



**THURBER** ENGINEERING LTD.

**FINAL  
FOUNDATION INVESTIGATION REPORT  
HIGHWAY 11 CULVERT  
1.5 KM SOUTH OF HIGHWAY 101, BOWMAN TOWNSHIP  
NEAR STATION 17+611**

**G.W.P. 5054-01-00**

Geocres No.: 42A00-118

Report to:

**McIntosh Perry Consulting Engineers Limited**

Latitude: 48.52320°  
Longitude: -80.45067°

October 2018  
Thurber File No.: 13058

## TABLE OF CONTENTS

### PART 1. FACTUAL INFORMATION

1	INTRODUCTION .....	1
2	SITE DESCRIPTION .....	1
3	SITE INVESTIGATION AND FIELD TESTING.....	2
4	LABORATORY TESTING.....	2
5	DESCRIPTION OF SUBSURFACE CONDITIONS .....	3
5.1	Embankment .....	3
5.1.1	Asphalt.....	3
5.1.2	Fill: Sand.....	3
5.1.3	Fill: Clay .....	3
5.2	Silty Clay (CL-ML) .....	4
5.3	Clay (CL to CH).....	4
5.4	Sandy Silt to Silty Sand to Sand.....	6
5.5	Groundwater.....	6
5.6	Analytical Testing .....	7
6	MISCELLANEOUS .....	8

### APPENDICES

Appendix A.	Drawings
Appendix B.	Record of Borehole Sheets
Appendix C.	Laboratory Testing
Appendix D.	Site Photographs

**FINAL  
FOUNDATION INVESTIGATION REPORT  
HIGHWAY 11 CULVERT  
1.5 KM SOUTH OF HIGHWAY 101, BOWMAN TOWNSHIP  
NEAR STATION 17+611**

**G.W.P. 5054-01-00  
Geocres No.: 42A00-118**

**PART 1. FACTUAL INFORMATION**

**1 INTRODUCTION**

This section of the report presents the factual findings obtained from a foundation investigation completed at the Highway 11 culvert crossing near Station 17+612. The culvert is located approximately 1.5 km south of Highway 101 within Bowman Township. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Agreement No. 5015-E-0041.

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 influencing design and construction was developed in the course of the current investigation. No previous foundation investigation information was available for the subject culvert site within the Geocres library.

**2 SITE DESCRIPTION**

The existing culvert is a 750 mm diameter non-structural corrugated steel pipe (CSP) culvert and is approximately 46.5 m long with a generally east to west alignment. The flow through the culvert is to the west.

At the location of the culvert at Station 17+612 (Linear Highway Referencing System Base Point: 17450, Offset: 13.0), Highway 11 is a two-lane highway with a rural cross-section and gravel shoulders. The Highway 11 embankment fill height is approximately 9.0 m with an elevation at the road surface of 273.7 m. The existing embankment slopes are inclined at approximately 2H:1V. Wooden post and steel cable guiderails are present on both sides of the highway. The land adjacent to the highway is generally undeveloped and densely vegetated with shrubs and trees. Russell Lake is located approximately 100 m southwest of the culvert site. A buried cable utility is located near the toe of the embankment on the east side of the Highway. Traffic volumes on Highway 11 are understood to be 3,250 AADT (2016).

Select photographs showing the existing conditions in the area of the culvert are included in Appendix D for reference.

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

The initial site investigation and field testing program was carried out between October 18<sup>th</sup> and October 19<sup>th</sup>, 2016. A supplemental site investigation to obtain additional soils information was carried out between May 3<sup>rd</sup> and May 7<sup>th</sup>, 2018. The field investigations consisted of advancing seven boreholes identified as 16-01 through 16-04 and 18-05 through 18-07. The drilling was carried out using portable equipment for off-road boreholes 16-03, 16-04 and 18-07, a track mounted CME 850 drill rig for the on-road Boreholes 16-01, 16-02, and a truck mounted CME 55 drill rig for on-road Boreholes 18-05 and 18-06. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Boreholes 16-03, 16-04 and 18-07, which were drilled with portable equipment, also utilized a full-weight hammer for SPT testing. A Thin Walled (Shelby) Tube sample of clay was retrieved from Borehole 16-04 to obtain a relatively undisturbed soil sample for further laboratory testing. The boreholes were sampled to depths ranging from 6.7 to 20.4 m (elev. 258.5 to 251.2 m) below the existing ground surface.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport.

A 19 mm diameter standpipe piezometer was installed in Borehole 16-03 to allow for measurements of the groundwater level after completion of drilling. The piezometer installation details are illustrated on the Record of Borehole sheet for Borehole 16-03 provided in Appendix B. Following completion of the field investigation the remaining boreholes were backfilled in accordance with MOE requirements (O.Reg. 903 as amended). Boreholes 16-01, 16-02, 18-05 and 18-06 were capped with 150 mm of cold patch asphalt to reinstate the traveling surface. The piezometer was decommissioned on June 12, 2017 in accordance with MOE requirements.

The borehole locations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix A. The coordinates and elevation of the boreholes are provided on this drawing and on the individual Record of Borehole sheets.

### **4 LABORATORY TESTING**

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. A single sample, obtained with a Thin Walled (Shelby) Tube, underwent one-dimensional consolidation testing. Three samples of soil recovered from within the boreholes were selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

## 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata drawing included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

In general terms, the embankment was found to include asphalt and granular fill over clay fill overlying native granular deposits varying from sand to sandy silt. A veneer of topsoil was present at the surface of the off-road boreholes followed by layers of native clay and sand to silty sand. Bedrock was not encountered within the depth of investigation.

### 5.1 Embankment

#### 5.1.1 Asphalt

Boreholes 16-01, 16-02, 18-05 and 18-06 were drilled through the existing Highway 11 embankment and encountered a layer of asphalt with a thickness of 130 to 400 mm. A buried asphalt layer with a thickness of 130 mm was also encountered in Borehole 18-06 at a depth of 0.6 m.

#### 5.1.2 Fill: Sand

Below the asphalt layers in Boreholes 16-01, 16-02, 18-05 and 18-06 was a layer of fill consisting of silty sand some gravel to sand and gravel. The underside of the fill was at 1.2 to 1.5 m (elev. 272.5 to 272.2 m) below the existing roadway surface.

A SPT N-value of 29 was measured in this fill in Borehole 16-01. A single SPT test with a result of 100 blows per 100 mm of penetration was recorded near the surface of the layer in Borehole 16-02. The remaining SPT tests from the current investigation were conducted in frozen materials and are not representative. Recorded moisture contents ranged from 2 to 4%. The results of grain size analyses conducted on two samples of the granular fill material are summarized below and are illustrated on Figure C1 of Appendix C.

Soil Particle	Percentage (%)
Gravel	26 - 34
Sand	61 - 71
Silt & Clay	3 - 5

#### 5.1.3 Fill: Clay

A layer of clay fill with trace sand was encountered directly below the sand fill in Boreholes 16-01, 16-02, 18-05 and 18-06 with a recorded thickness of 5.7 to 8.1 m and an underside depth of 7.2 to 9.6 m (elev. 266.6 to 264.1 m) below the existing roadway surface.

The SPT tests conducted in the clay fill gave N-values ranging from 4 to 17 blows indicating a firm to very stiff consistency. The recorded moisture contents varied from 22 to 38%. The

results of grain size analyses conducted on six samples of the clay fill material are summarized below and are illustrated on Figure C2 of Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	1 - 7
Silt	33 - 42
Clay	56 - 60

Atterberg Limit testing was completed on six samples of the clay fill. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C8 of Appendix C. The laboratory results are summarized below and indicate that the clay fill exhibits high to intermediate plasticity.

Parameter	Value
Liquid Limit	45 - 61
Plastic Limit	18 - 23
Plasticity Index	24 - 39

## 5.2 Silty Clay (CL-ML)

A native deposit of silty clay was encountered below a 50 mm thick rootmat in off-road Borehole 18-07 drilled near the culvert outlet. This layer had a thickness 2.0 m with an underside elevation of 262.7 m.

The SPT N-values ranged from 3 to 7 blows indicating a soft to firm consistency. The moisture content of the samples tested ranged from 24% to 50%. The results of a grain size analysis conducted on one sample of the native silty clay found the composition to be 0% gravel, 5% sand, 75% silt and 20% clay. The results are summarized on the Record of Borehole sheet in Appendix B and are illustrated on Figure C3 in Appendix C.

Atterberg Limit testing was completed on one sample of the native silty clay deposit. The laboratory results found a liquid limit of 22%, a plastic limit of 16% and a plasticity index of 6% and indicate that the silty clay is of low plasticity (CL-ML). The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graph is included in Figure C9 of Appendix C.

## 5.3 Clay (CL to CH)

A native deposit of clay was encountered below a 10 mm thick veneer of topsoil in off-road Boreholes 16-03 and 16-04 and below the silty clay layer in Borehole 18-07. Silty sand layers were noted within the clay deposit below a depth of 10.4 m in Borehole 16-04. This layer had a thickness 5.5 m in Borehole 16-03 with an underside elevation of 260.3 m. Boreholes 16-04 and 18-07 were terminated in the clay layer at depths of 13.4 and 6.7 m respectively below the ground surface (elev. 251.2 and 258.1 m). The SPT N-values typically ranged from weight of hammer to 6 blows. Field vane tests were performed within the deposit and recorded undrained shear strengths ranging from 21 to 72 kPa indicating a

soft to stiff consistency. Remolded field vane testing indicates that the clay shows some sensitivity.

The moisture content of the samples tested ranged from 21% to 61%. The results of grain size analyses conducted on seven samples of the native clay are summarized below and are illustrated on Figures C4 and C5 in Appendix C.

Soil Particle	Percentage (%)
Gravel	0
Sand	0 - 6
Silt	24 - 66
Clay	32 - 76

Atterberg Limit testing was completed on six samples of the native clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figures C10 and C11 of Appendix C. The laboratory results are summarized below and indicate that the clay varies from low to intermediate plasticity (CL to CH).

Parameter	Value
Liquid Limit	34 - 57
Plastic Limit	17 - 23
Plasticity Index	17 - 38

An Oedometer (one-dimensional consolidation) test was carried out on a relatively undisturbed sample obtained from a Thin Walled (Shelby) Tube sample taken in Borehole 16-04 at a depth of 3.4 m. The results are presented in Appendix C and summarized in the following table. The compressibility characteristics will vary with depth in accordance with the soil index parameters and stress history.

**Table 5-1. Summary of Oedometer Test Results and Interpretations**

Parameter		Units	Borehole BH16-04
Sample Depth (Elevation)		m	2.7 (261.9)
Natural Moisture Content, $w_n$		%	36.9
Initial Void Ratio, $e_o$		-	1.022
Unit Weight, $\gamma$		kN/m <sup>3</sup>	18.1
Existing Vertical Effective Stress, $\sigma'_{vo}$		kPa	49
Preconsolidation Pressure, $\sigma'_c$		kPa	60
Over Consolidation Ratio, OCR		-	1.2
Recompression Zone	Recompression Index, $C_r$	-	0.04
	Coefficient of Consolidation, $c_{vr}$	cm <sup>2</sup> /s	1.0 to 0.4 x 10 <sup>-2</sup>
	Average Permeability, $k_{vr}$	m/s	6 x 10 <sup>-9</sup>

**Table 5-1. Summary of Oedometer Test Results and Interpretations**

Parameter		Units	Borehole BH16-04
Virgin Compression Zone	Compression Index, $C_c$	-	0.38
	Coefficient of Consolidation, $c_v$	cm <sup>2</sup> /s	1.3 to 5.6 x 10 <sup>-4</sup>
	Average Permeability, $k_v$	m/s	1.6 x 10 <sup>-10</sup>
Modulus of Elasticity (Constrained), $E_c$		kPa	1,400

#### 5.4 Sandy Silt to Silty Sand to Sand

A deposit transitioning from sandy silt to sand was encountered below the clay fill in Boreholes 16-01, 16-02, 18-05 and 18-06 and below the native clay in Borehole 16-03. The boreholes were terminated in this stratum at depths ranging from 7.3 to 20.4 m (elev. 258.5 to 253.3 m). The SPT N-values ranged from 3 to 60 blows indicating a relative density of very loose to very dense; but was typically compact to dense.

