



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION REPORT
CULVERT 11-17025-008 REPLACEMENT
HIGHWAY 11
MORRISON TOWNSHIP
G.W.P. No. 5056-12-00**

GEOCREC Number: 31D-580

Report to

Ainley Group Limited

5012-E-0008

August 29, 2014

File: 19-6478-0

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**FOUNDATION INVESTIGATION REPORT
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G.W.P. No. 5056-12-00**

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at a culvert replacement site on Highway 11 near Gravenhurst, Ontario.

No previous foundation investigation information near the subject culvert was available.

The purpose of this investigation was to obtain subsurface information at the site and, based on that data, provide a comprehensive model of the subsurface conditions including borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber was retained by the Ainley Group Limited (Ainley) to carry out this foundation investigation under MTO Agreement Number 5012-E-0008.

2 SITE DESCRIPTION

Culvert 11-17025-008 is located within a tangent section on Highway 11, approximately 4.0 km north of the Severn River Bridge in the Township of Morrison. Sparrow Lake D Road and Rainbow Circle intersect with Highway 11 approximately 100 m to the north. A private entrance is located approximately 20 m to the south on the southbound side. The existing highway at this site includes two through lanes and an auxiliary lane in both the northbound and southbound directions which are separated by a median barrier. Gravel shoulders are present to the outside on either side of the highway. A 3-cable Guide Rail is present on the southbound side while an overhead utility line transverses the site near the northbound right-of-way limit.

A 600 mm corrugated steel pipe (CSP) 36.8 m in length is present at the site with a cover of approximately 2.4 m of fill. The grade of the existing Highway 11 in the vicinity of the culvert is at approximately 244.5 m geodetic. The invert elevation is 241.68 m on the east side and

241.5 m on the west side, indicating average gradients of approximately 0.5 % and a flow direction from east to west.

The site is located in a rural area with brush, forested land and occasional residential properties. Bedrock outcrops are present within 20 m in both directions along the highway. Local topography is generally rugged.

The site is located within the Canadian Shield. Soil cover is thin and consists primarily of glacial till and glaciolacustrine (clay, varved clay and silt) deposits with localized organic deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out between March 5 and 7, 2014 to augment information acquired during a pavement investigation at this site. The foundation program consisted of drilling and sampling two boreholes (numbered 14-1 and 14-2) to depths of 5.3 m below ground surface (elevations 240.9 m to 240.5 m) near the existing culvert inlet and outlet. Prior to the start of drilling, the borehole locations were staked in the field and utility clearances were obtained. The staked borehole locations were subsequently surveyed by staff under the direction of Ainley.

Portable drilling equipment including an electric core drill with NW casing and a tripod with a pulley and 140 lb SPT hammer was used to advance the inlet and outlet boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

A pavement engineering investigation was carried out in August 2013 and included ten boreholes drilled with a truck mount CME Drill Rig through the embankment to depths ranging from 4.4 to 7.6 m below ground surface. Hollow stem augers were used to advance the boreholes through the embankment fill and overburden soil. In seven of the boreholes (23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10), soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). The remaining three boreholes (23-2, 23-3 and 23-4), provide an indication of the depth to bedrock as inferred by auger refusal. Approximate locations of the boreholes are shown on the Borehole Location and Soil Strata Drawing in Appendix A.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

The boreholes were backfilled with a bentonite-grout mix. Boreholes through asphalt were capped with 150 mm of premium cold-mix asphalt.

Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

4 LABORATORY TESTING

Soil samples were subjected to Visual Identification and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the figures in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert replacement alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes located on the highway embankment consist of asphalt and/or fill overlying silty sand to silt deposits underlain by probable bedrock. More detailed descriptions of the individual strata are presented below.

5.2 Pavement Structure

Boreholes 23-1 and 23-5 were advanced through the southbound speed change lane of Highway 11 while boreholes 23-6, 23-7, 23-8, 23-9 and 23-10 were advanced through the northbound speed change lane of Highway 11. The thickness of the asphalt was 95 mm in the southbound direction and 135 to 140 mm in the northbound direction.

Granular fill material consisting of sand with silt to sand with silt and gravel was present directly beneath the asphalt in Boreholes 23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10 and extended to a depth of 0.8 m below ground surface. The base of the granular fill was encountered at elevations ranging from 242.7 to 243 m.

SPT N-values ranged from 13 to 41 blows per 0.3 m penetration indicating a compact to dense relative density. The water contents of the recovered fill samples ranged between 3% and 9%. Grain size analyses conducted on three samples of the granular

fill are presented on Figure 1 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	7 to 26
Sand	67 to 82
Silt and Clay	7 to 11

5.3 Embankment Fill

Embankment fill consisting of sand with silt to sand with silt and gravel was encountered below the pavement structure in Boreholes 23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10. The thickness of the embankment fill ranged from 1.4 to 2.2 m. The base of the embankment fill was encountered at elevations ranging from 240.6 to 241.6 m.

