



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
SITCH CREEK CULVERT REPLACEMENT
TOWNSHIP OF GILLIES, DISTRICT OF THUNDER BAY, ONTARIO
SITE No. 48W-124/C
HIGHWAY 595**

ASSIGNMENT NO. 6015-E-0023

**GEOCRES Number: 52A-227
W.O.# 2017-11029**

Report

to

MINISTRY OF TRANSPORTATION ONTARIO

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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 Sith Creek Culvert on Highway 595, located in the Township of Gillies, District of Thunder Bay, Ontario.

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

Thurber was retained by the Ministry of Transportation Ontario (MTO) to carry out this foundation investigation under the MTO Retainer Assignment Number 6015-E-0023.

2. SITE DESCRIPTION

The Sith Creek Culvert site is located on Highway 595, in the Township of Gillies approximately 600 m north of Highway 588, in the District of Thunder Bay, Ontario. The key plan showing the general location of the culvert site is presented on the Borehole Location and Soil Strata drawing in Appendix D.

Highway 595 runs in the general north-south direction in the area, with the culvert perpendicular to the centreline of the highway. The Sith Creek is a tributary of the Kaministiquia River and the creek flows from west to east at the culvert site.

The terrain in the culvert area is gently undulating and forested outside of the right-of-way. The existing culvert is a 4.9 m diameter Corrugated Steel Pipe (CSP) culvert approximately 35 m long. The Structural Inspection Report (SIR) prepared by McCormick Rankin, a member of MMM Group and dated January 2014 indicated that the structure is in fair condition.

The MTO Site Plan Drawing, E-1078-595-2, indicates that the existing culvert invert is at approximate Elevation 262.7 m at the inlet and Elevation 262.5 m at the outlet. The stream water level was reported to be at about Elevation 263.0 m at the upstream end and about Elevation 262.8 m at the downstream end in June 2008. At the culvert location, the highway embankment grade is at about Elevation 269.8 m. The depth of cover over the existing culvert is approximately 2.3 m.

Photographs in Appendix C show the general nature of the site and the existing culvert.

Based on published geological information, the culvert lies within a glaciolacustrine plain including deposits of silts and clays with minor sands. The bedrock at the site consists of rocks of Gunflint Formation.

3. INVESTIGATION PROCEDURES

The field investigation and testing program for this project was specified in the Terms of Reference. The field work was carried out on April 10, 11, 29 and 30, 2017 during which time four (4) boreholes designated as Boreholes 17-05 to 17-08 were advanced at the site. Boreholes 17-05 and 17-08 were advanced near the inlet and outlet of the culvert and Boreholes 17-06 and 17-07 were advanced through the highway embankment north and south of the culvert, respectively.

Utility clearances were obtained prior to the start of drilling. A rubber tire buggy mounted drill rig and a track-mounted CME 75 drill rig were used to advance the boreholes at the site using hollow stem augers.

Soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT) procedures as per ASTM D1586. Dynamic Cone Penetration Test (DCPT) was also conducted adjacent to Boreholes 17-06 and 17-07 from the ground surface to refusal and at Borehole 17-05 from a depth of about 12.8 m to refusal.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The site 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. One standpipe piezometer using 19 mm diameter PVC pipe was installed within the overburden in Borehole 17-05 to permit monitoring of the groundwater level at the site. The piezometer was

decommissioned and the borehole was backfilled on April 30, 2017. All other boreholes were backfilled on completion of drilling in general accordance with Ontario Regulation 903, as amended.

The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided by the MTO. The coordinate system MTM NAD 83, Zone 14 was used for the boreholes. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D. The borehole coordinates, ground surface elevations, drilled depths and the completion details are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Borehole Number	Coordinates (MTM NAD 83, Zone 14)		Ground Surface Elevation (m)	Termination Depth (m)	Completion Details
	Northing (m)	Easting (m)			
17-05	5,351,237.3	327,055.2	266.9	15.0	Standpipe piezometer was installed in the borehole. After removal of the piezometer the borehole was backfilled with bentonite holeplug and cuttings to ground surface.
17-06	5,351,234.2	327,064.4	269.6	18.2	Bentonite holeplug and cuttings to 0.6 m, cement to 0.1 m then asphalt cold patch to ground surface.
17-07	5,351,222.5	327,063.9	269.9	18.6	Bentonite holeplug to 1.6 m, cuttings to 0.9 m then asphalt cold patch to ground surface.
17-08	5,351,217.6	327,075.2	265.6	11.3	Bentonite holeplug to 2.4 m and cuttings to ground surface.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected soil samples were also subjected to grain size distribution analyses (sieve and/or hydrometer) and Atterberg limits test. The results of the 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, two samples of the native soil near the invert level of the culvert, and a sample of the surface water from the creek upstream were collected.

The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 of this report and are 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 subsurface conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered in the boreholes consisted of embankment fill comprising of sand fill and/or silty clay fill overlying a native silty sand to sand which extends to the borehole termination depths. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 17-06 and 17-07 were drilled through the existing asphalt pavement on Highway 595. The asphalt thickness was about 25 mm at the borehole locations. The thickness of asphalt may vary along the highway.

5.2 Fill

Fill was encountered below the asphalt in Boreholes 17-06 and 17-07 and at the ground surface in Boreholes 17-05 and 17-08. The fill extended to depths of between approximately 1.5 m and 8.1 m (base Elevation 261.8 m to 264.1 m). The fill generally consisted of sand to silty sand and/or silty clay.

5.2.1 Silty Clay Fill

Silty clay fill was encountered in Borehole 17-05 at the surface to a depth of about 0.8 m and from a depth of 2.1 m to 4.6 m; in Borehole 17-06 from a depth of 1.1 m to 1.7 m and from a depth of

5.6 m to 7.7 m; and in Borehole 17-08 from the ground surface to a depth of 1.5 m. The base of the clay fill ranges between Elevations 264.1 m and 261.9 m.

The SPT 'N' values within the silty clay fill ranged from 2 blows to 8 blows per 0.3 m of penetration, indicating a soft to firm consistency. Moisture content in the silty clay fill ranged from 23% to 38%.

The results of grain size analyses and Atterberg Limit testing conducted on selected samples of the silty clay fill are presented on the Record of Borehole sheets included in Appendix A, and on Figure B1 and B2 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	0 to 2
Sand	29 to 44
Silt	38 to 46
Clay	18 and 23
Measured Limit	Percentage (%)
Liquid Limit	35 and 39
Plastic Limit	22

The results of the Atterberg Limits testing indicate that the silty clay fill has a low to intermediate plasticity with group symbol CL to CI.

