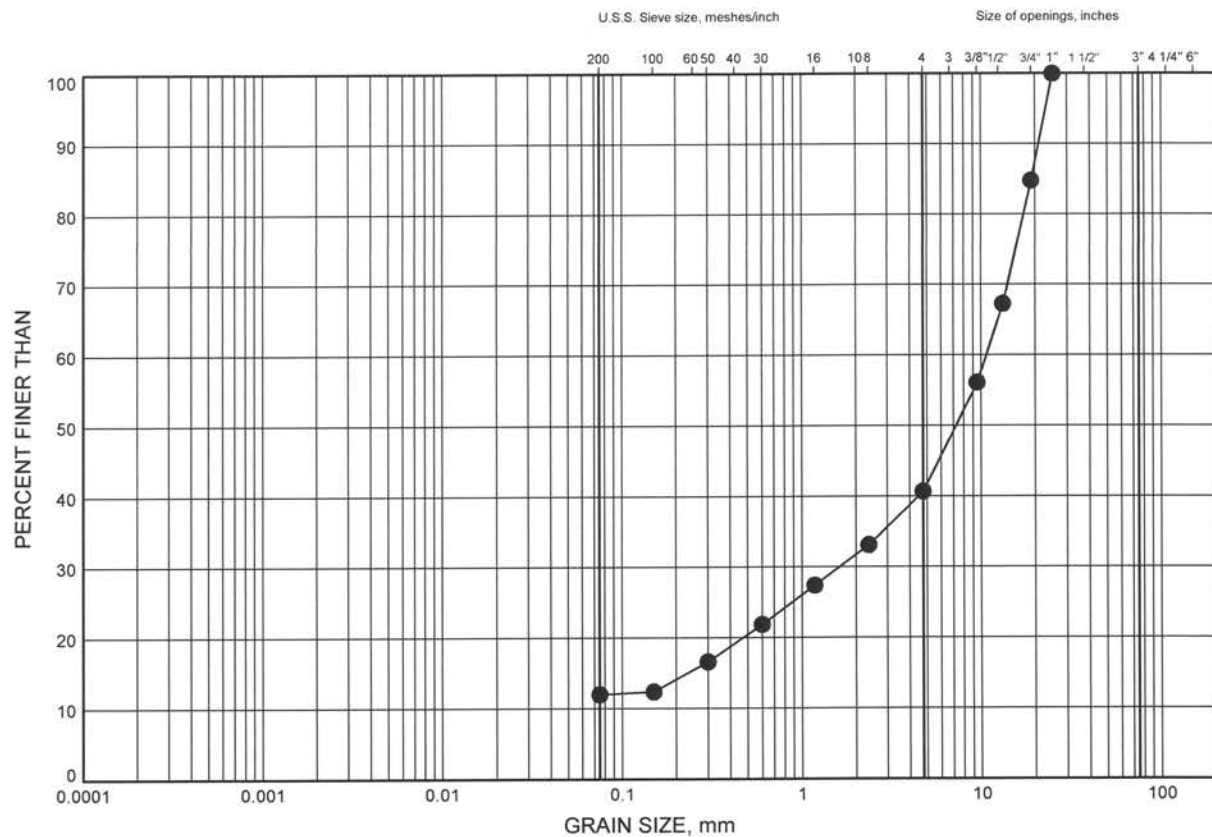
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-2	2.59	234.91