SPT N-values ranged from 3 to 34 blows per 0.3 m penetration, indicating a very loose to dense state. The water contents of the recovered fill samples ranged between 4% and 10%. Grain size analyses conducted on four samples of embankment fill are presented on Figure 2 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	10 to 23
Sand	71 to 84
Silt and Clay	6 to 9

Cobbles were inferred to be present between 2.3 and 3.0 m depths within the embankment fill in Borehole 23-8 based on grinding noises and vibration during advancement of the augers. Asphalt fragments were noted in the fill in Boreholes 23-1 and 23-5.

5.4 Organic Material

Organic material ranging from 50 mm to 100 mm in thickness was encountered at the ground surface in Boreholes 14-1 and 14-2. The thickness of the surficial organic material may vary between and beyond the borehole locations, and the limited data is not suitable for estimating stripping quantities.

5.5 Sandy Silt to Silty Sand

The surficial materials and fill were underlain by a sandy silt to silty sand deposit in all boreholes. In Boreholes 23-1, 23-5, 23-6, 23-9 and 23-10 the upper portion contained organic material; this layer was up to 0.8 m in thickness. Cobbles were noted from 3.7 m to 4.5 m depth in Borehole 23-1 and rock fragments were observed in Borehole 23-1 and 14-1 at a depth of 4.5 m to 5.2 m. The sandy silt to silty sand layer was observed to extend the full borehole depth in all boreholes except Boreholes 23-1, 23-7, 23-9 and 14-1. In these four boreholes the underside of the silty sand/sandy silt layer was observed at depths ranging from 4.7 m to 7.3 m (elevation 239.1 m to 235.6 m).

SPT N-values measured within this deposit ranged from 1 to 73 blows per 0.3 m penetration, but were typically indicative of a very loose to compact state. The colour of the sandy silt/silty sand ranged from brown to grey.

The moisture content of the samples tested ranged from 12% to 91% with the higher value recorded within the upper portion of Borehole 23-9 which contained organic material. A number of samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Fig. No 3, 4 and 5 in Appendix C.

Soil Particles	%
Gravel	0 to 4
Sand	32 to 83
Silt	15 to 62
Clay	2 to 12

5.6 Silt

Silt layers were noted within the sandy silt/silty sand deposit in Boreholes 23-5 and 14-2. In Borehole 14-2 the silt was found in two distinct layers, the top of the first was at an elevation of 238.8 m and had a thickness of 0.7 m while the top of the second layer was found at 237.2 m and had a thickness of 1.5 m. The top of the silt deposit in Borehole 23-5 was at an elevation 240.0 m and this deposit had a thickness of 2.1 m.

SPT N-values measured within this deposit ranged from 10 to 22 blows per 0.3 m penetration, indicating a loose to compact state. The colour of the silt was grey in all cases.

The moisture content of the samples tested ranged from 22% to 31%. Three samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Figure 6 in Appendix C.

Soil Particles	%
Gravel	0 to 2
Sand	2 to 3
Silt	78 to 88
Clay	7 to 20

Atterberg limit testing on samples from this layer indicated it to be a non-plastic material.

5.7 Sand with Gravel

A sand with gravel layer was observed at a depth of 7.0 m below ground surface in Borehole 23-7. This unit extended to the termination depth of the borehole at 7.5 m (elevation 236.0 m). It was observed to be compact based on an SPT N value of 16 blows per 0.3 m of penetration.

5.8 Bedrock

Boreholes 23-1, 23-9 and 14-1 were terminated at refusal on probable bedrock. Boreholes 23-2, 23-3 and 23-4 were drilled unsampled as rock probes to provide a further indication of bedrock depth. The following table provides a summary of the available information.

Borehole	Depth to Probable Bedrock	Probable Bedrock Elevation
23-1	4.7 m	239.1 m
23-2 Probe	4.5 m	239.3 m
23-3 Probe	not encountered to 4.5 m	deeper than 239.2 m
23-4 Probe	not encountered to 7.6 m	deeper than 236.1 m
23-5	not encountered to 6.7 m	deeper than 237.0 m
23-6	not encountered to 7.6 m	deeper than 235.9 m
23-7	not encountered to 7.5 m	deeper than 236.0 m

23-8	not encountered to 4.4 m	deeper than 239.2 m
23-9	7.3 m	236.3 m
23-10	not encountered to 7.5 m	deeper than 236.2 m
14-1	5.3 m	235.6 m
14-2	not encountered to 5.3 m	deeper than 235.2 m

It is noted that bedrock outcrops are present to the northwest and southeast of this culvert site.

5.9 Groundwater Conditions

Free water was observed in Boreholes 14-1, 14-2, 23-1 and 23-8 at the time of drilling at elevations of 240.9 m, 240.1 m, 240.8 m and 241.0 m respectively. Water at the inlet of the culvert was observed at approximately elevation 240.9 m at the time of drilling.

