

**FOUNDATION INVESTIGATION REPORT  
PAGWACHUAN RIVER EAST CULVERT REPLACEMENT  
HIGHWAY 11  
DISTRICT OF THUNDER BAY, ONTARIO**

**G.W.P. 6134-04-00, SITE No. 48E-71/C**

**Geocres Number: 42F-30**

**Report to**

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the proposed location of the replacement culvert carrying Highway 11 over Pagwachuan River East, approximately 80 km east of Longlac, in the District of Thunder Bay, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 6010-E-0011.

**2 SITE DESCRIPTION**

The existing Pagwachuan River East culvert is located approximately 80 km (by highway) east of Longlac, Ontario and about 3 km west of the intersection of Highway 11 and South Pagwachuan Road. Pagwachuan River East is a tributary of the main Pagwachuan River, which runs in a meandering west to east direction, south of Highway 11. At the existing Highway 11 crossing, the tributary flows in a general north to south direction before meeting the main Pagwachuan River.

The existing culvert under the highway embankment consists of a 36.2 m long cast-in-place concrete box culvert with a 3.1 by 3.1 m opening and the highway embankment is approximately 7.0 m high. Preliminary drawings provided by MMM indicate a water level of Elev. 221.3 m at the outlet of the culvert in April 2011.

The surrounding lands are densely treed with grass and shrubs in close proximity to the highway. Photographs in Appendix C show the existing Pagwachuan River East culvert and the general nature of the site.

The site lies within the physiographic region known as the Quetico Subprovince of the Superior Province of the Canadian Shield. Based on Ontario Geological Survey (OGS) Map s365, titled “Algoma-Cochrane Surficial Geology”, dated 1962, the site is located in an area consisting of lacustrine deposits of varved clay and silt, fine sand, and clayey till ground moraine. The bedrock in the region is early Precambrian and based on OGS Map 2543, titled “Bedrock Geology of Ontario, East-Central Sheet”, dated 1991, the bedrock consists of metasedimentary bedrock (paragneiss and migmatites).

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

The site investigation and field testing for this project was carried out between June 7 and 12, 2014. The investigation comprised drilling and sampling four boreholes identified as Boreholes PCE-01 to PCE-04 along the proposed replacement culvert alignment. Boreholes PCE-01 and PCE-04 were drilled near the proposed inlet and outlet respectively, and Boreholes PCE-02 and PCE-03 were drilled on the west and east sides of the culvert alignment through the existing highway embankment.

The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling.

Boreholes PCE-02, PCE-03 and PCE-04 were advanced to depths between 12.7 and 14.8 m (Elev. 207.9 to 214.5 m), with drilling carried out using a track mounted CME 55 drill rig with NW casing and wash boring techniques. Borehole PCE-01 was drilled using portable tripod equipment until encountering refusal material at a depth of 4.4 m (Elev. 216.5 m). Soil samples were obtained at selected intervals in the boreholes using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was conducted to further assess the undrained shear strength of the cohesive deposits.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber’s technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber’s laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes upon completion of the drilling operations. A standpipe piezometer was installed in one borehole to measure groundwater levels. The piezometer was subsequently decommissioned in general accordance with MOE Regulation

903 following completion of the final water level reading. The piezometer installation and borehole completion details are summarized in Table 3.1.

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

<b>Borehole</b>	<b>Piezometer Tip Depth/ Elev. (m)</b>	<b>Completion and Installation Details</b>
PCE-01	None installed	Borehole sloughed in to 1.2m, backfilled with cuttings to surface.
PCE-02	None installed	Backfilled with bentonite holeplug to 0.6m, concrete to 0.1 m, then asphalt cold patch to surface.
PCE-03	None installed	Backfilled with bentonite holeplug to 0.6m, concrete to 0.1 m, then asphalt cold patch to surface.
PCE-04	5.2 / 215.4	19 mm diameter piezometer installed with bentonite holeplug from 3.3 m to surface.

#### 4 LABORATORY TESTING

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

#### 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawings included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions.

In general, the subsurface stratigraphy encountered at the culvert site consisted of existing embankment fill, overlying deposits of organic sandy silt and peat/topsoil, underlain by silty sand to sand and gravel. Sandy silt till was encountered below the sand and gravel in one borehole. More detailed descriptions of the individual strata are presented below.

##### 5.1 Pavement Structure

A pavement structure comprising 115 to 125 mm of asphalt over sand and gravel fill was encountered in Boreholes PCE-02 and PCE-03 drilled on the highway. The sand and gravel fill extended to depths of 1.4 and 1.8 m (Elev. 226.3 and 225.9 m).

SPT N-values recorded in the sand and gravel fill ranged from 55 to 64 blows per 0.3 m, indicating a very dense relative density. An N-value of 50 blows for 0.15 m penetration

was recorded upon encountering a cobble in Borehole PCE-02. Moisture contents of the sand and gravel fill ranged from 4 to 12%.

Two samples of the sand and gravel fill were selected for laboratory grain size analysis testing. The grain size distribution curves for the samples are plotted on Figure B1 of Appendix B. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A.

Gravel %	42 to 64
Sand %	34 to 52
Silt and Clay %	2 to 6

## 5.2 Embankment Fill

Existing embankment fill was encountered below the pavement structure in Boreholes PCE-02 and PCE-03. The fill consisted of silt and sand over silty clay in Borehole PCE-02, and silty clay enclosing a 0.8 m thick zone of silty sand with wood pieces in Borehole PCE-03. The thickness of the embankment fill was 5.6 and 5.8 m, with a lower boundary encountered at depths of 7.0 and 7.6 m (Elev. 220.7 and 220.1 m).

SPT N-values recorded in the upper 1.5 m of the fill ranged from 11 to 15 blows per 0.3 m penetration, indicating a compact/stiff condition. Below this level, the N-values varied from 2 to 6 blows per 0.3 m, indicating a loose/soft to firm consistency. Moisture contents ranged from 15 to 26% in the silt/sand fill and 23 to 34% in the silty clay fill.

The results of grain size distribution analyses conducted on samples of the fill are presented on the Record of Borehole sheets in Appendix A and on Figures B2 and B3 in Appendix B. The results of Atterberg Limits testing conducted on two samples of the clay fill are presented on the Record of Borehole sheets and plotted on Figure B8 of Appendix B. The results are summarized below.

	<u>Silty Clay Fill</u>	<u>Silt and Sand Fill</u>
Gravel %	0 to 4	6
Sand %	4 to 21	36
Silt %	38 to 49	42
Clay %	26 to 50	16
Liquid Limit %	29 to 40	-
Plastic Limit %	15 to 19	-

### 5.3 Organic Deposits

Organic deposits primarily consisting of dark brown silt to sandy silt, some clay to clayey, were encountered at the ground surface in Boreholes PCE-01 and PCE-04, and beneath the existing embankment fill in Boreholes PCE-02 and PCE-03. These deposits contained peat inclusions and wood pieces. Locally, a 0.6 m thick layer of brown sand with trace organics was encountered within the organic silt in Borehole PCE-01, and a 0.9 m thick layer of peat and clayey silt was encountered in Borehole PCE-04.

The thickness of the organic deposits ranged from 1.8 to 2.4 m with a lower boundary encountered at depths varying from 1.8 to 9.4 m (Elev. 218.2 to 219.1 m).