# Blind Creek West - WBL GRAIN SIZE DISTRIBUTION

FIGURE B3

## SAND & GRAVEL



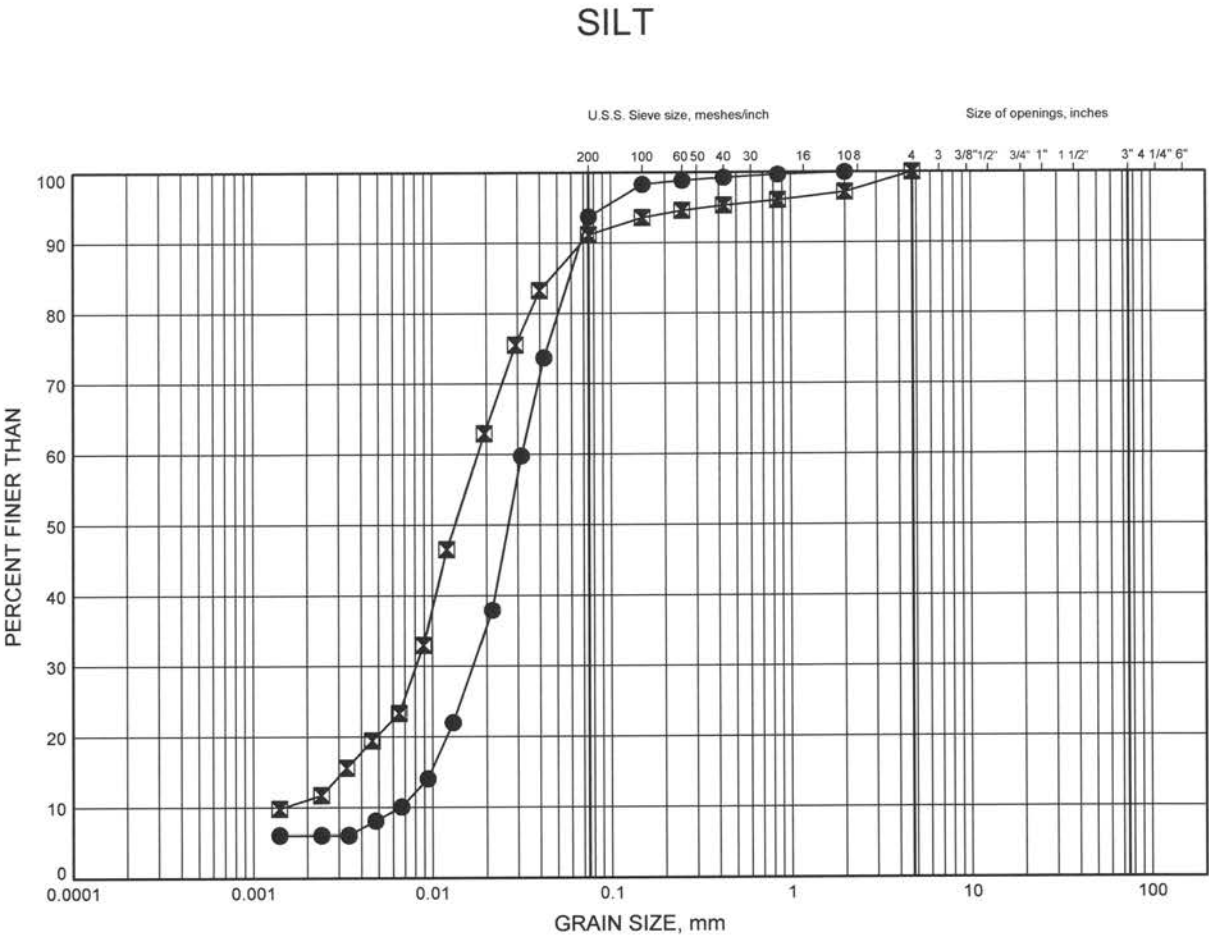
SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-1	3.35	234.15

Blind Creek West - WBL  
GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-3	3.05	233.25
⊠	BCWW-3	4.72	231.58

