THURBER ENGINEERING LTD.

FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT HIGHWAY 537 IMPROVEMENTS AND CULVERT REPLACEMENT 7.5 KM SOUTH OF HIGHWAY 17, STATION 18+280 TO 18+680
SITE NO.: 46-582

G.W.P. 5134-14-00

Geocres No.: 41I-353

Report to:

McIntosh Perry Consulting Engineers Limited

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FOUNDATION INVESTIGATION AND DESIGN REPORT HIGHWAY 537 IMPROVEMENTS AND CULVERT REPLACEMENT 7.5 KM SOUTH OF HIGHWAY 17, STATION 18+280 TO 18+680

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed culvert replacement at the Highway 537 crossing of Jumbo Creek (near Sta. 18+345) and highway improvements through a swamp crossing between approximate Station 18+280 and 18+680. The site is located in the Township of Cleland with the culvert structure located approximately 7.5 km south of the Highway 17. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to McIntosh Perry (MCPE) under Agreement No. 5015-E-0048.

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

An archived foundation investigation report that has been provided to Thurber and reviewed during preparation of this report is as follows:

> “Foundation Investigation Report, Jumbo Creek Alignment, Highway 537, Township of Cleland, Sudbury Area, Agreement No.: 5009-E-0061, GWP 5279-03-00”, prepared by DST Consulting Engineers Inc. of Thunder Bay, Ontario and dated July 5th, 2012 (Geocres No.: 41I00-286)

The relevant Record of Borehole sheets from the DST’s 2012 investigation report are provided in Appendix B. It must be noted that DST is solely responsible for the accuracy and quality of the subsurface information in their report.

2 SITE DESCRIPTION

2.1 Existing Conditions

The existing culvert is a concrete box culvert located near Sta. 18+345 on Highway 537 (Linear Highway Referencing System Base Point: 55302, Offset: 9.5). The culvert is reported to be 3.0 m wide by 1.5 m high and approximately 16.2 m long with a generally west to east flow alignment.

At the location of the culvert and along the highway embankment within the current study area, Highway 537 is a two-lane highway with a rural cross-section and relatively narrow gravel shoulders. A site-specific traffic count taken approximately 2 km north of the culvert was completed by MTO between July 19th to 26th, 2017 and extrapolated a traffic volume count of 800 AADT. The ground surface at all roadway boreholes locations from the culvert alignment and northward varied between 222.6 and 223.5 m indicating a relatively consistent elevation through the swamp. The lowest ground surface elevation in the locations of the off-road boreholes was recorded at 222.0 m. The road surface of the Highway 537 embankment is marginally higher than the adjacent swamp resulting in routine flooding and over-topping of the roadway surface. The existing highway side slopes are inclined at approximately 2.0H:1V. Steel guiderails with wooden posts are present on both sides of the highway in the area of the culvert. Overhead utilities are present along and crossing the highway.

The land adjacent to the highway is undeveloped and consists of wetlands with a high water table on both sides of the highway. The west side of the highway has a more pronounced ditch profile with a continual presence of standing water. Bedrock outcrops are visible adjacent to the highway alignment at the ends of the study area.

Select photographs showing the existing conditions within the study area are included in Appendix D for reference.

2.2 Construction History

The following list provides a brief outline of the known construction history based on historical documentation provided by MTO. This list is understood to be only a partial listing of the construction and maintenance activities undertaken at this site to date.

- 1966
    - Grade raise and alignment shift
    - 460 mm granulars
    - 457 mm sawdust
    - 610 mm of brush matte placed below sawdust
- 1967 to 1974
    - Settlement of 760 mm
    - No lifts of gravel placed since 1966
    - Ditches were excavated
    - Recommended 150 mm of Granular A grade placed per year
- 1983
    - 600 mm grade raise
- 1986
    - Widening with sawdust
    - Place 450 mm Granular B Type I on a geotextile
    - Place 150 mm Granular A
- 1992
    - Jumbo Creek culvert replacement
    - No grading in swamp area

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field testing program was carried out in conjunction with a pavement investigation between February 27th and March 25th, 2017 followed by a second round of drilling between July 17th and July 22nd. The second round of drilling for the off-road boreholes along the west side of the highway alignment was delayed to occur following the prescribed no in-water drilling restriction within fish and blanding turtle habitat areas. The field investigation consisted of advancing 48 sampled boreholes, 9 piezocone penetration tests (CPTu) and 1 electronic vane shear testing borehole. The investigated locations are spaced at approximately 25 m intervals along the length of highway. The distribution of investigated locations is summarized as follows:

Foundation Investigation

- 16 on-road boreholes sampled to refusal
    - 17-1 to 17-6, 17-8, 17-10 to 17-12, 17-16, 17-18 to 17-20, 17-22 and 17-24
- 2 off-road boreholes sampled to refusal with standpipe piezometer installation
    - 17-27 and 17-46
- 1 on-road borehole with electronic vane shear testing
    - 17-14
- 9 off-road boreholes with five including dynamic cone penetration testing (dCPT$^{(*)}$) to refusal
    - 17-29$^{(*)}$, 17-31$^{(*)}$, 17-32$^{(*)}$, 17-35$^{(*)}$, 17-39$^{(*)}$, 17-42 to 17-44 and 17-47
- 1 on-road seismic piezocone penetration testing (SCTPu) borehole
    - CPT1
- 5 on-road static piezocone penetration testing (CPTu) boreholes
    - CPT2 to CPT6
- 3 off-road static piezocone penetration testing (CPTu) boreholes
    - CPT7 to CPT9

Pavement Investigation

- 7 on-road boreholes with two including dynamic cone penetration testing (dCPT$^{(*)}$) to refusal
    - 17-7, 17-9, 17-13$^{(*)}$, 17-15, 17-17, 17-21 and 17-23$^{(*)}$
- 14 off-road boreholes with twelve including dynamic cone penetration testing (dCPT$^{(*)}$) to refusal
    - 17-25$^{(*)}$, 17-26$^{(*)}$, 17-28$^{(*)}$, 17-30$^{(*)}$, 17-33$^{(*)}$, 17-34$^{(*)}$, 17-36$^{(*)}$, 17-37$^{(*)}$, 17-38$^{(*)}$, 17-40$^{(*)}$, 17-41$^{(*)}$, 17-45$^{(*)}$, 17-48 and 17-49

All pavement boreholes will be included in a separate Pavement Design Report however, the pavement boreholes have also been included within this report for completeness as they provide relevant foundation information as well.

The drilling for the current investigation was carried out using portable tripod equipment for the off-road boreholes and a truck mounted CME 75 drill rig for the on-road boreholes. A barge with portable drilling equipment was utilised to drill the boreholes along the west side of the highway alignment that were completed during the second round of drilling. The six on-road CPTu tests (identified as CPT1 through CPT6) were pre-augered through the fill soils with the CME 75 drill rig and then pushed with truck mounted equipment. The three off-road CPTu tests (identified as CPT7 through CPT 9) were pushed with a geoprobe drill rig. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Boreholes drilled with a portable tripod equipment also utilized a full-weight hammer for SPT testing. Thin Walled (Shelby) Tube samples of the peat and clay deposits were retrieved within several boreholes at various elevation to obtain relatively undisturbed soil samples for further laboratory testing. The boreholes were advanced to depths ranging from 0.9 to 30.6 m (elev. 221.8 to 191.2 m) below the existing ground surface. As indicated above, nineteen boreholes were extended below the sampling depth with a dynamic cone penetration test.

The piezocones were statically pushed into the ground and continuous measurements of cone tip resistance, sleeve friction and dynamic pore water pressure were obtained. Pore pressure dissipation tests were carried out at selected depths. ConeTec's report in it's entirety with the inferred stratigraphy and soil paraments from CPTu testing and results of pore pressure dissipation tests is included in Appendix E

The drilling, sampling operations and piezocone testing were supervised on a full-time basis by members of Thurber's technical staff. The drilling supervisors logged the boreholes and processed the recovered soil samples for transport for further laboratory examination and testing.

A standpipe piezometer was installed in off-road Boreholes 17-27 and 17-46 to observe groundwater conditions after completion of drilling. The piezometers consisted of a 51 mm diameters PVC pipe with a 3.0 m long slotted screen installed within a filter sand. Rising head conductivity tests were completed within the standpipe piezometers between June 5th and 6th, 2017. The tests consisted of lowering the water level within the standpipe piezometer and then recording the recovery of the water level with the use of a datalogger over an elapsed time of approximately 21 hrs. The two standpipe piezometers are still available for additional monitoring. The standpipe piezometers should be decommissioned in accordance with O.Reg. 903 as part of the construction contract.

The remaining boreholes, without a standpipe piezometer installation, were backfilled in general accordance with MOEE requirements (O.Reg. 903) following completion of drilling. The on-road boreholes were capped with cold patch asphalt to reinstate the travelling surface.

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

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to Atterberg Limit testing and gradation analysis (hydrometer and/or sieve). The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. Relatively undisturbed soil samples obtained with Thin Walled (Shelby) Tubes underwent advanced testing including eight one-dimensional consolidation tests and two consolidated undrained triaxial tests. Thirty samples were tested for organic content. Five samples of soil recovered from within the boreholes and two grab samples were selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general terms, the stratigraphy encountered for the on-road boreholes consisted of highway embankment fill overlying peat, over a discontinuous layer of predominantly silt underlain by a thick deposit of clay, underlain by a silt to sand layer over inferred bedrock. Although bedrock was not cored during the current investigation, bedrock was both visible near the ends of the study area and boreholes were inferred to encounter refusal on bedrock.

5.1 Culvert Crossing (Sta. 18+345)

Four foundation boreholes (17-4, 17-5, 17-46 and 17-47) and one seismic piezocone (CPT1) were advanced to refusal near the alignment of the existing Jumbo Creek culvert. The results of the borehole investigation are provided below and the results of the SCPTu investigation is included within ConeTec's report provided in Appendix E. Borehole 17-46 included a standpipe piezometer installation for groundwater level monitoring.

5.1.1 Embankment Fill

5.1.1.1 Asphalt

Asphalt was encountered at the ground surface in Boreholes 17-4,17-5 and CPT1 which were drilled from the roadway surface. The asphalt thickness ranged between 60 and 85 mm.

5.1.1.2 Fill: Sand

Directly below the asphalt, in the on-road boreholes, was a fill layer of sand with silt and gravel. Off-road Boreholes 17-46 and 17-47 also encountered a sand with gravel fill layer at the ground surface. The granular fill had an underside depth of 1.5 to 3.7 m (elevation 221.3 to 219.6 m).

SPT tests in the on-road granular fill, below the depth of frost, recorded N-values typically ranging from 10 to 19 blows indicating compact conditions. N-values in the fill in the off-road boreholes ranged from 2 to 8 blows indicating a very loose to loose relative density. Recorded moisture contents ranged from 4 to 19%

Gradation analysis was completed on three samples of the granular fill. The grain size distribution curve for this sample is included in Figure C1 of Appendix C. The results of the test are summarized below and is presented on the corresponding Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	31 to 42
Sand	51 to 61
Silt	5 to 8
Clay	

5.1.2 Peat

A deposit of peat was encountered below the granular fill in Boreholes 17-5, 17-46 and 17-47. The peat thickness varied from 800 mm to 1.1 m with an underside depth at 2.3 to 3.4 m (elevation 220.4 to 220.0 m).

SPT N-values within the peat deposit ranged from 2 to 3 blows. A single field vane test provided a shear strength of 34 kPa. Moisture contents of 114 to 343% were recorded. A single test provided an organic content of 11.3%.

5.1.3 Silt to Sandy Silt

A deposit of silt was encountered below the granular fill in Borehole 17-4 and below the peat in Boreholes 17-5, 17-46 and 17-47. The silt layer varied in composition from silt to silt with some sand to sandy silt. The silt layer thickness ranged from 900 mm to 1.2 m with an underside depth at 3.5 to 4.6 m (elevation 219.0 to 218.7 m).

SPT tests in the silt recorded N-values ranging from 6 to 15 blows indicating loose to compact conditions. Recorded moisture contents ranged from 17 to 27%.

Gradation analysis was completed on three samples of the silt. The grain size distribution curves are included in Figure C2 of Appendix C. The results of the test are summarized below and is presented on the corresponding Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 6
Sand	4 to 32
Silt	55 to 86
Clay	7 to 12

5.1.4 Clay

Below the silt deposit in all four boreholes was a deposit of clay. The thickness of the clay ranged from 4.7 to 8.7 m with an underside depth of to 8.5 to 13.3 m (elevation to 214.3 to 210.1 m). Borehole 17-47 was terminated in the clay at a refusal depth of 4.8 m (elevation 217.9 m).

SPT tests performed within the clay deposit gave N-values typically ranging from weight of rods to 1 blow with a single test in Borehole 17-47 exhibiting an N-Value of 3. Field vane tests were performed within the deposit and recorded undrained shear strengths typically ranging from 10 to 26 kPa, gradually increasing with depth. The clay is very soft to firm in consistency. Remolded field vane testing indicates that the clay shows some sensitivity. The recorded moisture contents varied from 31 to 73%

Gradation analyses were completed on seven samples of the clay deposit. The grain size distribution curves for these samples are included in Figures C3 and C4 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	0 to 3
Silt	25 to 37
Clay	61 to 75

Atterberg Limit testing was completed on seven samples of the clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figures C30 and C31 of Appendix C. The laboratory results are summarized below and indicate that the clay varies from low to high plasticity (CL to CH).

Parameter	Value
Liquid Limit	47 to 56
Plastic Limit	21 to 24
Plasticity Index	24 to 32

An Oedometer (one-dimensional consolidation) test was carried out on a relatively undisturbed sample obtained from a Thin Walled (Shelby) tube sample taken in Borehole 17-05 at a depth of 6.4 m below the road surface during the current field investigation. The results are presented in Appendix C and summarized in the following table. The compressibility characteristics will vary with depth in accordance with the soil index parameters and stress history.

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

Parameter		Units	Borehole 17-5
Sample Depth (Elevation)		m	6.4 (216.9)
Natural Moisture Content, w_n		%	63
Initial Void Ratio, e_o		-	1.70
Unit Weight, γ		kN/m^3	16.1
Existing Vertical Effective Stress, σ'_{vo}		kPa	53
Preconsolidation Pressure, σ'_c		kPa	59
Over Consolidation Ratio, OCR		-	~1.1
Recompression Zone	Recompression Index, C_r	-	0.067
	Coefficient of Consolidation, c_{vr}	cm^2/s	2.5×10^{-3}
	Average Permeability, k_{vr}	m/s	1.5×10^{-11}
Virgin Compression Zone	Compression Index, C_c	-	1.03
	Coefficient of Consolidation, c_v	cm^2/s	1.5×10^{-4}
	Average Permeability, k_v	m/s	1.2×10^{-11}
Modulus of Elasticity (Constrained), E_c		kPa	1450

5.1.5 Silt to Silty Sand

A deposit varying from silt to silty sand was encountered below the clay in Boreholes 17-5 and 17-46. Both boreholes were terminated upon refusal at a depth of 8.9 to 14.9 m (elevation 213.9 to 208.5 m). A single representative SPT N-value of 6 blows was recorded in this layer indicating a loose consistency. Recorded moisture contents ranged from 11 to 26%. One gradation analysis was completed and indicated a material with 6% gravel, 50% sand, 35% silt and 9% clay. The results of the grain size analysis are illustrated on Figure C5 in Appendix C.

5.1.6 Inferred bedrock

Bedrock outcrops were visible in close proximity to the culvert alignment. Bedrock coring was not required as part of the scope of the current investigation, however all boreholes were advanced to refusal on inferred bedrock. A summary of refusal depth is provided in the table below:

Table 5-2 Refusal Depth

Southbound Lane		Northbound Lane		Off-Road	
Location ID	Refusal Depth* (m)	Location ID	Refusal Depth* (m)	Location ID	Refusal Depth* (m)
17-4	13.1 (210.2)	17-5	14.9 (208.5)	17-46 17-47	8.9 (213.9) 4.8 (217.9)

Note: (*) value in brackets is base elevation in meters

5.2 Swamp Crossing (Sta. 18+280 to 18+680)

Forty-eight boreholes and nine piezocones (CPTu) were advanced along the alignment of the swamp crossing in addition to one electronic vane shear testing borehole. The results of the borehole investigation are provided below and the results of the CPTu and electronic shear vane investigations are included within ConeTec's report provided in Appendix E. Boreholes 17-27 and 17-46 included a standpipe piezometer installation for groundwater level monitoring.

5.2.1 Embankment Fill

5.2.1.1 Asphalt/Surface Treatment

Asphalt/Surface Treatment was encountered at the ground surface in Boreholes 17-1 through 17-24 which were drilled on the highway. A summary of the thickness of the asphalt/surface treatment at each investigated location is presented below.

Table 5-3 Asphalt Thickness

Southbound Lane		Northbound Lane	
Location ID	Pavement Thickness (mm)	Location ID	Pavement Thickness (mm)
17-1	25, 25*	17-2	35
		17-3	40
17-4	85	17-5	60
		CPT1	60
17-6	40, 50*	17-7	60, 30*, 40*
CPT2	60	17-8	40
17-9	60, 30*, 50*	17-10	30
17-11	25	CPT3	60
17-12	25	17-13	25
CPT4	60		
17-14	30	17-15	70
17-16	15	CPT5	60
17-17	60	17-18	30
		17-19	25
17-20	25	17-21	30
17-22	30	CPT6	60
17-23	25, 30*	17-24	60

Note: (*) buried within granular embankment fill

5.2.1.2 Fill: Sand

Directly below the asphalt in the on-road boreholes was a fill layer varying from sand with gravel to sand with silt and gravel. Borehole 17-2 encountered a layer of silty sand fill. Off-road Boreholes 17-28, 17-30, 17-34, 17-36, 17-41 and 17-45 to 17-47 also encountered a fill layer consisting of sand with gravel and organics at the ground surface. The granular fill within in the on-road boreholes had an underside depth of 1.6 to 3.8 m (elevation 222.2 to 219.0 m). Intermittently within the granular fill were layers of wood chips/sawdust as discussed further in Section 5.2.1.3. Wooden pieces/logs were also encountered in the granular fill within Boreholes 17-9, 17-10, 17-13, 17-17 and 17-21 and are included in the summary provided in Table 5-4. Occasional cobbles were noted in Borehole 17-12 and 17-22.

SPT tests in the granular fill, below the depth of frost, recorded N-values typically ranging from 4 to 90 blows indicating loose to very dense conditions. N-values recorded within the depth of frost reached values in excess of 100 blows. SPT tests completed within the fill layers in the off-road boreholes were as low as the equivalent of the weight of hammer. Recorded moisture contents typically ranged from 2 to 30%. Moisture contents as high as 227% were recorded in the fill layers directly below the inundated ditch from within the off-road boreholes. An organic content of 0.4% was measured in a sample from Borehole 17-20

Gradation analysis was completed on 31 samples of the granular fill. The grain size distribution curve for this sample is included in Figure C6 to C11 of Appendix C. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)	
	Sand with Gravel	Silty Sand
Gravel	12 to 51	2
Sand	44 to 81	74
Silt	1 to 11	24
Clay		

5.2.1.3 Fill: Wood Chips/Sawdust

Layers of wood chips/sawdust fill were encountered within the granular fill and at locations below the granular fill in several boreholes. A summary of the thickness of the wood chips/sawdust fill, where encountered at each investigated location, is presented below. At some locations tarpaulin was noted at the interface of the wood chips/sawdust and the adjacent soil layer.

Table 5-4 Wood Chips/Sawdust Thickness

Southbound Lane		Northbound Lane	
Location ID	Wood Chips/Sawdust Thickness* (m)	Location ID	Wood Chips/Sawdust Thickness* (m)
CPT2	0.15 (1.1)		
17-9	0.25 (1.0), 1.0 (3.8)	17-10	0.1 (0.75)
17-11	0.3 (1.2)	CPT3	0.3 (1.4)
17-12	0.3 (1.8)	17-13	1.3 (2.3)
CPT4	0.1 (1.8)		
17-14	0.3 (1.8)	17-15	0.3 (1.5)
17-16	0.3 (1.8)	CPT5	0.9 (1.7)
17-17	0.2 (0.8), 0.5 (2.0)	17-18	0.6 (2.3)
		17-19	0.6 (2.1)
17-20	0.3 (1.8)	17-21	0.4 (1.7), 0.4 (3.4)
17-22	0.3 (1.8)	CPT6	0.3 (N/A)
17-23	0.2 (2.1)	17-24	0.9 (3.6)

Note: (*) value in brackets is base depth in meters

Where the thickness of the wood chips/sawdust fill layer was greater then 610 mm, SPT tests recorded N-values typically ranging from 7 to 22 blows indicating loose to compact conditions. Recorded moisture contents ranged from 37 to 436%. Organic contents of 3.0%, 51.5% and 65.4% were measured in samples from Boreholes 17-9, 17-16 and 17-20, respectively.

5.2.2 Peat

A layer of peat was encountered below the fill layers in on-road Boreholes 17-5 through 17-24. Peat was also encountered in all off-road borehole either at the ground surface, below the surficial snow/ice/water present at the time of drilling or below fill as noted in Boreholes 17-28, 17-30, 17-34, 17-36, 17-41, 17-45 to 17-47. A summary of the thickness of the peat, at each investigated location, is presented below.

Table 5-5 Peat Thickness

Southbound Lane		Northbound Lane		Off-Road	
Location ID	Peat Thickness* (m)	Location ID	Peat Thickness* (m)	Location ID	Peat Thickness* (m)
17-1	N/A	17-2	N/A	17-48	N/A
		17-3	N/A	17-49	N/A
17-4	N/A	17-5	1.1 (3.4)	17-46 17-47	1.1 (2.6) 0.8 (2.3)
17-6	1.8 (4.1)	17-7	1.4 (3.8)	17-44 17-45	3.1 (3.4) 0.8 (2.7)
		17-8	2.5 (4.3)	17-42 17-43	3.1 (3.5) 3.5 (3.5)
17-9	1.5 (5.3)	17-10	3.2 (5.2)	17-40 17-41	3.8 (4.7) 3.1 (4.5)
17-11	2.2 (5.6)			17-39	4.9 (4.9)
17-12	3.1 (6.9)	17-13	3.3 (5.6)	17-37 17-38	5.0 (5.9) 4.6 (5.6)
				17-35 17-36	5.0 (5.9) 4.8 (6.0)
17-14	3.1 (6.6)	17-15	2.3 (5.8)	17-33 17-34	5.0 (5.2) 3.7 (5.6)
17-16	2.6 (6.4)				
17-17	2.6 (6.4)	17-18	3.3 (5.6)	17-31 17-32	4.4 (5.0) 5.0 (5.6)
		17-19	3.7 (6.1)	17-29 17-30	3.5 (3.7) 3.3 (5.5)
17-20	2.4 (6.1)	17-21	2.7 (6.1)	17-27 17-28	2.8 (3.7) 2.9 (5.2)
17-22	1.6 (5.3)				
17-23	2.3 (5.5)	17-24	1.0 (4.6)	17-25 17-26	2.2 (3.1) 3.1 (4.1)

Note: (*) value in brackets is base depth in meters below ground or water surface at the time of drilling

The peat thickness beneath the highway was observed to range from 0 to 3.3 m with the elevation of the base of the layer ranging from 215.9 to 220.0 m. The peat thickness observed in the off-road boreholes ranged from 0 to 5.0 m with the underside elevation of the peat layer ranging from 216.6 to 220.4 m.

For boreholes drilled through the highway embankment, SPT tests performed within the peat deposit gave N-values typically ranging from 2 to 8 blows. Field vane tests were performed within the deposit and recorded undrained shear strengths typically ranging from 26 to 87 kPa. The peat is firm to stiff in consistency. The recorded moisture contents varied from 99 to 555% with a single value as high as 1100% recorded in Borehole 17-16.

Organic content measurements of 11.3, 21.8, 51.8, 54.7, 62.0, 65.3, 69.5, 70.2, 78.6 and 89.0% were obtained for select samples of the peat from within the on-road boreholes.

For off-road boreholes, SPT tests performed within the peat deposit gave N-values typically ranging from weight of hammer to 2 blows. Field vane tests were performed within the deposit and recorded undrained shear strengths typically ranging from 9 to 42 kPa. The peat is soft to firm. The recorded moisture contents varied from 132 to 1144%. Organic content measurement of 18.6, 47.0, 52.6, 52.8, 54.1, 56.2, 57.7, 62.9, 68.3, 73.9, 75.2, 85.3 and 90.3% were obtained for select samples of peat from within the off-road boreholes.

Two Oedometer (one-dimensional consolidation) test were carried out on relatively undisturbed samples obtained from Thin Walled (Shelby) tube samples taken in Boreholes 17-18 and 17-37 at depths of 4.1 and 4.9 m below the ground surface during the current field investigation. The results are presented in Appendix C and summarized in the following table. The compressibility characteristics will vary with depth in accordance with the soil index parameters and stress history.

Table 5-6. Summary of Oedometer Test Results and Interpretations

Parameter		Units	Borehole 17-18	Borehole 17-37
Sample Depth (Elevation)		m	4.1 (218.7)	4.9 (218.1)
Natural Moisture Content, w_n		%	555	843
Initial Void Ratio, e_o		-	10.46	13.44
Unit Weight, γ		kN/m^3	8.1	10.1
Existing Vertical Effective Stress, σ'_{vo}		kPa	21	2
Preconsolidation Pressure, σ'_c		kPa	27	2
Over Consolidation Ratio, OCR		-	1.3	~1
Recompression Zone	Recompression Index, C_r	-	0.62	N/A
	Coefficient of Consolidation, c_{vr}	cm^2/s	1.0×10^{-2}	N/A
Virgin Compression Zone	Compression Index, C_c	-	5.99	8.42
	Coefficient of Consolidation, c_v	cm^2/s	1.2×10^{-3}	1.1×10^{-4}
Modulus of Elasticity (Constrained), E_c		kPa	280	105
Organic Content		%	89	56

5.2.3 Silt to Sandy Silt

A layer of silt with varying amounts of sand and gravel was encountered below the fill and/or peat layers. Organics were noted in this silt layer at some locations. A summary of the thickness of the silt, where encountered at each investigated location, is presented below.

Table 5-7 Silt Thickness

Southbound Lane		Northbound Lane		Off-Road	
Location ID	Silt Thickness* (m)	Location ID	Silt Thickness* (m)	Location ID	Silt Thickness* (m)
17-1	1.3 (3.1**)	17-2	1.3 (3.3**)	17-78	1.5 (1.8)
		17-3	1.3 (3.0)	17-49	0.1 (0.9)
17-4	0.9 (4.6)	17-5	1.2 (4.6)	17-46 17-47	1.2 (3.8) 1.2 (3.5)
17-6	0.8 (4.9)	17-7	1.4 (5.2**)	17-44 17-45	0.4 (3.8) 0.6 (3.3**)
		17-8	1.0 (5.3)	17-42 17-43	N/A 0.3 (3.8)
17-9	N/A	17-10	N/A	17-40 17-41	1.4 (6.1) 0.2 (4.7**)
17-11	0.3 (5.9)			17-39	0.7 (5.6)
17-12	0.7 (7.6)	17-13	N/A	17-37 17-38	1.0 (6.9) 0.3 (6.1**)
				17-35 17-36	0.7 (6.6) 0.3 (6.3**)
17-14	1.3 (7.9)	17-15	0.9 (6.7**)	17-33 17-34	0.7 (5.9) 0.9 (6.5**)
17-16	0.8 (7.2)				
17-17	0.3 (6.7**)	17-18	N/A	17-31 17-32	N/A N/A
		17-19	0.6 (6.7)	17-29 17-30	N/A N/A
17-20	0.6 (6.7)	17-21	N/A	17-27 17-28	N/A N/A
17-22	0.8 (6.1)				
17-23	N/A	17-24	0.7 (5.3)	17-25 17-26	0.7 (3.8) 0.5 (4.6)

Note: (*) value in brackets is base depth in meters below ground or water surface at the time of drilling, (**) sampled borehole terminated at this depth

Where present, the silt ranged in thickness from 0.1 to 1.4 m. The elevation of the underside of the silt layer ranged from 215.0 to 221.8 m.

SPT N-values within the silt recorded N-values ranging from weight of hammer to 18 blows indicating very loose to compact relative density. Recorded moisture contents typically ranged from 17 to 55%, with one sample in Borehole 17-8 having a moisture content as high 82%. Organic contents of 1.8 and 2.8% were measured from samples within Boreholes 17-20 and 17-16, respectively.

Gradation analysis was completed on twenty-four samples of the silt. The grain size distribution curve for this sample is included in Figure C12 to C15 of Appendix C. The results of the test are summarized below and are presented on the corresponding Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)		
	Silt to Silt some Sand	Silt with Gravel	Sandy Silt
Gravel	0 to 1	17	6
Sand	0 to 11	9	32
Silt	64 to 90	54	55
Clay	10 to 35	20	7

5.2.4 Sand

Below the silt in Boreholes 17-3 and 17-39 and below the fill in Borehole 17-42 was a sand layer varying in composition from silty sand to sand with silt. Where fully penetrated, the thickness of the layer ranged from 0.4 to 0.8 m with an underside depth of 3.4 to 6.4 m (elevation 220.4 to 216.4 m). Recorded moisture contents ranged from 9 to 37%. One gradation analysis was completed and indicated a material with 13% gravel, 75% sand, 6% silt and 6% clay. The results of the grain size analysis are illustrated on Figure C16 in Appendix C.

5.2.5 Clay

A deposit of clay was encountered below the soil layers noted in Sections 5.2.1 to 5.2.4. Silt seams were noted within the deposit. A summary of the thickness of the clay, where encountered at each investigated location, is presented below.

Table 5-8 Clay Thickness

Southbound Lane		Northbound Lane		Off-Road	
Location ID	Clay Thickness* (m)	Location ID	Clay Thickness* (m)	Location ID	Clay Thickness* (m)
17-1	N/A	17-2	N/A	17-48	1.3 (3.1)
		17-3	N/A	17-49	N/A
17-4	8.5 (13.1)	17-5	8.7 (13.3)	17-46	4.7 (8.5)
				17-47	1.3 (4.8**)
17-6	13.8 (18.7)	17-7	(***)	17-44	14.8 (18.3**)
				17-45	14.2 (17.5**)
		17-8	12.5 (17.8)	17-42	13.6 (17.7)
				17-43	12.7 (16.5)
17-9	(***)	17-10	13.1 (18.3)	17-40	11.9 (18.0**)
				17-41	11.9 (16.6**)
17-11	18.5 (24.4)			17-39	16.8 (23.2**)
17-12	17.9 (25.5)	17-13	20.6 (26.2**)	17-37	18.7 (25.6**)
				17-38	18.2 (24.3**)
				17-35	19.3 (25.9**)
				17-36	19.3 (25.6**)
17-14	17.4 (25.3**)	17-15	(***)	17-33	17.6 (23.5**)
				17-34	16.6 (23.1**)
17-16	19.8 (27.0)				
17-17	(***)	17-18	18.0 (23.6)	17-31	21.5 (26.5**)
				17-32	22.7 (28.3**)
		17-19	16.9 (23.6)	17-29	18.2 (21.9)
				17-30	22.8 (28.3**)
17-20	16.4 (23.1**)	17-21	(***)	17-27	14.9 (18.6)
				17-28	19.0 (24.2**)
17-22	14.9 (21.0**)				
17-23	10.5 (16.0**)	17-24	5.9 (11.2)	17-25	2.6 (6.4**)
				17-26	16.1 (20.7**)

Note: (*) value in brackets is base depth in meters below ground or water surface at the time of drilling, (**) below sampled depth and inferred from DCPT, (***) pavement investigation boreholes terminated before reaching base of a clay layer

Where present, the thickness of the clay layer ranged from 0 to 22.8 m. The elevation of the base of the unit ranged from 194.3 to 219.2 m.

SPT tests performed within the clay deposit gave N-values ranging from weight of rods to 1 blow with higher values of 5 and 3 blows only obtained near the surface of the layer in Borehole 17-9 and 17-47, respectively. Field vane tests were performed within the deposit and recorded undrained shear strengths typically ranging from 7 to 42 kPa, generally increasing with depth. The clay is very soft to firm. The electronic field vane shear testing completed in Borehole 17-14 and interpretation of undrained strengths from CPTu test results compare closely to the values obtained with mechanical field vane readings.

Remolded field vane testing indicates that the clay shows some sensitivity. The recorded moisture contents varied from 31 to 95%. A single organic content of 2.4% was obtained within Borehole 17-42.

Gradation analyses were completed on seventy samples of the clay deposit. The grain size distribution curves for these samples are included in Figures C17 through C28 of Appendix C. The results of the tests are summarized below and are presented on the corresponding Record of Borehole sheets in Appendix B.

Soil Particle	Percentage (%)
Gravel	0 to 3
Sand	0 to 10
Silt	25 to 61
Clay	34 to 75

Atterberg Limit testing was completed on seventy samples of the clay deposit. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C32 through C43 of Appendix C. The laboratory results are summarized below and indicate that the clay varies from low to high plasticity (CL to CH).

Parameter	Value
Liquid Limit	30 to 56
Plastic Limit	17 to 24
Plasticity Index	12 to 32

A relatively undisturbed Thin-Walled (Shelby) tube sample from Boreholes 17-8 and 17-19 underwent consolidated undrained triaxial testing with pore water pressure measurements. Strength parameter of $c' = 9$ kPa and $\phi' = 25^{o}$ and $c' = 6$ kPa and $\phi' = 25^{o}$ was obtained from Borehole 17-8 and 17-19, respectively. The results are provided in Appendix C.

Six Oedometer (one-dimensional consolidation) tests were carried out on relatively undisturbed samples obtained from Thin Walled (Shelby) tube samples taken at depths of 6.4, 7.9, 9.4, 12.5, 14.0 and 18.6 m below the ground surface during the current field investigation. The results are presented in Appendix C and summarized in the following table. The interpretation of over consolidation ratio from CPTu test results compare closely with the results of the oedometer testing. The compressibility and strength characteristics will vary with depth in accordance with the soil index parameters and stress history. The horizontal coefficient of consolidation, c_h, from CPTu dissipation tests conducted in the clay typically ranged from 0.16 to 0.64 cm^2/min

Table 5-9. Summary of Oedometer Test Results and Interpretations

Parameter		Units	Borehole 17-5	Borehole 17-19	Borehole 17-19	Borehole 17-35	Borehole 17-43	Borehole 17-29
Sample Depth (Elevation)		m	6.4 (216.9)	14.0 (208.7)	18.6 (204.1)	7.9 (215.2)	9.4 (213.4)	12.5 (210.3)
Natural Moisture Content, w_n		%	63	67	65	64	60	68
Initial Void Ratio, e_o		-	1.70	1.81	1.78	1.73	1.64	1.84
Unit Weight, γ		kN/m^3	16.1	15.8	15.8	15.9	16.3	15.7
Existing Vertical Effective Stress, σ'_{vo}		kPa	53	73	101	21	43	56
Preconsolidation Pressure, σ'_c		kPa	59	75	131	44	43	90
Over Consolidation Ratio, OCR		-	~1.1	~1	1.3	2.1	~1	1.6
Recompression Zone	Recompression Index, C_r	-	0.067	0.020	0.029	0.01	0.11	0.044
	Coefficient of Consolidation, c_{vr}	cm^2/s	$2.5x10^{-3}$	$1.9x10^{-2}$	$1.2x10^{-2}$	$1.5x10^{-2}$	$9.7x10^{-4}$	$2.3x10^{-2}$
	Average Permeability, k_{vr}	m/s	$1.5x10^{-11}$	$3.9x10^{-9}$	$2.0x10^{-9}$	$2.1x10^{-9}$	$1.2x10^{-9}$	$9.5x10^{-9}$
Virgin Compression Zone	Compression Index$^{(*)}$, C_c	-	1.03	1.56	0.96	0.81	0.71	1.07
	Coefficient of Consolidation, c_v	cm^2/s	$1.5x10^{-4}$	$9.2x10^{-4}$	$7.3x10^{-4}$	$6.9x10^{-4}$	$1.1x10^{-4}$	$5.1x10^{-4}$
	Average Permeability, k_v	m/s	$1.2x10^{-11}$	$3.4x10^{-10}$	$1.1x10^{-10}$	$3.9x10^{-10}$	$7.2x10^{-11}$	$3.1x10^{-10}$
Modulus of Elasticity (Constrained), E_c		kPa	1450	3600	5525	1125	740	2400

Note: (*) compression index calculated over range encapsulated within the expected loading stress zone

5.2.6 Silty Clay

A 3.1 m thick layer of silty clay was encountered in Borehole 17-18 below the clay. The base of the silty clay was at a depth of 26.7 m (elevation 196.2 m). A single SPT test was completed with a recorded N-value equivalent to the weight of rods. Field vane tests provided undrained shear strengths of 21 to 34 kPa. A moisture content of 35% was recorded. One gradation analysis was completed and indicated a material with 74% silt and 26% clay. The Results of the grain size analysis are illustrated on Figure C29 in Appendix C. Atterberg limit testing provided a LL of 23 and PL of 18 indicating a CL-ML material and the results are shown on Figure C44 of Appendix C.

5.2.7 Silt to Silty Sand

Below the clay and silty clay layers was a deposit varying from silt to silt with sand to sandy silt to silty sand. The thickness of this layer ranged from 0.3 to 4.2 m (base elevation 213.9 to 191.2 m). This layer was observed or inferred in Boreholes 17-5, 17-6, 17-8, 17-10 to 17-14, 17-16, 17-18, 17-19, 17-23, 17-26 to 17-47 and 17-49. Where this soil deposit was encountered, the boreholes were terminated at the base of the layer. It should be noted that the off-road boreholes did not allow for sampling at the depths and therefore the continuity of this layer may extend into more locations than noted.

SPT tests performed within the silt to silty sand layers gave N-values ranging from 2 to 42 blows before reaching refusal blow counts on inferred bedrock at the base of the layer. The recorded moisture contents varied from 11 to 36% with a single value as high as 55% in Borehole 17-27.

Gradation analysis was completed on eight samples of the silt to sandy silt deposit. The grain size distribution curve for this sample is included in Figure C30 to C31 of Appendix C. The results of the test are summarized below and is presented on the corresponding Record of Borehole sheet in Appendix B.

Soil Particle	Percentage (%)	
	Silt to Sandy Silt	Silty Sand
Gravel	0 to 3	6
Sand	0 to 30	50
Silt	62 to 89	35
Clay	5 to 35	9

5.2.8 Inferred bedrock

Bedrock outcrops were visible near the limits of the swamp crossing. Bedrock coring was not required as part of the scope of the current investigation, however several boreholes were advanced to refusal on inferred bedrock. A summary of refusal depth is provided in the table below:

Table 5-10 Refusal Depth

Southbound Lane		Northbound Lane		Off-Road	
Location ID	Refusal Depth* (m)	Location ID	Refusal Depth* (m)	Location ID	Refusal Depth* (m)
17-1	3.1 (220.9)	17-2	3.3 (220.6)	17-48	0.9 (221.8)
		17-3	3.4 (220.4)	17-49	3.1 (219.2)
17-4	13.1 (210.2)	17-5	14.9 (208.5)	17-46 17-47	8.9 (213.9) 4.8 (217.9)
17-6	19.8 (203.2)	17-7	-	17-44 17-45	19.9 (202.8) 18.7 (204.1)
		17-8	18.4 (204.8)	17-42 17-43	19.0 (203.8) 17.5 (205.3)
17-9	-	17-10	19.2 (203.7)	17-40 17-41	18.5 (204.4) 17.1 (205.7)
17-11	26.2 (196.7)			17-39	23.2 (199.6)
17-12	25.9 (196.9)	17-13	28.4 (194.5)	17-37 17-38	26.8 (196.2) 25.9 (196.9)
				17-35 17-36	27.0 (196.1) 29.8 (192.8)
17-14	26.1 (196.8)	17-15	-	17-33 17-34	24.1 (198.7) 24.1 (198.6)
17-16	28.4 (194.5)				
17-17	-	17-18	28.4 (194.4)	17-31 17-32	30.5 (192.3) 29.5 (193.2)
		17-19	25.1 (197.6)	17-29 17-30	22.4 (200.4) 31.4 (191.2)
17-20	23.1 (199.8)	17-21	-	17-27 17-28	19.5 (203.2) 25.3 (197.3)
17-22	21.0 (202.2)				
17-23	17.4 (206.2)	17-24	11.2 (212.3)	17-25 17-26	6.4 (216.6) 22.1 (200.5)

Note: (*) value in brackets is base elevation in meters below ground or water surface at the time of drilling

5.3 Groundwater

Observations for water levels were completed in the open boreholes during and upon completion of drilling. A standpipe piezometer was installed in two boreholes to monitor groundwater levels and conduct a rising head test after drilling. The measured groundwater levels are summarized in the table below.

Table 5-11 Measured Groundwater Levels

Borehole	Date	Depth$^{(*)}$ (m)	Elevation (m)	Comments
17-1	March 10, 2017	1.4	222.7	Open Borehole
17-3	March 11, 2017	1.2	222.5	Open Borehole
17-5	February 27, 2017	0.5	222.9	Open Borehole
17-7	February 28, 2017	1.0	222.2	Open Borehole
17-9	March 4, 2017	0.4	222.5	Open Borehole
17-10	March 9, 2017	0.3	222.7	Open Borehole
17-13	March 10, 2017	0.3	222.7	Open Borehole
17-15	March 5, 2017	0.2	222.8	Open Borehole
17-17	March 4, 2017	1.2	221.6	Open Borehole
17-21	March 5, 2017	1.0	221.8	Open Borehole
17-26	July 18, 2017	-1.0	222.6	Open Borehole
17-27	March 17, 2017	-0.3	222.1	Piezometer
	June 12, 2017	-0.3	222.1	
17-28	July 17, 2017	-0.7	222.6	Open Borehole
17-29	March 19, 2017	0.2	222.5	Open Borehole
17-30	July 19, 2017	-0.8	222.6	Open Borehole
17-31	March 20, 2017	-0.6	222.8	Open Borehole
17-32	March 28, 2017	-0.6	222.7	Open Borehole
17-33	March 29, 2017	-0.2	222.8	Open Borehole
17-34	July 19, 2017	-0.8	222.7	Open Borehole
17-36	July 20, 2017	-0.8	222.7	Open Borehole
17-38	July 21, 2017	-1.0	222.8	Open Borehole
17-39	March 30, 2017	0.0	222.8	Open Borehole
17-41	July 21, 2017	-0.8	222.8	Open Borehole
17-42	March 23, 2017	-0.4	222.8	Open Borehole
17-43	March 23, 2017	0.0	222.8	Open Borehole
17-44	March 25, 2017	-0.3	222.6	Open Borehole
17-45	July 22, 2017	-0.7	222.8	Open Borehole
17-46	March 30, 2017	-0.4	222.6	Piezometer
	June 12, 2017	-0.2	222.4	
17-48	July 22, 2017	-0.4	222.7	Open Borehole
17-49	July 22, 2017	-0.1	222.9	Open Borehole

Note: (*) negative value indicates above ground surface

It should be noted that the groundwater level at the time of construction and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events and spring snow melts. It should be recognized that the road elevation is marginally higher then the surrounding swamp area and this area is historically prone to flooding.

Flooding was observed during the investigation. The water level in the creek was higher than the top of the box culvert and the south bound lanes were flooded and covered with water from approximate Station 18+400 to 18+550.

5.4 Analytical Testing

A total of seven soil samples were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, resistivity and conductivity. The analysis results are included in Appendix C and are summarized in the table below:

Table 5-12 Analytical Results

Borehole	Sample	Depth (m)	Sulphate (μg/g	pH (-)	Resistivity (Ohm-cm)	Chloride (μg/g)
17-4	SS6	3.8 – 4.4	11	7.64	2850	130
17-4	SS7	4.6 – 5.2	10	7.85	3310	43
17-30	SS5A	5.3 – 5.7	248	5.99	2790	27
17-34	SS3	2.7 – 3.3	118	5.44	4070	5390
17-36	SS5	5.9 – 6.5	12	7.49	7960	10
Grab #1	~18+562	0	30	4.54	6960	2910
Grab #2	~18+437	0	129	5.08	3930	4420

6 MISCELLANEOUS

Borehole and cone penetration testing locations were selected relative to existing site features, highway alignment and the proposed foundation locations. The investigated locations and elevations were measured by Thurber after completion of drilling.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario supplied and operated the drilling equipment to carry out the drilling, sampling, in-situ testing and borehole decommissioning for the on-road boreholes. Landcore Drilling of Chelmsford, Ontario supplied and operated the portable drilling equipment to conduct the drilling, soil sampling, in-situ testing, standpipe piezometer installations and borehole decommissioning for the off-road boreholes. Forage M3 Drilling of Hawkesbury, Ontario supplied the barge and portable drilling equipment to complete the second round of off-road drilling.

ConeTec Investigation Ltd. of Richmond Hill, Ontario supplied and operated the truck mounted and portable cone penetration testing equipment and electronic field vane shear test equipment.

The field investigation was supervised on a full-time basis by Mr. Chris Murray, E.I.T., Mr. Jeff Morrison, E.I.T, Mr. Nick Weil, C.E.T. and Ms. Katya Edney P.Eng. of Thurber. Overall supervision of the investigation program was conducted by Mr. Stephen Peters, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Oakville, Ontario. Consolidated undrained triaxials, oedometers and organic content testing was completed at Golder's laboratory in Mississauga, Ontario and at Stantec's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Dr. Fred Griffiths, P.Eng. and Mr. Stephen Peters, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.

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FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 537 IMPROVEMENTS AND CULVERT REPLACEMENT
7.5 KM SOUTH OF HIGHWAY 17, STATION 18+280 TO 18+680
SITE NO.: 46-582

G.W.P. 5134-14-00
Geocres No.: 41I-353

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report provides an interpretation of the factual data provided in the Foundation Investigation Report[1] and presents foundation design recommendations for the culvert replacement at the Highway 537 crossing of Jumbo Creek (Sta. 18+345) and the highway improvements through a swamp crossing between approximate Station 18+280 and 18+680. Design recommendations for pavement reconstruction are provided separately within the Pavement Design Report. Thurber Engineering Limited (Thurber) carried out the current investigation as a sub-consultant to McIntosh Perry Consulting Engineers Ltd. (MPCE) under Agreement No. 5015-E-0048.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The construction or design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The project information used for the preparation of this report was provided by MPCE and included plan and profile drawings of the proposed Highway 537 improvements. The discussion and recommendations presented in this report are based on the information provided by MPCE and the factual data obtained during the course of Thurber's field investigation.

An archived foundation investigation and design report has been provided to Thurber and reviewed in preparation of this report is as follows:

> "Foundation Investigation and Design Report, Jumbo Creek Alignment, Highway 537, Township of Cleland, Sudbury Area, Agreement No.: 5009-E-0061, GWP 5279-03-00", prepared by DST Consulting Engineers Inc. of Thunder Bay, Ontario and dated July 5th, 2012 (Geocres No.: 41I00-286)

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[1] Foundation Investigation Report, Highway 537 Improvements and Culvert Replacement, 7.5 km South of Highway 17, Station 18+280 to 18+680, Site No.: 46-582, G.W.P. 5134-14-00, Geocres *41I-353*

8 ENGINEERING AND ANALYSIS METHODOLOGY

8.1 General

The subsurface conditions were investigated to assess the stability of the proposed embankment foundations, potential settlement issues under the embankments as well as anticipated construction concerns. Analyses were carried out based on soil profiles and soil design parameters carefully chosen for critical and less favourable foundation soil conditions. Geotechnical factors to be addressed for design of the Highway 537 embankment include:

- The thickness, extent and engineering properties of the foundation soils, with consideration to more difficult soils such as peat, topsoil, organic deposits, compressible and/or excessively soft/loose soils.
- The depth and variations in depth of bedrock or refusal materials.
- Groundwater elevation and presence of near-by bodies of water
- Depth of ditches directly adjacent to the embankment toes
- Embankment material type (rock fill, granular fill, earth fill or lightweight fill)
- Embankment geometry including height, side slope angle and requirements for additional constraints such as stabilizing berms
- Construction and post-construction settlement of embankments and foundation soils
- Construction procedures

For the purpose of preparing geotechnical design recommendations, a number of assumptions have been made that are consistent with MTO's standard highway design practices:

- Peat, topsoil, organic deposits and other deleterious material were considered for removal prior to constructing embankments and associated widening.
- Where new fill is placed against an existing embankment slope or on a sloping ground surface steeper than 3H:1V, the existing slope will be benched (OPSD 208.010).
- The embankments will be constructed using conventional materials consisting of granular fill. Due to the limited height of grade raise, rock fill was not evaluated. The use of lightweight fills was reviewed and discussed.
- Embankments will be constructed as outlined in Section 9.5 with long term side slopes not steeper than 2H:1V for granular fill and 1.5H:1V for temporary granular fills. This will require initial construction of flatter slopes to allow for a settled slope to not be over steepened.
- No material or stockpiling will be allowed above the embankment design grades without further analysis.
- Permanent erosion protection will be provided for all granular embankment slopes

In addition to the geotechnical requirements there were other design constraints to take into consideration including construction costs, the sensitivity of the adjacent swamp/wetlands and protection of its inhabitants as well as maintaining a road surface elevation to satisfy hydraulic constraints from storm events. The hydraulic constraint was to maintain a minimum of 0.5 m clearance between the 1:100 year flood event at elev. 223.13 m (from Draft Drainage Design Memo dated August 9, 2017) and the underside of the pavement structure.

8.2 Embankment Design and Treatment Alternatives (Sta. 18+280 to 18+680)

Due to the high compressibility that is characteristic of the peat soils and thick deposits of lightly over-consolidated clay foundation soils that are present at this site, significant historic settlements have been observed. For this reason, standard embankment construction to maintain the full grade raise required to meet the hydraulic constraints is not considered feasible and supplementary analyses were carried out to assess design alternatives. An iterative approach was applied for embankment design to produce a practical and a cost-effective solution achieving acceptable factors of safety against slope instability and limiting post-construction settlement. Design alternatives considered during analysis of the embankments included the following:

Option 1:	"Do nothing", no change from existing and construction activities are limited to maintenance
Option 2:	New highway alignment through swamp adjacent to existing highway (completed as part of the assessment provided in Historic Report, Geocres No. 41I00-286)
Option 3:	Permanent detour utilizing existing side roads to avoid highway crossing through the swamp
Option 4:	a) Grade raise symmetrical about the existing highway centerline b) Grade raise off-set to the east of the existing highway centerline
Option 5:	Build a multi-span bridge across the swamp

Table F1 outlines the advantages and disadvantages of each of the five design options and is provided in Appendix F. To achieve Design Option 4 listed above, one or more of the following embankment options were considered:

- Full and/or partial sub-excavation of soft cohesive foundation soils in addition to stripping of the peat, topsoil and organic deposits adjacent to the highway embankment to improve foundation stability and reduce differential settlement.
- Reduction in embankment loading with the use of lightweight fills (such as: expanded polystyrene, foamed glass, slag, tire derived aggregate) as a replacement for conventional granular fill.
- Construction techniques to accelerate foundation settlement such as prefabricated vertical drain installation and vacuum consolidation.
- Ground improvement techniques such as providing a waiting period to allow for foundation preloading, surcharging, geosynthetic basal reinforcement (geotextiles and geogrids), deep soil mixing and geopiers.

- Limit widening of the embankment footprint by utilizing retained soil system (RSS) or contiguous sheet pile walls.

The analyses carried out for this project have indicated that, although the embankment options listed above may be technically feasible, several were not pursued due to the expected construction costs and/or based on their effect on the sensitive swamp environment. Table F2 outlines the options and is also provided in Appendix F.

9 EMBANKMENT DESIGN AND CONSTRUCTION

9.1 General

Peat deposits up to 5 m thick are present directly adjacent to both sides of the existing highway alignment. Partially compressed peat up to 3.3 m thick is present below the existing embankment fill. A grade raise implies an expansion of the embankment footprint and would typically be carried out as shown in OPSD 203.020 and 203.030 for peat deposits not exceeding 6 m in depth. However, since the excavation would occur in a swamp environment directly adjacent to the existing highway embankment and confirmation of complete removal of peat soils would be difficult under ponded water, it is suggested that the peat soils not be subexcavated from within the widened embankment footprint. Limited benefits would be achieved with only partial peat removal. The peat soils existing below the current highway embankment alignment would also remain in place.

The clay deposit is present throughout this site and is relatively consistent in properties as shown in the foundation soil summary Figure G1 in Appendix G. Figures G2 through G4 are also included to summarize the boreholes in the vicinity of Sta. 18+350, 18+450 and 18+550, respectively. The clay layer which varies in thickness to as much as 22.8 m and extends to depths of as much as 28.3 m below the existing ground surface will contribute significantly to time dependant foundation settlement. The clay is considered to be lightly over-consolidation to normally consolidated and the magnitude of settlement will become excessive for a grade raise inducing loadings beyond the preconsolidation pressure. The depth of clay is considered to be too deep or near the maximum depth of effective use of the various ground treatment options presented in Section 8.2 and therefore ground treatments are not considered a cost-effective solution given the AADT and classification of highway.

The use of light weight fills is also not recommended due to the prolonged high water levels within the swamp and resulting risks of buoyancy concerns. In addition, the introduction of various new materials into a swamp environment would not be achievable without proper approval from regulatory agencies. Lightweight fill placement would also require significant dewatering efforts so that construction could be carried out in the dry.

Based on collaboration with the design team, consultation with MTO senior staff and findings from analyses it has been determined that Design Option 4a, as outlined in Section 8.2, with a nominal 1 m grade raise (maximum of 1.4 m) utilizing conventional granular fill was the preferred choice. The use of a 1 m grade raise was deemed acceptable to alleviate the disruption to traffic during normal annual flood events but may not meet the hydraulic constraints for less frequent large flood events. Widening of the embankment footprint to only one side (Design Option 4b) could have construction staging benefits but the greater concentration of new fill to one side is expected to cause larger differential settlements than a symmetric grade raise.

The following sections will outline the design, analysis and recommendations for a 1 m embankment grade raise. It should be noted that the geometry is shown with a proposed centerline grade raise exhibiting a Low Point at Sta. 18+596 and a High Point at 18+340 to complement highway geometry requirements. Between these low and high points, the centerline grade raise varies from 1.0 to 1.4 m with slight variations across the pavement width.

9.2 Stability Analysis

Stability analyses were carried out for embankment grade raises under both static and seismic loading conditions. Stability analyses were carried out utilizing the commercially available slope stability program Slope/W (Version 8) of the GeoStudio software package developed by Geo-Slope International with the option for Morgenstern-Price method of slices for limit equilibrium analyses.

The input parameters and soil model used in the stability analysis, including soil stratigraphy, engineering properties, groundwater conditions and the embankment geometry for selected analyses are shown in Appendix H. The material properties used in the analyses are summarized in Table 9-1 and were determined by consolidated undrained triaxial testing, in-situ testing conducted during the current study as well as soil index correlations developed during current and past projects. A summary of the results of the stability analyses are provided in Table 9-2 for existing conditions and Table 9-3 for the proposed grade raise conditions.

Table 9-1 Summary of Material Properties in Slope Stability Analyses

Material	Unit Weight	Drained / Long Term		Undrained / Short Term
		Friction Angle	Cohesion Intercept	Cohesion
	(kN/m^3)	(degrees)	(kPa)	(kPa)
New Fill	21	32	-	-
Existing Fill	20	30	-	-
Wood Chips	10	28	2	-
Peat/Organics (*under roadway*)	10	28	2	20
Peat/Organics (*adjacent to roadway*)	10	28	2	12
Silt	18	28	-	-
Clay	16	25	7	varies, min = 12$^{(*)}$
Silty Sand to Sandy Silt	20	30	-	-

Note: (*) undrained strength modeled to increase linearly with depth below elevation 217 m at an approximate rate of 1.3 kPa/m to an upper bound of 25 kPa

Table 9-2 Summary of Slope Stability Analyses, Existing Conditions

Station	18+350	18+450	18+550
Geometry			
Existing Highway Centerline Elevation (m)	223.1	222.9	222.9
Factor of Safety[(*)] with water level at elevation 222.8 m			
Short Term (undrained)	1.9 to 2.5	2.5 to 3.1	2.8 to 3.1
Long Term (Drained)	1.3 to 1.5	1.6 to 1.9 (Figure H1)	1.7 to 1.8
Seismic (PGA = 0.070g)	1.5	1.8 to 1.9	1.9 to 2.0

Note: (*) range in factor of safety accounts for stability analyses completed on each side of the highway centerline

Table 9-3 Summary of Slope Stability Analyses, Proposed Grade Raise

Station	18+350	18+450	18+550
Geometry			
Existing Highway Centerline Elevation (m)	223.1	222.9	222.9
Proposed Grade Raise[(**)] (m)	1.3 to 1.4	1.3 to 1.4	1.0 to 1.1
Proposed Side Slope Inclination	3H:1V	3H:1V	3H:1V
Factor of Safety[(*)] with water level at elevation 222.8 m			
Short Term (undrained)	1.4	1.4 to 1.5 (Figure H2)	1.7 to 1.8
Long Term (Drained)	1.2 to 1.4	1.2 to 1.3 (Figure H3)	1.3 to 1.4
Seismic (PGA = 0.070g)	1.0 to 1.1	1.1 to 1.2 (Figure H4)	1.3
Factor of Safety[(*)] with water level at elevation 223.13 m			
Long Term (Drained)	1.2 to 1.5	1.2 to 1.3 (Figure H5)	1.4

Note: (*) range in factor of safety accounts for stability analyses completed on each side of the highway centerline (**) range in grade raise accounts for variations as measured across the width of the lanes

Based on consideration of the risk involved and past experience with highway embankment design/monitoring, the computed factors of safety shown in the tables are considered appropriate. It is anticipated that the factors of safety will be higher than reported in Table 9-3 after consolidation of the peat deposit which was not accounted for in the analyses.

9.3 Settlement Analysis

9.3.1 Inferred Historical Foundation Settlements

The known construction history has been summarized within Section 2.2 in Part 1 of this report which outlined the past, documented grade raises. Noted within Boreholes 17-1, 17-6, 17-7, 17-9 and 17-23 are buried asphalt layers between successive granular layers alluding to the ongoing settlements and grade raises that have occurred within the area of the swamp.

An observational assessment was carried out to compute the historical settlement that has occurred under the existing embankment fills. Since the swamp's surface elevation has minor localized variations, it was assumed that at each cross section of drilled boreholes, the peat under the highway embankment, prior to fill placement, was historically at the same surface elevation of the current peat elevation adjacent to the road elevation. Therefore, the difference in the top elevation of the peat at the locations of the on-road and off-road boreholes (ie. settlement) was compared to the embankment fill height noted within the on-road boreholes (ie. loading) correcting for submerged unit weights of the embankment fills below the water table. This assessment therefore includes settlements from all foundation soil layers taking into consideration varying soil parameters and layer thicknesses but is expected to be predominantly from the peat layer. The findings are provided in Figure I1 in Appendix I and the following estimation was formulated:

$$\frac{\sigma'_v}{25} \leq \delta \leq \frac{\sigma'_v}{10}$$

where:

σ'_v = vertical effective stress from embankment fills (kPa)

δ = total estimated foundation settlement (m)

If the unit weight of the existing embankment fills is 20 kN/m^3 and the road surface in the low areas of the highway alignment is at the same elevation of the water surface within the adjacent ditch/swamp (as observed by prolonged shoulder flooding occurring through the summer of 2017), full submergence is applicable. Therefore, the submerged unit weight of embankment fill is approximately 10 kN/m^3 and the anticipated settlement has been expected to range from 0.4 to 1.0 m for each meter of embankment fill height based on the historic performance.

9.3.2 Predicted Foundation Settlement

Settlement analyses for embankment grade raises were carried out to assess the immediate (elastic) settlement, magnitude and rate of primary consolidation settlement of fine grained foundation soils occurring during construction as well as post-construction (long-term) under the weight of the imposed new embankment fill materials.

In accordance with MTO's document "Embankment Settlement Criteria for Design" (March 2, 2010), the criteria adopted for embankment design is as follows:

Table 9-4 Summary of MTO Settlement Criteria

Type	Settlement Limits				Post Construction Settlement Period (years)
	New Embankments		Embankment Widening		
	Total (mm)	Differential	Total (mm)	Differential	
Non-freeways on compressible soils	200	100:1	75	100:1	15
Surface treated and gravel on compressible soils	300	50:1	100	50:1	15

Time dependent settlement analyses were carried out utilizing the commercially available settlement program Settle^{3D} (Version 4) developed by Rocscience Inc. with the option of Terzaghi's one-dimensional consolidation theory and three dimensional Boussinesq stress computation. The engineering parameters used in the analyses are summarized in Table 9-5 and were determined by laboratory oedometer testing (Table 5-6 and Table 5-9 in Part 1 of this report), CPTu and in-situ testing conducted during the current study as well as soil index correlations developed during current and past projects.

Table 9-5 Summary of Material Properties in Settlement Analyses

Material	Unit Weight	Immediate Settlement	Primary Consolidation Settlement							Secondary Settlement	
		E_s	C_c	C_r	e_o	P_c	OCR	C_v	C_{vr}	C_α	$C_{\alpha\square}$
	(kN/m^3)	(kPa)	(-)	(-)	(-)	(kPa)	(-)	(cm^2/s)	(cm^2/s)	(-)	(-)
New Fill	21	N/A	-	-	-	-	-	-	-	-	-
Existing Fill	20	20,000	-	-	-	-	-	-	-	-	-
Wood Chips	10	1,000	-	-	-	-	-	-	-	-	-
Peat/Organics (*under roadway*)	10	-	6.0	0.62	10.5	30	-	0.0030	0.0100	0.3	0.04
Peat/Organics (*adjacent to roadway*)	10	-	8.4	0.62	13.4	10	-	0.0001	0.0006	0.3	0.04
Silt	18	8,000	-	-	-	-	-	-	-	-	-
Clay (properties *vary with depth*)	16	-	0.84 1.02	0.06 0.04	1.69 1.81	-	2.75 – 1.3 1.3 - 1	0.0005	0.0200	0.015	0.0015
Sandy Silt	20	12,500	-	-	-	-	-	-	-	-	-

The estimated foundation settlements occurring after completion of fill placement, are provided in Table 9-6 and reported as the sum of the immediate settlement, primary consolidation and secondary settlement. In general, primary consolidation within the 15 year design life constitutes approximately 80% of the predicted total on-road settlement and up to 96% of the total off-road settlement. The settlements provided in this table are for an embankment grade raise that is constructed with a 9 m roadway width with a side slope inclination of 3H:1V. Approximate fill heights at each of the stations analyzed is summarized in the table.

Table 9-6 Summary of Estimated Foundation Settlement

Station	18+350		18+450		18+550	
Geometry						
Existing Highway Centerline Elevation (m)	223.1		222.9		222.9	
Proposed Grade Raise(*) (m)	1.3 to 1.4		1.3 to 1.4		1.0 to 1.1	
Proposed Side Slope Inclination	3H:1V		3H:1V		3H:1V	
Proposed Roadway Width	9 m		9 m		9 m	
Foundation Settlement (mm)						
Location(**)	3R, 3L	7.5R, 7.5L	3R, 3L	7.5R, 7.5L	3R, 3L	7.5R, 7.5L
0 to 1 yr.	190	550	315	740	165	650
1 to 5 yrs.	100	200	160	395	45	300
5 to 15 yrs.(***)	80	60	135	195	35	170
15 to 50 yrs.	55	55	120	135	50	120
Figure Number	I2		I3		I4	

Note: (*) range in grade raise accounts for variations as measured across the width of the lanes, (**) notation (typical): 3R = 3 m right of centerline & 3L = 3 m left of centerline, (***) design life = 15 years as summarized in Table 9-4

As a result of the proposed grade raise, the embankment footprint will be widened into areas containing thick deposits of unconsolidated peat and normally to lightly over-consolidated clay. Greater settlements are to be expected in the areas of the widened embankment slopes as indicated in Table 9-6 and therefore do not meet the requirements as outlined in Table 9-4. It is noted that the predicted settlements in widened areas are in general agreement with the range of observed historical settlements as discussed in Section 9.3.1.

The embankment must be reinstated to the design cross-section. To maintain embankment stability, the reinstatement should be delayed after the initial fill placement and the Contract should include a second round of fill placement. It is understood that the Highway 537 improvements will be a multi-year contract with the initial embankment construction occurring in the beginning of the first year of the contract and that a one-year embankment preload period will be achievable. Periodic regrading will be required during the preload period to maintain a trafficable surface and mitigate differential settlements.

Additional settlement analyses were completed to estimate the increase in foundation settlement resulting from the top-up of the embankment fill one year after completion of initial fill placement. As part of this assessment, settlement analyses with variations in embankment geometry were also completed with the objective of determining if in-water work could be minimized for future maintenance activities. The analyses included variations in embankment geometry which incorporated flattening the embankment slope to 4H:1V or widening the road width by 1 m to each side (11 m road width). These additional analyses were completed at Sta. 18+450 to quantify the relative differences in foundation settlement between each option.

Table 9-7 Summary of Estimated Foundation Settlement at Station 18+450 with Top-Up

Station	18+450		18+450		18+450	
Geometry(****)						
Existing Highway Centerline Elevation (m)	222.9		222.9		222.9	
Proposed Grade Raise(*) (m)	1.3 to 1.4		1.3 to 1.4		1.3 to 1.4	
Proposed Side Slope Inclination	3H:1V		**4H:1V**		3H:1V	
Proposed Roadway Width	9 m		9 m		**11 m**	
Top-up at end of One Year(*****)	**315 mm**		**340 mm**		**355 mm**	
Foundation Settlement (mm)						
Location(**)	3R, 3L	7.5R, 7.5L	3R, 3L	7.5R, 7.5L	3R, 3L	7.5R, 7.5L
0 to 1 yr.	315	740	340	865	355	870
1 to 5 yrs.	310	585	330	630	355	670
5 to 15 yrs.(***)	180	250	200	300	210	305
15 to 50 yrs.	135	150	135	180	135	180
Figure Number	I5		I6		I7	

Note: (*) range in grade raise accounts for variations as measured across the width of the lanes, (**) notation (typical): 3R = 3 m right of centerline& 3L = 3 m left of centerline, , (***) design life = 15 years as summarized in Table 9-4, (****) ***bold text*** *highlights differences from Sta. 18+450 data presented in Table 9-6, (*****) top-up is the estimated thickness of material required on the lanes and shoulders to re-establish grade.*

It was concluded that providing an initially wider embankment footprint does not in itself alleviate the concern of embankment slopes settling below the water level; some work in the water will be required during top-up operations. However, it was noted that an embankment constructed with an 11 m wide road width will likely require less material to re-establish a 9 m road width in the future. Therefore, it is recommended that an 11 m wide road be constructed initially throughout the swamp length and that the cross-section be reviewed for post-contract top-ups.

Additional settlement analyses were completed to estimate the increase in foundation settlement near the culvert at Sta. 18+350 resulting from an 11 m wide embankment with a top-up of the embankment fill one year after completion of initial fill placement. The results are provided in Table 9-8 and can be used to interpret the settlement expected along the culvert length. The culvert length (see Section 10) would need to be lengthened to accommodate a wider embankment footprint.

Table 9-8 Summary of Estimated Foundation Settlement at Station 18+350 with Top-Up

Station	18+350		
Geometry(****)			
Existing Highway Centerline Elevation (m)	223.1		
Proposed Grade Raise(*) (m)	1.3 to 1.4		
Proposed Side Slope Inclination	3H:1V		
Proposed Roadway Width	**11 m**		
Top-up at end of One Year(*****)	**205 mm**		
Foundation Settlement (mm)			
Location(**)	3R, 3L	7.5L	7.5R
0 to 1 yr.	205	425	655
1 to 5 yrs.	175	135	320
5 to 15 yrs.(***)	110	35	80
15 to 50 yrs.	60	30	60
Figure Number	I8		

*Note: (*) range in grade raise accounts for variations as measured across the width of the lanes, (**) notation (typical): 3R = 3 m right of centerline& 3L = 3 m left of centerline, , (***) design life = 15 years as summarized in Table 9-4, (****) **bold text** highlights differences from Sta. 18+350 data presented in Table 9-6, (*****) top-up is the estimated thickness of material required on the lanes and shoulders to re-establish grade.*

Given the magnitude of the long-term settlement predicted for this project, periodic maintenance will be required to re-establish grades during the design life. It is noted that the Settlement Criteria of Table 9-4 are not likely achievable for this embankment. Installation of geotechnical monitoring instrumentation is recommended to record and confirm the magnitude and rate of settlement as discussed later in Section 9.6.

9.3.3 Embankment Compression

An assessment of the compression of fill materials under self-weight was also completed. In accordance with the MTO document "Post-Construction Rock Fill Settlement and Guidelines for Estimating Rock Fill Quantity" (April 12, 2010), the estimated settlement of granular fill embankments placed in the dry due to compression of the compacted fill is 0.5% of the embankment height and is expected to occur after fill placement. For the proposed centerline grade raises up to 1.4 m, the expected embankment compression is in the order of ~10 mm.

Compaction of granular fill below water will not be achievable and will result in greater embankment compression in the areas of embankment widening.

9.3.4 Accuracy of Settlement Calculations

The estimated magnitudes of settlement are considered approximate. It should be noted that settlements may vary along and across the highway alignment subject to the thickness of soil layers at a particular location, variations in settlement characteristics of the foundation deposits with depth and location, layer boundary conditions, variations in the relative density of soils, the presence of organics, distribution of sand/silt/clay partings within the various strata, the depth to bedrock and the height of embankment.

The settlement predictions in this report have been carried out based on a field and laboratory program and on assumptions based on our experience with other embankments founded on similar soils. Notwithstanding the care taken in predicting the embankment performance, the settlement values observed in the field could vary from the predictions. This is due to the degree of variability of the soil properties along the embankment alignment. The presence of locally sensitive deposits adds uncertainty to the prediction of the performance of the embankment proposed in this project. Therefore, the results of the settlement analysis should be used to assess the most likely performance of the embankments. During construction, the Contract Administrator should employ experienced geotechnical staff to observe foundation performance related to construction activities and to assess the settlement monitoring results.

9.4 Subgrade Sensitivity

The deposits of peat and organics soils present adjacent to the highway embankment are sensitive and are not considered suitable for the direct support of construction equipment. Stripping and grubbing operation should **not** be undertaken as this will disturb the existing ground conditions (see Section 11.1). The Contractor must be aware of this issue so that he may adjust his operations to suit the difficult subgrade conditions.

9.5 Embankment Construction and Restrictions

Embankment construction should be carried out in accordance with OPSS.PROV 206. Embankment fill should consist of OPSS Granular B Type II in compliance with OPSS.PROV 1010. All granular fill placed above water must be compacted as per OPSS 501. Compaction of granular fill below water will not be achievable and will result in greater embankment compression in the areas of embankment widening.

To reduce the loss of granular fill and to provide a more evenly distributed loading it is recommended that a geotextile be placed above the initial layer of Granular B Type II (see Section 11.1). The ends of the geotextile should be wrapped back into the granular fill.

The granular fill embankments should be constructed with side slopes of 3H:1V. Granular fill embankment slopes must be provided with erosion protection in accordance with OPSS 804.

Construction of embankments should be carried out in accordance with OPSS.PROV 209 “Construction Specification for Embankments Over Swamps and Compressible Soils”.

The Contractor should be made aware that due to the sensitivity of the foundation soils, additional construction restrictions are required to maintain a stable embankment including:

- No materials shall be stockpiled within the limits or adjacent to the embankment area
- Construction equipment should not be permitted to travel in areas of exposed peat soils or exposed geotextiles

9.6 Geotechnical Instrumentation and Monitoring Program

Geotechnical instrumentation and monitoring, to control construction of embankments and waiting periods, is recommended. The geotechnical instrumentation will consist of a combination of vibrating wire piezometers, settlement rods and settlement pins. The instrumentation locations, types of instrumentation, installation details and monitoring frequency will be provided in an Instrumentation Installation and Monitoring Memorandum.

The results of the geotechnical instrumentation monitoring program will control the rate of the embankment construction and consequently the construction schedule. Although not anticipated, there is a risk that the pore pressure dissipation in the foundation clay will be slower than anticipated. If this situation occurs, the embankment construction may have to be slowed down or have the one year preload period (see Section 9.3.2) extended which may impact the overall construction schedule. It is considered important that the construction contract includes clauses that allow for a flexible construction schedule to allow for delays associated with dissipation of excess pore pressures in the foundation soils slower than anticipated. In addition, a detailed and regular analysis of the results of the geotechnical instrumentation monitoring program during construction is considered critical to:

- Reduce the potential of an embankment failure
- Reduce the risk of a premature paving
- Reduce the risk of installing the permanent culverts too early, if applicable

During construction, the Contract Administration should include experienced geotechnical staff to implement the geotechnical monitoring program and to observe foundation performance related to construction activities.

10 CULVERT DESIGN AND CONSTRUCTION

10.1 General

The existing structure is described in the RFP to be a concrete closed box culvert that is 3.0 m wide by 1.5 m high with an invert elevation of 220.8 to 220.7 m. The current water levels are above the top of the culvert and the culvert is not readily visible.

The 30% drawings received from MPCE on October 25th, 2017 indicates the replacement culvert will consist of twin 2.74 m diameter SPCSP culverts. The culverts are shown to be constructed 0.33 m south and 5.21 m north of the existing culvert centerline and both culverts are have an approximate invert elevation of 221.1 m.

10.2 Design Options

10.2.1 Culvert Type and Foundation Alternatives

Selection of the culvert type must consider the proposed construction procedures, staging requirement, geotechnical resistance available in the foundation soils, the depth to suitable bearing stratum and post-construction settlement criteria. It should be noted that construction of the replacement culvert will be carried out in a swamp environment with a high water level. From a geotechnical perspective, the following culvert types were considered:

- <u>Circular Pipes (Concrete, HDPE, Steel)</u>

  From a foundation engineering perspective, pipe culverts are a feasible alternative.

- <u>Open Bottom Culvert (Box, Arch)</u>

  Open bottom culverts are not considered feasible for this site from a foundation engineering perspective due to the relatively low bearing capacity available in the foundation soils, magnitude of settlements and based on the greater excavation and dewatering efforts that would be required during construction to place the foundation in the dry.

- <u>Closed Bottom Culvert (Box)</u>

  A precast segmental box culvert in an open cut construction is considered a feasible option from a foundation engineering perspective. Precast sections, rather than cast-in-place construction, can be installed expediently with less potential for disturbance of the founding soils during installation. The culvert would need to be installed following the one year preload period (see Section 9.3.2) and would need to be able to accommodate the settlements included in Table 9-8.

- <u>Steel Sheet Pile Walls with Precast Concrete Slab</u>

  A culvert consisting of two rows of parallel sheet pile walls supporting precast concrete slabs is not considered feasible at this site based on the low capacities of the peat and clay foundation soils. In addition, shallower bedrock was encountered on the west end of the culvert which will limit the available lateral capacities.

A comparison of these alternatives, based on their respective advantages and disadvantages, is included in Appendix F. It is not considered to be economical or practical to support a culvert on deep foundations at this site and therefore this option is not presented in this report.

10.2.2 Construction Methodology Alternatives

For the proposed culvert replacement, the following construction methods were considered.

- Open Cut with Full Road Closure and Temporary Detour
  Installation of a new culvert using open cut techniques and a full road closure would allow for an expedited construction schedule and could reduce costs associated with requiring roadway protection and water control. It is understood that a detour period up to 6 months is available

- Open Cut with Staged Temporary Widening
  Widening of the existing highway and/or construction of a temporary detour embankment to accommodate traffic passage during construction is not considered feasible from a geotechnical perspective due to the significant settlement that would be expected to occur. A review of the environmental acceptability for placing additional fill within the swamp, the requirement for property acquisition and alteration to highway geometry would also be needed to assess this option.

- Open Cut with Staged Replacement and Temporary Protection System
  The use of open cut techniques in conjunction with staged culvert replacement is a potentially feasible construction option from a geotechnical perspective. This option will require roadway protection, as discussed further in Section 11.3, installed along the embankment centerline to maintain a single lane of traffic along the current highway alignment. Due to the relatively low geotechnical capacity of the peat and clay foundation soils, the roadway protection may need bracing such as struts, deadman and anchors to reduce lateral deflections.

- Trenchless Techniques
  Trenchless techniques are not feasible at this site due to the high water levels at inlet and outlet and the limited cover over the new pipes.

10.2.3 Recommended Approach for the Culvert Replacement

From a foundation engineering perspective with reference to the anticipated settlements, the alternative of replacing the existing culvert with a pipe culvert using open cut techniques is the recommended culvert replacement option. If a full road closure is deemed not to be viable, temporary protection systems (TPS) would be needed to facilitate construction.

Consideration should be given to installing the permanent culvert with a camber to accommodate foundation settlement. The camber can be interpreted from Table 9-8 or Figure I8 in Appendix I which predicts the foundation settlement adjacent to the culvert alignment. It is estimated that settlement in the first 15 years beneath the roadway will be approximately 490 mm, while settlements of 600 mm and 1050 mm are estimated for the same time frame at locations 7.5 m left and right of centreline respectively.

Delaying the installation of the permanent culverts should be considered. A one year embankment preload period would allow for significant settlement to have occurred prior to culvert construction however a camber should still be included. It is estimated that settlement from after top-up to 15 years after initial construction beneath the roadway will be approximately 285 mm, while settlements of 170 mm and 400 mm are estimated for the same time frame at locations 7.5 m left and right of centreline respectively.

If the existing culvert cannot tolerate the anticipated settlement during the preload period, a sacrificial culvert could be used.

The use of closed box culvert is also considered feasible and Thurber can provide design recommendations upon request. However, it is anticipated that a box culvert would be considered a structure and a more stringent design would be required to meet bearing capacity and seismic constraints.

10.3 Open Cut Foundation Design Recommendations

10.3.1 Culvert Foundation Bearing Resistance

A pipe culvert with an open cut installation technique should be designed and constructed in accordance with OPSS 421, OPSD 802.010 (with Granular A used as bedding and embedment material) and OPSD 803.031 (with a frost depth as noted in Section 10.3.3). The recommendations of Sections 10.3.2, 9.5, 10.3.5, and 12 should be applied. Geotechnical resistance values are not required for pipe culverts, however a modulus of subgrade reaction of 7 MN/m^3 can be used for a pipe culvert installed at this site. The use of headwalls is not recommended.

10.3.2 Subgrade Preparation, Bedding and Backfilling

Existing fill, peat, soft or loose deposits, disturbed soils, alluvial deposits and deleterious materials must be stripped from the culvert footprints to expose competent native subgrade material at or below the desired founding elevations. Excavation to remove the existing culvert will be to below the elevation of the new culvert bedding. This excavation depth should be sufficient for the removal of peat (noted at a base elevation of 220.0 m near the culvert alignment). The excavation below the new culvert bedding elevation should be backfilled and compacted as per OPSS.PROV 501 with granular fill consisting of OPSS.PROV 1010 Granular A material as soon as practical to protect the subgrade from disturbance during construction.

Given that loose silt and firm clay materials are anticipated at the founding level of the replacement culvert, construction equipment should not be permitted to travel on the exposed subgrade as indicated in Section 9.4. The exposed subgrade may vary across the excavation and must be inspected to confirm that the subgrade is suitable and uniformly competent.

In order to provide a more uniform foundation subgrade condition for the culvert on clay soils, a minimum 0.5 m thick layer of well compacted bedding material conforming to OPSS.PROV 1010 Granular A requirements must be provided under the base of the culvert as per OPSS 422 and OPSD 802.010 (pipe culvert).

The compaction of granular bedding directly above the subgrade may result in disturbance of the material with pumping of fines into the granular bedding and difficulty achieving the specified degree of compaction. Protection of the subgrade should include installation of Class II a non-woven geotextile with an FOS between 75 and 150 □m (OPSS 1860) installed beneath the Granular A material. The geotextile should be placed as soon as possible after reaching the subgrade level and following receipt of written notice to proceed in accordance with SP 109S12.

Culvert construction should be carried out in the dry. It is noted that construction will extend below the swamp elevation. Water diversion and dewatering will be required to prepare the subgrade in the dry. Please refer to Section 11.4 for additional comments on groundwater and surface water control.

It is recommended that culvert cover be in accordance with OPSS 902 and consist of free-draining, non-frost susceptible granular materials such as Granular A or Granular B Type II material meeting the requirements of OPSS.PROV 1010.

Culvert backfill above the granular cover should be in accordance with OPSS 902 and consist of material meeting the requirements of OPSS Select Subgrade Material or better and should be compacted in regular lifts as per OPSS.PROV 501. Heavy compaction equipment, used adjacent to the culvert, must be restricted in accordance with OPSS.PROV 501. Care must be exercised when compacting the fill adjacent to and above the culvert in order not to damage the culvert.

10.3.3 Frost Depth

The design depth of frost penetration at this site is 2.1 m. Accordingly, a minimum of 2.1 m of earth cover must be provided where required to serve as frost protection. Frost tapers for the culvert should be as per the Pavement Design Report.

10.3.4 Lateral Earth Pressure

Lateral earth pressures should be computed in accordance with the CHBDC but, under drained conditions, is generally given by the following expression:

$$p_h = K * (\gamma h + q)$$

where:

p_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see table below)
γ = unit weight of retained soil (see table below and adjusted for groundwater level)
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill are shown in the following table.

Table 10-1 Static Earth Pressure Coefficients

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II ϕ = 35°, γ = 22.8 kN/m^3		OPSS Granular B Type I ϕ = 32°, γ = 21.2 kN/m^3		OPSS SSM and Existing Sand Fill ϕ = 30°, γ = 21.0 kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active, K_A (Yielding Wall)	0.27	0.40	0.31	0.48	0.33	0.54
At Rest, K_O (Non-Yielding Wall)	0.43	-	0.47	-	0.50	-
Passive, K_P (Movement towards Soil Mass)	3.7	-	3.3	-	3.0	-

The parameters in the table correspond to full mobilization of active and passive earth pressure and require certain relative movements between the structure and adjacent soil to produce these conditions. Where ground surfaces are sloped, the corresponding coefficients provided in the table should be used.

The culvert must be designed to withstand full hydrostatic pressure assuming a water level at least equal to the design storm water level. This is applicable when the water level behind the culvert is higher than the swamp level.

10.3.5 Cement Type and Corrosion Potential

Analytical tests were completed to determine the potential for degradation of concrete in the presence of soluble sulphates and the potential for corrosion of exposed steel. The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. Soluble sulphate concentrations less than 1000 μg/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. The class of concrete selected should consider the effects of road de-icing salts.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The tests results provided in Part 1 of this report may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road de-icing salts should also be considered.

11 CONSTRUCTION CONSIDERATIONS

11.1 Construction Sequencing

The following construction sequence is recommended:

- Remove boulders, logs and similar debris from within the final footprint of the widening and close-cut any tree stumps, otherwise do not disturb the natural surface and underlying root mat
- Place a layer of geogrid on top of the existing ground surface from the existing shoulder to beyond the limit of widening (with the strong axis perpendicular to the highway alignment according to manufacturers instructions). Consideration can be given to extending the geogrid across the width of the existing road provided that the guiderail posts and asphalt are removed to avoid damage to the geogrid.
- Place a minimum of 300 mm of OPSS Granular B Type II over the geogrid and compact carefully, avoid undue disturbance of the subgrade. It is estimated that approximately 150 mm of material loss into the underlying peat could occur.
- Place a layer of geotextile and the remaining embankment fill (see Section 9.5)
- Allow for a preloading period of one year (see Section 9.3.2)
- Construct culvert replacement
- Reinstate grades throughout project length

It is anticipated that the construction of the embankment grade raise and widening can be constructed in a single stage of construction. A preload period of approximately one year (see Section 9.3.2) after placing the embankment fill is recommended to allow for a significant amount of foundation settlement to occur before reinstating the cross-section. During this preload period it is recommended that the highway remain as a granular surface. Periodic regrading will be required during the preload period to maintain a trafficable surface. It is anticipated that additional embankment fill placement will be required after the preload period to compensate for the settlement that has occurred and these estimates have been presented in Table 9-7. The timing of paving and installations (guiderails) should follow the recommendations provided in the Pavement Design Report.

11.2 Excavation

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the fills above the water table may be classified as Type 3 soil. The fills below the water table, peat and cohesionless soils may be classified as Type 4 soil.

Excavation for the culvert replacement must be carried out in accordance with OPSS 902 and will be carried out through the existing embankment fill and extend into the underlying native peat and clay deposits. The sides of temporary excavations must be sloped in accordance with the requirement of the OHSA.

At locations where there are space restrictions or where a slope has to be retained, the excavations will need to be carried out within a protection system. Further discussion is presented in Section 11.3.

11.3 Temporary Roadway Protection

Temporary Protection Systems may be required during various stages of culvert construction and must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2 (maximum 25 mm horizontal deflection). The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The protection system should be installed at a suitable distance away from the new culvert to limit the disturbance to subgrade associated with removal of the protection system following completing of construction. Alternatively, the protection system near the culvert could be left in place and cut off at or below 1.2 m beneath the finished pavement grade or 0.6 m below stream invert.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through embankment fill and culvert backfill are provided in Table 10-1. The lateral earth pressure coefficients for the existing native peat and clay soils are given below:

Peat

γ = 10 kN/m^3 (must be adjusted for water table)
K_A = assume negligible
K_P = assume negligible

Clay

γ = 16 kN/m^3 (must be adjusted for water table)
S_u = 12 kPa

Temporary protection systems are the responsibility of the Contractor and should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The depth to bedrock varies along the length of the culvert and a suitable strutting or bracing system may need to be incorporated into the roadway protection design to resist the lateral loadings including traffic loading and surcharge loading due to construction equipment and operations. The foundation soils are soft and there is a risk of failure under a heavily loaded crane. The Contractor must undertake an assessment of the foundation soils ability to support the weight of the crane used during installation of the protection system.

11.4 Groundwater and Surface Water Control

Culvert construction, subgrade preparation and placement and compaction of granular bedding must be carried out in the dry. The Contractor must be prepared to control the groundwater and surface water flow at this site to permit construction in a dry and stable excavation. Temporary groundwater and surface water control measures will be required to remain operational during construction until the culvert is installed and backfilled. Dewatering systems must be designed, operated and removed in accordance with OPSS.PROV 517 and Special Provision No. 517F01 with the following inputs for Table A: Note 1 = Yes and Note 2 = N/A.

The groundwater level will fluctuate and the minimum groundwater elevation for the site at the time of the proposed culvert replacement should be taken as the water level in the swamp at the time of construction as defined by SP517F01. Excavation below the groundwater level to construct the culvert foundation will be required and excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause base heave/boiling and sloughing of the granular foundation soil below the water level, making it difficult to maintain a dry, sound base on which to work.

Construction of cofferdams will be required to divert flow away from the culvert subgrade area. It is recommended that excavation be enclosed within a water tight enclosure. The recommendations provided in Section 11.3 above for Temporary Protection Systems are also applicable to sheet piled cofferdams. The cofferdams should extend deep enough to penetrate a sufficient distance in the clay layer. The groundwater level within the culvert footprint should be lowered by pumping from sumps prior to excavation to at least 500 mm below the underside of the planned base of the excavation stage. Further assessment of dewatering requirements and the need for a PTTW should be carried out by specialists experienced in this field.

11.5 Scour Protection and Erosion Control

Scour and erosion protection should be provided for the culvert inlet and outlet areas. Design of the scour and erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field. It is understood that the culvert acts as an equalizer culvert and the need for a cut-off wall and clay seal are not required in this case.

Typically, rock protection should be provided over all earth surfaces subjected to flowing water. Treatment at the outlet should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

Temporary and/or permanent erosion and sedimentation control measures must be in place and maintained at all times so as to prevent any deleterious material or fines from entering into any drainage feature or watercourse.

12 CONSTRUCTION CONCERNS

During construction, qualified geotechnical staff should be retained to observe activities related to embankment construction and advise the Contract Administrator on construction concerns or issues related to embankment and cut slope stability or settlement.

Potential construction concerns include, but are not necessarily limited to:

- The thickness and presence of organic deposits were investigated at the borehole locations only. Organic deposits may extend to greater depths or be encountered at other locations between and beyond boreholes.
- Trafficability of construction equipment may be difficult in areas of organic deposits or excessively soft, loose/unstable and/or saturated subgrade. Disturbance of the

subgrade by construction traffic must be minimized and the Contractor may have to adjust his operations in soft subgrade areas.

- Although not anticipated, there is a risk that the pore pressure dissipation and settlement will be slower than anticipated. If this situation occurs, the embankment construction may have to be slowed down which may impact the overall construction schedule. It is considered important that the construction contract includes clauses that allow for a flexible construction schedule to allow for delays associated with dissipation of excess pore pressures in the foundation soils slower than anticipated.
- In the area of the culvert construction, care must be exercised during excavation to avoid disturbing the founding subgrade. When the excavation reaches the required elevation, the subgrade should be inspected and approved as per SP109S12.
- Where new embankments are constructed directly adjacent to existing embankments, settlement of the existing embankment will occur. Maintenance measures may be required to compensate the settlement. Periodic regrading will be required during the preload period to maintain a trafficable surface

The successful performance of the embankment and culvert will depend largely upon good workmanship and quality control during construction. Inspections as per SP109S12 should be carried out during construction to confirm that foundation recommendations are correctly implemented and material specification are met.

13 MISCELLANEOUS

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

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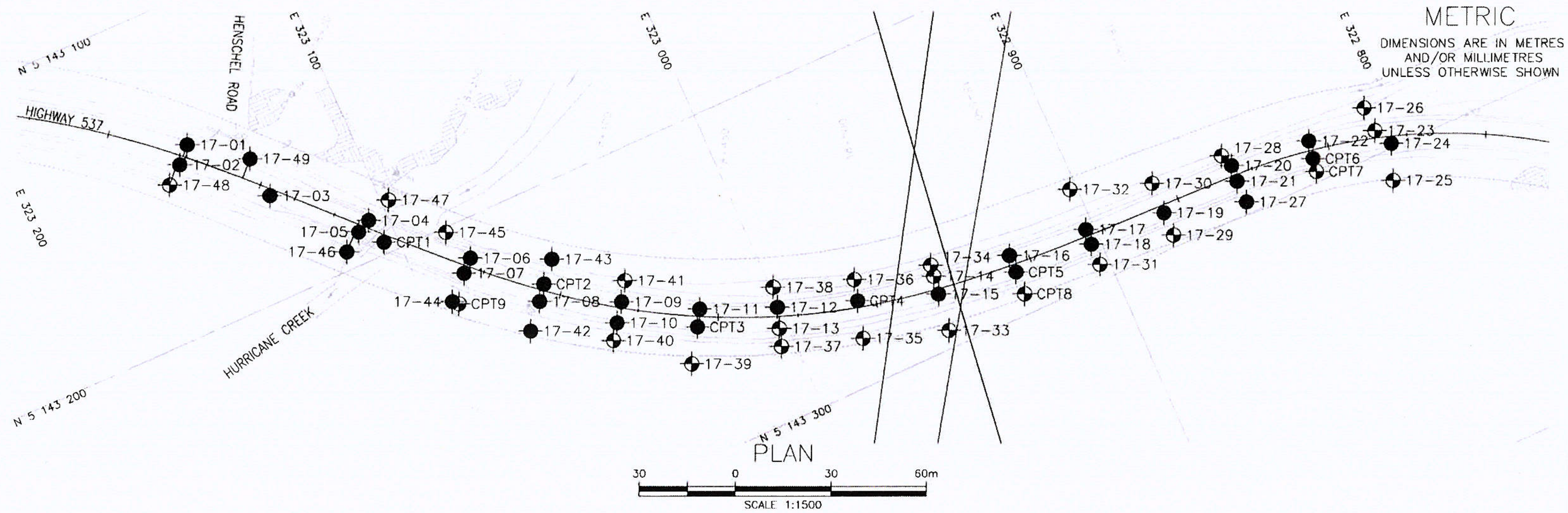
Appendix A.

Borehole Location Plan and Stratigraphic Drawings

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



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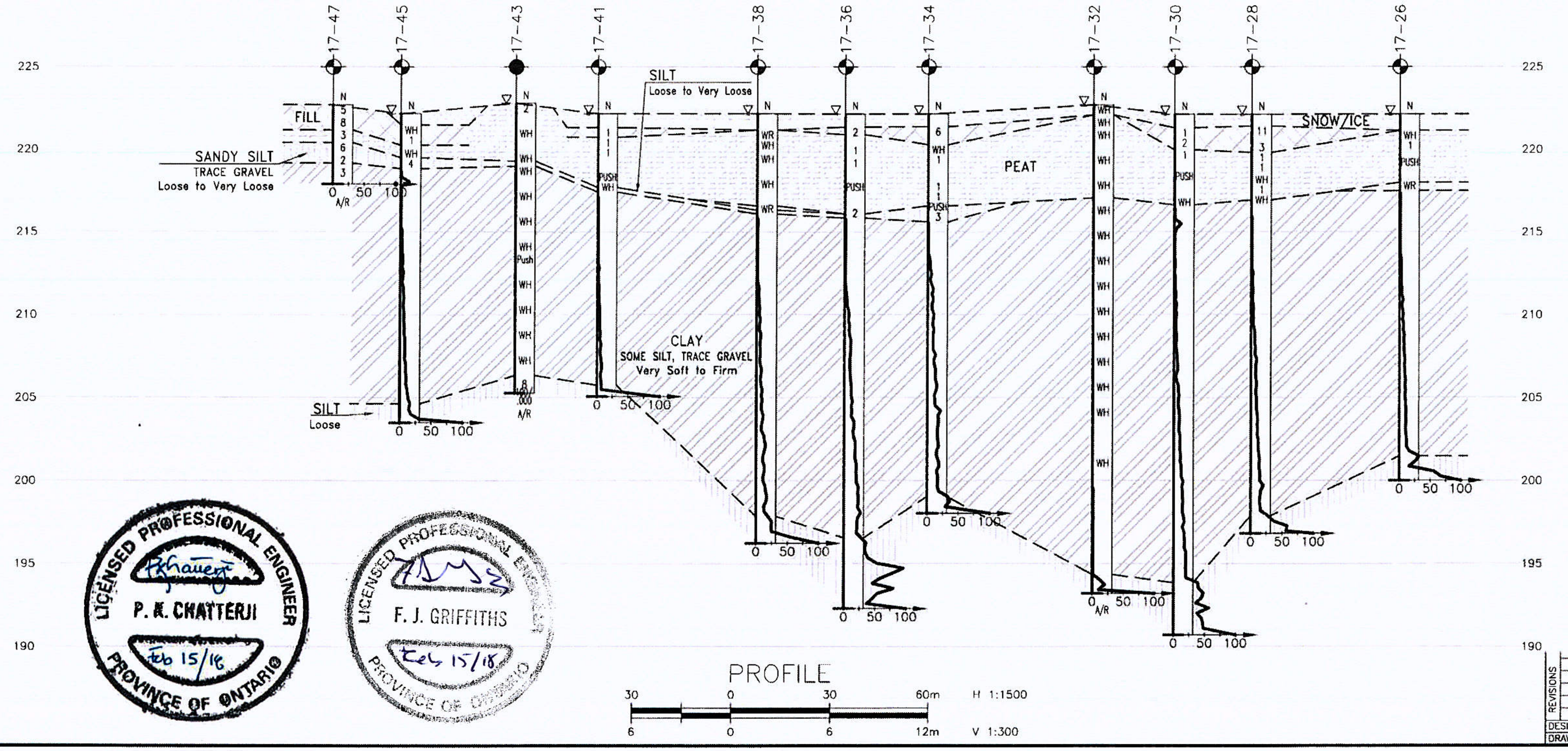

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CONT No
GWP No 5134-14-00

SHEET

HIGHWAY 537
JUMBO CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.

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

NO	ELEVATION	NORTHING	EASTING
17-26	222.6	5 143 284.9	322 807.3
17-28	222.6	5 143 280.0	322 854.2
17-30	222.6	5 143 278.8	322 877.6
17-32	222.7	5 143 269.8	322 902.1
17-34	222.7	5 143 273.5	322 951.2
17-36	222.7	5 143 267.7	322 975.0
17-38	222.8	5 143 259.4	322 999.2
17-41	222.8	5 143 238.4	323 040.4
17-43	222.8	5 143 222.8	323 058.6
17-45	222.8	5 143 201.5	323 085.4
17-47	222.7	5 143 184.9	323 097.6

-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. 41I-353

REVISIONS	DATE	BY	DESCRIPTION		
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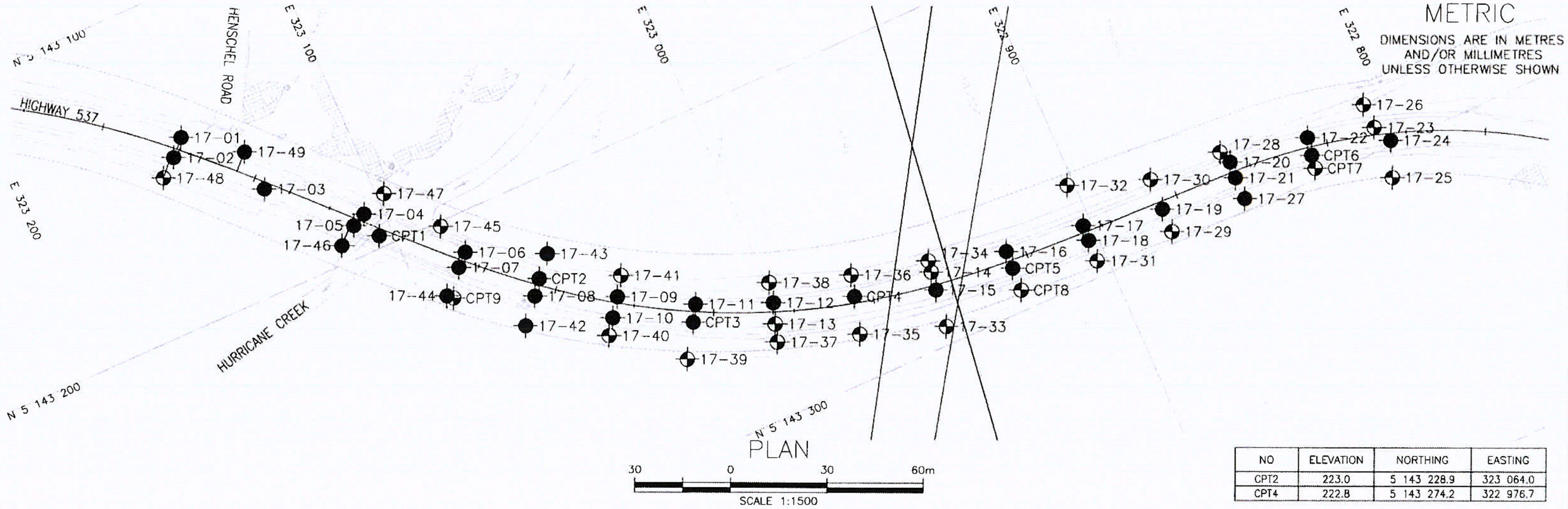
UNLESS OTHERWISE SHOWN



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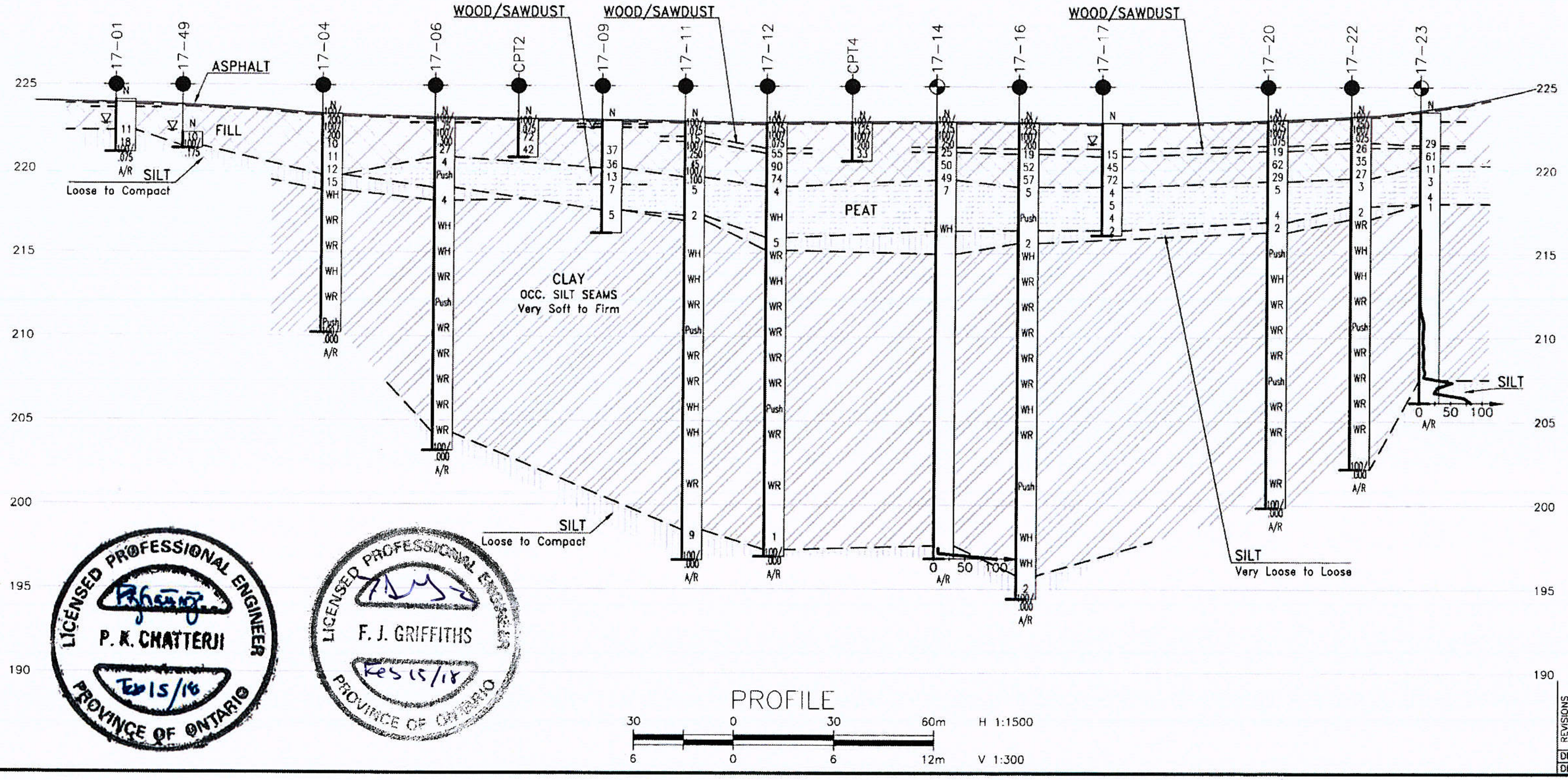

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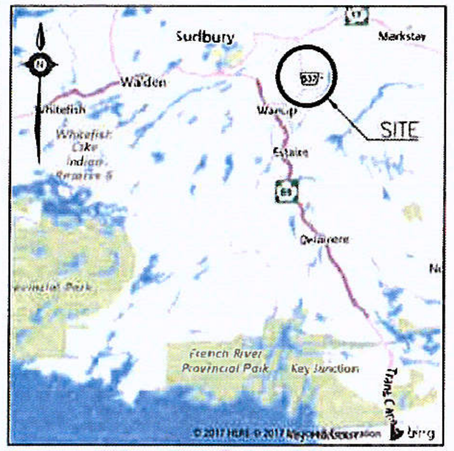
GWP No 5134-14-00

HIGHWAY 537
JUMBO CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



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

NO	ELEVATION	NORTHING	EASTING
17-01	224.1	5 143 143.3	323 148.0
17-04	223.3	5 143 188.2	323 105.8
17-06	223.0	5 143 212.0	323 081.7
17-09	222.9	5 143 244.0	323 044.1
17-11	222.9	5 143 256.1	323 022.8
17-12	222.8	5 143 265.6	323 000.5
17-14	222.9	5 143 277.1	322 951.7
17-16	222.8	5 143 280.9	322 927.6
17-17	222.8	5 143 283.3	322 902.6
17-20	223.0	5 143 284.1	322 852.6
17-22	223.2	5 143 287.1	322 827.4
17-23	223.5	5 143 292.8	322 807.1
17-49	222.8	5 143 155.4	323 131.8

-NOTES-

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GEOCRES No. 41I-353

REVISIONS	DATE	BY	DESCRIPTION

DESIGN SP	CHK FG	CODE	LOAD	DATE FEB 2018
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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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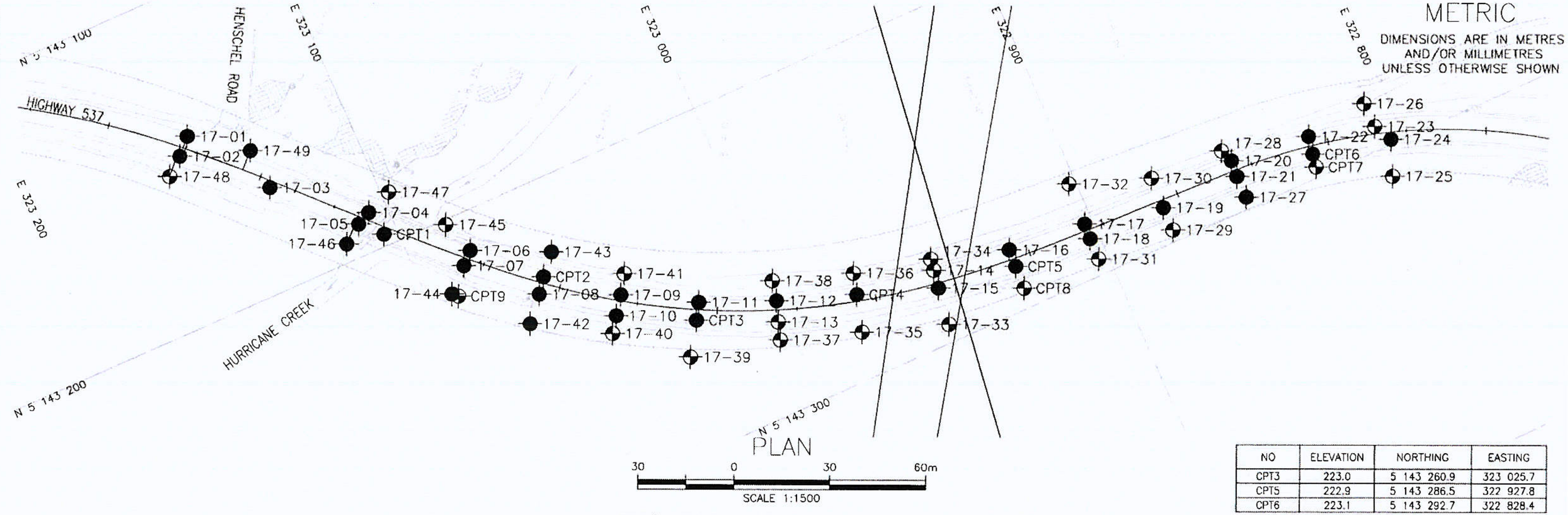
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



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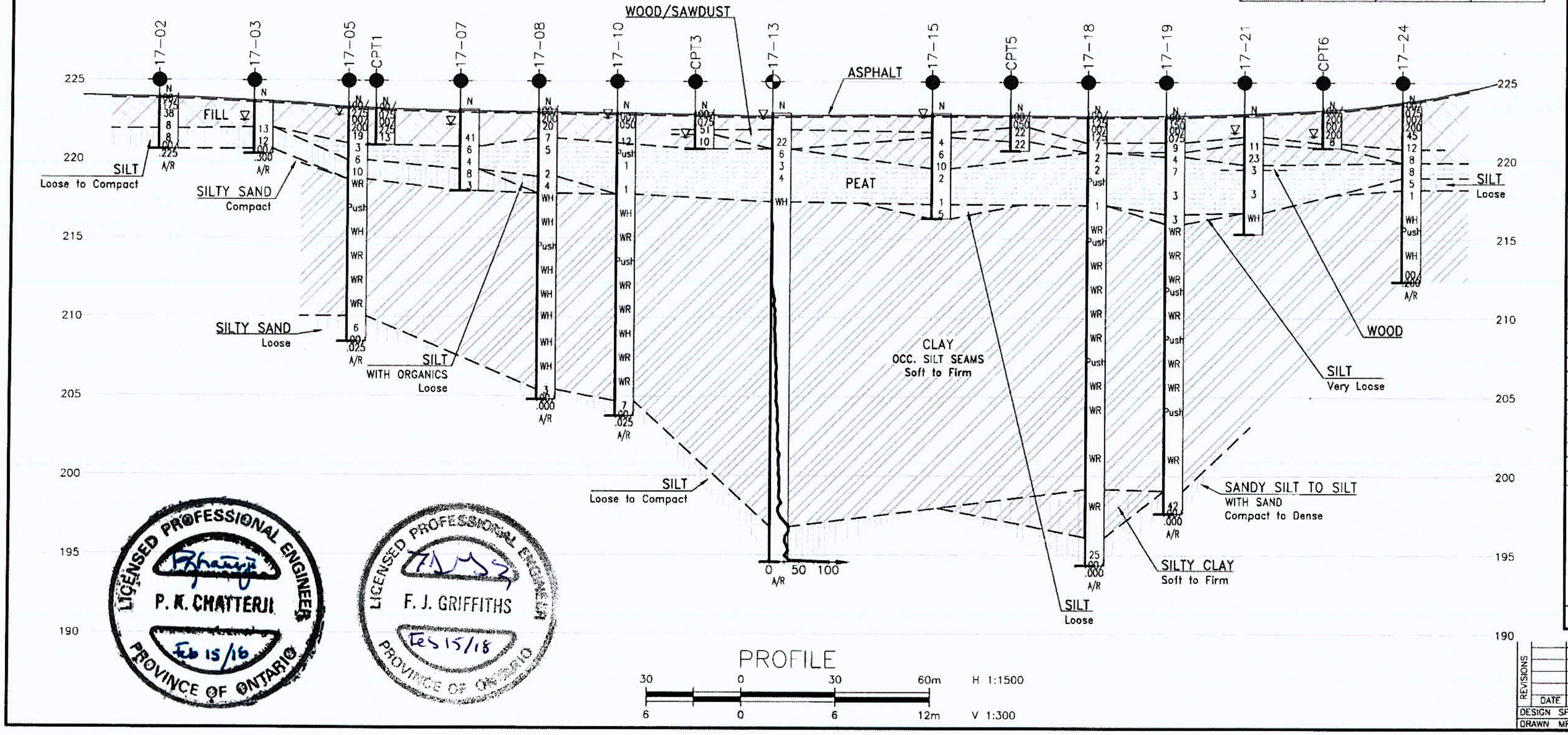

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CONT No
GWP No 5134-14-00

HIGHWAY 537
JUMBO CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

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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
17-02	223.9	5 143 148.1	323 152.6
17-03	223.7	5 143 168.5	323 130.8
17-05	223.3	5 143 190.2	323 110.1
17-07	223.2	5 143 215.5	323 085.4
17-08	223.2	5 143 233.3	323 067.4
17-10	223.0	5 143 249.4	323 048.0
17-13	223.0	5 143 271.9	323 002.6
17-15	223.0	5 143 282.8	322 952.6
17-18	222.8	5 143 288.2	322 902.9
17-19	222.7	5 143 288.8	322 877.9
17-21	222.8	5 143 289.3	322 853.0
17-24	223.5	5 143 298.6	322 804.0
CPT1	223.2	5 143 196.3	323 104.2

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GEOCRES No. 41I-353

REVISIONS	DATE	BY	DESCRIPTION

DESIGN SP	CHK FG	CODE	LOAD	DATE FEB 2018
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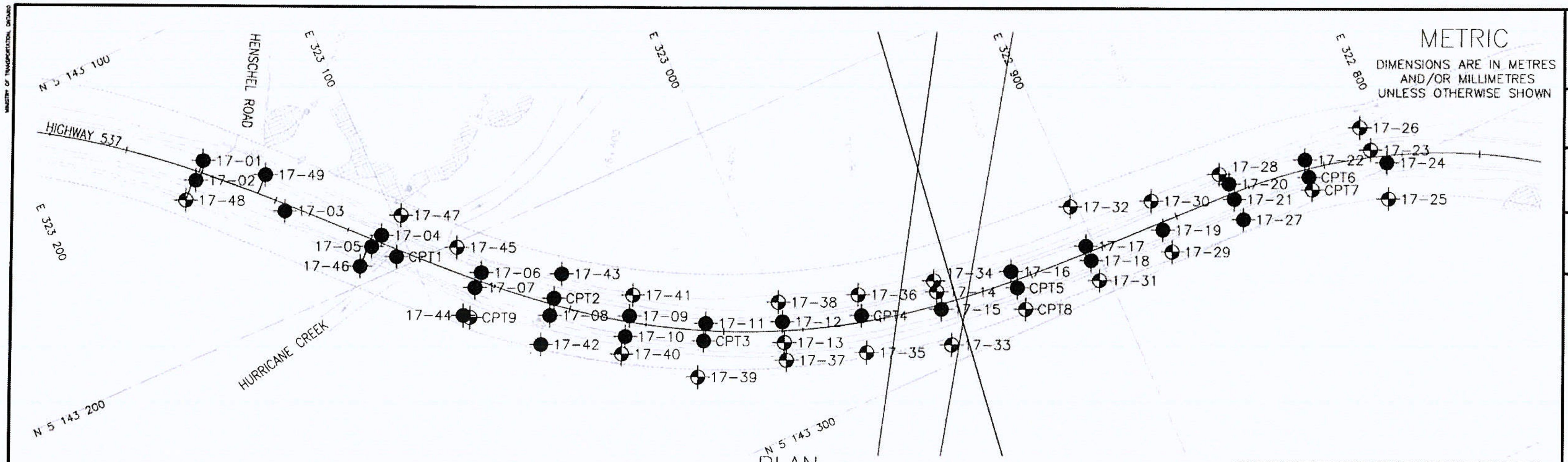
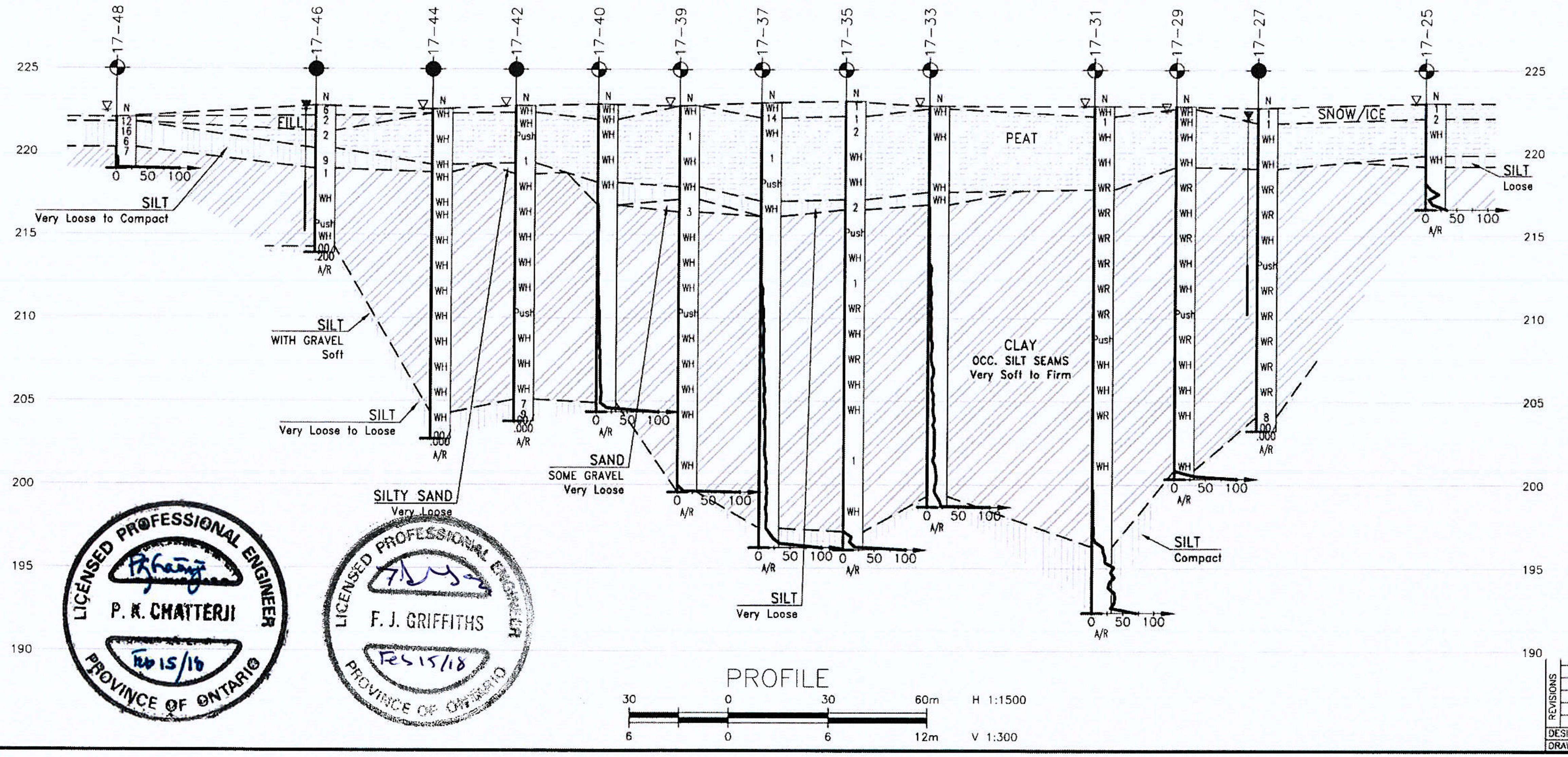


PLAN

30 0 30 60m

SCALE 1:1500

NO	ELEVATION	NORTHING	EASTING
CPT7	NOT DRILLED	5 143 296.8	322 829.1
CPT8	NOT DRILLED	5 143 293.8	322 928.2
CPT9	NOT DRILLED	5 143 223.6	323 090.7



P. K. CHATTERJI
Feb 15/18

F. J. GRIFFITHS
Feb 15/18

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PROFILE

30 0 30 60m H 1:1500

6 0 6 12m V 1:300

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

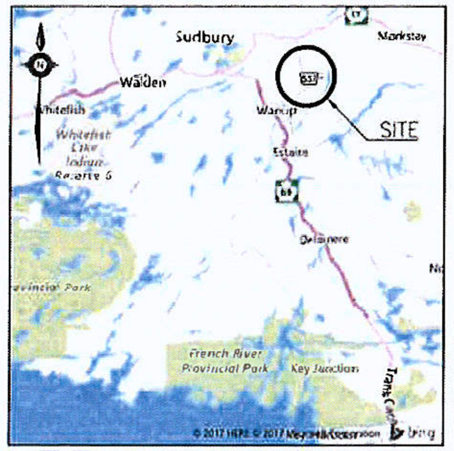
CONT No
GWP No 5134-14-00

SHEET

HIGHWAY 537
JUMBO CREEK

BOREHOLE LOCATIONS AND SOIL STRATA

THURBER ENGINEERING LTD.



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

NO	ELEVATION	NORTHING	EASTING
17-25	223.0	5 143 309.4	322 808.2
17-27	222.7	5 143 296.4	322 853.0
17-29	222.8	5 143 296.4	322 878.0
17-31	222.8	5 143 295.1	322 903.0
17-33	222.8	5 143 294.5	322 954.2
17-35	223.1	5 143 285.6	322 979.9
17-37	223.0	5 143 277.3	323 004.3
17-39	222.8	5 143 270.7	323 032.0
17-40	222.9	5 143 254.0	323 051.3
17-42	222.8	5 143 240.6	323 073.7
17-44	222.6	5 143 222.1	323 092.3
17-46	222.8	5 143 194.4	323 116.0
17-48	222.3	5 143 152.6	323 158.0

-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.

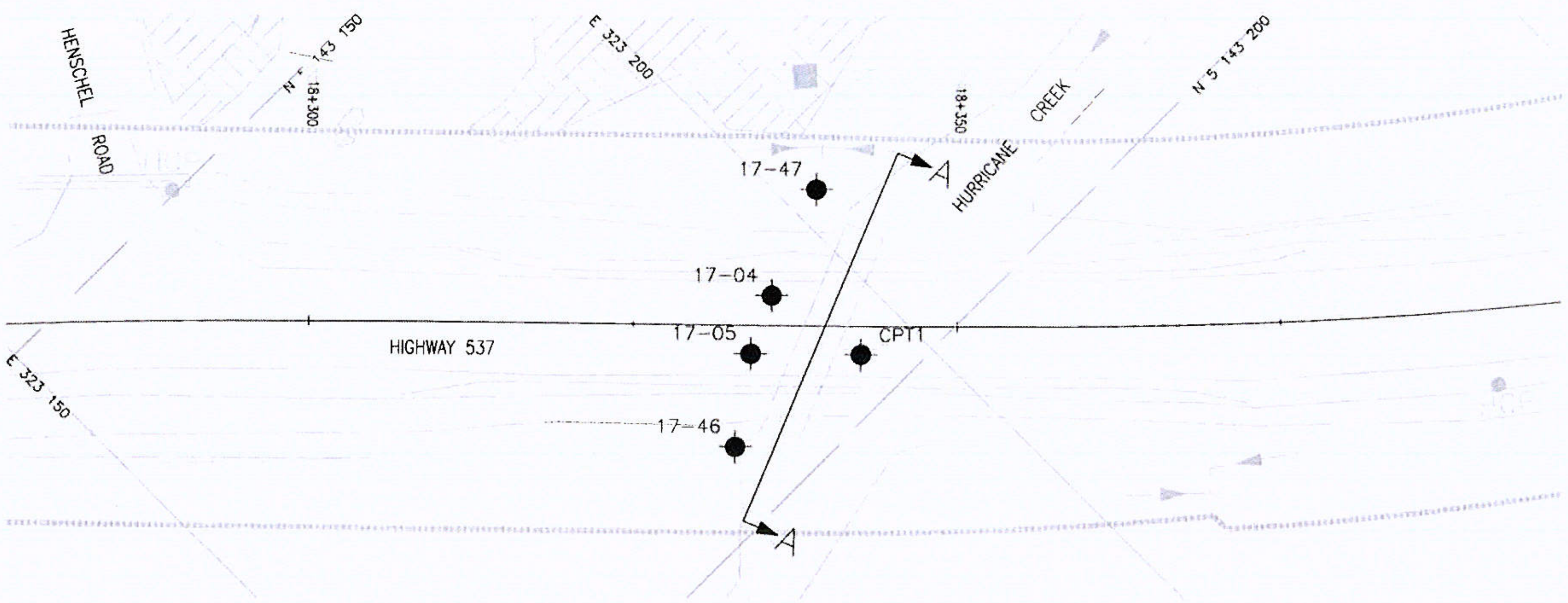
GEOCRES No. 41I-353

REVISIONS	DATE	BY	DESCRIPTION

DESIGN SP	CHK FG	CODE	LOAD	DATE FEB 2018
DRAWN MFA	CHK SP	SITE	STRUCT	DWG 4

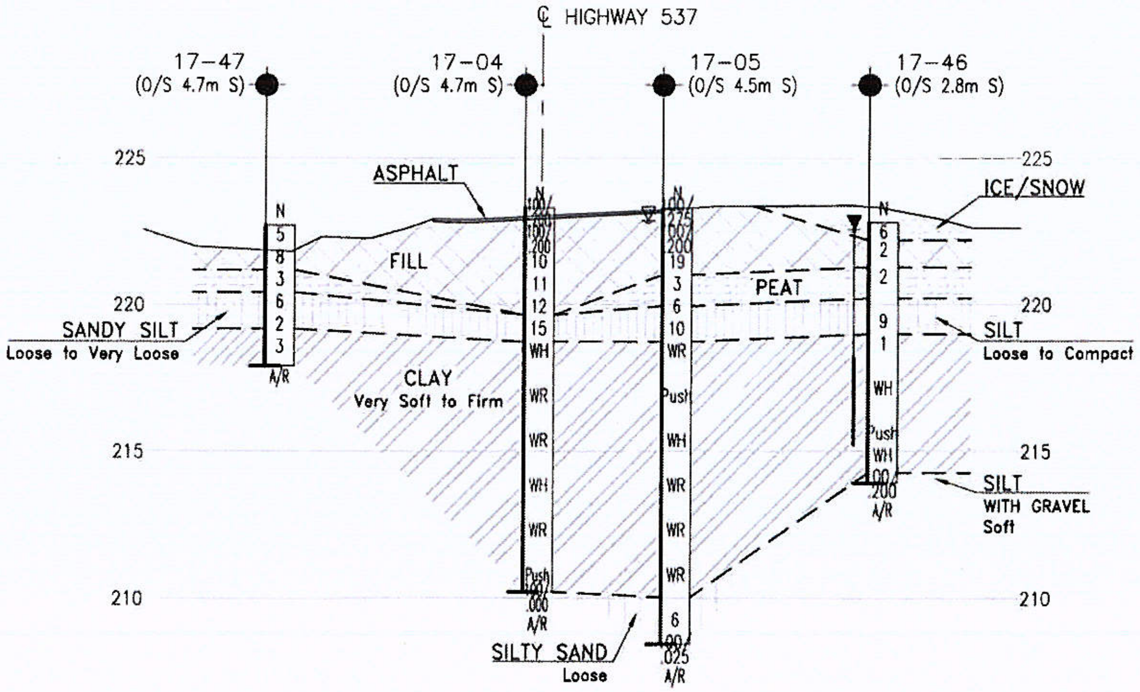
FILENAME: H:\Drafting\14000\14967\TED-14967-BHPP.dwg
PLOTDATE: 2/15/2018 12:26 PM

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE 1:500



SECTION A–A

SCALE 1:250

P. K. CHATTERJI
Feb 15/18

F. J. GRIFFITHS
Feb 15/18

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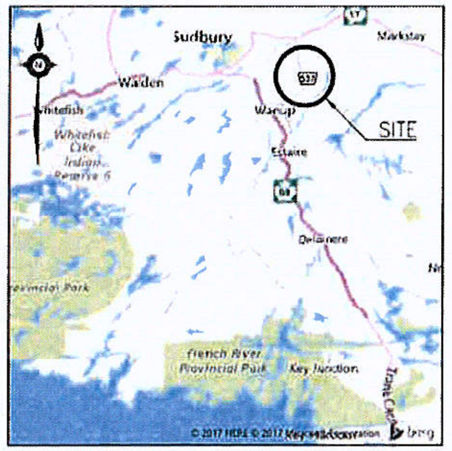
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 5134-14-00

HIGHWAY 537
JUMBO CREEK
CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



KEYPLAN

L E G E N D

●	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
17-04	223.300	5143188.200	323105.800
17-05	223.300	5143190.200	323110.100
17-46	222.800	5143194.400	323116.000
17-47	222.700	5143184.900	323097.600
CPT1	223.200	5143196.346	323104.164

-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. 41I-353

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN SP	CHK FG	CODE	LOAD	DATE FEB 2018	
DRAWN MFA	CHK SP	SITE	STRUCT	DWG 5	

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Appendix B.

