

**FOUNDATION INVESTIGATION REPORT  
CASH CREEK TRIBUTARY CULVERT  
HIGHWAY 11, DISTRICT OF THUNDER BAY  
G.W.P. 6932-10-00, STRUCTURE NO. 48C-188/C**

**Geocres Number: 52H-17**

**Report to  
McCormick Rankin Corporation**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a geotechnical investigation conducted at the location of a culvert carrying Highway 11 over the Cash Creek Tributary in the District of Thunder Bay, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the culvert location and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile, cross-sections, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

**2 SITE DESCRIPTION**

The site is located on Highway 11 approximately 18 km north of the intersection with Highway 17 in the Geographic Township of Ledger, District of Thunder Bay, Ontario.

Highway 11 at the existing culvert location is constructed on an approximate 10 m high embankment crossing a ravine carrying Cash Creek Tributary. The embankment slopes are grass covered with some trees growing on the lower parts of the slope. The surrounding lands are heavily wooded. The ground surface has a gently undulating topography.

Photographs 1 to 4 in Appendix C show views of the culvert site. The existing culvert is a rigid frame concrete culvert with a width of 2.9 m and a length of 46.1 m. The existing culvert has settled and cracked severely.

The site lies within the Canadian Shield, characterized by low, rounded hills of Pre-Cambrian bedrock mantled by varying thicknesses of overburden. At this site, the overburden primarily consists of glaciolacustrine silts and clays that are well sorted and well bedded to massive. The thickness of this geologic stratum is generally 1 to 3 m, locally greater than 30 m. The underlying bedrock consists of paragneiss and migmatite.

### 3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out during the period January 12 to 19, 2011. A total of three sampled boreholes (numbered CC11-01 to CC11-03) were drilled adjacent to the existing culvert, from the top of the embankment to depths of 28.0 to 31.1 m. In addition, two Dynamic Cone Penetration Tests (DCPTs numbered CC11-04 and CC11-05) were advanced near the ends of the culvert to depths of 14.9 and 15.8 m.

The approximate locations of the boreholes and DCPTs are shown on the Borehole Locations and Soil Strata Drawing in Appendix D. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

Hollow stem augers and wash-boring with casing were used to advance the boreholes. Samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). To supplement the SPT information, a DCPT test was also completed near Borehole CC11-02.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Borehole CC11-02, a standpipe piezometer consisting of 19 mm PVC pipe with screen was installed and enclosed in filter sand to permit longer term groundwater level monitoring. Boreholes without piezometer installations were grouted with bentonite upon completion. The borehole decommissioning details are shown in Table 3.1.

**Table 3.1 – Borehole Decommissioning Details**

<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Completion Details</b>
CC11-01	None installed	Borehole backfilled with holeplug to 0.1 m, then cold patch asphalt to surface.
CC11-02	12.2/210.3	Holeplug from 31.1 to 12.2 m, sand filter from 12.2 to 10.4 m, holeplug from 10.4 to 9.1 m, auger cuttings from 9.1 to 0.1 m, then cold patch asphalt to surface.
CC11-03	None installed	Borehole backfilled with holeplug to 0.1 m, then cold patch asphalt 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 grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B.

#### **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A stratigraphic profile is presented on the Borehole Locations and Soil Strata Drawing in Appendix D, for illustrative purposes. Overall descriptions of the stratigraphy are given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

The soil stratigraphy encountered at the borehole locations typically consists of an asphalt layer overlying sand fill and clayey silt fill (embankment fill), underlain by native silt to the full exploration depth.

More detailed descriptions of the individual strata are presented below.

##### **5.1 Asphalt**

A 150 mm thick layer of asphalt was encountered in each borehole drilled on the travelled lanes of Highway 11.

##### **5.2 Sand Fill**

The asphalt was underlain by fill consisting of sand, some gravel to gravelly, with occasional cobbles. The lower boundary of the sand fill was encountered at depths of 4.1 to 4.9 m (Elev. 217.6 to 218.5 m).

SPT 'N' values in the sand fill typically decreased with depth, ranging from 105 blows/0.1 m penetration (probably frozen) to 4 blows/0.3 m (loose). Typically the 'N' values were in the order of 11 to 22 blows/0.3m, indicating a compact condition. Moisture contents varied from 2 to 8%.

Grain size distribution curves for three samples of the sand fill are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

Gravel %	19 to 32
Sand %	59 to 73
Silt & Clay %	8 to 11

### 5.3 Clayey Silt Fill

Grey clayey silt fill was encountered below the sand fill in each borehole. The thickness of the silt fill was 3.8 to 5.9 m. The depth to the base of the clayey silt fill ranged from 8.7 to 9.9 m (Elev. 212.6 to 213.9 m), and a further 0.9 m of silt fill (base at Elev. 211.7 m) was encountered in Borehole CC11-03.