5.2.2 Sand Fill

Sand fill with varying quantities of silt and gravel was encountered in Borehole 17-05 from a depth of 0.8 m to 2.1 m; in Borehole 17-06 from beneath the asphalt to 1.1 m and from 1.7 m to 5.6 m; and in Borehole 17-07 from beneath the asphalt to 8.1 m below road surface. The base of the sand fill ranges between Elevations 261.8 m and 264.8 m.

SPT 'N' values within the sand fill ranged from 4 blows to 50 blows per 0.3 m of penetration, indicating a loose to dense relative density, predominantly loose to compact. Moisture contents in the sand fill ranged from 7% to 22%.

The results of grain size analysis on selected samples of the sand fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	6 to 29
Sand	51 to 76
Silt and Clay	18 to 32

5.3 Silty Sand to Sand

A deposit of grey to dark grey silty sand to sand was encountered below the fill in all boreholes and extended to the borehole termination depths of 11.3 m to 18.6 m (Elevation 254.3 m to 251.3 m). The deposit was loose to dense, predominantly compact, as indicated by SPT 'N' values ranging between 7 blows and 42 blows per 0.3 m of penetration. The measured moisture content of the silty sand to sand ranged between 8% and 28%.

The results of grain size analysis on selected samples of the silty sand to sand deposit are presented on the Record of Borehole sheets included in Appendix A and on Figure B4 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	0 to 13
Sand	67 to 95
Silt	4 to 29
Clay Size Fines	1 to 4

Approximately 1.0 m to 1.9 m thick interlayer of silt containing some sand was encountered above or within the silty sand to sand deposit in Boreholes 17-07 and 17-08 at depths of 8.1 m and 2.2 m (Elevations 261.8 m and 263.4 m), respectively. SPT 'N' values within the silt layer were 1 blow and 3 blows per 0.3 m of penetration indicating a very loose material. The results of grain size analysis on two selected samples of the silt are presented on the Record of Borehole sheet included in Appendix A and on Figure B5 in Appendix B.

The results are summarized in the following table:

Soil Particle	Percentage (%)
Gravel	0
Sand	16 and 23
Silt	72 and 77
Clay Size Fines	5 and 7

5.4 Auger Refusal

Auger refusal on probable bedrock or boulders was inferred in Boreholes 17-06 and 17-07 at depths of about 18.2 m and 18.6 m (Elevations 251.4 m and 251.3 m), respectively. The DCPT penetration was refused adjacent to these boreholes at the same depths.

5.5 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A standpipe piezometer was installed in Borehole 17-05 on April 29, 2017 and a groundwater level reading was taken in the piezometer on April 30, 2017. The groundwater levels measured in the open boreholes and in the piezometer are summarized in Table 5.1 below.

Table 5.1 – Groundwater Measurements

Borehole	Date	Piezometer Installation		Water Level (m)		Remark
		Screen Depth / Elevation (m)	Screened Deposit	Depth	Elevation	
17-05	April 30, 2017	9.1 to 12.2 / 275.8 to 254.7	Sand	5.9	261.0	Piezometer
17-06	April 11, 2017	No Piezometer in the Borehole		5.6	264.0	Open borehole
17-07	April 10, 2017	No Piezometer in the Borehole		6.3	263.6	Open borehole
17-08	April 30, 2017	No Piezometer in the Borehole		2.9	262.7	Open borehole

The groundwater level should be assumed to reflect the local creek water level. Water level measurements in the creek were reported on the MTO Site Plan Drawing, E-1078-595-2, which

reported measurements of Elevation 263.0 m at the inlet and 262.8 m at the outlet in June 2008. 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

Three samples of the native and fill soils from Boreholes 17-06, 17-07, and 17-08 and a sample of the surface water from the creek were submitted for analytical testing of corrosivity parameters and sulphate content. 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			
			17-06, SS#7, 7.7 m – 8.2 m	17-07, SS#7, 7.6 m – 8.1 m	17-08, SS#6, 6.1 m – 6.7 m	Sitch Creek
			(Sand)	(Sand Fill)	(Sand)	(Creek Water)
Sulphide	%	mg/L	0.51	0.39	0.53	<0.006
Chloride	µg/g	mg/L	15	59	5.9	2.3
Sulphate	µg/g	mg/L	200	200	68	3.6
pH	No unit	No unit	8.51	8.47	8.22	7.39
Electrical Conductivity	µS/cm	µS/cm	173	200	92	89
Resistivity	Ohms.cm	Ohms.cm	5,780	5,000	10,900	11,200
Redox Potential	mV	mV	272	256	152	142

7. MISCELLANEOUS

Thurber obtained the coordinates and ground surface elevations of the boreholes from measurements taken in the field and relative to the topographic plans provided by the MTO.

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. Amir Fereidouni and Ms. Eckie Siu of Thurber. Overall supervision of the field program was provided by Mr. Cory Zanatta, B.A.Sc. of Thurber.

Geotechnical laboratory testing was carried out at 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 Mr. Mehdi Mostakhdemi, 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 ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

RECORD OF BOREHOLE No 17-05

1 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 237.3 E 327 055.2 ORIGINATED BY AHF
 HWY 595 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.04.29 - 2017.04.29 CHECKED BY CZ

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 ³	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											w _P w w _L		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE													
266.9	GROUND SURFACE																				
0.0	Silty CLAY , trace sand, trace gravel, organics Dark Brown Wet (FILL)		1	GS																	
266.1																					
0.8	SAND , some silt, trace to some gravel Loose Brown Moist (FILL)		1	SS	5		266										6	76 13 5			
			2	SS	4		265														
264.8																					
2.1	Silty CLAY , sandy to trace sand, trace gravel Soft Brown Wet (FILL)		3	SS	4		264										2	29 46 23			
			4	SS	2		263														
262.3																					
4.6	Silty SAND , trace gravel Compact Dark Grey Wet		5	SS	13		262														
							261														
			6	SS	15		260														
259.7																					
7.2	SAND , trace to some silt Compact Dark Grey Wet		7	SS	29		259														
							258														
			8	SS	28		257										0	95 4 1			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-05