The moisture content for the samples tested ranged from was 4% to 30%. The results of grain size analyses conducted on nine samples of the sandy silt to sand are summarized below and are illustrated on Figures C6 and C7 in Appendix C.

Soil Particle	Percentage (%)	
Gravel	0 - 1	
Sand	44 - 95	
Silt	8 - 51	5 - 40
Clay	1 - 6	

Atterberg limit testing on five samples of the sandy silt indicated it to be non-plastic.

#### 5.5 Groundwater

At the completion of drilling, the groundwater level was measured at 5.1 m below the ground surface (elev. 260.7 m) within the standpipe piezometers installed in Borehole 16-03. The culvert was dry prior to the field investigation but accumulated water during a precipitation event that occurred at the time of drilling. During a site visit on April 17, 2017 the water level within the standpipe piezometer was observed at 5.4 m (elev. 260.4 m) below the ground surface and a low level of water was present in the culvert. The water level in the standpipe piezometer was recorded at 0.6 m below the ground surface (elev. 265.2 m) on June 12, 2017 and was subsequently decommissioned on the same date.

During the 2018 field investigation, both Boreholes 18-05 and 18-06 recorded a water level at 13.6 m below the ground surface within the open borehole upon completion of drilling (elev. 260.2 m). A reliable water level could not be obtained within Borehole 18-07 due to water being introduced into the borehole as part of the drilling operations.

These observations are considered short term and it should be noted that the groundwater level at the time of construction and seasonal fluctuations of the groundwater level are to



be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

## 5.6 Analytical Testing

Three samples of the native soils were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are summarized in the table below.

Borehole	Sample	Depth (m)	Sulphate (µg/g)	pH ( - )	Resistivity (Ohm-cm)	Conductivity (uS/cm)	Chloride (µg/g)
16-03 (C2-3*)	SS1	0 - 0.6	11	7.6	2800	357	49
16-04 (C2-4*)	SS3	1.5 – 2.1	8	7.5	2020	494	236
18-05	SS13	9.1 – 9.7	7	7.1	1530	654	17

Note: (\*) sample label as submitted to Paracel

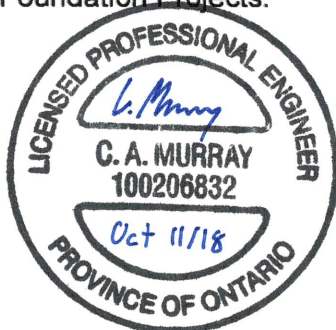
## 6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the culvert location. The as-drilled locations and ground surface elevation of the 2016 borehole investigation were interpreted from measurements provided by McIntosh Perry following completion of the initial field program. Thurber surveyed the location of the boreholes from the 2018 investigation based on benchmarks provided by MPCE.

Landcore Drilling of Chelmsford, Ontario supplied and operated the equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning. The field investigation was supervised on a full-time basis by Mr. Jeff Morrison, E.I.T., Mr. Sean O'Bryan and Mr. Nick Weil of Thurber. Overall supervision of the investigation program was provided by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. One-dimensional consolidation testing was completed by Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario.

Interpretation of the factual data and preparation of this report were carried out by Mr. Christopher Murray, P.Eng. and Mr. Stephen Peters P.Eng. The report was reviewed by Dr. Fred Griffiths, P.Eng. and Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



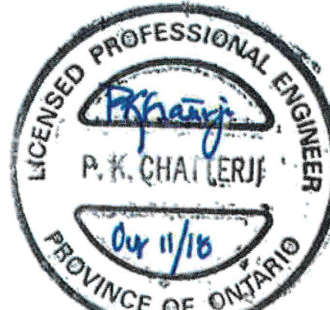
Christopher Murray, M.A.Sc., P.Eng.  
Geotechnical Engineer



Stephen Peters, P.Eng.  
Geotechnical Engineer



Dr. Fred Griffiths, P.Eng.  
Senior Associate  
Senior Geotechnical Engineer

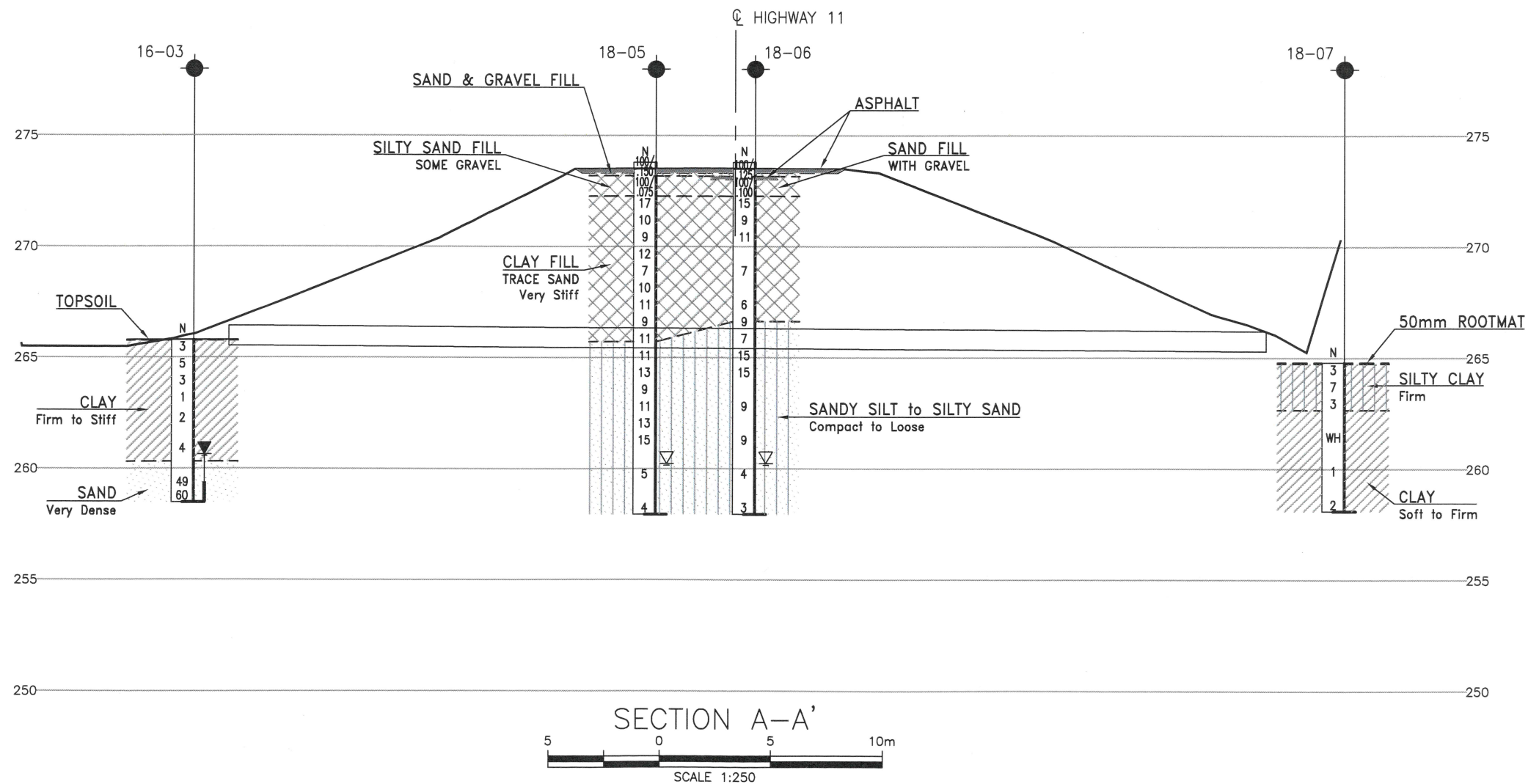
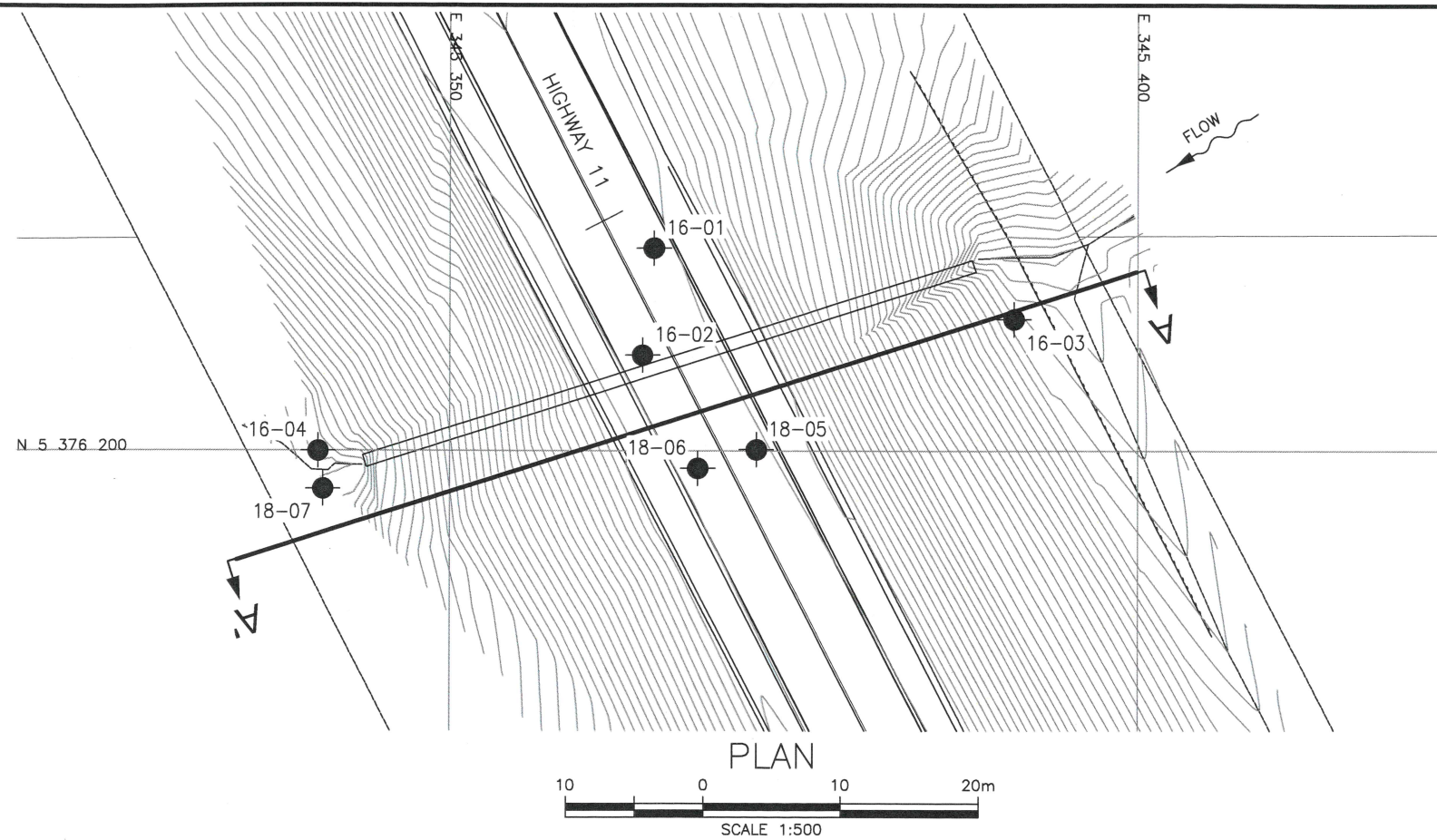


