



**THURBER** ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT  
DILKE CREEK NO. 2 CULVERT REPLACEMENT  
HIGHWAY 11, TOWNSHIP OF DILKE  
DISTRICT OF RAINY RIVER, ONTARIO**

**G.W.P. No. 6813-14-00, W.P. No. 6342-14-00, SITE No. 45-149/C**

**GEOCRES Number: 52D-30**

**Report**

**to**

**HATCH**

Date: February 17, 2017  
File: 13983

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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Dilke Creek Timber Culvert on Highway 11, located east of Rainy River, in the Township of Dilke, District of Rainy River, Ontario.

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

Thurber was retained by Hatch Ltd. (Hatch) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0018-005.

**2. SITE DESCRIPTION**

The site is located on Highway 11, approximately 8 km west of Highway 617, in the Township of Dilke, Ontario. The existing culvert allows Dilke Creek to flow in a southwesterly direction under Highway 11 towards Rainy River. Highway 11 generally runs in a northwest to southeast direction at the culvert site.

The Ontario Structure Inspection Manual (Inspection Form) prepared by MTO on Nov. 2, 2015 indicates that the existing structure is a double-cell timber box culvert, approximately 30.6 m long and 4.2 m wide with approximately 2.6 m fill above the culvert. The inspection report indicated that the structure is in an overall poor condition.

The lands surrounding the culvert site predominantly consist of agricultural lands dotted with

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forested areas. Dilke Creek discharges into Rainy River approximately 150 m southwest of the culvert. Rainy River runs generally parallel to the highway alignment in the area. Local topography is of low relief with no evident bedrock outcrops.

Photographs of the culvert and surrounding areas are presented in Appendix C.

Based on published geological information, the culvert lies within glaciolacustrine fine-grained deposits of silt and clay and silty clay to clayey silt till. Bedrock at the site is identified as felsic to intermediate metavolcanic rocks.

### **3. INVESTIGATION PROCEDURES**

The site investigation and field testing program for this project was carried out on August 27 and 28, 2016, and consisted of drilling and sampling four (4) boreholes (16-42 to 16-45). Boreholes 16-43 and 16-44 were drilled through the paved portion of Highway 11, north and south of the existing culvert. Boreholes 16-42 and 16-45 were drilled near the inlet/outlet of the existing culvert.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the cross sections and topographic drawings provided to Thurber by Hatch. The coordinate system MTM NAD 83, Zone 16 was used for these boreholes.

A rubber track mounted drill rig was used to advance the boreholes using hollow stem augers. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Field vane shear testing using a MTO “N” size shear vane was carried out in the cohesive soils.

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 throughout the drilling operations and in the open boreholes upon completion of drilling. The boreholes were backfilled in general accordance with Ontario Regulation 903. A piezometer was installed in BH 16-42 for monitoring of groundwater level.

Completion details of the boreholes and the piezometer are summarized in Table 3.1.

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**Table 3.1 – Borehole Completion Details**

Borehole Number	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
16-42	12.5 / 319.5	9.1 / 322.9	Bentonite holeplug from 12.5 m to 9.1 m, sand filter from 9.1 m to 5.8 m, then bentonite holeplug from 5.8 m to ground surface.
16-43	14.3 / 319.0	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.1 m, then asphalt to surface.
16-44	14.3 / 319.0	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.1 m, then asphalt to surface.
16-45	9.8 / 319.7	None installed	Borehole backfilled with bentonite holeplug and cuttings to ground surface.

#### **4. LABORATORY TESTING**

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) and plasticity testing (Atterberg Limits) where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the native soil, and a sample of the surface water from the creek upstream of the existing culvert were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters. The results of the analytical testing are summarized in this report and also presented 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 on the Record of Borehole sheets and on the Borehole Locations and Soil Strata drawing included in Appendix D. 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 and must be used for interpretation of the site conditions. It must be recognized and expected that soil conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered below the existing embankment fill consisted of glaciolacustrine silty clay underlain by sandy silty clay till. Descriptions of the individual strata are presented below.

### **5.1 Asphalt**

Boreholes 16-43 and 16-44 were drilled through the paved portion of Highway 11. The asphalt was approximately 100 mm thick in both boreholes.

### **5.2 Topsoil**

Topsoil was encountered in Boreholes 16-42 and 16-45 drilled near the inlet and outlet of the existing culvert. The thickness of the topsoil ranged from 25 to 50 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities of topsoil removal.

### **5.3 Fill**

Embankment fill was encountered in Boreholes 16-43 and 16-44, and beneath the topsoil in Borehole 16-42. The fill was predominantly cohesionless consisting of gravelly sand to sand except in Borehole 16-44 where 0.8 m thick silty clay fill was encountered below the gravelly sand fill. The fill ranged from 2.1 to 2.9 m in thickness and extended to Elevation 330.4 to 329.9 m.

The SPT 'N' values of the fill ranged from 3 to 33 blows for 0.3 m penetration, indicating very loose to dense relative density. The measured moisture content ranged from 3% to 9% in the gravelly sand to sand fill and was 28% in the silty clay fill.

The results of grain size analyses conducted on samples of the cohesionless fill are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B1 of Appendix B. The results are summarized as follows:

Gravel %	1 to 21
Sand %	63 to 90
Silt and Clay %	9 to 16

## 5.4 Silty Clay

Grey silty clay was encountered beneath the embankment fill, at 2.1 to 3.0 m depth (Elevations 329.9 to 330.4), in Boreholes 16-42 to 16-44. The silty clay contained trace to some sand with trace organic staining. The silty clay layer was approximately 1.1 to 3.5 m thick and extended to 4.1 to 5.6 m depth (Elevations 326.4 to 329.2) in Boreholes 16-42 to 16-44.

SPT 'N' values recorded in the silty clay ranged between 2 to 6 blows for 0.3m penetration, indicating a soft to firm consistency. Measured moisture contents in the clay ranged from 35% to 47%. A field shear vane test carried out in the silty clay measured an undrained shear strength of 54 kPa, indicating a stiff consistency.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B2 of Appendix B. The results are summarized as follows:

Gravel %	0
Sand %	10 to 15
Silt %	14 to 19
Clay %	71

## 5.5 Sandy Silty Clay Till

A layer of grey sandy silty clay till was encountered in all boreholes beneath the silty clay, with the exception of Borehole 16-45 where it was encountered immediately beneath the topsoil. The till generally contains trace gravel. Till formations are known to contain cobbles and boulders. All boreholes were terminated within the till deposit at depths ranging from 9.8 to 14.3 m (Elevation 319.0 to 319.7).