The consistency of the cohesive fill was firm to stiff in Borehole CC11-01, based on SPT 'N' values ranging from 4 to 13 blows/0.3 m. In Boreholes CC11-02 and CC11-03, the clayey silt fill was very stiff to hard, based on 'N' values of 25 to 31 blows/0.3 m. The moisture content typically varied from 18 to 25%, with one value of 39% measured in Borehole CC11-01.

Grain size distribution curves for two silt fill samples are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results are summarized as follows:

Gravel %	0
Sand %	2 to 3
Silt %	71 to 74
Clay %	23 to 27

### 5.4 Silt

A deep deposit of native grey silt with some clay was contacted below the embankment fill at depths of 8.7 to 10.8 m (Elev. 211.7 to 213.9 m) in all boreholes. The boreholes were terminated within the silt at depths of 28.0 to 31.1 m (Elev. 191.4 to 194.6 m), indicating a strata thickness of at least 17.2 to 22.4 m.

SPT 'N' values in the silt ranged from 5 to 19 blows/0.3 m, indicating a loose to compact relative density. The moisture contents typically varied from 19 to 28%, with localized values of 35 to 42%.

Grain size distribution curves for the silt are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	78 to 84
Clay %	16 to 22

A dynamic cone penetration test conducted near Borehole CC11-02 indicated relatively consistent blow counts in the native silt, typically in the order of 60 to 70 blows/0.3 m, increasing to over 80 blows/0.3 m near the test termination depth of 22.5 m. In Boreholes CC11-04 and CC11-05, the DCPT blow counts typically/gradually increased from less than 10 blows/0.3 m near the ground surface to around 80 blows/0.3 m at about 13 m depth.

These tests were terminated at depths of 14.9 and 15.8 m after counts of 100 to 126 blows/0.3 m were obtained.

### 5.5 Silty Clay

The native deposits graded to silty clay from 10.7 to 12.2 m depth in Borehole CC11-01 and from 13.9 to 16.8 m depth in Borehole CC11-02. The thickness of the silty clay zone was 1.5 and 2.9 m.

SPT 'N' values of 3 and 7 blows/0.3 m were obtained in the silty clay, indicating a soft to firm consistency. The undrained shear strength determined by an in situ vane test conducted in Borehole CC11-02 was 30 kPa (firm). Moisture contents of 21 and 22% were measured.

The results of a grain size distribution analysis conducted on a sample of the silty clay are presented on the Record of Borehole sheets and on Figure B4 of Appendix B. The results are summarized as follows:

Gravel %	0
Sand %	0
Silt %	67
Clay %	33

### 5.6 Water Levels

Water was added into the drill casing to counterbalance hydraulic pressures during drilling and therefore natural groundwater levels were not measured during drilling. A standpipe piezometer was installed in Borehole CC11-02 to monitor water levels after completion of drilling. The water level measured in the piezometer on April 30, 2011 was at 8.5 m depth (Elev. 214.0 m).

The water level in the Cash Creek tributary in February 2011 was at Elev. 212.7 m (from preliminary General Arrangement drawing).

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

## 6 MISCELLANEOUS

The borehole locations were established in the field by Thurber Engineering. The coordinates and ground surface elevations at the boreholes were subsequently determined by MMM Group Limited survey personnel.

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

Eastern Ontario Diamond Drilling Ltd. supplied truck-mounted drilling equipment and conducted the drilling, sampling and in-situ testing operations for the boreholes drilled on the highway. OGS Inc. supplied portable equipment to advance the DCPT tests at the base of the embankment slope.

The field program was supervised on a full time basis by Ms. Eckie Siu and Mr. Ryan Kromer of Thurber Engineering Ltd. Overall supervision of the field program was provided by Mr. Alastair E. Gorman, P.Eng. and Mr. Tony Harte, M.Sc.

Interpretation of the data and preparation of the report was carried out by Mr. Murray R. Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations Projects.

### Thurber Engineering Ltd.

Murray R. Anderson, P.Eng., M.Eng.  
Senior Foundations Engineer



P.K. Chatterji, P.Eng., Ph.D.  
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 <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			

# RECORD OF BOREHOLE No CC11-01

1 OF 3

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 495.7 E 215 049.0 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.14 - 2011.01.16 CHECKED BY TJH