GRAIN SIZE DISTRIBUTION - THURBER 1182.GPJ 1/3/12

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

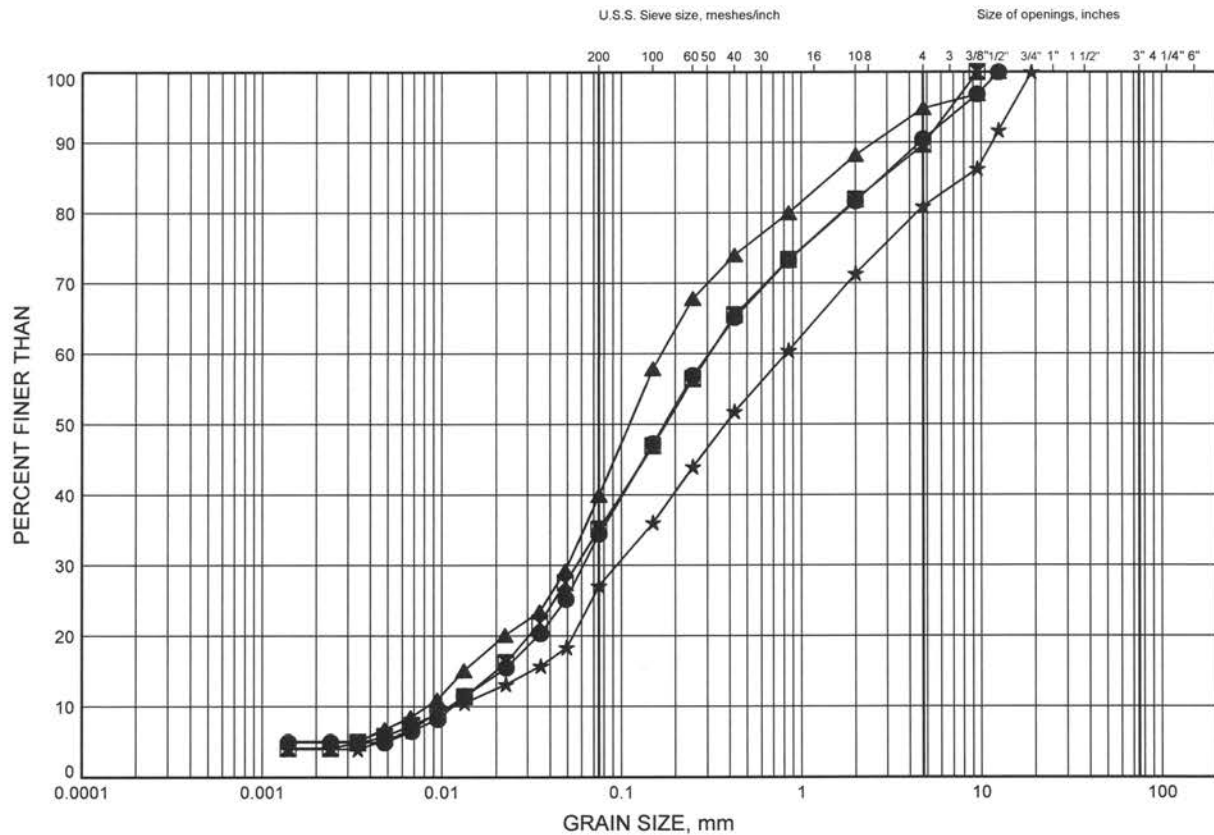




# Blind Creek West - WBL GRAIN SIZE DISTRIBUTION

FIGURE B5