2 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 237.3 E 327 055.2 ORIGINATED BY AHF
 HWY 595 BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test COMPILED BY AN
 DATUM Geodetic DATE 2017.04.29 - 2017.04.29 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	Continued From Previous Page															
			9	SS	29		256									
							255									
			10	SS	42											
254.1 12.8	End of sampling and start of DCPT						254									
							253									
251.9 15.0	END OF BOREHOLE AT 15.0m UPON DCPT REFUSAL. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.04.30 5.9 261.0						252									

ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/1/17

RECORD OF BOREHOLE No 17-06

1 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 234.2 E 327 064.4 ORIGINATED BY ES
 HWY 595 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 0217.04.11 - 2017.04.11 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
269.6	GROUND SURFACE							20 40 60 80 100						
0.0	ASPHALT: (25mm)							20 40 60 80 100						
	SAND, trace gravel Dense Brown Moist (FILL)		1	GS			269			○				
268.5			1	SS	39					○				
1.1	Silty CLAY, trace sand, trace gravel Compact Brown Moist (FILL)						268			○				
267.9			2	SS	17					○				10 58 25 7
1.7	Silty SAND, trace to some gravel, trace clay Compact to Loose Brown Moist (FILL)		3	SS	16		267			○				
			4	SS	17		266			○				
							265			○				
264.0			5	SS	6					○				
5.6	Silty CLAY, with sand Soft Brown Moist (FILL)		6	SS	3		264							0 37 40 23
							263							
261.9							262			○				
7.7	SAND, fine grained, silty to some silt, trace gravel Compact to Dense Dark Grey Moist to Wet		7	SS	26		261							
			8	SS	19		260			○				0 67 29 4

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-06

2 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 234.2 E 327 064.4 ORIGINATED BY ES
 HWY 595 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 0217.04.11 - 2017.04.11 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL LIQUID MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W P W W L							
								SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
	Continued From Previous Page															
			9	SS	7		259									
							258									
			10	SS	12		257									
							256									
			11	SS	22		255									
							254									
			12	SS	31		253									
							252									
251.4			13	SS	25											
18.2	END OF BOREHOLE AT 18.2m UPON AUGER REFUSAL. WATER LEVEL AT 5.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CEMENT TO 0.1m, THEN ASPHALT TO SURFACE.															

ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/1/17

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-07

2 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 222.5 E 327 063.9 ORIGINATED BY ES
 HWY 595 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED + FIELD VANE	○ QUICK TRIAXIAL × LAB VANE							
	Continued From Previous Page							20 40 60 80 100	20 40 60							
	SAND , fine grained Compact to Dense Dark Grey Wet															
			9	SS	28		259								0 88 9 3	
							258									
					10	SS	17									
								257								
					11	SS	38									
								256								
						255										
			12	SS	37											
						254										
						253										
						252										
251.3			14	SS	100/ 0.175											
18.6	END OF BOREHOLE AT 18.6m UPON AUGER REFUSAL. WATER LEVEL AT 6.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.6m, CUTTINGS TO 0.9m, CEMENT TO 0.1m, THEN ASPHALT TO SURFACE.															






ONTMT4S MTO-17840.GPJ 2015TEMPLATE(MTO).GDT 6/1/17

RECORD OF BOREHOLE No 17-08

1 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 217.6 E 327 075.2 ORIGINATED BY AHF
 HWY 595 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.04.30 - 2017.04.30 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
20 40 60 80 100														
○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE														
20 40 60 80 100				WATER CONTENT (%) w P w w L										
265.6	GROUND SURFACE													
0.0	Silty CLAY , with sand, trace gravel, roots and rootlets Firm Brown Wet (FILL)		1	GS										
			1	SS	8									0 44 38 18
264.1														
1.5	Silty SAND , some gravel, trace clay Loose Brown Wet		2	SS	8									
263.4														
2.2	SILT , some sand Very Loose Grey Wet		3	SS	1									0 16 77 7
			4	SS	3									
261.5														
4.1	SAND , some silt to silty Compact Dark Grey Wet		5	SS	12									
			6	SS	15									
			7	SS	17									
			8	SS	20									2 79 17 2

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-08

2 OF 2

METRIC

W.P. _____ LOCATION Sitch Creek N 5 351 217.6 E 327 075.2 ORIGINATED BY AHF
 HWY 595 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.04.30 - 2017.04.30 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
254.3			9	SS	33		255										
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 2.9m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 2.4m AND CUTTINGS TO SURFACE.																



Appendix B

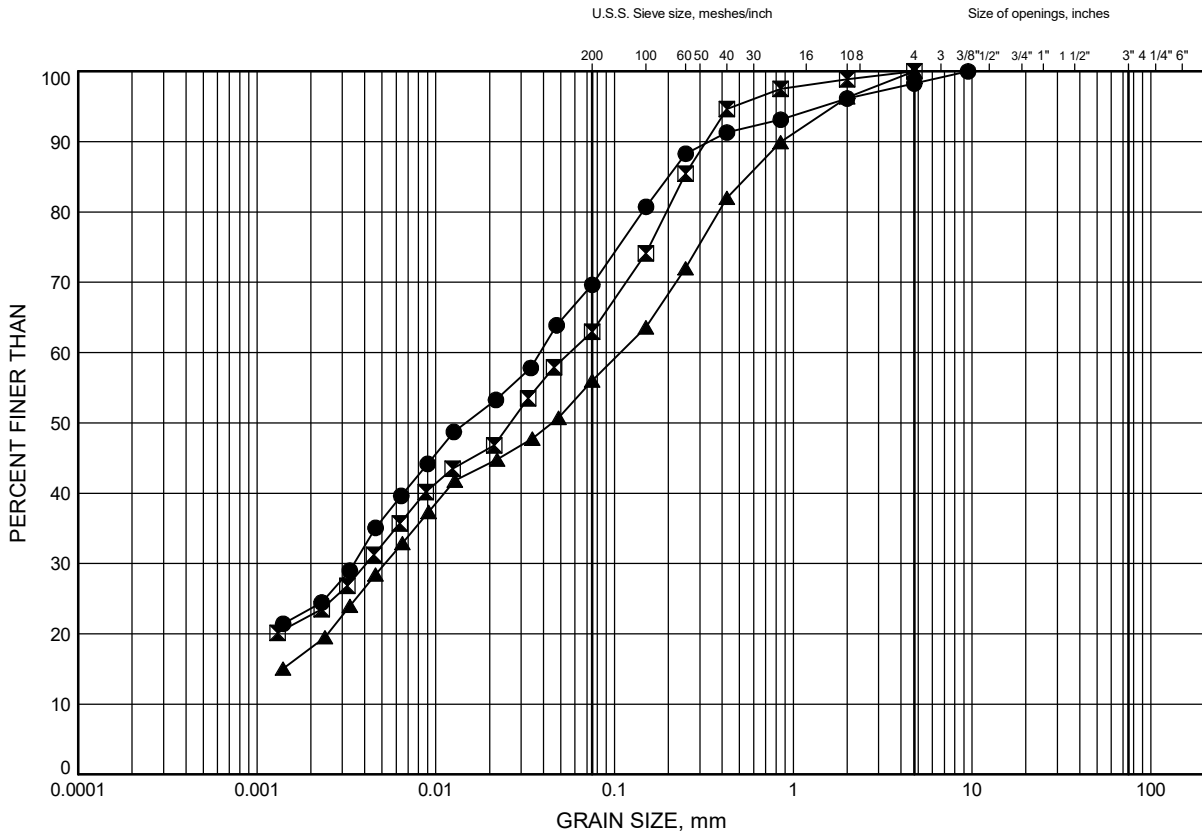
Geotechnical and Analytical Laboratory Test Results