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	20	40	60	80	100	w <sub>p</sub>	w		w <sub>L</sub>				
222.6																					
0.0	ASPHALT: (150mm)																				
0.2	SAND, some gravel, occasional cobbles Very Dense to Compact Brown Damp (FILL)		1	SS	105/ 0.100								○								
				2	SS	39								○							
				3	SS	22								○							
	Loose			4	SS	11								○					19 73 8 (SI+CL)		
				5	SS	4								○							
218.5																					
4.1	Clayey SILT, trace sand, occasional wood fibres Firm to Stiff Grey (FILL)		6	SS	13									○							
			7	SS	4									○							
			8	SS	9									○							
213.9																					
8.7	SILT, some clay Loose Grey Moist		9	SS	10									○					0 0 84 16		

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CC11-01

2 OF 3

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 495.7 E 215 049.0 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.14 - 2011.01.16 CHECKED BY TJH

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					w <sub>p</sub> w   w <sub>L</sub>								
								● QUICK TRIAXIAL   × LAB VANE													
	Continued From Previous Page						20	40	60	80	100	20	40	60							
211.9	SILT, some clay Loose Grey Moist																				
10.7	Silly CLAY Soft Grey		10	SS	3								○								
210.4																					
12.2	SILT, some clay Loose to Compact Grey Wet		11	SS	6								○								
			12	SS	6								○				0   0   78   22				
			13	SS	9								○								
			14	SS	9								○								
			15	SS	11								○								

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CC11-01

3 OF 3

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 495.7 E 215 049.0 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.14 - 2011.01.16 CHECKED BY TJH

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 × LAB VANE				WATER CONTENT (%)						
						20	40	60	80	100	20	40	60			
	Continued From Previous Page		16	SS	9											
	SILT, some clay Loose to Compact Grey Wet															0 0 83 17
			17	SS	14											
			18	SS	15											
			19	SS	19											
194.6																
28.0	END OF BOREHOLE AT 28.0m. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.1m, THEN ASPHALT TO SURFACE.															

ONTMT4S 1197.GPJ 5/6/11

# RECORD OF BOREHOLE No CC11-02

1 OF 4

METRIC

W.P. 6048-08-00 LOCATION Cash Creek Culvert N 5 448 490 4 E 215 051 4 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.12 - 2011.01.13 CHECKED BY TJH

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	20 40 60 80 100	20 40 60 80 100		
222.5												
0.0	ASPHALT: (150mm)											
0.2	SAND, some gravel to gravelly, occasional cobbles Very Dense Brown Damp (FILL)		1	SS	100/ 0.150							
			2	SS	120/ 0.200							
	Compact to loose		3	SS	17							
			4	SS	14							32 59 9 (SI+CL)
			5	SS	7							
217.6			6	SS	14							
4.9	Clayey SILT, trace sand Very Stiff Grey Moist (FILL)		7	SS	25							0 2 71 27
			8	SS	29							
213.8												
8.7	SILT, some clay Compact to Loose Grey Damp		9	SS	12							

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 CC11-02

2 OF 4

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 490.4 E 215 051.4 ORIGINATED BY ES  
HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.01.12 - 2011.01.13 CHECKED BY TJH

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							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
	Continued From Previous Page							20 40 60 80 100								
	SILT, some clay Compact to Loose Grey Moist		10	SS	13		212									
							211									
			11	SS	7		210									
208.6							209									
13.9	Silty CLAY, occasional silt seams Firm Grey		12	SS	7		208							0 0 67 33		
							207									
205.8							206									
16.8	SILT, some clay Compact Grey Wet		13	SS	13		205									
							204									
			14	SS	11		203									

Continued Next Page

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



# RECORD OF BOREHOLE No CC11-02

3 OF 4

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 490.4 E 215 051.4 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.12 - 2011.01.13 CHECKED BY TJH

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			20 40 60 80 100	20 40 60 80 100					
Continued From Previous Page			15	SS	12									
	SILT, some clay Compact Grey Wet						202							
			16	SS	13		201							0 0 81 19
							200							
							199							
			17	SS	11		198							
							197							
							196							
	Occasional clay seams		18	SS	12		195							
							194							
							193							

Continued Next Page

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

RECORD OF BOREHOLE No CC11-02

4 OF 4

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 490.4 E 215 051.4 ORIGINATED BY ES  
HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
DATUM Geodetic DATE 2011.01.12 - 2011.01.13 CHECKED BY TJH

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			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					WATER CONTENT (%)			
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued From Previous Page															
191.4	SILT, some clay Compact Grey Wet		19	SS	14	192										
31.1	END OF BOREHOLE AT 31.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2011.04.30 8.5 214.0															

# RECORD OF BOREHOLE No CC11-03

1 OF 3

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 485.3 E 215 044.6 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.18 - 2011.01.19 CHECKED BY TJH