Dr. P.K. Chatterji, P.Eng.  
Review Principal  
Senior Geotechnical Engineer

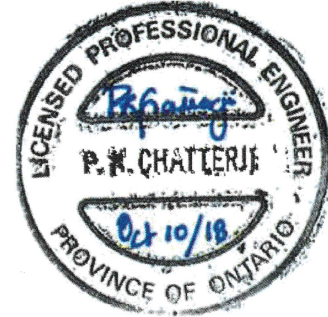
**Appendix A.**

**Drawings**





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

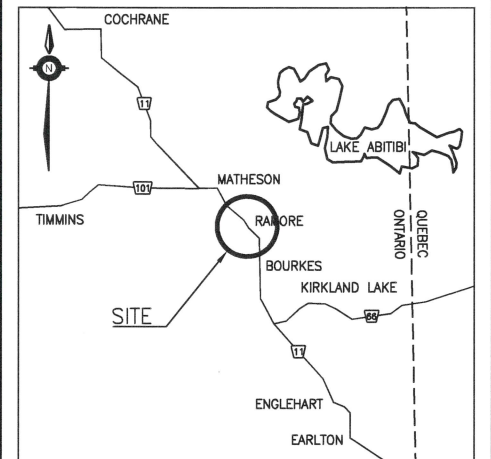


CONT No  
GWP No 5054-01-00

HIGHWAY 11  
CULVERT AT 17+611  
BOWMAN TOWNSHIP  
BOREHOLE LOCATIONS AND SOIL STRATA

**McINTOSH PERRY** **MP**

**THURBER ENGINEERING LTD.**



# LEGEND

●	Borehole
◆	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊥	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-01	273.7	5 376 214.8	345 364.8
16-02	273.7	5 376 207.0	345 364.0
16-03	265.8	5 376 209.6	345 391.0
16-04	264.6	5 376 200.0	345 340.4
18-05	273.8	5 376 200.1	345 372.3
18-06	273.8	5 376 198.7	345 368.0
18-07	264.8	5 376 197.2	345 340.8

## NOTES

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCREs No. 42A00-118

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SBP	CHK	CODE
DRAWN	AN/MA	CHK	SBP
			SITE
			STRUCT
			DWG 1

**Appendix B.**  
**Record of Borehole Sheets**



## SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

### TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

### TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

### RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

### N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

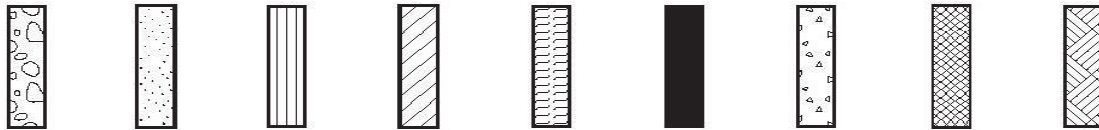
### DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.



### STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders  
Cobbles  
Gravel      Sand      Silt      Clay      Organics      Asphalt      Concrete      Fill      Bedrock

### TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

### TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

### SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

### TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT "N" Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

### MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note -  $W_L$  = Liquid Limit





## EXPLANATION OF ROCK LOGGING TERMS

### ROCK WEATHERING CLASSIFICATION

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

### 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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

### DISCONTINUITY SPACING

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

### STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

# RECORD OF BOREHOLE No 16-01

1 OF 3

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5232156°, Long: -80.4507886°  
Hwy 11 BOREHOLE TYPE SSA / NW Casing / CME 850 Trackmount ORIGINATED BY SOB  
DATUM Geodetic DATE 2016.10.18 - 2016.10.18 COMPILED BY JM  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
273.7																			
0.0																			
0.1	ASPHALT (130mm)																		
	SAND with Gravel		1	AS															
	Compact																		
	Brown																		
	FILL																		
272.5			1	SS	29										34 61 5				
															(SI+CL)				
1.2	CLAY trace sand																		
	Firm to stiff																		
	Brown																		
	FILL		2	SS	12														
			3	SS	10														
			4	SS	8														
			5	SS	6														
			6	SS	10										0 7 33 60				
			7	SS	17														
264.6																			
9.1	Sandy SILT (ML)																		
	Compact to dense		8	SS	30										0 45 49 6				
	Brown														non-plastic				

Continued Next Page

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

20  
15  
10

(%) STRAIN AT FAILURE

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

# RECORD OF BOREHOLE No 16-01

2 OF 3

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5232156°, Long: -80.4507886°  
Hwy 11 BOREHOLE TYPE SSA / NW Casing / CME 850 Trackmount ORIGINATED BY SOB  
DATUM Geodetic DATE 2016.10.18 - 2016.10.18 COMPILED BY JM  
CHECKED BY SP

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						
								20 40 60 80 100						
	Continued From Previous Page													
261.5 12.2	<b>Sandy SILT (ML)</b> Compact to dense Brown		9	SS	42		263							
							262							
			10	SS	22		261							
							260							
	<b>SAND (SP-SM) with Silt</b> Compact to dense Brown		11	SS	19		259							
							258							
			12	SS	33		257							
							256							
255.4 18.3	<b>Silty SAND</b> Dense Grey		13	SS	40									
			14	SS	37		255							
							254							

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No 16-02

1 OF 3

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5231456°, Long: -80.4508008°  
Hwy 11 BOREHOLE TYPE SSA / NW Casing / CME 850 Trackmount ORIGINATED BY SOB  
DATUM Geodetic DATE 2016.10.19 - 2016.10.19 COMPILED BY JM  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100					
273.7													
0.0	ASPHALT (400mm)												
273.3													
0.4	SAND and GRAVEL Very Dense Brown FILL		1	AS			273						
			1	SS	100/								
					100mm								
272.2													
1.5	CLAY trace sand Firm to stiff Brown FILL		2	SS	8		272						
			3	SS	9		271						0 7 34 59
			4	SS	10		270						
			5	SS	5		269						
							268						
			6	SS	9		267						
							266						0 5 39 56
			7	SS	4								
							265						
264.1			8	SS	33		264						
9.6	Silty SAND (SM) Compact												

Continued Next Page

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

20  
15  
10  
(%) STRAIN AT FAILURE

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE	w P      w      w L					
	Continued From Previous Page							20   40   60   80   100		20   40   60				
260.0 13.7	Silty SAND (SM) Compact Brown		9	SS	23		263					○		0   60   40 (SI+CL)
							262							
							261					○		
							260					○		
							259							
	SAND (SP) Compact to Dense Brown to Grey		11	SS	20		258					○		0   95   5 (SI+CL)
							257					○		
							256							
							255					○		
							254							

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

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

## METRIC

[illegible]

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

# RECORD OF BOREHOLE No 16-03

1 OF 1

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5231674° Long: -80.4504348°  
Hwy 11 BOREHOLE TYPE NW Casing / Tripod ORIGINATED BY JM  
DATUM Geodetic DATE 2016.10.18 - 2016.10.18 COMPILED BY JM  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W P W W L								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%)								
265.8								20 40 60 80 100												
0.8	TOPSOIL (10mm)																			
	CLAY (CH to CI) trace sand Firm to stiff Grey		1	SS	3								○							
			2	SS	5								○						0 6 45 49	
			3	SS	3								○							
			4	SS	1								○							
			5	SS	2								○						0 1 42 57	
			6	SS	4								○							
260.3																				
5.5	SAND (SP) Very Dense Grey  - casing refusal at 6.1 m		7	SS	49								○							
			8	SS	60								○						0 95 5 (SI+CL)	
258.5																				
7.3	End of borehole Casing left in ground overnight Piezometer readings: DATE DEPTH (m) ELEV. (m) 2016.10.20 5.1 260.7 2017.04.17 5.4 260.4 2017.06.12 0.6 265.2																			

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

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

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 16-04

1 OF 2

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5230843° Long: -80.4511208°  
Hwy 11 BOREHOLE TYPE NW Casing / Tripod ORIGINATED BY JM  
DATUM Geodetic DATE 2016.10.19 - 2016.10.19 COMPILED BY JM  
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED      + FIELD VANE								
								● QUICK TRIAXIAL      × LAB VANE								
				WATER CONTENT (%)												
264.6							20	40	60	80	100	20	40	60		
0.0	TOPSOIL (10mm)		1	SS	3											0 4 57 39
	CLAY (CL to Cl) Firm to stiff Grey															
			2	SS	3											
			3	SS	1											
			1	ST												0 2 66 32
			4	SS	WH											0 0 50 50
			5	SS	1											
			6	SS	1											

Continued Next Page

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

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

# RECORD OF BOREHOLE No 16-04

2 OF 2

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5230843° Long: -80.4511208°  
Hwy 11 BOREHOLE TYPE NW Casing / Tripod ORIGINATED BY JM  
DATUM Geodetic DATE 2016.10.19 - 2016.10.19 COMPILED BY JM  
CHECKED BY SP

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 $\gamma$  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 ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
	Continued From Previous Page							20	40	60	80	100		20	40	60	
251.2 13.4	- silty sand layers below 10.4 m						254										
			9	SS	4												
			10	SS	4												

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

## METRIC

[illegible]

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

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

## METRIC

[illegible][illegible]

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

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

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT	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	W P W L	PLASTIC LIMIT			LIQUID LIMIT
								SHEAR STRENGTH kPa	WATER CONTENT (%)				
273.8 0.0	ASPHALT (130mm)	[Pattern]	1	SS	100/								
0.1	SAND and GRAVEL Frozen Brown	[Pattern]			125mm								
273.2 279.6	FILL	[Pattern]	2	SS	100/								
0.8	ASPHALT (130mm)	[Pattern]			100mm								
	SAND with Gravel Frozen Brown	[Pattern]											
272.3 1.5	FILL	[Pattern]	3	SS	15								
	CLAY trace sand Very stiff Grey	[Pattern]											
		[Pattern]	4	SS	9								
		[Pattern]	5	SS	11								
		[Pattern]	6	SS	7								
		[Pattern]	7	SS	6								
266.6 7.2	Sandy SILT (ML) to Silty SAND (SM) Compact to Very Loose Brown	[Pattern]	8	SS	9								
		[Pattern]	9	SS	7								
		[Pattern]	10	SS	15								
		[Pattern]	11	SS	15								

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

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

# RECORD OF BOREHOLE No 18-06

2 OF 2

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5230712°, Long: -80.4507472°  
Hwy 11 BOREHOLE TYPE HSA / CME 55 Truck Mount ORIGINATED BY NW  
DATUM Geodetic DATE 2018.05.03 - 2018.05.03 COMPILED BY CM  
CHECKED BY SP