Where surface water is present, the groundwater level should be assumed to coincide with the local surface water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Ainley arranged for the survey of the borehole locations, and provided the northing and easting coordinates and ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated the truck-mounted CME 75 drill rig to carry out the drilling, sampling and in-situ testing operations on the existing highway platform. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drill rig.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Justin Gray, Ms. Eckie Siu and Mr. Christopher Murray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Dr. Fred Griffiths. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Fred J. Griffiths, P.Eng.
Associate/Senior Foundations Engineer



P. K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

Appendix A

Borehole Locations and Soil Strata Drawings

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Appendix B

Explanation of Terms and Symbols

Record of Borehole Sheets

19-6478-0



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.

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>		
Fresh (FR)	No visible signs of weathering.			
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.			CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.			SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.			SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.			COAL
Completely Weathered (CW)	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 (MPa) (psi)	Field Estimation of Hardness*
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 14-1

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Southbound Highway 11 N 4 963 373.5 E 632 396.7 ORIGINATED BY CM
 HWY 11 BOREHOLE TYPE Portable Split Spoon COMPILED BY GM
 DATUM Geodetic DATE 2014.03.06 - 2014.03.06 CHECKED BY FG

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						
240.9						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100								
0.0	Organic material (50mm) Dark Brown		1	SS	1									
0.9	Silty Sand Loose to compact Brown to Grey Wet		2	SS	12							0 50 48 2		
			3	SS	9									
			4	SS	15							0 61 36 3		
			5	SS	21									
			6	SS	19									
			7	SS	23							0 68 30 2		
			8	SS	21									
235.6	-Trace rock fragments at 5.2m		9	SS	50/ 130mm							4 52 41 3		
5.3	End of Borehole Probable Bedrock													
	Groundwater observed at elevation 240.9 m at time of drilling													

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT_29/8/14

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

RECORD OF BOREHOLE No 14-2

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Northbound Highway 11 N 4 963 378.5 E 632 348.0 ORIGINATED BY ES
 HWY 11 BOREHOLE TYPE Portable Split Spoon COMPILED BY GM
 DATUM Geodetic DATE 2014.03.05 - 2014.03.05 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
240.5															
0.0	Organic material (100mm) Dark brown Frozen		1	SS	9	▽	240								
0.1	Silty Sand Loose to compact Brown Moist Trace silt		2	SS	22		239								0 83 15 2
238.8			3	SS	20		238								
1.7	Silt with clay Compact Grey		4	SS	10		237								0 2 82 16
238.1			5	SS	19		236								0 35 53 12
2.4	Sandy Silt, trace clay Compact Brown Moist		6	SS	14										
237.5			7	SS	22										2 3 88 7
3.0	Sand, trace silt Compact Brown to grey Moist		8	SS	11										
237.2			9	SS	73										0 71 24 5
3.3	Silt, trace clay Compact Brown/grey Moist														
235.7															
4.8	Silty Sand Very dense Brown Moist														
235.2															
5.3	End of Borehole														
	Groundwater observed at elevation 240.1 m at time of drilling														

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT_29/8/14

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

RECORD OF BOREHOLE No 23-1

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Southbound Highway 11, 10+010 N 4 963 395.2 E 632 369.8 ORIGINATED BY JAG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 2013.08.22 - 2013.08.22 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa						
						20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	W P	W	W L		
							WATER CONTENT (%)							
							20 40 60							
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
243.8														
0.0	95mm ASPHALT													
0.1	Sand with silt and gravel Compact Brown Dry FILL		1	SS	13									
243.0						243								
0.8	Sand with silt and gravel, occasional asphalt fragments Compact Brown Moist FILL		2	SS	27									
						242								
241.6														
2.2	Sand trace organic material, trace gravel Loose to compact Brown Wet		4	SS	4									
						241								
						240								
	-occasional cobbles from 3.7 to 4.5 m													
239.3														
239.5	Sand with silt, occasional rock fragments Brown Wet		7	SS	50/									
4.7	End of Borehole Auger refusal on possible bedrock				100mm									
	Groundwater observed at elevation 240.8 m at time of drilling													

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT_29/8/14

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

RECORD OF BOREHOLE No 23-5

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Southbound Highway 11, 9+990 N 4 963 374.5 E 632 361.9 ORIGINATED BY JAG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 2013.08.22 - 2013.08.22 CHECKED BY FG

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							
							20	40	60	80	100				
243.7															
0.0	95mm ASPHALT														
0.1	Sand with silt Dense to compact Brown FILL		1	AS										7	82 11 (SI+CL)
242.9															
0.8	Sand with silt and gravel Compact Brown Moist FILL		2	AS										16	75 9 (SI+CL)
241.6															
2.1	Sand with silt and gravel, occasional asphalt fragments Looses Brown Moist FILL		3	SS	14										
240.8															
2.9	Sand with organic material Very Loose Brown Moist		4	SS	3										
240.0															
3.7	Silt with clay Compact Grey		5	SS	2										
237.9															
5.8	Sandy silt Compact Grey		6	AS										0	2 78 20
237.0															
6.7	End of Borehole		7	AS										0	43 53 4