Sitch Creek - Highway 595

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty Clay Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	2.6	264.3
⊠	17-06	6.4	263.2
▲	17-08	1.1	264.5

Date June 2017
W.P. _____

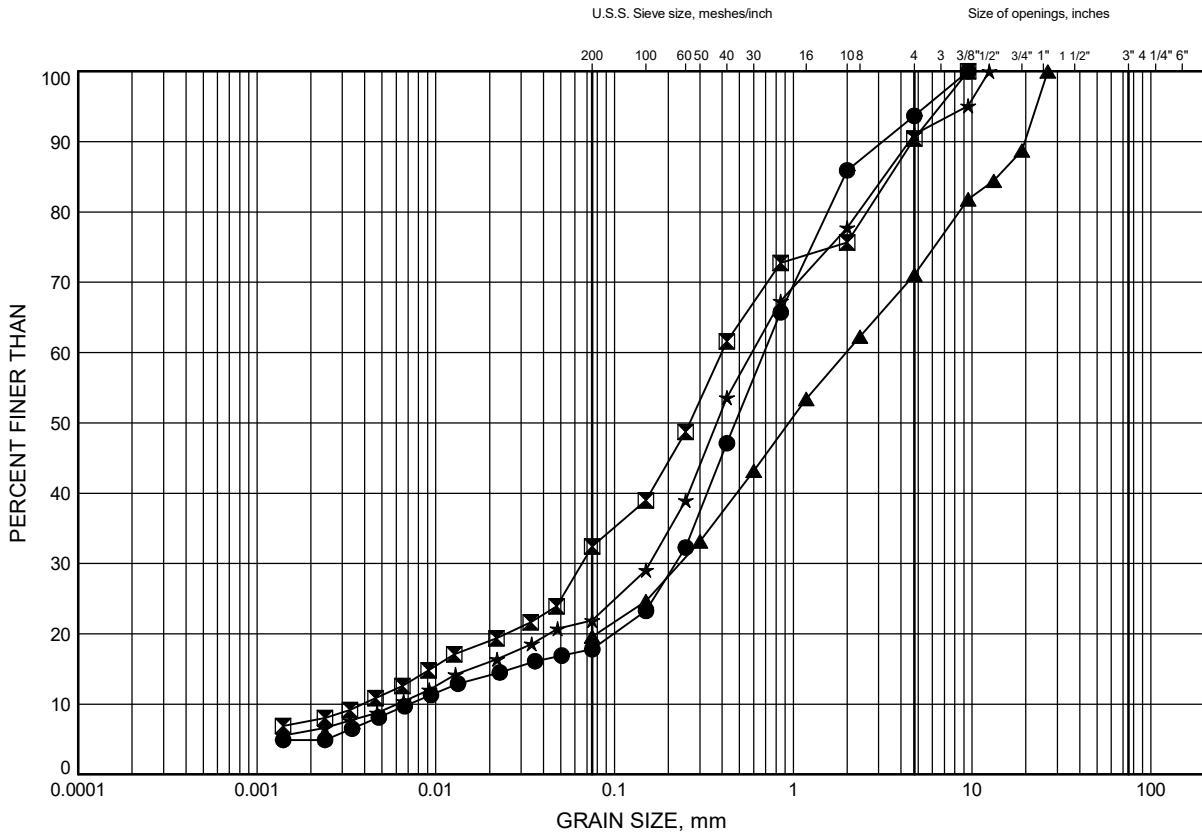


Prep'd MFA
Chkd. CZ

Sitch Creek - Highway 595 GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	1.1	265.8
⊠	17-06	1.8	267.8
▲	17-07	1.8	268.1
★	17-07	6.4	263.5

