

**FOUNDATION INVESTIGATION REPORT
ROBIN CREEK CULVERT REPLACEMENT
STATION 15+035, HIGHWAY 11,
TOWNSHIP OF OLIVE, ONTARIO
GWP 5578-04-00
SITE No. 43-363**

GEOCRESS No.: 31L-157

Report to

MMM Group Limited

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H:\19\5161\103 Hwy11 Tomiko River\Reports & Memos\4) Culvert Report (Jan-2012)\HWY 11, Robin Creek - FIR_Final.docx



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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of the replacement of the Robin Creek culvert, Site 43-363, located just north of Pan Lake on HWY 11, in the Township of Olive, Ontario. The purpose of the investigation was to explore the subsurface conditions beneath the existing embankment near Station 15+035.

Based on the borehole data obtained from this investigation, a borehole location plan, records of boreholes, stratigraphic profile and a written description of the subsurface conditions are provided. A model of the subsurface conditions was developed through considering a combination of the data obtained in the course of the present investigation and the data obtained from previous investigations near the project site. Data available from the following two previous investigations have also been considered:

- Foundation Investigation and Design Report – Highway 11 Pan Lake, 9.5 km North of Highway 64 Embankment from Sta. 14+550 to 15+210, Township of Olive, Geocres No. 31L-15, December 14, 2011, by Thurber
- Supplementary Preliminary Foundation Investigation Report – For Re-Alignment of Highway 11 at Robins Creek, Sudbury Area, August 26, 2006, Agreement No. 5004-E-0058, by Shaheen and Peaker Limited (S&P)

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under MTO Assignment Number 5009-E-0024.



2 SITE DESCRIPTION

The site is located on Highway 11, approximately 10.0 km north of Highway 64. Highway 11 at this location is a two lane road with gravel shoulders. The site location is shown on Drawing 1 in Appendix C. Site photographs are presented in Appendix F of this report.

Robin Creek culvert crosses Highway 11 in an approximate west-east orientation. The existing Robin Creek Culvert connects a swampy area east of Highway 11 to the west side of the highway where the creek flows into Pan Lake. The culvert was submerged at the time of the investigation and existence of beaver dams was noted in the area. It is proposed to replace this existing culvert and the replacement culvert will be constructed at the same alignment as the existing culvert.

This site lies within the physiographic region known as Laurentian Highlands, located in the southernmost part of the Canadian Shield (Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1). The local physiography is characterized by undulating rock outcrops and variable overburden soils, with swamps and lakes covering the low-lying areas. The bedrock at this site consists of Precambrian granite and gneiss.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation for this site was carried out in two phases spanning from April 12, 2011 to January 18, 2012. A total of 6 boreholes (BH 11-13, 11-14, RCC-01, RCC-02, 12-01, 12-02 and 12-03) and one DCPT were drilled during this time.

All boreholes were advanced to auger or split spoon refusal at depths ranging from 1.1 to 10.1 m. Approximate locations of the boreholes are shown on the attached Borehole Location Plan drawing in Appendix C. The borehole locations and elevation were either surveyed by MMM Group Limited or referenced to a known surveyed point.

Boreholes BH11-13 and 14 were drilled using a truck-mounted drill rig while boreholes BH12-01 to 03 were drilled with a track-mounted drill rig, both supplied and operated by George Downing Estate Drilling Ltd. Hollow stem auger drilling techniques were used to advance the boreholes in the overburden. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with SPT testing.

Boreholes RCC-01 and 02 were drilled using a portable tripod drill rig on a raft supplied and operated by OGS INC. of Almonte, Ontario. Casing/wash boring drilling techniques were used to advance the boreholes. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with SPT testing.

The coordinates and elevations of the boreholes are provided on the Borehole Locations and Soil Strata Drawing in Appendix C and on the individual Record of Borehole Sheets in Appendix A.

A standpipe piezometer, consisting of 19 mm PVC pipes with slotted tip, was installed in 1 borehole to monitor the groundwater level. The installation and backfilling details of the piezometer and borehole are provided below:

Borehole	Piezometer Tip Depth/Elev. (m)	Installation Details
11-13	7.0 / 286.3	19 mm diameter piezometer with 1.5 m slotted screen installed, sand filter from 7.0 to 5.2 m, bentonite seal from 5.2 m to ground surface.

The remaining boreholes were backfilled with bentonite holeplug in general accordance with O-Reg 903.

A member of Thurber's engineering staff supervised the borehole drilling and sampling operations on a full time basis. The inspector logged the boreholes and the recovered soil samples and processed them for transport to Thurber's laboratory.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Selected samples were subjected to gradation analysis (sieve and hydrometer) and the results are shown on the Record of Borehole sheets in Appendix A and on the figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 GENERAL

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the attached Borehole Locations and Soil Strata Drawing. An overall description of the stratigraphy is provided below. The factual data presented in the borehole logs governs any interpretation of the site conditions.

Based on the boreholes advanced through the HWY 11 embankment, the embankment soils that will be excavated within Hwy 11 for the replacement of the Robin Creek culvert were noted to contain loose to compact gravelly sand, silt and rockfill below the pavement structure. These soils are underlain largely by loose to compact granular soils consisting of sand, silts and gravel. The water level in the boreholes was measured to be near Elev. 291.

In the boreholes drilled near the east embankment toe (BH RCC-01, RCC-02 and R4 (by S&P)), the stratigraphy below the 1.4 to 1.5 m of standing water/snow/ice consists of a 1.9 to 2.6 m thick layer of peat/silty clay/clayey silt overlying a deposit of loose to compact sandy silt.

Auger or split spoon refusal was encountered at 1.1 to 10.1 m depth (Elev. 291.5 to 280.7 m) in these boreholes.

A more detailed description of the individual strata is presented below.

5.2 HIGHWAY 11 EMBANKMENT (BH11-13 and 14, BH12-02 and 03)

5.2.1 Asphalt

Asphalt was encountered at the ground surface in Boreholes BH11-13 and 14. The thickness ranged from 38 mm to 50 mm.

5.2.2 Granular Fill

Sand fill with trace gravel to gravelly and silty to trace silt was encountered below the asphalt in Boreholes BH11-13 and 14 and BH12-02. The granular fill layer extends to depths varying from 1.9 m of 3.6 m with the underside Elevations ranging from 291.5 to 290.2 m. This fill layer is described as very loose to dense with SPT values between 1 to 39 blows for 0.30 m of penetration. A 0.7 m thick layer of silt with some sand was present within the sand layer in BH12-02.