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT 29/8/14

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

RECORD OF BOREHOLE No 23-6

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Northbound Highway 11, 9+990 N 4 963 366.1 E 632 382.3 ORIGINATED BY JAG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 2013.08.23 - 2013.08.23 CHECKED BY FG

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								WATER CONTENT (%)	
						20	40	60	80	100	20	40	60	GR	SA	SI	CL
243.5																	
0.0	140mm ASPHALT																
0.1	Sand with silt and gravel Dense Brown Dry		1	SS	33												
242.7	FILL																
0.8	Sand with silt and gravel Compact Brown Moist		2	SS	27									15	79	6	(SI+CL)
	FILL		3	SS	10												
241.1																	
2.4	Sand with organic material Very loose Brown		4	SS	1												
240.8																	
2.7	Sandy Silt Compact Grey to brown Wet		5	SS	20									0	39	57	4
			6	SS	7												
			7	SS	9												
			8	AS													
			9	SS	7												
			10	AS													
235.9																	
7.6	End of Borehole																

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT_29/8/14

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

RECORD OF BOREHOLE No 23-7

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Northbound Highway 11, 9+995 N 4 963 371.8 E 632 384.7 ORIGINATED BY JAG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 2013.08.27 - 2013.08.27 CHECKED BY FG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60					
243.5															
0.0	135mm ASPHALT														
0.1	Sand with silt and gravel Compact Brown Dry		1	SS	23										
242.7	FILL														
0.8	Sand with silt and gravel Compact to loose Brown Dry		2	SS	29										
			3	SS	7										
			4	SS	6										
240.9	Sandy silt Compact to Loose Brown Wet		5	SS	17										
2.6			6	SS	16										
			7	SS	9										
			8	SS	16										
236.5	Sand with Gravel Compact Grey Wet														
7.0															
236.0	End of Borehole														
7.5															

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO)_GDT_29/8/14

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

RECORD OF BOREHOLE No 23-10

1 OF 1

METRIC

GWP# 5056-12-00 LOCATION Northbound Highway 11, 10+010 N 4 963 387.4 E 632 390.9 ORIGINATED BY JAG
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 2013.08.27 - 2013.08.27 CHECKED BY FG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
243.7																
0.0	135mm ASPHALT															
0.1	Sand with silt and gravel Dense Brown Dry		1	SS	32											
242.9	FILL															
0.8	Sand with silt and gravel Compact to loose Brown Dry		2	SS	28											
	FILL															
			3	SS	9											
241.5																
241.3	Sand trace gravel, trace organic material Very loose Brown Wet		4	SS	4											
2.4	Sandy silt Loose to Compact Brown/grey Wet		5	SS	17											
			6	SS	9											
			7	SS	12											
236.2	End of Borehole															
7.5																