Date June 2017
W.P. _____



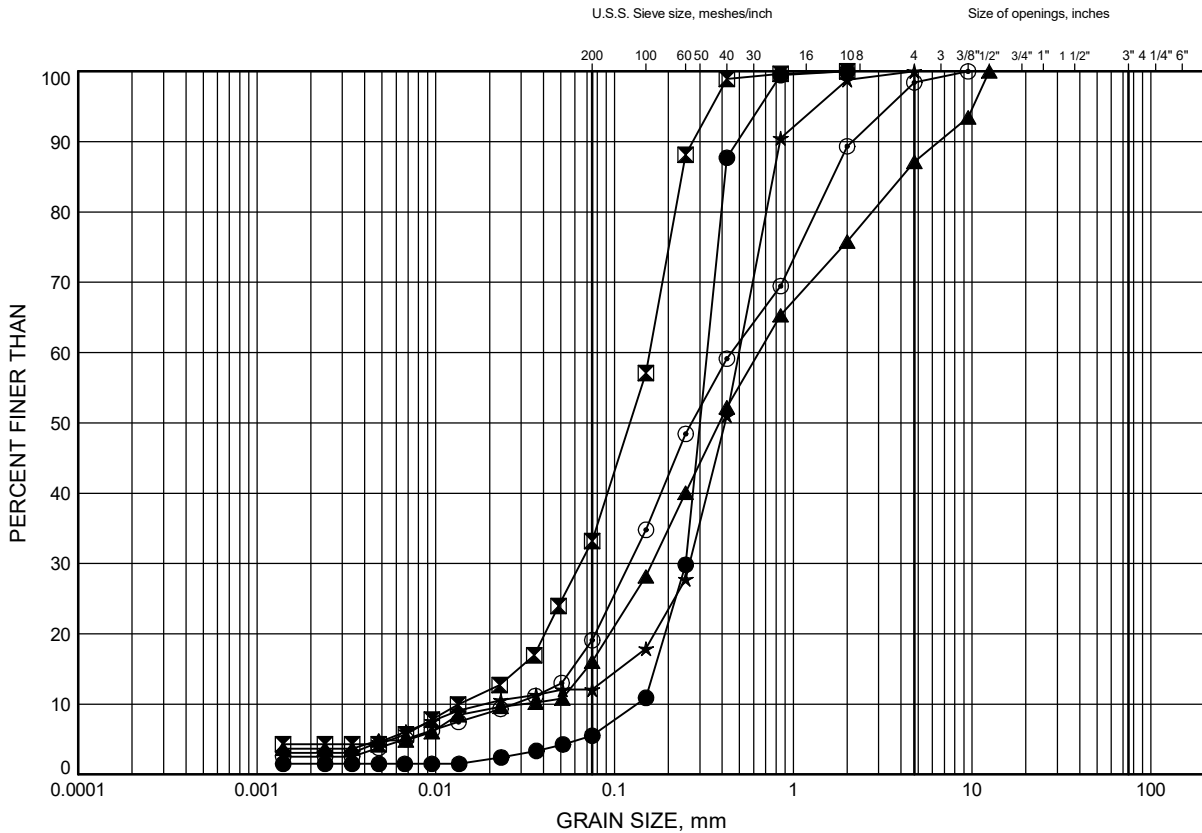
Prep'd MFA
Chkd. CZ

Sitch Creek - Highway 595

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Sand to Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	9.4	257.5
⊠	17-06	9.4	260.2
▲	17-06	15.5	254.1
★	17-07	11.0	258.9
⊙	17-08	9.4	256.2

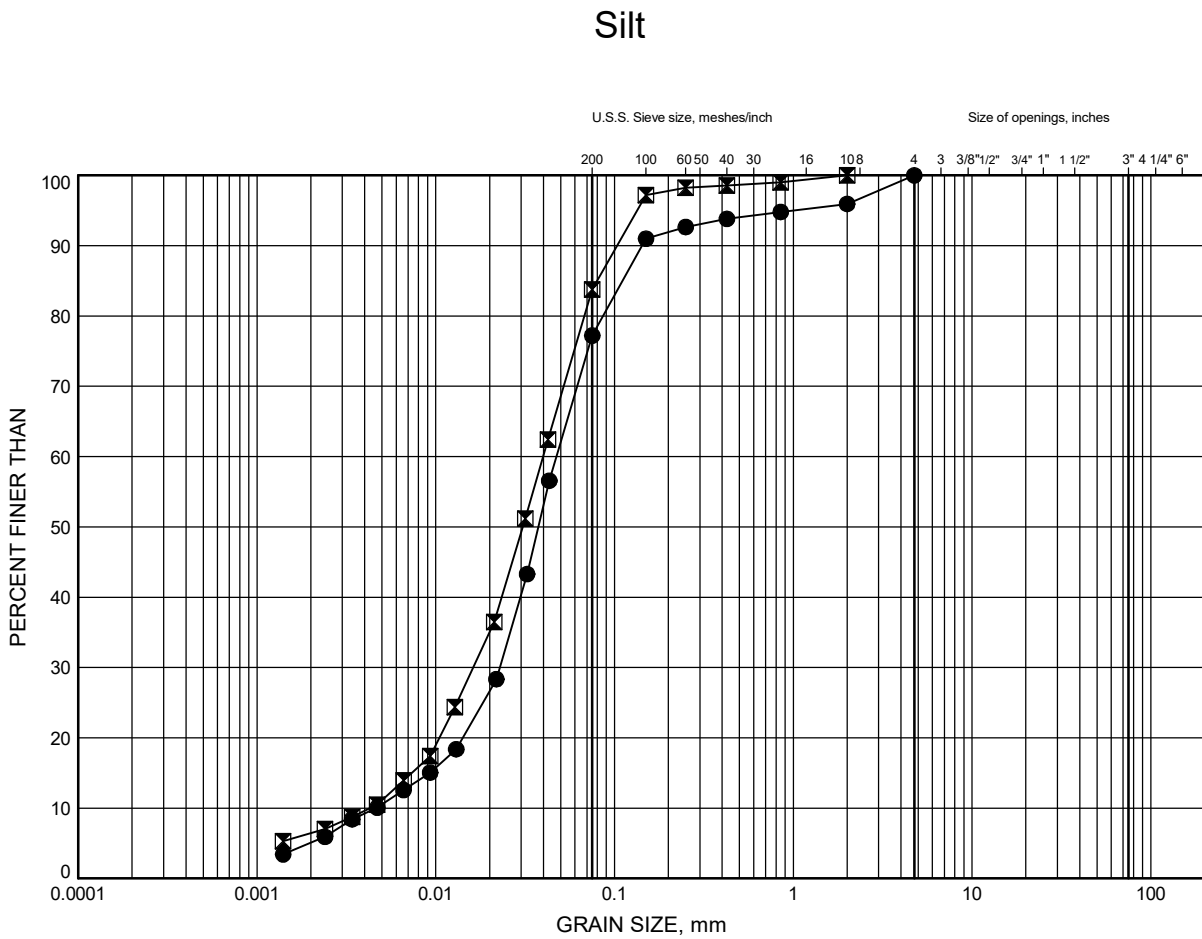
Date June 2017
W.P.



Prep'd MFA
Chkd. CZ

Sitch Creek - Highway 595 GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-07	7.9	262.0
⊠	17-08	2.6	263.0

Date June 2017
W.P.