Record of Borehole Sheets

Appendix B.1

Current Investigation

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

N-VALUE:

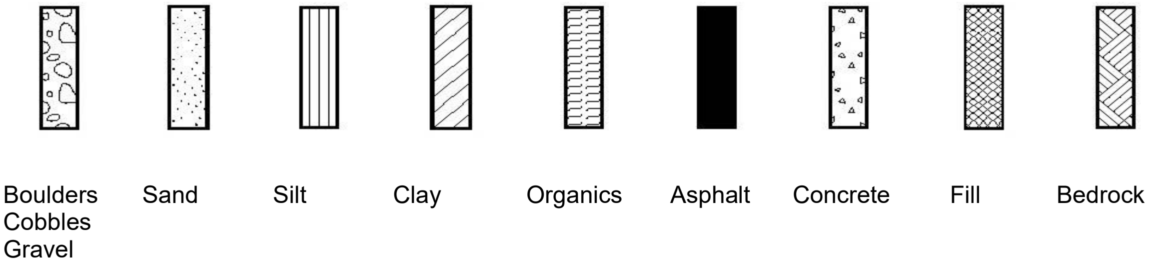
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented,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

DYNAMIC CONE PENETRATION TEST (DCPT):

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

STRATA PLOT:

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



TEXTURING CLASSIFICATION OF SOILS

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		**Group Symbol**	**Typical Description**
COARSE GRAINED SOIL	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

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

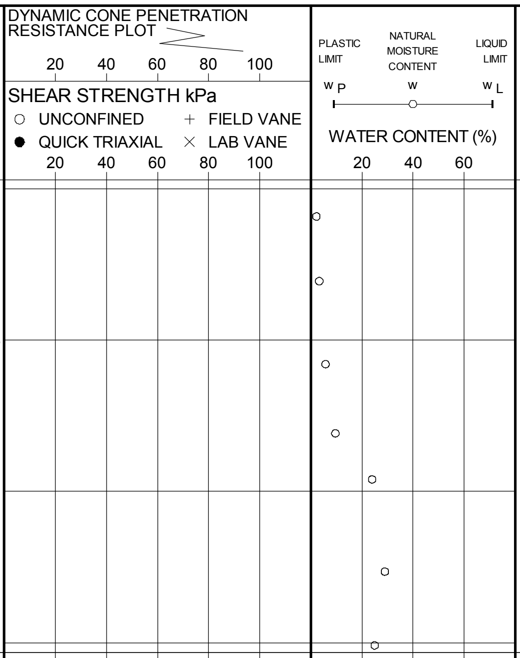
Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-01

1 OF 1 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 143.3 E 323 148.0	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA	COMPILED BY JG
DATUM Geodetic	DATE 10.03.2017 - 10.03.2017	CHECKED BY SP



ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
224.1 0.0 0.0	**25 mm ASPHALT**					224					
223.6 223.6 0.5	SAND with Gravel **FILL** *Frozen* Brown	1	AS								
0.5	**25 mm ASPHALT**	2	AS					35	56	9 (SI+CL)	
	SAND with Silt and Gravel **FILL** *Frozen* to Compact Brown	3	AS		▼	223					
222.2 1.8	**SILT (ML)** Compact Brown	1	SS	11		222					
		2	SS	18				0	4	79	17
220.9		3	SS	100/ 75mm		221					
3.1	End of Borehole on Inferred Bedrock Groundwater at 1.4 m BGS (Elev. 222.7 m) on completion of drilling										

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

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THURBER

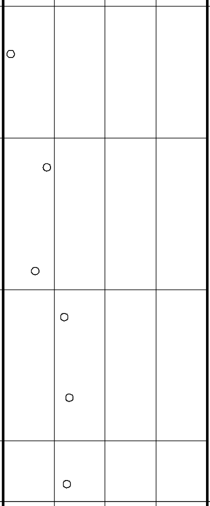
RECORD OF BOREHOLE No 17-02

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 148.1 E 323 152.6
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 10.03.2017 - 10.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
223.9														
0.0	**35 mm ASPHALT**													
	Silty SAND **FILL** *Frozen* to Loose Brown		1	SS	100/ 175mm									
							223							
			2	SS	38						2	74	24 (SI+CL)	
			3	SS	8		222							
221.9 2.0	**SILT (ML)** Compact Brown													
			4	SS	8		221							
			5	SS	100/ 225mm									
220.6 3.3	End of Borehole on Inferred Bedrock													



$+^3, \times^3$: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No 17-03

1 OF 1

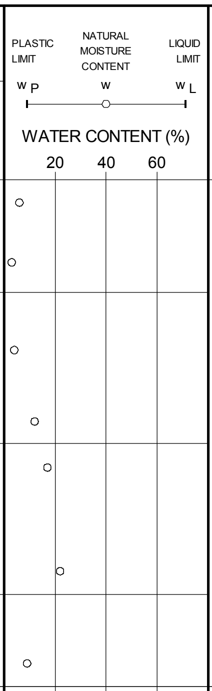
METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 168.5 E 323 130.8
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 11.03.2017 - 11.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
223.7 0.0	**40 mm ASPHALT**									
0.0	SAND with Silt and Gravel **FILL** Brown	1	AS				50	44	6 (SI+CL)	
		2	AS							
						223				
		3	AS		▼		42	52	6 (SI+CL)	
222.1 1.7	**SILT (ML)**, trace Sand Compact Brown	1	SS	13		222				
		2	SS	12			0	10	71	19
						221				
220.7 3.0	**Silty SAND (SM)** Compact Brown	3	SS	100/ 300mm						
220.4 3.4	End of Borehole on Inferred Bedrock Groundwater at 1.2 m BGS (Elev. 222.5 m) on completion of drilling									

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100



UNIT WEIGHT γ kN/m3

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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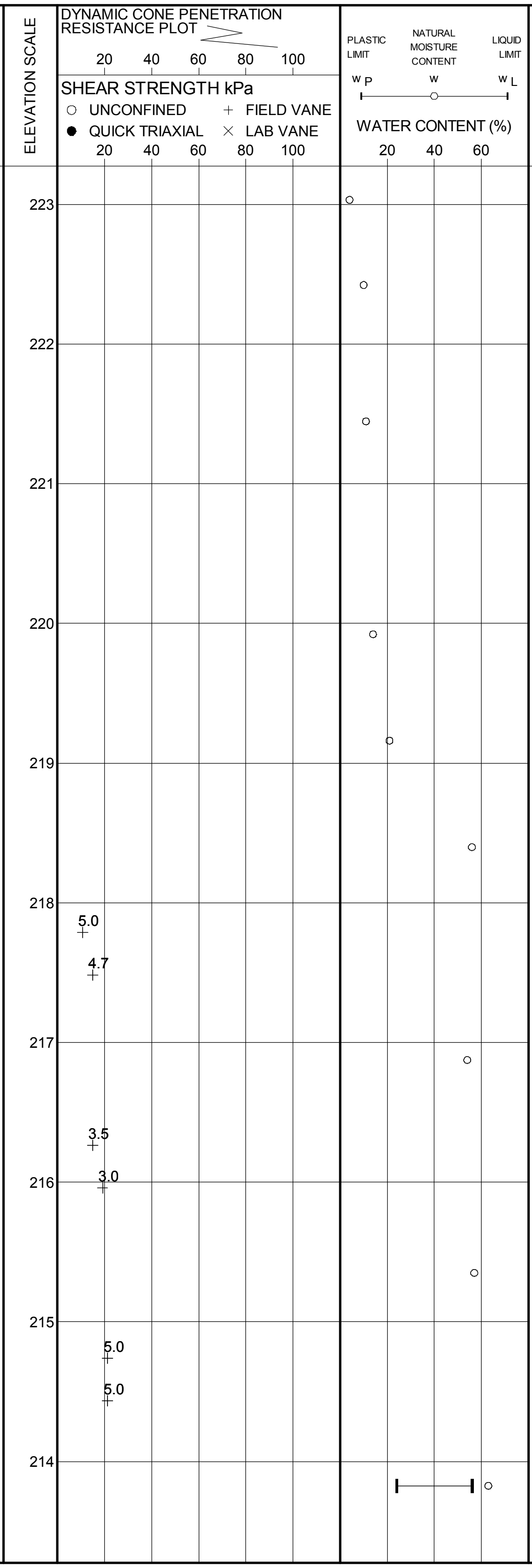
RECORD OF BOREHOLE No 17-04

1 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 188.2 E 323 105.8
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE HSA / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 28.02.2017 - 28.02.2017
CHECKED BY SP

SOIL PROFILE ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.3							
0.0 0.1	**85 mm ASPHALT**						
	SAND with Silt and Gravel **FILL** *Frozen* to Compact Brown	1	SS	100/ 200mm			
		2	SS	100/ 200mm			31 61 8 (SI+CL)
	- frost depth 1.2 m						
		3	SS	10			
		4	SS	11			
219.6		5	SS	12			
3.7	**SILT (ML)** Compact Grey	6	SS	15			
218.7 4.6	**CLAY (CH to CI)** Very Soft to Soft Grey	7	SS	WH			
		8	SS	WR			
		9	SS	WR			
		10	SS	WH			0 0 25 75



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

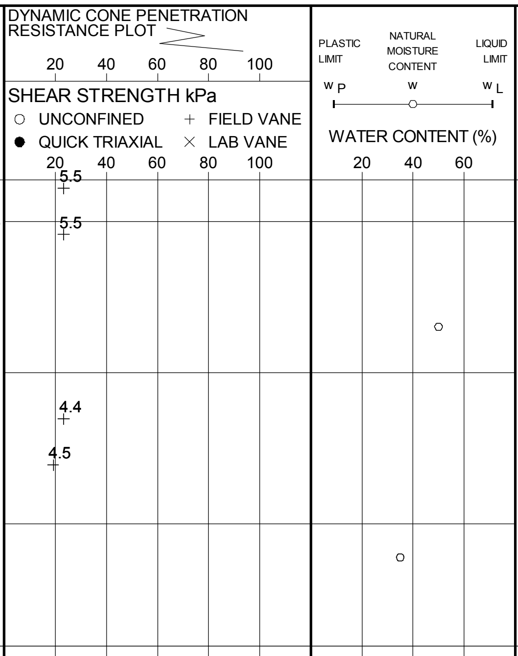
RECORD OF BOREHOLE No 17-04

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 188.2 E 323 105.8
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE HSA / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 28.02.2017 - 28.02.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
	CLAY (CH to CI) Very Soft to Soft Grey	▨					213		
		▨	11	SS	WR				
		▨					212		
		▨					211		
		▨	12	ST	Push				
210.2 13.1	End of Borehole on Inferred Bedrock		~~13~~	~~SS~~	~~100/~~ 0mm				



+³, ×³: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No 17-05

1 OF 2

METRIC

GWP# 5134-14-00

LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 190.2 E 323 110.1

ORIGINATED BY CM

HWY 537

BOREHOLE TYPE HSA

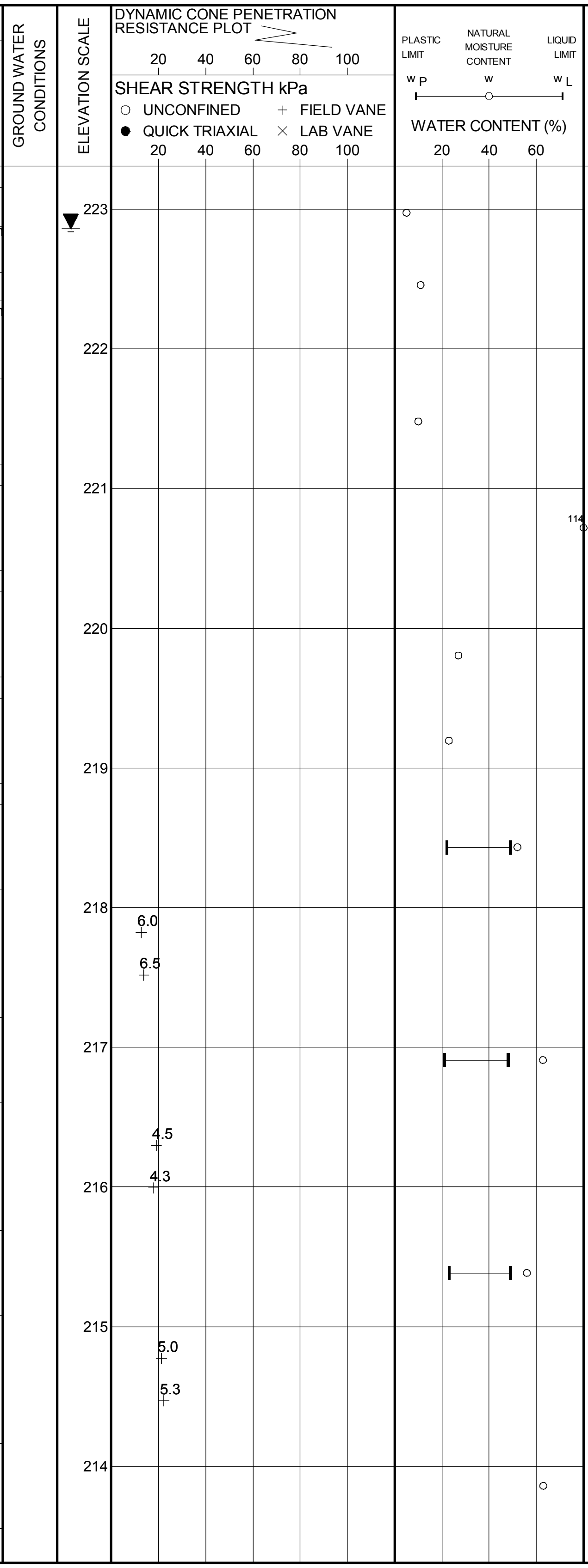
COMPILED BY JG

DATUM Geodetic

DATE 27.02.2017 - 27.02.2017

CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL	REMARKS
223.3									
0.0 0.1	**60 mm ASPHALT**								
	SAND with Silt and Gravel **FILL** *Frozen* to Compact Brown	1	SS	100/275mm					
		2	SS	100/200mm	42	51	7 (SI+CL)		
	- frost depth 1.2 m								
		3	SS	19					
221.0 2.3	**PEAT**, Fine Fibrous Soft Black	4	SS	3					11.3% organic content
220.0 3.4	**SILT (ML)**, some Sand Compact Grey	5	SS	6					
		6	SS	10	0	10	78	12	
218.7 4.6	**CLAY (CI)** Soft to Firm Grey	7	SS	WR	3	3	33	61	
		8	ST	Push	0	0	36	64	OED: e_o = 1.704 C_c = 1.032 C_r = 0.067
		9	SS	WH	0	0	30	70	
		10	SS	WR					



UNIT WEIGHT γ kN/m 3

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

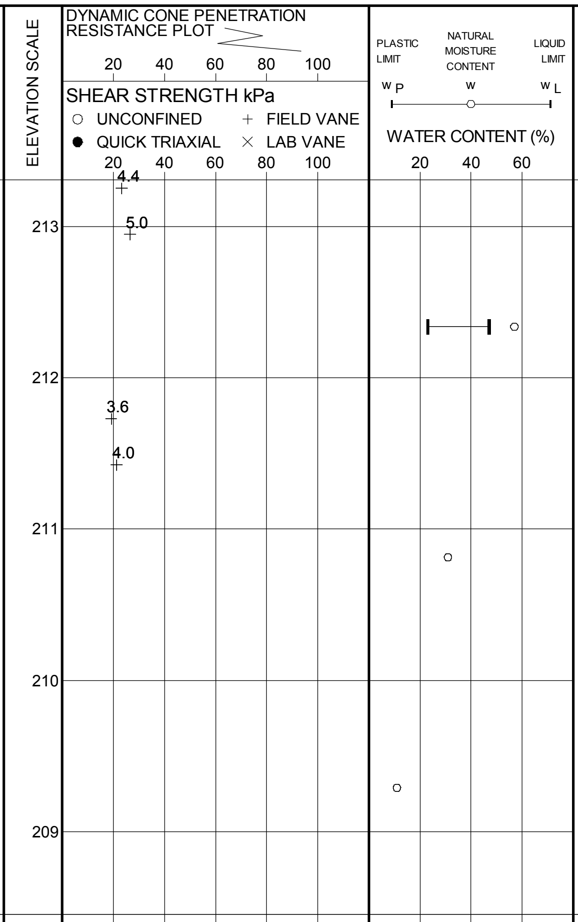
RECORD OF BOREHOLE No 17-05

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 190.2 E 323 110.1
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 27.02.2017 - 27.02.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
	Continued From Previous Page										
	CLAY (CI) Soft to Firm Grey										
			11	SS	WR			0	1	36	63
			12	SS	WR						
210.1 13.3	**Silty SAND (SM)**, trace Gravel Loose Grey										
			13	SS	6			6	50	35	9
208.5 14.9	End of Borehole on Inferred Bedrock Groundwater at 0.45 m BGS (Elev. 222.9 m) on completion of drilling		14	SS	100/ 25mm						



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

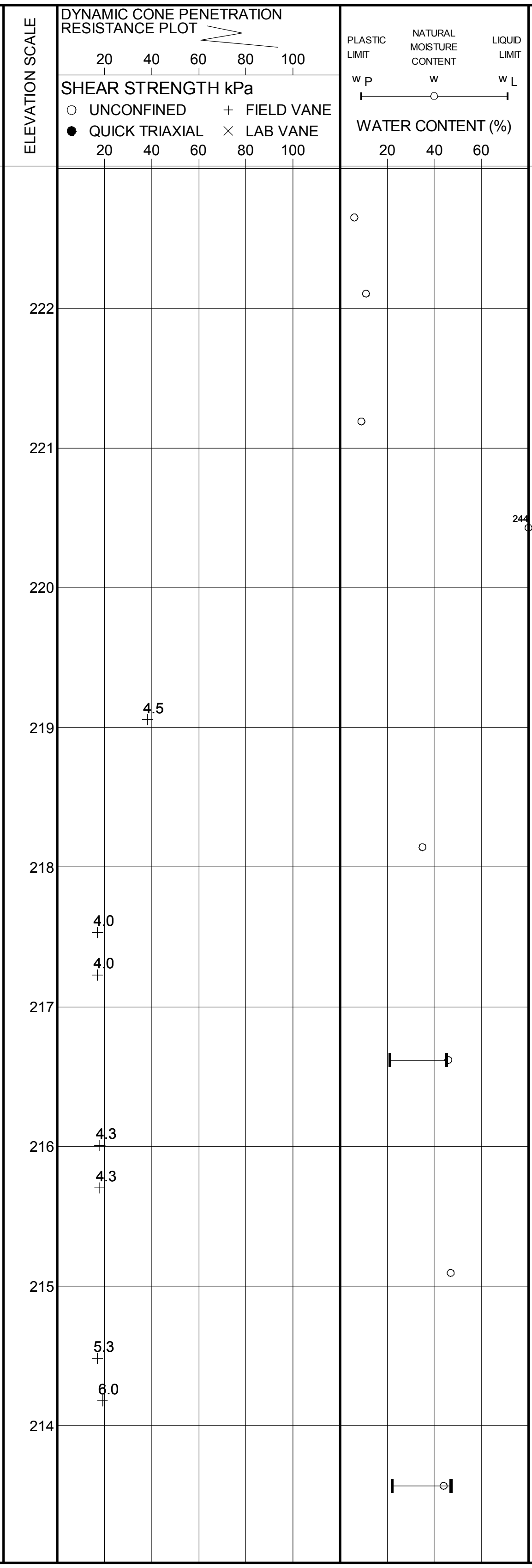
ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-06

1 OF 2 **METRIC**

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 212.0 E 323 081.7	ORIGINATED BY	CM
HWY	537	BOREHOLE TYPE	HSA / NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	02.03.2017 - 06.03.2017	CHECKED BY	SP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
223.0								
0.0	**40mm ASPHALT**							
0.0 222.8 0.2	SAND with Silt and Gravel **FILL** *Frozen* Brown	1	SS	100/ 275mm	24	65	11 (SI+CL)	
0.3	**50mm ASPHALT**							
	SAND with Gravel **FILL** *Frozen* to Compact Brown - frost depth 1.4 m	2	SS	100/ 300mm				
		3	SS	27				
220.7 2.3	**PEAT**, Fine to Coarse Fibrous Stiff to Firm Black	4	SS	4				
		5	ST	Push				
218.9 4.1	**SILT (ML)** Loose Grey							
218.1 4.9	**CLAY (CI to CL)**, occasional Silt seams Soft to Firm Grey	6	SS	4				
		7	SS	WH	0	0	28	72
		8	SS	WH				
		9	SS	WR	0	0	38	62



UNIT WEIGHT γ kN/m3

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

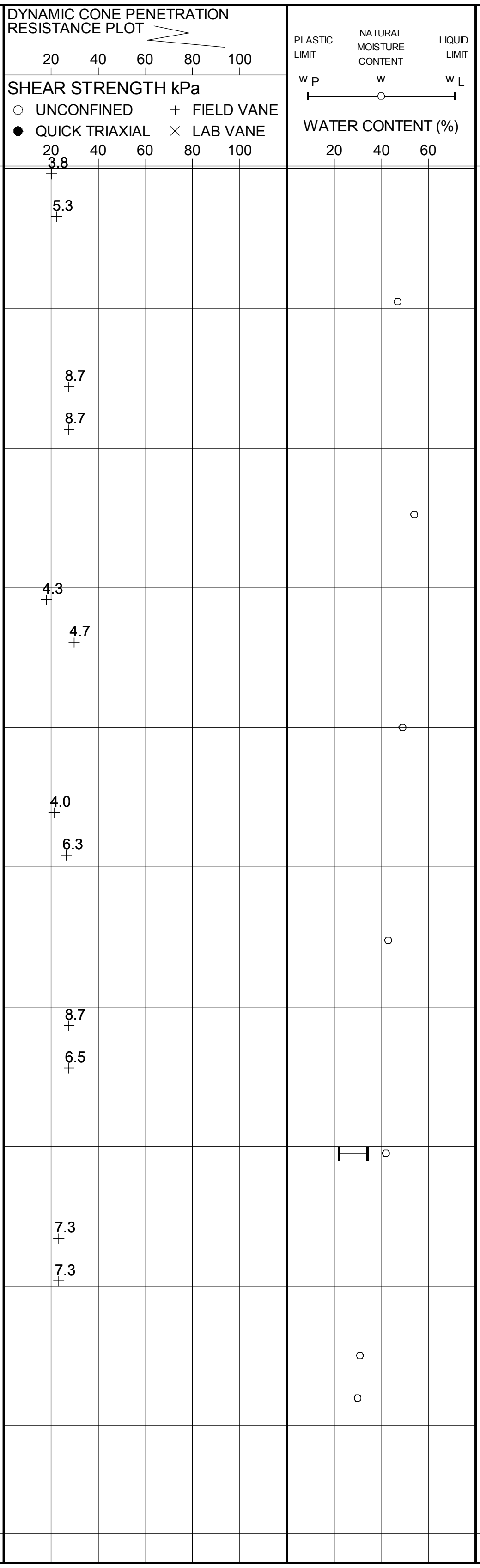
RECORD OF BOREHOLE No 17-06

2 OF 2 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 212.0 E 323 081.7	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE HSA / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 02.03.2017 - 06.03.2017	CHECKED BY SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	CLAY (CI to CL), occasional Silt seams Soft to Firm Grey								
		10	ST	Push	212				
					211				
		11	SS	WR					
					210				
		12	SS	WR	209				
					208				
		13	SS	WR					
					207				
		14	SS	WR	206	0	0	53	47
					205				
204.3 18.7	**SILT (ML)** Loose Brown	15	SS	WR	204				
203.2 19.8	End of Borehole on Inferred Bedrock	16	SS	100/0mm					



UNIT WEIGHT γ kN/m3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-07

1 OF 1

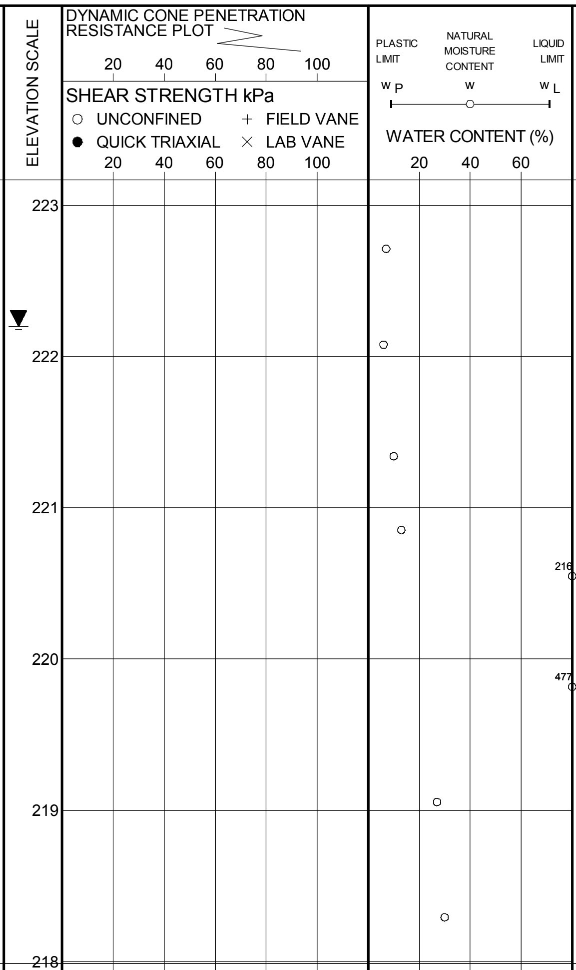
METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 215.5 E 323 085.4	ORIGINATED BY	CM/JM
HWY	537	BOREHOLE TYPE	HSA	COMPILED BY	JG
DATUM	Geodetic	DATE	28.02.2017 - 28.02.2017	CHECKED BY	SP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
223.2 0.0	**60mm ASPHALT**							
0.1 222.9 0.1 0.1	Silty SAND **FILL** *Frozen* Brown	1	AS		51	46	3 (SI+CL)	
0.2 0.3	**30mm ASPHALT**							
	Silty SAND **FILL** *Frozen* Brown	2	AS		36	60	4 (SI+CL)	
	40mm ASPHALT							
	SAND with Gravel **FILL** *Frozen* to Dense Grey	3	SS	41				
220.8 2.4	**PEAT**, Fine to Coarse Fibrous Soft Black	4	SS	6				
		5	SS	4	65.3% organic content			
219.4 3.8	**SILT (ML)** Loose Grey	6	SS	8	0	1	89	10
		7	SS	3				
218.0 5.2	End of Borehole Groundwater at 0.97 m BGS (Elev. 222.2 m) on completion of drilling							

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-08

1 OF 2

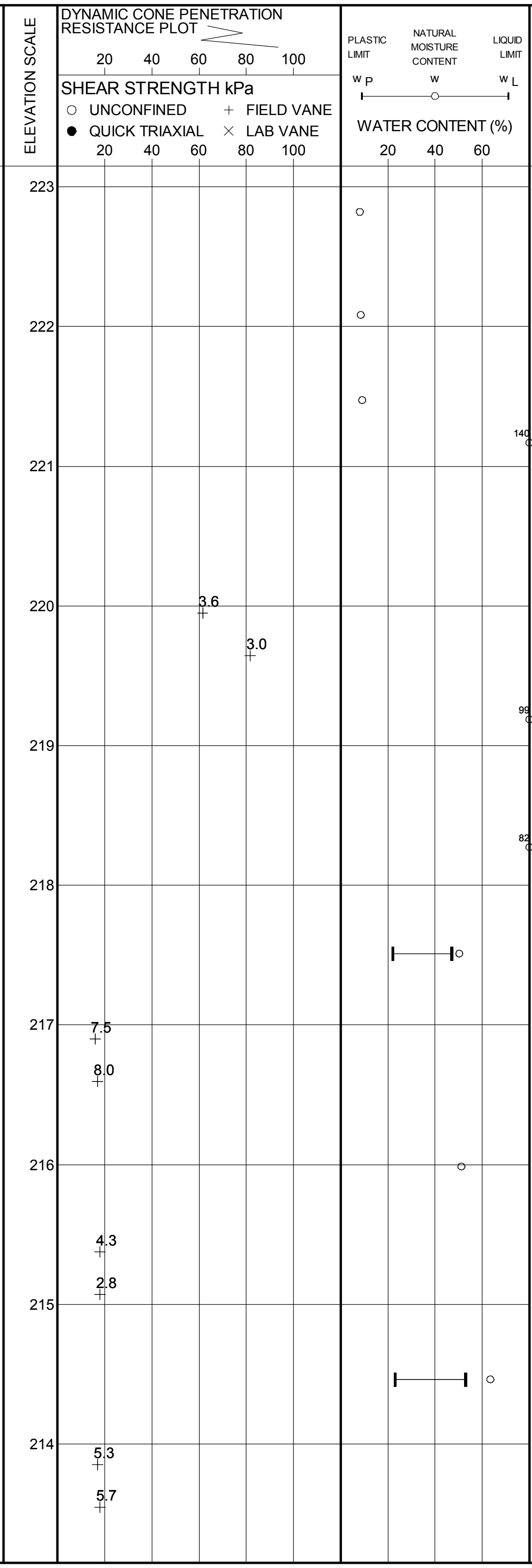
METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 233.3 E 323 067.4
ORIGINATED BY CM/NW

HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG

DATUM Geodetic
DATE 20.03.2017 - 21.03.2017
CHECKED BY SP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
223.2								
0.0 0.1	**40mm ASPHALT**							
	SAND with Silt and Gravel **FILL** *Frozen* to Compact Grey	1	SS	100/ 200mm	36	55	9 (SI+CL)	
		2	SS	20				
221.3 1.8	**PEAT**, Coarse Fibrous Very Stiff to Stiff Dark Brown	3	SS	7				
		4	SS	5				
		5	SS	2				
218.9 4.3	**SILT (ML)** with Organics Loose Grey	6	SS	4				
217.8 5.3	**CLAY (CH to CI)** Soft to Firm Grey	7	SS	WH	0	1	41	58
		8	SS	WH				
		1	ST	Push	0	0	43	57



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-08

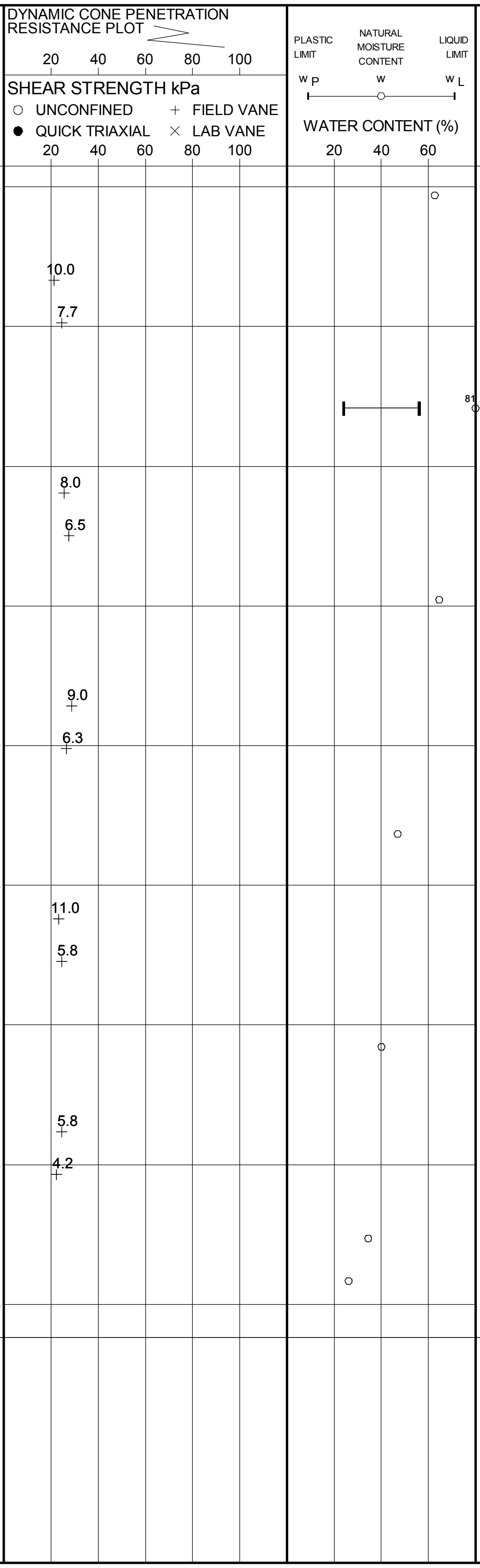
2 OF 2

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 233.3 E 323 067.4	ORIGINATED BY	CM/NW
HWY	537	BOREHOLE TYPE	NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	20.03.2017 - 21.03.2017	CHECKED BY	SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
	CLAY (CH to CI) Soft to Firm Grey		9	SS	WH		213					
							212					
			10	SS	WH				0	0	27	73
							211					
			11	SS	WH		210					
							209					
			12	SS	WH							
							208					
			13	SS	WH		207					
							206					
205.4 17.8	**SILT (ML)** Compact Grey		14	SS	3		205					
204.8 18.4	End of Borehole on Inferred Bedrock		15	SS	100/ 0mm							



+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-09

1 OF 1 **METRIC**

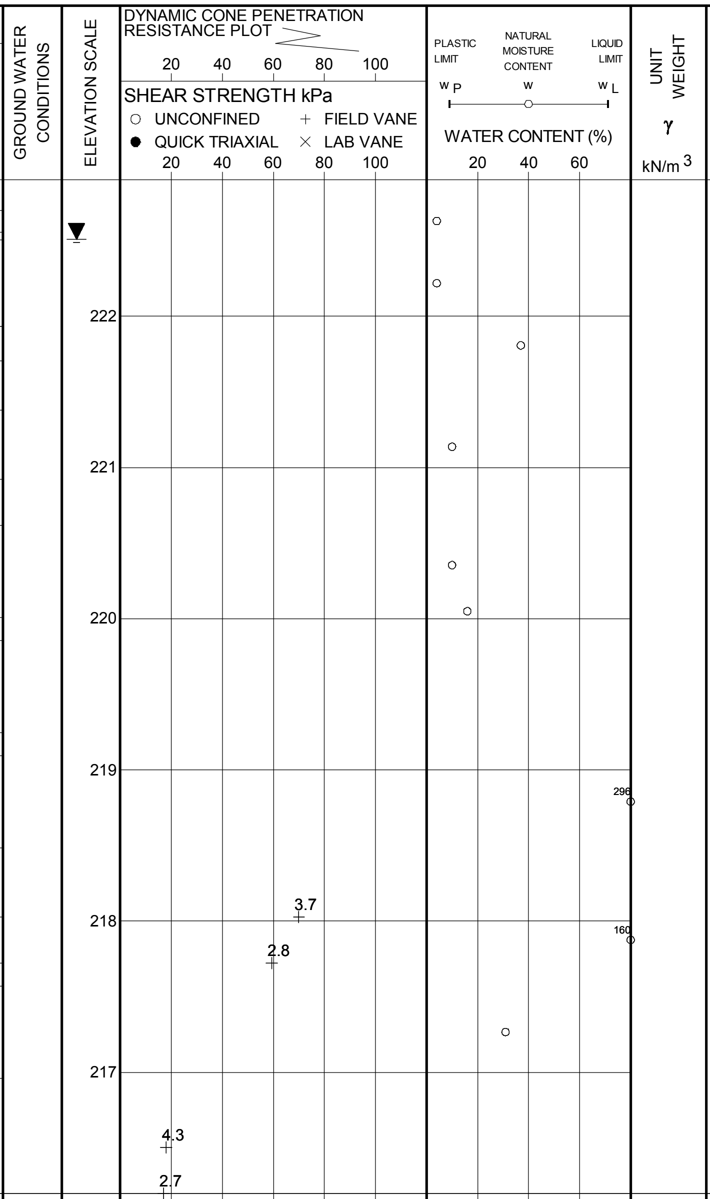
GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 244.0 E 323 044.1
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 04.02.2017 - 04.02.2017
CHECKED BY SP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
222.9	
0.0	**60mm ASPHALT**
0.1	Silty SAND **FILL** *Frozen* Brown
222.6 0.2	**30mm ASPHALT**
222.5 0.2	SAND with Gravel **FILL** *Frozen* Grey
0.4	**50mm ASPHALT**
0.4	SAND with Silt and Gravel **FILL** *Frozen* Grey - 250 mm wood log at 1.0 m - frost depth 1.5 m
220.1 2.8	**Wood/Sawdust** Compact Brown
219.1 3.8	**PEAT**, Fine to Coarse Fibrous Loose Orange/Brown
217.6 5.3	**CLAY** Soft Grey
216.2 6.7	End of Borehole Groundwater at 0.4 m BGS (Elev. 222.5 m) on completion of drilling

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS		28 62 10 (SI+CL)
2	AS		
3	AS		
1	SS	37	
2	SS	36	
3	SS	13	3.0% Organic Content
4	SS	7	
5	GS		
6	SS	5	



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

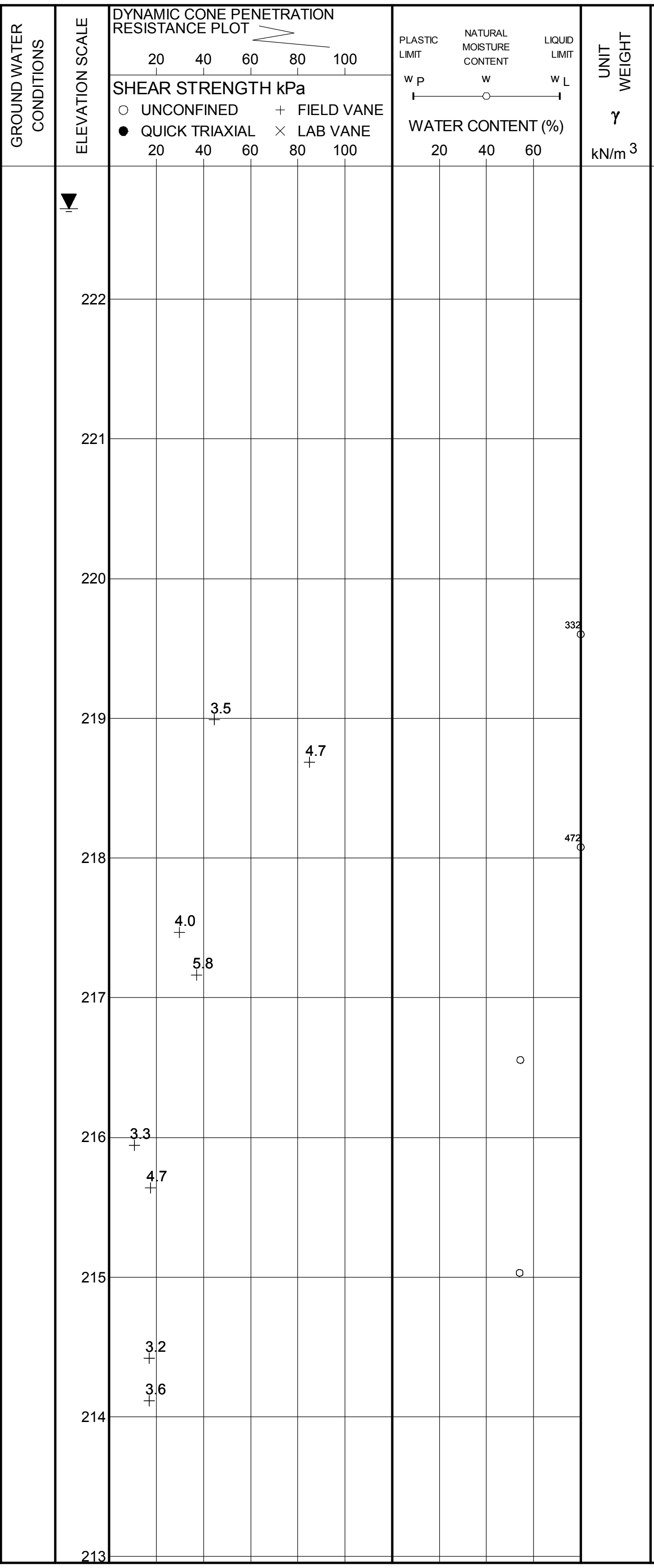
RECORD OF BOREHOLE No 17-10

1 OF 2

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 249.4 E 323 048.0		ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / NW Casing		COMPILED BY JG
DATUM Geodetic	DATE 09.03.2017 - 09.03.2017		CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS	GR	SA	SI	CL
223.0 0.0	**30mm ASPHALT**								
	SAND with Gravel **FILL** *Frozen* to Compact Brown - Augerd through wood log at 0.75 m	1	SS	100/ 50mm					
		2	SS	12					
221.0 2.0	**PEAT** Stiff to Soft Reddish Brown	3	ST	Push					
		4	SS	1					
		5	SS	1	54.7% organic content				
217.8 5.2	**CLAY (CI)**, frequent Silt seams within first 1.5 m Soft to Firm Grey	6	SS	WH		0	2	45	53
		7	SS	WR					
		8	SS	Push					



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+ 3, × 3: Numbers refer to Sensitivity

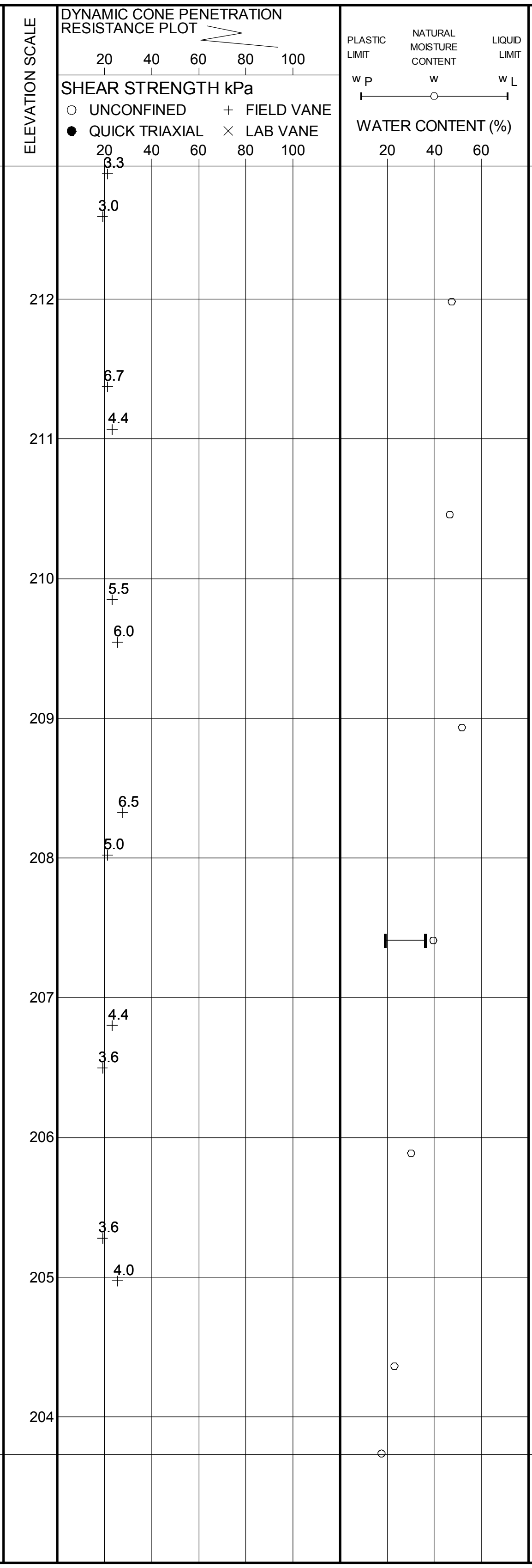
20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-10

2 OF 2 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 249.4 E 323 048.0	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 09.03.2017 - 09.03.2017	CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
	Continued From Previous Page										
	CLAY (CI) Soft to Firm Grey										
			9	SS	WR						
			10	SS	WR						
			11	SS	WH						
			12	SS	WR			0	0	55	45
			13	SS	WR						
204.7 18.3	**SILT (ML)** Loose Brown		14	SS	7			3	4	83	10
203.7 19.2	End of Borehole on Inferred Bedrock Groundwater at 0.3 m BGS (Elev. 222.7 m) on completion of drilling		15	SS	100/ 25mm						



+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

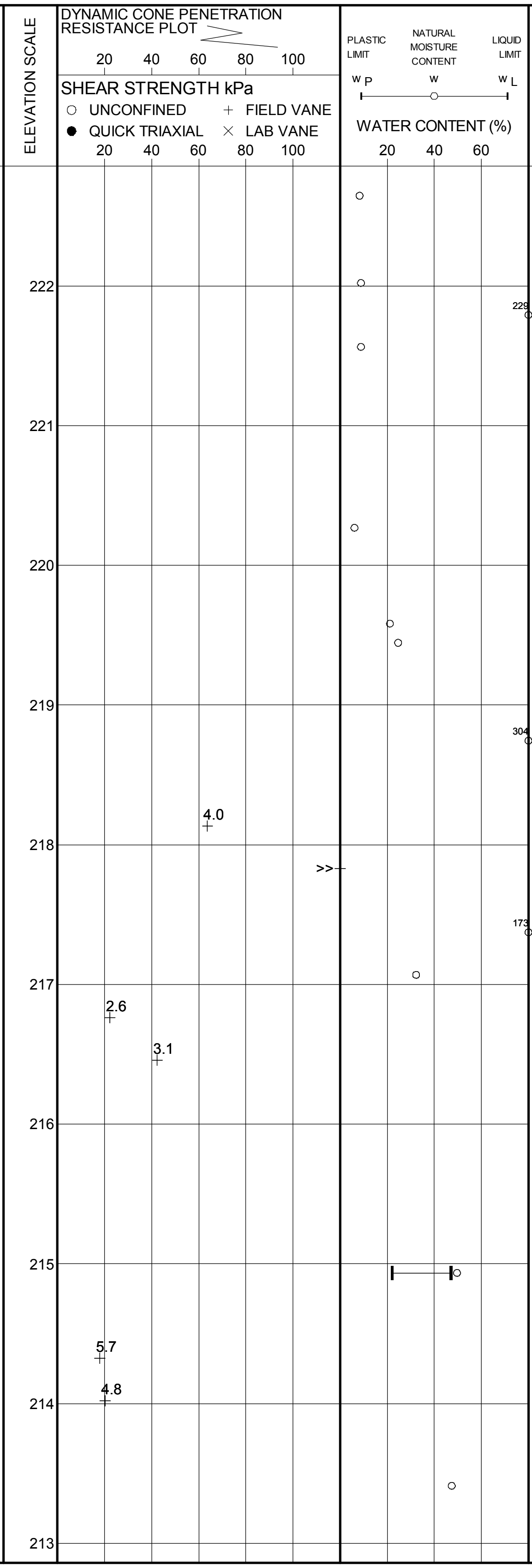
RECORD OF BOREHOLE No 17-11

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 256.1 E 323 022.8
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 13.03.2017 - 13.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
222.9										
0.0 0.1	**25mm ASPHALT**									
	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 75mm						
221.9 0.9	Sawdust **FILL** - frost depth 1.1 m	2	SS	15						
221.6 1.2	SAND with Silt and Gravel **FILL** Very Dense to Dense Grey	3	SS	100/ 250mm						
		4	SS	45			27	66	7 (SI+CL)	
		5	SS	100/ 100mm						
219.5 3.4	**PEAT**, Fine to Coarse Fibrous Firm to Very Stiff Reddish Brown - wood log at 3.6 m	6	SS	5						
217.2 5.6	**SILT (ML)** Very Loose Grey	7	SS	2			0	3	69	28
216.9 5.9	**CLAY (CI)** Soft to Firm Grey	8	SS	WH			0	0	37	63
		9	SS	WH						



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-11

2 OF 3

METRIC

GWP# 5134-14-00

LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 256.1 E 323 022.8

ORIGINATED BY JM

HWY 537

BOREHOLE TYPE HSA / NW Casing

COMPILED BY JG

DATUM Geodetic

DATE 13.03.2017 - 13.03.2017

CHECKED BY SP

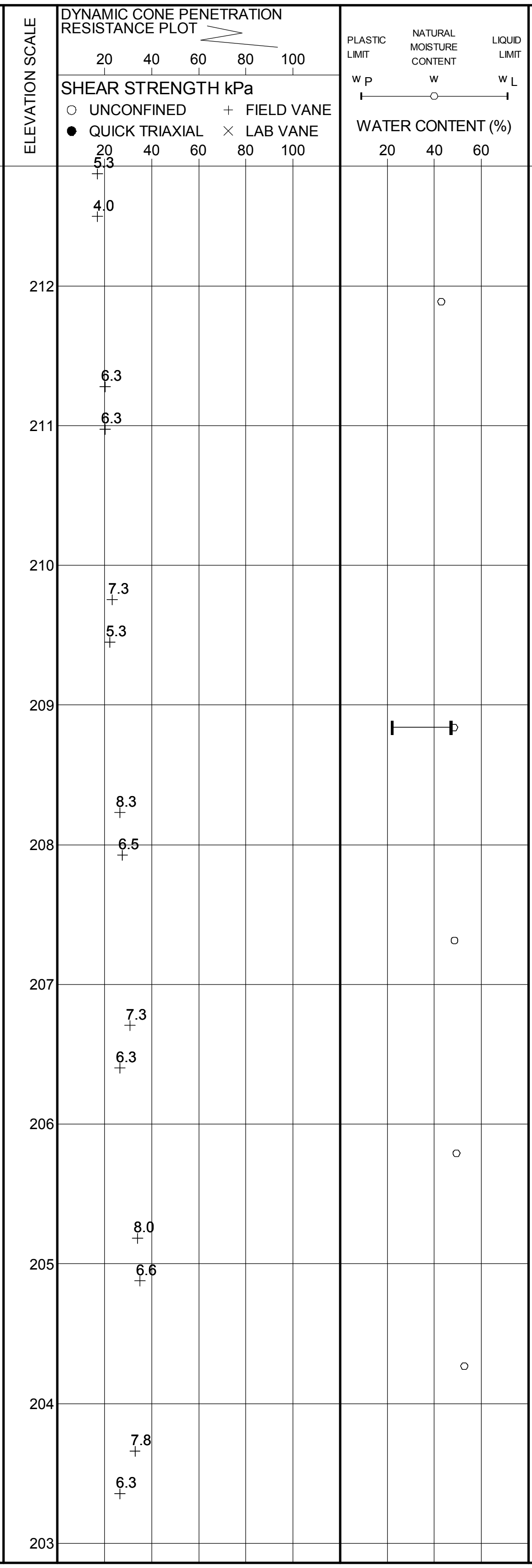
SOIL PROFILE

Continued From Previous Page

CLAY (CI)
Soft to Firm
Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
10	SS	WR				
11	ST	Push				
12	SS	WR	0	0	36	64
13	SS	WR				
14	SS	WH				
15	SS	WH				



UNIT WEIGHT γ kN/m3

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

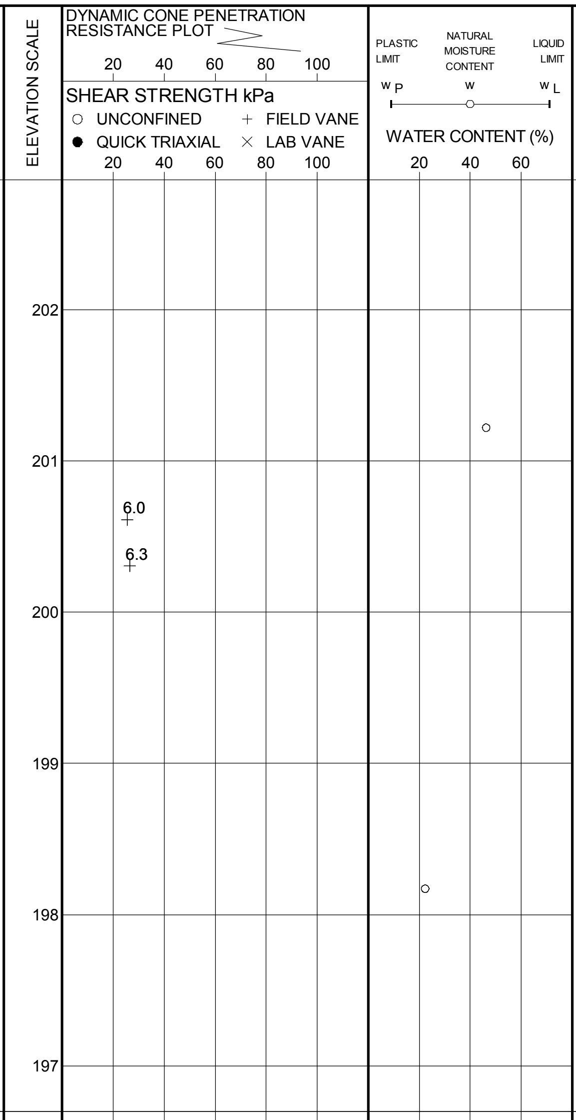
RECORD OF BOREHOLE No 17-11

3 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 256.1 E 323 022.8	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 13.03.2017 - 13.03.2017	CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	CLAY (CI) Soft to Firm Grey	16	SS	WR			
198.5 24.4	**SILT (ML)** Loose Grey	17	SS	9			
196.7 26.2	End of Borehole on Inferred Bedrock	18	SS	100/ 0mm			



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

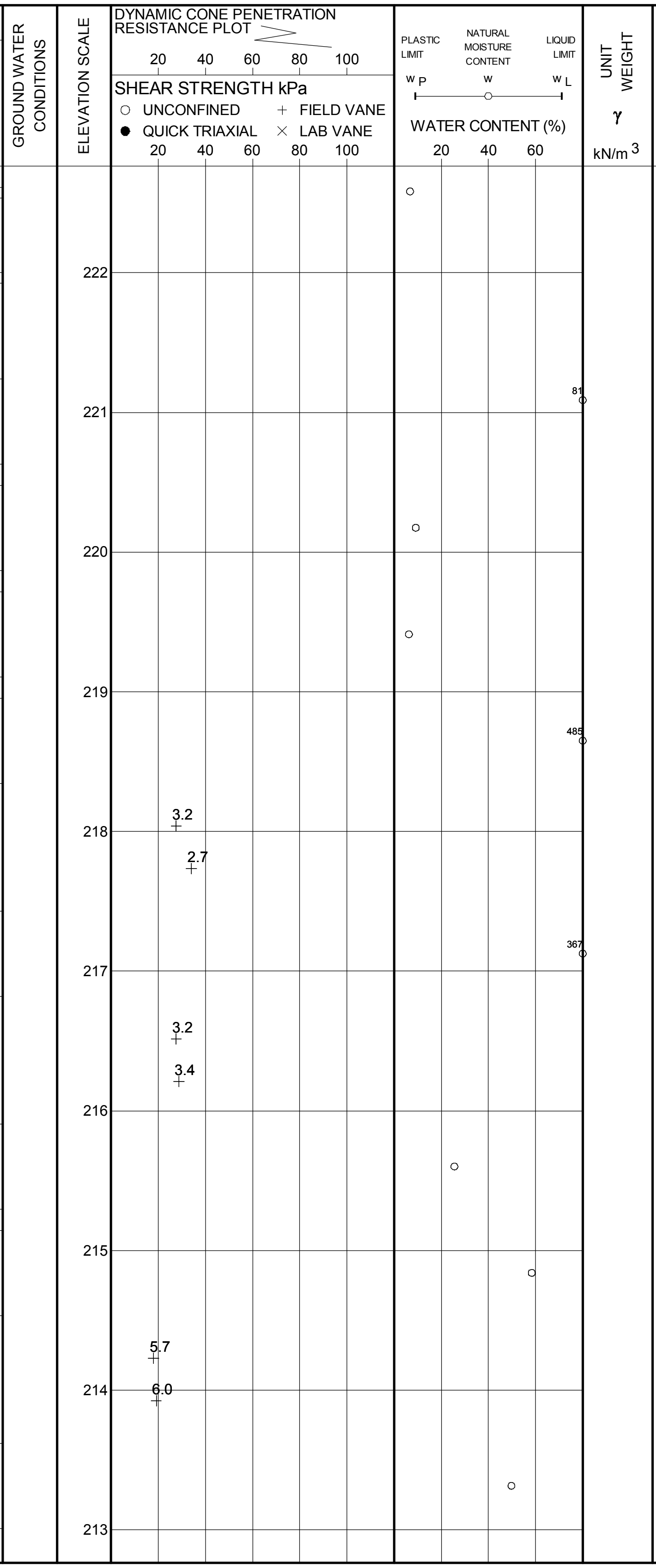
RECORD OF BOREHOLE No 17-12

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 265.6 E 323 000.5
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 14.03.2017 - 15.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.8 0.0	**25mm ASPHALT**				
0.0	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 75mm	
		2	SS	100/ 75mm	
221.2 1.5	Sawdust **FILL**				
220.9 1.8	SAND with Silt and Gravel, occasional Cobbles **FILL** Very Dense Brown	3	SS	55	
		4	SS	90	
		5	SS	74	41 50 9 (SI+CL)
219.0 3.8	**PEAT**, Coarse Fibrous Firm Brown	6	SS	4	
		7	SS	WH	51.8% organic content
215.9 6.9	**SILT (ML)** Loose Grey	8	SS	5	0 0 83 17
215.1 7.6	**CLAY (CH to CI)** Soft to Firm Grey	9	SS	WR	
		10	SS	WH	



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-12

2 OF 3

METRIC

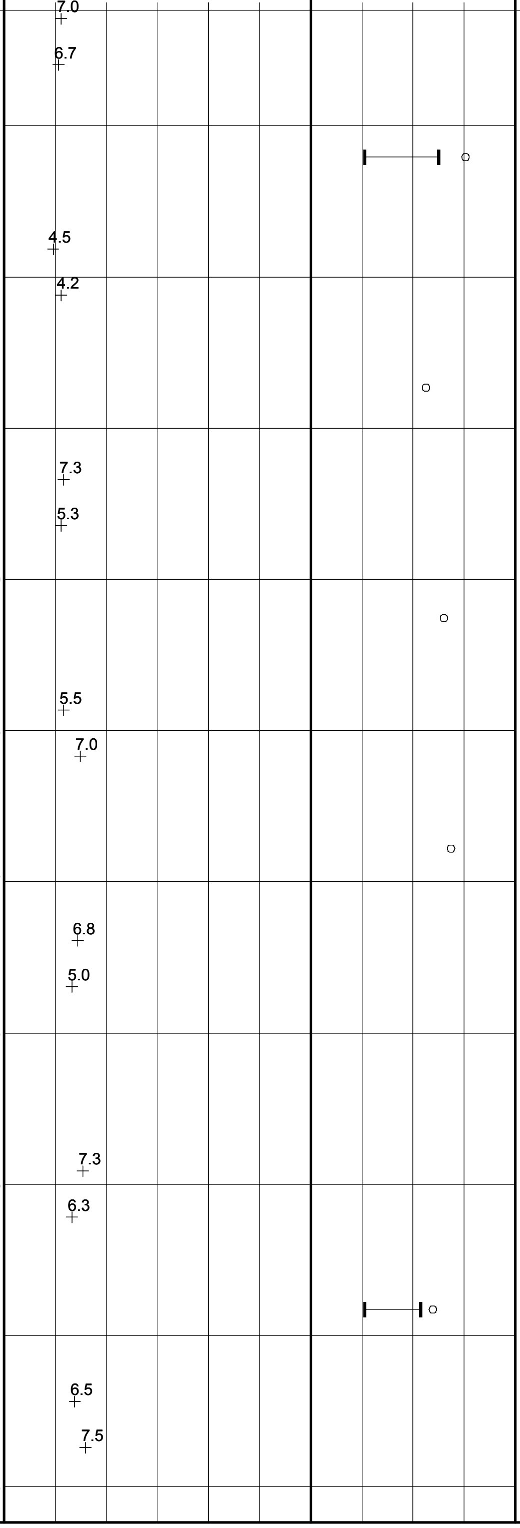
GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 265.6 E 323 000.5	ORIGINATED BY	CM
HWY	537	BOREHOLE TYPE	NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	14.03.2017 - 15.03.2017	CHECKED BY	SP

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

SOIL PROFILE		SAMPLES						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
	CLAY (CH to CI) Soft to Firm Grey								
							212		
			11	SS	WR				0 0 32 68
							211		
			12	SS	WR				
							210		
							209		
			13	SS	WR				
							208		
			14	SS	WR				
							207		
							206		
			15	ST	Push				
							205		
			16	SS	WR				0 0 43 57
							204		
							203		



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-12

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 265.6 E 323 000.5
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 14.03.2017 - 15.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							
	CLAY (CH to CI) Soft to Firm Grey							
			17	SS	WR			
			18	SS	1			
197.3 25.5	**SILT (ML)** Loose Grey							
196.9 25.9	End of Borehole on Inferred Bedrock		19	SS	100/ 0mm			

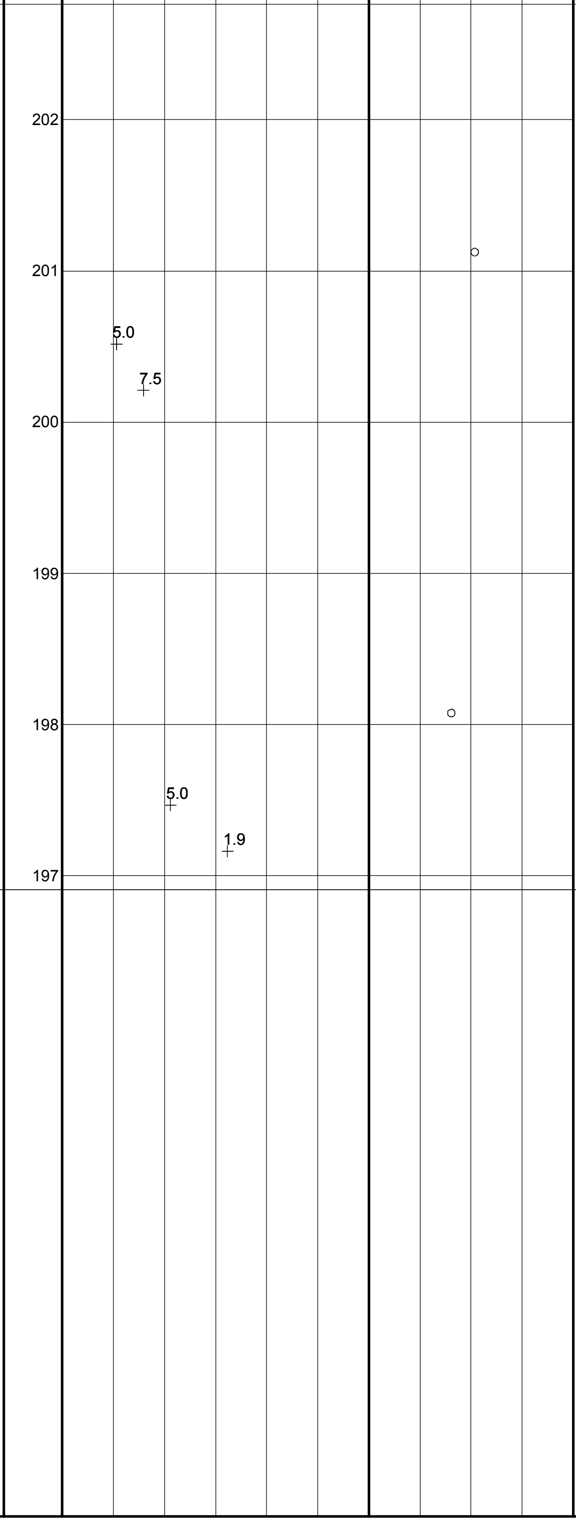
ELEVATION SCALE

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%)
20 40 60



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

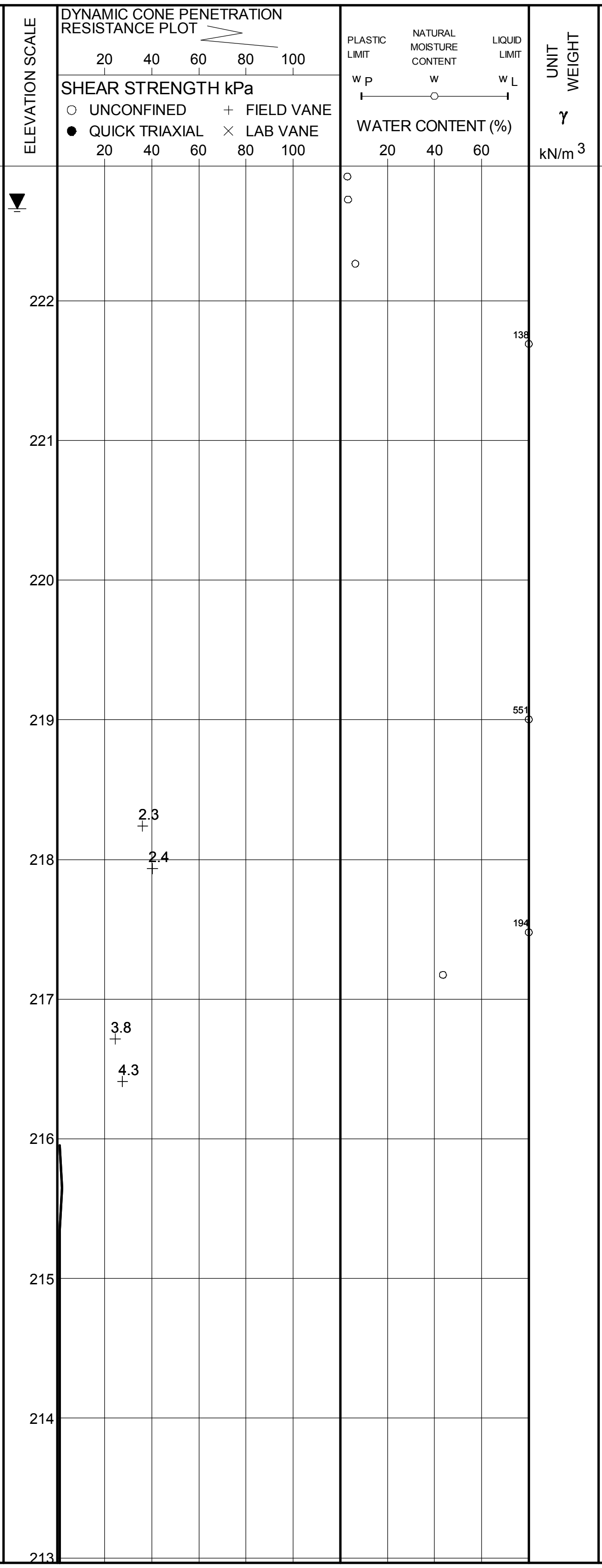
RECORD OF BOREHOLE No 17-13

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 271.9 E 323 002.6
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / DCPT
COMPILED BY JG
DATUM Geodetic
DATE 10.03.2017 - 10.03.2017
CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.0					
0.0	**25mm ASPHALT**	1	AS		
	SAND with Gravel **FILL** *Frozen* Brown	2	AS		
		3	AS		37 62 1 (SI+CL)
221.9 1.0	Wood Logs/Sawdust **FILL** Compact Brown	4	AS		
		1	SS	22	
220.7 2.3	**PEAT** Firm Reddish Brown	2	SS	6	
		3	SS	3	
		4	SS	4	
217.3 5.6	**CLAY** Soft Grey	5	SS	WH	0 1 60 39
216.3 6.7	End of Sampled Borehole Groundwater at 0.3 m BGS (Elev. 222.7 m) on completion of drilling DCPT from 6.7 m to 28.4 m **Inferred CLAY**				



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

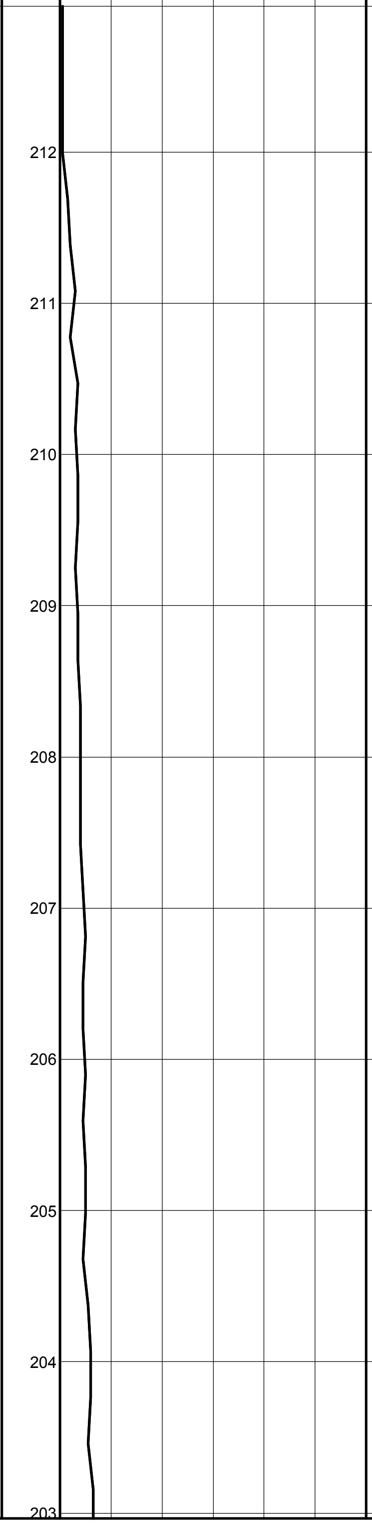
RECORD OF BOREHOLE No 17-13

2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 271.9 E 323 002.6
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / DCPT
COMPILED BY JG
DATUM Geodetic
DATE 10.03.2017 - 10.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Inferred CLAY	▨									



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+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ◐ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-13

3 OF 3 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 271.9 E 323 002.6		ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / DCPT		COMPILED BY JG
DATUM Geodetic	DATE 10.03.2017 - 10.03.2017		CHECKED BY SP

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION (Continued From Previous Page)	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Inferred CLAY							
196.8 26.2	**Inferred SILT**							
194.5 28.4	End of dCPT on Inferred Bedrock							

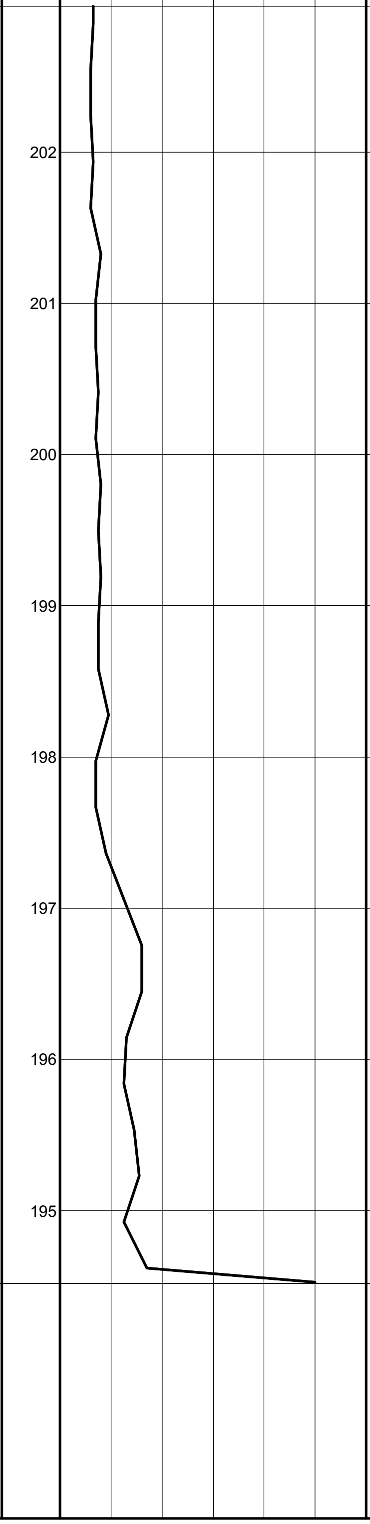
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3



$+^3, \times^3$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-14

1 OF 3 **METRIC**

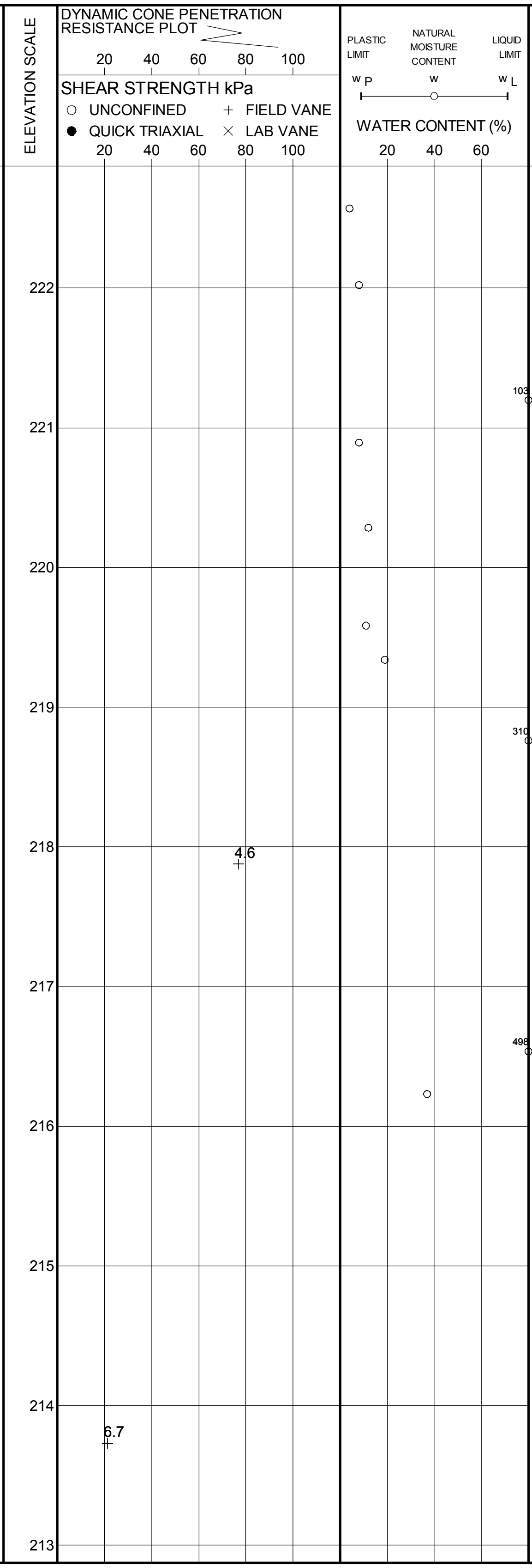
GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 951.7	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	HSA / HW Casing / Electronic Vane	COMPILED BY	JG
DATUM	Geodetic	DATE	07.03.2017 - 08.03.2017	CHECKED BY	SP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
222.9	
0.0	**30mm Asphalt**
	SAND with Silt and Gravel **FILL** Frozen Brown
221.4 / 1.5	Sawdust **FILL** Compact Redish Brown
221.0 / 1.8	SAND with Silt and Gravel **FILL** Dense Grey
219.4 / 3.5	**PEAT**, Coarse Fibrous Stiff to Soft Dark Brown
216.3 / 6.6	**SILT** Very Loose Grey
215.0 / 7.9	**INFERRED CLAY** Soft to Firm

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	100/ 275mm	33 59 8 (SI+CL)
2	SS	100/ 250mm	
3	SS	25	
4	SS	50	12 81 7 (SI+CL)
5	SS	49	
6	SS	7	21.8% organic content
7	SS	WH	



UNIT WEIGHT γ kN/m3

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

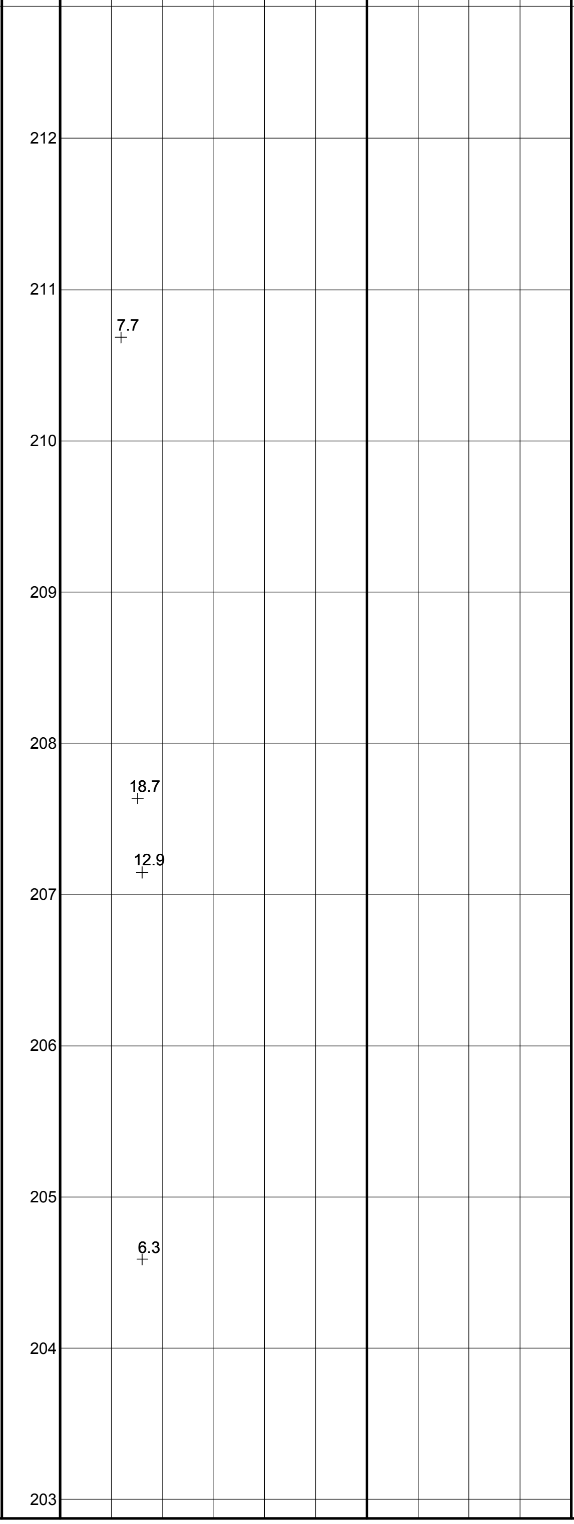
THURBER

RECORD OF BOREHOLE No 17-14

2 OF 3 METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 951.7	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	HSA / HW Casing / Electronic Vane	COMPILED BY	JG
DATUM	Geodetic	DATE	07.03.2017 - 08.03.2017	CHECKED BY	SP

SOIL PROFILE			SAMPLES									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY Soft to Firm	▨									



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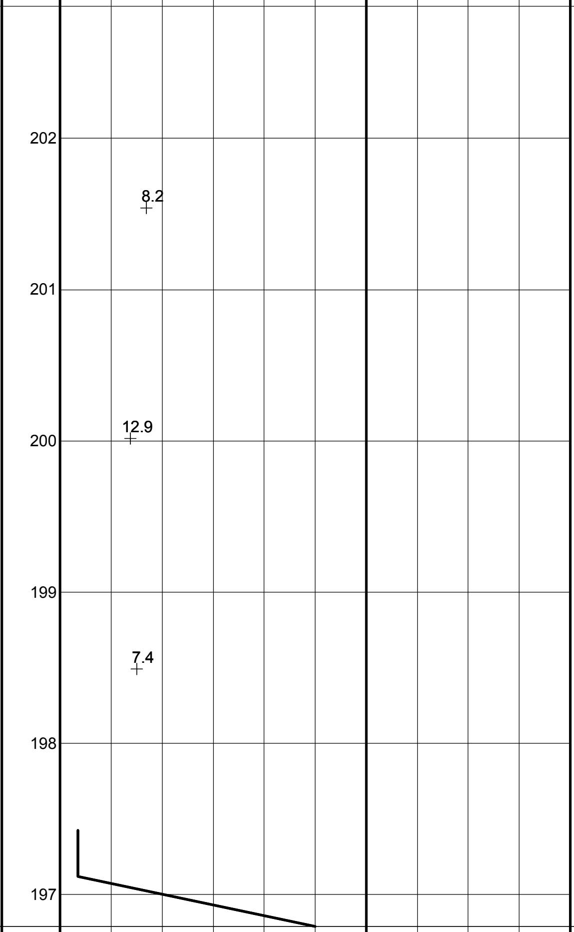
+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-14 3 OF 3 METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 951.7	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	HSA / HW Casing / Electronic Vane	COMPILED BY	JG
DATUM	Geodetic	DATE	07.03.2017 - 08.03.2017	CHECKED BY	SP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
	Continued From Previous Page										
	INFERRED CLAY Soft to Firm										
197.6 25.3	**INFERRED SILT** Compact										
196.8 26.1	End of dCPT on Inferred Bedrock										



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

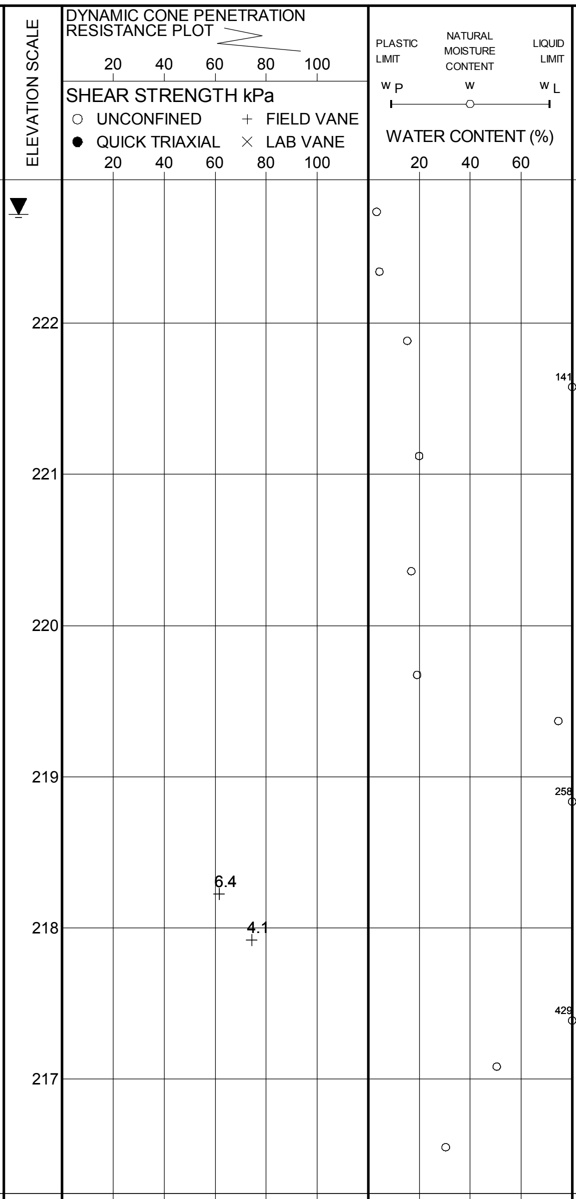
RECORD OF BOREHOLE No 17-15

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 282.8 E 322 952.6
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 05.03.2017 - 05.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
223.0											
0.0 0.1	**70mm ASPHALT**										
	SAND with Silt and Gravel **FILL** *Frozen* Brown		1	AS							
			2	AS							
			3	AS				28	63	9 (SI+CL)	
221.7 1.2	Sawdust **FILL** Compact Redish Brown		4	AS							
221.4 1.5	SAND with Gravel **FILL** Loose Brown		1	SS	4						
			2	SS	6						
			3	SS	10						
219.4 3.5	**PEAT**, Fine to Coarse Fibrous Soft Reddish Brown to Brown		4	SS	2						
			5	SS	1						
217.2 5.8	**SILT (ML)** Loose Grey		6	SS	5			0	2	86	12
216.2 6.7	End of Borehole Groundwater at 0.23 m BGS (Elev. 222.8 m) on completion of drilling										



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

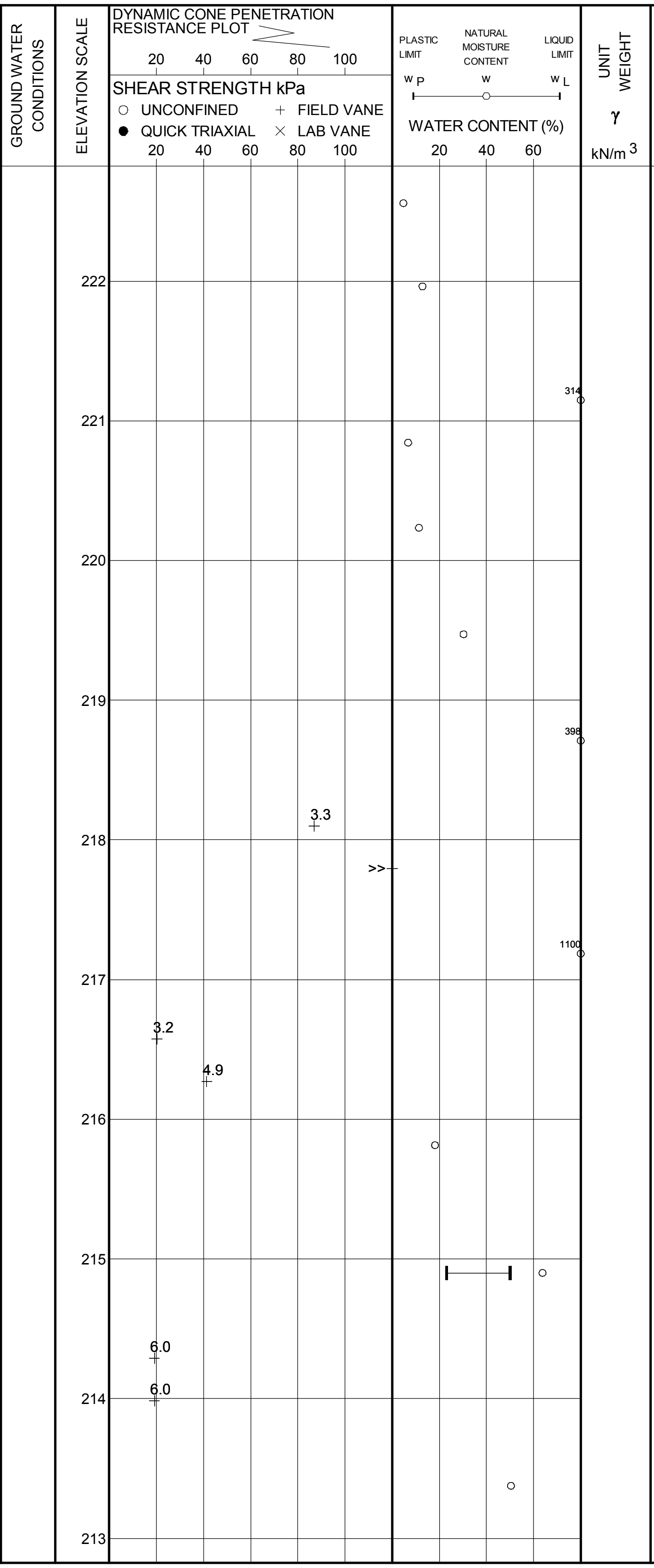
THURBER

RECORD OF BOREHOLE No 17-16

1 OF 3 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.9 E 322 927.6	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 15.03.2017 - 16.03.2017	CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
222.8 0.0	**15mm ASPHALT**							
	SAND with Silt and Gravel **FILL** *Frozen* Brown	1	SS	100/225mm	41	52	7 (SI+CL)	
		2	SS	100/200mm				
221.3 1.5	Sawdust **FILL** Compact Red	3	SS	19	51.5% organic content			
221.0 1.8	SAND with Gravel **FILL** Very Dense Grey	4	SS	52				
		5	SS	57				
219.0 3.8	**PEAT**, Coarse Fibrous Very Stiff to Firm Brown	6	SS	5	69.5% organic content			
		7	GS	Push				
216.4 6.4	**SILT (ML)** Very Loose Grey							
215.7 7.2	**CLAY (CI to CH)** Soft to Firm Grey	8	SS	2	2.8% organic content			
		9	SS	WH	1	2	32	65
		10	SS	WR				



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+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-16

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.9 E 322 927.6		ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing		COMPILED BY JG
DATUM Geodetic	DATE 15.03.2017 - 16.03.2017		CHECKED BY SP

Continued From Previous Page

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	CLAY (CI to CH) Soft to Firm Grey	▨								
			11	SS	WR					
			12	SS	WR					
			13	SS	WR					
			14	SS	WR					
	- occasional silt seams below 16.8 m		15	SS	WH		0	0	27	73
			16	SS	WR					

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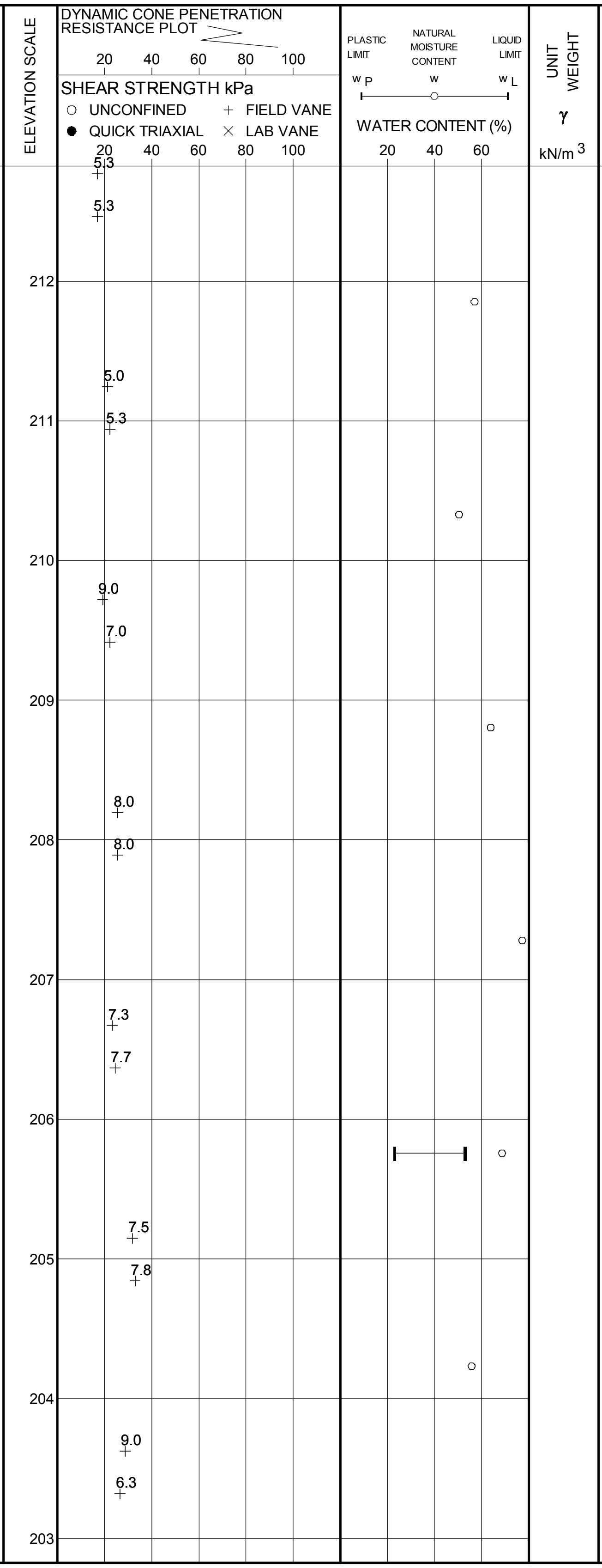


+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

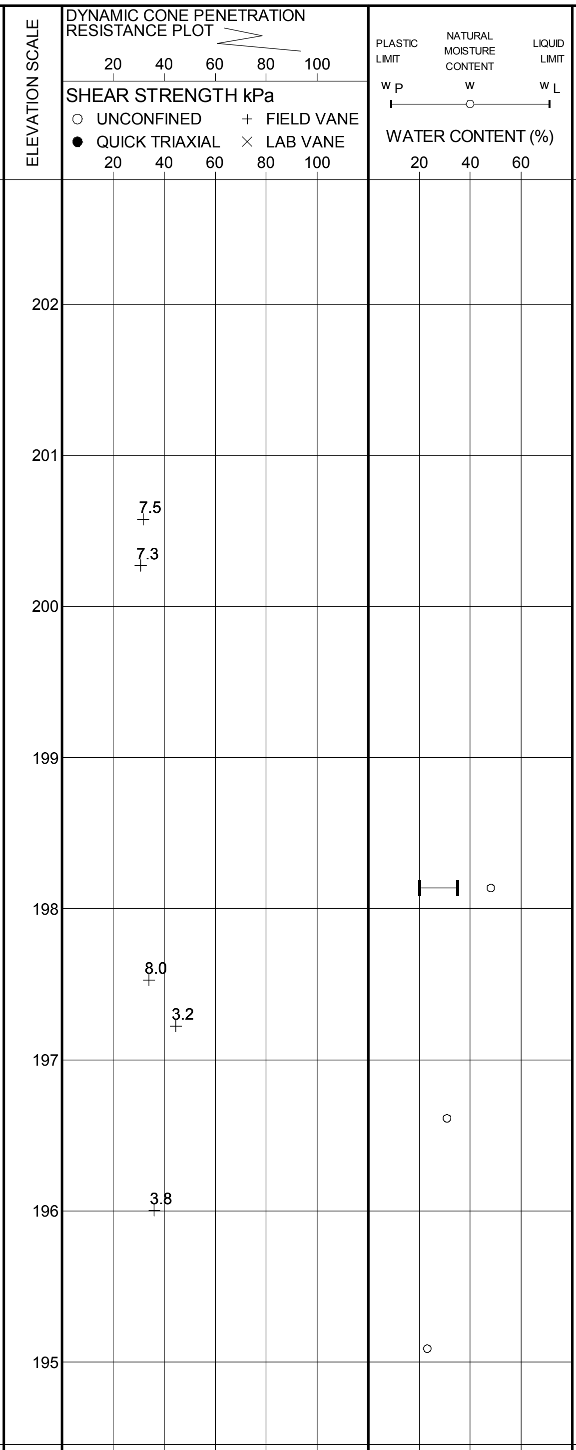
RECORD OF BOREHOLE No 17-16

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.9 E 322 927.6
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 15.03.2017 - 16.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
	Continued From Previous Page										
	CLAY (CI to CH) Soft to Firm Grey										
			17	ST	Push						
			18	SS	WH			0	0	57	43
			19	SS	WH						
195.9 27.0	**SILT (ML)**, trace Sand Loose Grey										
			20	SS	2			0	9	79	12
			21	SS	100/ 0mm						
194.5 28.4	End of Borehole on Inferred Bedrock										



+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-17

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 283.3 E 322 902.6
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 04.03.2017 - 04.03.2017
CHECKED BY SP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
222.8		
0.0 0.1	**60mm ASPHALT**	
	SAND with Gravel **FILL** *Frozen* Brown	
222.2 0.6	- Tarpaulin at 0.65 m	
222.1 0.8	Wood Logs **FILL**	
	SAND with Silt and Gravel **FILL** *Frozen* Brown	
221.3 1.5	- frost depth 1.5 m	
	Sawdust **FILL** Compact Brown	
220.9 2.0	SAND with Gravel **FILL** Dense to Very Dense Brown	
219.0 3.8	**PEAT**, Fine to Coarse Fibrous Stiff Reddish Brown to Brown	
216.4 6.4	**SILT (ML)** Very Loose Grey	
216.1 6.7	End of Borehole Groundwater at 1.2 m BGS (Elev. 221.6 m) on completion of drilling	

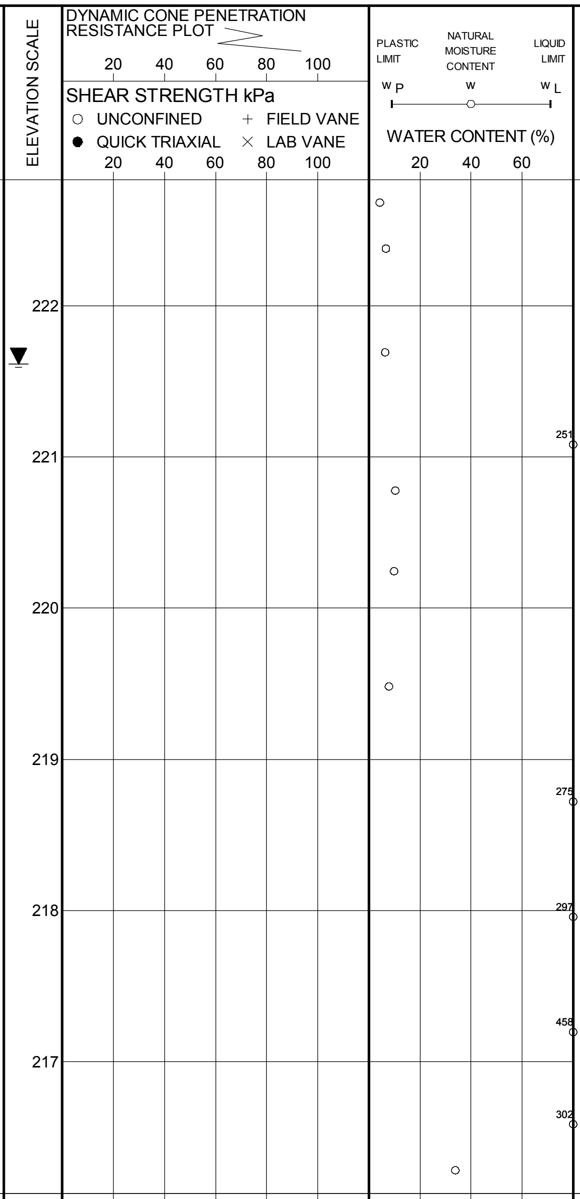
SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	AS		43	53	4 (SI+CL)	
2	AS					
3	AS		29	60	11 (SI+CL)	
4	SS	15				
5	SS	45				
6	SS	72				
7	SS	4				
8	SS	5				
9	SS	4				
10	SS	2	0	1	64	35

GROUND WATER CONDITIONS ▼

ELEVATION SCALE

UNIT WEIGHT γ kN/m³



+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

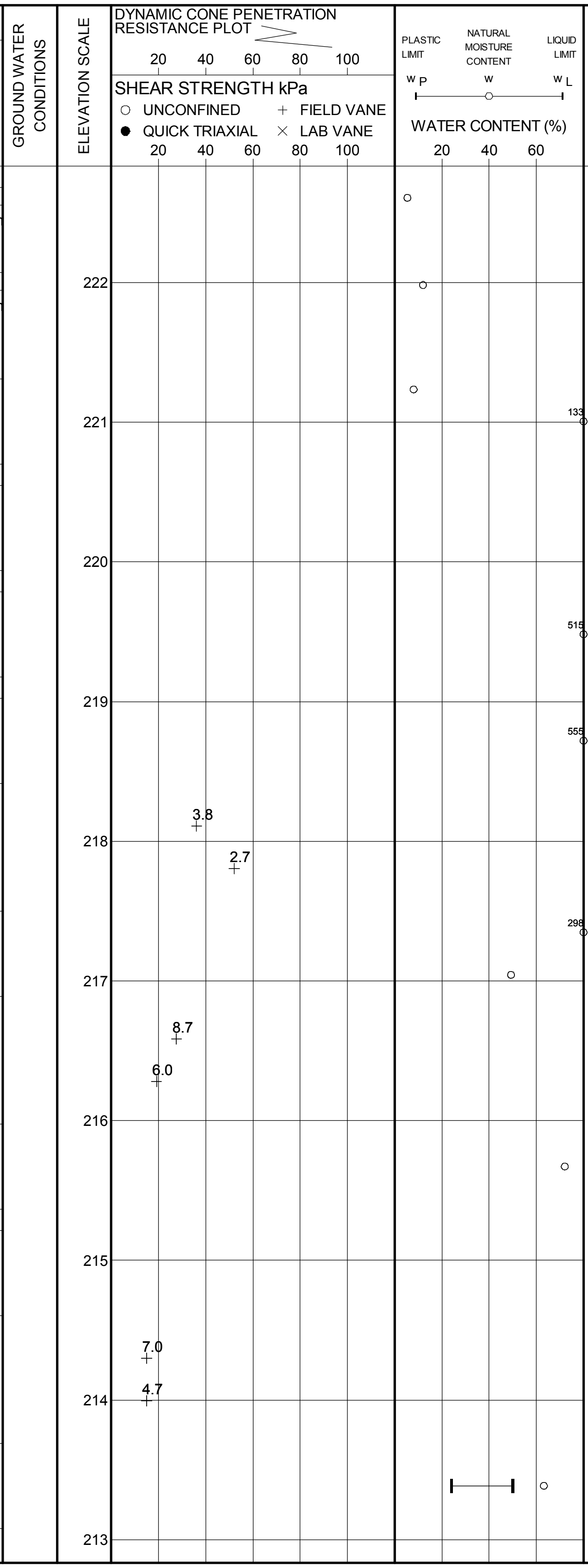
RECORD OF BOREHOLE No 17-18

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.2 E 322 902.9
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 17.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.8					
0.0 0.1	**30mm ASPHALT**				
	SAND with Gravel **FILL** *Frozen* to Loose Brown	1	SS	100/ 125mm	
		2	SS	100/ 125mm	
	- frost depth 1.1 m				
221.2 1.7	Sawdust **FILL** Very Loose Red	3	SS	7	
220.5 2.3	**PEAT**, Fine to Coarse Fibrous Stiff to Firm Dark Brown	4	SS	2	
		5	SS	2	78.6% organic content
		6	ST	Push	OED: e_o = 10.464 C_c = 5.99 C_r = 0.62 89.0% organic content
217.2 5.6	**CLAY (CI to CH)** Soft to Firm Grey	7	SS	1	
		8	SS	WR	
		9	ST	Push	
		10	SS	WR	0 0 33 67



UNIT WEIGHT γ kN/m3

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-18

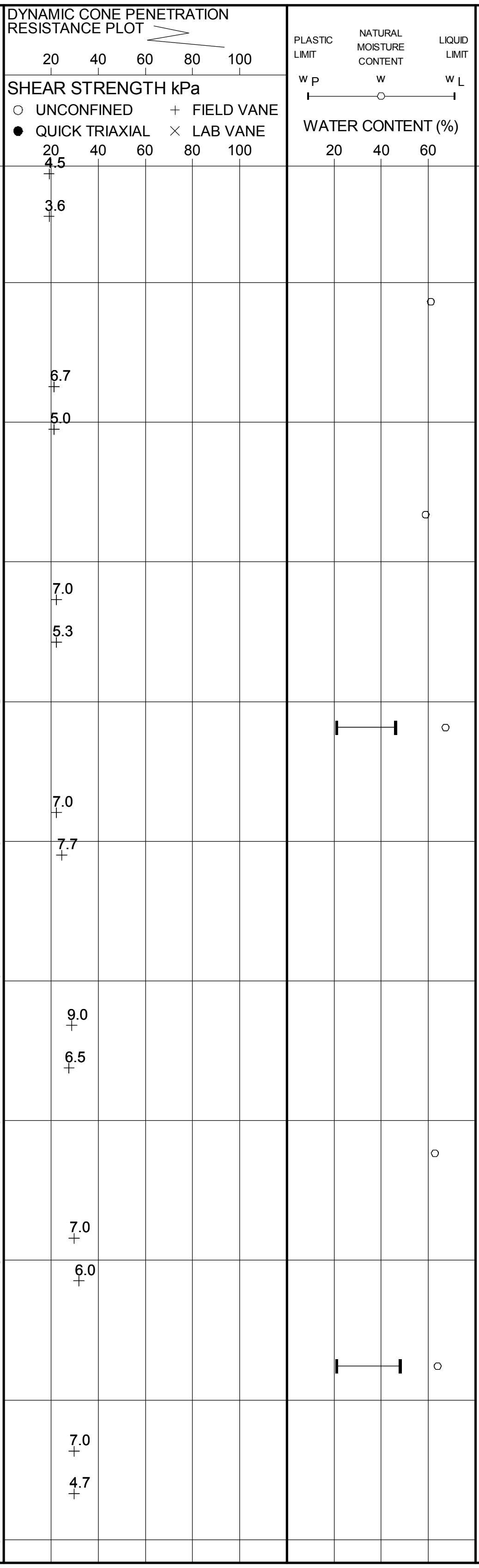
2 OF 3 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.2 E 322 902.9	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 16.03.2017 - 17.03.2017	CHECKED BY SP

Continued From Previous Page

CLAY (CI to CH)
Soft to Firm
Grey

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	CLAY (CI to CH) Soft to Firm Grey										
						212					
		11	SS	WR							
						211					
		12	SS	WR							
						210					
						209					
		13	SS	WR				0	0	35	65
						208					
		14	ST	Push							
						207					
						206					
		15	SS	WR							
						205					
		16	SS	WR				0	0	34	66
						204					
						203					



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+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

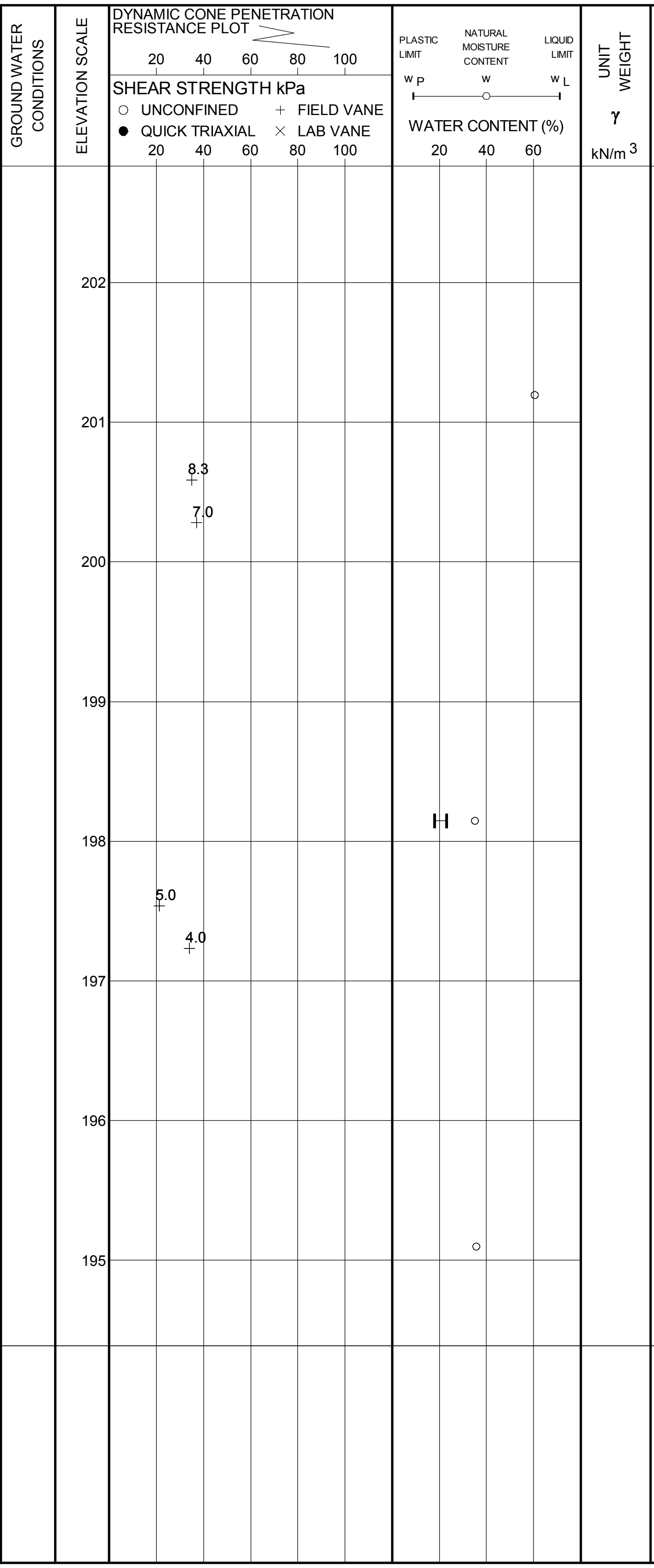
RECORD OF BOREHOLE No 17-18

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.2 E 322 902.9
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 17.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Continued From Previous Page							
	CLAY (CI to CH) Soft to Firm Grey							
		17	SS	WR				
199.2 23.6	**Silty CLAY (CL-ML)** Soft to Firm Grey							
		18	SS	WR	0	0	74	26
196.2 26.7	**SILT with Sand (ML)** Compact Grey							
		19	SS	25	2	21	72	5
		21	SS	100/ 0mm				
194.4 28.4	End of Borehole on Inferred Bedrock							



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

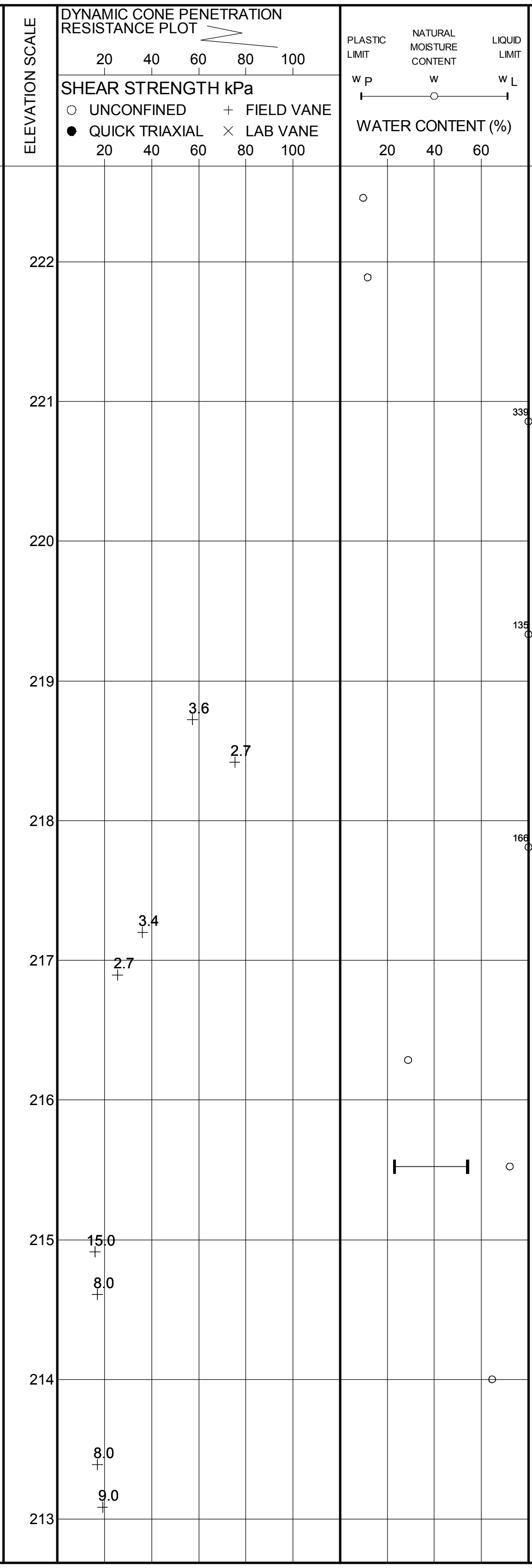
RECORD OF BOREHOLE No 17-19

1 OF 3

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.8 E 322 877.9	ORIGINATED BY	CM
HWY	537	BOREHOLE TYPE	NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	18.03.2017 - 18.03.2017	CHECKED BY	SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
222.7										
0.0	**25mm ASPHALT**									
	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 150mm						
		2	SS	100/ 75mm						
221.2 1.5	Sawdust **FILL** Loose Red	3	SS	9						
220.6 2.1	SAND with Gravel **FILL** Compact Brown									
220.2 2.4	**PEAT**, Coarse Fibrous Stiff to Firm Brown	4	SS	4						
		5	SS	7						
		6	SS	3			70.2% organic content			
216.6 6.1	**SILT (ML)** Very Loose Grey	7	SS	3			0	1	73	26
216.0 6.7	**CLAY (CI to CH)** Soft to Firm Grey	8	SS	WR			0	0	27	73
		9	SS	WR						



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

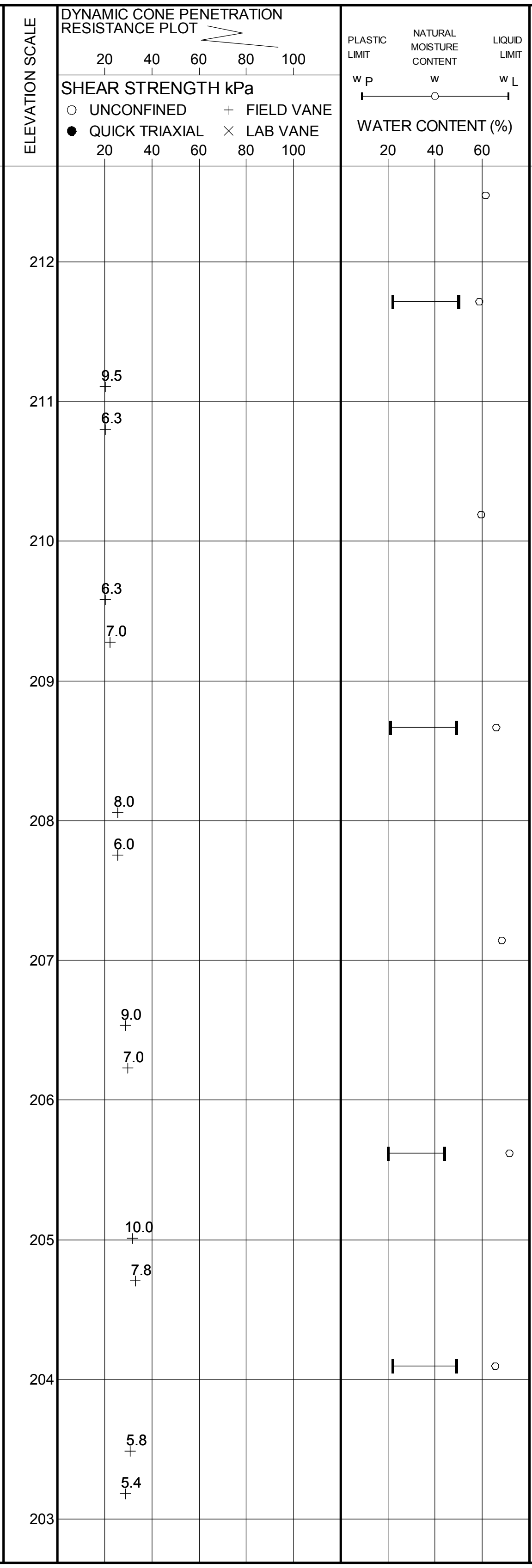
RECORD OF BOREHOLE No 17-19

2 OF 3 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.8 E 322 877.9	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 18.03.2017 - 18.03.2017	CHECKED BY SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	CLAY (CI to CH) Soft to Firm Grey	10	SS	WR				
		11	ST	Push	0	0	41	59
		12	SS	WR				
		13	ST	Push	OED: e_o = 1.813 C_c = 1.559 C_r = 0.202 0	0	39	61
		14	SS	WR				
		15	SS	WR	0	10	30	60
		16	ST	Push	OED: e_o = 1.775 C_c = 0.961 C_r = 0.029 0	0	36	64



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m^3

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

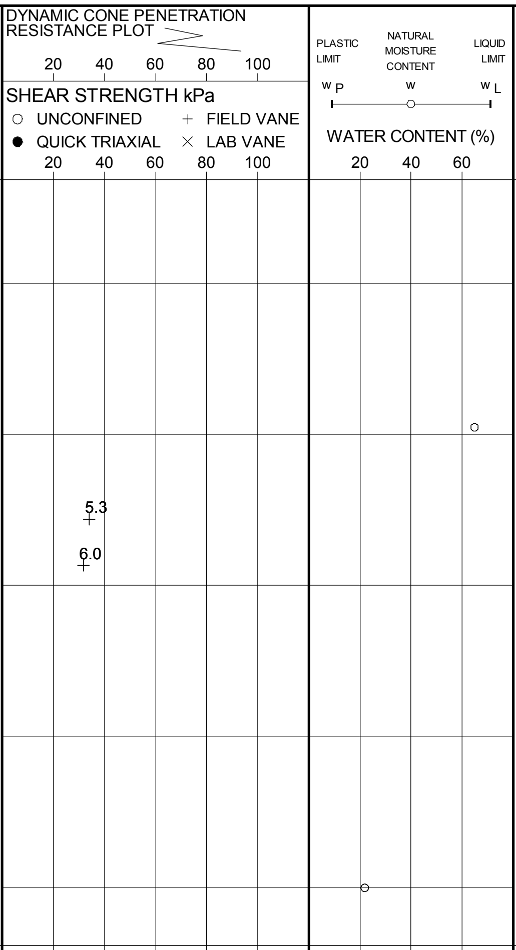
RECORD OF BOREHOLE No 17-19

3 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 288.8 E 322 877.9	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 18.03.2017 - 18.03.2017	CHECKED BY SP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Continued From Previous Page											
	CLAY (CI to CH) Soft to Firm Grey	▨					202					
			17	SS	WR		201					
							200					
199.1 23.6	**Sandy SILT** Dense Grey	⁘					199					
			18	SS	42		198		2	30	62	6
197.6 25.1	End of Borehole on Inferred Bedrock		19	SS	100/ 0mm							



+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of
Transportation
Ontario

THURBER

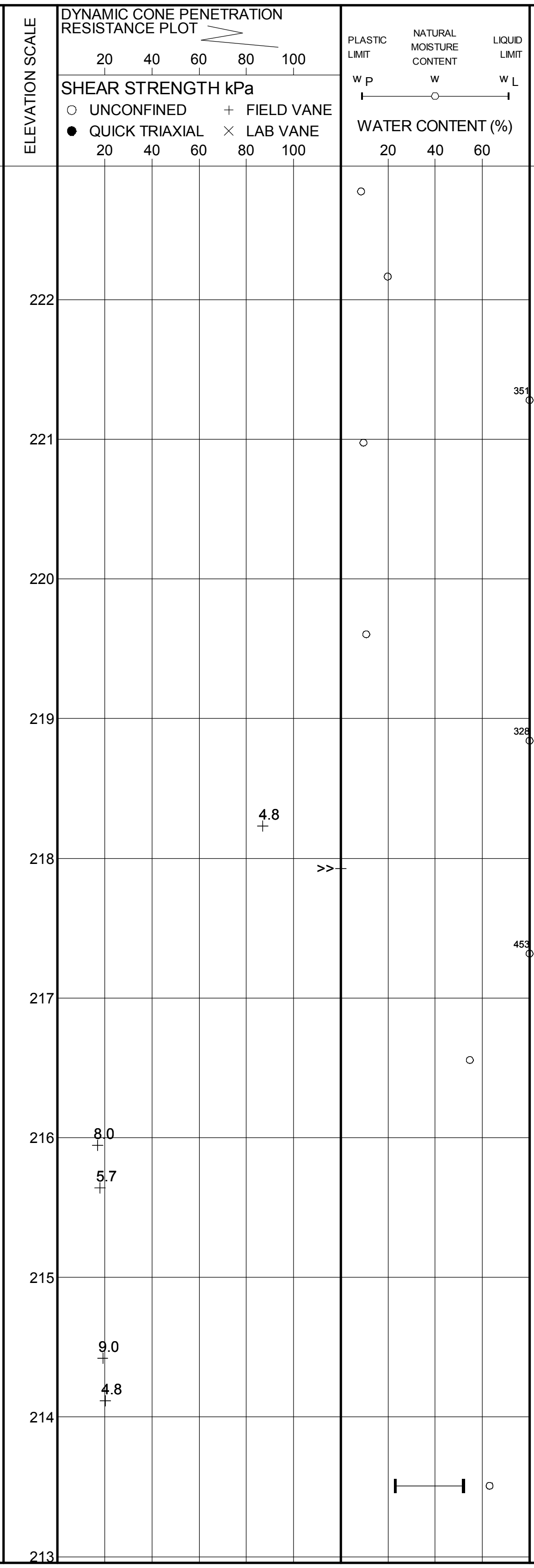
RECORD OF BOREHOLE No 17-20

1 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.1 E 322 852.6		ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 19.03.2017 - 19.03.2017		CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
223.0 0.0	**25mm ASPHALT**						
0.0	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 75mm			
		2	SS	100 75mm			
221.4 1.5	Sawdust **FILL** Loose Red	3	SS	19			65.4% organic content
221.1 1.8	SAND with Gravel **FILL** Compact to Very Dense Brown						0.4% organic content
		4	SS	62			
		5	SS	29			
219.3 3.7	**PEAT**, Coarse Fibrous Stiff to Very Stiff Brown	6	SS	5			
		7	SS	4			
216.9 6.1	**SILT** Very Loose Grey	8	SS	2			1.8% organic content
216.3 6.7	**CLAY (CI to CH)** Soft to Firm Grey	9	ST	Push			
		10	SS	WH			0 0 36 64



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+3, ×3: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-20

2 OF 3

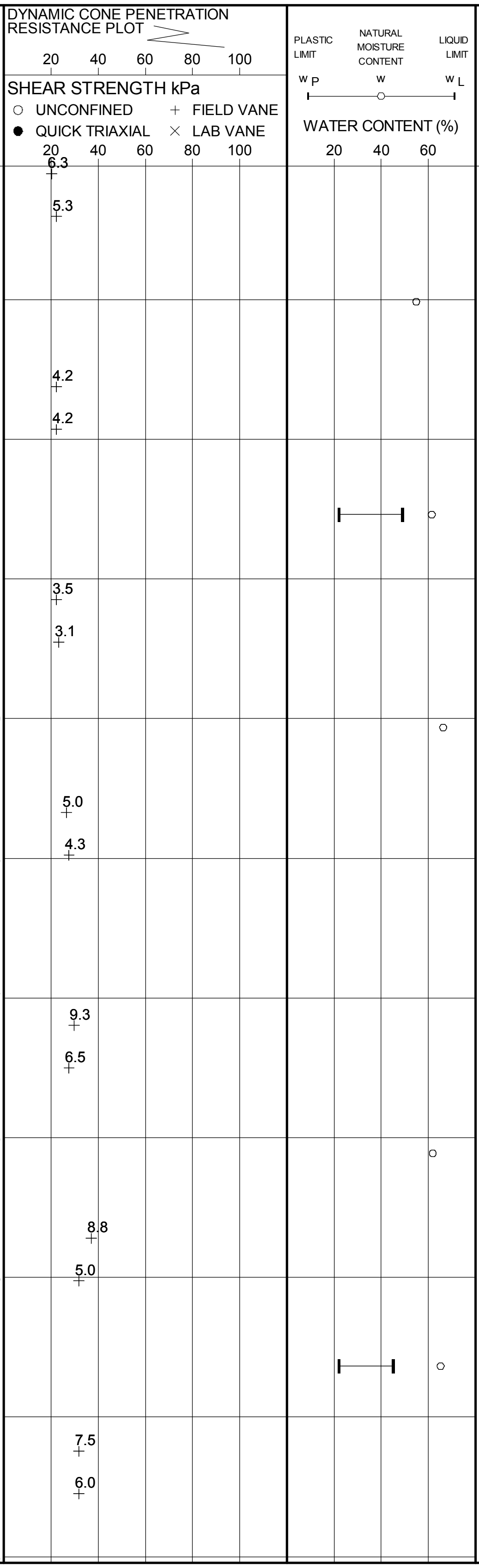
METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.1 E 322 852.6	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 19.03.2017 - 19.03.2017	CHECKED BY SP

Continued From Previous Page

CLAY (CI to CH)
Soft to Firm
Grey

SOIL PROFILE ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
			11	SS	WR		212					
							211					
			12	SS	WR				0	0	33	67
							210					
			13	SS	WR		209					
							208					
			14	ST	Push							
							207					
			15	SS	WR		206					
							205					
			16	SS	WR				0	0	42	58
							204					
							203					



REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

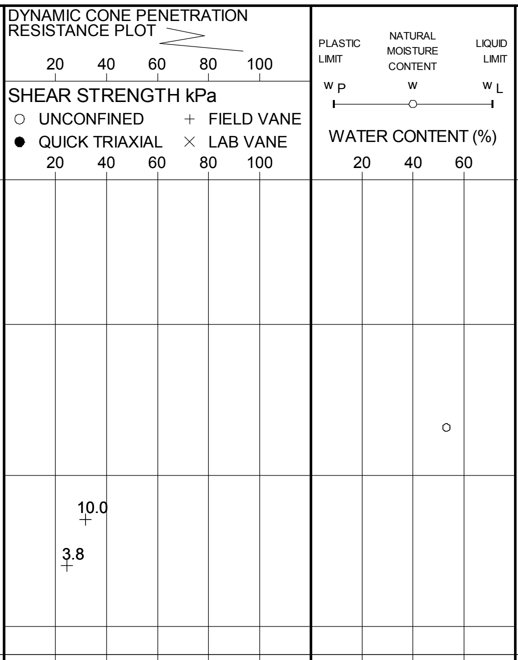
RECORD OF BOREHOLE No 17-20

3 OF 3

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.1 E 322 852.6	ORIGINATED BY	CM
HWY	537	BOREHOLE TYPE	NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	19.03.2017 - 19.03.2017	CHECKED BY	SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							
	CLAY (CI to CH) Soft to Firm Grey	▨					202	
			17	SS	WR		201	
199.8							200	
23.1	End of Borehole on Inferred Bedrock		18	SS	100/ 0mm			



UNIT WEIGHT γ kN/m3

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

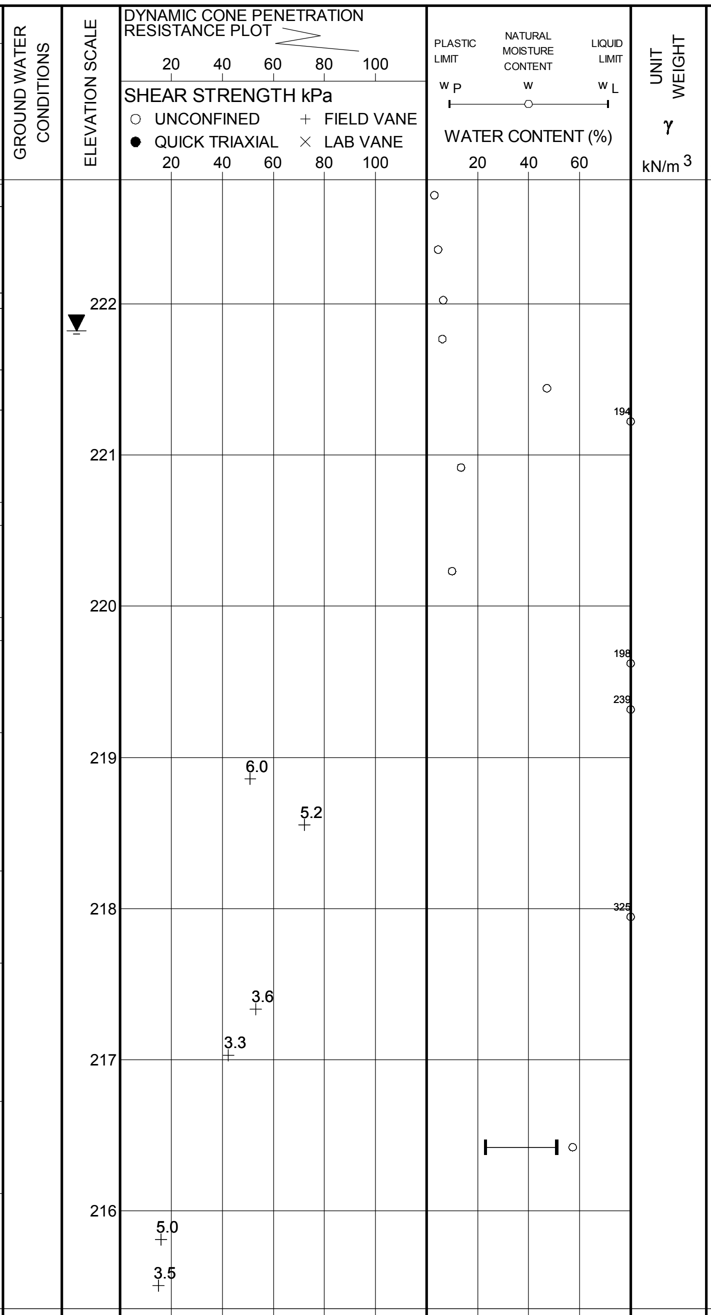
THURBER

RECORD OF BOREHOLE No 17-21

1 OF 1 **METRIC**

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 289.3 E 322 853.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 05.03.2017 - 05.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.8 0.0	**30mm ASPHALT**	1	AS		
	SAND with Gravel **FILL** *Frozen* Brown	2	AS		
		3	AS		
		4	AS		40 58 2 (SI+CL)
221.6 1.3	Sawdust **FILL** Loose Brown	5	AS		
221.1 1.7	SAND with Gravel **FILL** Compact Brown	1	SS	11	
		2	SS	23	
219.8 3.0	**Wood** Brown				
219.5 3.4	**PEAT**, Fine to Coarse Fibrous Soft Reddish Brown	3	SS	3	
		4	SS	3	
216.7 6.1	**CLAY (CH)** Soft Grey	5	SS	WH	0 2 37 61
215.4 7.5	End of Borehole Groundwater at 1.0 m BGS (Elev. 221.8 m) on completion of drilling				



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

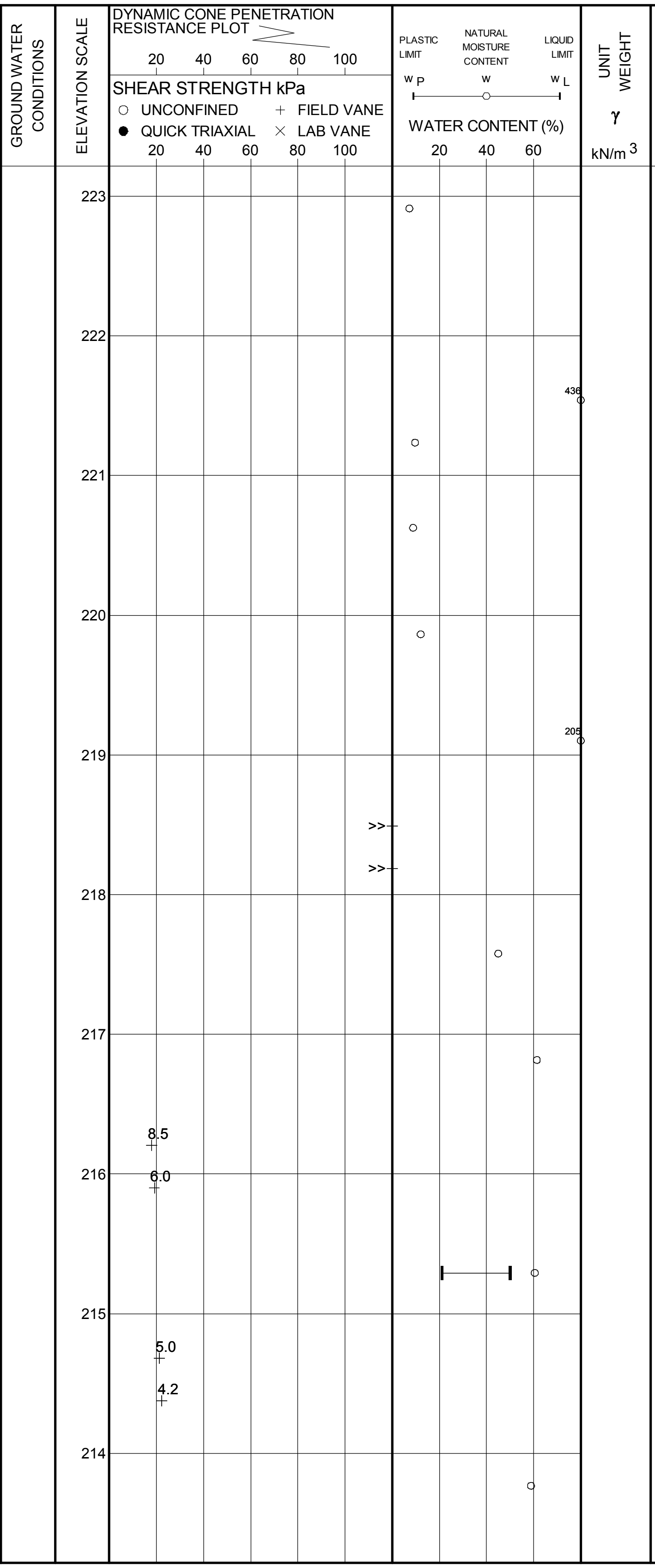
RECORD OF BOREHOLE No 17-22

1 OF 3

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 287.1 E 322 827.4	ORIGINATED BY	CM
HWY	537	BOREHOLE TYPE	NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	20.03.2017 - 20.03.2017	CHECKED BY	SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
223.2								
0.0	**30mm ASPHALT**							
	SAND with Gravel, frequent Cobbles **FILL** *Frozen* Brown	1	SS	100/ 250mm				
		2	SS	100/ 25mm				
221.7 1.5	Sawdust **FILL** Loose Red	3	SS	26				
221.4 1.8	SAND with Silt and Gravel **FILL** Compact to Dense Grey							
		4	SS	35	35	59	6 (SI+CL)	
		5	SS	27				
219.6 3.7	**PEAT**, Coarse Fibrous Very Stiff Brown	6	SS	3				
217.9 5.3	**SILT (ML)** Very Loose Grey	7	SS	2	1	2	68	29
217.1 6.1	**CLAY (CI to CH)** Soft to Firm Grey	8	SS	WR				
		9	SS	WH	0	0	30	70
		10	SS	WH				



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+ 3, × 3 : Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-22

2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 287.1 E 322 827.4
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 20.03.2017 - 20.03.2017
CHECKED BY SP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Continued From Previous Page							
	CLAY (CI to CH) Soft to Firm Grey							
		11	SS	WR				
		12	ST	PUSH				
		13	SS	WR	0	0	35	65
		14	SS	WR				
		15	SS	WR				
		16	SS	WR				

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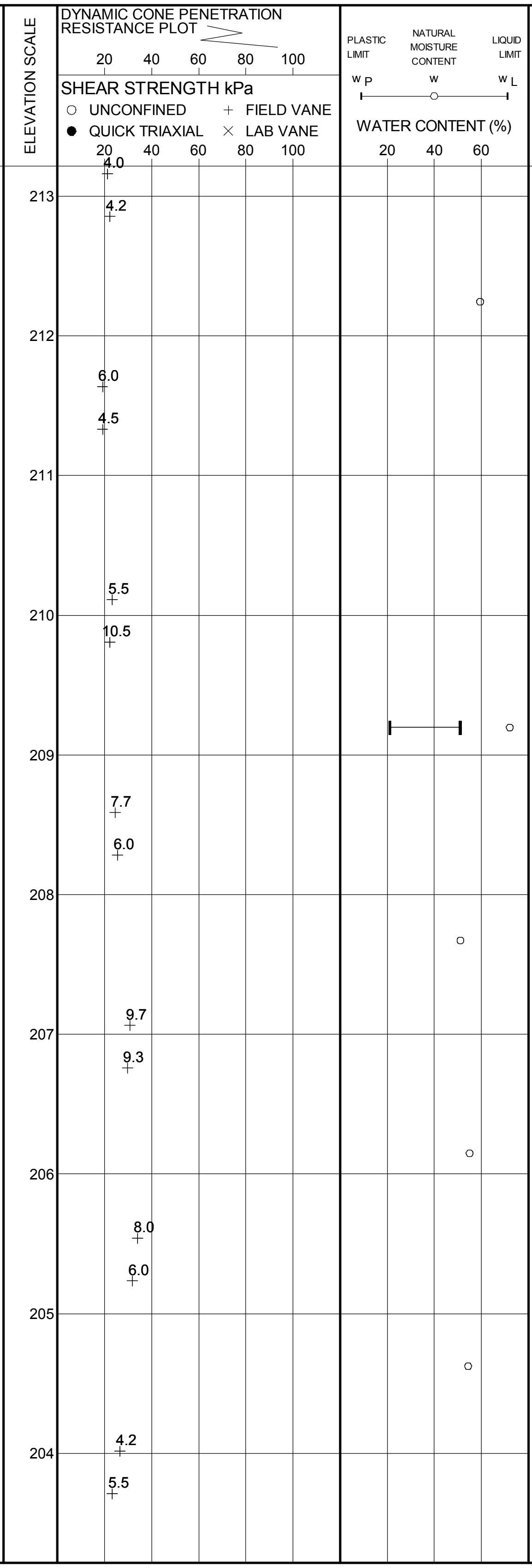


UNIT WEIGHT γ kN/m3

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-22

3 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 287.1 E 322 827.4	ORIGINATED BY CM
HWY 537	BOREHOLE TYPE NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 20.03.2017 - 20.03.2017	CHECKED BY SP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY (CI to CH) Soft to Firm Grey	▨					203				
202.2 21.0	End of Borehole on Inferred Bedrock		17	SS	100/ 0mm						

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-23

1 OF 2

METRIC

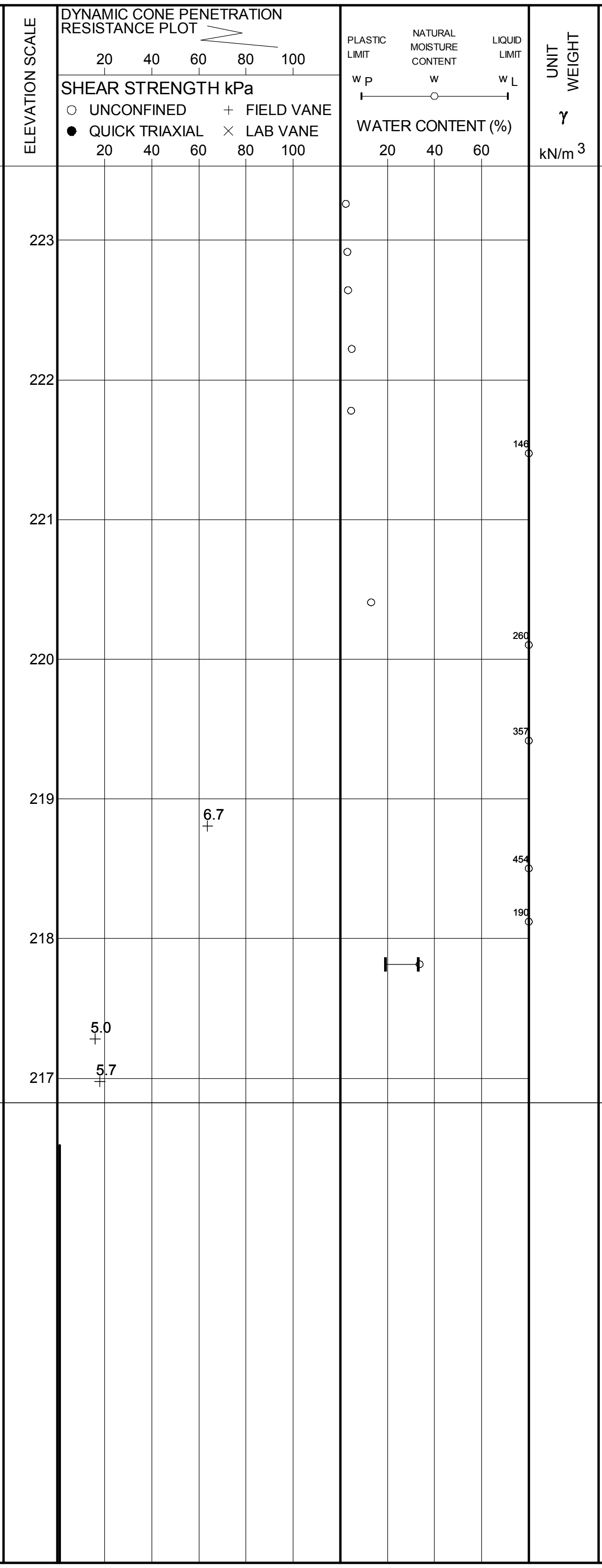
GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 292.8 E 322 807.1
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / DCPT
COMPILED BY JG
DATUM Geodetic
DATE 11.03.2017 - 11.03.2017
CHECKED BY SP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION	STRAT PLOT
223.5 0.0 0.0	**25mm ASPHALT** SAND with Gravel **FILL** *Frozen* Brown	
223.0 223.0 0.5 0.5	**30mm ASPHALT** SAND with Silt and Gravel **FILL** *Frozen* to Compact Brown	
221.6 221.4 2.0 2.1	Sawdust **FILL** Compact Brown SAND with Silt and Gravel **FILL** Very Dense Brown	
220.3 3.2	**PEAT**, Fine to Coarse Fibrous Stiff to Very Stiff Brown to Reddish Brown	
218.0 5.5	**CLAY** Firm Grey	
216.8 6.7	End of Sampled Borehole DCPT 6.7 m to 17.4 m **INFERRED CLAY**	

SAMPLES

NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS	GR	SA	SI	CL
1	AS							
2	AS				29	65	6 (SI+CL)	
3	AS							
4	AS							
1	SS	29						
2	SS	61						
					44	48	8 (SI+CL)	
3	SS	11						
4	SS	3		62.0% organic content				
5	SS	4						
6	SS	1			2	1	54	43



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+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

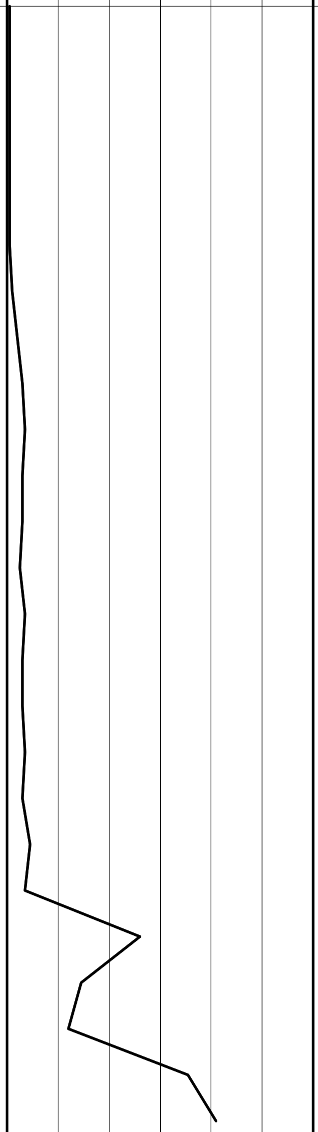
RECORD OF BOREHOLE No 17-23

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 292.8 E 322 807.1
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / DCPT
COMPILED BY JG
DATUM Geodetic
DATE 11.03.2017 - 11.03.2017
CHECKED BY SP

SOIL PROFILE: ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY	▨									
207.5 16.0	**INFERRED SILT**										
206.2 17.4	End of DCPT on Inferred Slanted Bedrock Surface, Bent Cone Rods										



+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-24

1 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 298.6 E 322 804.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 05.03.2017 - 05.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
223.5								
0.0	**60mm ASPHALT**							
0.1	SAND with Silt and Gravel **FILL** *Frozen* to Compact Grey	1	SS	100/ 75mm				
		2	SS	100/ 200mm				
	- frost depth 1.5 m	3	SS	45	36	57	7 (SI+CL)	
		4	SS	12				
220.7 2.7	Sawdust **FILL** Compact Brown	5	SS	8				
219.9 3.6	**PEAT**, Fine to Coarse Fibrous Stiff Reddish Brown	6	SS	8				
218.9 4.6	**SILT (ML)** Loose Grey	7	SS	5				
218.1 5.3	**CLAY (CI to CH)** Soft Grey	8	SS	1	0	1	33	66
		9	SS	WH				
		10	ST	Push				
		11	SS	WH				

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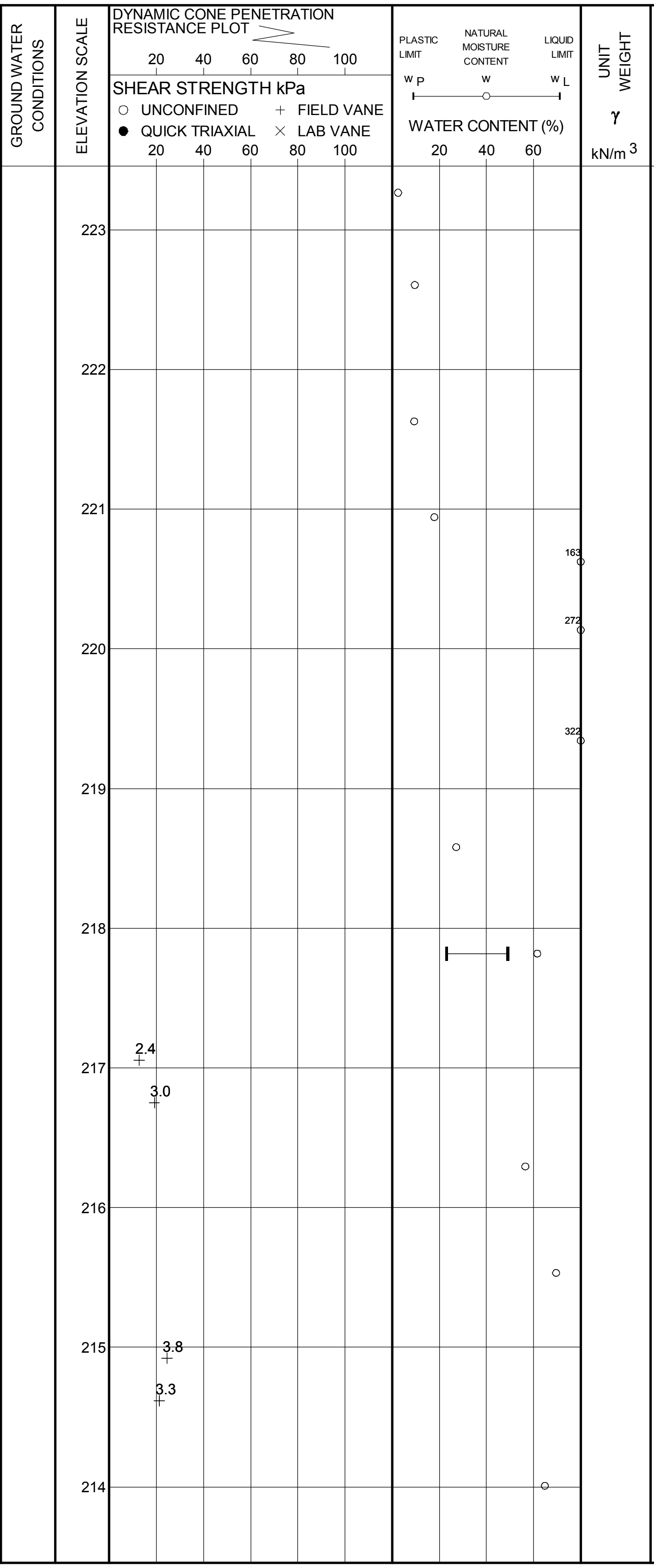


REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-24

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 298.6 E 322 804.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA
COMPILED BY JG
DATUM Geodetic
DATE 05.03.2017 - 05.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT wP, NATURAL MOISTURE CONTENT w, LIQUID LIMIT wL WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				GR	SA	SI	CL
	Continued From Previous Page													
	CLAY (CI to CH) Soft Grey	▨					213	+ 4.5 + 5.3						
		▨	12	SS	100/ 200mm				⊢—⊣ ○		0	2	30	68
212.3 11.2	End of Borehole on Inferred Bedrock													

+ 3, × 3: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

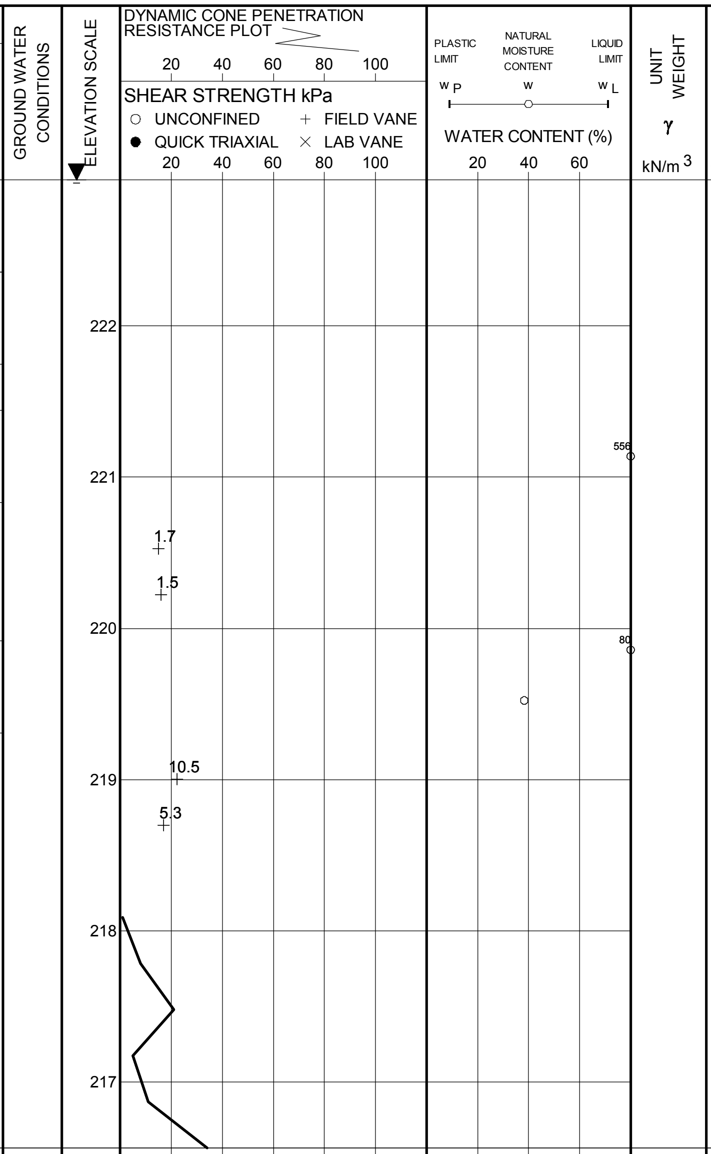
RECORD OF BOREHOLE No 17-25

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 309.4 E 322 808.2
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 16.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
223.0								
0.0	SNOW / ICE	1	SS	1				
		2	SS	2				
222.1 0.9	**PEAT**, Fine to Coarse Fibrous Soft Brown	3	SS	WH				
219.8 3.1	**SILT (ML)** Loose Grey	4	SS	WH	0	1	70	29
219.2 3.8	**INFERRED CLAY** Soft Grey							
218.4 4.6	End of Sampled Borehole DCPT 6.7 m to 17.4 m **INFERRED CLAY**							
216.6 6.4	End of DCPT on Inferred Slanted Bedrock Surface, Bent Cone Rods Groundwater at 0.9 m AGS (Elev. 223.0 m) on completion of drilling							



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

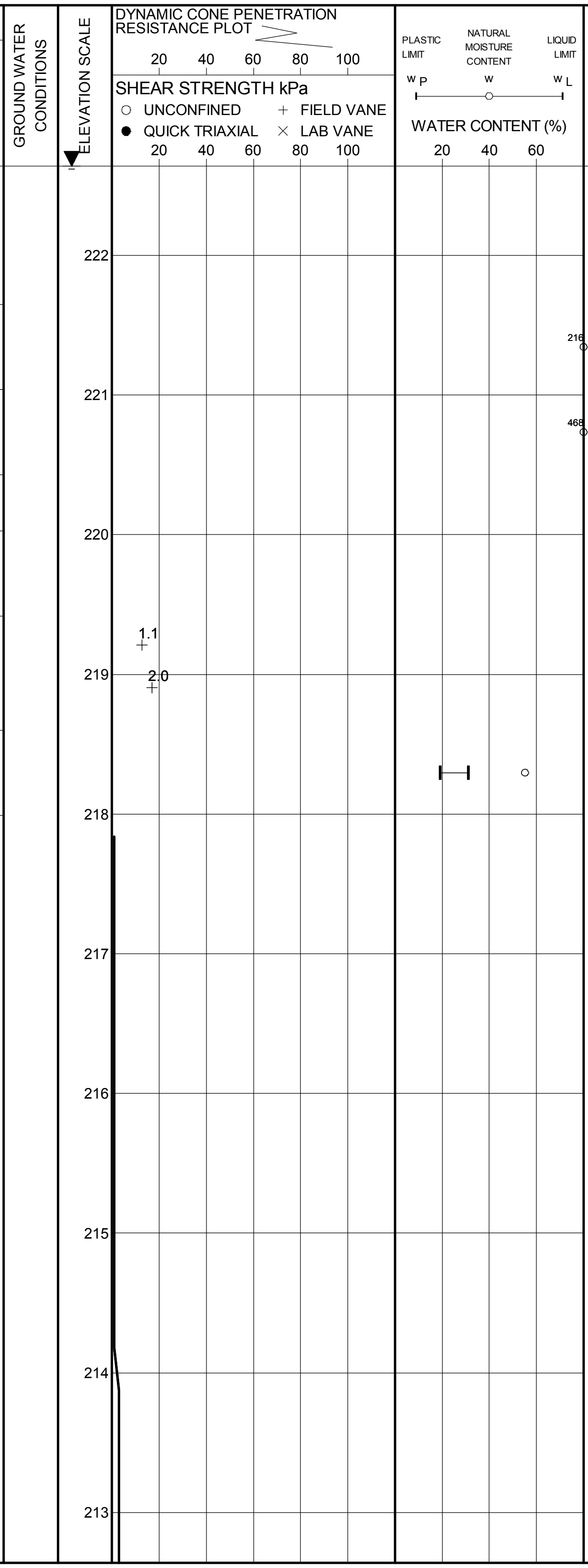
RECORD OF BOREHOLE No 17-26

1 OF 3

METRIC

GWP#	5134-14-00	ORIGINATED BY	KE
LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.5 E 322 808.7	COMPILED BY	CM
HWY	537	CHECKED BY	SP
BOREHOLE TYPE	Portable Raft / NW Casing		
DATUM	Geodetic		
DATE	18.07.2017 - 18.07.2017		

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.6					
0.0	**WATER**				
221.6 1.0	**PEAT**, Fine to Coarse Fibrous Very Soft to Soft Black	1	SS	WH	
		2	SS	1	organic content 57.7%
		3	ST	PUSH	
218.5 4.1	**SILT (ML)**, Frequent Clay seams Very Loose Grey	4	SS	WR	0 0 68 32
218.0 4.6	End of Sampled Borehole DCPT from 4.6 m to 22.1 m **INFERRED CLAY**				



UNIT WEIGHT γ kN/m³

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+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

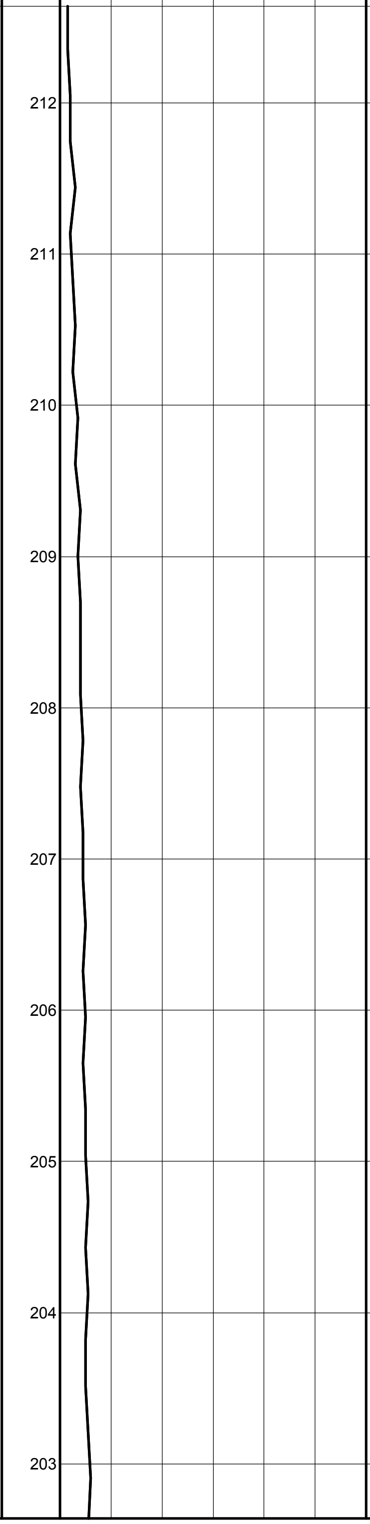
RECORD OF BOREHOLE No 17-26

2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.5 E 322 808.7
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 18.07.2017 - 18.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	INFERRED CLAY	▨									



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-26

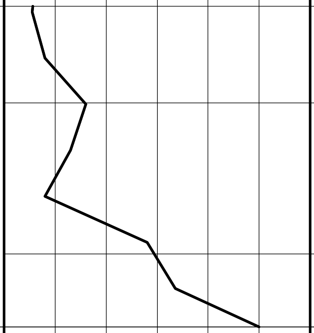
3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 284.5 E 322 808.7
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 18.07.2017 - 18.07.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
	INFERRED CLAY	▨								
202.0 20.7	**INFERRED SILT**	▥					202			
							201			
200.5 22.1	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.6 m) on completion of drilling									

DYNAMIC CONE PENETRATION RESISTANCE PLOT



+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

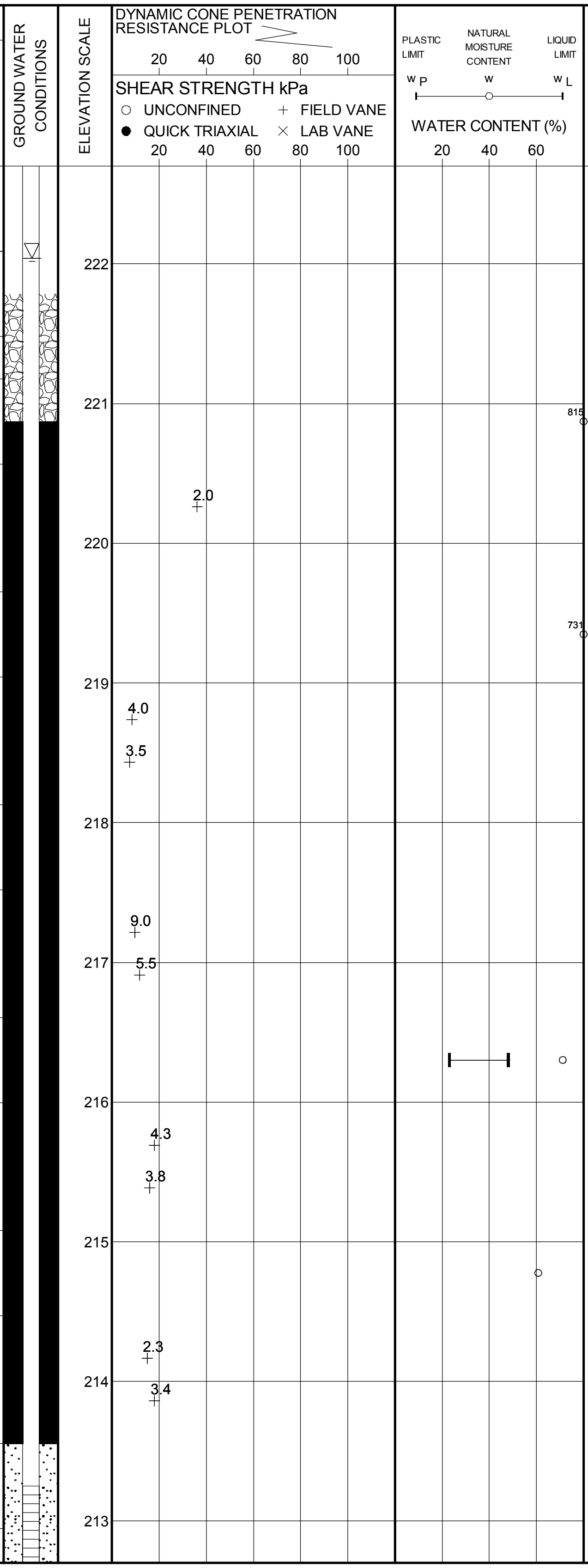
RECORD OF BOREHOLE No 17-27

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 852.3
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 17.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.7					
0.0	SNOW/ICE	1	SS	1	
221.8 0.9	**PEAT**, Fine to Coarse Fibrous Very Soft to Firm Brown	2	SS	1	
		3	SS	WH	85.3% organic content
		4	SS	WH	
219.0 3.7	**CLAY (CI to CH)** Soft to Firm Grey				
		5	SS	WR	
		6	SS	WR	0 1 39 60
		7	SS	WH	
		8	ST	Push	



UNIT WEIGHT γ kN/m3

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-27

2 OF 3

METRIC

GWP# 5134-14-00

LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 852.3

ORIGINATED BY JM

HWY 537

BOREHOLE TYPE Portable / NW Casing

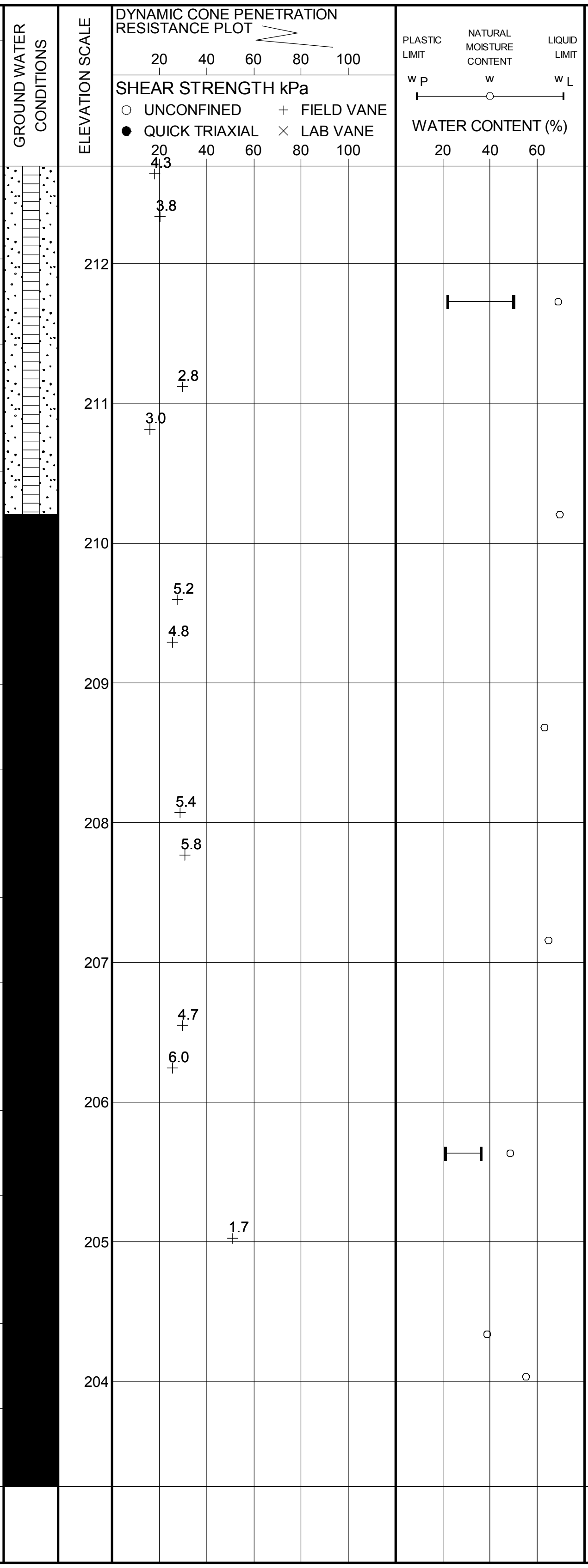
COMPILED BY JG

DATUM Geodetic

DATE 16.03.2017 - 17.03.2017

CHECKED BY SP

SOIL PROFILE			SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Continued From Previous Page								
	CLAY (CI to CH) Soft to Firm Grey								
			9	SS	WR	0	0	32	68
	- silt seams								
			10	SS	WR				
			11	SS	WR				
			12	SS	WR				
			13	SS	WR	0	0	59	41
	- silt seams								
204.1 18.6	**SILT (ML)** Compact Grey		14	SS	8				
203.2 19.5	End of Borehole on Inferred Bedrock Groundwater at Elev. 222.1 m on 17/03/2017		15	SS	100/ 0mm				



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-27

3 OF 3 **METRIC**

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.1 E 322 852.3	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	Portable / NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	16.03.2017 - 17.03.2017	CHECKED BY	SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Groundwater at Elev. 222.8 m on 12/06/2017										

+ 3 , × 3 : Numbers refer to Sensitivity

20 / 15 ◑ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-28

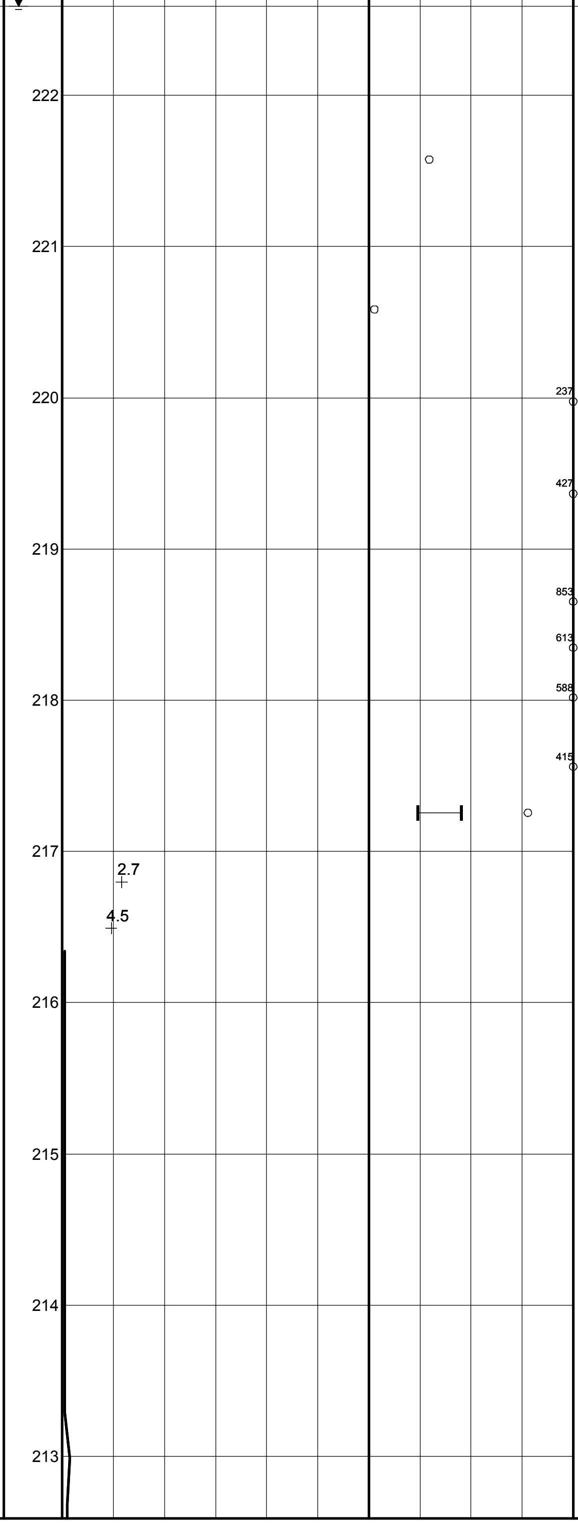
1 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.0 E 322 854.2		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 17.07.2017 - 17.07.2017		CHECKED BY SP

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
222.6								
0.0	**WATER**							
221.9 0.7	SAND with Organics **FILL** Compact Black	1	SS	11	34	63	3 (SI+CL)	
221.1 1.5	GRAVEL with Sand **FILL** Very Loose Grey	2	SS	3				
220.3 2.3	**PEAT**, Coarse Fibrous with Wood fragments Very Soft to Soft Black	3	SS	1				
		4	SS	1				
		5	SS	WH				
218.4 4.2	**PEAT**, Fine Fibrous with Wood fragments Soft Brown	6	SS	1				
		7	SS	WH				
217.4 5.2	**CLAY** Soft Grey				0	0	61	39
216.3 6.2	End of Sampled Borehole DCPT from 6.1 m to 25.3 m **INFERRED CLAY**							

STRAT PLOT · GROUND WATER CONDITIONS · ELEVATION SCALE · DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) · SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100) · PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L · WATER CONTENT (%) 20 40 60 · UNIT WEIGHT γ kN/m^3 · REMARKS & GRAIN SIZE DISTRIBUTION (%)



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+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

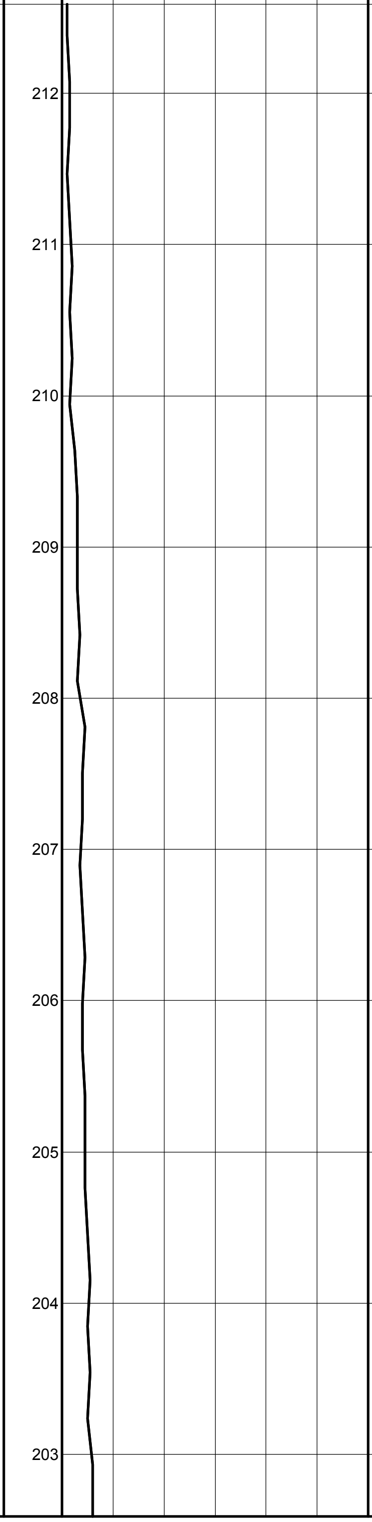
RECORD OF BOREHOLE No 17-28

2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.0 E 322 854.2
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 17.07.2017 - 17.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED CLAY	▨					212 211 210 209 208 207 206 205 204 203				