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								WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
222.5							20	40	60	80	100	20	40	60						
0.0	ASPHALT: (150mm)		1	SS	100/ 0.125							○								
0.2	SAND, some gravel to gravelly, occasional cobbles Very Dense to Compact Brown Damp (FILL)		2	SS	100/ 0.150							○								
			3	SS	20							○				29 60 11 (SI+CL)				
			4	SS	18							○								
			5	SS	20							○								
217.6			6	SS	20							○								
4.9	Clayey SILT, trace sand, occasional wood fibres Very Stiff to Hard Grey to Brownish Grey Damp (FILL)																			
			7	SS	26							○				0 3 73 24				
			8	SS	31							○								

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No CC11-03

2 OF 3

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 485.3 E 215 044.6 ORIGINATED BY ES  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.01.18 - 2011.01.19 CHECKED BY TJH

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      × LAB VANE	WATER CONTENT (%)							
	Continued From Previous Page						20 40 60 80 100									
9.9	SILT, some sand, trace clay Dense Grey Damp (FILL)						212									
211.7							211									
10.8	SILT, some clay Compact to Loose Grey Moist		10	SS	16											
			11	SS	9		210									
			12	SS	7		209									
			13	SS	5		208									
			14	SS	10		207									
							206									
							205									
							204									
			15	SS	13											
							203									

Continued Next Page

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

## METRIC

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

# RECORD OF BOREHOLE No CC11-04

1 OF 2

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 499.3 E 215 026.0 ORIGINATED BY RK  
 HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY MFA  
 DATUM Geodetic DATE 2011.02.19 - 2011.02.19 CHECKED BY TJH

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					
212.3 0.0	Start of DCPT						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60					
212													
211													
210													
209													
208													
207													
206													
205													
204													
203													

Continued Next Page

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

RECORD OF BOREHOLE No CC11-04

2 OF 2

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 499.3 E 215 026.0 ORIGINATED BY RK  
HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY MFA  
DATUM Geodetic DATE 2011.02.19 - 2011.02.19 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL LIMIT      MOISTURE      LIQUID CONTENT      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      W <sub>L</sub> WATER CONTENT (%)				
	Continued From Previous Page							20   40   60   80   100	○ UNCONFINED      + FIELD VANE					
								● QUICK TRIAXIAL      x LAB VANE						
197.4								202						
14.9	END OF DCPT AT 14.9m.							201						
								200						
								199						
								198						

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

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



RECORD OF BOREHOLE No CC11-05

2 OF 2

METRIC

W.P. 6932-10-00 LOCATION Cash Creek Culvert N 5 448 474.1 E 215 070.7 ORIGINATED BY RK  
HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY MFA  
DATUM Geodetic DATE 2011.02.19 - 2011.02.19 CHECKED BY TJH

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa	WATER CONTENT (%)	W <sub>p</sub>	W		
	Continued From Previous Page						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	20 40 60					
196.8													
15.8	END OF DCPT AT 15.8m.												

**Appendix B**  
**Laboratory Test Results**

## FIGURE B1

U.S.S. Sieve size, meshes/inch

Size of openings, inches

PERCENT FINER THAN

GRAIN SIZE, mm

Grain Size (mm)	Percent Finer (%) - Circles	Percent Finer (%) - Squares	Percent Finer (%) - Triangles
0.075	10	10	8
0.15	15	14	12
0.3	25	22	20
0.6	47	32	30
1.2	65	44	42
2.5	75	57	56
5.0	82	69	70
10.0	87	80	86
20.0	95	89	95
75.0	100	100	100