## SILTY SAND



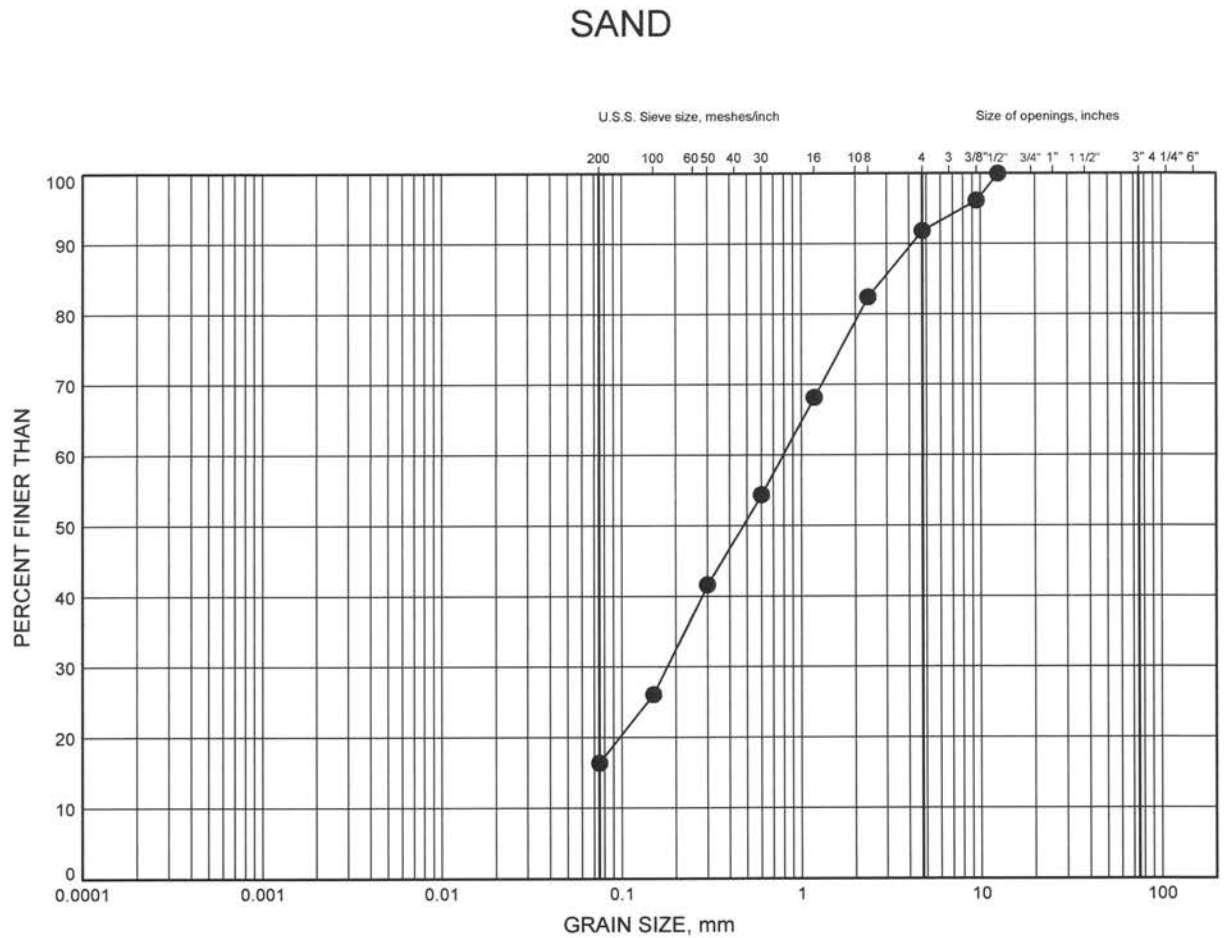
SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-3	6.25	230.05
■	BCWW-4	3.24	234.16
▲	BCWW-5	1.83	234.87
★	BCWW-6	1.68	234.02