SPT 'N' values recorded in the silty clay till varied between 3 and 14 blows for 0.3 m penetration. The field vane shear test (VST) measured in-situ undrained shear strength ranging from 52 kPa to greater than 100 kPa. Based on the SPT and VST data, the consistency of the silty clay till is typically stiff to very stiff. Lower SPT 'N' values of 0 to 2 blows per 0.3 m of penetration were measured within the upper 2 m of the till in Borehole 16-45, indicating presence of streambed deposit. The sensitivity of the till, calculated as a ratio of undisturbed strength to remoulded strength, ranged from 2 to 4, indicative of low sensitivity.

Natural moisture contents in the silty clay till ranged from 16% to 21%.

The results of grain size analyses conducted on samples of the silty clay till are provided on the Record of Borehole sheets in Appendix A and illustrated in Figures B3 and B4 of Appendix B. The results are summarized as follows:

Gravel %	0 to 7
Sand %	25 to 31
Silt %	36 to 43
Clay %	25 to 33

The results of Atterberg Limits tests conducted on samples of the silty clay till are provided on the Record of Borehole sheets in Appendix A and illustrated in Figures B5 and B6 of Appendix B. The results are summarized as follows:

Liquid Limit	27 to 32
Plastic Limit	12 to 14
Plasticity Index	14 to 20

The results of the Atterberg Limits testing indicate that the sandy silty clay till has a low plasticity with group symbol CL.

## 5.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured in the open borehole is summarized in Table 5.1 below.

**Table 5.1 – Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
16-42	August 27, 2016	Dry	-	Open borehole
16-43	August 27, 2016	Dry	-	Open borehole
16-44	August 28, 2016	Dry	-	Open borehole
16-45	August 28, 2016	0.6	328.9	Open borehole

The groundwater level should be assumed to reflect the local creek water level. The above groundwater levels are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.



## 6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty clay till from Borehole 16-45, and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

**Table 6.1 – Analytical Test Results**

Parameter	Units (Soil)	Units (Water)	Test Results	
			16-45 SS#3 1.7 m	Dilke Creek
			(Silty Clay)	(Creek Water)
Corrosivity Index	-	-	4	4
Sulphide	%	mg/L	0.07	0.74
Chloride	µg/g	mg/L	23	180
Sulphate	µg/g	mg/L	260	9.4
pH	-	-	8.21 - 9.10	7.58
Conductivity	µS/cm	µS/cm	90	1360
Resistivity	Ohms.cm	MOhms.cm	11100	3630
Redox Potential	mV	mV	160	275

## 7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by Hatch.

RPM Drilling Inc. of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Tim Sivak of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrant, P.Eng. of Thurber.

Geotechnical laboratory testing was carried out in Thurber's geotechnical laboratory. Analytical laboratory testing was carried out by SGS Canada Inc.

Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT and Ms. R. Palomeque Reyna, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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## **Appendix A**

### **Record of Borehole Sheets**

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT      Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

## EXPLANATION OF ROCK LOGGING TERMS


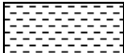



### ROCK WEATHERING CLASSIFICATION

<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 (MPa)</b>	<b>Approximate Uniaxial Compressive Strength (psi)</b>	<b>Field Estimation of Hardness*</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.

# 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 <sub>L</sub> < 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 <sub>L</sub> < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W <sub>L</sub> < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W <sub>L</sub> > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

# RECORD OF BOREHOLE No 16-42

1 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 512.9 E 212 005.0 ORIGINATED BY TS  
HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2016.08.27 - 2016.08.27 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE													
332.0	GROUND SURFACE																				
0.0	<b>TOPSOIL:</b> (25mm)  Gravelly <b>SAND</b> , some silt Very Loose to Loose Brown Moist (FILL)		1	SS	4																
			2	SS	3																
			3	SS	3																
329.9																					
2.1	Silty <b>CLAY</b> , some sand, organic staining Firm to Stiff Grey Moist		4	SS	4												0	15	14	71	
			5	SS	4																
			6	SS	2																
326.4																					
5.6	Silty <b>CLAY</b> , sandy, trace gravel Stiff Grey Moist (TILL)		7	SS	5																
			8	SS	7													0	30	42	28
			9	SS	7																

Continued Next Page

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


20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-42

2 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 512.9 E 212 005.0 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.27 - 2016.08.27 CHECKED BY RPR

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 (%)		
								20 40 60 80 100										20 40 60		
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE													
319.5	Silty <b>CLAY</b> , sandy, trace gravel Stiff Grey Moist (TILL)		10	SS	6		321										0 29 41 30			
12.5	END OF BOREHOLE AT 12.5m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m)																			






# RECORD OF BOREHOLE No 16-43

1 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 493.7 E 212 007.2 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.27 - 2016.08.27 CHECKED BY RPR

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 <sub>P</sub> W      W <sub>L</sub>						
333.3	GROUND SURFACE						20	40	60	80	100							
0.0	ASPHALT: (100mm)  Gravelly <b>SAND</b> , some silt Dense to Loose Brown Moist (FILL)																	
0.1			1	GS			333											
			2	SS	28													21   63   16 (SI+CL)
			3	SS	33													
			4	SS	7													
330.4																		
2.9	Silty <b>CLAY</b> , some sand, organic staining Firm to Stiff Grey Moist																	
			5	SS	4			330										0   10   19   71
329.1																		
4.2	Silty <b>CLAY</b> , sandy, trace gravel Stiff to Very Stiff Grey Moist (TILL)																	
			6	SS	3			329										
			7	SS	6			328										
			8	TW														

Continued Next Page

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

# RECORD OF BOREHOLE No 16-43

2 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 493.7 E 212 007.2 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.27 - 2016.08.27 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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						
								20 40 60 80 100						
	Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
	Silty <b>CLAY</b> , sandy, trace gravel Very Stiff Grey Moist (TILL)		10	SS	10		323							
							322							
			11	SS	9		321							
							320							
319.0			12	SS	8		319							0 30 40 30
14.3	END OF BOREHOLE AT 14.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.													

