



THURBER ENGINEERING LTD.

**DETAILED FOUNDATION INVESTIGATION REPORT
BLACKBIRD CREEK CULVERT REPLACEMENT
HIGHWAY 17, UNSURVEYED TERRITORY
THUNDER BAY DISTRICT, ONTARIO
LATITUDE: 48.845825°, LONGITUDE: -87.037083**

G.W.P. 6808-14-00, W.P. 6808-14-01, SITE No. 48E-052C

GEOCRES Number: 42D-54

Report

to

HATCH

Date: November 12, 2018
File: 15595



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HIGHWAY 17, UNSURVEYED TERRITORY
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G.W.P. 6808-14-00, W.P. 6808-14-01, SITE No. 48E-052C**

GEOCRES Number: 42D-54

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the detailed design of the proposed Blackbird Creek Culvert replacement. The Blackbird culvert is located on Highway 17, east of the township of Terrace Bay, in the District of Thunder Bay, Ontario. Thurber previously completed a preliminary foundation investigation at the culvert site in 2018.

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 carried out the investigation as a sub-consultant to Hatch under the Ministry of Transportation Ontario (MTO) Agreement Number 6016-E-0008.

The preliminary investigation conducted by Thurber is described in the following report:

- Preliminary Foundation Investigation and Design Report, Blackbird Creek Culvert Replacement, Highway 17, Unsurveyed Territory, Thunder Bay District, Ontario, GEOCRES Number 42D-50, prepared by Thurber Engineering Ltd.

The borehole logs from the preliminary investigation are included in this report.

2. SITE DESCRIPTION

The site is located along Highway 17, approximately 9 km east of the township of Terrace Bay, Ontario. The culvert allows Blackbird Creek to flow from a southerly to northerly direction under



Highway 17. Highway 17 generally runs in a northeast-southwest direction at the culvert site with the culvert running perpendicular to the roadway.

Based on the Ontario Structure Inspection Manual (OSIM) prepared by MTO on November 20, 2014, the existing culvert is a cast in place concrete box culvert that is 6.1 m wide, 1.8 m high and 30.6 m long. The culvert barrel is in overall poor condition with light to medium erosion along the bottom 0.7 m of both side walls. The side wall erosion is severe in some locations. There is a 750 mm long crack near the inlet on the west wall. Medium scaling and cracking were observed in the soffit, and severe scaling was observed on the southeast wall. The water level in the creek on June 7, 2016 was reported at approximate Elevation 205.6 m upstream of the inlet and 204.6 m downstream of the outlet.

The grade level of Highway 17 at the existing culvert is at an elevation of 209 m. The invert elevation (southeast) is approximately 204.4 m, and the outlet elevation (northwest) is approximately 204.2 m. The height of fill above the existing culvert is approximately 3 m.

The area on either side of the creek near the inlet and outlet of the culvert is vegetated with tall grass and trees, and the overall surrounding area is densely forested. There are also pine trees and grass growing on top of the culvert at the inlet and outlet. Photographs in Appendix D show the culvert and the surrounding area.

The site lies within the physiographic region known as the Wawa Subprovince of the Superior Province of the Canadian Shield. Based on Ontario Geological Survey (OGS) Map 2518, titled "Surficial Geology of Northern Ontario", dated 1987, the site is located in an area of "bare bedrock with thin glacial sediment cover". Based on OGS Map 2545, titled "Bedrock Geology of Ontario", dated 1991, the bedrock is of the Archean age and consists of intrusive rocks, mainly massive to foliated granodiorite and granite.

3. INVESTIGATION PROCEDURES

The current investigation and field testing program was carried out between June 25 and July 16, 2018, and consisted of drilling and sampling five (5) boreholes, designated as Boreholes 18-01 to 18-05, to depths ranging from 2.9 m to 20.1 m below the existing ground surface. A Dynamic Cone Penetration Test (DCPT) conducted at the base of Borehole 18-03 extended the borehole to a depth of 15.8 m from 12.8 m. Boreholes 18-01 and 18-02 were drilled within the paved portion of Highway 17 near the locations of the abutments for a potential temporary modular bridge, approximately 30 m to the north, and 12 m to the south, of the existing culvert, respectively. Boreholes 18-03, 18-04 and 18-05 were drilled near the inlet and outlet of the proposed culvert



alignment and to delineate peat thickness along the new alignment.

The previous preliminary investigation for this project was carried out between August 20 and September 17, 2017, during which time four boreholes denoted as Boreholes 17-34 to 17-37 were drilled at selected locations at the culvert site to depths of between 2.1 m and 18.9 m.

The Record of Borehole sheets for the boreholes from the current and previous preliminary investigation are included in Appendix A. The approximate locations of the boreholes from both investigations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix C.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from topographic drawings provided to Thurber by Hatch. The boreholes drilled from the Highway platform from the current investigation were drilled using a truck-mounted drill rig using wash boring drilling techniques, Borehole 18-03 was drilled using a portable Hilti drill and tripod equipment using wash boring techniques, and Boreholes 18-04 and 18-05 were sampled using hand held sampling equipment with a 22 kg hammer. Samples of the overburden soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

The field investigation was supervised on a full-time basis by a member of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Piezometers were installed as part of the current investigation in Boreholes 18-01, 18-02, and 18-03 and water level readings were taken throughout the investigation. The piezometers were decommissioned at the completion of the field investigation. The remaining boreholes were backfilled in general accordance with Ontario regulation 903, as amended. A piezometer was also installed in Borehole 17-36 drilled during the preliminary investigation.

Completion details of the borehole are summarized in Table 3.1 below.



Table 3.1 – Borehole Completion Details

Borehole Number	Borehole-DCPT Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
18-01	20.1 / 188.8	15.2 / 193.7	Bentonite holeplug to 15.5 m, sand to 13.4 m, bentonite holeplug to 0.2 m then asphalt to surface.
18-02	19.9 / 189.1	19.8 / 189.2	Sand to 18.0 m, bentonite holeplug to 0.2 m then asphalt to surface.
18-03	15.8 / 190.0	3.0 / 202.8	Borehole caved to 9.1 m, then backfilled with bentonite holeplug to 3.4 m, sand to 1.2 m then bentonite holeplug to surface.
18-04	3.7 / 202.0	None Installed	Borehole backfilled with cuttings to surface.
18-05	2.9 / 203.4	None Installed	Borehole backfilled with cuttings to surface.
17-34	15.3/190.1	None Installed	Bentonite holeplug and cuttings to surface and covered with gravel
17-35	18.9/190.1	None Installed	Cuttings to 0.9 m, then dry cement to 0.1 m and asphalt to surface
17-36	15.8/190.1	11.2/194.7	Sand to 7.9 m, then bentonite holeplug and cuttings to surface
17-37	2.1/206.9	None Installed	Cuttings to 0.75 m, then concrete to 0.15 m and asphalt to surface

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Laboratory testing

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Design\FINAL\Blackbird Creek Culvert FIR FINAL - Nov 12-2018.docx



results are summarized on the Record of Borehole sheets included in Appendix A and are presented 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, during the previous investigation, a sample of the existing native soil, and a sample of the surface water from the creek upstream of the existing culvert 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 and are presented in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets 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 and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in these boreholes consisted of asphalt, large thicknesses of topsoil and fill overlying varying thicknesses of silty sand, which was in turn underlain by silty clay and lower silty sand and sand layers. Descriptions of the individual strata are presented below.

5.1 Asphalt

Boreholes 18-01, 18-02, 17-35 and 17-37 were drilled through the paved sections of Highway 17 and encountered approximately 100 to 175 mm thick layer of asphalt.

5.2 Sand to Sand and Gravel Fill

Sand and gravel to sand fill with some gravel and containing trace to some silt, and trace clay was encountered in all Boreholes drilled within the paved sections of Highway 17 beneath the asphalt structure. The sand and gravel to sand fill layer was approximately 0.8 m to 1.4 m thick and extended to depths of between 1.0 m and 1.5 m (Elevations 207.9 m and 207.5 m).



SPT 'N' values in the sand and gravel to sand fill ranged from 64 blows for 0.3 m penetration to 50 blows for 0.15 m penetration indicating a very dense condition. Measured moisture contents in the sand and gravel to sand fill ranged from 4 to 8 percent.

The results of grain size distribution analyses carried out on selected samples of the sand to sand and gravel fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	13 to 42
Sand	50 to 68
Silt	14 to 15
Clay	4 to 5
Silt and Clay	8

5.3 Silty Sand to Sand and Silt Fill

Silty sand to sand and silt fill, containing trace clay and trace gravel, was encountered in Boreholes 18-01, 18-02, 17-35, and 17-37 beneath the sand to sand and gravel fill at depths of between 1.0 m to 1.5 m (Elevations 207.9 m to 207.5 m). Where fully penetrated the silty sand to sand and silt fill layer was approximately 1.2 m to 1.7 m thick and extended to depths of between 2.2 m to 3.1 m (Elevations 206.7 m to 205.9 m). Borehole 17-37 was terminated in the sand and silt fill layer at a depth of approximately 2.1 m (Elevation 206.9 m).

SPT 'N' values in the silty sand to sand and silt fill ranged from 10 to 46 blows for 0.3 m penetration indicating a compact to dense condition. Measured moisture contents in the silty sand to sand and silt fill ranged from 11 to 19 percent.