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+ ³, × ³: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

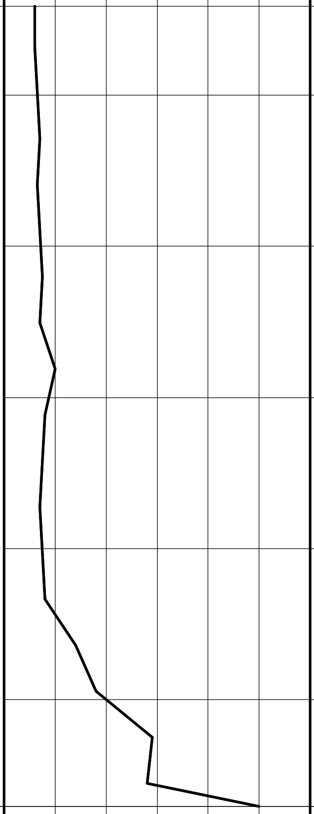
RECORD OF BOREHOLE No 17-28

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 280.0 E 322 854.2
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 17.07.2017 - 17.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	INFERRED CLAY	▨					202 201 200 199				
198.4 24.2	**INFERRED SILT**	▥					198				
197.3 25.3	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.6 m) on completion of drilling										



+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

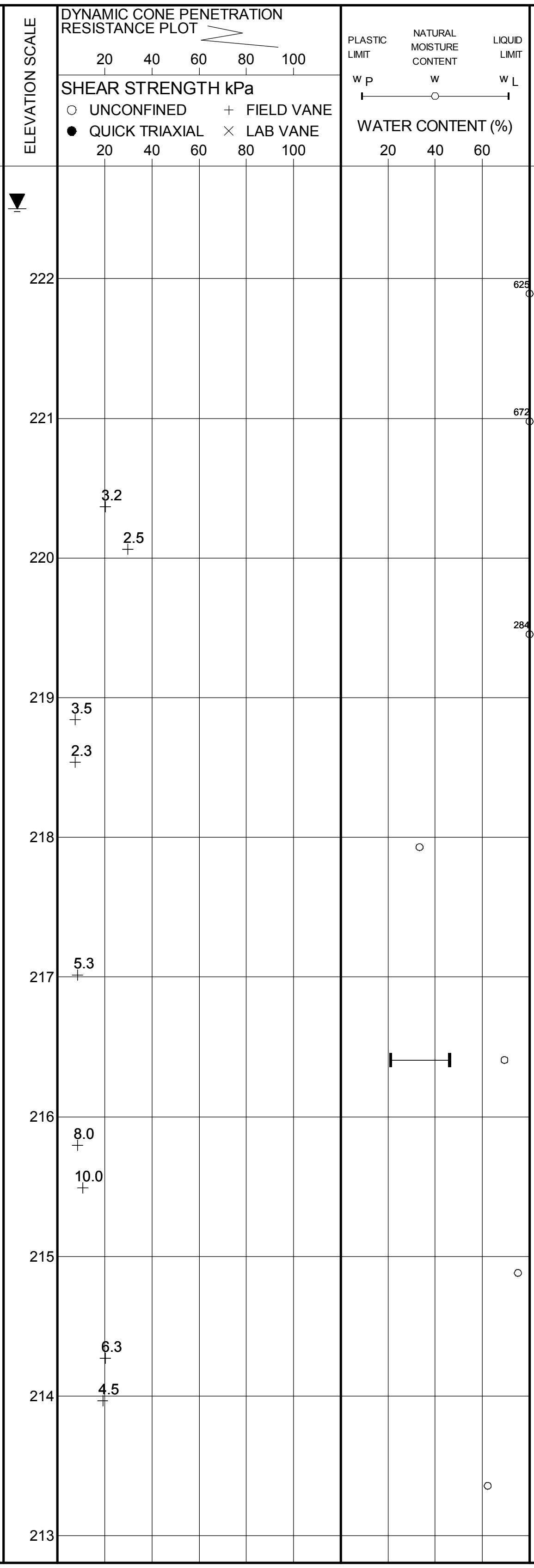
RECORD OF BOREHOLE No 17-29

1 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 296.4 E 322 878.0	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 18.03.2017 - 19.03.2017	CHECKED BY SP

SOIL PROFILE			SAMPLES					REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
222.8											
0.0	SNOW / ICE										
0.2	**PEAT**, Fine to Coarse Fibrous Very Soft to Firm Brown		1	SS	WH						
			2	SS	WH						
			3	SS	WH						
			4	SS	WH						
219.1 3.7	**CLAY (CI to CH)** Soft to Firm Grey										
			5	SS	WR						
			6	SS	WH			0	0	45	55
			7	SS	WR						
			8	SS	WH						



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+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-29

2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 296.4 E 322 878.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 18.03.2017 - 19.03.2017
CHECKED BY SP

SOIL PROFILE — ELEV DEPTH — DESCRIPTION — STRAT PLOT

Continued From Previous Page

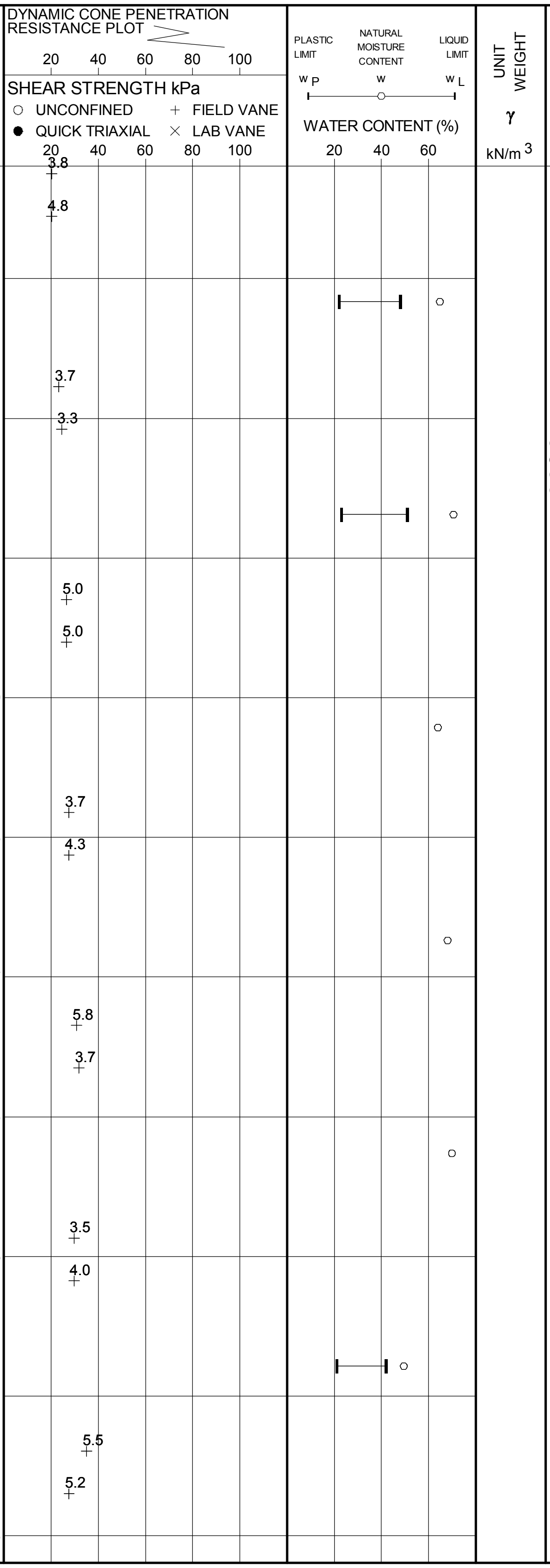
CLAY (CI to CH)
Soft to Firm
Grey

- occasional silt seams

- varved

Continued Next Page

SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
9	SS	WH		212	2	0	36	62
				211	OED: e_o = 1.838 C_c = 1.070 C_r = 0.044			
10	ST	Push		210	0	0	38	62
11	SS	WR		209				
12	SS	WH		208 / 207				
13	SS	WH		206				
14	SS	WH		205 / 204	0	0	46	54
				203				



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-29

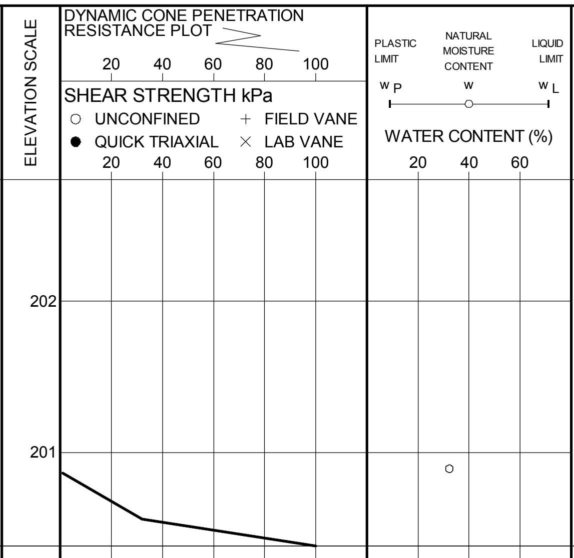
3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 296.4 E 322 878.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 18.03.2017 - 19.03.2017
CHECKED BY SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CLAY (CI to CH) Soft to Firm Grey	▨					202	
			15	SS	WH		201	
200.9 21.9	**SILT (ML)** Compact Grey	▥						
200.4 22.4	DCPT from 21.9 m to 22.4 m End of Borehole on Inferred Bedrock Groundwater at 0.15 m BGS (Elev. 222.5 m) on completion of drilling							



UNIT WEIGHT γ kN/m³

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

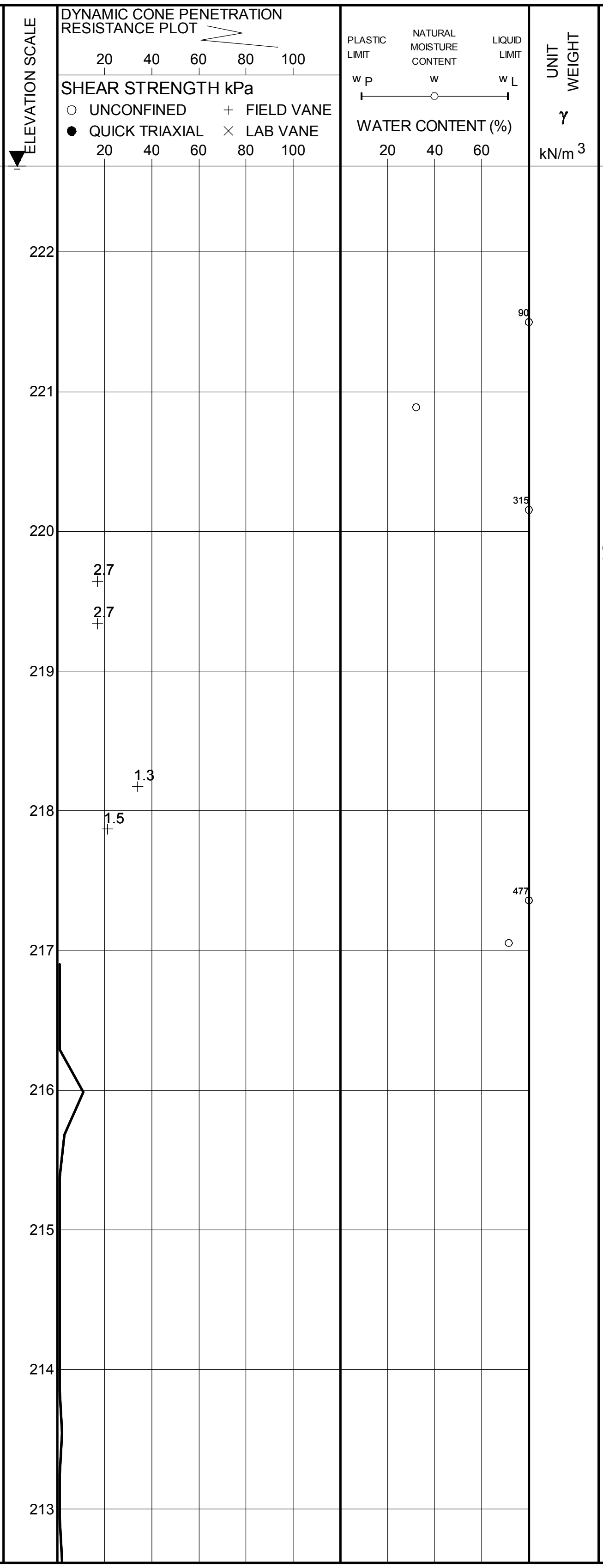
RECORD OF BOREHOLE No 17-30

1 OF 4

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 278.8 E 322 877.6	ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 18.07.2017 - 19.07.2017	CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		
222.6 0.0	**WATER**					▼	
221.8 0.8	SAND with Gravel and Organics **FILL** Very Loose Black		1	SS	1		
			2	SS	2		
220.5 2.2	**PEAT**, Coarse to Fine Fibrous with Wood fragments Very Soft to Firm Black to Dark Brown		3	SS	1		organic content 75.2%
			4	ST	PUSH		
			5	SS	WH		
217.1 5.5	**CLAY** Soft Grey						
217.0 5.6	End of Sampled Borehole DCPT from 5.6 m to 31.4 m **INFERRED CLAY**						



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-30

2 OF 4

METRIC

GWP# 5134-14-00

LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 278.8 E 322 877.6

ORIGINATED BY KE

HWY 537

BOREHOLE TYPE Portable Raft / NW Casing

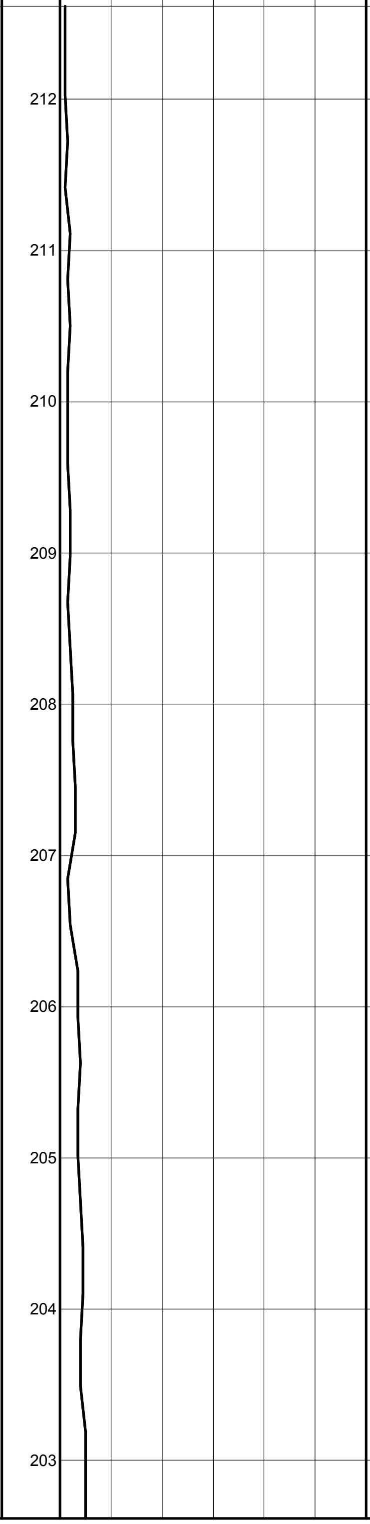
COMPILED BY CM

DATUM Geodetic

DATE 18.07.2017 - 19.07.2017

CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED CLAY	▨									



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+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

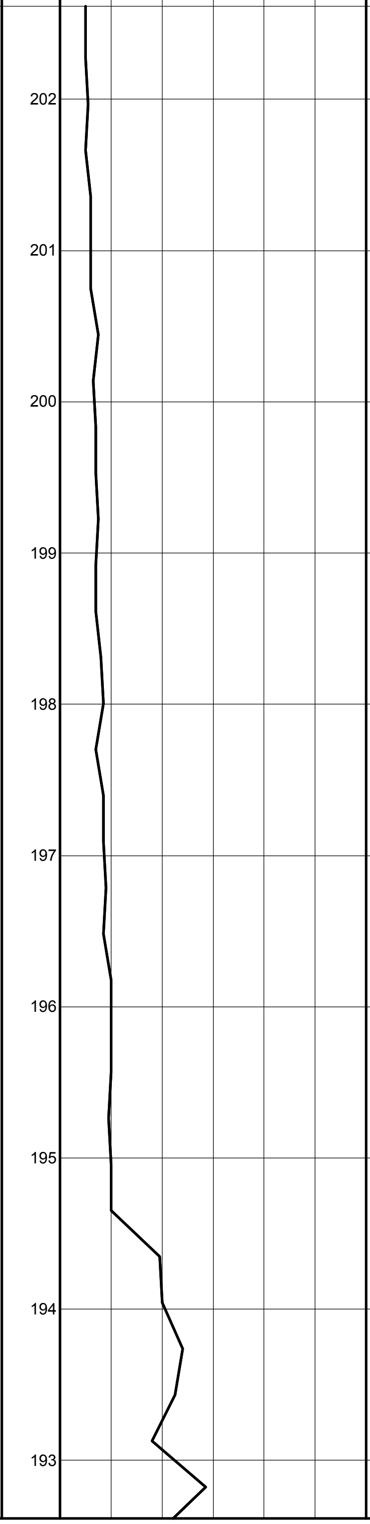
RECORD OF BOREHOLE No 17-30

3 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 278.8 E 322 877.6
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 18.07.2017 - 19.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED CLAY	▨									
194.3 28.3	**INFERRED SILT**	▥									



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-30

4 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 278.8 E 322 877.6
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 18.07.2017 - 19.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED SILT						192				
191.2 31.4	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.6 m) on completion of drilling										

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

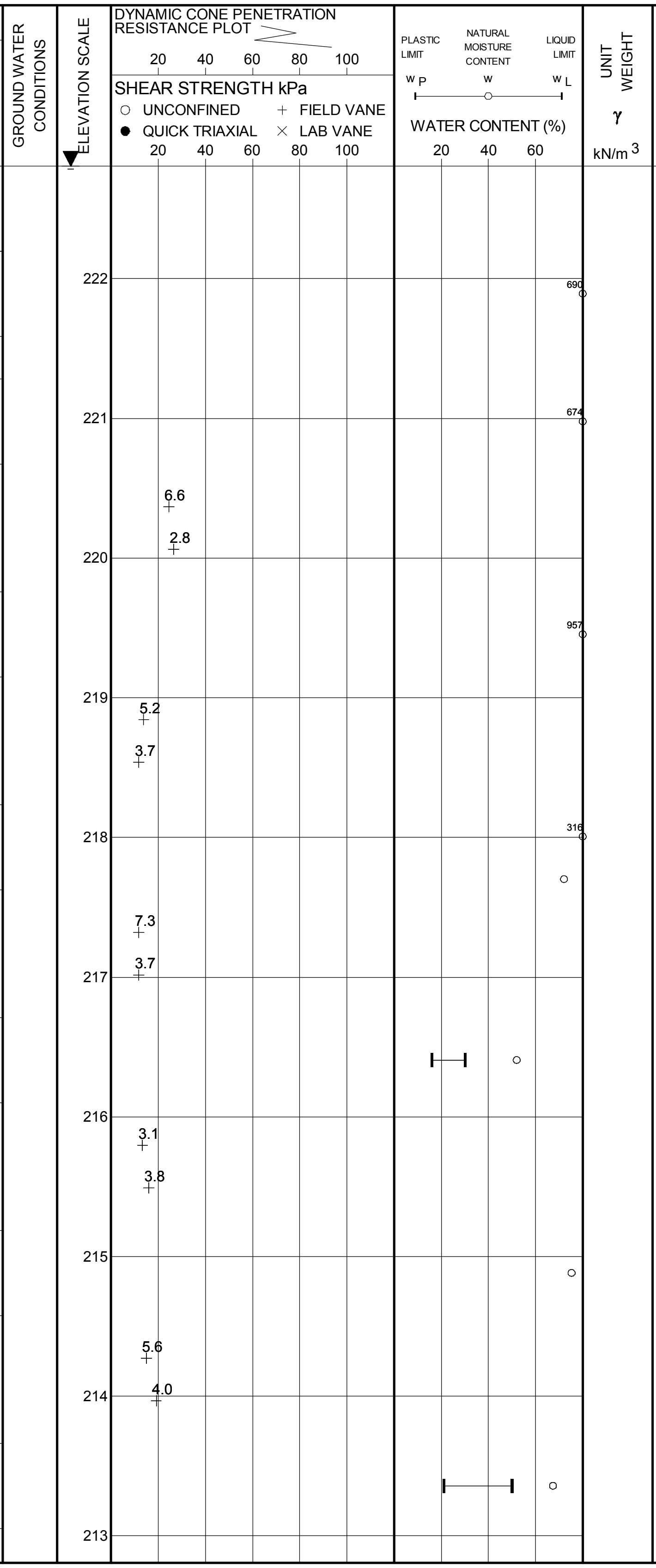
RECORD OF BOREHOLE No 17-31

1 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 295.1 E 322 903.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 19.03.2017 - 20.03.2017
CHECKED BY SP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS	GR	SA	SI	CL
222.8									
0.0	SNOW / ICE	1	SS	WH					
222.2 0.6	**PEAT**, Fine to Coarse Fibrous Firm to Soft Brown	2	SS	1					
		3	SS	WH	73.9% organic content				
		4	SS	WH					
		5	SS	WR					
217.8 5.0	**CLAY (CL)**, some Sand Soft Grey	6	SS	WR		2	10	54	34
215.2 7.6	**CLAY (CI to CH)** Soft to Firm Grey	7	SS	WR					
		8	SS	WR		0	0	36	64



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+3, ×3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-31

2 OF 4

METRIC

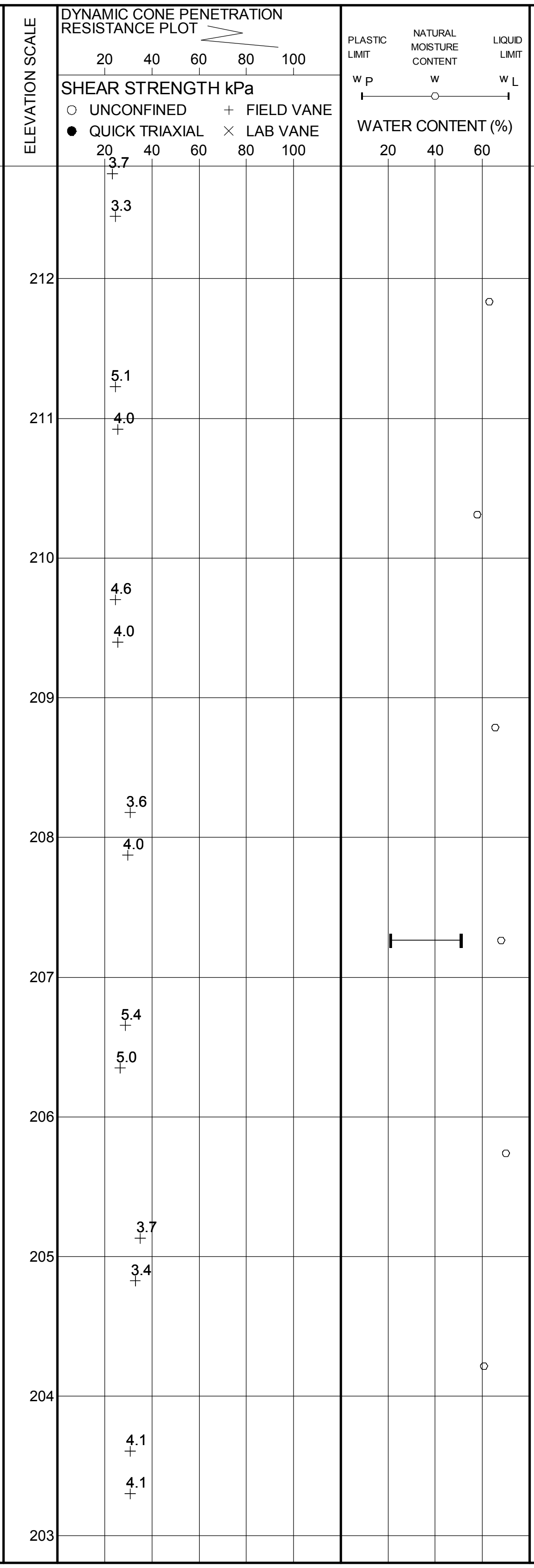
GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 295.1 E 322 903.0
HWY	537	BOREHOLE TYPE	Portable / NW Casing
DATUM	Geodetic	DATE	19.03.2017 - 20.03.2017

ORIGINATED BY JM
COMPILED BY JG
CHECKED BY SP

Continued From Previous Page

CLAY (CI to CH)
Soft to Firm
Grey

SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
9	SS	WR				
10	SS	WR				
11	ST	Push				
12	SS	WH	0	3	32	65
13	SS	WH				
14	SS	WR				



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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+ 3, × 3 : Numbers refer to Sensitivity

20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

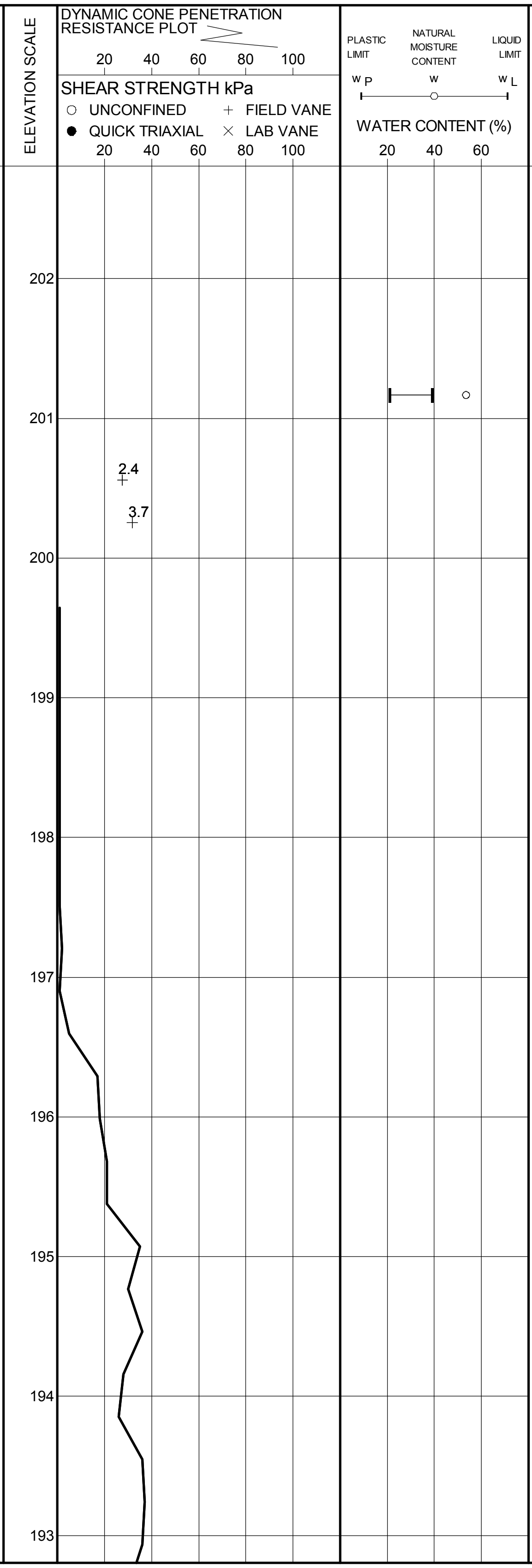
RECORD OF BOREHOLE No 17-31

3 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 295.1 E 322 903.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 19.03.2017 - 20.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	CLAY (CI to CH) Soft to Firm Grey										
	- varved		15	SS	WH			0	0	46	54
199.9 22.9	End of Sampled Borehole DCPT from 22.4 m to 30.5 m **INFERRED CLAY**										
196.3 26.5	**INFERRED SILT**										



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

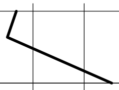
THURBER

RECORD OF BOREHOLE No 17-31

4 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 295.1 E 322 903.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 19.03.2017 - 20.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
192.3	**INFERRED SILT**										
30.5	End of DCPT Groundwater at 0.6 m AGS (Elev. 222.8 m) on completion of drilling										

+³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

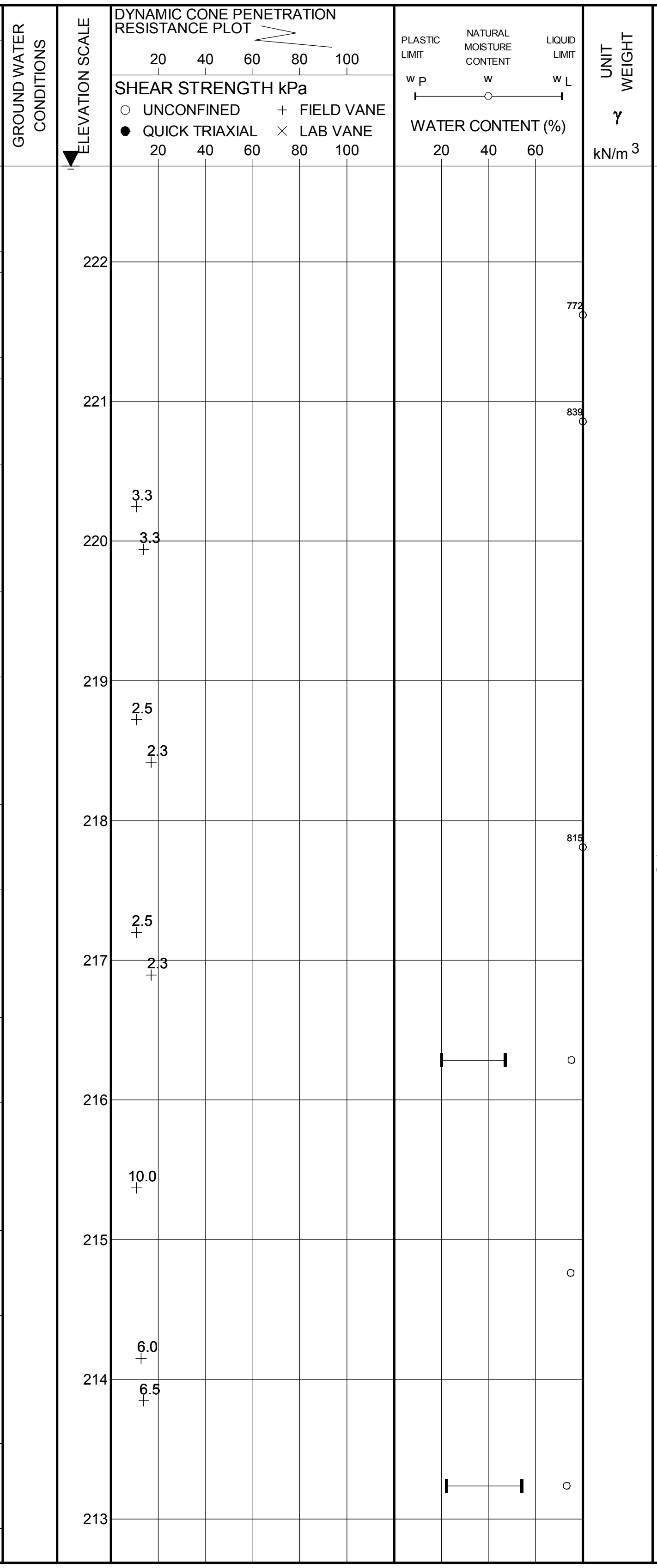
RECORD OF BOREHOLE No 17-32

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 269.8 E 322 902.1
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 27.03.2017 - 28.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		GR	SA	SI	CL
222.7										
0.0	SNOW / ICE		1	SS	WH					
222.1 0.6	**PEAT**, Fine to Coarse Fibrous Soft Brown		2	SS	WH					
			3	SS	WH					
			4	SS	WH					
			5	SS	WH	52.6% organic content				
217.0 5.6	**CLAY (CI to CH)**, Frequent Silt seams for top 1.5 m Very Soft to Firm Grey		6	SS	WH					
			7	SS	WH					
			8	SS	WH		0	0	33	67



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

RECORD OF BOREHOLE No 17-32

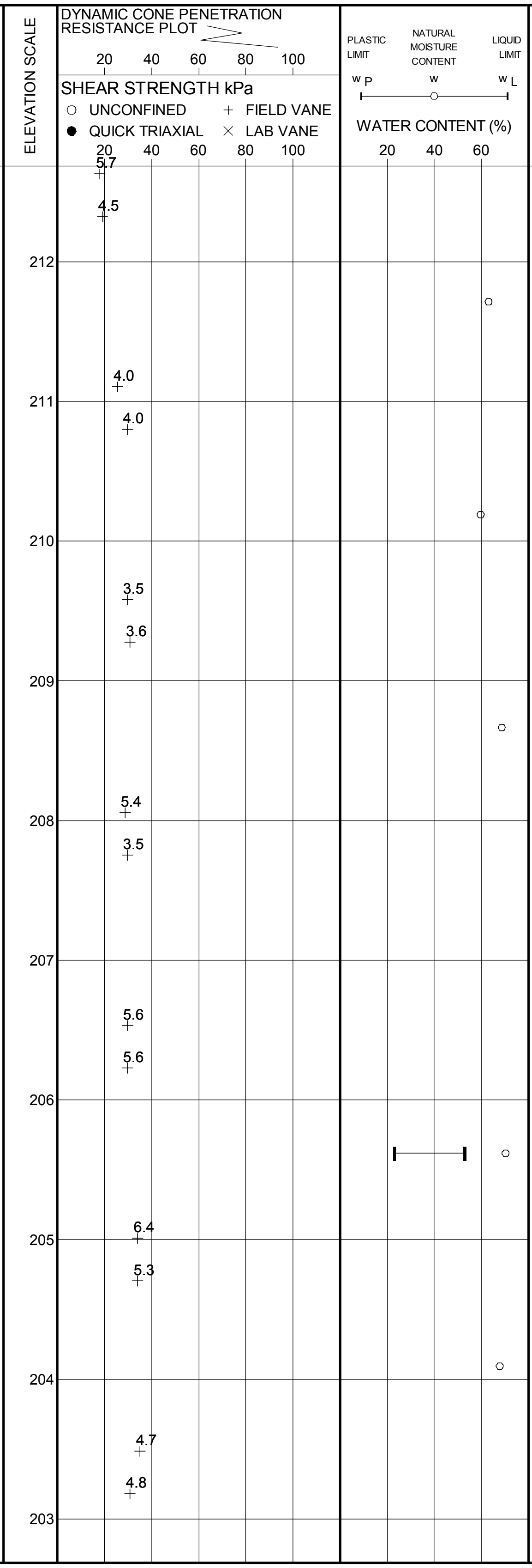
2 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 269.8 E 322 902.1
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 27.03.2017 - 28.03.2017
CHECKED BY SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
	CLAY Soft to Firm Grey	▨									
			9	SS	WH						
			10	SS	WH						
			11	SS	WH						
			1	ST	WH						
			12	SS	WH			0	0	28	72
			13	SS	WH						



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+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

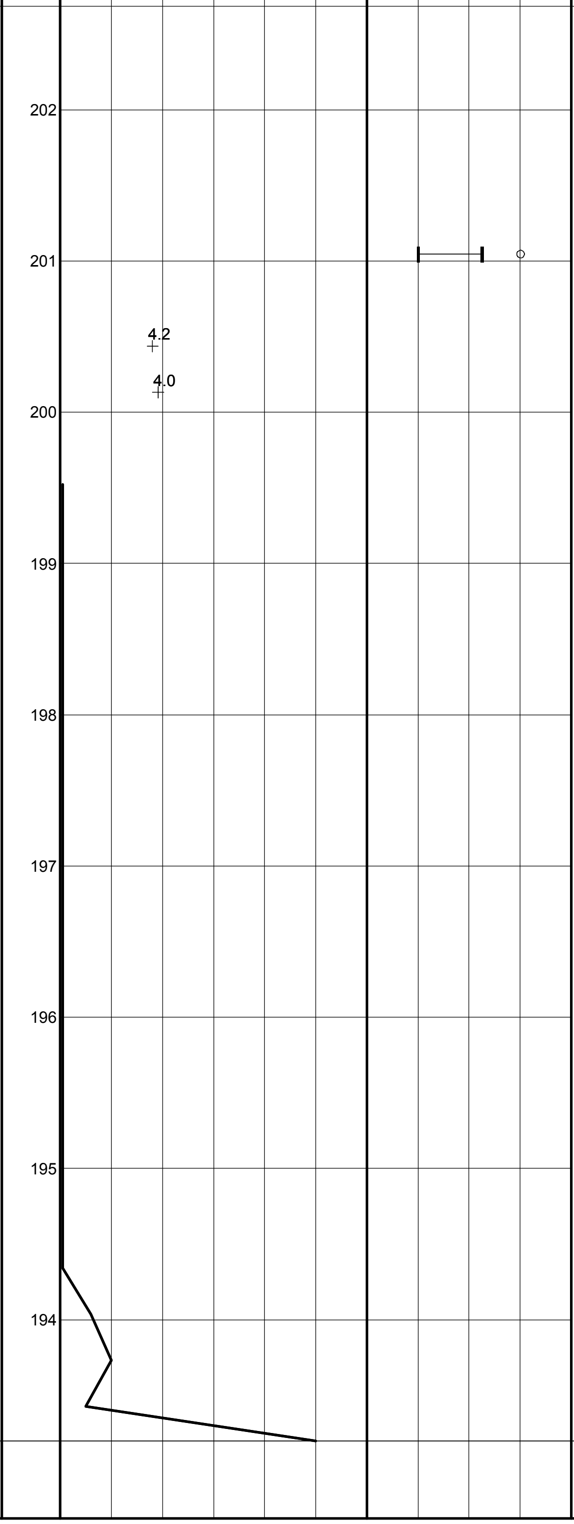
RECORD OF BOREHOLE No 17-32

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 269.8 E 322 902.1
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 27.03.2017 - 28.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	CLAY Soft to Firm Grey		14	SS	WH						0 0 42 58
199.8 22.9	End of Sampled Borehole DCPT from 22.4 m to 29.5 m **INFERRED CLAY**										
194.3 28.3	**INFERRED SILT**										
193.2 29.5	End of DCPT on Inferred Bedrock Groundwater at 0.6 m AGS (Elev. 222.7 m) on completion of drilling										



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

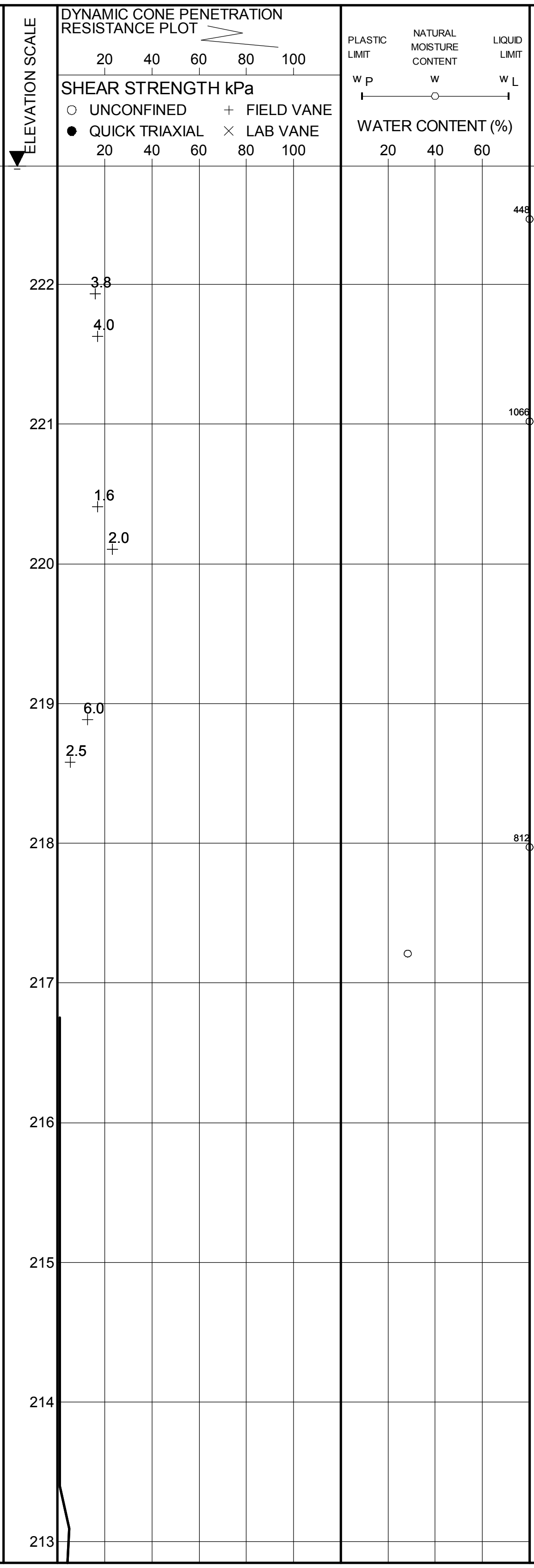
RECORD OF BOREHOLE No 17-33

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 294.5 E 322 954.2
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 29.03.2017 - 29.03.2017
CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
222.8										
0.0	SNOW / ICE									
0.2	**PEAT** Soft Brown	1	SS	WH						
		2	SS	WH						
		1	ST							
217.7		3	SS	WH						
5.2	**SILT (ML)** Very Loose Grey	4	SS	WH			0	0	74	26
216.9 5.9	End of Sampled Borehole DCPT from 22.4 m to 29.5 m **INFERRED CLAY**									



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-33

2 OF 3

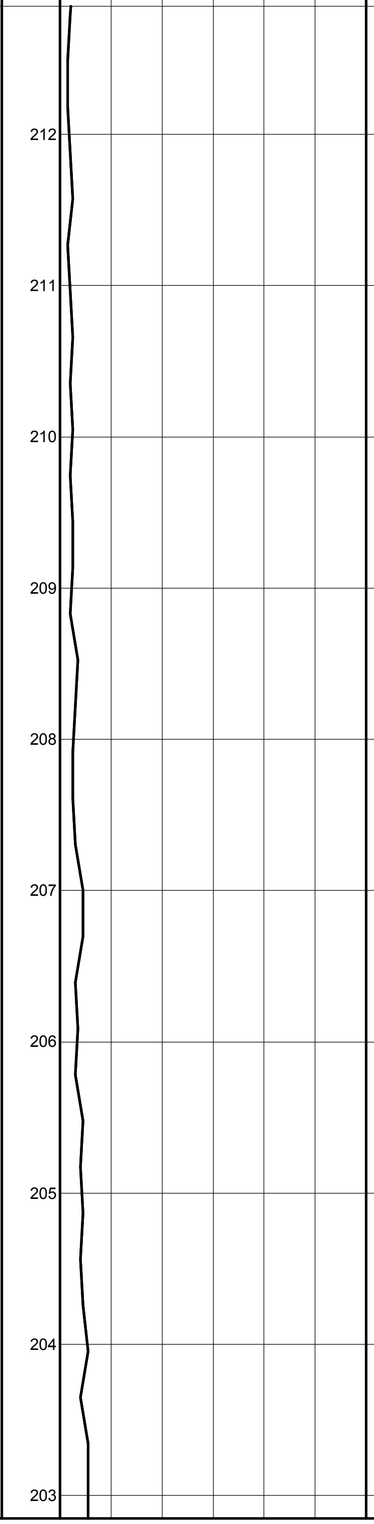
METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 294.5 E 322 954.2		ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing		COMPILED BY JG
DATUM Geodetic	DATE 29.03.2017 - 29.03.2017		CHECKED BY SP

SOIL PROFILE: ELEV / DEPTH | DESCRIPTION | STRAT PLOT
SAMPLES: NUMBER | TYPE | "N" VALUES
GROUND WATER CONDITIONS
ELEVATION SCALE
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued From Previous Page

INFERRED CLAY



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+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

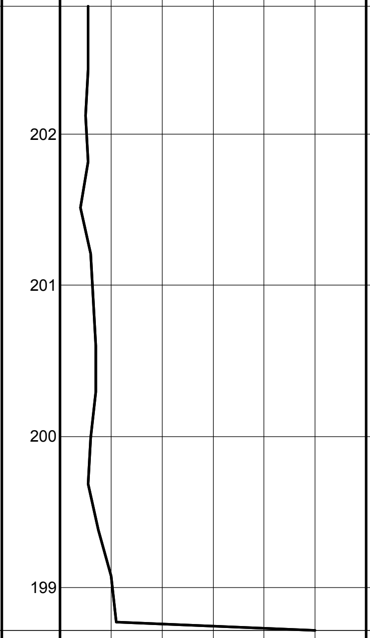
THURBER

RECORD OF BOREHOLE No 17-33

3 OF 3 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 294.5 E 322 954.2	ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 29.03.2017 - 29.03.2017	CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY						202 201 200				
199.4 23.5	**INFERRED SILT**						199				
198.7 24.1	End of DCPT on Inferred Bedrock Groundwater at 0.2 m AGS (Elev. 222.8 m) on completion of drilling										



+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-34

1 OF 3

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 273.5 E 322 951.2	ORIGINATED BY	KE
HWY	537	BOREHOLE TYPE	Portable Raft / NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	19.07.2017 - 19.07.2017	CHECKED BY	SP

SOIL PROFILE

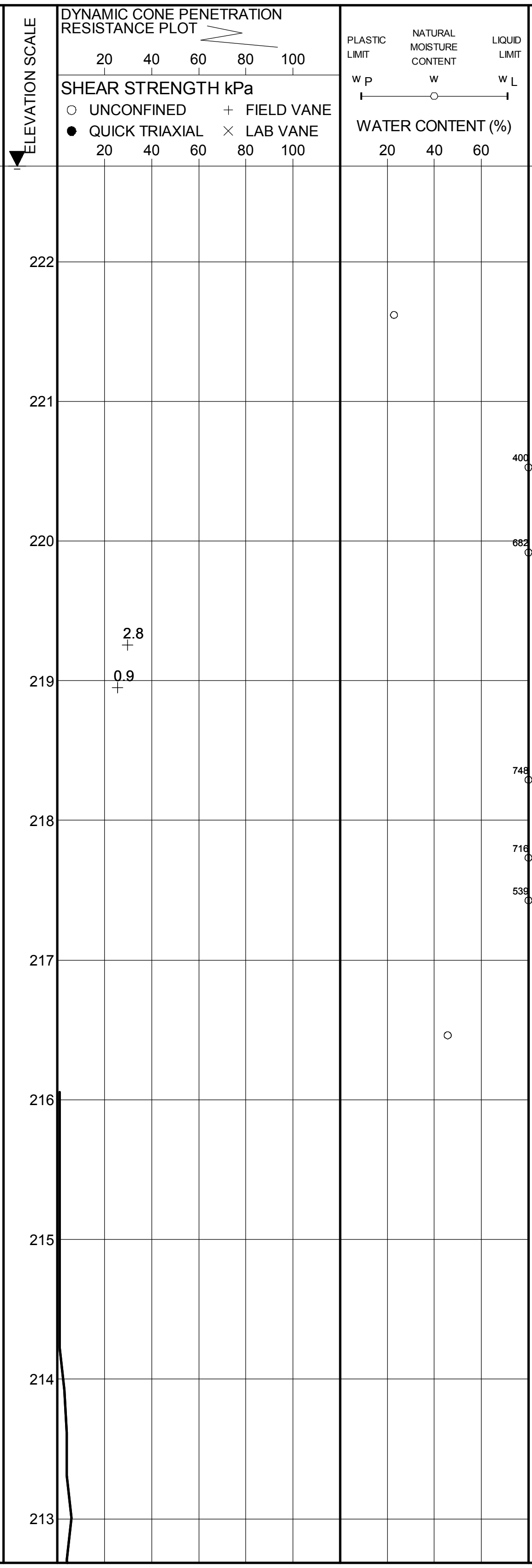
ELEV DEPTH	DESCRIPTION
222.7	
0.0	**WATER**
221.9 0.8	SAND with Gravel and Organics **FILL** Loose Black
220.8 1.9	**PEAT**, Coarse to Fine Fibrous with Wood fragments Very Soft to Firm Black to Dark Brown
217.1 5.6	**SILT** with Clay seams Very Loose Grey
216.2 6.5	End of Sampled Borehole DCPT from 6.5 m to 24.1 m **INFERRED CLAY**

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	6	
2	SS	WH	
3	SS	1	
4	SS	1	
5	SS	1	
6	ST	PUSH	
7	SS	3	0 0 76 24 non-plastic

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³



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+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

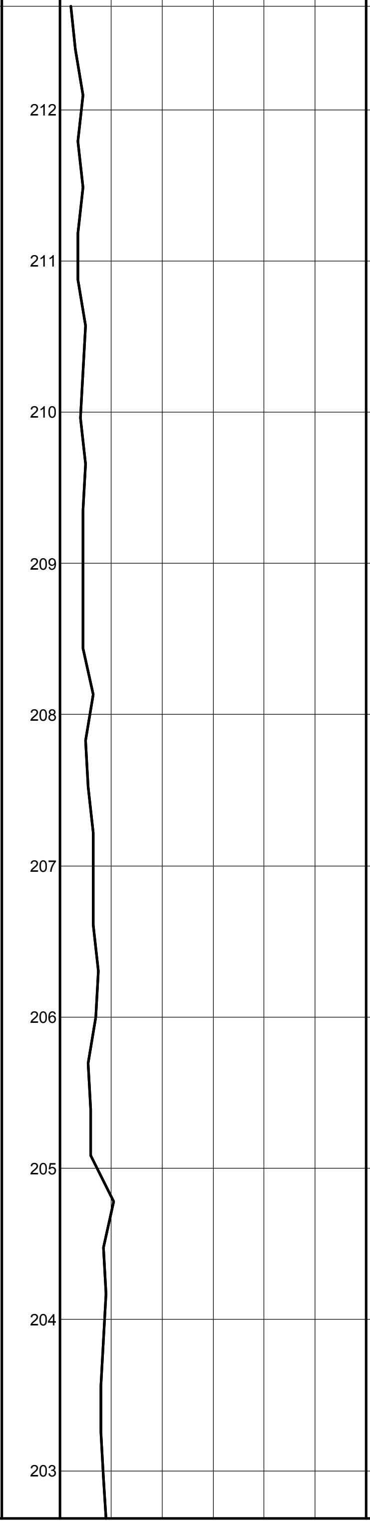
RECORD OF BOREHOLE No 17-34

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 273.5 E 322 951.2		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 19.07.2017 - 19.07.2017		CHECKED BY SP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY	▨									



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+³, ×³: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

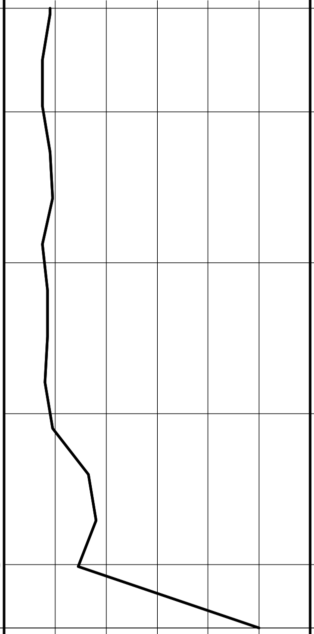
RECORD OF BOREHOLE No 17-34

3 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 273.5 E 322 951.2		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 19.07.2017 - 19.07.2017		CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED CLAY	▨					202 201 200				
199.6 23.1	**INFERRED SILT**	▥					199				
198.6 24.1	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.7 m) on completion of drilling										



+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

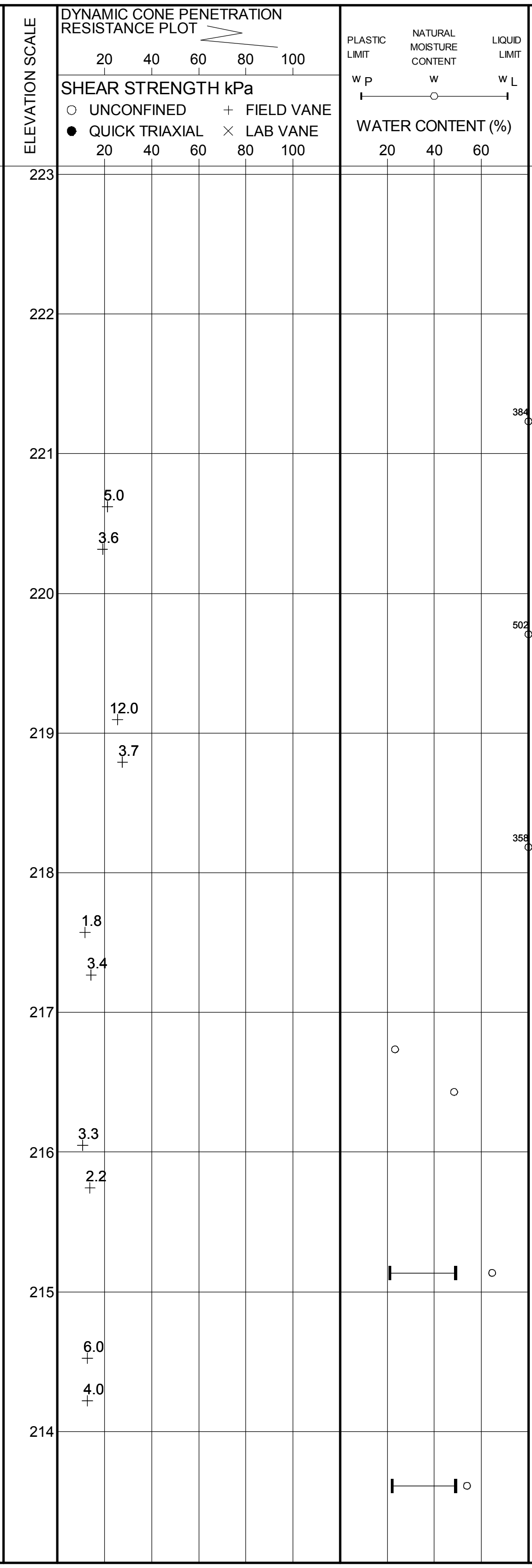
RECORD OF BOREHOLE No 17-35

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 285.6 E 322 979.9
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 13.03.2017 - 14.03.2017
CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS	GR	SA	SI	CL
223.1											
0.0	SNOW/ICE/WATER	1	SS	1							
222.1 0.9	**PEAT**, Fine to Coarse Fibrous Soft to Firm Brown	2	SS	1							
		3	SS	2							
		4	SS	WH			90.3% organic content				
		5	SS	WH							
217.1 5.9	**SILT (ML)** with Gravel, trace Sand Very Loose Grey	6	SS	2				17	9	54	20
216.5 6.6	**CLAY (CI to CH)** Soft to Firm Grey	8	ST	Push			OED: e_o = 1.732 C_c = 0.807 C_r = 0.010	0	0	34	66
		10	SS	WH							



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-35

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 285.6 E 322 979.9	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 13.03.2017 - 14.03.2017	CHECKED BY SP

SOIL PROFILE: ELEV / DEPTH, DESCRIPTION, STRAT PLOT

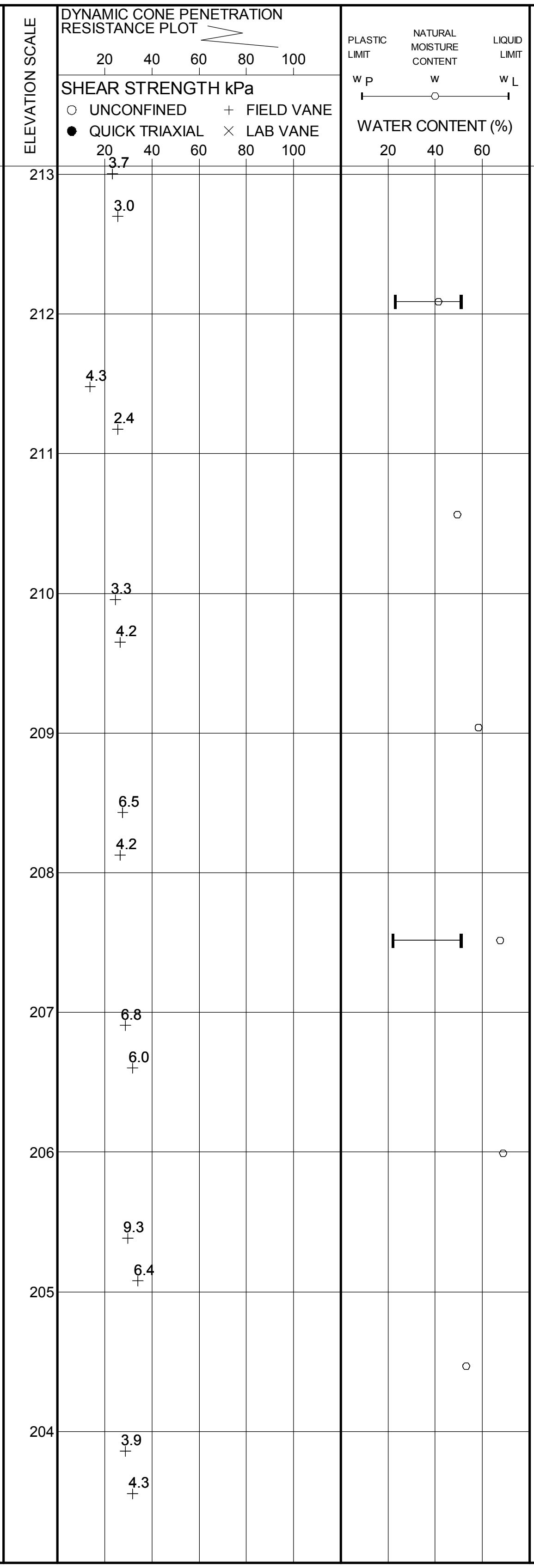
Continued From Previous Page

CLAY (CI to CH)
Soft to Firm
Grey

- silt seams

Continued Next Page

SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
11	SS	1			0	0	30	70
12	SS	WR						
13	SS	WH						
14	SS	WR			0	1	30	69
15	SS	WH						
16	SS	WH						



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-35

3 OF 3 **METRIC**

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 285.6 E 322 979.9
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 13.03.2017 - 14.03.2017
CHECKED BY SP

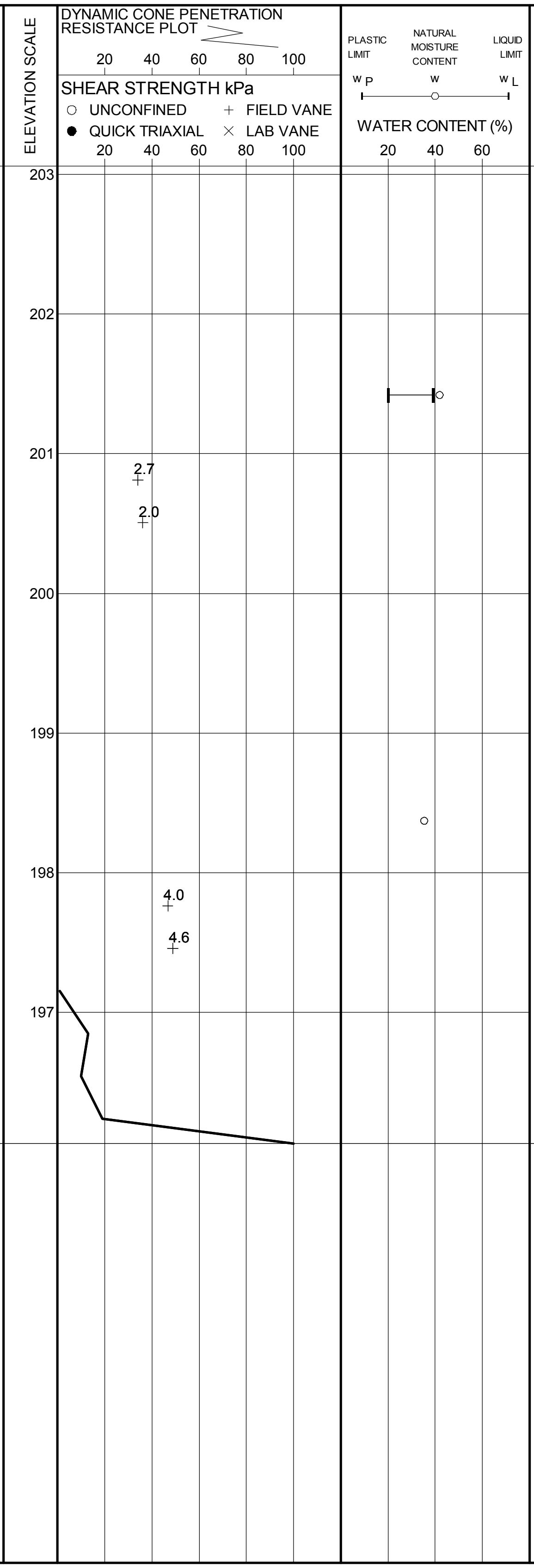
SOIL PROFILE

Continued From Previous Page

ELEV DEPTH	DESCRIPTION
	CLAY (CI to CH) Soft to Firm Grey - silt seams
197.2 25.9	End of Sampled Borehole DCPT from 25.9 m to 27.0 m **INFERRED SILT**
196.1 27.0	End of DCPT on Inferred Bedrock

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
17	SS	1	0	0	44	56
18	SS	WH				



UNIT WEIGHT γ kN/m³

+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

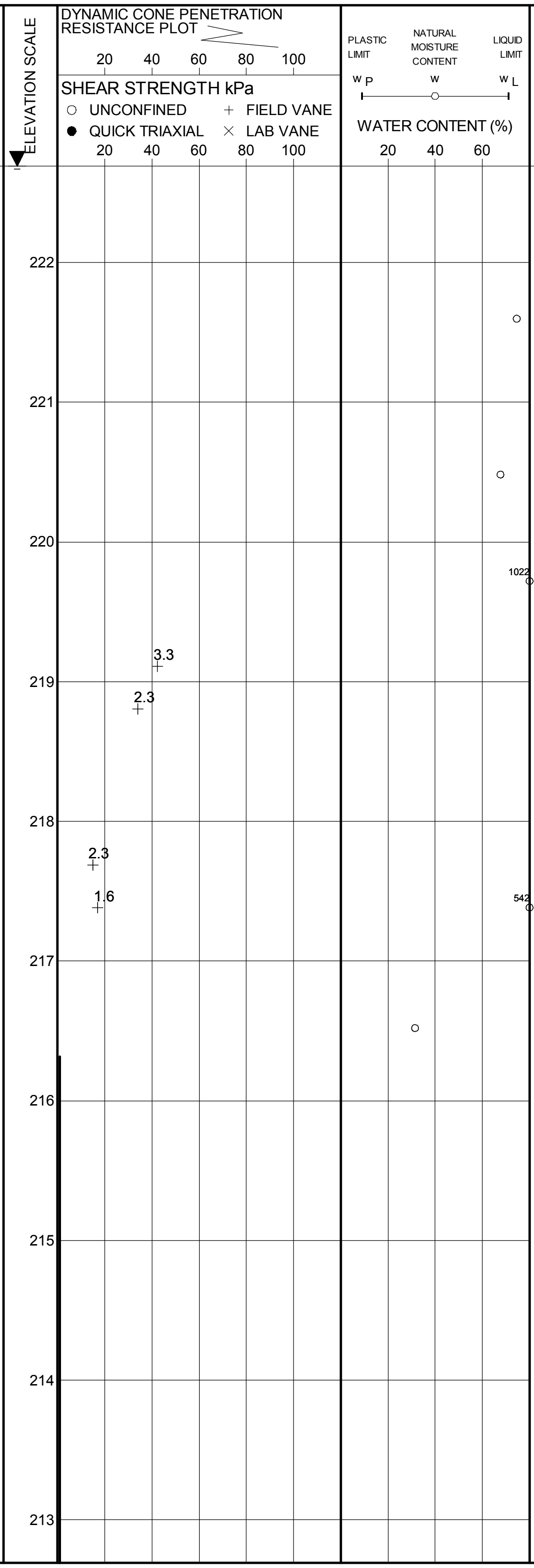
THURBER

RECORD OF BOREHOLE No 17-36

1 OF 4 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 267.7 E 322 975.0	ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 20.07.2017 - 20.07.2017	CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.7					
0.0	**WATER**				
221.9 0.8	SAND with Gravel and Organics **FILL** Very Loose Black	1	SS	2	
221.4 1.2	**PEAT**, Coarse to Fine Fibrous with Wood fragments Very Soft to Firm Black to Dark Brown	2	SS	1	
		3	SS	1	
		4	ST	PUSH	organic content 54.1%
216.6 6.0	**SILT** with Clay seams Very Loose Grey	5	SS	2	
216.4 6.3	End of Sampled Borehole DCPT from 6.2 m to 29.8 m **INFERRED CLAY**				



UNIT WEIGHT γ kN/m3

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

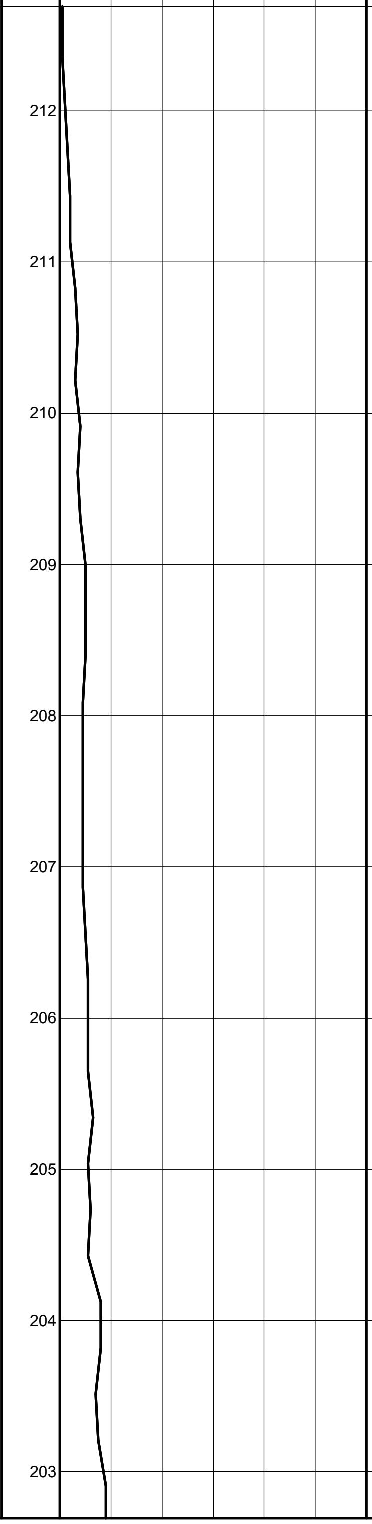
RECORD OF BOREHOLE No 17-36

2 OF 4

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 267.7 E 322 975.0
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 20.07.2017 - 20.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	INFERRED CLAY	▨					212 211 210 209 208 207 206 205 204 203				



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-36

3 OF 4

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 267.7 E 322 975.0	ORIGINATED BY	KE
HWY	537	BOREHOLE TYPE	Portable Raft / NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	20.07.2017 - 20.07.2017	CHECKED BY	SP

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	INFERRED CLAY						
197.1 25.6	**INFERRED SILT**						
192.8 29.8	End of DCPT on Inferred Bedrock						

Continued Next Page

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m3

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-36

4 OF 4 **METRIC**

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 267.7 E 322 975.0	ORIGINATED BY	KE
HWY	537	BOREHOLE TYPE	Portable Raft / NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	20.07.2017 - 20.07.2017	CHECKED BY	SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Groundwater at surface (Elev. 222.7 m) on completion of drilling										

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-37

1 OF 3 **METRIC**

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.3 E 323 004.3	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	Portable / NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	15.03.2017 - 15.03.2017	CHECKED BY	SP

SOIL PROFILE

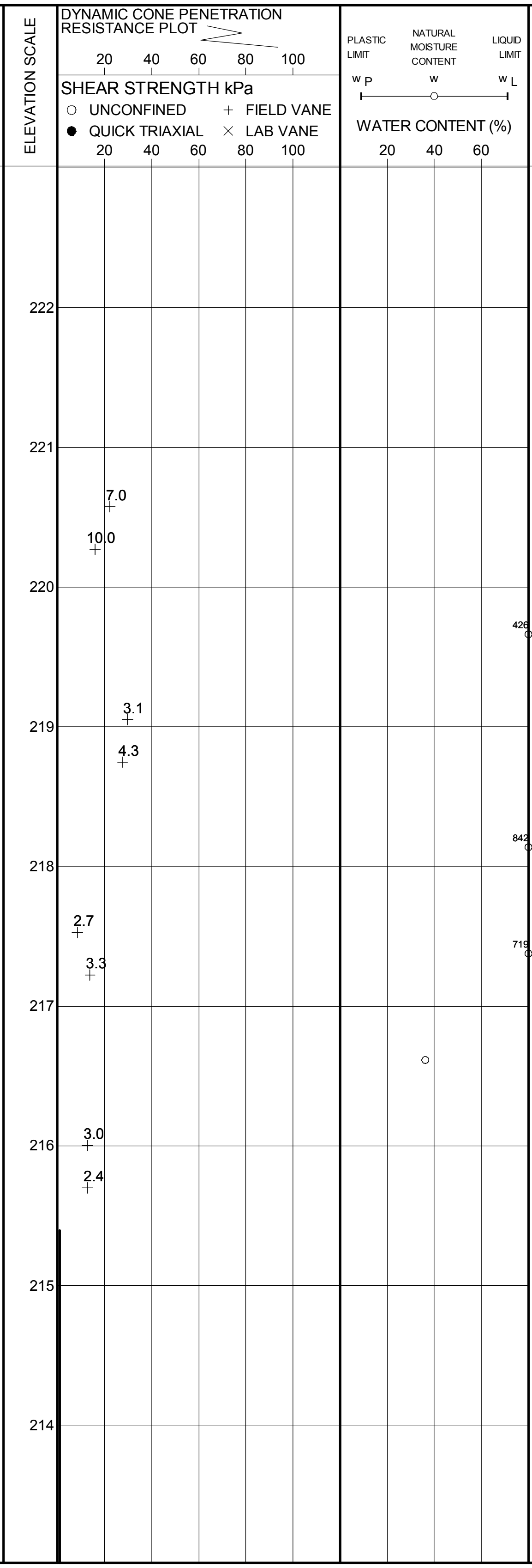
ELEV DEPTH	DESCRIPTION	STRAT PLOT
223.0		
0.0	SNOW / ICE	
222.1 0.9	**PEAT**, Fine to Coarse Fibrous Soft Brown	≈
217.1 5.9	**SILT (ML)** Very Loose Grey	‖
216.2 6.9	**CLAY** Firm Grey	▨
215.4 7.6	End of Sampled Borehole DCPT from 7.6 m to 27.0 m **INFERRED CLAY**	▨

Continued Next Page

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	WH
2	SS	14
3	SS	WH
4	SS	1
5	ST	Push
1	GS	
6	SS	WH

GROUND WATER CONDITIONS



UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	68.3% organic content
	OED: e_o = 13.440 C_c = 8.422
	56.2% organic content
	GR 0, SA 0, SI 85, CL 15

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

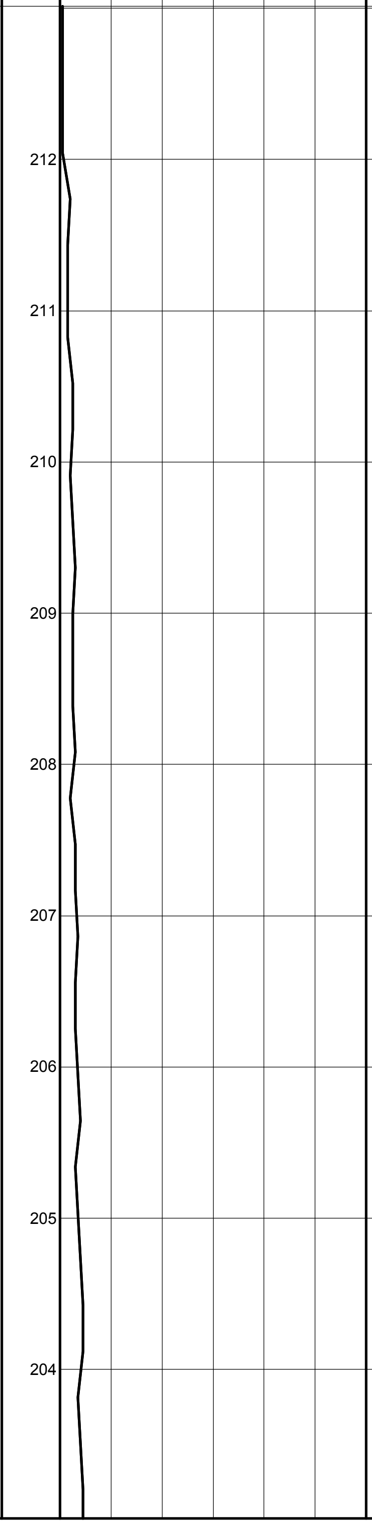
RECORD OF BOREHOLE No 17-37

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.3 E 323 004.3	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 15.03.2017 - 15.03.2017	CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	INFERRED CLAY	▨									



Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

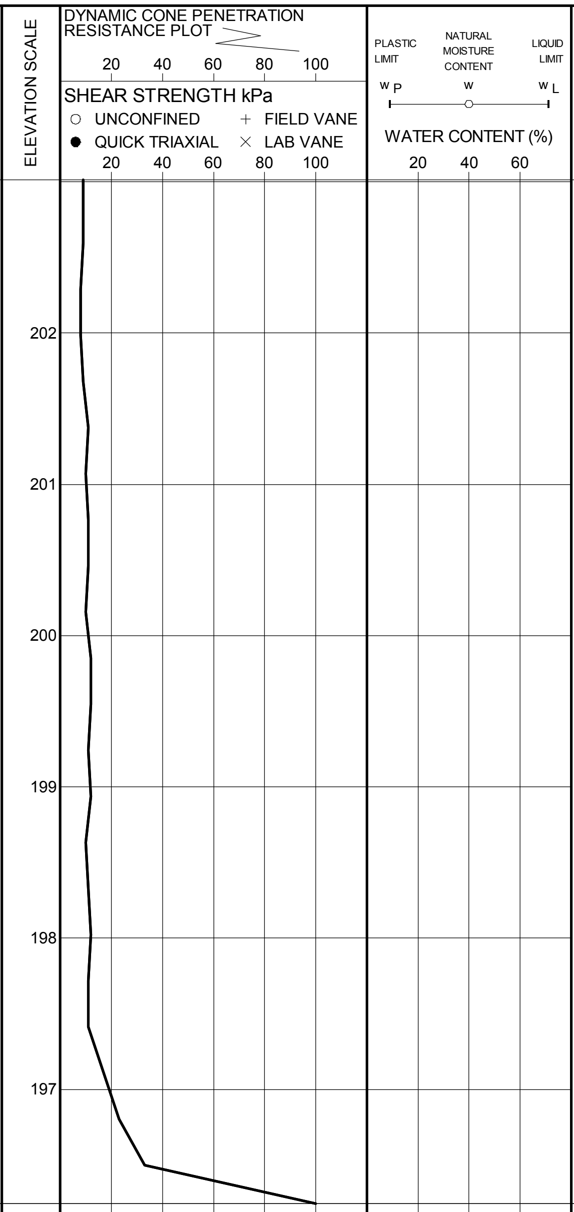
RECORD OF BOREHOLE No 17-37

3 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 277.3 E 323 004.3	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 15.03.2017 - 15.03.2017	CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION Continued From Previous Page	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	INFERRED CLAY							
197.4 25.6	**INFERRED SILT**							
196.2 26.8	End of Borehole on Inferred Bedrock							



+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

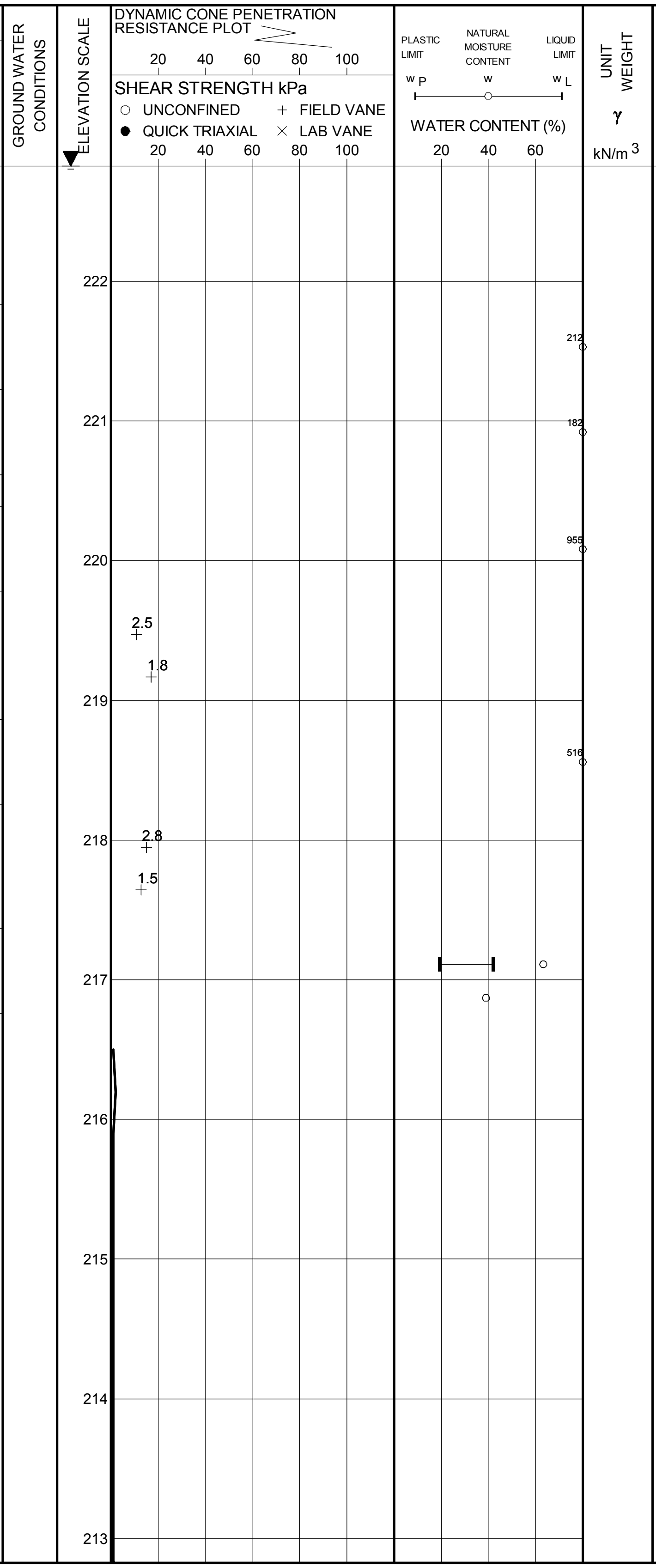
RECORD OF BOREHOLE No 17-38

1 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 259.8 E 322 998.1
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 20.07.2017 - 21.07.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
222.8								
0.0	**WATER**							
221.8 1.0	**PEAT**, Coarse to Fine Fibrous with Wood fragments Very Soft to Soft Black to Dark Brown	1	SS	WR				
		2	SS	WH				
		3	SS	WH				
		4	SS	WH				
217.2 5.6	**CLAY** Very Soft Grey	5	SS	WR	0	0	58	42
217.0 5.8								
216.8 6.1	**SILT** Very Loose Grey							
	End of Sampled Borehole DCPT from 6.2 m to 25.9 m **INFERRED CLAY**							



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

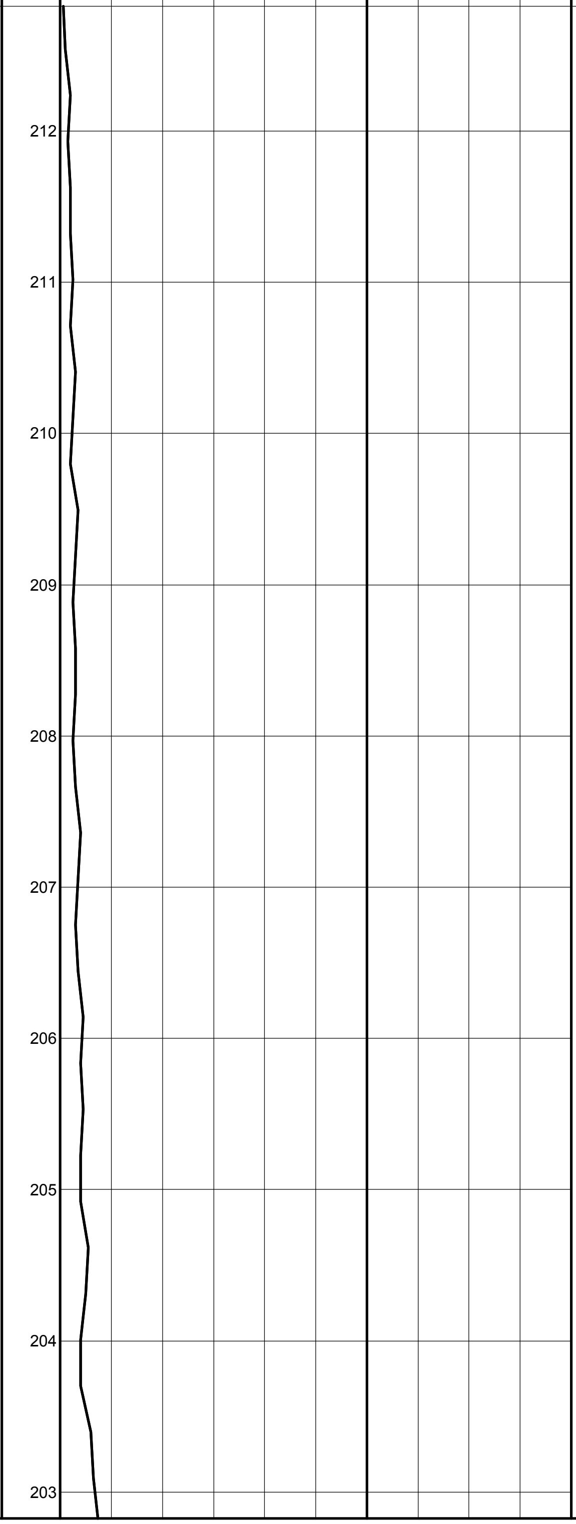
RECORD OF BOREHOLE No 17-38

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 259.8 E 322 998.1	ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing	COMPILED BY CM
DATUM Geodetic	DATE 20.07.2017 - 21.07.2017	CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	INFERRED CLAY	▨					212 211 210 209 208 207 206 205 204 203				



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

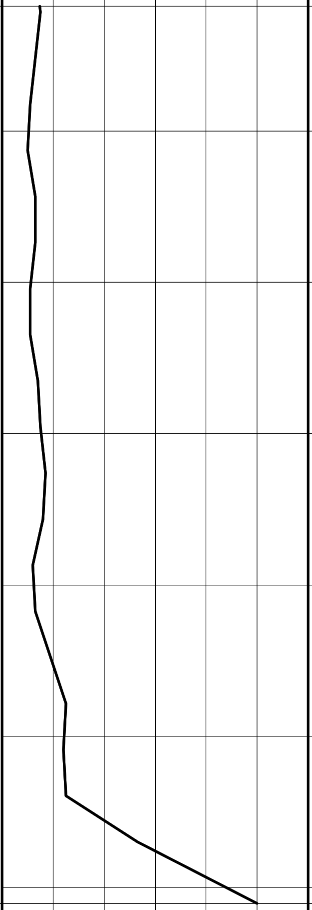
RECORD OF BOREHOLE No 17-38

3 OF 3

METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 259.8 E 322 998.1	ORIGINATED BY	KE
HWY	537	BOREHOLE TYPE	Portable Raft / NW Casing	COMPILED BY	CM
DATUM	Geodetic	DATE	20.07.2017 - 21.07.2017	CHECKED BY	SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY										
							202				
							201				
							200				
							199				
198.5 24.3	**INFERRED SILT**										
							198				
							197				
196.9 25.9	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.8 m) on completion of drilling										



ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

$+^3, \times^3$: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-39

1 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 270.7 E 323 032.0	ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 30.03.2017 - 30.03.2017	CHECKED BY SP

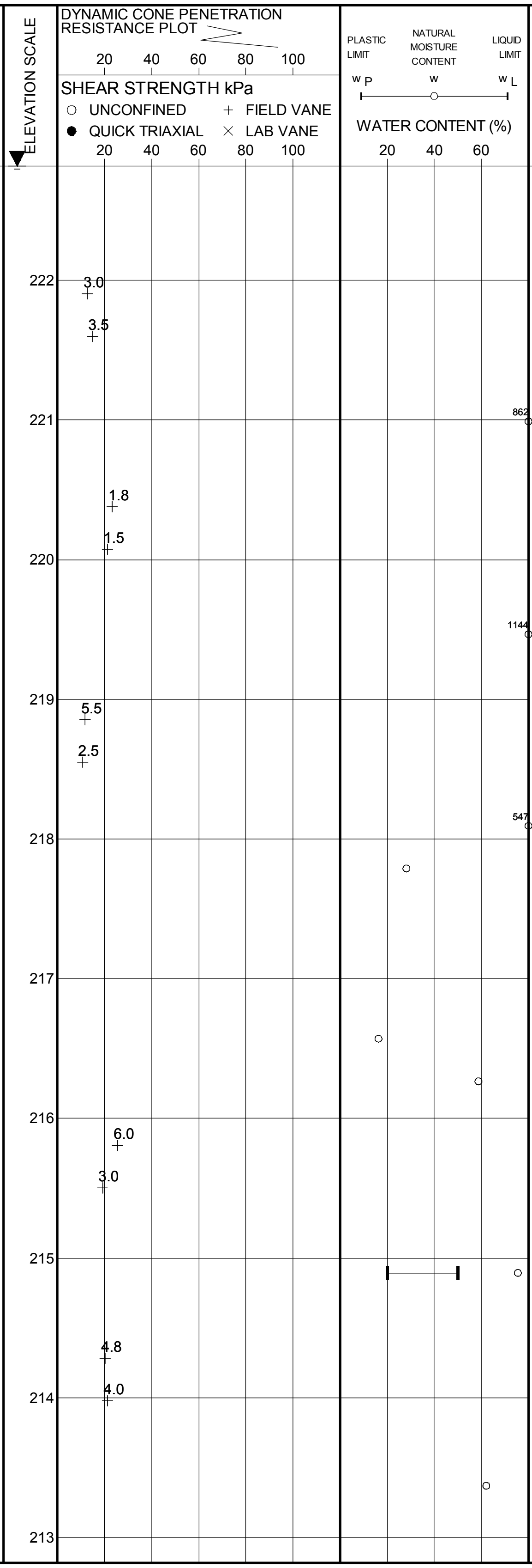
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
222.8	
0.0	**PEAT**, Fine Fibrous to Amorphous Soft Brown
217.9 4.9	**SILT (ML)** Very Loose Grey
217.2 5.6	**SAND** with Silt, some Gravel Very Loose Grey
216.4 6.4	**CLAY (CI to CH)** Soft to Firm Grey

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	WH
2	SS	1
3	SS	WH
4	SS	WH
5	SS	3
6	SS	WH
7	SS	WH

GROUND WATER CONDITIONS: ▼ (at surface)



Sample	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
3		62.9% organic content			
4		0	0	88	12
5		13	75	6	6
6		2	1	32	65

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-39

2 OF 3

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 270.7 E 323 032.0	ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 30.03.2017 - 30.03.2017	CHECKED BY SP

SOIL PROFILE

ELEV / DEPTH | DESCRIPTION | STRAT PLOT

Continued From Previous Page

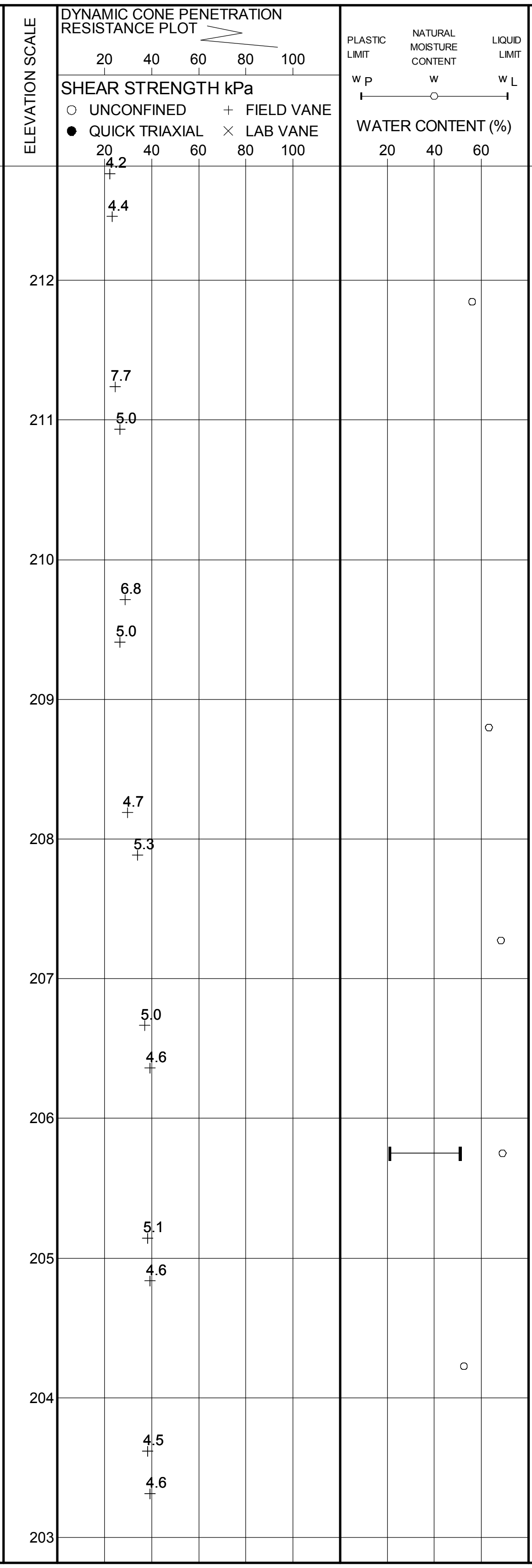
CLAY (CI to CH)
Soft to Firm
Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
8	SS	WH	
1	ST	Push	
9	SS	WH	
10	SS	WH	
11	SS	WH	0 0 29 71
12	SS	WH	

GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³



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+³, ×³: Numbers refer to Sensitivity

20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

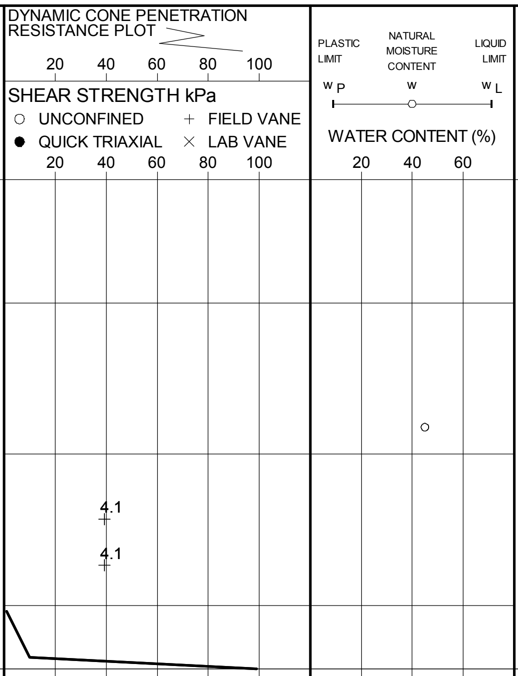
RECORD OF BOREHOLE No 17-39

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 270.7 E 323 032.0
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 30.03.2017 - 30.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	CLAY (CI to CH) Soft to Firm Grey	▨					202				
		▨	13	SS	WH		201				
200.0 22.9	End of Sampled Borehole DCPT from 22.9 m to 29.5 m	▨					200				
199.6 23.2	**INFERRED CLAY** End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.8 m) on completion of drilling	▨									



+3, ×3: Numbers refer to Sensitivity

20, 15, 5, 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

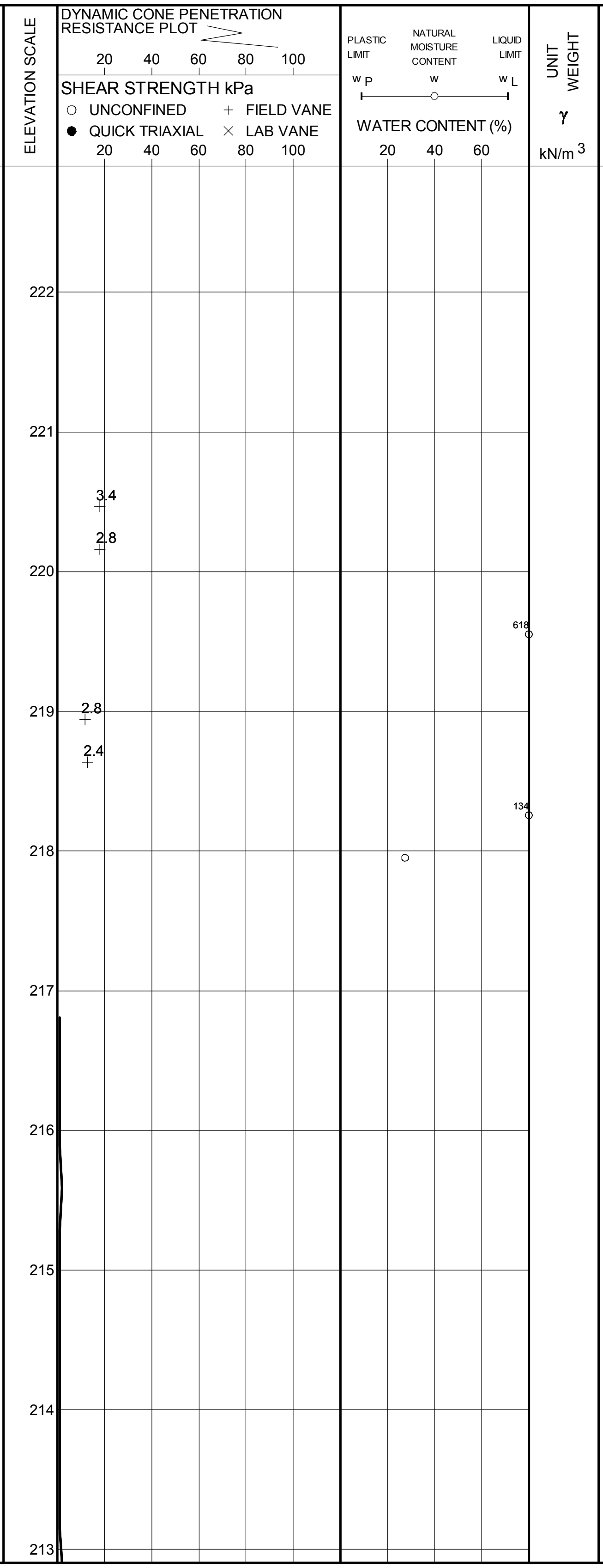
RECORD OF BOREHOLE No 17-40

1 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 254.0 E 323 051.3
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 16.03.2017
CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
222.9									
0.0	SNOW / ICE	1	SS	WH					
		2	SS	WH					
222.0 0.9	**PEAT**, Fine Fibrous to Coarse Fibrous Very Soft Brown	3	SS	WH					
		4	SS	WH					
218.2 4.7	**SILT (ML)** Very Loose Grey	5	SS	WH		0	1	82	17
217.7 5.2	End of Sampled Borehole DCPT from 6.1 m to 18.5 m **INFERRED SILT**								
216.8 6.1	**INFERRED CLAY**								



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

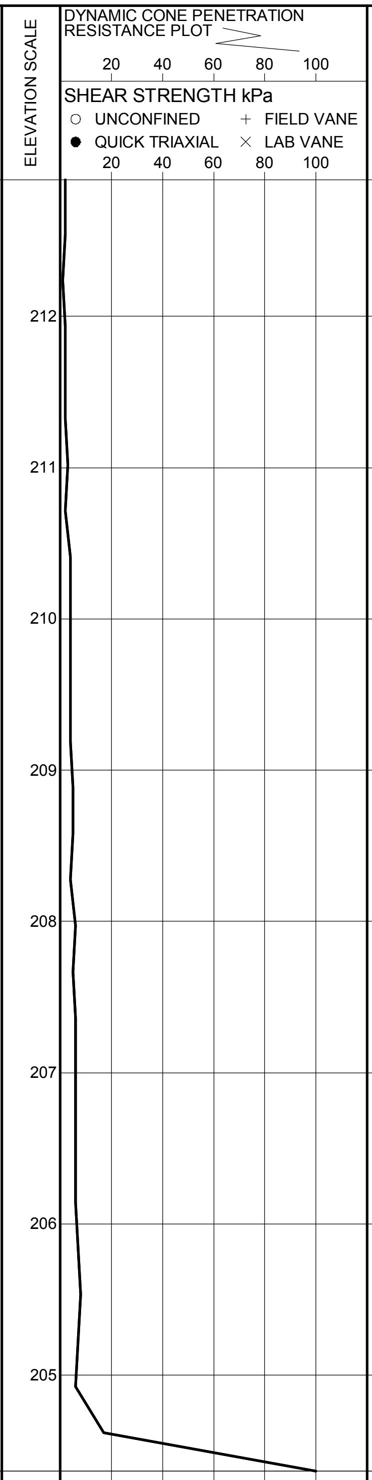
RECORD OF BOREHOLE No 17-40

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 254.0 E 323 051.3
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 16.03.2017 - 16.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY										
204.9 18.0	**INFERRED SILT**										
204.4 18.5	End of DCPT on Inferred Bedrock										



+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

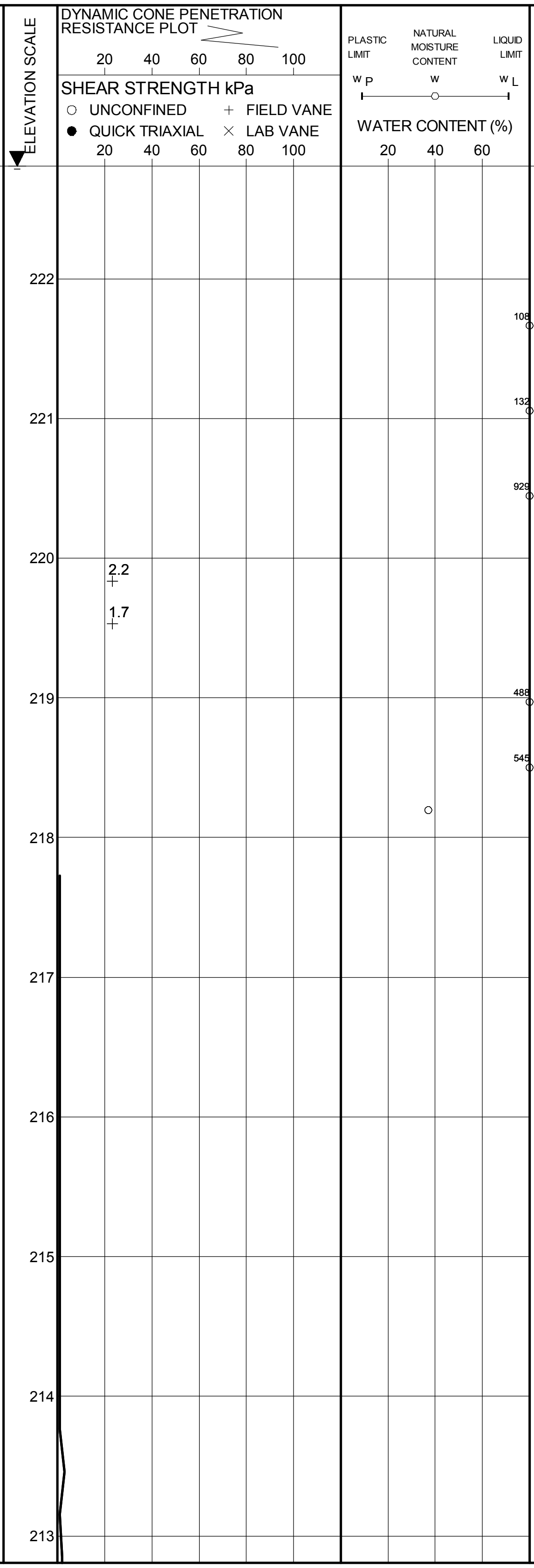
RECORD OF BOREHOLE No 17-41

1 OF 2

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 238.4 E 323 040.4		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 21.07.2017 - 21.07.2017		CHECKED BY SP

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	"N" VALUES	REMARKS	GR	SA	SI	CL
222.8									
0.0	**WATER**								
222.0 0.8	SAND with Gravel and Organics **FILL** Very Loose Black	1	SS	1					
221.4 1.4	**PEAT**, Coarse to Fine Fibrous Very Soft to Soft Black to Dark Brown	2	SS	1					
		3	SS	1					
		4	ST	PUSH					
		5	SS	WH	organic content 52.8%				
218.3 4.5	**SILT** with Clay seams Very Loose Grey				non-plastic	0	0	82	18
218.1 4.7	End of Sampled Borehole DCPT from 4.9 m to 17.1 m **INFERRED CLAY**								



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

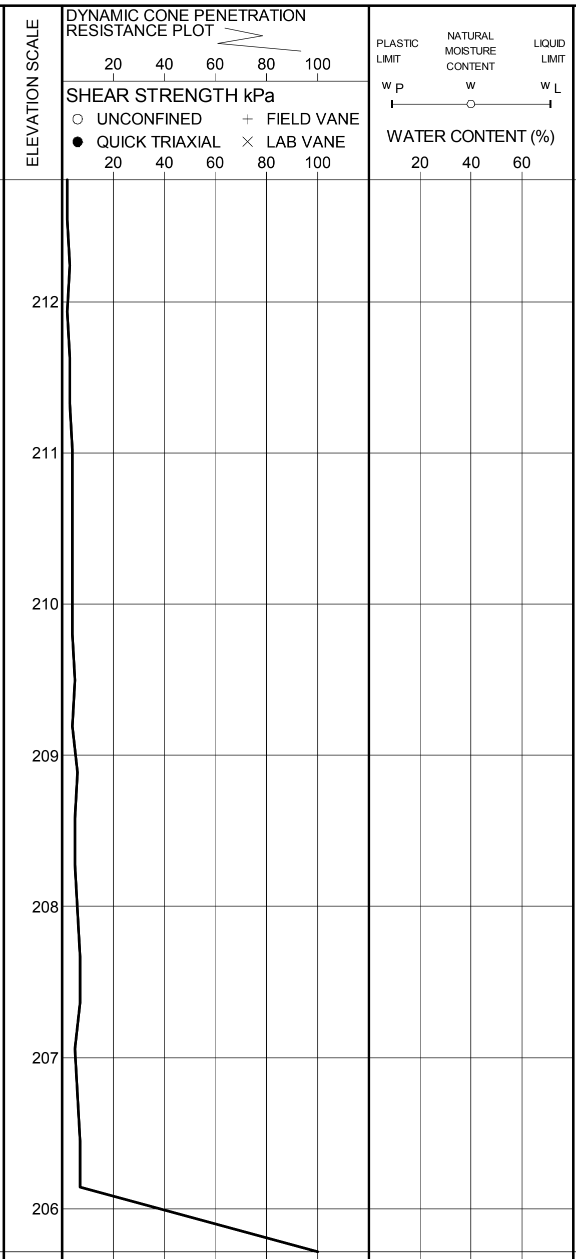
RECORD OF BOREHOLE No 17-41

2 OF 2

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 238.4 E 323 040.4		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable Raft / NW Casing		COMPILED BY CM
DATUM Geodetic	DATE 21.07.2017 - 21.07.2017		CHECKED BY SP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	INFERRED CLAY										
205.7 17.1	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.8 m) on completion of drilling										



+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

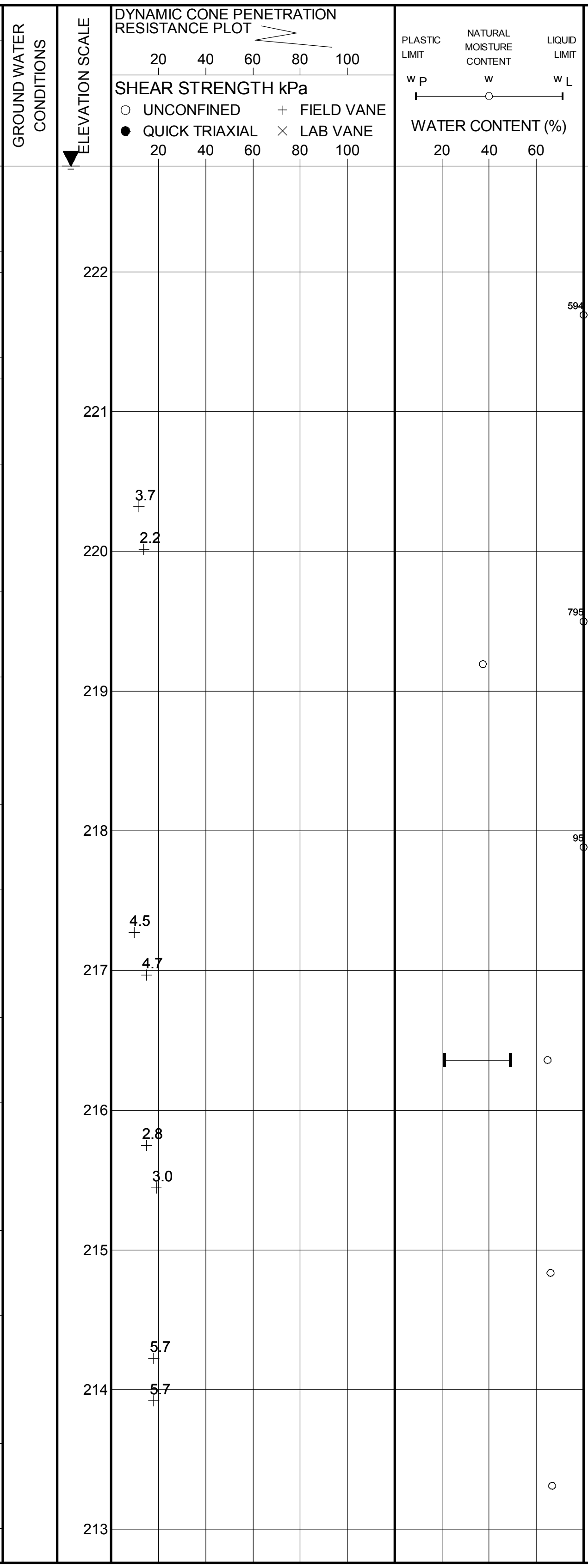
RECORD OF BOREHOLE No 17-42

1 OF 2

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 240.6 E 323 073.7		ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing		COMPILED BY JG
DATUM Geodetic	DATE 23.03.2017 - 23.03.2017		CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.8						
0.0	SNOW / ICE	1	SS	WH		
222.4 0.4	**PEAT**, FIne Fibrous to Amorphous Soft Brown	2	SS	WH		
		1	ST	Push		
219.3		3	SS	1		47.0% organic content
3.5	**Silty SAND** Very Loose Grey					
218.6 4.1	**CLAY (CI)** Very Soft to Firm Grey	4	SS	WH		2.4% organic content
		5	SS	WH		0 0 35 65
		6	SS	WH		
		7	SS	WH		



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+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

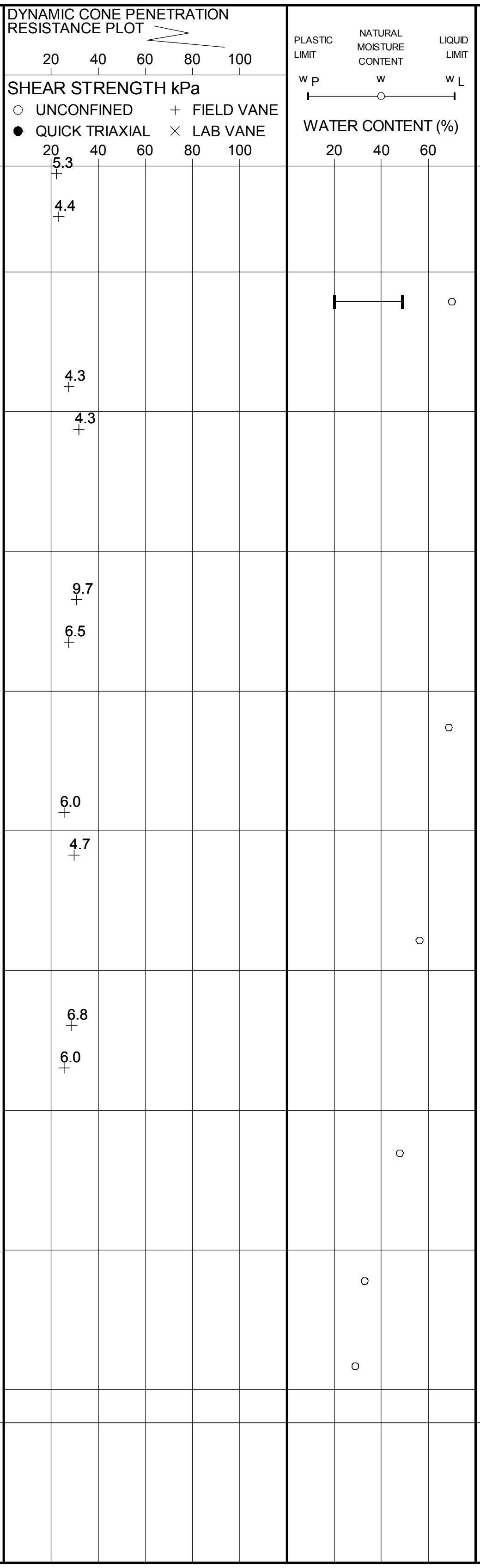
RECORD OF BOREHOLE No 17-42

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 240.6 E 323 073.7
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 23.03.2017 - 23.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
	Continued From Previous Page											
	CLAY (CI) Soft to Firm Grey											
							212					
			8	SS	WH				0	0	37	63
							211					
			2	ST	Push							
							210					
							209					
			9	SS	WH							
							208					
			10	SS	WH							
							207					
							206					
			11	SS	WH							
205.1 17.7	**SILT (ML)** Loose Grey						205					
			12	SS	7				0	0	74	26
			13	SS	9							
							204					
203.8 19.0	End of Borehole on Inferred Bedrock Groundwater at 0.4 m AGS (Elev. 222.8 m) on completion of drilling		14	SS	100/ 0mm							



+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-43

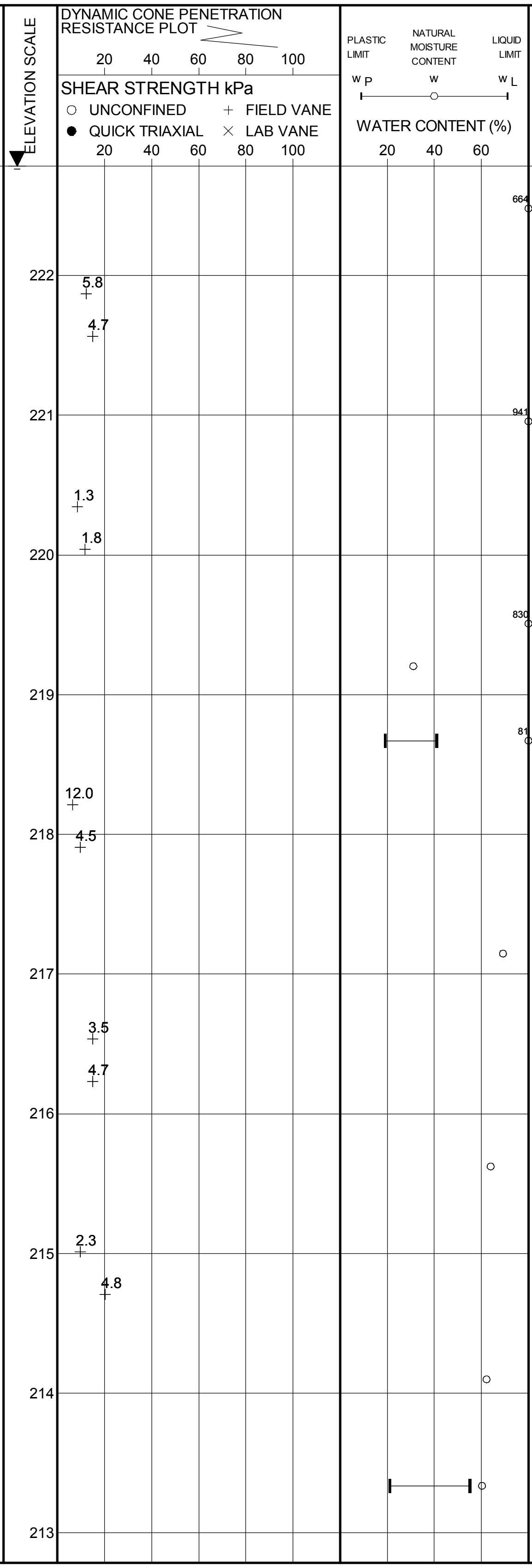
1 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 222.8 E 323 058.6
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 22.03.2017 - 23.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION
222.8	
0.0	**PEAT**, Amorphous to Fine Fibrous Very Soft to Soft Brown
219.3 3.5	**SILT (ML)** Very Loose
219.0 3.8	Grey **CLAY (CI to CH)** Very Soft to Soft Grey

NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	2	664	
2	SS	WH	941	
3	SS	WH	830	
4	SS	WH	81	1 1 45 53
5	SS	WH		
6	SS	WH		
7	SS	WH		
1	ST	Push		OED: e_o = 1.636 C_c = 0.714 C_r = 0.106 0 0 25 75



GROUND WATER CONDITIONS

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-43

2 OF 2

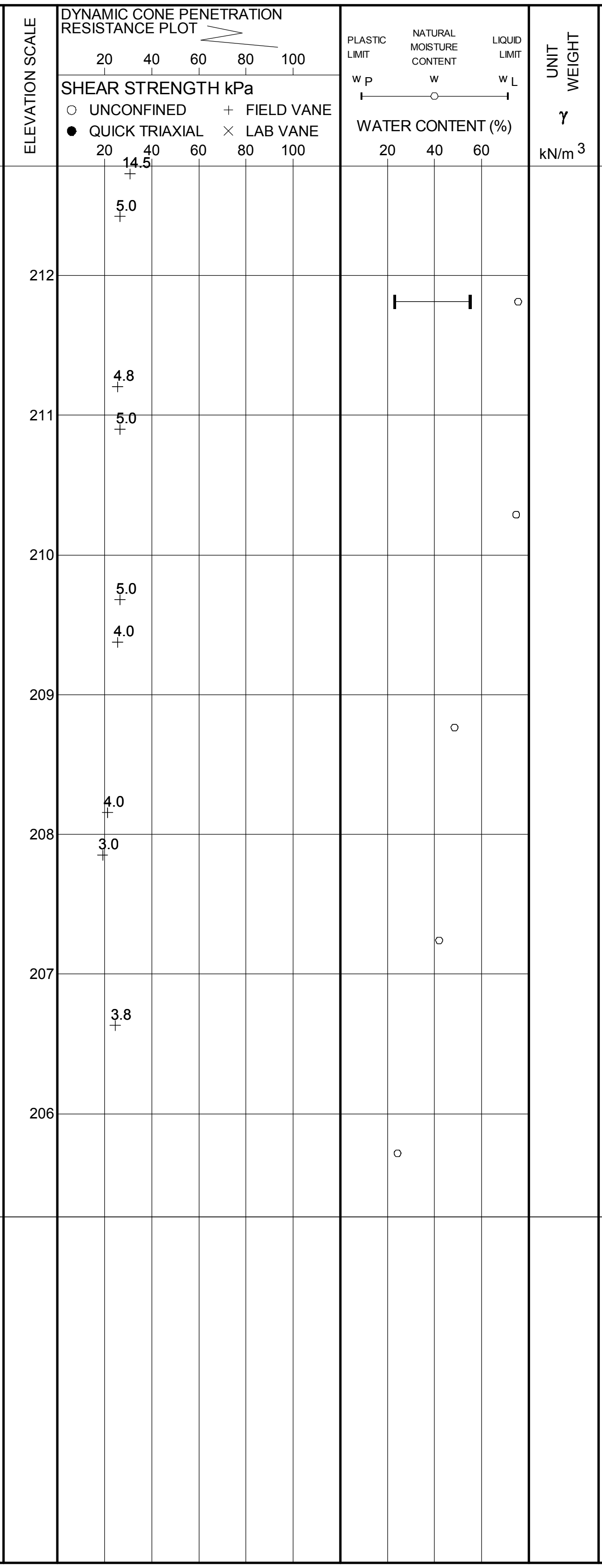
METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 222.8 E 323 058.6	ORIGINATED BY	NW
HWY	537	BOREHOLE TYPE	Portable / NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	22.03.2017 - 23.03.2017	CHECKED BY	SP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
	CLAY (CI to CH) Soft to Firm Grey	▨
206.3 16.5	**SILT (ML)** Loose Grey	▥
205.3 17.5	End of Borehole on Inferred Bedrock Groundwater at surface (Elev. 222.8 m)	

SAMPLE NUMBER	TYPE	"N" VALUES	GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
8	SS	WH	2	0	27	71
9	SS	WH				
10	SS	WH				
11	SS	WH				
12	SS	8	0	3	83	14
13	SS	100/ 0mm				



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-44

1 OF 3

METRIC

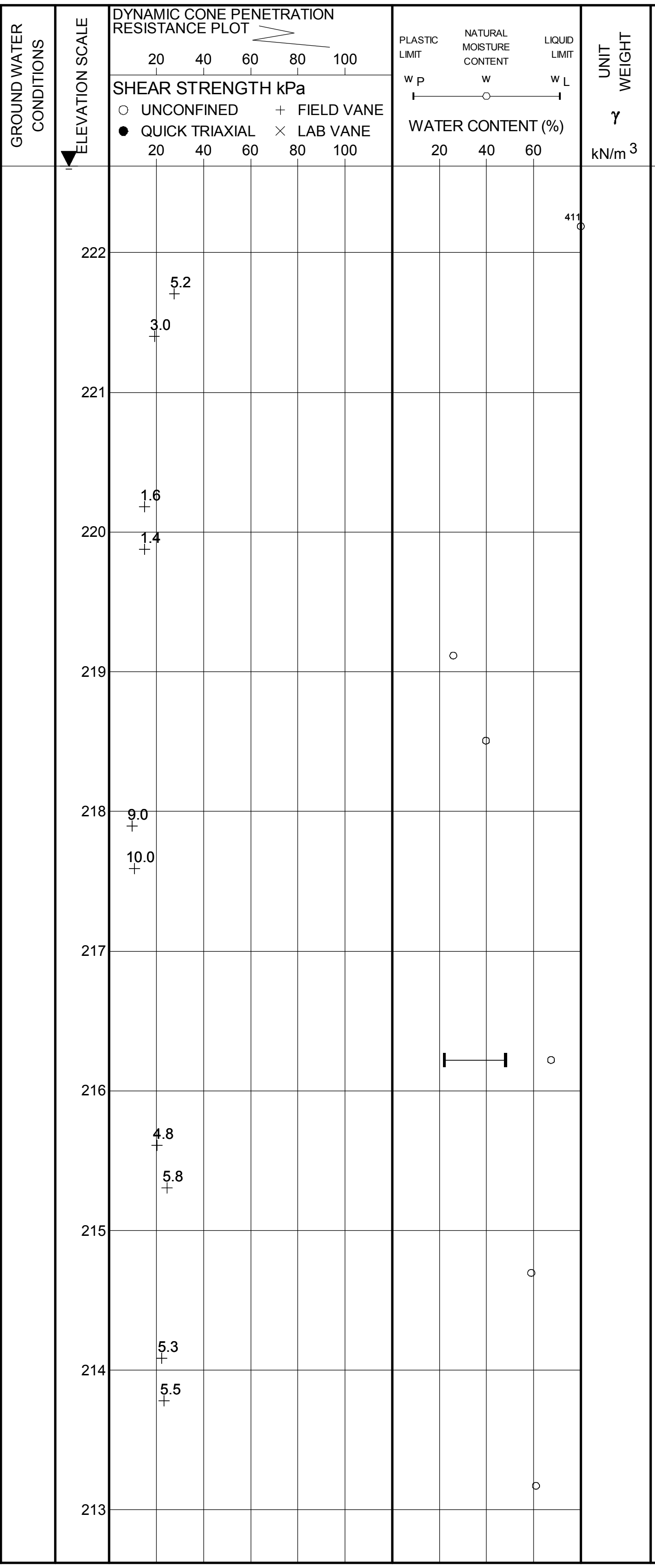
GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 222.1 E 323 092.3	ORIGINATED BY NW
HWY 537	BOREHOLE TYPE Portable / NW Casing	COMPILED BY JG
DATUM Geodetic	DATE 25.03.2017 - 25.03.2017	CHECKED BY SP

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
222.6	
0.0	Snow / Ice
222.4 0.3	**PEAT**, Fine Fibrous to Amorphous Very Soft Brown
219.3 3.4	**SILT (ML)** Very Loose Grey
218.8 3.8	**CLAY (CI to CH)** Very Soft to Soft Grey

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	WH				
2	SS	WH				
3	SS	WH				
4	SS	WH				
1	ST	WH				
5	SS	WH	0	0	39	61
6	SS	WH				
7	SS	WH				



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 17-44

2 OF 3

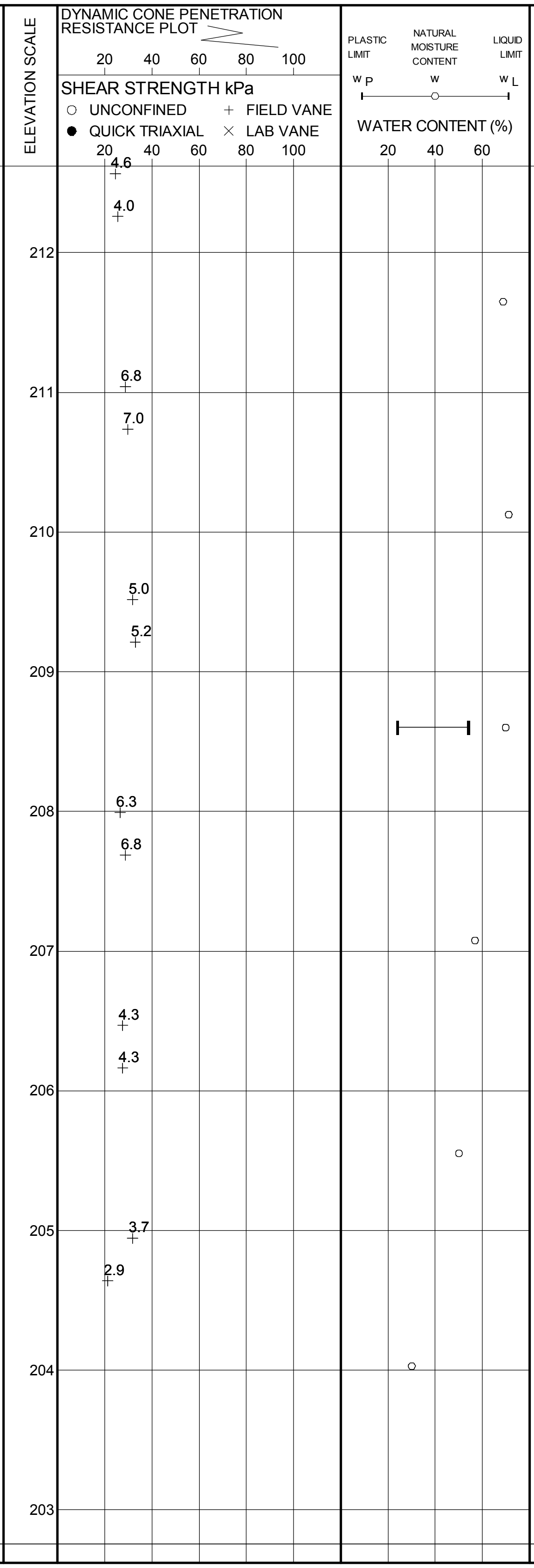
METRIC

GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 222.1 E 323 092.3	ORIGINATED BY	NW
HWY	537	BOREHOLE TYPE	Portable / NW Casing	COMPILED BY	JG
DATUM	Geodetic	DATE	25.03.2017 - 25.03.2017	CHECKED BY	SP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	CLAY (CI to CH) Soft to Firm Grey	▨							
			8	SS	WH				
			9	SS	WH				
			10	SS	WH	0	0	35	65
			11	SS	WH				
			12	SS	WH				
204.3 18.3	**SILT (ML)** Very Loose Grey		13	SS	WH	0	0	77	23
202.8 19.9			14	SS	100/0mm				

Continued Next Page



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-44

3 OF 3

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 222.1 E 323 092.3
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 25.03.2017 - 25.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	End of Borehole on Inferred Bedrock Groundwater at 0.3 m AGS (Elev. 222.6 m) on completion of drilling										

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ◐ 5 / 10 (%) STRAIN AT FAILURE

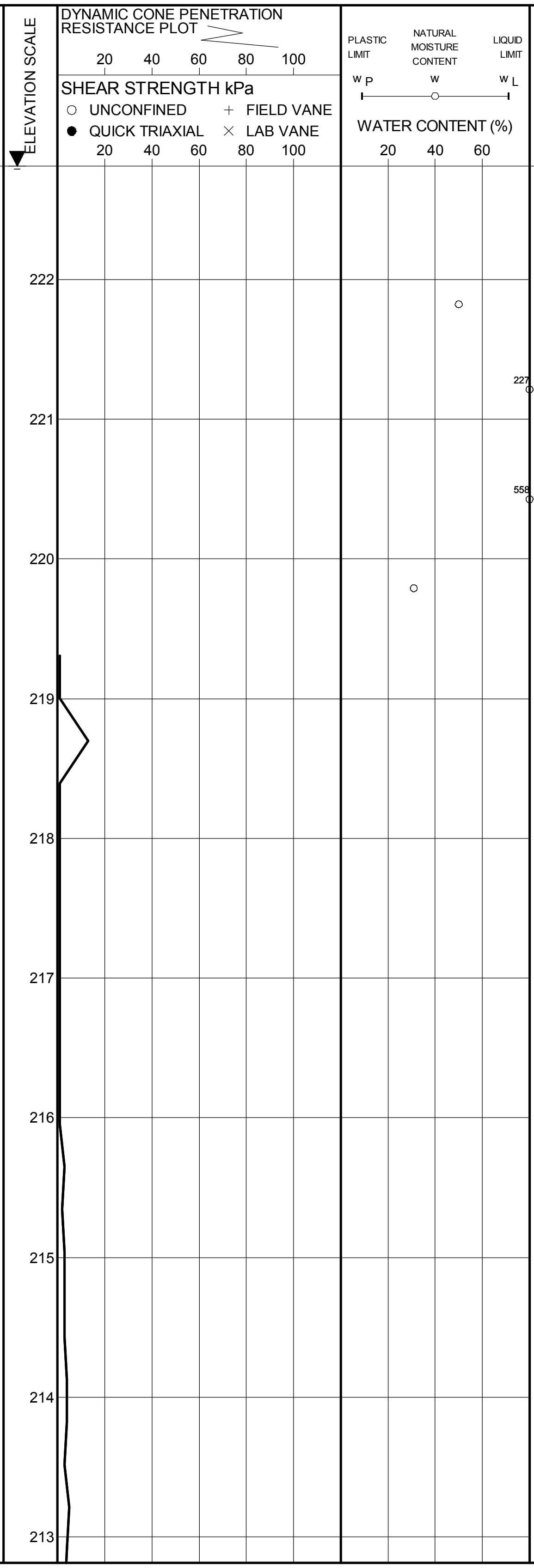
RECORD OF BOREHOLE No 17-45

1 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 201.5 E 323 085.4
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 21.07.2017 - 22.07.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.8						
0.0	**WATER**					
222.1 0.7	SAND with Gravel and Organics **FILL** Very Loose Black	1	SS	WH		
		2	SS	1		
220.9 1.9	**PEAT**, Fine Fibrous Very Soft Dark Brown					organic content 18.6%
		3	SS	WH		
220.1 2.7	**SILT** with Clay seams Loose Grey	4	SS	4		0 0 90 10 non-plastic
219.5 3.3	End of Sampled Borehole DCPT from 3.4 m to 18.7 m **INFERRED CLAY**					



UNIT WEIGHT γ kN/m3

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

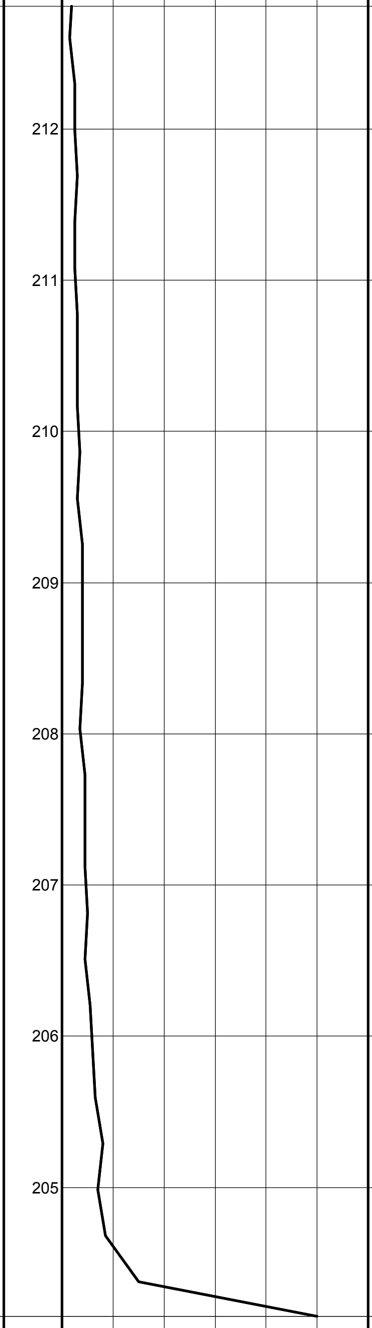
RECORD OF BOREHOLE No 17-45

2 OF 2

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 201.5 E 323 085.4
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable Raft / NW Casing
COMPILED BY CM
DATUM Geodetic
DATE 21.07.2017 - 22.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ^{3}	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	INFERRED CLAY										
205.3 17.5	**INFERRED SILT**										
204.1 18.7	End of DCPT on Inferred Bedrock Groundwater at surface (Elev. 222.8 m) on completion of drilling										



+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

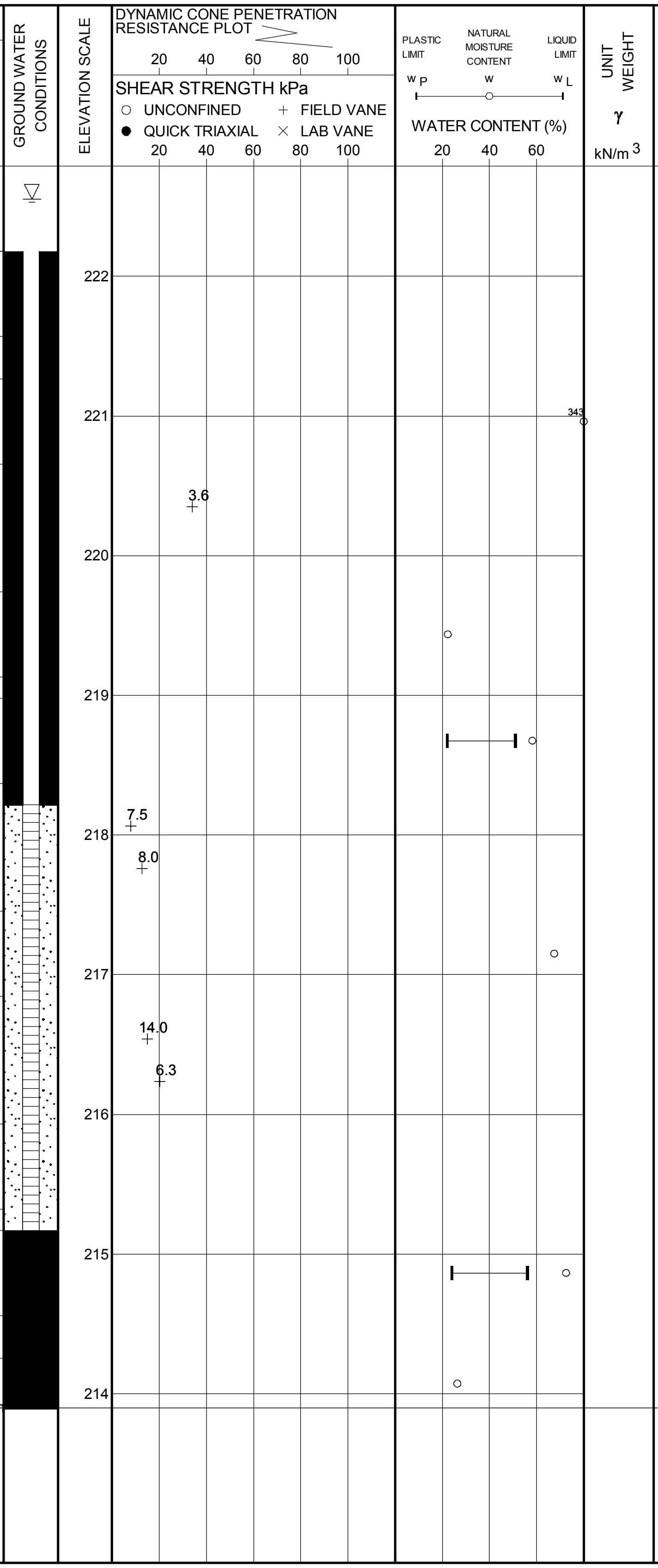
RECORD OF BOREHOLE No 17-46

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 194.4 E 323 116.0
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 21.03.2017 - 21.03.2017
CHECKED BY SP

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
222.8								
0.0	Ice / Snow	1	SS	6				
222.2 0.6	SAND with Gravel **FILL** Loose Brown	2	SS	2				
221.3 1.5	**PEAT**, Fine Fibrous Firm Brown	3	SS	2				
220.2 2.6	**SILT (ML)** Loose Grey	4	SS	9	0	4	86	10
219.0 3.8	**CLAY (CH)** Very Soft to Soft Grey	5	SS	1	0	0	37	63
		6	SS	WH				
		7	ST	Push				
		8	SS	WH	0	0	29	71
214.3 8.5	**SILT (ML)** with Gravel Soft Grey	9	SS	100/ 200mm				
213.9 8.9	End of Borehole on Inferred Bedrock Groundwater at Elev. 222.6 m on 30/03/2017 Groundwater at Elev. 222.3 m on 12/06/2017							



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

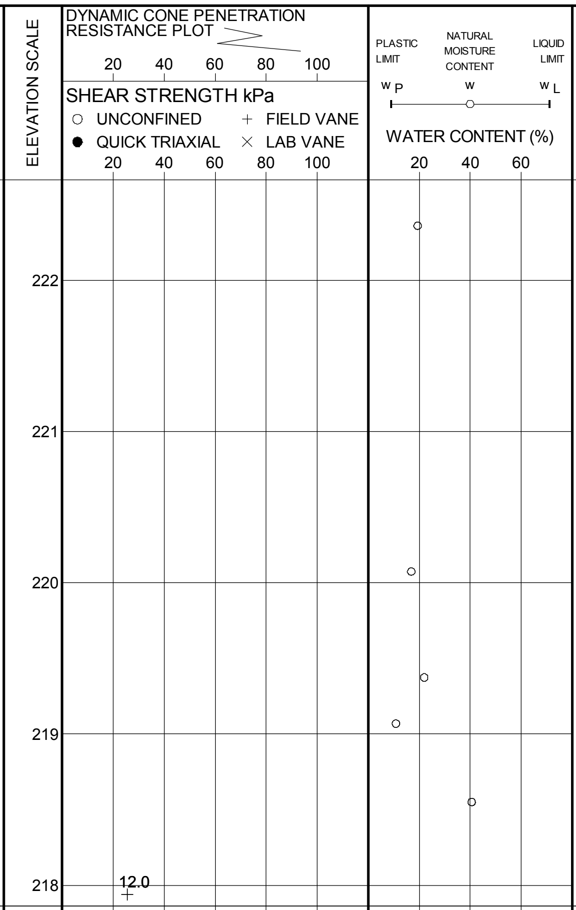
THURBER

RECORD OF BOREHOLE No 17-47

1 OF 1 **METRIC**

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 184.9 E 323 097.6
ORIGINATED BY NW
HWY 537
BOREHOLE TYPE Portable / NW Casing
COMPILED BY JG
DATUM Geodetic
DATE 22.03.2017 - 22.03.2017
CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
222.7 0.0	SAND with Gravel **FILL** Loose Grey		1	SS	5						
			2	SS	8						
221.1 1.5	**PEAT**, FIne Fibrous Very Soft Brown		3	SS	3						
220.4 2.3	**Sandy SILT**, trace Gravel Loose to Very Loose Grey		4	SS	6			6	32	55	7
			5	SS	2						
219.1 3.5	**CLAY**, trace Gravel Firm Grey		6	SS	3						
217.9 4.8	End of Borehole on Inferred Bedrock										



+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

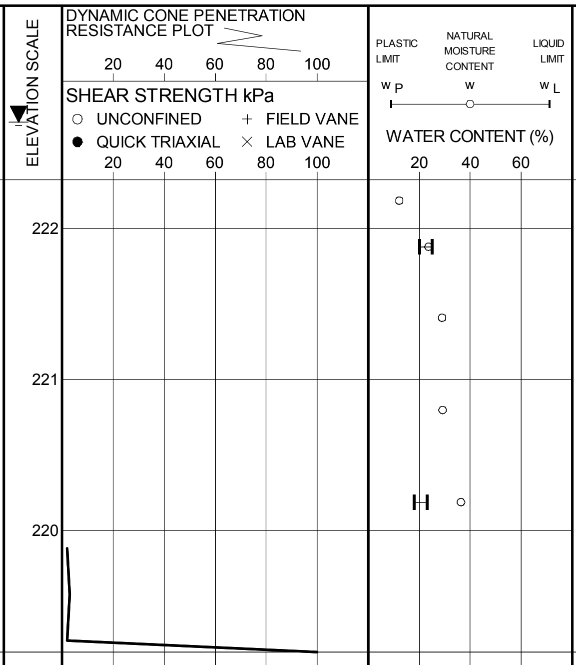
RECORD OF BOREHOLE No 17-48

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 152.6 E 323 158.0
ORIGINATED BY KE
HWY 537
BOREHOLE TYPE Portable
COMPILED BY CM
DATUM Geodetic
DATE 22.07.2017 - 22.07.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES				REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
222.3										
0.0 222.0 0.3	GRAVEL with Sand, Organics near surface, Occasional Cobbles and Boulders **FILL** Compact Brown		1	SS	12					
	SILT Compact Grey		2	SS	16		0	7	71	22
220.5			3	SS	6					
1.8	**CLAY** Firm Grey		4	SS	7		0	1	76	23
219.9 2.4	End of Sampled Borehole DCPT from 2.4 m to 3.1 m **INFERRED CLAY**									
219.2 3.1	End of DCPT on Inferred Bedrock Groundwater at 0.4 m AGS (Elev. 222.7 m) on completion of drilling									



UNIT WEIGHT γ kN/m^3

+^{3}, ×^{3}: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 17-49

1 OF 1 **METRIC**

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 152.9 E 323 129.2		ORIGINATED BY KE
HWY 537	BOREHOLE TYPE Portable		COMPILED BY CM
DATUM Geodetic	DATE 22.07.2017 - 22.07.2017		CHECKED BY SP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	GR	SA	SI	CL
222.8							▼							
0.0	**SAND with Gravel FILL** Compact Greyish Brown		1	SS	10				○					
221.9			2	SS	100/ 175mm		222		○					
221.8 0.8	**SILT** Loose Grey								├○		0	11	68	21
0.9														
	End of Borehole Groundwater at 0.1 m AGS (Elev. 222.9 m) on completion of drilling													

REMARKS & GRAIN SIZE DISTRIBUTION (%)

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$\overset{20}{15 \oplus 5}$ 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

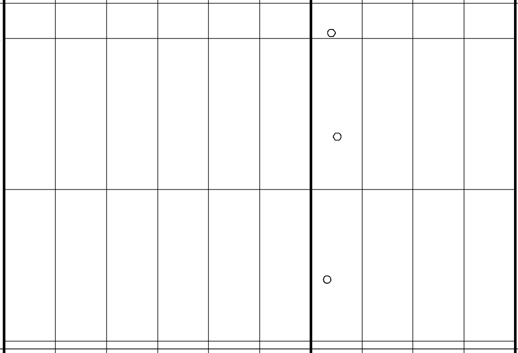
RECORD OF BOREHOLE No CPT1

1 OF 1

METRIC

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 196.3 E 323 104.2
ORIGINATED BY CM
HWY 537
BOREHOLE TYPE HSA / CPT
COMPILED BY JG
DATUM Geodetic
DATE 03.03.2017 - 03.03.2017
CHECKED BY SP

SOIL PROFILE			SAMPLES								REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
223.2														
0.0 0.1	**60mm ASPHALT**													
	SAND with Silt and Gravel **FILL** *Frozen* Brown		1	SS	100/ 75 mm		223							
			2	SS	100/ 275 mm		222							
	- Frost depth 1.4 m		3	SS	13						37	58	5 (SI+CL)	
220.9 2.3	End of Pre-Augered CPT Hole						221							



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

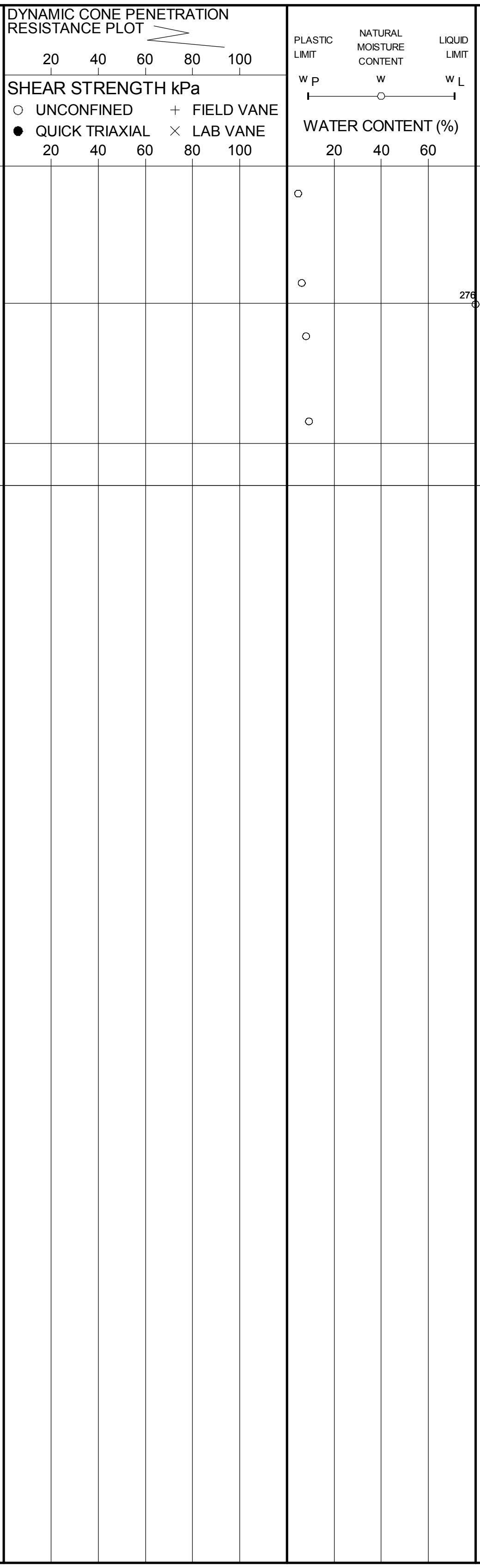
RECORD OF BOREHOLE No CPT2

1 OF 1

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 228.9 E 323 064.0		ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / CPT		COMPILED BY JG
DATUM Geodetic	DATE 04.03.2017 - 04.03.2017		CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES				GR	SA	SI	CL
223.0 0.0 0.1	**60mm ASPHALT**										
	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 75 mm							
222.1 0.9	150 mm Wood Log **FILL**										
221.9 1.1	SAND with Silt and Gravel **FILL** *Frozen* to Dense Brown - Frost depth 1.5 m	2	SS	72		222					
		3	SS	42		221		18	73	9 (SI+CL)	
220.7 2.3	End of Pre-Augered CPT Hole										



+ 3, × 3: Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

ONTMT4S 14967 - HWY 537 JUMBO CREEK.GPJ 2012TEMPLATE(MTO).GDT 20/2/18

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CPT3

1 OF 1

METRIC

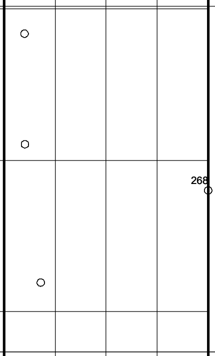
GWP#	5134-14-00	LOCATION	Hwy 537 - Jumbo Creek, MTM z12: N 5 143 260.9 E 323 025.7	ORIGINATED BY	JM
HWY	537	BOREHOLE TYPE	HSA / CPT	COMPILED BY	JG
DATUM	Geodetic	DATE	06.03.2017 - 06.03.2017	CHECKED BY	SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES						GR	SA	SI	CL
223.0													
0.0 0.1	**60mm ASPHALT**												
	SAND with Silt and Gravel **FILL** *Frozen* Brown	1	SS	100/ 75 mm									
		2	SS	51		222				40	51	9 (SI+CL)	
222.0 1.1	- Tarpaulin at 1.07 m							268					
221.6 1.4	Sawdust **FILL** *Frozen* Brown				▼								
	SAND with Gravel **FILL** *Frozen* to Compact Brown	3	SS	10		221							
220.7 2.3	- Frost depth 1.5 m End of Pre-Augered CPT Hole Groundwater at 1.5 m BGS (Elev. 221.5 m) on completion of drilling												

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L



+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

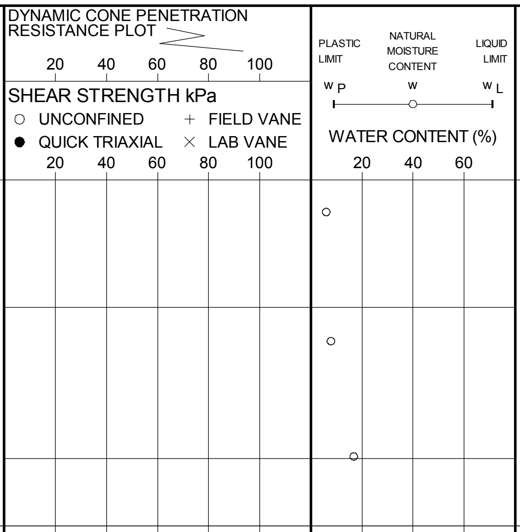
THURBER

RECORD OF BOREHOLE No CPT4

1 OF 1 **METRIC**

GWP# 5134-14-00
LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 274.2 E 322 976.7
ORIGINATED BY JM
HWY 537
BOREHOLE TYPE HSA / CPT
COMPILED BY JG
DATUM Geodetic
DATE 04.03.2017 - 04.03.2017
CHECKED BY SP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
222.8												
0.0 0.1	**60mm ASPHALT**											
	SAND with Gravel **FILL** *Frozen* Brown		1	SS	100/ 125 mm							
			2	SS	100/ 200 mm		222		32	59	9 (SI+CL)	
	- Frost depth 1.5 m											
	- Some wood		3	SS	33		221					
220.6 2.3	End of Pre-Augered CPT Hole											



REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CPT5

1 OF 1

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 286.5 E 322 927.8		ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / CPT		COMPILED BY JG
DATUM Geodetic	DATE 05.03.2017 - 05.03.2017		CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT wP — NATURAL MOISTURE CONTENT w — LIQUID LIMIT wL / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.9											
0.0	**60mm ASPHALT**										
0.1	SAND with Gravel **FILL** *Frozen* Brown		1	SS	100/ 50 mm				○		
222.1 0.8	Sawdust **FILL** Tarpaulin at top and bottom of layer Compact Brown		2	SS	22		222		183		
									211		
221.3 1.7	SAND with Gravel **FILL** Compact Brown		3	SS	22		221		○		
220.6 2.3	End of Pre-Augered CPT Hole										