This fill was brown in colour. The moisture content ranges from 3% to 19%, being typically described as moist.

The grain size distribution of the granular fill is provided in Appendix B as Figure B1. The gradation of the fill is summarized as follows:

Soil Particles	(%)
Gravel	21 to 39
Sand	53 to 72
Silt and Clay	7 to 8

5.2.3 Rockfill

Rockfill was encountered below the granular fill in Borehole BH11-13. The thickness of the rockfill was 3.1 m, with underside at Elevation 288.3 m. The borehole was advanced through the rockfill by coring.

5.2.4 Peat

Peat was encountered below the granular fill in BH12-02. The thickness of this layer was 200 mm, with underside at Elevation 290.0 m. The peat was dark brown, very loose in consistency and described as moist.

5.2.5 Silt

A deposit of silt, some sand, trace gravel, trace clay was encountered underlying the rockfill in BH11-13. The thickness of this deposit was 2.4 m. Borehole BH11-13 was terminated in this deposit at Elevation 286.0 m.

The silt layer is described as loose to compact, becoming very dense at the refusal depth. SPT N-values ranged from 9 to 60. The moisture content varied from 17% to 25%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figures B2) are summarized below:

Soil Particles	(%)
Gravel	2 to 4
Sand	12
Silt	80 to 81
Clay	4 to 5

5.2.6 Gravel and Gravelly Sand

A layer of gravelly sand was encountered below the granular fill in Borehole BH11-14 with a thickness of 1.2 m. A 3.0 m thick layer of gravel with some sand was also encountered in BH11-14 at 4.6 m depth with underside at Elevation 286.0 m.

SPT N-values of 3 to 20 blows for 0.30 m of penetration were measured in this layer, indicating a loose to compact condition.

The measured natural moisture content in this layer ranged from 13% to 26% and the soil is described as wet.

5.2.7 Sand and Silt

A deposit of sand and silt, trace gravel and trace clay was encountered below the gravelly sand deposit in Borehole BH11-14. The thickness of this soil layer was 1.1 m with underside Elevation at 289.0 m.

Based on a SPT N-value of 10, this soil is classified as loose to compact.

The measured natural moisture content was 25% and the soil is described as wet.

A lower layer of sand, some gravel and trace silt was encountered at 7.6m depth in BH11-14. A layer of sand, some gravel to gravelly was also encountered at 3.8 m depth in BH12-02. This deposit was loose to very dense, with SPT N-values of 5 to 71 blows for 0.30 m of penetration. The measured moisture contents were between 13% and 21%, being described as wet. The boreholes were terminated within this deposit at Elevation 284.9 and 283.7 m.

The grain size distributions of selected samples of these soils are reported on the Record of Borehole sheets and shown in Figure B3 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	0 to 31
Sand	53 to 82
Silt and Clay	4 to 47

5.2.8 Auger Refusal

The boreholes drilled through the HWY 11 embankment met auger or split spoon refusal at the depths noted below:

Borehole	Depth to Refusal (m)	Refusal Elevation (m) ⁽¹⁾
BH11-13	7.4	286.0
BH11-14	8.7	284.9
BH12-02	10.1	283.7

Note: (1) refusal on boulder or probable bedrock

5.2.9 Water Levels

The groundwater depth and elevation monitored in the piezometer is shown in the following table.

Borehole	May 05, 2011	
	Depth (m)	Elev. (m)
BH11-13	2.50	290.8

The water levels measured in the open boreholes at the completion of drilling is summarized below:

Borehole	May 04 and 05, 2011	
	Depth (m)	Elev. (m)
BH11-14	2.6	291.0
BH12-02	2.7	291.1

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by the water level in Robin Creek and the associated swamp and may fluctuate in elevation after spring snowmelt or after periods of heavy rainfall.

5.3 East of Robin Creek Culvert (BH RCC-1 and RCC-2)

5.3.1 Water

Standing water was encountered at the surface in Boreholes RCC-1 and RCC-2. The water surface was at Elevation 290.8 m, and the depth of water ranged from 1.4 to 1.5m.

5.3.2 Peat

Peat was encountered in Borehole RCC-2. The thickness of the peat deposit was 0.6 m, with underside at Elevation 288.7 m. This peat is described as very loose based on a single recorded SPT N-value of 1 blow for 0.30 m of penetration.

The peat was dark brown in colour. The measured moisture content was 129%.

5.3.3 Sand

A 0.4 m thick layer of sand, trace gravel and trace silt was encountered surficially in Borehole RCC-1. The underside of this deposit was at Elevation 289.0 m.

Based on one SPT N-value of 7, this soil is classified as loose. The moisture content of this layer is 52%.

5.3.4 Clayey Silt

A 1.3 m thick layer of clayey silt was encountered below the peat deposit in Borehole RCC-2. This soil extends to a depth of 3.4 m, with underside at Elevation 287.4 m.

The clayey silt layer is soft to firm in consistency and is grey in colour. The SPT N-values were 2 and 8 blows for 0.3 m of penetration. The measured water contents were 32% and 47%.

The grain size distribution of one sample of this clayey silt layer is reported on the Record of Borehole sheet and gradation test result (Figures B4) is summarized below:

Soil Particles	(%)
Sand	6
Silt	67
Clay	27

5.3.5 Silt to Sandy Silt

Deposits of silt, trace sand to sandy, and trace to some clay were encountered underlying the sand layer in Borehole RCC-1 and the clayey silt layer in Borehole RCC-2. The underside of the silt deposits ranged from Elevations 281.6 m to 281.3 m. The thickness of this deposit ranges from 6.0 m to 7.3 m. Borehole RCC-1 was terminated within this deposit at Elevation 281.6 m.

This silt is loose to very dense, typically compact. SPT N-values ranged from 4 to 69 blows for 0.3 m of penetration. The moisture content varied from 10% to 28%.

The grain size distributions of selected samples of this soil are reported on the Record of Borehole sheets and gradation test results (Figure B5) are summarized below:

Soil Particles	(%)
Gravel	0 to 17
Sand	5 to 50
Silt	29 to 80
Clay	4 to 15

5.3.6 Sandy Gravel

A deposit of sandy gravel was encountered below the sandy silt in Borehole RCC-2. This layer is 0.7 m thick and the borehole was terminated within this layer at Elevation 280.7 m.

SPT N-values of 78 and 100 blows for 0.025 m of penetration were measured, indicating a very dense layer.

The measured natural moisture content was about 10% and the soil is described as wet.