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												
								20 40 60 80 100												
								20 40 60 80 100												
	Continued From Previous Page																			
258.0  15.8	Sandy SILT (ML) to Silty SAND (SM) Compact to Very Loose Brown		12	SS	9		263													
							262													
			13	SS	9		261													
			14	SS	4		260													

DOUBLE LINE 13058 CULVERT 2.GPJ 2012TEMPLATE(MTO).GDT 10/10/18

# RECORD OF BOREHOLE No 18-07

1 OF 1

METRIC

GWP# 5015-E-0041 LOCATION Lat: 48.5230594° Long: -80.4511162°  
Hwy 11 BOREHOLE TYPE HW Casing / Tripod ORIGINATED BY NW  
DATUM Geodetic DATE 2018.05.07 - 2018.05.07 COMPILED BY CM  
CHECKED BY SP

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				
								20 40 60 80 100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W		
264.8												
0.0	50 mm Rootmat											
0.1	Silty CLAY (CL-ML) Firm Grey		1	SS	3							
			2	SS	7							
			3	SS	3							
262.7												
2.1	Clay (CH) Soft to Firm Grey											
			4	SS	WH							
			5	SS	1							
			6	SS	2							
258.1												
6.7	End of borehole											

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

**Appendix C.**  
**Laboratory Testing**



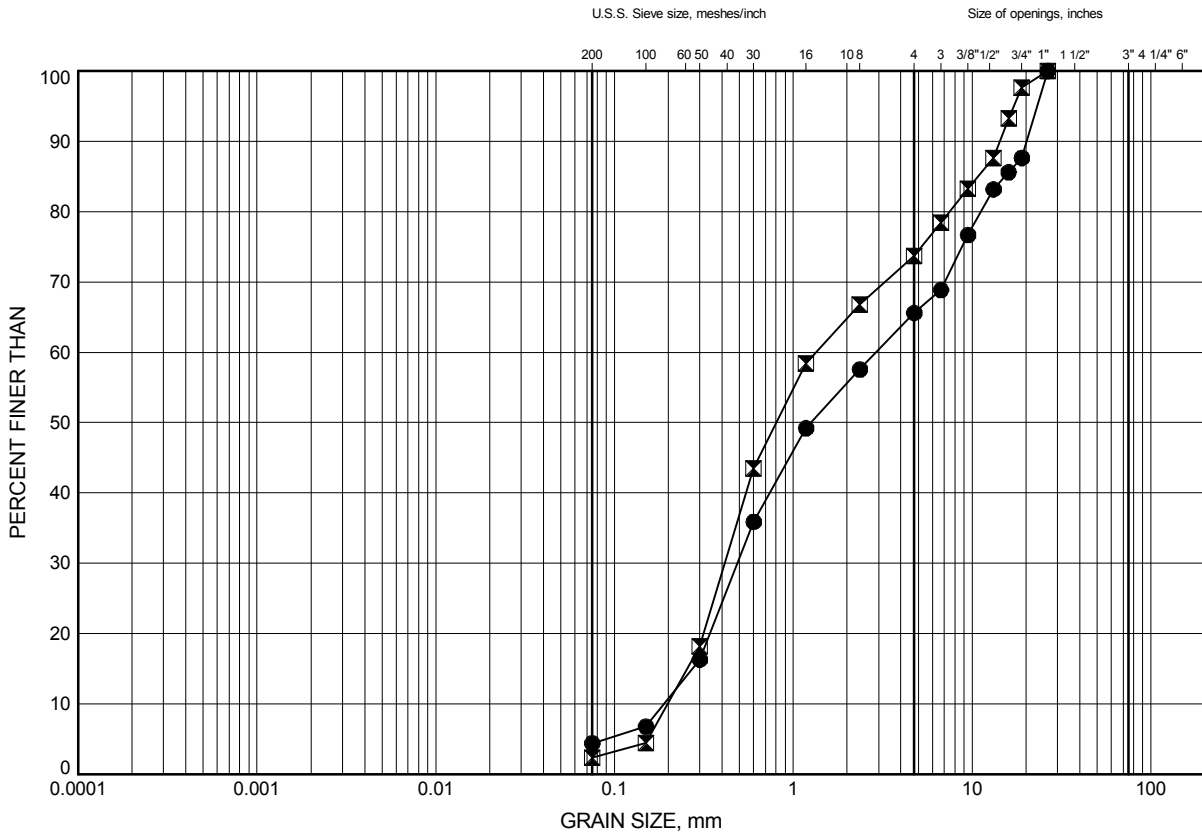
**Appendix C.1**  
**Particle Size Analysis Figures**

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C1

### Sand Fill



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	0.99	272.71
⊠	18-06	0.84	272.99

Date June 2018  
GWP# 5015-E-0041

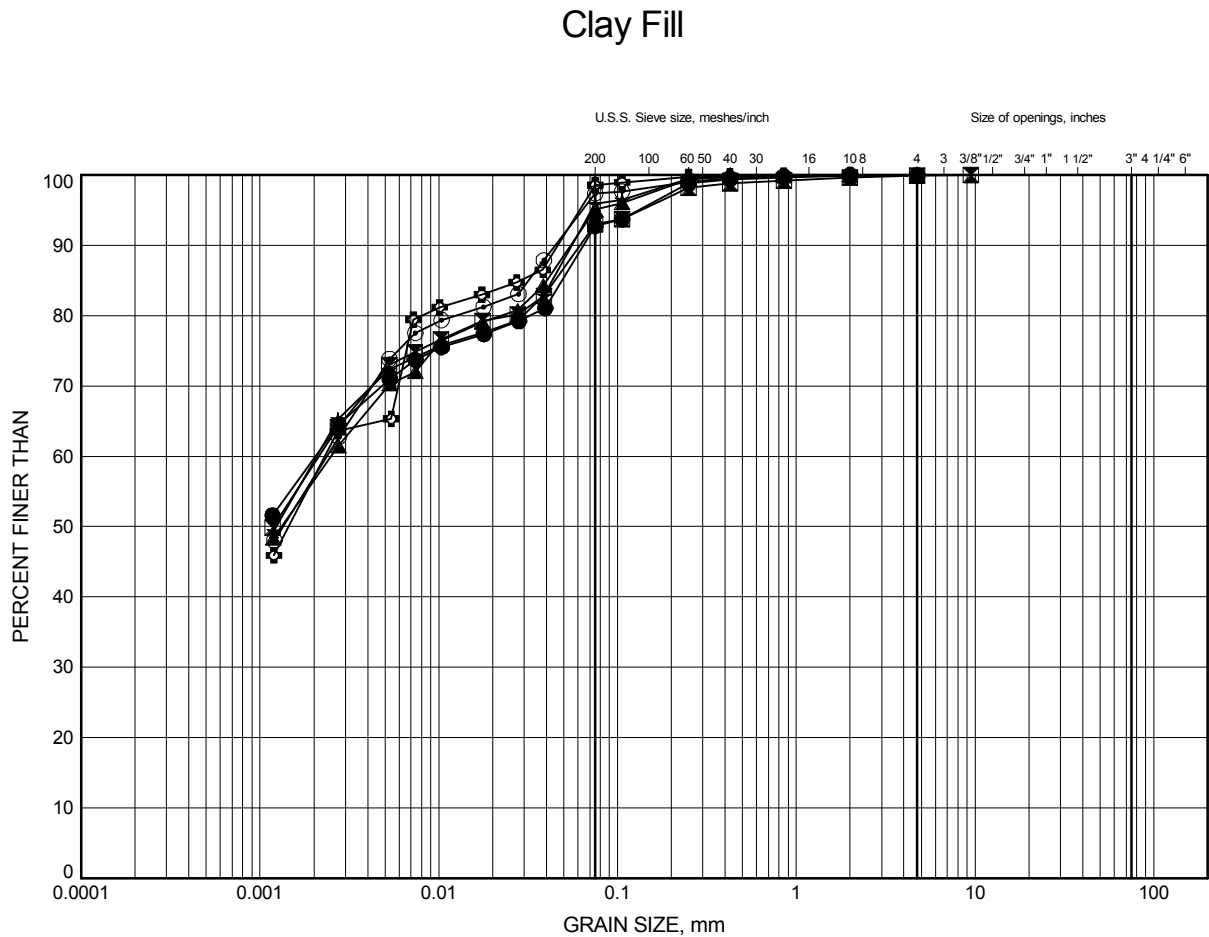


Prep'd CM  
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C2



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	6.28	267.42
⊠	16-02	2.59	271.11
▲	16-02	7.92	265.78
★	18-05	4.11	269.70
⊙	18-05	7.16	266.65
⊕	18-06	6.40	267.43

Date June 2018  
GWP# 5015-E-0041



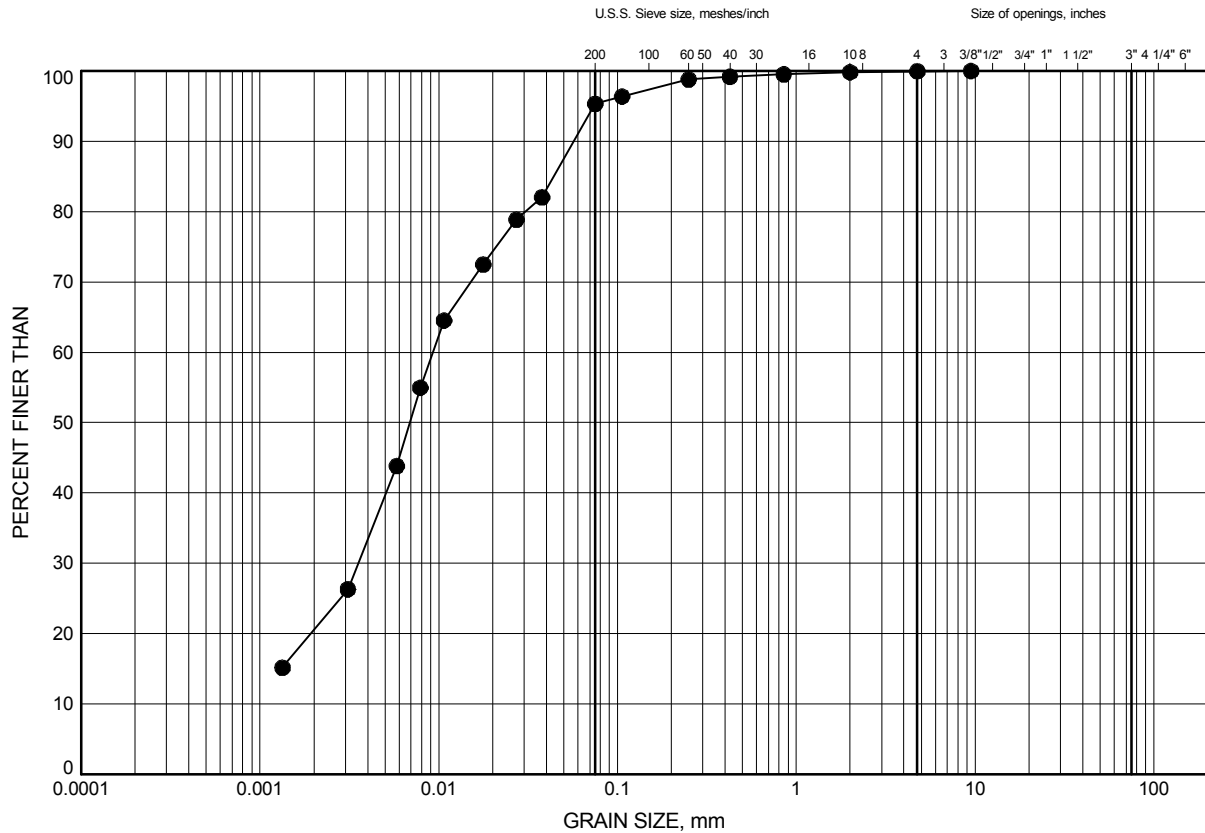
Prep'd CM  
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C3