# Blind Creek West - WBL GRAIN SIZE DISTRIBUTION

FIGURE B6



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	BCWW-6	4.72	230.98

## **Appendix C**

### **Site Photographs**



**Photograph 1 – Blind Creek West looking north**

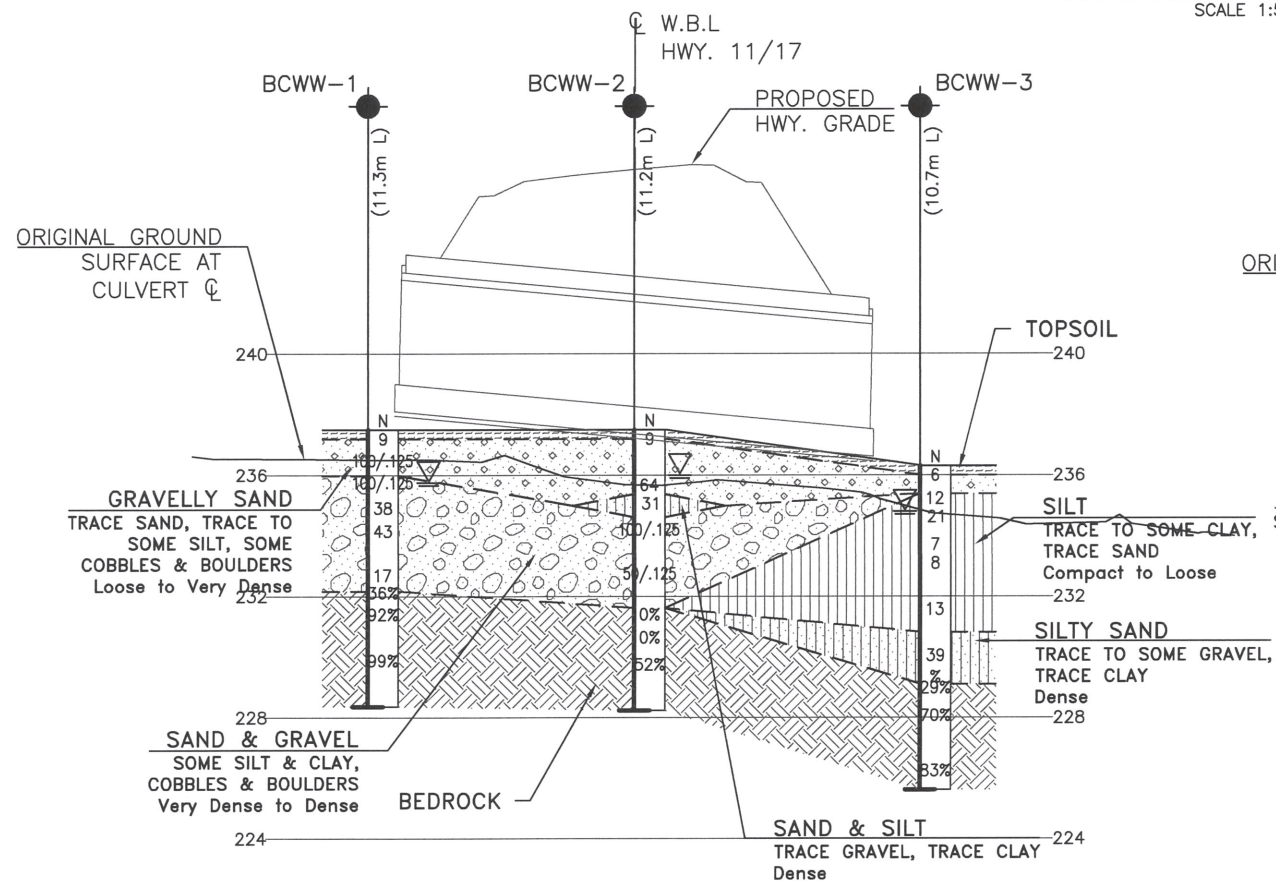
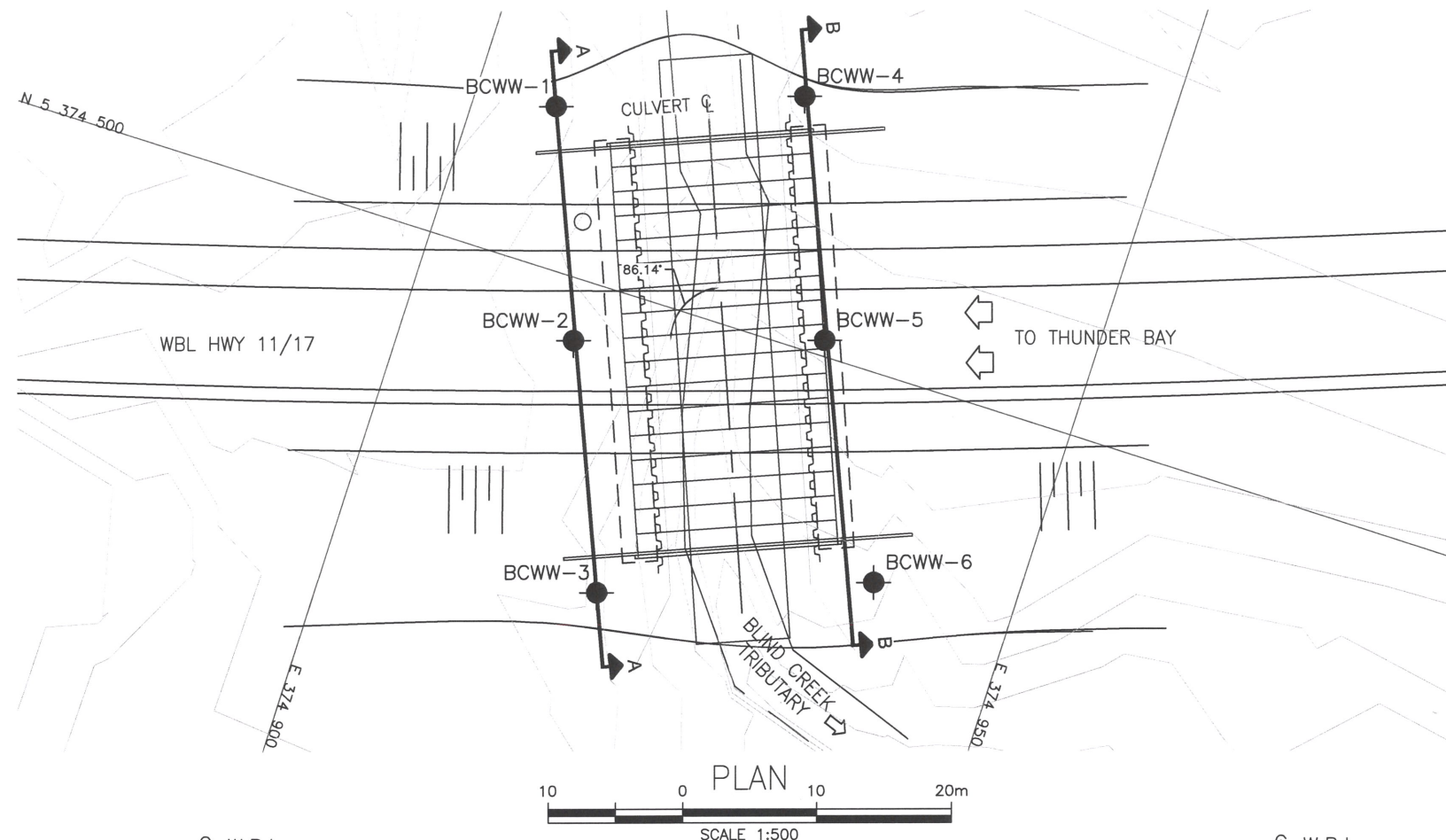