The grain size distribution of one selected sample of this soil is reported on the Record of Borehole sheets and shown in Figure B6 in Appendix B. The gradation data is summarized below:

Soil Particles	(%)
Gravel	44
Sand	24
Silt & Clay	32

5.3.7 Drill Refusal

The drill refusal noted in the boreholes drilled on the east side of the Robin Creek culvert are summarized below:

Borehole	Depth to Refusal (m)	Refusal Elevation (m)
RCC-1	9.1	281.6
RCC-2	10.1	280.7

5.3.8 Water Levels

The water level at the completion of Boreholes RCC-1 and RCC-2 was at surface, at Elevation 290.8 m.

5.4 West of Robin Creek Culvert (BH12-01)

A single borehole was advanced near the West end of the culvert. Site access constraints restricted the drill rig from drilling closer to the alignment of the culvert. The borehole was terminated at 1.1 m below the existing ground surface upon auger refusal. The borehole encountered 75 mm of organics over 1.0 m of sand fill.

6 MISCELLANEOUS

Surveying of the locations and elevation of the boreholes was provided by MMM Group Limited.

Full time supervision of field drilling, including obtaining utility clearances was carried out by Ms. Eckie Siu of Thurber.

Overall supervision of the field program, interpretation of the data and preparation of the report was carried out by Mr. Stephen Peters, E.I.T. and Mr. Jason Lee, P.Eng.

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

Thurber Engineering Ltd.

Stephen Peters, M.A.Sc., E.I.T.
Project Manager

Jason Lee, M.Sc., P.Eng.
Geotechnical Engineer



P.K. Chatterji, Ph.D., P.Eng.
Review Principal



Appendix A
Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

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

 Water Level
 C_{pen} 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.

RECORD OF BOREHOLE No 11-13

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 532 488 E 282 246 147 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.04 - 2011.05.04 CHECKED BY JPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
293.3	ASPHALT: (50mm)													
291.5	SAND, some to trace gravel Compact to Very Dense Brown Moist (FILL)		1	GS			293							
			1	SS	29		292							
1.9	ROCKFILL		2	SS	73/ 0.260									
288.3							291							
5.0	SILT, some sand, trace gravel, trace clay Loose to Compact Grey Wet		3	SS	15		288							4 12 80 4
			4	SS	9		287							
	Becoming very dense		5	SS	60									2 12 81 5
286.0														
7.4	END OF BOREHOLE AT 7.4m UPON SPLIT SPOON REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2011.05.05 2.50 290.8													

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

RECORD OF BOREHOLE No 11-14

1 OF 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 542.937 E 282 249.374 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers/Casing/NQ COMPILED BY AN
 DATUM Geodetic DATE 2011.05.04 - 2011.05.04 CHECKED BY JPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
293.6	ASPHALT: (38mm)		1	GS			293					
	Gravelly SAND, trace silt, trace clay Loose to Compact Brown Moist (FILL)		1	SS	24		292					
			2	SS	8		291					21 72 7 (SI+CL)
291.3			3	SS	20		290					
2.3	Gravelly SAND, some silt, mixed with peat Compact Dark Brown Wet		4	SS	7		289					
290.1			5	SS	10		288					0 53 38 9
3.5	SAND and SILT, trace clay, occasional oxide staining Loose Grey Wet		6	SS	6		287					
289.0			7	SS	17		286					No sample for WC testing.
4.6	GRAVEL, some sand Very Loose to Compact Grey Wet		8	SS	10		285					
	Occasional cobble		9	SS	3							
			10	SS	7							11 82 7 (SI+CL)
286.0			11	SS	156/ 0.200							
7.6	SAND, coarse grained, some gravel, trace silt, trace clay Loose to Very Dense Brown Wet											
284.9	END OF BOREHOLE AT 8.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 2.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.4m, CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE											

ONTMT4S 1103.GPJ 1/25/12

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-01

1 of 1

METRIC

W.P. 19-5161-103 LOCATION N 5 189 548 E 282 233 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.01.17 - 2012.01.17 CHECKED BY SBP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100	20
292.6																		
0.0	ORGANICS: (75mm)																	
0.1	SAND, some gravel, mixed with organics																	
292.0	Dark Brown																	
0.6	Frozen to Damp (FILL)		1	SS	50/0.05		292											
291.5	SAND, trace silt, trace gravel																	
1.1	Very Dense Brown Damp (FILL)																	
	END OF BOREHOLE AT 1.1m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																	

ONTM74S 1103.GPJ 1/25/12

+³, X³: Numbers refer to Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-02

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 536 E 282 237 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2012.01.16 - 2012.01.16 CHECKED BY SBP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE				
293.8 0.0	SAND, some gravel Compact Brown to dark brown Moist (FILL)		1	GS									
293.0 0.8			1	SS	21								3 20 64 13
292.3 1.5	SILT, some sand, some clay, trace gravel Compact Brown Moist (FILL)		2	SS	39								
	SAND, gravelly, occasional cobbles Dense to loose Brown Moist (FILL)		3	SS	8							39 53 8 (SI+CL)	
			4	SS	1								
290.2 3.6			PEAT, organic, trace wood pieces Very loose Dark brown Moist	5	SS	23							
290.0 3.8				6	SS	15							31 63 6 (SI+CL)
	SAND, some gravel to gravelly Loose to compact Brown Wet		7	SS	20								
			8	SS	5								
			9	SS	7								
			10	SS	10								
			11	SS	16								14 82 4 (SI+CL)
			12	SS	71								
	Occasional cobbles												