The results of grain size distribution analyses carried out on selected samples of the silty sand to sand and silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B2 of Appendix B. The results of the grain size distribution analyses are summarized below:



Soil Particle	Percentage (%)
Gravel	0 to 9
Sand	34 to 60
Silt	24 to 63
Clay	3 to 7

5.4 Topsoil

Surficial topsoil, containing sand, silt and rootlets, was encountered in Boreholes 18-03, 18-04, 18-05, 17-34 and 17-36. The surficial topsoil was approximately 50 mm to 600 mm thick. A buried layer of topsoil, containing sand, silt, rootlets and wood fragments was encountered in Boreholes 17-35 at a depth of approximately 3.1 m (Elevation 205.9 m) and was approximately 2.5 m thick, extending to a depth of approximately 5.6 m (Elevation 203.4 m).

SPT 'N' values within in the topsoil ranged from 4 to 9 blows per 0.3 m penetration, indicating a loose condition. Measured moisture contents in the topsoil ranged from 11 to 65 percent.

5.5 Upper Silty Sand to Sandy Silt

An upper layer of silty sand to sandy silt, containing trace to some clay, trace gravel, and trace organics near the surface, was encountered in Boreholes 18-01, 18-03, 17-34, and 17-36 at depths of between 0.1 m to 2.2 m (Elevations 206.7 m to 203.9 m). The silty sand to sandy silt was approximately 0.8 m to 3.9 m thick and extended to depths of between 1.4 m to 6.1 m (Elevations 204.5 m to 201.3 m).

SPT 'N' values in the silty sand to sandy silt ranged from 1 to 11 blows per 0.3 m penetration, indicating a very loose to compact condition. Measured moisture contents ranged from 8 to 46 percent.

The results of grain size distribution analyses testing carried out on selected samples of the silty sand to sandy silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 Appendix B. The results of the grain size distribution analyses are summarized below:



Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	30 to 58
Silt	29 to 64
Clay	5 to 13

5.6 Silty Clay

Silty clay with sand to trace sand and trace gravel was encountered in Boreholes 18-01 to 18-05 and 17-34 to 17-36 at depths of between 0.1 m to 6.1 m (Elevations 206.2 m to 201.3 m). Where fully penetrated the silty clay was 6.7 m to 10.7 m thick and extended to depths of between 9.1 m and 14.0 m (Elevations 196.7 m and 192.9 m). Boreholes 18-04 and 18-05 were terminated with the silty clay layer at depths of 3.7 m and 2.9 m (Elevations 202.0 m and 203.4 m), respectively.

SPT 'N' values in the silty clay ranged from 0 (weight of hammer) to 20 blows per 0.3 m penetration, however typical values ranged from 0 to 5 blows. In-situ vane shear tests were conducted in the silty clay and measured undrained shear strengths of between 7 and 57 kPa (typically 10 to 50 kPa). The results of the SPTs and vane shear tests indicate the silty clay is very soft to firm. The sensitivity of the silty clay was measured to range between 1.1 and 3.5, indicating low to medium sensitivity. Measured moisture contents in the silty clay range from 20 to 75 percent.

The results of grain size distribution analyses and Atterberg Limits testing carried out on selected samples of the silty clay are presented on the Record of Borehole sheets included in Appendix A and on Figures B4 and B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 1
Silt	15 to 75
Clay	25 to 84

The results of Atterberg Limits testing are summarized below:



Index Property	Percentage (%)
Plastic Limit	17 to 25
Liquid Limit	28 to 74
Plasticity Index	10 to 49

The results of the Atterberg Limits testing indicate the layer to be of low to high plasticity with group symbols CL, CI and CH.

5.7 Lower Silt to Silty Sand

A lower layer of Silty Sand to silt with some sand and containing trace clay and trace gravel, was encountered in Boreholes 18-01 to 18-03, and 17-34 to 17-36 at depths of between 9.1 m and 14.0 m (Elevations 196.7 m and 192.9 m). The lower silt to silty sand was approximately 1.6 to 4.9 m thick and extended to depths of between 10.7 m and 18.3 m (Elevations 195.1 m to 190.6 m).

SPT 'N' values within the silt to silty sand ranged from 0 (weight of hammer) to 20 blows per 0.3 m penetration, indicating a very loose to compact condition. Measured moisture contents in the silt to silty sand ranged from 15 percent to 27 percent.

The results of grain size distribution analyses testing carried out on selected samples of the lower silt to silty sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	10 to 75
Silt	56 to 83
Clay	7
Silt and Clay	24

5.8 Sand and Gravel to Sand

A lower layer of sand and gravel to sand with trace to some gravel was encountered in Boreholes 18-03, 17-34, 17-35, and 17-36 at depths of between 10.7 m and 17.1 m (Elevations 195.1 m and 190.6 m). These four boreholes were terminated within the sand and gravel to sand layer at depths of between 12.8 m and 18.9 m (Elevations 193.0 m to 190.1 m).



SPT 'N' values within the sand and gravel to sand ranged from 6 to over 100 blows per 0.3 m of penetration, indicating a loose to very dense condition. Measured moisture contents within the sand and gravel to sand deposit varied between 4 percent and 23 percent.

The results of grain size distribution analyses testing carried out on a selected sample of the sand and gravel to sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B5 Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	4
Sand	87
Silt and Clay	9

5.9 Silty Clay to Clayey Silt Till

Silty clay to clayey silt till, containing trace sand, trace gravel, and occasional cobbles and boulders was encountered in Boreholes 18-01 and 18-02 at depths of 18.3 m and 18.6 m (Elevations 190.6 m and 190.4 m), respectively. Both boreholes were terminated in the silty clay to clayey silt till at depths of 20.1 m and 19.9 m (Elevations 188.8 m and 189.1 m). A boulder layer, 0.6 m thick was encountered in BH 18-02 between Elevations 189.8 m to 189.2 m.

SPT 'N' values in the silty clay to clayey silt till ranged from 50 blows per 150 mm to 50 blows per 75 mm of penetration indicating a hard consistency. Measure moisture contents in the silty clay to clayey silt till ranged from 5 to 11 percent.

5.10 Groundwater Conditions

Groundwater conditions were observed during drilling operations, and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Borehole 18-01, 18-02, 18-03 and 17-36 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the standpipe piezometer are summarized below.

Table 5.1 – Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
18-01	June 26, 2018	1.0	207.9	Standpipe piezometer
	July 24, 2018	0.7	208.2	
18-02	June 25, 2018	0.7	208.3	Standpipe piezometer
	June 26, 2018	0.8	208.2	
	July 24, 2018	0.7	208.3	
18-03	July 16, 2018	0.6	205.2	Standpipe piezometer. Artesian condition in encountered at 11.3 m.
18-04	July 15, 2018	1.4	204.3	Open borehole
18-05	July 15, 2018	0.0	206.3	Open borehole
17-34	August 17, 2017	Dry	Dry	Open borehole
17-35	August 20, 2017	3.7	205.3	Open borehole
17-36	August 28, 2017	0.6	205.3	Standpipe piezometer
17-37	August 20, 2017	Dry	Dry	Open borehole

The creek water level on June 7, 2016, was reported to be Elevation 205.6 m upstream of the inlet and 204.6 m downstream of the outlet.

Artesian conditions were encountered while drilling in Borehole 18-03 at a depth of approximately 11.3 m. The artesian condition was successfully plugged in accordance with Regulation 903, as amended.

The groundwater levels above 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 after periods of significant or prolonged precipitation.

6. CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the native silty sand from Borehole 17-36 and a sample of the creek water 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	
			17-36, SS#2, 0.8 m – 1.4 m	Blackbird Creek
			(Silty Sand)	(Creek Water)
Sulphide	mg/L	mg/L	<0.02	0.08
Chloride	mg/L	mg/L	340	110
Sulphate	mg/L	mg/L	10	180
pH	No unit	No unit	7.99	7.78
Electrical Conductivity	µS/cm	µS/cm	397	1180
Resistivity	Ohms.cm	Ohms.cm	2520	847
Redox Potential	mV	mV	137	224

7. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

Forage Downing Drilling of Hawkesbury, Ontario and Ohlmann Geotechnical Services (OGS) of Almonte, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the current investigation. The field investigation was supervised on a full-time basis by Mr. Ryan McCourt and Ms. Judy Mei of Thurber. Overall supervision of the field program was provided by Mr. Mark Farrent, P.Eng..