**Photograph 2 – Blind Creek West at Borehole BCWW-1**

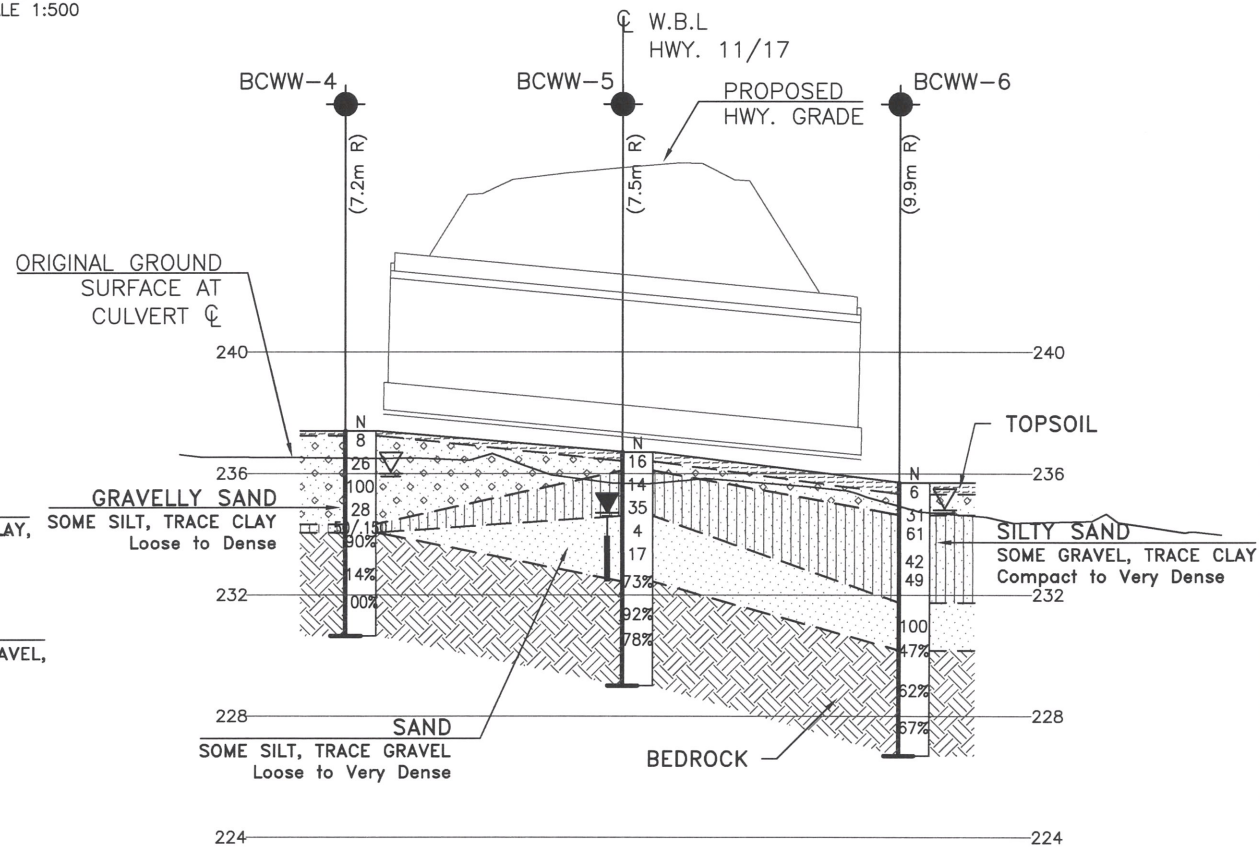
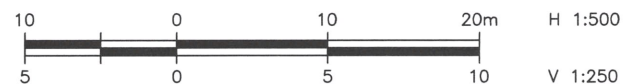
## **Appendix D**

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



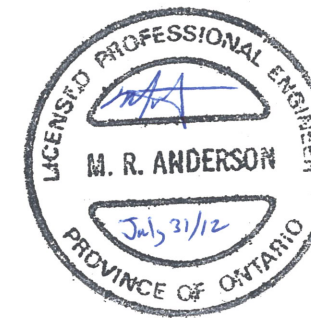


SECTION A-A

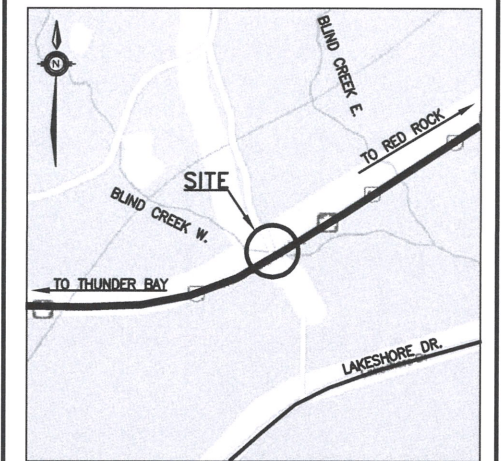


SECTION B-B

## METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWNCONT No 2012-6010  
WP No 623-89-00HIGHWAY 11/17 FOUR LANING  
BLIND CREEK WEST  
CULVERT WEST BOUND LANE  
BOREHOLE LOCATIONS AND SOIL STRATAHatch Mott  
MacDonaldSHEET  
236

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
BCWW-1	237.5	5 374 511.8	374 906.1
BCWW-2	237.5	5 374 495.5	374 912.7
BCWW-3	236.3	5 374 478.1	374 920.1
BCWW-4	237.4	5 374 518.1	374 923.5
BCWW-5	236.7	5 374 501.2	374 930.5
BCWW-6	235.7	5 374 485.1	374 939.5

## -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. 52A-163

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LRB	CHK LRB	CODE CAN/CSA S6-06 [LOAD CL-625-ONT] DATE JUL. 2012
DRAWN	AN	CHK RPR	SITE 48C-350/C2/STRUCT DWG 1