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

# RECORD OF BOREHOLE No 16-44

1 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 505.3 E 211 993.8 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.28 - 2016.08.28 CHECKED BY RPR

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
333.3	GROUND SURFACE							20	40	60	80	100					
0.0	ASPHALT: (100mm)							20	40	60	80	100					
0.1	Gravelly <b>SAND</b> , some silt, trace clay Loose Brown Moist (FILL)		1	GS			333										
			2	SS	8												
331.9							332										
1.4	Silty <b>CLAY</b> , trace sand and gravel Firm Brown Moist (FILL)		3	SS	6												
331.1																	
2.2	<b>SAND</b> , trace silt, organic staining Compact Brown Moist (FILL)		4	SS	10		331										
330.3																	
3.0	Silty <b>CLAY</b> , some sand Firm to Stiff Grey Moist		5	SS	6		330										
329.2																	
4.1	Silty <b>CLAY</b> , sandy, trace gravel Stiff to Very Stiff Grey Moist (TILL)		6	SS	3		329										
							328										

Continued Next Page

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

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 16-44

2 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 505.3 E 211 993.8 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.28 - 2016.08.28 CHECKED BY RPR

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							20 40 60 80 100					
	Silty <b>CLAY</b> , sandy, trace gravel Stiff to Very Stiff Grey Moist (TILL)		10	SS	14		323						2 29 36 33
							322						
			11	SS	10		321						
							320						
319.0			12	SS	10		319						
14.3	END OF BOREHOLE AT 14.3m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.1m, THEN ASPHALT COLD PATCH TO SURFACE.												

# RECORD OF BOREHOLE No 16-45

1 OF 2

METRIC

W.P. 6813-14-00 LOCATION Dilke Creek N 5 396 486.5 E 211 982.4 ORIGINATED BY TS  
 HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2016.08.28 - 2016.08.28 CHECKED BY RPR

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						
							20 40 60 80 100							
329.5	GROUND SURFACE													
0.0	TOPSOIL: (50mm)													
	Silty CLAY, sandy, trace gravel Very Soft to Stiff Grey Moist (TILL)		1	SS	0									
			2	SS	0									3 25 40 32
			3	SS	2									
			4	SS	5									
								2.7						
			5	SS	8									
			6	SS	9									
			7	SS	10									0 31 39 30
			8	SS	10									
319.7	END OF BOREHOLE AT 9.8m.													
9.8														

Continued Next Page

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

## METRIC

[illegible]



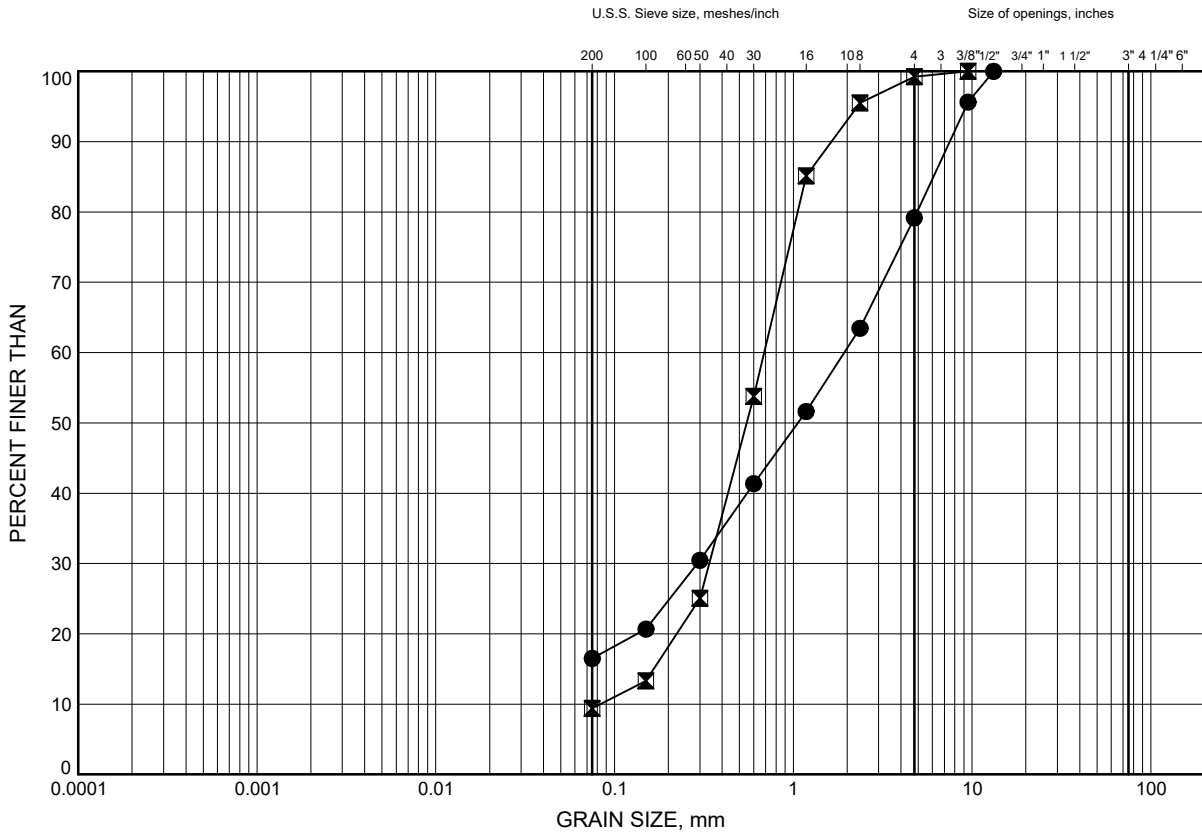
## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**

# Dilke Creek GRAIN SIZE DISTRIBUTION

FIGURE B1

## Gravelly SAND to SAND FILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-43	1.07	332.23
⊠	16-44	2.59	330.71

Date ..October 2016.....  
W.P. ..6813-14-00.....