### Silty Clay (CL-ML)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-07	1.07	263.74

Date June 2018

GWP# 5015-E-0041



Prep'd CM

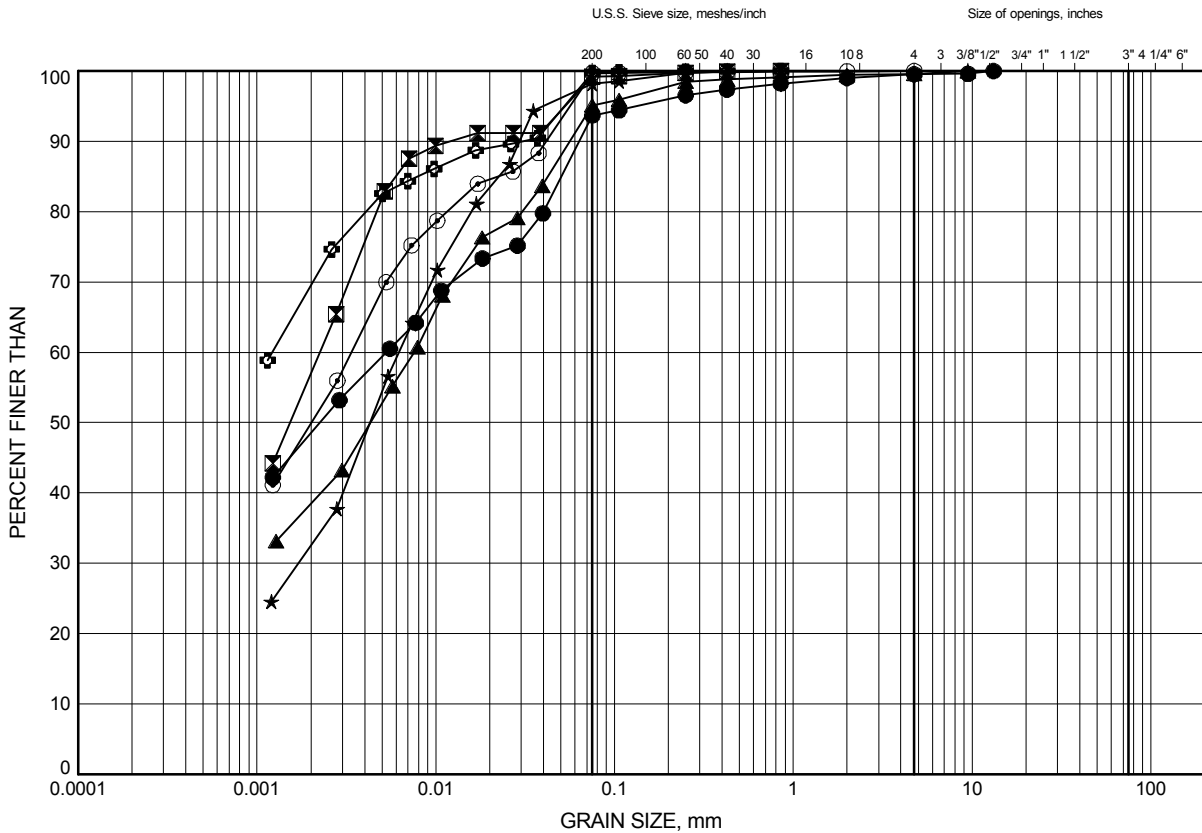
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C4

Clay (CL to CH)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	1.07	264.73
⊠	16-03	3.51	262.29
▲	16-04	0.30	264.30
★	16-04	2.74	261.86
⊙	16-04	4.11	260.49
⊕	16-04	12.50	252.10

Date June 2018

GWP# 5015-E-0041



Prep'd CM

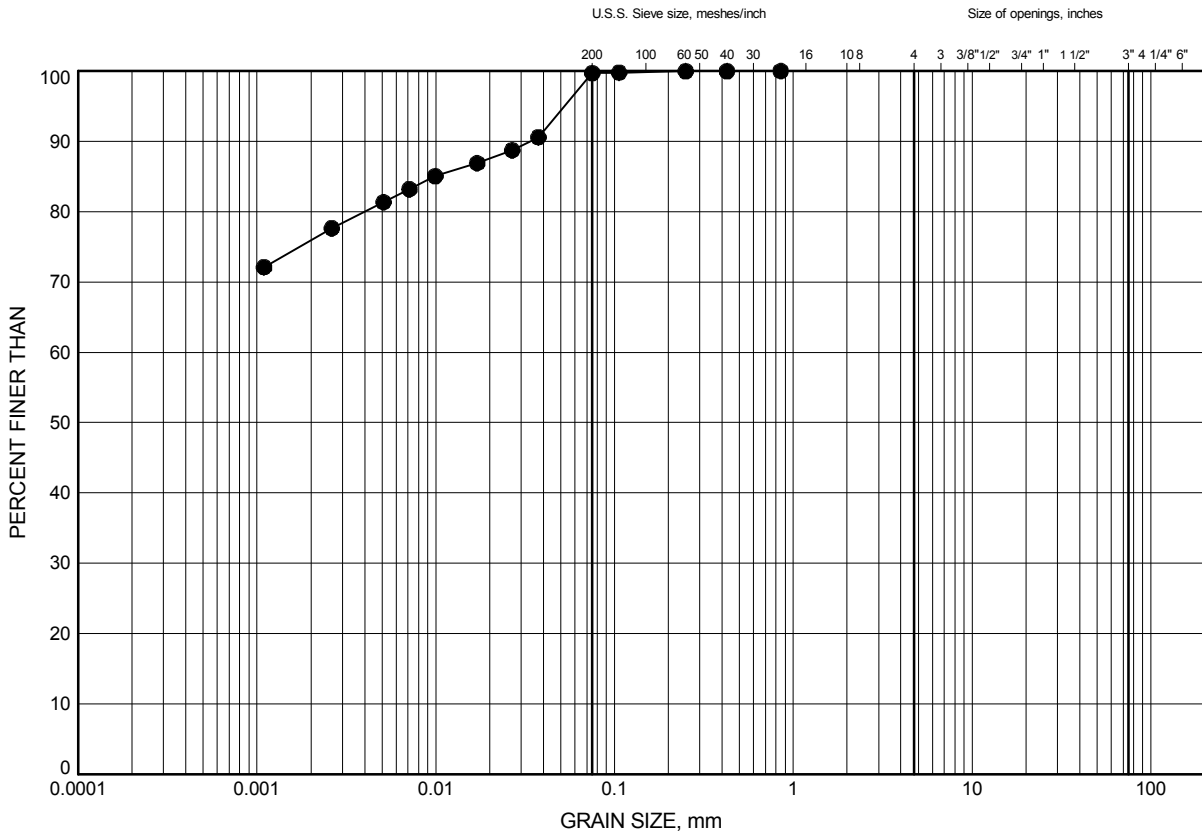
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C5

Clay (CL to CH)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-07	4.88	259.93

Date June 2018  
GWP# 5015-E-0041



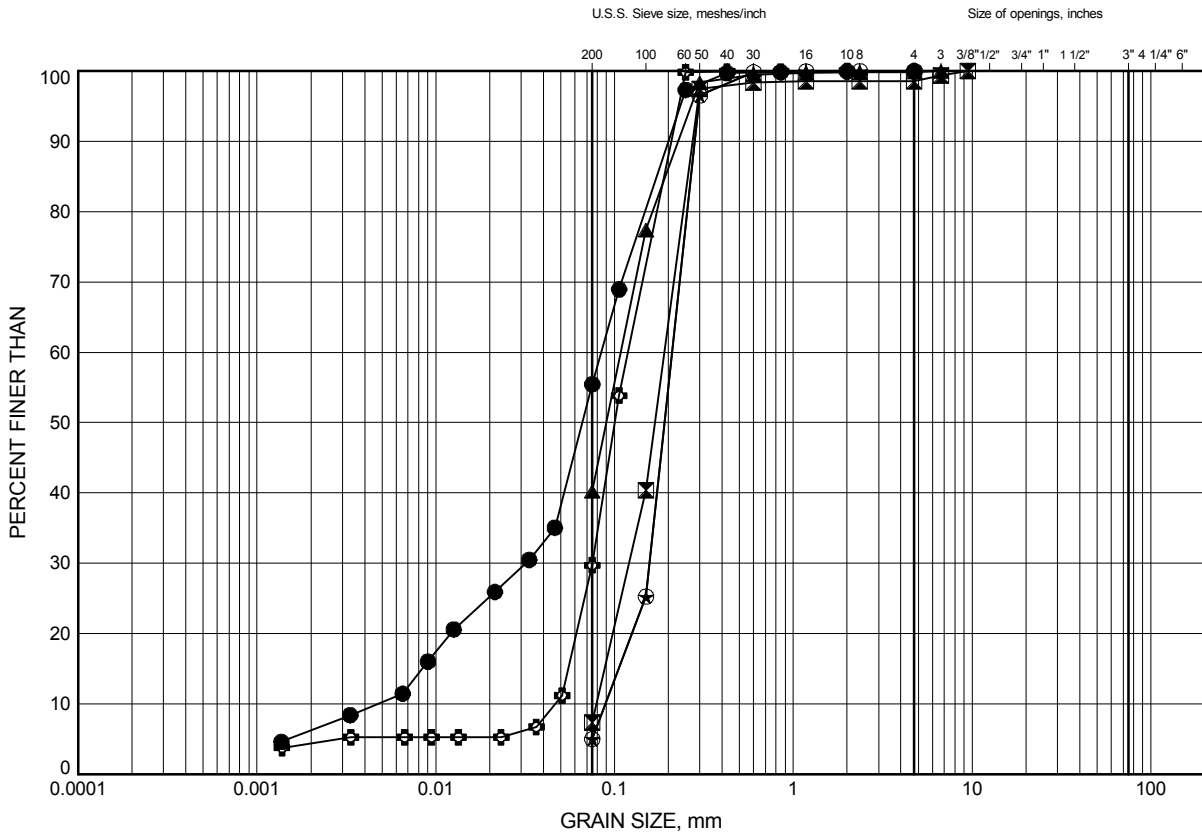
Prep'd CM  
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C6

Sandy Silt (ML) to Silty Sand (SM) to Sand (SP)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	9.45	264.25
⊠	16-01	15.54	258.16
▲	16-02	10.97	262.73
★	16-02	15.54	258.16
⊙	16-03	7.01	258.79
⊕	18-05	8.69	265.13