ONTMT4S_19-6478-0 SITE 23.GPJ_2012TEMPLATE(MTO).GDT_29/8/14

Appendix C

Laboratory Test Results

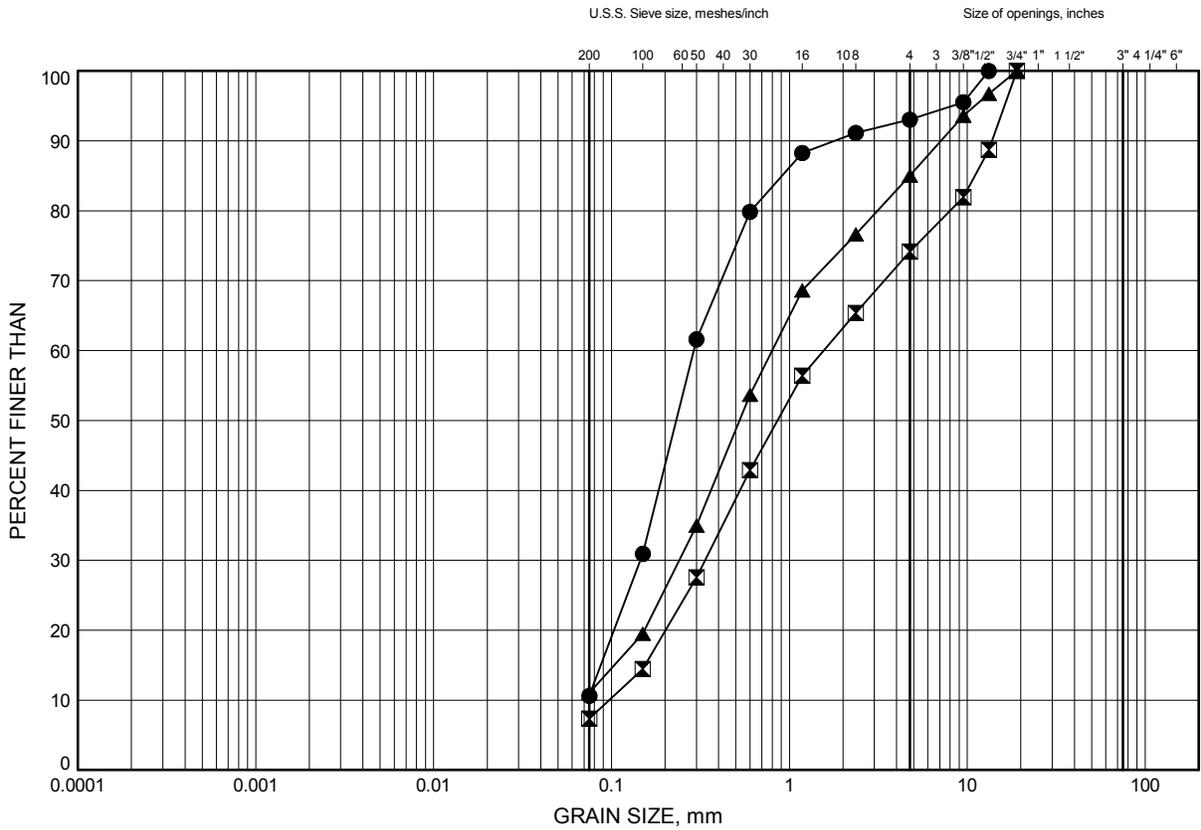
19-6478-0



Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	23-5	0.46	243.24
⊠	23-8	0.46	243.14
▲	23-9	0.46	243.14

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 2/13/14

Date March 2014
 GWP# 5056-12-00

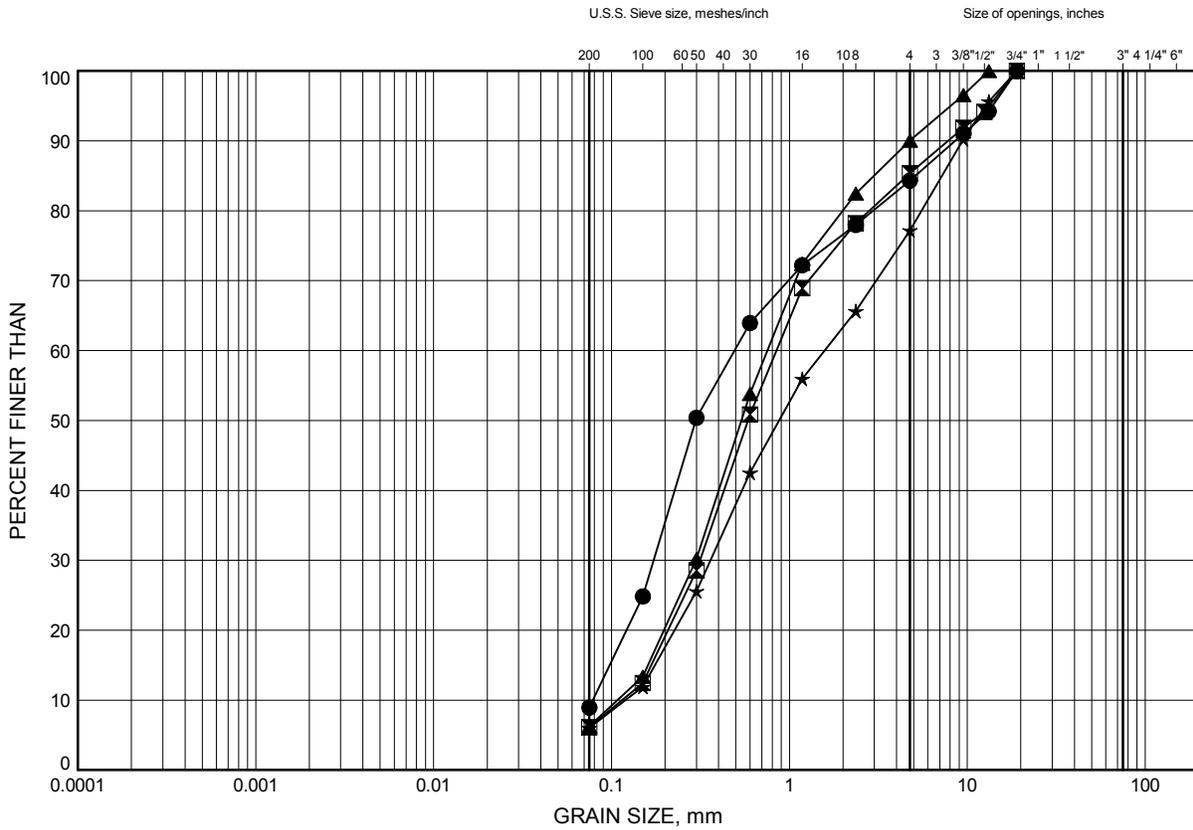


Prep'd CM
 Chkd. FJG

Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 2

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	23-5	1.07	242.63
⊠	23-6	1.07	242.43
▲	23-9	1.07	242.53
★	23-9	1.83	241.77