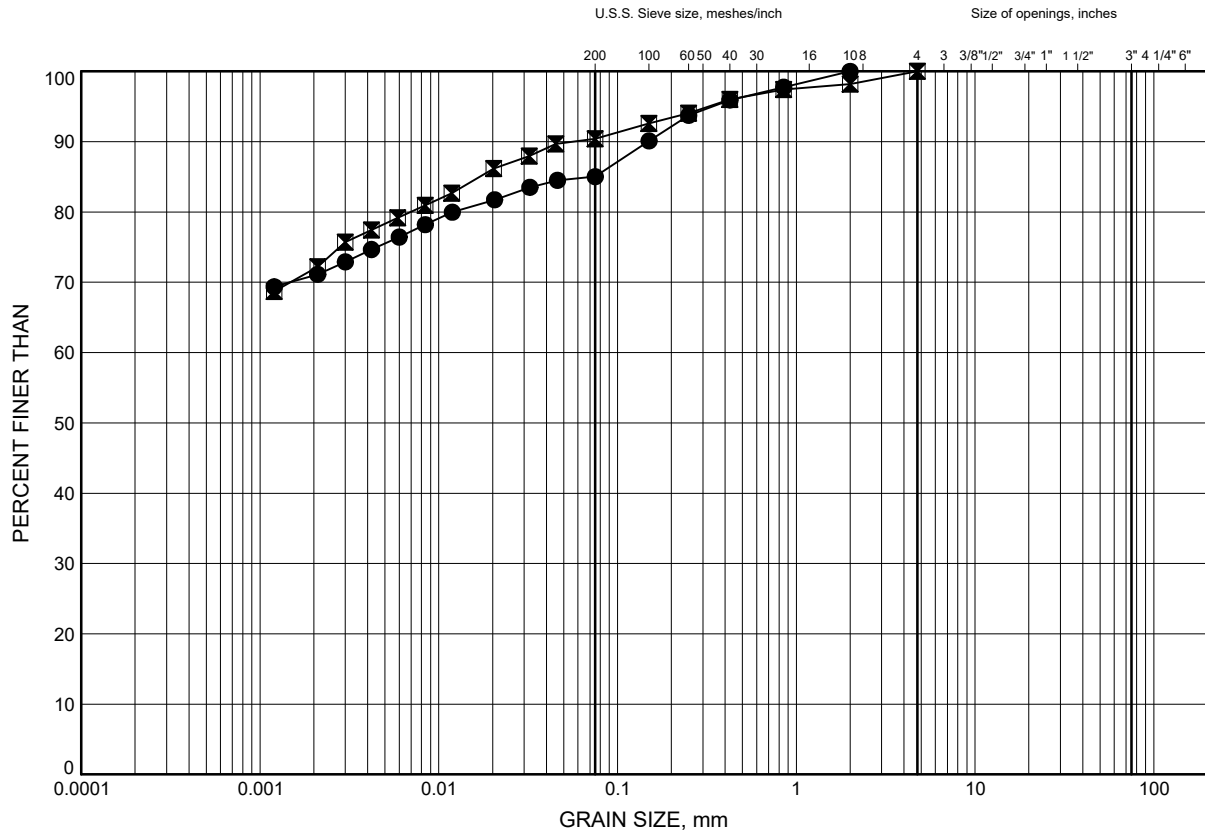
Prep'd .....AN.....  
Chkd. ....KS.....



# Dilke Creek GRAIN SIZE DISTRIBUTION

FIGURE B2

## Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-42	2.59	329.41
⊠	16-43	3.35	329.95

Date ..October 2016.....  
W.P. ..6813-14-00.....

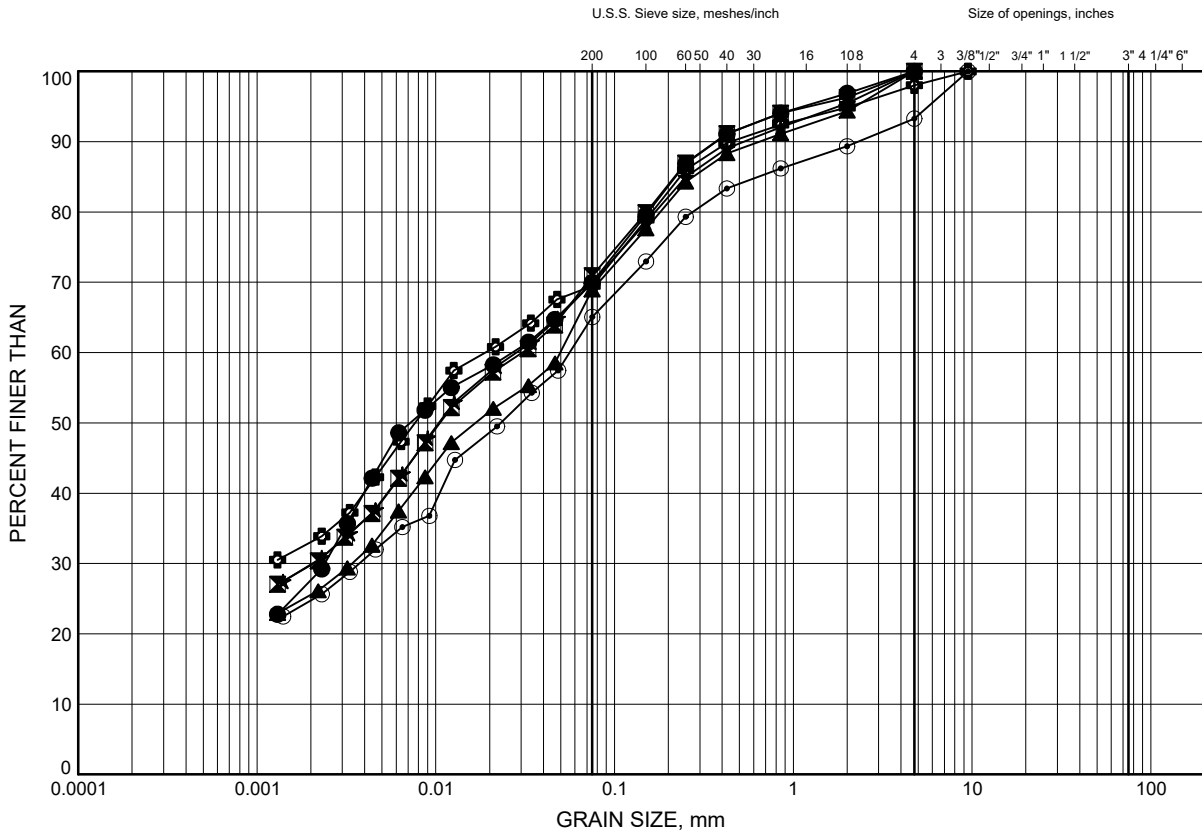


Prep'd .....AN.....  
Chkd. ....KS.....

# Dilke Creek GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy, Silty CLAY TILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-42	7.92	324.08
⊠	16-42	10.97	321.03
▲	16-43	9.45	323.85
★	16-43	14.02	319.28
⊙	16-44	6.40	326.90
⊕	16-44	10.97	322.33

Date ..October 2016.....  
W.P. ..6813-14-00.....