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

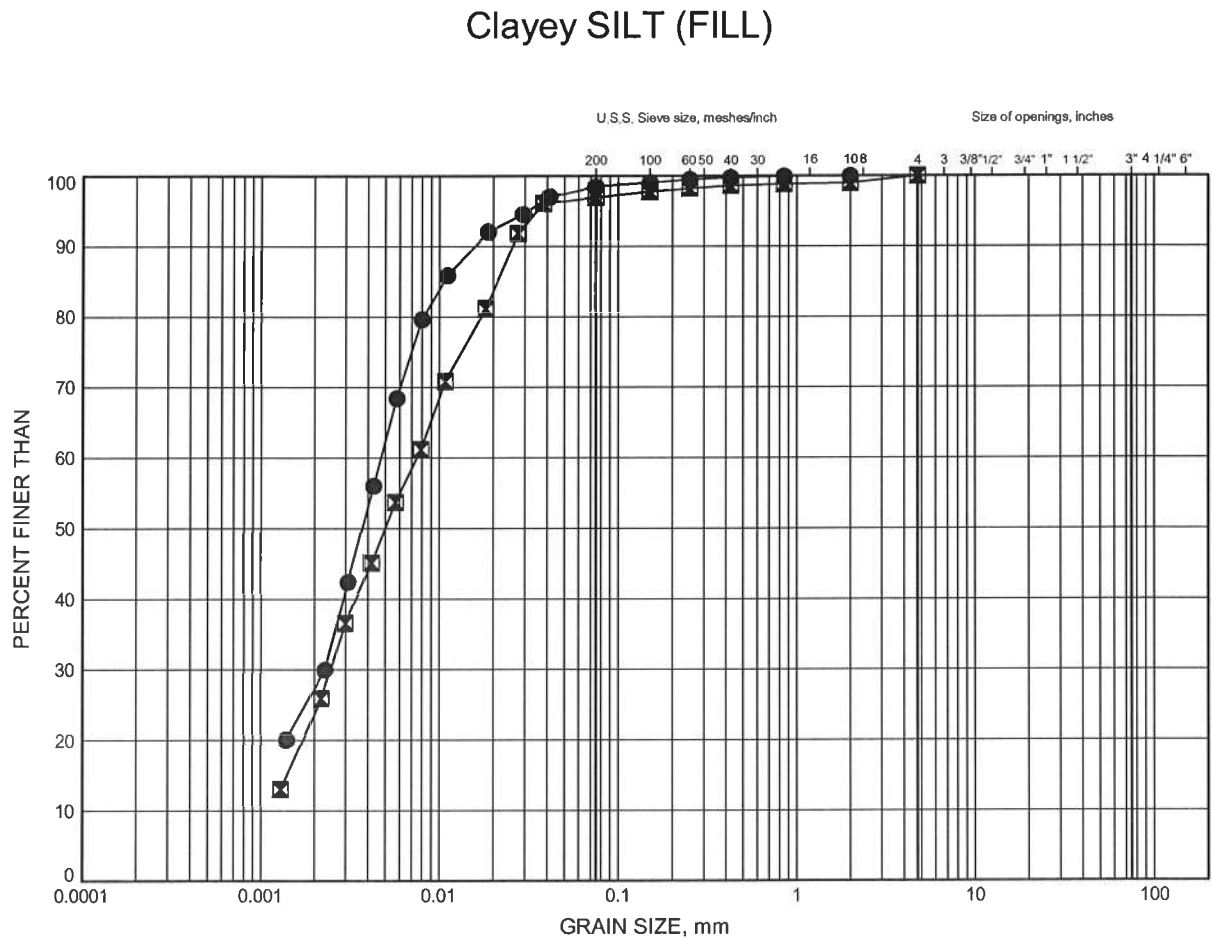
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC11-01	2.59	220.03
■	CC11-02	2.59	219.93
▲	CC11-03	1.83	220.65



W.P.# 6932-10-00  
Prepared By MFA  
Checked By MRA

NWR 32 Rehabs  
GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC11-02	6.40	216.12
⊠	CC11-03	6.40	216.08