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CPT6

1 OF 1

METRIC

GWP# 5134-14-00	LOCATION Hwy 537 - Jumbo Creek, MTM z12: N 5 143 292.7 E 322 828.4	ORIGINATED BY JM
HWY 537	BOREHOLE TYPE HSA / CPT	COMPILED BY JG
DATUM Geodetic	DATE 06.03.2017 - 06.03.2017	CHECKED BY SP

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
222.9								
0.0 0.1	**60mm ASPHALT**							
	SAND with Gravel **FILL** *Frozen* Brown	1	SS	100/ 200 mm				
		2	SS	100/ 200 mm		222		19 70 11 (SI+CL)
	- Diesel odour - Frost depth 1.5 m				▼			
220.9 2.0		3	SS	8		221		
220.6 2.3	Sawdust **FILL** Loose Brown						101	
	End of Pre-Augered CPT Hole Groundwater at 1.5 m BGS (Elev. 221.6 m) on completion of drilling							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

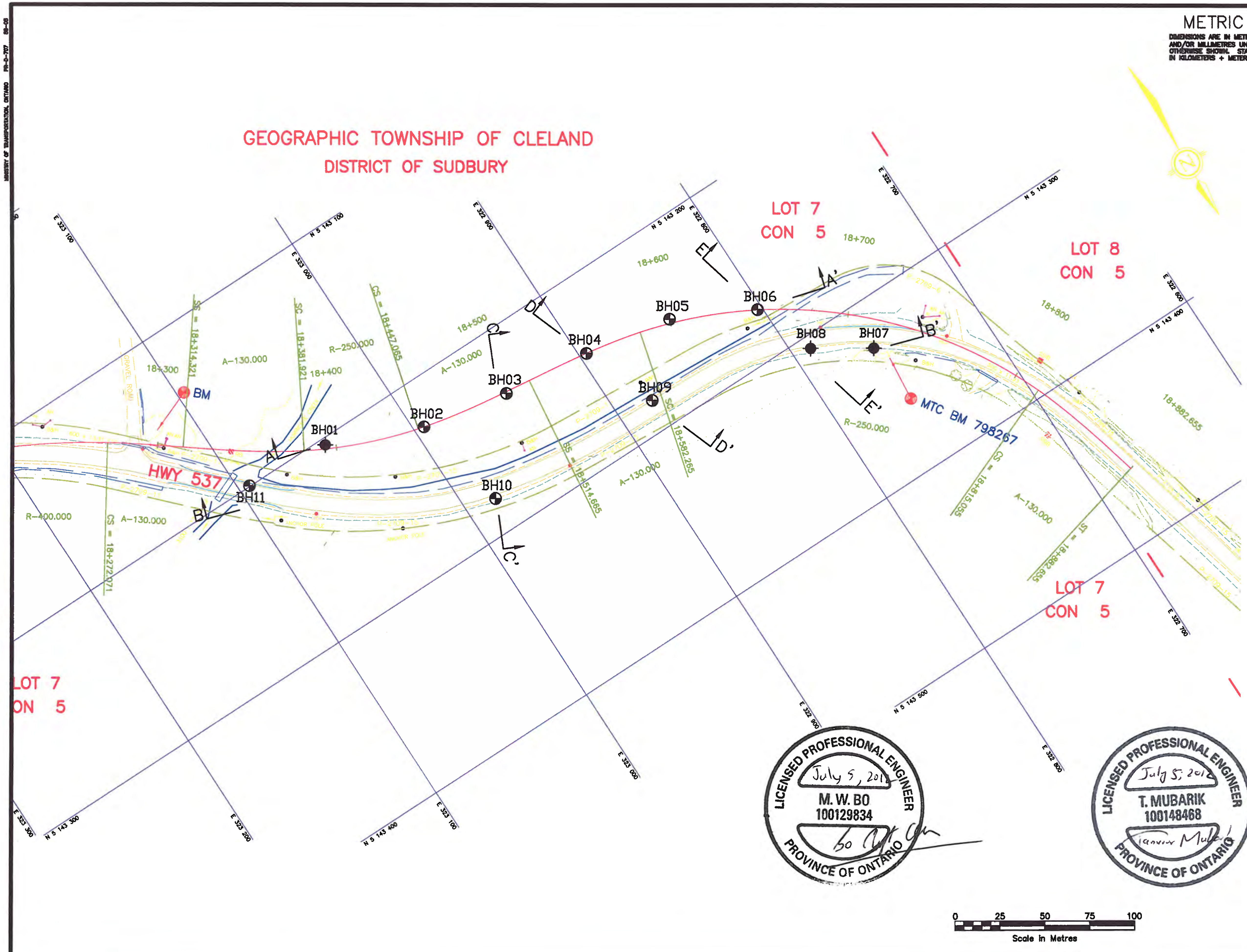
+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Appendix B.2

Geocres No.: 41I00-286

MINISTRY OF TRANSPORTATION, ONTARIO PH–D–707 08–05



LICENSED PROFESSIONAL ENGINEER
July 5, 2012
M. W. BO
100129834
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
July 5, 2012
T. MUBARIK
100148468
Tanvir Mubarik
PROVINCE OF ONTARIO

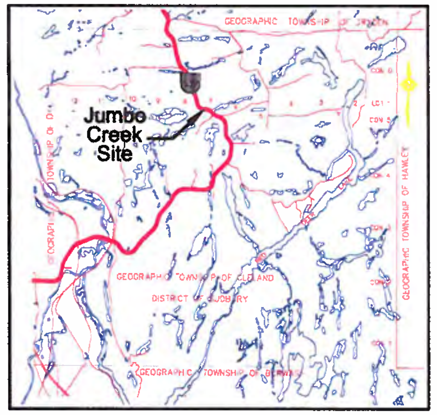
0 25 50 75 100
Scale in Metres

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLES OTHERWISE SHOWN. STATIONS IN KILOMETERS + METERS

CONT No
GWP No 5279–03–00
WP No
Site No
GeoCres No 421–286

SHEET

ROAD ALIGNMENT
AT JUMBO CREEK
Hwy 537 – Cleland Twp.
Borehole Locations



KEY PLAN
0 8
SCALE IN KILOMETRES

LEGEND

◈	Borehole/Hand Auger
◕	Borehole with DCPT
⊕	Dynamic Cone Penetration Test (DCPT)
●	Rock Probe
'N'	Blows/0.3m (Std. Pen Test, 475 J/Blow)
▼	Water level at time of investigation.
⊕	Benchmark
☒	Fill
▨	Organics
▨	Topsoil
▨	Till
▨	Bedrock
▨	Sand
▥	Silt
▨	Clay
▨	Sand & Gravel
▨	Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	221.761	5141673	518228	18+412	2.2 m LT
BH2	221.841	5141686	518187	18+450	CL
BH3	221.936	5141694	518138	18+500	0.9 m RT
BH4	221.970	5141699	518090	18+550	CL
BH5	221.889	5141712	518046	18+600	2.3 m LT
BH6	221.815	5141731	517998	18+650	CL
BH7	225.300	5141762	517947	18+715	3.0 m RT
BH8	222.806	5141762	517982	18+675	4.0 m RT
BH9	221.832	5141738	518087	18+575	4.0 m LT
BH10	221.974	5141731	518189	18+475	4.8 m RT
BH11	222.130	5141652	518293	18+350	3.0 m LT

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

DST
consulting engineers

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Thunder Bay, ON P7B 5V5
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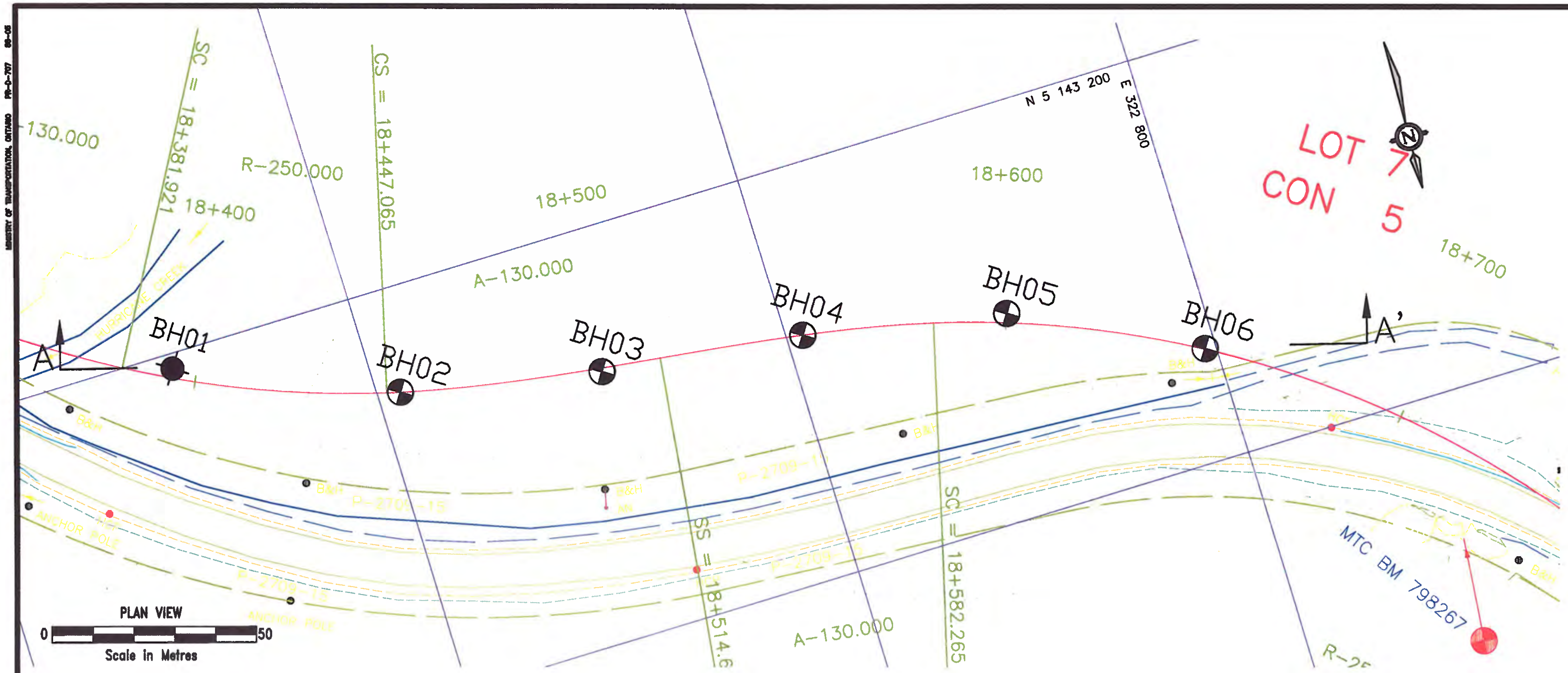
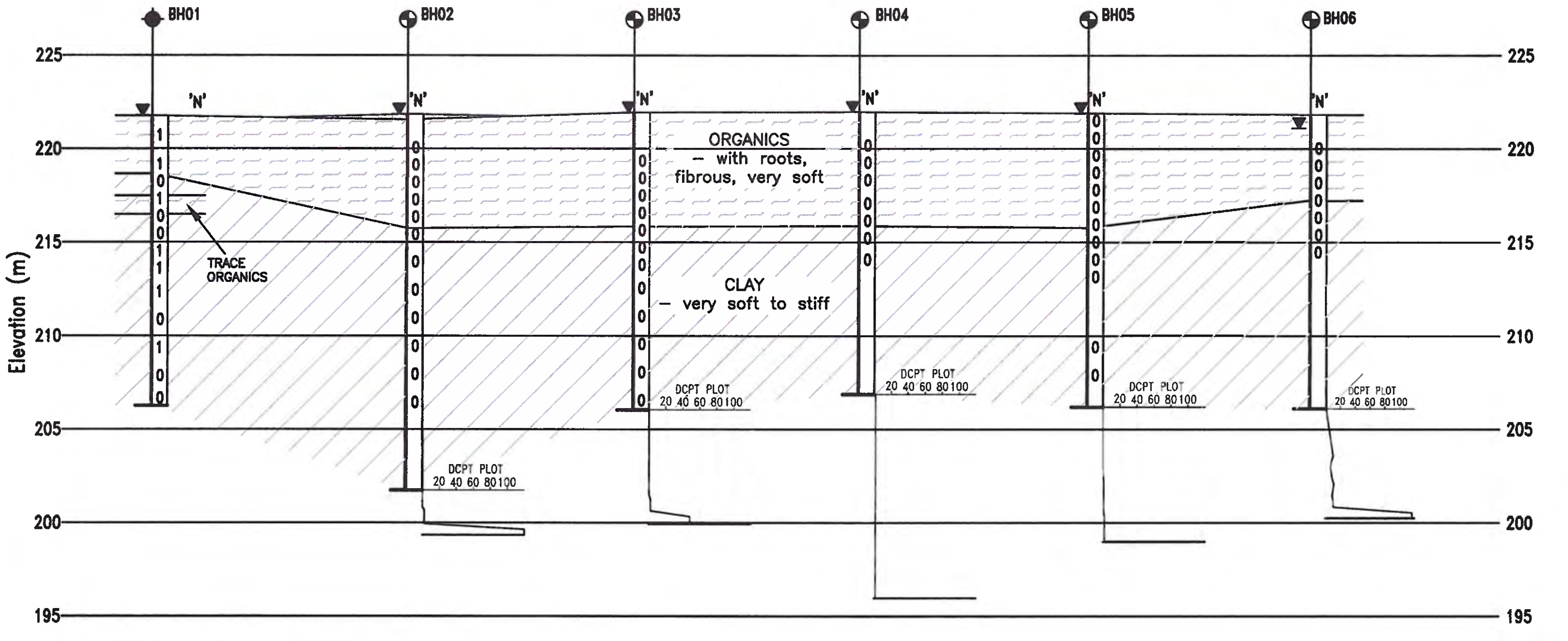
Email: thunderbay@dstgroup.com

DRAWING 1



PROFILE ALONG THE PROPOSED ALIGNMENT

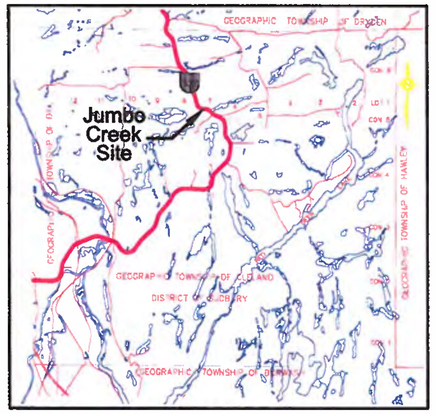


METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLES OTHERWISE SHOWN. STATIONS IN KILOMETERS + METERS

CONT No
GWP No 5279–03–00
WP No
Site No
GeoCres No 421–286

PROPOSED ROAD ALIGNMENT
AT JUMBO CREEK
Hwy 537 – Cleland Twp.
Borehole Locations & Soil Strata

SHEET



KEY PLAN
0 8
SCALE IN KILOMETRES

LEGEND

- ⯁ Borehole/Hand Auger
- ⊕ Borehole with DCPT
- ⌖ Dynamic Cone Penetration Test (DCPT)
- ● Rock Probe
- 'N' Blows/0.3m (Std. Pen Test, 475 J/Blow)
- ▼ Water level at time of investigation.
- ⊕ Benchmark

☒	Fill	▦	Sand
▤	Organics	▥	Silt
≋	Topsoil	▨	Clay
▩	Till	⁘	Sand & Gravel
▧	Bedrock	⬬	Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	221.761	5141673	518228	18+412	2.2 m LT
BH2	221.841	5141686	518187	18+450	CL
BH3	221.936	5141694	518136	18+500	0.9 m RT
BH4	221.970	5141699	518090	18+550	CL
BH5	221.889	5141712	518046	18+600	2.3 m LT
BH6	221.815	5141731	517998	18+650	CL
BH7	225.300	5141762	517947	18+715	3.0 m RT
BH8	222.606	5141762	517982	18+675	4.0 m RT
BH9	221.832	5141736	518087	18+575	4.0 m LT
BH10	221.974	5141731	518189	18+475	4.8 m RT
BH11	222.130	5141652	518293	18+350	3.0 m LT

LICENSED PROFESSIONAL ENGINEER
July 5, 2012
M. W. BO
100129834
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
July 5, 2012
T. MUBARIK
100148468
PROVINCE OF ONTARIO

Vertical Scale in Metres
0 5
Horizontal Scale in Metres
0 25

NOTE:
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DRAWING 2

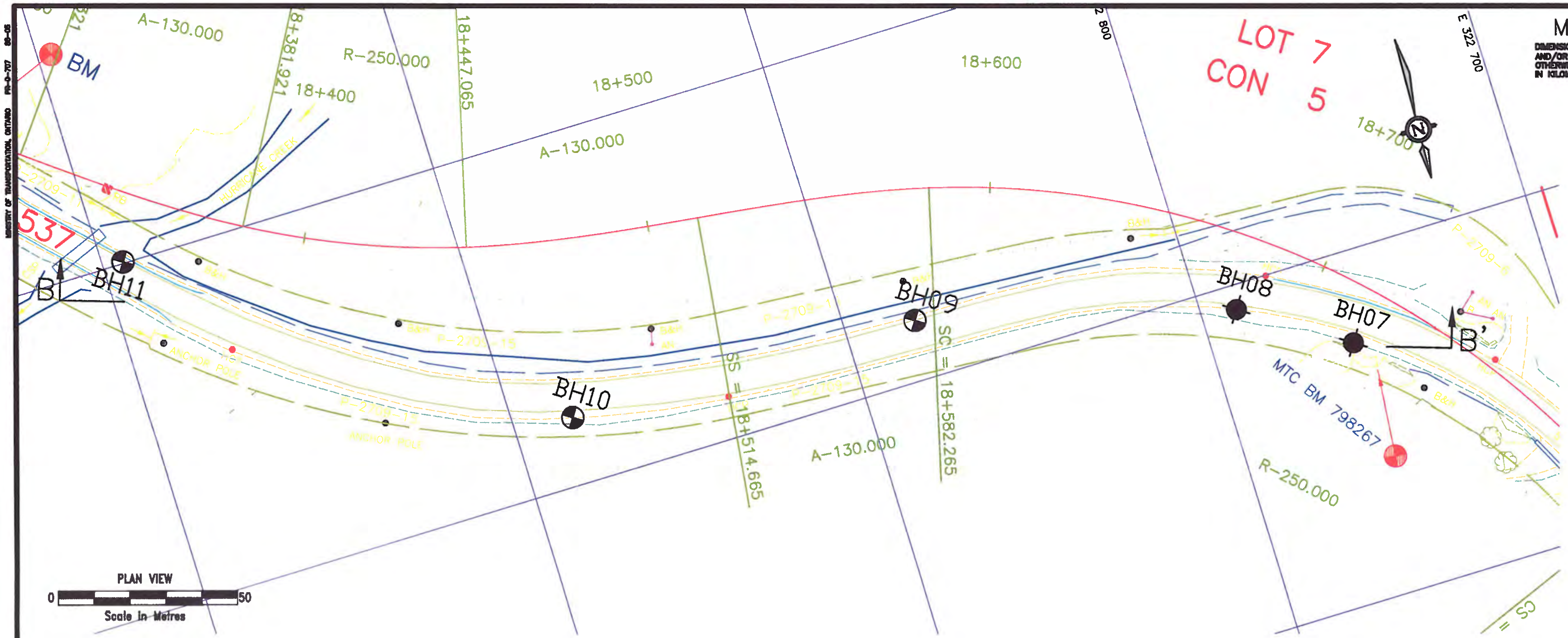
MINISTRY OF TRANSPORTATION, ONTARIO PH-D-707 89-05

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METERS

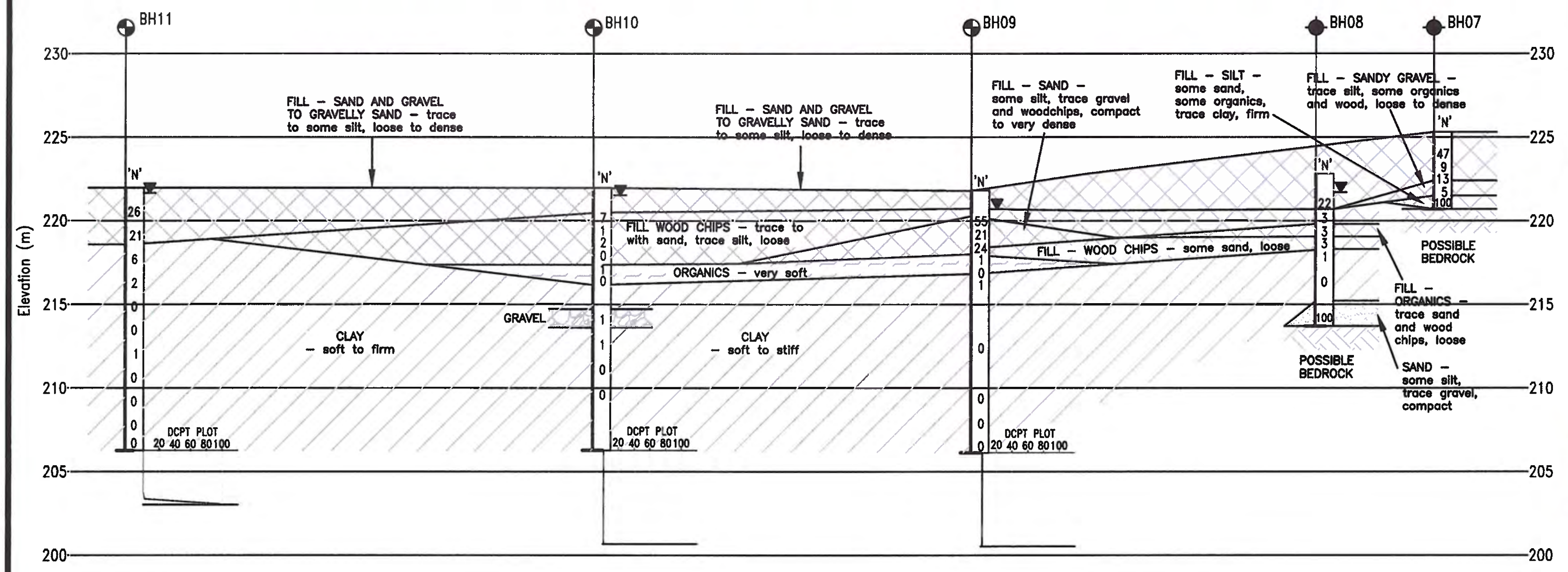
CONT	No
GWP	No 5279–03–00
WP	No
Site	No
GeoCres	No 42I–286

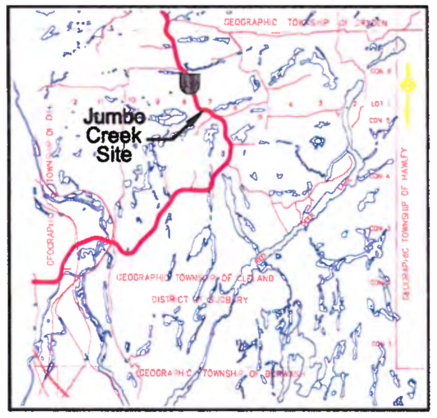
EXISTING ROAD ALIGNMENT
AT JUMBO CREEK
Hwy 537 – Cleland Twp.
Borehole Locations & Soil Strata

SHEET



PROFILE ALONG THE EXISTING ALIGNMENT





KEY PLAN
0 8
SCALE IN KILOMETRES

LEGEND

- ⯁ Borehole/Hand Auger
- ◒ Borehole with DCPT
- ⌖ Dynamic Cone Penetration Test (DCPT)
- ● Rock Probe
- 'N' Blows/0.3m (Std. Pen Test, 475 J/Blow)
- ▼ Water level at time of investigation.
- ⊕ Benchmark

☒	Fill	▨	Sand
▨	Organics	▥	Silt
▤	Topsoil	▧	Clay
▩	Till	▨	Sand & Gravel
▨	Bedrock	▨	Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	221.761	5141673	518228	18+412	2.2 m LT
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BH9	221.832	5141738	518087	18+575	4.0 m LT
BH10	221.974	5141731	518169	18+475	4.8 m RT
BH11	222.130	5141652	518293	18+350	3.0 m LT

Vertical Scale in Metres
0 5
Horizontal Scale in Metres
0 25

July 5, 2012
M. W. BO
100129834

July 5, 2012
T. MUBARIK
100148468

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.

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DRAWING 3

Appendix C.

Laboratory Testing

Appendix C.1

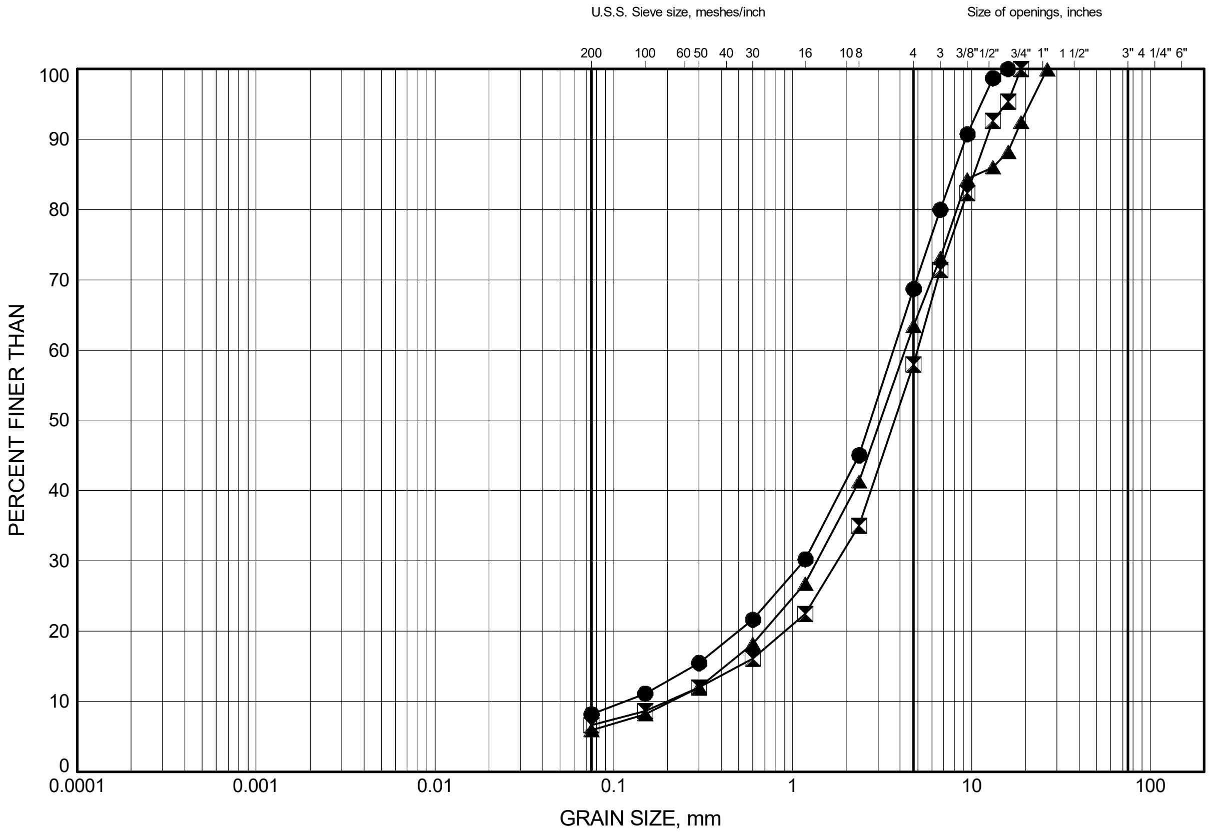
Particle Size Analysis Figures

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C1

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	0.85	222.42
⧗	17-05	0.85	222.46
▲	CPT1	1.83	221.41

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

Chkd. SP

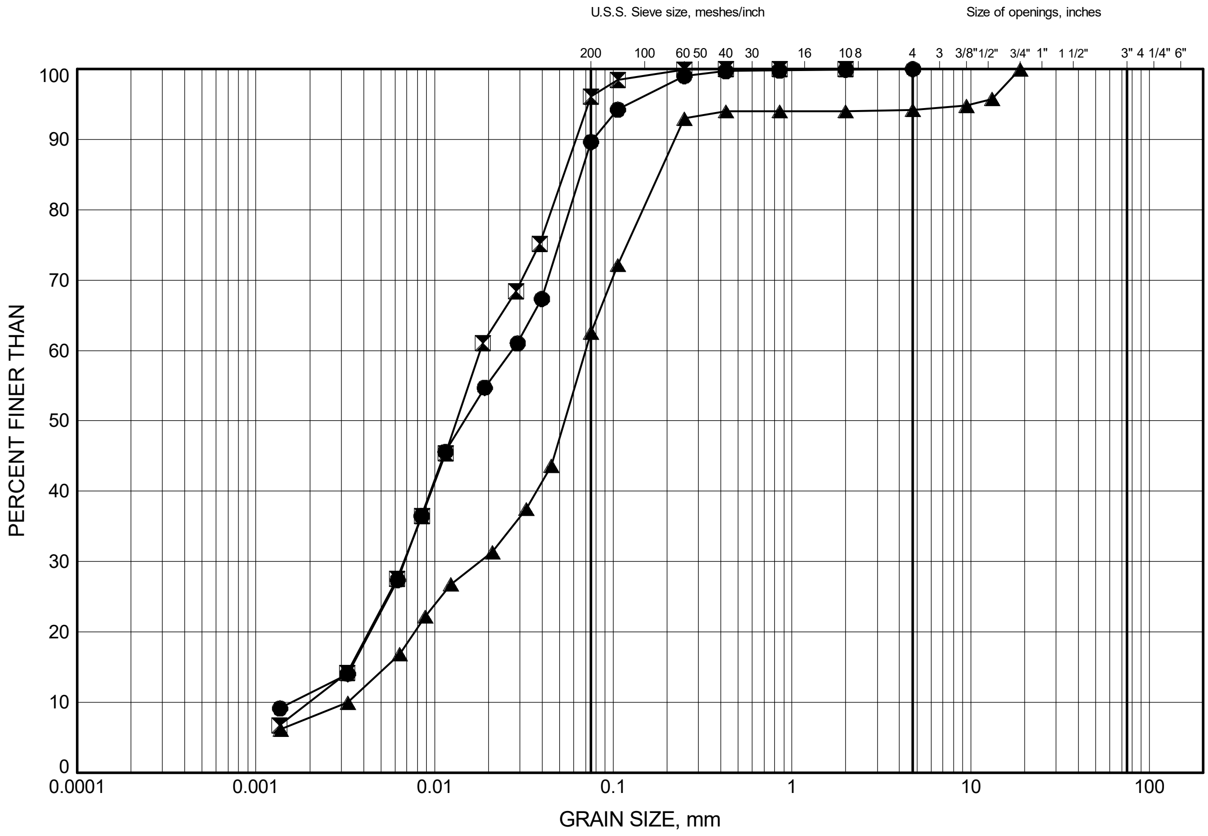
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C2

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	4.11	219.20
⧗	17-46	3.35	219.44
▲	17-47	2.59	220.07

Date October 2017

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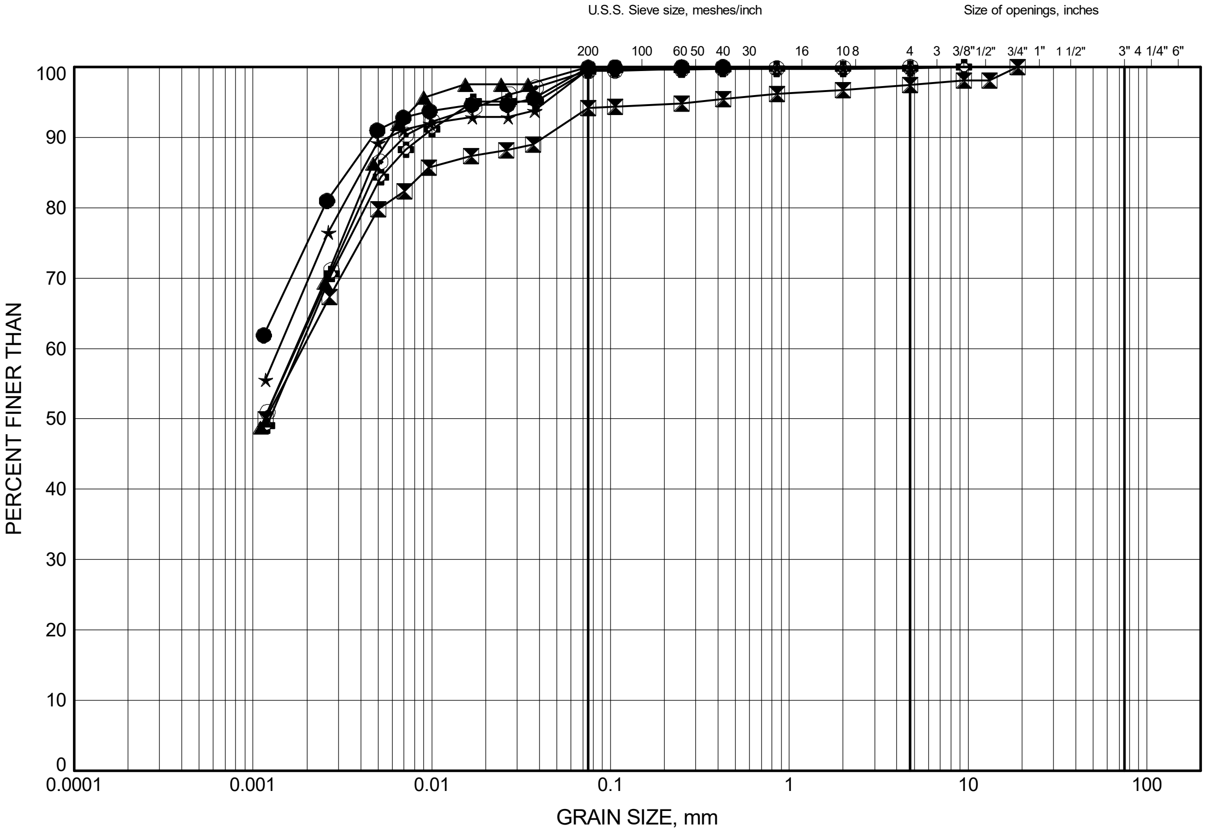
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C3

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	9.45	213.83
⧗	17-05	4.88	218.43
▲	17-05	6.40	216.91
★	17-05	7.92	215.39
☉	17-05	10.97	212.34
✤	17-46	4.11	218.68

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

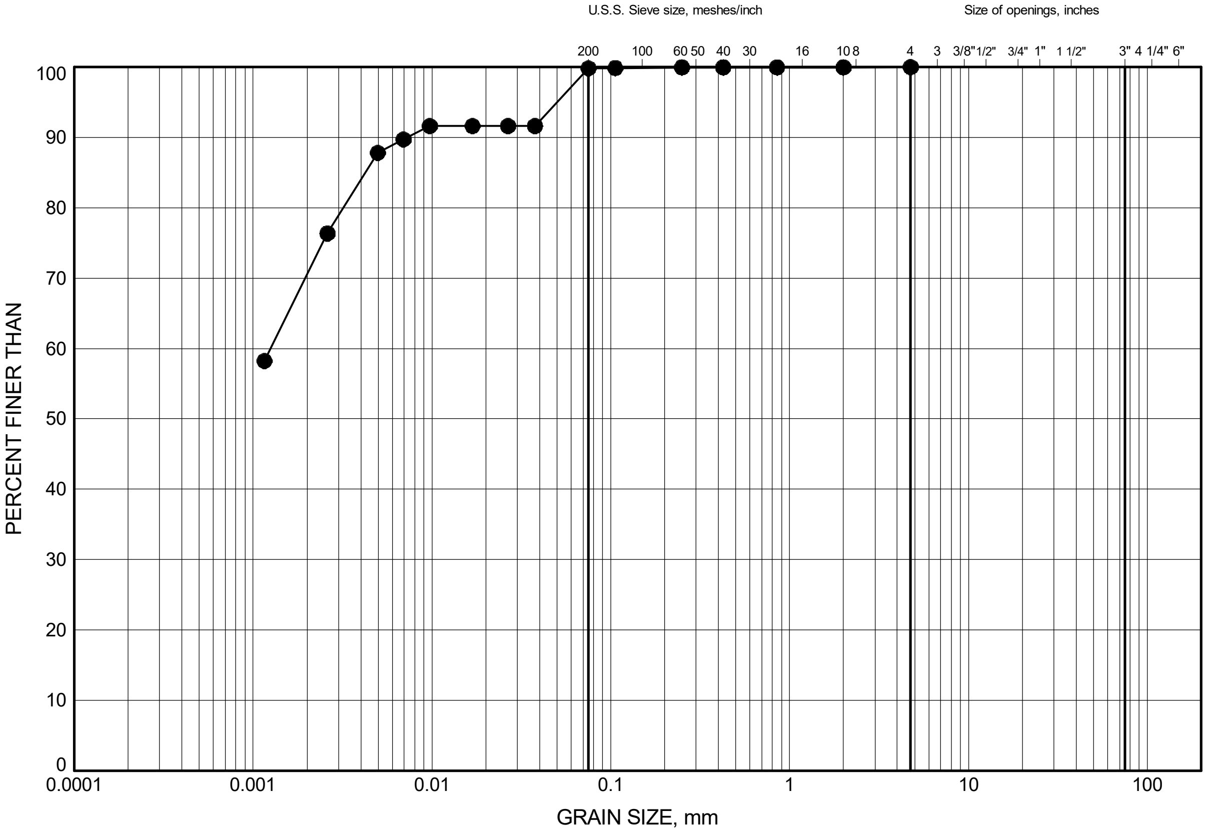
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C4

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-46	7.92	214.87

Date October 2017

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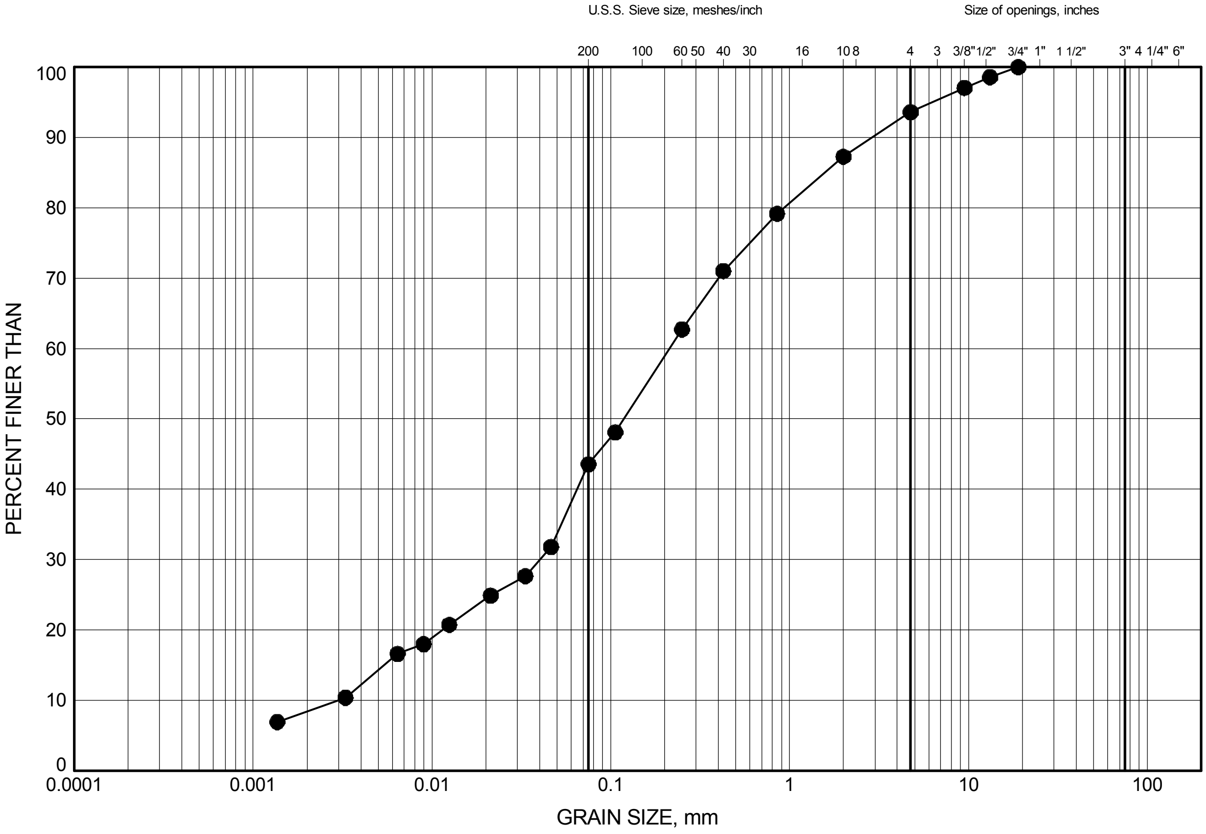
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C5

Silt to Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	14.02	209.29

Date February 2018

GWP# 5134-14-00

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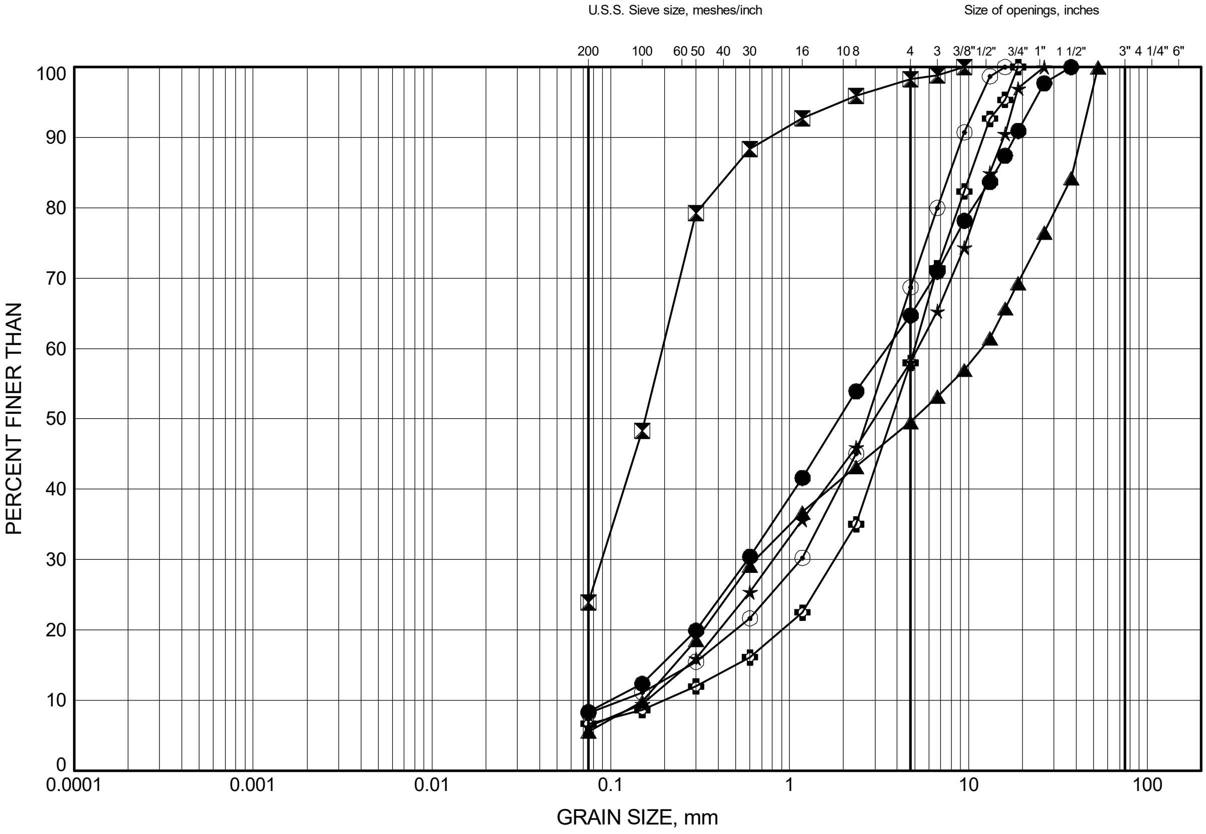
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 20/2/18

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C6

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	0.67	223.39
⧗	17-02	1.07	222.81
▲	17-03	0.15	223.59
★	17-03	1.13	222.62
⊙	17-04	0.85	222.42
✤	17-05	0.85	222.46

Date October 2017

GWP# 5134-14-00

THURBER

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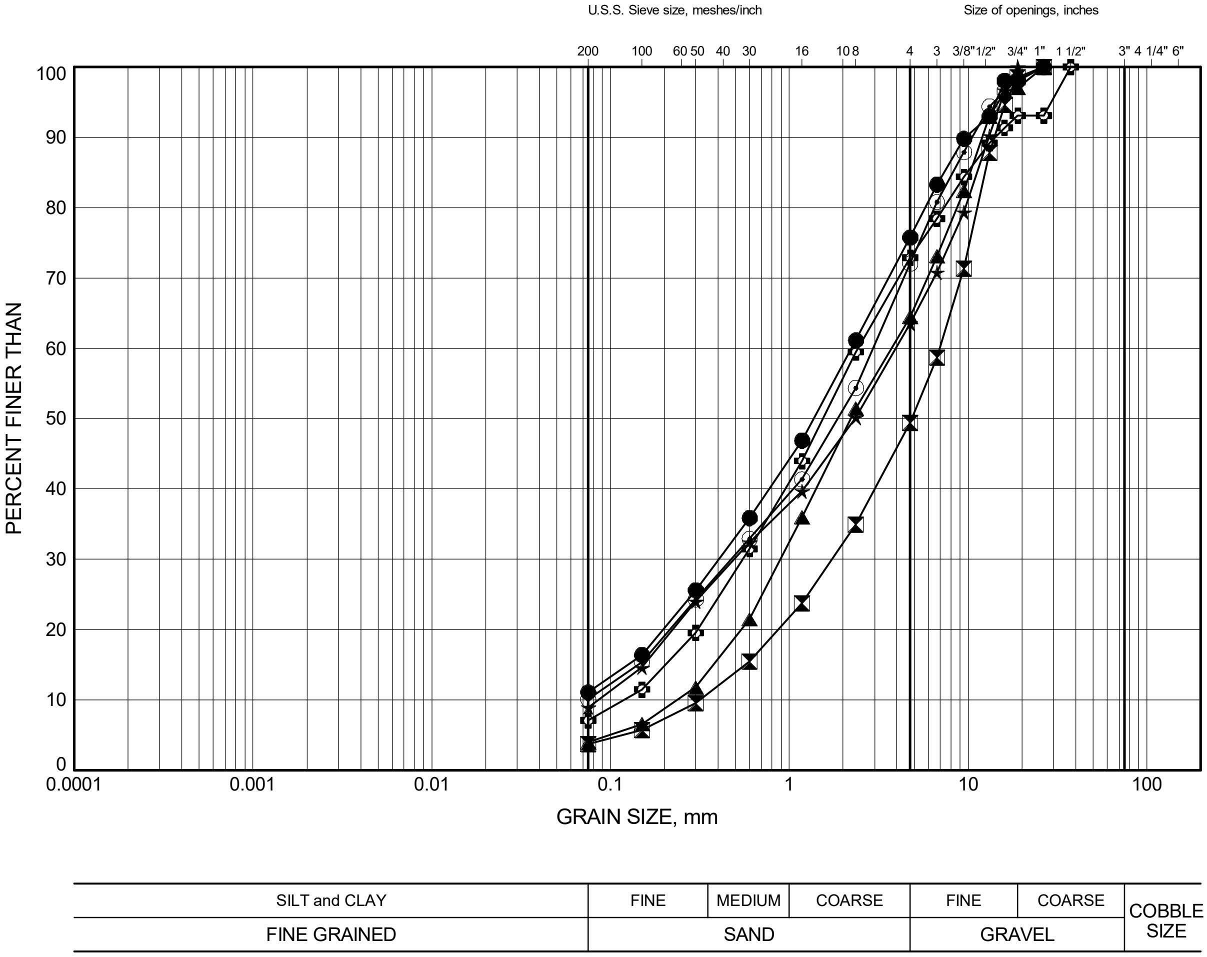
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C7

Fill



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	0.37	222.65
⧗	17-07	0.46	222.71
▲	17-07	1.09	222.08
★	17-08	0.33	222.82
⊙	17-09	0.27	222.63
✿	17-11	2.59	220.27

Date October 2017

GWP# 5134-14-00

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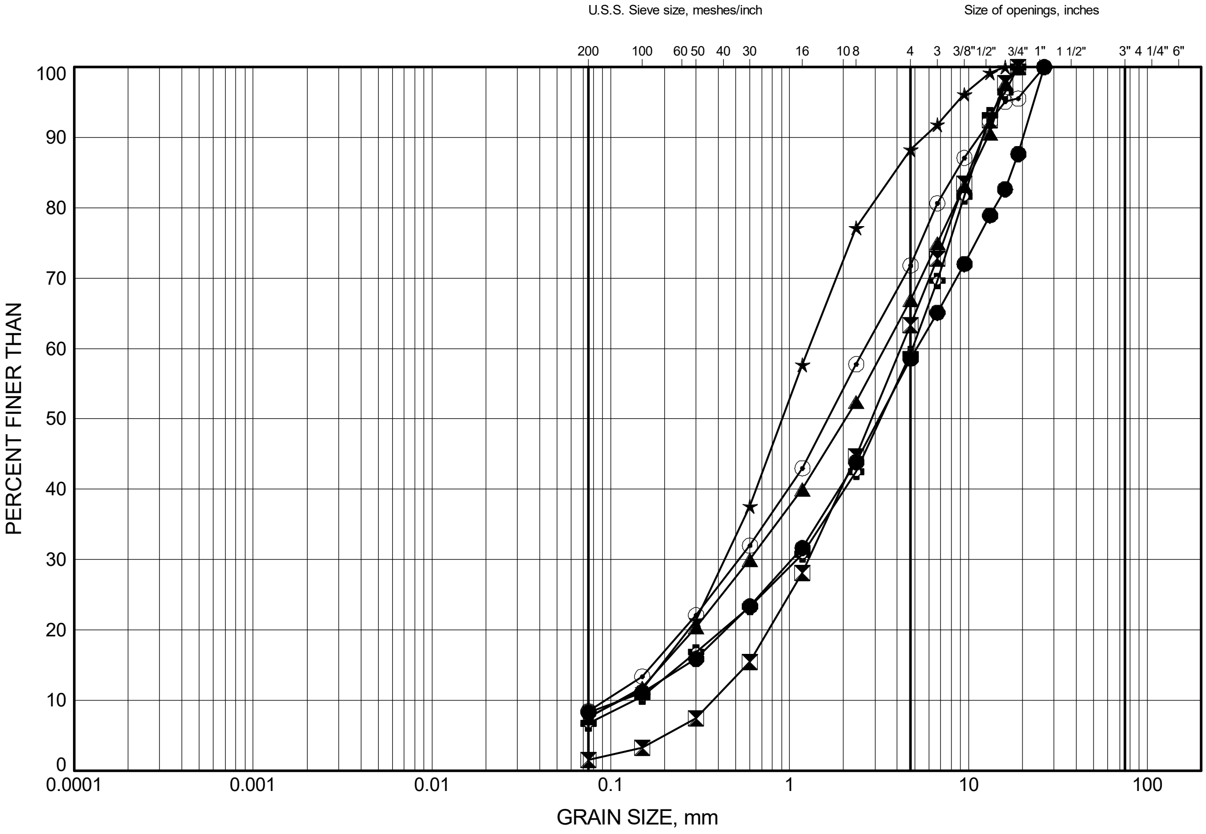
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C8

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-12	3.35	219.41
⧗	17-13	0.70	222.26
▲	17-14	0.30	222.57
★	17-14	2.59	220.28
⊙	17-15	1.07	221.88
✤	17-16	0.27	222.56

Date October 2017

GWP# 5134-14-00

Prep'd CM

Chkd. SP

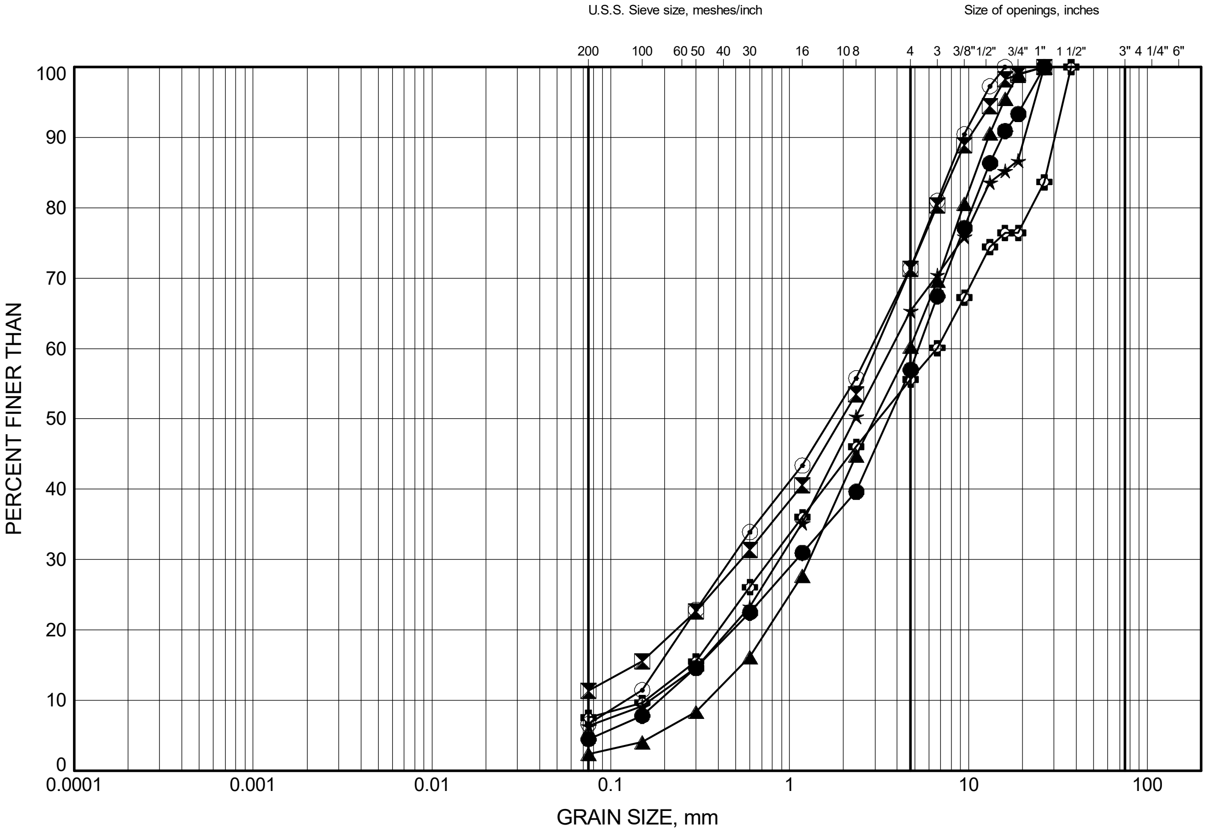
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C9

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-17	0.15	222.68
⧗	17-17	1.14	221.69
▲	17-21	1.05	221.77
★	17-22	2.59	220.63
⊙	17-23	0.62	222.92
✤	17-23	3.12	220.41

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

Chkd. SP

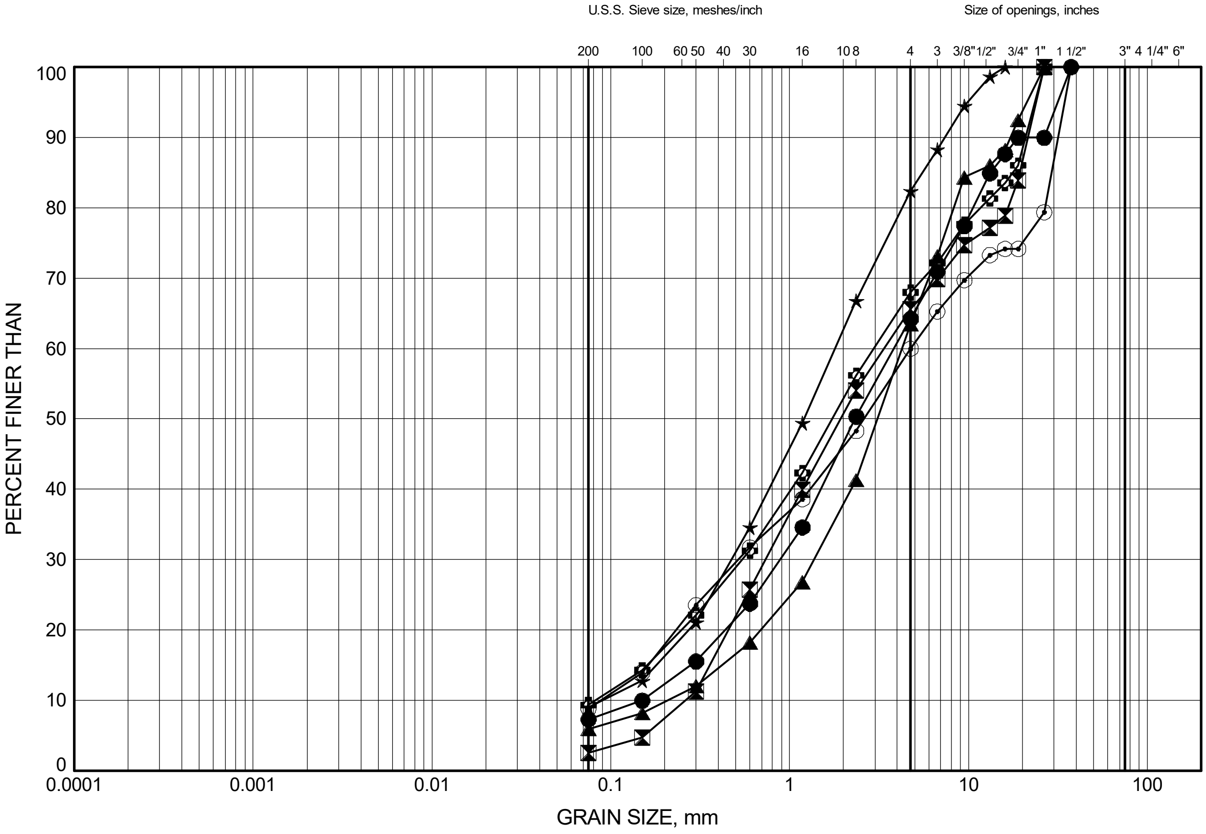
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C10

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-24	1.83	221.63
⧗	17-28	1.01	221.58
▲	CPT1	1.83	221.41
★	CPT2	1.83	221.16
⊙	CPT3	0.91	222.11
✿	CPT4	0.88	221.96

GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Date October 2017

GWP# 5134-14-00

THURBER

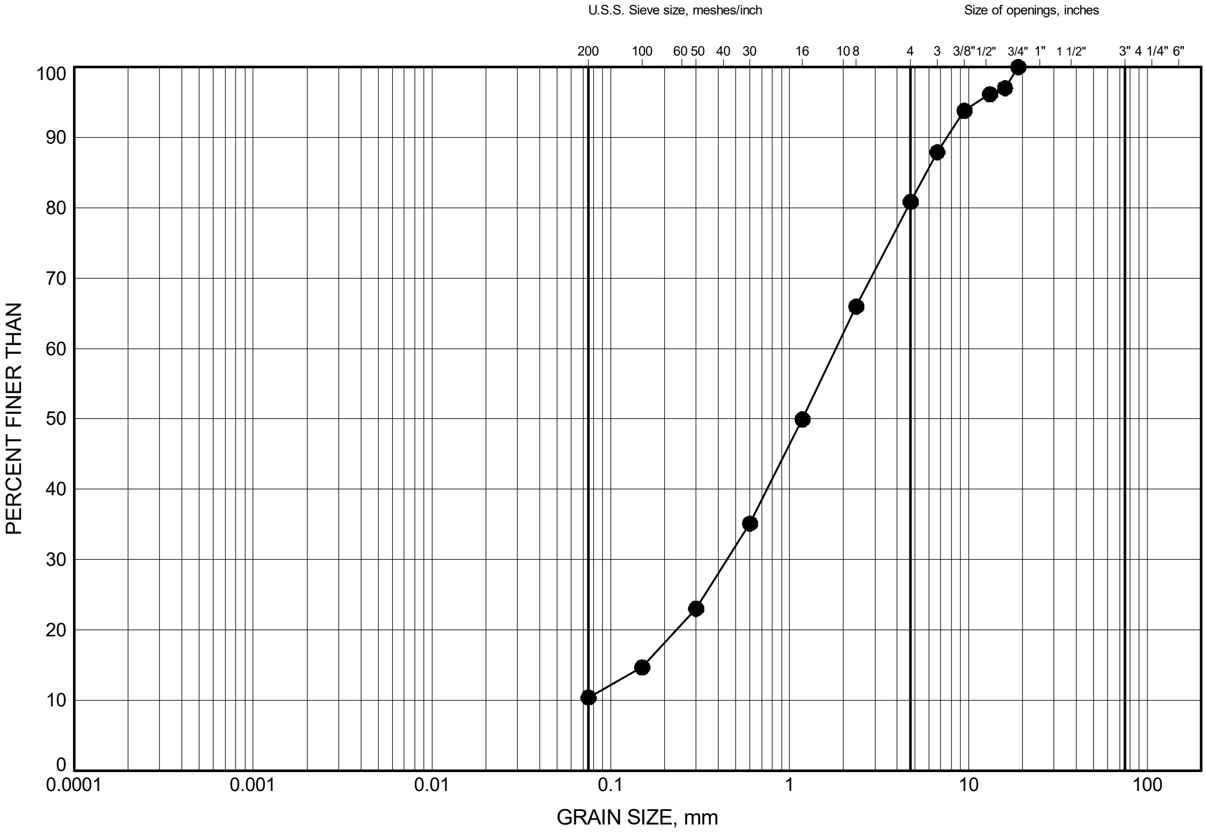
Prep'd CM

Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CPT6	0.94	221.96

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

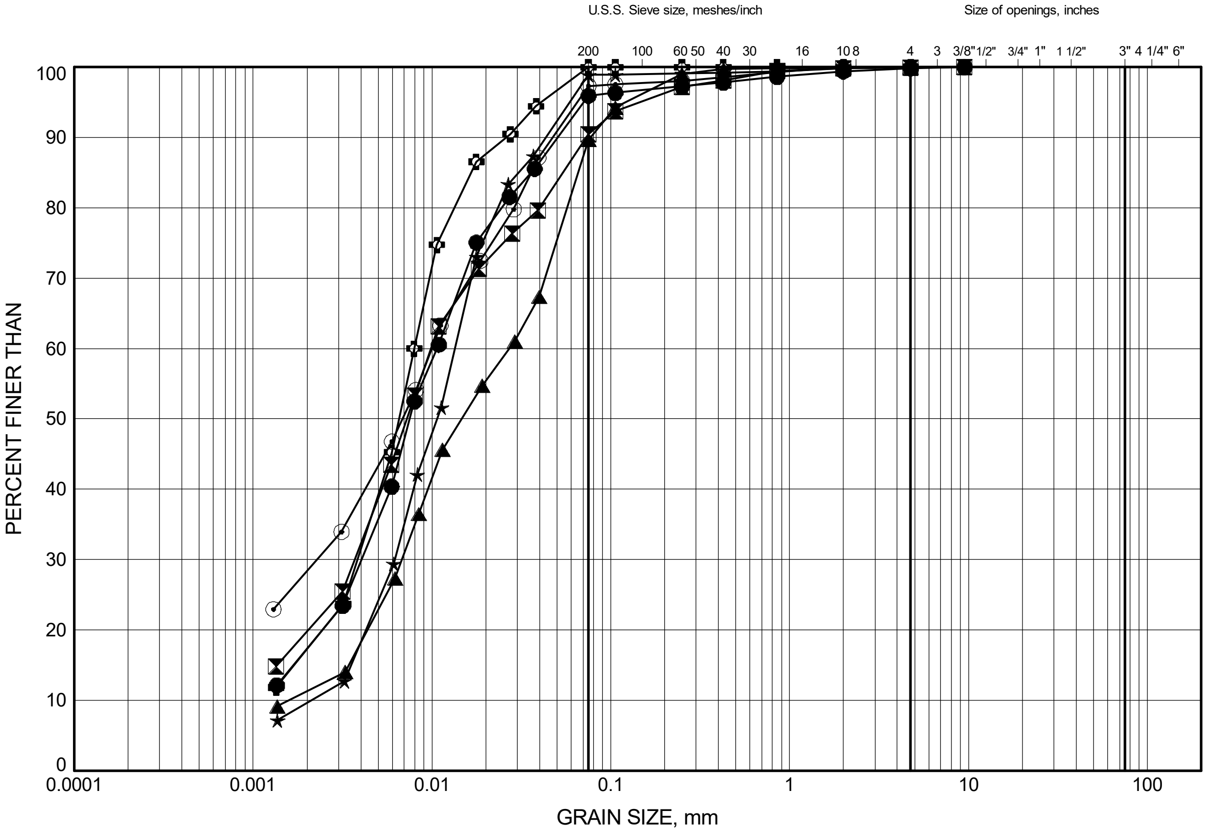
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C12

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-01	2.59	221.47
⧗	17-03	2.59	221.15
▲	17-05	4.11	219.20
★	17-07	4.11	219.06
⊙	17-11	5.79	217.07
✥	17-12	7.16	215.60

GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Date October 2017

GWP# 5134-14-00

Prep'd CM

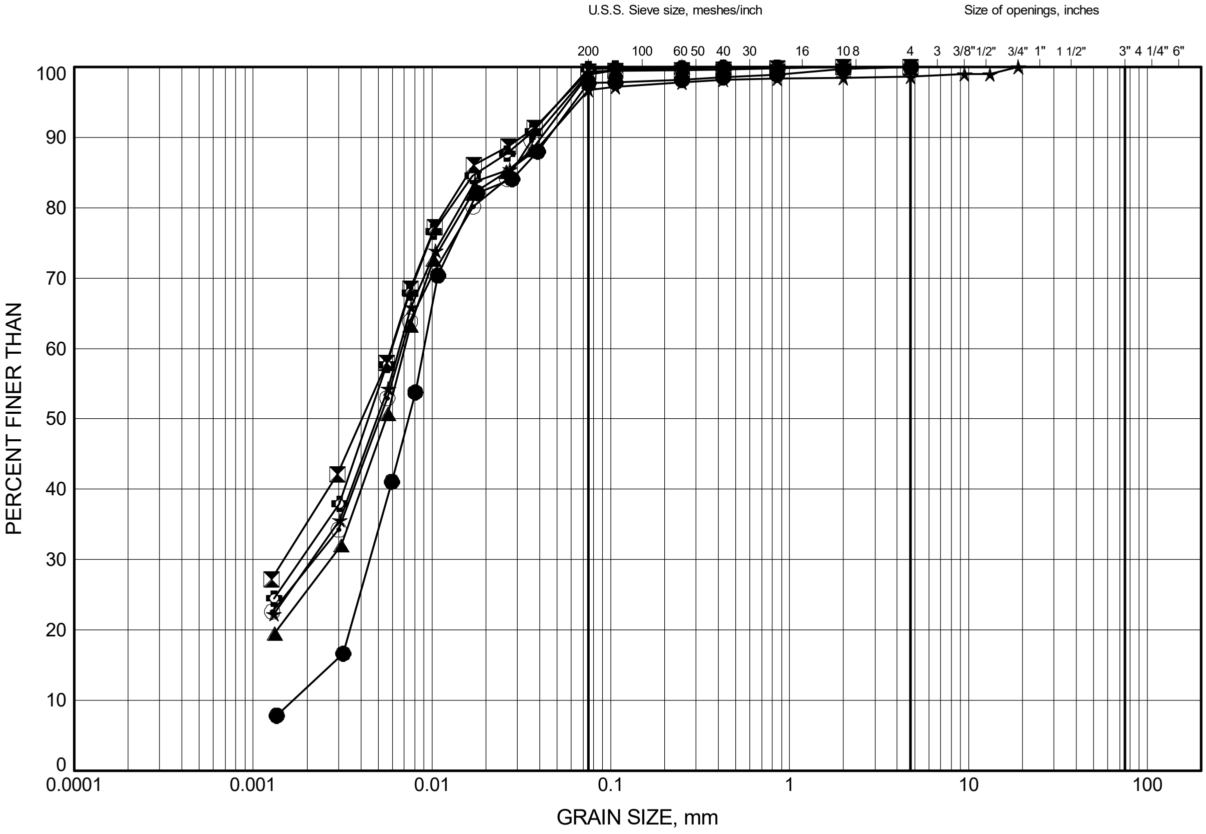
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C13

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-15	6.40	216.55
⧗	17-17	6.55	216.28
▲	17-19	6.40	216.29
★	17-22	5.64	217.58
⊙	17-25	3.44	219.52
✿	17-26	4.34	218.30

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

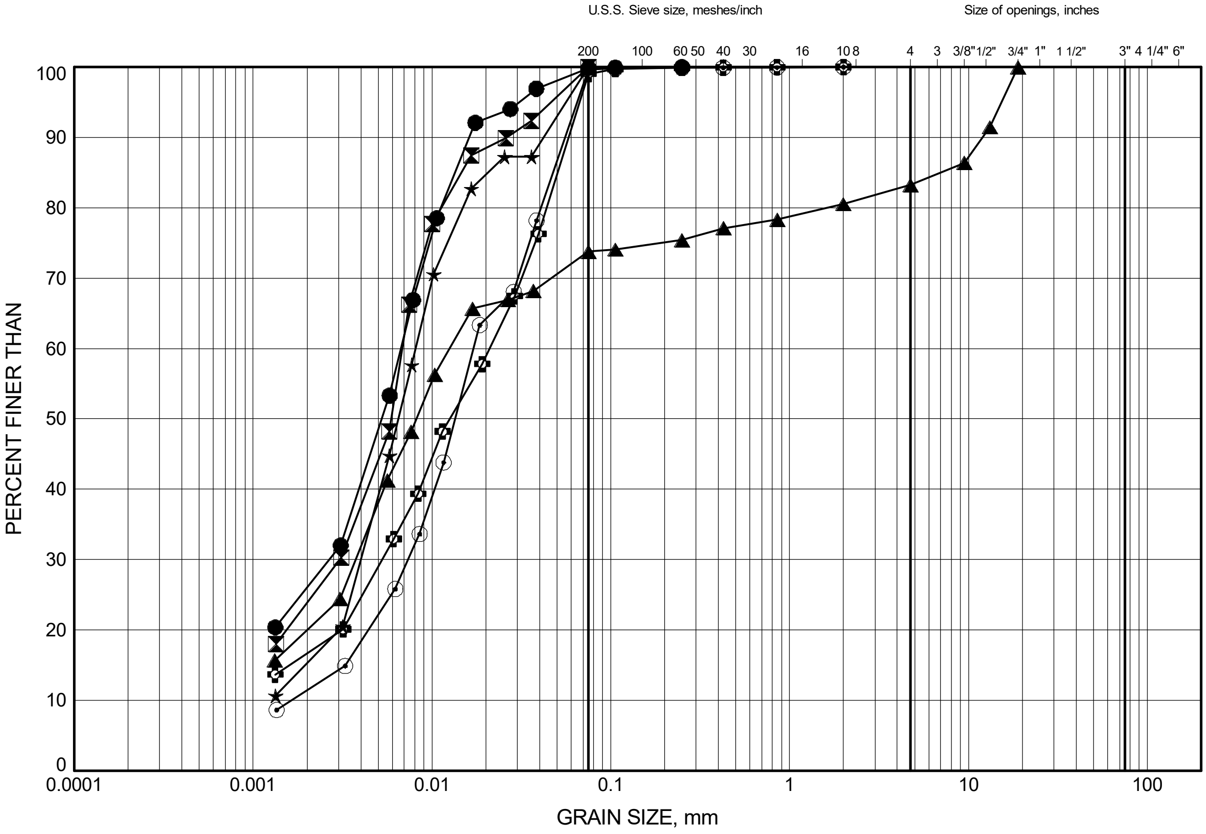
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C14

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-33	5.64	217.21
⧗	17-34	6.22	216.46
▲	17-35	6.32	216.74
★	17-37	6.40	216.61
⊙	17-39	5.03	217.79
✜	17-40	4.95	217.95

Date October 2017

GWP# 5134-14-00

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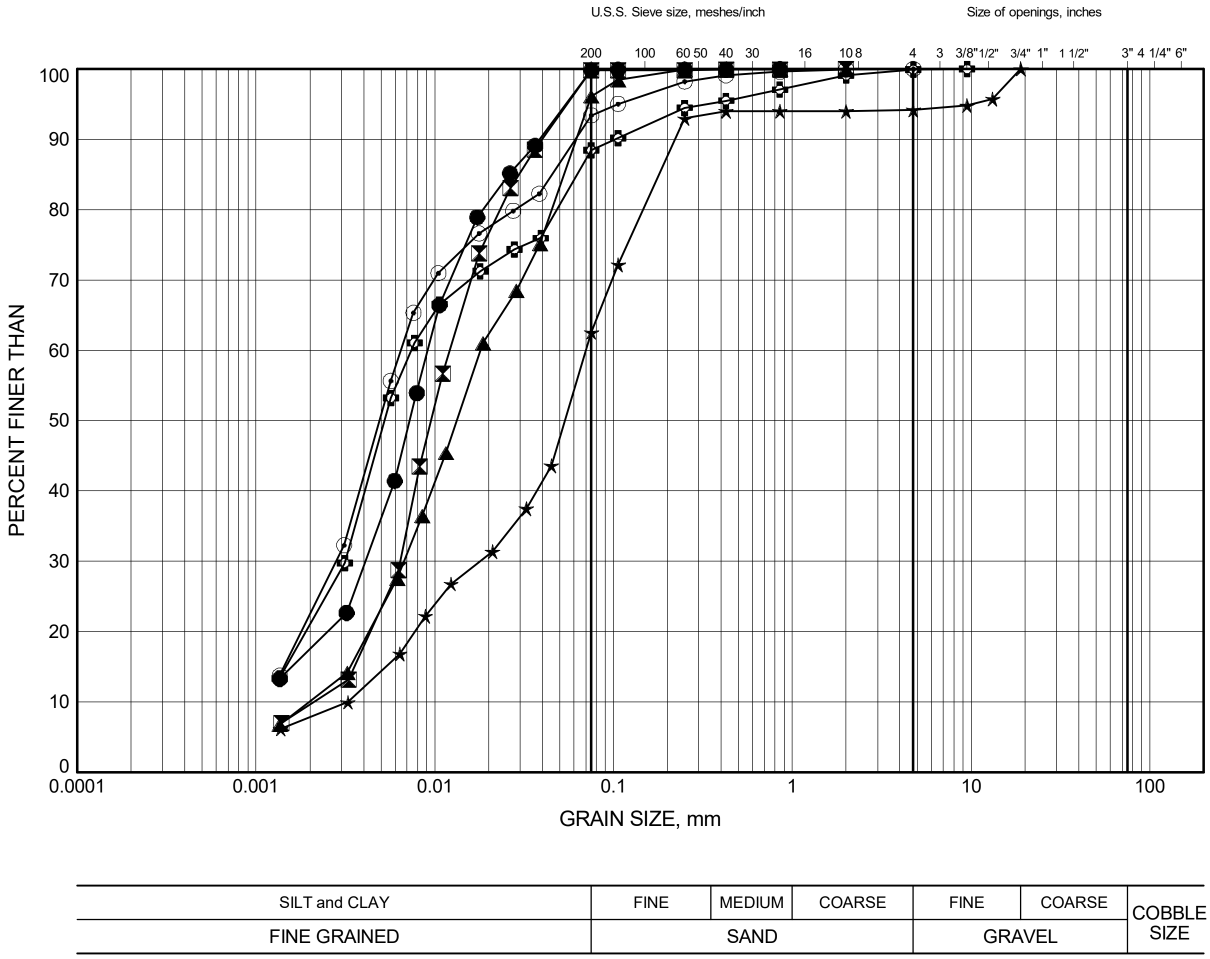
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C15

Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-41	4.61	218.20
⧗	17-45	3.02	219.79
▲	17-46	3.35	219.44
★	17-47	2.59	220.07
⊙	17-48	0.91	221.41
✥	17-49	0.88	221.88

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

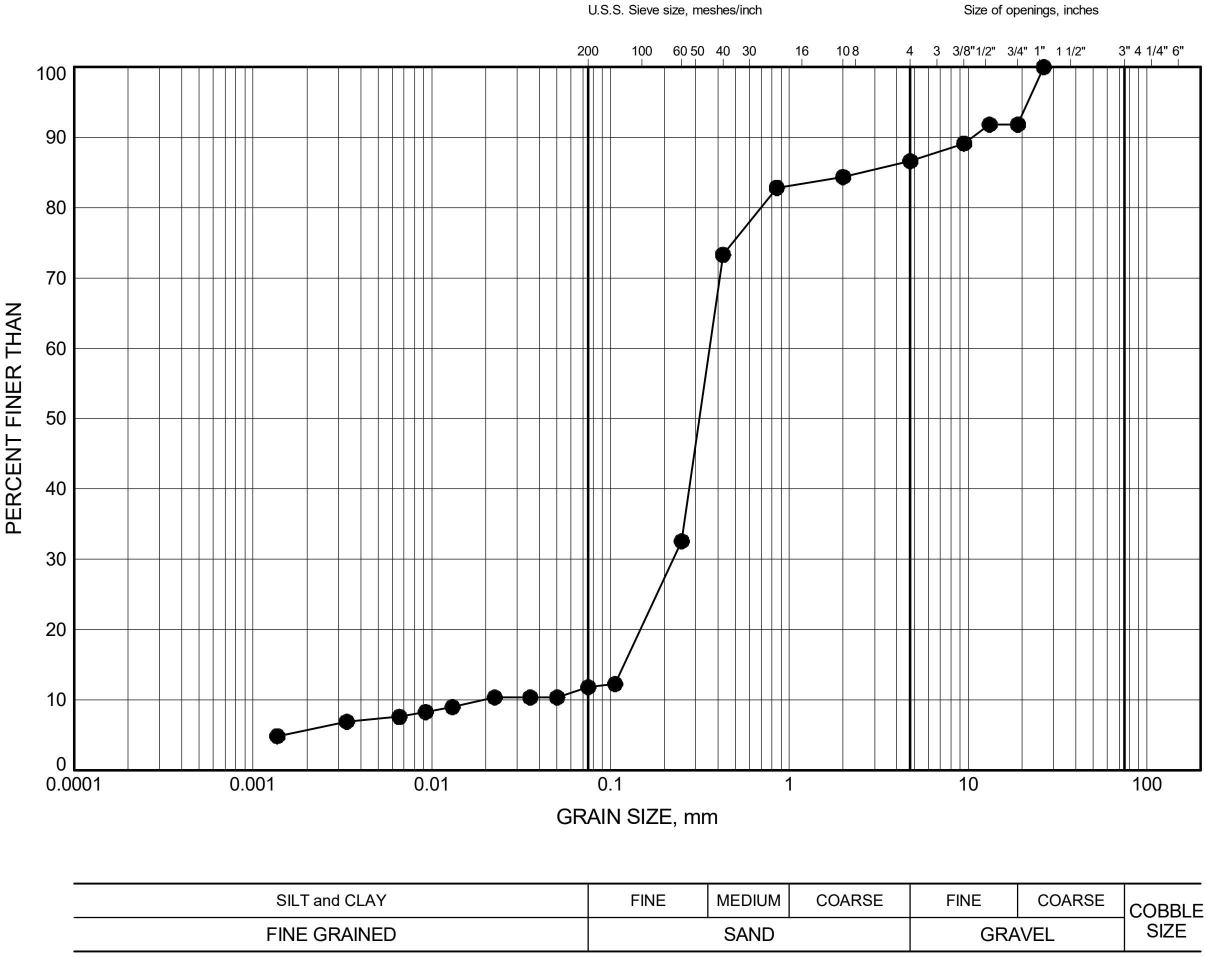
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C16

Sand



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-39	6.25	216.57

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

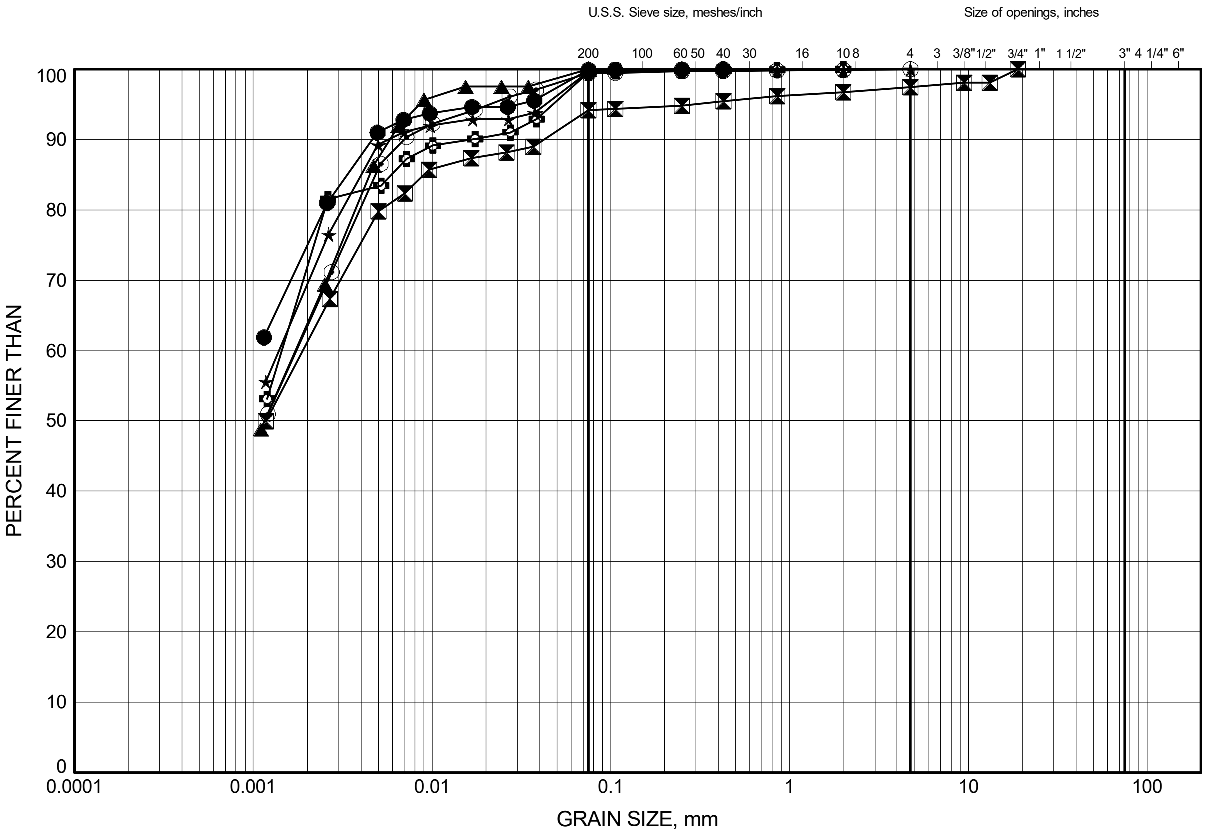
Chkd. SP

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C17

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	9.45	213.83
⧗	17-05	4.88	218.43
▲	17-05	6.40	216.91
★	17-05	7.92	215.39
⊙	17-05	10.97	212.34
✤	17-06	6.40	216.62

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Chkd. SP

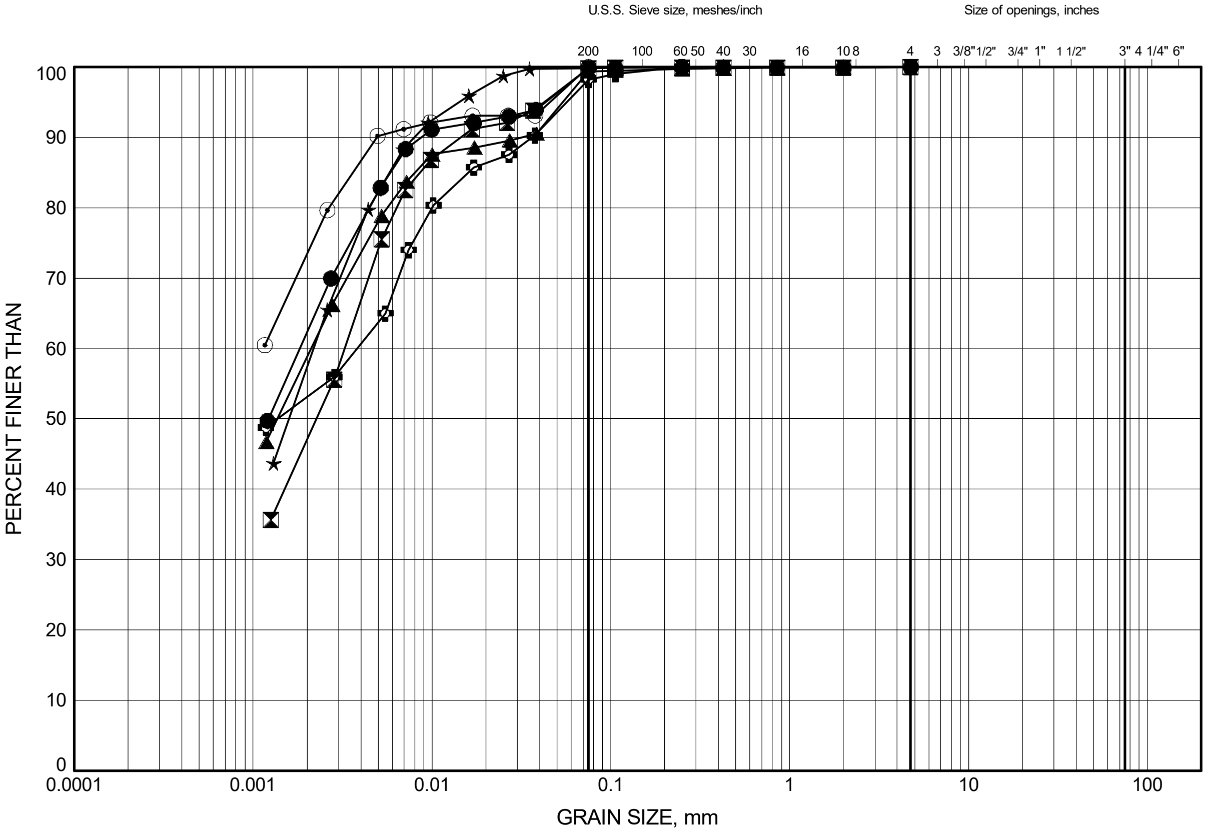
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C18

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	9.45	213.57
⧗	17-06	17.07	205.95
▲	17-08	5.64	217.51
★	17-08	8.69	214.46
⊙	17-08	11.73	211.42
✤	17-10	6.40	216.55

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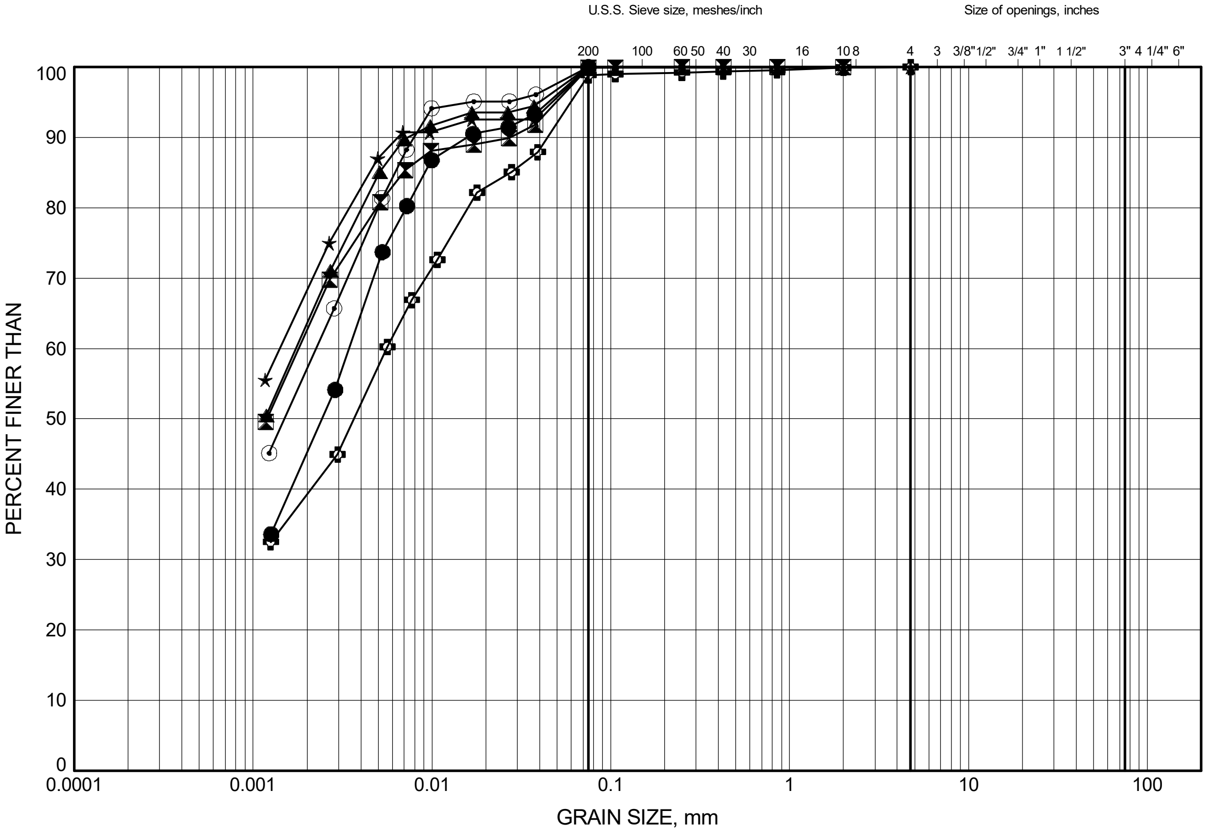
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C19

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-10	15.54	207.41
⧗	17-11	7.92	214.94
▲	17-11	14.02	208.84
★	17-12	10.97	211.79
⊙	17-12	18.59	204.17
✥	17-13	5.64	217.33

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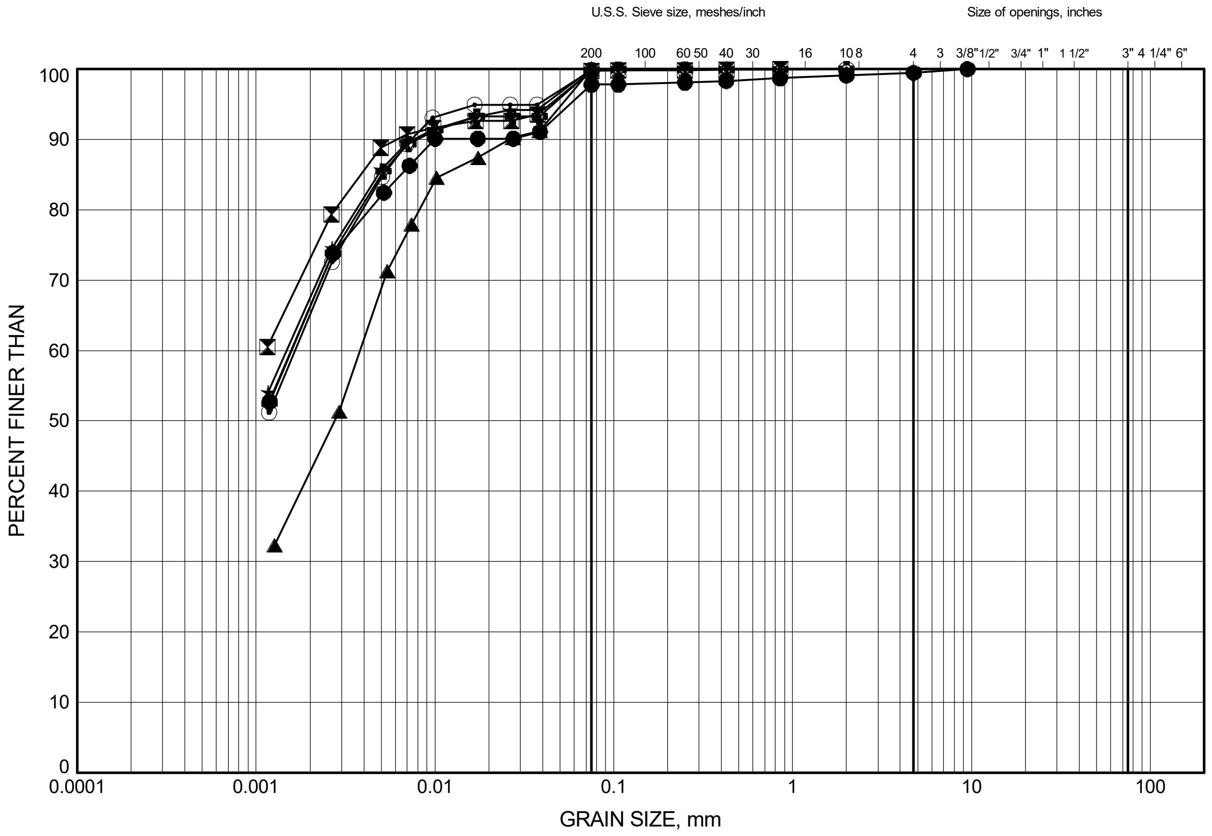
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C20

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-16	7.92	214.90
⧗	17-16	17.07	205.76
▲	17-16	24.69	198.14
★	17-18	9.45	213.39
⊙	17-18	14.02	208.81
✿	17-18	18.59	204.24

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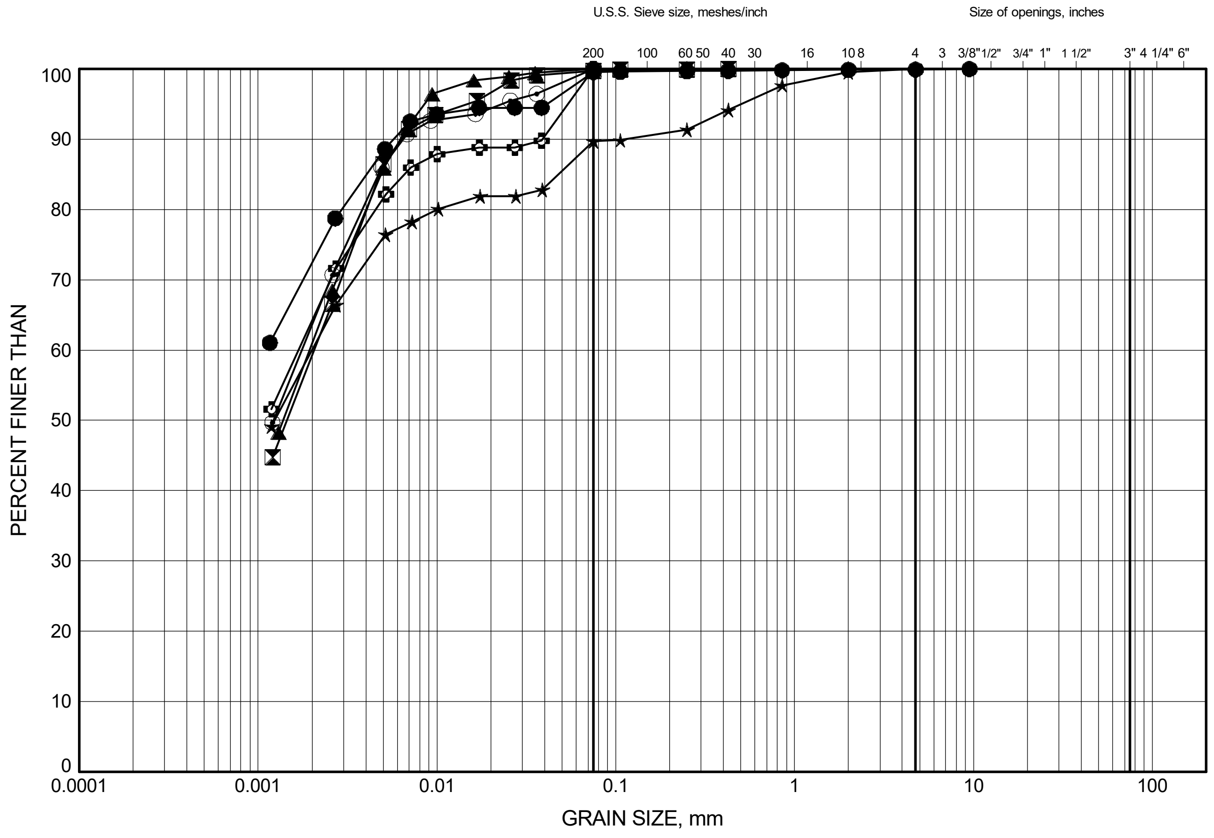
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C21

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-19	7.16	215.52
⧗	17-19	10.97	211.71
▲	17-19	14.02	208.67
★	17-19	17.07	205.62
⊙	17-19	18.59	204.09
✤	17-20	9.45	213.51

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THURBER

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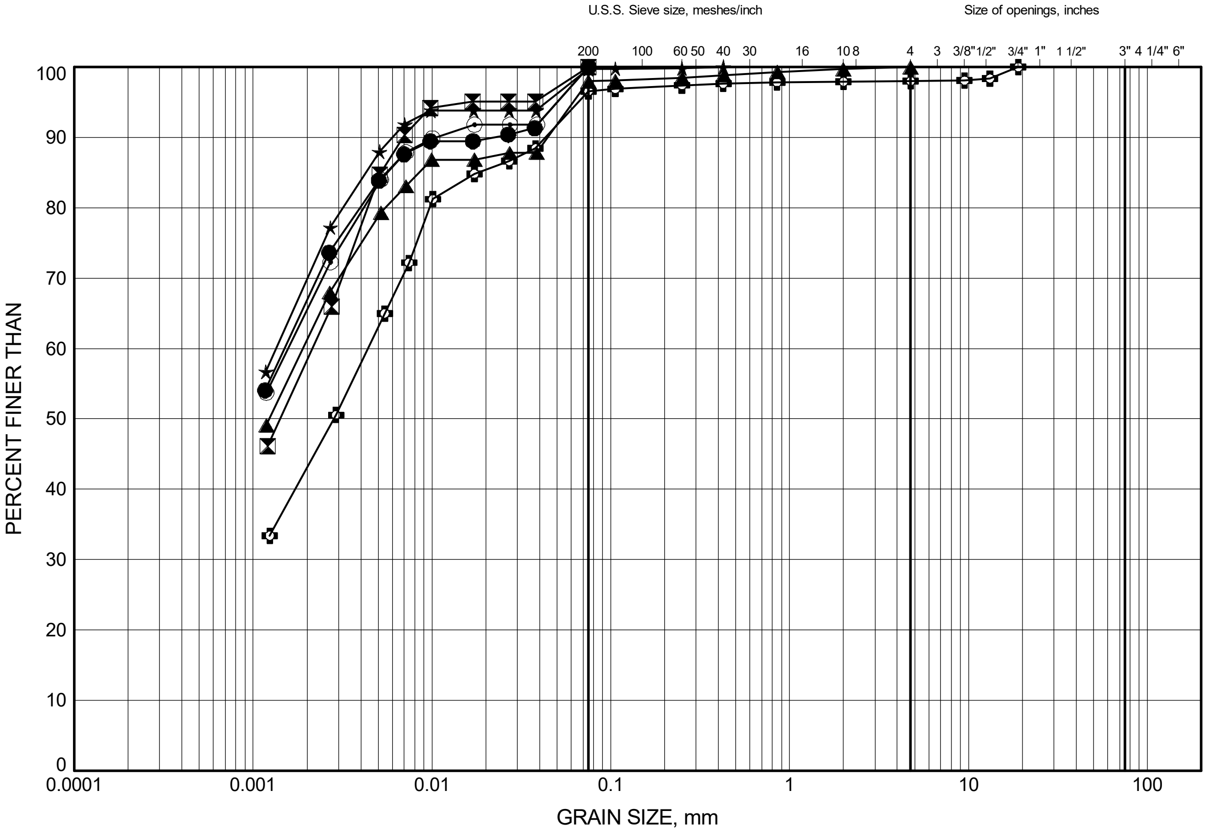
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C22

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-20	12.50	210.46
⧗	17-20	18.59	204.36
▲	17-21	6.40	216.42
★	17-22	7.92	215.29
⊙	17-22	14.02	209.20
✥	17-23	5.72	217.82

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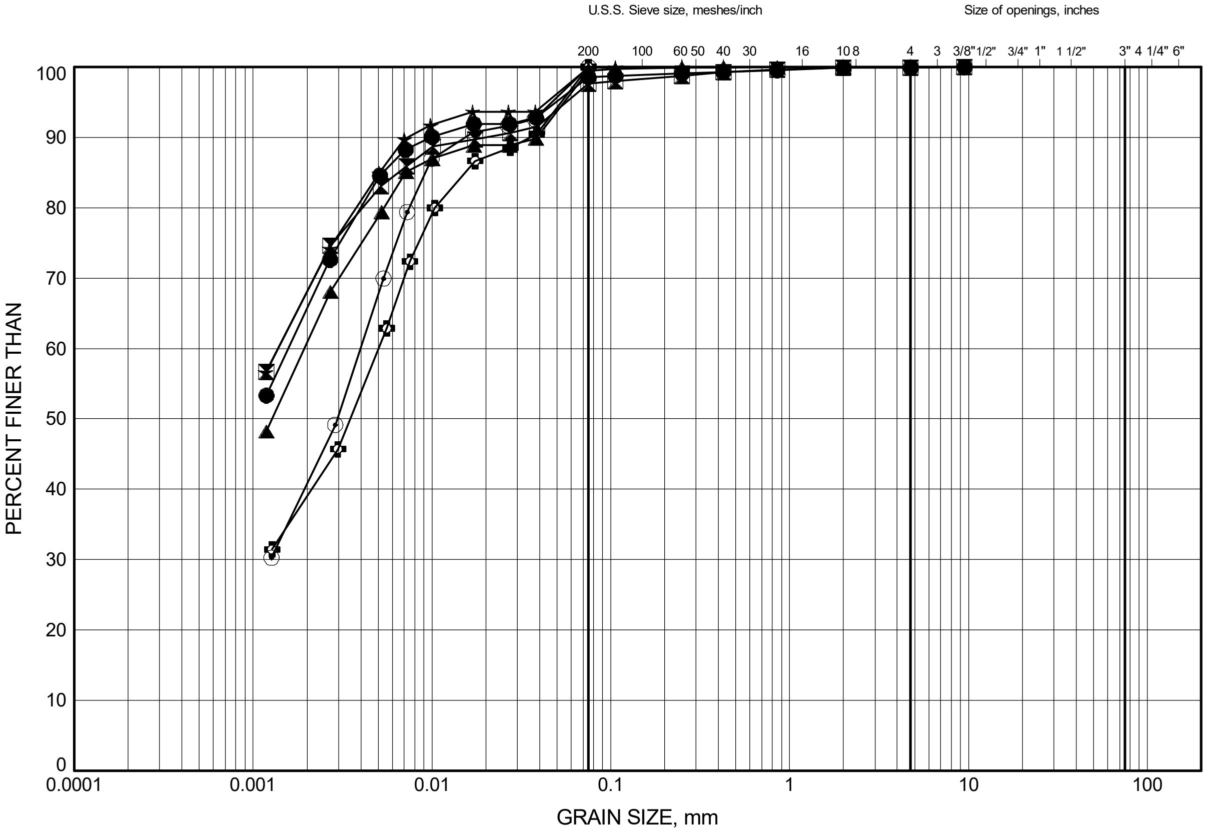
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C23

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-24	5.64	217.82
⧗	17-24	10.91	212.55
▲	17-27	6.40	216.30
★	17-27	10.97	211.73
⊙	17-27	17.07	205.63
✤	17-28	5.33	217.26

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THURBER

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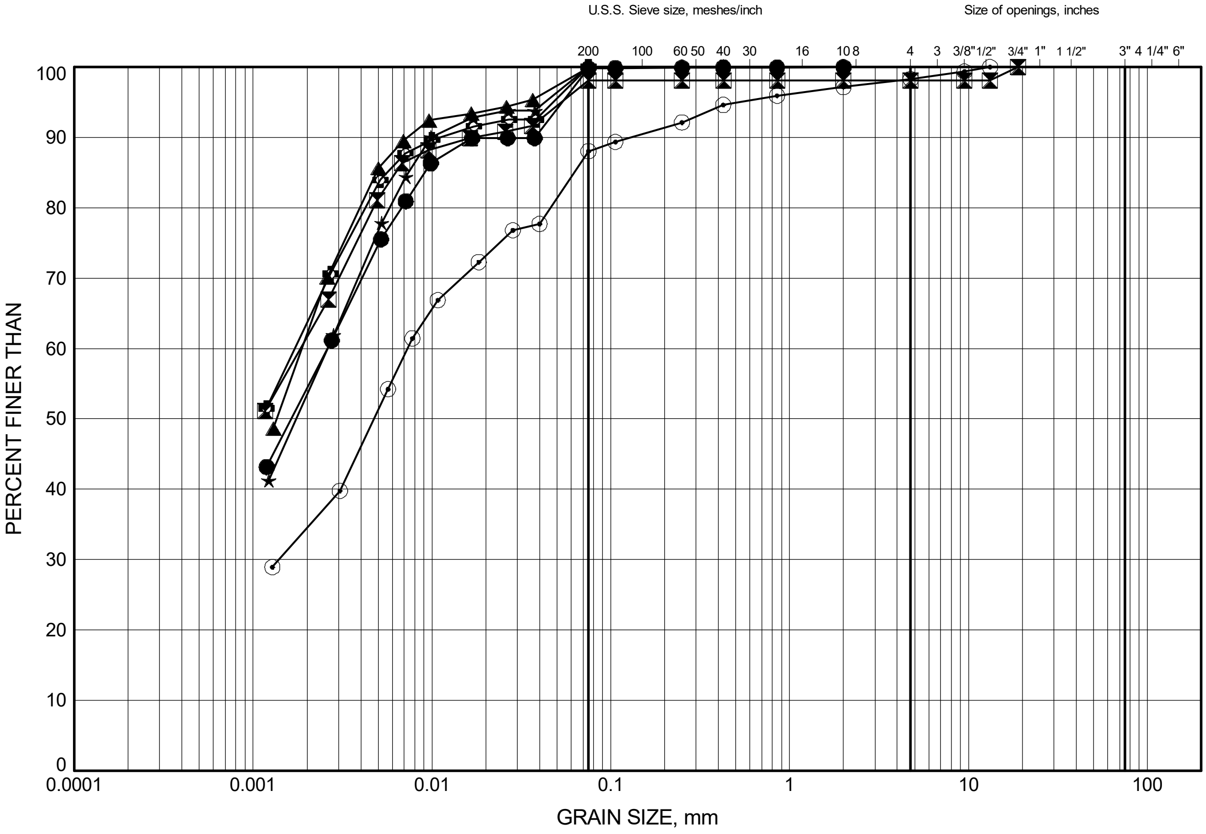
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C24

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-29	6.40	216.41
⧗	17-29	10.97	211.83
▲	17-29	12.50	210.31
★	17-29	18.59	204.21
⊙	17-31	6.40	216.41
✿	17-31	9.45	213.36

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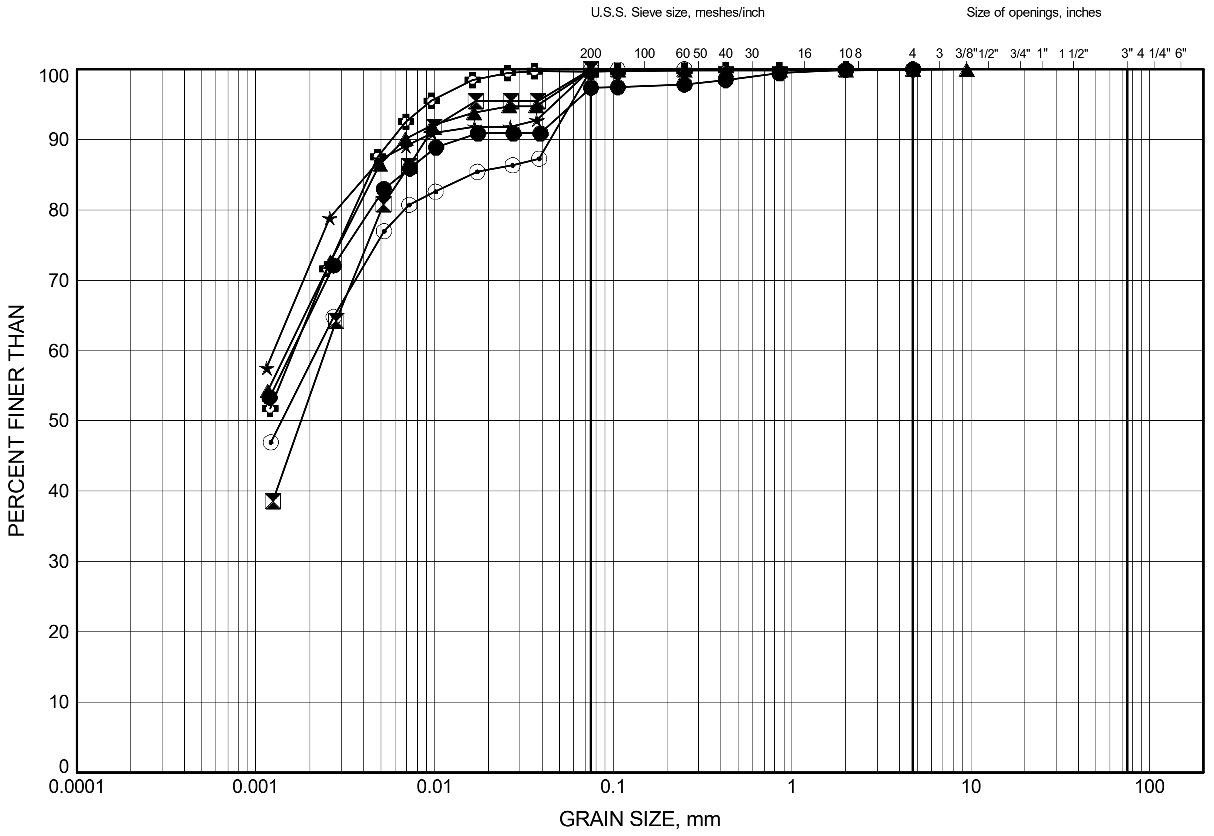
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C25

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-31	15.54	207.26
⧗	17-31	21.64	201.17
▲	17-32	9.45	213.24
★	17-32	17.07	205.62
⊙	17-32	21.64	201.05
✿	17-35	7.92	215.14

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THURBER

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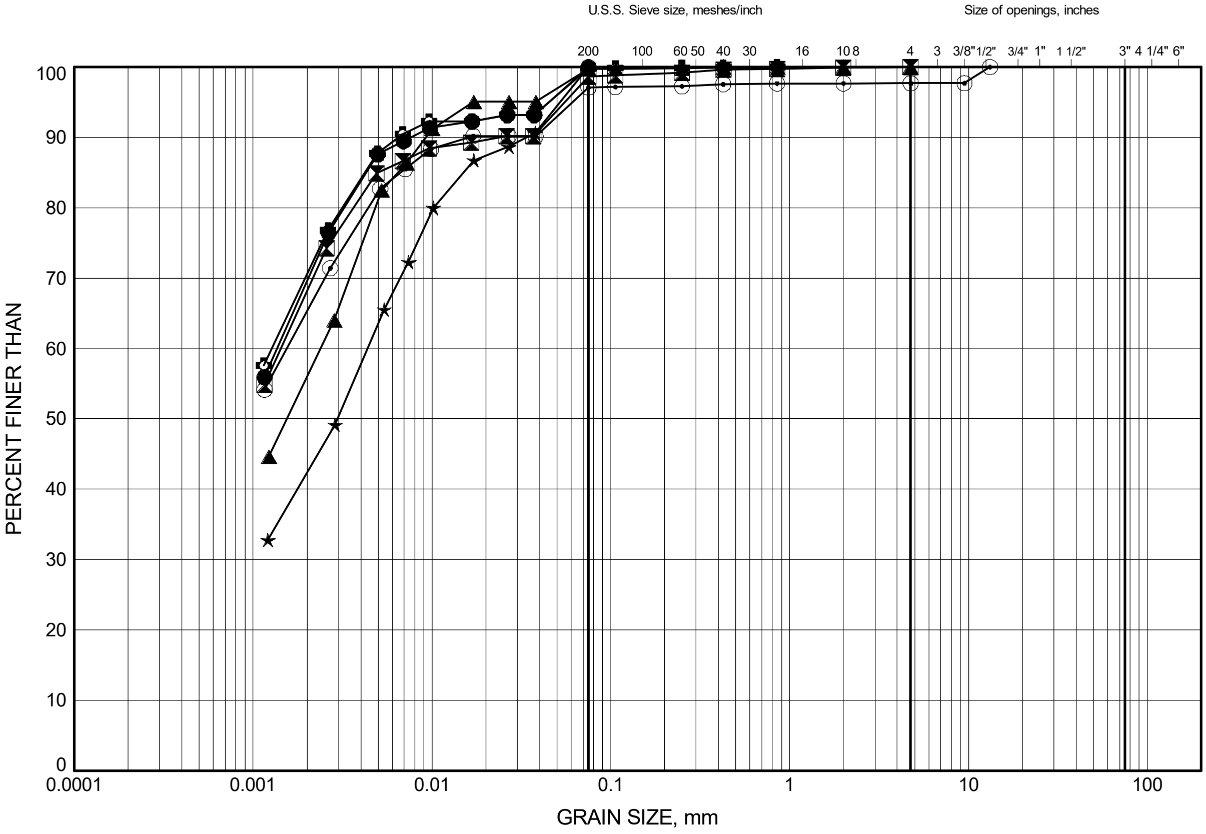
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C26

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-35	10.97	212.09
⧗	17-35	15.54	207.52
▲	17-35	21.64	201.42
★	17-38	5.72	217.11
⊙	17-39	7.92	214.89
✿	17-39	17.07	205.75

GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

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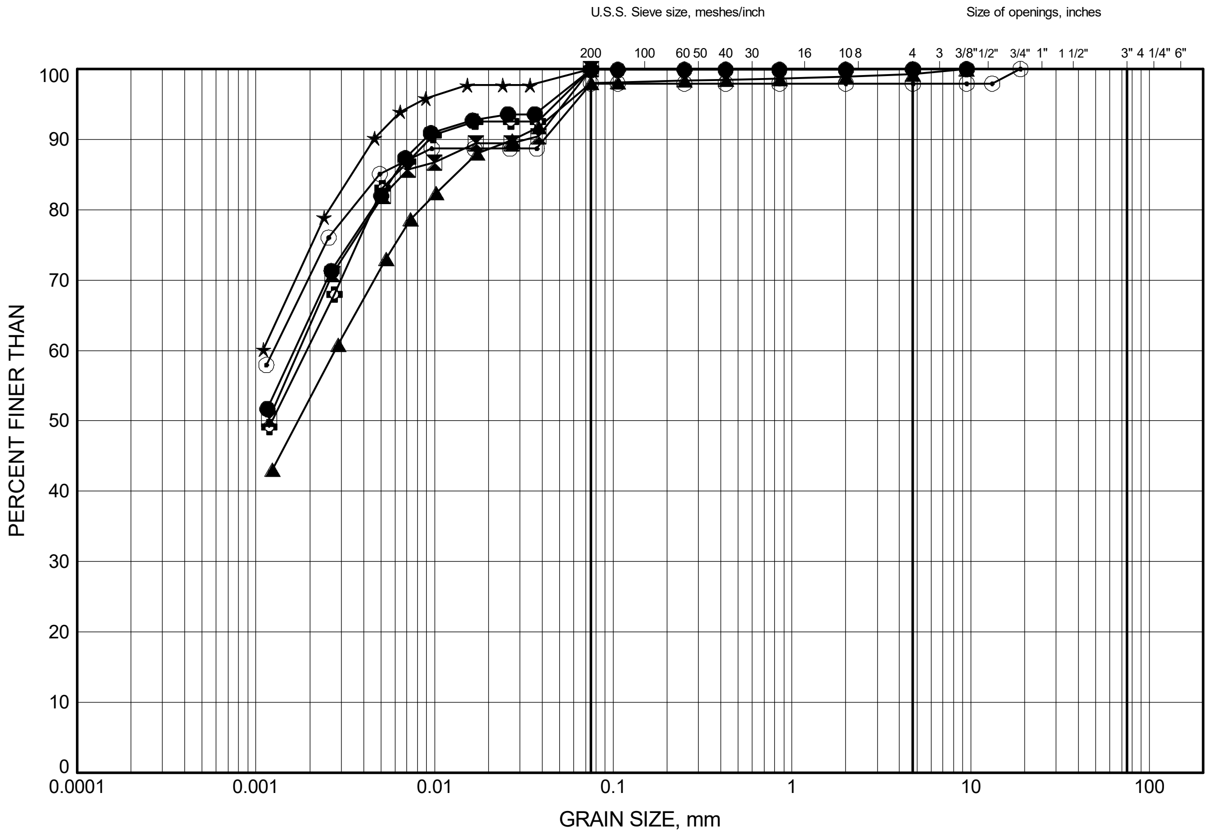
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C27

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-42	6.40	216.36
⧗	17-42	10.97	211.79
▲	17-43	4.11	218.67
★	17-43	9.45	213.34
⊙	17-43	10.97	211.81
✣	17-44	6.40	216.22

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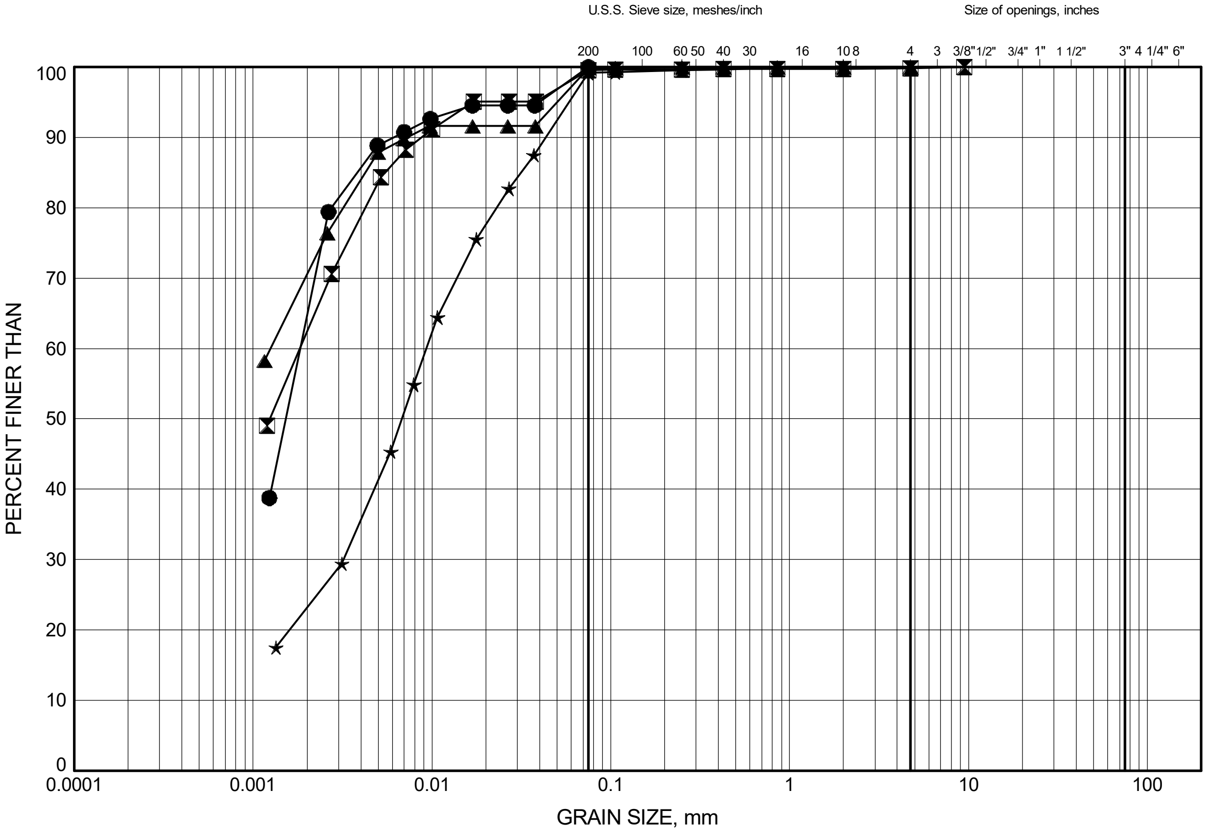
GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C28

Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-44	14.02	208.60
☒	17-46	4.11	218.68
▲	17-46	7.92	214.87
★	17-48	2.13	220.19

GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Date October 2017

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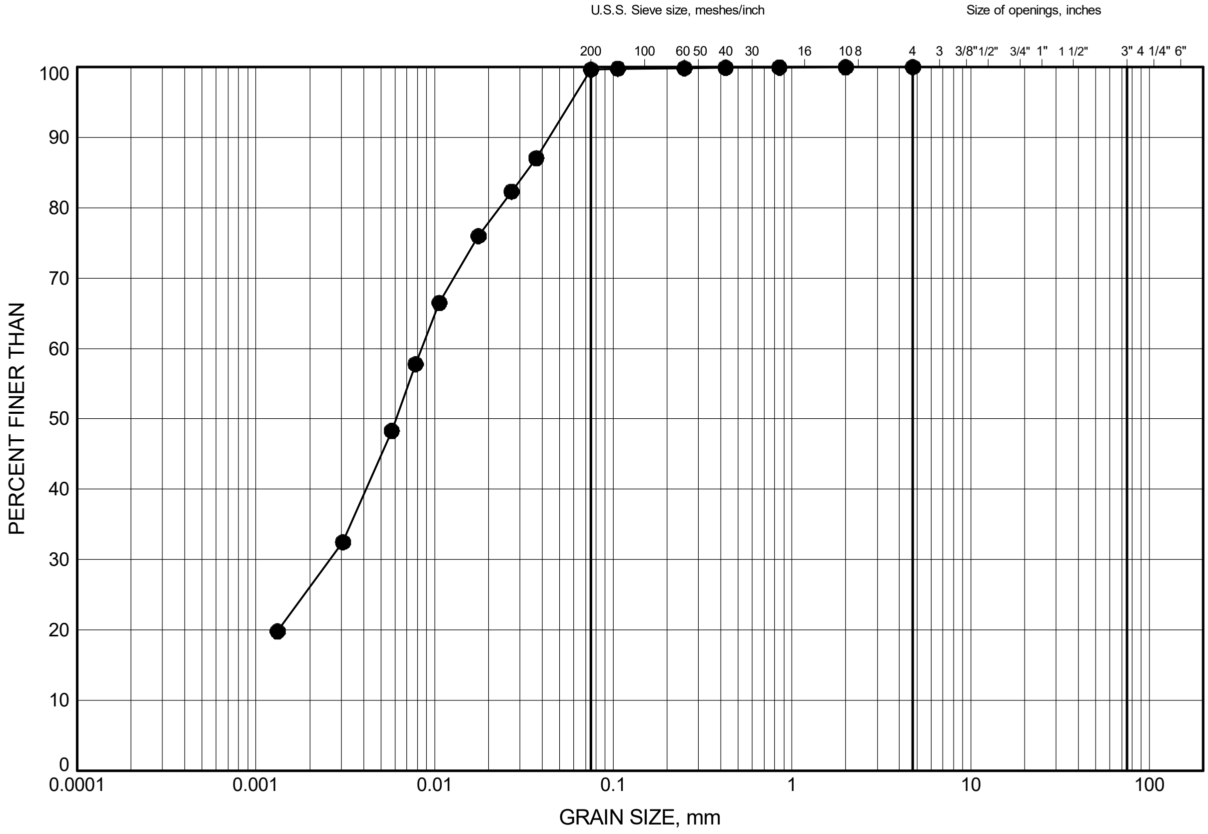
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C29

Silty Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-18	24.69	198.15

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THURBER

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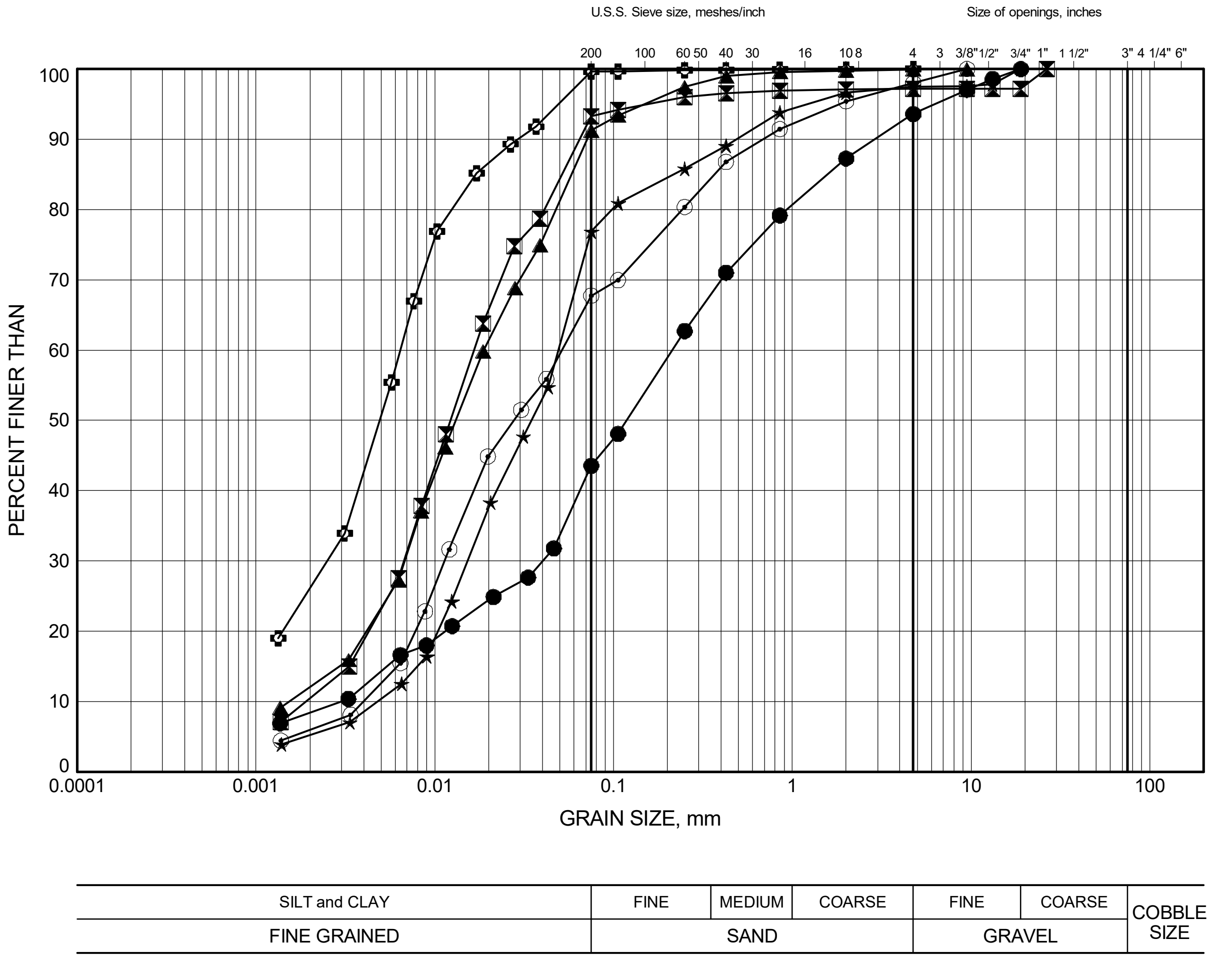
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C30

Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-05	14.02	209.29
⧗	17-10	18.59	204.36
▲	17-16	27.74	195.09
★	17-18	27.74	195.10
⊙	17-19	24.69	198.00
✿	17-42	17.98	204.78

GRAIN SIZE DISTRIBUTION - THURBER 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

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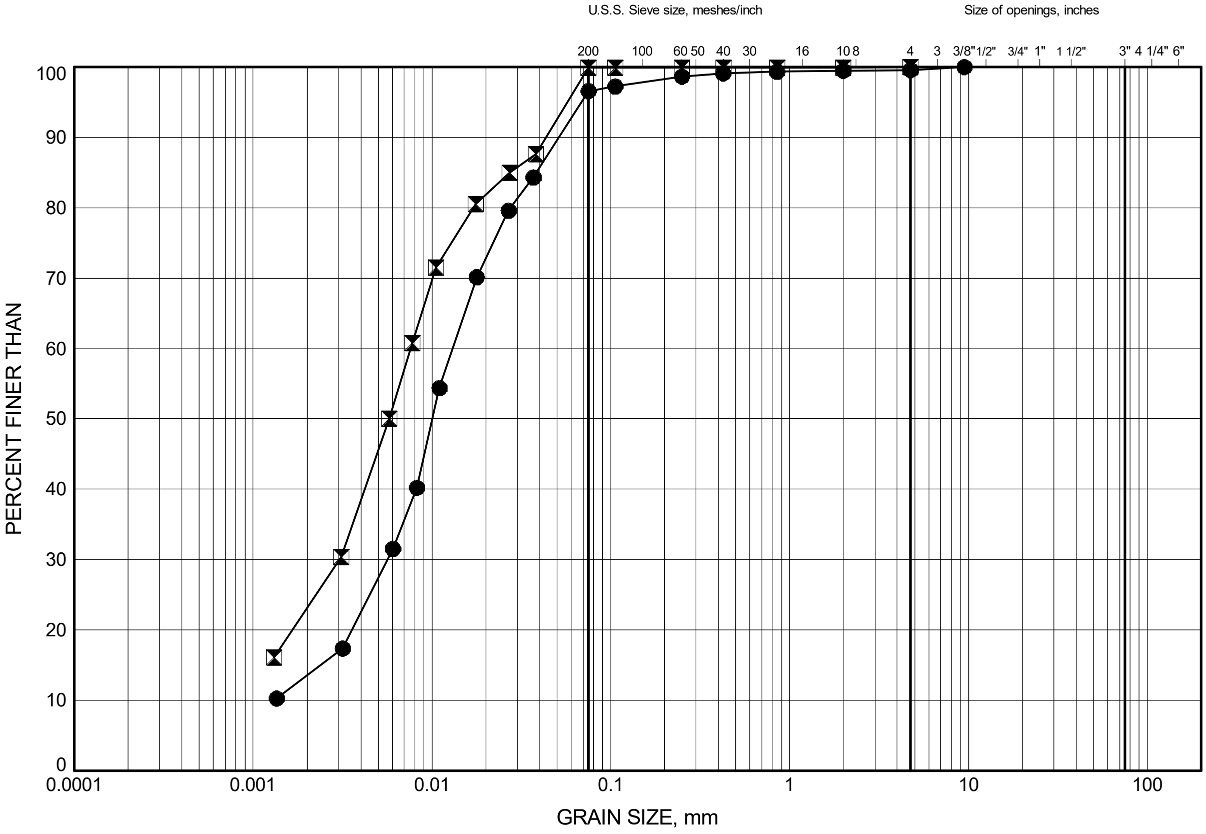
Jumbo Creek

GRAIN SIZE DISTRIBUTION

FIGURE C31

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-43	17.07	205.72
⧗	17-44	18.59	204.03

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Appendix C.2

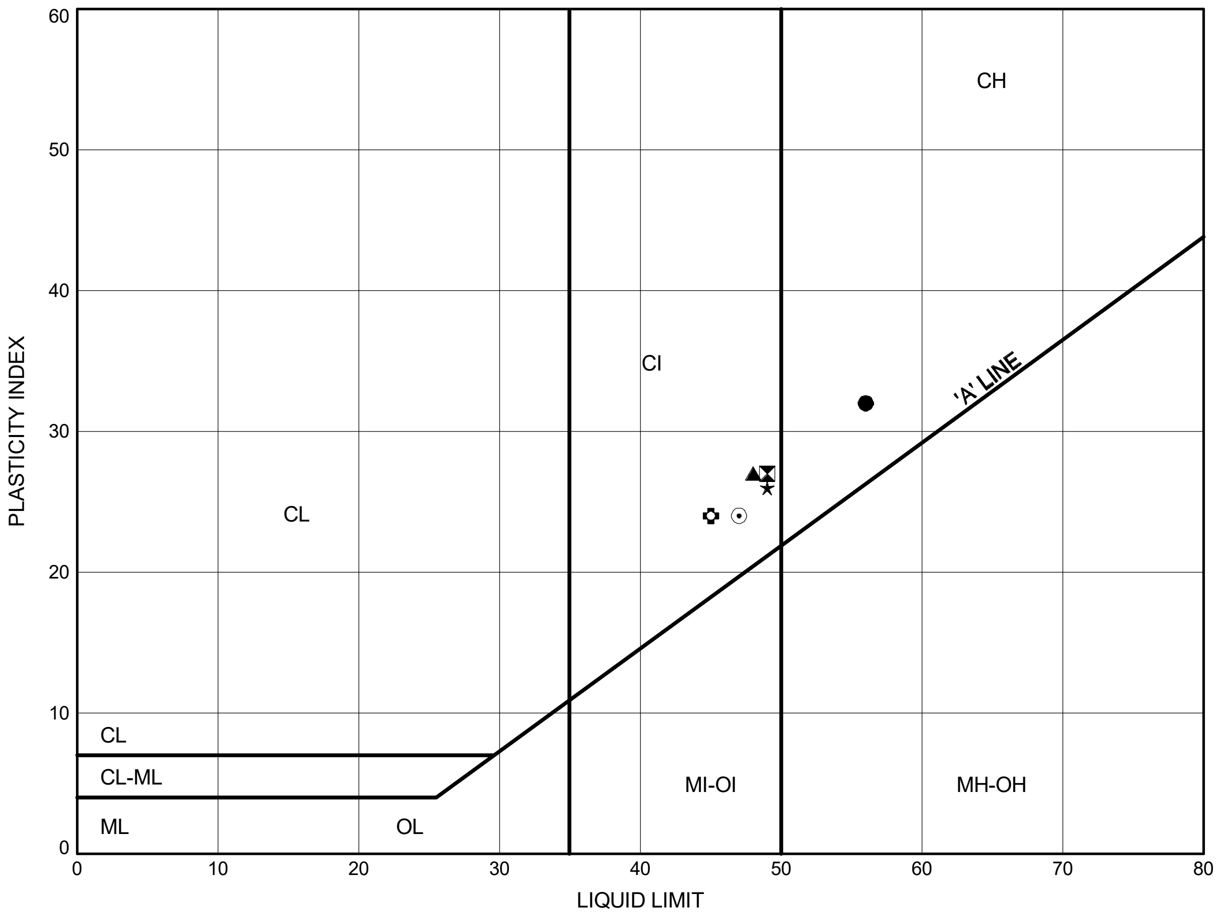
Atterberg Limit Testing Figures

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C32

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-04	9.45	213.83
⧗	17-05	4.88	218.43
▲	17-05	6.40	216.91
★	17-05	7.92	215.39
⊙	17-05	10.97	212.34
✿	17-06	6.40	216.62

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THURBER

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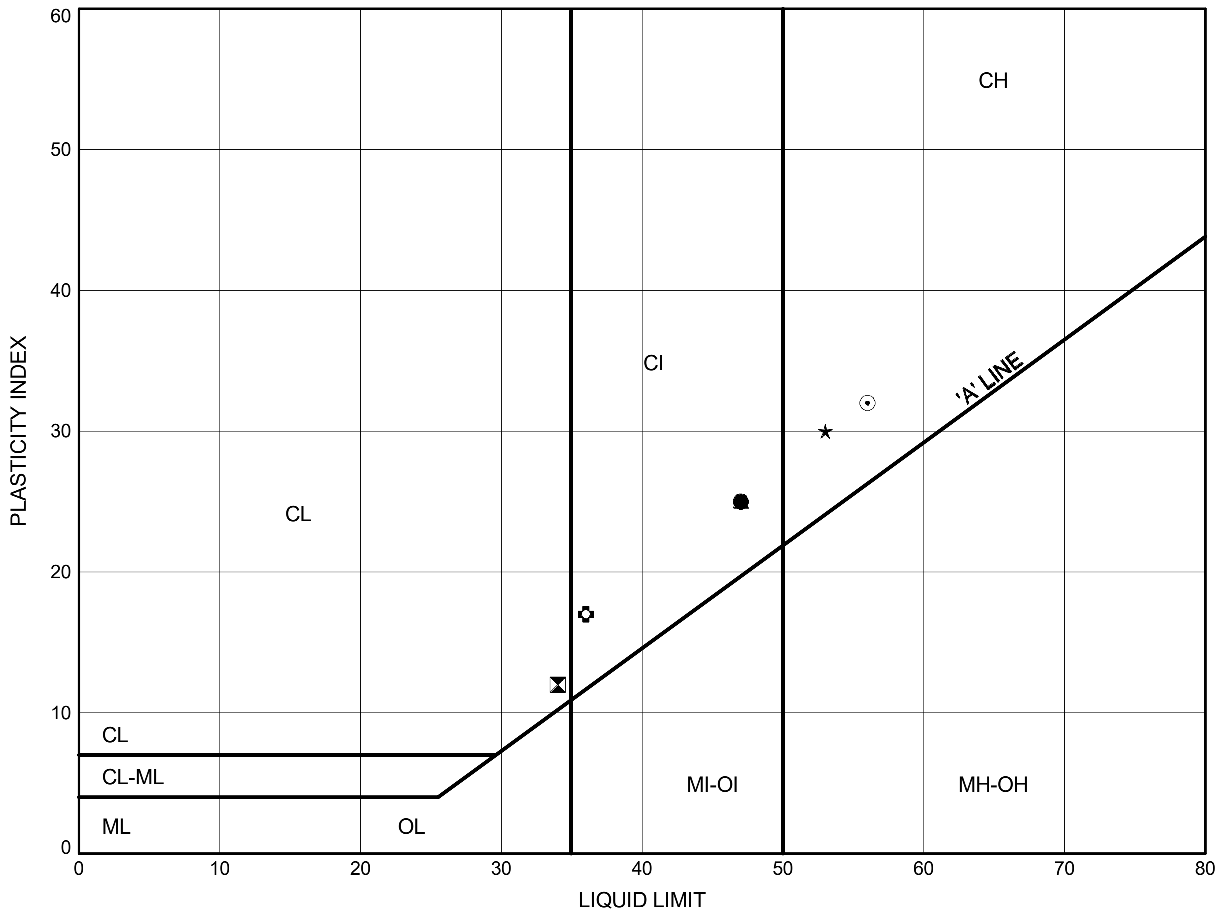
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C33

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-06	9.45	213.57
⧗	17-06	17.07	205.95
▲	17-08	5.64	217.51
★	17-08	8.69	214.46
☉	17-08	11.73	211.42
✿	17-10	15.54	207.41

THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

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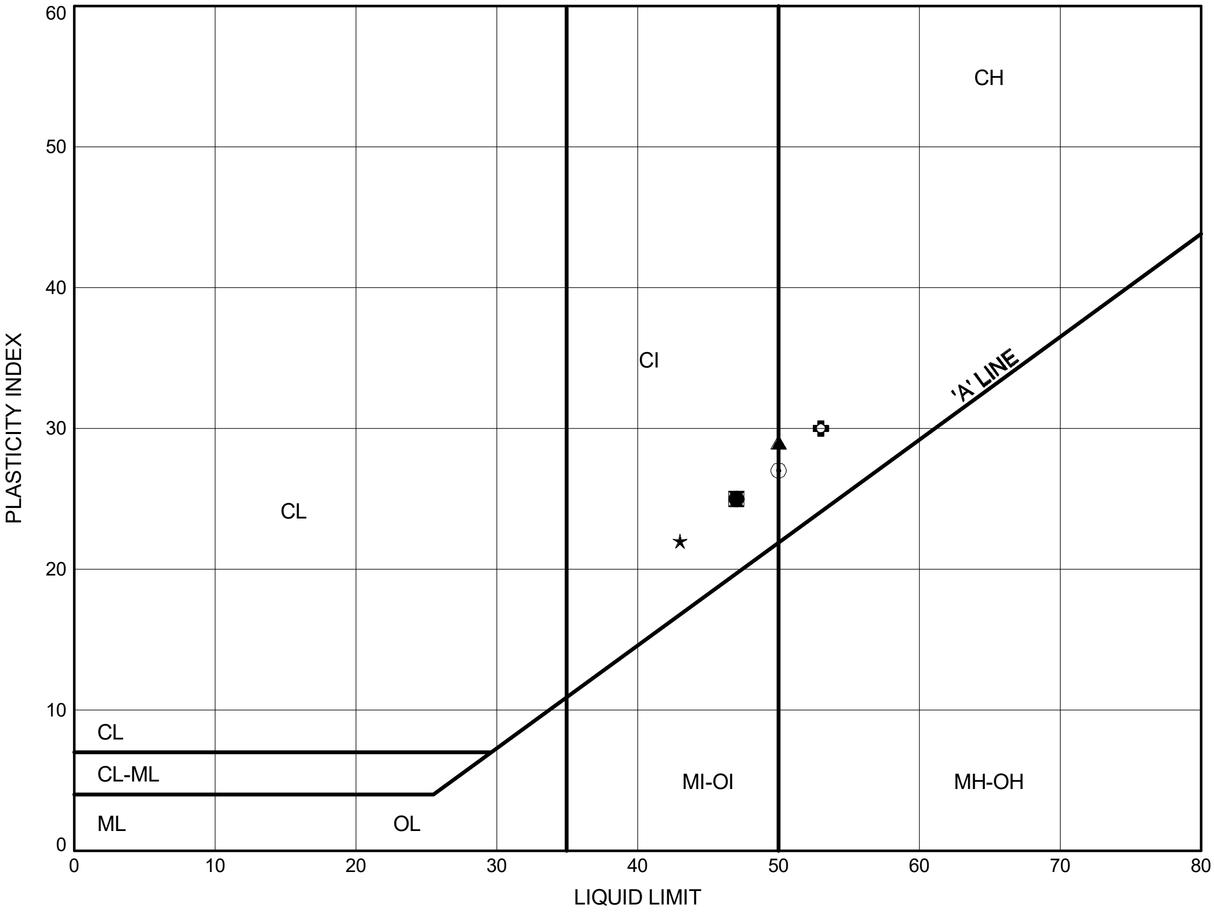
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C34

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-11	7.92	214.94
⧗	17-11	14.02	208.84
▲	17-12	10.97	211.79
★	17-12	18.59	204.17
⊙	17-16	7.92	214.90
✪	17-16	17.07	205.76

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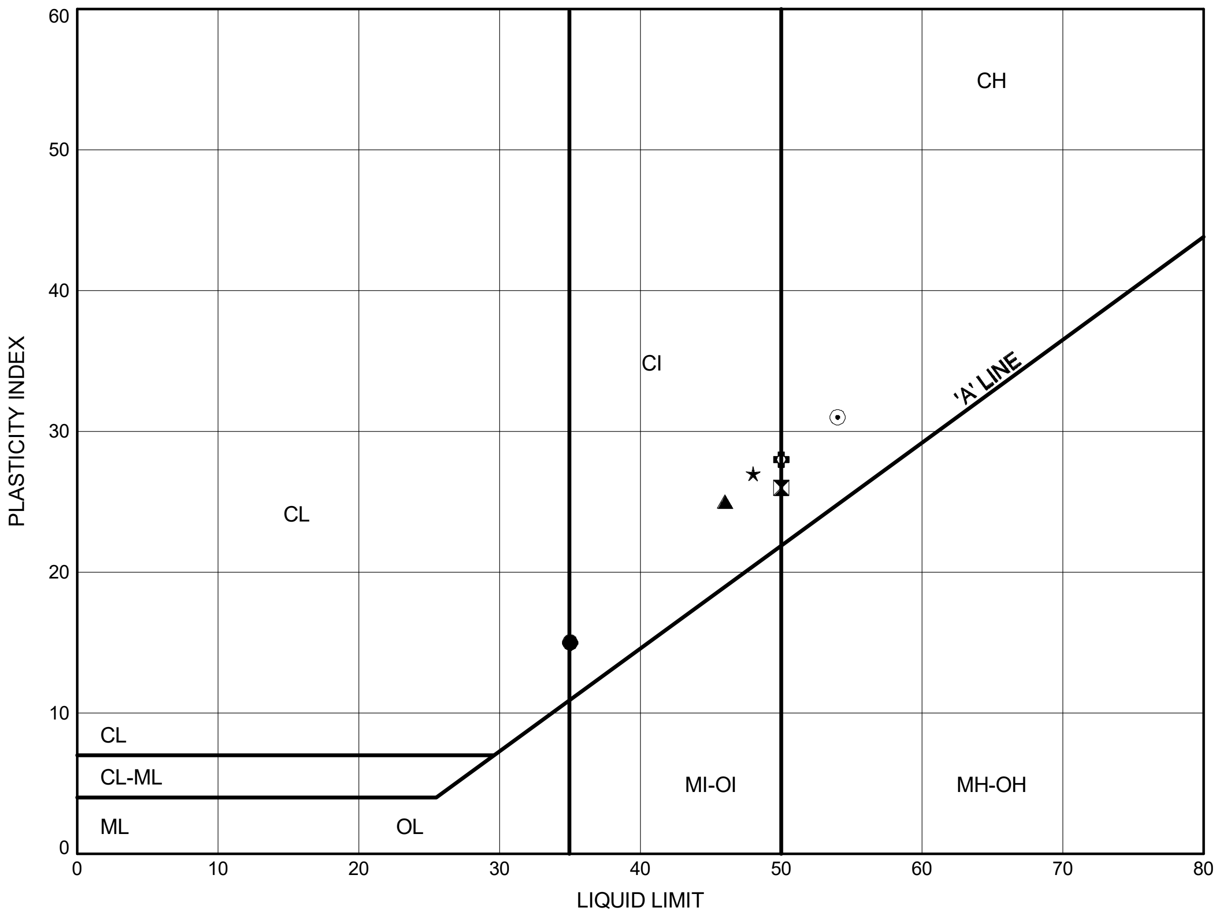
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C35

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-16	24.69	198.14
⧗	17-18	9.45	213.39
▲	17-18	14.02	208.81
★	17-18	18.59	204.24
⊙	17-19	7.16	215.52
✿	17-19	10.97	211.71

THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

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THURBER

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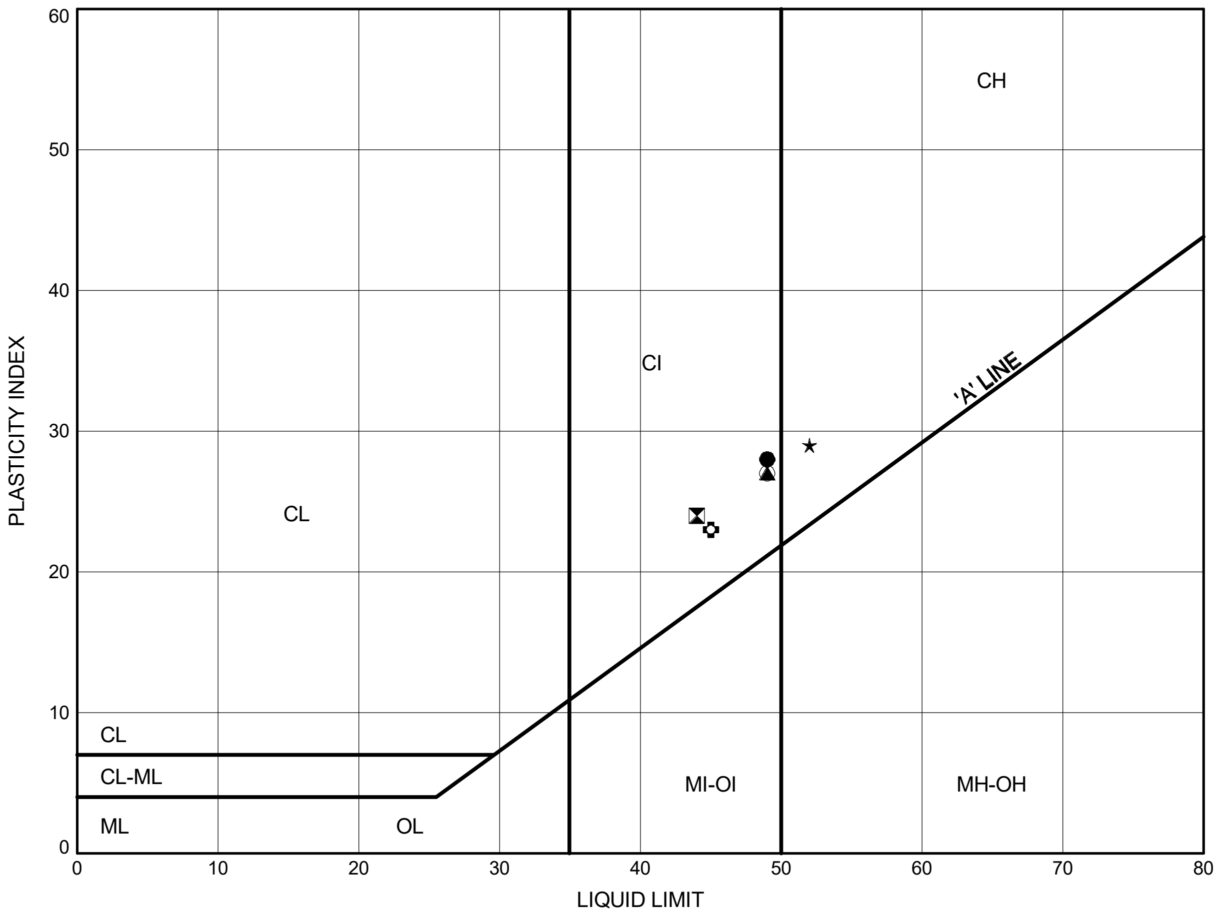
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C36