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 12-02

2 OF 2

METRIC

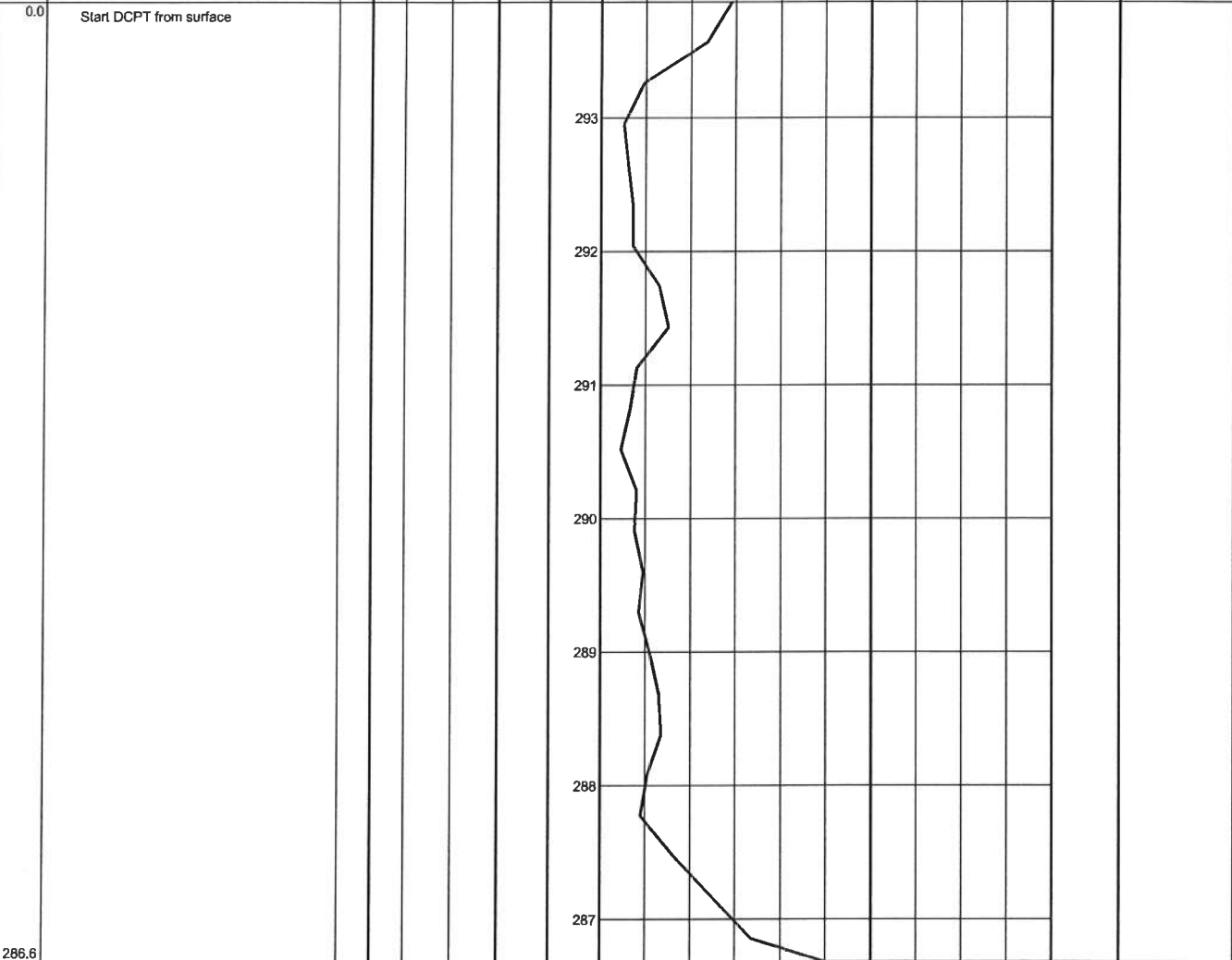
W.P. 19-5161-103 LOCATION N 5 189 536 E 282 237 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2012.01.16 - 2012.01.16 CHECKED BY SBP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	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	W _p W W _L			
283.7	Continued From Previous Page		13	SS	bouncing								
10.1	END OF BOREHOLE AT 10.1m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 2.7 m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH HOLEPLUG TO 150 mm, THEN SAND TO SURFACE.					283							

ONTMT4S 1103.GPJ 1/25/12

METRIC

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100			
293.8											



END OF DCPT AT 7.2m UPON DCPT
REFUSAL.

+³, X³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No RCC-1

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 534.691 E 282 254.844 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
 DATUM Geodetic DATE 2011.04.12 - 2011.04.12 CHECKED BY JPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE	WATER CONTENT (%)								
290.8						20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	GR	SA	SI	CL	
0.0	WATER																	
289.4																		
1.4	SAND, trace gravel, trace silt Loose		1	SS	7													
289.0	Dark Brown																	
1.8	Wet																	
	SILT, some clay, trace sand Loose to Compact		2	SS	4												0	5
	Grey																80	15
	Moist																	
	Black coarse sand seam at 2.6m		3	SS	10													
			4	SS	13													
286.8																		
4.0	Sandy SILT, trace clay Loose to Very Dense		5	SS	9												0	23
	Grey																72	5
	Wet																	
			6	SS	6													
			7	SS	7													
			8	SS	10													
	Occasional cobbles																	
			9	SS	7													
			10	SS	17													
			11	SS	29													
			12	SS	31													
	Becoming silty sand, some gravel, trace clay																	
	Granite fragments																	
			13	SS	127												17	50
281.6																	29	4
9.1	END OF BOREHOLE AT 9.1m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT SURFACE UPON COMPLETION. BOREHOLE CAVED TO 5.1m																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCC-1

2 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 534.691 E 282 254.844 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.04.12 - 2011.04.12 CHECKED BY JPL

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
	Continued From Previous Page												
	BACKFILLED WITH SAND TO SURFACE.												

ONTMT4S 1103.GPJ 1/25/12

+³, X³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCC-2

1 OF 2

METRIC

W.P. 19-5161-103 LOCATION N 5 189 536.616 E 282 260.706 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Tripod/Casing COMPILED BY AN
DATUM Geodetic DATE 2011.04.13 - 2011.04.13 CHECKED BY JPL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
290.8							20 40 60 80 100											
0.0	WATER																	
289.2																		
1.5	PEAT, trace roots and rootlets Very Loose Dark Brown Wet		1	SS	1													
288.7																		
2.1	Clayey SILT, trace sand Soft to Firm Grey Wet		2	SS	2									0 6 68 27				
	Black coarse sand		3	SS	8													
287.4																		
3.4	Sandy SILT, trace clay Loose to Very Dense Grey Wet		4	SS	14													
			5	SS	10									0 24 71 5				
			6	SS	9													
			7	SS	6													
			8	SS	12													
			9	SS	10													
			10	SS	15									0 32 63 5				
	Trace to some gravel																	
			11	SS	24													
			12	SS	23													
			13	SS	69													
281.3																		
9.4	Sandy GRAVEL, some silt to silty, trace clay Very Dense Brown		14	SS	78									44 24 32 (SI+CL)				