SPT N-values recorded in the organic deposits ranged from 1 to 9 blows per 0.3 m penetration, indicating a very soft to stiff consistency, typically soft to firm. Moisture contents ranged from 16 to 80%, locally up to 126% in the peat and clayey silt layer.

Three samples of the organic silt were selected for laboratory grain size analysis testing. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for the samples are plotted on Figure B4 of Appendix B.

Gravel %	0 to 2
Sand %	24 to 40
Silt %	42 to 51
Clay %	16 to 28

### 5.4 Silty Clay

A localized 1.0 m thick layer of silty clay with trace sand was encountered beneath the peat and clayey silt in Borehole PCE-04. The lower boundary of the silty clay was encountered at a depth of 3.4 m (Elev. 217.2 m).

A single SPT N-value of 4 blows per 0.3 m penetration was recorded in the silty clay. In situ shear vane testing indicated an undrained shear strength of 48 kPa. Based on this data, the consistency of the silty clay is generally firm. The measured sensitivity of 7, from remoulded field vane testing, indicates that the silty clay is sensitive. The measured moisture contents varied between 26 and 28%.

### 5.5 Silty Sand to Sand

A layer ranging in composition from silty sand with trace gravel and trace clay to sand with some gravel, some cobbles and trace silt was encountered beneath the organic silt in Boreholes PCE-01 and PCE-02. This deposit became gravelly with depth in Borehole

PCE-02. Both boreholes were terminated within this deposit at depth of 4.4 and 14.8 m (Elev. 216.5 to 212.9 m).

SPT N-values ranged from 12 to 19 blows per 0.3 m penetration in the upper 2.0 m of this layer, indicating a compact condition. N-values of 73 blows per 0.3 m to 100 blows per 0.1 m of penetration were recorded below this level, indicating a very dense relative density. Moisture contents varied between 9 and 25%.

Two samples of the silty sand to sand were selected for laboratory grain size analysis testing. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets included in Appendix A. The grain size distribution curves for the samples are plotted on Figure B5 of Appendix B.

Gravel %	4 to 15
Sand %	67 to 68
Silt and Clay %	18 to 28

### 5.6 Sand and Gravel

A deposit of sand and gravel with trace to some silt and occasional cobbles and pockets of clay and silt was encountered beneath the organic silt and silty clay layer in Boreholes PCE-03 and PCE-04. The sand and gravel deposit had a thickness of 1.5 m and a lower boundary at 4.9 m depth (Elev. 215.7 m) in Borehole PCE-04. Borehole PCE-03 was terminated within the sand and gravel deposit at a depth of 13.2 m (Elev. 214.5 m).

SPT N-values recorded in the sand and gravel ranged from 51 blows per 0.3 m penetration to 50 blows per 0.075 m of penetration, indicating a very dense relative density. Moisture contents varied between 6 and 15%.

One sample of the sand and gravel was selected for laboratory grain size analysis testing. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for the sample is plotted on Figure B6 of Appendix B.

Gravel %	46
Sand %	47
Silt and Clay %	7

### 5.7 Sandy Silt Till

A deposit of sandy silt till with some clay (to clayey) and trace gravel, cobbles and boulders was encountered beneath the sand and gravel deposit at 4.9 m depth (Elev. 215.7)

in Borehole PCE-04. The borehole was terminated within this layer at a depth of 12.7 m (Elev. 207.9 m).

SPT N-values recorded in the sandy silt till ranged from 113 blows per 0.3 m penetration to 50 blows per 0.1 m of penetration, indicating a very dense relative density. Moisture contents measured in the sandy silt till were between 9 and 12%.

One sample of the sandy silt till was selected for laboratory grain size analysis testing. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet included in Appendix A. The grain size distribution curve for the sample is plotted on Figure B7 of Appendix B.

Gravel %	3
Sand %	29
Silt %	47
Clay %	21

### 5.8 Water Levels

Groundwater levels in the boreholes were observed during drilling and a standpipe piezometer was installed in one borehole to monitor groundwater levels after completion of drilling. A summary of the recorded groundwater levels is provided below.

**Table 5.1 - Groundwater Level Measurements**

Borehole	Date	Groundwater Level		Comment
		Depth (m)	Elevation	
PCE-02	June 11, 2014	6.4	221.3	Open Borehole
PCE-04	June 11, 2014	-0.8*	221.4	In piezometer
	June 12, 2014	-0.8*	221.4	

\* indicates artesian groundwater level above the ground surface

The water levels recorded above the ground surface are indicative of artesian pressures present in the sand and gravel layer below the silty clay.

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected. Higher water levels may occur, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

The groundwater level is also expected to be influenced by the water level in the Pagwachuan River East, which is shown on the preliminary drawings provided by MMM to be at Elev. 221.3 at the outlet in April 2011.

## 6 MISCELLANEOUS

In general, the borehole locations were positioned in the field by Thurber staff and were established relative to site features. The co-ordinates and ground surface elevations at the boreholes were inferred from the MMM Group Limited General Arrangement drawing dated March 2014.

Eastern Ontario Diamond Drilling Limited from Hawkesbury, Ontario supplied a tri-pod and track mounted CME 55 drill rig and conducted the drilling, sampling and in-situ testing operations.

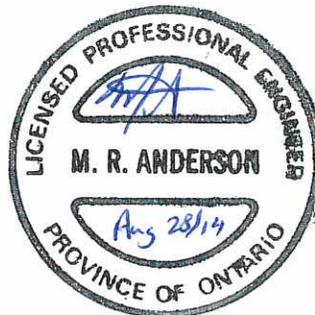
Full time supervision of the field activities was carried out by Mr. Matthew Whalen of Thurber. Overall supervision of the field program was conducted by Mr. Mark Farrant, P. Eng.

Interpretation of the data and preparation of this report were carried out by Mr. Michael Eastman and 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

*Michael Eastman* Aug 28/14

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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  
 $C_{pen}$  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

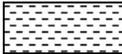
### ROCK WEATHERING CLASSIFICATION

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

### DISCONTINUITY SPACING

<b>Bedding</b>	<b>Bedding Plane Spacing</b>
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

### SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

### STRENGTH CLASSIFICATION

<b>Rock Strength</b>	<b>Approximate Uniaxial Compressive Strength</b>		<b>Field Estimation of Hardness*</b>
	<b>(MPa)</b>	<b>(psi)</b>	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
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

### TERMS

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 % 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 PCE-01

1 OF 1

METRIC

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 942.1 E 203 469.0 ORIGINATED BY MW  
 HWY 11 BOREHOLE TYPE Tripod & NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2014.06.12 - 2014.06.12 CHECKED BY MEF

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
			NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
220.9 0.0	<b>ORGANIC SILT</b> , trace peat, trace to some sand, trace gravel Very Soft to Soft Dark Brown Wet		1	SS	2													
220.3 0.6	<b>SAND</b> , some silt, some gravel, trace organics Loose Brown Wet		2	SS	5		220											
219.7 1.2	<b>ORGANIC SILT</b> , sandy, some clay, trace gravel, trace wood Firm Dark Brown Wet		3	SS	5		219											2 40 42 16
219.1 1.8	<b>ORGANIC SILT</b> , sandy, some clay, trace gravel, trace wood Firm Dark Brown Wet		4	SS	12		219											4 68 28 (SI+CL)
	Silty <b>SAND</b> , trace gravel, trace clay Compact Brown Wet		5	SS	14		218											
			6	SS	17													
216.5 4.4	END OF BOREHOLE AT 4.4m. BOREHOLE SLOUGHED IN TO 1.2m, BACKFILLED WITH CUTTINGS TO SURFACE.		7	SS	100/		217											
					0.100													