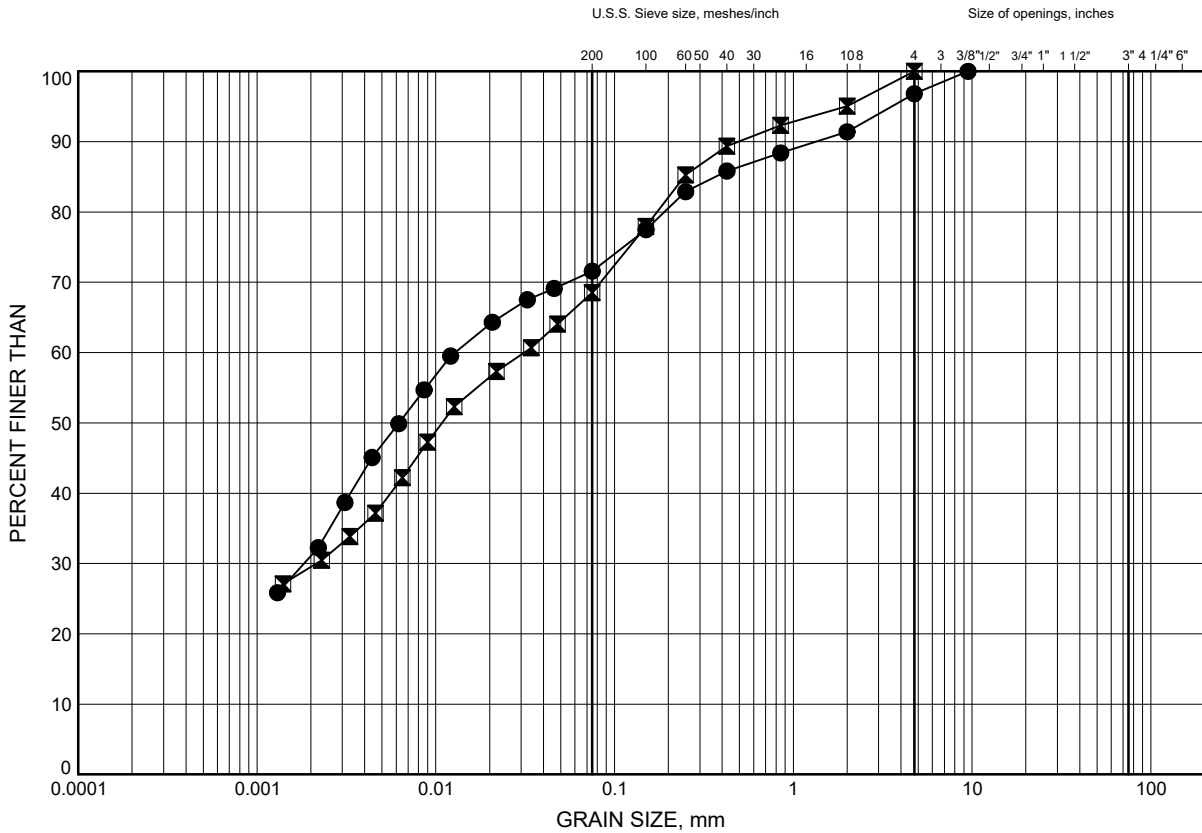


Prep'd .....AN.....  
Chkd. ....KS.....

# Dilke Creek GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy, Silty CLAY TILL



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-45	1.07	328.43
⊠	16-45	7.92	321.58

Date ..October 2016.....  
W.P. ..6813-14-00.....

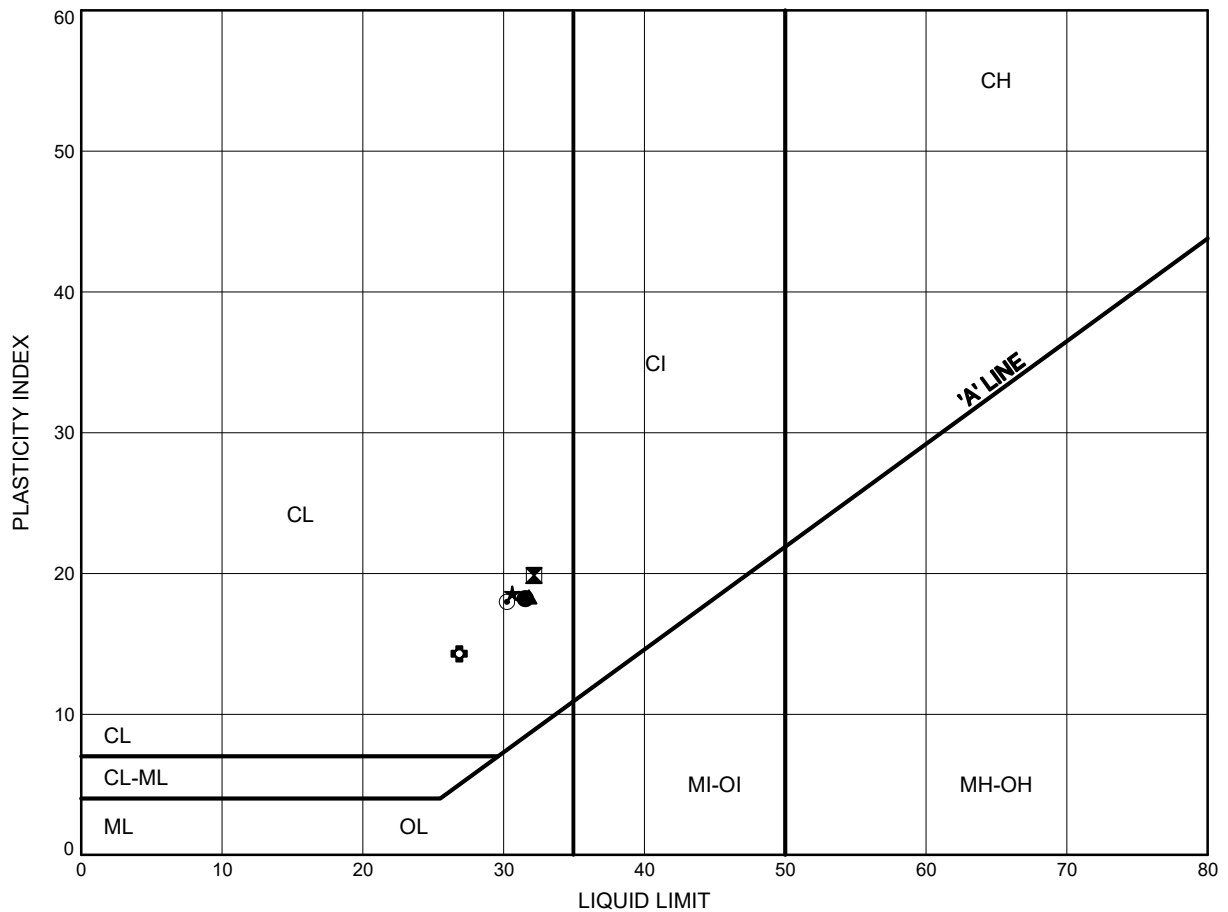


Prep'd .....AN.....  
Chkd. ....KS.....