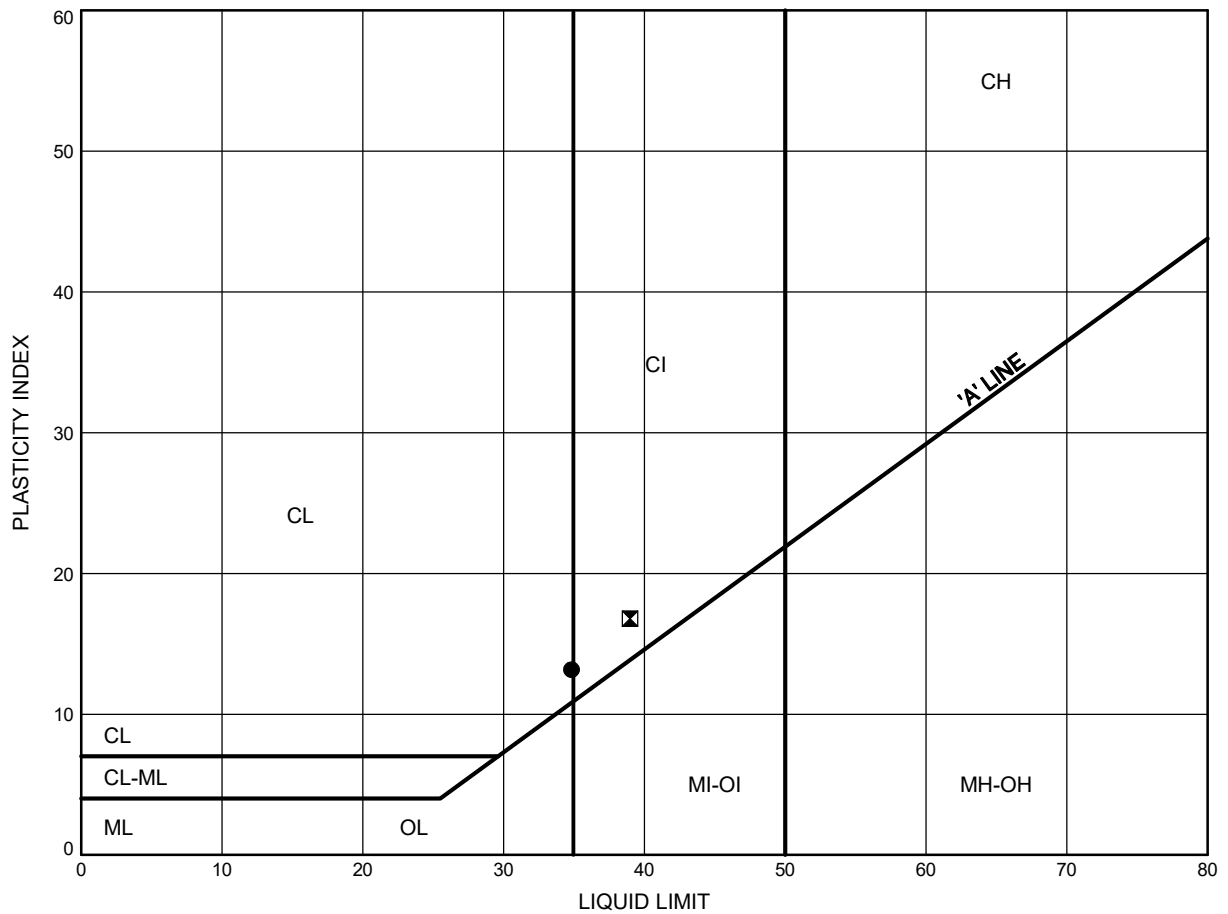
Prep'd MFA
Chkd. CZ

Sitch Creek - Highway 595

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	2.6	264.3
⊠	17-06	6.4	263.2

Date June 2017
W.P.



Prep'd MFA
Chkd. CZ

**SGS Canada Inc.**

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

Project : 17840**Thurber Engineering Ltd.****Attn : Mark Farrant**

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

Phone: 905-829-8666 x 228
Fax:

19-April-2017

Date Rec. : 13 April 2017
LR Report: CA13586-APR17
Reference: 17840 Mark Farrant

Copy: #1

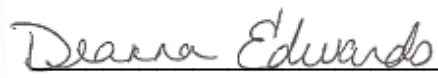
CERTIFICATE OF ANALYSIS

Final Report

Analysis	1: Analysis Start Date	2: Analysis Start Time	3: Analysis Approval Date	4: Analysis Approval Time	5: MDL	6: Sitch Creek Culvert Hwy 595
Sample Date & Time						11-Apr-17 16:00
Temperature Upon Receipt [°C]					---	11.0
pH [no unit]	17-Apr-17	13:30	18-Apr-17	08:37	0.05	7.39
Conductivity [uS/cm]	17-Apr-17	13:30	18-Apr-17	08:37	2	89
Resistivity (calculated) [ohms.cm]	19-Apr-17	15:07	19-Apr-17	15:07	---	11200
Redox Potential [mV]	13-Apr-17	13:28	17-Apr-17	12:58	---	142
Chloride [mg/L]	18-Apr-17	06:49	19-Apr-17	14:39	0.04	2.3
Sulphate [mg/L]	18-Apr-17	06:49	19-Apr-17	14:39	0.04	3.6
Sulphide [mg/L]	18-Apr-17	11:00	18-Apr-17	15:43	0.006	< 0.006

Temperature of Sample upon Receipt: 11 degrees C
Cooling Agent Present: Yes
Custody Seal Present and Intact: Yes

Sample Sitch Creek Hwy 595 contains visible sediment


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

**SGS Canada Inc.**

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

Project : 17840**LR Report : CA13586-APR17**

Method Descriptions

Parameter	Units	SGS Method Code	Reference Method Code
Anions by IC	mg/L	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Conductivity	uS/cm	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
pH	no unit	ME-CA-[ENV]EWL-LAK-AN-006	SM 4500
Redox Potential	mV		SM 2580
Sulphide by SFA	mg/L	ME-CA-[ENV]SFA-LAK-AN-008	SM 4500



SGS Canada Inc.