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-19	14.02	208.67
⧗	17-19	17.07	205.62
▲	17-19	18.59	204.09
★	17-20	9.45	213.51
⊙	17-20	12.50	210.46
✿	17-20	18.59	204.36

Date October 2017

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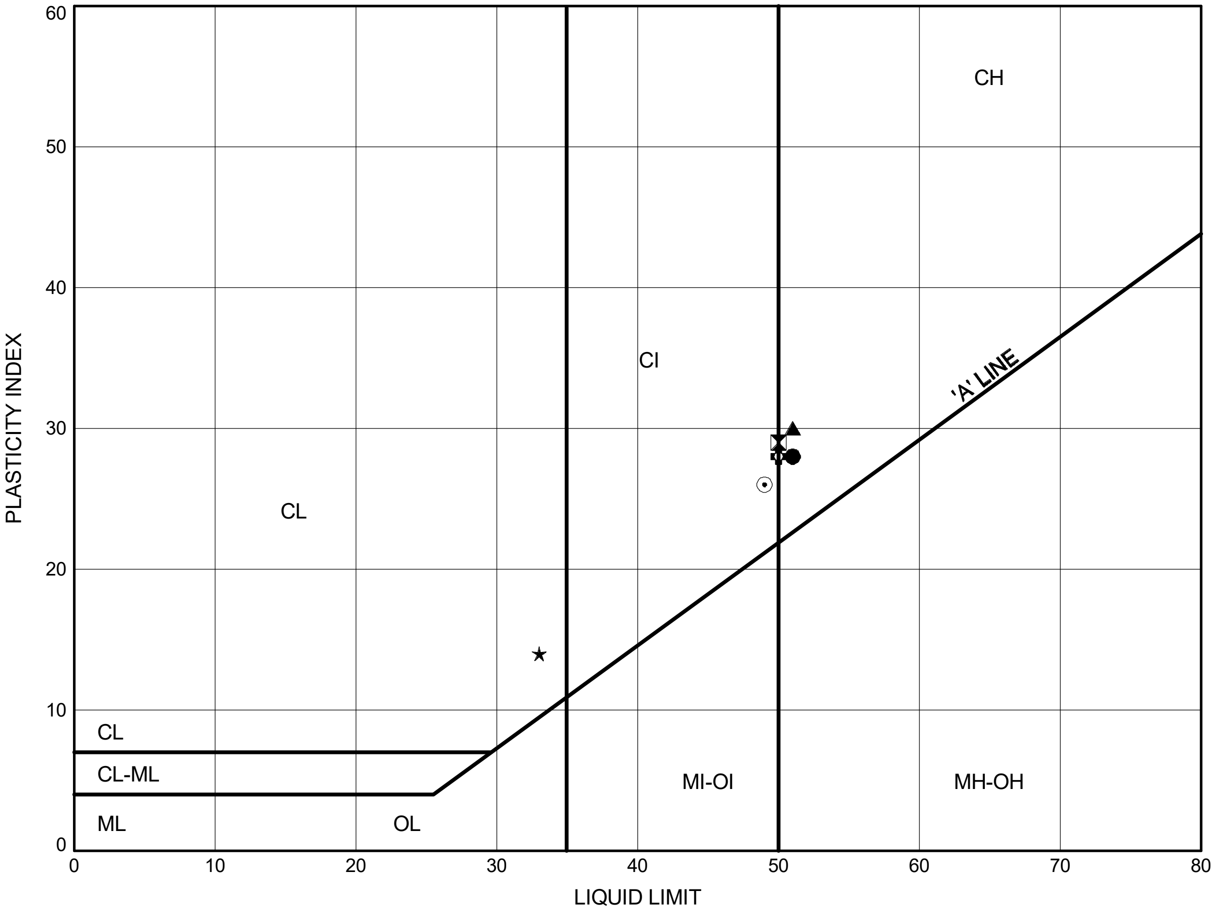
THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C37

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-21	6.40	216.42
⧗	17-22	7.92	215.29
▲	17-22	14.02	209.20
★	17-23	5.72	217.82
⊙	17-24	5.64	217.82
✿	17-24	10.91	212.55

THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

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THURBER

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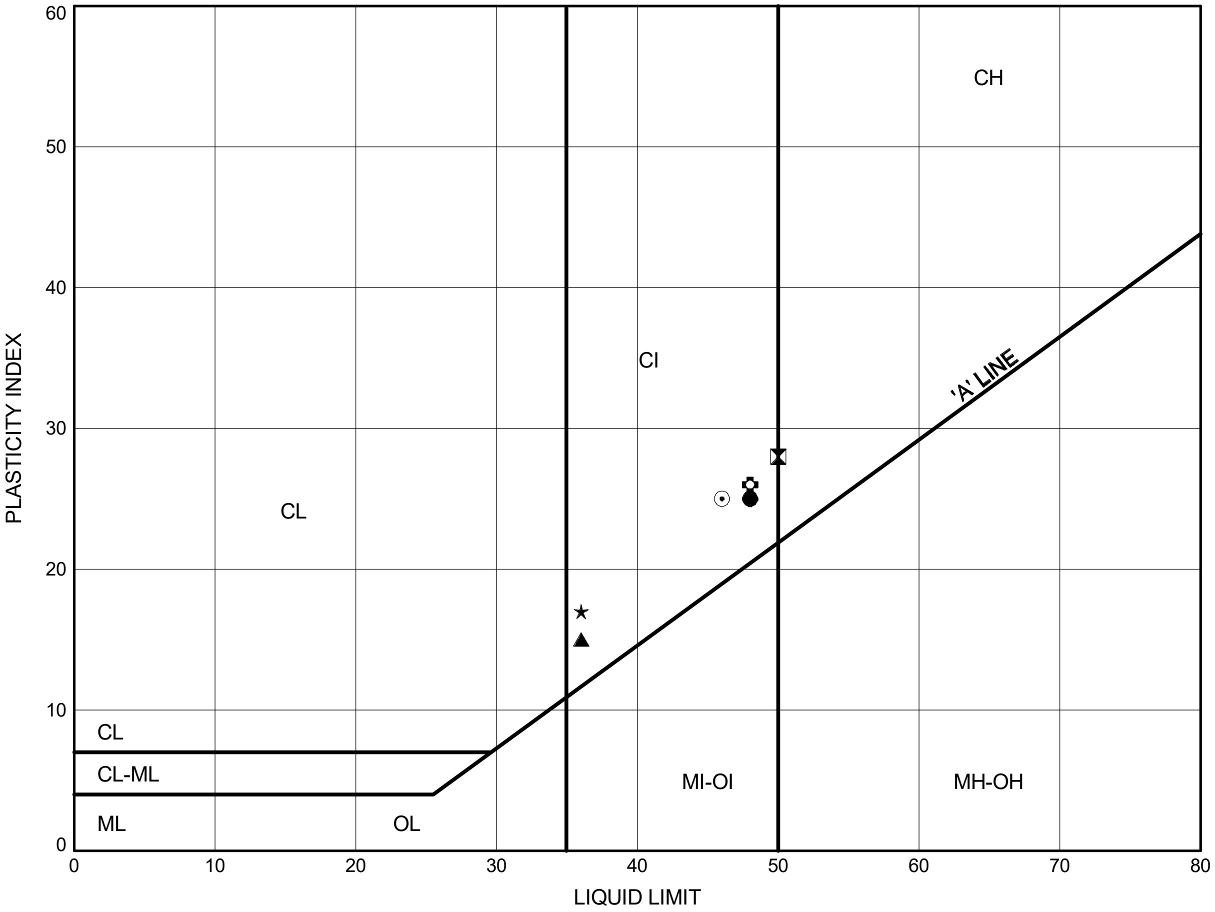
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C38

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-27	6.40	216.30
⧗	17-27	10.97	211.73
▲	17-27	17.07	205.63
★	17-28	5.33	217.26
⊙	17-29	6.40	216.41
✿	17-29	10.97	211.83

Date October 2017

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THURBER

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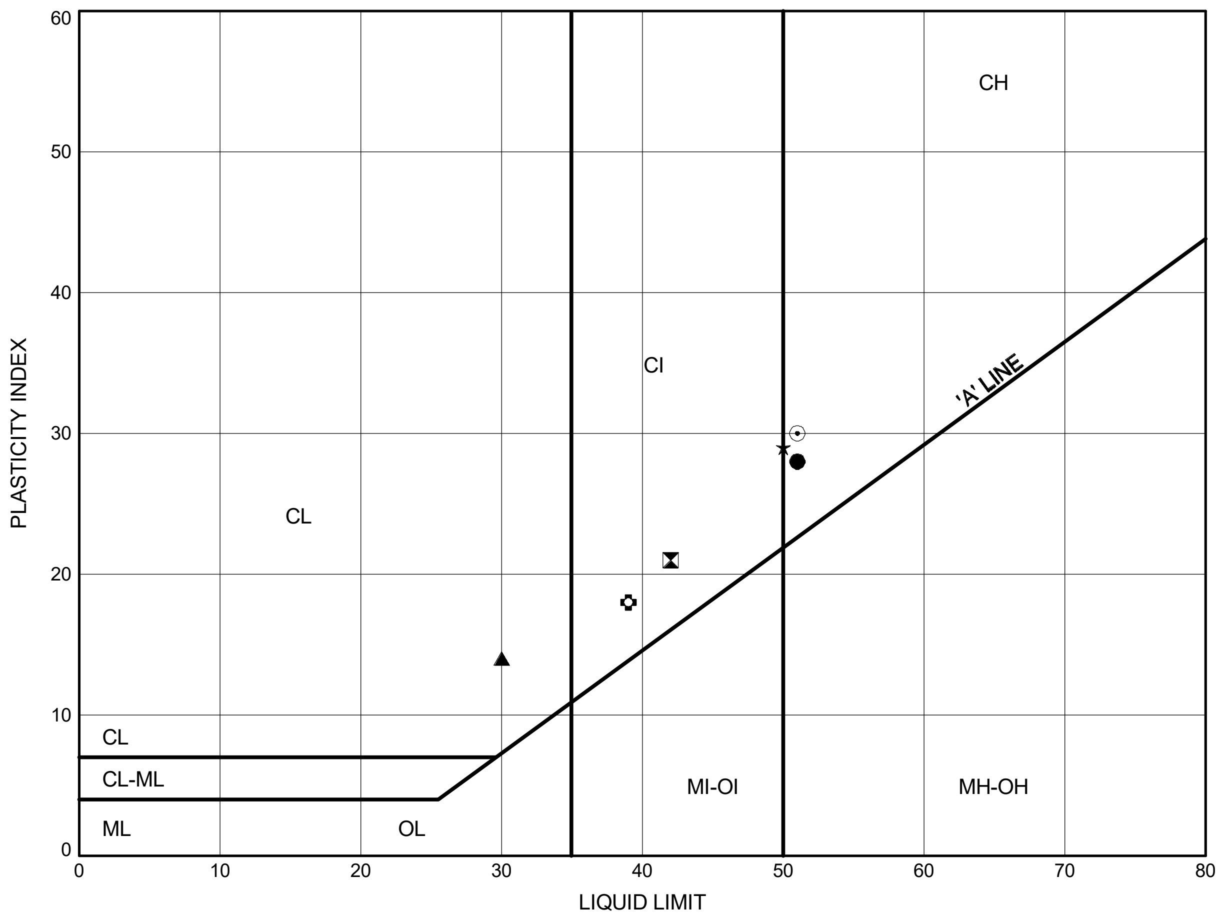
THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C39

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-29	12.50	210.31
⧗	17-29	18.59	204.21
▲	17-31	6.40	216.41
★	17-31	9.45	213.36
⊙	17-31	15.54	207.26
✿	17-31	21.64	201.17

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GWP# 5134-14-00

Prep'd CM

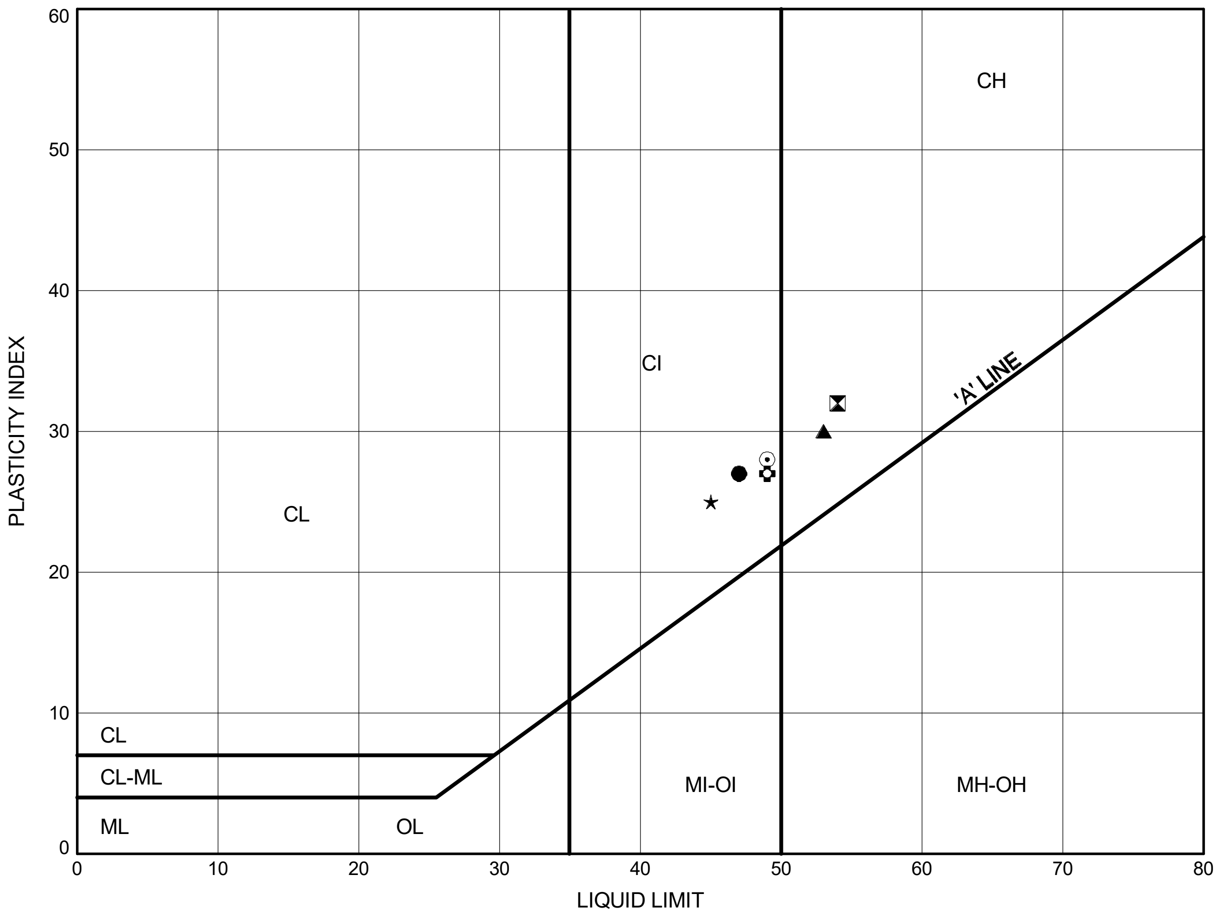
Chkd. SP

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C40

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-32	6.40	216.29
⧗	17-32	9.45	213.24
▲	17-32	17.07	205.62
★	17-32	21.64	201.05
⊙	17-35	7.92	215.14
✿	17-35	9.45	213.61

Date October 2017

GWP# 5134-14-00

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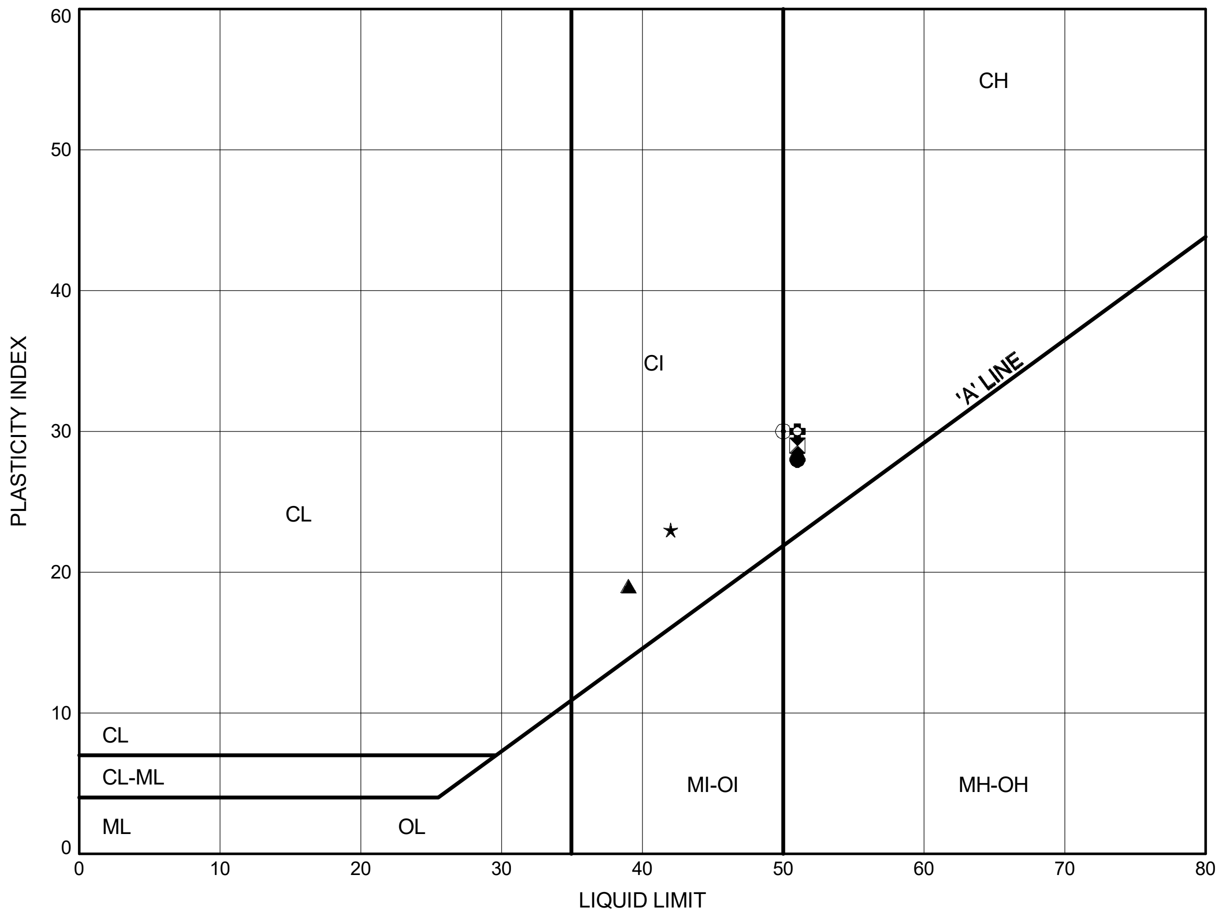
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C41

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-35	10.97	212.09
⧗	17-35	15.54	207.52
▲	17-35	21.64	201.42
★	17-38	5.72	217.11
⊙	17-39	7.92	214.89
✿	17-39	17.07	205.75

Date October 2017

GWP# 5134-14-00

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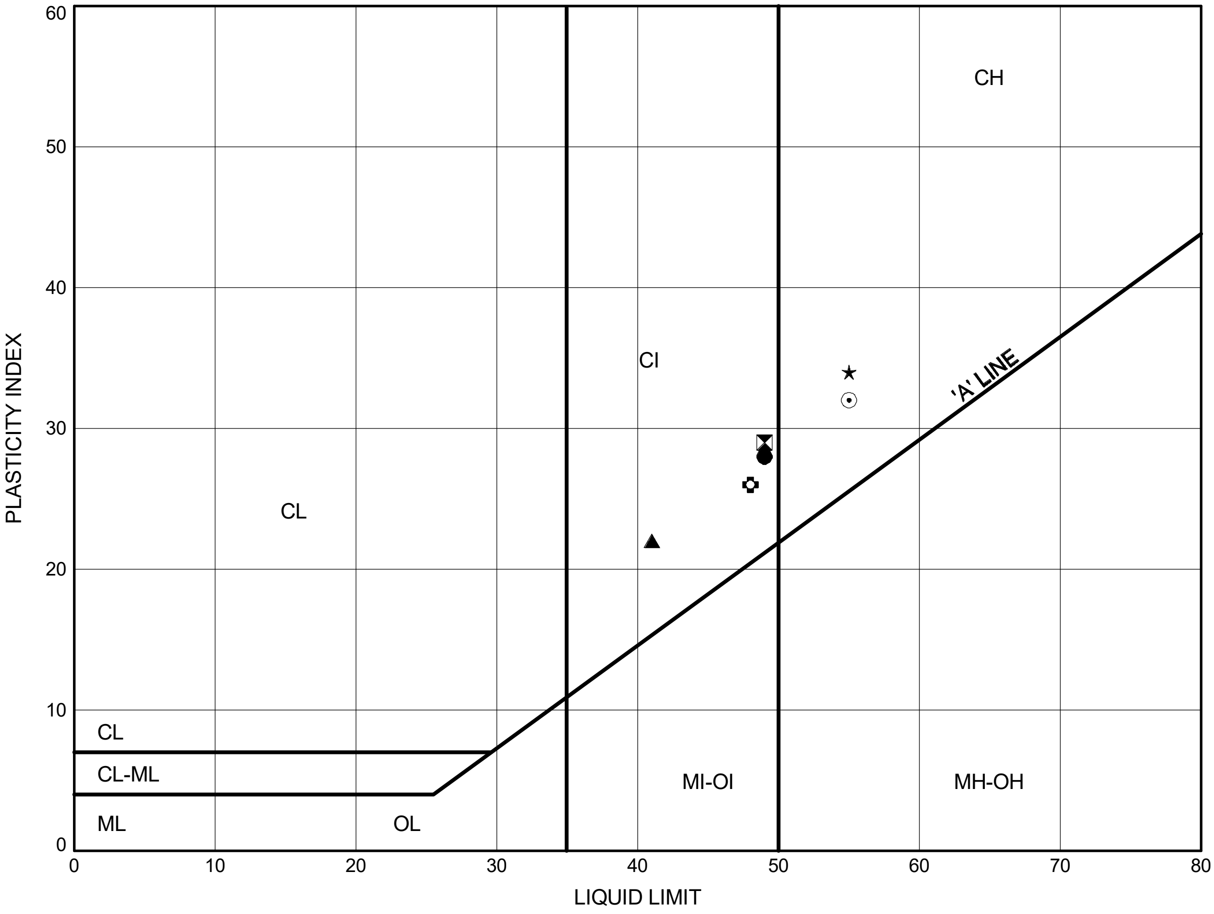
Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C42

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-42	6.40	216.36
⧗	17-42	10.97	211.79
▲	17-43	4.11	218.67
★	17-43	9.45	213.34
⊙	17-43	10.97	211.81
✪	17-44	6.40	216.22

THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

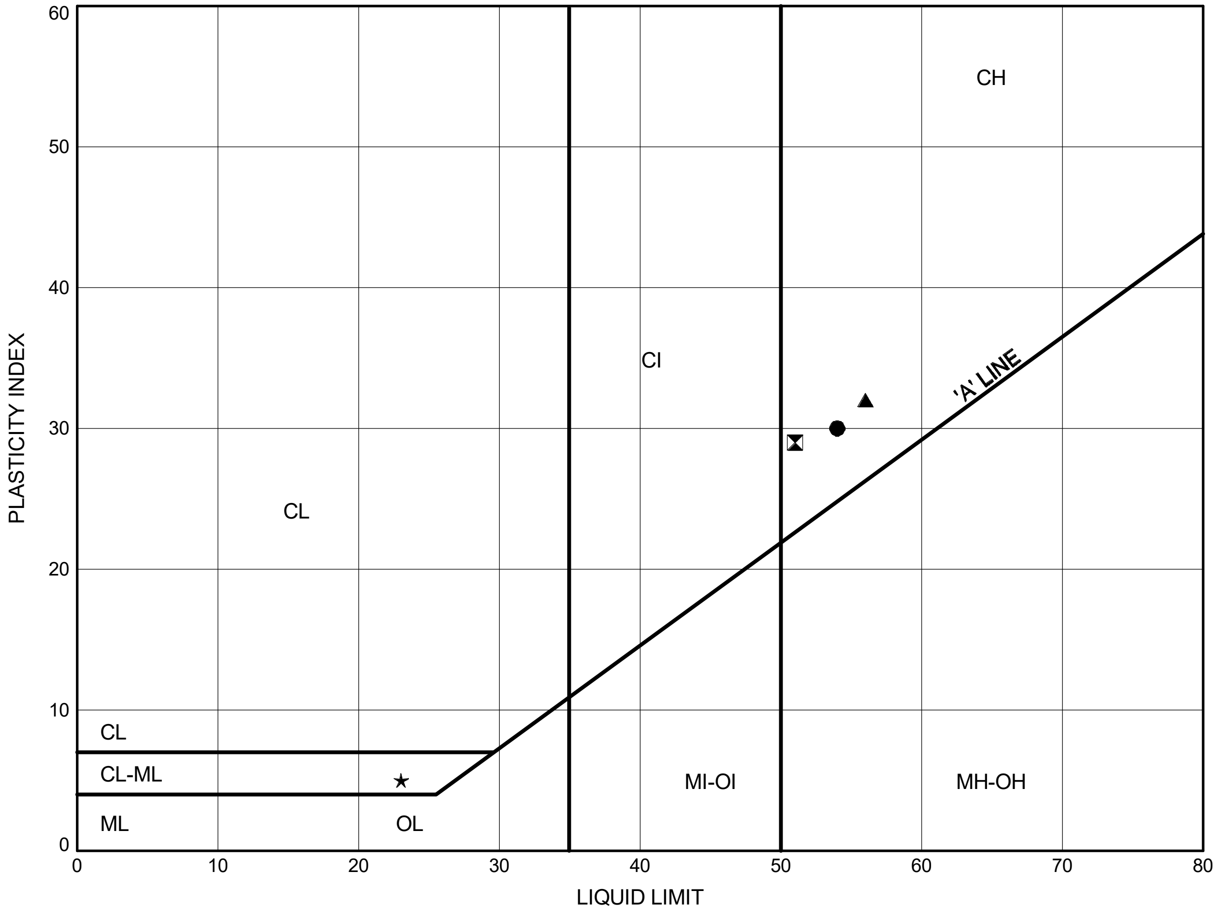
Chkd. SP

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C43

Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-44	14.02	208.60
⧗	17-46	4.11	218.68
▲	17-46	7.92	214.87
★	17-48	2.13	220.19

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

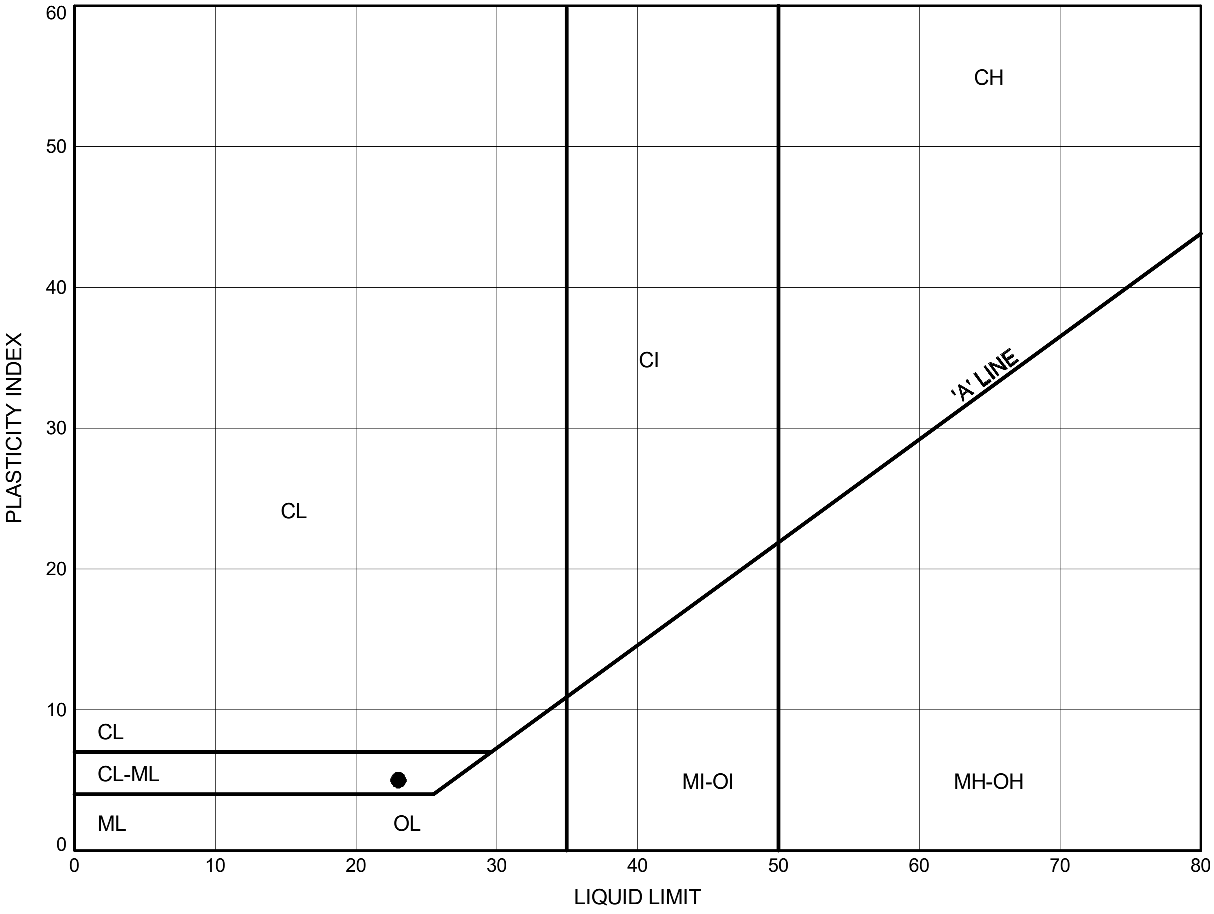
Chkd. SP

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C44

Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-18	24.69	198.15

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

Chkd. SP

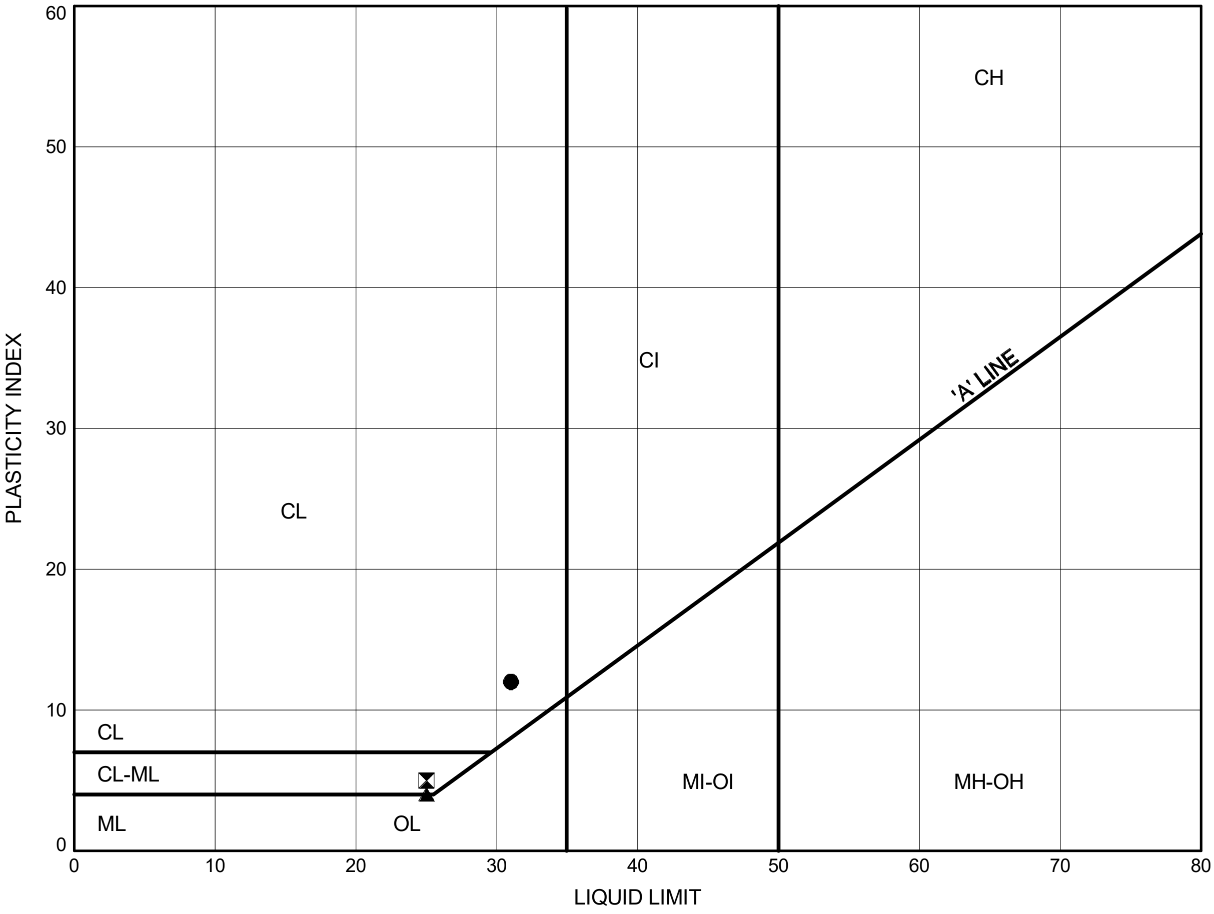
THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Jumbo Creek

ATTERBERG LIMITS TEST RESULTS

FIGURE C45

Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-26	4.34	218.30
⧗	17-48	0.44	221.88
▲	17-49	0.88	221.88

THURBALT 14967 - HWY 537 JUMBO CREEK.GPJ 23/10/17

Date October 2017

GWP# 5134-14-00

THURBER

Prep'd CM

Chkd. SP

Appendix C.3

Oedometer (One-Dimensional) Consolidation and Consolidated Undrained Triaxial Testing Results

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 1 OF 4

FIGURE

TEST STAGE	A	B	C
BOREHOLE NUMBER		BH17-8	
SAMPLE		ST1	
SPECIMEN DIAMETER, cm	5.10	5.12	5.09
SPECIMEN HEIGHT, cm	10.16	10.13	10.16
NATURAL WATER CONTENT, %	60.8	65.7	63.5
DRY DENSITY, Mg/m^3	1.024	0.977	1.005
WATER CONTENT AFTER SATURATION, %	61.1	66.5	65.7
CELL PRESSURE, σ_3, kPa	315.0	275.0	515.0
BACK PRESSURE, kPa	200.0	130.0	340.0
PORE PRESSURE PARAMETER "B"	0.96	0.96	0.96
EFFECTIVE CONSOLIDATION STRESS, σc, kPa	115.0	145.0	175.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	14.3	17.6	17.8
WATER CONTENT AFTER CONSOLIDATION, %	47.1	48.5	48.0
AVERAGE RATE OF STRAIN, %/hr	0.50	0.50	0.50
TIME TO FAILURE, HOURS	12.9	12.2	11.2
WATER CONTENT AFTER TEST, %	47.4	48.5	45.4
MAX. DEVIATOR STRESS, (σ_1-σ_3), kPa	82.5	96.8	113.9
AXIAL STRAIN AT (σ_1-σ_3) maximum, %	6.4	6.1	5.6
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1/σ'_3) maximum	3.0	3.3	3.0
DEVIATOR STRESS AT (σ'_1/σ'_3) maximum, kPa	77.5	91.3	99.6
AXIAL STRAIN AT (σ'_1/σ'_3) maximum, %	8.8	13.7	13.1
PORE PRESSURE PARAMETER, Af, AT (σ_1-σ_3) maximum	0.89	0.97	0.98
PORE PRESSURE PARAMETER, Af, AT (σ'_1/σ'_3) maximum	0.99	1.15	1.26
FILTER DRAINS USED, y/n	y	y	y

TEST NOTES: Effective consolidation stresses are assigned by the client.
Specimen A taken 4-17cm from top of the tube.
Specimen B taken 17-29cm from top of the tube.
Specimen C taken 29-40cm from top of the tube.

FAILURE PLANE NUMBER	-	-	-
ANGLE OF FAILURE, DEGREES	Bulged	Bulged	Bulged

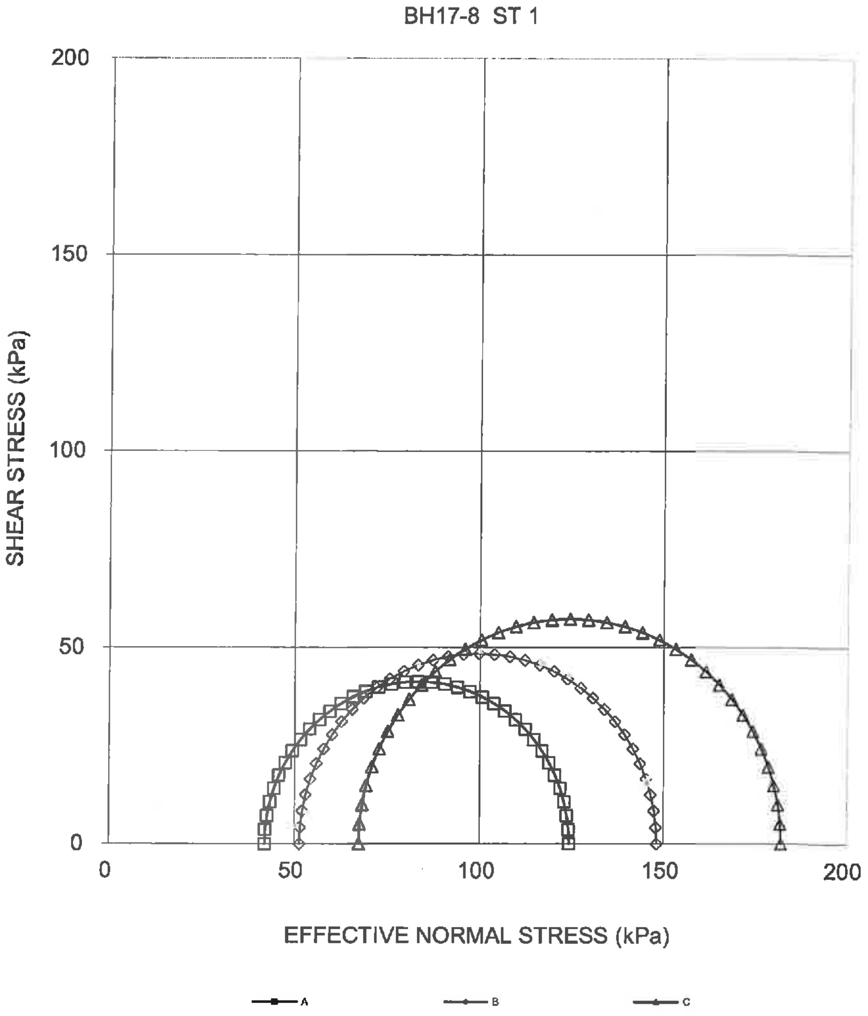
Date: 05/02/2017
Project No. 1778186(1000)

Golder Associates

Prepared By LH
Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 2 OF 4

FIGURE



Date: 05/02/2017

Project No. 1778186(1000)

Golder Associates

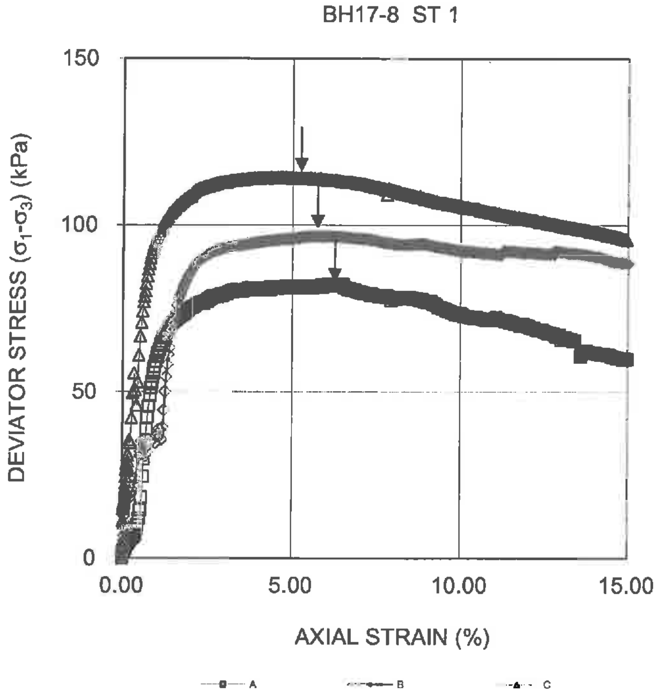
Prepared By LH

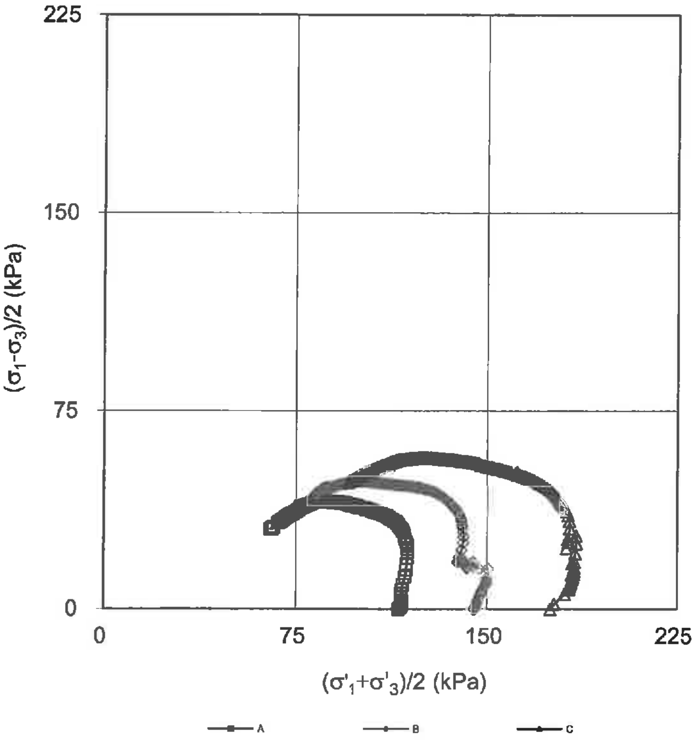
Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 3 OF 4

FIGURE

BH17-8 ST 1





Date: 05/02/2017

Project No. 1778186(1000)

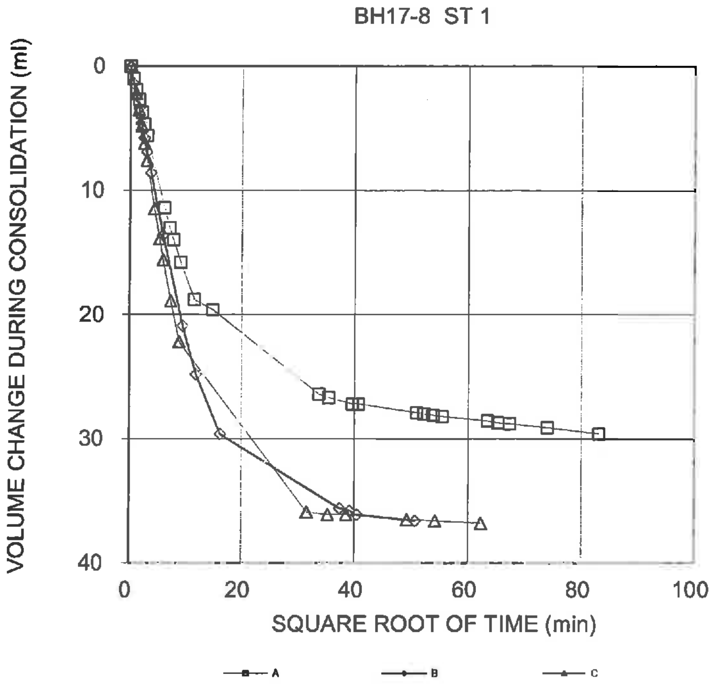
Golder Associates

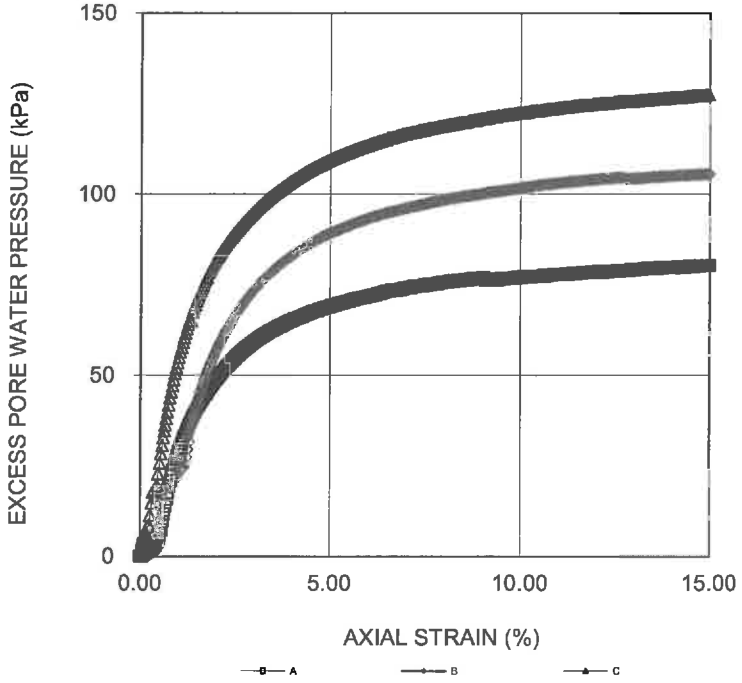
Prepared By LH

Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 4 OF 4

FIGURE





Date: 05/02/2017

Project No. 1778186(1000)

Golder Associates

Prepared By LH

Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 1 OF 4

FIGURE

TEST STAGE	A	B	C
BOREHOLE NUMBER		BH17-19	
SAMPLE		TW11	
SPECIMEN DIAMETER, cm	6.93	6.94	6.95
SPECIMEN HEIGHT, cm	13.99	13.96	13.97
NATURAL WATER CONTENT, %	60.1	58.8	58.8
DRY DENSITY, Mg/m^3	1.045	1.055	1.056
WATER CONTENT AFTER SATURATION, %	60.1	59.7	56.5
CELL PRESSURE, σ_3, kPa	265.0	295.0	395.0
BACK PRESSURE, kPa	130.0	130.0	200.0
PORE PRESSURE PARAMETER "B"	0.96	0.96	0.96
EFFECTIVE CONSOLIDATION STRESS, σc, kPa	135.0	165.0	195.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	15.0	18.3	22.8
WATER CONTENT AFTER CONSOLIDATION, %	45.8	42.3	34.8
AVERAGE RATE OF STRAIN, %/hr	0.50	0.50	0.50
TIME TO FAILURE, HOURS	14.6	15.5	15.1
WATER CONTENT AFTER TEST, %	45.8	43.2	34.8
MAX. DEVIATOR STRESS, $(\sigma_1-\sigma_3)$, kPa	79.9	106.1	126.1
AXIAL STRAIN AT $(\sigma_1-\sigma_3)$ maximum, %	7.3	7.8	7.6
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1/σ'_3) maximum	2.9	3.1	2.6
DEVIATOR STRESS AT (σ'_1/σ'_3) maximum, kPa	75.5	101.5	121.6
AXIAL STRAIN AT (σ'_1/σ'_3) maximum, %	14.3	14.9	13.3
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1-\sigma_3)$ maximum	1.08	1.03	0.87
PORE PRESSURE PARAMETER, Af, AT (σ'_1/σ'_3) maximum	1.26	1.15	0.97
FILTER DRAINS USED, y/n	y	y	y

TEST NOTES:

Effective consolidation stresses are assigned by the client.
Specimen A taken 7-22cm from top of the tube.
Specimen B taken 22-37cm from top of the tube.
Specimen C taken 37-50cm from top of the tube.

FAILURE PLANE NUMBER	-	-	-
ANGLE OF FAILURE, DEGREES	Bulged	Bulged	Bulged

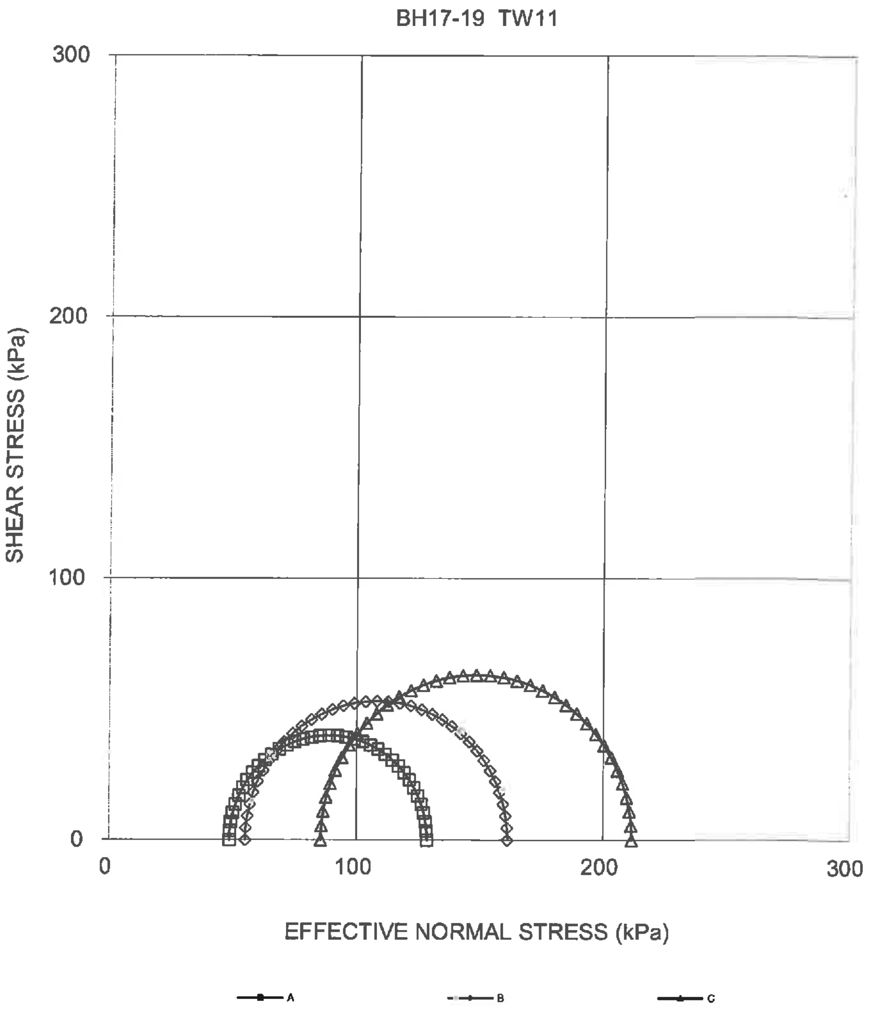
Date: 05/03/2017
Project No. 1778186(1000)

Golder Associates

Prepared By: LH
Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 2 OF 4

FIGURE



Date: 05/03/2017

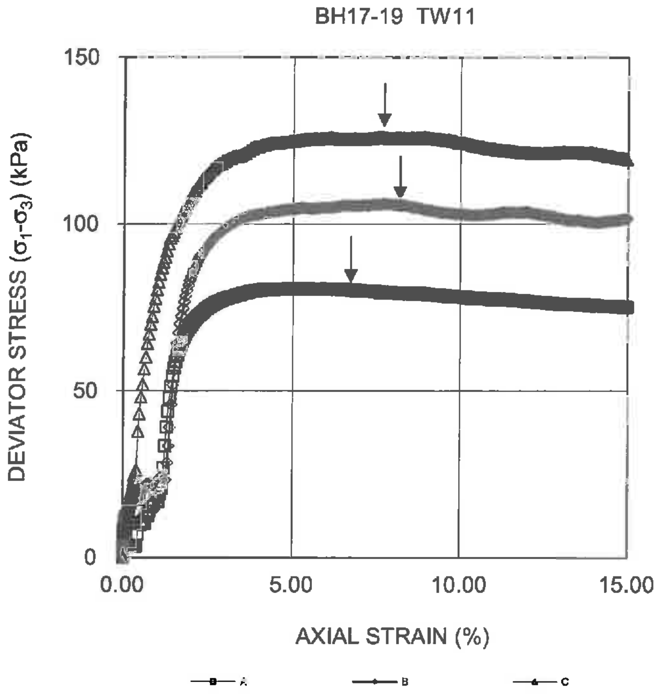
Project No. 1778186(1000)

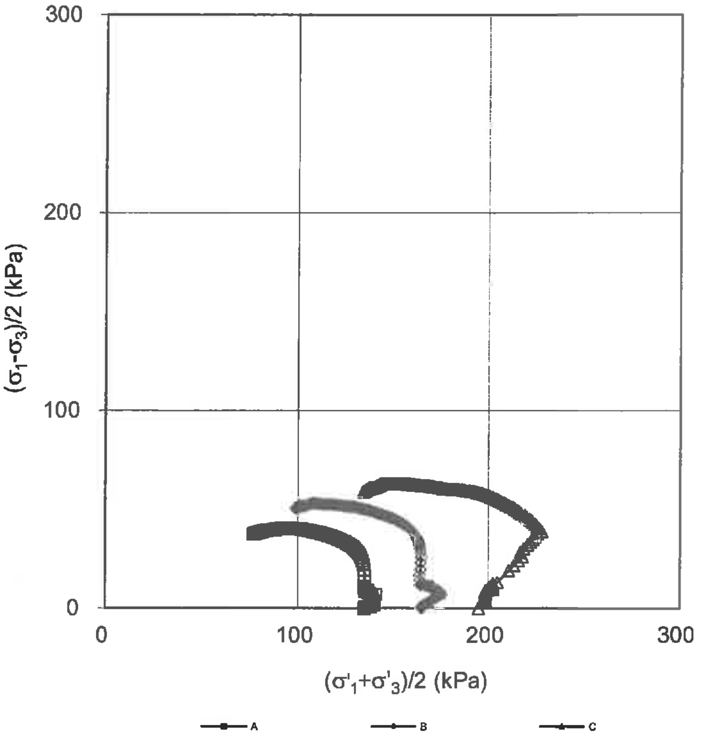
Golder Associates

Prepared By LH

Checked By:

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS ASTM D4767 SHEET 3 OF 4	FIGURE

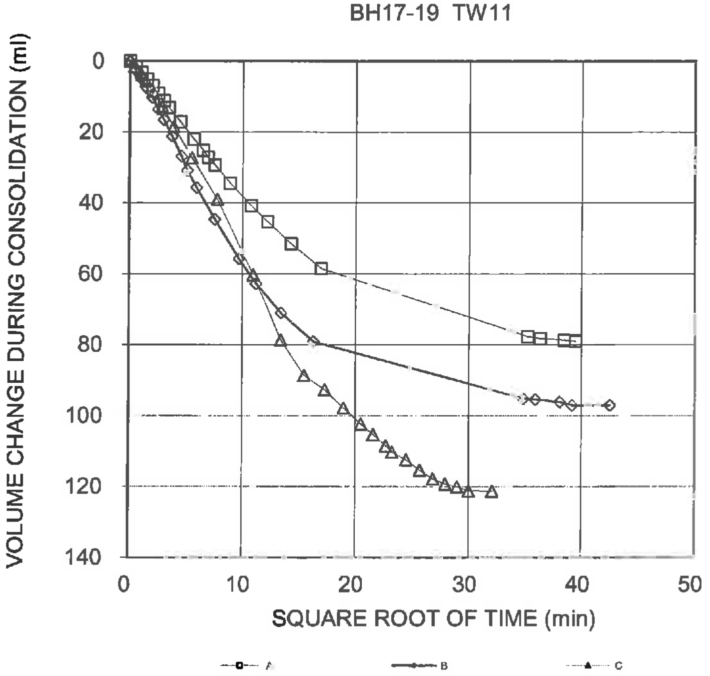


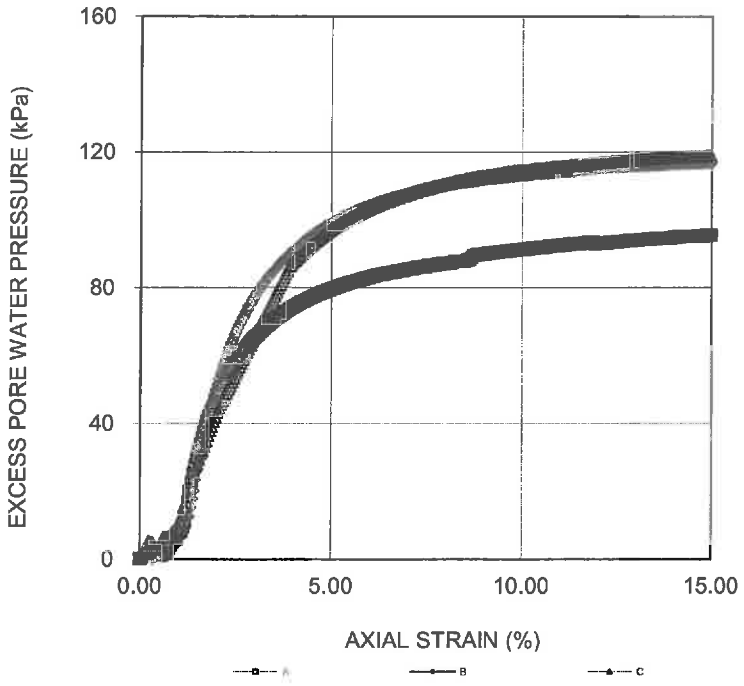


Date:	05/03/2017		Prepared By	LH
Project No.	1778186(1000)	**Golder Associates**	Checked By:	

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS
ASTM D4767
SHEET 4 OF 4

FIGURE





Date: 05/03/2017
Project No. 1778186(1000)

Golder Associates

Prepared By. LH
Checked By:

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW6
Borehole Number	17-18	Sample Depth, m	3.81-4.42

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	12		
Date Started	03/31/2017		
Date Completed	04/18/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.55	Unit Weight, kN/m^3	8.07
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	1.23
Area, cm^2	31.52	Specific Gravity, measured	1.44
Volume, cm^3	80.25	Solids Height, cm	0.222
Water Content, %	555.46	Volume of Solids, cm^3	7.00
Wet Mass, g	66.07	Volume of Voids, cm^3	73.25
Dry Mass, g	10.08	Degree of Saturation, %	76.4

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.546	10.464	2.546				
5.99	2.541	10.440	2.543				
10.62	2.507	10.288	2.524	135	1.00E-02	2.88E-03	2.82E-06
20.47	2.424	9.915	2.465	126	1.02E-02	3.30E-03	3.31E-06
39.98	2.198	8.896	2.311	226	5.01E-03	4.56E-03	2.24E-06
78.38	1.809	7.146	2.003	205	4.15E-03	3.97E-03	1.62E-06
156.54	1.465	5.598	1.637	290	1.96E-03	1.73E-03	3.32E-07
311.90	1.176	4.295	1.321	346	1.07E-03	7.31E-04	7.66E-08
622.65	0.953	3.291	1.064	454	5.29E-04	2.82E-04	1.46E-08
1243.85	0.788	2.549	0.871	735	2.19E-04	1.04E-04	2.23E-09
2488.40	0.648	1.918	0.718	1058	1.03E-04	4.42E-05	4.48E-10
622.65	0.700	2.151	0.674				
156.54	0.775	2.490	0.737				
39.98	0.880	2.963	0.828				
10.78	0.966	3.347	0.923				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 8-13cm from top of the tube.

Specimen swelled under 5.99 kPa.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	0.97	Unit Weight, kN/m^3	10.19
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	3.25
Area, cm^2	31.52	Specific Gravity, measured	1.44
Volume, cm^3	30.43	Solids Height, cm	0.222
Water Content, %	213.59	Volume of Solids, cm ^{3}	7.00
Wet Mass, g	31.61	Volume of Voids, cm ^{3}	23.43
Dry Mass, g	10.08		

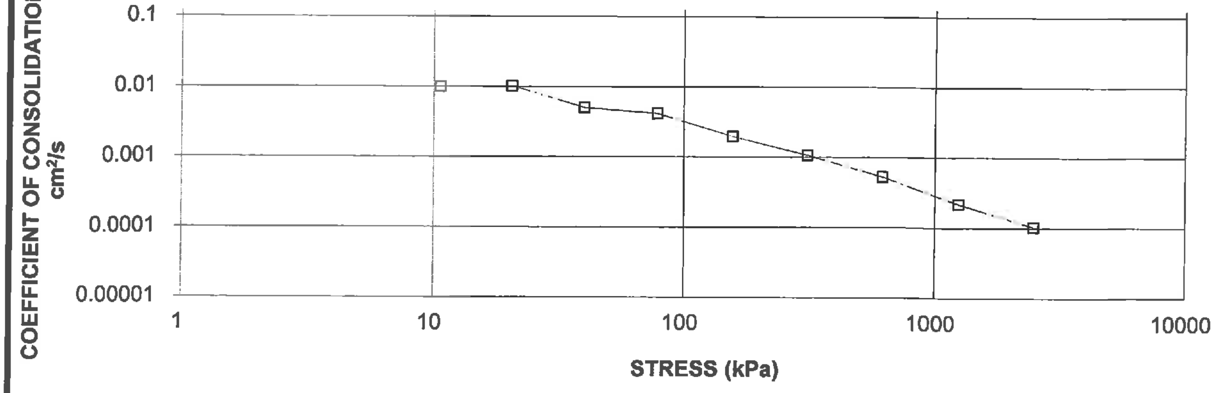
Prepared By: LH

Golder Associates

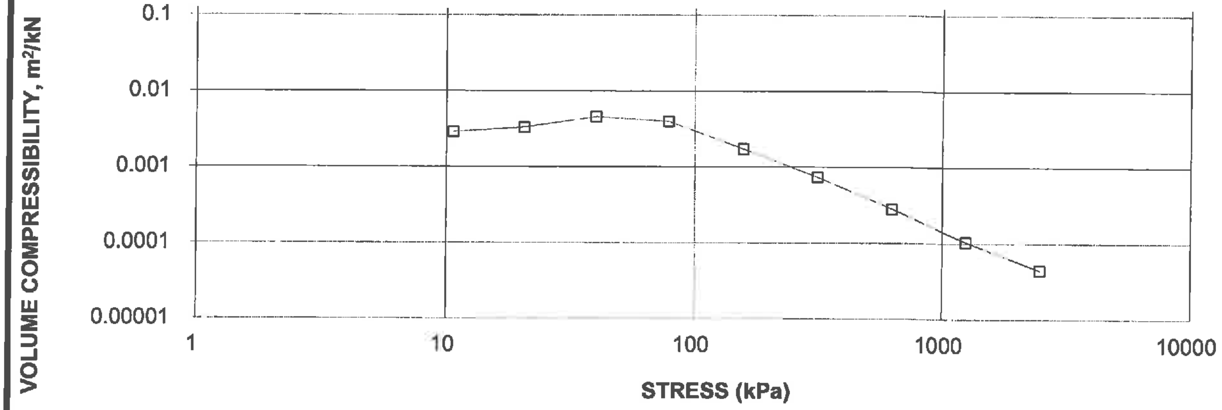
Checked By:

CONSOLIDATION TEST SUMMARY

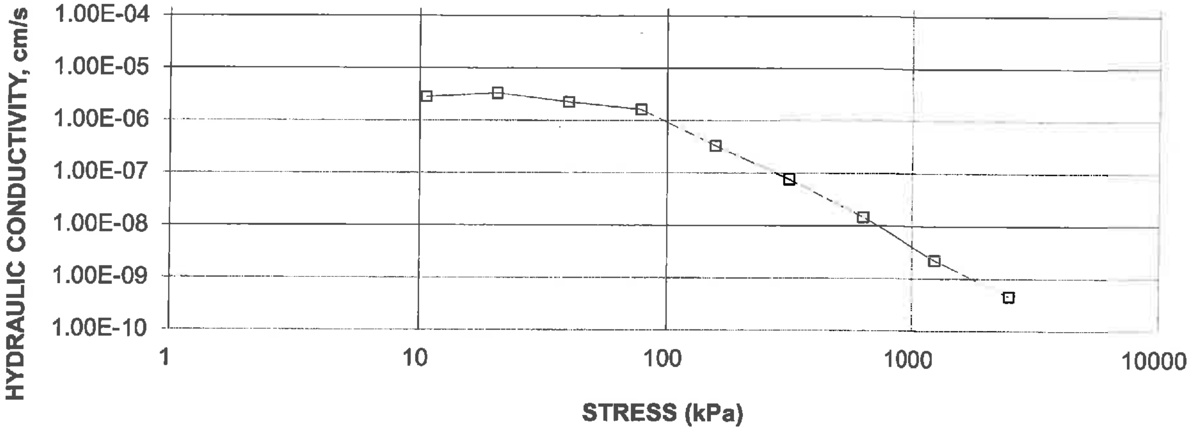
FIGURE



CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH 17-18 SA TW6



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH 17-18 SA TW6



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-18 SA TW6

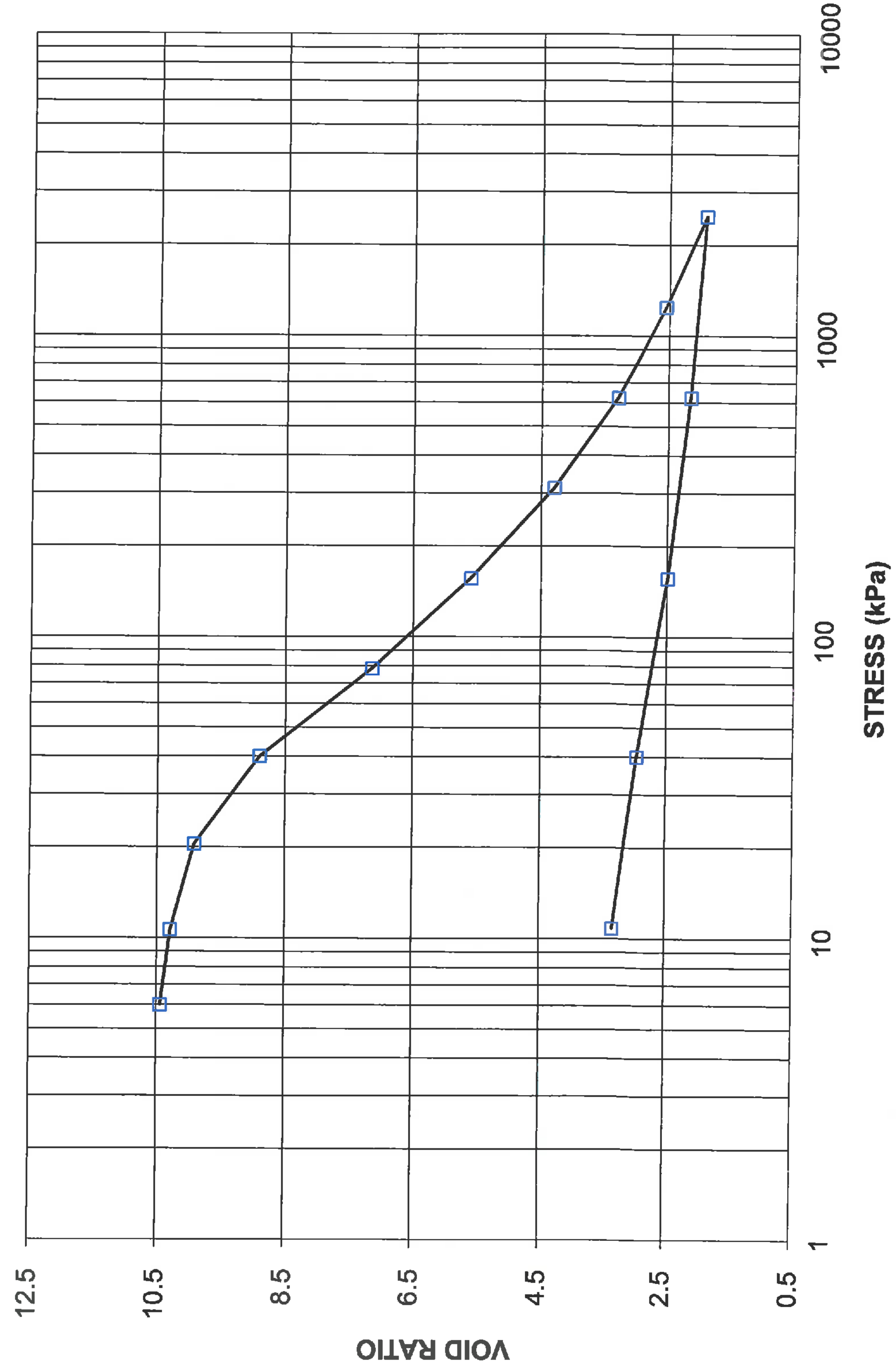
Project No. 1778186(1000)
Prepared By: LH

Golder Associates

Checked By:

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE



CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 17-18 SA TW6

Project No. 1778186(1000)

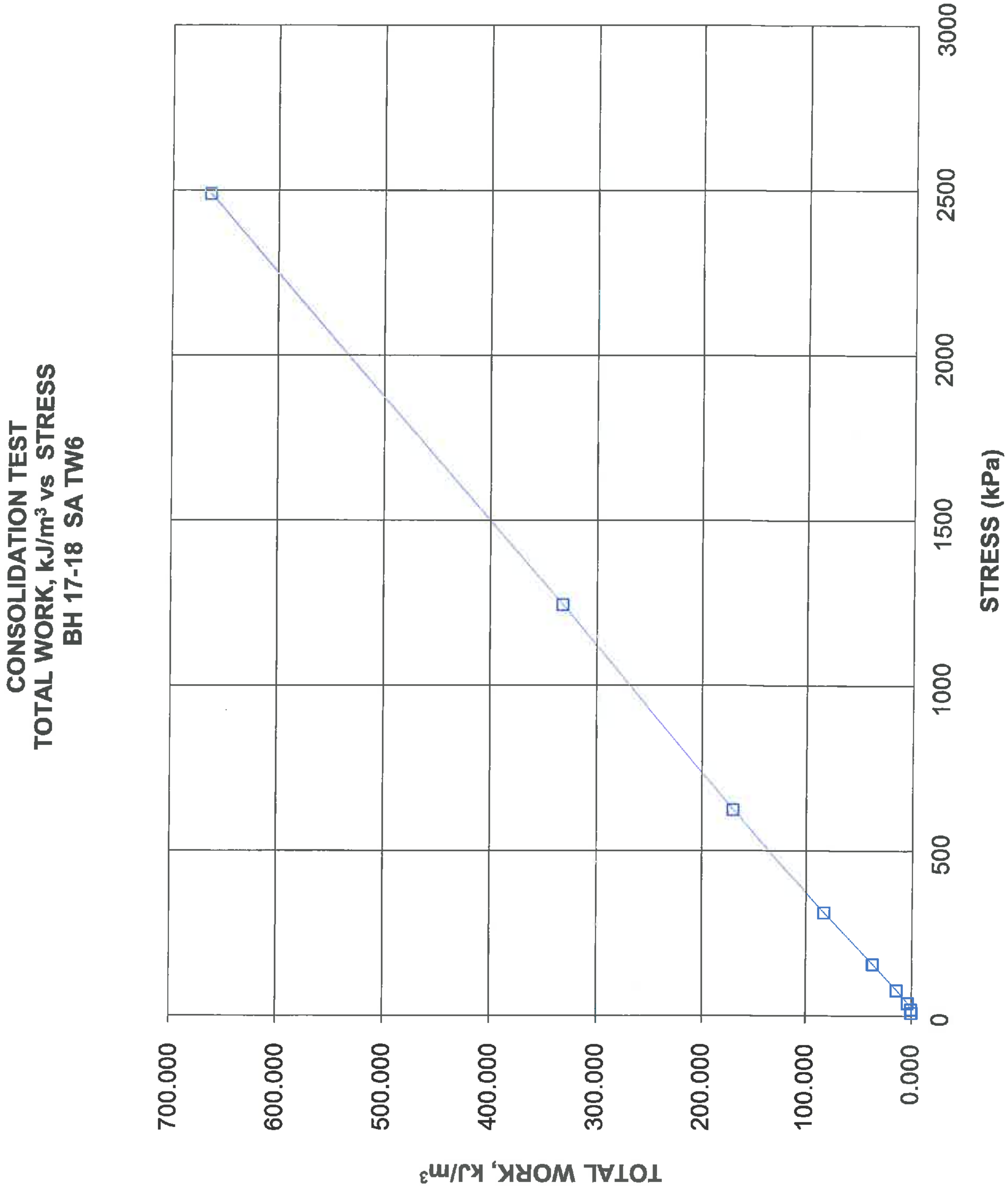
Prepared By: LH

Golder Associates

Checked By:

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE



Project No. 1778186(1000)

Prepared By: LH

Golder Associates

Checked By: LL

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW5
Borehole Number	17-37	Sample Depth, m	-

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	11		
Date Started	03/31/2017		
Date Completed	04/21/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.54	Unit Weight, kN/m^3	10.12
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	1.07
Area, cm^2	31.47	Specific Gravity, measured	1.58
Volume, cm^3	80.06	Solids Height, cm	0.176
Water Content, %	843.04	Volume of Solids, cm^3	5.54
Wet Mass, g	82.61	Volume of Voids, cm^3	74.52
Dry Mass, g	8.76	Degree of Saturation, %	99.1

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.544	13.440	2.544				
5.88	2.353	12.356	2.449	2241	5.67E-04	1.28E-02	7.10E-07
10.69	2.123	11.049	2.238	1500	7.08E-04	1.88E-02	1.31E-06
20.65	1.783	9.122	1.953	1949	4.15E-04	1.34E-02	5.45E-07
40.06	1.356	6.695	1.569	2471	2.11E-04	8.66E-03	1.79E-07
79.00	1.116	5.337	1.236	3275	9.89E-05	2.42E-03	2.34E-08
156.68	0.882	4.003	0.999	4133	5.12E-05	1.19E-03	5.96E-09
312.29	0.697	2.956	0.789	5245	2.52E-05	4.66E-04	1.15E-09
623.51	0.558	2.169	0.628	2693	3.10E-05	1.75E-04	5.32E-10
1245.71	0.456	1.588	0.507	2982	1.83E-05	6.47E-05	1.16E-10
2490.99	0.374	1.123	0.415	3025	1.21E-05	2.59E-05	3.06E-11
623.51	0.413	1.342	0.393				
156.74	0.477	1.706	0.445				
40.05	0.552	2.132	0.514				
10.74	0.648	2.675	0.600				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Load stage of 40kPa was held for a week as per clients request

Specimen taken 24-31cm from top of the tube.

Specimen is very soft and wet organic peat sample and contains fibers and wood pieces.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	0.65	Unit Weight, kN/m^3	11.44
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	4.22
Area, cm^2	31.47	Specific Gravity, measured	1.58
Volume, cm^3	20.38	Solids Height, cm	0.176
Water Content, %	171.46	Volume of Solids, cm ^{3}	5.54
Wet Mass, g	23.78	Volume of Voids, cm ^{3}	14.83
Dry Mass, g	8.76		

Prepared By: LH

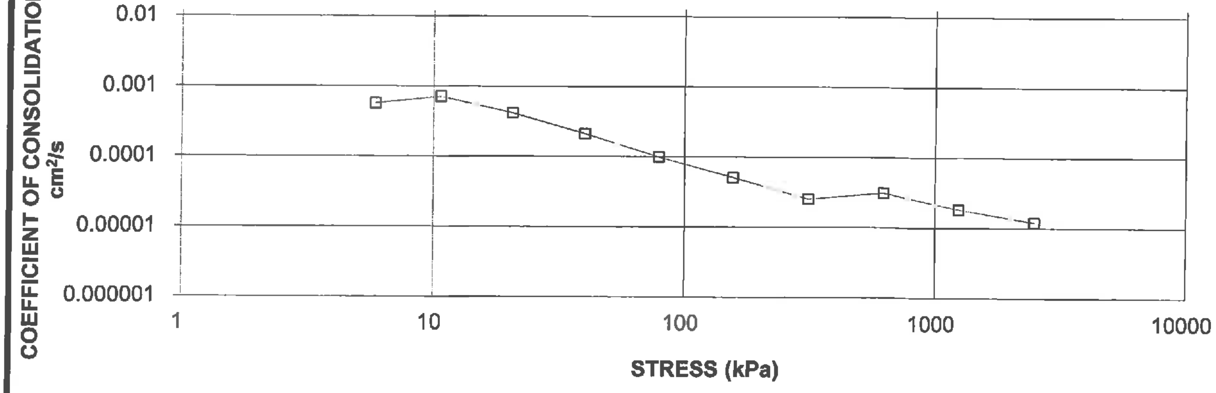
Golder Associates

Checked By:

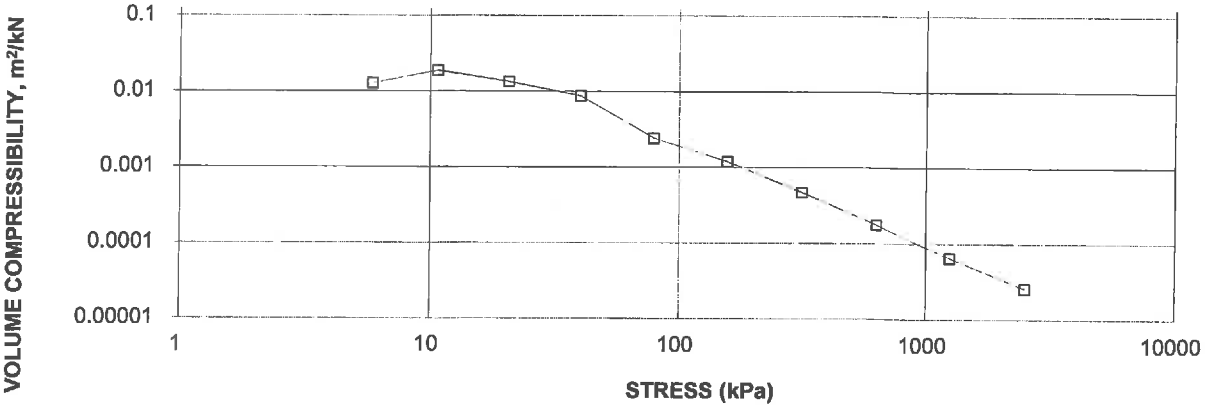
CONSOLIDATION TEST SUMMARY

FIGURE

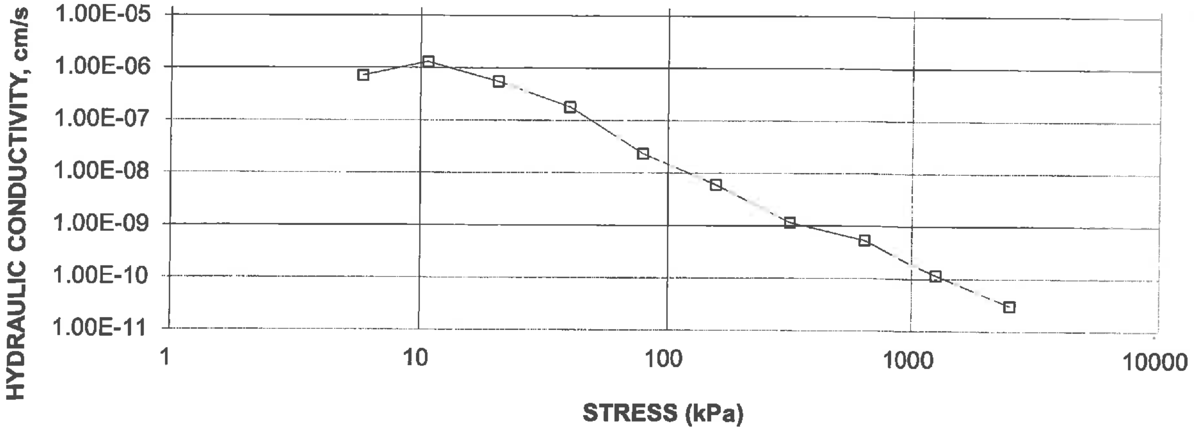
CONSOLIDATION TEST
CV cm^2/s VS STRESS (kPa)
BH 17-37 SA TW5



CONSOLIDATION TEST
MV m^2/kN vs STRESS (kPa)
BH 17-37 SA TW5



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-37 SA TW5



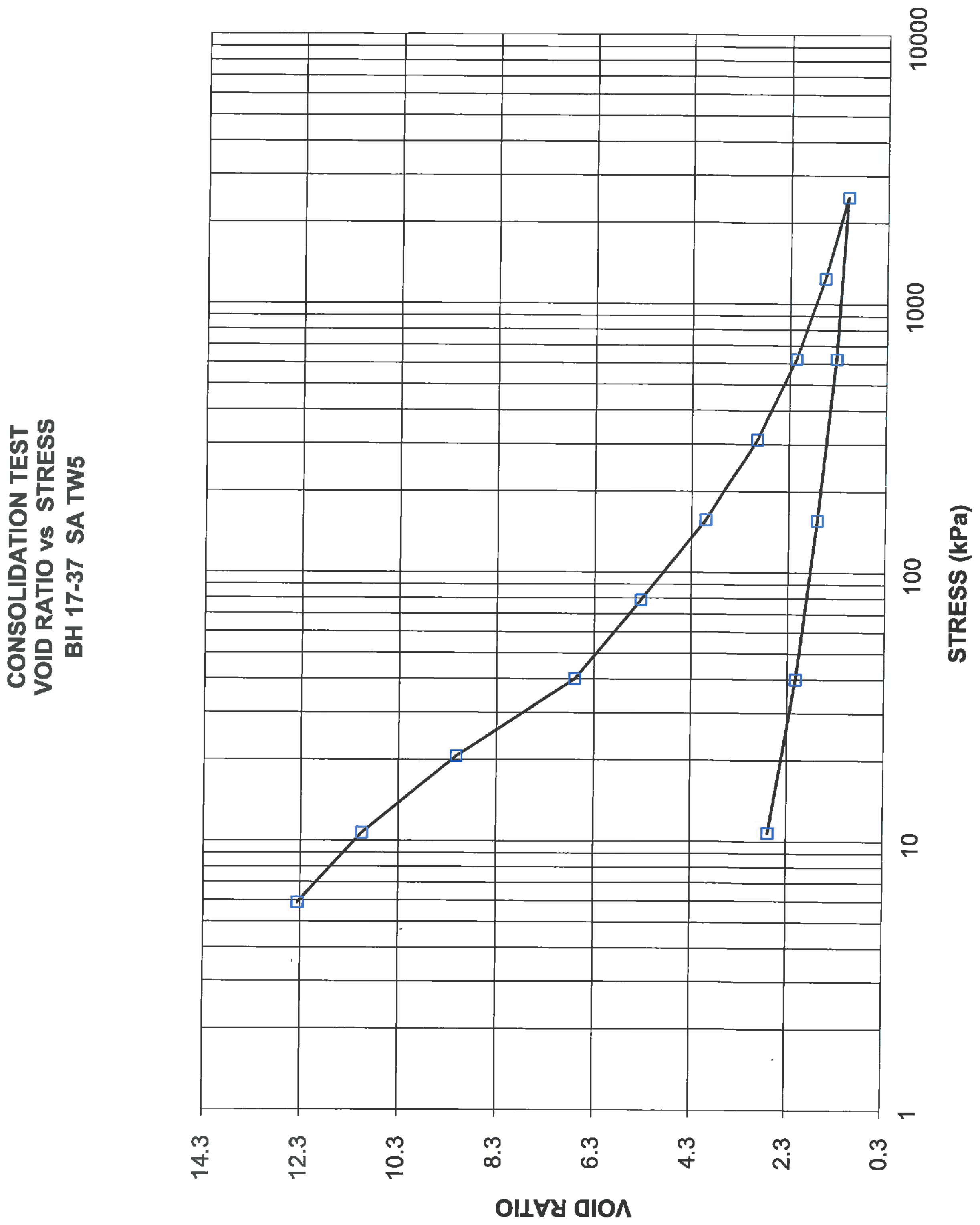
Project No. 1778186(1000)
Prepared By: LH

Golder Associates

Checked By:

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE



Project No. 1778186(1000)

Prepared By: LH

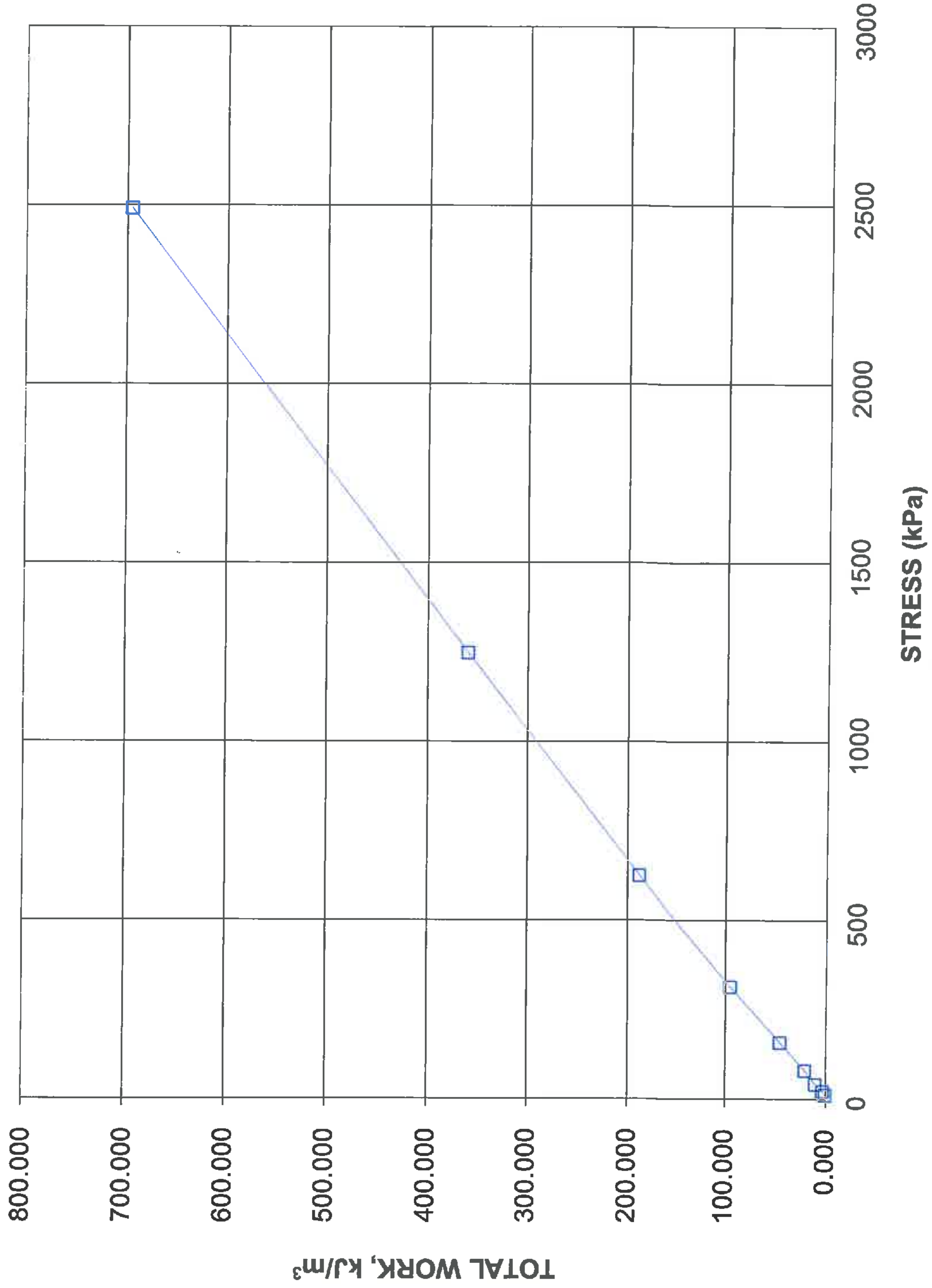
Golder Associates

Checked By:

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH 17-37 SA TW5



Project No. 1778186(1000)

Prepared By: LH

Golder Associates

Checked By:

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW13
Borehole Number	17-19	Sample Depth, m	-

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	2		
Date Started	03/24/2017		
Date Completed	04/10/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.53	Unit Weight, kN/m^3	15.76
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	9.45
Area, cm^2	31.57	Specific Gravity, measured	2.71
Volume, cm^3	80.00	Solids Height, cm	0.901
Water Content, %	66.81	Volume of Solids, cm^3	28.44
Wet Mass, g	128.56	Volume of Voids, cm^3	51.56
Dry Mass, g	77.07	Degree of Saturation, %	99.9

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.534	1.813	2.534				
6.03	2.532	1.810	2.533	47	2.89E-02	1.64E-04	4.64E-07
10.68	2.529	1.807	2.530	83	1.64E-02	2.04E-04	3.26E-07
20.65	2.522	1.800	2.526	82	1.65E-02	2.77E-04	4.48E-07
40.00	2.511	1.788	2.517	86	1.56E-02	2.18E-04	3.34E-07
78.80	2.477	1.749	2.494	109	1.21E-02	3.52E-04	4.17E-07
159.73	2.046	1.271	2.261	2666	4.07E-04	2.10E-03	8.38E-08
311.33	1.851	1.055	1.948	1620	4.97E-04	5.07E-04	2.47E-08
621.50	1.706	0.894	1.779	960	6.99E-04	1.84E-04	1.26E-08
1242.69	1.585	0.759	1.645	277	2.07E-03	7.73E-05	1.57E-08
2483.89	1.476	0.638	1.530	194	2.56E-03	3.45E-05	8.66E-09
621.50	1.506	0.671	1.491				
156.34	1.550	0.720	1.528				
40.19	1.601	0.777	1.575				
10.84	1.635	0.815	1.618				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 23-31cm from top of the tube.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

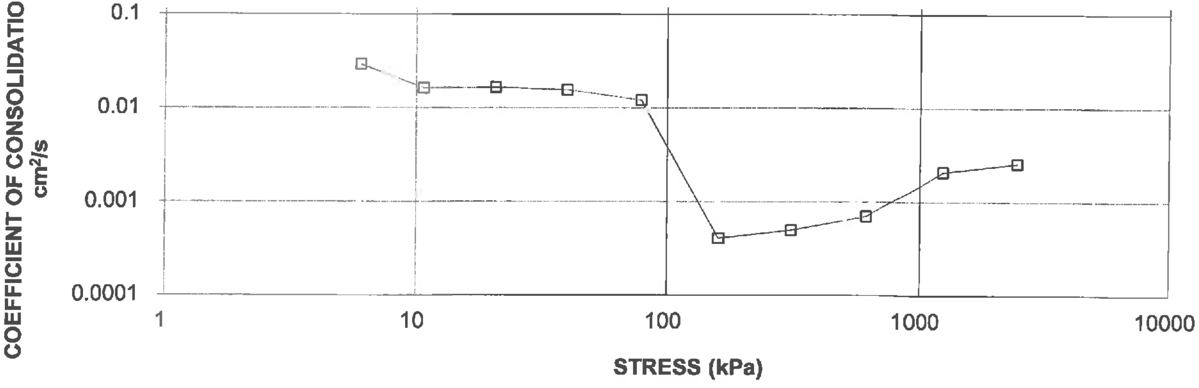
Sample Height, cm	1.64	Unit Weight, kN/m^3	19.48
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	14.64
Area, cm^2	31.57	Specific Gravity, measured	2.71
Volume, cm^3	51.63	Solids Height, cm	0.901
Water Content, %	33.06	Volume of Solids, cm ^{3}	28.44
Wet Mass, g	102.55	Volume of Voids, cm ^{3}	23.19
Dry Mass, g	77.07		

Prepared By: LH

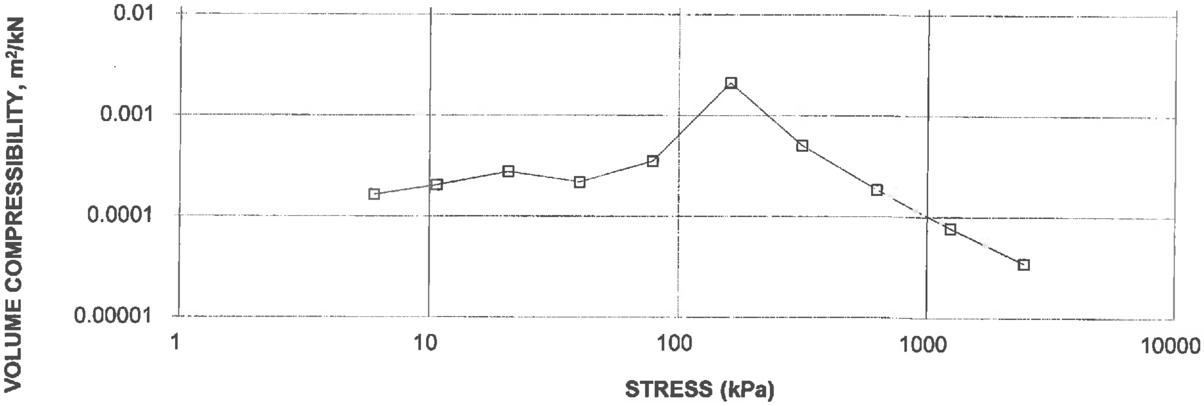
Golder Associates

Checked By: MM

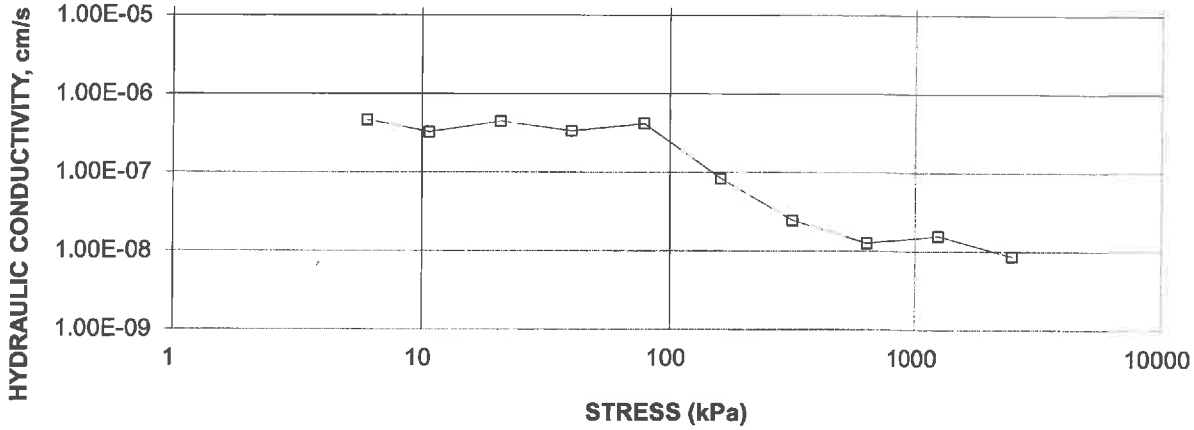
CONSOLIDATION TEST SUMMARY	FIGURE



CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH 17-19 SA TW13



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH 17-19 SA TW13



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-19 SA TW13

Project No. 1778186(1000)

Prepared By: LH

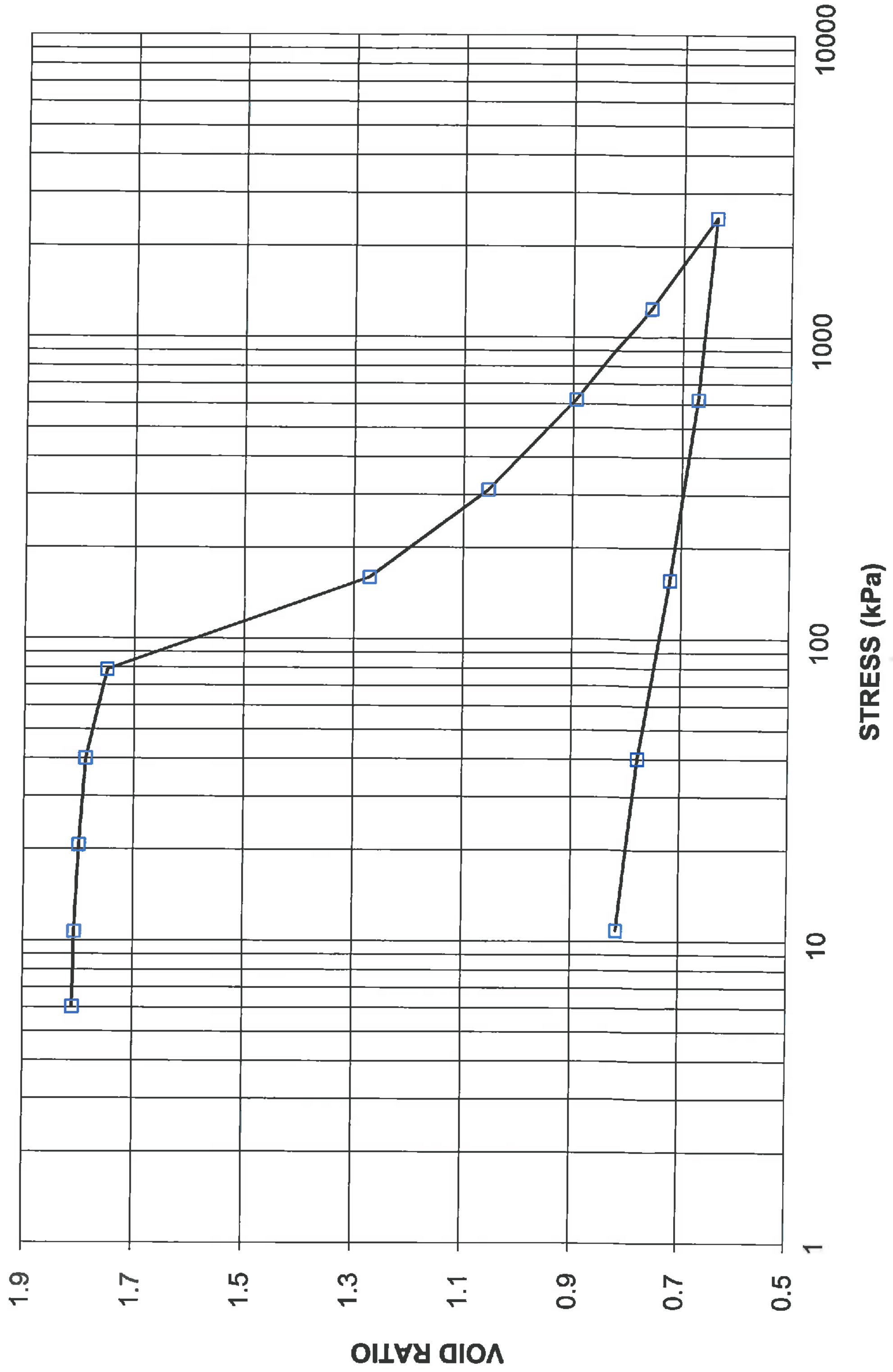
Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 17-19 SA TW13



Project No. 1778186(1000)

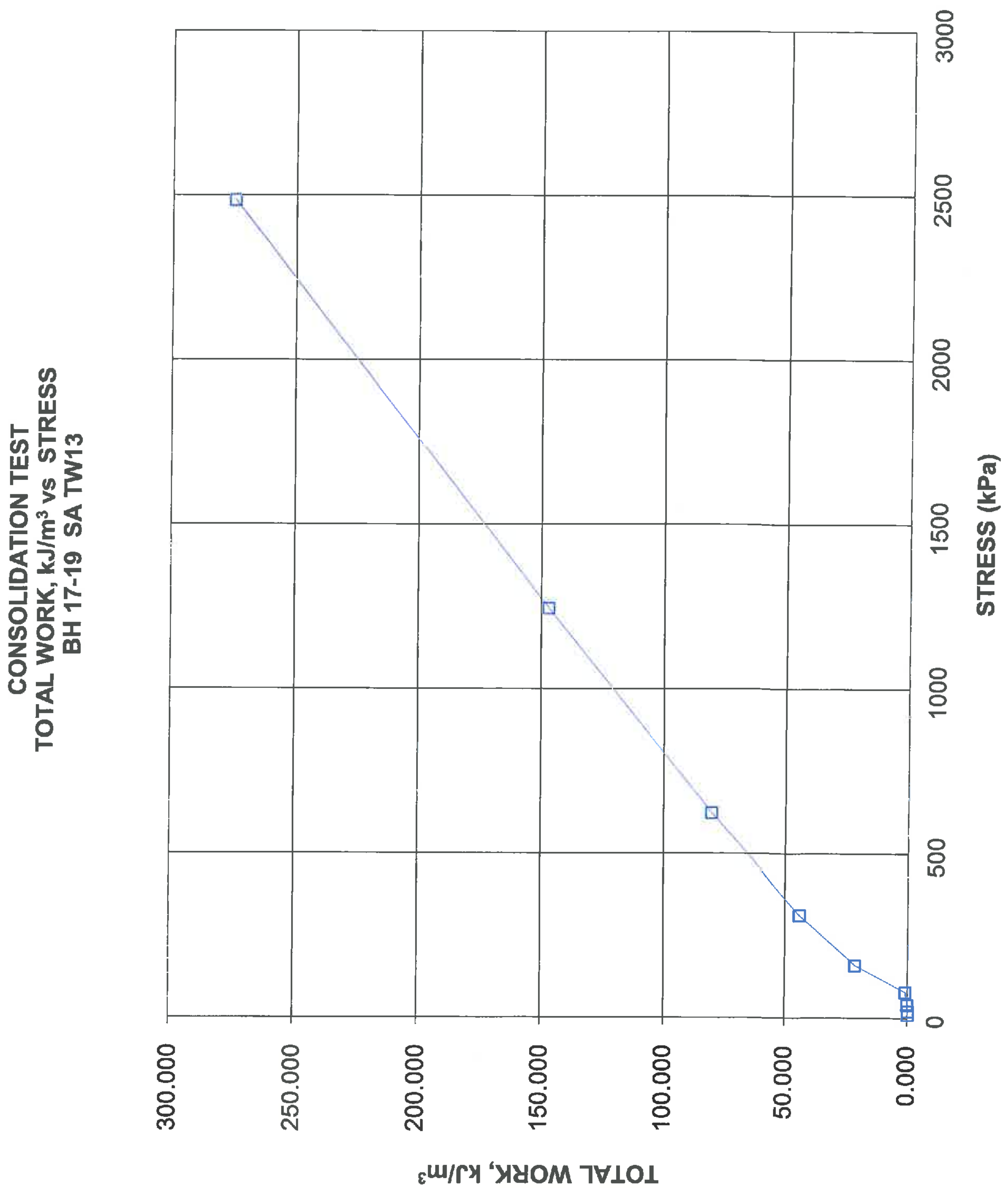
Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE



Project No. 1778186(1000)

Golder Associates

Prepared By: LH

Checked By: MM

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW16
Borehole Number	17-19	Sample Depth, m	18.29-18.90

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	03/24/2017		
Date Completed	04/08/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.52	Unit Weight, kN/m^3	15.84
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	9.58
Area, cm^2	31.53	Specific Gravity, measured	2.71
Volume, cm^3	79.52	Solids Height, cm	0.909
Water Content, %	65.42	Volume of Solids, cm^3	28.65
Wet Mass, g	128.45	Volume of Voids, cm^3	50.86
Dry Mass, g	77.65	Degree of Saturation, %	99.9

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.522	1.775	2.522				
6.26	2.520	1.773	2.521				
10.96	2.518	1.771	2.519	58	2.32E-02	1.60E-04	3.64E-07
20.90	2.511	1.764	2.515	86	1.56E-02	2.79E-04	4.27E-07
40.22	2.497	1.747	2.504	230	5.78E-03	3.04E-04	1.72E-07
79.25	2.473	1.722	2.485	485	2.70E-03	2.36E-04	6.23E-08
156.68	2.358	1.595	2.416	1109	1.12E-03	5.89E-04	6.44E-08
311.96	1.982	1.181	2.170	4111	2.43E-04	9.62E-04	2.29E-08
622.51	1.804	0.985	1.893	2053	3.70E-04	2.27E-04	8.23E-09
1242.93	1.668	0.835	1.736	778	8.21E-04	8.69E-05	6.99E-09
2485.72	1.552	0.708	1.610	454	1.21E-03	3.69E-05	4.37E-09
1242.93	1.563	0.720	1.558				
161.02	1.642	0.807	1.603				
40.46	1.692	0.862	1.667				
10.96	1.741	0.915	1.716				

Note:
Consolidation loading and unloading schedule assigned by the client.
cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)
Specimen taken 15-20cm from top of the tube.
Specimen swelled under 6.26 kpa.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.74	Unit Weight, kN/m^3	18.87
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	13.88
Area, cm^2	31.53	Specific Gravity, measured	2.71
Volume, cm^3	54.88	Solids Height, cm	0.909
Water Content, %	35.98	Volume of Solids, cm ^{3}	28.65
Wet Mass, g	105.59	Volume of Voids, cm ^{3}	26.22
Dry Mass, g	77.65		

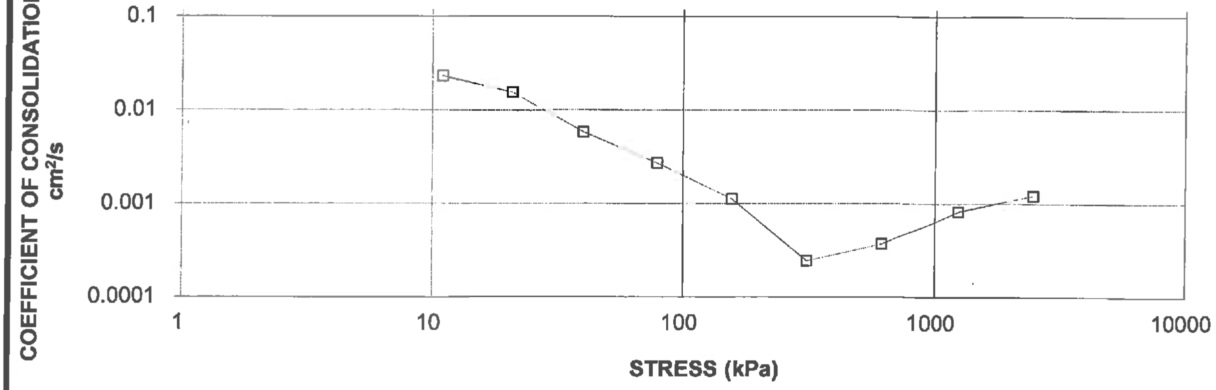
Prepared By: LH

Golder Associates

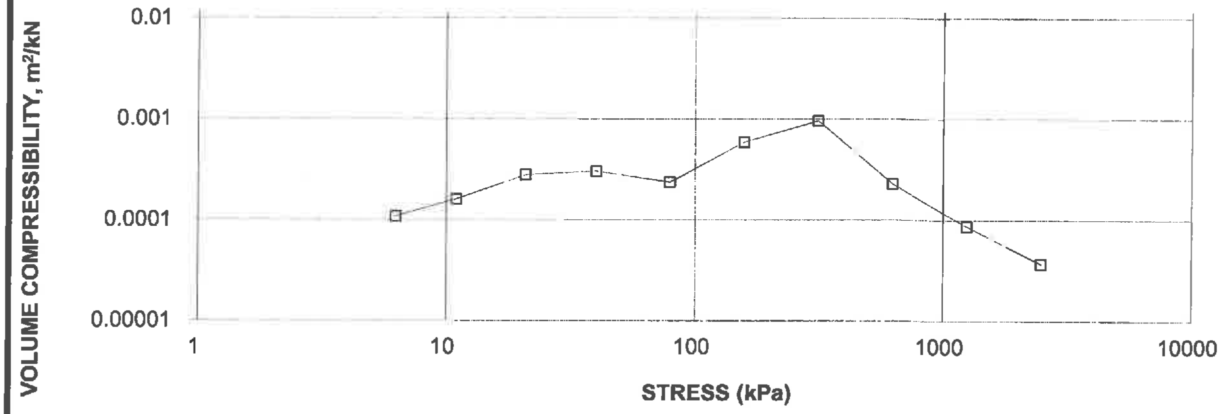
Checked By: MM

CONSOLIDATION TEST SUMMARY	FIGURE

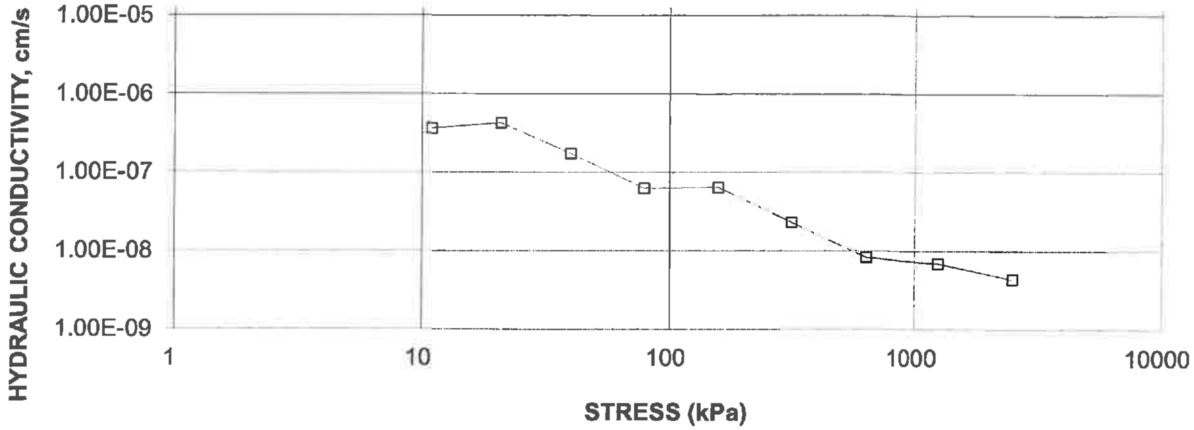
CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH 17-19 SA TW16



CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH 17-19 SA TW16



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-19 SA TW16



Project No. 1778186(1000)

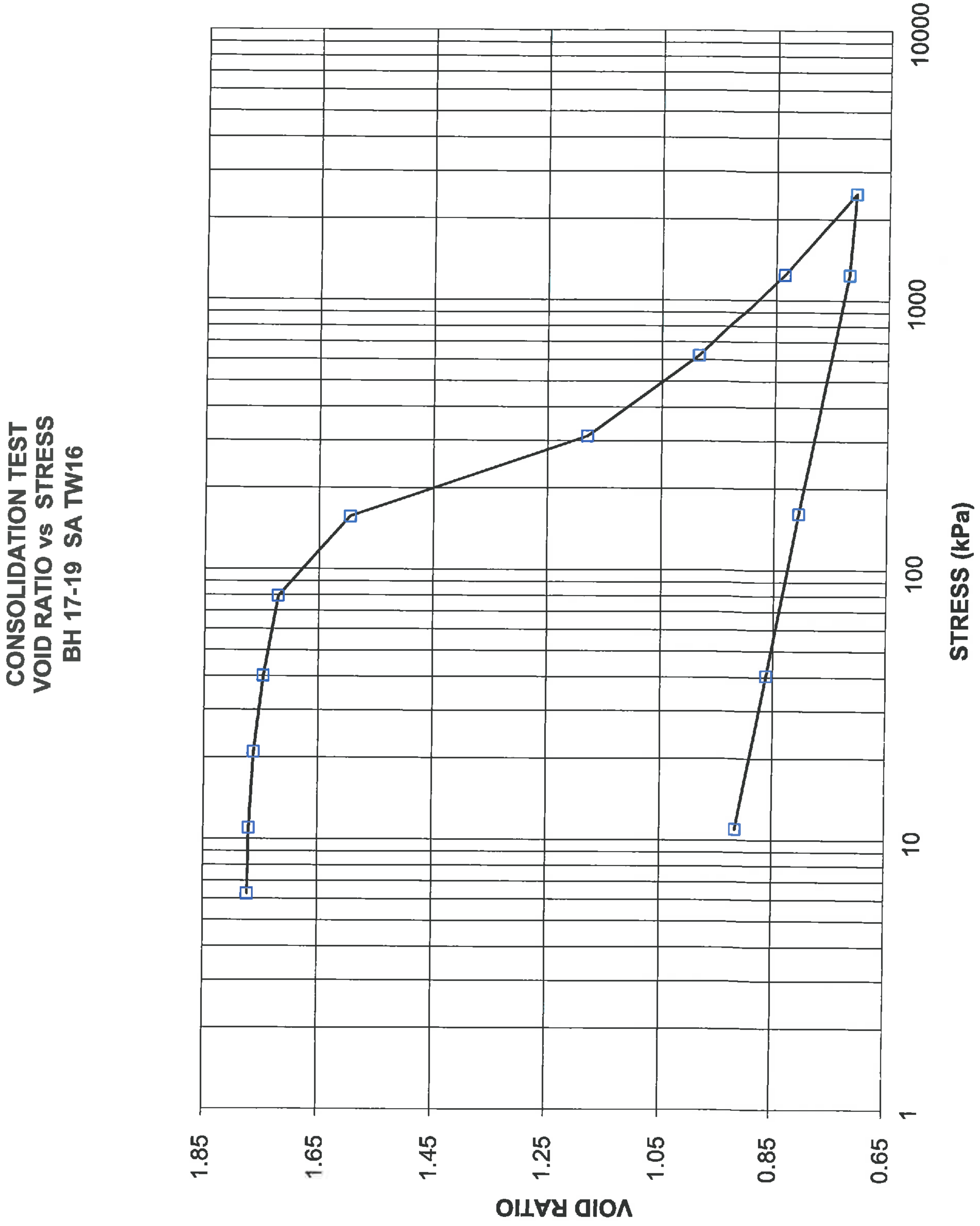
Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE



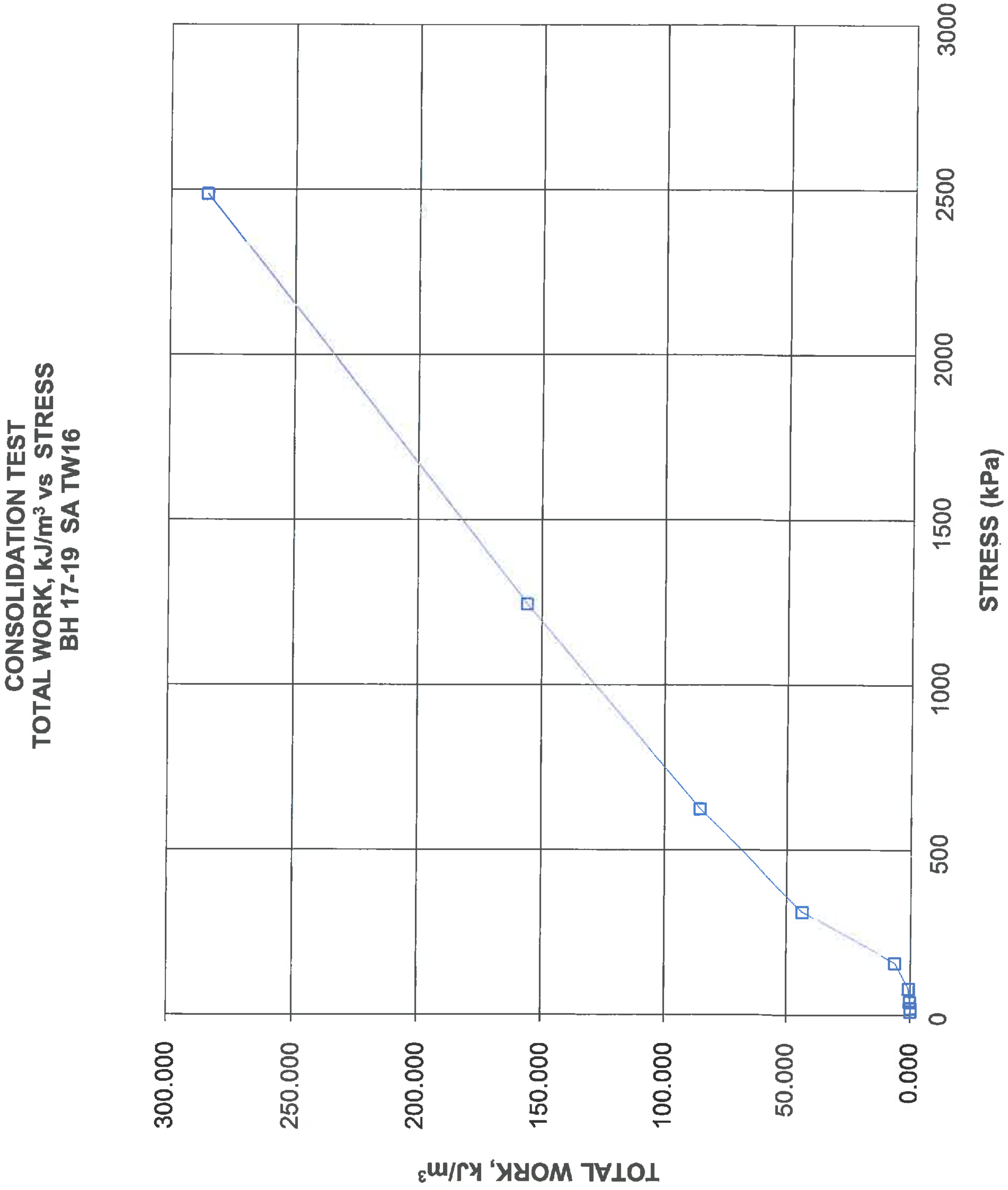
Project No. 1778186(1000)

Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST TOTAL WORK VS STRESS	FIGURE



Project No. 1778186(1000)

Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW10
Borehole Number	17-29	Sample Depth, m	-

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	6		
Date Started	03/24/2017		
Date Completed	04/10/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m^3	15.70
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	9.36
Area, cm^2	31.48	Specific Gravity, measured	2.71
Volume, cm^3	59.40	Solids Height, cm	0.665
Water Content, %	67.67	Volume of Solids, cm^3	20.93
Wet Mass, g	95.10	Volume of Voids, cm^3	38.47
Dry Mass, g	56.72	Degree of Saturation, %	99.8

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	1.887	1.838	1.887				
5.86	1.880	1.827	1.883	6	1.25E-01	6.60E-04	8.11E-06
10.62	1.877	1.822	1.878	34	2.20E-02	3.56E-04	7.68E-07
20.71	1.866	1.806	1.871	29	2.56E-02	5.78E-04	1.45E-06
40.22	1.850	1.783	1.858	36	2.03E-02	4.18E-04	8.33E-07
78.96	1.798	1.704	1.824	487	1.45E-03	7.15E-04	1.02E-07
156.81	1.558	1.343	1.678	1354	4.41E-04	1.63E-03	7.06E-08
312.38	1.371	1.063	1.465	1325	3.43E-04	6.35E-04	2.14E-08
623.27	1.245	0.873	1.308	614	5.91E-04	2.15E-04	1.24E-08
1245.83	1.150	0.729	1.198	144	2.11E-03	8.13E-05	1.68E-08
2492.44	1.064	0.600	1.107	130	2.00E-03	3.64E-05	7.13E-09
1245.83	1.080	0.624	1.072				
157.01	1.139	0.713	1.109				
39.83	1.178	0.772	1.159				
10.69	1.214	0.826	1.196				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 0-6cm from bottom of the tube.

SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.21	Unit Weight, kN/m^3	19.57
Sample Diameter, cm	6.33	Dry Unit Weight, kN/m^3	14.55
Area, cm^2	31.48	Specific Gravity, measured	2.71
Volume, cm^3	38.22	Solids Height, cm	0.665
Water Content, %	34.45	Volume of Solids, cm ^{3}	20.93
Wet Mass, g	76.26	Volume of Voids, cm ^{3}	17.29
Dry Mass, g	56.72		

Prepared By: LH

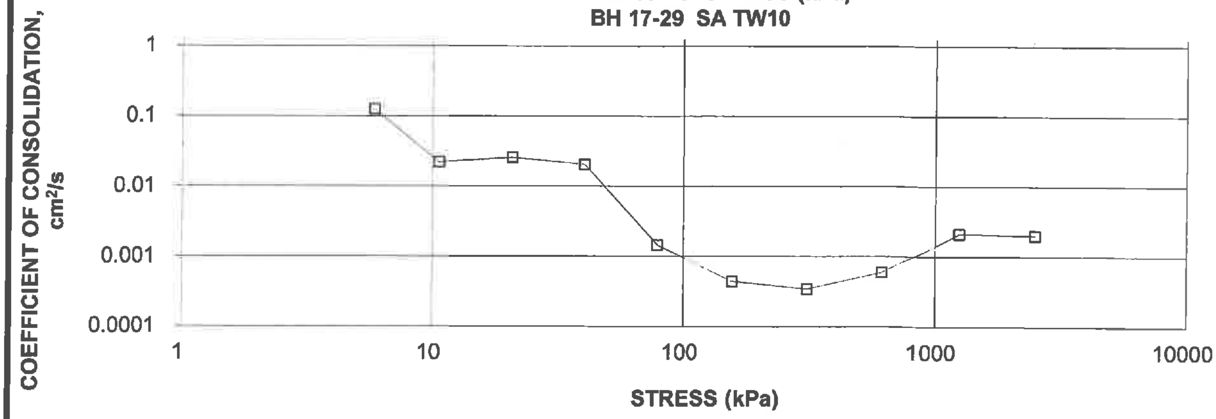
Golder Associates

Checked By: MM

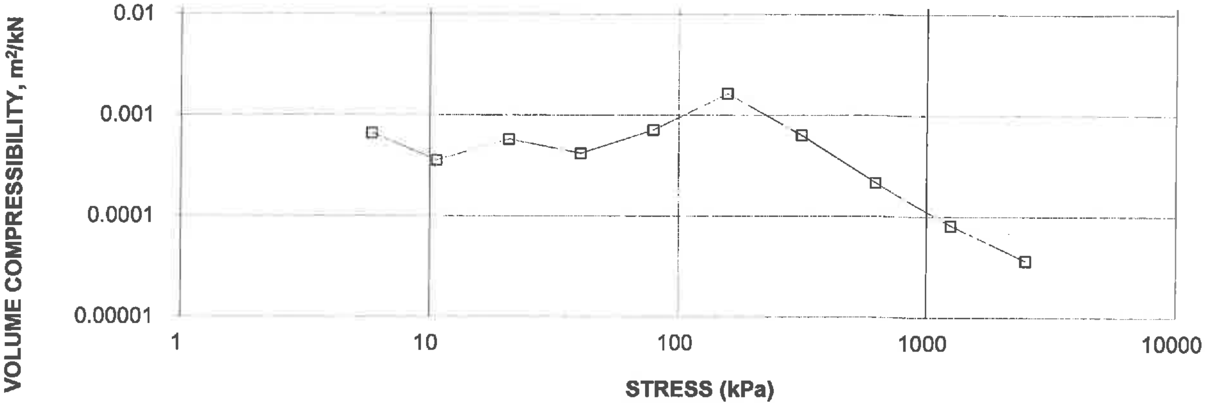
CONSOLIDATION TEST SUMMARY

FIGURE

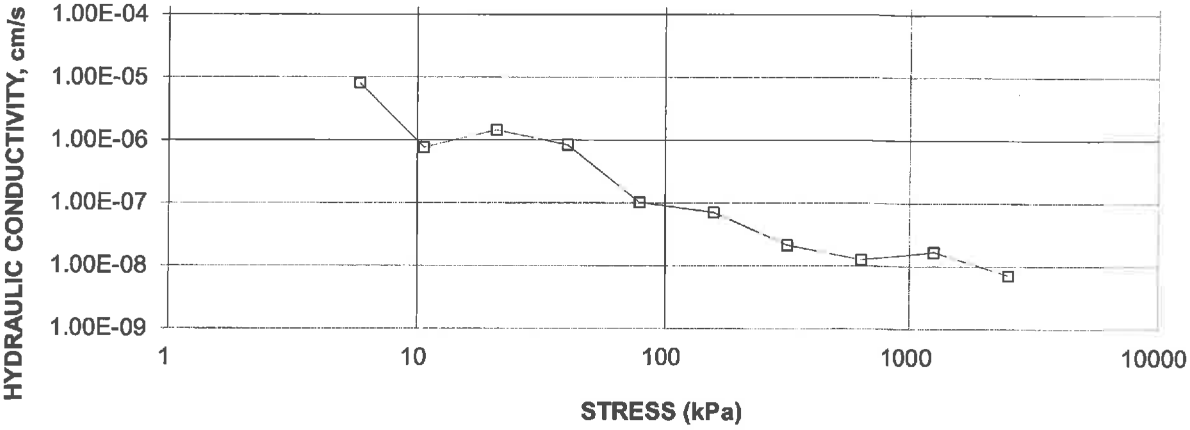
CONSOLIDATION TEST
CV cm^2/s VS STRESS (kPa)
BH 17-29 SA TW10



CONSOLIDATION TEST
MV m^2/kN vs STRESS (kPa)
BH 17-29 SA TW10



CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-29 SA TW10



Project No. 1778186(1000)

Prepared By: LH

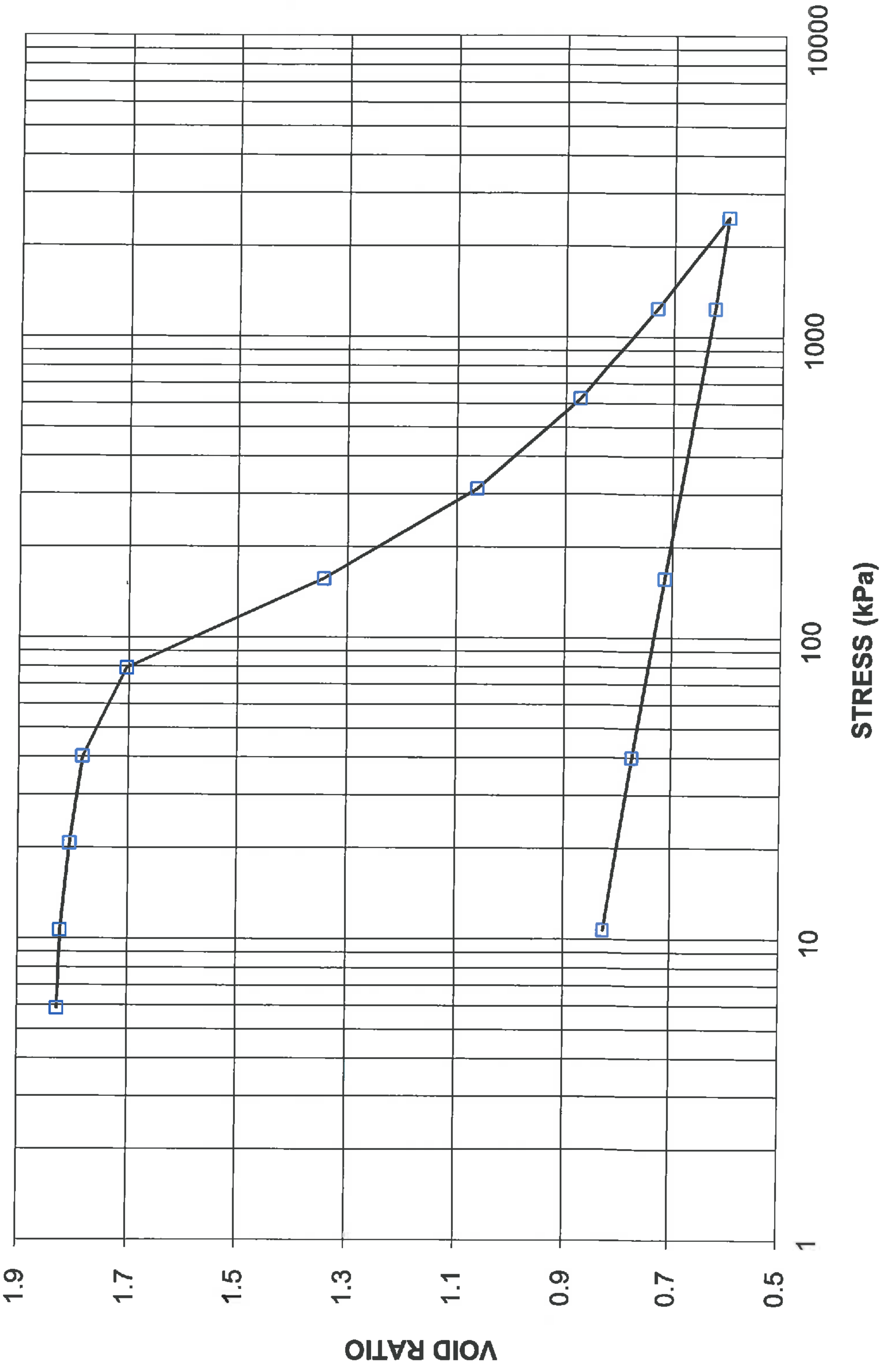
Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE

CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 17-29 SA TW10



Project No. 1778186(1000)

Prepared By: LH

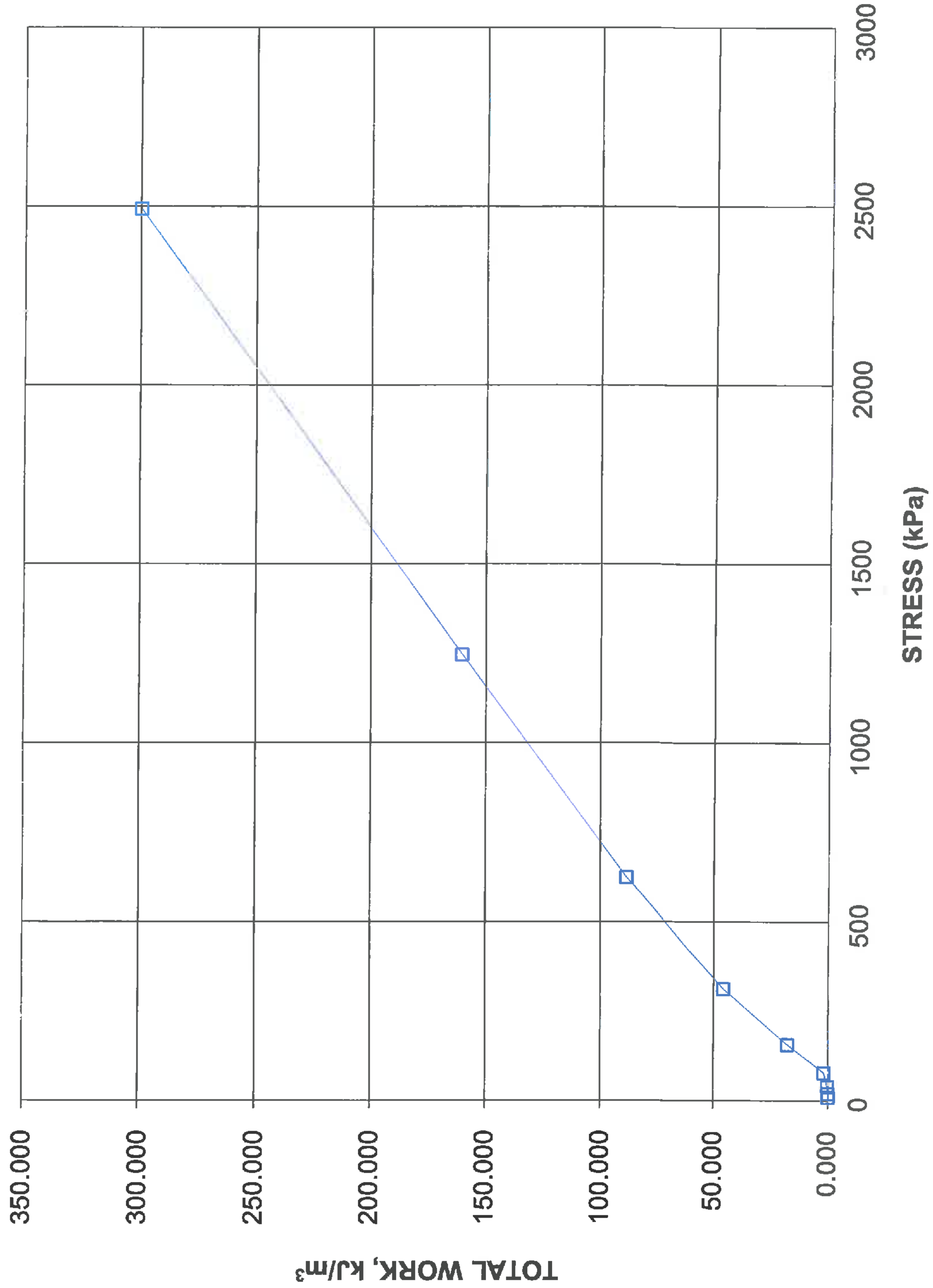
Golder Associates

Checked By: MM

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE

CONSOLIDATION TEST
TOTAL WORK, kJ/m³ vs STRESS
BH 17-29 SA TW10



Project No. 1778186(1000)

Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

SAMPLE IDENTIFICATION

Project Number	1778186(1000)	Sample Number	TW8
Borehole Number	17-35	Sample Depth, m	-

TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	3		
Date Started	03/24/2017		
Date Completed	04/08/2017		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.53	Unit Weight, kN/m^3	15.94
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	9.73
Area, cm^2	31.59	Specific Gravity, measured	2.71
Volume, cm^3	80.02	Solids Height, cm	0.927
Water Content, %	63.84	Volume of Solids, cm^3	29.28
Wet Mass, g	130.02	Volume of Voids, cm^3	50.73
Dry Mass, g	79.36	Degree of Saturation, %	99.9

TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t_{90} sec	cv. cm^2/s	mv m^2/kN	k cm/s
0.00	2.533	1.732	2.533				
5.89	2.532	1.731	2.533				
10.76	2.530	1.729	2.531	94	1.44E-02	1.62E-04	2.30E-07
20.49	2.525	1.723	2.527	86	1.57E-02	2.15E-04	3.32E-07
39.97	2.467	1.661	2.496	819	1.61E-03	1.17E-03	1.85E-07
78.80	2.219	1.394	2.343	3888	2.99E-04	2.52E-03	7.38E-08
156.49	2.020	1.179	2.120	2381	4.00E-04	1.01E-03	3.97E-08
311.54	1.871	1.018	1.945	1009	7.95E-04	3.79E-04	2.95E-08
621.56	1.742	0.879	1.806	653	1.06E-03	1.65E-04	1.71E-08
1246.16	1.629	0.757	1.685	240	2.51E-03	7.13E-05	1.75E-08
2486.81	1.527	0.647	1.578	254	2.08E-03	3.24E-05	6.60E-09
1246.16	1.536	0.657	1.531				
156.49	1.598	0.724	1.567				
41.74	1.638	0.766	1.618				
10.75	1.678	0.810	1.658				

Note:

Consolidation loading and unloading schedule assigned by the client.

cv and k are approximate only based on t90 estimated from Square Root of Time Method (ASTMD2435/2435M)

Specimen taken 16-22cm from bottom of the tube.

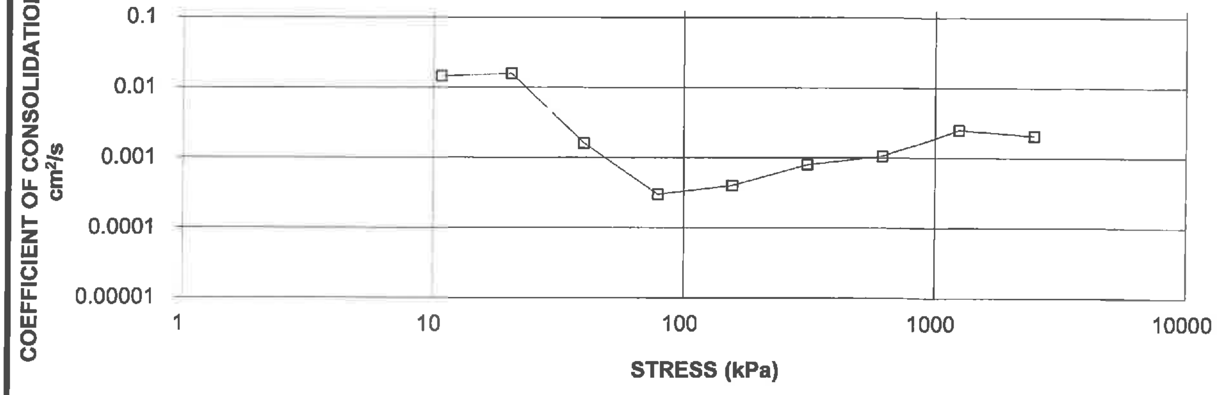
Specimen swelled under 5.89 kpa.