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

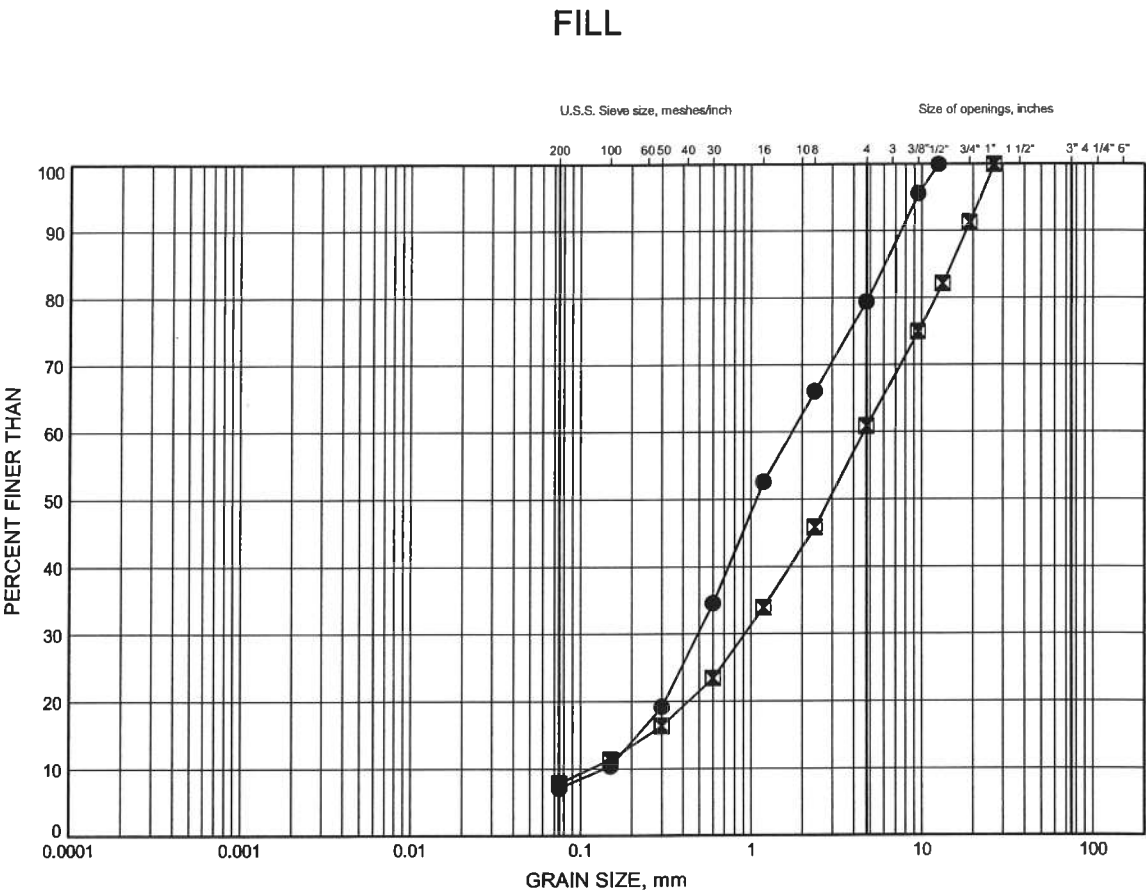
+ 3, × 3: Numbers refer to Sensitivity

Appendix B
Laboratory Test Results

Hwy 11 Tomiko River

GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-14	1.83	291.76
⊠	12-02	2.59	291.21

GRAIN SIZE DISTRIBUTION - THURBER 1103.GPJ 1/25/12

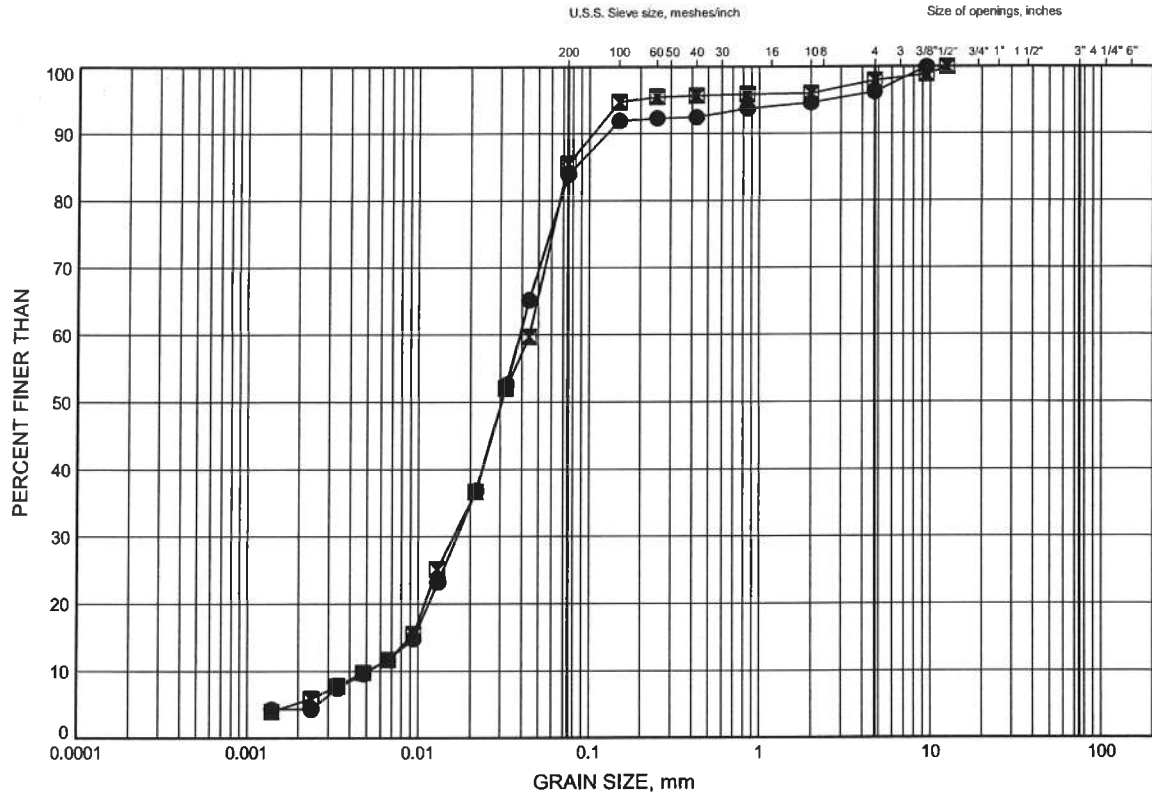
W.P.# 19-5161-103
Prepared By MFA
Checked By SP



Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B2

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-13	5.64	287.69
◻	11-13	7.16	286.17

GRAIN SIZE DISTRIBUTION - THURBER 1103.GPJ 1/25/12

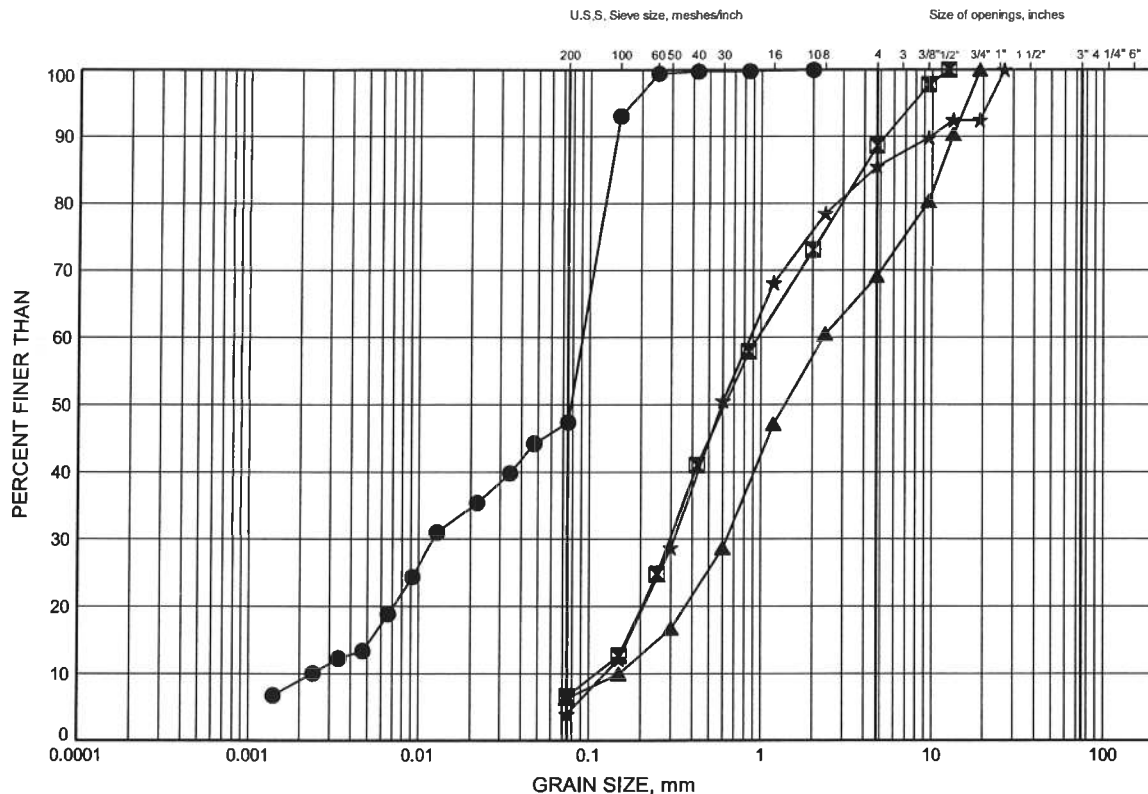
W.P.# 19-5161-103
Prepared By MFA
Checked By SP



Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND and SILT



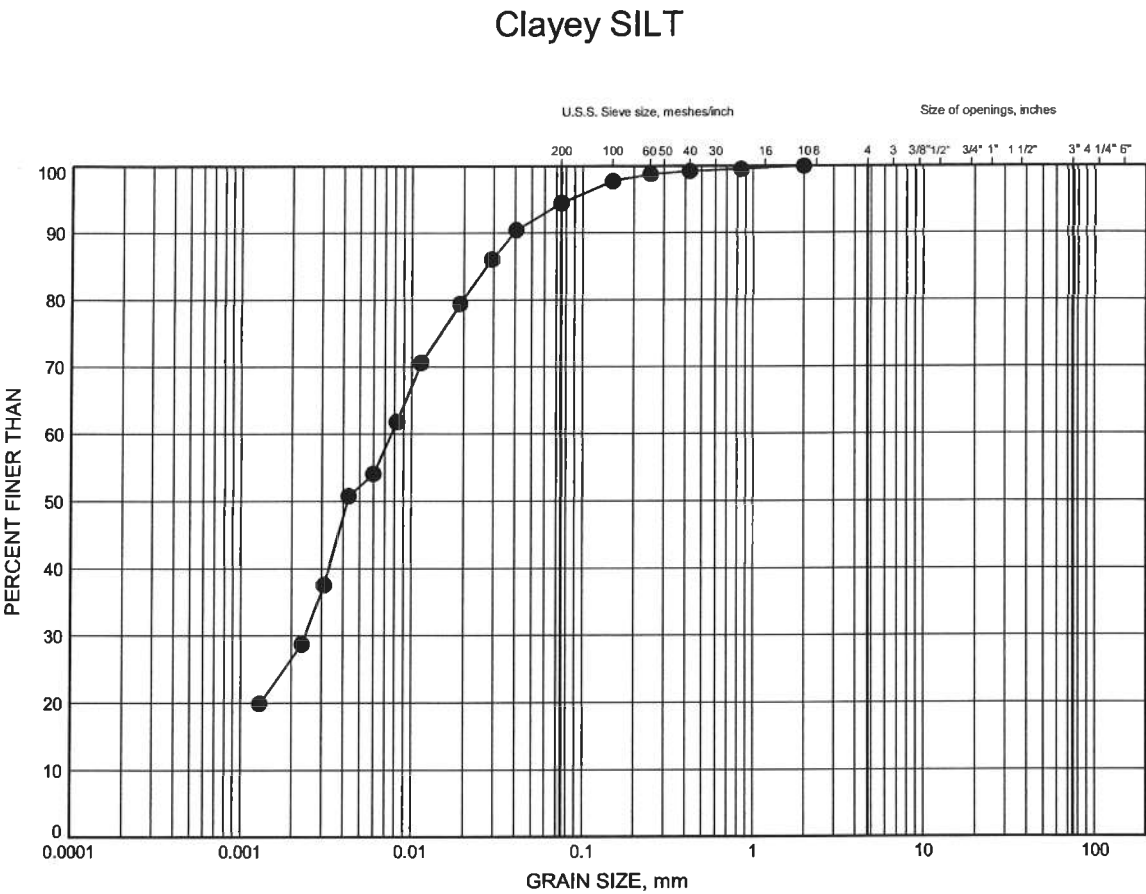
SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11-14	4.11	289.47
⊠	11-14	7.92	285.66
▲	12-02	4.88	288.92
★	12-02	8.69	285.11