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Lakefield - Ontario - KOL 2H0

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

Project : 17840

LR Report : CA13586-APR17

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 (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0184-APR17												
Chloride	0.04	mg/L	<0.04		8	20	98	80	120	98	75	125
Sulphate	0.04	mg/L	<0.04		10	20	97	80	120	89	75	125
Conductivity - QCBatchID: EWL0199-APR17												
Conductivity	2	uS/cm	< 2		0	10	100	90	110	NA		
pH - QCBatchID: EWL0199-APR17												
pH	0.05	no unit	NA		0		100			NA		
Redox Potential - QCBatchID: EWL0181-APR17												
Redox Potential	no	mV	NA		1	20	104	80	120	NA		
Sulphide by SFA - QCBatchID: SKA0124-APR17												
Sulphide	0.006	mg/L	<0.006		ND	20	85	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

Thurber Engineering Ltd

Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240

Fax:

Project : 17742/17840

24-May-2017

Date Rec. : 17 May 2017

LR Report: CA14528-MAY17

Reference: 17742/17840 Cory Zanatta

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: 17840 17-09 SS9	6: 17840 17-08 SS6	7: 17840 17-06 SS7	8: 17840 17-03 SS5
Sample Date & Time					15-May-17	15-May-17	15-May-17	15-May-17
Temperature Upon Receipt [°C]	---	---	---	---	10.0	10.0	10.0	10.0
Corrosivity Index [none]	24-May-17	13:45	24-May-17	13:45	7.5	4.5	7.5	4.0
Soil Redox Potential [mV]	18-May-17	19:36	19-May-17	14:01	139	152	272	237
Sulphide [%]	23-May-17	12:52	23-May-17	13:09	0.67	0.53	0.51	< 0.02
% Moisture (wet wt) [%]	23-May-17	10:42	23-May-17	10:44	19.3	19.8	9.9	17.9
pH [no unit]	19-May-17	14:44	24-May-17	13:14	8.73	8.22	8.51	8.55
Chloride [µg/g]	19-May-17	12:04	23-May-17	11:42	16	5.9	15	25
Sulphate [µg/g]	19-May-17	12:04	23-May-17	11:42	54	68	200	61
Conductivity [uS/cm]	19-May-17	14:44	24-May-17	13:14	76	92	173	109
Resistivity (calculated) [Ohms.cm]	19-May-17	14:44	24-May-17	13:14	13200	10900	5780	9170



SGS Canada Inc.

P.O. Box 4300 - 185 Concession St.

Lakefield - Ontario - KOL 2H0

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

Project : 17742/17840

LR Report : CA14528-MAY17

Analysis	9: 17840 17-02 SS6	10: 17840 17-07 SS7	11: 17792 17-03 SS3	12: 17792 17-02 SS4
Sample Date & Time	15-May-17	15-May-17	15-May-17	15-May-17
Temperature Upon Receipt [°C]	10.0	10.0	10.0	10.0
Corrosivity Index [none]	7.5	7.5	2.0	1.0
Soil Redox Potential [mV]	200	256	278	315
Sulphide [%]	0.05	0.39	< 0.02	< 0.02
% Moisture (wet wt) [%]	18.9	14.1	20.1	10.9
pH [no unit]	8.68	8.47	7.40	6.03
Chloride [µg/g]	55	59	260	66
Sulphate [µg/g]	110	200	8.3	32
Conductivity [uS/cm]	157	200	384	150
Resistivity (calculated) [Ohms.cm]	6370	5000	2600	6670

Temperature of Sample upon Receipt: 10 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

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 : 17742/17840

LR Report : CA14528-MAY17

Method Descriptions

Parameter	SGS Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006
Metals Prep	ME-CA-[ENV]ARD-LAK-AN-013
pH	ME-CA-[ENV]EWL-LAK-AN-001



SGS Canada Inc.

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Lakefield - Ontario - KOL 2H0

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

Project : 17742/17840

LR Report : CA14528-MAY17

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	
Anions by IC - QCBatchID: DIO0347-MAY17												
Chloride	0.4	µg/g	<0.4		12	20	97	80	120	97	75	125
Sulphate	0.4	µg/g	<0.4		5	20	97	80	120	86	75	125
Carbon/Sulphur - QCBatchID: ECS0026-MAY17												
Sulphide	0.02	%	<0.02		ND	20	117	80	120			
Conductivity - QCBatchID: EWL0361-MAY17												
Conductivity	2	uS/cm	< 2		0	10	96	90	110	NA		
pH - QCBatchID: EWL0361-MAY17												
pH	0.05	no unit	NA		0		100			NA		



Appendix C

Selected Site Photographs



Photograph 1 – Sitch Creek Culvert – HWY 595, West End (Inlet)