Thurber obtained the northing and easting coordinates and ground surface elevations from measurements taken in the field relative to the topographic plans provided by Hatch. The coordinate system MTM NAD83 Zone 14 was used for these boreholes.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta and Mr. Mark Farrant, 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 18-01

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METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 980.2 E 302 097.2 ORIGINATED BY BRM
DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.25 - 2018.06.26 LATITUDE 48.84617297 LONGITUDE -87.03682814 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								
208.9	GROUND SURFACE																			
0.0	ASPHALT: (175mm)																			
0.2	Gravelly SAND Very Dense Brown Moist (FILL)		1	SS	100															
207.9			2	SS	86															
1.0	Silty SAND , trace gravel, trace clay Very Dense to Dense Brown Moist (FILL)																			
			3	SS	46															
206.7																				
2.2	Sandy SILT , trace clay, trace gravel Compact to Very Loose Grey Wet		4	SS	11															
			5	SS	8															
			6	SS	1															
202.8																				
6.1	CLAY , some silt, trace sand Very Soft Grey Wet (CH)		7	SS	0															
			8	T																

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-01

2 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 980.2 E 302 097.2 ORIGINATED BY BRM
DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.25 - 2018.06.26 LATITUDE 48.84617297 LONGITUDE -87.03682814 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	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									
	Continued From Previous Page																			
	CLAY , trace silt Very Soft Grey Wet		9	SS	0															
195.2																				
13.7	SILT , some sand, trace clay Very Loose to Loose Grey Wet		10	SS	3											0	10	83	7	
			11	SS	6															
192.6																				
16.3	SAND and SILT , trace clay Loose Grey Wet		12	SS	9												0	37	56	7
190.6																				
18.3	Silty CLAY , trace sand, trace gravel, trace cobbles and boulders Hard Dark Grey Moist (TILL)		13	SS	50/ 0.075															
			14	SS	50/															

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-01

3 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 980.2 E 302 097.2 ORIGINATED BY BRM
 DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
 DATUM Geodetic DATE 2018.06.25 - 2018.06.26 LATITUDE 48.84617297 LONGITUDE -87.03682814 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 (%)					
188.8 20.1	Continued From Previous Page END OF BOREHOLE AT 20.1m. WATER LEVEL AT 3.1m UPON COMPLETION. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.				0.150									

RECORD OF BOREHOLE No 18-02

1 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 935.1 E 302 079.9 ORIGINATED BY BRM
DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.25 - 2018.06.25 LATITUDE 48.84576731 LONGITUDE -87.03706357 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	W _P	W					
209.0	GROUND SURFACE																		
0.0	ASPHALT: (100mm)																		
0.1	SAND, some silt, trace clay Very Dense Brown Moist (FILL)		1	SS	50/ 0.150							○					13 68 14 5		
			2	SS	94							○							
207.5																			
1.5	Silty SAND Compact Brown Moist (FILL)		3	SS	28							○							
			4	SS	32							○							
206.0																			
3.0	CLAY, some silt, trace sand Very Stiff Grey Wet (CH)		5	SS	20							○							
	Very Soft to Soft		6	SS	0												0 1 15 84		
			7	T															
			8	SS	2							○							
			9	SS	2							○							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-02

2 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 935.1 E 302 079.9 ORIGINATED BY BRM
DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.25 - 2018.06.25 LATITUDE 48.84576731 LONGITUDE -87.03706357 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						
								○ UNCONFINED + FIELD VANE						
Continued From Previous Page								● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)					
								20 40 60 80 100		20 40 60				

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 18-02

3 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 935.1 E 302 079.9 ORIGINATED BY BRM
DIST TB HWY 17 BOREHOLE TYPE NW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.06.25 - 2018.06.25 LATITUDE 48.84576731 LONGITUDE -87.03706357 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																		
19.9	<p>Continued From Previous Page</p> <p>Hard Grey Moist (TILL)</p> <p>END OF BOREHOLE AT 19.9m. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen.</p> <p>WATER LEVEL READINGS</p> <table border="1"> <thead> <tr> <th>DATE</th> <th>DEPTH(m)</th> <th>ELEV.(m)</th> </tr> </thead> <tbody> <tr> <td>2018.06.25</td> <td>0.7</td> <td>208.3</td> </tr> <tr> <td>2018.06.25</td> <td>0.8</td> <td>208.2</td> </tr> </tbody> </table>	DATE	DEPTH(m)	ELEV.(m)	2018.06.25	0.7	208.3	2018.06.25	0.8	208.2				0.100												
DATE	DEPTH(m)	ELEV.(m)																								
2018.06.25	0.7	208.3																								
2018.06.25	0.8	208.2																								

RECORD OF BOREHOLE No 18-03

1 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 944.8 E 302 104.1 ORIGINATED BY JM
DIST TB HWY 17 BOREHOLE TYPE BW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.07.15 - 2018.07.16 LATITUDE 48.84585465 LONGITUDE -87.03673389 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)										
								○ UNCONFINED			+ FIELD VANE			w P					w			w L		
								● QUICK TRIAXIAL			× LAB VANE													
205.8	GROUND SURFACE							20	40	60	80	100												
0.0	TOPSOIL: (125mm)							20	40	60	80	100												
0.1	Silty SAND , trace gravel, trace organics Very Loose to Loose Brown Moist		1	SS	4																			
			2	SS	2																			
			3	SS	5																			
203.4																								
2.4	Silty CLAY Soft Grey Moist		4	SS	6																			
			5	SS	2																			
			6	SS	4																			
			7	SS	0																			
196.7																								
9.1	Silty SAND , trace gravel Very Loose Grey Moist		9	GS	0																			

Continued Next Page

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

RECORD OF BOREHOLE No 18-03

2 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 944.8 E 302 104.1 ORIGINATED BY JM
DIST TB HWY 17 BOREHOLE TYPE BW Casing COMPILED BY MP
DATUM Geodetic DATE 2018.07.15 - 2018.07.16 LATITUDE 48.84585465 LONGITUDE -87.03673389 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	○ UNCONFINED + FIELD VANE	● QUICK TRIAXIAL × LAB VANE	W _P W W _L					
	Continued From Previous Page						20 40 60 80 100				20 40 60					
195.1																
10.7	SAND and GRAVEL to Sandy GRAVEL , trace silt Loose to Compact Grey Moist to Wet		10	SS	9		195									
							194									
			11	SS	14											
193.0																
12.8	END OF CASING ADVANCE AT 12.8m. BEGINNING OF DCPT.						193									
							192									
							191									
190.0																
15.8	END OF DCPT AT 15.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.07.16 0.6 205.2															

RECORD OF BOREHOLE No 18-04

1 OF 1

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 971.7 E 302 076.7 ORIGINATED BY JM
DIST TB HWY 17 BOREHOLE TYPE Pionjar, 50lb Hammer COMPILED BY MP
DATUM Geodetic DATE 2018.07.15 - 2018.07.15 LATITUDE 48.84609644 LONGITUDE -87.03710742 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	REMARKS & GRAIN SIZE DISTRIBUTION (%)											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)										
								20	40	60	80	100						20	40	60								
205.7	GROUND SURFACE					▽																						
0.0	TOPSOIL: (200mm)																											
0.2	Silty CLAY , with organics, some sand Soft to Firm Grey Wet		1	SS	3																							
			2	SS	2																							
			3	SS	5																							
	organic sand seam from 2.6m to 3.2m		4	SS	5																							
5			SS	2																								
202.0																												
3.7	END OF BOREHOLE AT 3.7m. WATER LEVEL AT 1.4m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																											

RECORD OF BOREHOLE No 18-05

1 OF 1

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 954.5 E 302 104.7 ORIGINATED BY JM
DIST TB HWY 17 BOREHOLE TYPE Pionjar, 50lb Hammer COMPILED BY MP
DATUM Geodetic DATE 2018.07.15 - 2018.07.15 LATITUDE 48.84594188 LONGITUDE -87.03672578 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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
206.3	GROUND SURFACE												
0.0	TOPSOIL: (50mm)		1	SS	2		206						
	Silty CLAY , with organics, some sand Soft Grey Moist		2	SS	4		205						
204.4			3	SS	13								
1.9	Silty CLAY , trace sand Stiff Grey Moist		4	SS	11		204						
203.4													
2.9	END OF BOREHOLE AT 3.0m. WATER LEVEL AT GROUND SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.												











+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-34

1 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 964.3 E 302 071.6 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE BW Casing COMPILED BY MP
 DATUM Geodetic DATE 2017.09.17 - 2017.09.17 CHECKED BY NLB

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									
205.4	GROUND SURFACE							20	40	60	80	100					GR SA SI CL
0.0	TOPSOIL, silt, some sand, roots Loose Dark Brown Moist		1	SS	6		205										0 58 29 13
204.8																	
0.6	Silty CLAY, some sand, rootlets Soft Brown Moist		2	SS	3		204										
203.9																	
1.5	Silty SAND, some clay, occasional wood fragments Loose to Very Loose Brown Moist		3	SS	5		203										
			4	SS	6		202										
			5	SS	3		201										
201.3																	
4.1	Silty CLAY, trace to some sand Firm to Very Soft Grey Moist to Wet (CI)		6	SS	5		200										0 0 52 48
							199										
							198										
			7	SS	0		197										
							196										

Continued Next Page

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-34

2 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 964.3 E 302 071.6 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE BW Casing COMPILED BY MP
 DATUM Geodetic DATE 2017.09.17 - 2017.09.17 CHECKED BY NLB

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL
	Continued From Previous Page							20	40	60	80	100							
192.9	Silty CLAY , trace to some sand Soft Grey Wet (CI)		8	SS	3		195												
							194												
12.5	Silty SAND , trace gravel Compact to Very Loose Grey Moist		9	SS	18		193												
							192												
			10	SS	0		191												
190.6																			
14.8	SAND , some gravel, some silt Very Dense Grey																		
190.1	Wet		11	SS	100														
15.3	END OF BOREHOLE AT 15.3m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN GRAVEL TO SURFACE.				0.025														

1 75 24
(SI+CL)

+³, ×³: Numbers refer to Sensitivity
 20
15 5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-35