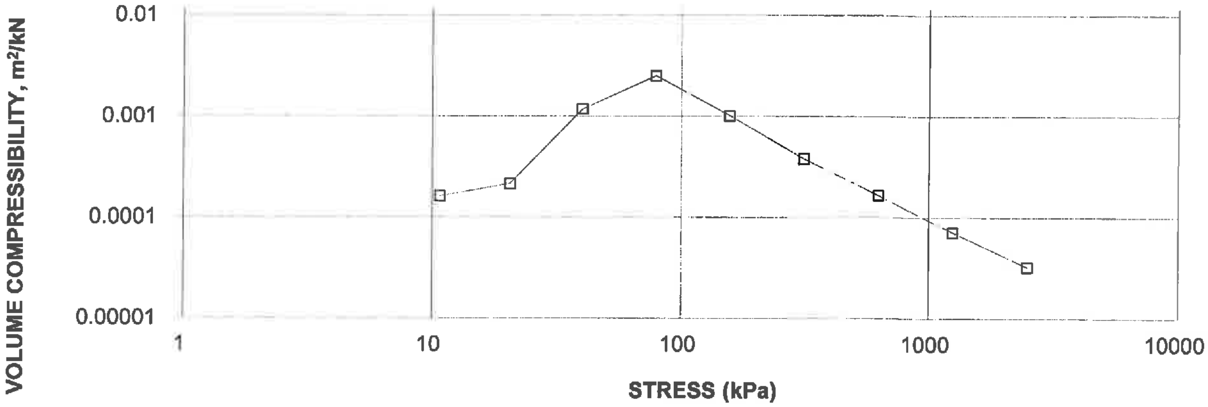
SAMPLE DIMENSIONS AND PROPERTIES - FINAL

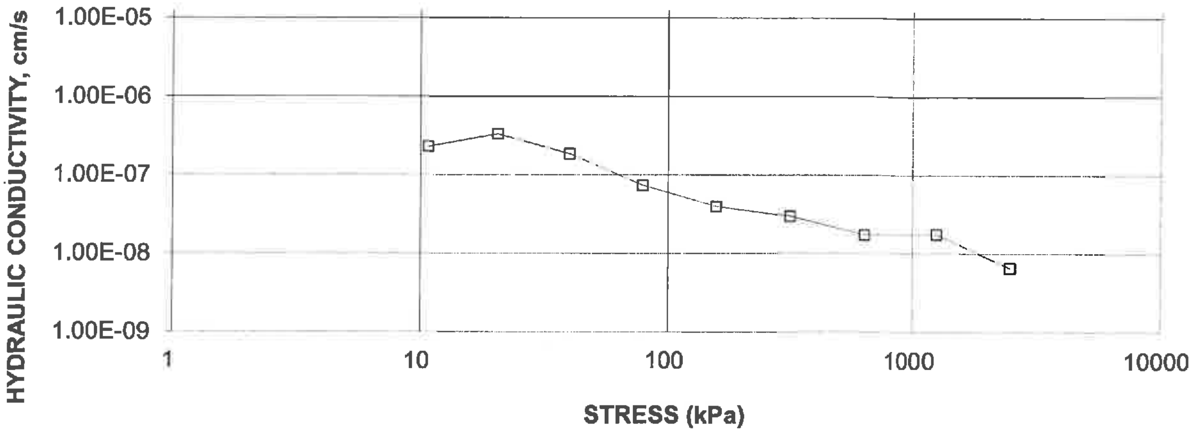
Sample Height, cm	1.68	Unit Weight, kN/m^3	19.35
Sample Diameter, cm	6.34	Dry Unit Weight, kN/m^3	14.68
Area, cm^2	31.59	Specific Gravity, measured	2.71
Volume, cm^3	53.01	Solids Height, cm	0.927
Water Content, %	31.82	Volume of Solids, cm ^{3}	29.28
Wet Mass, g	104.61	Volume of Voids, cm ^{3}	23.73
Dry Mass, g	79.36		

Prepared By: LH **Golder Associates** Checked By: MM

CONSOLIDATION TEST SUMMARY	FIGURE


CONSOLIDATION TEST
CV cm²/s VS STRESS (kPa)
BH 17-35 SA TW8


CONSOLIDATION TEST
MV m²/kN vs STRESS (kPa)
BH 17-35 SA TW8


CONSOLIDATION TEST
HYDRAULIC CONDUCTIVITY vs STRESS
BH 17-35 SA TW8

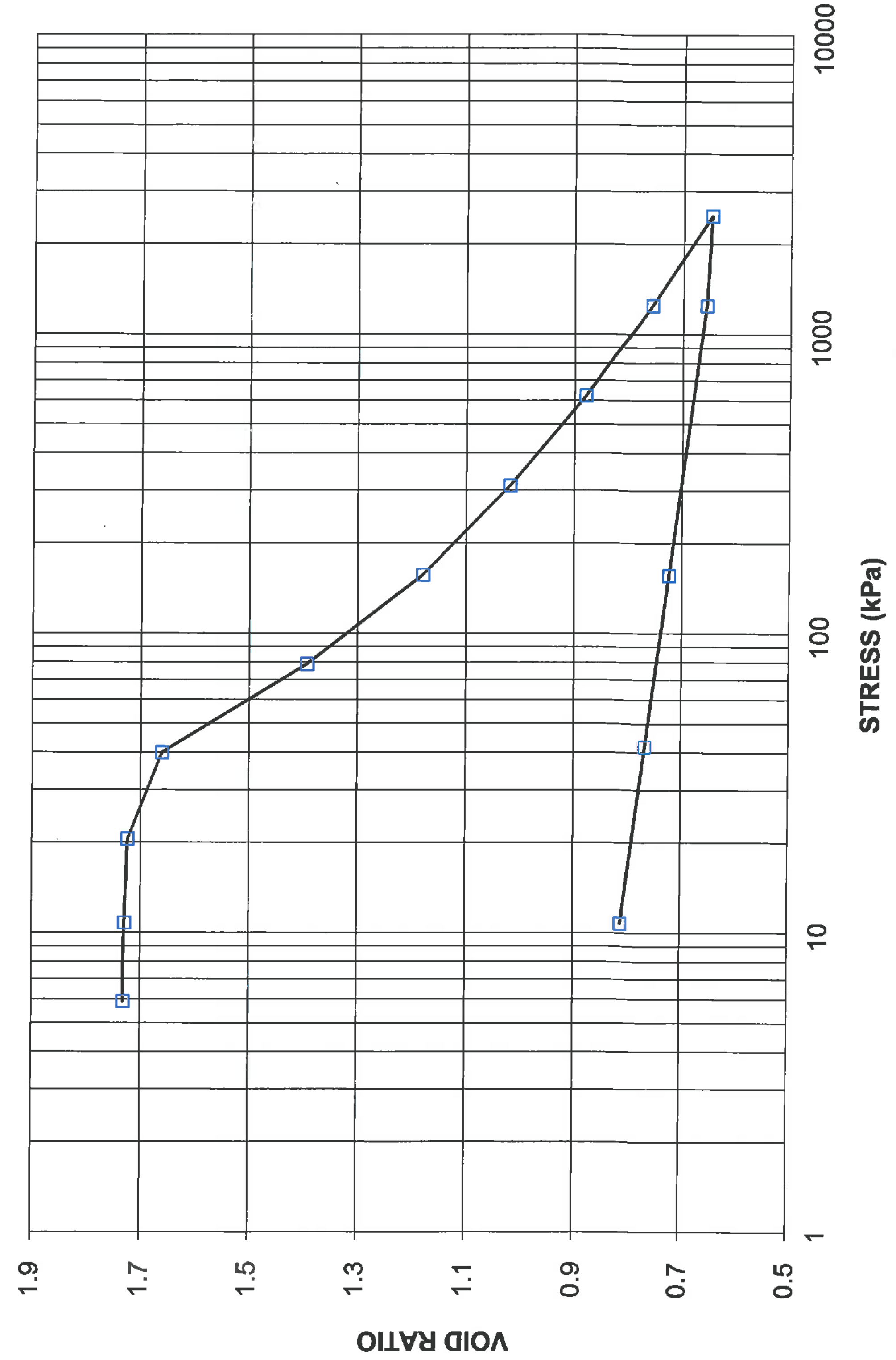
Project No. 1778186(1000)
Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST
VOID RATIO VS LOG STRESS

FIGURE



CONSOLIDATION TEST
VOID RATIO vs STRESS
BH 17-35 SA TW8

Project No. 1778186(1000)

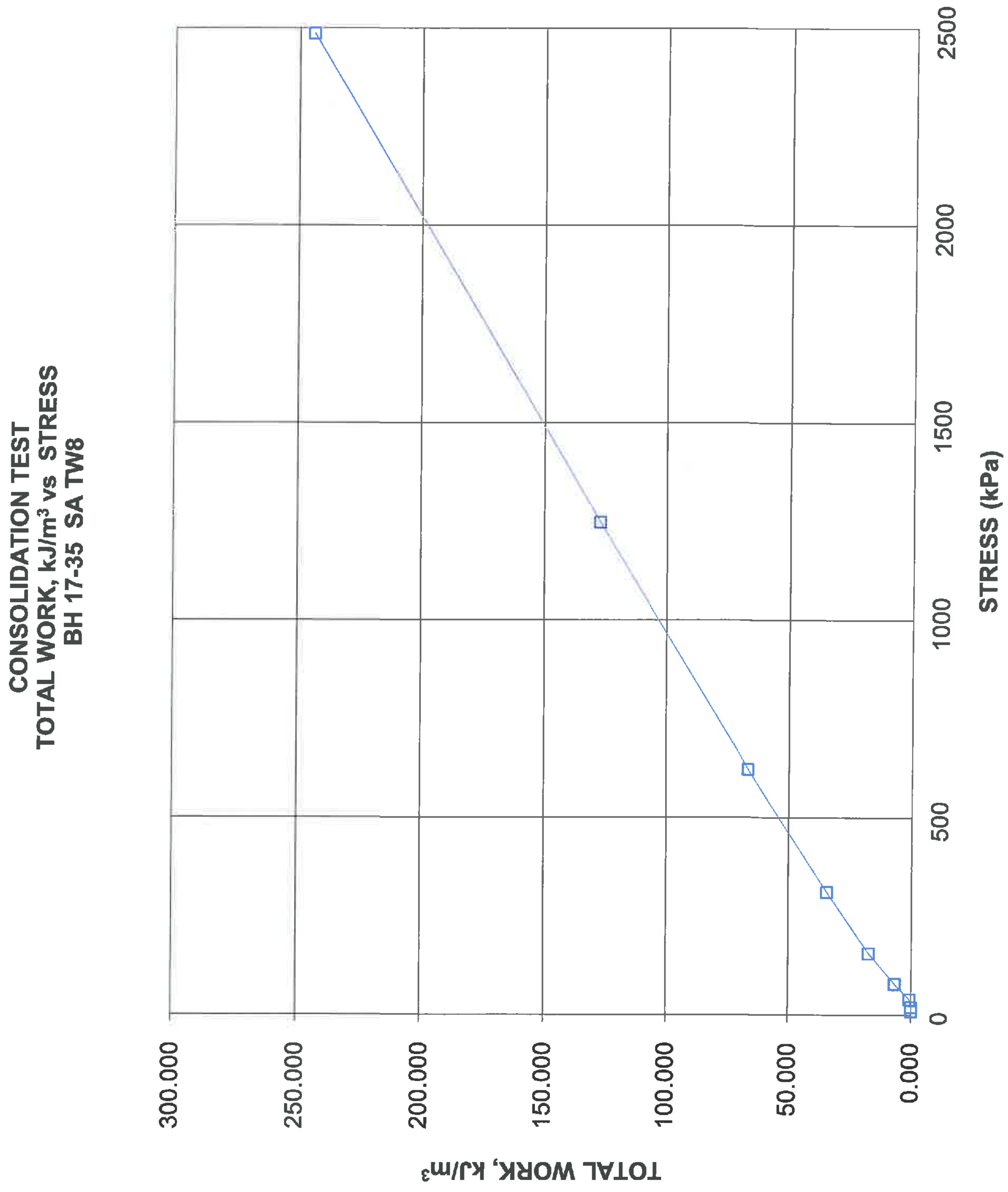
Prepared By: LH

Golder Associates

Checked By: MM

CONSOLIDATION TEST
TOTAL WORK VS STRESS

FIGURE



Project No. 1778186(1000)

Prepared By: LH

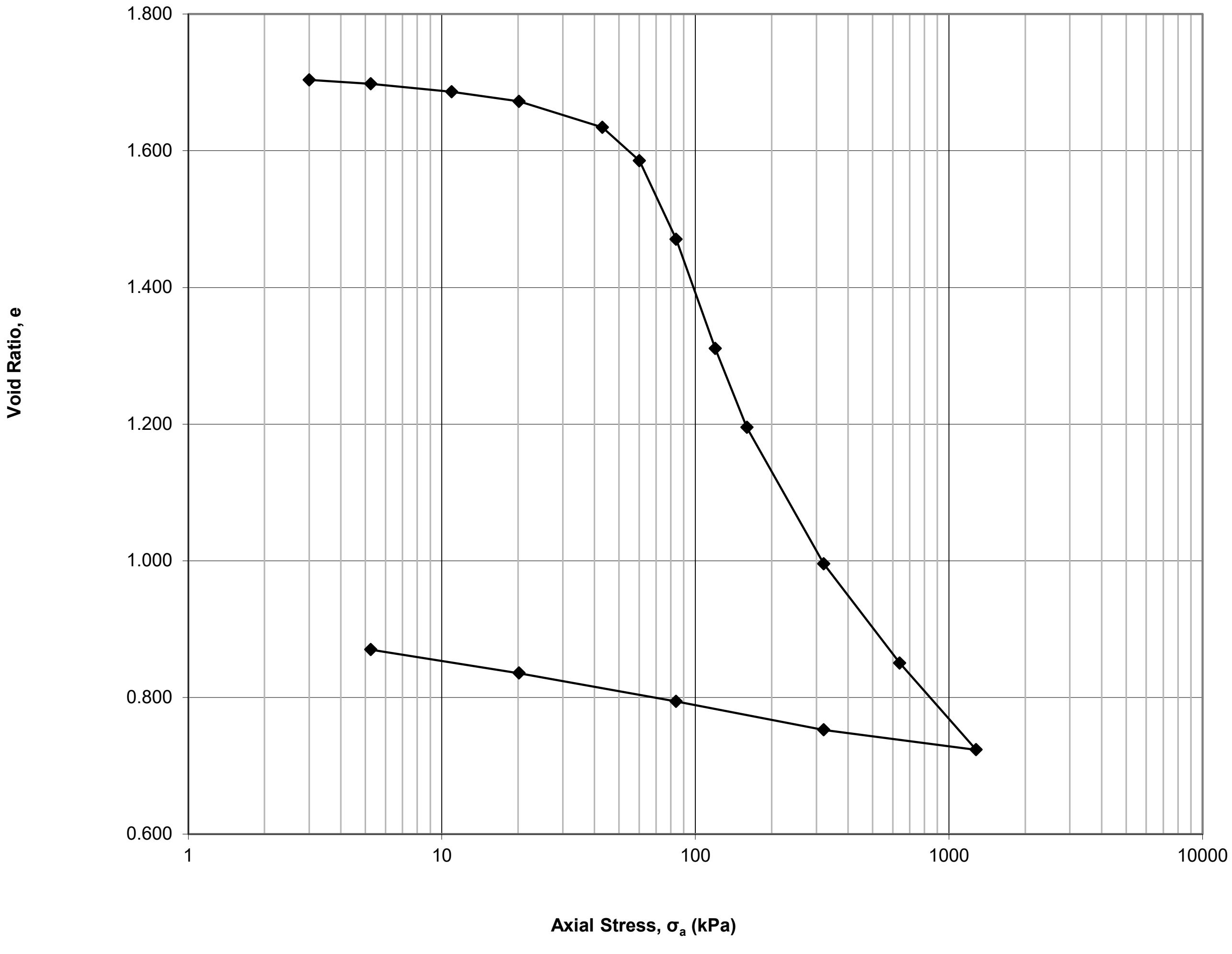
Golder Associates

Checked By: MM

One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**Thurber Engineering, File# 14967**
Project No.	**122410864**
Borehole No.	**BH 17-5**
Sample No.	**ST-8**
Sample Depth	**20-22 ft**



Filename: V:\01224\active\laboratory_standing_offers\2017 L

Checked by: D. Boateng Date: 6-Apr-17

Approved by: R. Hache Date: 6-Apr-17

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON
Borehole	BH 17-5
Sample No.	ST-8
Depth	20-22 ft
Sample Date	February 27, 2017
Test Number	One
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, CH		
Specific Gravity of Solids		2.738
Liquid Limit	%	48
Plastic Limit	%	21
Plasticity Index	%	27
Average water content of trimmings	%	63
Additional Notes (information source, occurence and size of large isolated particles etc.)		
See Photographs		

Initial Specimen Conditions

Height	mm	19.01
Diameter	mm	50.02
Area	mm^2	1965
Volume	mm^3	37356
Mass	g	61.66
Dry Mass	g	37.83
Density	Mg/m^3	1.651
Dry Density	Mg/m^3	1.013
Water Content	%	62.99
Degree of Saturation	%	99.0
Height of Solids	mm	7.03
Initial Void Ratio		1.704

Final Specimen Conditions

Water Content	%	33.65
Final Void Ratio		0.870

Filename: V:\01224\active\laboratory_standing_offers\2017 Laboratory Standing Offers\122‹

Checked by: D. Boateng Date: 6-Apr-17

Approved by: R. Hache Date: 6-Apr-17

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON
Borehole	BH 17-5
Sample No.	ST-8
Depth	20-22 ft
Sample Date	February 27, 2017
Test Number	One
Technician Name	Daniel Boateng

Test Procedure

Date Started		March 16, 2017
Date Finished		April 6, 2017
Machine Number		Frame A
Cell Number		A
Ring Number		A
Trimming Procedure		Turntable
Moisture Condition		Inundated
Axial Stress at Inundation	kPa	3
Water Used		Distilled
Test Method		A
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	3	0.0000	19.0100	0.00	1.704
1	1440.0	5	0.0390	18.9710	0.21	1.698
2	1440.0	11	0.1220	18.8880	0.64	1.686
3	1440.0	20	0.2210	18.7890	1.16	1.672
4	1440.0	43	0.4880	18.5220	2.57	1.634
5	1440.0	60	0.8320	18.1780	4.38	1.585
6	1440.0	84	1.6410	17.3690	8.63	1.470
7	1440.0	120	2.7650	16.2450	14.54	1.310
8	1440.0	160	3.5770	15.4330	18.82	1.195
9	1440.0	321	4.9810	14.0290	26.20	0.995
10	1440.0	640	6.0020	13.0080	31.57	0.850
11	1440.0	1282	6.8930	12.1170	36.26	0.723
12	1440.0	321	6.6890	12.3210	35.19	0.752
13	1440.0	84	6.3970	12.6130	33.65	0.794
14	1440.0	20	6.1050	12.9050	32.11	0.835
15	1440.0	5	5.8630	13.1470	30.84	0.870

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Checked by: D. Boateng Date: 6-Apr-17

Approved by: R. Hache Date: 6-Apr-17

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

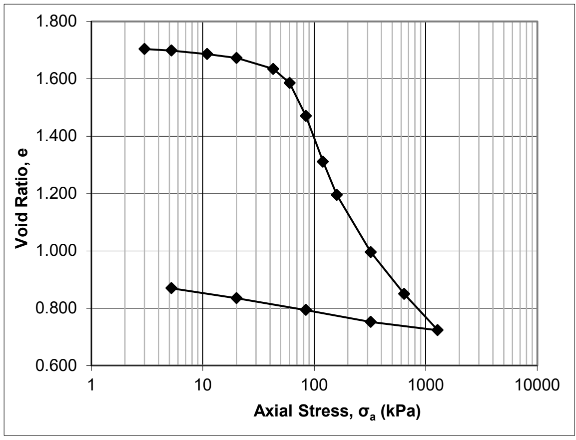
ASTM D2435/D2435M - 11

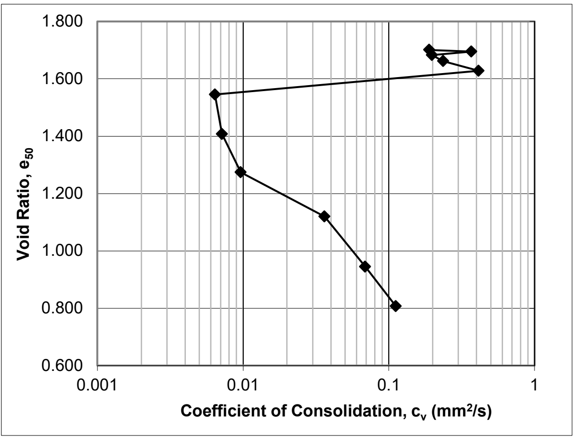
Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON
Borehole	BH 17-5
Sample No.	ST-8
Depth	20-22 ft
Sample Date	February 27, 2017
Test Number	One
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	3								
1	5	0.0207	18.9893	0.11	1.701			404	1.89E-01
2	8	0.0618	18.9482	0.33	1.695			206	3.69E-01
3	16	0.1453	18.8647	0.76	1.683			382	1.97E-01
4	32	0.2964	18.7136	1.56	1.662			314	2.36E-01
5	52	0.5329	18.4771	2.80	1.628			175	4.13E-01
6	72	1.1139	17.8961	5.86	1.545			10582	6.42E-03
7	102	2.0812	16.9288	10.95	1.408			8479	7.17E-03
8	140	3.0232	15.9868	15.90	1.274			5628	9.63E-03
9	240	4.1075	14.9025	21.61	1.119			1302	3.62E-02
10	481	5.3338	13.6762	28.06	0.945			577	6.87E-02
11	961	6.3025	12.7075	33.15	0.807			307	1.12E-01
12	801	6.7452	12.2648	35.48	0.744				
13	202	6.5273	12.4827	34.34	0.775				
14	52	6.2705	12.7395	32.99	0.812				
15	13	6.0235	12.9865	31.69	0.847				

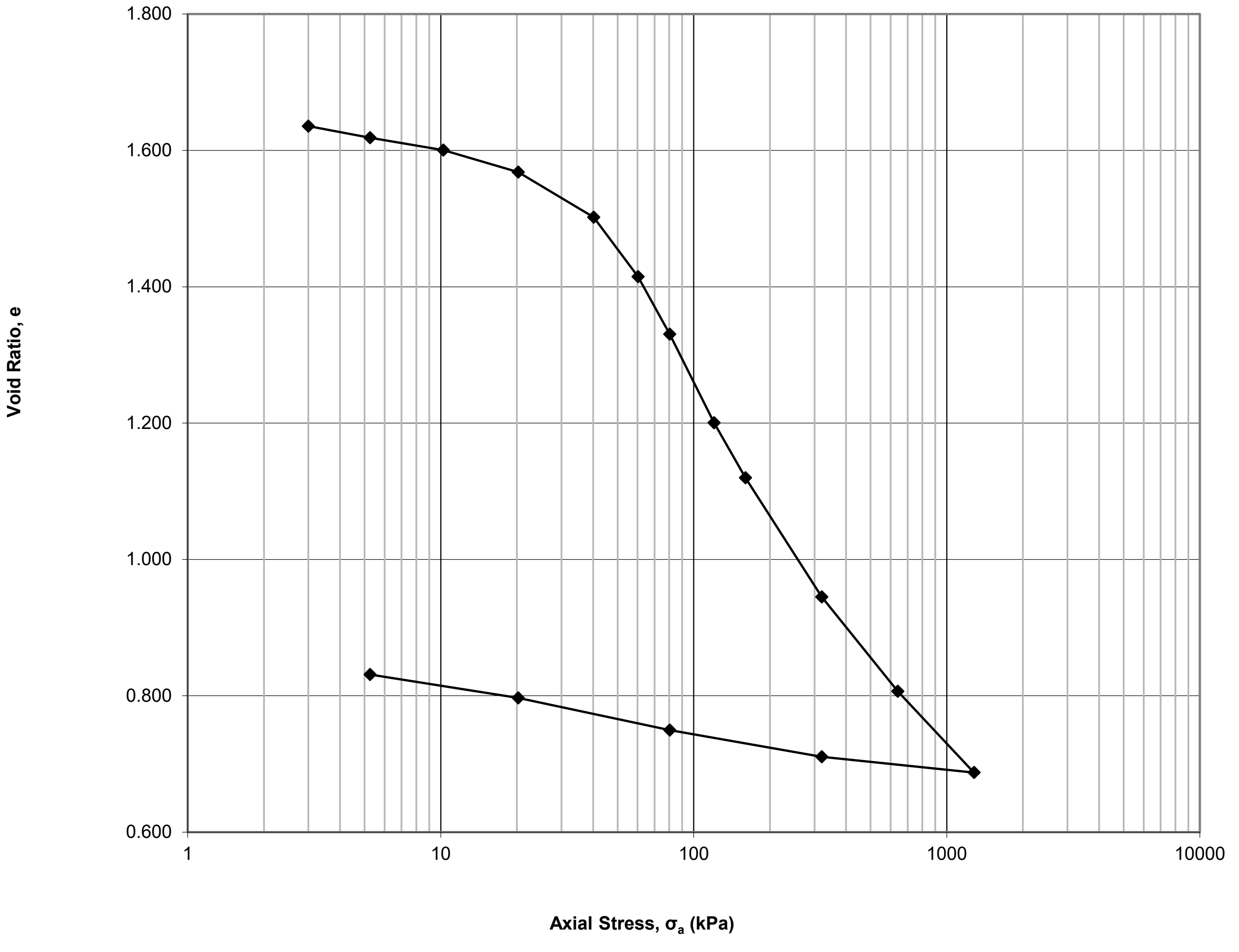




One-Dimensional Consolidation Properties of Soils Using Incremental Loading

ASTM D2435/D2435M - 11

Project	**Thurber Engineering, File# 14967**
Project No.	**122410864**
Borehole No.	**BH 17-43**
Sample No.	**ST-1**
Sample Depth	**30-32 ft**



Stantec

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Filename: V:\01224\active\laboratory_standing_offers\2017 L

Checked by: D. Boateng Date: 4-May-17

Approved by: R. Hache Date: 4-May-17

Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON.
Borehole	BH 17-43
Sample No.	ST-1
Depth	30-32 ft
Sample Date	March 23, 2017
Test Number	Two
Technician Name	Daniel Boateng

Soil Description & Classification

Silty Clay, Soft to Firm, Grey, Moist- CH

Specific Gravity of Solids		2.745
Liquid Limit	%	55
Plastic Limit	%	21
Plasticity Index	%	34
Average water content of trimmings	%	60

Additional Notes (information source, occurence and size of large isolated particles etc.)

Initial Specimen Conditions

Height	mm	20.00
Diameter	mm	50.00
Area	mm^2	1963
Volume	mm^3	39270
Mass	g	65.63
Dry Mass	g	40.90
Density	Mg/m^3	1.671
Dry Density	Mg/m^3	1.042
Water Content	%	60.46
Degree of Saturation	%	100.0
Height of Solids	mm	7.59
Initial Void Ratio		1.636

Final Specimen Conditions

Water Content	%	33.52
Final Void Ratio		0.831

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Checked by: D. Boateng Date: 4-May-17

Approved by: R. Hache Date: 4-May-17

Stantec Consulting Ltd.

One-Dimensional Consolidation Test using Incremental Loading

ASTM D2435/D2435M - 11

Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON.
Borehole	BH 17-43
Sample No.	ST-1
Depth	30-32 ft
Sample Date	March 23, 2017
Test Number	Two
Technician Name	Daniel Boateng

Test Procedure

Date Started		April 13, 2017
Date Finished		April 29, 2017
Machine Number		Frame D
Cell Number		D
Ring Number		D
Trimming Procedure		Turntable
Moisture Condition		Inundated
Axial Stress at Inundation	kPa	3
Water Used		Distilled
Test Method		A
Interpretation Procedure for c_v		2

All Departures from Outlined ASTM D2435/D2435M-11 Procedure

Calculations

Load Increment	Increment Duration min	Axial Stress σ_a kPa	Corrected Deformation ΔH mm	Specimen Height H mm	Axial Strain ε_a %	Void Ratio e
Seating	0.0	3	0.0000	20.0000	0.00	1.636
1	1440.0	5	0.1281	19.8719	0.64	1.619
2	1440.0	10	0.2685	19.7315	1.34	1.600
3	1440.0	20	0.5114	19.4886	2.56	1.568
4	1440.0	40	1.0147	18.9853	5.07	1.502
5	1440.0	60	1.6755	18.3245	8.38	1.415
6	1440.0	80	2.3146	17.6854	11.57	1.331
7	1440.0	120	3.3028	16.6972	16.51	1.200
8	1440.0	160	3.9141	16.0859	19.57	1.120
9	1440.0	320	5.2414	14.7586	26.21	0.945
10	1440.0	640	6.2893	13.7107	31.45	0.807
11	1440.0	1280	7.1952	12.8048	35.98	0.687
12	1440.0	320	7.0197	12.9803	35.10	0.711
13	1440.0	80	6.7222	13.2778	33.61	0.750
14	1440.0	20	6.3634	13.6366	31.82	0.797
15	1440.0	5	6.1029	13.8971	30.51	0.831

Filename: V:\01224\active\laboratory_standing_offers\2017 Laboratory Standing Offers\12:

Checked by: D. Boateng Date: 4-May-17

Approved by: R. Hache Date: 4-May-17

One-Dimensional Consolidation Test using Incremental Loading

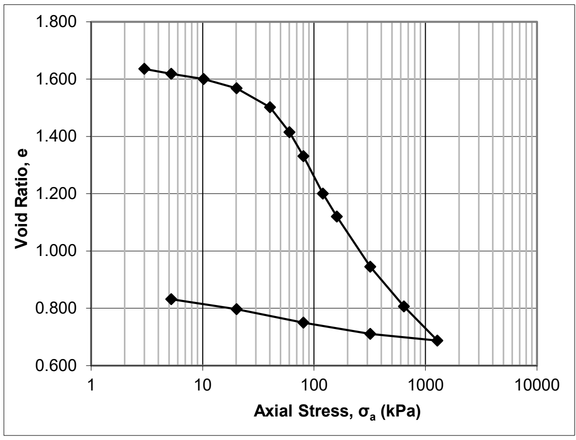
ASTM D2435/D2435M - 11

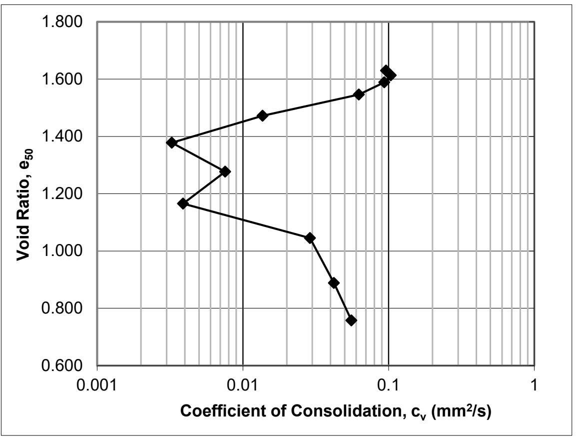
Specimen Details

Project Name	Thurber Engineering, File# 14967
Project Location	Hwy 537, Jumbo Creek, Sudbury, ON.
Borehole	BH 17-43
Sample No.	ST-1
Depth	30-32 ft
Sample Date	March 23, 2017
Test Number	Two
Technician Name	Daniel Boateng

Calculations

		Calculated using Interpretation Procedure 2				Interpretation Procedure 1		Interpretation Procedure 2	
Load Increment	Axial Stress $\sigma_{a,\ average}$ kPa	Corrected Deformation ΔH_{50} mm	Specimen Height H_{50} mm	Axial Strain $\varepsilon_{a,50}$ %	Void Ratio e_{50}	Time t_{50} sec	Coeff. Consol. c_v mm^2/s	Time t_{90} sec	Coeff. Consol. c_v mm^2/s
Seating	3								
1	5	0.0426	19.9574	0.21	1.630			880	9.60E-02
2	8	0.1705	19.8295	0.85	1.613			805	1.04E-01
3	15	0.3563	19.6437	1.78	1.589			876	9.34E-02
4	30	0.6762	19.3238	3.38	1.546			1265	6.26E-02
5	50	1.2380	18.7620	6.19	1.472			5465	1.37E-02
6	70	1.9532	18.0468	9.77	1.378			21209	3.26E-03
7	100	2.7208	17.2792	13.60	1.277			8354	7.58E-03
8	140	3.5655	16.4345	17.83	1.166			14708	3.89E-03
9	240	4.4808	15.5192	22.40	1.045			1769	2.89E-02
10	480	5.6690	14.3310	28.35	0.889			1034	4.21E-02
11	960	6.6593	13.3407	33.30	0.758			678	5.57E-02
12	800	7.0899	12.9101	35.45	0.701				
13	200	6.8716	13.1284	34.36	0.730				
14	50	6.5785	13.4215	32.89	0.769				
15	13	6.2385	13.7615	31.19	0.813				





Appendix C.4

Organic Content Testing Results

Stantec Consulting Ltd
100B – 2781 Lancaster Rd
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 738-6067

Date: May 2, 2017
File: 122410864
Page 1 of 2

Attention: **Thurber Engineering, File #14967**

Reference: **ASTM D2974 Organic Matter of Peat & Other Soils**

The table below summarizes 17 test results for Organic Matter of Peat and Other Soils.

Source	Depth	% Organic Content
BH17-9 SS-3	10'-12'	**3.0**
BH17-10 SS-5	15'-17'	**54.7**
BH17-12 SS-7	17'6"-19'6"	**51.8**
BH17-14 SS-6	12'6"-14'6"	**21.8**
BH17-16 SS-3A	5'-6'	**51.5**
BH17-16 SS-6	12'6"-14'6"	**69.5**
BH17-18 SS-5	10'-12'	**78.6**
BH17-19 SS-6	15'-17'	**70.2**
BH17-20 SS-3B	6'-7'	**65.4**
BH17-23 SS-4	12'6"-14-6"	**62.0**

Stantec

Stantec Consulting Ltd
100B – 2781 Lancaster Rd
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 738-6067

April 21, 2017
File: 122410864

Attention: **Thurber Engineering, File #14967**

Reference: **ASTM D2974 Organic Matter of Peat & Other Soils**

The table below summarizes six test results for Organic Matter of Peat and Other Soils.

Source	Depth	Organic Content
BH17-5, SS4	7'6"-9'6"	**11.3%**
BH17-7, SS5	10'-12'	**65.3%**
BH17-16, SS8	22'6"-24'6"	**2.8%**
BH17-20, SS3A	5'-6'	**0.4%**
BH17-20, SS8	20'-22'	**1.8%**
BH17-42, SS4	15'-17'	**2.4%**

Sincerely,

Stantec Consulting Ltd.

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-738-6067
brian.prevost@stantec.com

Reference: ASTM D2974 Organic Matter of Peat & Other Soils

BH17-27 SS-3	5’-7’	**85.3**
BH17-31 SS-3	5’-7’	**73.9**
BH17-32 SS-5	15’-17’	**52.6**
BH17-35 SS-4	10’-12’	**90.3**
BH17-37 SS-4	10’-12’	**68.3**
BH17-39 SS-3	10’-12’	**62.9**
BH17-42 SS-3A	10’-11’4”	**47.0**

Sincerely,

Stantec Consulting Ltd.

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-738-6067
brian.prevost@stantec.com

Stantec

Stantec Consulting Ltd
100 A&B – 2781 Lancaster Rd
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 738-6067

August 9, 2017
File: 122410864

Attention: **Thurber Engineering, File #14967**

Reference: **ASTM D2974 Organic Matter of Peat & Other Soils**

The table below summarizes five test results for Organic Matter of Peat and Other Soils.

Source	**Depth**	**Location**	**Organic Content**
17-26, SS2	**6’- 8’**	**Jumbo Creek**	**57.7%**
17-30, SS3	**7.83’-9.83’**	**Jumbo Creek**	**75.2 %**
17-36, GS1	**18’**	**Jumbo Creek**	**54.1 %**
17-41, GS1	**13.83’-14.42’**	**Jumbo Creek**	**52.8 %**
17-45, SS2	**5.25’-7.25’**	**Jumbo Creek**	**18.6 %**

Sincerely,

Stantec Consulting Ltd.

Denis Rodriguez for Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
Fax: 613-738-6067
brian.prevost@stantec.com

v:\01216\active\laboratory_standing_offers\2017 laboratory standing offers\122410864 thurber engineering ltd\july 28, 5 organics, thurber #14967\letter, organic content, astm d2974.doc

Appendix C.5

Analytical Testing Results

PARACEL LABORATORIES LTD.
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Ottawa, ON, K1G 4J8
1-800-749-1947
www.paracellabs.com

Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Stephen Peters

Client PO:
Project: 14967
Custody: 14049

Report Date: 16-Mar-2017
Order Date: 10-Mar-2017

Order #: 1710489

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1710489-01	17-4 SS6 (12'6-14'6)
1710489-02	17-4 SS7 (15-17)

Approved By:

Dale Robertson, BSc
Laboratory Director

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

Report Date: 16-Mar-2017
Order Date: 10-Mar-2017
Project Description: 14967

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	15-Mar-17	15-Mar-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	16-Mar-17	16-Mar-17
Resistivity	EPA 120.1 - probe, water extraction	11-Mar-17	11-Mar-17
Solids, %	Gravimetric, calculation	11-Mar-17	11-Mar-17

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

Report Date: 16-Mar-2017
Order Date: 10-Mar-2017
Project Description: 14967

	Client ID:	17-4 SS6 (12'6-14'6)	17-4 SS7 (15-17)	-	-
	Sample Date:	28-Feb-17	28-Feb-17	-	-
	Sample ID:	1710489-01	1710489-02	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	80.2	61.5	-	-
General Inorganics					
pH	0.05 pH Units	7.64	7.85	-	-
Resistivity	0.10 Ohm.m	28.5	33.1	-	-
Anions					
Chloride	5 ug/g dry	130	43	-	-
Sulphate	5 ug/g dry	11	10	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	370	5	ug/g dry	356			3.7	20	
Sulphate	359	5	ug/g dry	363			1.1	20	
General Inorganics									
pH	7.42	0.05	pH Units	7.41			0.1	10	
Resistivity	8.81	0.10	Ohm.m	8.85			0.4	20	
Physical Characteristics									
% Solids	85.2	0.1	% by Wt.	83.8			1.7	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	457	5	ug/g	356	101	78-113			
Sulphate	458	5	ug/g	363	95.5	78-111			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 14967
Custody: 14061

Report Date: 1-Aug-2017
Order Date: 26-Jul-2017

Order #: 1730350

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1730350-01	Grab #1 St. 18 + 562
1730350-02	Grab #2 St. 18 + 437
1730350-03	17-30 SS #5A
1730350-04	17-34 SS #3
1730350-05	17-36 SS #5

Approved By:

Dale Robertson, BSc
Laboratory Director

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	28-Jul-17	28-Jul-17
Conductivity	MOE E3138 - probe @25 °C, water ext	28-Jul-17	29-Jul-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	26-Jul-17	27-Jul-17
Resistivity	EPA 120.1 - probe, water extraction	28-Jul-17	29-Jul-17
Solids, %	Gravimetric, calculation	27-Jul-17	27-Jul-17

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 01-Aug-2017

Order Date: 26-Jul-2017

Project Description: 14967

	Client ID:	Grab #1 St. 18 + 562	Grab #2 St. 18 + 437	17-30 SS #5A	17-34 SS #3
	Sample Date:	19-Jul-17	19-Jul-17	18-Jul-17	19-Jul-17
	Sample ID:	1730350-01	1730350-02	1730350-03	1730350-04
	MDL/Units	Other	Other	Other	Other
Physical Characteristics					
% Solids	0.1 % by Wt.	25.8	22.4	22.7	37.4
General Inorganics					
Conductivity	5 uS/cm	1440	2540 [1]	359 [1]	2460 [1]
pH	0.05 pH Units	4.54	5.08	5.99	5.44
Resistivity	0.10 Ohm.m	6.96 [1]	3.93 [1]	27.9 [1]	4.07 [1]
Anions					
Chloride	5 ug/g dry	2910	4420	27	5390
Sulphate	5 ug/g dry	60	129	248	118

	Client ID:	17-36 SS #5	-	-	-
	Sample Date:	20-Jul-17	-	-	-
	Sample ID:	1730350-05	-	-	-
	MDL/Units	Other	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	73.3	-	-	-
General Inorganics					
Conductivity	5 uS/cm	126	-	-	-
pH	0.05 pH Units	7.49	-	-	-
Resistivity	0.10 Ohm.m	79.6	-	-	-
Anions					
Chloride	5 ug/g dry	10	-	-	-
Sulphate	5 ug/g dry	12	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	8.2	5	ug/g dry	10.5			24.9	20	QR-01
Sulphate	11.8	5	ug/g dry	12.3			3.9	20	
General Inorganics									
Conductivity	268	5	uS/cm	266			0.8	6.2	
pH	10.99	0.05	pH Units	10.95			0.4	10	
Physical Characteristics									
% Solids	90.2	0.1	% by Wt.	90.5			0.3	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	107	5	ug/g	10.5	96.7	78-113			
Sulphate	117	5	ug/g	12.3	104	78-111			

Qualifier Notes:

Sample Qualifiers :

1 : Due to the nature of the matrix, sample preparation for this analysis deviated from the Paracel prescribed method.

QC Qualifiers :

QR-01 : Duplicate RPD is high, however, the sample result is less than 10x the MDL.

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Appendix D.

Site Photographs

Photo 1. Looking north along Highway 537 (approx. Sta. 18+300)

Photo 2. Looking north along Highway 537 near Jumbo Creek Culvert outlet (approx. Sta. 18+345)

Photo 3. Looking north along 537 near Jumbo Creek Culvert inlet (approx. Sta. 18+345)

Photo 4. Looking north along south side of Highway 537 (approx. Sta. 18+400)

Photo 5. (approx. Sta. 18+500)

Photo 6. (approx. Sta. 18+600)

Appendix E.

ConeTec Field Report

PRESENTATION OF SITE INVESTIGATION RESULTS

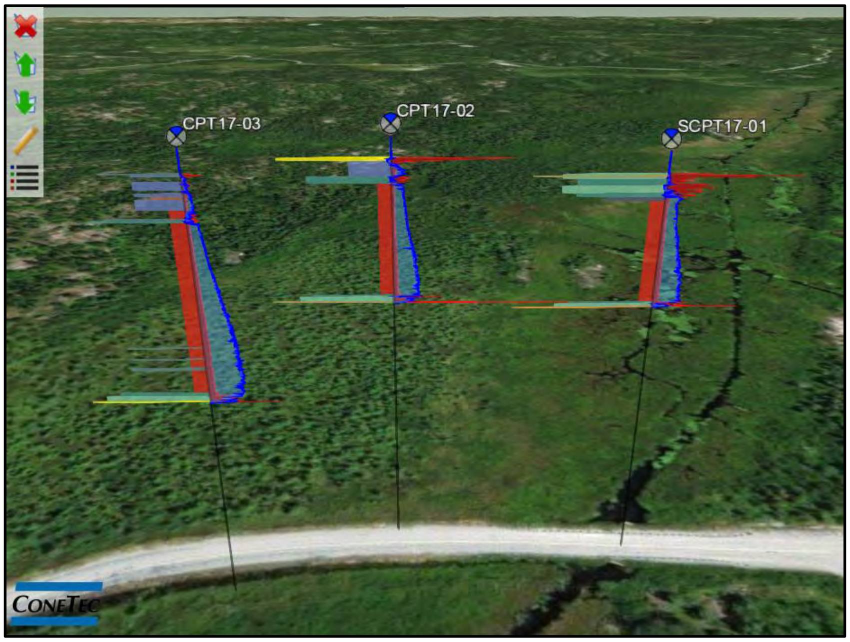
Highway 537 and Jumbo Creek

Prepared for:

Thurber Engineering Ltd.

ConeTec Job No: 17-05009

Project Start Date: 03-Mar-2017
Project End Date: 28-Mar-2017
Report Date: 30-Mar-2017



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Introduction

The enclosed report presents the results of the site investigation program conducted by ConeTec Investigations Ltd. for Thurber Engineering Ltd. on Highway 537 near Jumbo Creek. The program consisted of ten cone penetration tests (CPT), one seismic cone penetration test (SCPT), and one electronic field vane shear test (VST).

Project Information

Project	
Client	Thurber Engineering Ltd.
Project	Highway 537 and Jumbo Creek
ConeTec project number	17-05009

A map from Google Earth including the CPT test locations is presented below.

Rig Description	Deployment System	Test Type
CPT Truck Rig (C-3)	30 Ton Rig Cylinder	SCPT,CPT
CME-750x Mounted Drill	Drill Head	VST
Geoprobe 7822DT	Drill Head	CPT

Coordinates		
Test Type	Collection Method	EPSG Number
SCPT,CPT,VST	Consumer grade GPS	32617

Cone Penetration Test (CPT)	
Depth reference	Depths are referenced to the existing ground surface at the time of each test.
Tip and sleeve data offset	0.1 meter This has been accounted for in the CPT data files.
Additional plots	Advanced CPT plots with Ic, Su(Nkt), and OCR, CPT plots with expanded scales, along with CPT plots displaying seismic shear wave velocities are included.

Cone Penetrometers Used for this Project						
Cone Description	Cone Number	Cross Sectional Area (cm^2)	Sleeve Area (cm^2)	Tip Capacity (bar)	Sleeve Capacity (bar)	Pore Pressure Capacity (psi)
323:T1500:F15:U500	323	15	225	1500	15	500
379:T1500:F15:U500	379	15	225	1500	15	500
417:T375:F10:U200	417	15	225	375	10	200
The CPT summary indicates which cone was used for each sounding.						

Interpretation Tables	
Additional information	The Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997) was used to classify the soil for this project. A detailed set of CPT interpretations were generated and are provided in Excel format files in the release folder. The CPT interpretations are based on values of corrected tip (q_t), sleeve friction (f_s) and pore pressure (u_2). Soils were classified as either drained or undrained based on the Soil Behaviour Type (SBT) classification chart (Robertson et al., 1986 presented by Lunne, Robertson and Powell, 1997). Calculations for both drained and undrained parameters were included for materials that classified as silt (zone 6). Materials that classified as undefined (zone 0) were treated as undrained.

Electronic Field Vane Shear Test (VST)	
Depth reference	Depths are referenced to the existing ground surface at the time of the test.
Load cell capacity	100 Nm

Limitations

This report has been prepared for the exclusive use of Thurber Engineering Ltd. (Client) for the project titled “Highway 537 and Jumbo Creek”. The report’s contents may not be relied upon by any other party without the express written permission of ConeTec Investigations Ltd. (ConeTec). ConeTec has provided site investigation services, prepared the factual data reporting, and provided geotechnical parameter calculations consistent with current best practices. No other warranty, expressed or implied, is made.

The information presented in the report document and the accompanying data set pertain to the specific project, site conditions and objectives described to ConeTec by the Client. In order to properly understand the factual data, assumptions and calculations, reference must be made to the documents provided and their accompanying data sets, in their entirety.

The cone penetration tests (CPTu) are conducted using an integrated electronic piezocone penetrometer and data acquisition system manufactured by Adara Systems Ltd. of Richmond, British Columbia, Canada.

ConeTec's piezocone penetrometers are compression type designs in which the tip and friction sleeve load cells are independent and have separate load capacities. The piezocones use strain gauged load cells for tip and sleeve friction and a strain gauged diaphragm type transducer for recording pore pressure. The piezocones also have a platinum resistive temperature device (RTD) for monitoring the temperature of the sensors, an accelerometer type dual axis inclinometer and a geophone sensor for recording seismic signals. All signals are amplified down hole within the cone body and the analog signals are sent to the surface through a shielded cable.

ConeTec penetrometers are manufactured with various tip, friction and pore pressure capacities in both 10 cm^2 and 15 cm^2 tip base area configurations in order to maximize signal resolution for various soil conditions. The specific piezocone used for each test is described in the CPT summary table presented in the first Appendix. The 15 cm^2 penetrometers do not require friction reducers as they have a diameter larger than the deployment rods. The 10 cm^2 piezocones use a friction reducer consisting of a rod adapter extension behind the main cone body with an enlarged cross sectional area (typically 44 mm diameter over a length of 32 mm with tapered leading and trailing edges) located at a distance of 585 mm above the cone tip.

The penetrometers are designed with equal end area friction sleeves, a net end area ratio of 0.8 and cone tips with a 60 degree apex angle.

All ConeTec piezocones can record pore pressure at various locations. Unless otherwise noted, the pore pressure filter is located directly behind the cone tip in the "u_2" position (ASTM Type 2). The filter is 6 mm thick, made of porous plastic (polyethylene) having an average pore size of 125 microns (90-160 microns). The function of the filter is to allow rapid movements of extremely small volumes of water needed to activate the pressure transducer while preventing soil ingress or blockage.

The piezocone penetrometers are manufactured with dimensions, tolerances and sensor characteristics that are in general accordance with the current ASTM D5778 standard. ConeTec's calibration criteria also meets or exceeds those of the current ASTM D5778 standard. An illustration of the piezocone penetrometer is presented in Figure CPTu.

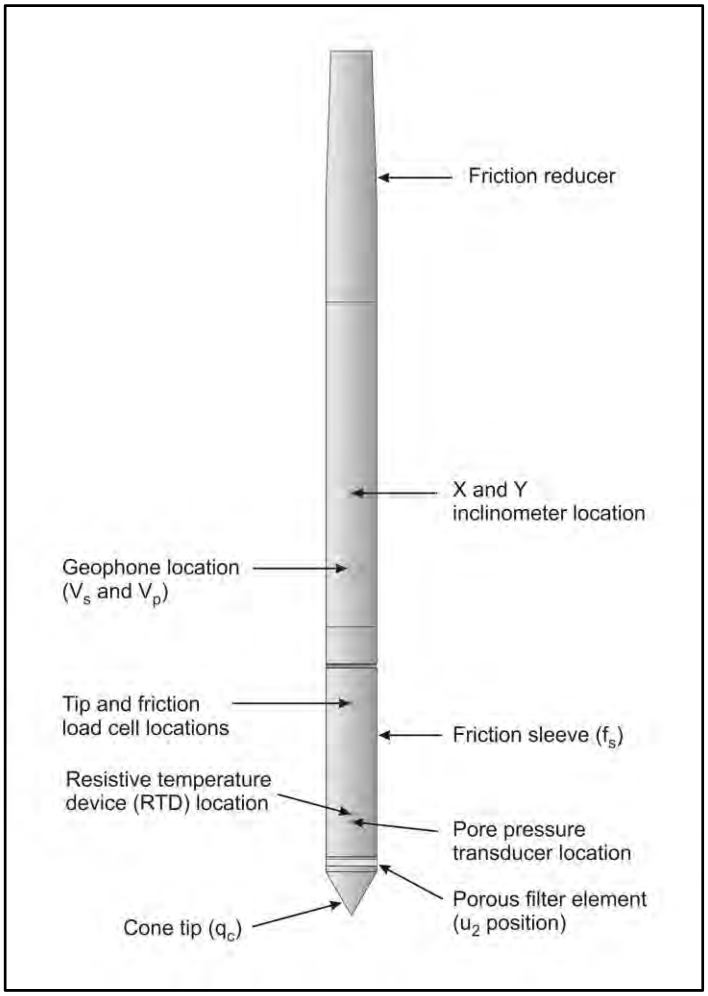

Figure CPTu. Piezocone Penetrometer (15 cm^2)

The ConeTec data acquisition systems consist of a Windows based computer and a signal conditioner and power supply interface box with a 16 bit (or greater) analog to digital (A/D) converter. The data is recorded at fixed depth increments using a depth wheel attached to the push cylinders or by using a spring loaded rubber depth wheel that is held against the cone rods. The typical recording intervals are either 2.5 cm or 5.0 cm depending on project requirements; custom recording intervals are possible. The system displays the CPTu data in real time and records the following parameters to a storage media during penetration:

- Depth
- Uncorrected tip resistance (q_c)
- Sleeve friction (f_s)
- Dynamic pore pressure (u)
- Additional sensors such as resistivity, passive gamma, ultra violet induced fluorescence, if applicable

All testing is performed in accordance to ConeTec's CPT operating procedures which are in general accordance with the current ASTM D5778 standard.

Prior to the start of a CPTu sounding a suitable cone is selected, the cone and data acquisition system are powered on, the pore pressure system is saturated with either glycerine or silicone oil and the baseline readings are recorded with the cone hanging freely in a vertical position.

The CPTu is conducted at a steady rate of 2 cm/s, within acceptable tolerances. Typically one meter length rods with an outer diameter of 1.5 inches are added to advance the cone to the sounding termination depth. After cone retraction final baselines are recorded.

Additional information pertaining to ConeTec's cone penetration testing procedures:

- Each filter is saturated in silicone oil or glycerine under vacuum pressure prior to use
- Recorded baselines are checked with an independent multi-meter
- Baseline readings are compared to previous readings
- Soundings are terminated at the client's target depth or at a depth where an obstruction is encountered, excessive rod flex occurs, excessive inclination occurs, equipment damage is likely to take place, or a dangerous working environment arises
- Differences between initial and final baselines are calculated to ensure zero load offsets have not occurred and to ensure compliance with ASTM standards

The interpretation of piezocone data for this report is based on the corrected tip resistance (q_t), sleeve friction (f_s) and pore water pressure (u). The interpretation of soil type is based on the correlations developed by Robertson (1990) and Robertson (2009). It should be noted that it is not always possible to accurately identify a soil type based on these parameters. In these situations, experience, judgment and an assessment of other parameters may be used to infer soil behaviour type.

The recorded tip resistance (q_c) is the total force acting on the piezocone tip divided by its base area. The tip resistance is corrected for pore pressure effects and termed corrected tip resistance (q_t) according to the following expression presented in Robertson et al, 1986:

$$q_t = q_c + (1\text{-}a) \bullet u_2$$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the piezocone (0.8 for ConeTec probes)

The sleeve friction (f_s) is the frictional force on the sleeve divided by its surface area. As all ConeTec piezocones have equal end area friction sleeves, pore pressure corrections to the sleeve data are not required.

The dynamic pore pressure (u) is a measure of the pore pressures generated during cone penetration. To record equilibrium pore pressure, the penetration must be stopped to allow the dynamic pore pressures to stabilize. The rate at which this occurs is predominantly a function of the permeability of the soil and the diameter of the cone.

The friction ratio (Rf) is a calculated parameter. It is defined as the ratio of sleeve friction to the tip resistance expressed as a percentage. Generally, saturated cohesive soils have low tip resistance, high friction ratios and generate large excess pore water pressures. Cohesionless soils have higher tip resistances, lower friction ratios and do not generate significant excess pore water pressure.

A summary of the CPTu soundings along with test details and individual plots are provided in the appendices. A set of interpretation files were generated for each sounding based on published correlations and are provided in Excel format in the data release folder. Information regarding the interpretation methods used is also included in the data release folder.

For additional information on CPTu interpretations, refer to Robertson et al. (1986), Lunne et al. (1997), Robertson (2009), Mayne (2013, 2014) and Mayne and Peuchen (2012).

Shear wave velocity testing is performed in conjunction with the piezocone penetration test (SCPTu) in order to collect interval velocities. For some projects seismic compression wave (Vp) velocity is also determined.

ConeTec's piezocone penetrometers are manufactured with a horizontally active geophone (28 hertz) that is rigidly mounted in the body of the cone penetrometer, 0.2 meters behind the cone tip.

Shear waves are typically generated by using an impact hammer horizontally striking a beam that is held in place by a normal load. In some instances an auger source or an imbedded impulsive source maybe used for both shear waves and compression waves. The hammer and beam act as a contact trigger that triggers the recording of the seismic wave traces. For impulsive devices an accelerometer trigger may be used. The traces are recorded using an up-hole integrated digital oscilloscope which is part of the SCPTu data acquisition system. An illustration of the shear wave testing configuration is presented in Figure SCPTu-1.

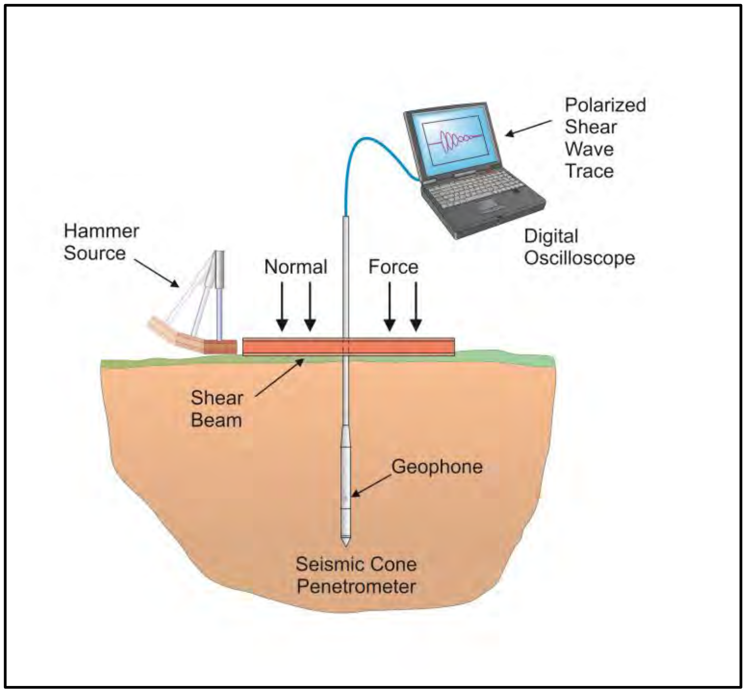

Figure SCPTu-1. Illustration of the SCPTu system

All testing is performed in accordance to ConeTec's SCPTu operating procedures.

Prior to the start of a SCPTu sounding, the procedures described in the Cone Penetration Test section are followed. In addition, the active axis of the geophone is aligned parallel to the beam (or source) and the horizontal offset between the cone and the source is measured and recorded.

Prior to recording seismic waves at each test depth, cone penetration is stopped and the rods are decoupled from the rig to avoid transmission of rig energy down the rods. Multiple wave traces are recorded for quality control purposes. After reviewing wave traces for consistency the cone is pushed to the next test depth (typically one meter intervals or as requested by the client). Figure SCPTu-2 presents an illustration of a SCPTu test.

For additional information on seismic cone penetration testing refer to Robertson et.al. (1986).

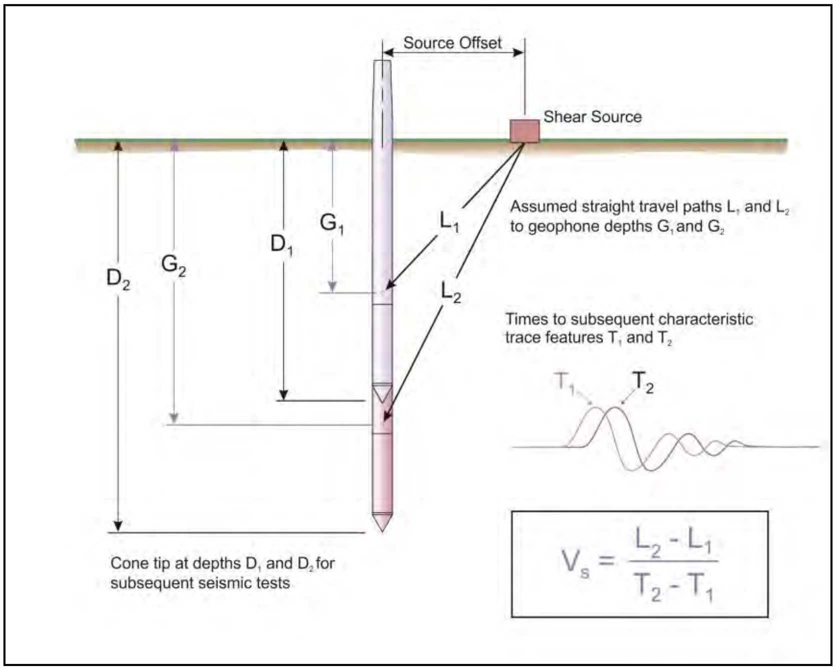

Figure SCPTu-2. Illustration of a seismic cone penetration test

Calculation of the interval velocities are performed by visually picking a common feature (e.g. the first characteristic peak, trough, or crossover) on all of the recorded wave sets and taking the difference in ray path divided by the time difference between subsequent features. Ray path is defined as the straight line distance from the seismic source to the geophone, accounting for beam offset, source depth and geophone offset from the cone tip.

The average shear wave velocity to a depth of 30 meters (V_{s30}) has been calculated and provided for all applicable soundings using an equation presented in Crow et al., 2012.

$$V_{s30} = \frac{total\ thickness\ of\ all\ layers\ (30m)}{\sum(layer\ traveltimes)}$$

The layer travel times refers to the travel times propagating in the vertical direction, not the measured travel times from an offset source.

Tabular results and SCPTu plots are presented in the relevant appendix.

The cone penetration test is halted at specific depths to carry out pore pressure dissipation (PPD) tests, shown in Figure PPD-1. For each dissipation test the cone and rods are decoupled from the rig and the data acquisition system measures and records the variation of the pore pressure (u) with time (t).

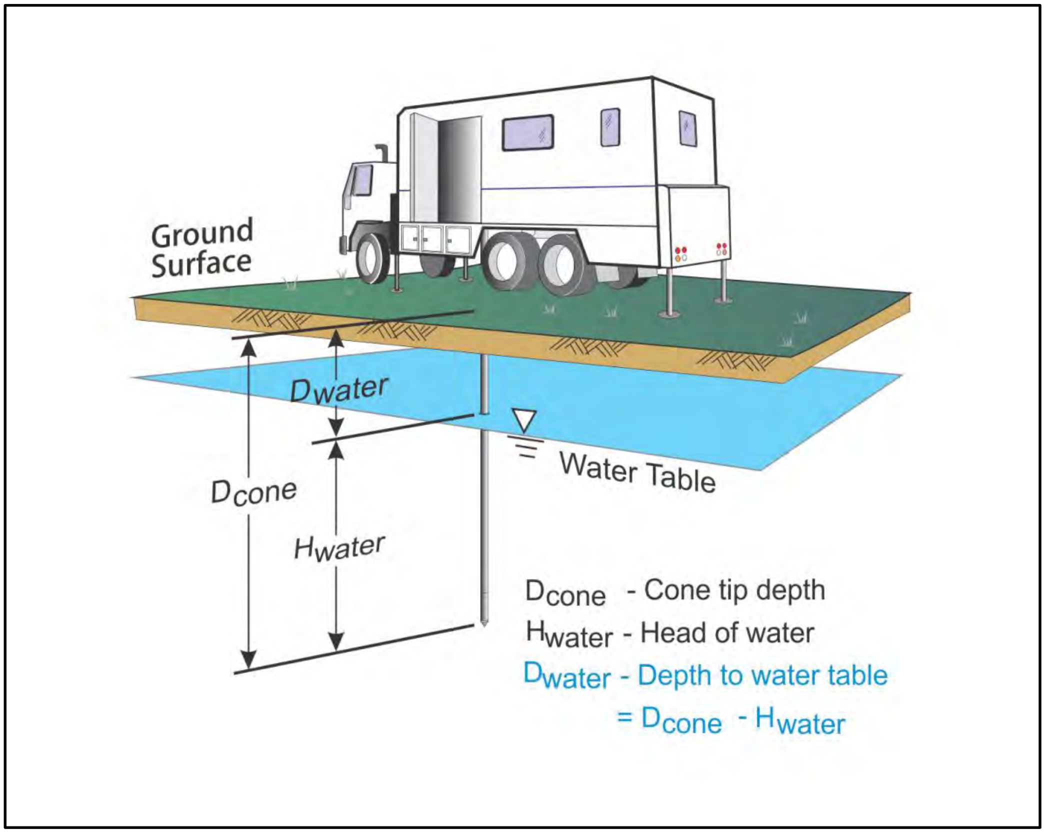

Figure PPD-1. Pore pressure dissipation test setup

Pore pressure dissipation data can be interpreted to provide estimates of ground water conditions, permeability, consolidation characteristics and soil behaviour.

The typical shapes of dissipation curves shown in Figure PPD-2 are very useful in assessing soil type, drainage, in situ pore pressure and soil properties. A flat curve that stabilizes quickly is typical of a freely draining sand. Undrained soils such as clays will typically show positive excess pore pressure and have long dissipation times. Dilative soils will often exhibit dynamic pore pressures below equilibrium that then rise over time. Overconsolidated fine-grained soils will often exhibit an initial dilatory response where there is an initial rise in pore pressure before reaching a peak and dissipating.

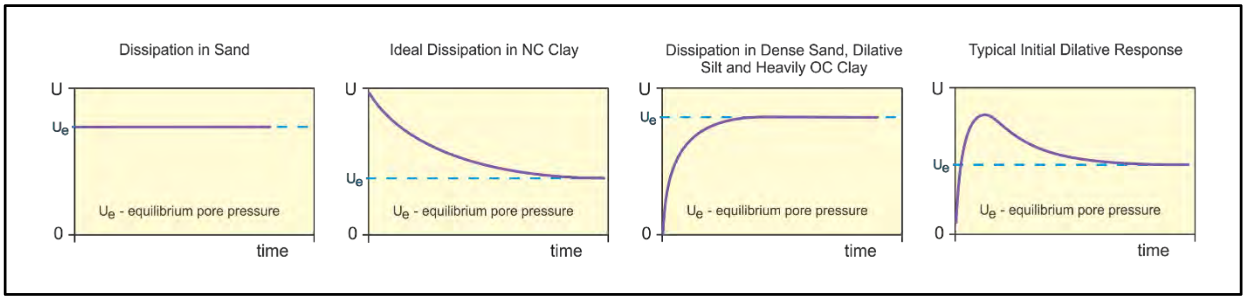

Figure PPD-2. Pore pressure dissipation curve examples

In order to interpret the equilibrium pore pressure (u_{eq}) and the apparent phreatic surface, the pore pressure should be monitored until such time as there is no variation in pore pressure with time as shown for each curve of Figure PPD-2.

In fine grained deposits the point at which 100% of the excess pore pressure has dissipated is known as t_{100}. In some cases this can take an excessive amount of time and it may be impractical to take the dissipation to t_{100}. A theoretical analysis of pore pressure dissipations by Teh and Houlsby (1991) showed that a single curve relating degree of dissipation versus theoretical time factor (T*) may be used to calculate the coefficient of consolidation (c_h) at various degrees of dissipation resulting in the expression for c_h shown below.

$$c_h = \frac{T^* \cdot a^2 \cdot \sqrt{I_r}}{t}$$

Where:

T*	is the dimensionless time factor (Table Time Factor)
a	is the radius of the cone
I_r	is the rigidity index
t	is the time at the degree of consolidation

Table Time Factor. T* versus degree of dissipation (Teh and Houlsby, 1991)

Degree of Dissipation (%)	20	30	40	50	60	70	80
T* (u_2)	0.038	0.078	0.142	0.245	0.439	0.804	1.60

The coefficient of consolidation is typically analyzed using the time (t_{50}) corresponding to a degree of dissipation of 50% (u_{50}). In order to determine t_{50}, dissipation tests must be taken to a pressure less than u_{50}. The u_{50} value is half way between the initial maximum pore pressure and the equilibrium pore pressure value, known as u_{100}. To estimate u_{50}, both the initial maximum pore pressure and u_{100} must be known or estimated. Other degrees of dissipations may be considered, particularly for extremely long dissipations.

At any specific degree of dissipation the equilibrium pore pressure (u at t_{100}) must be estimated at the depth of interest. The equilibrium value may be determined from one or more sources such as measuring the value directly (u_{100}), estimating it from other dissipations in the same profile, estimating the phreatic surface and assuming hydrostatic conditions, from nearby soundings, from client provided information, from site observations and/or past experience, or from other site instrumentation.

For calculations of c_h (Teh and Houlsby, 1991), t_{50} values are estimated from the corresponding pore pressure dissipation curve and a rigidity index (I_r) is assumed. For curves having an initial dilatory response in which an initial rise in pore pressure occurs before reaching a peak, the relative time from the peak value is used in determining t_{50}. In cases where the time to peak is excessive, t_{50} values are not calculated.

Due to possible inherent uncertainties in estimating I_r, the equilibrium pore pressure and the effect of an initial dilatory response on calculating t_{50}, other methods should be applied to confirm the results for c_h.

Additional published methods for estimating the coefficient of consolidation from a piezocone test are described in Burns and Mayne (1998, 2002), Jones and Van Zyl (1981), Robertson et al. (1992) and Sully et al. (1999).

A summary of the pore pressure dissipation tests and dissipation plots are presented in the relevant appendix.

ASTM D5778-12, 2012, "Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils", ASTM, West Conshohocken, US.

Burns, S.E. and Mayne, P.W., 1998, “Monotonic and dilatory pore pressure decay during piezocone tests”, Canadian Geotechnical Journal 26 (4): 1063-1073.

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Jones, G.A. and Van Zyl, D.J.A., 1981, “The piezometer probe: a useful investigation tool”, Proceedings, 10th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, Stockholm: 489-495.

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Mayne, P.W., 2013, “Evaluating yield stress of soils from laboratory consolidation and in-situ cone penetration tests”, Sound Geotechnical Research to Practice (Holtz Volume) GSP 230, ASCE, Reston/VA: 406-420.

Mayne, P.W., 2014, “Interpretation of geotechnical parameters from seismic piezocone tests”, CPT’14 Keynote Address, Las Vegas, NV, May 2014.

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Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, “Use of Piezometer Cone Data”, Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K., Campanella, R.G., Gillespie D and Rice, A., 1986, “Seismic CPT to Measure In-Situ Shear Wave Velocity”, Journal of Geotechnical Engineering ASCE, Vol. 112, No. 8: 791-803.

Robertson, P.K., Sully, J.P., Woeller, D.J., Lunne, T., Powell, J.J.M. and Gillespie, D.G., 1992, “Estimating coefficient of consolidation from piezocone tests”, Canadian Geotechnical Journal, 29(4): 551-557.

Sully, J.P., Robertson, P.K., Campanella, R.G. and Woeller, D.J., 1999, “An approach to evaluation of field CPTU dissipation data in overconsolidated fine-grained soils”, Canadian Geotechnical Journal, 36(2): 369-381.

Teh, C.I., and Houlsby, G.T., 1991, “An analytical study of the cone penetration test in clay”, Geotechnique, 41(1): 17-34.

The electronic field vane system is manufactured by ConeTec Investigations Ltd. of Richmond, British Columbia, Canada. An illustration of the vane system is presented in Figure eVST.

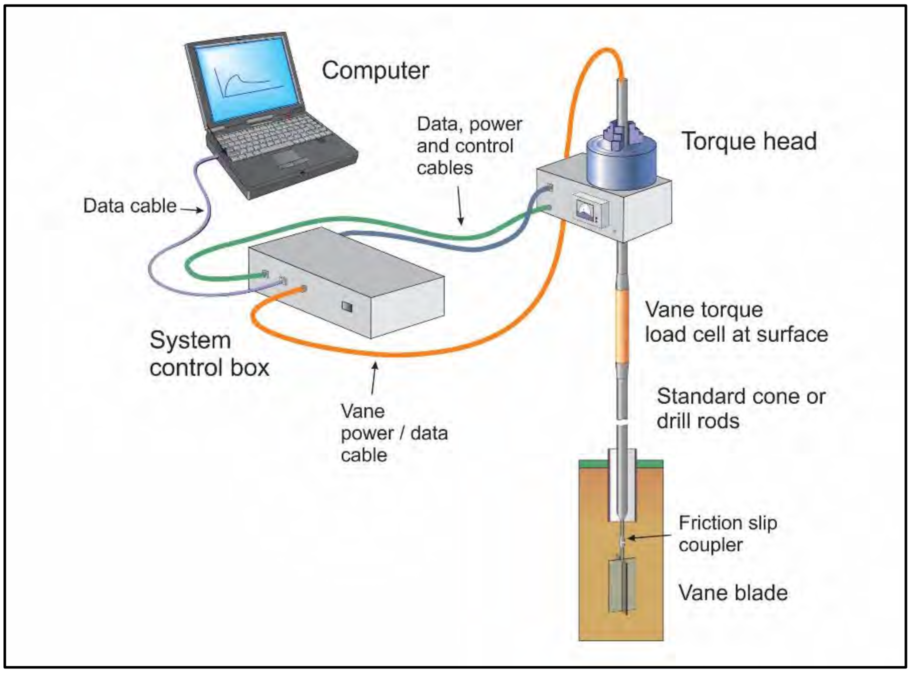


Figure eVST. Illustration of the downhole electronic field vane system

The vane system is designed with an array of strain gauges in a load cell that measure the applied torque. The torque signals are amplified and converted to digital data within the tool and are sent to the data acquisition system through a shielded cable. The system uses a friction slip coupler to permit the free slip or play of approximately fifteen degrees between the rods and the vane in order to isolate and record rod friction from the soil before rotation of the vane starts. The system is designed to use vanes of various sizes and configurations that connect to the friction slip coupler. The vanes manufactured by ConeTec have dimensions and tolerances that are in general accordance with the current ASTM D2573 standards. In very soft soil conditions and at the request of the client, ConeTec may use a large diameter vane that exceeds the ASTM D2573 size specifications in order to maximize torque resolution.

The electric motor (capable of 100 Nm of torque) is designed to clamp onto and rotate the rods and vane at a constant rate.

ConeTec's calibration criteria of the load cells are in accordance with the current ASTM D2573 standard.

The data acquisition system consists of a computer that typically records the vane data every 0.2 degrees of rotation. The system records the following parameters and saves them to a file as the test is conducted:

- Torque in newton meters
- Rotation in degrees
- Elapsed time in seconds (from the start of the test)

All testing is performed in accordance to ConeTec's field vane testing operating procedures and in general accordance with the current ASTM D2573 standard. For additional information on vane shear testing refer to Greig et. al, (1987).

Prior to the start of a vane shear test profile, a suitable sized vane is selected, the vane system is powered on and the vane load cell baseline reading is recorded with the load cell hanging freely in a vertical position.

The vane is advanced to the desired test depth through a cased hole, typically using one meter length rods with an outer diameter of 1.5 inches. Test depths are referenced to the middle of the vane. The motor rotates the vane rods at a near constant rate up to and beyond the yield stress (peak) until the load remains near constant (post peak). Following post peak readings, the vane is then rapidly rotated clockwise, typically ten times to completely remold the soil. The test procedure is repeated in order to record the remolded strength of the soil. The vane is then advanced to the next depth and the procedure is repeated or the vane is retracted to allow for drilling and vane size changes. Once the vane is retracted the final baseline is recorded and compared to previous readings as a QA/QC check.

Undrained shear strength from the field vane, $(S_u)_{fv}$, is typically calculated from torque measurements using the following general equation (ASTM D2573, 2015) taking into consideration the case of rectangular or tapered ends at the top and/or bottom of the vane.

$$(S_u)_{fv} = \frac{12 \cdot T_{max}}{\pi D^2 \left(\frac{D}{\cos(i_T)} + \frac{D}{\cos(i_B)} + 6H \right)}$$

where:

$(S_u)_{fv}$ = undrained shear strength from the field vane

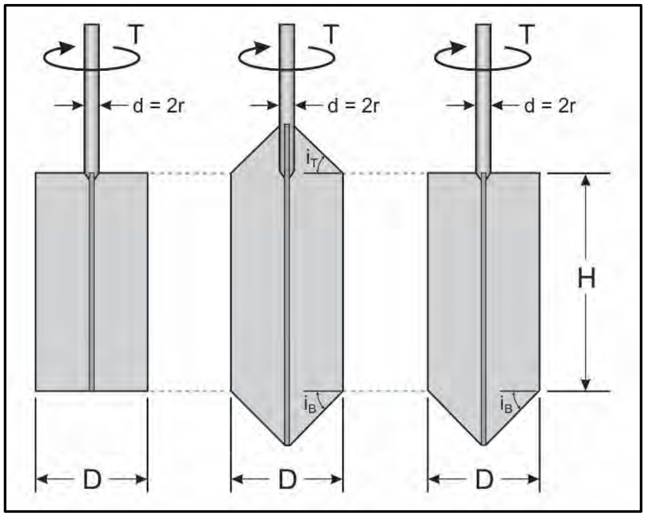
T_{max} = maximum value of torque

D = vane diameter

H = height of the rectangular portion of the vane

i_T = angle of taper at vane top (with respect to horizontal)

i_B = angle of taper at vane bottom (with respect to horizontal)



For rectangular vanes where H/D = 2, the above equation simplifies to:

$$(S_u)_{fv} = \frac{6 \cdot T_{max}}{7 \pi D^3}$$

The recorded rod friction is subtracted from the peak and remolded torque. No correction factors are applied to the vane results to derive the mobilized shear strength ($\tau_{mobilized}$).

A summary of the vane shear tests, a table of results and individual VST plots are provided in the relevant appendices. Tabular data in Excel format is provided in the data release folder.

References

ASTM D2573 / D2573M-15, 2015, “Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils”, ASTM International, West Conshohocken, PA.

Greig, J.W., R.G. Campanella and P.K. Robertson, 1987, “Comparison of Field Vane Results With Other In-Situ Test Results”, International Symposium on Laboratory and Field Vane Shear Strength Testing, ASTM, Tampa, FL, Proceedings.

The appendices listed below are included in the report:

- Cone Penetration Test Summary and Standard Cone Penetration Test Plots
- Advanced Cone Penetration Test Plots with Ic, Su(Nkt), and OCR
- Cone Penetration Test Plots with Expanded Scales
- Seismic Cone Penetration Test Plots
- Seismic Cone Penetration Test Tabular Results
- Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots
- Electronic Field Vane Shear Test Profile Summary and Results
- Electronic Field Vane Shear Test Plots

Cone Penetration Test Summary and Standard Cone Penetration Test Plots

ConeTec

CONETEC

Job No: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Start Date: 03-Mar-2017
End Date: 28-Mar-2017

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date	Cone	Assumed Phreatic Surface[1] (m)	Final Depth (m)	Northing[2] (m)	Easting (m)	Refer to Notation Number
SCPT17-01	17-05009_SP01	03-Mar-2017	379:T1500:F15:U500	0.2	16.425	5141652	518295	
CPT17-02	17-05009_CP02	04-Mar-2017	379:T1500:F15:U500	0.0	18.375	5141694	518258	
CPT17-03	17-05009_CP03	06-Mar-2017	417:T375:F10:U200	0.3	25.575	5141702	518216	
CPT17-04	17-05009_CP04	04-Mar-2017	379:T1500:F15:U500	0.0	27.125	5141732	518172	3
CPT17-04b	17-05009_CP04d	06-Mar-2017	417:T375:F10:U200	0.0	27.000	5141729	518168	
CPT17-05	17-05009_CP05	05-Mar-2017	323:T1500:F15:U500	0.0	27.500	5141747	518125	
CPT17-06	17-05009_CP06	06-Mar-2017	417:T375:F10:U200	0.2	18.450	5141745	518025	
CPT17-07	17-05009_CP07	28-Mar-2017	417:T375:F10:U200	0.0	16.250	5141753	518027	
CPT17-07B	17-05009_CP07B	28-Mar-2017	417:T375:F10:U200	0.0	10.000	5141753	518029	4
CPT17-08	17-05009_CP08	27-Mar-2017	417:T375:F10:U200	0.0	25.800	5141749	518127	
CPT17-09	17-05009_CP09	27-Mar-2017	417:T375:F10:U200	0.0	19.150	5141697	518268	

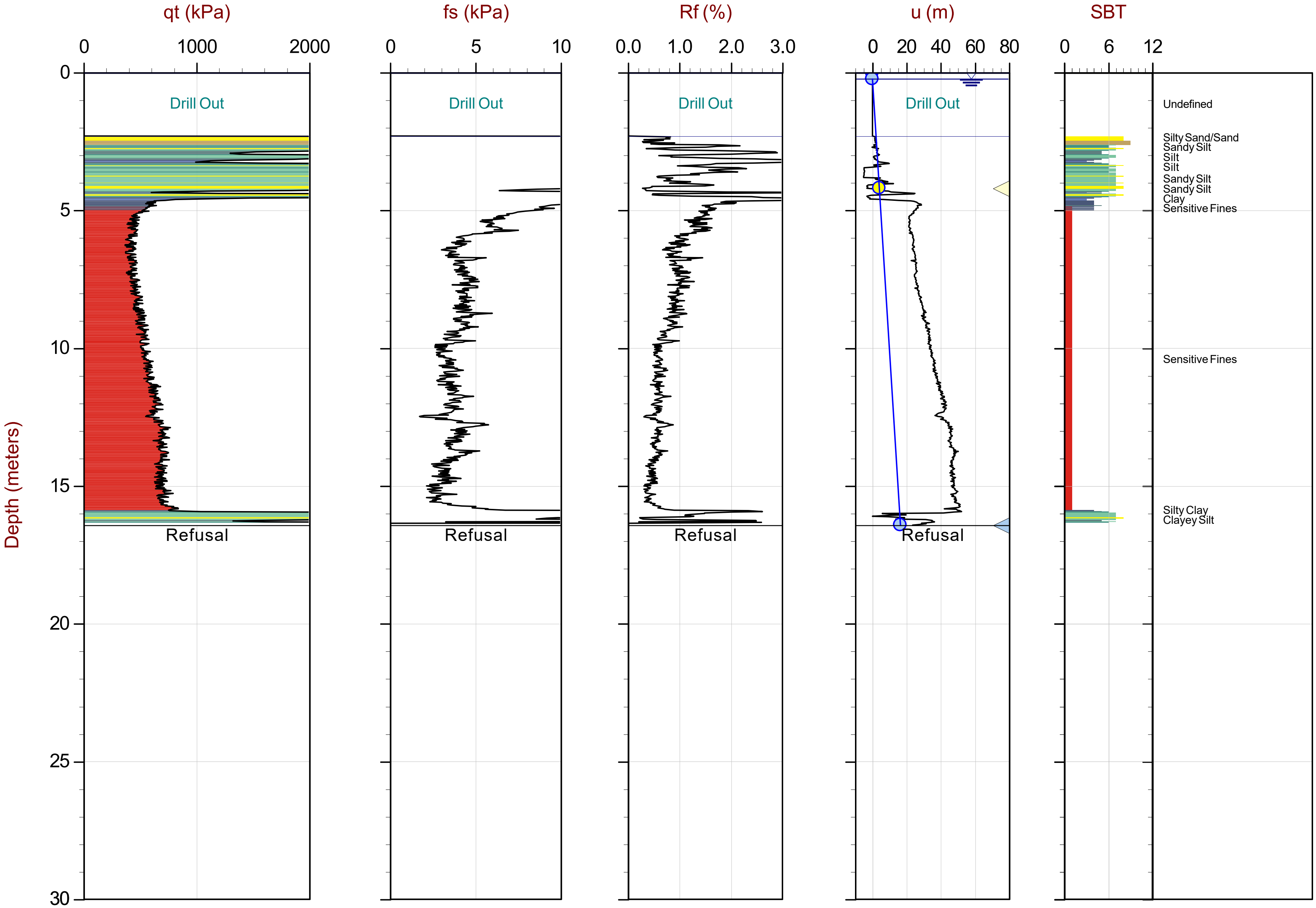
1. The assumed phreatic surface was based on pore pressure dissipation tests. Hydrostatic conditions were assumed for the calculated parameters.
2. Coordinates were collected with a consumer grade GPS device in datum WGS84/UTM Zone 17 North.
3. Due to subdued friction sleeve response during this sounding CPT17-04b was performed to obtain better sleeve data.
4. At client's request a second sounding was done in this location in order to perform a dissipation at 10.000 m.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/03 14:13
Site: Highway 537 and Jumbo Creek

Sounding: SCPT17-01
Cone: 379:T1500F15U500



Max Depth: 16.425 m / 53.89 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_SP01.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141652m E: 518295m
Sheet No: 1 of 1

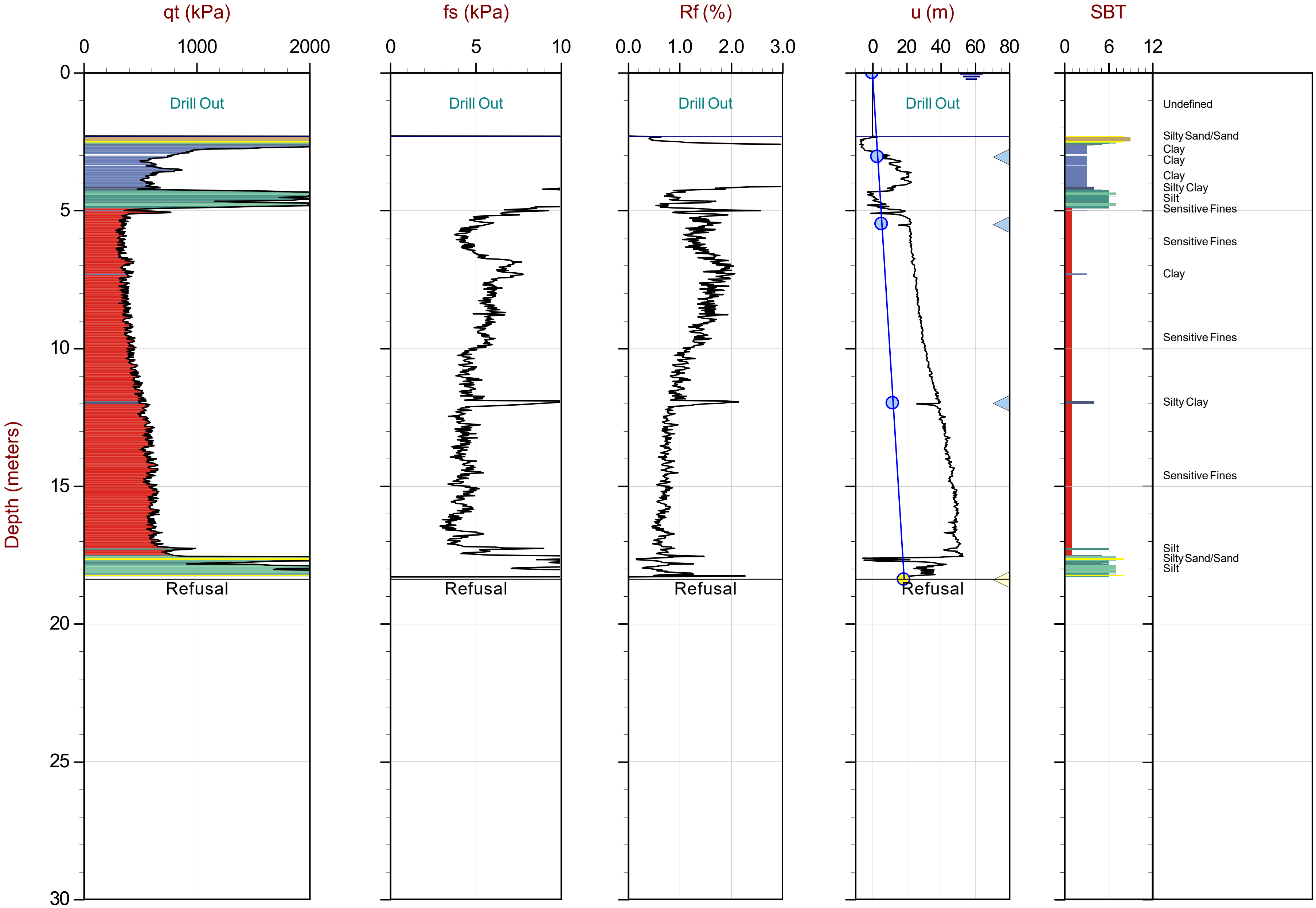
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500



Max Depth: 18.375 m / 60.28 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP02.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N:5141694m E:518258m
Sheet No: 1 of 1

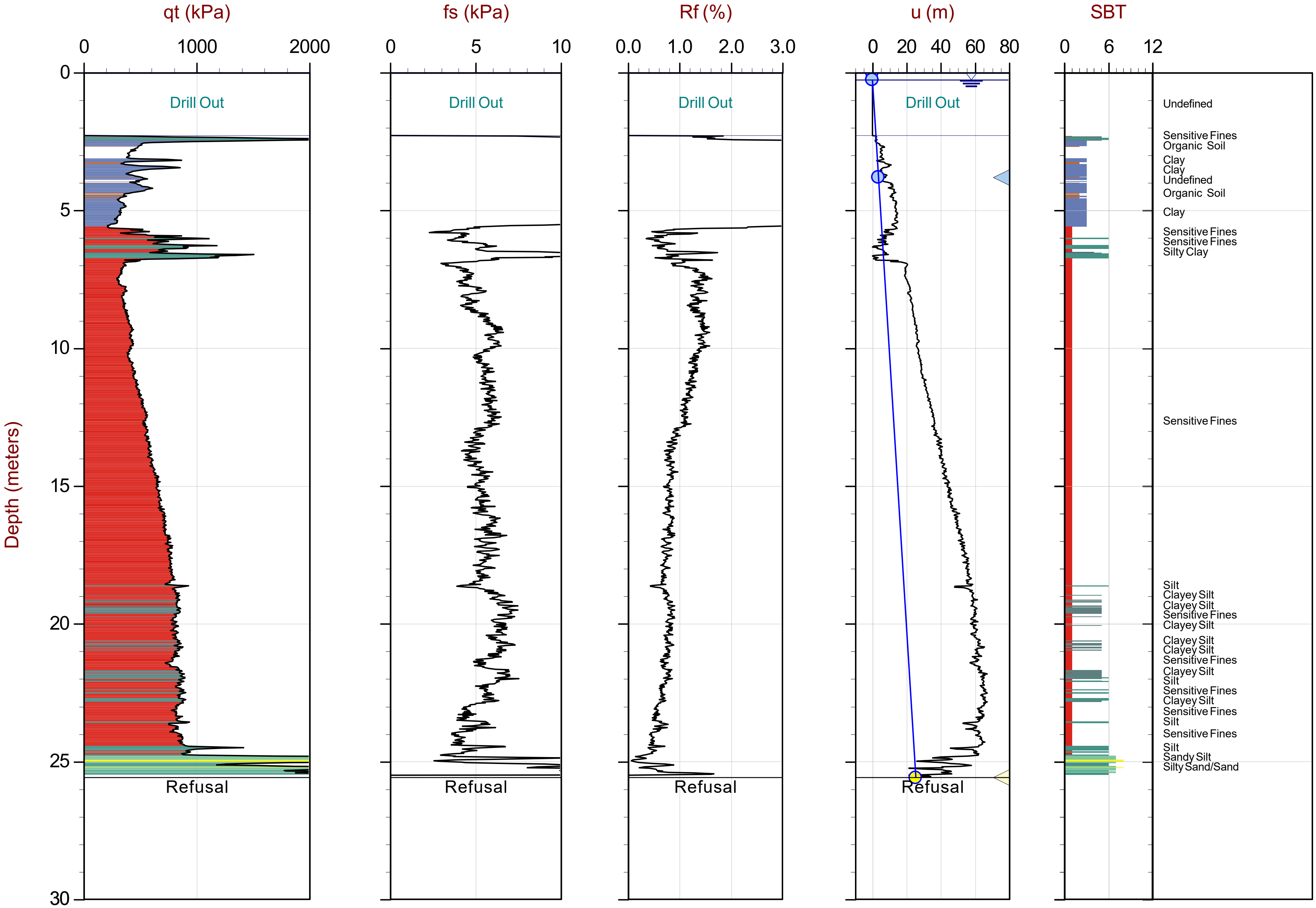
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 09:48
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-03
Cone: 417:T375F10U200



Max Depth: 25.575 m / 83.91 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP03.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141702m E: 518216m
Sheet No: 1 of 1

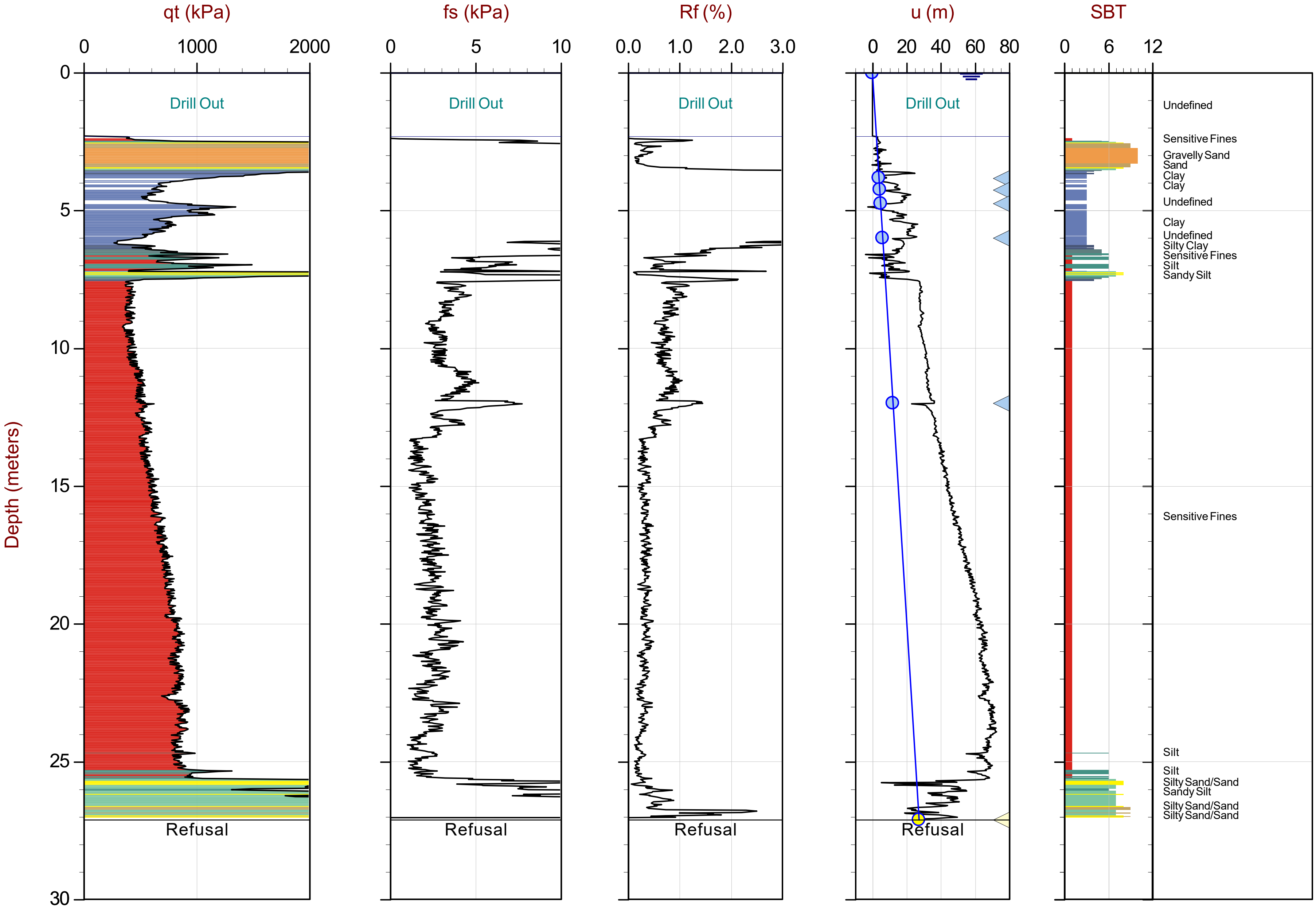
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 13:47
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04
Cone: 379:T1500F15U500



Max Depth: 27.125 m / 88.99 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141732m E: 518172m
Sheet No: 1 of 1

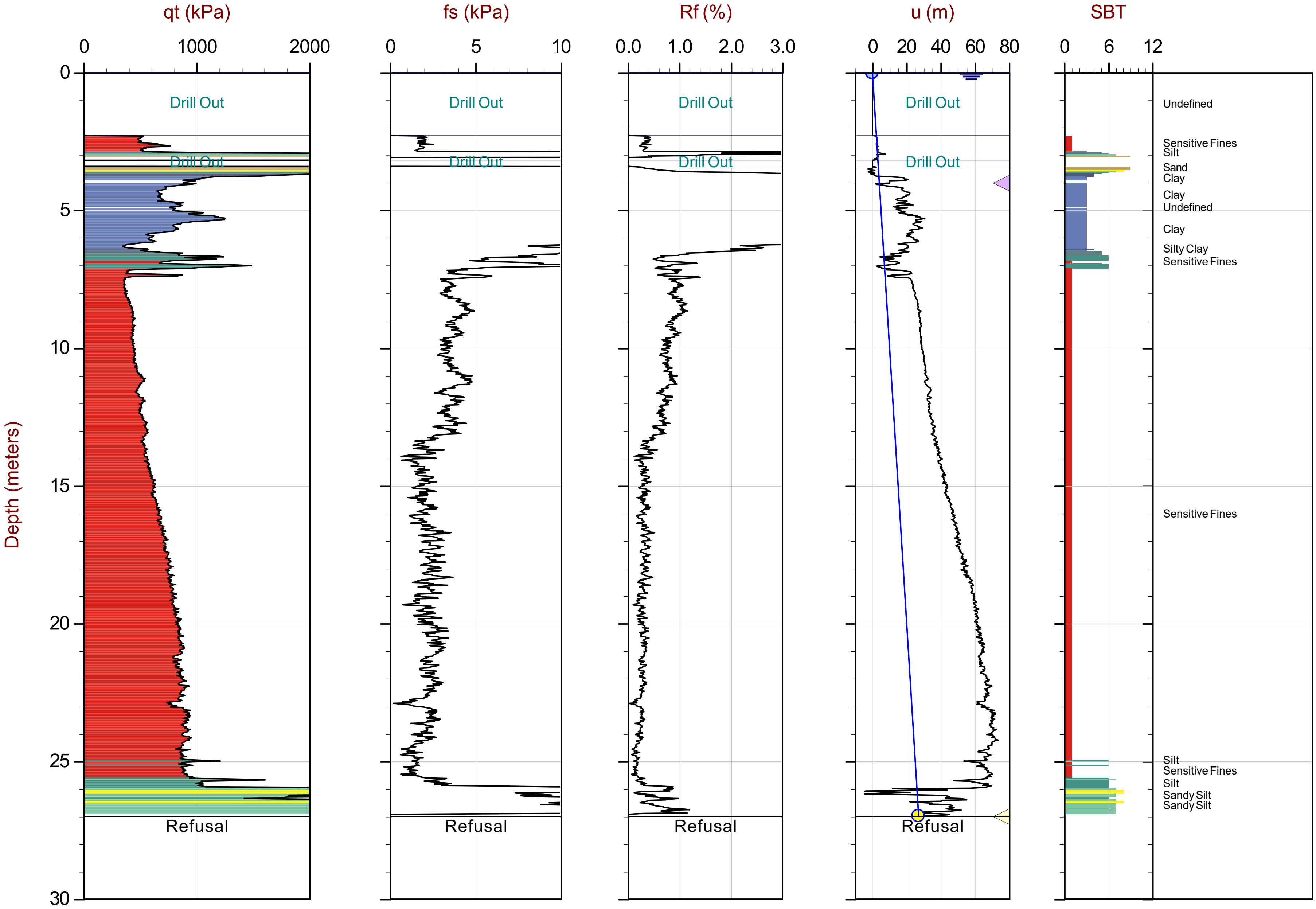
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 14:04
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04B
Cone: 417:T375F10U200



Max Depth: 27.000 m / 88.58 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04D.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141729m E: 518168m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

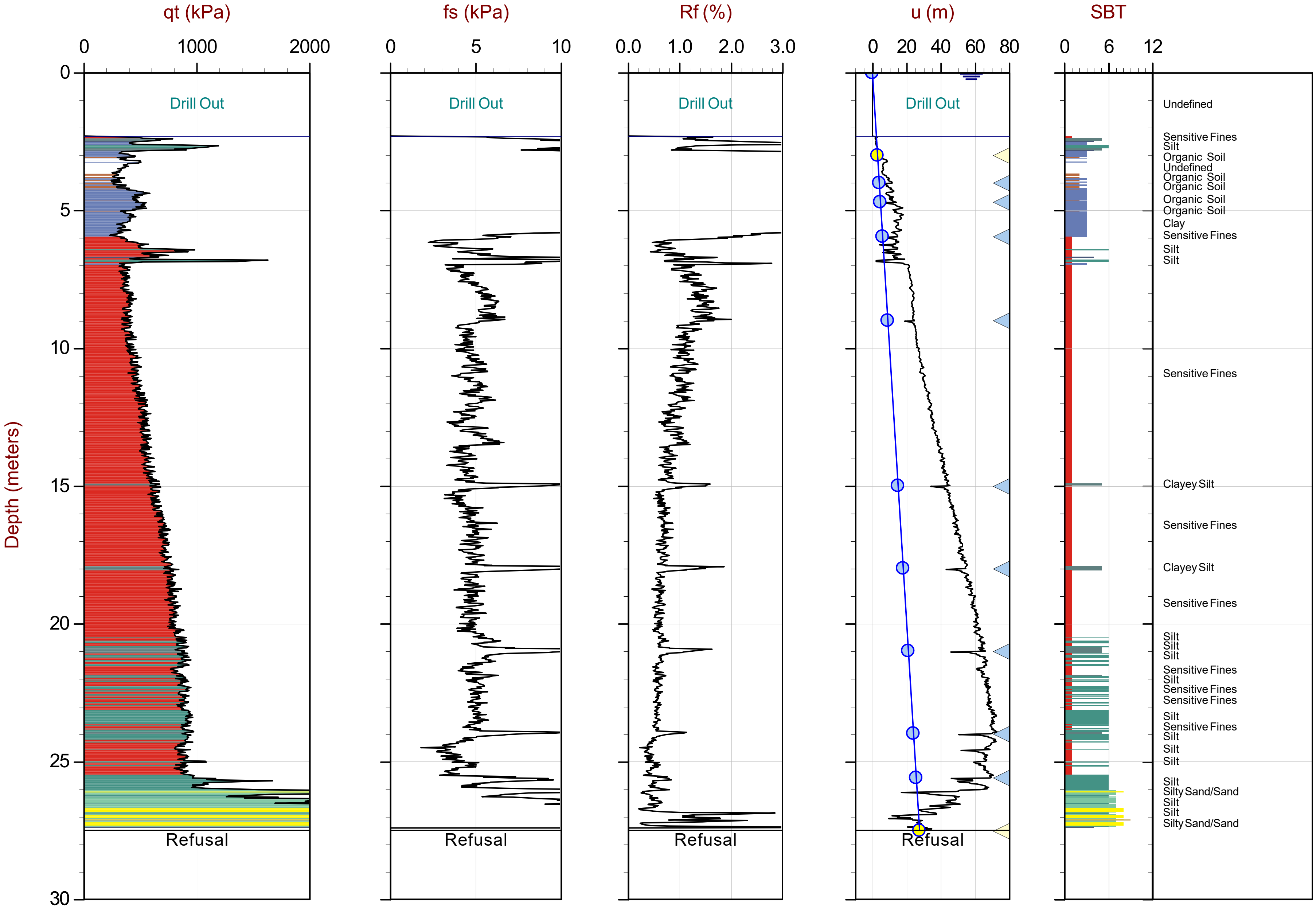
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/05 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500



Max Depth: 27.500 m / 90.22 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP05.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141747m E: 518125m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

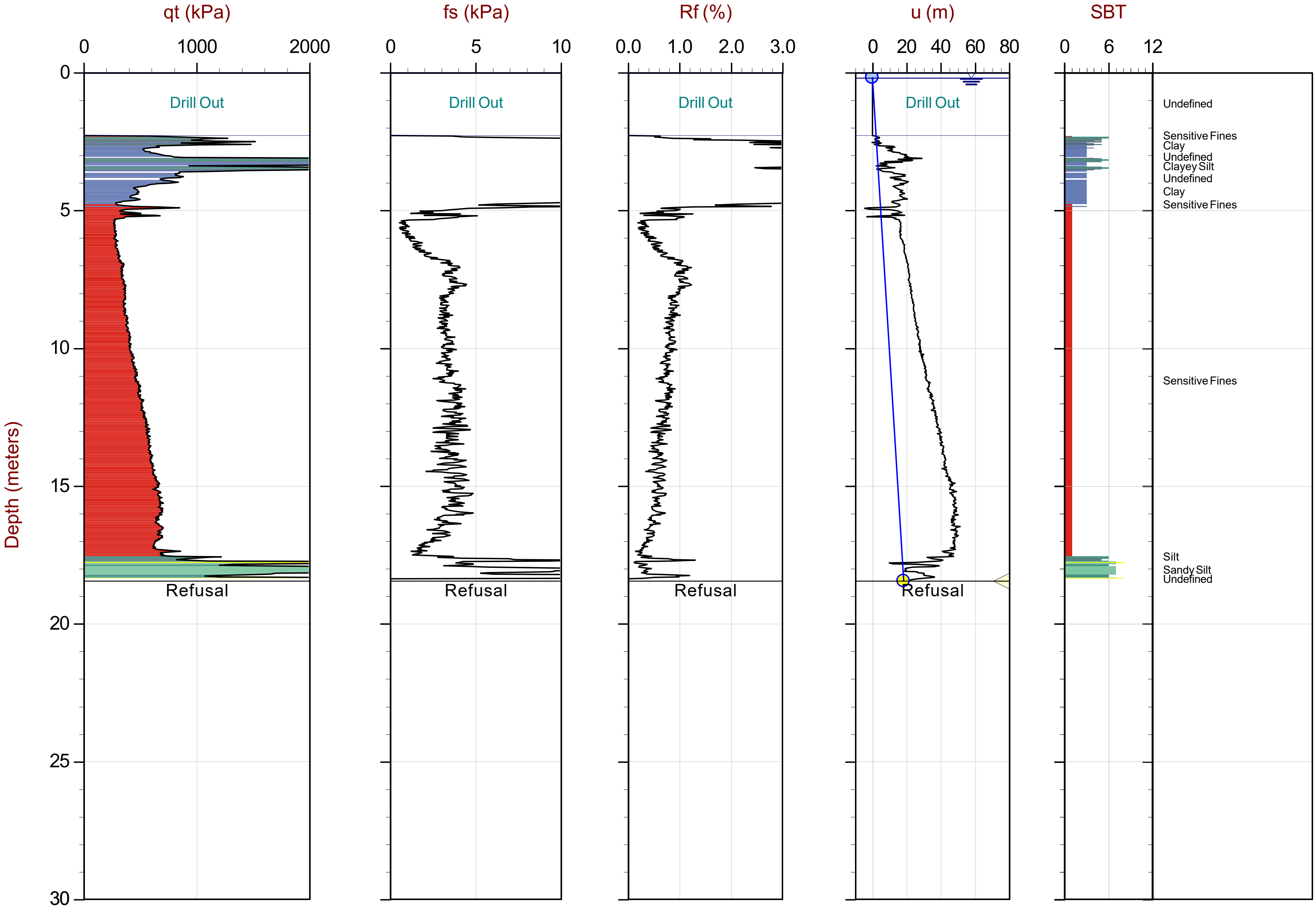
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 11:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-06
Cone: 417:T375F10U200



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP06.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141745m E: 518025m
Sheet No: 1 of 1

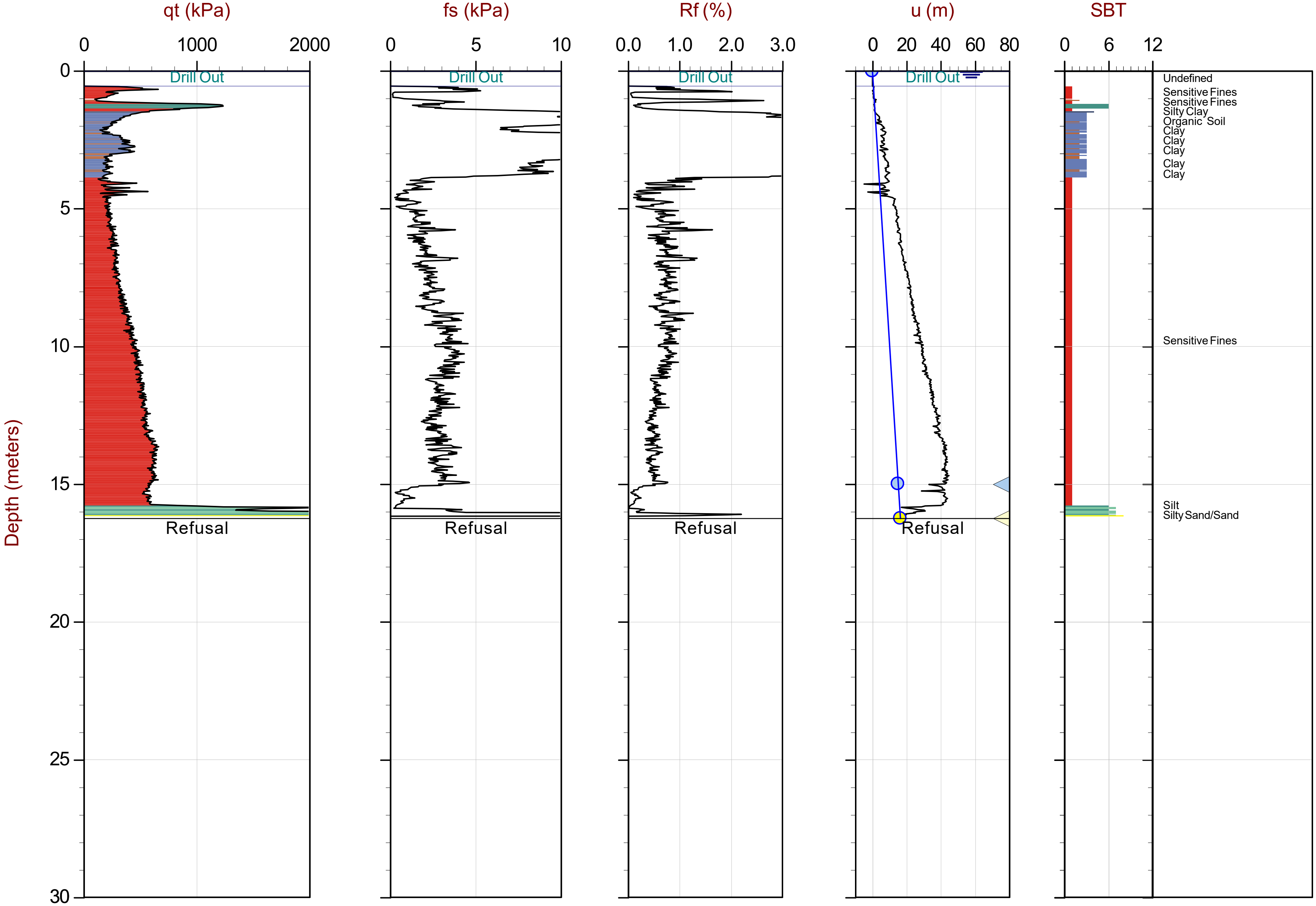
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 09:27
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07
Cone: 417:T375F10U200



Max Depth: 16.250 m / 53.31 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518027m
Sheet No: 1 of 1

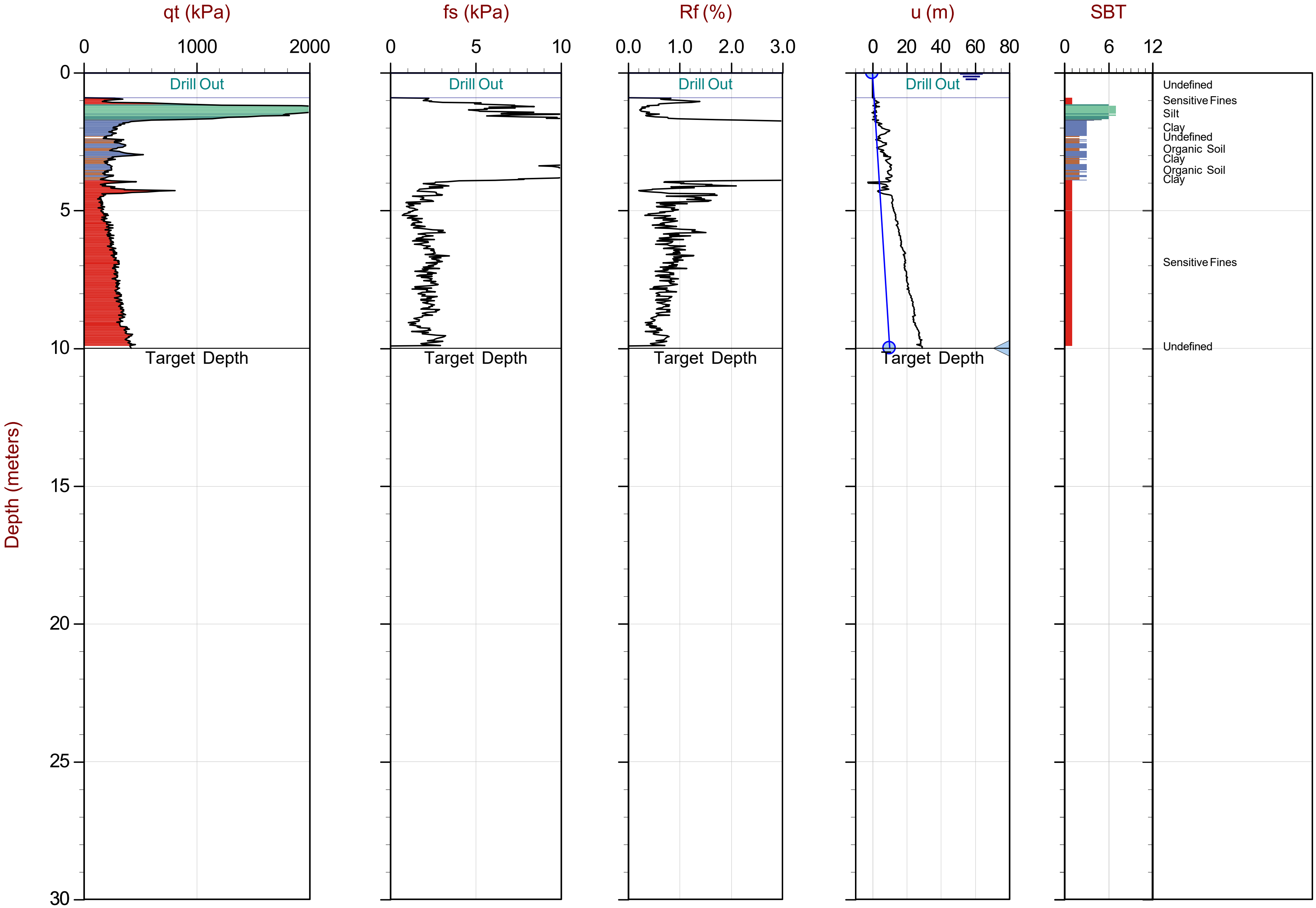
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 12:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07B
Cone: 417:T375F10U200



Max Depth: 10.000 m / 32.81 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07B.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518029m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

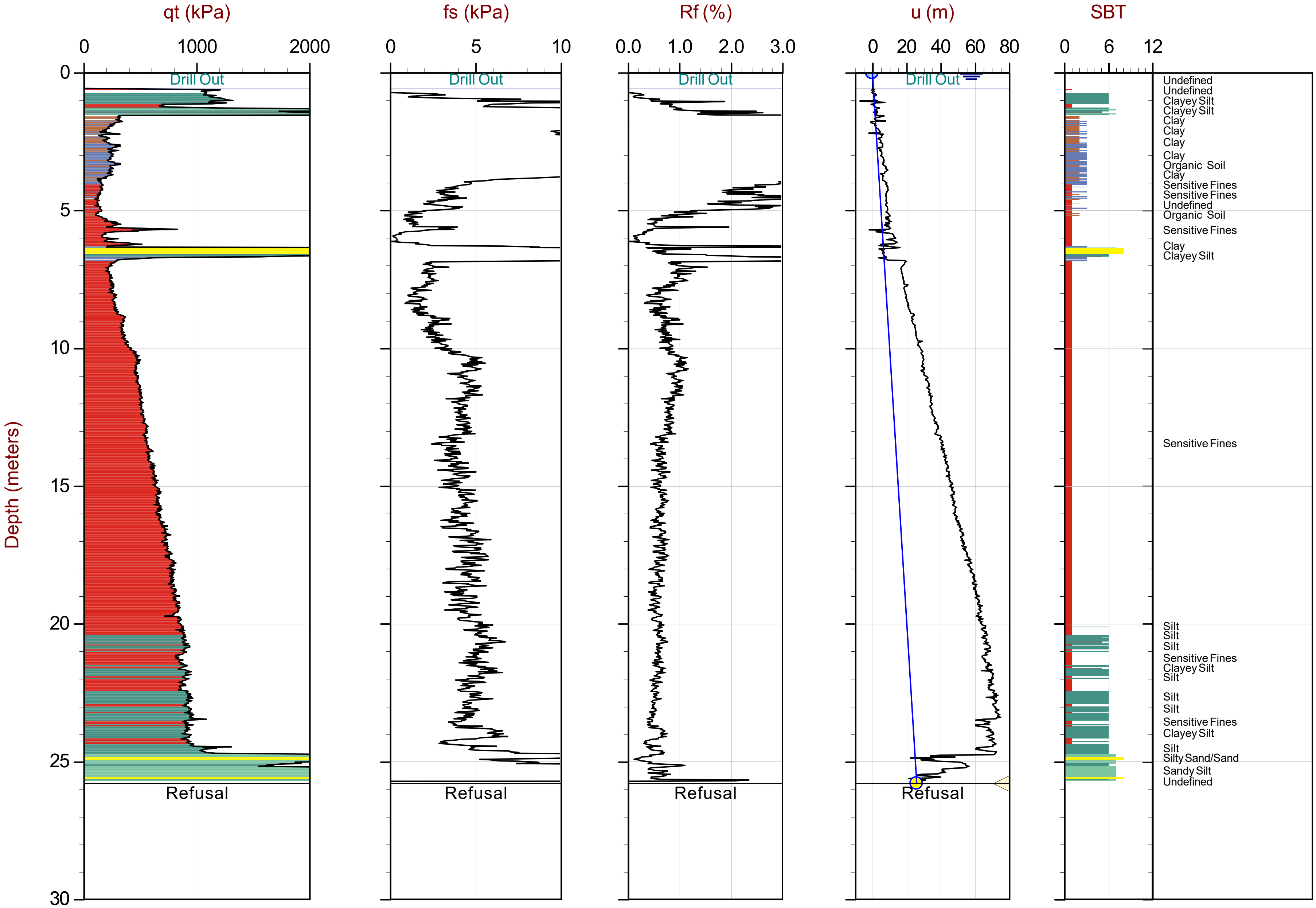
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 15:17
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-08
Cone: 417:T375F10U200



Max Depth: 25.800 m / 84.64 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP08.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141749m E: 518127m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

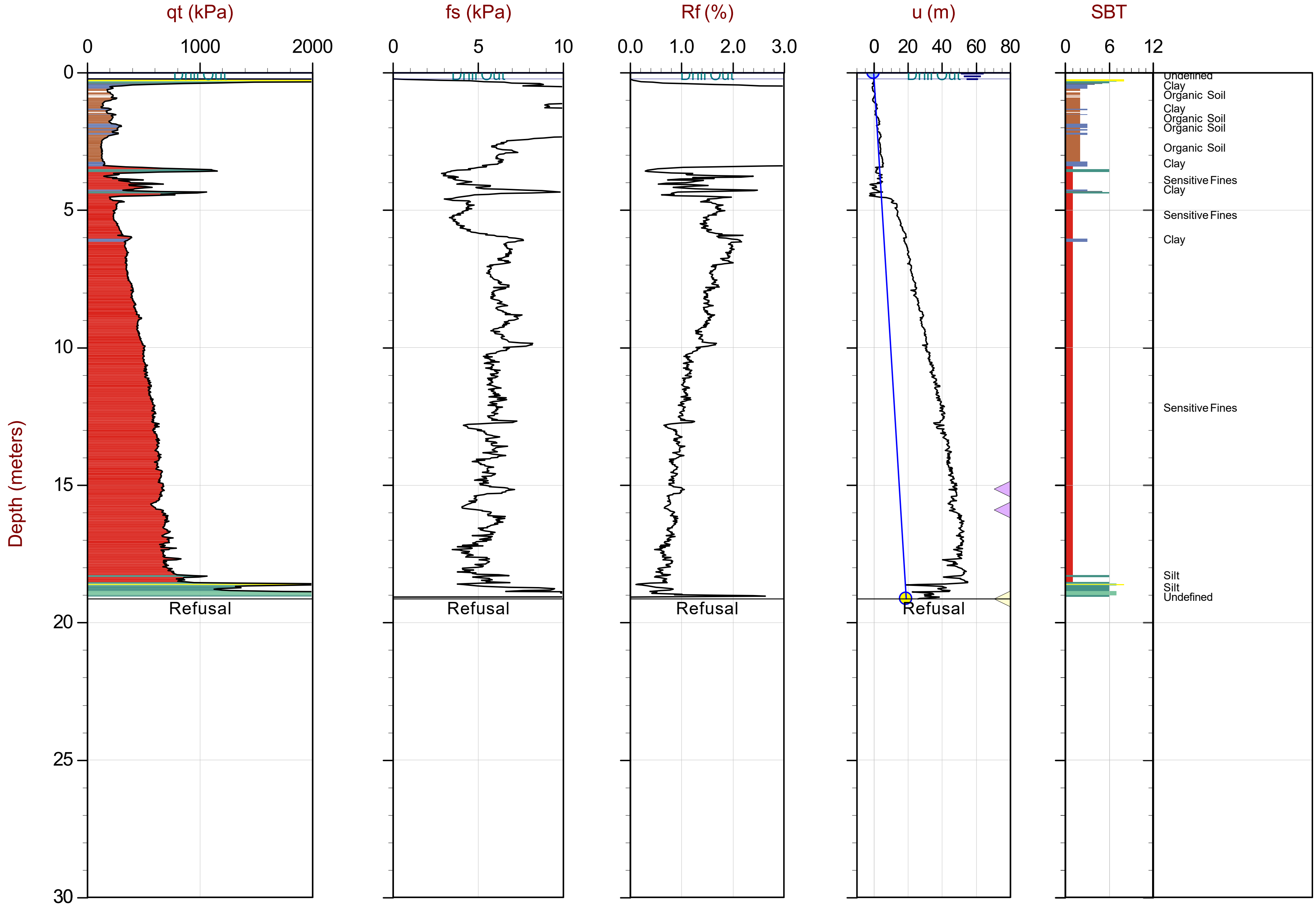
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 11:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-09
Cone: 417:T375F10U200



Max Depth: 19.150 m / 62.83 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP09.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141697m E: 518268m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Advanced Cone Penetration Test Plots with Ic, Su(Nkt), and OCR

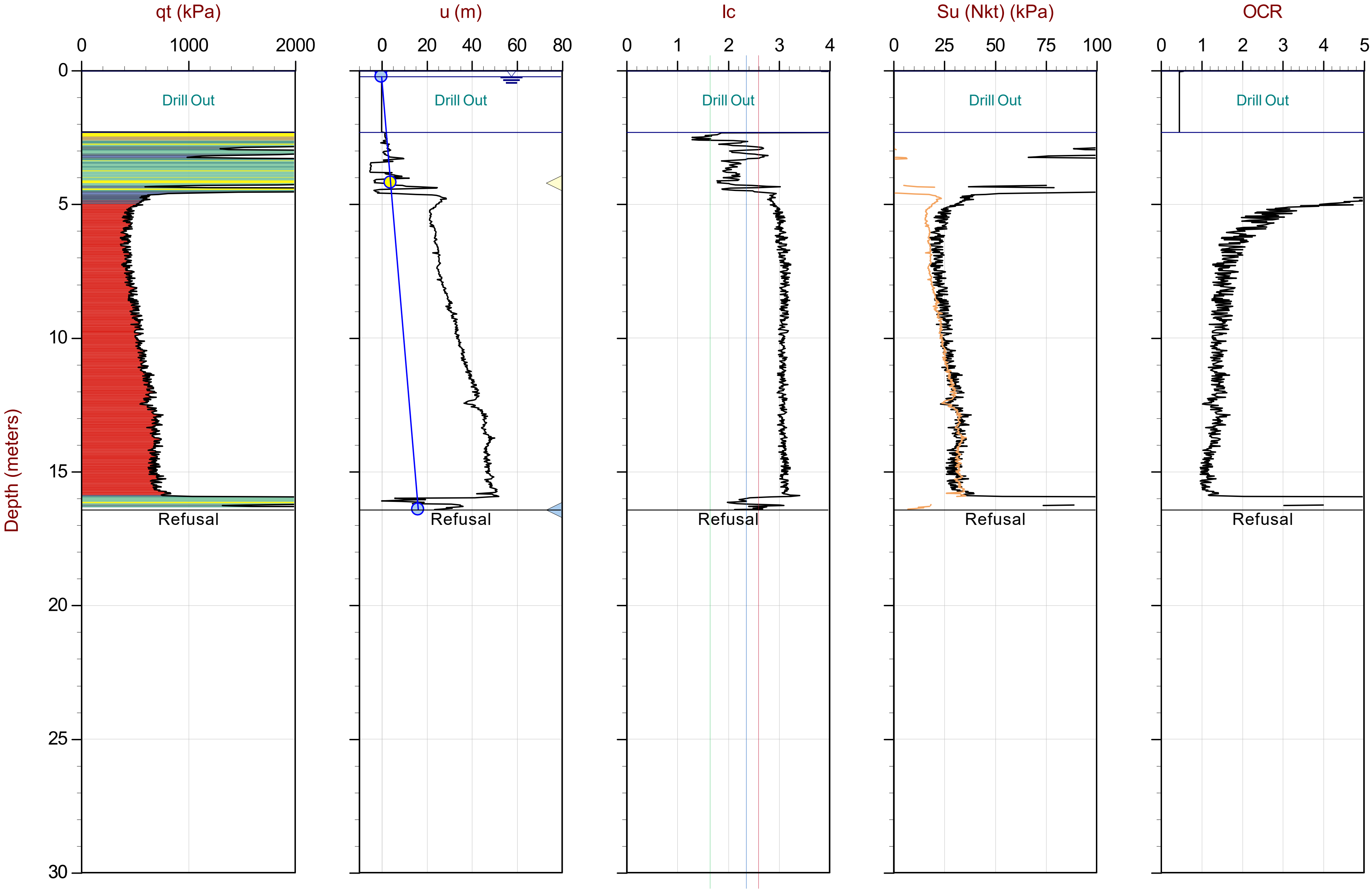
CONETEC

ConeTec

Thurber Engineering

Job No: 17-05009
Date: 2017/03/03 14:13
Site: Highway 537 and Jumbo Creek

Sounding: SCPT17-01
Cone: 379:T1500F15U500



Max Depth: 16.425 m / 53.89 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_SP01.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141652m E: 518295m
Sheet No: 1 of 1

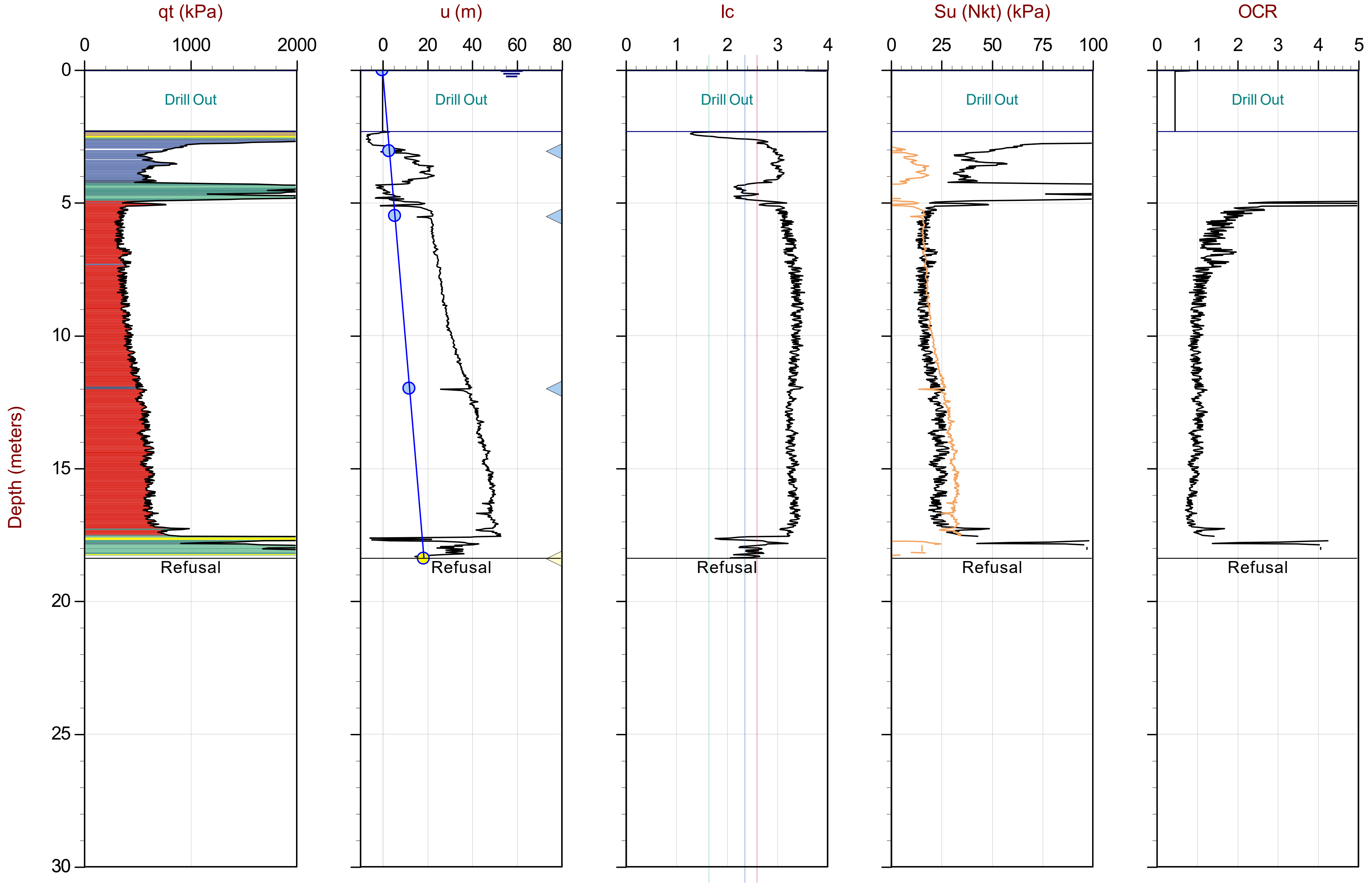
Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved Hydrostatic Line ■ Su (VST)

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500



Max Depth: 18.375 m / 60.28 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP02.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141694m E: 518258m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

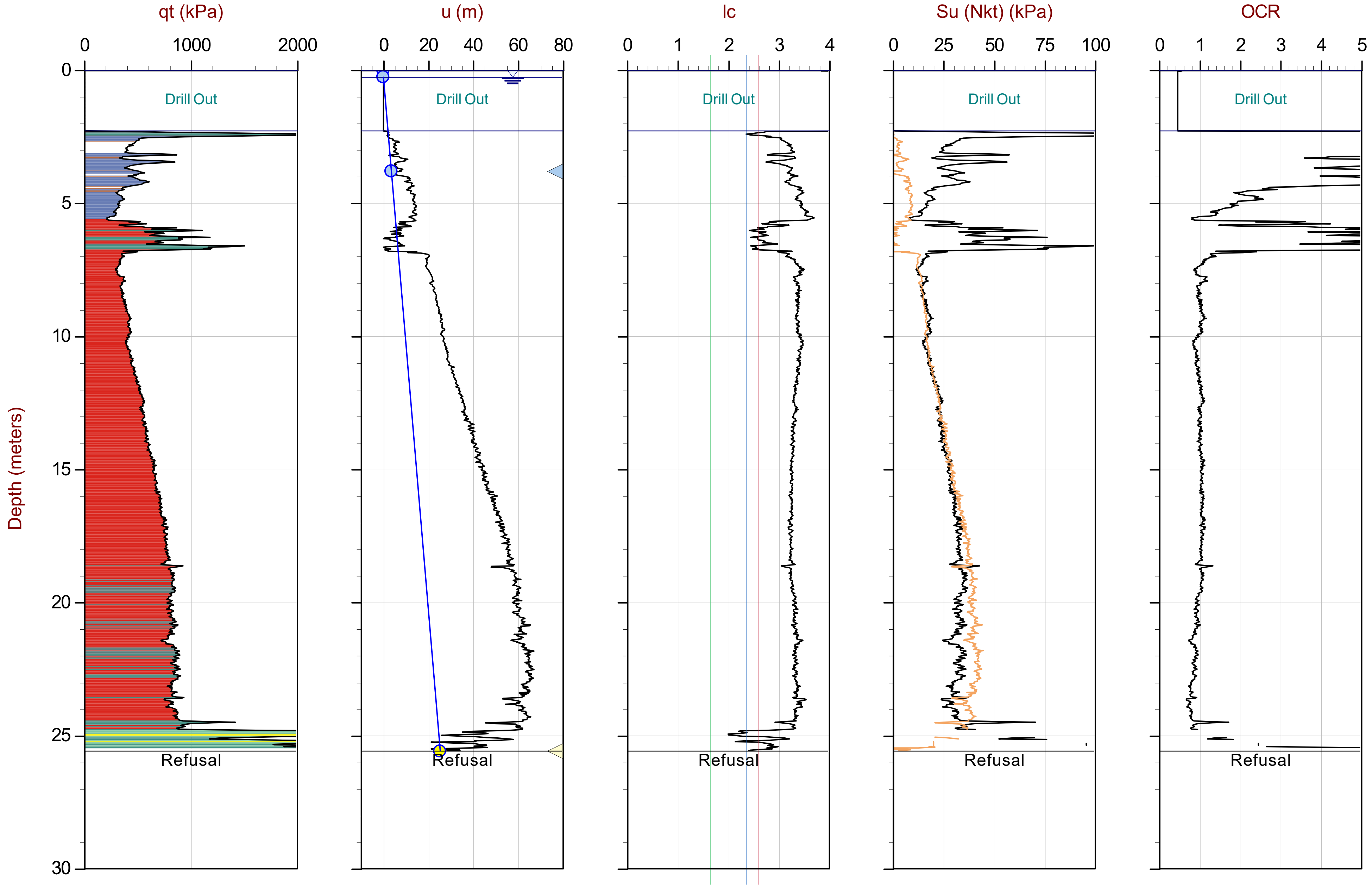
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 09:48
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-03
Cone: 417:T375F10U200



Max Depth: 25.575 m / 83.91 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP03.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141702m E: 518216m
Sheet No: 1 of 1

Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved Hydrostatic Line ■ Su (VST)

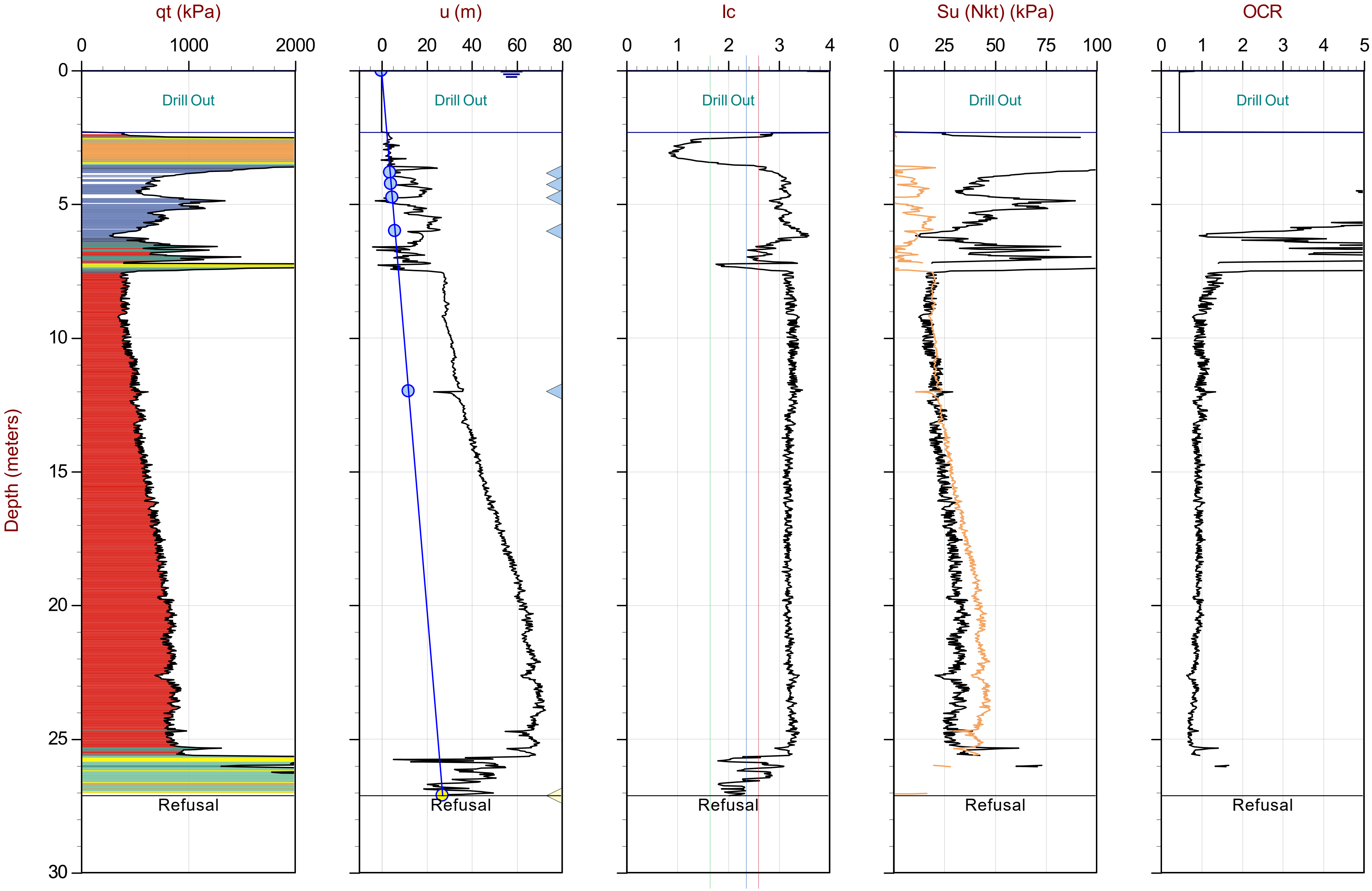
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 13:47
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04
Cone: 379:T1500F15U500



Max Depth: 27.125 m / 88.99 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141732m E: 518172m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

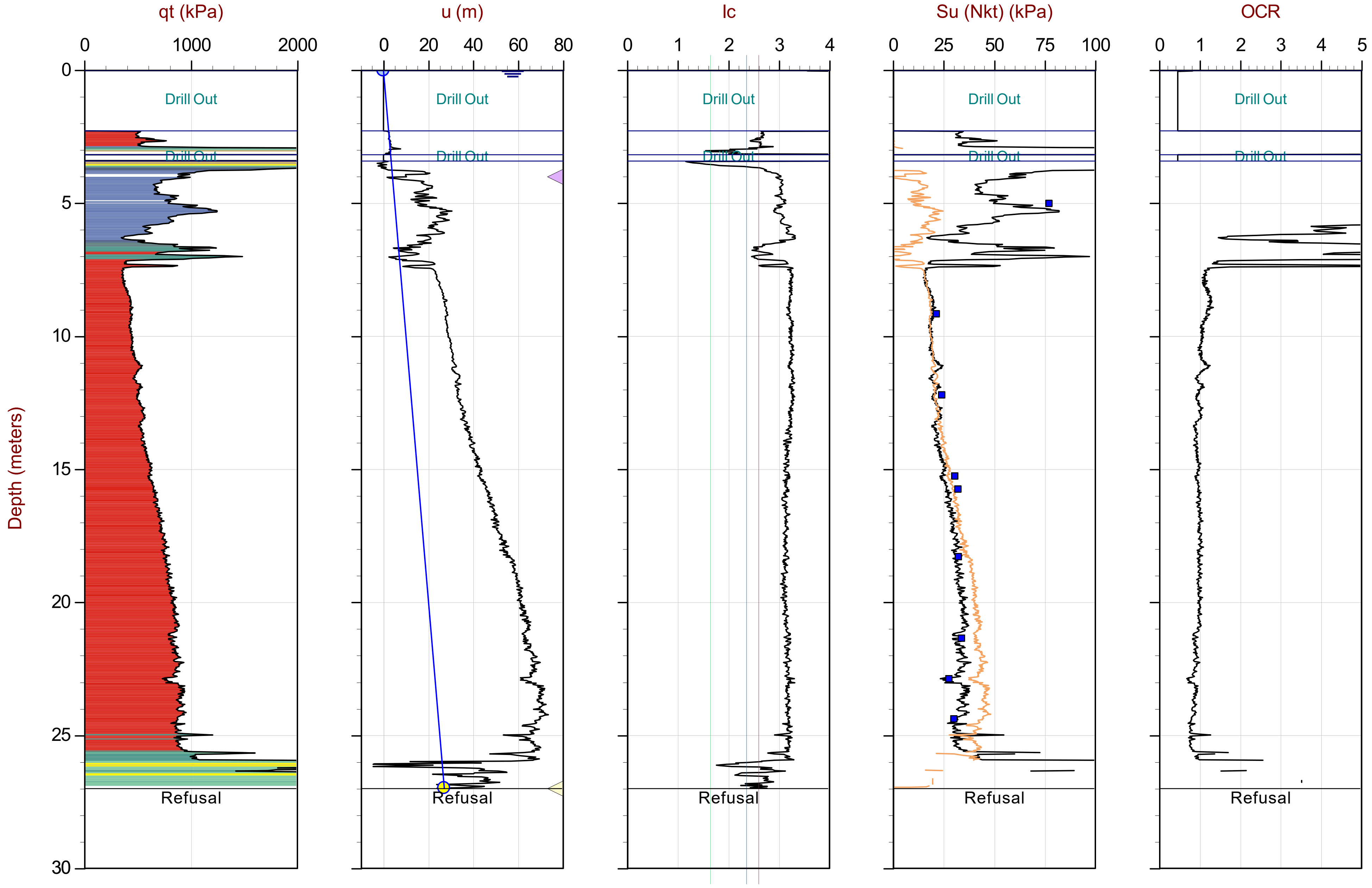
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 14:04
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04B
Cone: 417:T375F10U200



Max Depth: 27.000 m / 88.58 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04D.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141729m E: 518168m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

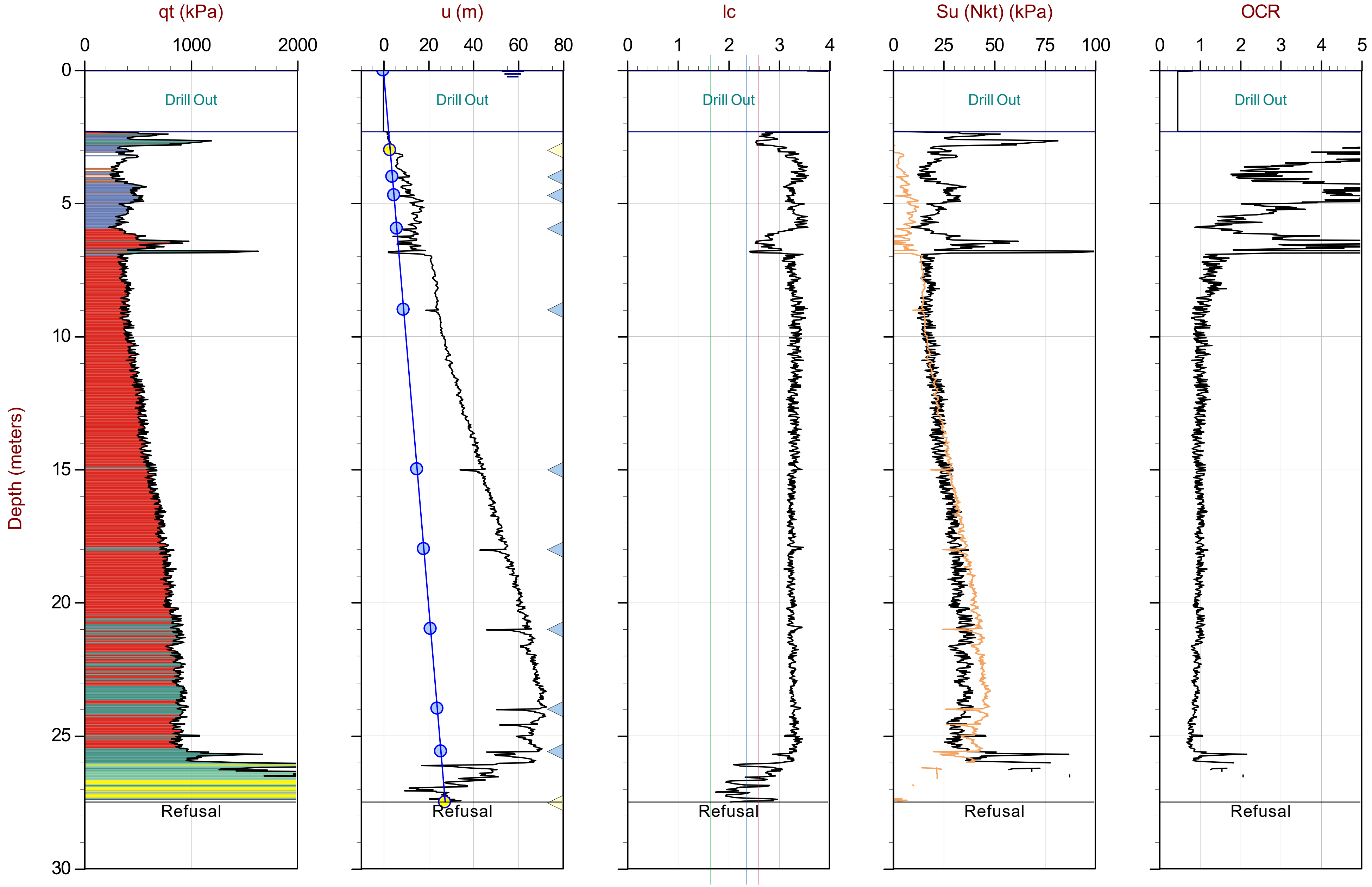
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/05 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500



Max Depth: 27.500 m / 90.22 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP05.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N:5141747m E:518125m
Sheet No: 1 of 1

Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved Hydrostatic Line ■ Su (VST)

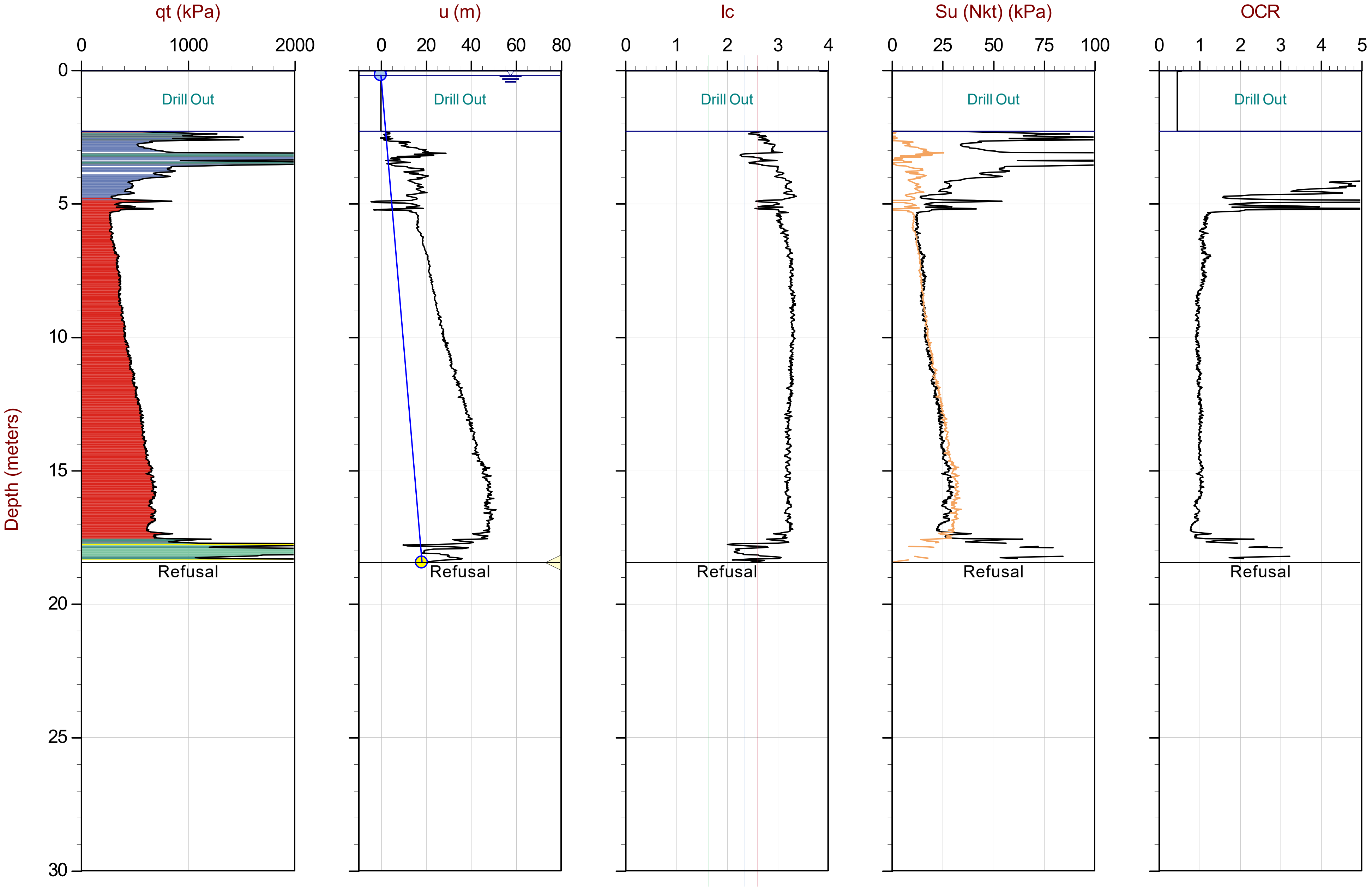
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

ConeTec

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 11:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-06
Cone: 417:T375F10U200



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP06.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141745m E: 518025m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

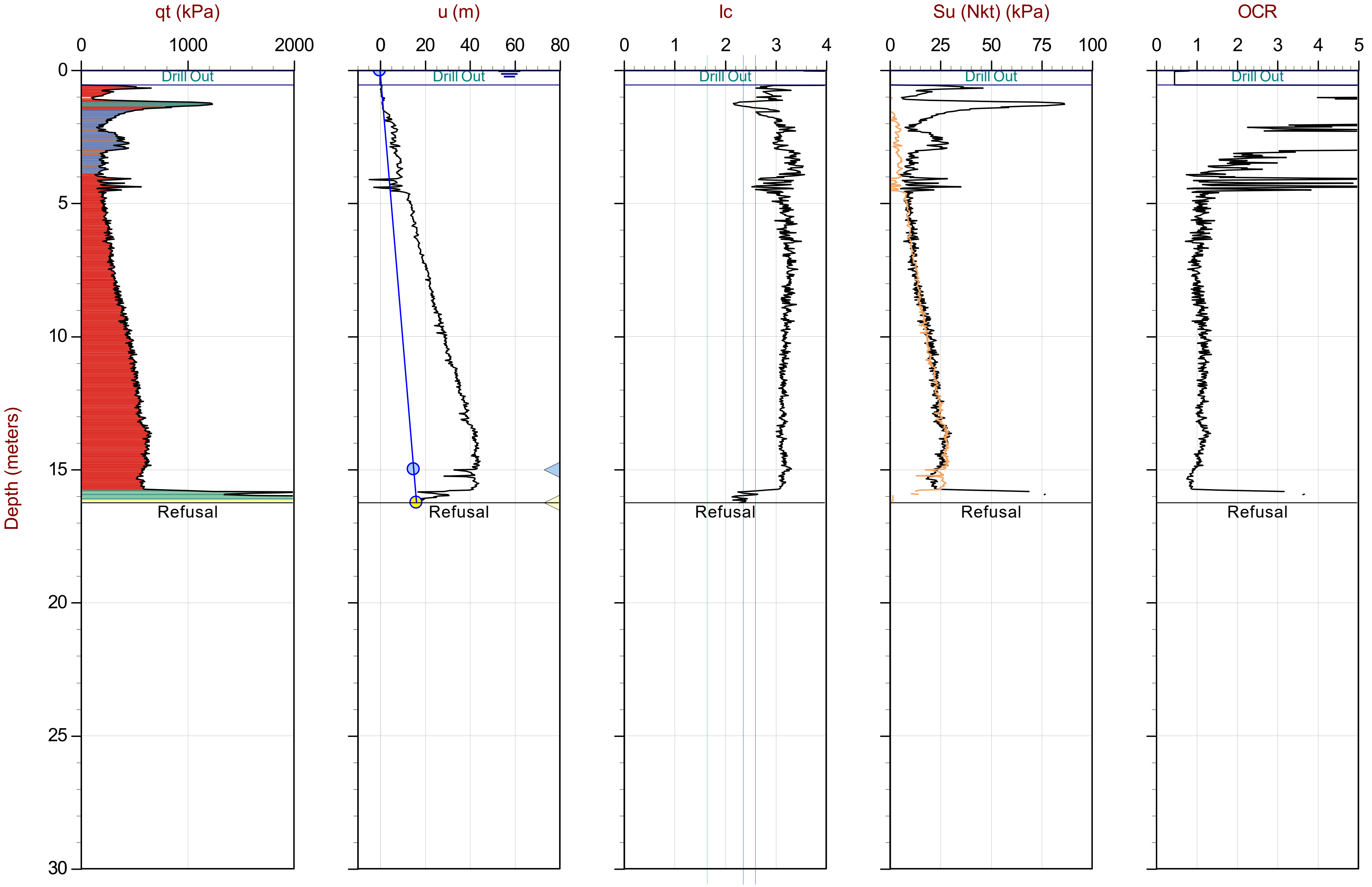
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 09:27
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07
Cone: 417:T375F10U200



Max Depth: 16.250 m / 53.31 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518027m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

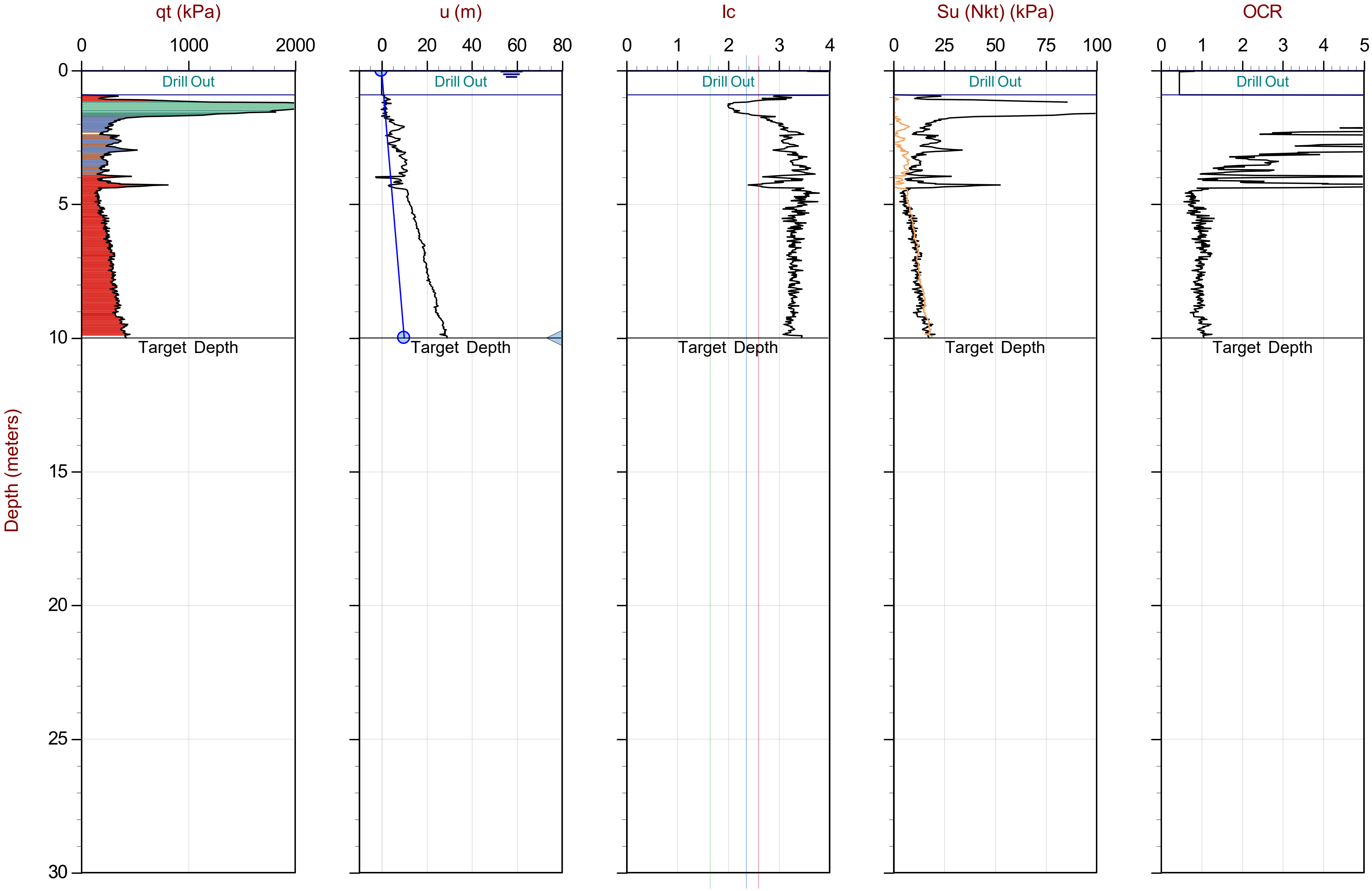
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 12:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07B
Cone: 417:T375F10U200



Max Depth: 10.000 m / 32.81 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07B.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518029m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