Hwy 11 Tomiko River
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)
●	RCC-2	2.44	288.33

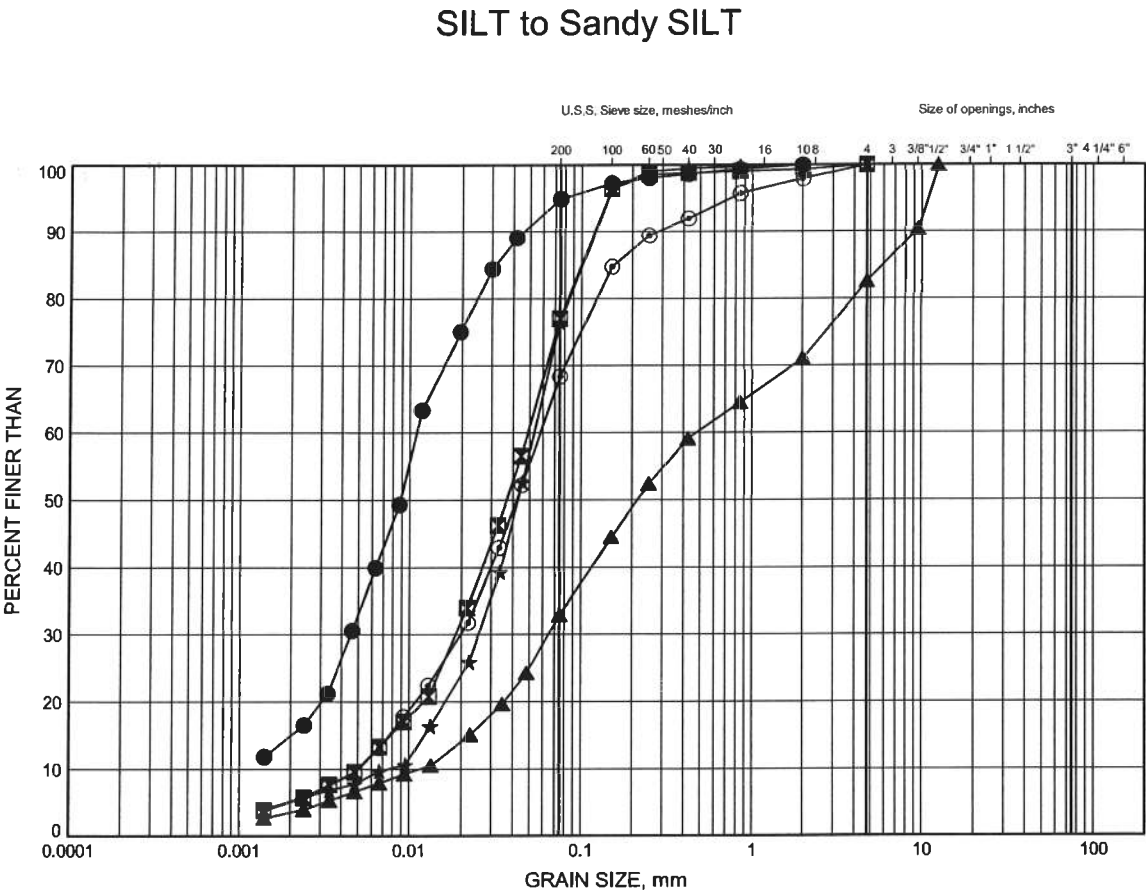
GRAIN SIZE DISTRIBUTION - THURBER 1103.GPJ 1/25/12

W.P.# 19-5161-103
Prepared By MFA
Checked By SP



Hwy 11 Tomiko River
GRAIN SIZE DISTRIBUTION

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RCC-1	2.29	288.49
⊠	RCC-1	4.42	286.36
▲	RCC-1	8.92	281.86
★	RCC-2	4.27	286.50
⊙	RCC-2	7.32	283.45

GRAIN SIZE DISTRIBUTION - THURBER 1103.GPJ 1/25/12

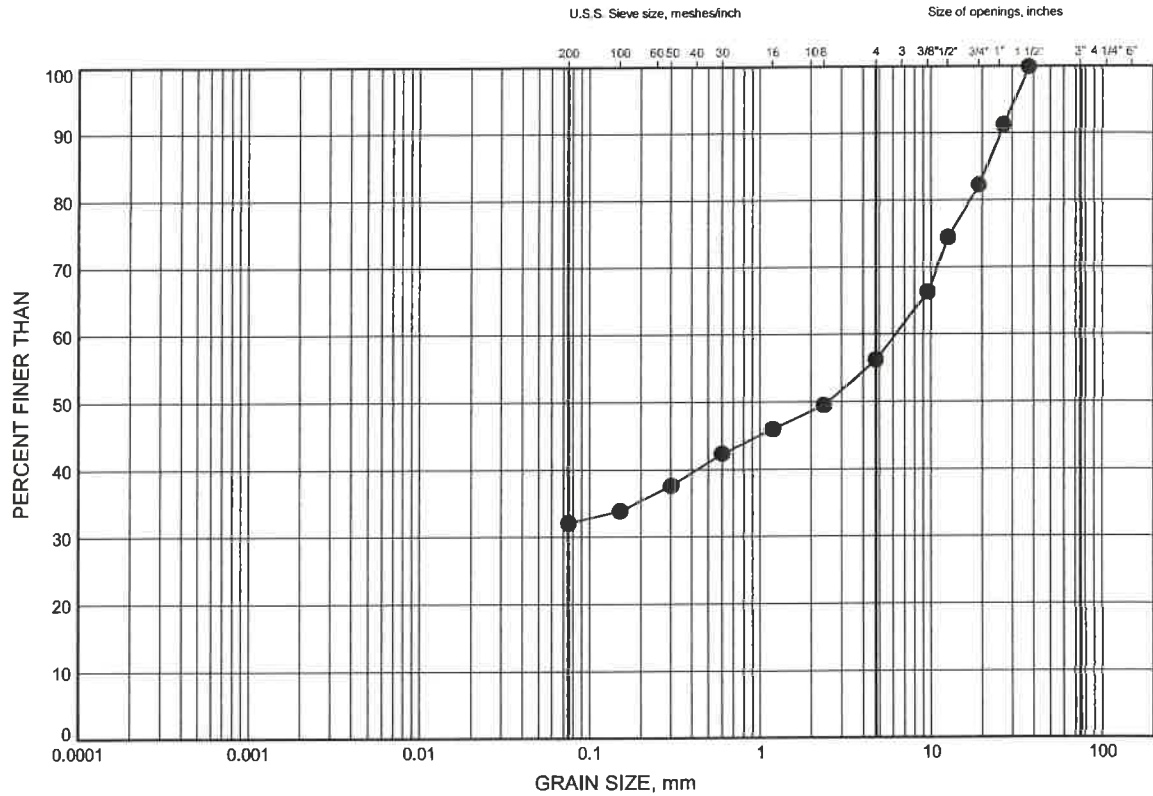
W.P.# 19-5161-103
Prepared By MFA
Checked By SP