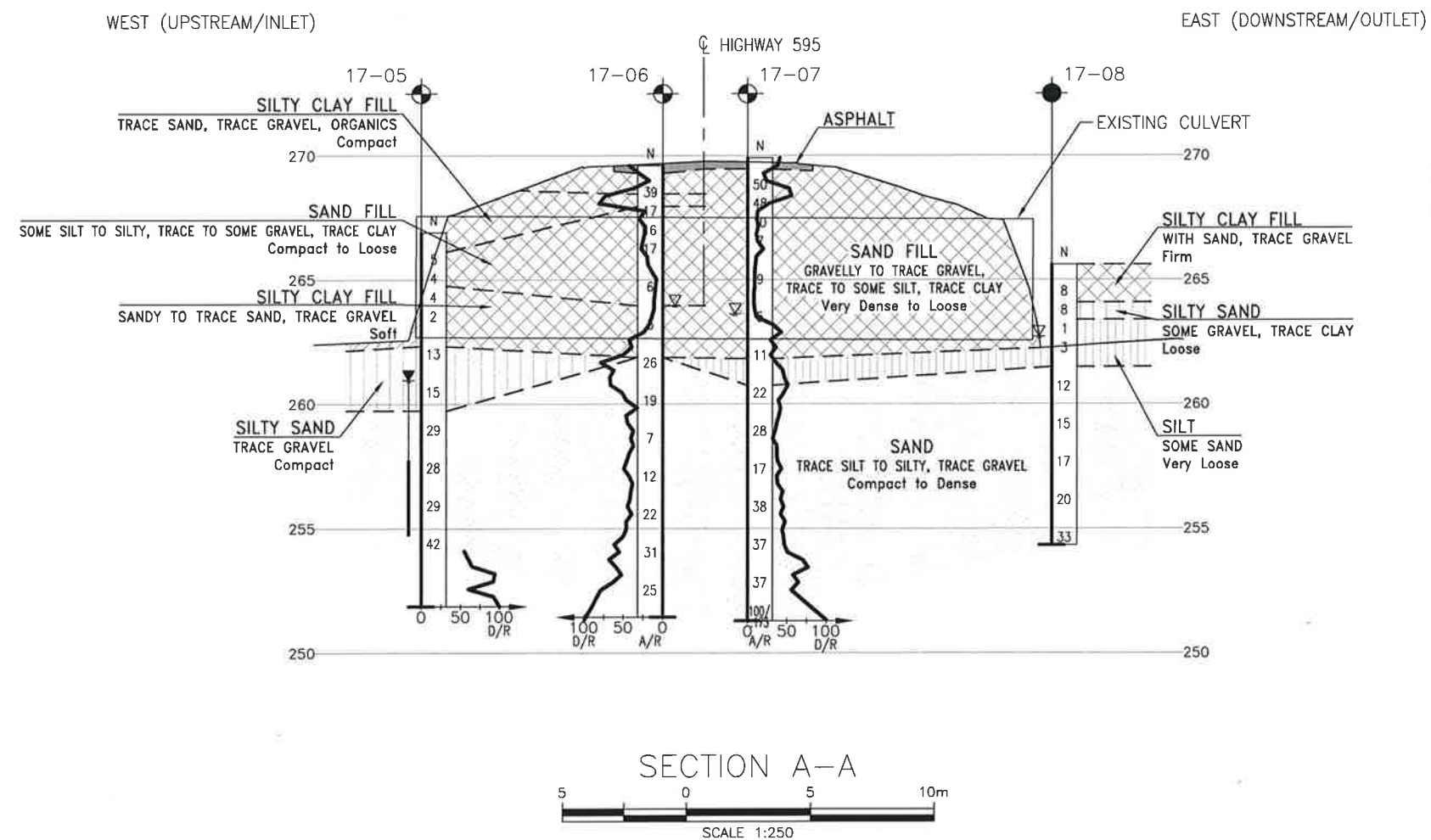
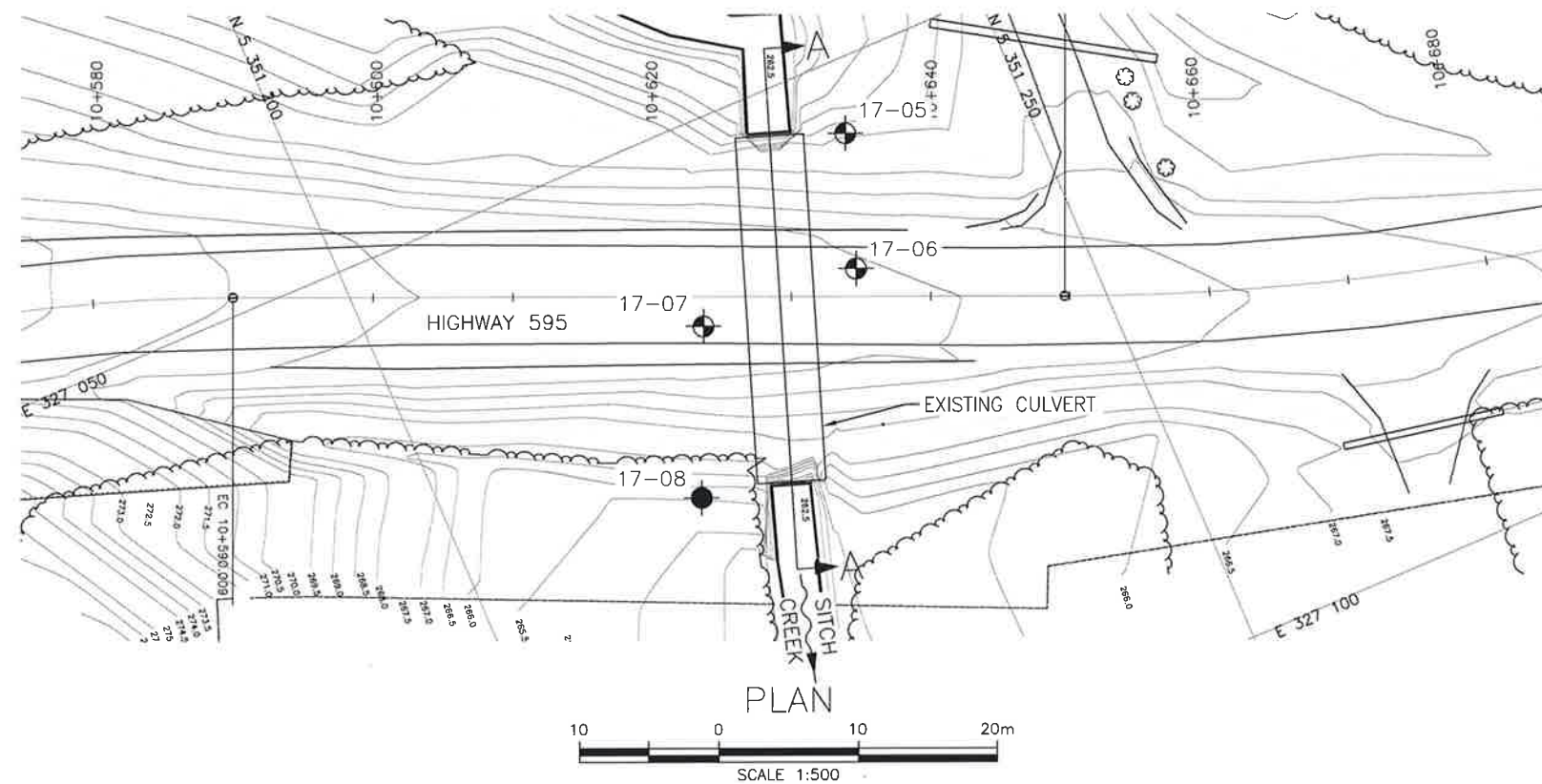


Photograph 2 – Sitch Creek Culvert – HWY 595, East End (Outlet)



Appendix D

Borehole Locations and Soil Strata Drawing



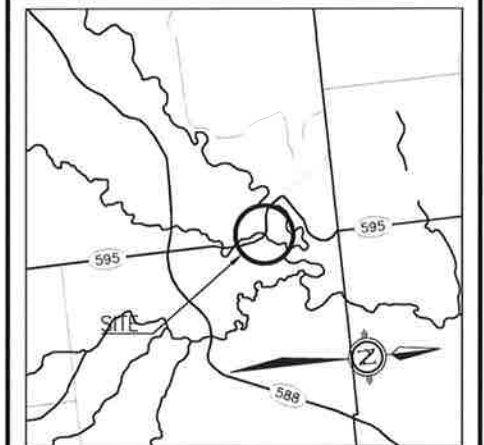
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No








HIGHWAY 595
SITCH CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

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
A/R	Auger Refusal
D/R	DCPT Refusal

[illegible]

-NOTES-

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

GEOCRES No. 52A-227

[illegible]