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 2/13/14

Date March 2014
 GWP# 5056-12-00

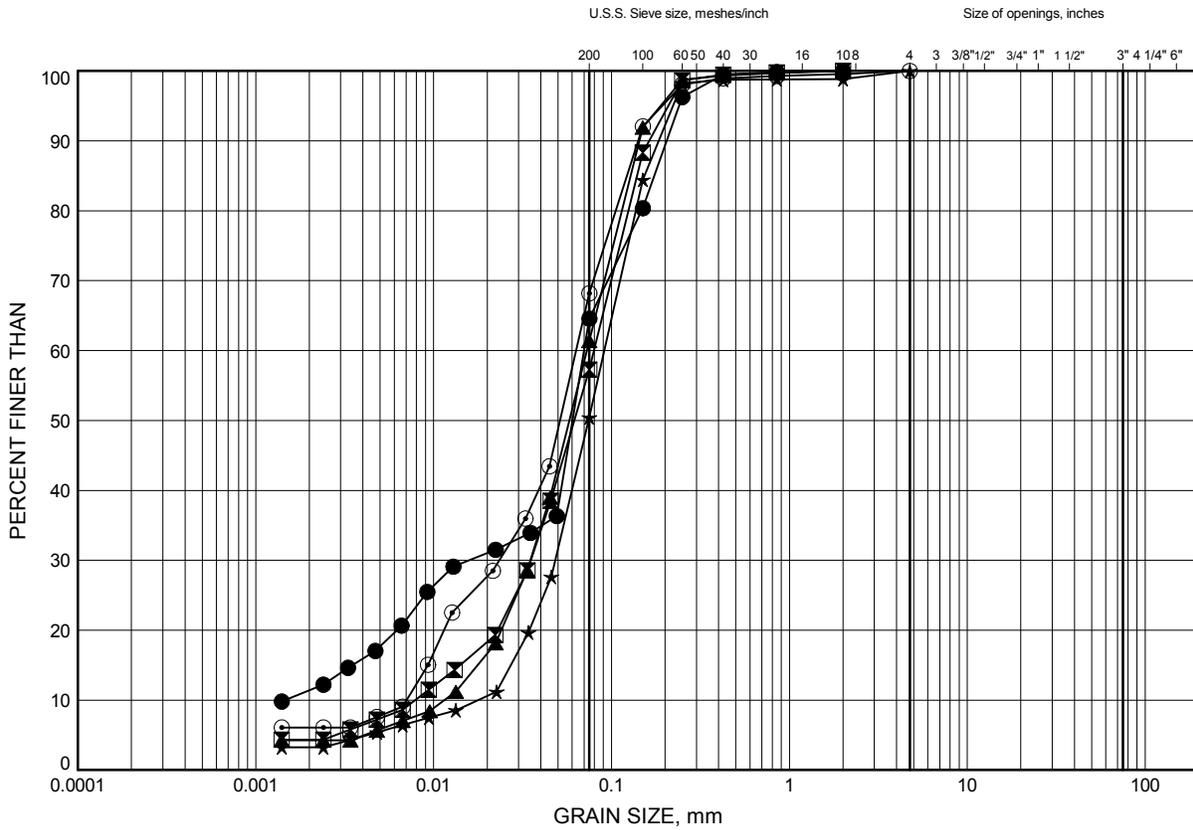


Prep'd CM
 Chkd. FJG

Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 3

Sandy Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	2.74	237.76
⊠	23-5	6.40	237.30
▲	23-6	3.35	240.15
★	23-8	3.35	240.25
⊙	23-9	3.35	240.25