Hwy 11 Tomiko River GRAIN SIZE DISTRIBUTION

FIGURE B6

Sandy GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RCC-2	9.75	281.02



W.P.# 19-5161-103
Prepared By MFA
Checked By SP

Appendix C
Drawing

Appendix D

Select Record of Borehole Sheet from Agreement No. 5004-E-0058

SPT 1151G

RECORD OF BOREHOLE No R4

1 OF 1

METRIC

GWP _____ LOCATION Robins Creek, Station 15+223; 12 m Rt C/L ORIGINATED BY JZ
 DIST _____ HWY 11 BOREHOLE TYPE Wash boring/Tripod COMPILED BY JZ
 DATUM Geodetic DATE 3/17/2006 CHECKED BY RM

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
			NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
291.2 0.0	Ground Surface																GR SA SI CL
289.6 1.4	SNOW & ICE (0.4 m) and WATER						291										
288.9 2.3	SILTY CLAY with peat inclusions grey, wet, very soft		1	SS	2		290										
287.4 3.8	SILT to CLAYEY SILT occ. silty clay seams & peat inclusions trace gravel grey, wet		2	SS	2		289										0 2 74 24
285.2 6.0	SANDY SILT with silt layer occ. clay seams, grey, wet		3	SS	6		288										9 6 53 32
			4	SS	9		287										0 21 63 16
			5	SS	9		286										0 12 72 17
			6	SS	23												0 25 58 17
			7	SS	100/0												
	End of borehole. Wash boring refusal at 5.9 m. Water level at surface (not stabilized) and hole open to full depth on completion.																

+ 3, X 3: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

Appendix E

Site Photos



Photo 1: Highway 11 East Embankment Slope North of Robin Creek Culvert (looking northeast at Swamp)

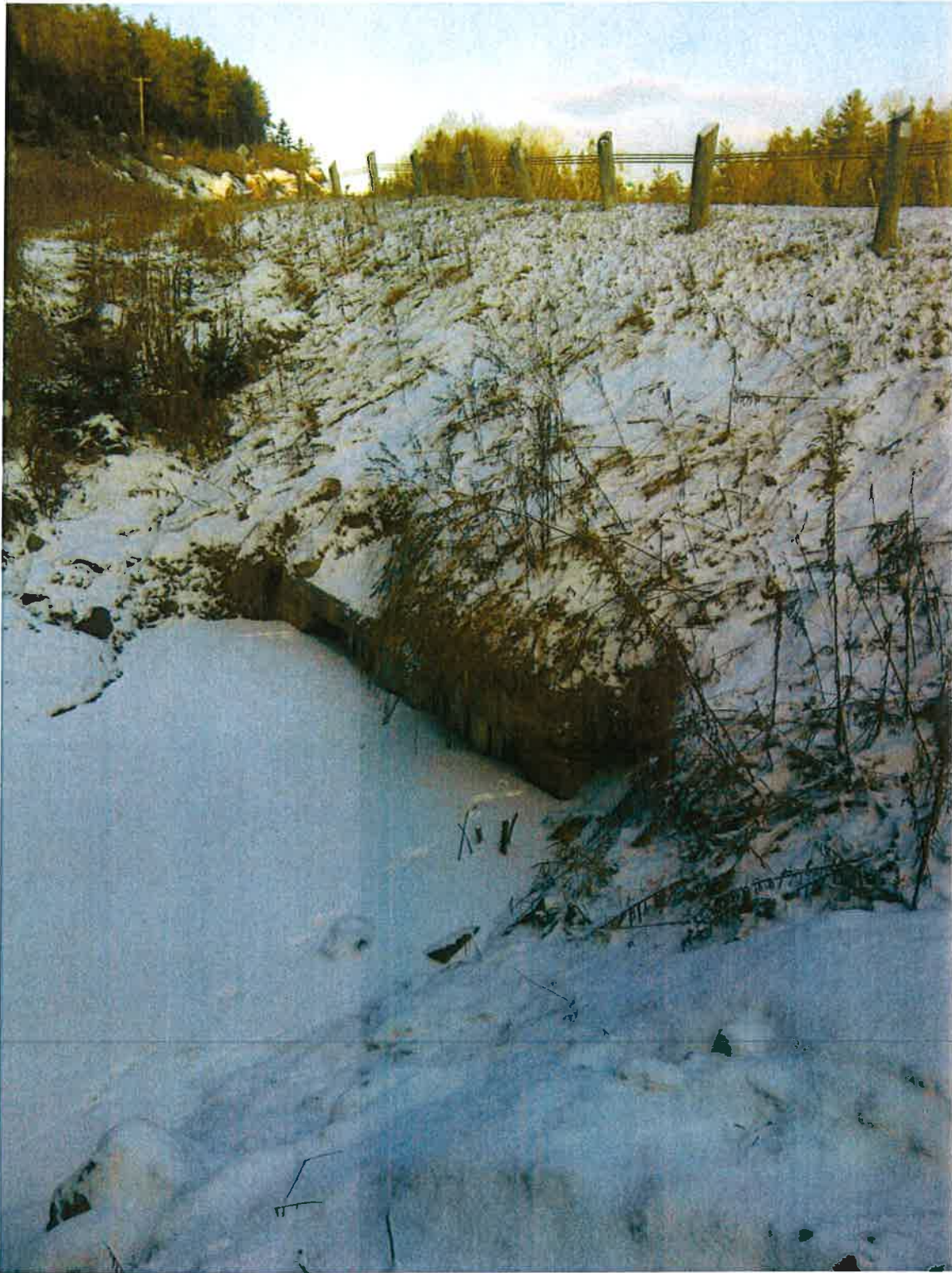


Photo 2: Highway 11 West Embankment Slope at Robin Creek Culvert (looking northeast at culvert outlet)