1 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 958.4 E 302 086.0 ORIGINATED BY TY
HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2017.08.20 - 2017.08.20 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
209.0	GROUND SURFACE							20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-35

2 OF 3

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 958.4 E 302 086.0 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.08.20 - 2017.08.20 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
195.0	Silty CLAY , trace sand Very Soft Grey Wet (CL)						198	1.5									
			10	SS	0		197										
							196										
14.0	Silty SAND , trace to some clay, trace gravel Loose Grey Wet						195										
							194										
			11	SS	8		193										
191.9	SAND , some gravel, some silt Compact Grey Wet						192										
							191										
			12	SS	22												
190.1																	
18.9	END OF BOREHOLE AT 18.9m. BOREHOLE OPEN TO 6.0m AND WATER LEVEL AT 3.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.9m, DRY CEMENT TO 0.1m, THEN COLD PATCH																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/24/17

METRIC

[illegible]

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 17-36

2 OF 2

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 932.8 E 302 095.1 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers/Dynamic Cone Penetration Test COMPILED BY MP
 DATUM Geodetic DATE 2017.08.22 - 2017.08.22 CHECKED BY NLB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
195.7	Continued From Previous Page																
10.2	Silty SAND Very Loose Grey Wet		7	SS	0												
193.9																	
12.0	SAND, some silt, trace gravel Loose Grey Wet		8	SS	6												
192.5																	
13.4	End of sampling and start DCPT at 13.4m																
190.1																	
15.8	END OF DCPT AT 15.8m. BOREHOLE OPEN TO 11.3m 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) 2017.08.26 0.6 205.3																

ONTMT4S MTO-15595.GPJ 2017TEMPLATE(MTO).GDT 11/8/17

RECORD OF BOREHOLE No 17-37

1 OF 1

METRIC

W.P. 6808-14-01 LOCATION BlackBird Creek Culvert, MTM NAD 83 Zone 14 N 5 411 939.3 E 302 076.6 ORIGINATED BY TY
 HWY 17 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2017.08.20 - 2017.08.20 CHECKED BY NLB

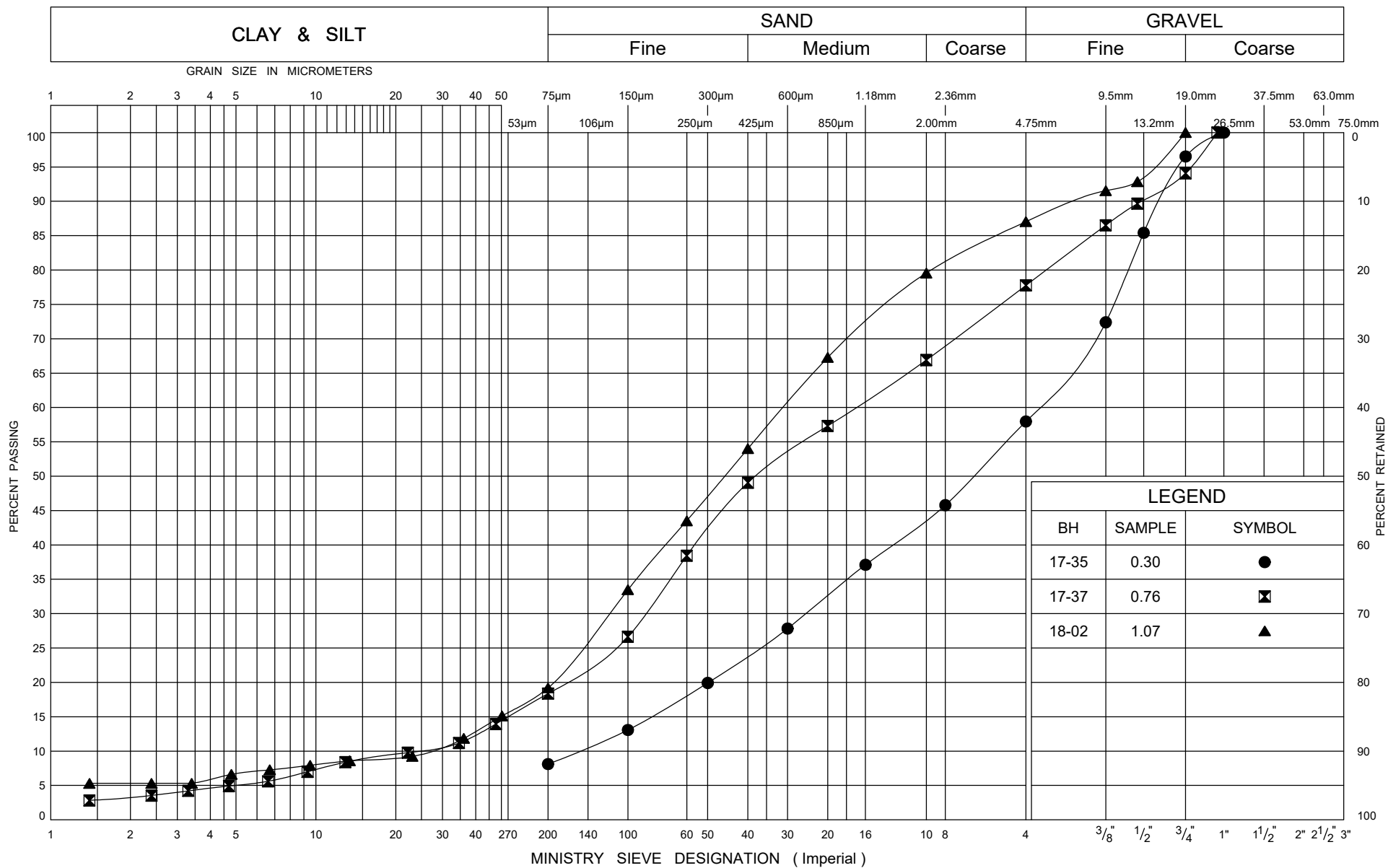
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT							UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
209.0	GROUND SURFACE							20 40 60 80 100											
0.0	ASPHALT: (140mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
0.1	Gravelly SAND, some silt, trace clay Brown Dry (FILL)		1	GS			208												22 59 15 4
207.5																			
1.5	SAND and SILT Compact Brown Moist (FILL)		1	SS	15		207												
206.9																			
2.1	END OF BOREHOLE AT 2.13m. HOLE FILLED WITH CUTTINGS TO 0.6m, DRY CEMENT TO 0.2m, THEN COLD-PATCH ASPHALT TO THE SURFACE.																		

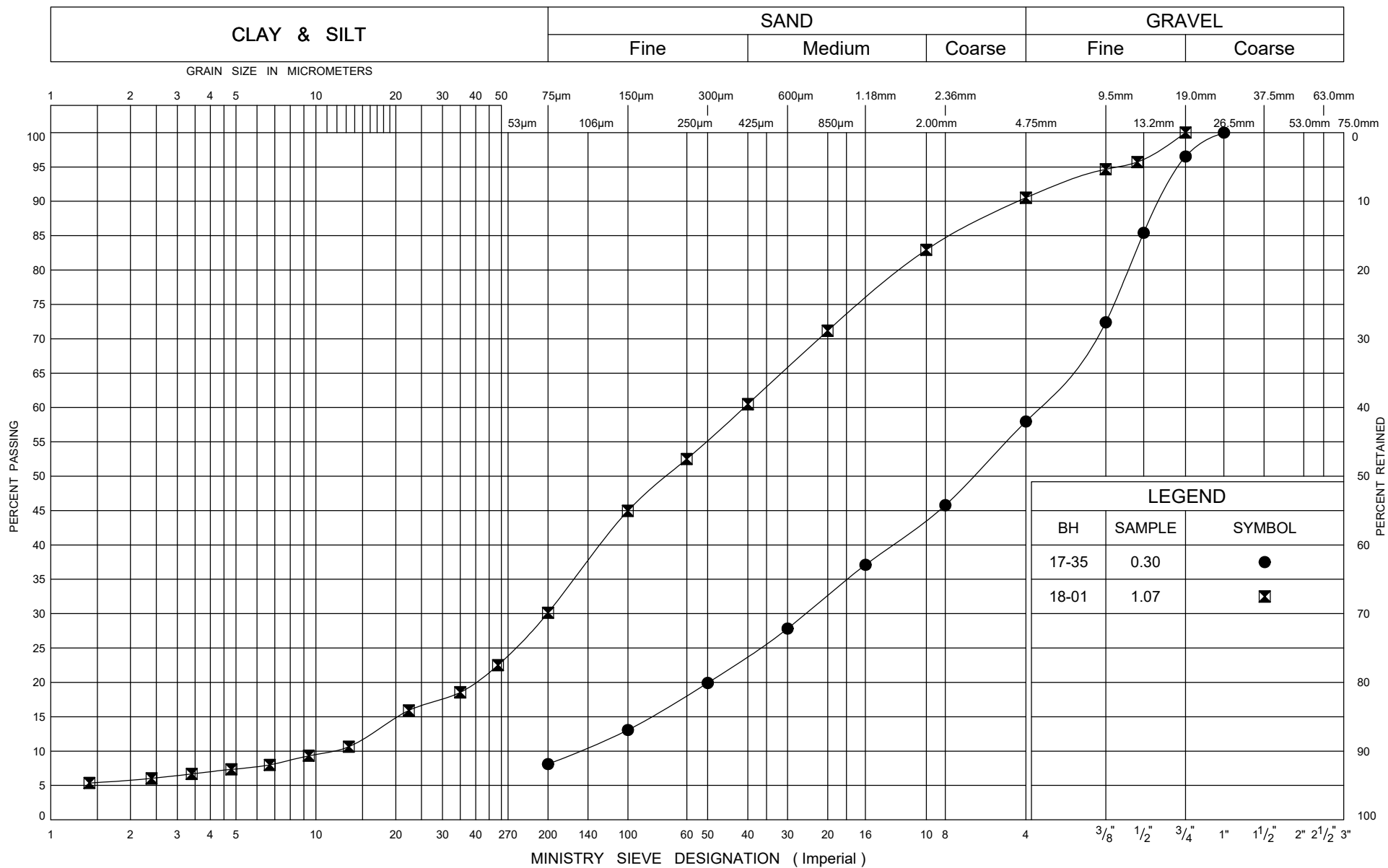
+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