ONTMT4S\_1197.GPJ 2012TEMPLATE(MTO).GDT 8/8/14

### RECORD OF BOREHOLE No PCE-02

1 OF 2

METRIC

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 925.1 E 203 454.3 ORIGINATED BY MNW  
 HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2014.06.11 - 2014.06.11 CHECKED BY MEF

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							
227.7															
0.0	<b>ASPHALT:</b> (115mm)														
0.1	<b>SAND</b> and <b>GRAVEL</b> , trace silt Very Dense Dark Brown Moist (FILL)		1	SS	64										
			2	SS	50/ 0.150									64 34 2 (SI+CL)	
226.3	Cobble at 1.1m														
1.4	<b>SILT</b> and <b>SAND</b> , some clay to clayey, trace gravel Compact to Loose Brown Moist (FILL)		3	SS	15										
			4	SS	11										
			5	SS	4									6 36 42 16	
223.6			6	SS	5										
4.1	Silty <b>CLAY</b> , trace sand, trace gravel, trace oxide lenses Firm Brown (FILL)		7	SS	5									0 4 46 50	
220.7			8	SS	5										
7.0	<b>ORGANIC SILT</b> , sandy, some clay to clayey, trace peat, trace wood pieces Firm Dark Brown Moist		9	SS	6									0 31 51 18	
218.3															
9.4	<b>SAND</b> , some gravel, some silt, with cobbles Compact Brown														

ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 8/8/14

Continued Next Page

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

**RECORD OF BOREHOLE No PCE-02**

2 OF 2

**METRIC**

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 925.1 E 203 454.3 ORIGINATED BY MNW  
 HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2014.06.11 - 2014.06.11 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
	Continued From Previous Page						20	40	60	80	100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) 20 40 60			
	SAND, some gravel, some silt, with cobbles Compact Brown Wet		10	SS	19										
	With silt till pockets Very Dense														
	Gravelly		11	SS	73										15 67 18 (SI+CL)
			12	SS	50/ 0.125										
			13	SS	50/ 0.150										
212.9															
14.8	END OF BOREHOLE AT 14.8m. WATER LEVEL AT 6.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.6m, CONCRETE TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.														

ONTMT4S\_1197.GPJ 2012TEMPLATE(MTO).GDT 8/8/14

### RECORD OF BOREHOLE No PCE-03

1 OF 2

METRIC

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 920.4 E 203 463.0 ORIGINATED BY MW  
 HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AN  
 DATUM Geodetic DATE 2014.06.11 - 2014.06.12 CHECKED BY MEF

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
							20 40 60 80 100								
227.7	ASPHALT: (125mm)														
0.0	SAND and GRAVEL, trace silt Very Dense Brown/Dark brown Damp (FILL)	[Cross-hatched pattern]	1	SS	62										42 52 6 (SI+CL)
0.1			2	SS	55										
225.9	Silty CLAY, some sand, trace gravel, trace till pockets Stiff to Soft Brown (FILL)	[Cross-hatched pattern]	3	SS	14										
1.8			4	SS	12										1 17 38 44
			5	SS	5										
223.6	Silty SAND, trace gravel, trace wood pieces Loose Light Brown Moist (FILL)	[Cross-hatched pattern]	6	SS	2										
4.1															
222.8	Silty CLAY, some sand, trace gravel, trace sand and gravel pockets Soft to Firm Brown (FILL)	[Cross-hatched pattern]	7	SS	3										4 21 49 26
4.9															
220.1	ORGANIC SILT, sandy, some clay to clayey, trace wood pieces Stiff Dark Brown Moist	[Cross-hatched pattern]	8	SS	6										
7.6															
218.3	SAND and GRAVEL, trace silt, trace pockets of clay and silt Very Dense	[Cross-hatched pattern]	9	SS	9										
9.4															

ONTMT4S 1197.GPJ 2012TEMPLATE(MTO).GDT 8/8/14

Continued Next Page

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



**RECORD OF BOREHOLE No PCE-04**

1 OF 2

**METRIC**

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 901.5 E 203 449.2 ORIGINATED BY MNW  
 HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AB  
 DATUM Geodetic DATE 2014.06.07 - 2014.06.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W
220.6	<b>ORGANIC SILT</b> , sandy, some clay to clayey, trace peat Very Soft to Soft Brown Wet		1	SS	2											
			2	SS	2											
219.1	<b>PEAT</b> and Clayey <b>SILT</b> , trace wood Very Soft Dark Brown		3	SS	1											
218.2	Silty <b>CLAY</b> , trace sand, trace oxides Soft to Firm Brown		4	SS	4											
217.2	<b>SAND</b> and <b>GRAVEL</b> , trace to some silt, trace cobbles Compact Light Brown Wet		5	SS	9											
215.7	Sandy <b>SILT</b> , some clay to clayey, trace gravel, cobbles and boulders Very Dense Dark Greyish Brown Moist (TILL)		6	SS	50/ 0.100											
			7	SS	50/ 0.100											
			8	SS	113											
			9	SS	50/ 0.100											

ONTMT4S\_1197.GPJ\_2012TEMPLATE(MTO).GDT\_8/8/14

Continued Next Page

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

**RECORD OF BOREHOLE No PCE-04**

2 OF 2

**METRIC**

WP# 6134-04-01 LOCATION Pagwachuan River East Culvert N 5 514 901.5 E 203 449.2 ORIGINATED BY MNW  
 HWY 11 BOREHOLE TYPE NW Casing & Wash Boring COMPILED BY AB  
 DATUM Geodetic DATE 2014.06.07 - 2014.06.07 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
			10	SS	50/ 0.100		210							
							209							
207.9			11	SS	91/ 0.200		208				o			
12.7	END OF BOREHOLE AT 12.7m. ARTESIAN WATER ENCOUNTERED AT 3.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.8m slotted screen.  WATER LEVEL READINGS: DATE    DEPTH (m)    ELEV. (m) 2014.06.11    0.8*    221.4 2014.06.12    0.8*    221.4  *Measured above ground level.													