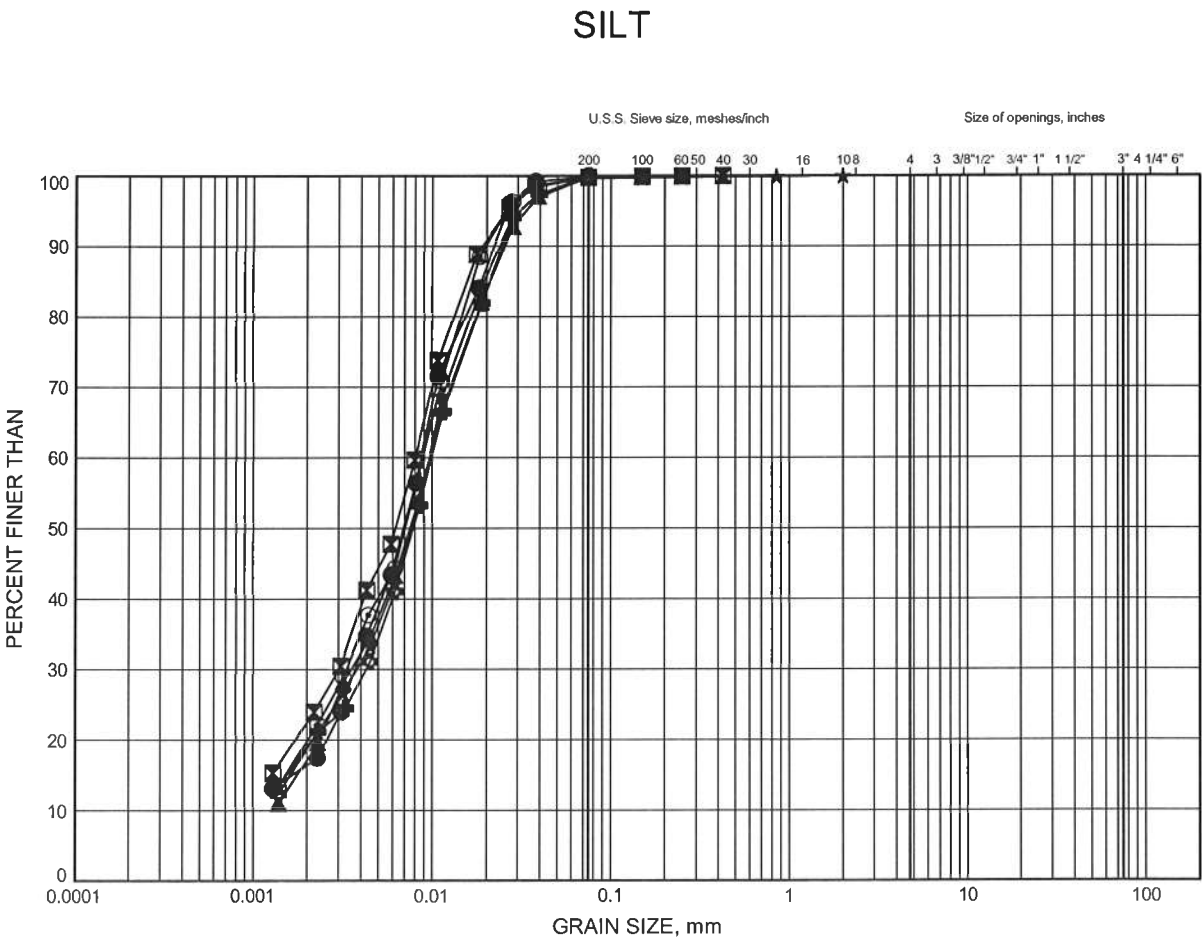


W.P.# 6932-10-00  
Prepared By MFA  
Checked By MRA

# NWR 32 Rehabs

## GRAIN SIZE DISTRIBUTION

FIGURE B3



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

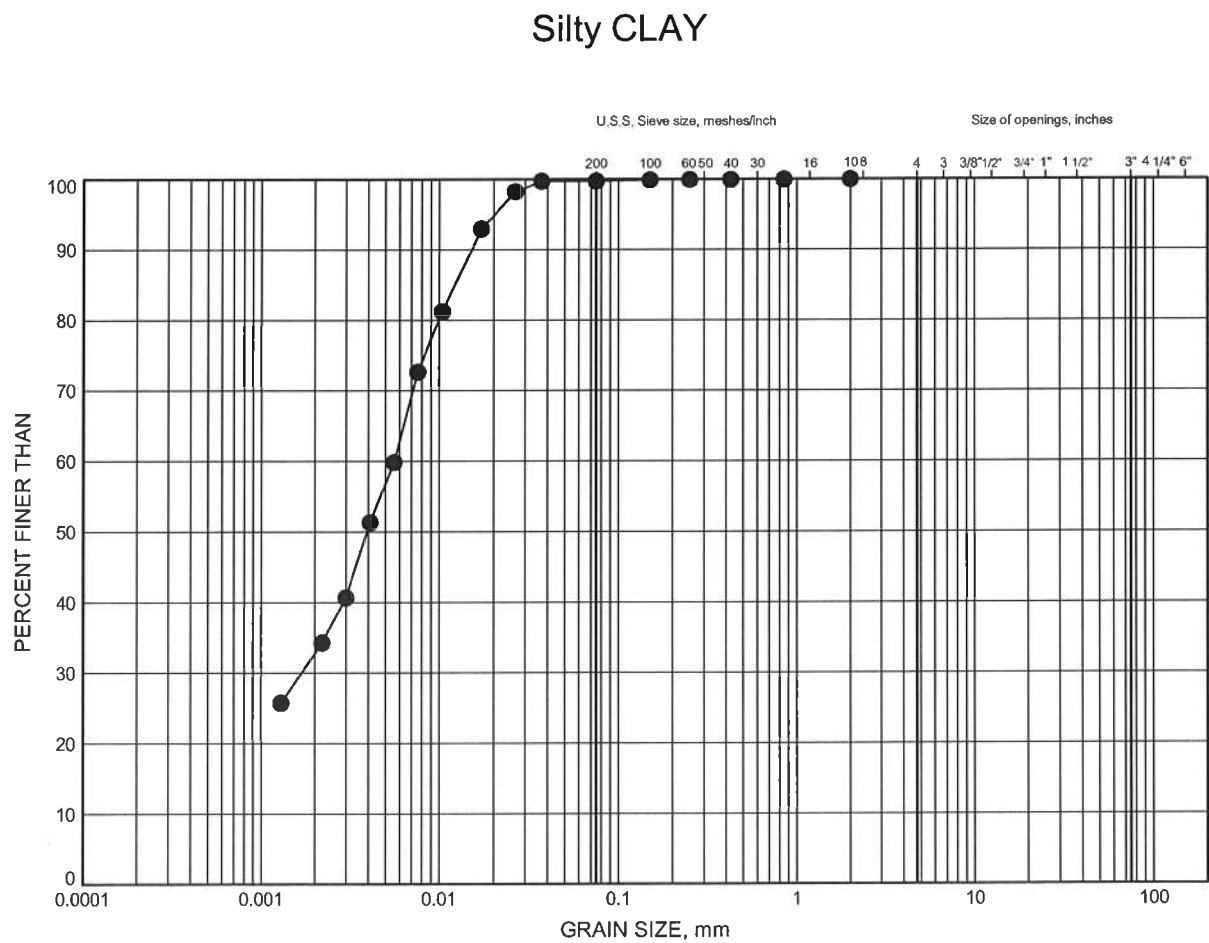
### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CC11-01	9.45	213.17
⊠	CC11-01	14.02	208.60
▲	CC11-01	20.12	202.50
★	CC11-02	21.64	200.88
⊙	CC11-03	14.02	208.46
⊕	CC11-03	20.12	202.36