Dilke Creek  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B5

Sandy, Silty CLAY TILL



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-42	10.97	321.03
⊠	16-43	9.45	323.85
▲	16-43	14.02	319.28
★	16-44	6.40	326.90
⊙	16-44	10.97	322.33
⊕	16-45	1.07	328.43

Date October 2016  
 W.P. 6813-14-00

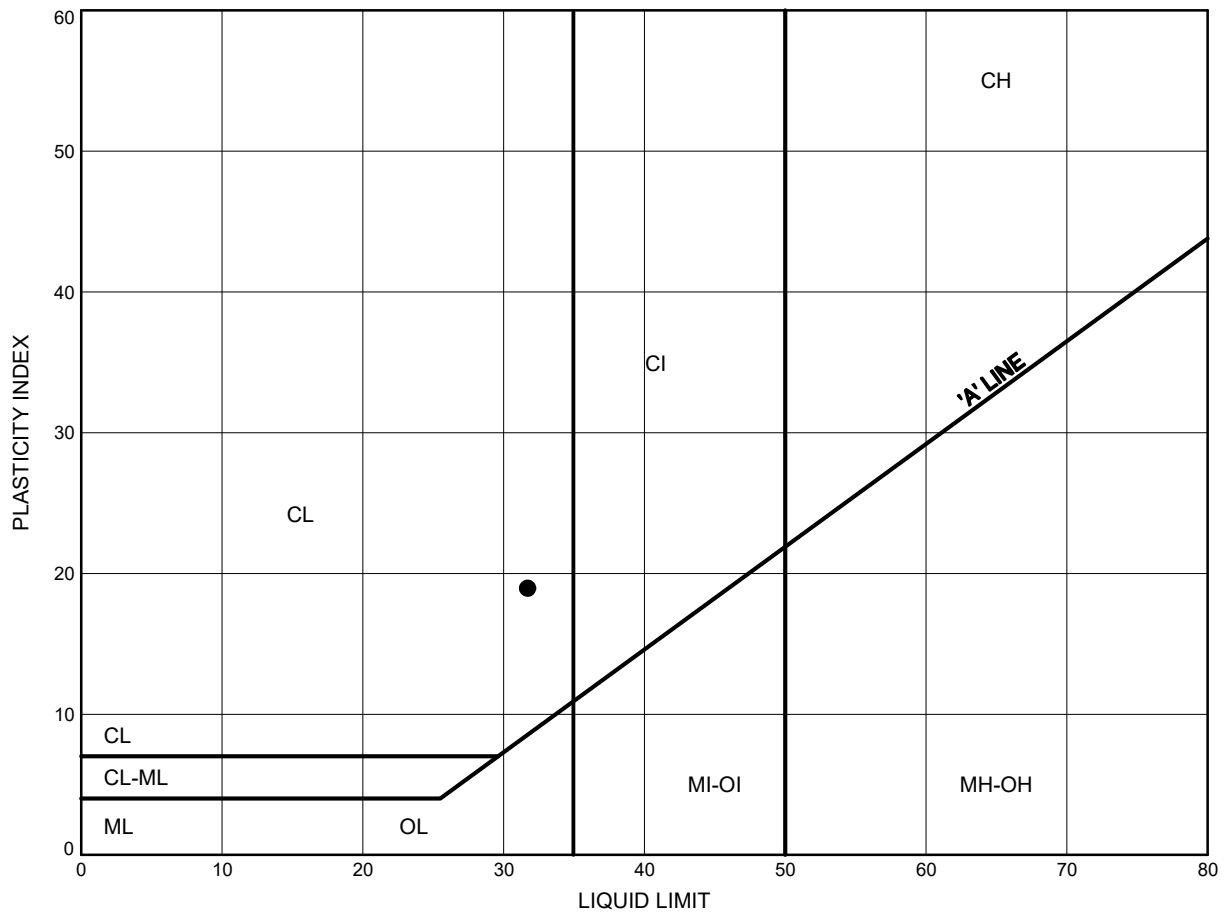


Prep'd AN  
 Chkd. KS

# Dilke Creek ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Sandy, Silty CLAY TILL



## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-45	7.92	321.58

Date ..October 2016.....  
W.P. ..6813-14-00.....



Prep'd ..AN.....  
Chkd. ....KS.....

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13983****12-September-2016****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 228  
Fax:

**Date Rec. :** 06 September 2016  
**LR Report:** CA15062-SEP16  
**Reference:** 13983 Mark Farrant

**Copy: #1**

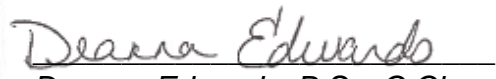
## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	7: Dilke
Sample Date & Time						21-Aug-16
Temperature Upon Receipt [°C]	---	---	--	--	---	23.0
Corrosivity Index [none]	12-Sep-16	17:18	12-Sep-16	17:18		4
pH [no unit]	07-Sep-16	06:39	07-Sep-16	15:48	0.05	7.58
Conductivity [µS/cm]	07-Sep-16	06:39	07-Sep-16	15:48	2	1360
Resistivity (calculated) [MOhms.cm]	07-Sep-16	14:35	07-Sep-16	14:35	---	3630
Redox Potential [mV]	06-Sep-16	14:30	07-Sep-16	08:34	---	275
Chloride [mg/L]	08-Sep-16	09:42	12-Sep-16	13:27	0.04	180
Sulphate [mg/L]	08-Sep-16	09:42	12-Sep-16	13:27	0.04	9.4
Sulphide [mg/L]	07-Sep-16	12:00	08-Sep-16	10:41	0.006	0.74

Temperature of Samples upon receipt 23 degrees C  
Cooling Agent Present  
Custody Seal not Present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

  
**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13983**LR Report :** CA15062-SEP16

### Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential		SM 2580
Sulphide by SFA	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500



**SGS Canada Inc.**

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Lakefield - Ontario - K0L 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13983

**LR Report :** CA15062-SEP16

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD		LCS / Spike Blank			Matrix Spike / Reference Material		
							Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)
					%	Low			High	Low		High
Anions by IC - QCBatchID: DIO0089-SEP16												
Anions by IC - QCBatchID: DIO0105-SEP16												
Chloride	0.04	mg/L	<0.04		2	20	94	80	120	105	75	125
Sulphate	0.04	mg/L	<0.04		0	20	101	80	120	100	75	125
Conductivity - QCBatchID: EWL0061-SEP16												
Conductivity	2	µS/cm	< 2		0	10	98	90	110	NA		
pH - QCBatchID: EWL0061-SEP16												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0056-SEP16												
Redox Potential	no	mV	NA		2	20	100	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0038-SEP16												
Sulphide	0.006	mg/L	<0.006		ND	20	84	80	120	nv	75	125