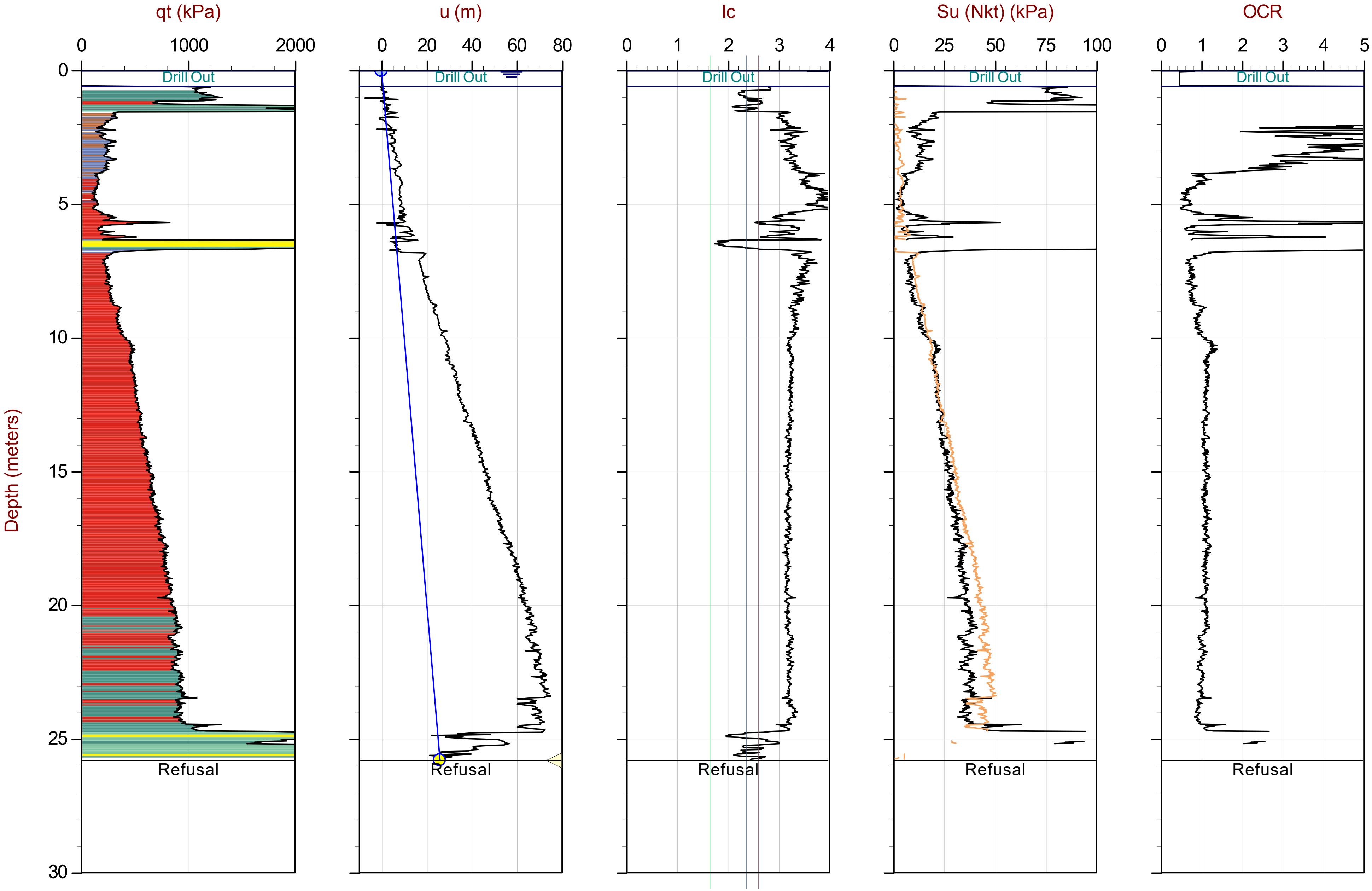
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 15:17
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-08
Cone: 417:T375F10U200



Max Depth: 25.800 m / 84.64 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP08.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141749m E: 518127m
Sheet No: 1 of 1

— Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line ■ Su (VST)

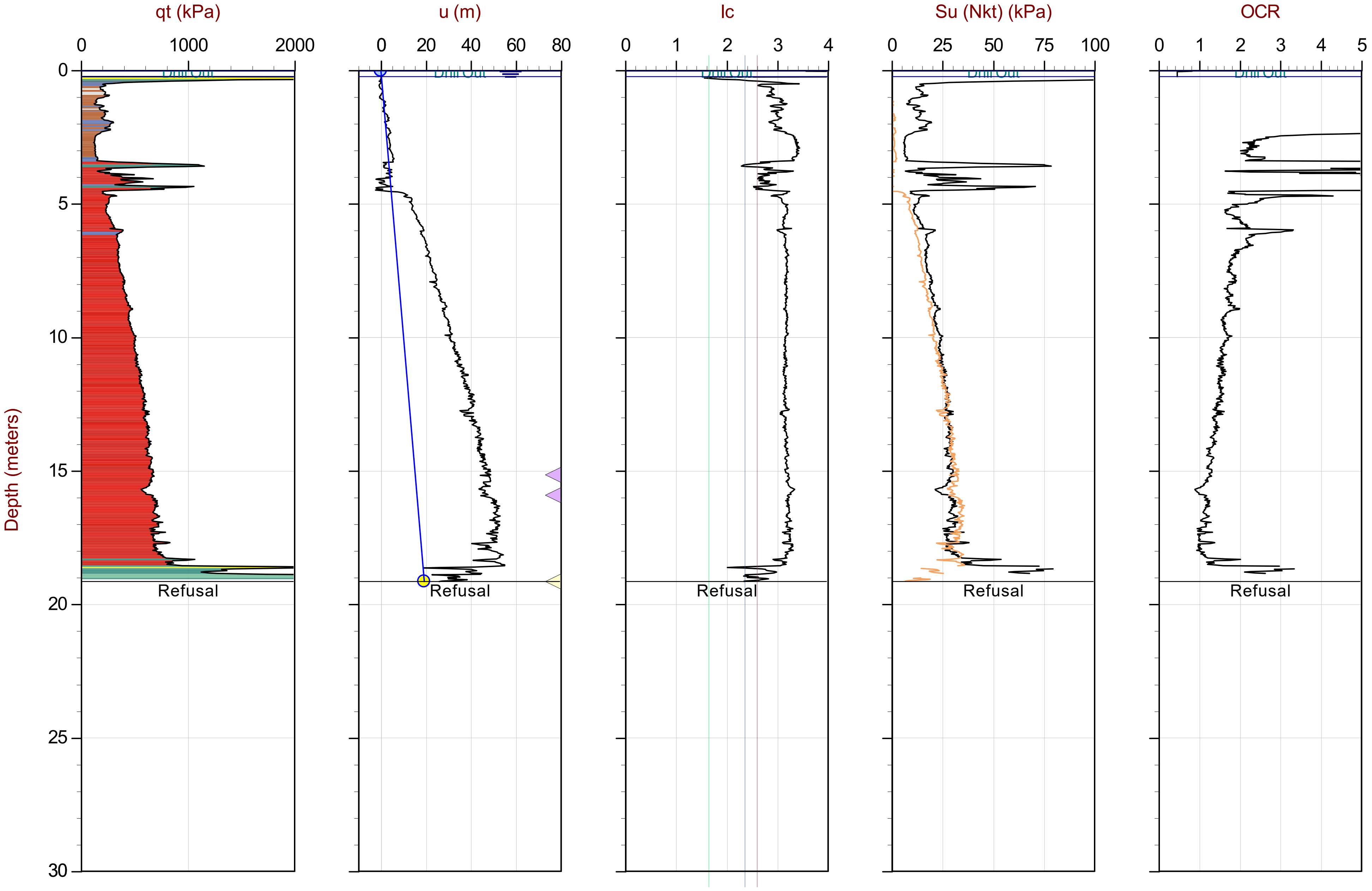
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 11:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-09
Cone: 417:T375F10U200



Max Depth: 19.150 m / 62.83 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP09.COR
Unit Wt: SBT Zones
Su Nkt/Ndu: 14.0 / 10.0

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141697m E: 518268m
Sheet No: 1 of 1

Su(Ndu) ● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved Hydrostatic Line ■ Su (VST)

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

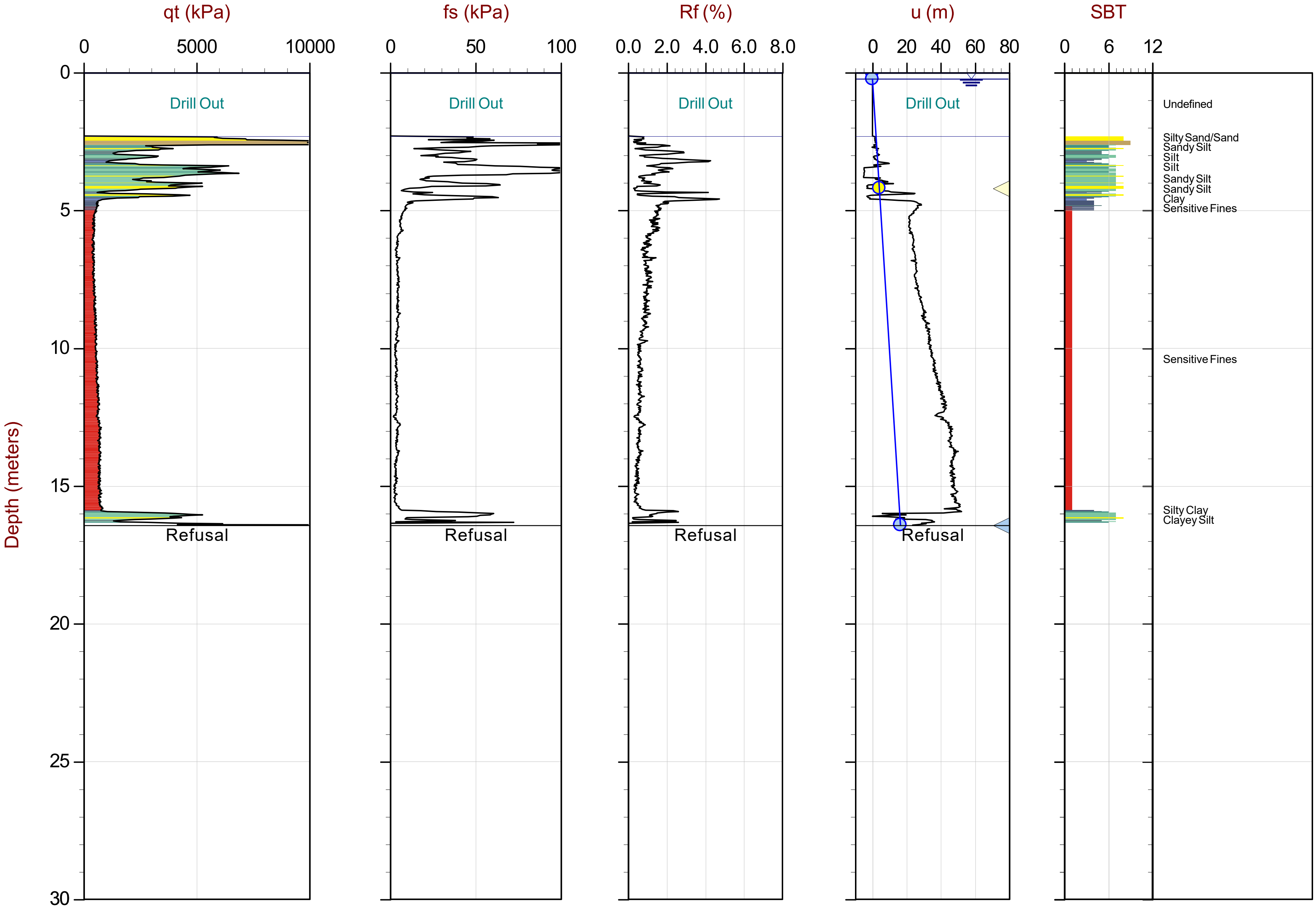
Cone Penetration Test Plots with Expanded Scales

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/03 14:13
Site: Highway 537 and Jumbo Creek

Sounding: SCPT17-01
Cone: 379:T1500F15U500



Max Depth: 16.425 m / 53.89 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_SP01.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141652m E: 518295m
Sheet No: 1 of 1

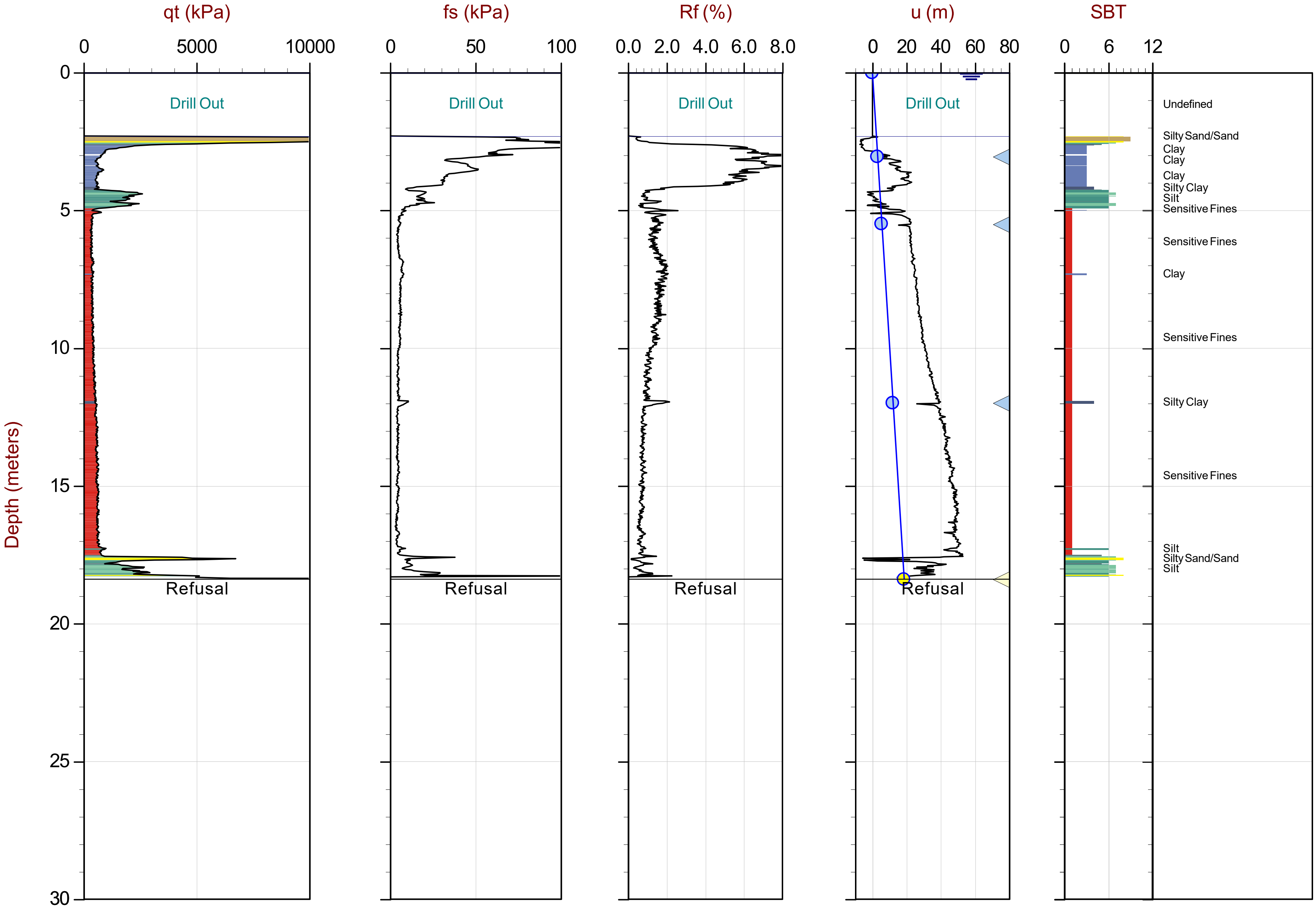
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500



Max Depth: 18.375 m / 60.28 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP02.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141694m E: 518258m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

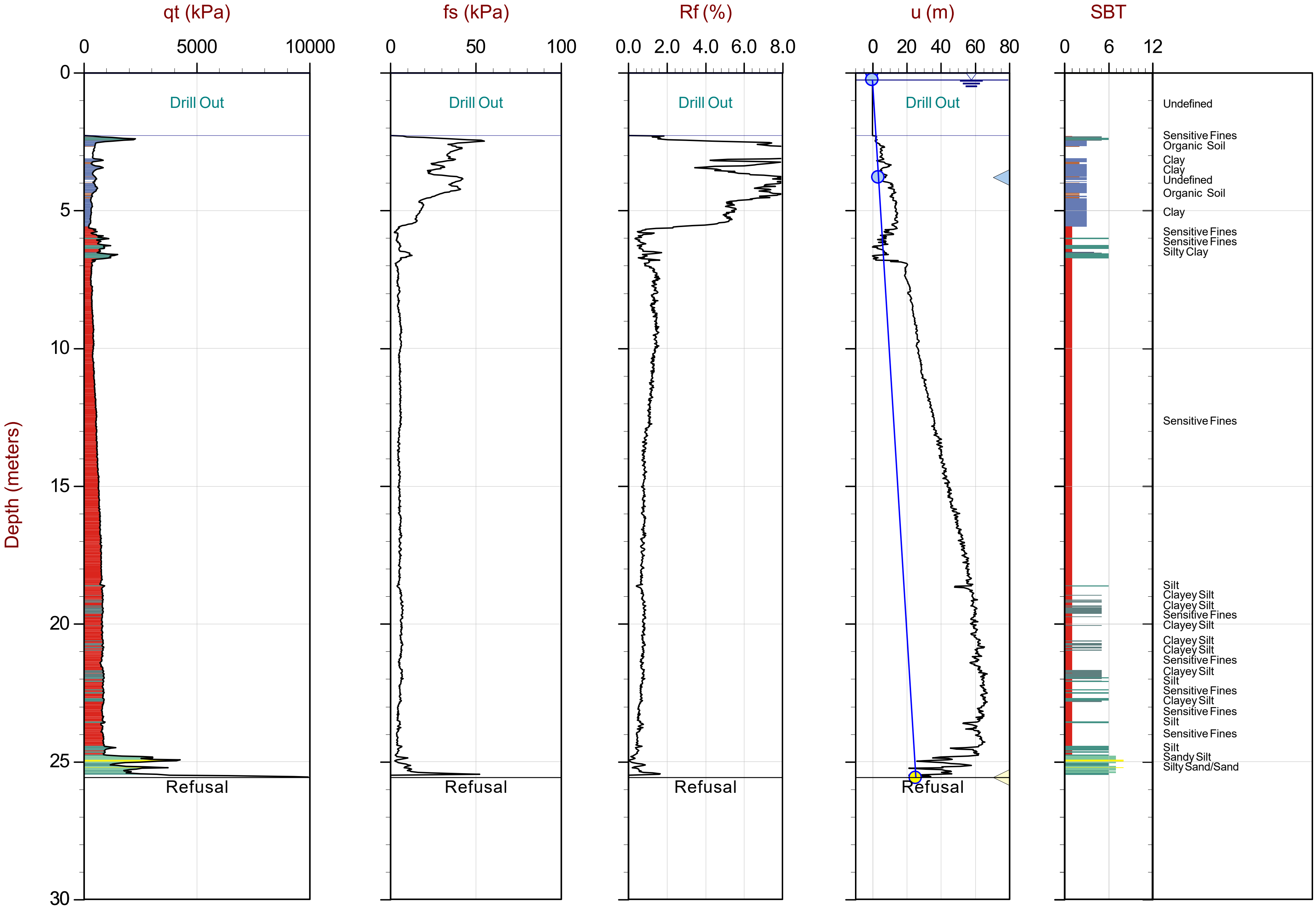
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 09:48
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-03
Cone: 417:T375F10U200



Max Depth: 25.575 m / 83.91 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP03.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141702m E: 518216m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

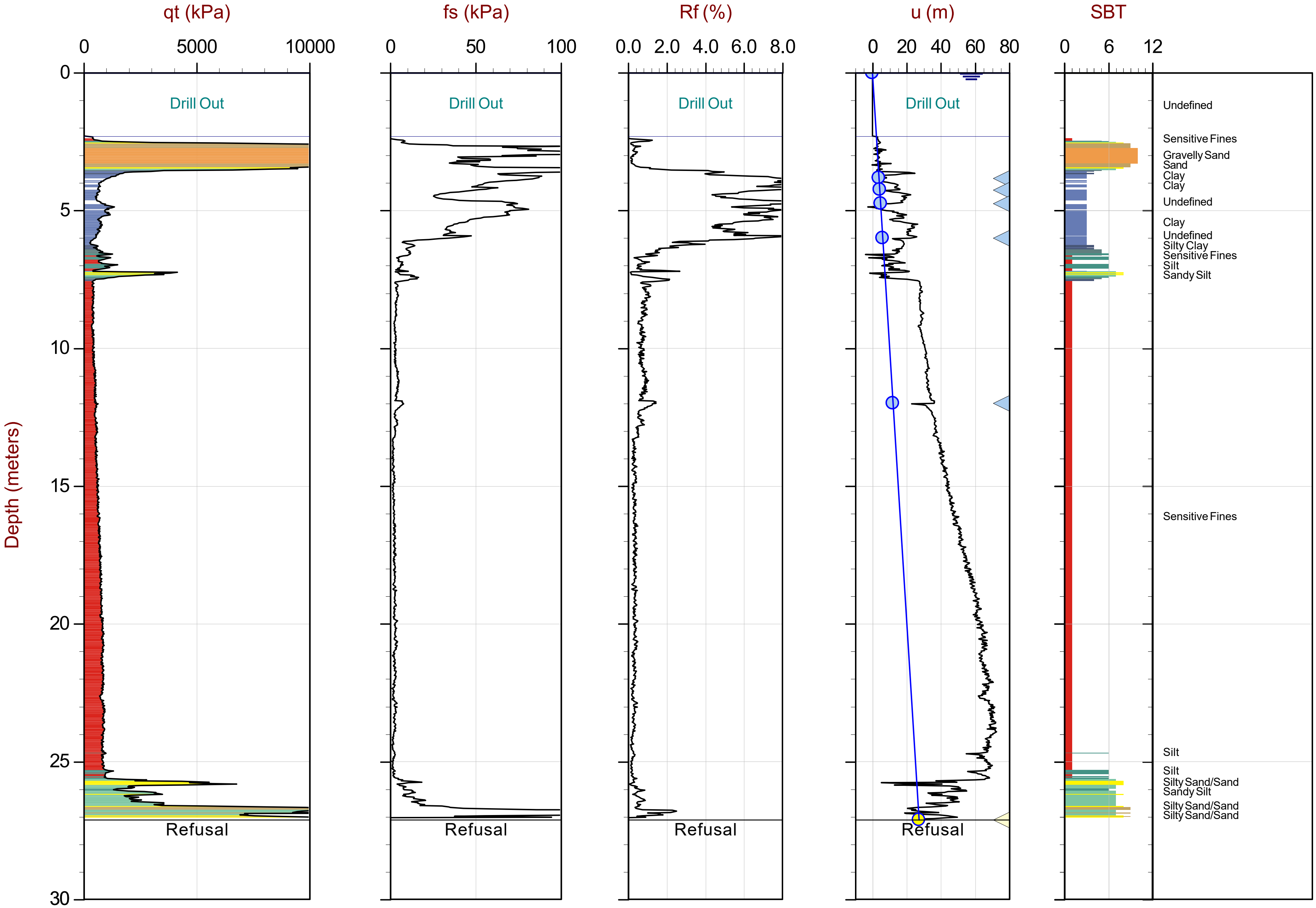
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/04 13:47
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04
Cone: 379:T1500F15U500



Max Depth: 27.125 m / 88.99 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141732m E: 518172m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

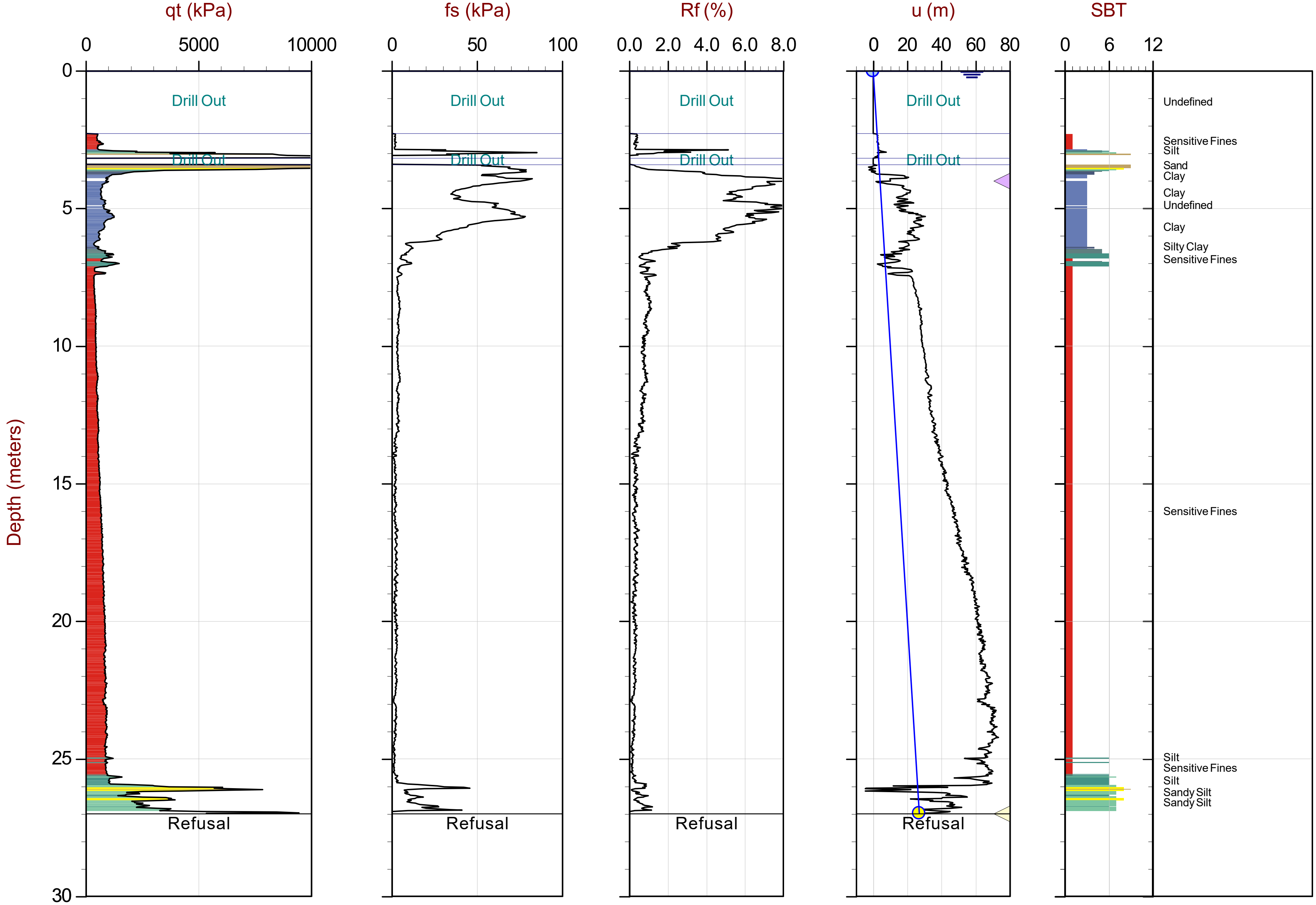
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 14:04
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04B
Cone: 417:T375F10U200



Max Depth: 27.000 m / 88.58 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP04D.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141729m E: 518168m
Sheet No: 1 of 1

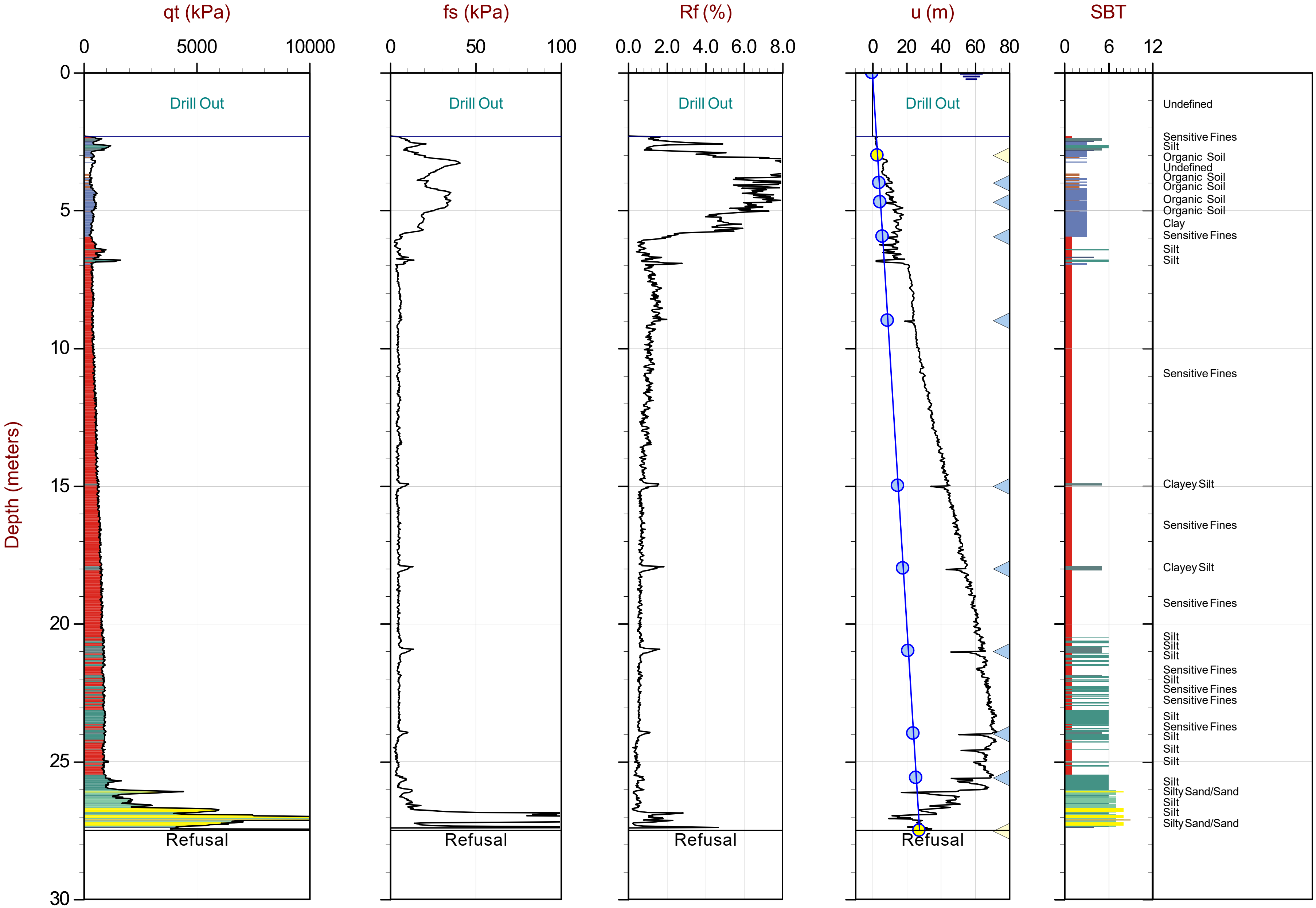
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/05 09:25
Site: Highway 537 and Jumbo Creek
Sounding: CPT17-05
Cone: 323:T1500F15U500



Max Depth: 27.500 m / 90.22 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP05.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141747m E: 518125m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

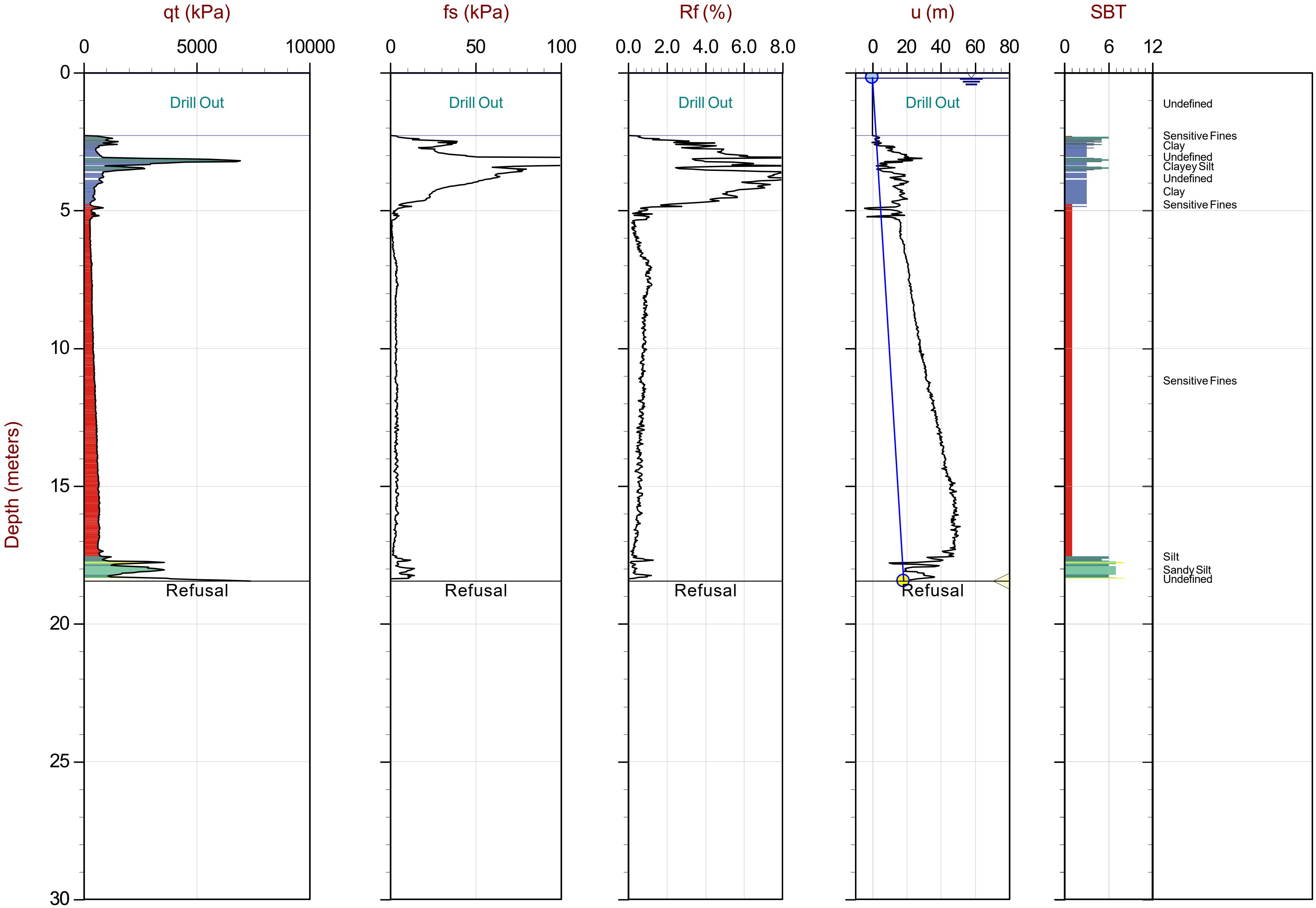
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/06 11:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-06
Cone: 417:T375F10U200



Max Depth: 18.450 m / 60.53 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP06.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141745m E: 518025m
Sheet No: 1 of 1

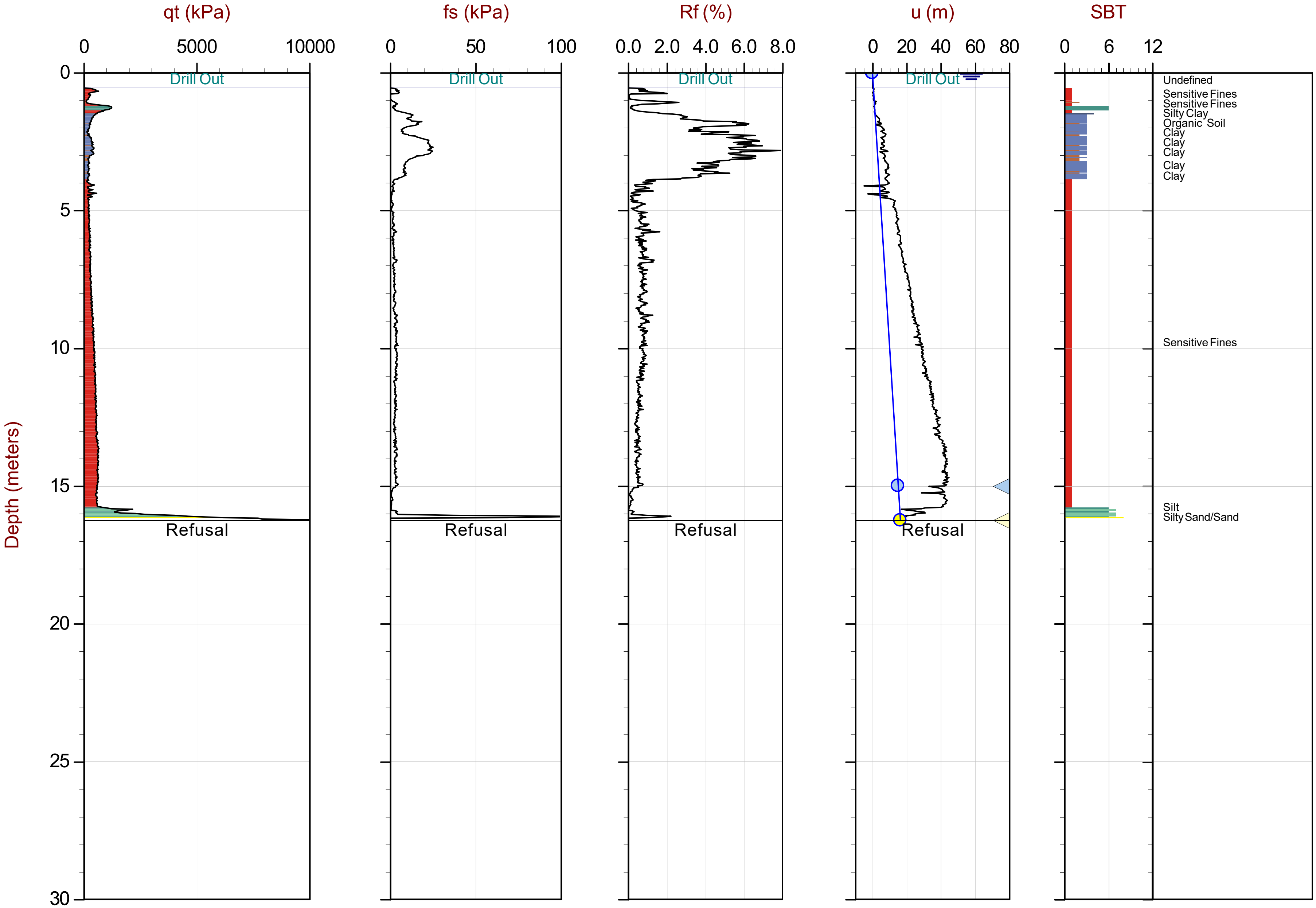
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 09:27
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07
Cone: 417:T375F10U200



Max Depth: 16.250 m / 53.31 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518027m
Sheet No: 1 of 1

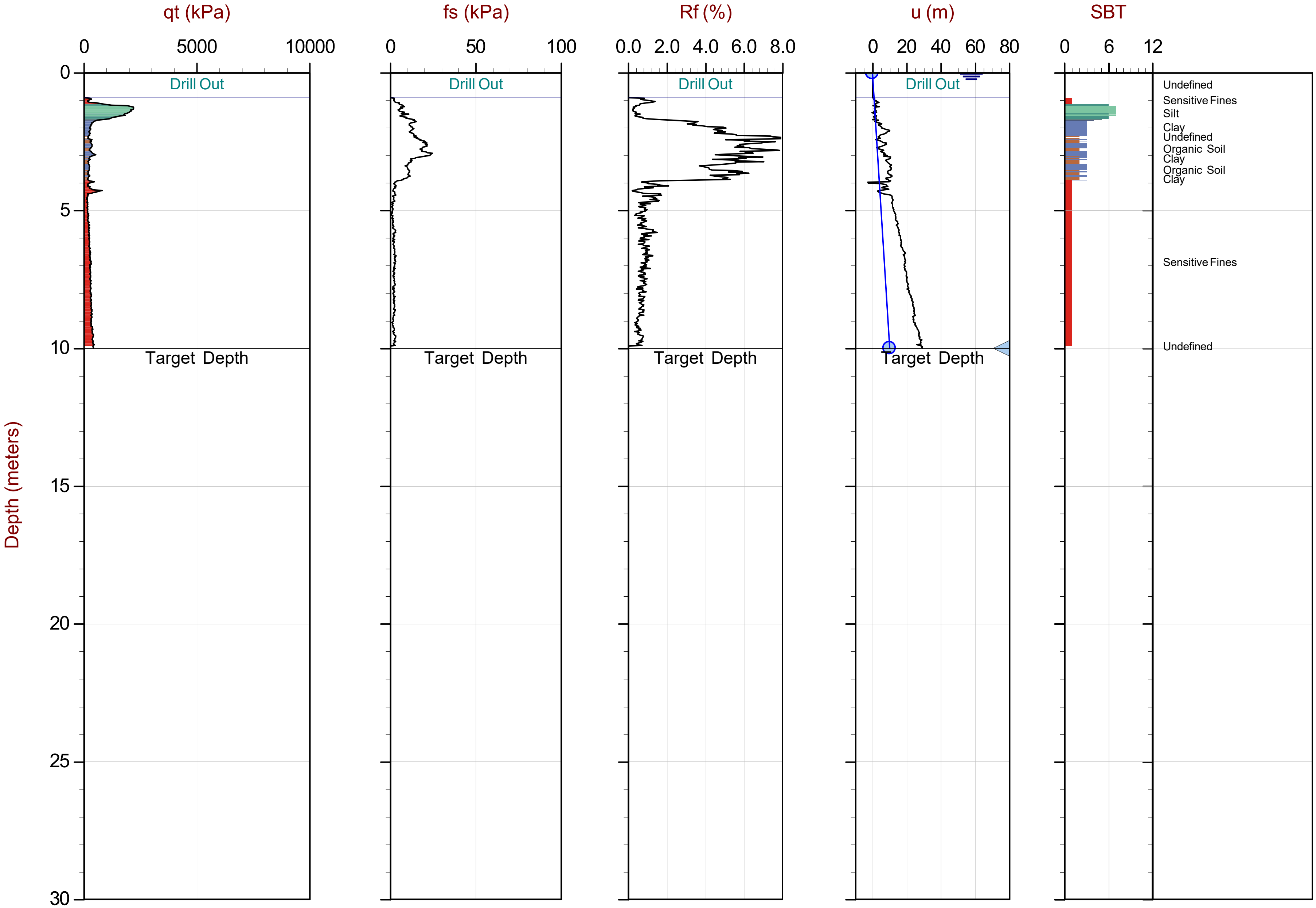
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/28 12:00
Site: Highway 537 and Jumbo Creek
Sounding: CPT17-07B
Cone: 417:T375F10U200



Max Depth: 10.000 m / 32.81 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP07B.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141753m E: 518029m
Sheet No: 1 of 1

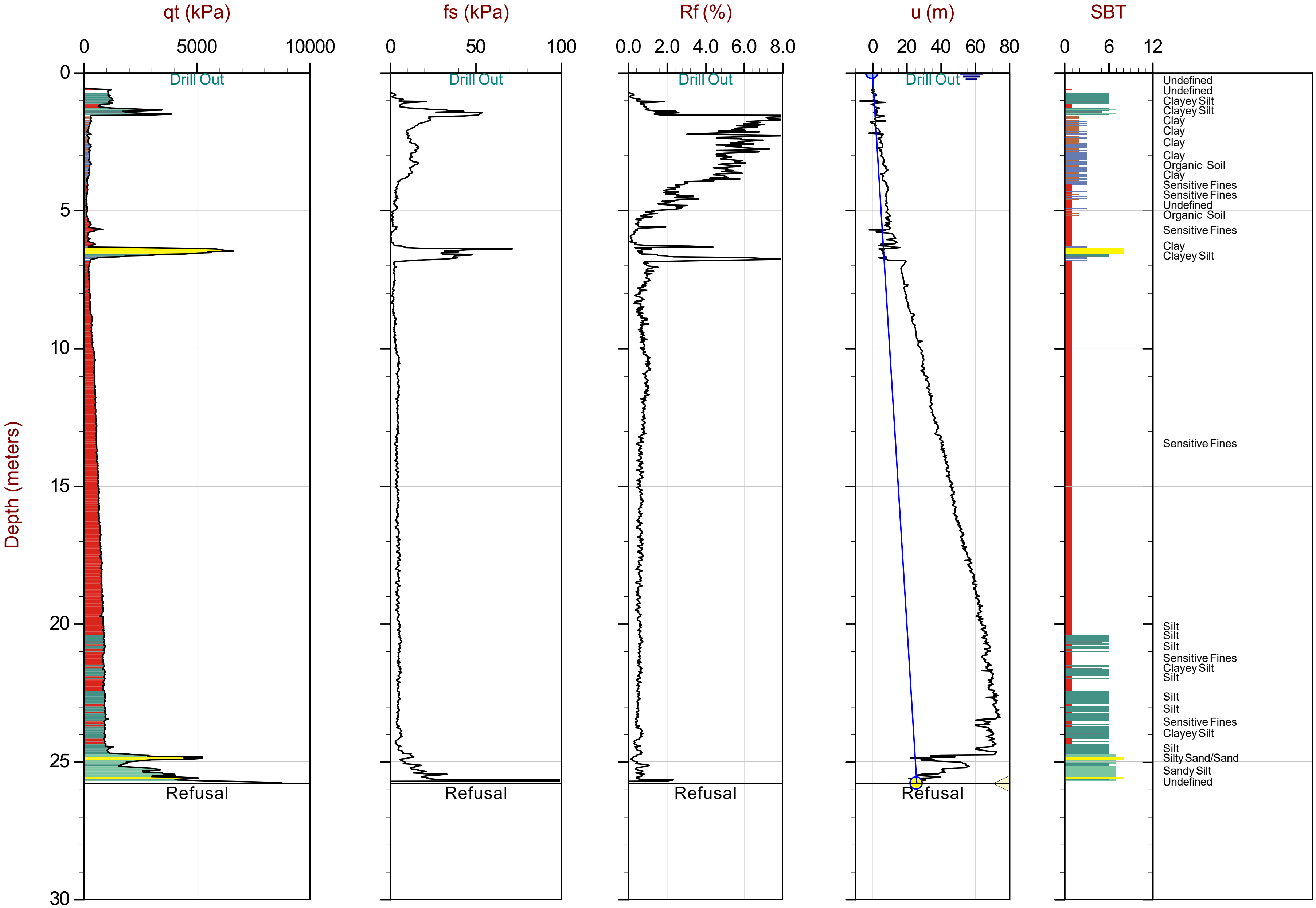
● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 15:17
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-08
Cone: 417:T375F10U200



Max Depth: 25.800 m / 84.64 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP08.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141749m E: 518127m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

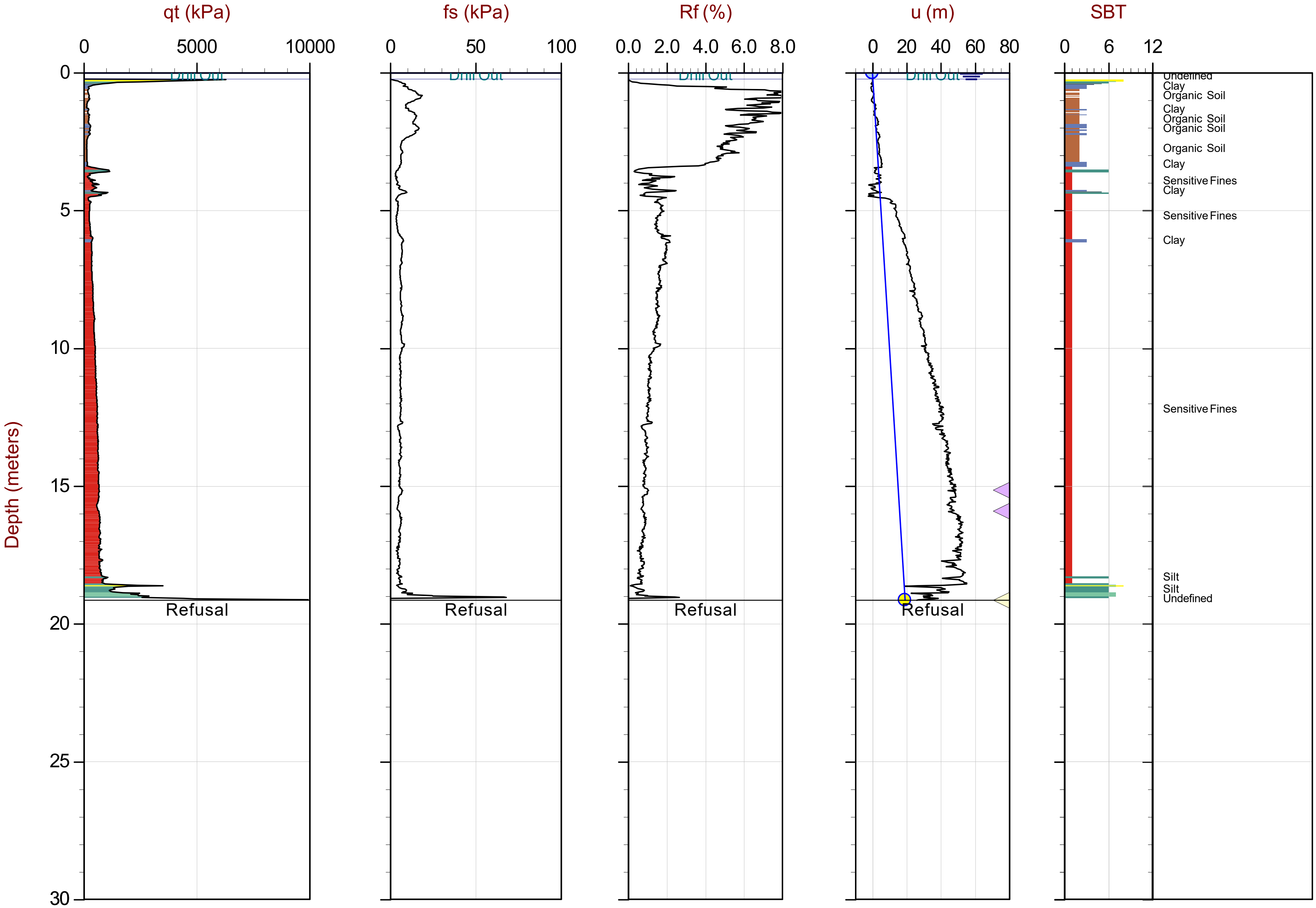
The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/27 11:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-09
Cone: 417:T375F10U200



Max Depth: 19.150 m / 62.83 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_CP09.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17 N N: 5141697m E: 518268m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Plots

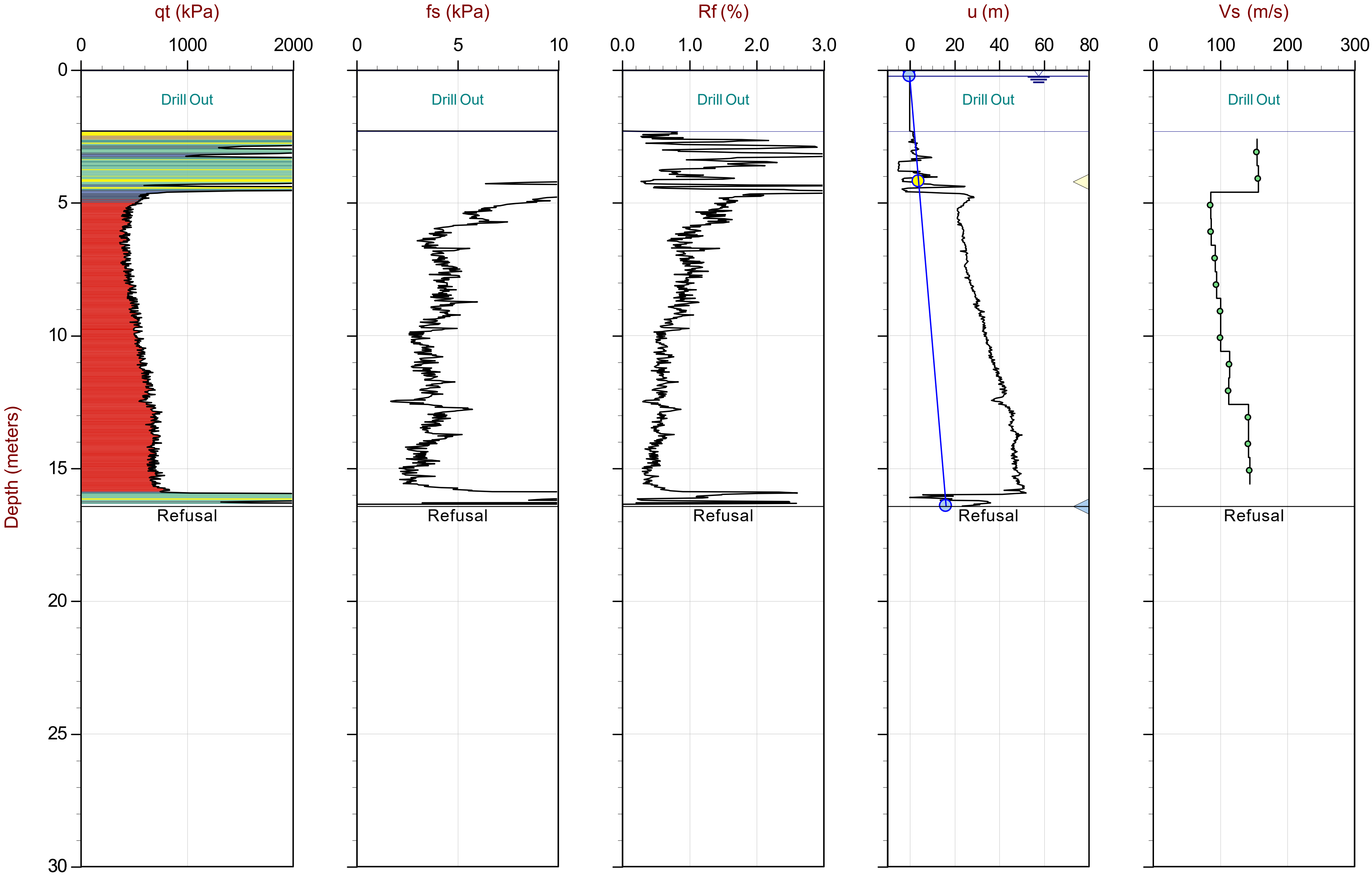
ConeTec

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 2017/03/03 14:13
Site: Highway 537 and Jumbo Creek

Sounding: SCPT17-01
Cone: 379:T1500F15U500



Max Depth: 16.425 m / 53.89 ft
Depth Inc: 0.025 m / 0.082 ft
Avg Int: Every Point

File: 17-05009_SP01.COR
Unit Wt: SBT Zones

SBT: Robertson and Campanella, 1986
Coords: UTM 17N N: 5141652m E: 518295m
Sheet No: 1 of 1

● Equilibrium Pore Pressure (Ueq) ● Assumed Ueq ◁ Dissipation, Ueq achieved ◁ Dissipation, Ueq not achieved — Hydrostatic Line

The reported coordinates were acquired from consumer grade GPS equipment and are only approximate locations. The coordinates should not be used for design purposes.

Seismic Cone Penetration Test Tabular Results

ConeTec

Job No: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding ID: SCPT17-01
Date: 03-Mar-2017

Seismic Source: Beam
Source Offset (m): 0.55
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPTu SHEAR WAVE VELOCITY TEST RESULTS - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
2.80	2.60	2.66			
3.80	3.60	3.64	0.98	6.36	155
4.80	4.60	4.63	0.99	6.29	157
5.80	5.60	5.63	0.99	11.55	86
6.80	6.60	6.62	1.00	11.39	87
7.80	7.60	7.62	1.00	10.73	93
8.80	8.60	8.62	1.00	10.49	95
9.80	9.60	9.62	1.00	9.86	101
10.80	10.60	10.61	1.00	9.93	101
11.80	11.60	11.61	1.00	8.76	114
12.80	12.60	12.61	1.00	8.86	113
13.80	13.60	13.61	1.00	7.02	142
14.80	14.60	14.61	1.00	7.06	142
15.80	15.60	15.61	1.00	6.93	144

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots

CONETEC

Job No:	17-05009
Client:	Thurber Engineering
Project:	Highway 537 and Jumbo Creek
Start Date:	03-Mar-2017
End Date:	28-Mar-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)	Estimated Phreatic Surface (m)	t_{50}[a] (s)	Assumed Rigidity Index (I_r)	c_h[b] (cm^2/min)	Refer to Notation Number
SCPT17-01	17-05009_SP01	15	500	4.200	4.0	0.2					
SCPT17-01	17-05009_SP01	15	200	16.425	Not Achieved		0.2	62	100	11.41	
CPT17-02	17-05009_CP02	15	500	3.050	Not Achieved		0.0	180	100	3.91	
CPT17-02	17-05009_CP02	15	5400	5.500	Not Achieved		0.0	3994	100	0.18	
CPT17-02	17-05009_CP02	15	2800	12.000	Not Achieved		0.0	2349	100	0.30	
CPT17-02	17-05009_CP02	15	300	18.400	18.4	0.0					
CPT17-03	17-05009_CP03	15	400	3.800	Not Achieved		0.3				
CPT17-03	17-05009_CP03	15	250	25.575	25.3	0.3					
CPT17-04	17-05009_CP04	15	300	3.825	Not Achieved		0.0	41	100	17.30	
CPT17-04	17-05009_CP04	15	300	4.250	Not Achieved		0.0	187	100	3.76	
CPT17-04	17-05009_CP04	15	300	4.750	Not Achieved		0.0	34	100	20.40	
CPT17-04	17-05009_CP04	15	2695	6.000	Not Achieved		0.0	1944	100	0.36	
CPT17-04	17-05009_CP04	15	5400	12.000	Not Achieved		0.0	4310	100	0.16	
CPT17-04	17-05009_CP04	15	300	27.125	27.1	0.0					
CPT17-04B	17-05009_CP04d	15	145	4.000	Not Achieved						
CPT17-04B	17-05009_CP04d	15	300	27.000	27.0	0.0					
CPT17-05	17-05009_CP05	15	200	3.000	3.0	0.0					
CPT17-05	17-05009_CP05	15	300	4.000	Not Achieved		0.0	128	100	5.50	
CPT17-05	17-05009_CP05	15	300	4.700	Not Achieved		0.0	67	100	10.56	
CPT17-05	17-05009_CP05	15	1500	5.950	Not Achieved		0.0	1373	100	0.51	
CPT17-05	17-05009_CP05	15	4795	9.000	Not Achieved		0.0	4594	100	0.16	1
CPT17-05	17-05009_CP05	15	3505	15.000	Not Achieved		0.0	3173	100	0.22	

Job No: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Start Date: 03-Mar-2017
End Date: 28-Mar-2017

CPTu PORE PRESSURE DISSIPATION SUMMARY

Sounding ID	File Name	Cone Area (cm^2)	Duration (s)	Test Depth (m)	Estimated Equilibrium Pore Pressure U_{eq} (m)	Calculated Phreatic Surface (m)	Estimated Phreatic Surface (m)	t_{50}[a] (s)	Assumed Rigidity Index (I_r)	c_h[b] (cm^2/min)	Refer to Notation Number
CPT17-05	17-05009_CP05	15	2695	18.000	Not Achieved		0.0	2485	100	0.28	
CPT17-05	17-05009_CP05	15	2400	21.000	Not Achieved		0.0	2180	100	0.32	
CPT17-05	17-05009_CP05	15	1205	24.000	Not Achieved		0.0	1101	100	0.64	
CPT17-05	17-05009_CP05	15	350	25.600	Not Achieved		0.0	323	100	2.17	
CPT17-05	17-05009_CP05	15	300	27.525	27.5	0.0					
CPT17-06	17-05009_CP06	15	300	18.450	18.3	0.2					
CPT17-07	17-05009_CP07	15	2750	15.000	Not Achieved		0.0	1533	100	0.46	
CPT17-07	17-05009_CP07	15	500	16.250	16.3	0.0					
CPT17-07B	17-05009_CP07B	15	3600	10.000	Not Achieved		0.0	2828	100	0.25	2
CPT17-08	17-05009_CP08	15	300	25.800	25.8	0.0					
CPT17-09	17-05009_CP09	15	230	15.150	Not Achieved						
CPT17-09	17-05009_CP09	15	150	15.900	Not Achieved						
CPT17-09	17-05009_CP09	15	700	19.150	19.2	0.0					

a. Time is relative to where umax occurred

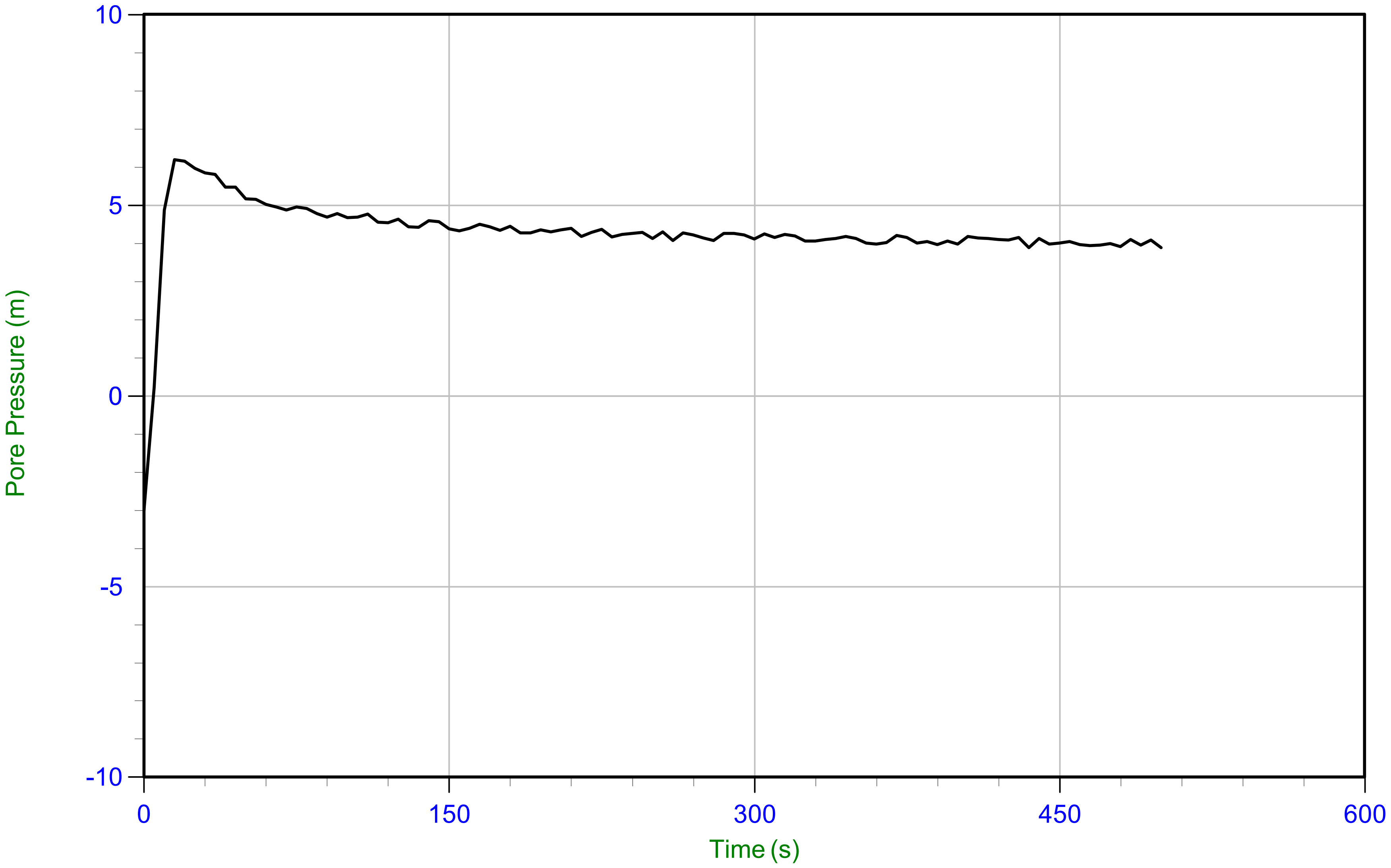
b. Houlsby and Teh, 1991

1. Due to nearby ground disturbance during this dissipation a transient spike in the pore pressure occurred at 4330 seconds.
2. Estimated phreatic surface was determined from proximity to CPT17-07.

Thurber Engineering

Job No: 17-05009
Date: 03/03/2017 14:13
Site: Highway 537 and Jumbo Creek

Sounding: SCPT17-01
Cone: 379:T1500F15U500 Area=15 cm²



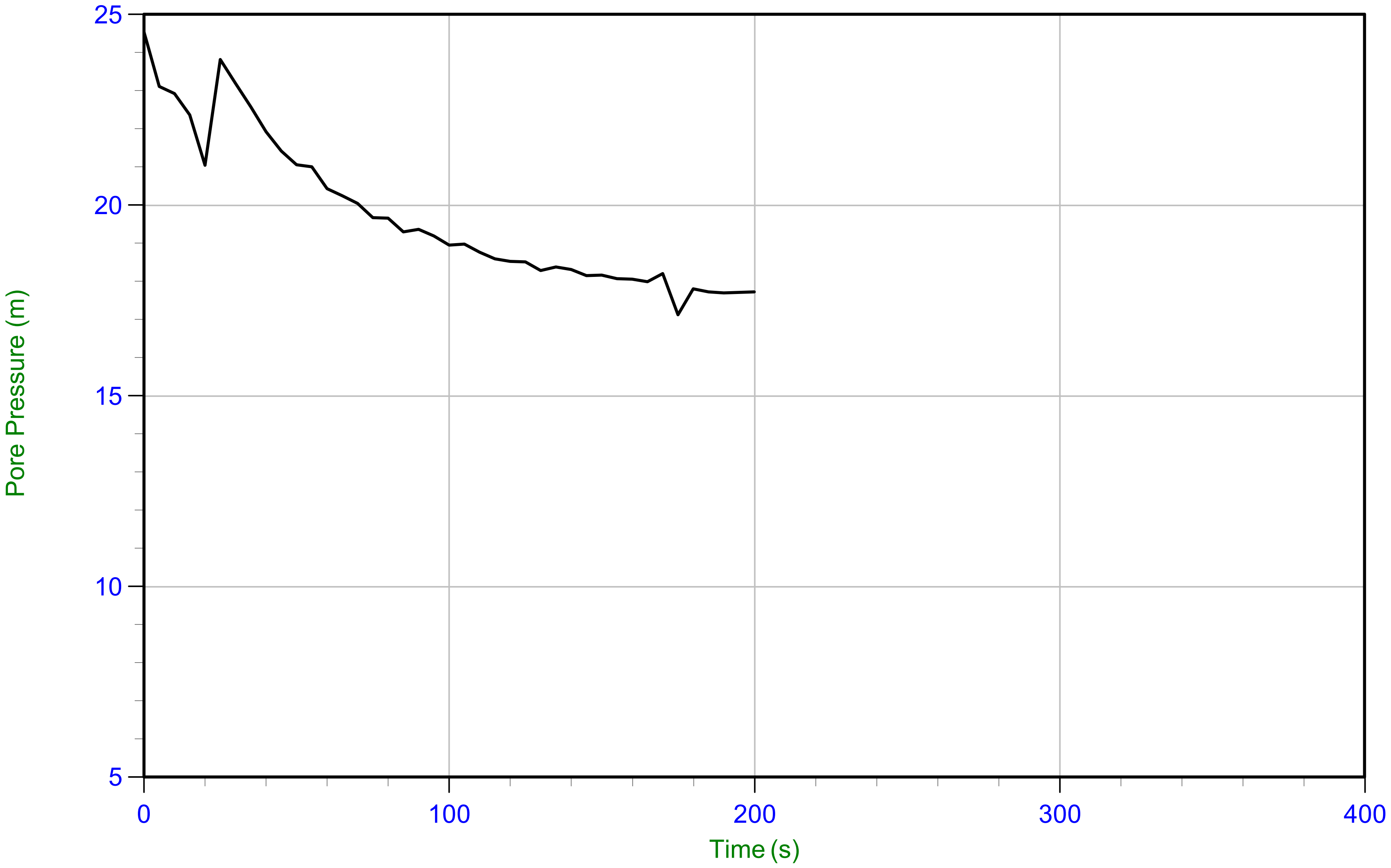
Trace Summary:

Filename: 17-05009_SP01.PPF
Depth: 4.200 m / 13.779 ft
Duration: 500.0 s

U Min: -3.0 m
U Max: 6.2 m

WT: 0.221 m / 0.725 ft
Ueq: 4.0 m

Thurber Engineering	Job No: 17-05009	Sounding: SCPT17-01
	Date: 03/03/2017 14:13	Cone: 379:T1500F15U500 Area=15 cm²
	Site: Highway 537 and Jumbo Creek	



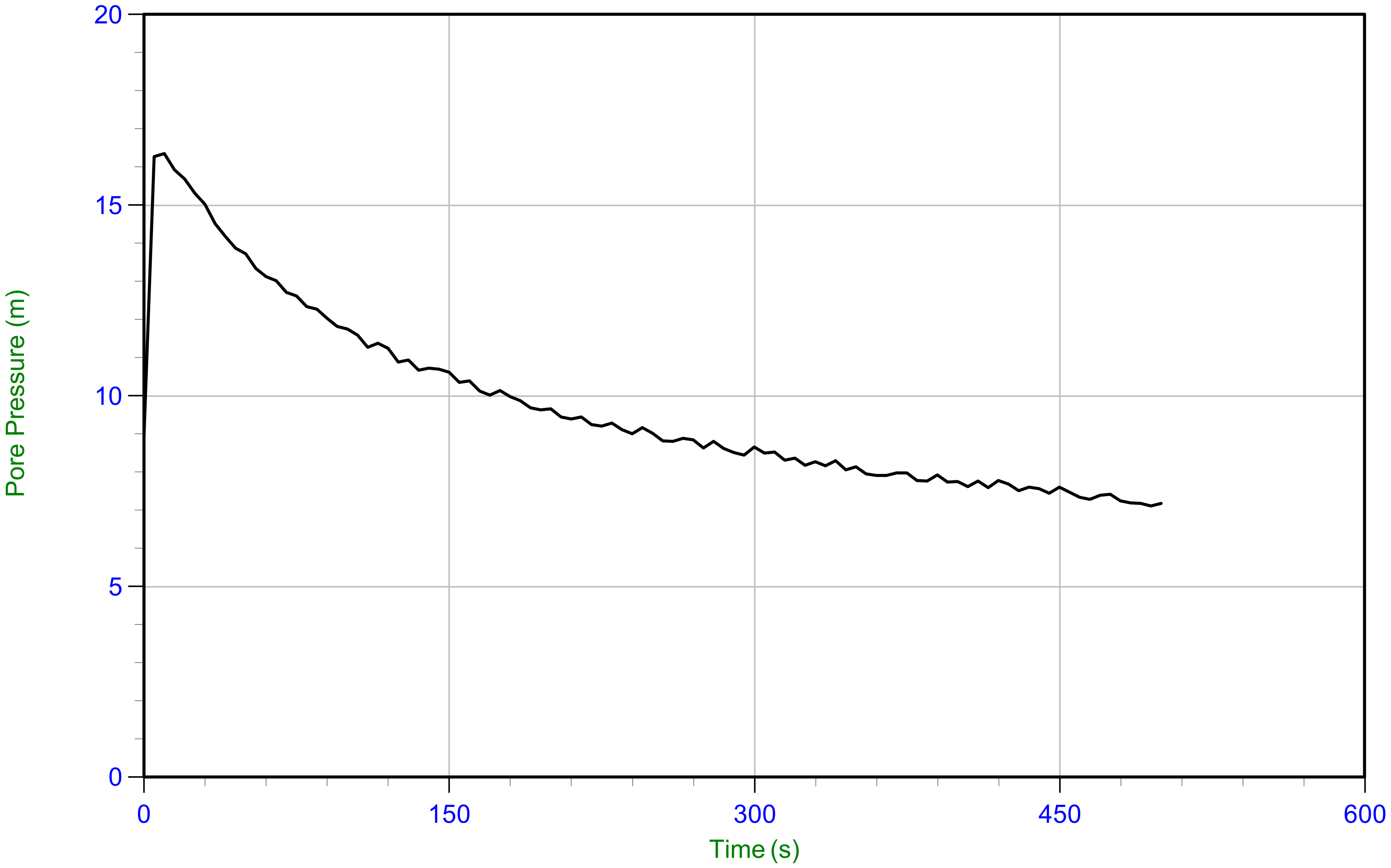
Trace Summary:				
	Filename: 17-05009_SP01.PPF	U Min: 17.1 m	WT: 0.221 m / 0.725 ft	T(50): 61.5 s
	Depth: 16.425 m / 53.887 ft	U Max: 24.5 m	Ueq: 16.2 m	Ir: 100
	Duration: 200.0 s		U(50): 20.38 m	Ch: 11.4 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/04/2017 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP02.PPF
Depth: 3.050 m / 10.006 ft
Duration: 500.0 s

U Min: 7.1 m
U Max: 16.4 m

WT: 0.000 m / 0.000 ft
Ueq: 3.0 m
U(50): 9.70 m

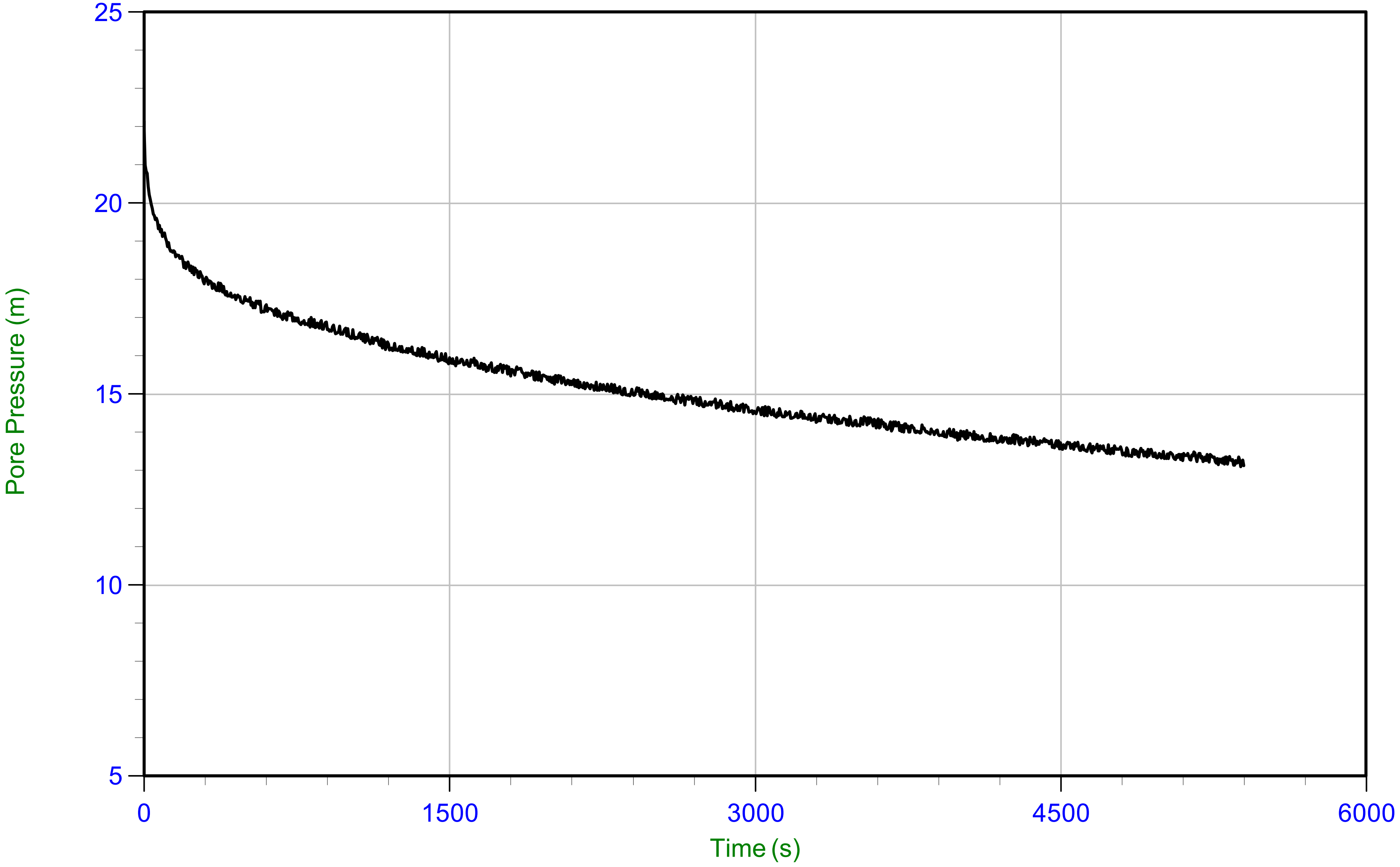
T(50): 179.5 s
Ir: 100
Ch: 3.9 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/04/2017 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP02.PPF
Depth: 5.500 m / 18.044 ft
Duration: 5400.0 s

U Min: 13.1 m
U Max: 22.2 m

WT: 0.000 m / 0.000 ft
Ueq: 5.5 m
U(50): 13.82 m

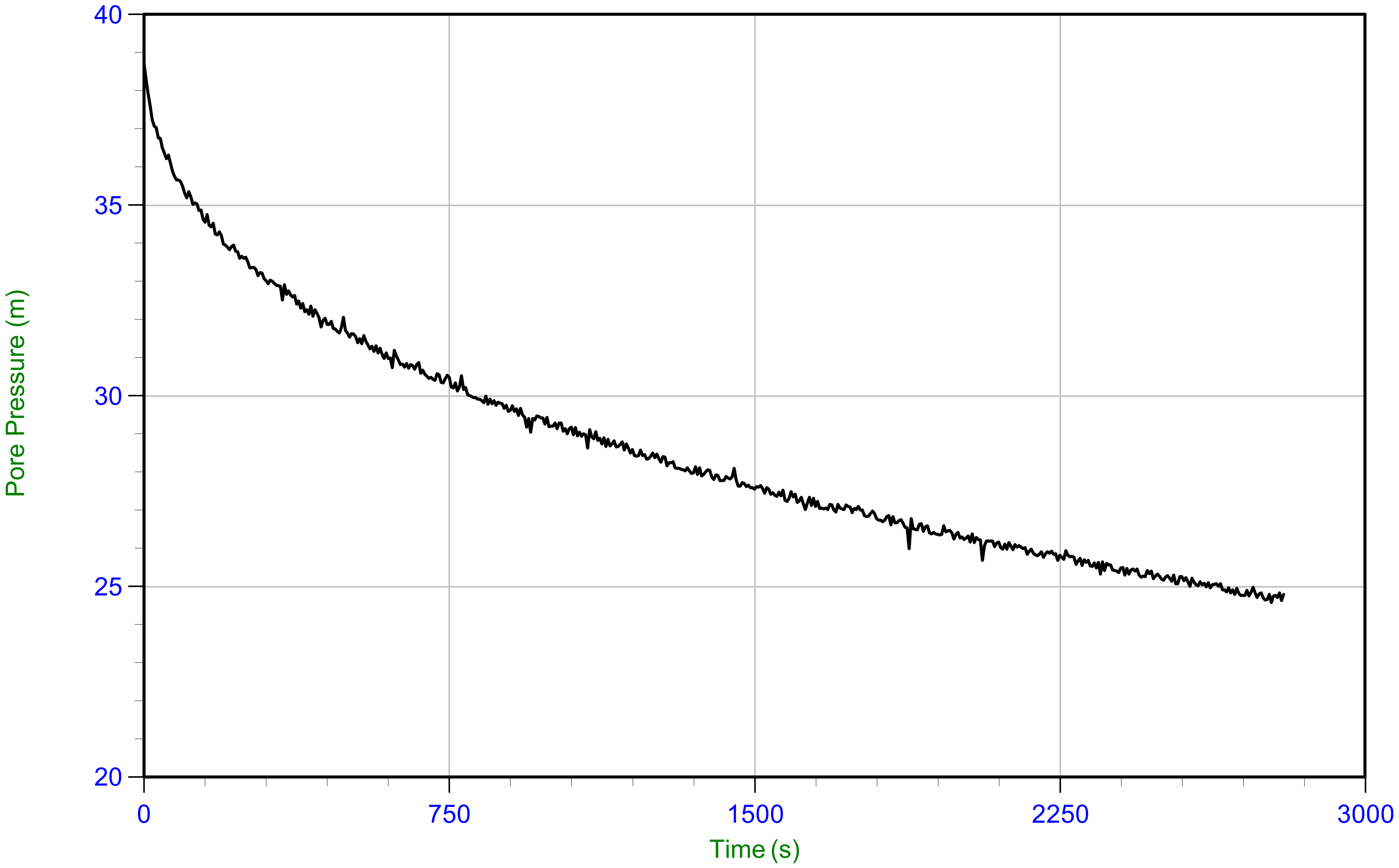
T(50): 3994.3 s
Ir: 100
Ch: 0.2 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/04/2017 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500 Area=15 cm²



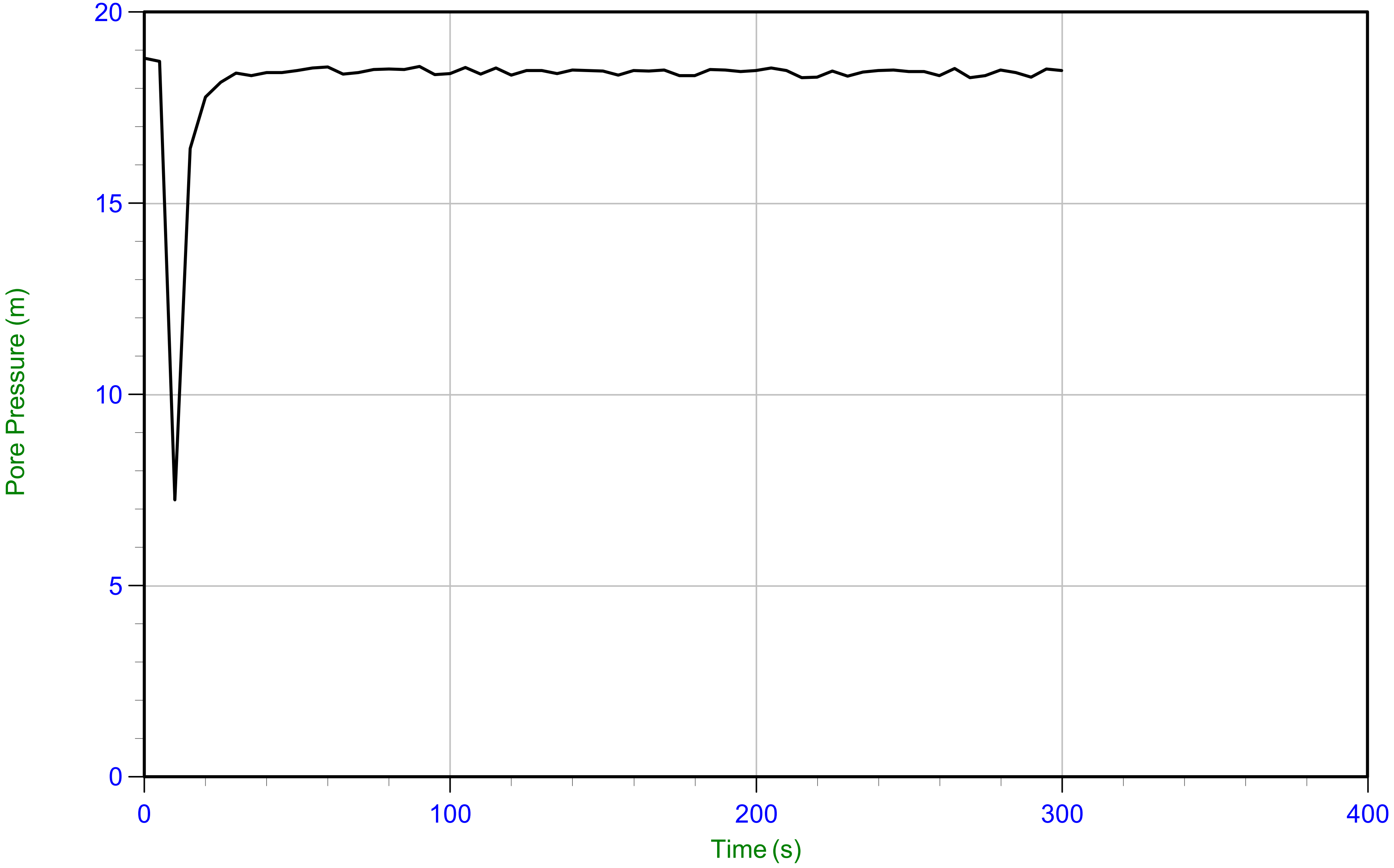
Trace Summary:	Filename: 17-05009_CP02.PPF	U Min: 24.6 m	WT: 0.000 m / 0.000 ft	T(50): 2348.6 s
	Depth: 12.000 m / 39.370 ft	U Max: 38.8 m	Ueq: 12.0 m	Ir: 100
	Duration: 2800.0 s		U(50): 25.41 m	Ch: 0.3 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/04/2017 10:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-02
Cone: 379:T1500F15U500 Area=15 cm²

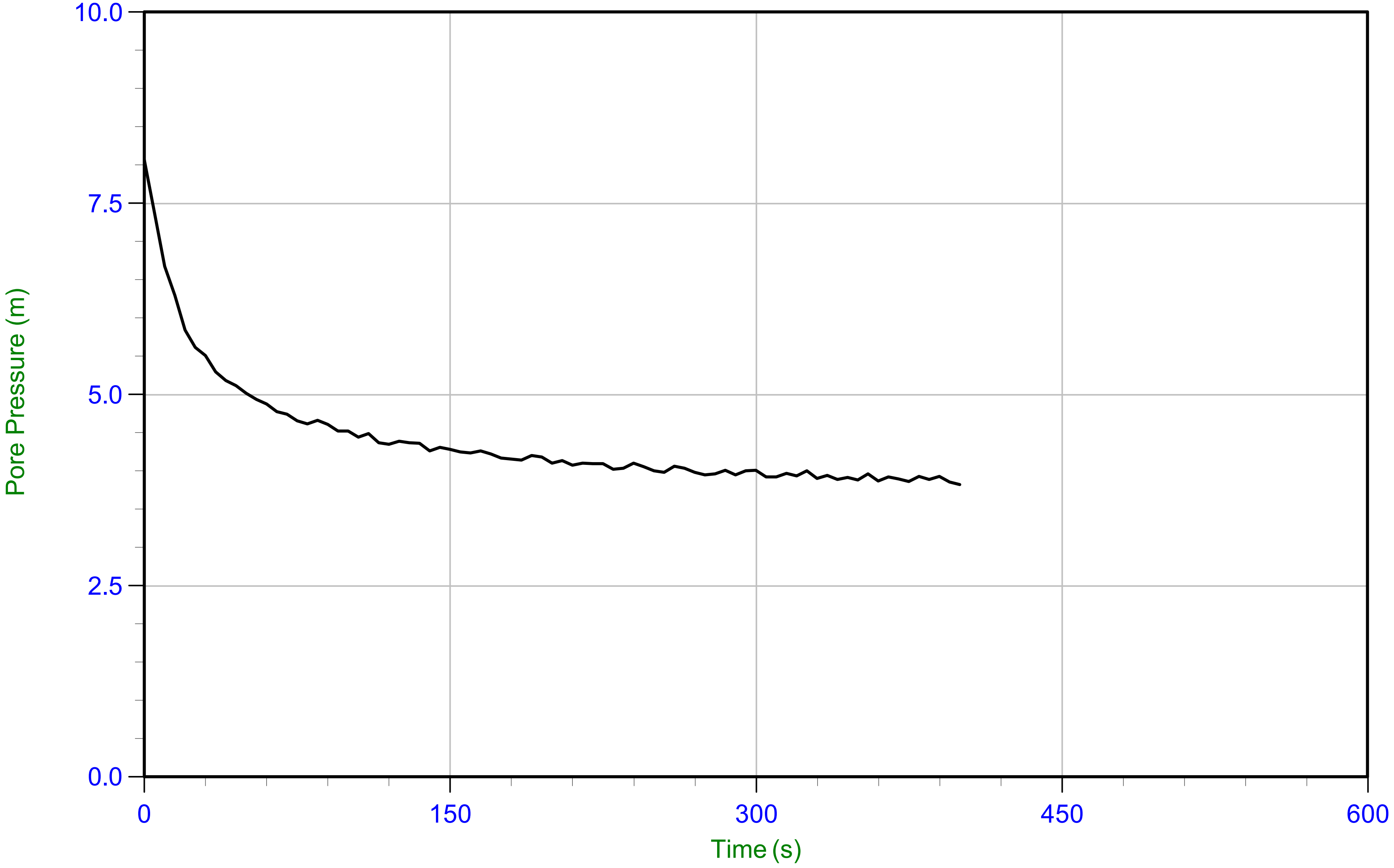


Trace Summary:

Filename: 17-05009_CP02.PPF
Depth: 18.400 m / 60.367 ft
Duration: 300.0 s

U Min: 7.2 m
U Max: 18.8 m

WT: 0.000 m / 0.000 ft
Ueq: 18.4 m



Trace Summary:

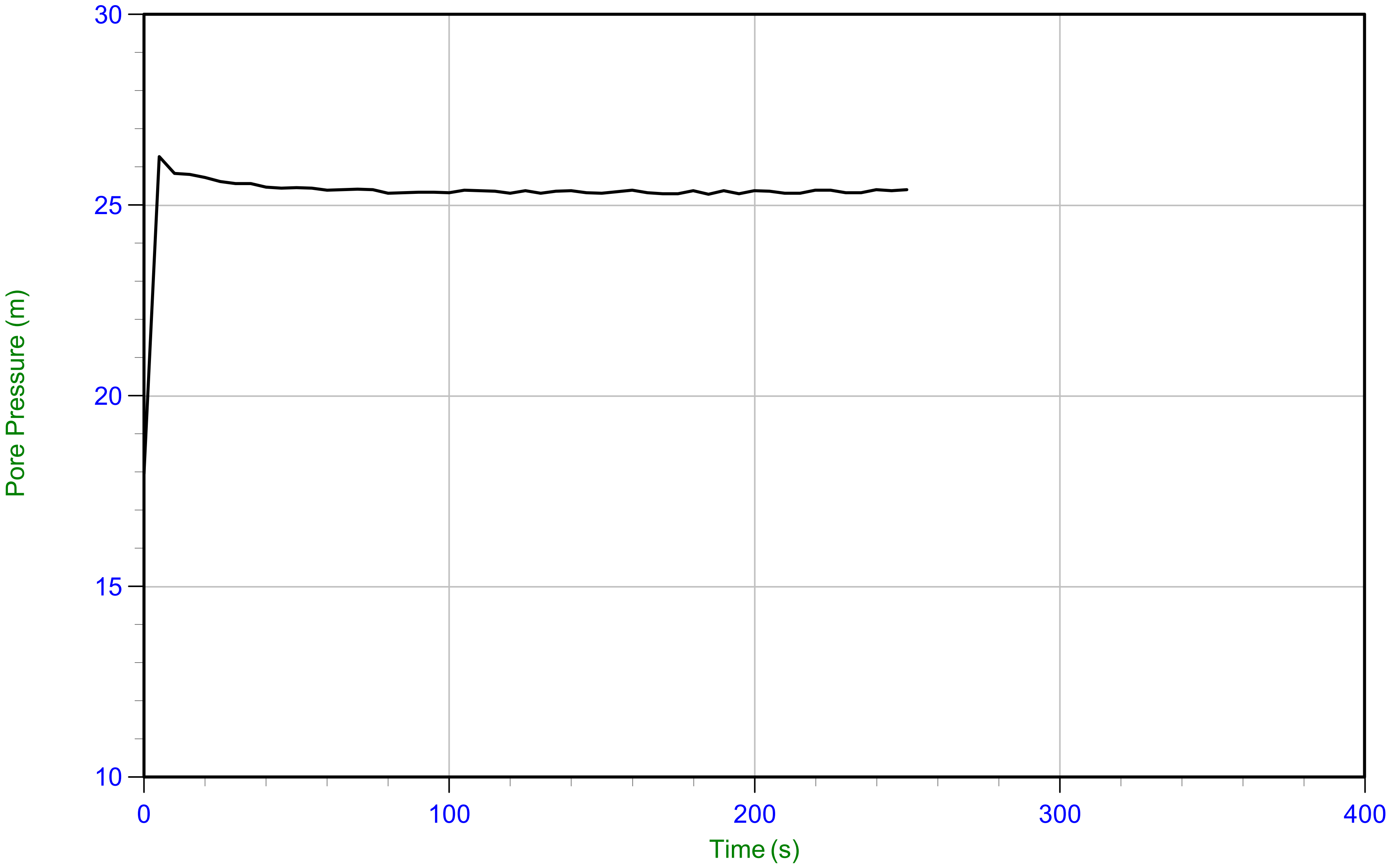
Filename: 17-05009_CP03.PPF
Depth: 3.800 m / 12.467 ft
Duration: 400.0 s

U Min: 3.8 m
U Max: 8.1 m

Thurber Engineering

Job No: 17-05009
Date: 03/06/2017 09:48
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-03
Cone: 417:T375F10U200 Area=15 cm²

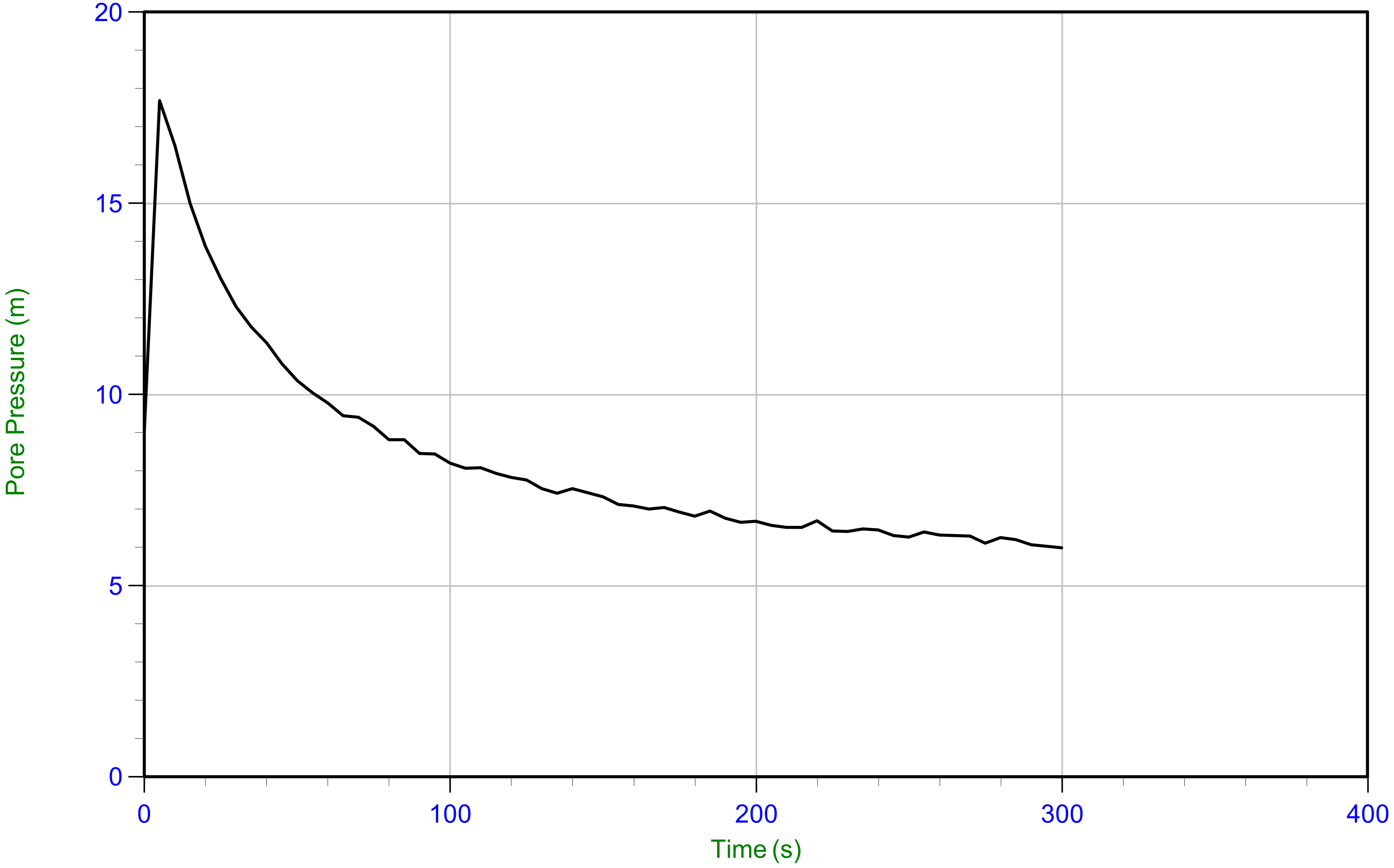


Trace Summary:

Filename: 17-05009_CP03.PPF
Depth: 25.575 m / 83.906 ft
Duration: 250.0 s

U Min: 18.0 m
U Max: 26.3 m

WT: 0.261 m / 0.856 ft
Ueq: 25.3 m



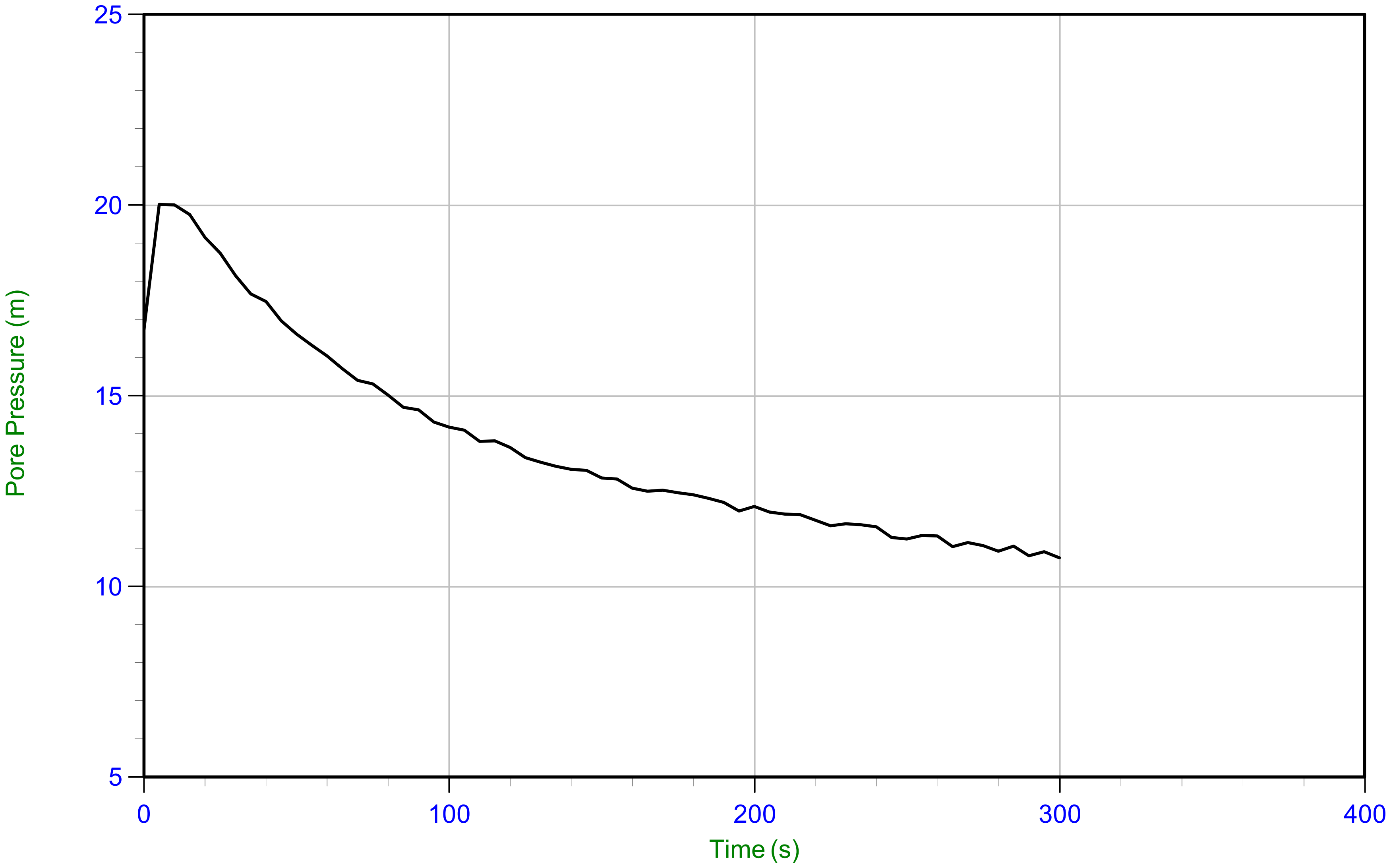
Trace Summary:

Filename: 17-05009_CP04.PPF
Depth: 3.825 m / 12.549 ft
Duration: 300.0 s

U Min: 6.0 m
U Max: 17.7 m

WT: 0.000 m / 0.000 ft
Ueq: 3.8 m
U(50): 10.76 m

T(50): 40.6 s
Ir: 100
Ch: 17.3 sq cm/min



Trace Summary:

Filename: 17-05009_CP04.PPF
Depth: 4.250 m / 13.943 ft
Duration: 300.0 s

U Min: 10.7 m
U Max: 20.0 m

WT: 0.000 m / 0.000 ft
Ueq: 4.2 m
U(50): 12.14 m

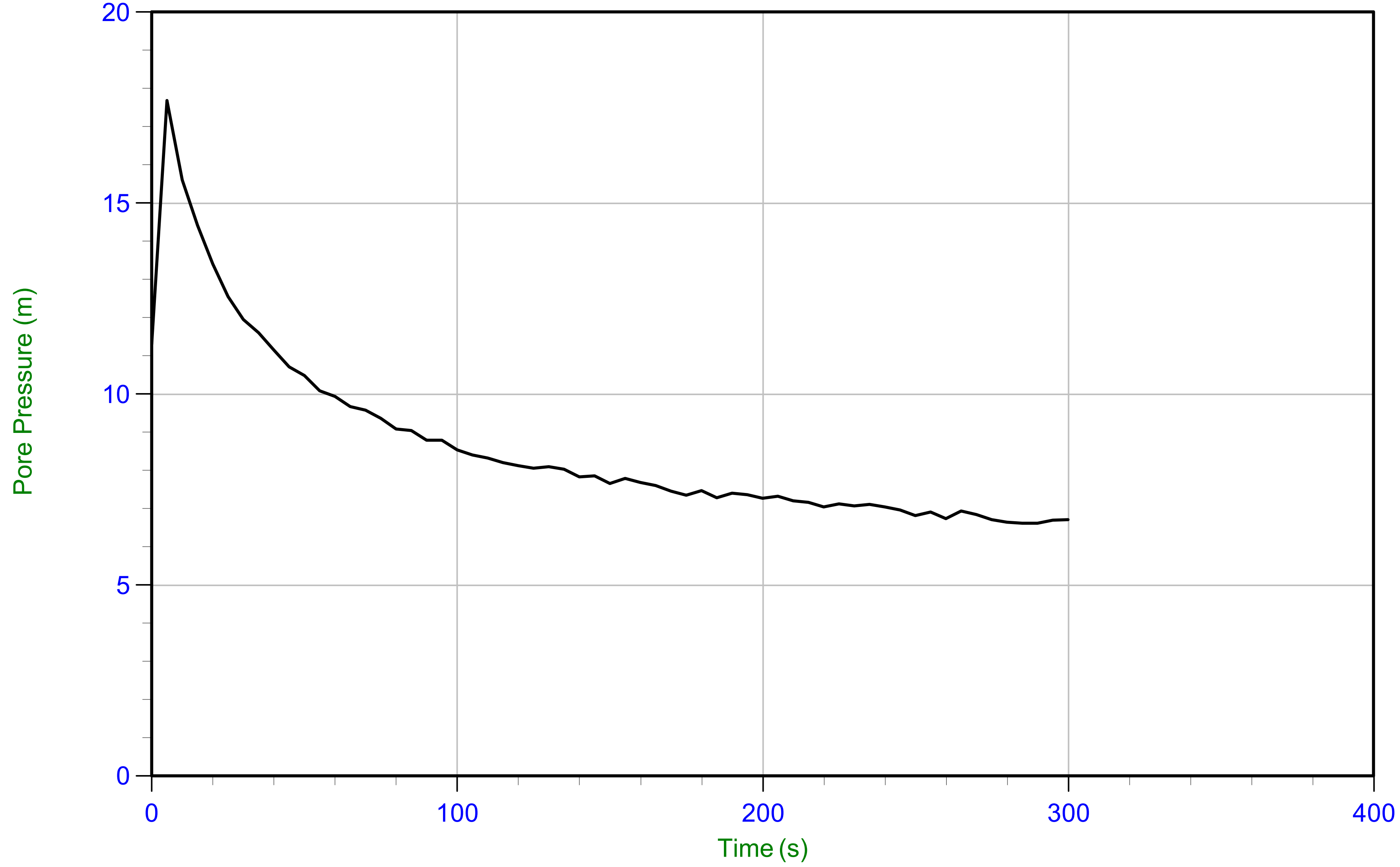
T(50): 186.6 s
Ir: 100
Ch: 3.8 sq cm/min

CONETEC

Thurber Engineering

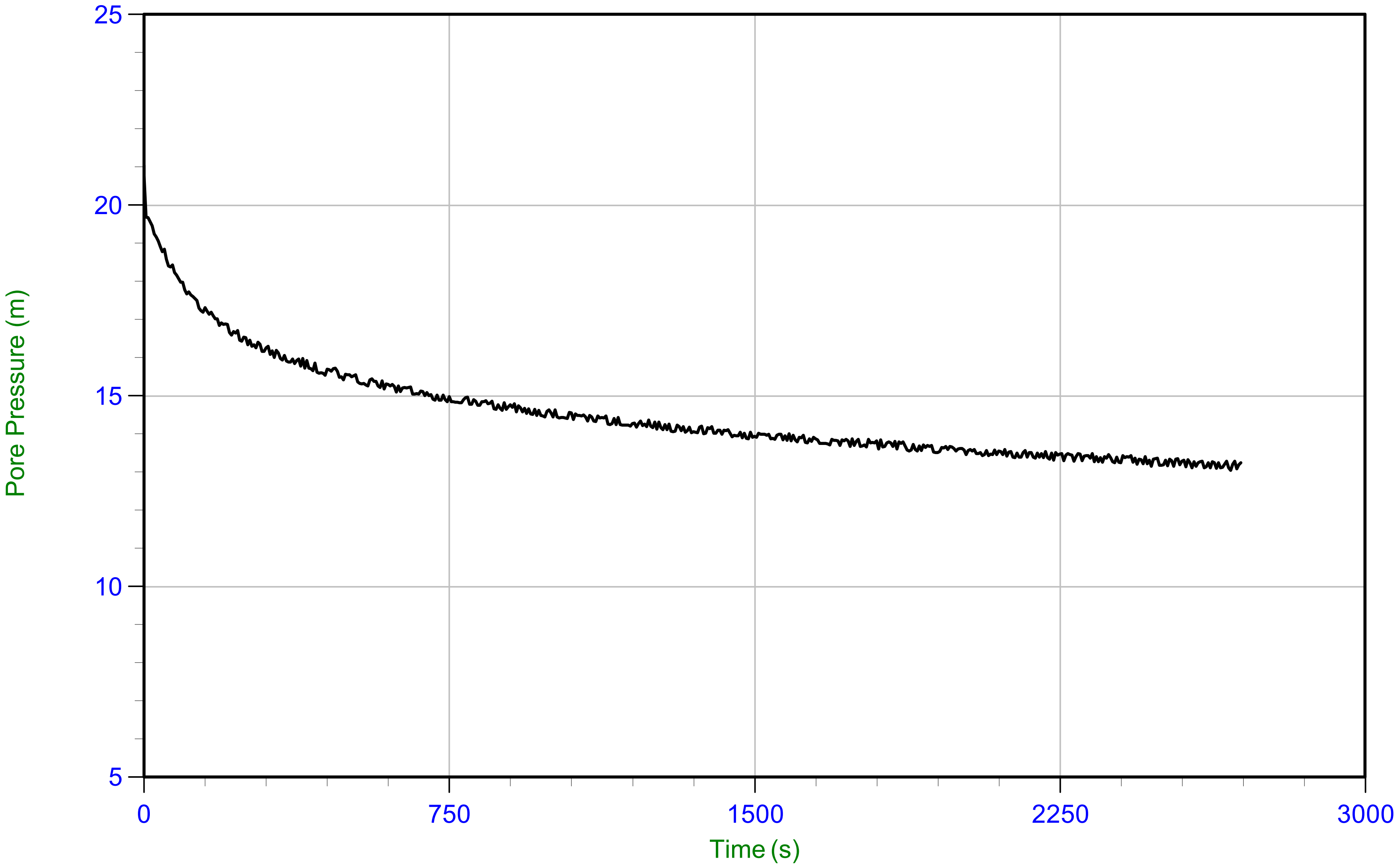
Job No: 17-05009
Date: 03/04/2017 13:47
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04
Cone: 379:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP04.PPF	U Min: 6.6 m	WT: 0.000 m / 0.000 ft	T(50): 34.4 s
Depth: 4.750 m / 15.584 ft	U Max: 17.7 m	Ueq: 4.8 m	Ir: 100
Duration: 300.0 s		U(50): 11.22 m	Ch: 20.4 sq cm/min



Trace Summary:

Filename: 17-05009_CP04.PPF
Depth: 6.000 m / 19.685 ft
Duration: 2695.0 s

U Min: 13.0 m
U Max: 21.0 m

WT: 0.000 m / 0.000 ft
Ueq: 6.0 m
U(50): 13.52 m

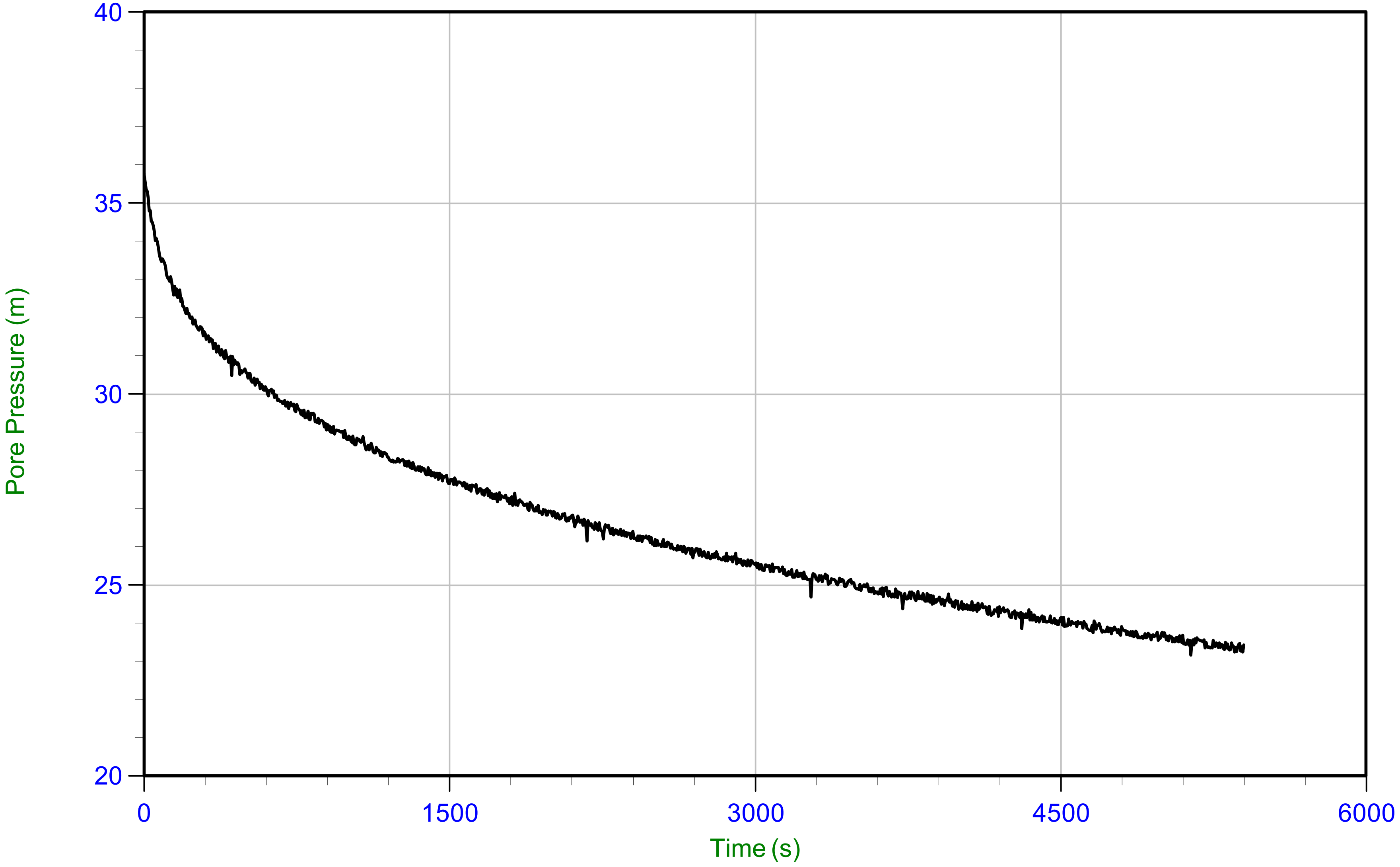
T(50): 1943.5 s
Ir: 100
Ch: 0.4 sq cm/min

ConeTec

Thurber Engineering

Job No: 17-05009
Date: 03/04/2017 13:47
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04
Cone: 379:T1500F15U500 Area=15 cm²



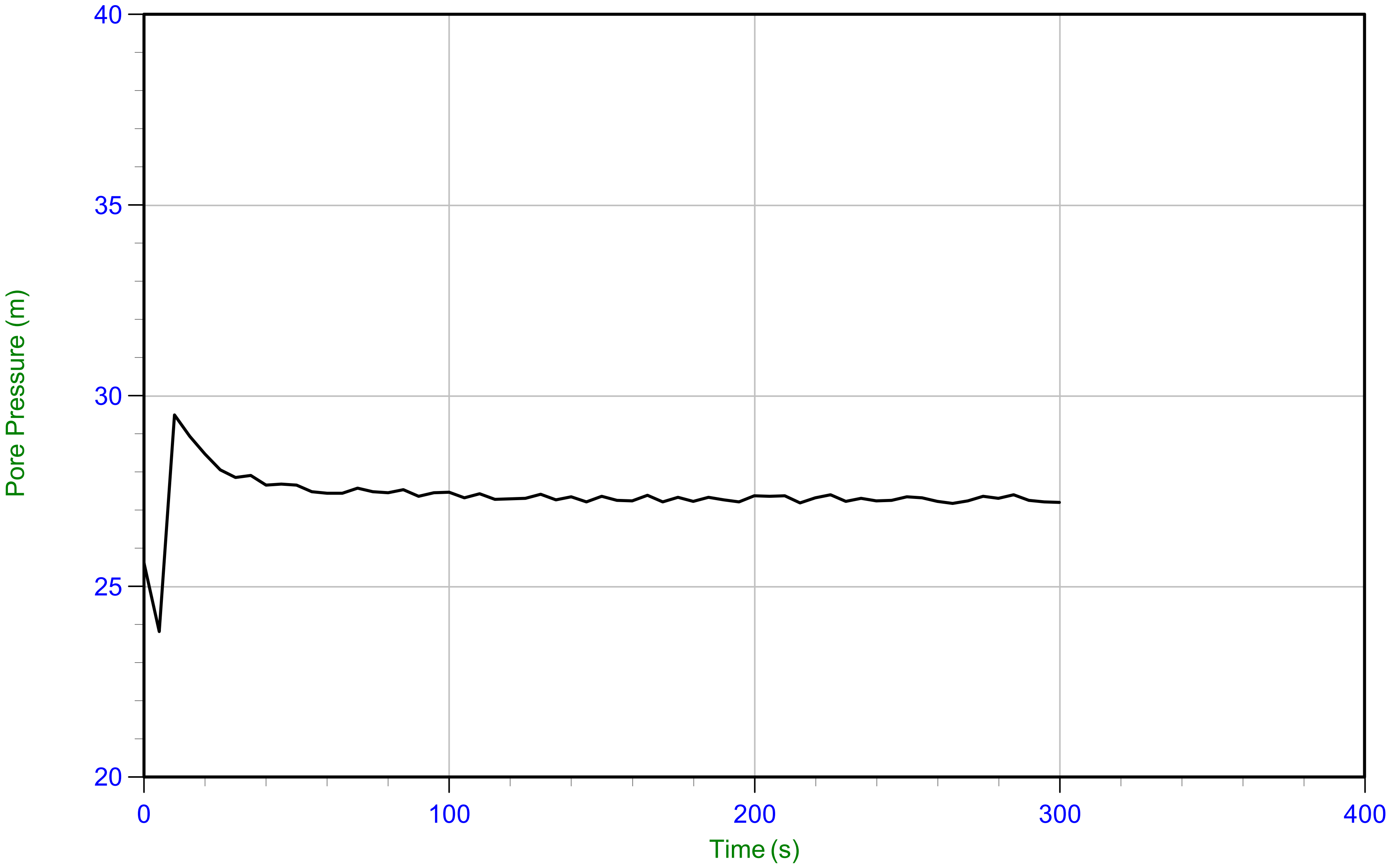
Trace Summary:

Filename: 17-05009_CP04.PPF
Depth: 12.000 m / 39.370 ft
Duration: 5400.0 s

U Min: 23.2 m
U Max: 35.8 m

WT: 0.000 m / 0.000 ft
Ueq: 12.0 m
U(50): 23.89 m

T(50): 4309.7 s
Ir: 100
Ch: 0.2 sq cm/min



Trace Summary:

Filename: 17-05009_CP04.PPF
Depth: 27.125 m / 88.992 ft
Duration: 300.0 s

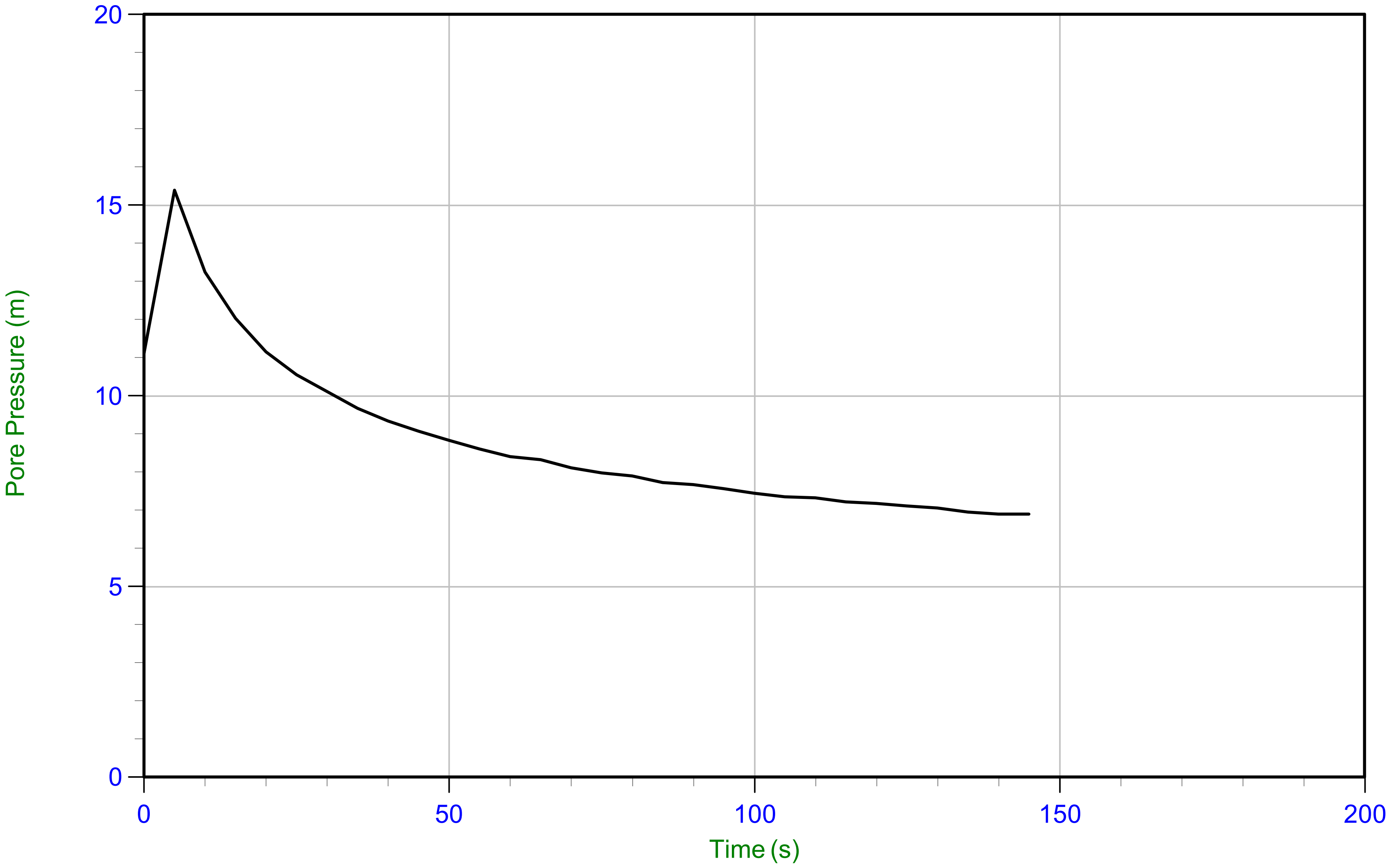
U Min: 23.8 m
U Max: 29.5 m

WT: 0.000 m / 0.000 ft
Ueq: 27.1 m

Thurber Engineering

Job No: 17-05009
Date: 03/06/2017 14:04
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04B
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP04D.PPF
Depth: 4.000 m / 13.123 ft
Duration: 145.0 s

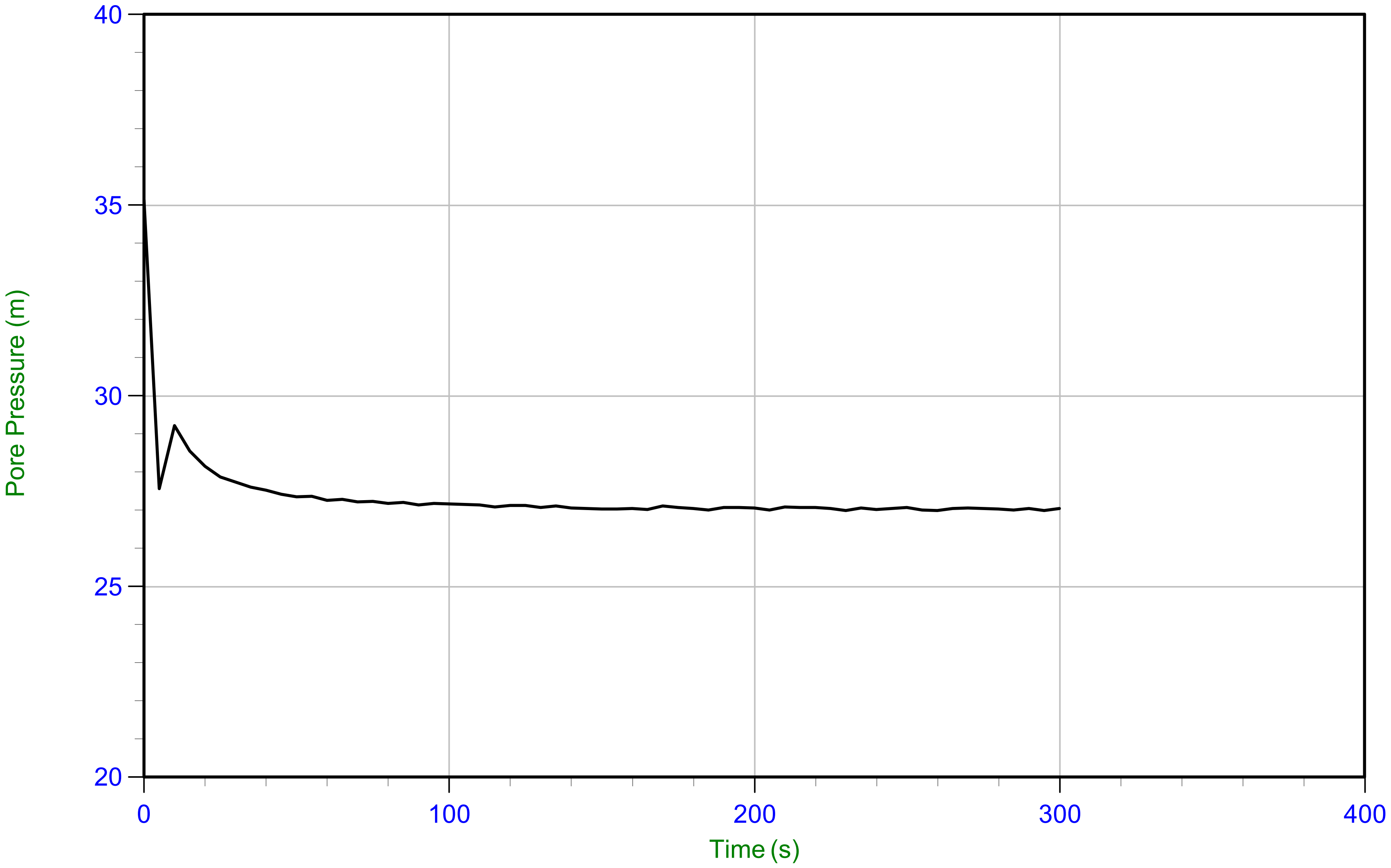
U Min: 6.9 m
U Max: 15.4 m

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/06/2017 14:04
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-04B
Cone: 417:T375F10U200 Area=15 cm²

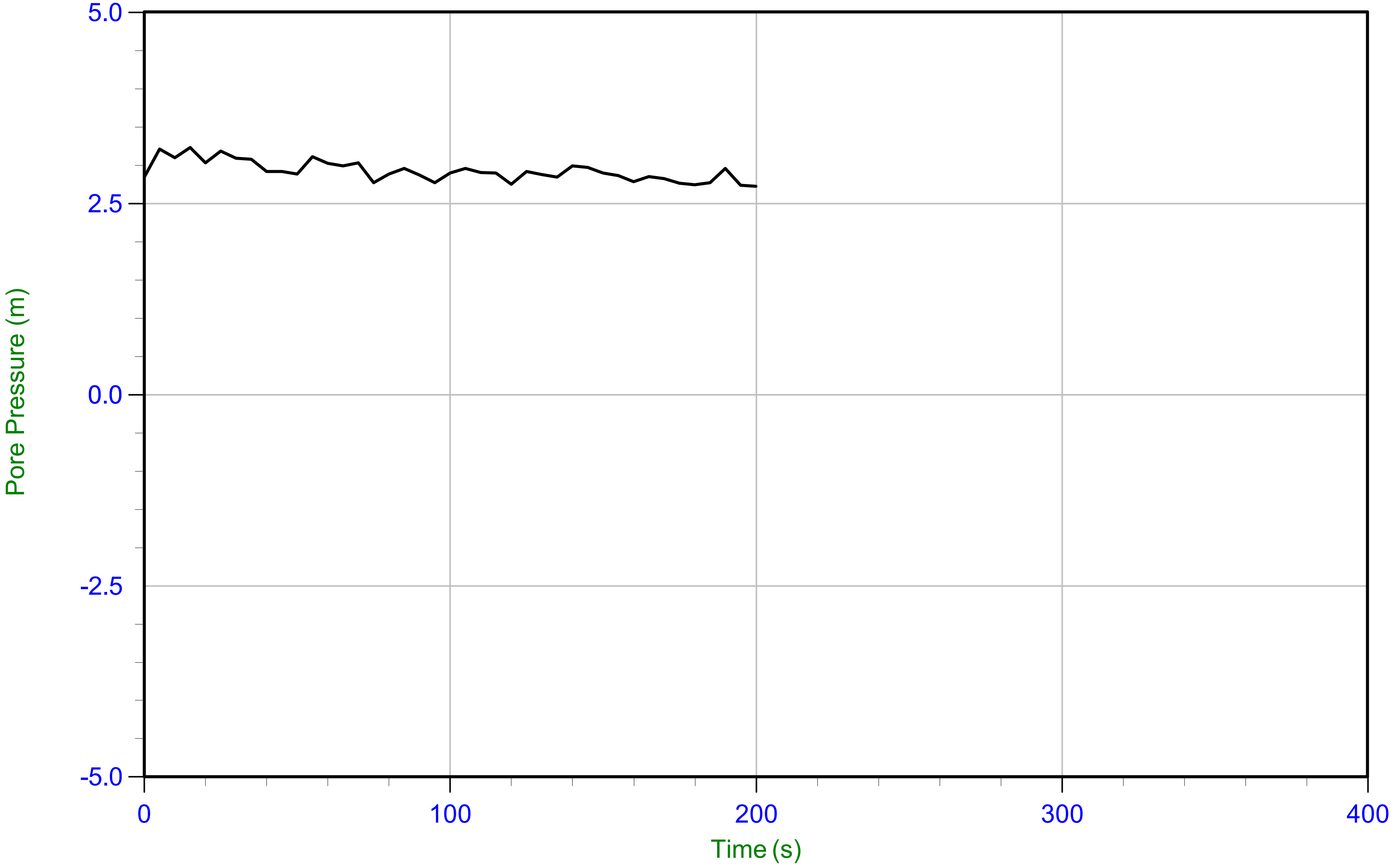


Trace Summary:

Filename: 17-05009_CP04D.PPF
Depth: 27.000 m / 88.582 ft
Duration: 300.0 s

U Min: 27.0 m
U Max: 35.1 m

WT: 0.000 m / 0.000 ft
Ueq: 27.0 m

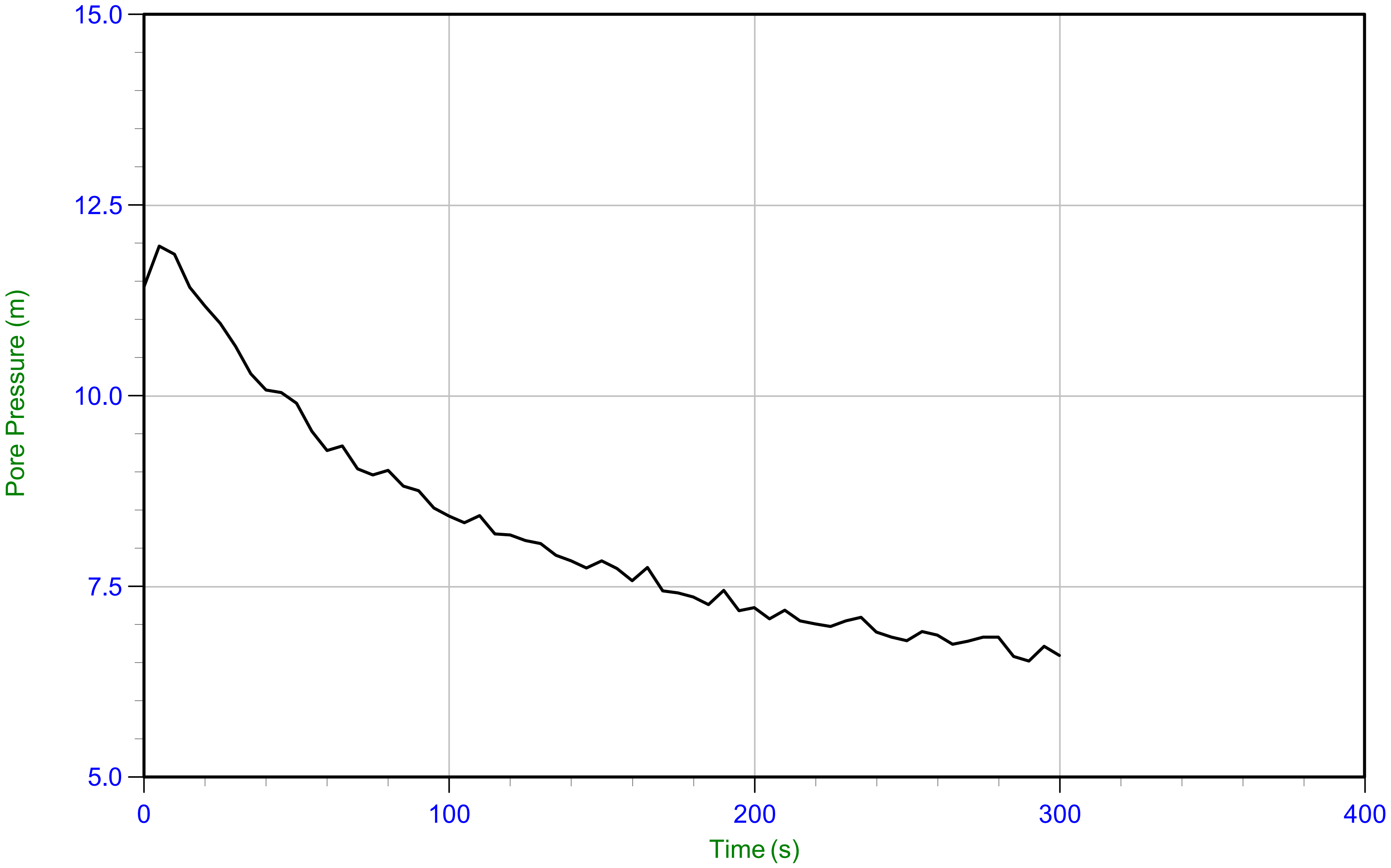


Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 3.000 m / 9.842 ft
Duration: 200.0 s

U Min: 2.7 m
U Max: 3.2 m

WT: 0.000 m / 0.000 ft
Ueq: 3.0 m



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 4.000 m / 13.123 ft
Duration: 300.0 s

U Min: 6.5 m
U Max: 12.0 m

WT: 0.000 m / 0.000 ft
Ueq: 4.0 m
U(50): 7.98 m

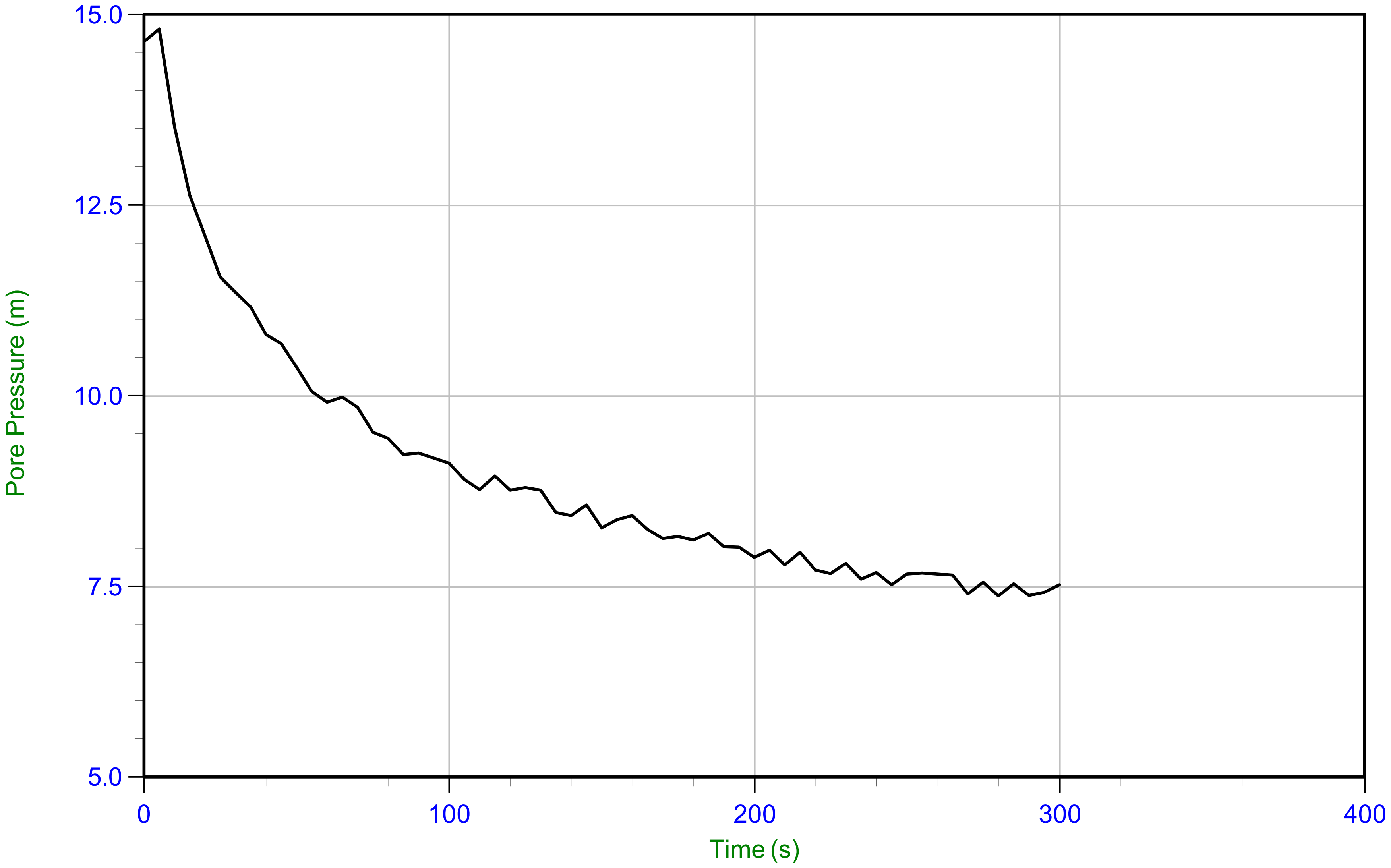
T(50): 127.6 s
Ir: 100
Ch: 5.5 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 4.700 m / 15.420 ft
Duration: 300.0 s

U Min: 7.4 m
U Max: 14.8 m

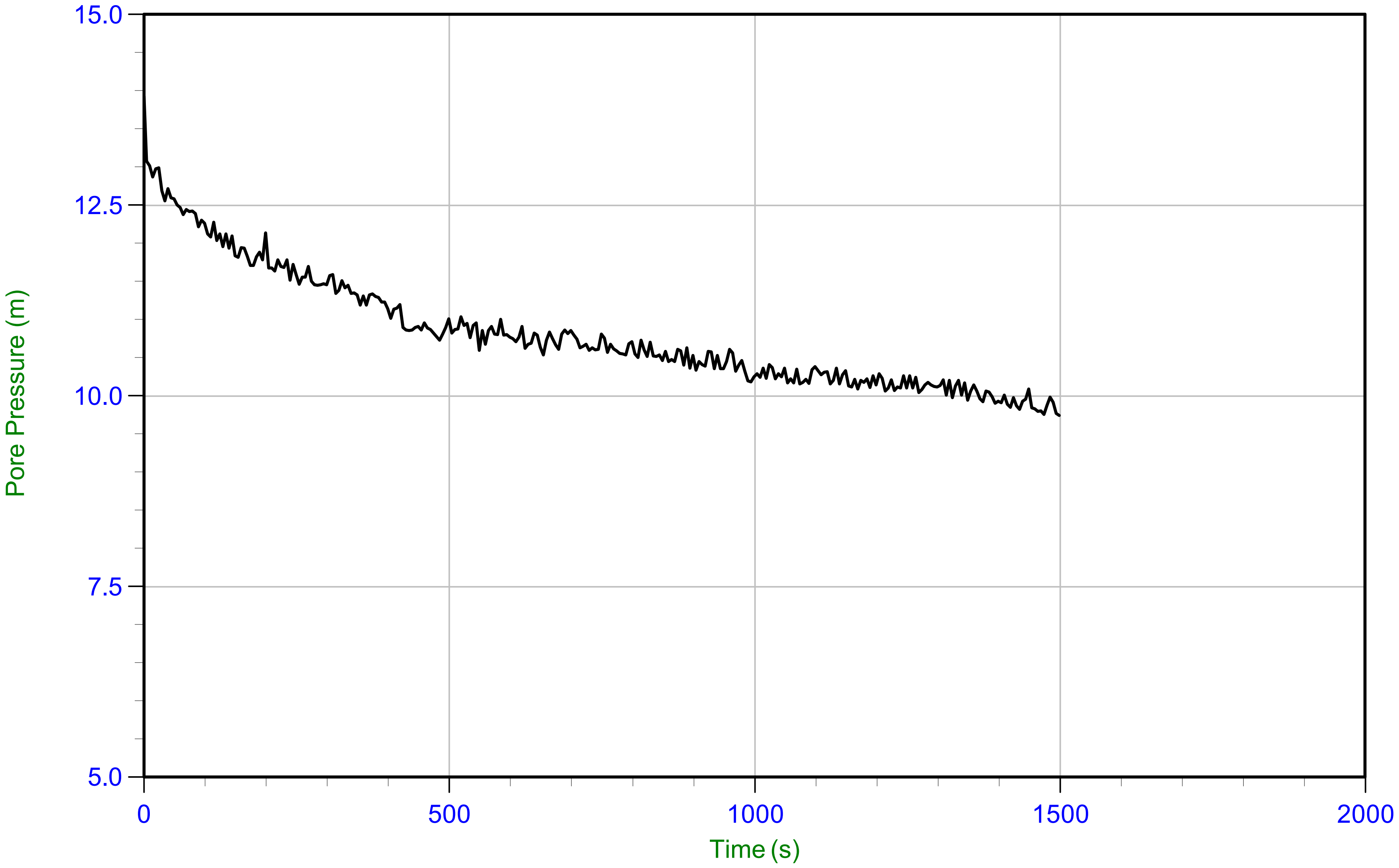
WT: 0.000 m / 0.000 ft
Ueq: 4.7 m
U(50): 9.75 m

T(50): 66.5 s
Ir: 100
Ch: 10.6 sq cm/min

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



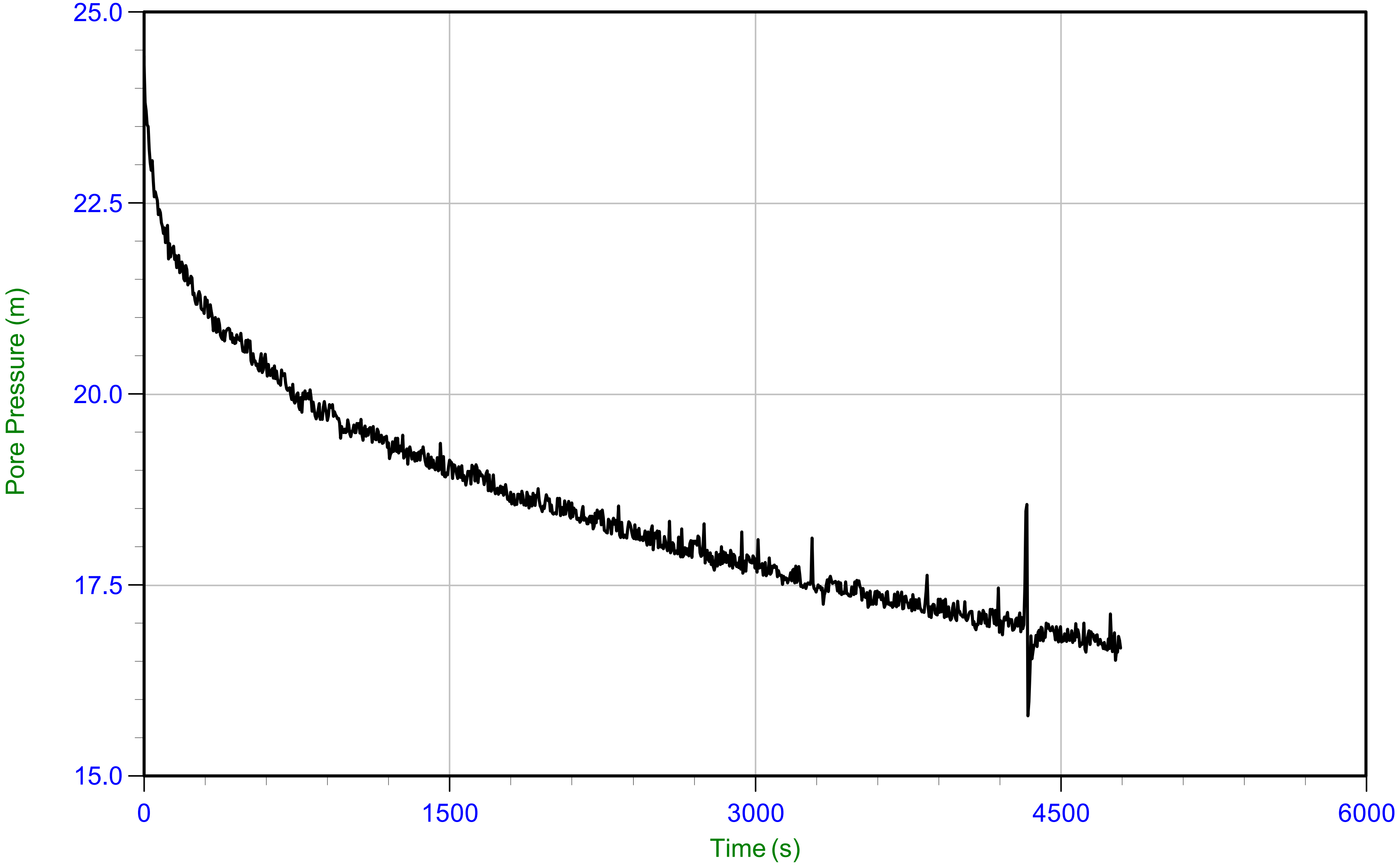
Trace Summary:	Filename: 17-05009_CP05.PPF	U Min: 9.7 m	WT: 0.000 m / 0.000 ft	T(50): 1373.0 s
	Depth: 5.950 m / 19.521 ft	U Max: 13.9 m	Ueq: 6.0 m	Ir: 100
	Duration: 1500.0 s		U(50): 9.94 m	Ch: 0.5 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



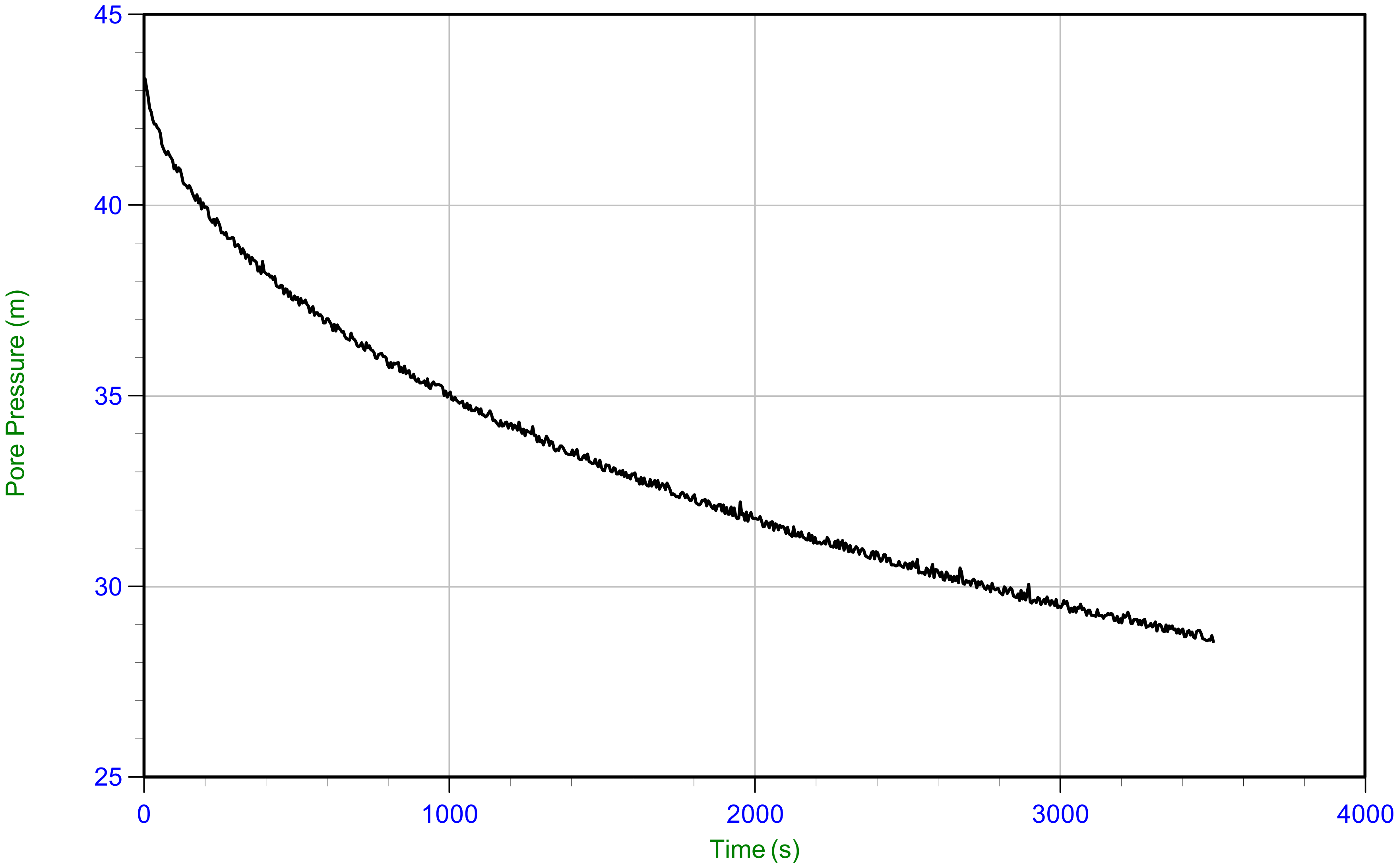
Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 9.000 m / 29.527 ft
Duration: 4795.0 s