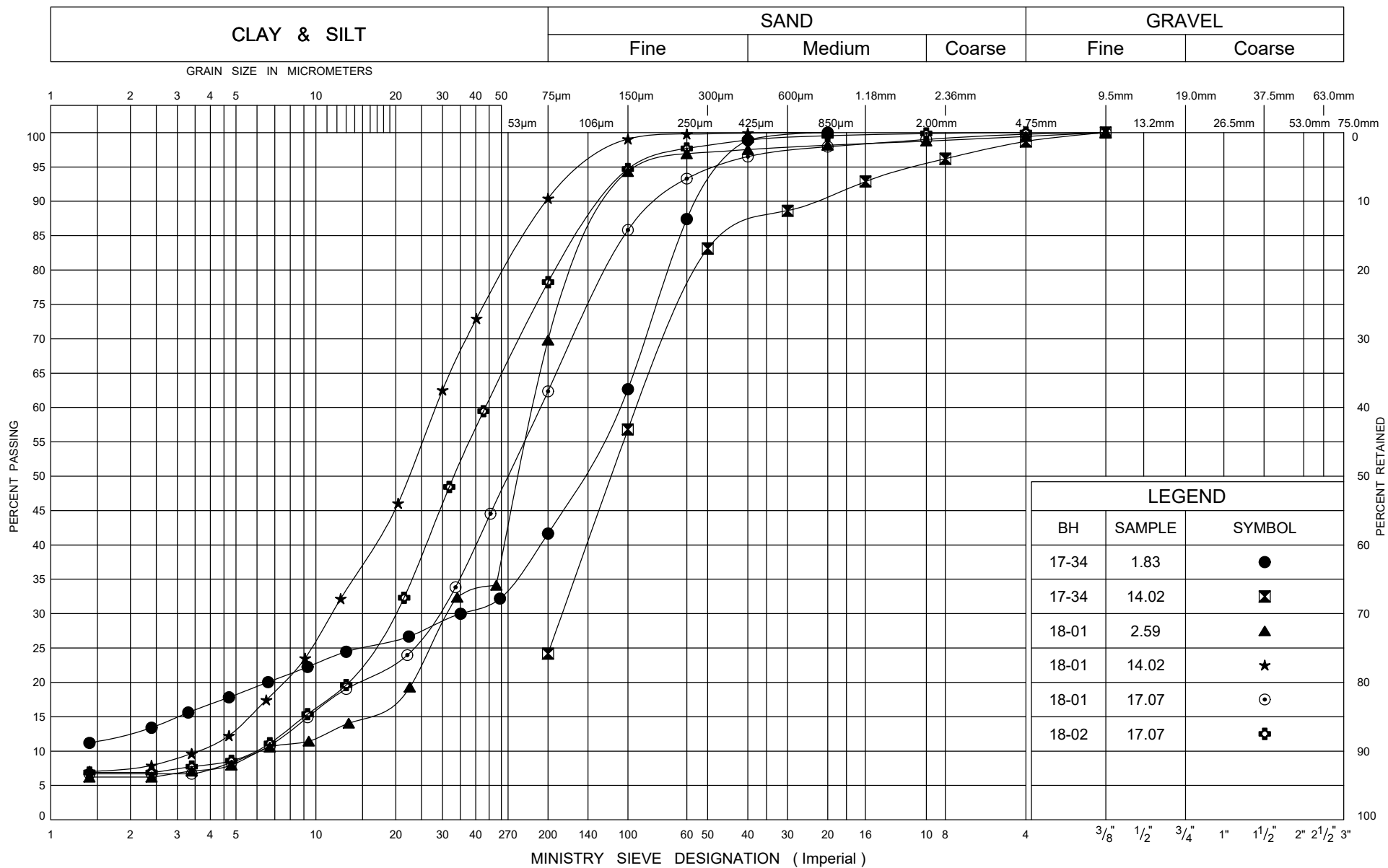


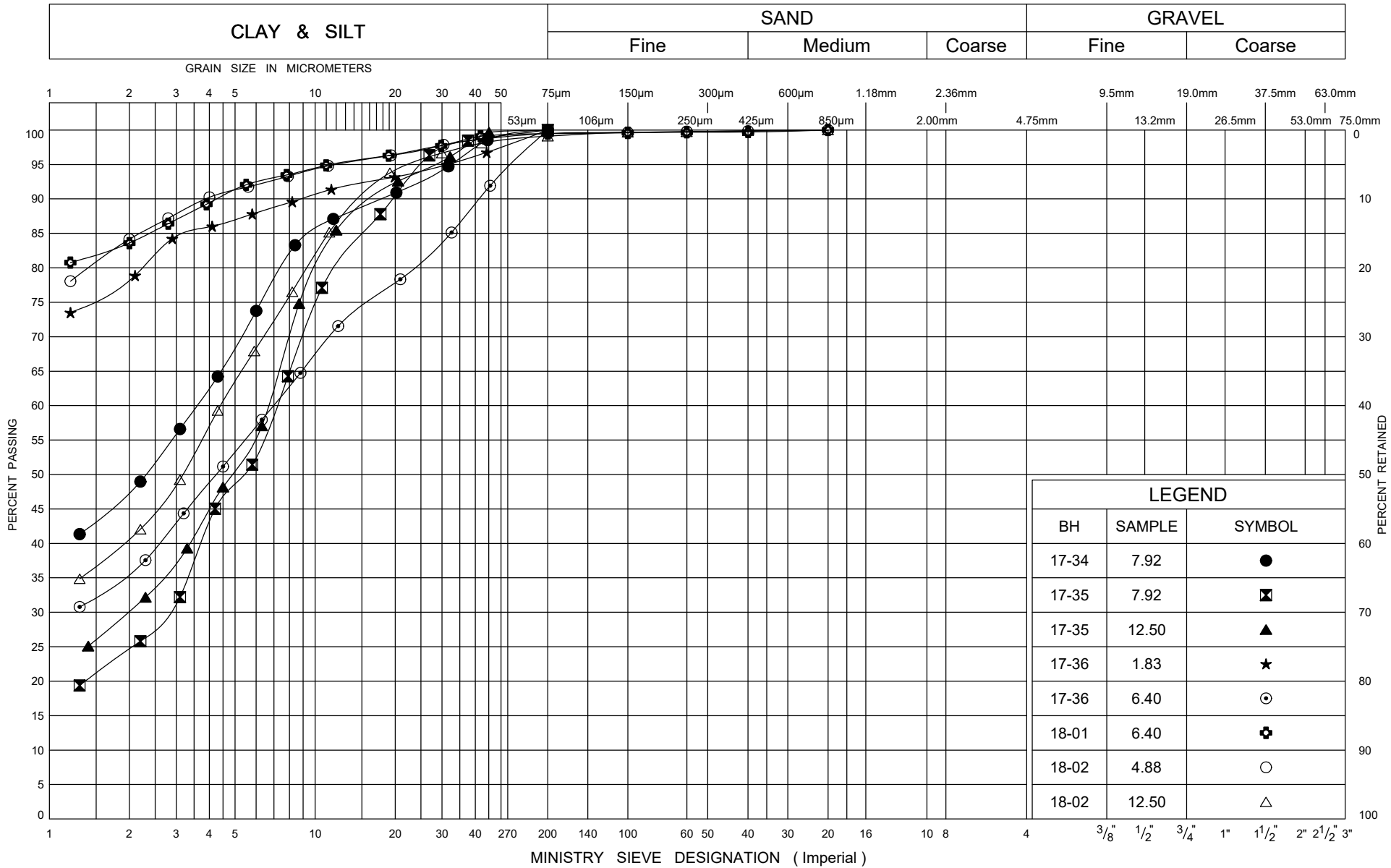
Appendix B

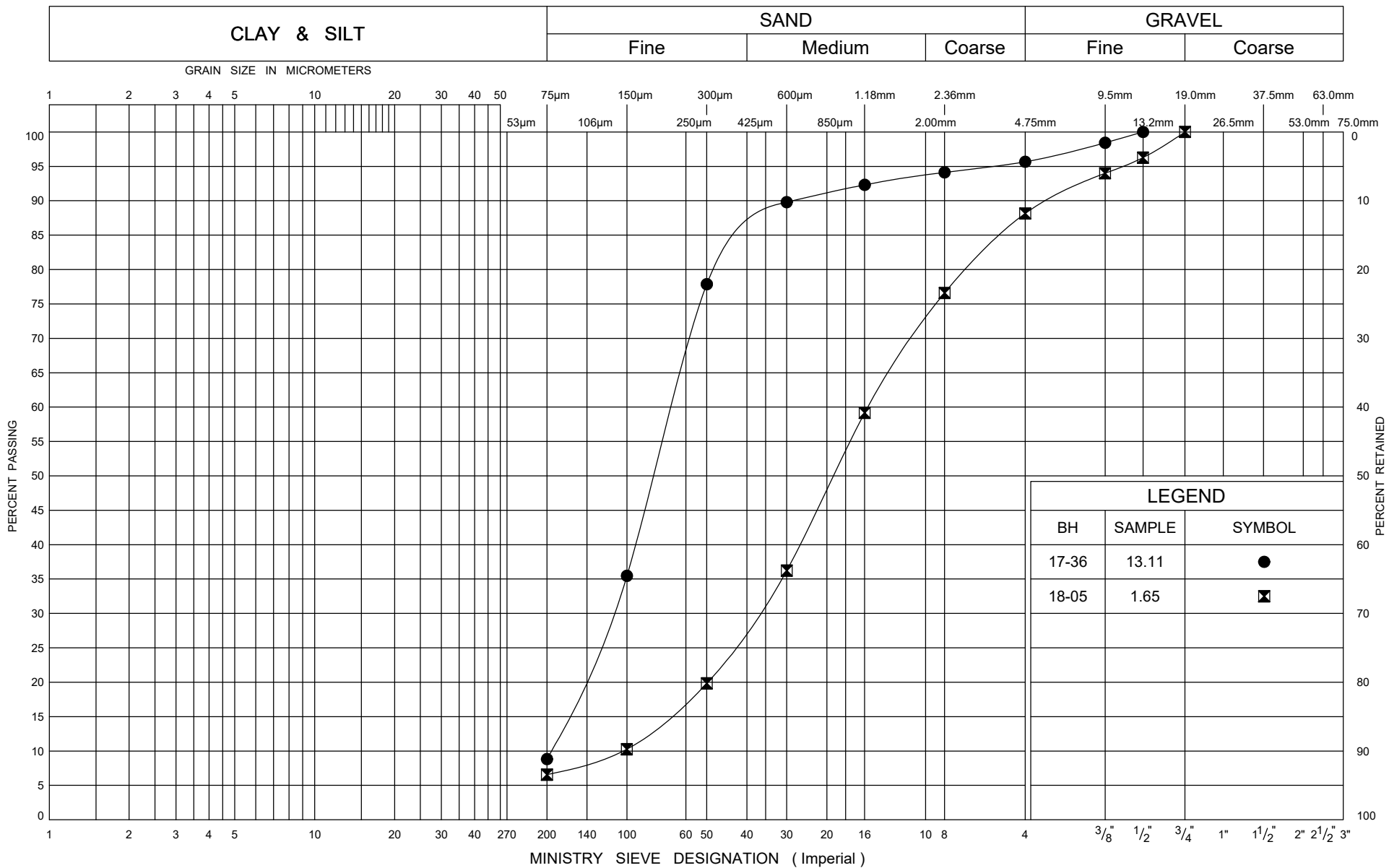
Laboratory Test Results

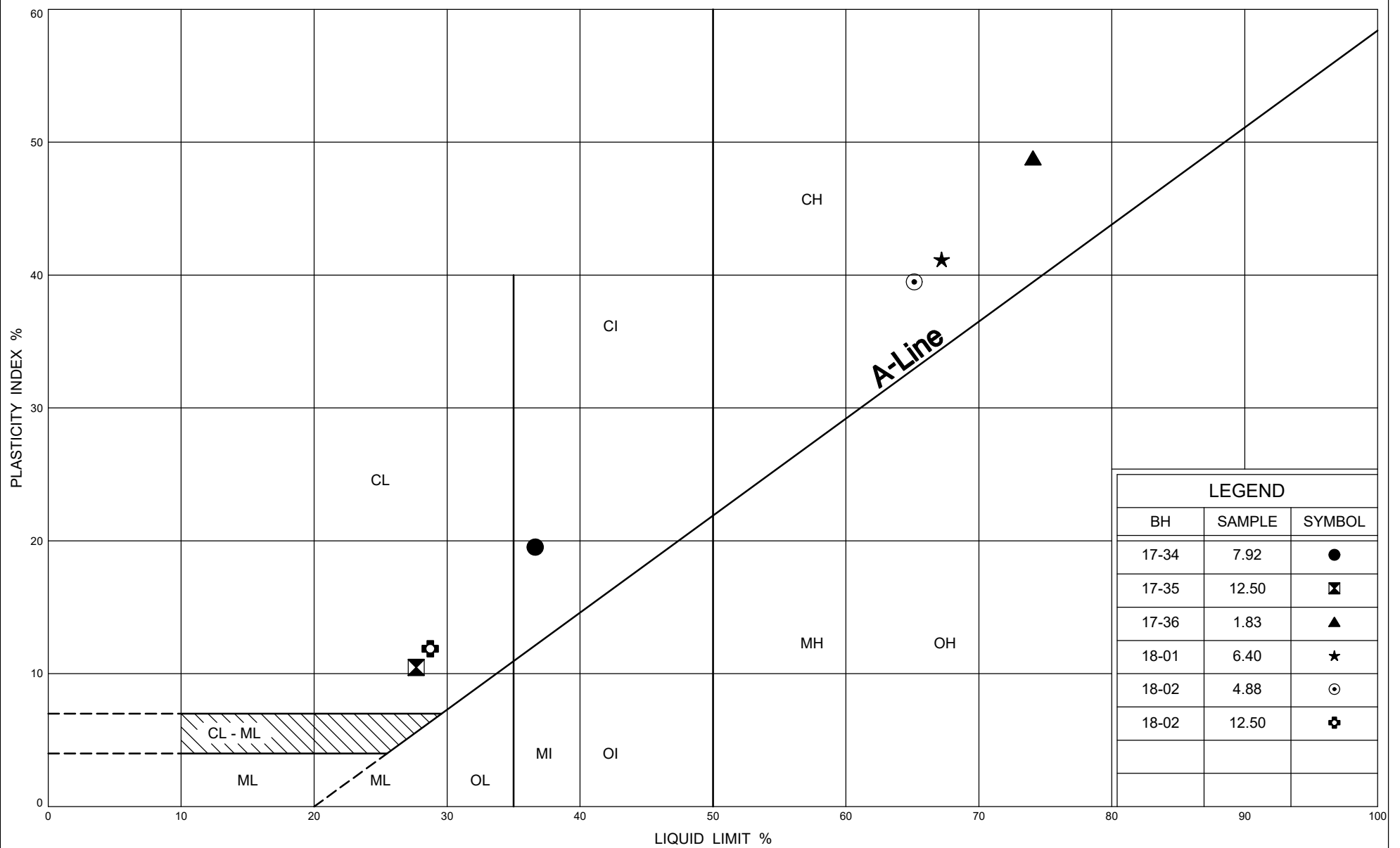












LEGEND

BH	SAMPLE	SYMBOL
17-34	7.92	●
17-35	12.50	⊠
17-36	1.83	▲
18-01	6.40	★
18-02	4.88	⊙
18-02	12.50	⊕



Ministry of
Transportation

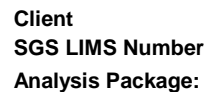
PLASTICITY CHART Silty CLAY

FIG No B6

W P 6808-14-01

BlackBird Creek Culvert

SGS Canada Inc.
185 Concession St. Box 4300
Lakefield, Ont., Canada, K0L 2H0



Attention: Mark Farrant
Project#: 15595
Thurber Engineering Ltd.
CA14253-SEP17
Corrosivity (Soil)

Sample ID	Unit	BH-36, SS#2, 2.5'-4.5'
-----------	------	------------------------

Sample Date/Time 22-Aug-17

Moisture	%	27.9
pH	no unit	7.99
Corrosivity Index	none	2.0
Soil Redox Potential	mV	137
Sulphide	mg/L	<0.02
Chloride	mg/L	340.0
Sulphate	mg/L	10
Conductivity	uS/cm	397
Resistivity (calculated)	ohms.cm	2520

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

Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

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Client
SGS LIMS Number
Analysis Package:

Attention: Cory Zanatta
Project#: 15595, North Superior Lake Region
Thurber Engineering Ltd.
CA15829-AUG17
Corrosivity (Solution)

SGS Canada Inc.
185 Concession St.
Box 4300
Lakefield, Ont.
Canada, K0L 2H0

Sample ID	Unit	Blackbird Creek
Sample Date/Time		21-Aug-17
Moisture	%	NA
pH	no unit	7.78
Corrosivity Index	none	NA
Redox Potential	mV	224
Sulphide	mg/L	0.076
Chloride	mg/L	110
Sulphate	mg/L	180
Conductivity	uS/cm	1180
Resistivity (calculated)	ohms.cm	847

Corrosivity Scale according to AWWA C-105.
An index greater than 10 indicates the
soil matrix may be corrosive to cast iron alloys.