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13983****22-September-2016****Thurber Engineering Ltd.****Attn : Mark Farrant**

103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7,

Phone: 905-829-8666 x 228  
Fax:

**Date Rec. : 16 September 2016****LR Report: CA14401-SEP16****Reference: 13983 Mark Farrant****Copy: #1**

## CERTIFICATE OF ANALYSIS

### Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	8: 16-45 SS#3 5'7'
Sample Date & Time					12-Sep-16
Temperature Upon Receipt [°C]	---	---	---	---	9.0
Corrosivity Index [none]	21-Sep-16	16:51	21-Sep-16	16:51	4
pH [no unit]	19-Sep-16	10:18	19-Sep-16	13:26	8.21
Soil Redox Potential [mV]	19-Sep-16	16:42	20-Sep-16	10:53	160
Sulphide [%]	21-Sep-16	11:12	21-Sep-16	11:40	0.07
% Moisture (wet wt) [%]	21-Sep-16	07:55	21-Sep-16	08:50	17.4
pH [no unit]	19-Sep-16	06:59	20-Sep-16	10:41	9.10
Chloride [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	23
Sulphate [µg/g]	20-Sep-16	20:39	21-Sep-16	16:30	260
Conductivity [µS/cm]	19-Sep-16	06:59	20-Sep-16	10:42	90
Resistivity (calculated) [Ohms.cm]	21-Sep-16	10:49	21-Sep-16	10:49	11100

**Deanna Edwards, B.Sc, C.Chem**  
**Project Specialist**  
**Environmental Services, Analytical**



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.  
Lakefield - Ontario - K0L 2H0  
Phone: 705-652-2000 FAX: 705-652-6365

**Project : 13983**

**LR Report : CA14401-SEP16**

Temperature of Samples upon receipt 15 degrees C  
No cooling agent present

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

Temperature of Samples upon receipt 9 degrees C  
Cooling agent present  
Custody Seal not present

**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13983**LR Report :** CA14401-SEP16

## Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1918
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500



**SGS Canada Inc.**

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

Phone: 705-652-2000 FAX: 705-652-6365

**Project :** 13983

**LR Report :** CA14401-SEP16

## Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank				LCS / Spike Blank			Matrix Spike / Reference Material		
							RPD	Acceptance Criteria	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)
						%	Low	High		Low	High	
Anions by IC - QCBatchID: DIO0260-SEP16												
Chloride	0.4	µg/g	<0.4		1	20	107	80	120	105	75	125
Sulphate	0.4	µg/g	<0.4		0	20	101	80	120	100	75	125
Carbon/Sulphur - QCBatchID: ECS0026-SEP16												
Sulphide	0.02	%	<0.02		4	20	106	80	120			
Conductivity - QCBatchID: EWL0235-SEP16												
Conductivity	2	uS/cm	< 2		ND	10				NA		
pH - QCBatchID: ARD0047-SEP16												
pH	0.05	no unit			0	20	100	80	120			