ONTMT4S\_1197.GPJ 2012TEMPLATE(MTO).GDT 8/8/14

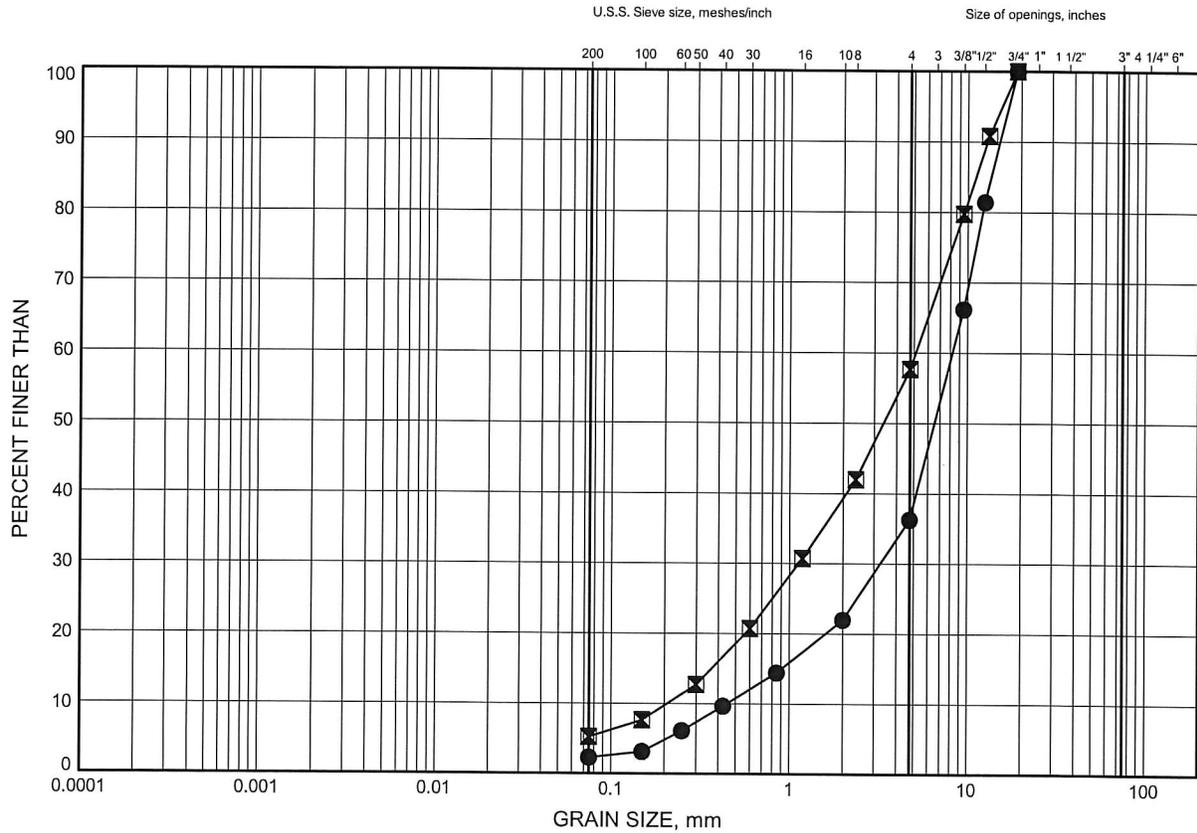
**Appendix B**

**Laboratory Test Results**

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B1

**SAND & GRAVEL FILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-02	1.07	226.63
⊠	PCE-03	0.43	227.27

GRAIN SIZE DIST. / ION - THURBER 1197.GPJ 7/31/14

Date July 2014  
 WP# 6134-04-01

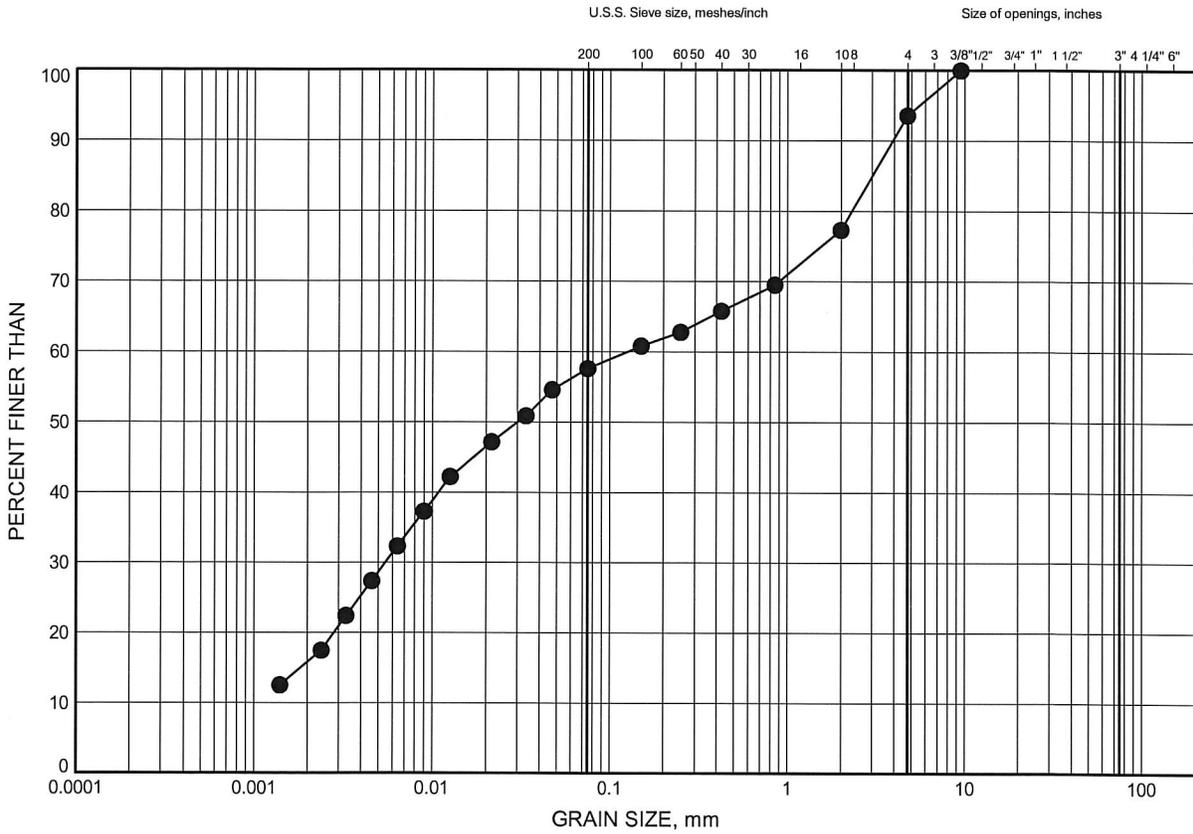


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B2

**SILT & SAND FILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-02	3.35	224.35

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/8/14