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 2/13/14

Date March 2014
 GWP# 5056-12-00

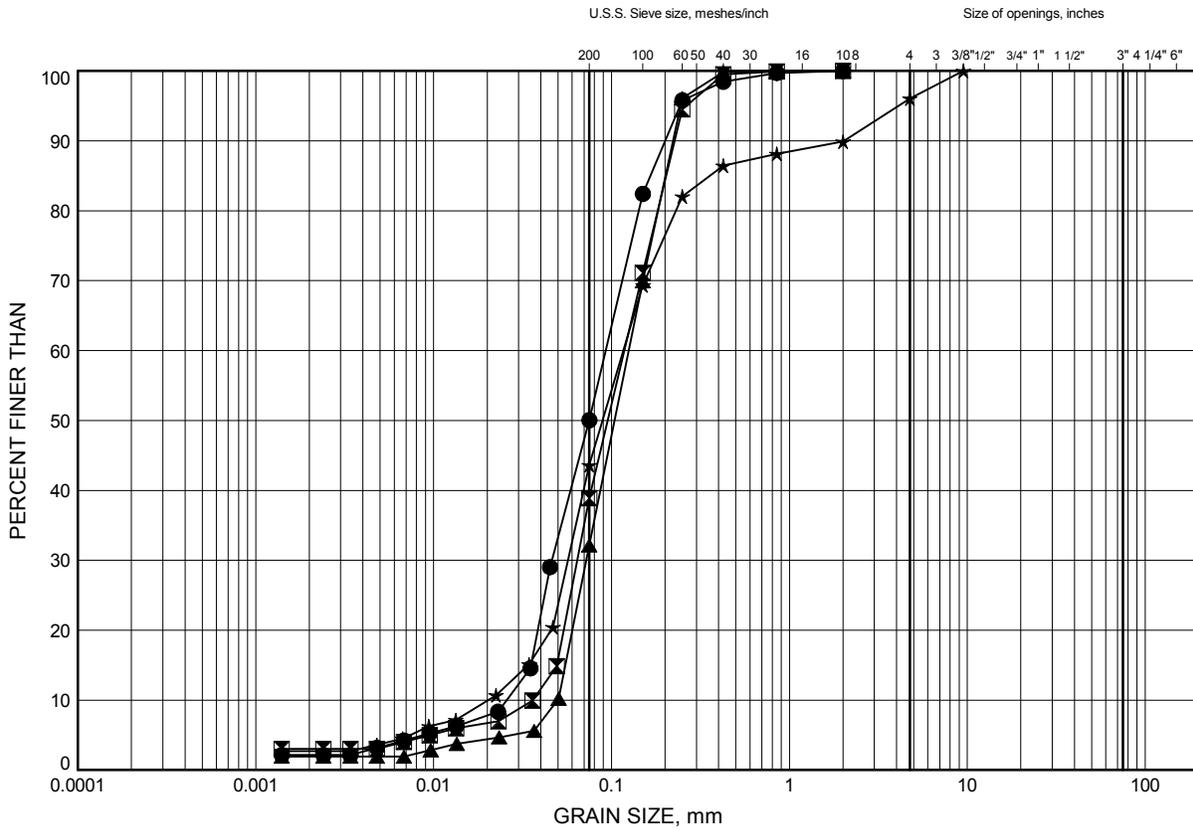


Prep'd CM
 Chkd. FJG

Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 4

Silty Sand



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1	0.91	239.98
☒	14-1	2.13	238.77
▲	14-1	3.96	236.94
★	14-1	5.09	235.81