## **Appendix C**

### **Site Photographs**



**Photo 1: Dilke Creek Culvert, looking West**



**Photo 2: Dilke Creek Culvert**





**Photo 3: Dilke Creek Culvert**





**Photo 4: Dilke Creek Culvert, embankment**





**Photo 5: Dilke Creek Culvert, embankment**

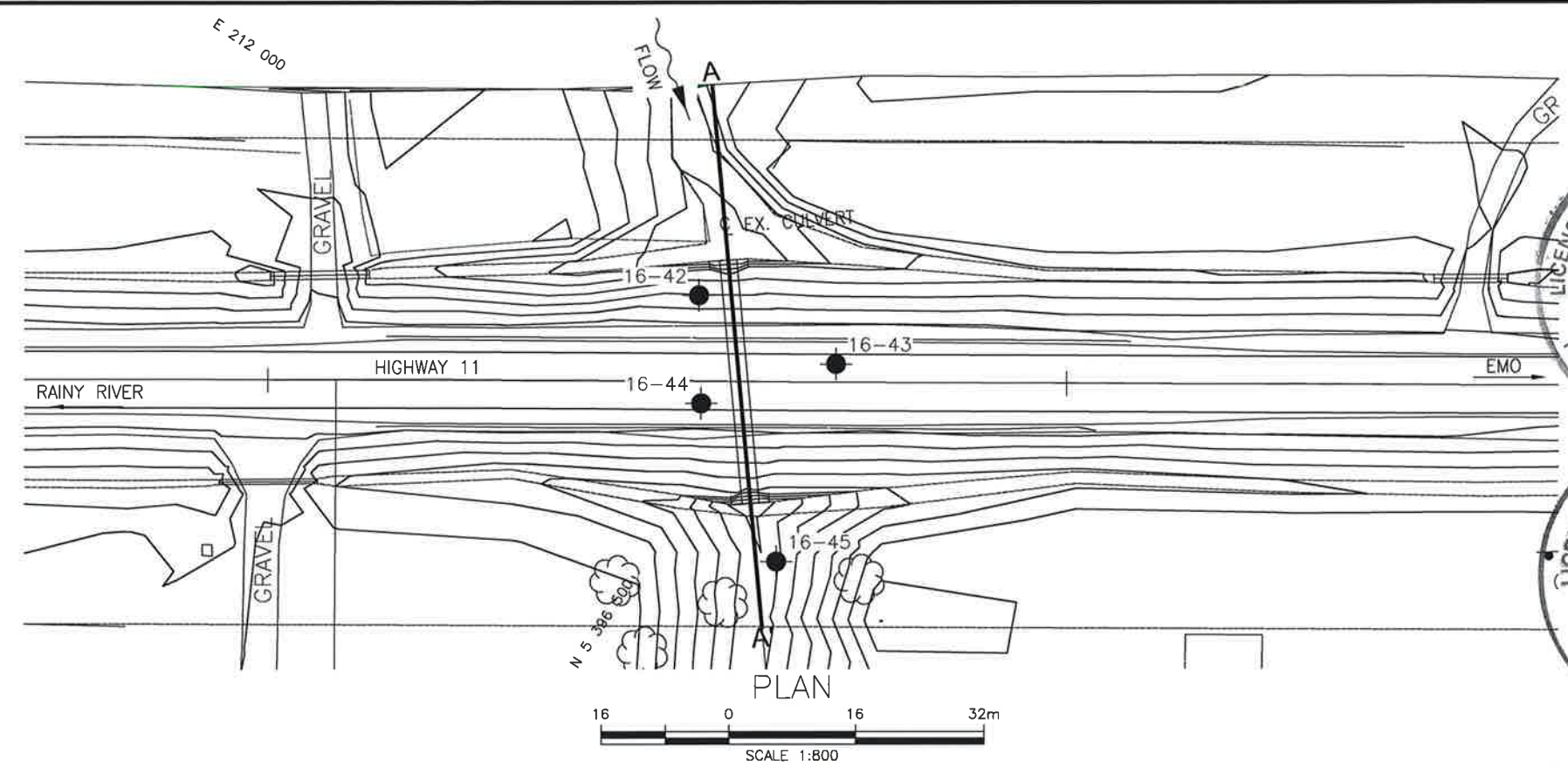


## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**



MINISTRY OF TRANSPORTATION, ONTARIO

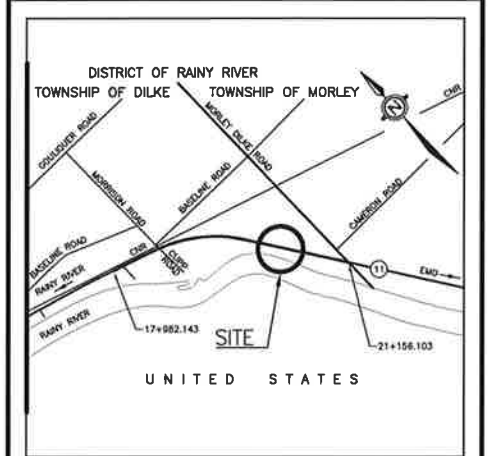


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



CONT No  
WP No 6813-14-00

HIGHWAY 11  
DILKE CREEK NO. 2  
CULVERT REPLACEMENT  
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

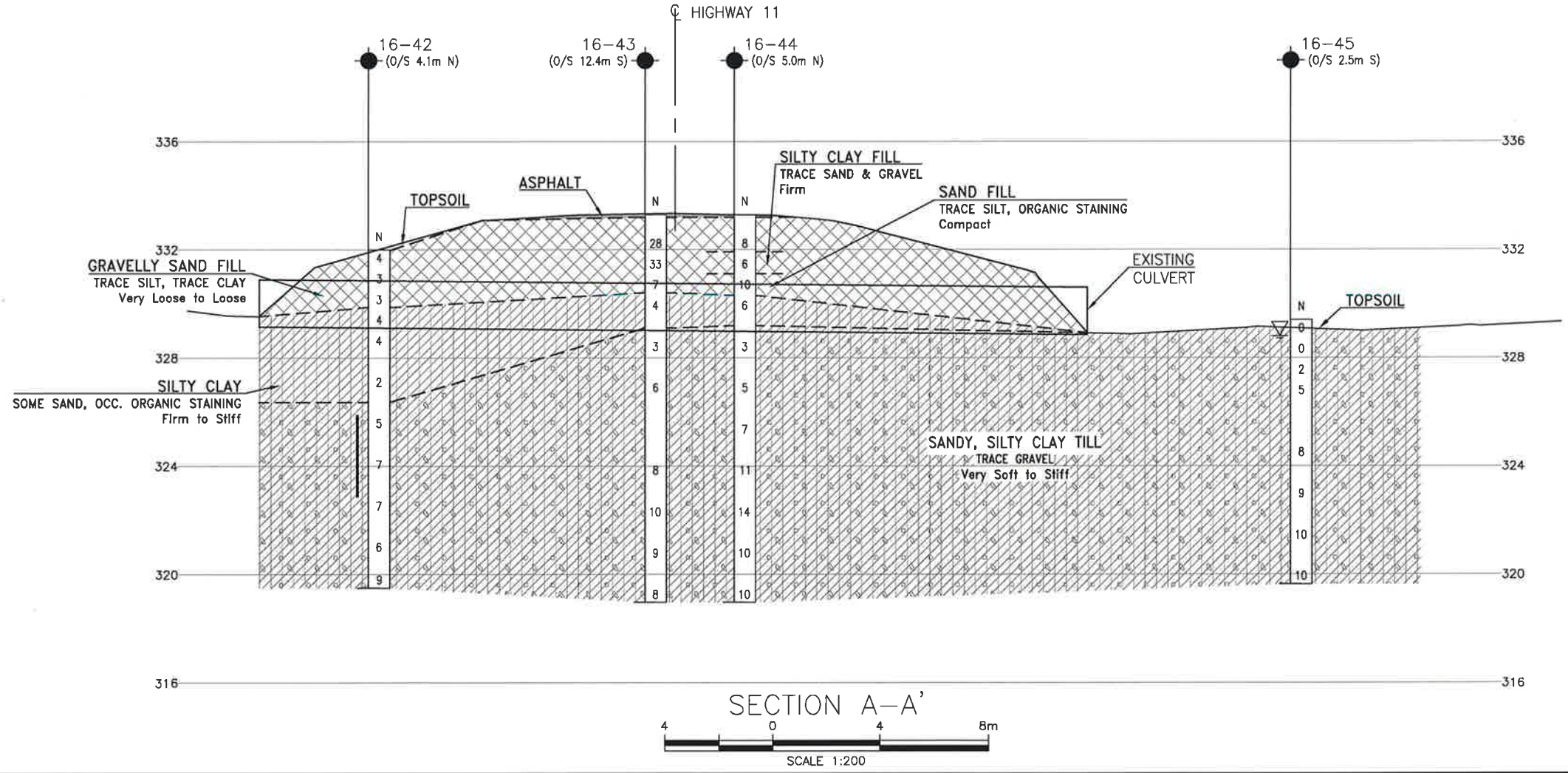
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- Borehole and Cone
- N  
Blows /0.3m (Std Pen Test, 475J/blow)
- CONE  
Blows /0.3m (60' Cone, 475J/blow)
- PH  
Pressure, Hydraulic
- W  
Water Level
- HA  
Head Artesian Water
- P  
Piezometer
- 90%  
Rock Quality Designation (RQD)
- A/R  
Auger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

NO	ELEVATION	NORTHING	EASTING
16-42	332.0	5 396 512.9	212 005.0
16-43	333.3	5 396 493.7	212 007.2
16-44	333.3	5 396 505.3	211 993.8
16-45	329.5	5 396 486.5	211 982.4

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.
- MTM Zone 16 co-ordinate system used to obtain borehole Northings and Eastings.
- Preliminary general arrangement drawing provided by Hatch in digital format.

GEOCRES No. 52D-30



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK	PKC
CODE	LOAD	DATE	FEB 2017
DRAWN	AN	CHK	MEF
SITE	STRUCT	DWG	1

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