Date August 2014  
 WP# 6134-04-01

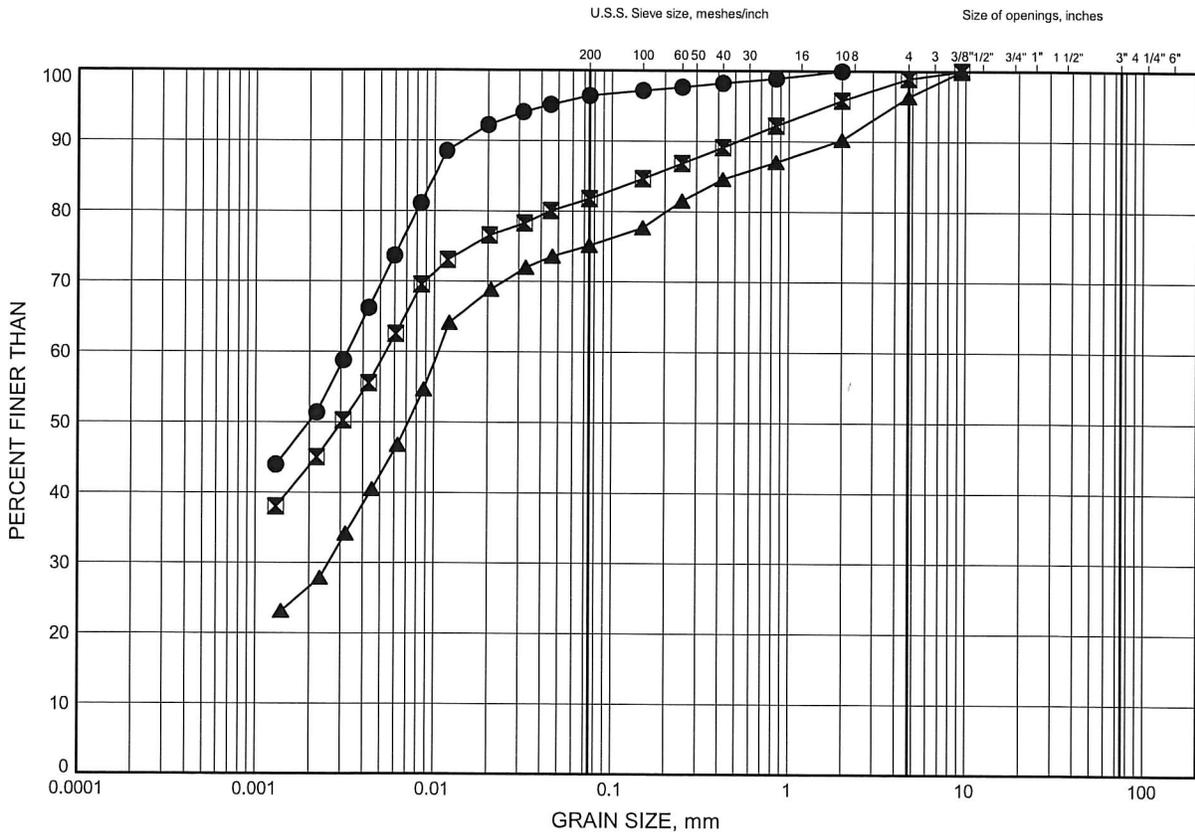


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B3

**SILTY CLAY FILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-02	5.64	222.06
⊠	PCE-03	2.59	225.11
▲	PCE-03	5.64	222.06

GRAIN SIZE DIST. - THURBER 1197.GPJ 7/31/14

Date July 2014  
 WP# 6134-04-01

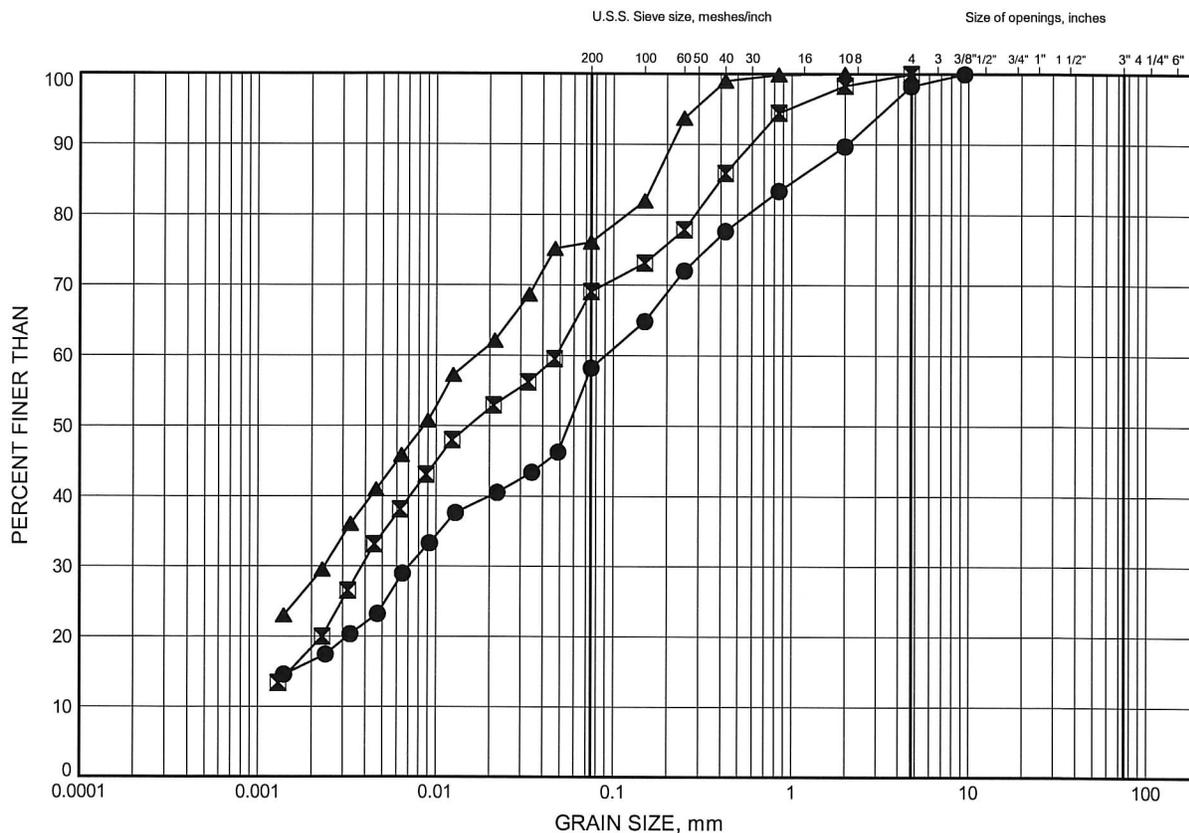


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B4

**ORGANIC SANDY SILT**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-01	1.68	219.22
⊠	PCE-02	8.65	219.05
▲	PCE-04	1.14	219.46