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 2/13/14

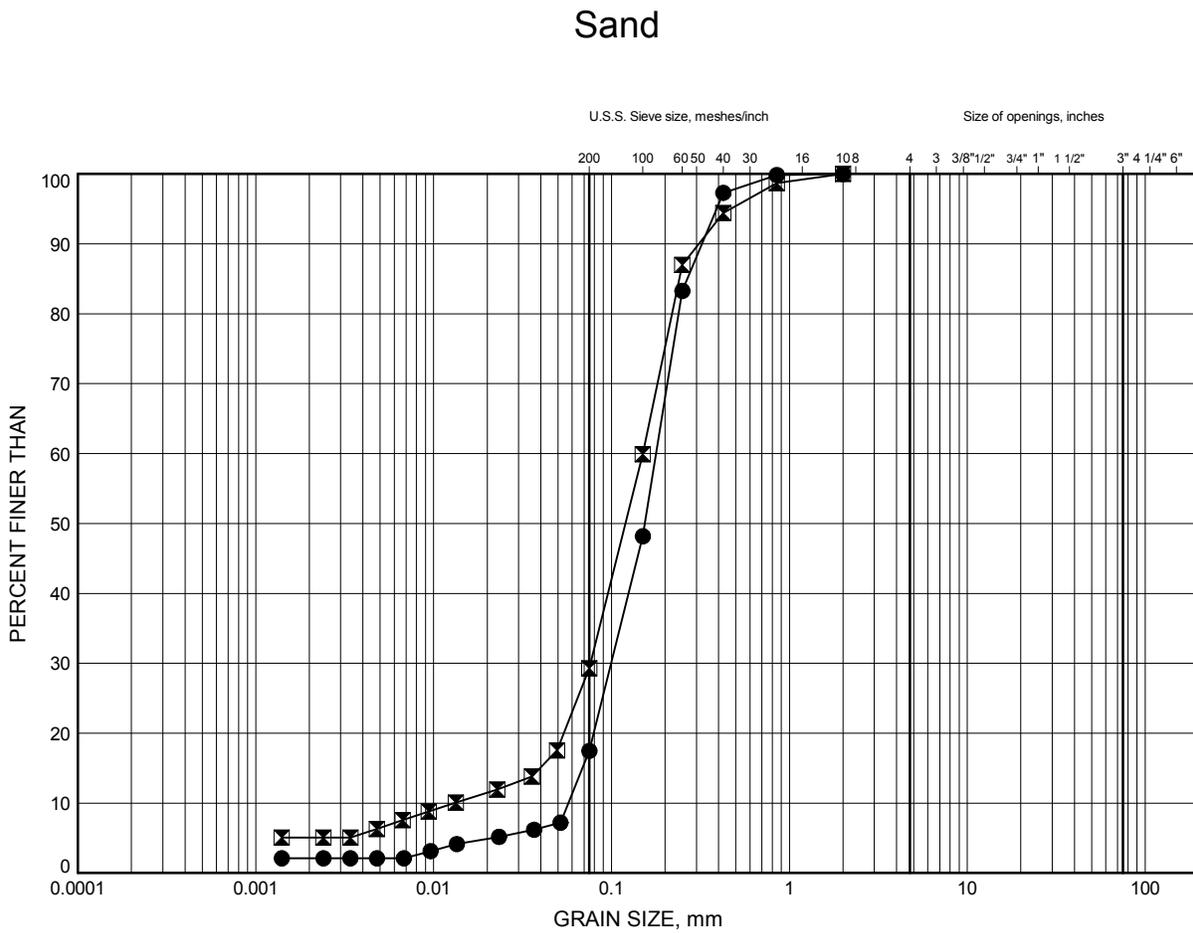
Date March 2014
 GWP# 5056-12-00



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Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	0.91	239.58
⊠	14-2	5.11	235.39

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 21/3/14

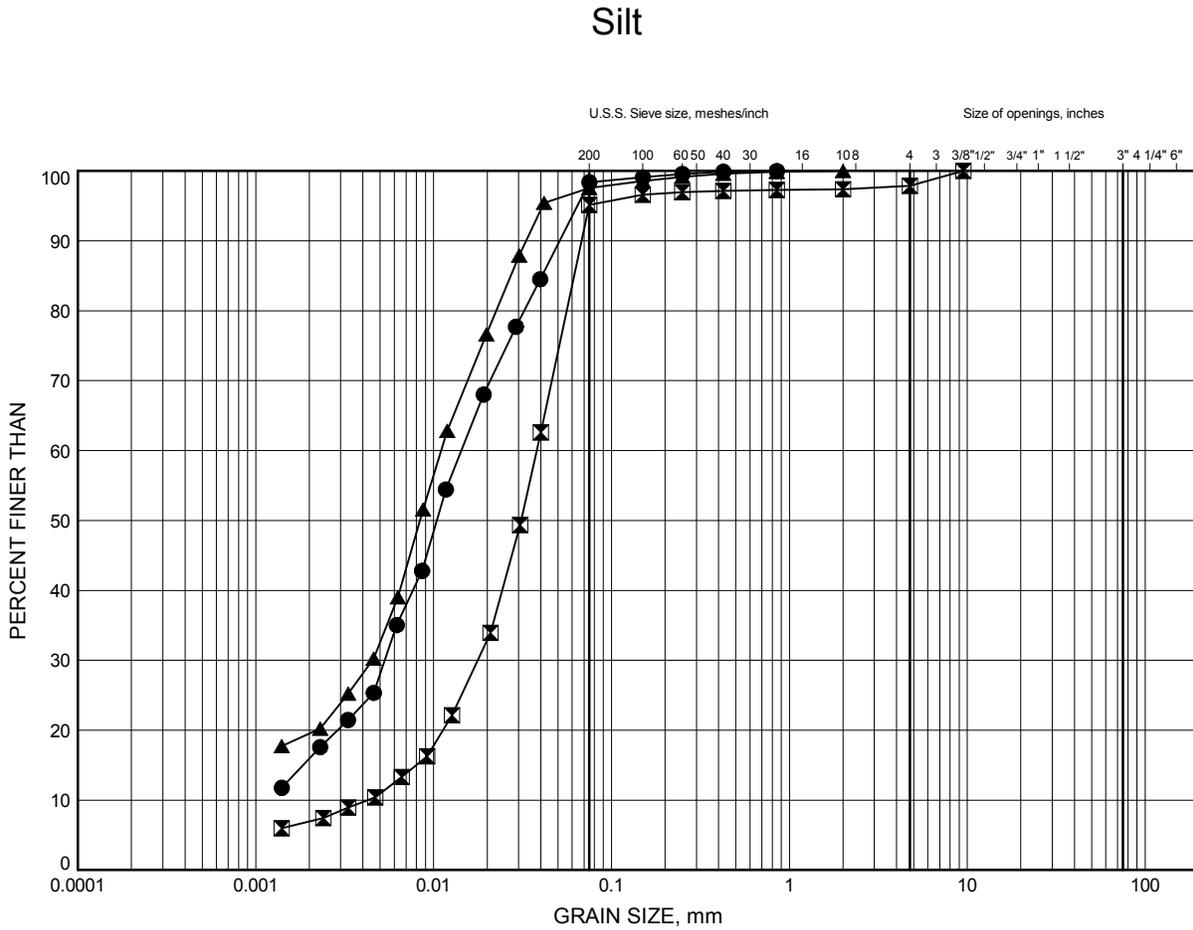
Date March 2014
 GWP# 5056-12-00



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 Chkd. FJG

Culvert 11-17025-008
GRAIN SIZE DISTRIBUTION

FIGURE 6



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	2.13	238.37
⊠	14-2	3.96	236.54
▲	23-5	4.88	238.82

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 2/13/14

Date March 2014
 GWP# 5056-12-00



Prep'd CM
 Chkd. FJG