Date June 2018

GWP# 5015-E-0041



Prep'd CM

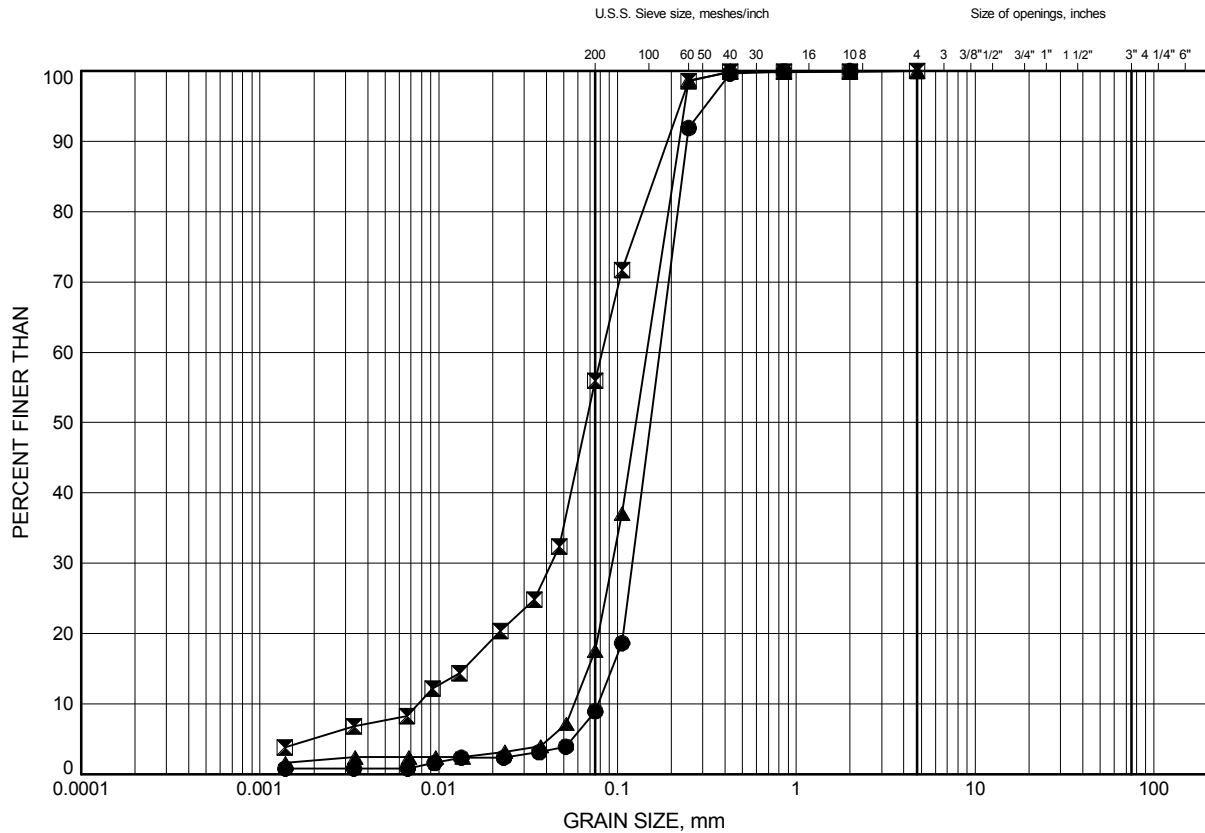
Chkd. SP

# Hwy 11 - Culvert at 17+611

## GRAIN SIZE DISTRIBUTION

FIGURE C7

Sandy Silt (ML) to Silty Sand (SM) to Sand (SP)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-05	12.50	261.32
⊠	18-06	7.92	265.90
▲	18-06	15.54	258.28

Date June 2018

GWP# 5015-E-0041



Prep'd CM

Chkd. SP



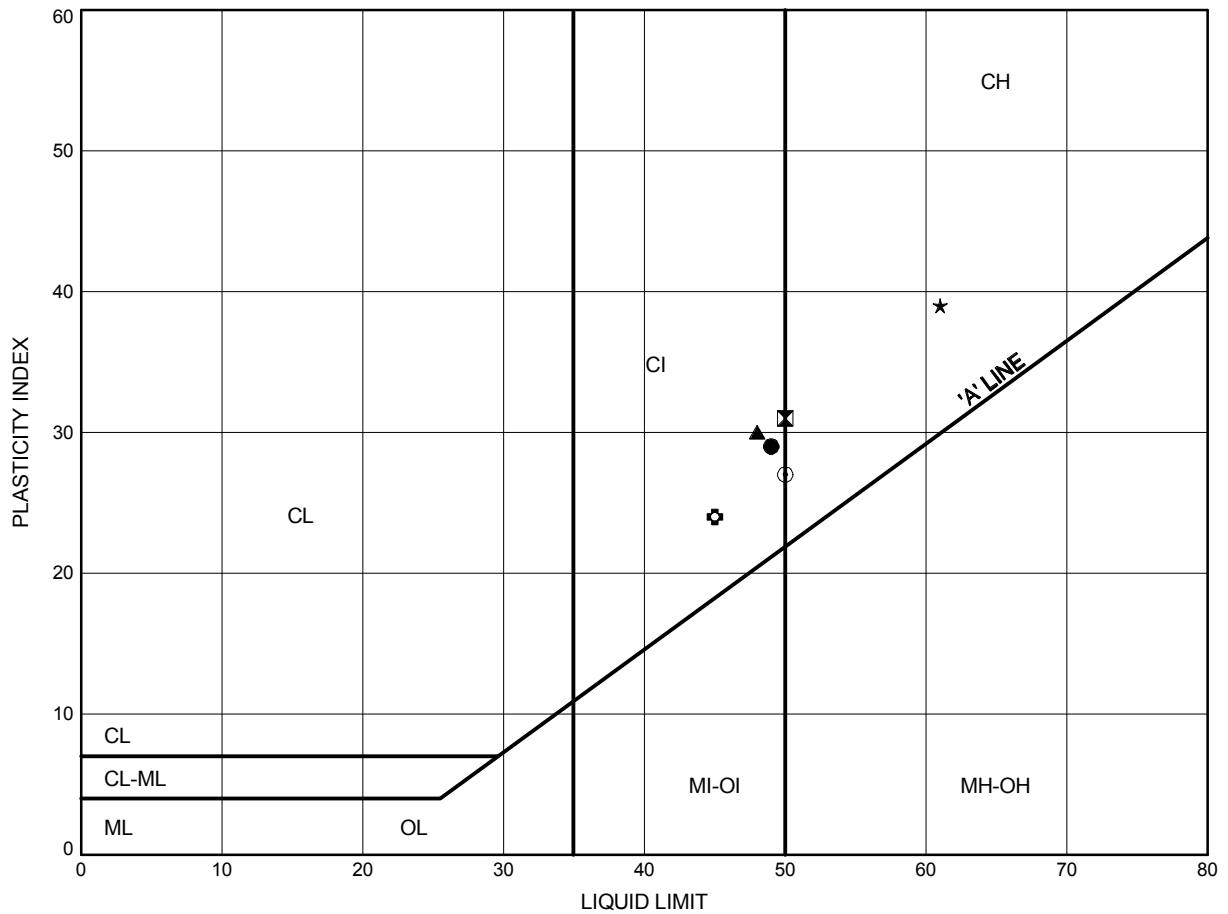
**Appendix C.2**  
**Atterberg Limit Analysis Figures**

Hwy 11 - Culvert at 17+611

# ATTERBERG LIMITS TEST RESULTS

FIGURE C8

Clay Fill



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	6.28	267.42
⊠	16-02	2.59	271.11
▲	16-02	7.92	265.78
★	18-05	4.11	269.70
⊙	18-05	7.16	266.65
⊕	18-06	6.40	267.43

Date June 2018  
GWP# 5015-E-0041



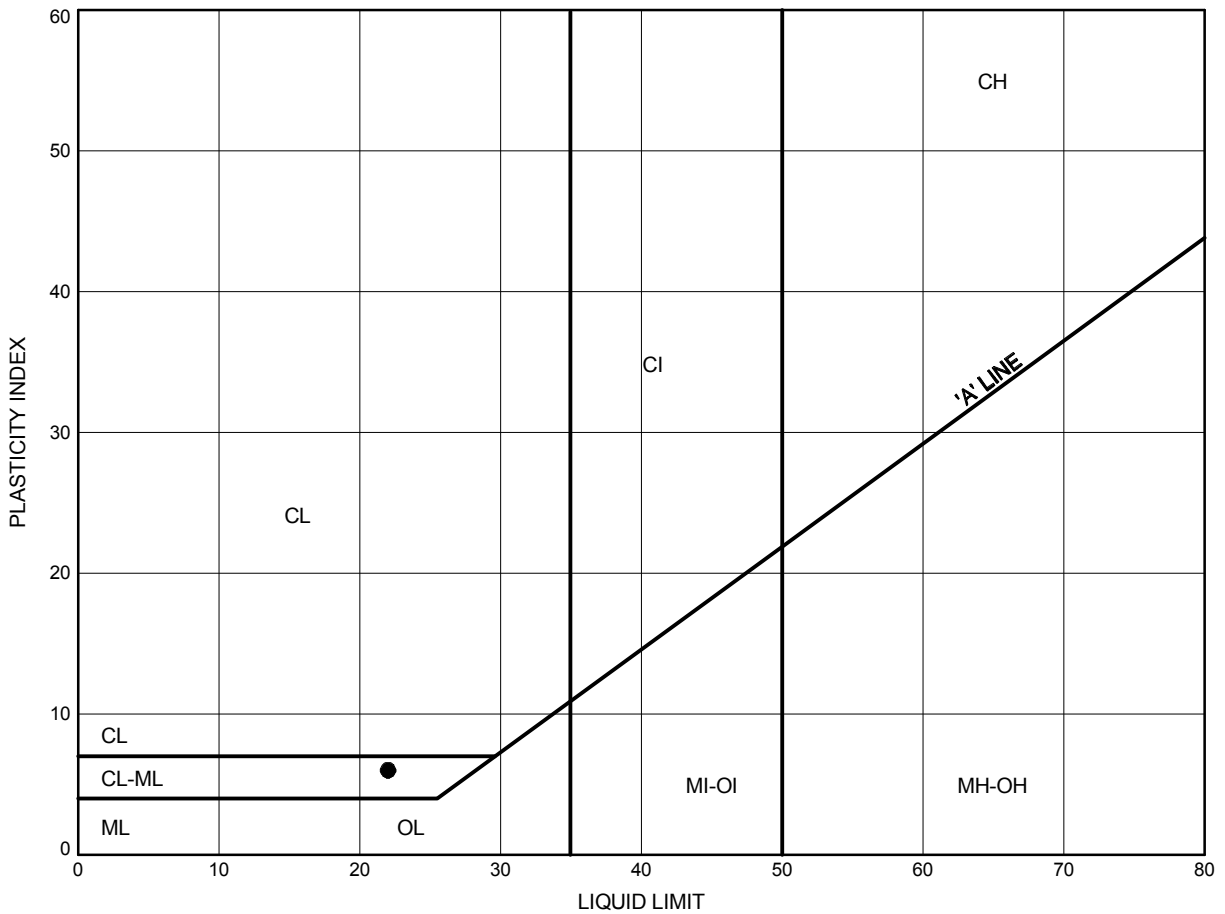
Prep'd CM  
Chkd. SP

Hwy 11 - Culvert at 17+611

# ATTERBERG LIMITS TEST RESULTS

FIGURE C9

Silty Clay (CL-ML)