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 8/8/14

Date August 2014  
 WP# 6134-04-01

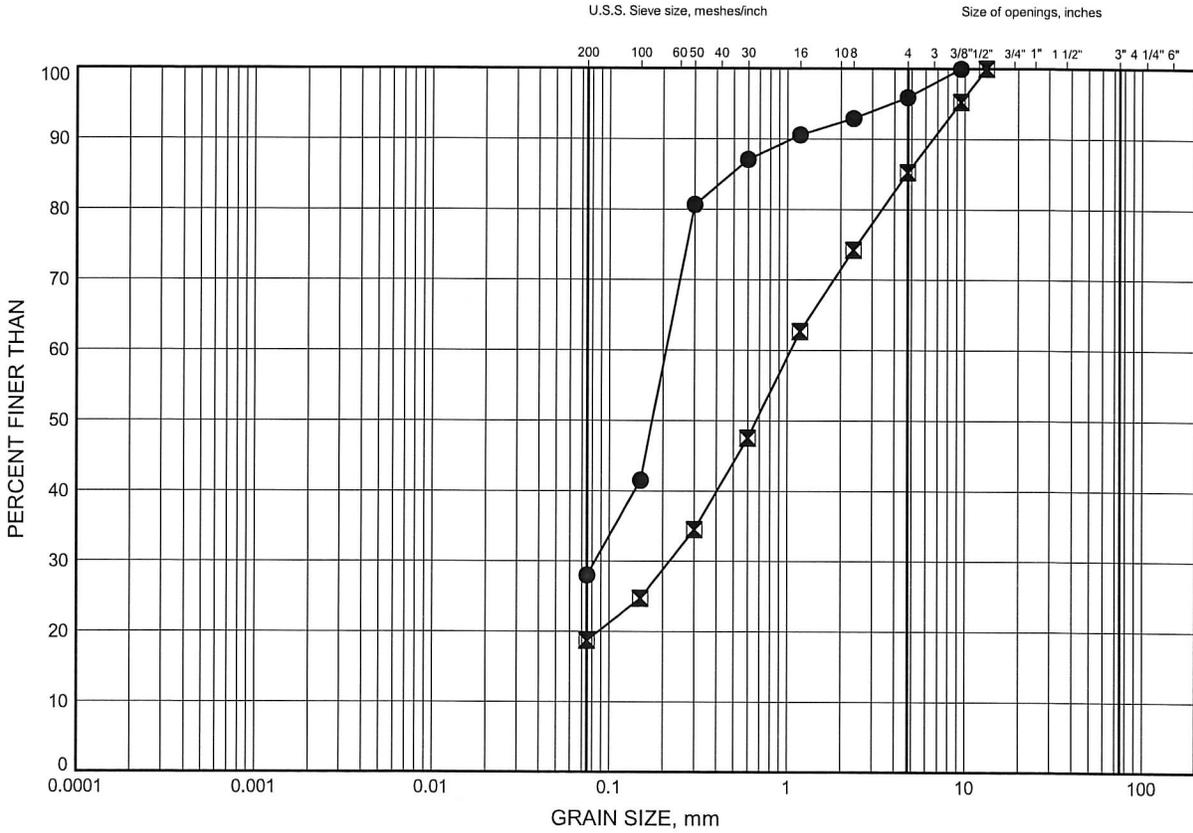


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B5

**SILTY SAND to SAND**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-01	2.13	218.77
⊠	PCE-02	11.89	215.81

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 7/31/14

Date July 2014  
 WP# 6134-04-01

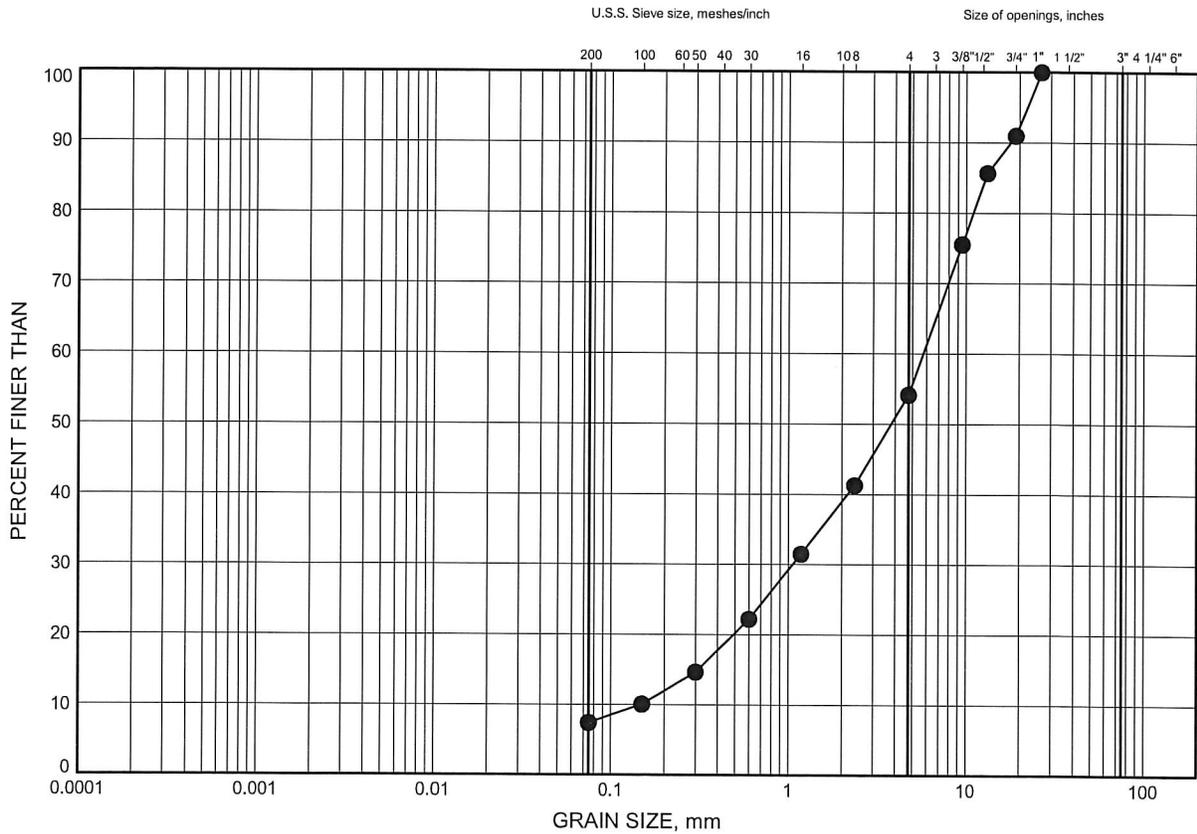


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B6