NWR 32 Rehabs  
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)
●	CC11-02	14.02	208.50



W.P.# 6932-10-00  
Prepared By MFA  
Checked By MRA

**Appendix C**  
**Photographs**



Photograph 1: South end of Cash Creek culvert.



Photograph 2: North end of Cash Creek culvert.





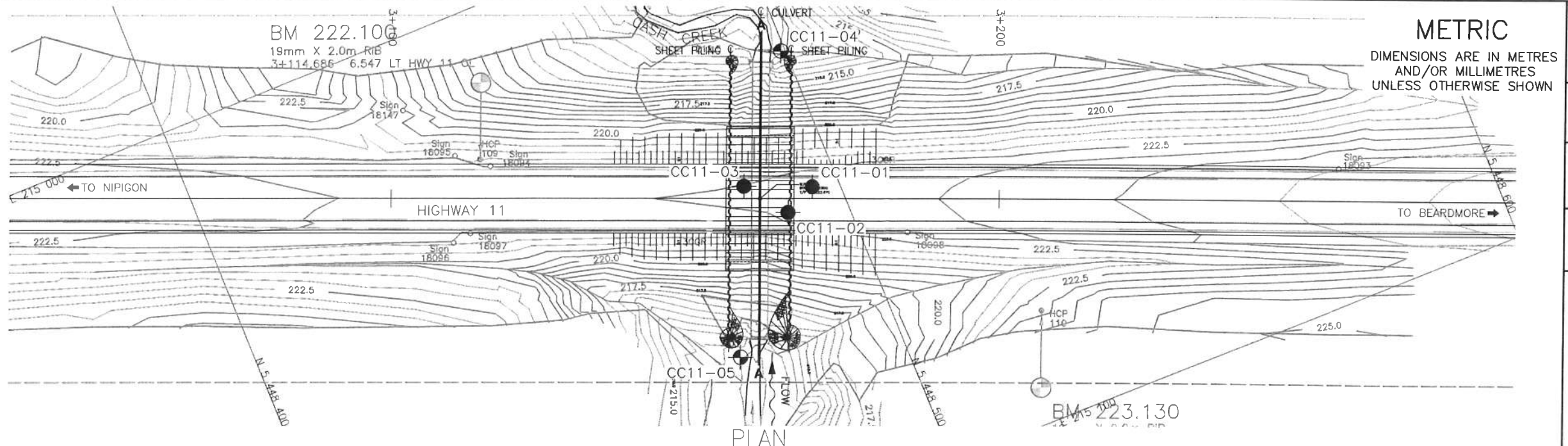
Photograph 3: Creek valley from top of roadway embankment.



Photograph 4: Highway 11 over culvert location.