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-07	1.07	263.74

Date June 2018  
GWP# 5015-E-0041



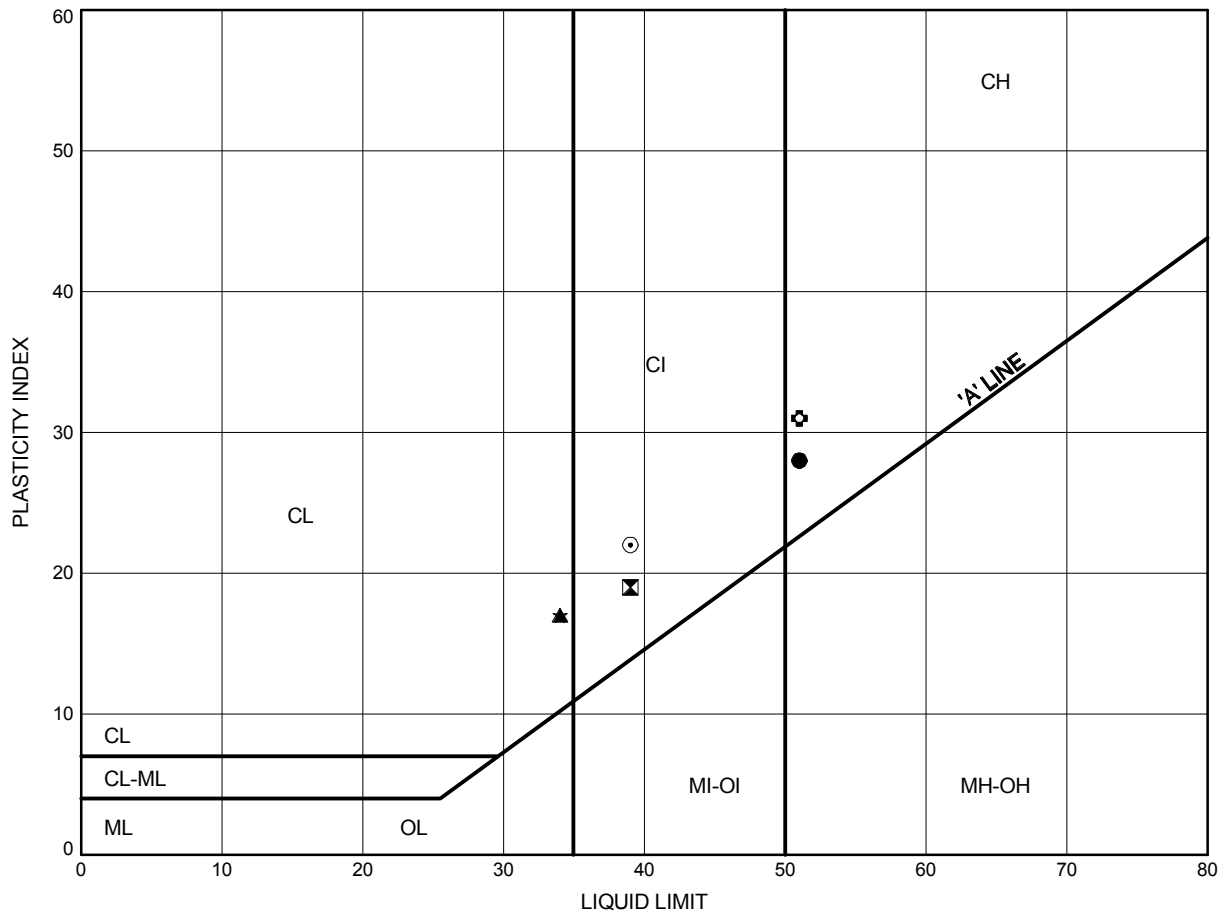
Prep'd CM  
Chkd. SP

Hwy 11 - Culvert at 17+611

# ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Clay (CL to CH)



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	1.07	264.73
⊠	16-03	3.51	262.29
▲	16-04	0.30	264.30
★	16-04	2.74	261.86
⊙	16-04	4.11	260.49
⊕	16-04	12.50	252.10

Date June 2018  
GWP# 5015-E-0041



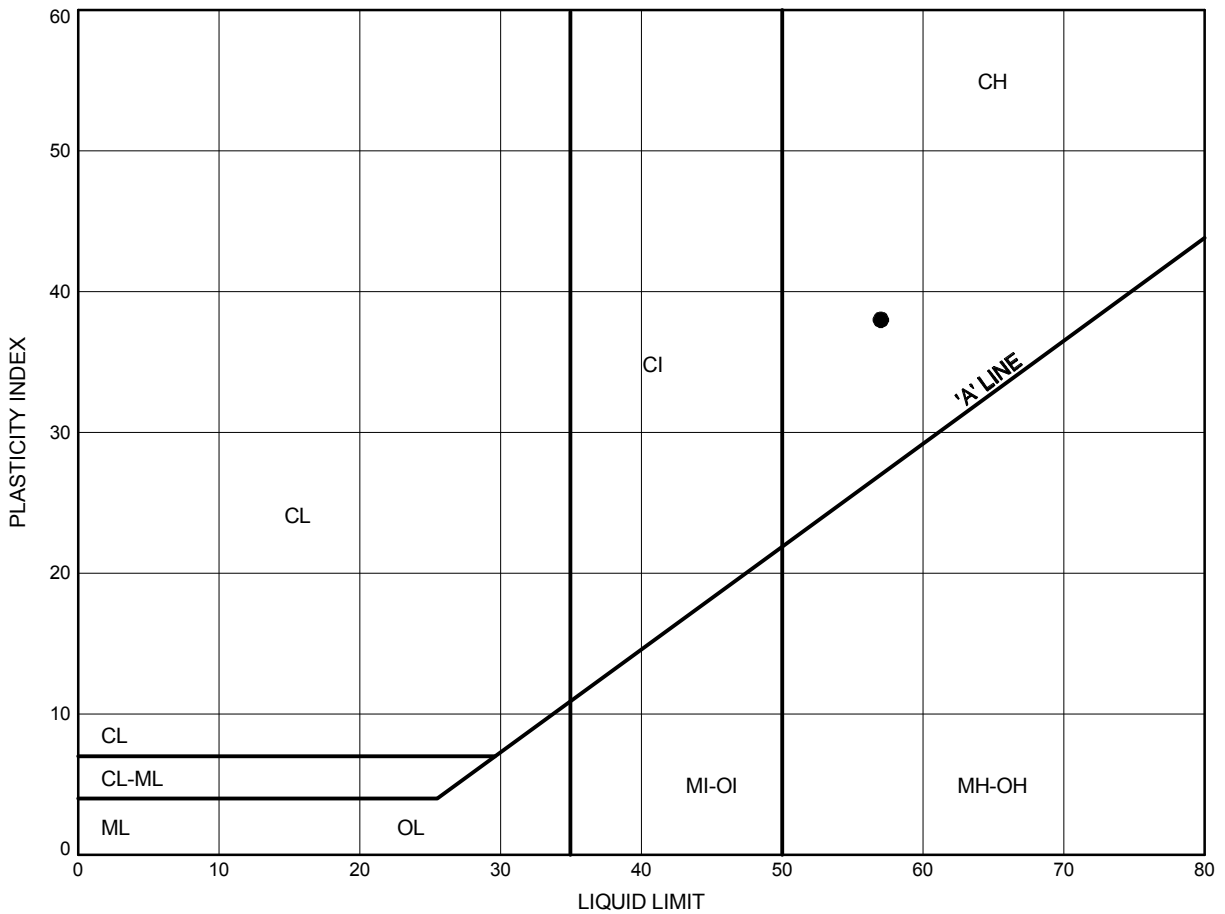
Prep'd CM  
Chkd. SP

Hwy 11 - Culvert at 17+611

# ATTERBERG LIMITS TEST RESULTS

FIGURE C11

Clay (CL to CH)



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	18-07	4.88	259.93

Date June 2018  
GWP# 5015-E-0041

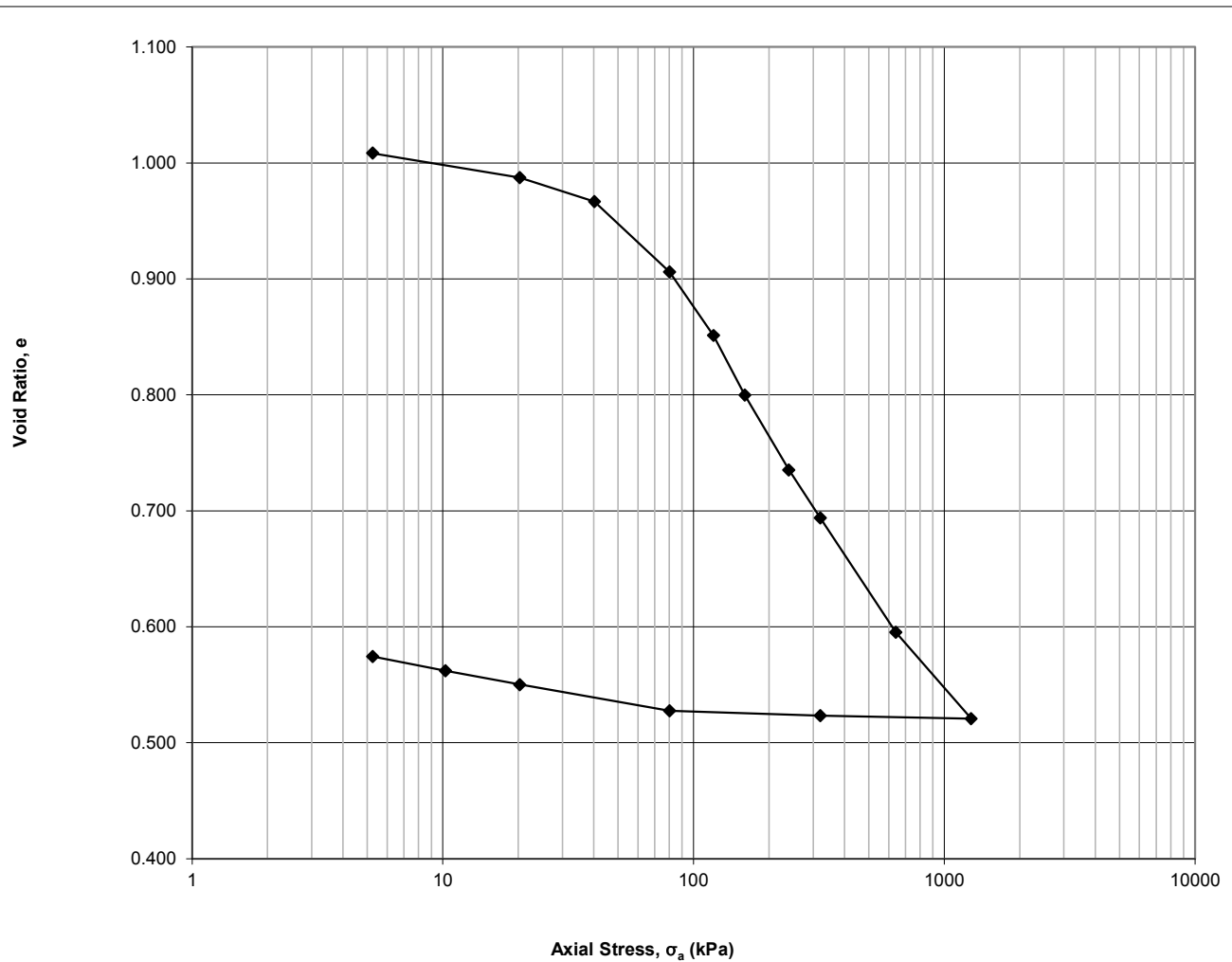


Prep'd CM  
Chkd. SP

**Appendix C.3**  
**Consolidation Test Results**

**Project**  
**Project No.**  
**Borehole No.**  
**Sample No.**  
**Sample Depth**

**Thurber Engineering, File# 13058**  
**122410864**  
**C2**  
**4**  
**10-12 ft**



**One-Dimensional Consolidation Test using Incremental Loading**  
**ASTM D2435/D2435M - 11**

**Specimen Details**

Project Name	Thurber Engineering, File# 13058
Project Location	-
Borehole	C2
Sample No.	4
Depth	10-12 ft
Sample Date	October 19, 2016
Test Number	One
Technician Name	Daniel Boateng