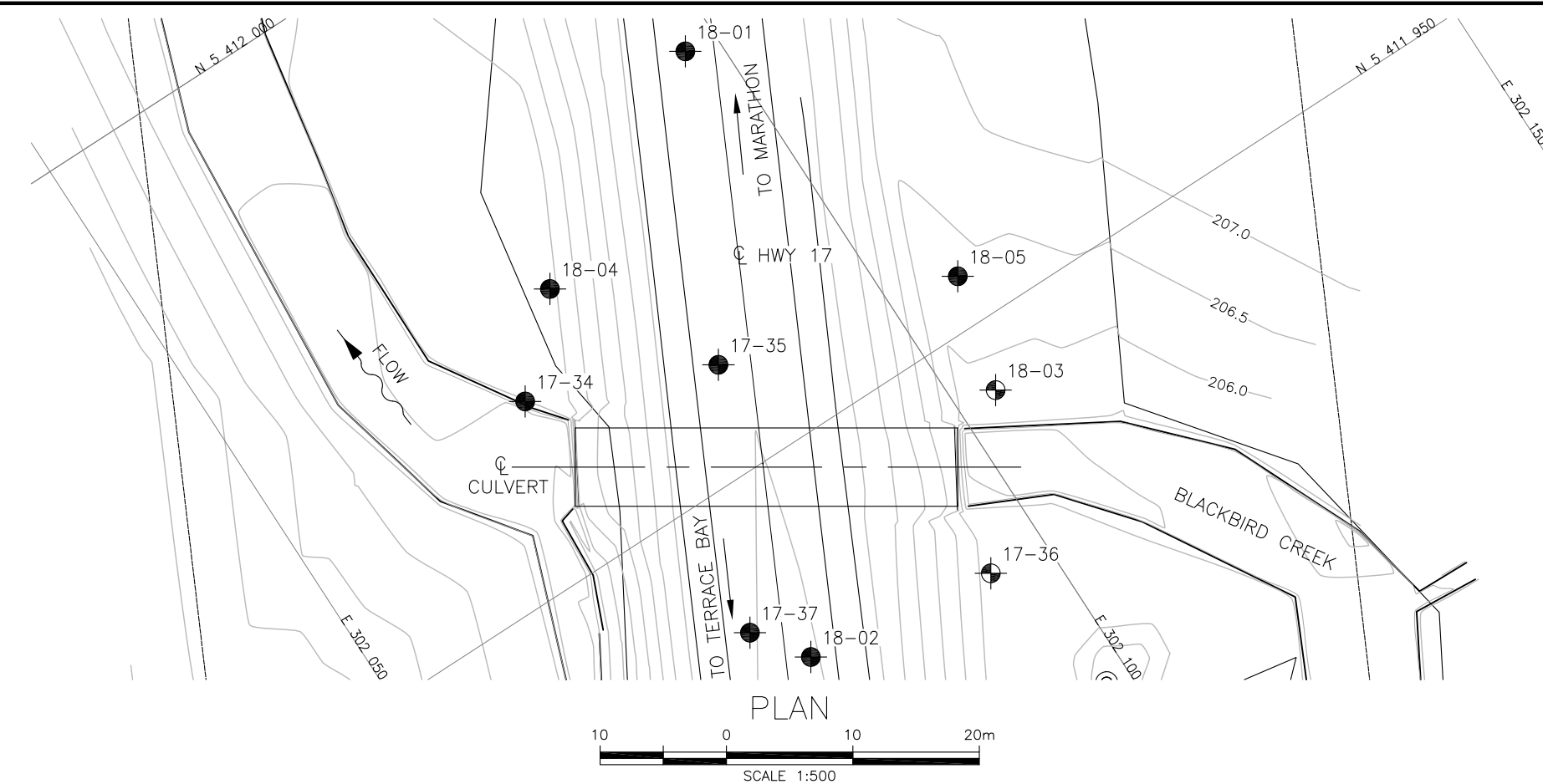
Deanna Edwards B.Sc., C.Chem
Project Specialist
Environment, Health and Safety

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(Printed copies are available upon request.). Test Method information available upon request. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.



Appendix C

Borehole Locations and Soil Strata Drawing

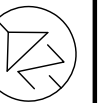


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No 2018-6018
WP No 6808-14-01

HIGHWAY 17
BLACKBIRD CREEK
CULVERT NO. 2
BOREHOLE LOCATIONS AND SOIL STRATA

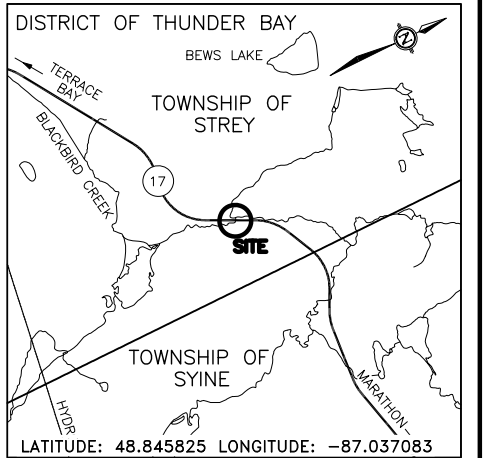


SHEET
9

HATCH



THURBER ENGINEERING LTD.



LEGEND

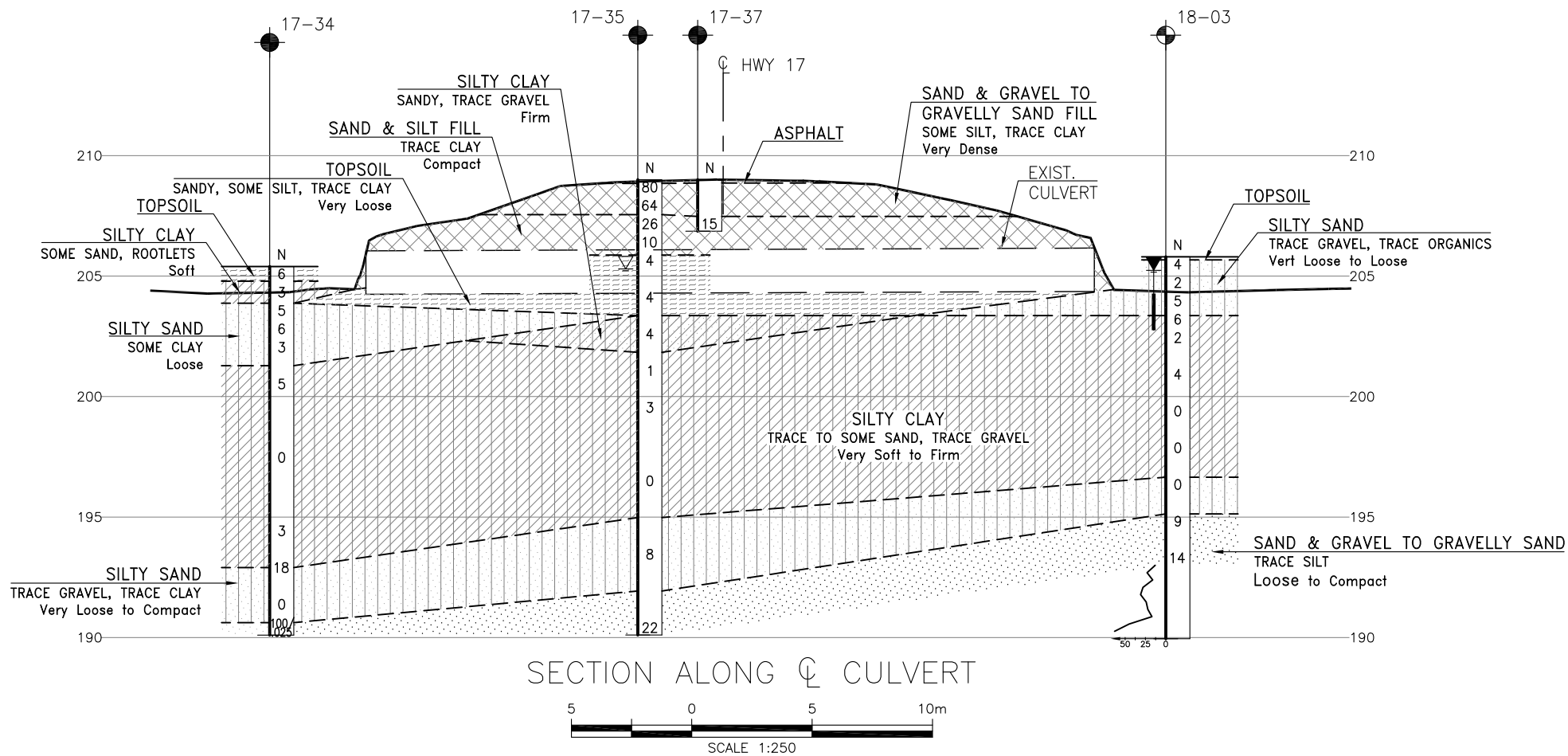
◆	Borehole
◆	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
⊕	Water Level
↑	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-34	205.4	5 411 964.3	302 071.6
17-35	209.0	5 411 958.4	302 086.0
17-36	205.9	5 411 932.8	302 095.1
17-37	209.0	5 411 939.3	302 076.6
18-01	208.9	5 411 980.6	302 097.3
18-02	209.0	5 411 935.0	302 079.6
18-03	205.8	5 411 944.8	302 103.3
18-04	205.7	5 411 970.7	302 078.1
18-05	206.3	5 411 954.0	302 105.7