**SAND & GRAVEL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-03	11.70	216.00

GRAIN SIZE DIST. - ITON - THURBER 1197.GPJ 7/31/14

Date July 2014  
 WP# 6134-04-01

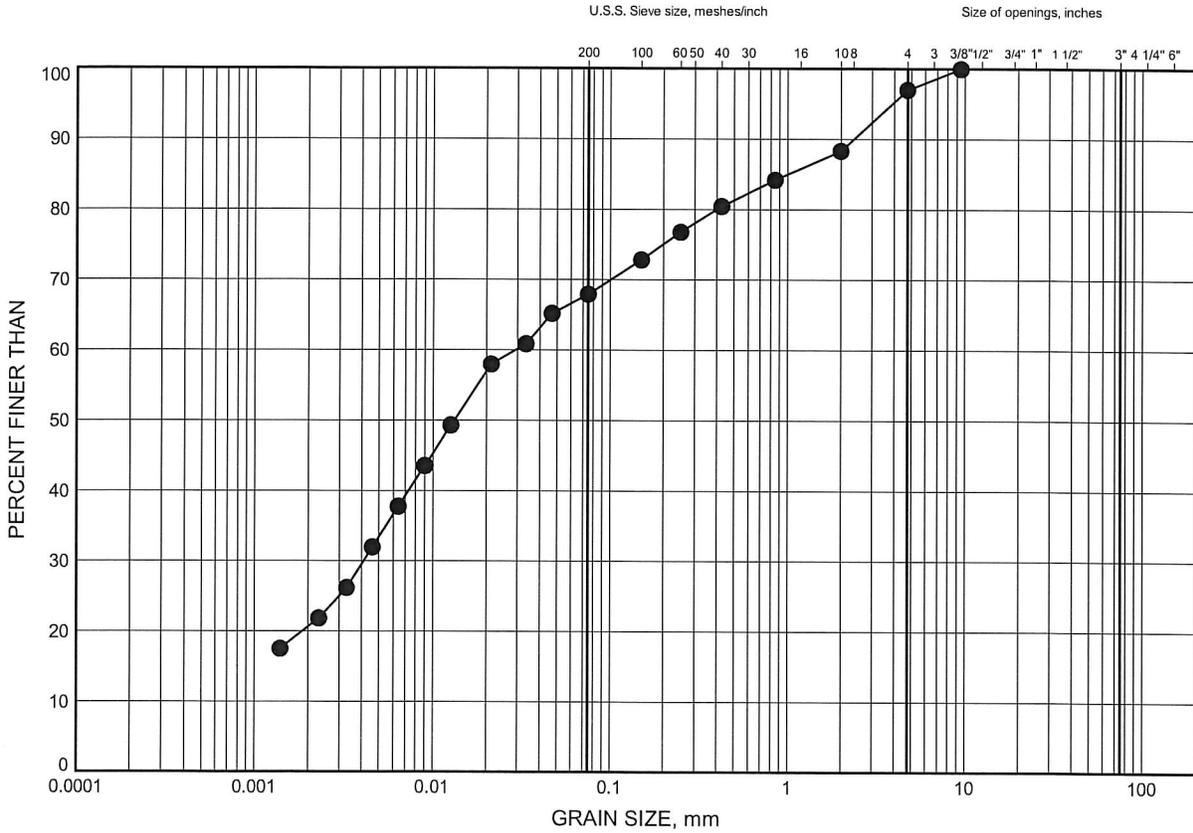


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**GRAIN SIZE DISTRIBUTION**

FIGURE B7

**SANDY SILT TILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-04	6.22	214.38

GRAIN SIZE DISTRIBUTION - THURBER 1197.GPJ 7/31/14

Date July 2014  
 WP# 6134-04-01

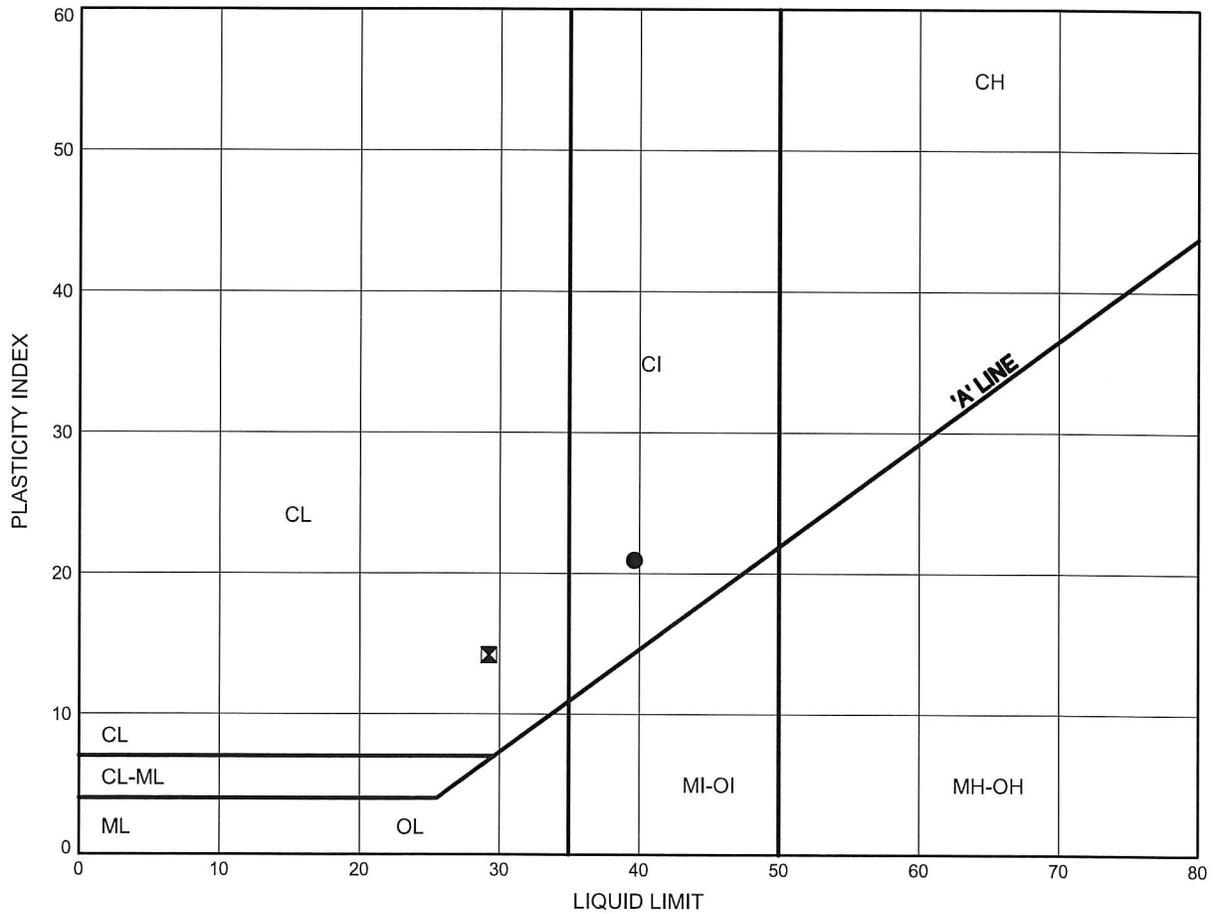


Prep'd AN  
 Chkd. MKE

Pagwachuan River East Culvert  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B8