**Soil Description & Classification**

CL	
Specific Gravity of Solids	2.72
Liquid Limit %	34
Plastic Limit %	17
Plasticity Index %	17
Average water content of trimmings %	37
<b>Additional Notes (information source, occurrence and size of large isolated particles etc.)</b>	
Specific Gravity of Solids Assumed	

**Initial Specimen Conditions**

Height	mm	20.00
Diameter	mm	50.00
Area	mm <sup>2</sup>	1963
Volume	mm <sup>3</sup>	39270
Mass	g	72.42
Dry Mass	g	52.89
Density	Mg/m <sup>3</sup>	1.844
Dry Density	Mg/m <sup>3</sup>	1.347
Water Content	%	36.93
Degree of Saturation	%	98.4
Height of Solids	mm	9.89
Initial Void Ratio		1.022

**Final Specimen Conditions**

Water Content	%	23.79
Final Void Ratio		0.574



## One-Dimensional Consolidation Test using Incremental Loading

### ASTM D2435/D2435M - 11

**Specimen Details**

Project Name	Thurber Engineering, File# 13058
Project Location	-
Borehole	C2
Sample No.	4
Depth	10-12 ft
Sample Date	October 19, 2016
Test Number	One
Technician Name	Daniel Boateng

**Test Procedure**

Date Started	November 7, 2016
Date Finished	November 21, 2016
Machine Number	Frame C
Cell Number	C
Ring Number	C
Trimming Procedure	Turntable
Moisture Condition	Inundated
Axial Stress at Inundation kPa	5
Water Used	Distilled
Test Method	A
Interpretation Procedure for $c_v$	2

**All Departures from Outlined ASTM D2435/D2435M-11 Procedure**

--

**Calculations**

Load Increment	Increment Duration	Axial Stress $\sigma_a$ kPa	Corrected Deformation $\Delta H$ mm	Specimen Height H mm	Axial Strain $\epsilon_a$ %	Void Ratio e
Seating	0.0	5	0.0000	20.0000	0.00	1.022
1	1440.0	5	0.1320	19.8680	0.66	1.008
2	1440.0	20	0.3405	19.6595	1.70	0.987
3	1440.0	40	0.5437	19.4563	2.72	0.967
4	1440.0	80	1.1437	18.8563	5.72	0.906
5	1440.0	120	1.6882	18.3118	8.44	0.851
6	1440.0	160	2.1946	17.8054	10.97	0.800
7	1440.0	240	2.8355	17.1645	14.18	0.735
8	1440.0	320	3.2430	16.7570	16.22	0.694
9	1440.0	640	4.2184	15.7816	21.09	0.595
10	1440.0	1280	4.9561	15.0439	24.78	0.521
11	1440.0	320	4.9302	15.0698	24.65	0.523
12	1440.0	80	4.8889	15.1111	24.44	0.528
13	1440.0	20	4.6648	15.3352	23.32	0.550
14	1440.0	10	4.5474	15.4526	22.74	0.562
15	1440.0	5	4.4268	15.5732	22.13	0.574

## One-Dimensional Consolidation Test using Incremental Loading

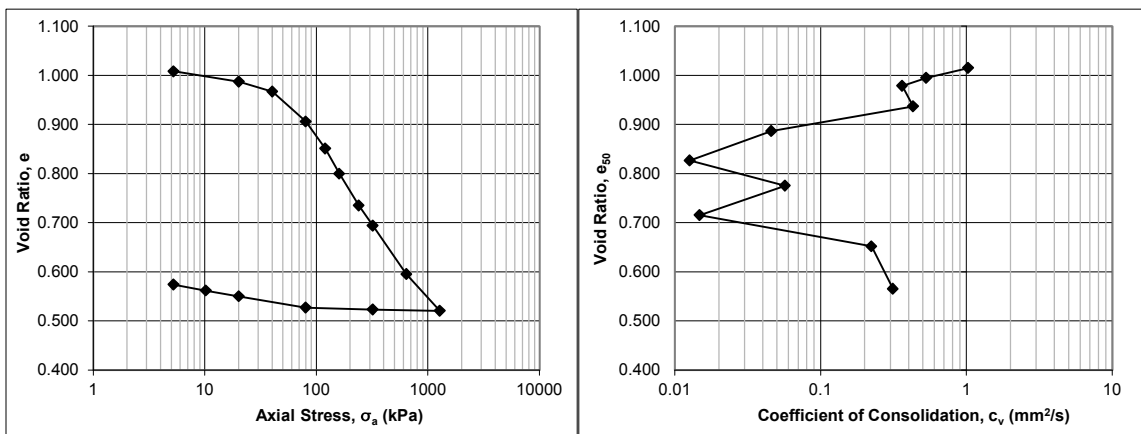
### ASTM D2435/D2435M - 11

**Specimen Details**

Project Name	Thurber Engineering, File# 13058
Project Location	-
Borehole	C2
Sample No.	4
Depth	10-12 ft
Sample Date	October 19, 2016
Test Number	One
Technician Name	Daniel Boateng

**Calculations**

Load Increment	Axial Stress $\sigma_a$ , average kPa	Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
		Corrected Deformation $\Delta H_{50}$ mm	Specimen Height $H_{50}$ mm	Axial Strain $\epsilon_{a,50}$ %	Void Ratio $e_{50}$	Time $t_{50}$ sec	Coeff. Consol. $c_v$ mm <sup>2</sup> /s	Time $t_{90}$ sec	Coeff. Consol. $c_v$ mm <sup>2</sup> /s
Seating	3								
1	5	0.0617	19.9383	0.31	1.016			82	1.03E+00
2	13	0.2674	19.7326	1.34	0.995			156	5.30E-01
3	30	0.4261	19.5739	2.13	0.979			225	3.61E-01
4	60	0.8381	19.1619	4.19	0.937			181	4.31E-01
5	100	1.3344	18.6656	6.67	0.887			1609	4.59E-02
6	140	1.9298	18.0702	9.65	0.827			5477	1.26E-02
7	200	2.4390	17.5610	12.19	0.775			1149	5.69E-02
8	280	3.0324	16.9676	15.16	0.715			4115	1.48E-02
9	480	3.6560	16.3440	18.28	0.652			254	2.23E-01
10	960	4.5108	15.4892	22.55	0.566			162	3.13E-01
11	800	4.9462	15.0538	24.73	0.522				
12	200	4.9090	15.0910	24.55	0.526				
13	50	4.7872	15.2128	23.94	0.538				
14	15	4.6103	15.3897	23.05	0.556				
15	8	4.4872	15.5128	22.44	0.568				



**Appendix C.4**  
**Analytical Testing Results**

Certificate of Analysis  
Client: Thurber Engineering Ltd.  
Client PO:

Report Date: 02-Nov-2016

Order Date: 28-Oct-2016

Project Description: 13058

<b>Client ID:</b>		C2-3 SS1 0'-2'	C2-4 SS3 5'-7'	C6-3 SS2 2'-6'-4'6	C6-4 SS3A 5'-6'
<b>Sample Date:</b>		18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
<b>Sample ID:</b>		1644497-01	1644497-02	1644497-03	1644497-04
<b>MDL/Units</b>		Soil	Soil	Soil	Soil
<b>Physical Characteristics</b>					
% Solids	0.1 % by Wt.	74.7	79.6	76.7	74.5
<b>General Inorganics</b>					
Conductivity	5 uS/cm	357	494	795	344
pH	0.05 pH Units	7.59	7.52	7.54	7.60
Resistivity	0.10 Ohm.m	28.0	20.2	12.6	29.1
<b>Anions</b>					
Chloride	5 ug/g dry	49	236	314	67
Sulphate	5 ug/g dry	11	8	21	14
<b>Client ID:</b>		C7-3 SS2 2'-6'-4'6	C7-4 SS3 5'-7'	MC16-4 SS1 0'-2'	MC16-6 SS3 5'-7'
<b>Sample Date:</b>		18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
<b>Sample ID:</b>		1644497-05	1644497-06	1644497-07	1644497-08
<b>MDL/Units</b>		Soil	Soil	Soil	Soil
<b>Physical Characteristics</b>					
% Solids	0.1 % by Wt.	64.7	72.9	65.0	88.2
<b>General Inorganics</b>					
Conductivity	5 uS/cm	226	616	729	56
pH	0.05 pH Units	7.52	7.62	6.21	6.35
Resistivity	0.10 Ohm.m	44.3	16.2	13.7	179
<b>Anions</b>					
Chloride	5 ug/g dry	11	187	328	9
Sulphate	5 ug/g dry	19	21	30	7
<b>Client ID:</b>		C28-3 SS2 2'-6'-4'6	C28-4 SS1 0'-2'	C34-3 SS3 5'-7'	C34-4 SS1 0'-2'
<b>Sample Date:</b>		18-Oct-16	18-Oct-16	18-Oct-16	18-Oct-16
<b>Sample ID:</b>		1644497-09	1644497-10	1644497-11	1644497-12
<b>MDL/Units</b>		Soil	Soil	Soil	Soil
<b>Physical Characteristics</b>					
% Solids	0.1 % by Wt.	71.3	70.8	79.9	91.9
<b>General Inorganics</b>					
Conductivity	5 uS/cm	765	999	233	208
pH	0.05 pH Units	7.47	7.60	7.65	6.95
Resistivity	0.10 Ohm.m	13.1	10.0	42.8	48.2
<b>Anions</b>					
Chloride	5 ug/g dry	343	493	13	18
Sulphate	5 ug/g dry	15	21	36	24

Certificate of Analysis  
 Client: Thurber Engineering Ltd.  
 Client PO:

Report Date: 10-May-2018

Order Date: 4-May-2018

Project Description: 13058

<b>Client ID:</b>	20+172 Bowman,18-5,SS11 (25'-27')	11+967 PlayFair,18-5, SS9(25'-27')	20+237 Bowman,18-5,SS8(1 7'6"-19'6")	17+619 Bowman,18-5,SS13 (30'-32')
<b>Sample Date:</b>	05/02/2018 12:00	04/30/2018 14:30	05/02/2018 16:00	05/03/2018 11:30
<b>Sample ID:</b>	1818665-01	1818665-02	1818665-03	1818665-04
<b>MDL/Units</b>	Soil	Soil	Soil	Soil

#### Physical Characteristics

% Solids	0.1 % by Wt.	71.9	61.4	72.8	92.1
----------	--------------	------	------	------	------

#### General Inorganics

Conductivity	5 uS/cm	308	408	564	654
pH	0.05 pH Units	7.79	7.56	6.82	7.11
Resistivity	0.10 Ohm.m	32.5	24.5	17.7	15.3

#### Anions

Chloride	5 ug/g dry	56	118	284	17
Sulphate	5 ug/g dry	23	14	11	7

**Appendix D.**  
**Site Photographs**



**Photo 1. Looking north along Highway 11 (September 2016).**



**Photo 2. Looking south along Highway 11 (September 2016).**