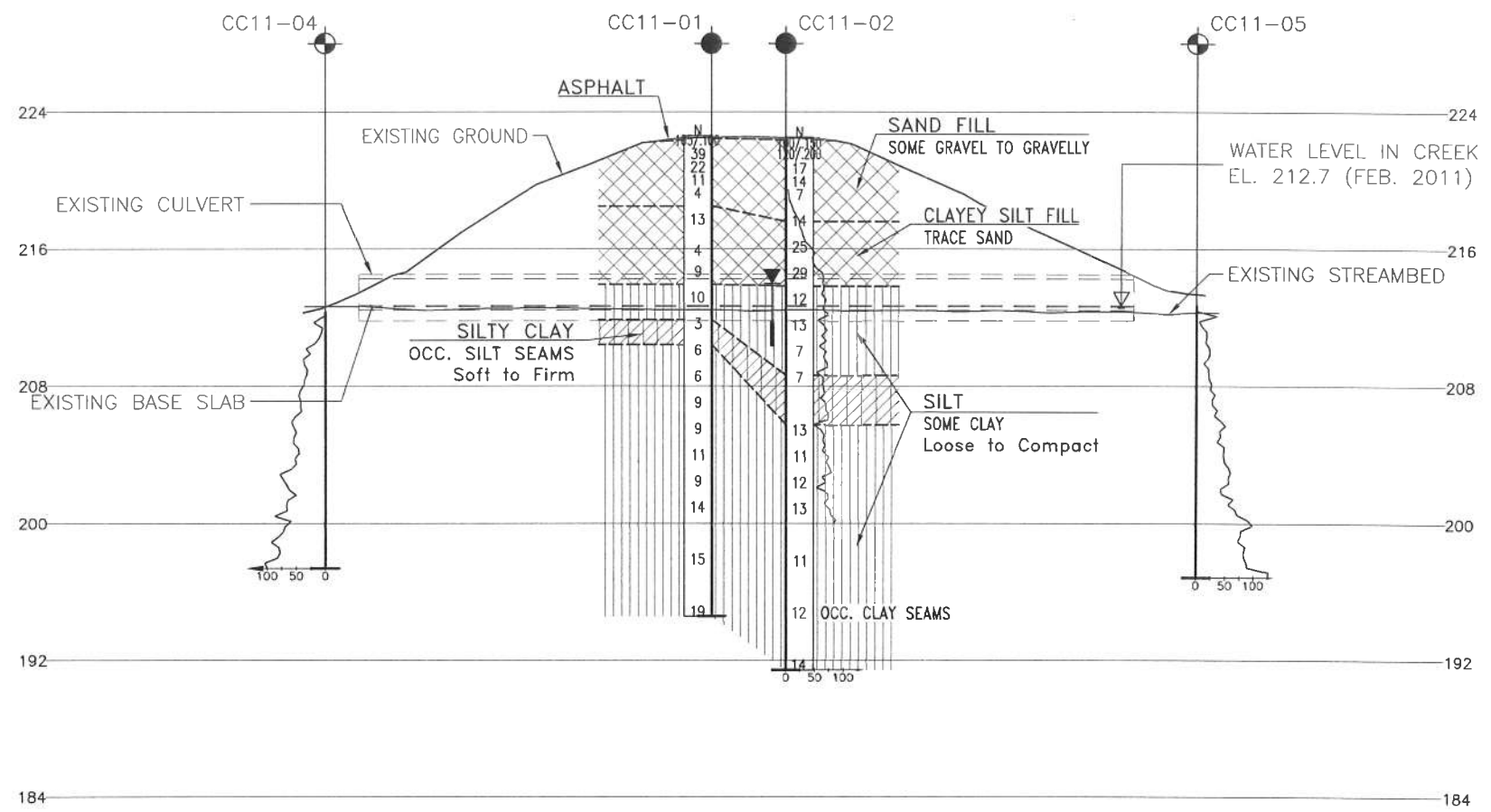
**Appendix D**

**Drawing titled “Borehole Locations and Soil Strata”**



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

SCALE 1:800



SECTION A-A ALONG C OF CULVERT

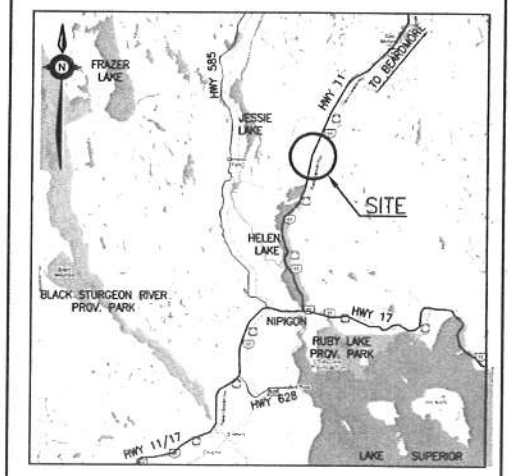
SCALE 1:400

CONT No  
WP No 6932-10-00

HIGHWAY 11  
CASH CREEK  
CULVERT  
BOREHOLE LOCATIONS AND SOIL STRATA

MRC MCCORMICK RANKIN  
CORPORATION

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole
- Cone (DCPT)
- 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
- Piezometer
- 90%
- Rock Quality Designation (RQD)
- A/R
- Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CC11-01	222.6	5 448 495.7	215 049.0
CC11-02	222.5	5 448 490.4	215 051.4
CC11-03	222.5	5 448 485.3	215 044.6
CC11-04	212.3	5 448 499.3	215 026.0
CC11-05	212.7	5 448 474.1	215 070.7

-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. 52H-17

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								</
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