**SILTY CLAY FILL**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	PCE-02	5.64	222.06
⊠	PCE-03	5.64	222.06

THURBALT 1197.c.j 7/31/14

Date July 2014  
 WP# 6134-04-01



Prep'd AN  
 Chkd. MKE

**Appendix C**

**Site Photographs**



**Photograph 1 – South end of existing culvert**



**Photograph 2 – South end of culvert, looking west at culvert outlet**



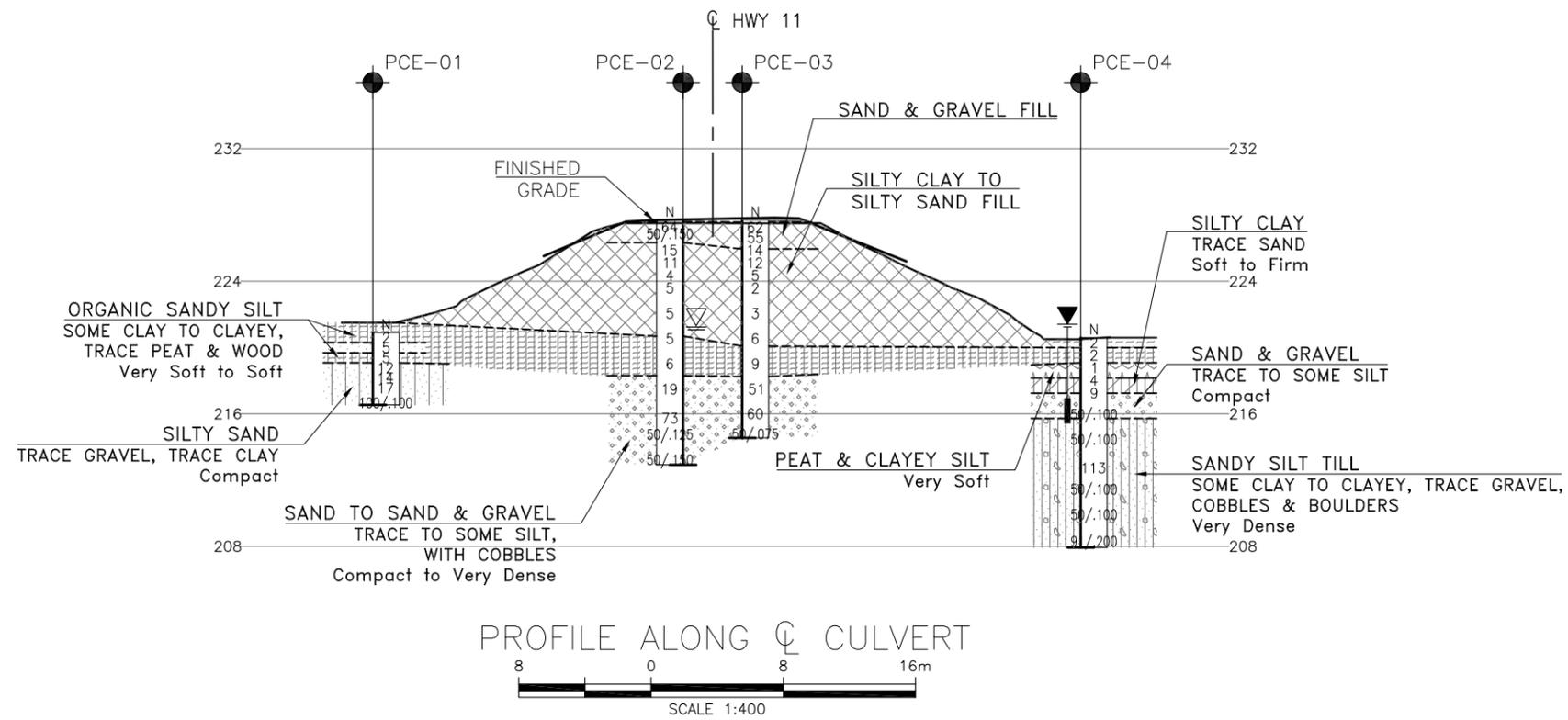
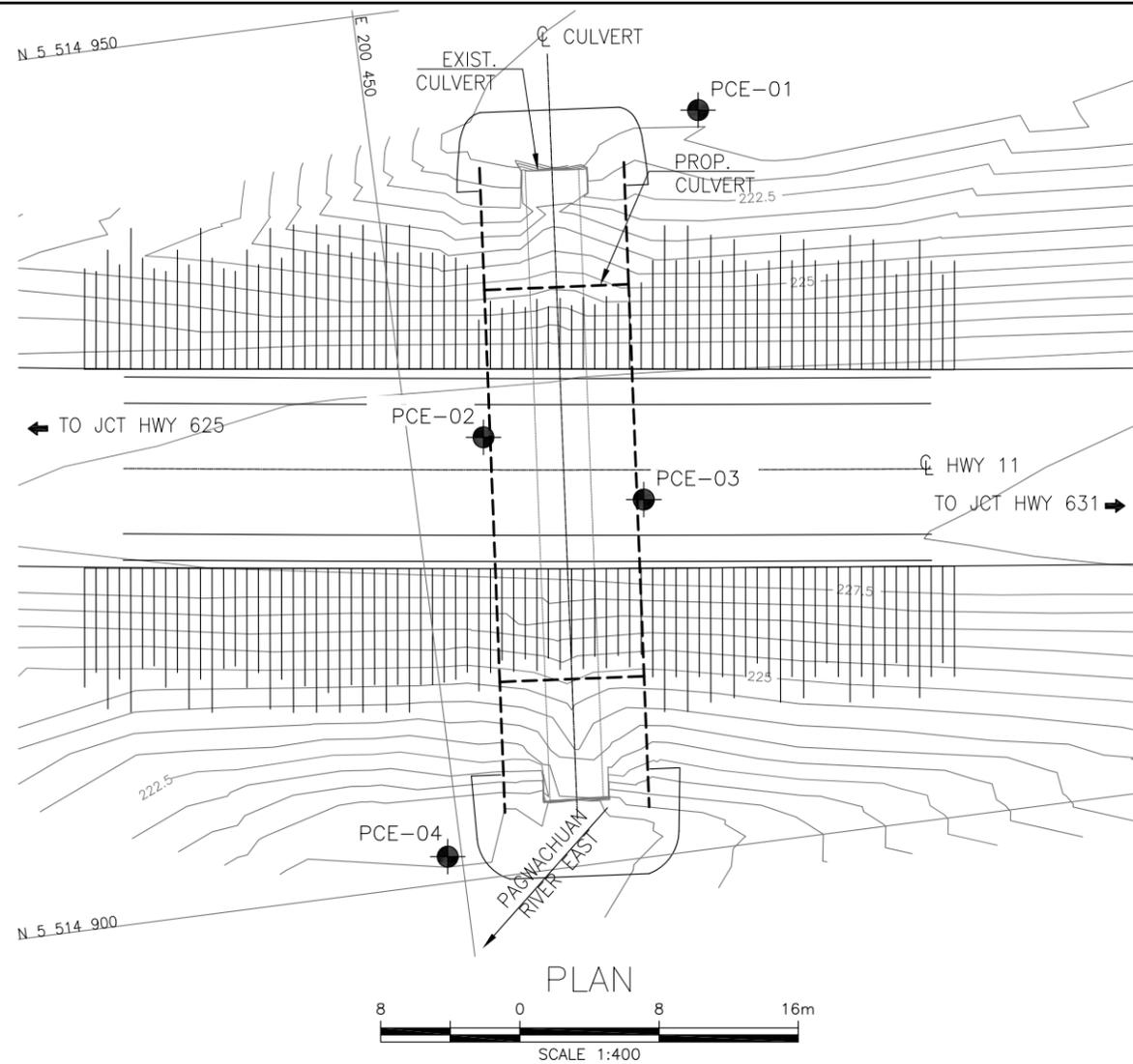
**Photograph 3 – North end of existing culvert**



**Photograph 4 – North end of culvert, looking east at culvert inlet**

**Appendix D**

**Borehole Locations and Soil Strata Drawing**



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

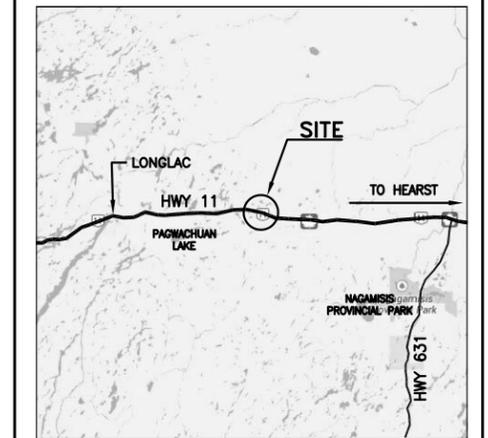


CONT No  
WP No 6134-04-01

HIGHWAY 11  
PAGWACHUAN RIVER EAST  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET  
43



LEGEND

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

NO	ELEVATION	NORTHING	EASTING
PCE-01	220.9	5 514 942.1	203 469.0
PCE-02	227.7	5 514 925.1	203 454.3
PCE-03	227.7	5 514 920.4	203 463.0
PCE-04	220.6	5 514 901.5	203 449.2

- 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.

GEOGRES No. 42F-30

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK SBP	CODE LOAD DATE AUG 2014
DRAWN	AN	CHK MRA	SITE 48E-71C STRUCT DWG 2