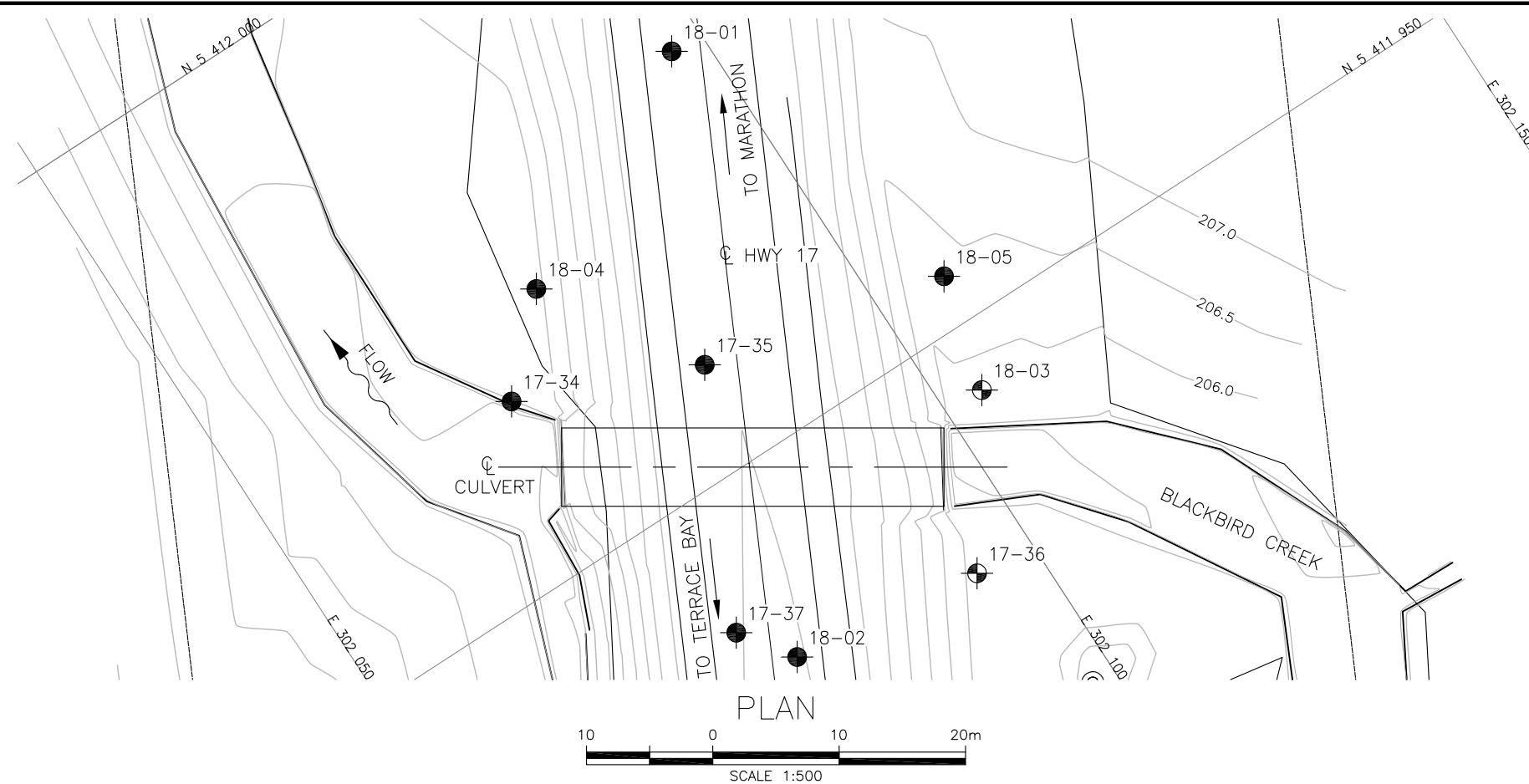
NOTES-

- 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.
- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D-54



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	CZ	CHK MEF	CODE
DRAWN	AN	CHK CZ	SITE 48E-052/C/STRUCT
			LOAD
			DATE
			NOV 2018
			DWG 2




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

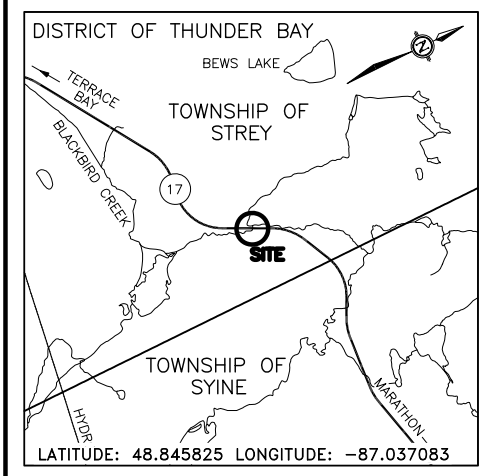


CONT No 2018-6018
WP No 6808-14-01

HIGHWAY 17
BLACKBIRD CREEK
CULVERT NO. 2
BOREHOLE LOCATIONS AND SOIL STRATA







SHEET
10

HATCH



KEYPLAN

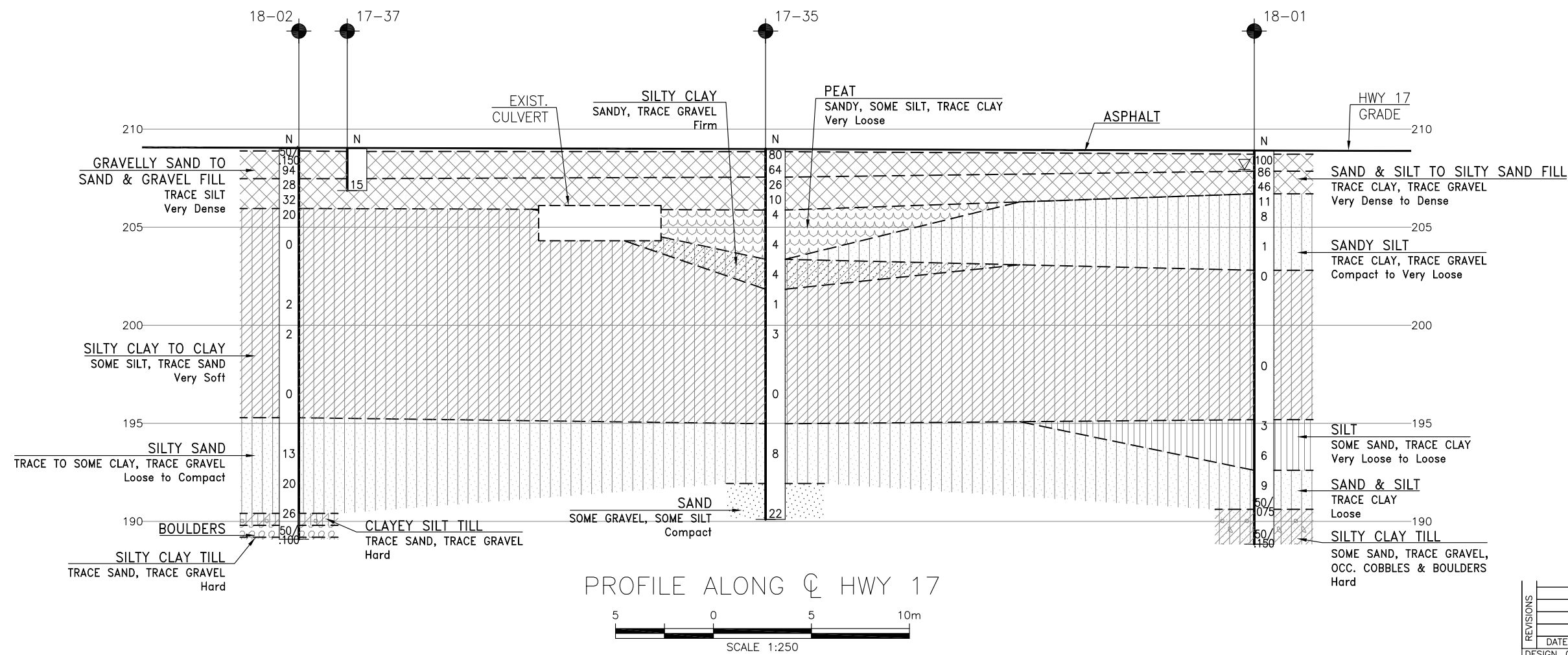
LEGEND

	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
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

-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.
- 3) Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D-54



REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	CZ	CHK	MEF	CODE	LOAD			DATE	NOV 2018
DRAWN	AN	CHK	CZ	SITE 48E-052/C	STRUCT			DWG	3



Appendix D

Site Photographs



Photo 1: Road approach looking south. Photo taken May 16, 2017.



Photo 2: Road approach looking north. Photo taken October, 2015.



Photo 3: East embankment looking north (inlet). Photo taken June 27, 2017.



Photo 4: East embankment looking south (inlet). Photo taken June 27, 2017.



Photo 5: West embankment looking south (outlet). Photo taken June 27, 2017.



Photo 6: Culvert outlet looking south. Photo taken May 16, 2017.



Photo 7: Culvert inlet looking west. Photo taken May 16, 2017.