U Min: 15.8 m
U Max: 24.4 m

WT: 0.000 m / 0.000 ft
Ueq: 9.0 m
U(50): 16.72 m

T(50): 4594.4 s
Ir: 100
Ch: 0.2 sq cm/min



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 15.000 m / 49.212 ft
Duration: 3505.0 s

U Min: 28.6 m
U Max: 43.3 m

WT: 0.000 m / 0.000 ft
Ueq: 15.0 m
U(50): 29.16 m

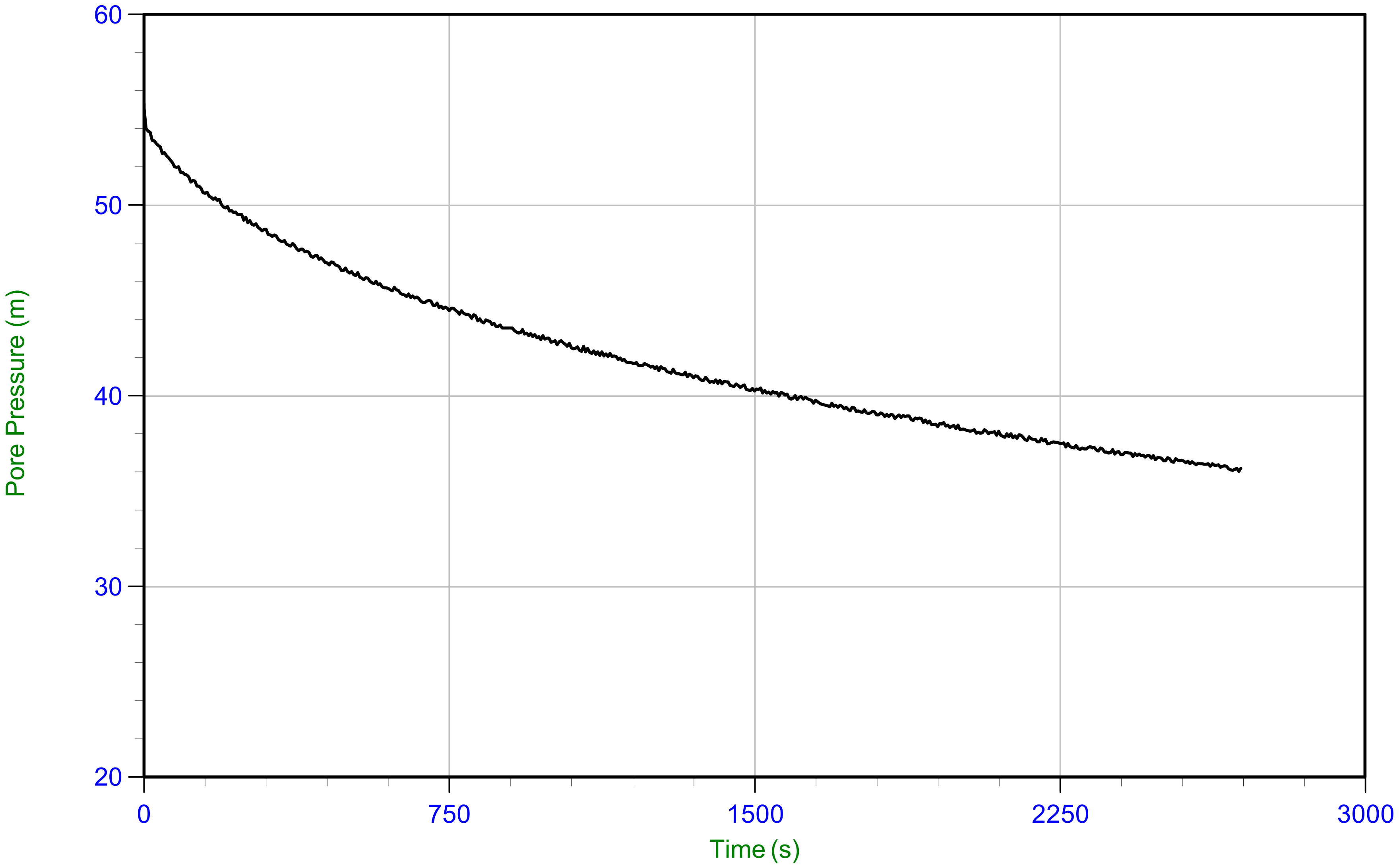
T(50): 3173.4 s
Ir: 100
Ch: 0.2 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 18.000 m / 59.054 ft
Duration: 2695.0 s

U Min: 36.0 m
U Max: 55.3 m

WT: 0.000 m / 0.000 ft
Ueq: 18.0 m
U(50): 36.67 m

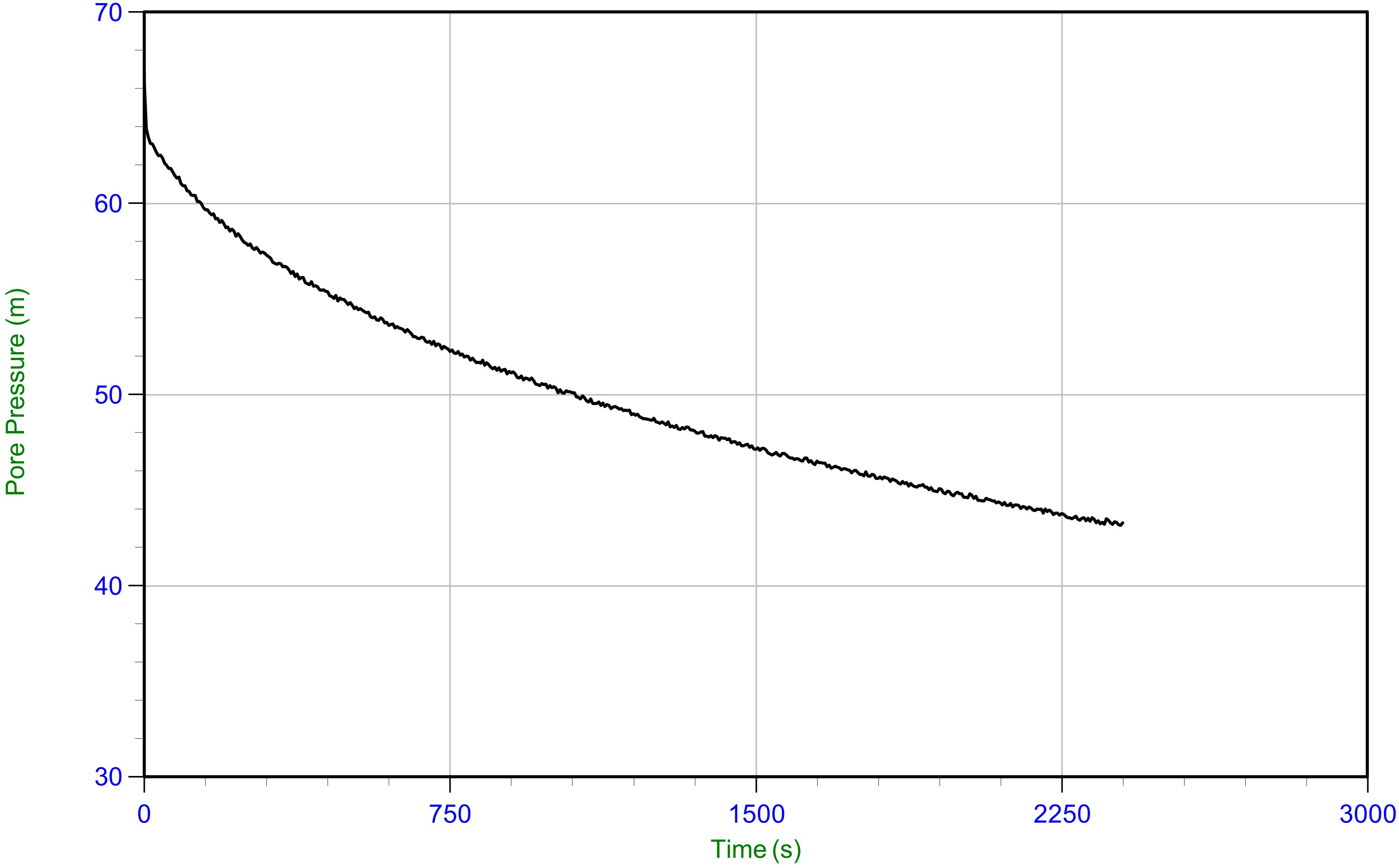
T(50): 2484.6 s
Ir: 100
Ch: 0.3 sq cm/min

ConeTec

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 21.000 m / 68.897 ft
Duration: 2400.0 s

U Min: 43.2 m
U Max: 66.9 m

WT: 0.000 m / 0.000 ft
Ueq: 21.0 m
U(50): 43.96 m

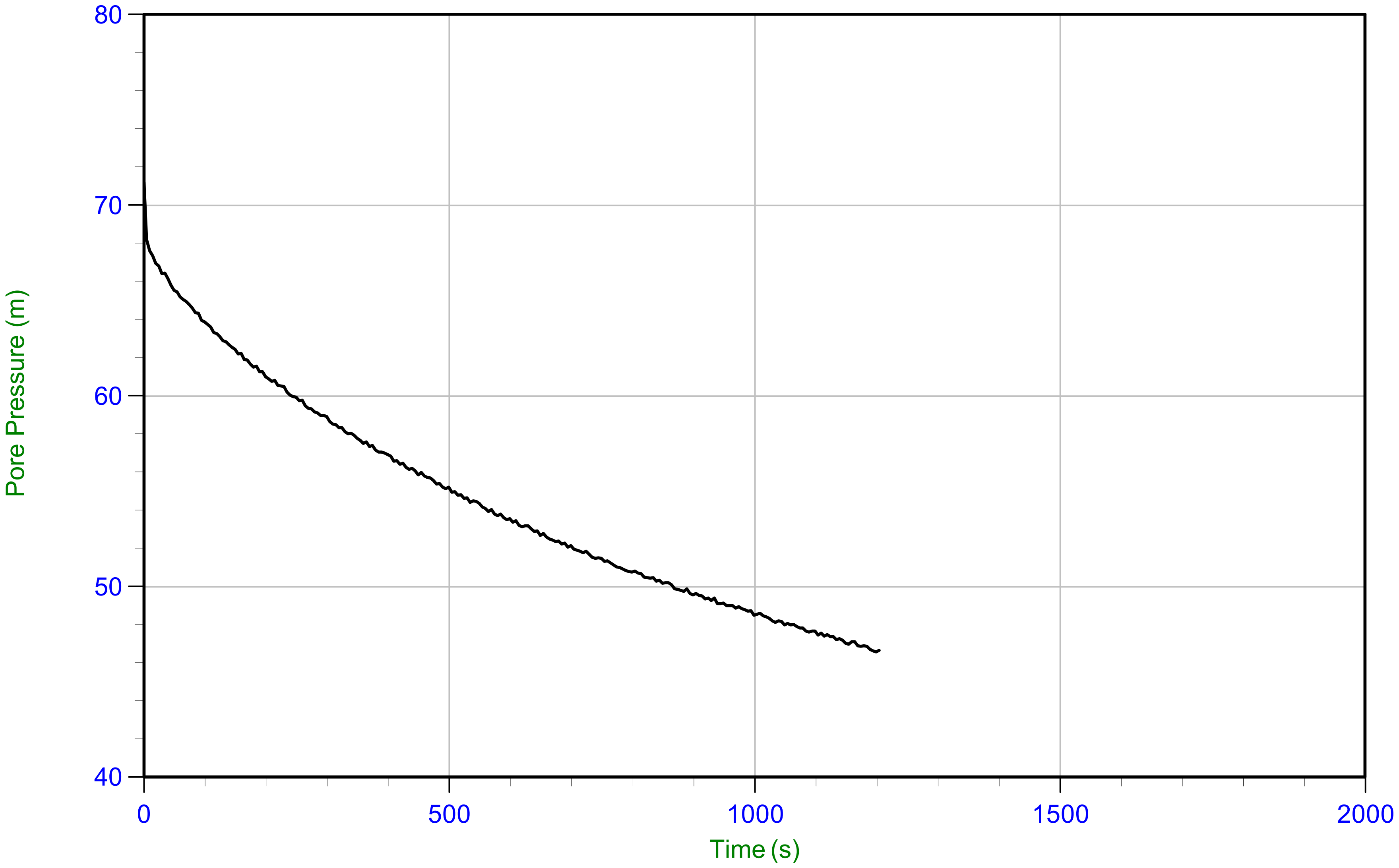
T(50): 2180.3 s
Ir: 100
Ch: 0.3 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



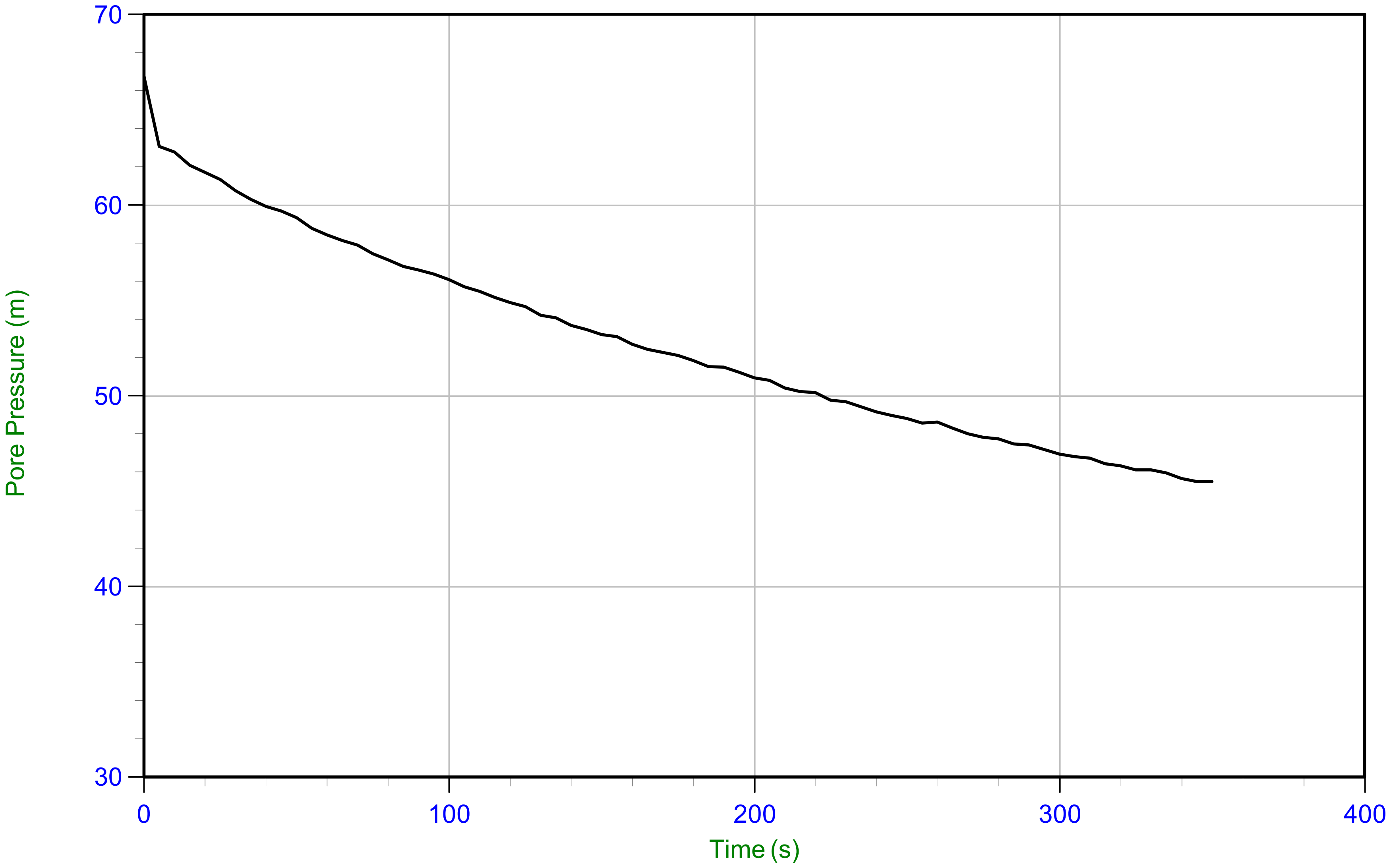
Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 24.000 m / 78.739 ft
Duration: 1205.0 s

U Min: 46.6 m
U Max: 71.2 m

WT: 0.000 m / 0.000 ft
Ueq: 24.0 m
U(50): 47.60 m

T(50): 1101.4 s
Ir: 100
Ch: 0.6 sq cm/min



Trace Summary:

Filename: 17-05009_CP05.PPF

Depth: 25.600 m / 83.988 ft

Duration: 350.0 s

U Min: 45.5 m

U Max: 66.8 m

WT: 0.000 m / 0.000 ft

Ueq: 25.6 m

U(50): 46.18 m

T(50): 323.4 s

Ir: 100

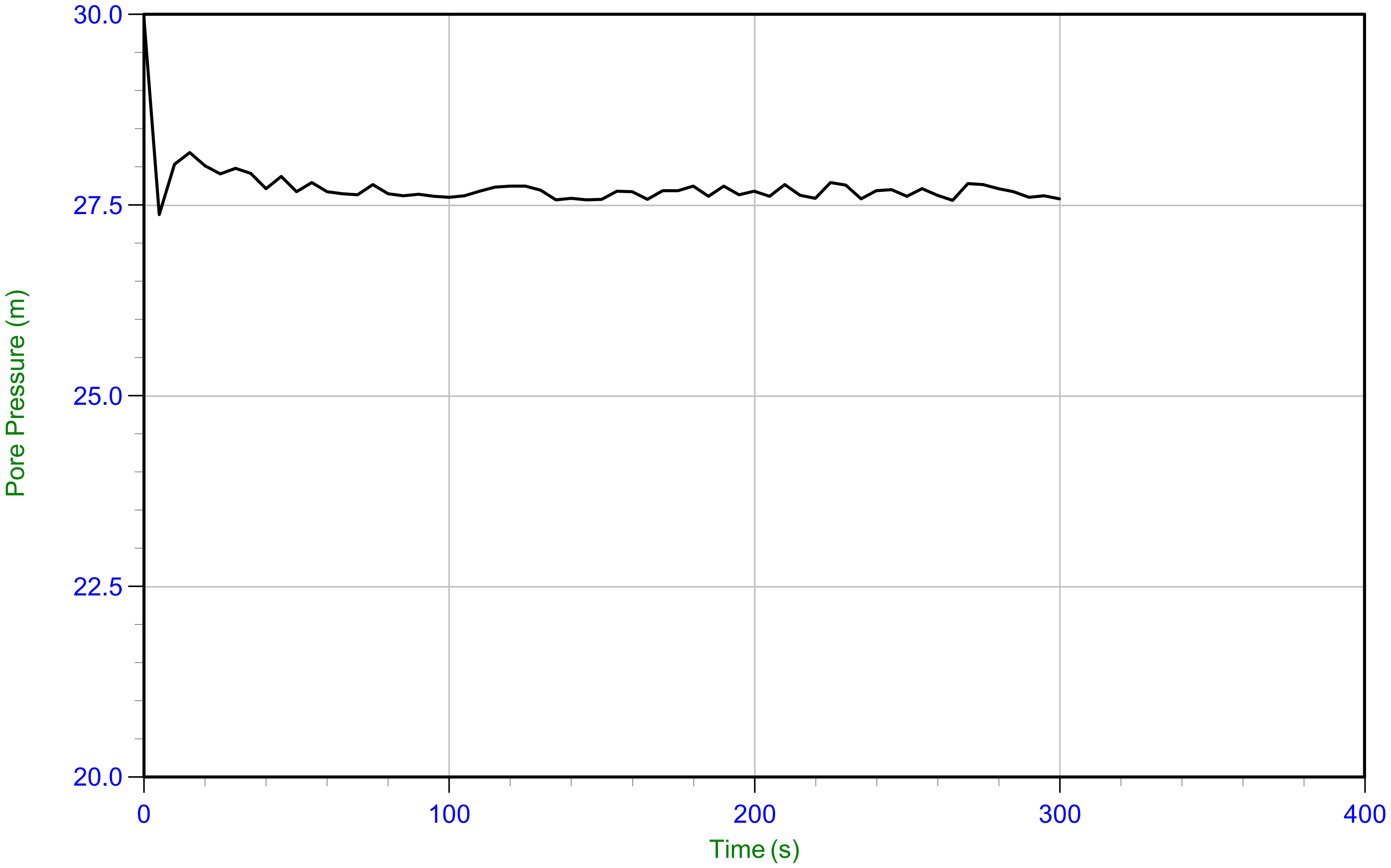
Ch: 2.2 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/05/2017 09:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-05
Cone: 323:T1500F15U500 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP05.PPF
Depth: 27.525 m / 90.304 ft
Duration: 300.0 s

U Min: 27.4 m
U Max: 29.9 m

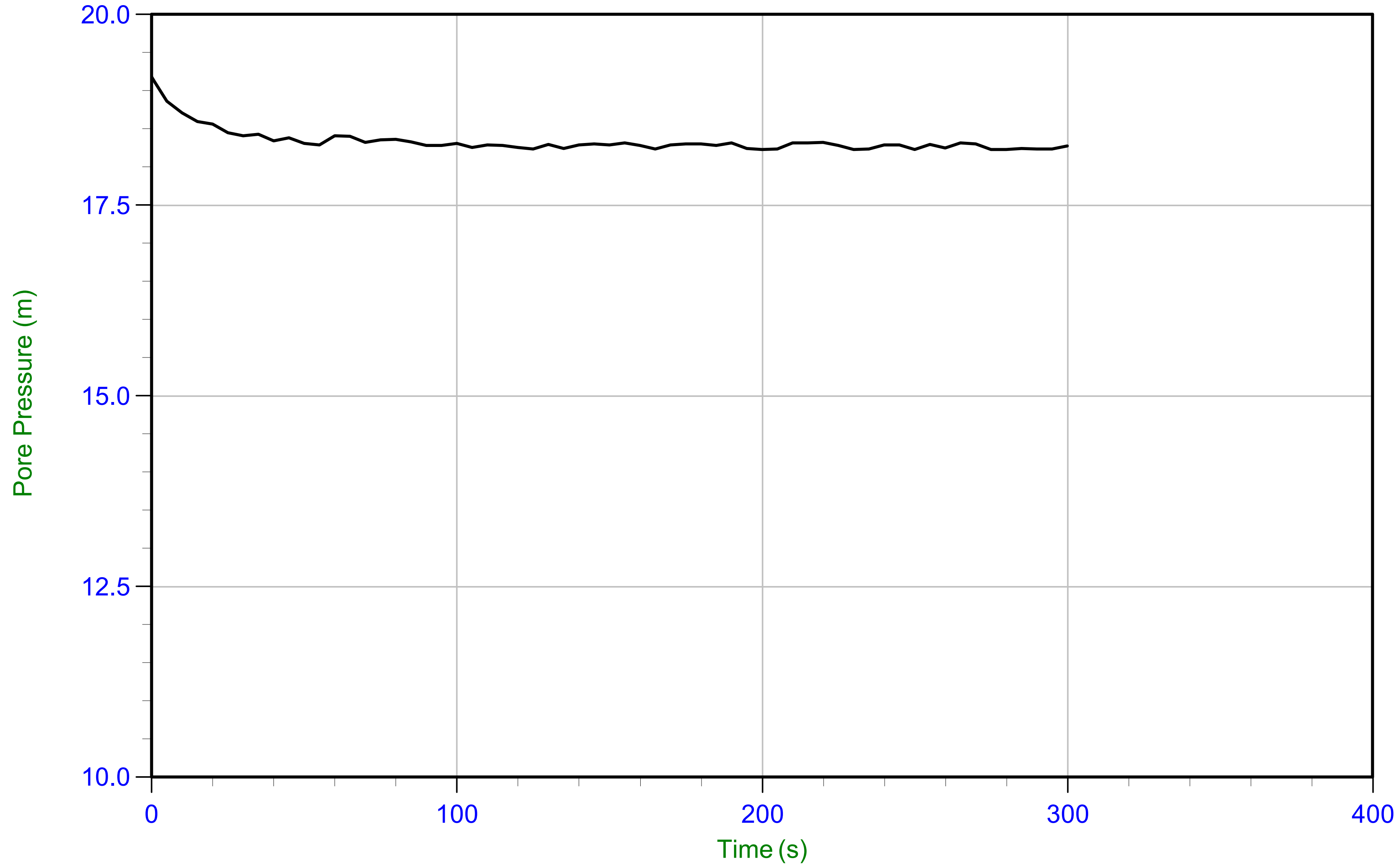
WT: 0.000 m / 0.000 ft
Ueq: 27.5 m

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/06/2017 11:25
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-06
Cone: 417:T375F10U200 Area=15 cm²

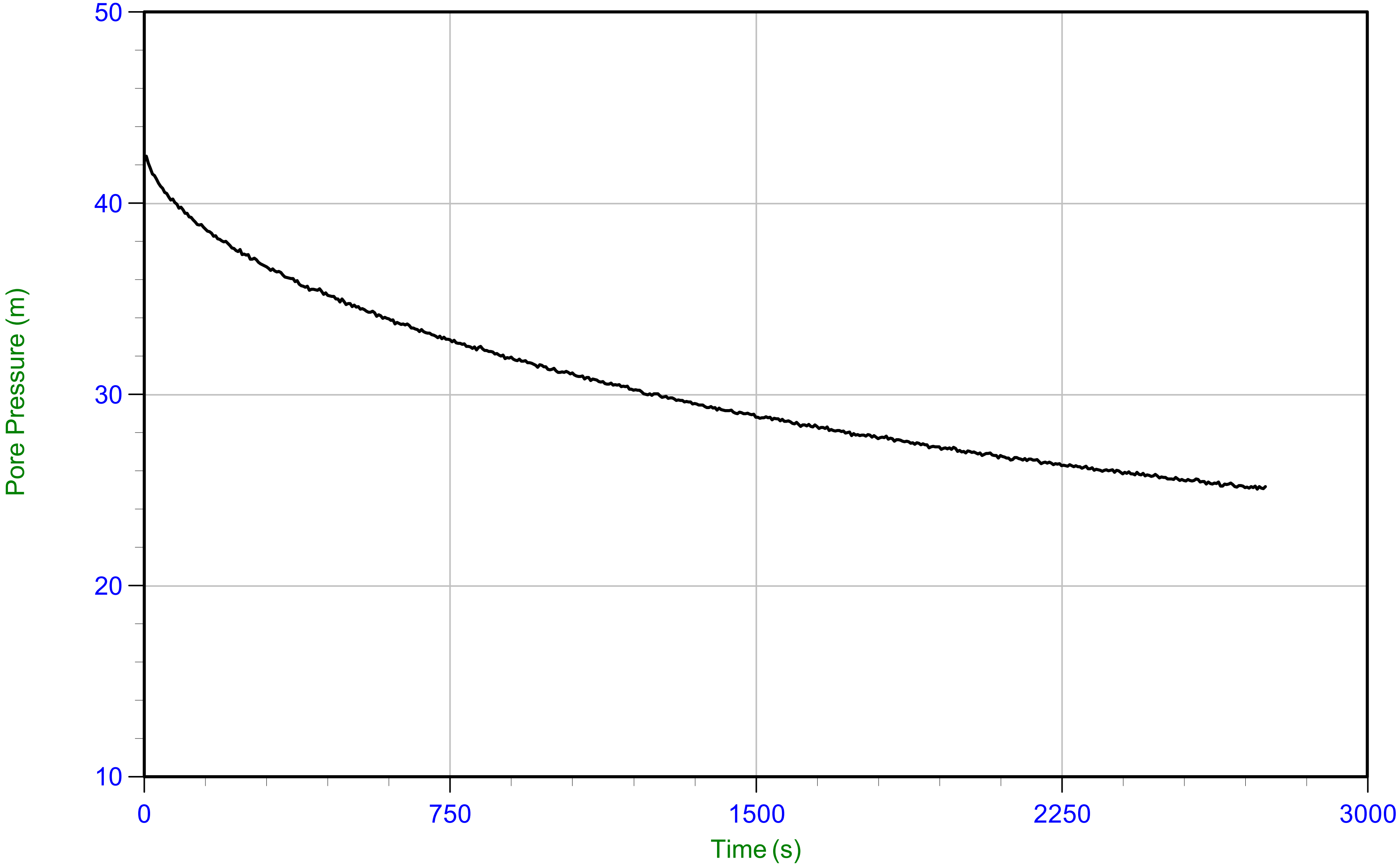


Trace Summary:

Filename: 17-05009_CP06.PPF
Depth: 18.450 m / 60.531 ft
Duration: 300.0 s

U Min: 18.2 m
U Max: 19.2 m

WT: 0.186 m / 0.610 ft
Ueq: 18.3 m



Trace Summary:

Filename: 17-05009_CP07.PPF
Depth: 15.000 m / 49.212 ft
Duration: 2750.0 s

U Min: 25.1 m
U Max: 42.5 m

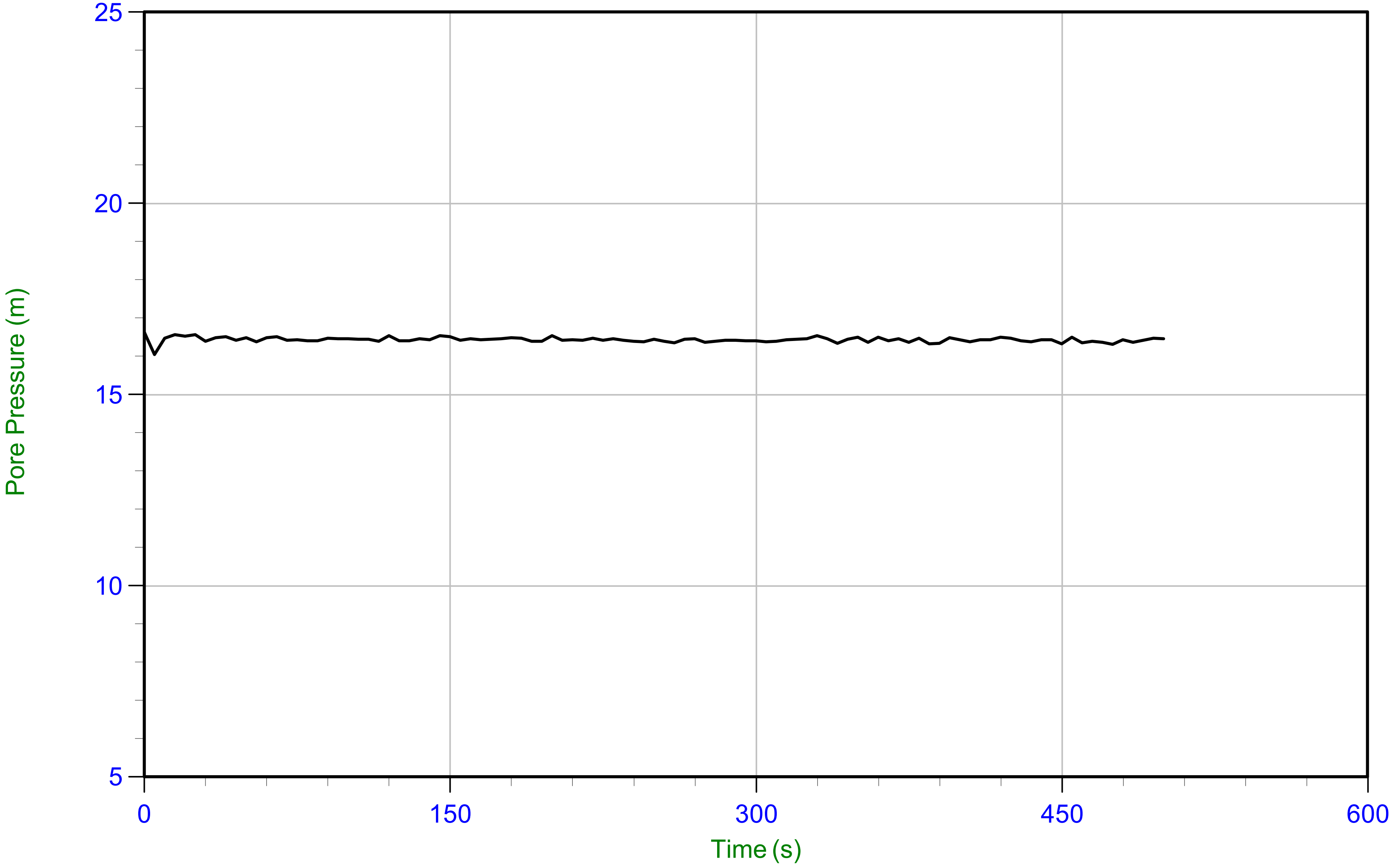
WT: 0.000 m / 0.000 ft
Ueq: 15.0 m
U(50): 28.74 m

T(50): 1532.8 s
Ir: 100
Ch: 0.5 sq cm/min

Thurber Engineering

Job No: 17-05009
Date: 03/28/2017 09:27
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP07.PPF
Depth: 16.250 m / 53.313 ft
Duration: 500.0 s

U Min: 16.0 m
U Max: 16.6 m

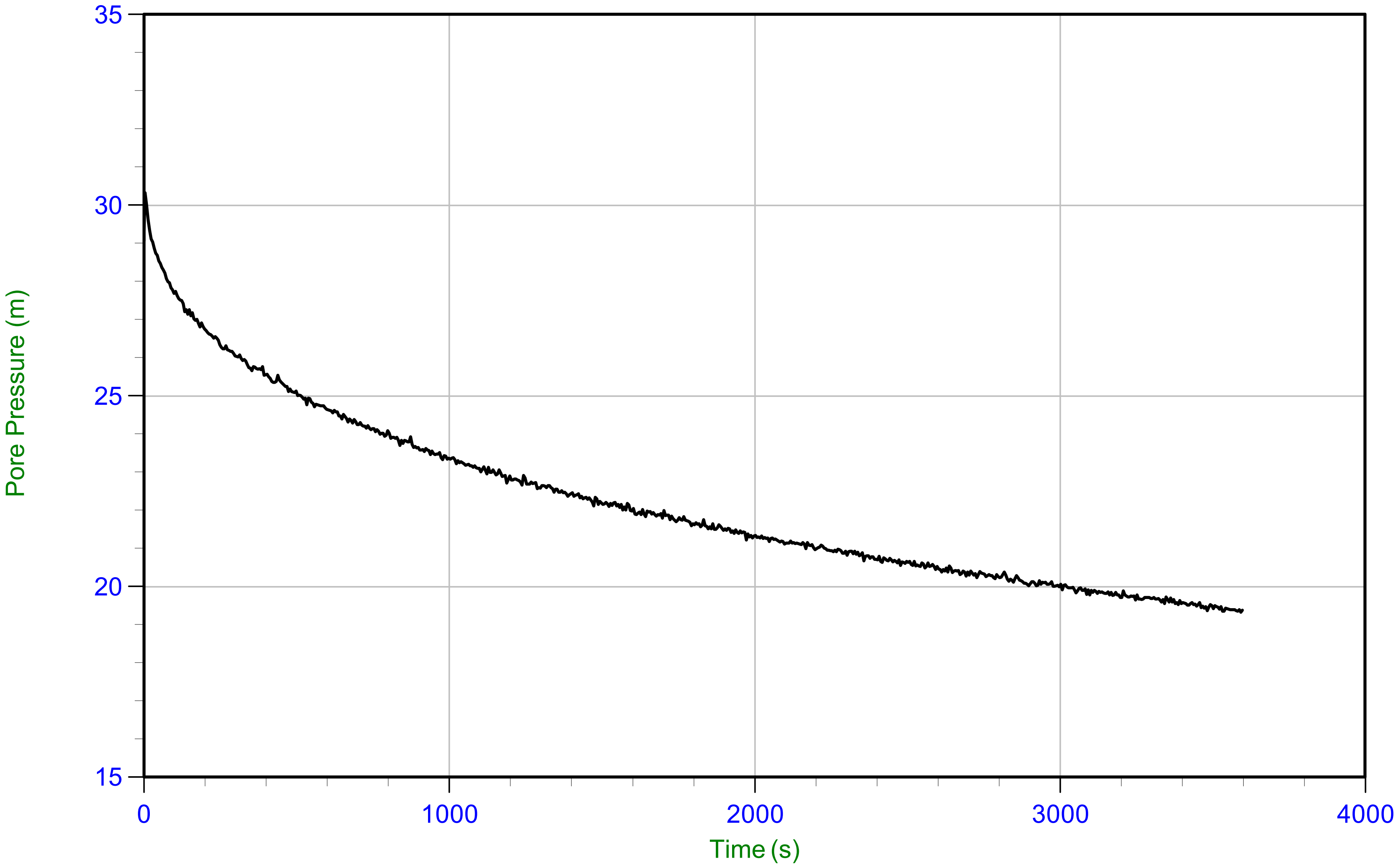
WT: 0.000 m / 0.000 ft
Ueq: 16.2 m

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/28/2017 12:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-07B
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP07B.PPF
Depth: 10.000 m / 32.808 ft
Duration: 3600.0 s

U Min: 19.3 m
U Max: 30.3 m

WT: 0.000 m / 0.000 ft
Ueq: 10.0 m
U(50): 20.16 m

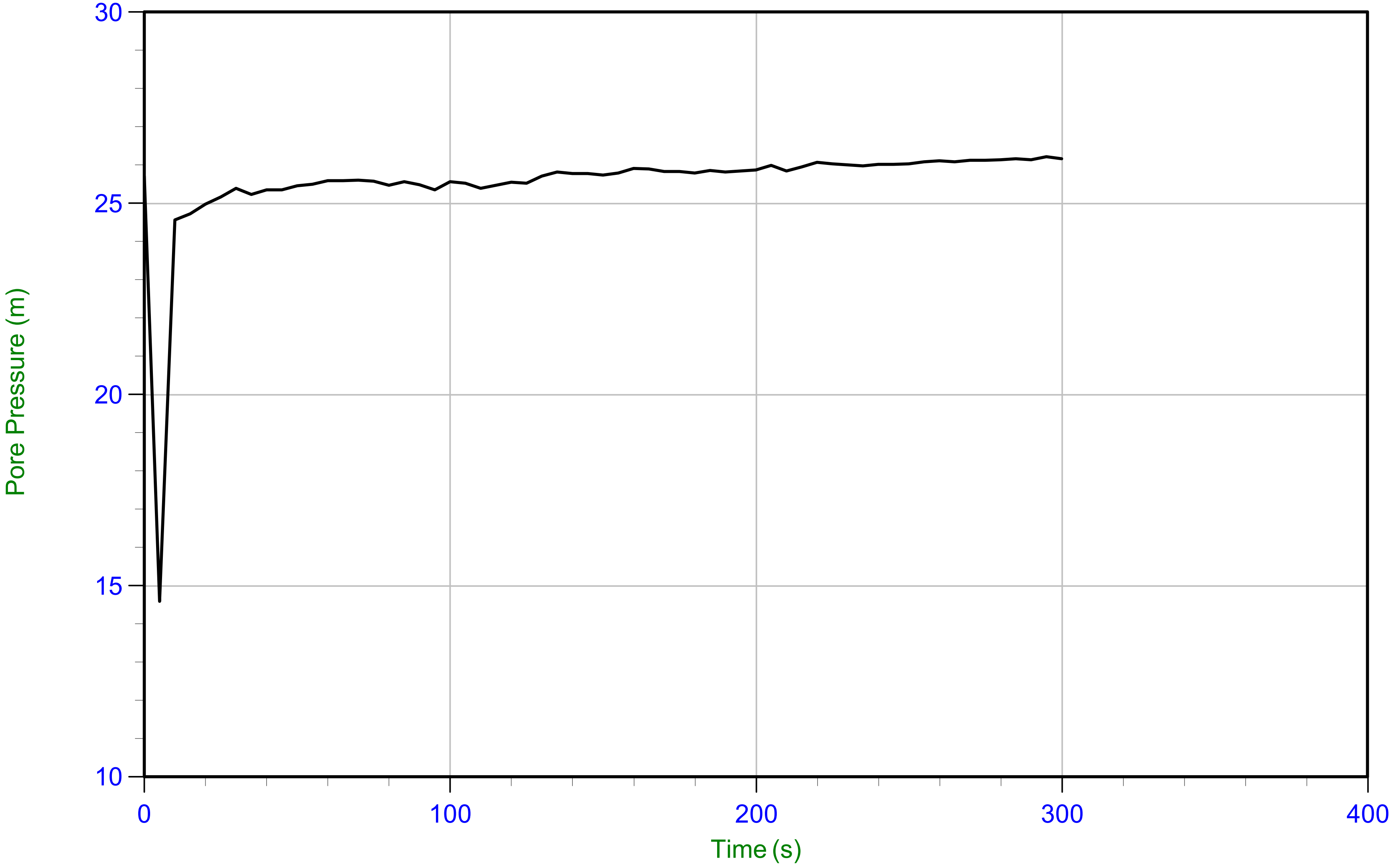
T(50): 2827.7 s
Ir: 100
Ch: 0.2 sq cm/min

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/27/2017 15:17
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-08
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP08.PPF
Depth: 25.800 m / 84.645 ft
Duration: 300.0 s

U Min: 14.6 m
U Max: 26.2 m

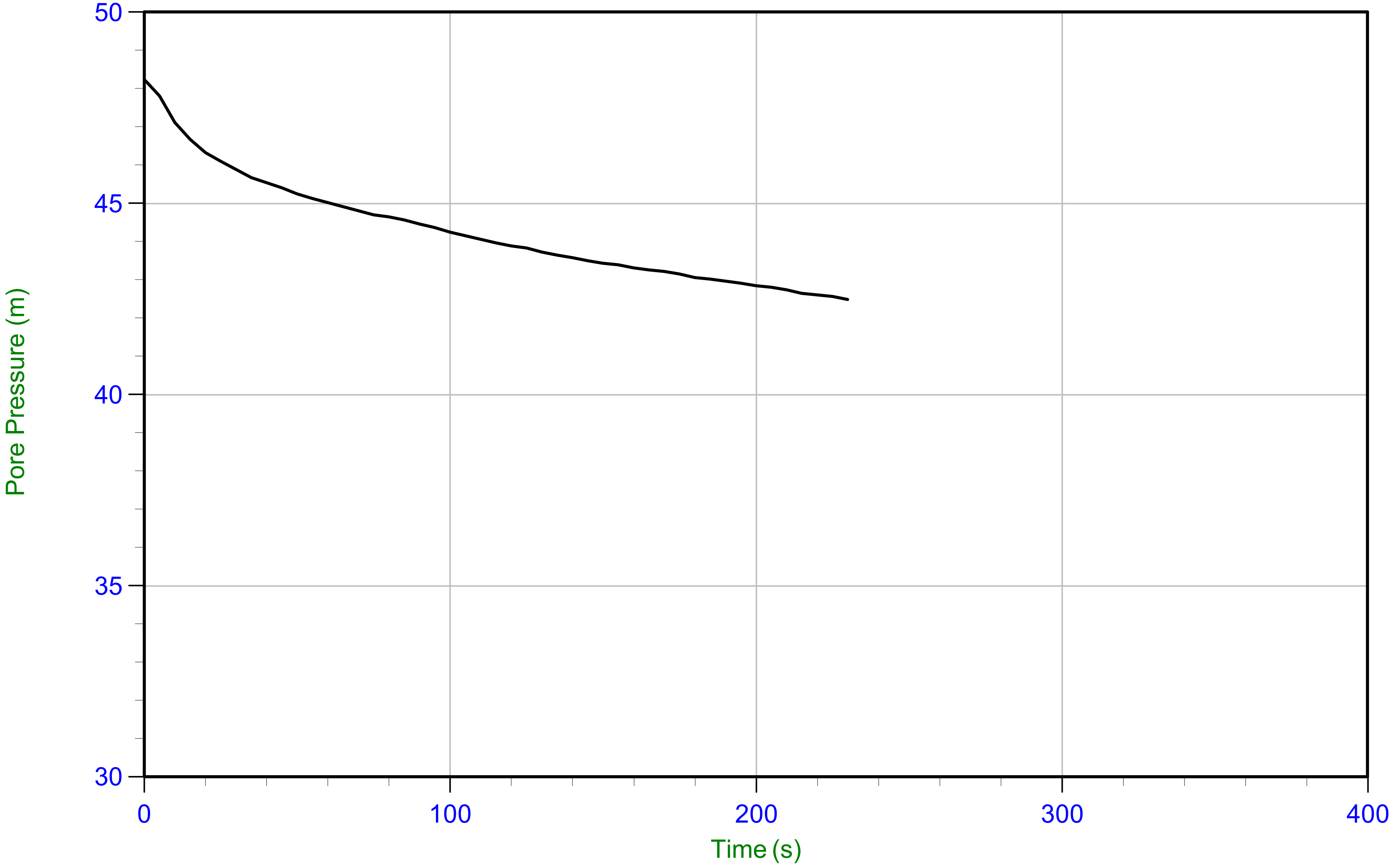
WT: 0.000 m / 0.000 ft
Ueq: 25.8 m

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/27/2017 11:00
Site: Highway 537 and Jumbo Creek

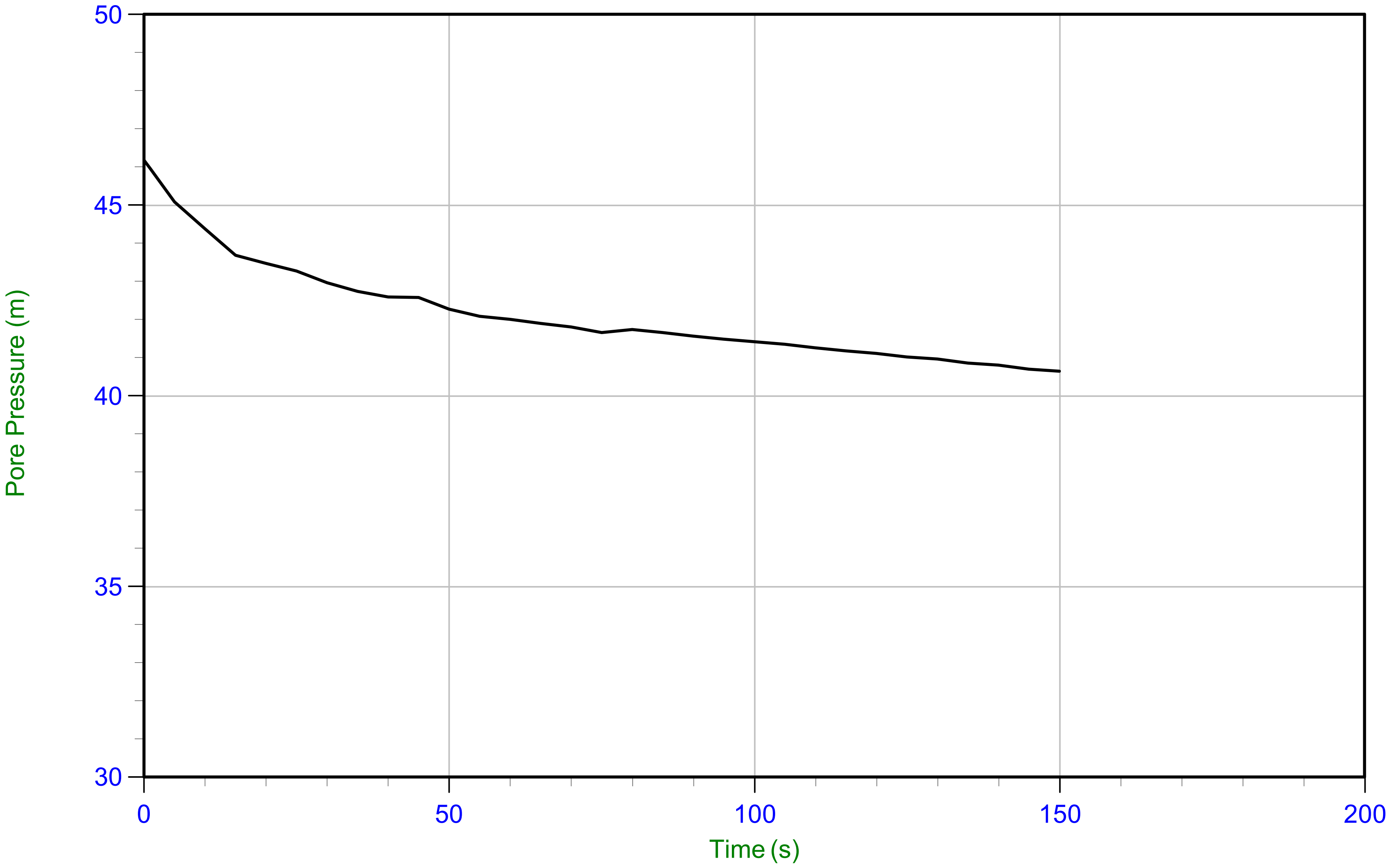
Sounding: CPT17-09
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP09.PPF
Depth: 15.150 m / 49.704 ft
Duration: 230.0 s

U Min: 42.5 m
U Max: 48.2 m



Trace Summary:

Filename: 17-05009_CP09.PPF
Depth: 15.900 m / 52.165 ft
Duration: 150.0 s

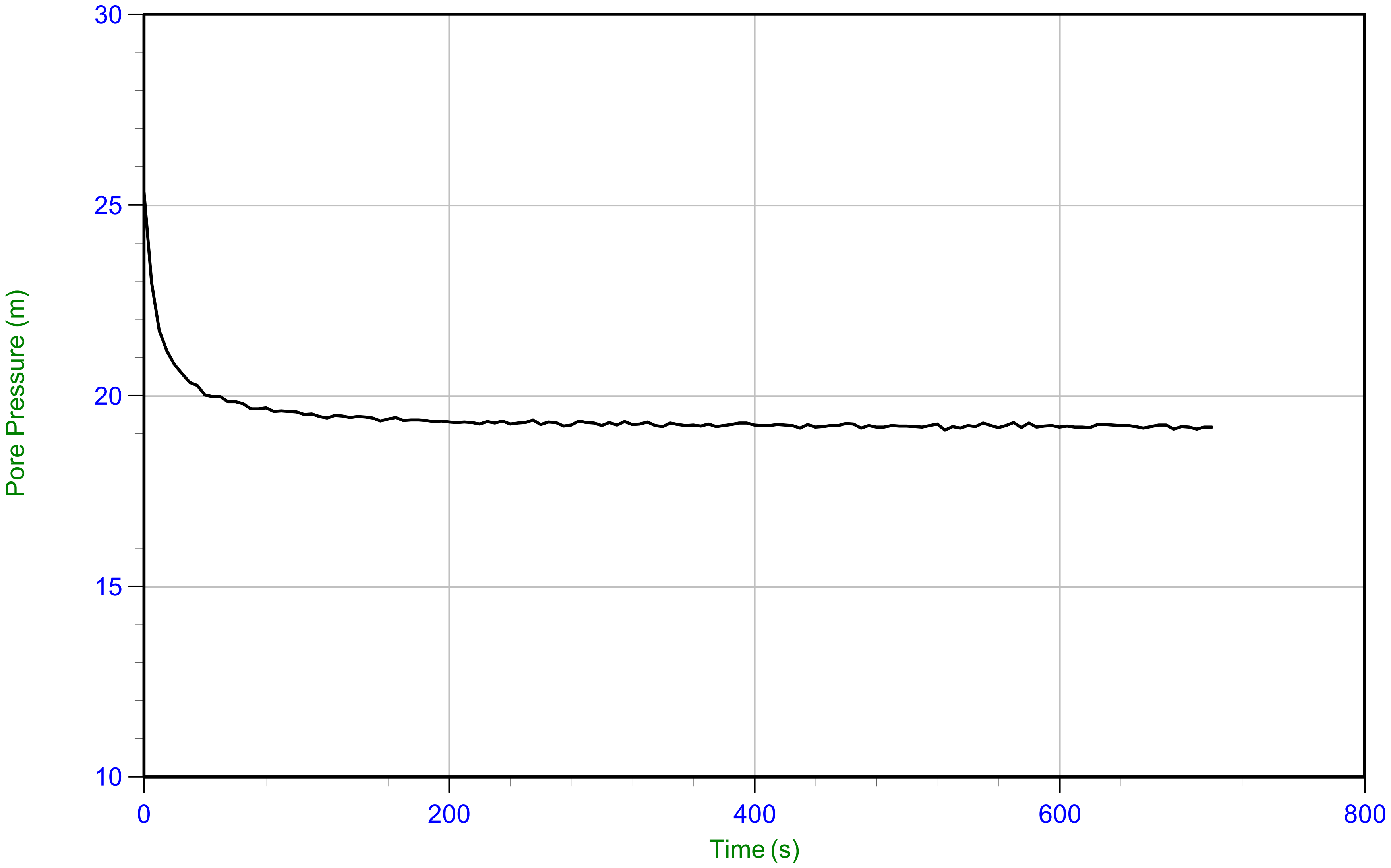
U Min: 40.6 m
U Max: 46.2 m

CONETEC

Thurber Engineering

Job No: 17-05009
Date: 03/27/2017 11:00
Site: Highway 537 and Jumbo Creek

Sounding: CPT17-09
Cone: 417:T375F10U200 Area=15 cm²



Trace Summary:

Filename: 17-05009_CP09.PPF
Depth: 19.150 m / 62.827 ft
Duration: 700.0 s

U Min: 19.1 m
U Max: 25.3 m

WT: 0.000 m / 0.000 ft
Ueq: 19.1 m

Electronic Field Vane Shear Test Profile Summary and Results

Job No: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Start Date: 07-Mar-2017
End Date: 08-Mar-2017

ELECTRONIC FIELD VANE SHEAR TEST PROFILE SUMMARY

Sounding ID	File Name	Adjacent Test Sounding ID	Date from	Date to	Northing[1] (m)	Easting (m)	Refer to Notation Number
VST17-14	17-05009_VST14	CPT17-04B	07-Mar-2017	08-Mar-2017	5141732	518146	2

1. Coordinates were collected with a consumer grade GPS device in datum WGS84/UTM Zone 17 North.
2. The nearest CPT sounding is located 22 m away.

CONETEC

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Start Date: 07-Mar-2017
End Date: 08-Mar-2017

ELECTRONIC FIELD VANE SHEAR TEST RESULTS

Sounding ID	File Name	Date	Load Cell Serial Number	Casing Depth (m)	Test Depth[1] (m)	Vane Diameter D (mm)	Vane Height H (mm)	Top Taper Angle i_T (deg)	Bottom Taper Angle i_B (deg)	Vane Factor (Nm to kPa)	Peak Torque (Nm)	Remolded Torque (Nm)	Peak Stress (kPa)	Remolded Stress (kPa)	Peak Frictional Stress (kPa)	Remolded Frictional Stress (kPa)	Su Peak (kPa)	Su Remolded (kPa)	Sensitivity	Refer to Notation Number
VST17-14	17-02009_VST14	07-Mar-2017	AVLC019	4.42	5.00	50	100	45	45	2.0608	45.04	13.59	92.8	28.0	15.9	11.5	76.9	16.6	4.6	
VST17-14	17-02009_VST14	07-Mar-2017	AVLC019	6.70	9.15	75	150	45	45	0.6106	37.18	7.65	22.7	4.7	1.5	1.5	21.2	3.2	6.7	
VST17-14	17-02009_VST14	07-Mar-2017	AVLC019	10.67	12.19	75	150	45	45	0.6106	43.66	10.97	26.7	6.7	2.9	3.6	23.8	3.1	7.7	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	13.72	15.24	75	150	45	45	0.6106	51.85	6.30	31.7	3.8	1.4	2.2	30.3	1.6	18.7	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	13.72	15.74	75	150	45	45	0.6106	57.13	8.09	34.9	4.9	2.9	2.5	32.0	2.5	12.9	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	16.76	18.28	75	150	45	45	0.6106	56.41	10.90	34.4	6.7	2.3	1.5	32.1	5.1	6.3	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	19.81	21.34	75	150	45	45	0.6106	58.70	10.48	35.8	6.4	2.2	2.3	33.7	4.1	8.2	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	19.81	22.86	75	150	45	45	0.6106	52.89	7.65	32.3	4.7	4.8	2.5	27.5	2.1	12.9	
VST17-14	17-02009_VST14	08-Mar-2017	AVLC019	19.81	24.38	75	150	45	45	0.6106	56.68	10.43	34.6	6.4	4.8	2.4	29.9	4.0	7.4	

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Start Date: 07-Mar-2017
End Date: 08-Mar-2017

ELECTRONIC FIELD VANE SHEAR TEST TIMING

Sounding ID	Date	Test Depth (m)	Vane Insertion Time (HH:mm)	Peak Test Start Time (HH:mm)	Insertion to Start Interval (min)	Start to Failure Interval (sec)	Peak Test Avg Rate (deg/sec)	Remolding Completion Time (HH:mm)	Remold Test Start Time (HH:mm)	Remolding to Start Interval (min)	Remold Test Avg Rate (deg/sec)
VST17-14	07-Mar-2017	5.00	11:58	11:59	1	587	0.11	12:15	12:17	2	0.12
VST17-14	07-Mar-2017	9.15	15:10	15:10	0	262	0.11	15:33	15:35	2	0.11
VST17-14	07-Mar-2017	12.19	16:16	16:16	0	284	0.11	16:25	16:27	2	0.11
VST17-14	08-Mar-2017	15.24	09:32	09:33	1	33	0.11	09:38	09:41	3	0.11
VST17-14	08-Mar-2017	15.74	09:47	09:47	0	311	0.11	10:06	10:08	2	0.11
VST17-14	08-Mar-2017	18.28	10:48	10:48	0	326	0.11	11:06	11:08	2	0.11
VST17-14	08-Mar-2017	21.34	12:00	12:00	0	332	0.11	12:12	12:14	2	0.11
VST17-14	08-Mar-2017	22.86	12:28	12:28	0	348	0.11	12:42	12:44	2	0.11
VST17-14	08-Mar-2017	24.38	13:40	13:41	1	400	0.10	14:02	14:05	3	0.10

Electronic Field Vane Shear Test Plots

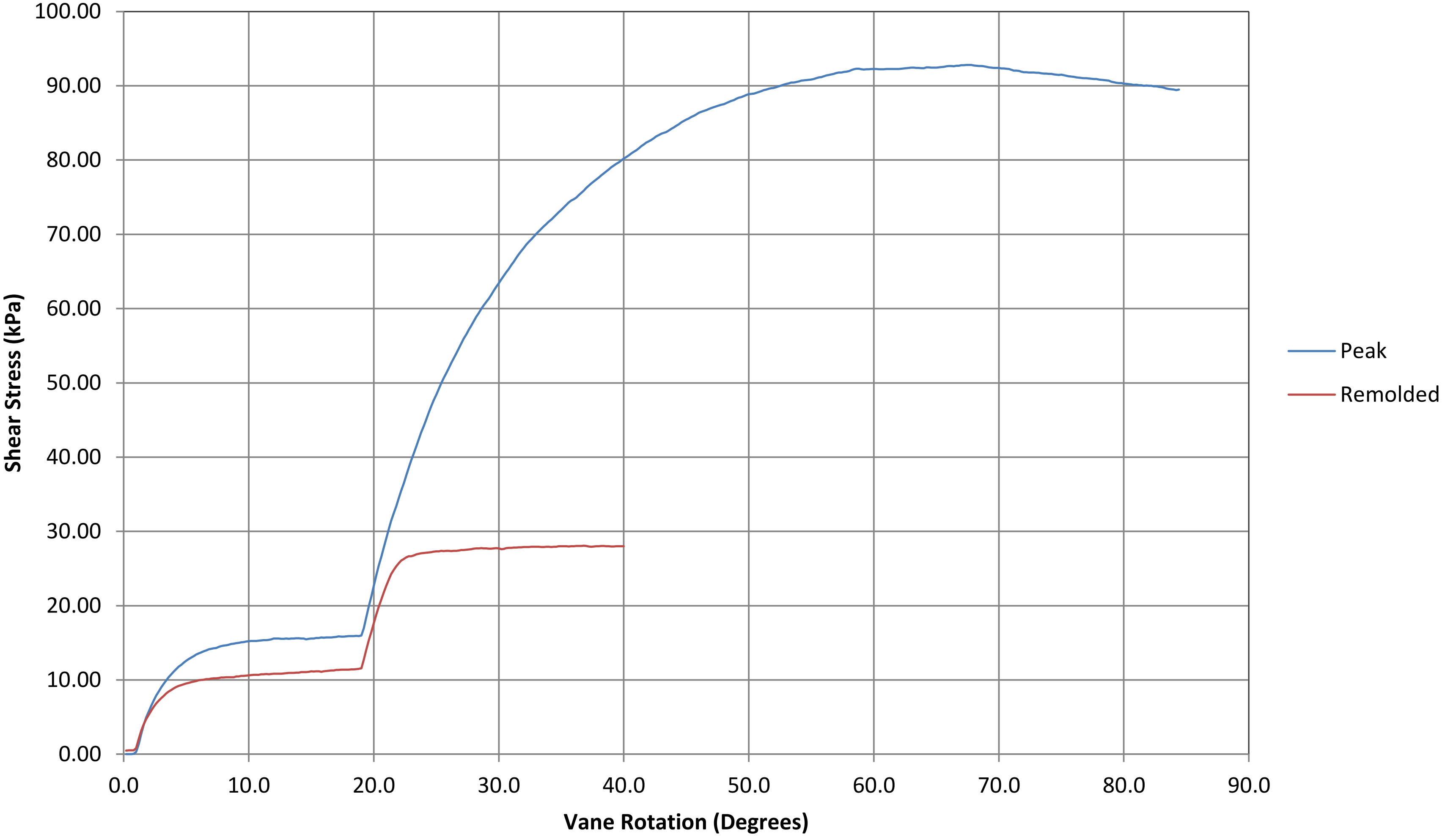
ConeTec

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 07-Mar-2017 11:59

Test Depth: (m): 5.00
Vane Type: Adara solid double tapered
50 x 100 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



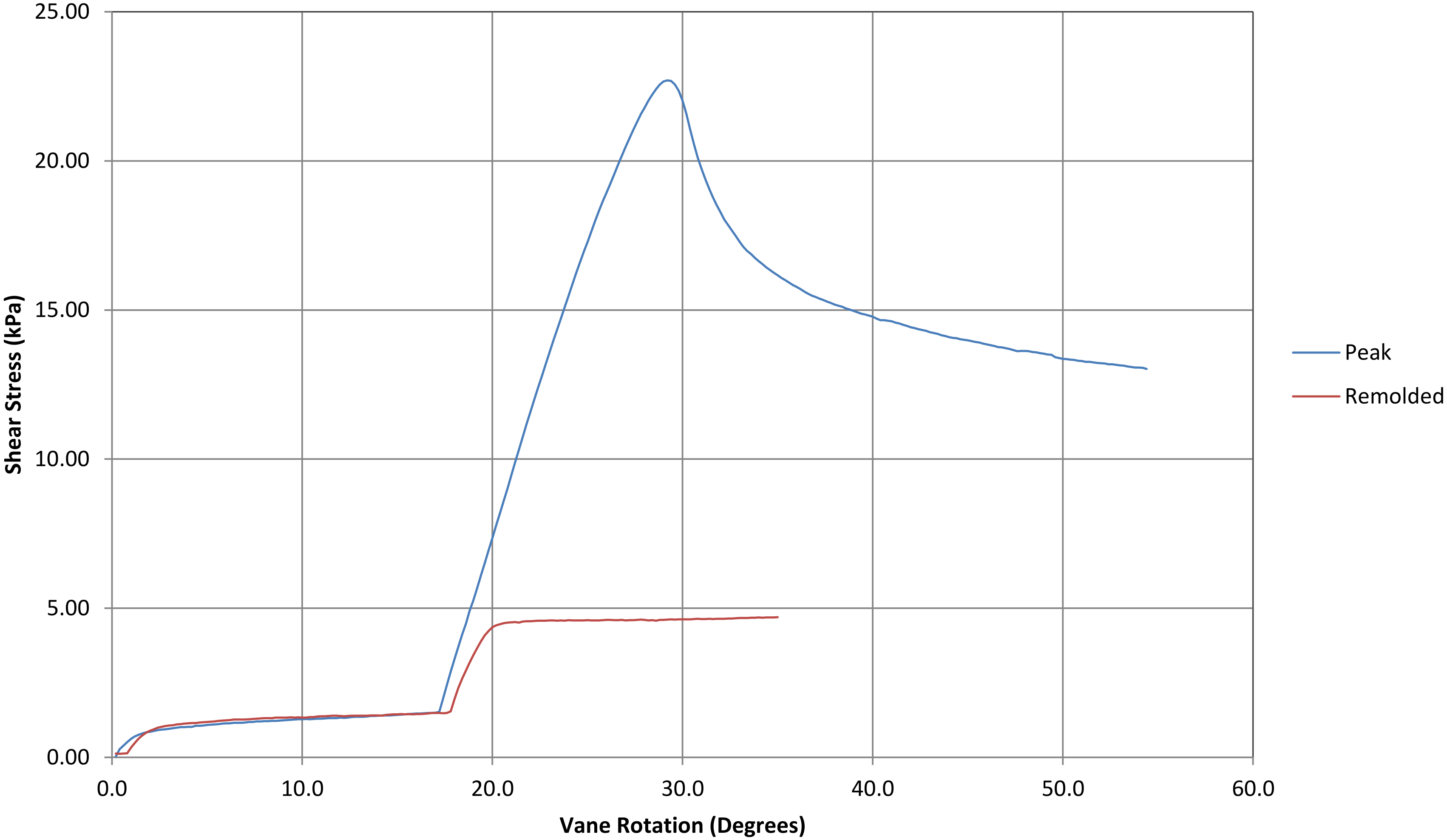
CONETEC

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 07-Mar-2017 15:10

Test Depth: (m): 9.15
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



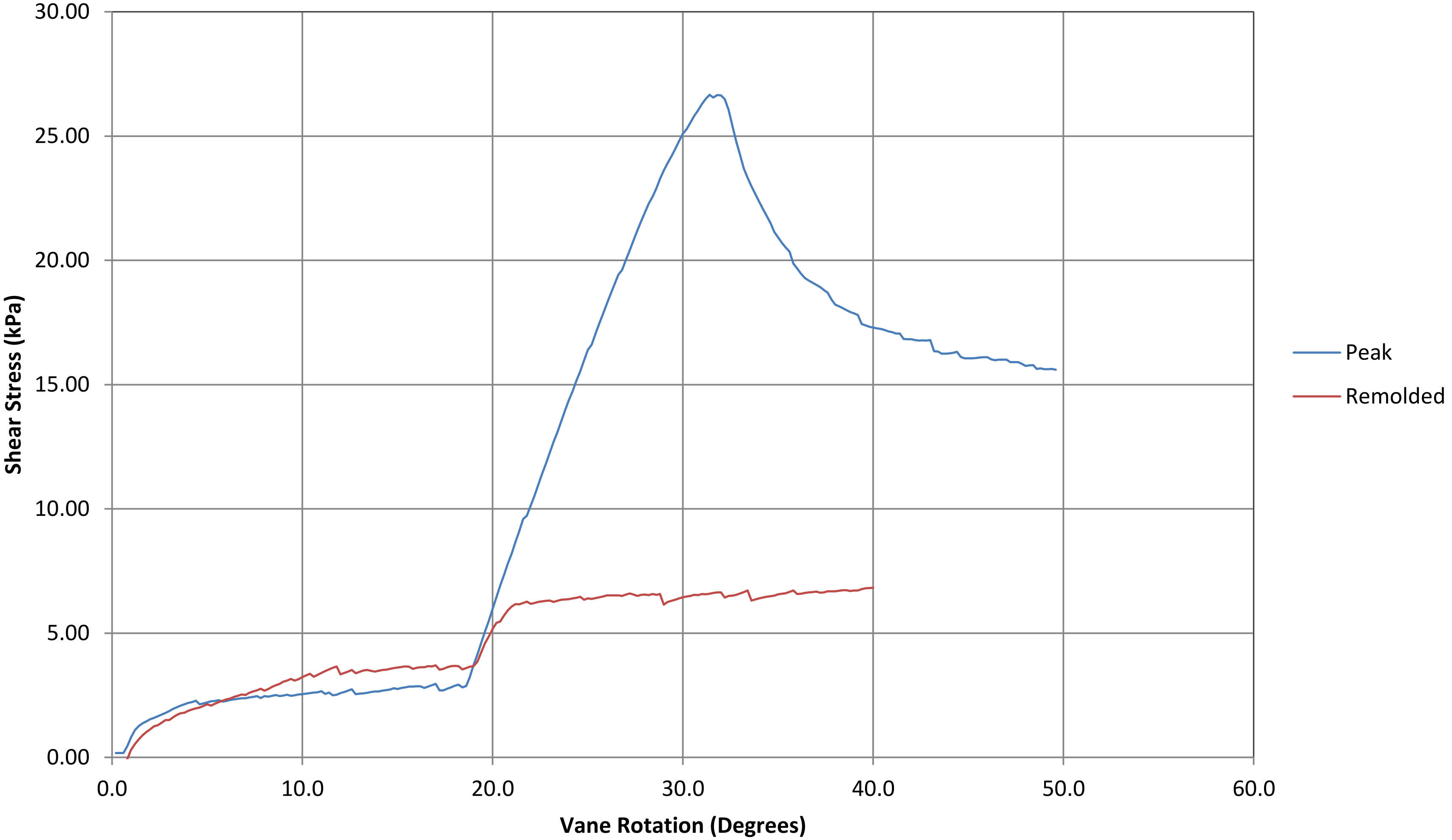
CONETEC

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 07-Mar-2017 16:16

Test Depth: (m): 12.19
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



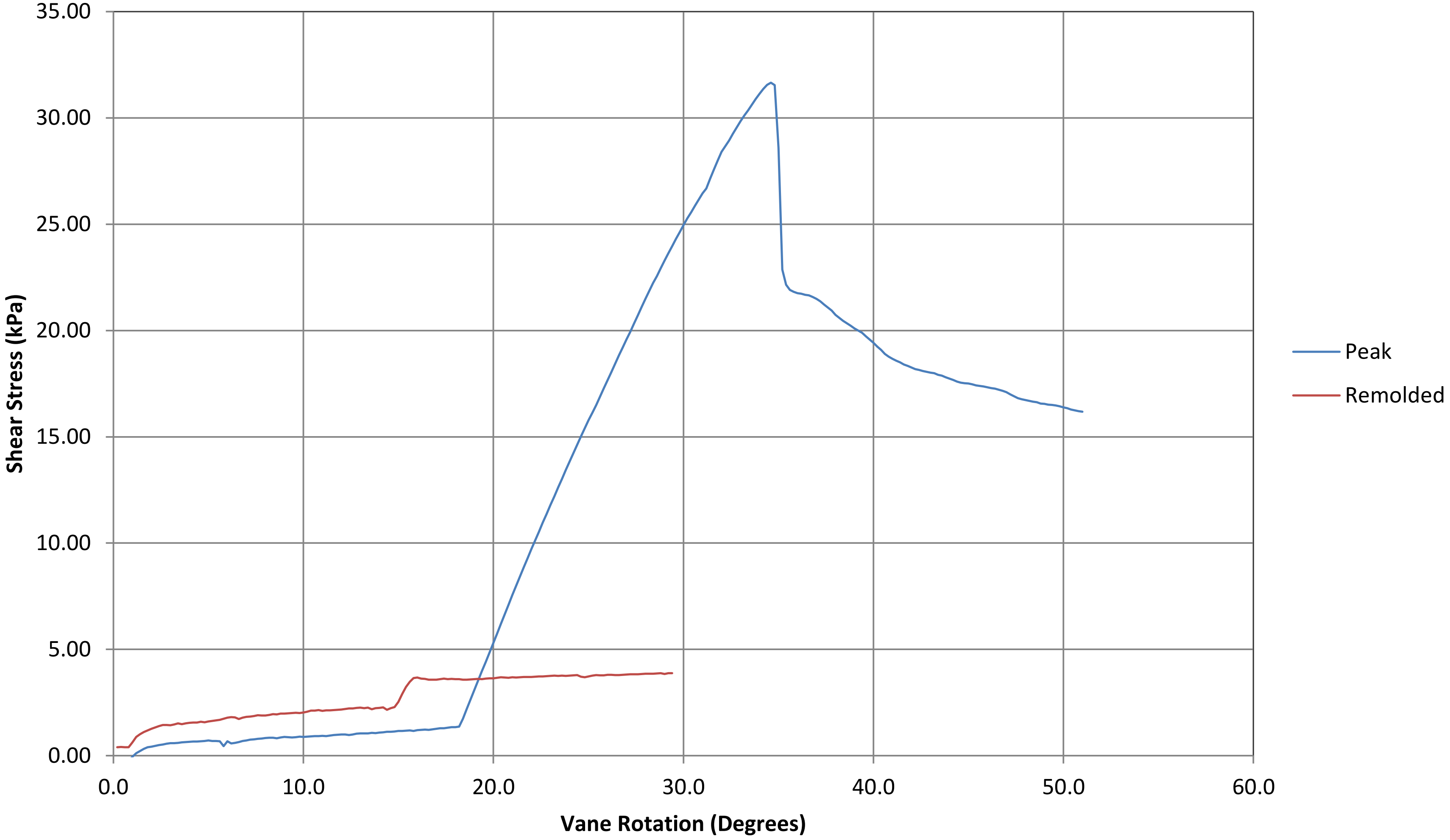
ConeTec

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 09:33

Test Depth: (m): 15.24
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test

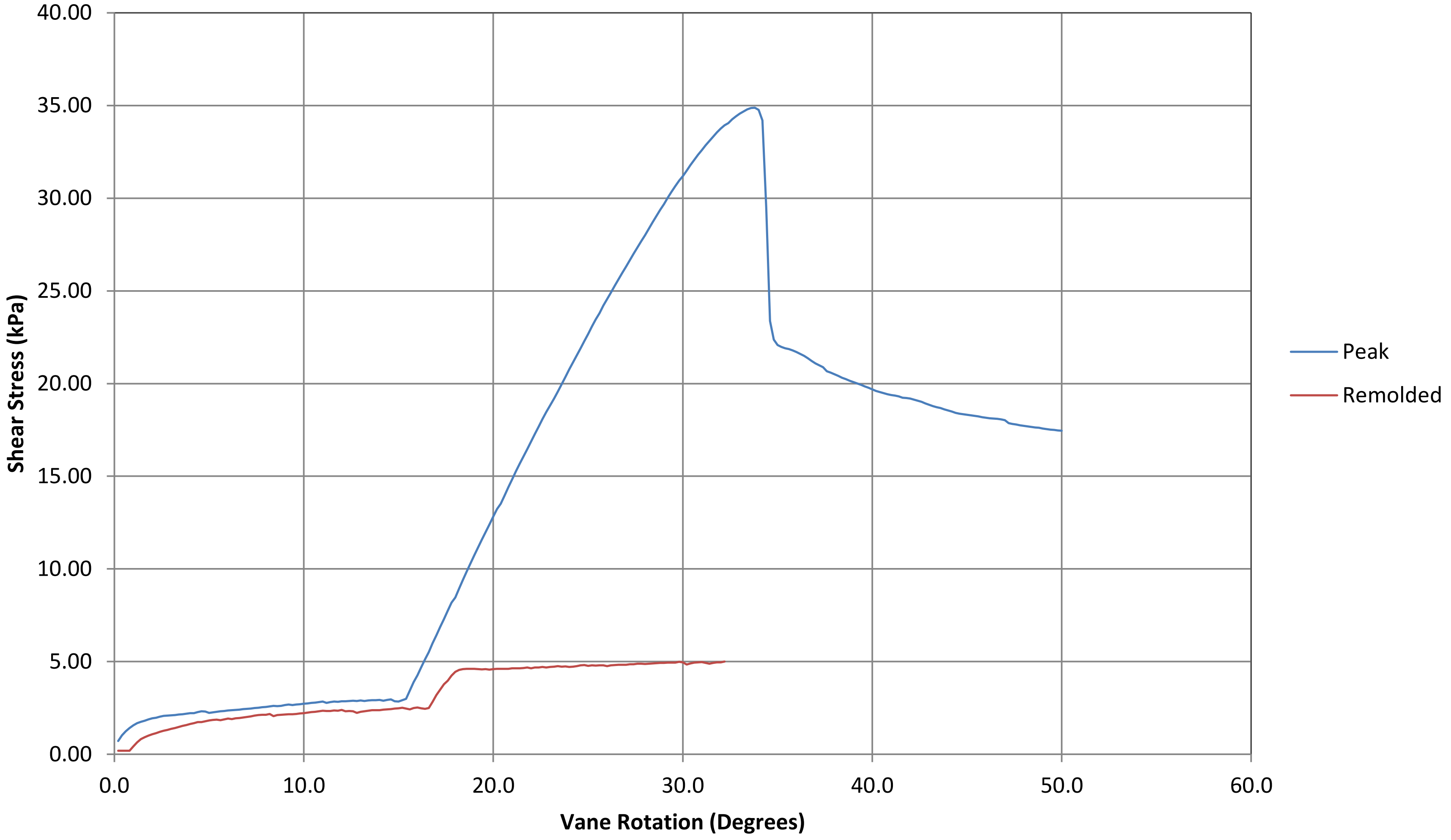


Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 09:47

Test Depth: (m): 15.74
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test

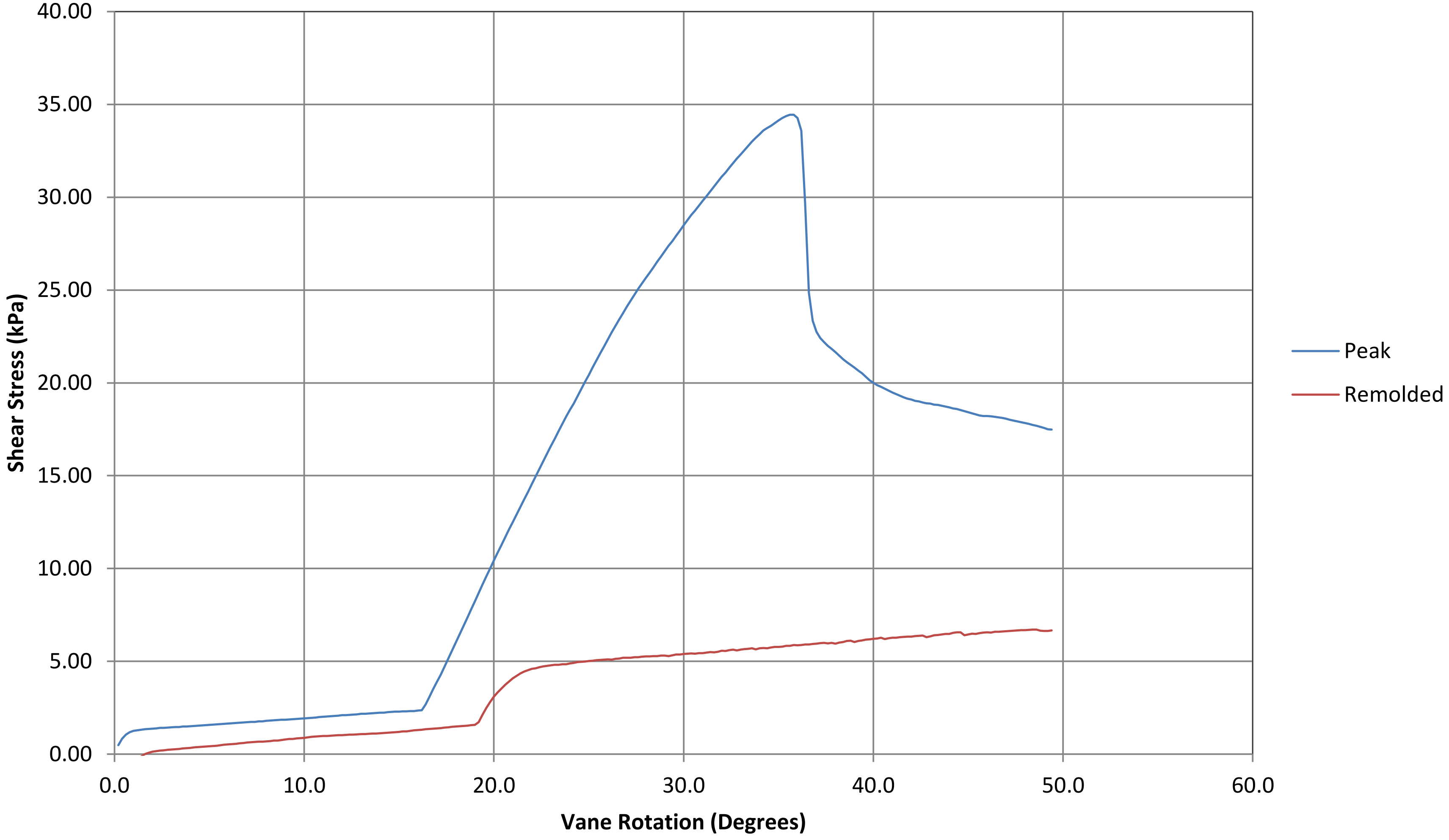


Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 10:48

Test Depth: (m): 18.28
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test

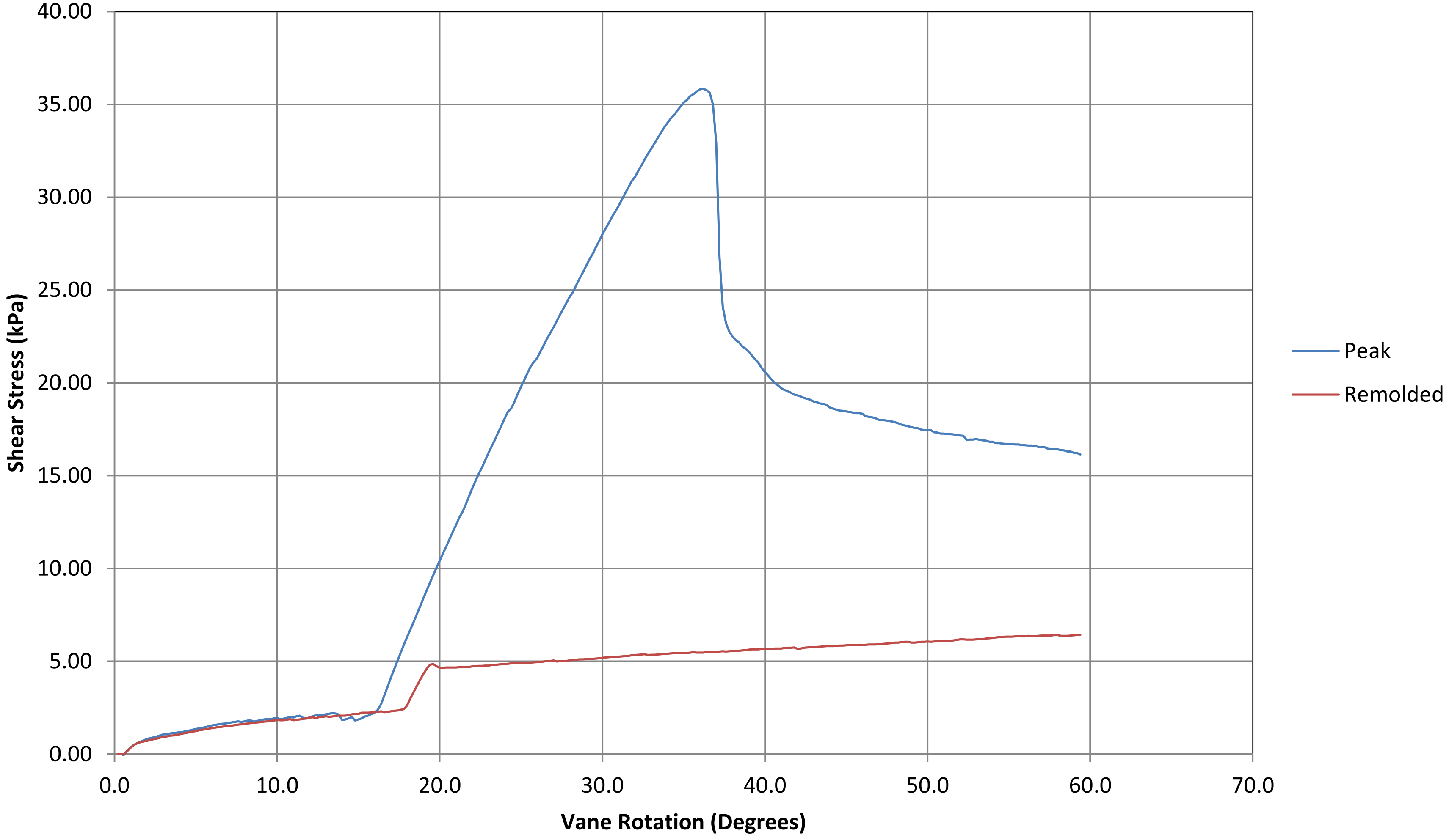


Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 12:00

Test Depth: (m): 21.34
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



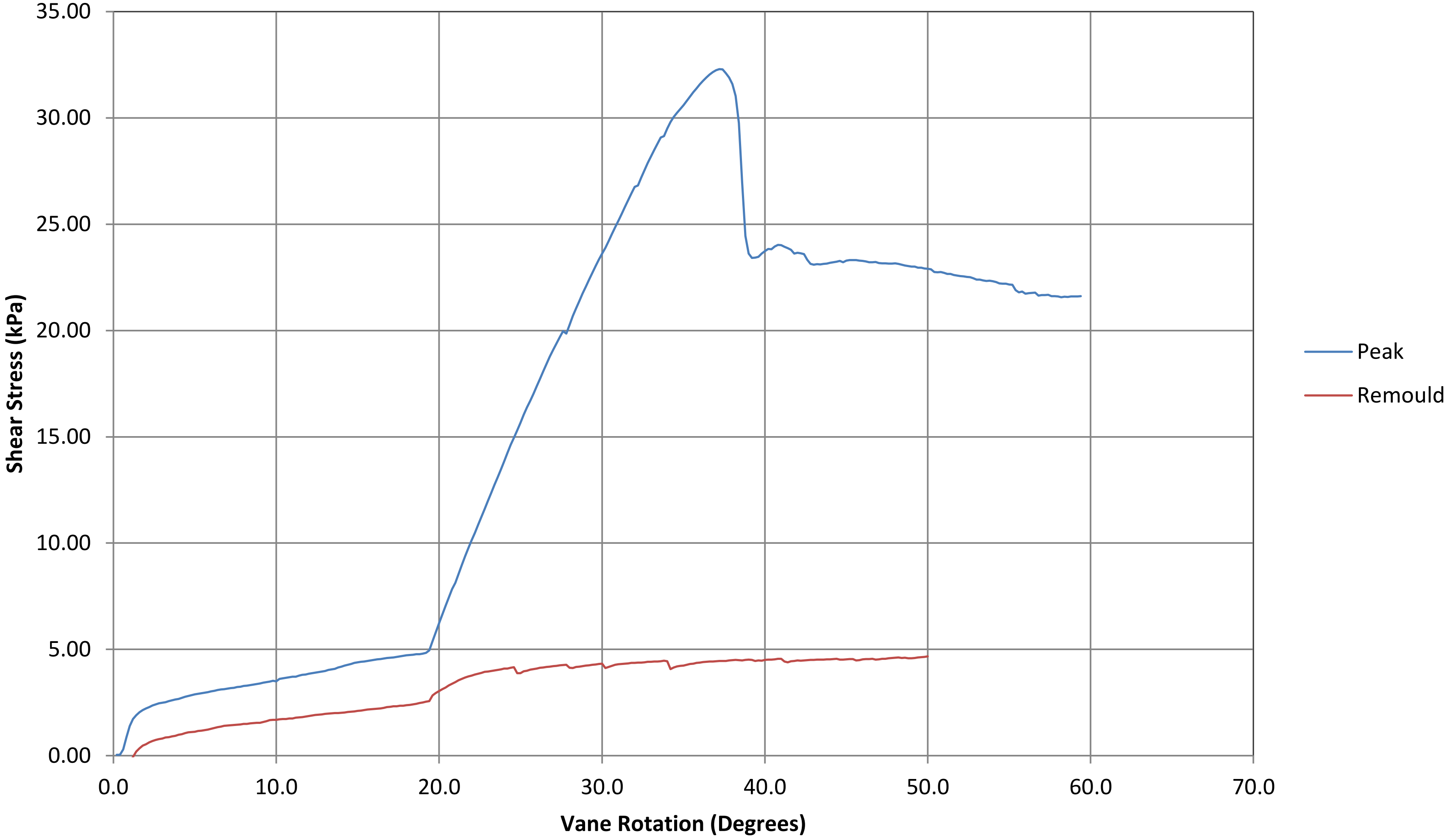
CONETEC

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 12:28

Test Depth: (m): 22.86
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



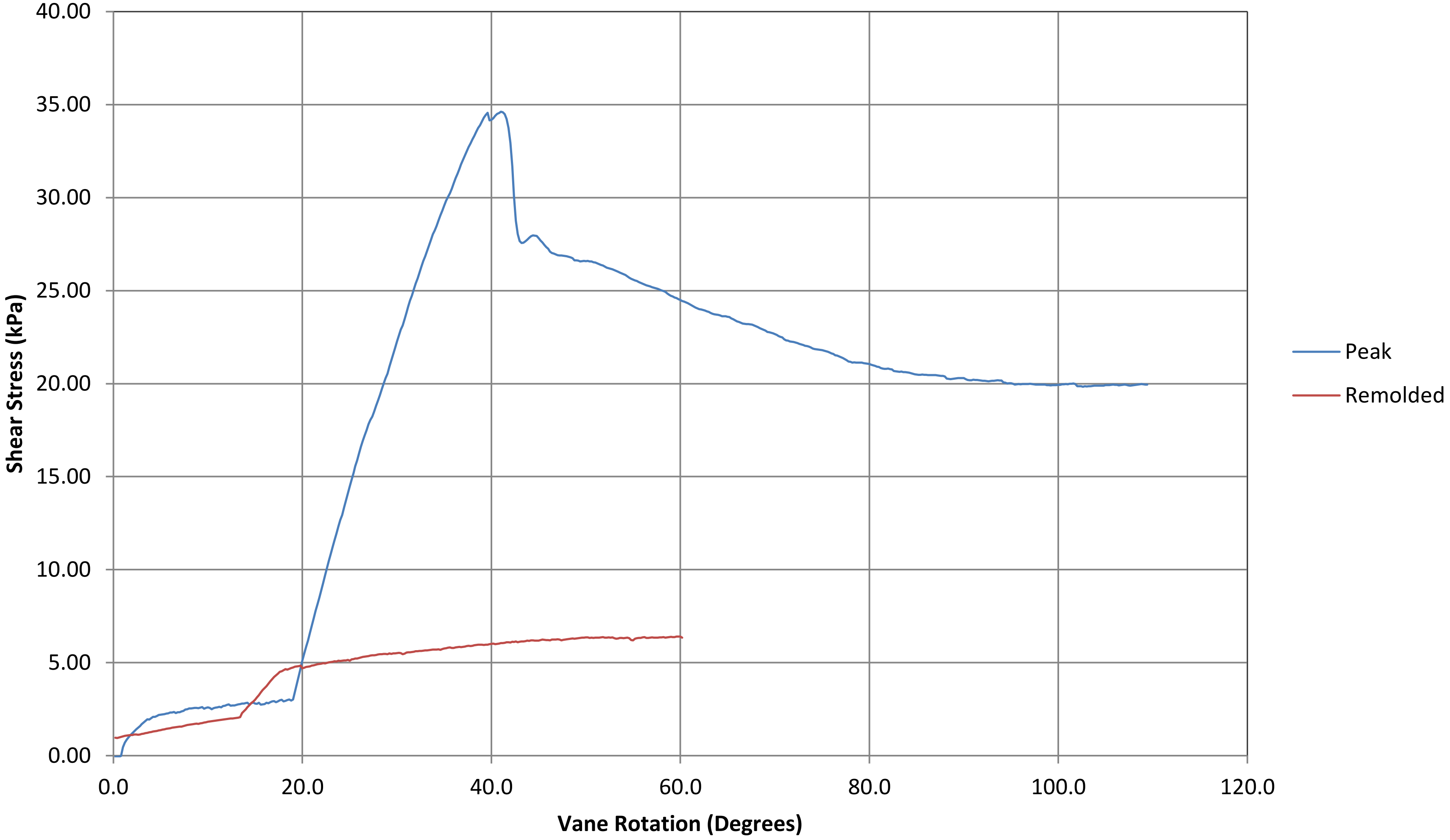
CONETEC

Job Number: 17-05009
Client: Thurber Engineering
Project: Highway 537 and Jumbo Creek
Sounding: VST17-14
Sounding Date: 08-Mar-2017 13:41

Test Depth: (m): 24.38
Vane Type: Adara solid double tapered
75 x 150 mm

Coordinate System: UTM North (WGS84)
Northing (m): 5141732.00
Easting: (m): 518146.00

Vane Shear Test



Appendix F.

Tables

Table F1 – Design Options

Option	Advantage	Disadvantage	Risk	Relative Cost
(1) Do nothing (*maintenance only*)	- lower construction costs - limited disruption to traffic	- requires continued maintenance resulting in recurring costs and efforts - ongoing highway embankment settlement - continued disruption to traffic during times of high water (risk of repeated flooding) - minimal improvement to highway performance - may require granular road surface - does not meet hydraulic design requirements	- unscheduled road closures during flooding events	Low
(2) New alignment	- limited disruption to traffic during construction - less restrictions on treatment options - allows for space for construction activities - allows for treatment of settlement without reducing performance of existing highway - allows for time dependant treatment options without reducing performance of existing highway	- larger embankment footprint and land requirements - larger impacts to wetlands and habitat - larger amount of materials required - requires re-alignment of highway geometry	- does not have the advantage of having existing foundation soil compression history	Moderate to High
(3) Permanent Detour	- eliminates concern with settlement - reduces impact to wetlands	- may require land purchase - may require upgrades along detour route	- unknown condition of detour - unknown impact to public	Moderate to High

Table F1 – Design Options

Option	Advantage	Disadvantage	Risk	Relative Cost
(4) Grade raise with widening to one side or symmetrically	- retains foundation soil compression history under existing highway embankment fill - provides a working platform - reduced interference with wetlands and habitat compared to 'new alignment' option - can be completed with a 'net zero' increase in foundation soil loading in most locations with use of EPS	- disruption to traffic with temporary road closures and single lane traffic - requires wider embankment footprint with some impact to wetlands and habitat - long term settlements throughout and beyond design life; will require periodic maintenance - cannot achieve MTO Settlement Criteria - may not achieve all drainage criteria - large settlements without removal of peats soils. Peat removal would require deep excavation adjacent to live traffic supported by TPS - buoyancy a concern at select locations if using light weight fill	- potential for failure of existing highway if poor construction practices - potential for extended waiting time for settlement to occur if longer than predicted	Moderate to high (dependant on treatment choice)
(5) Build a bridge crossing the wetlands	- eliminates potential for ongoing embankment settlement and required maintenance - allows for reduced long-term interference with wetlands and habitat - eliminates need for a culvert	- requires deep foundations through relatively low strength soils - requires long spans to reduce number of foundations - large costs for amount of vehicular traffic - requires detour or full road closure during construction - potential for de-icing salts to be introduced into wetlands - requires bridge maintenance	- potential for increased construction costs/ overruns	High

Table F2 – Embankment Options

Options	Advantage	Disadvantage	Risk	Relative Cost
Light weight fill (*LWF*)	*<u>expanded polystyrene (EPS)</u>* - lowest increase in foundation loading undergoing a grade raise - potential for 'net zero' increase in foundation loading in select locations	*<u>expanded polystyrene (EPS)</u>* - expensive material compared to granular fill - requires soil cover to counter buoyancy - requires design for thermal qualities - requires subexcavation of existing material before placement - reduces the ability to be combined with other options listed in this table - rigid element that will not 'flow' with adjacent soil	- buoyancy under water levels higher than design levels	High
	<u>slag, shale, tire derived aggr., etc</u> - lower increase in foundation loading compared to granular fill	*<u>slag, shale, tire derived aggr., etc</u>* - environmental concerns from fill material leachate - limited reduction in foundation loading compared to granular fill - buoyancy concern	- may contaminate wetlands	Moderate to High
Granular fill	- readily available and Contractor has knowledge with material handling - allows for ease of future maintenance and grade raises	- greater weight then LWF options (such as EPS), resulting in greater settlements - ongoing long-term settlements - will disperse into adjacent peat soils, thus increase quantities (difficult to predict) - significant overbuild required to maintain pavement elevation	- may have larger quantifies than estimated	Moderate

Table F2 – Embankment Options

Options	**Advantage**	**Disadvantage**	**Risk**	**Relative Cost**
Peat excavation (*adjacent to existing highway embankment*)	- removes soil layer with largest settlement - reduces long-term (post construction) settlement	- large excavation adjacent to live highway traffic may require TPS - peat remains under existing highway alignment, could result in differential settlements - difficult to determine extend of peat excavation and adjacent soil interface - large spoil quantities to dispose - larger loading stresses on underlying clay with replacement soil heavier then peat	- may excavate larger quantifies than estimated - potential to not remove all peat, thus increasing the potential for on-going settlements	Moderate to High
Prefabricated vertical drains (*PVD*)	- allows for expedited settlement wait times - not necessary to remove soils as part of installation of drains	- does not reduce magnitude of settlement - required specialized construction equipment - requires construction of working platform and installation of drainage layer - connects lower water sources to surface - disruption to traffic - may require pre-augering if installed through highway embankment	- lengths longer than estimated - potential for reduced flow capacity, thus increasing dissipation time - connecting water sources	Moderate to High

Table F2 – Embankment Options

Options	Advantage	Disadvantage	Risk	Relative Cost
Vacuum Consolidation	- reduces consolidation time - rate of consolidation can be estimated based on measured withdraw rates	- still requires installation of PVD's - difficult to create seal to reduce loss of vacuum pressure - difficult to seal off surface water sources (wetlands)	- may not decrease waiting time and may have higher than expected quantities due to surface water	High
Geopiers (*or similar*)	- reduces foundation settlement - could increase foundation bearing capacity in area of culvert	- not effective in deep foundation soil deposits - excess spoil material to dispose - disruption to traffic - requires specialized construction equipment	- Not as effective within deep deposits	High
Sheet pile enclosure	- allows for creating enclosed construction area - increases ability to reduce lateral extents of excavation limits - increases ability to dewater	- deep soil deposits will require long sheet piles - disruption to traffic during construction - large downdrag forces - low lateral capacities in foundation soils - foundation settlements will cause additional loading on bracing elements	- Downdrag forces	High

Table F2 – Embankment Options

Options	**Advantage**	**Disadvantage**	**Risk**	**Relative Cost**
Geotextiles/ Geogrids	- increases foundation strength - reduces differential settlement	- added construction step - poor construction techniques could cause damage - may require granular separation layer - does not reduce magnitude of settlement	- damaged material	Moderate
Retained soil slope (*RSS*)	- reduces (or eliminates) the requirement for embankment widening	- requires increased bearing capacity below RSS - requires subexcavation of existing soils - reduces the possibility to be used with light weight fill options	- bearing capacity failure	Moderate
Surcharge	- reduces long-term (post construction) settlements	- increases foundation settlement during surcharging period - increase possibility of embankment instability - disruption to traffic	- embankment failure	Moderate

Table F3 – Culvert Design Options

Culvert Type	***Pipe Culvert or Closed Box Culvert***	***Open Bottom Culvert***	***Precast Concrete Slab on Steel Sheet Piles***
Advantages	- Typically the least costly culvert type - Relatively expedient installation if precast units are used. - Smaller magnitude of settlement than open footing culvert due to lower bearing stress on subgrade.	- Relatively expedient installation if precast units are used. - Possibility to maintain work zone outside of existing waterway.	- Potentially minimizes volume of excavation and roadway protection - Maintains water flow throughout construction and minimizes potential for disturbance of streambed - Allows for winter construction
Disadvantages	- Requires large excavation and roadway protection. - Requires compacted granular pad on subgrade. - Requires waterflow realignment or installation of a temporary by-pass culvert to maintain existing waterflow alignment	- Requires deeper excavation increasing excavation volume and dewatering concern. - Founding subgrade will provide lower geotechnical resistances. - Potential for post construction settlement.	- Quantity and cost of sheet piles - Unconventional design - Differential settlement could occur between non-yielding culvert and approach fills
Risks/ Consequences	- Disruption to traffic	- Increased risk of basal instability of footing excavation due to depth of excavation below water table.	- Possibility of encountering obstruction and varying depth to suitable bearing stratum
Relative Cost	**Low to Medium**	**Medium to High**	**Medium to High**
Recommendation	**Recommended**	**Not Recommended**	**Not Recommended**

Appendix G.

Summary of Subsurface Conditions

Rehabilitation of Highway 537

GWP 5134-14-00

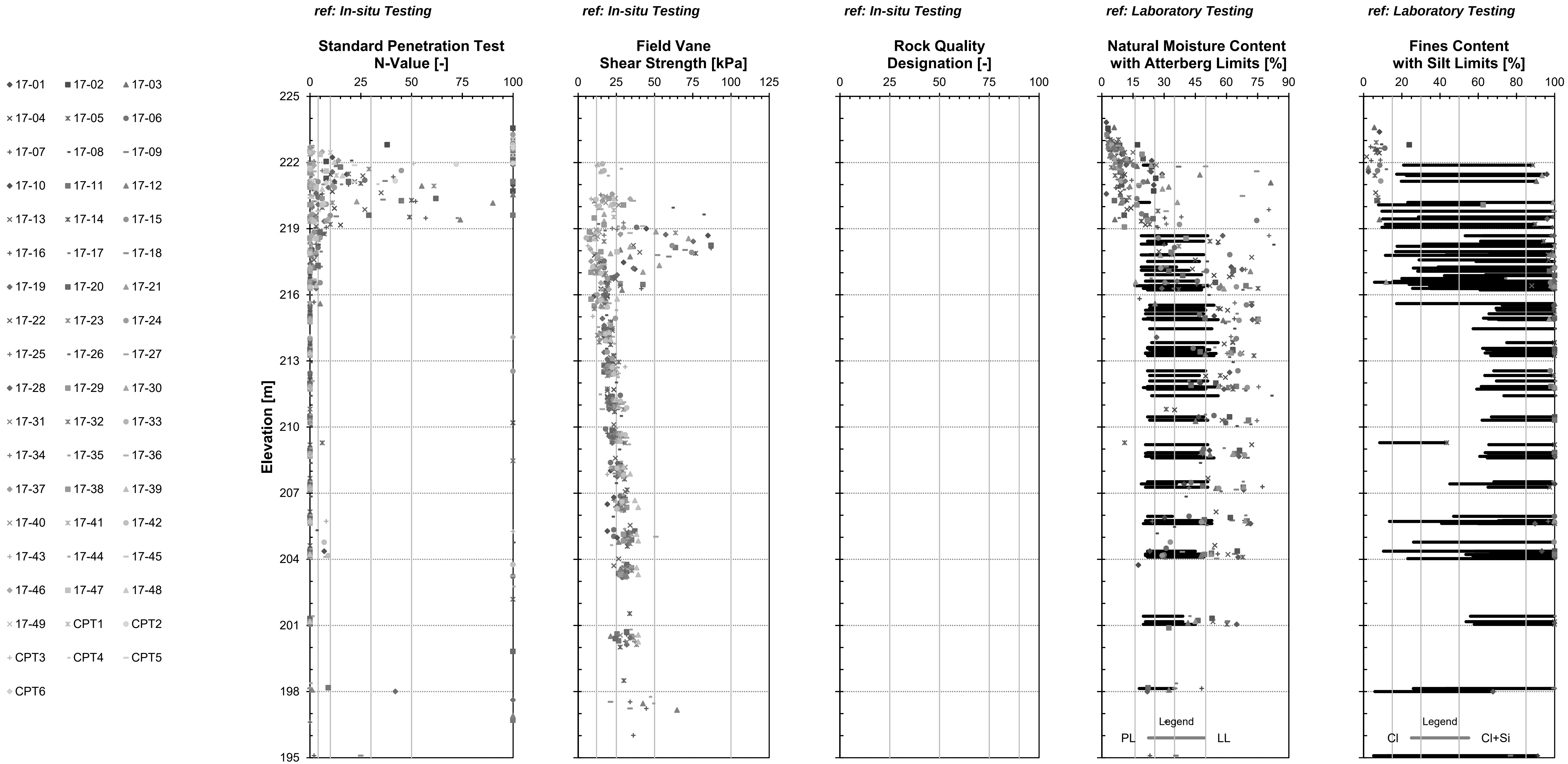


Figure G1

Rehabilitation of Highway 537

GWP 5134-14-00

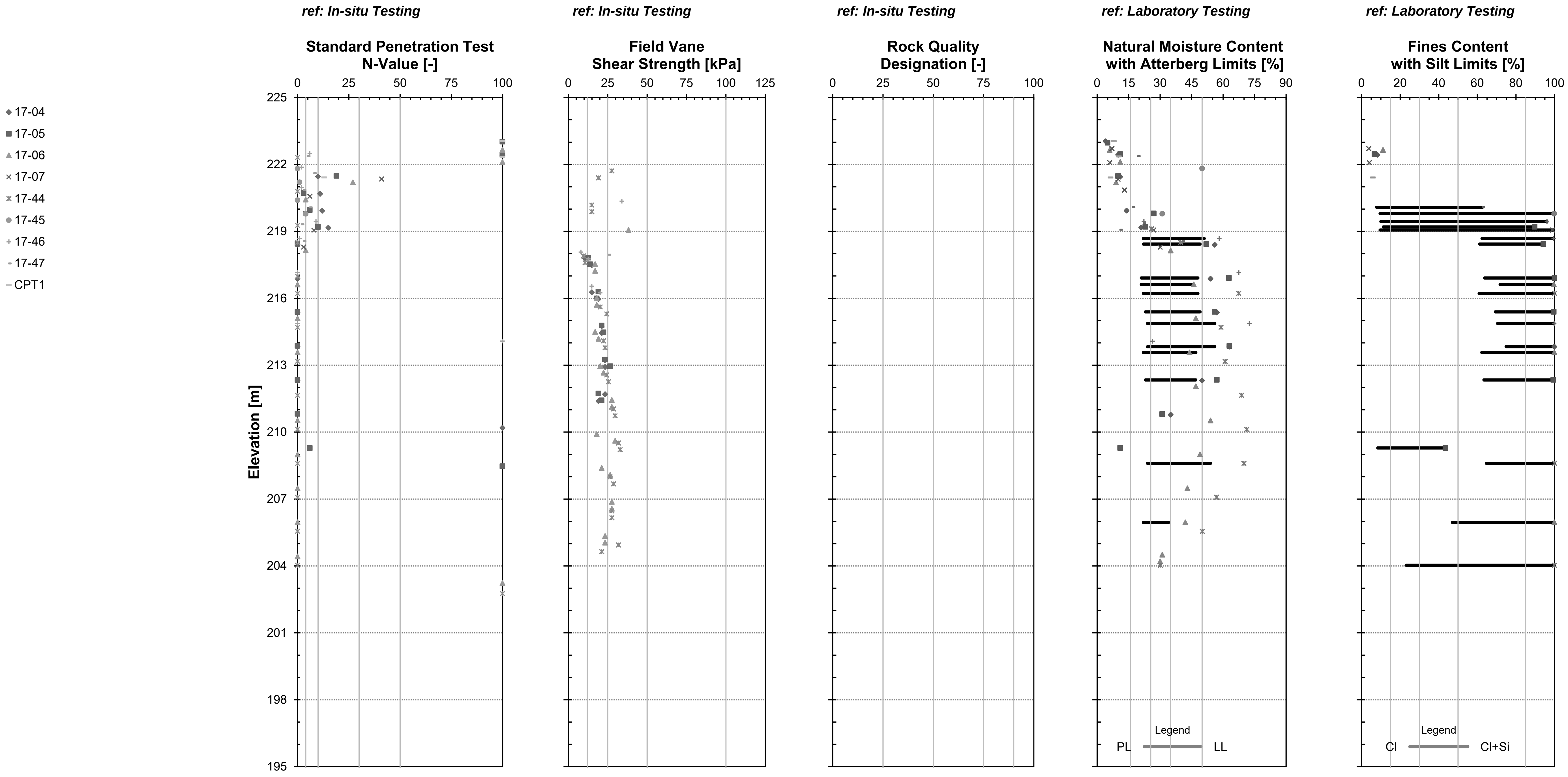


Figure G2

Rehabilitation of Highway 537

GWP 5134-14-00

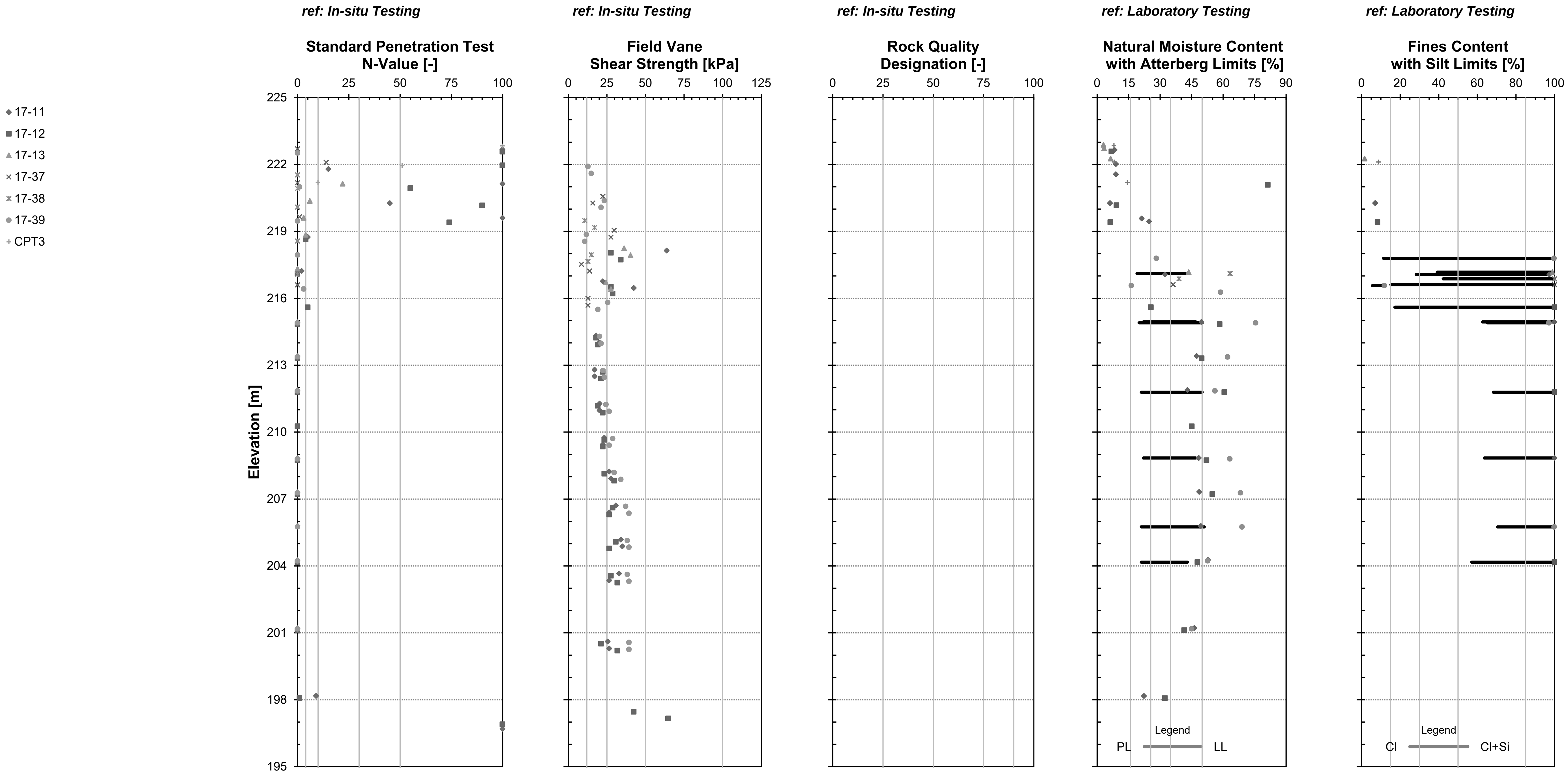


Figure G3

Rehabilitation of Highway 537

GWP 5134-14-00

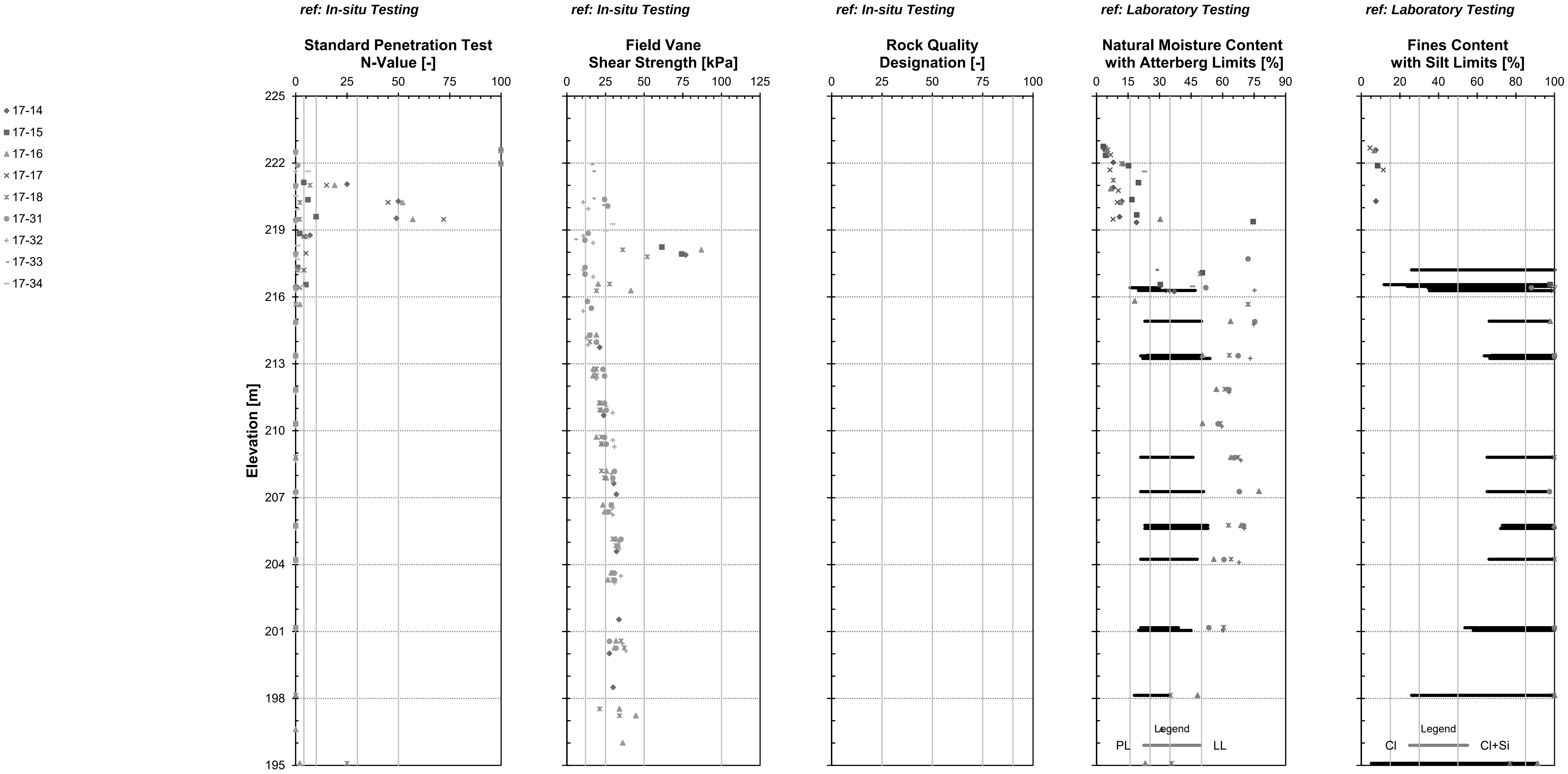


Figure G4

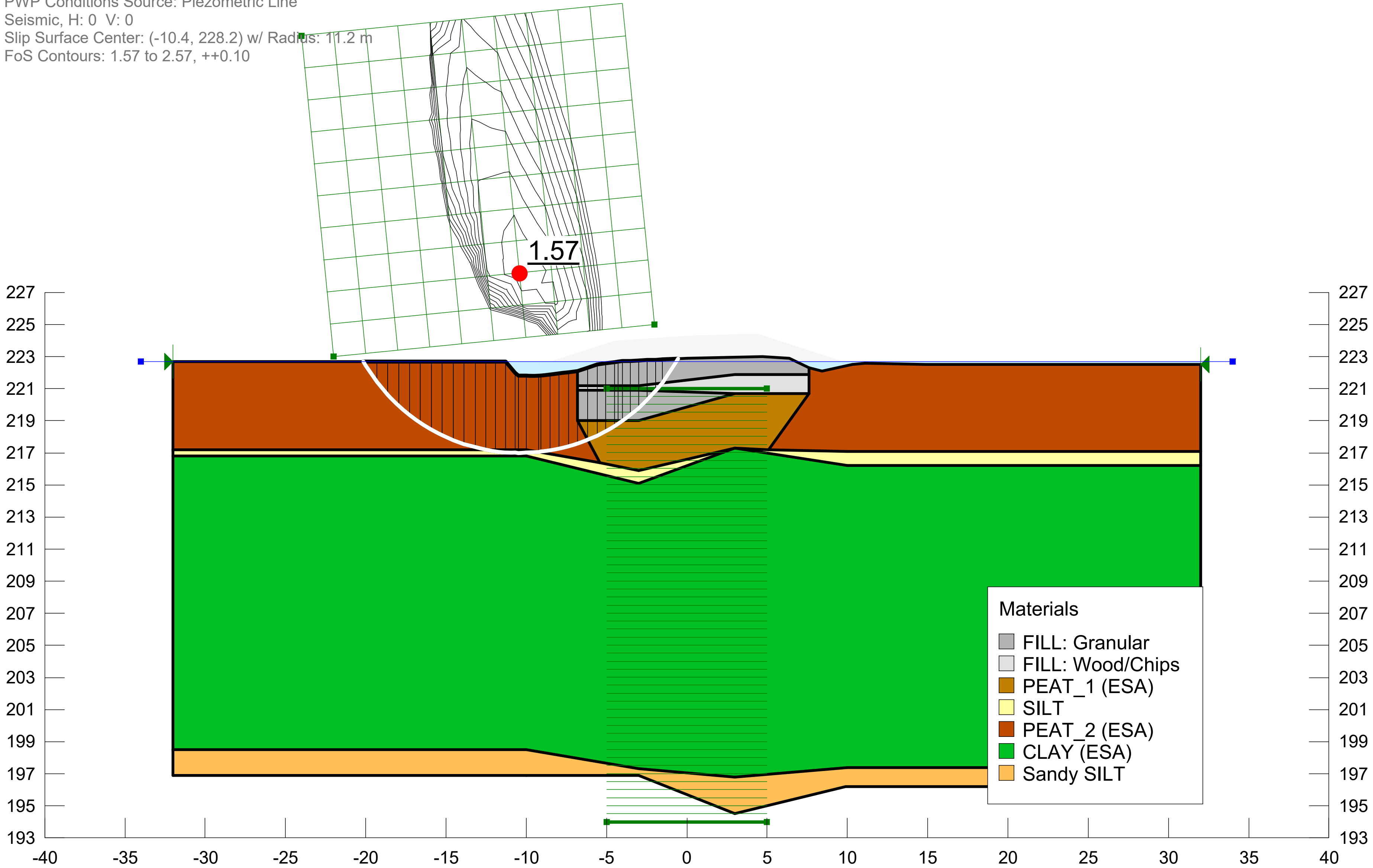
Appendix H.

Select Slope Stability Analysis Figures

Title: Highway 537 - GWP 5134-14-00
Comments: Stability Assessment, Sta. 18+450
Name: W: +0.0 (ESA)

FILL: Granular	20 kN/m³	0 kPa	30 °
FILL: Wood/Chips	10 kN/m³	2 kPa	28 °
PEAT_1 (ESA)	10 kN/m³	2 kPa	28 °
SILT	18 kN/m³	0 kPa	28 °
PEAT_2 (ESA)	10 kN/m³	2 kPa	28 °
CLAY (ESA)	16 kN/m³	7 kPa	25 °
Sandy SILT	20 kN/m³	0 kPa	30 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic, H: 0 V: 0
Slip Surface Center: (-10.4, 228.2) w/ Radius: 11.2 m
FoS Contours: 1.57 to 2.57, ++0.10



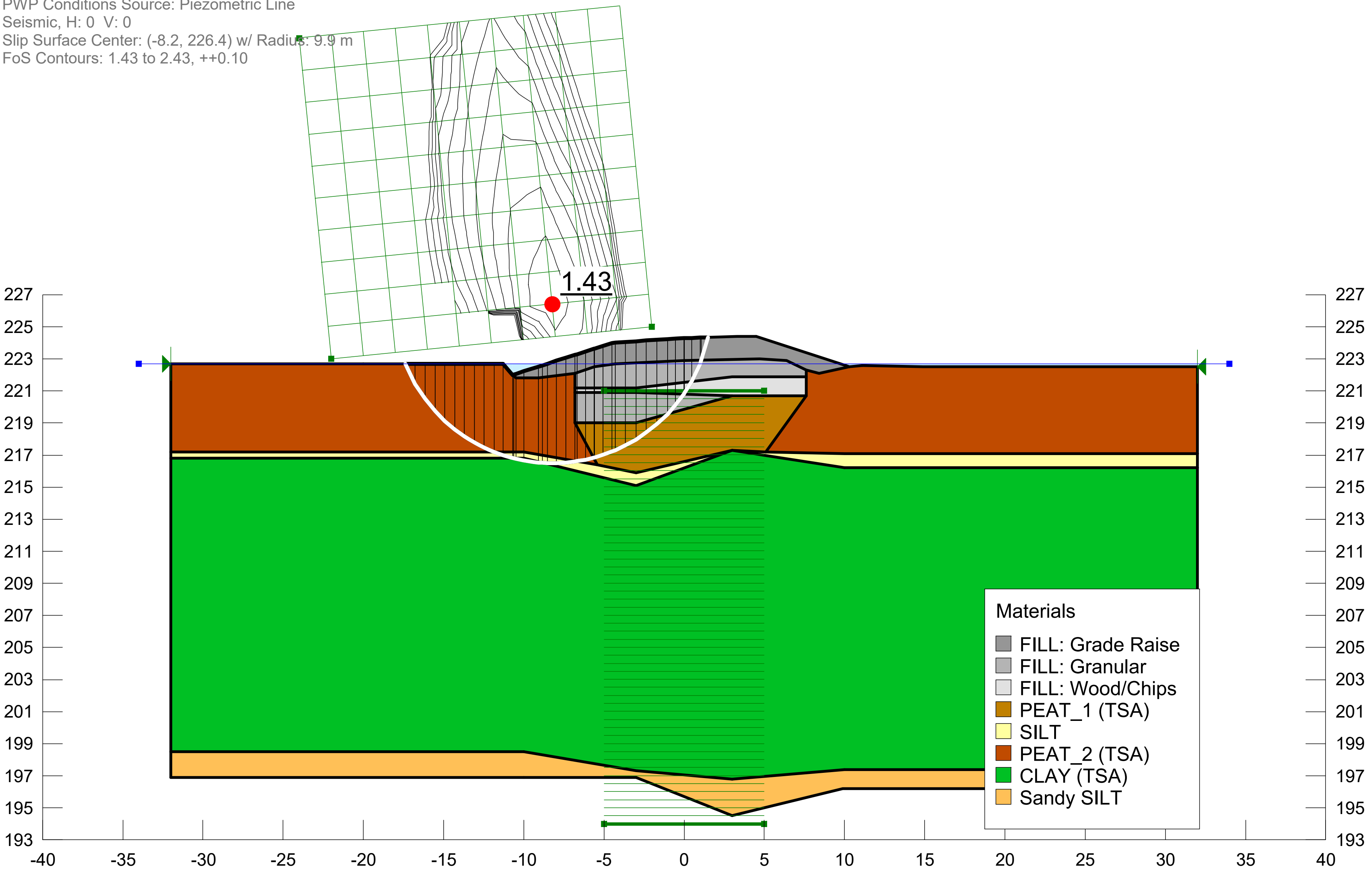
Reviewed By: ________________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-02-16, 11:55:33 AM

Figure H1

Title: Highway 537 - GWP 5134-14-00
Comments: Stability Assessment, Sta. 18+450
Name: W: +1.0 (TSA)

FILL: Grade Raise	21 kN/m³	0 kPa	32 °			
FILL: Granular	20 kN/m³	0 kPa	30 °			
FILL: Wood/Chips	10 kN/m³	2 kPa	28 °			
PEAT_1 (TSA)	10 kN/m³	20 kPa	0 °			
SILT	18 kN/m³	0 kPa	28 °			
PEAT_2 (TSA)	10 kN/m³	12 kPa	0 °			
CLAY (TSA)	16 kN/m³	12 kPa	1.3 (kN/m²)/m	25 kPa	217 m	
Sandy SILT	20 kN/m³	0 kPa	30 °			

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic, H: 0 V: 0
Slip Surface Center: (-8.2, 226.4) w/ Radius: 9.9 m
FoS Contours: 1.43 to 2.43, ++0.10



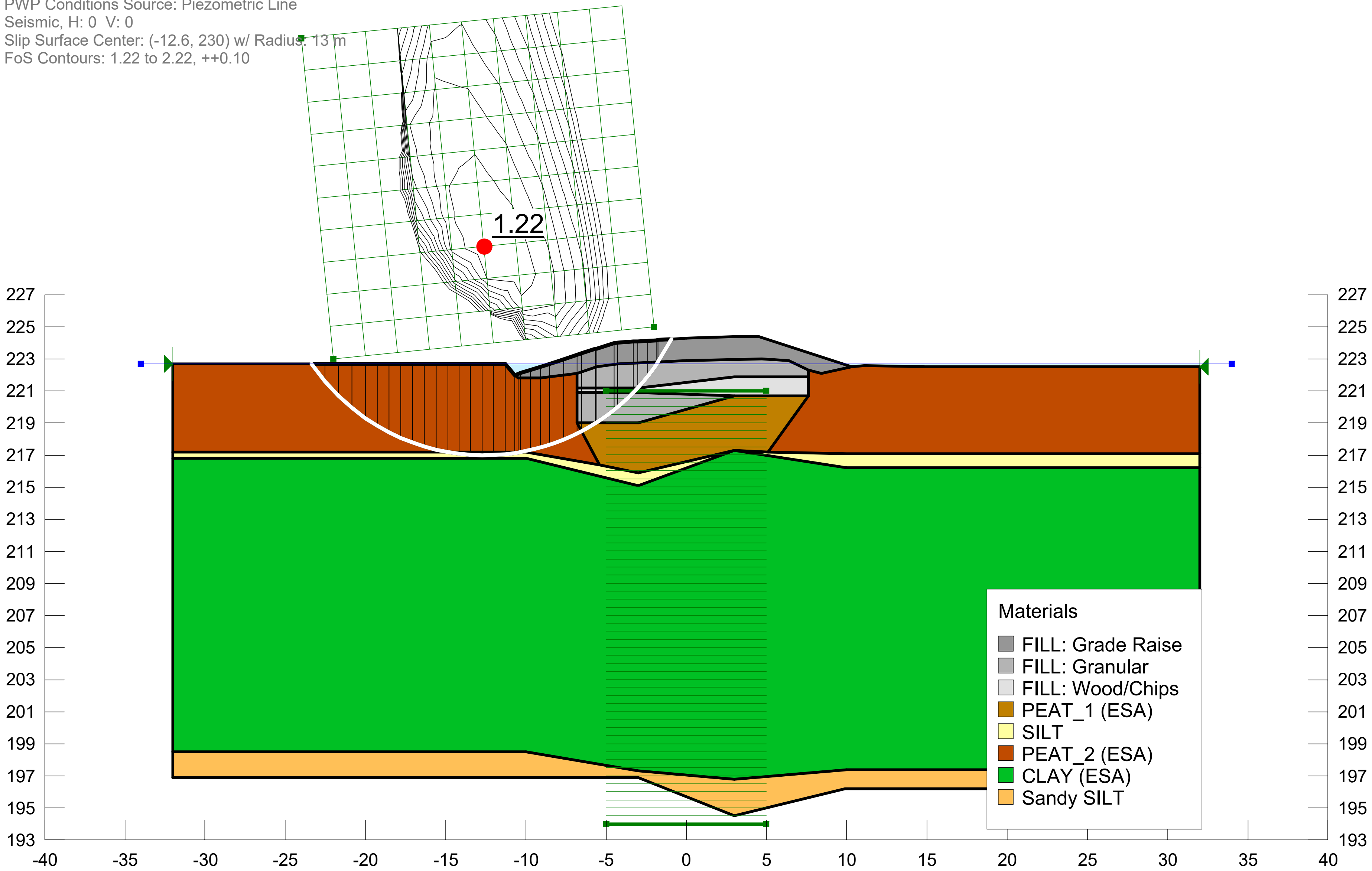
Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-02-16, 11:55:41 AM

Figure H2

Title: Highway 537 - GWP 5134-14-00
Comments: Stability Assessment, Sta. 18+450
Name: W: +1.0 (ESA)

FILL: Grade Raise	21 kN/m³	0 kPa	32 °
FILL: Granular	20 kN/m³	0 kPa	30 °
FILL: Wood/Chips	10 kN/m³	2 kPa	28 °
PEAT_1 (ESA)	10 kN/m³	2 kPa	28 °
SILT	18 kN/m³	0 kPa	28 °
PEAT_2 (ESA)	10 kN/m³	2 kPa	28 °
CLAY (ESA)	16 kN/m³	7 kPa	25 °
Sandy SILT	20 kN/m³	0 kPa	30 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic, H: 0 V: 0
Slip Surface Center: (-12.6, 230) w/ Radius: 13 m
FoS Contours: 1.22 to 2.22, ++0.10



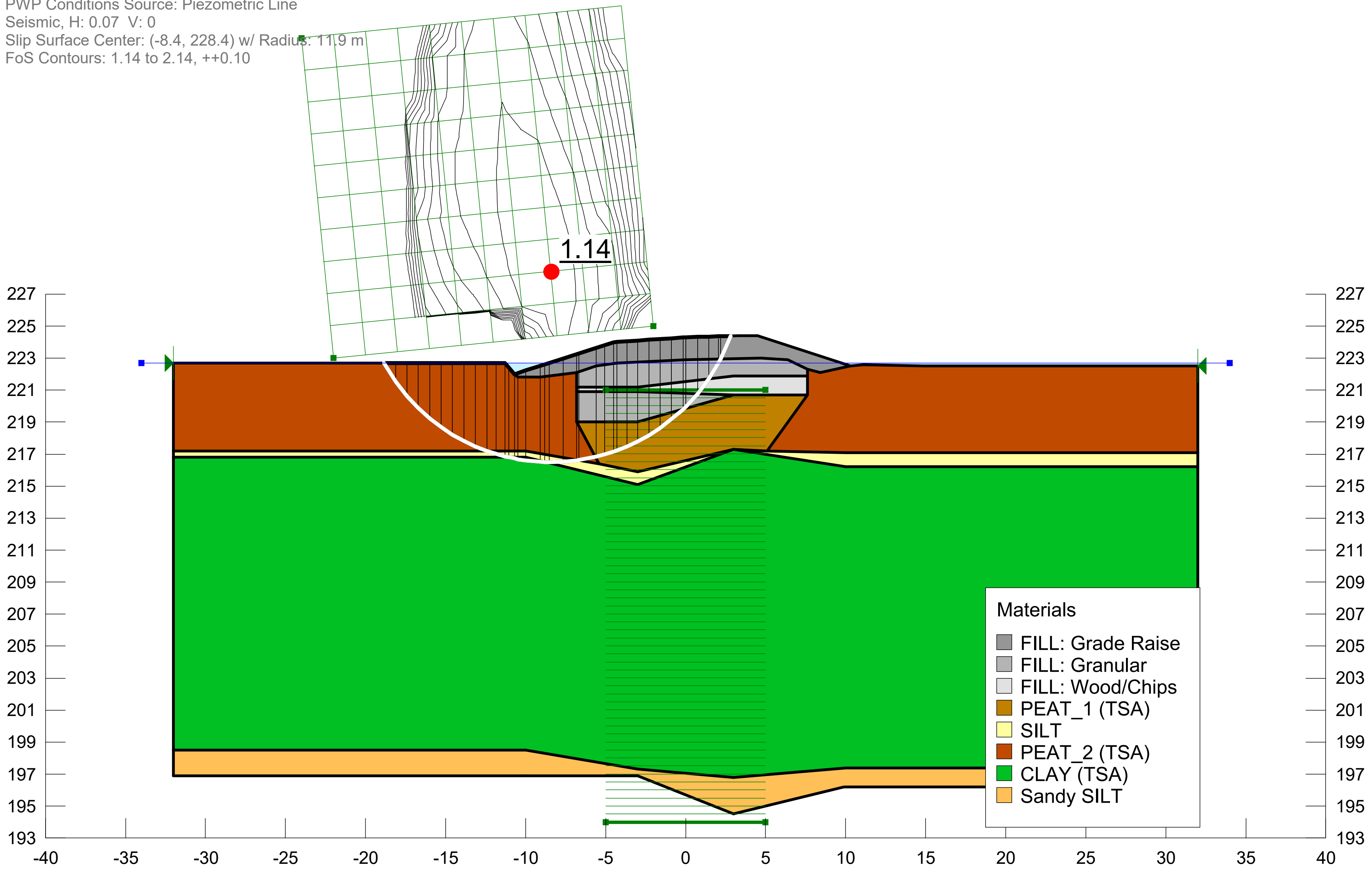
Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-02-16, 11:55:37 AM

Figure H3

Title: Highway 537 - GWP 5134-14-00
Comments: Stability Assessment, Sta. 18+450
Name: W: +1.0 (TSA)_seismic

FILL: Grade Raise	21 kN/m³	0 kPa	32 °		
FILL: Granular	20 kN/m³	0 kPa	30 °		
FILL: Wood/Chips	10 kN/m³	2 kPa	28 °		
PEAT_1 (TSA)	10 kN/m³	20 kPa	0 °		
SILT	18 kN/m³	0 kPa	28 °		
PEAT_2 (TSA)	10 kN/m³	12 kPa	0 °		
CLAY (TSA)	16 kN/m³	12 kPa	1.3 (kN/m²)/m	25 kPa	217 m
Sandy SILT	20 kN/m³	0 kPa	30 °		

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic, H: 0.07 V: 0
Slip Surface Center: (-8.4, 228.4) w/ Radius: 11.9 m
FoS Contours: 1.14 to 2.14, ++0.10



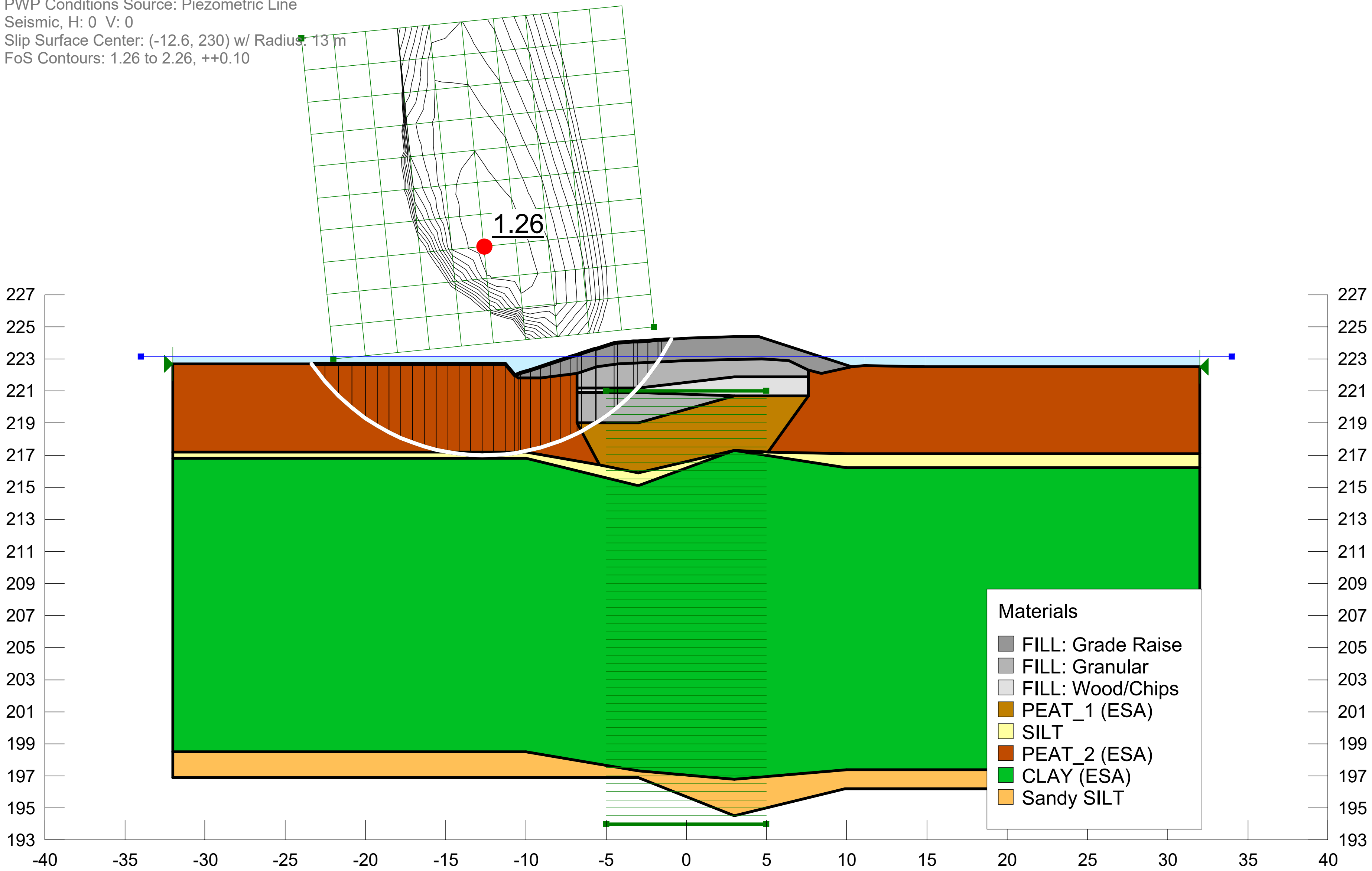
Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-02-16, 11:55:45 AM

Figure H4

Title: Highway 537 - GWP 5134-14-00
Comments: Stability Assessment, Sta. 18+450
Name: W: +1.0 (ESA) HWL

FILL: Grade Raise	21 kN/m³	0 kPa	32 °
FILL: Granular	20 kN/m³	0 kPa	30 °
FILL: Wood/Chips	10 kN/m³	2 kPa	28 °
PEAT_1 (ESA)	10 kN/m³	2 kPa	28 °
SILT	18 kN/m³	0 kPa	28 °
PEAT_2 (ESA)	10 kN/m³	2 kPa	28 °
CLAY (ESA)	16 kN/m³	7 kPa	25 °
Sandy SILT	20 kN/m³	0 kPa	30 °

Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
PWP Conditions Source: Piezometric Line
Seismic, H: 0 V: 0
Slip Surface Center: (-12.6, 230) w/ Radius: 13 m
FoS Contours: 1.26 to 2.26, ++0.10



Reviewed By: _______________
Tool Version: 8.15.6.13446
Last Solved Date: 2018-02-16, 11:55:48 AM

Figure H5

Appendix I.

Select Settlement Analysis Figures

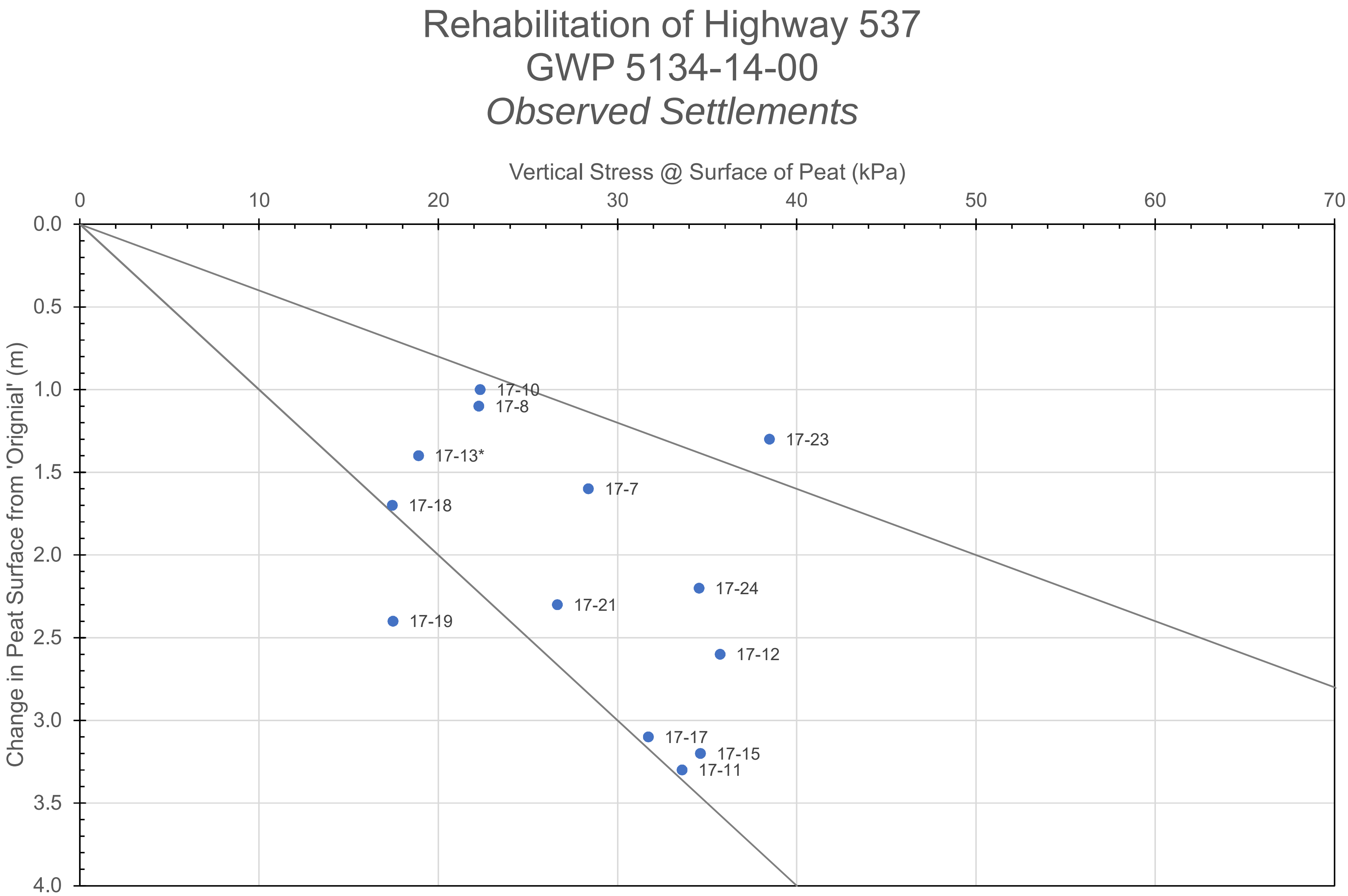

Rehabilitation of Highway 537
GWP 5134-14-00
Observed Settlements
Vertical Stress @ Surface of Peat (kPa)
0
10
20
30
40
50
60
70
Change in Peat Surface from 'Orignial' (m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
17-10
17-8
17-23
17-13*
17-7
17-18
17-24
17-21
17-19
17-12
17-17
17-15
17-11

Figure I1

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+350, 3H:1V Side Slopes, 9m Road Width

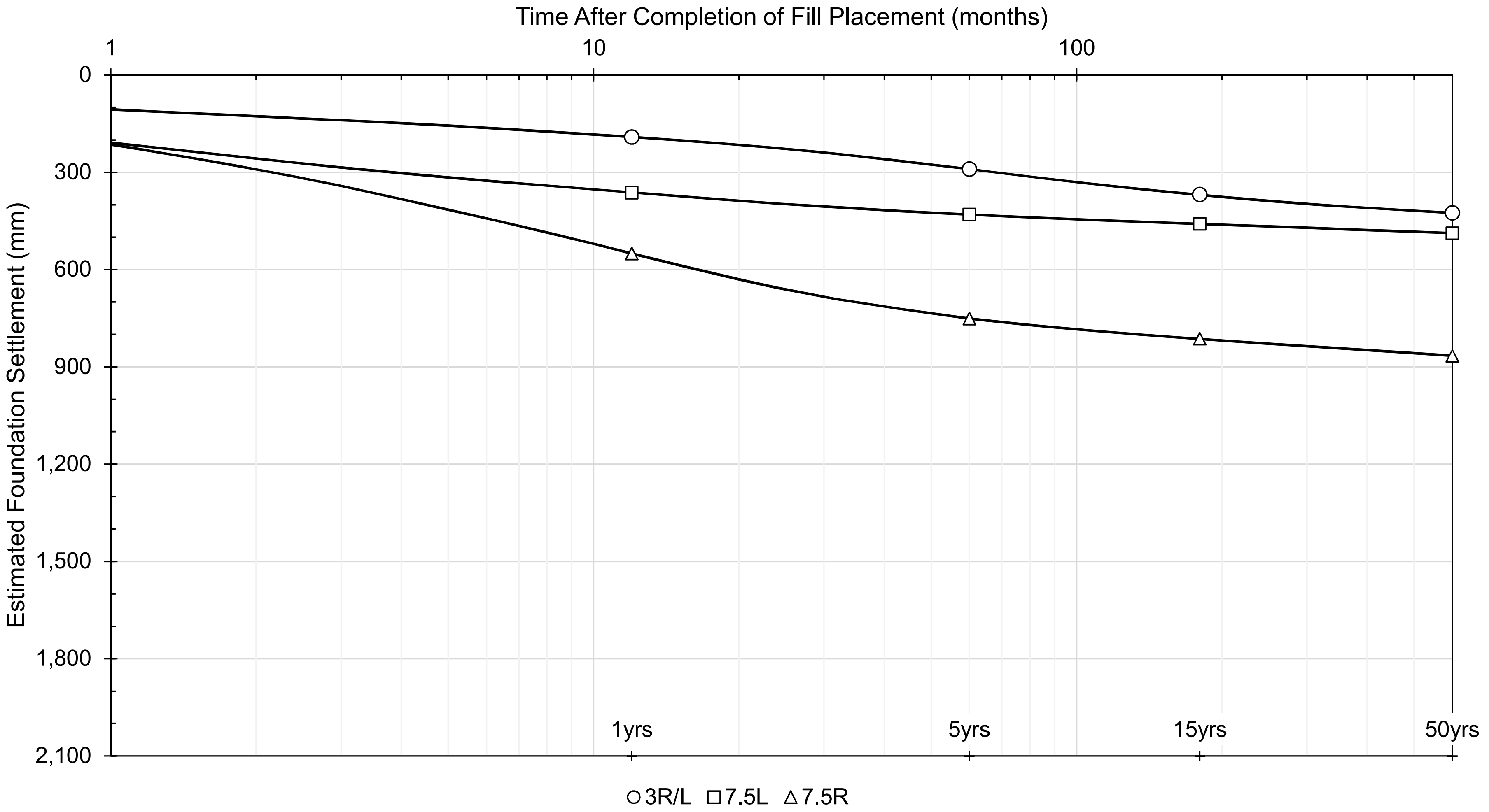


Figure I2

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+450, 3H:1V Side Slopes, 9m Road Width

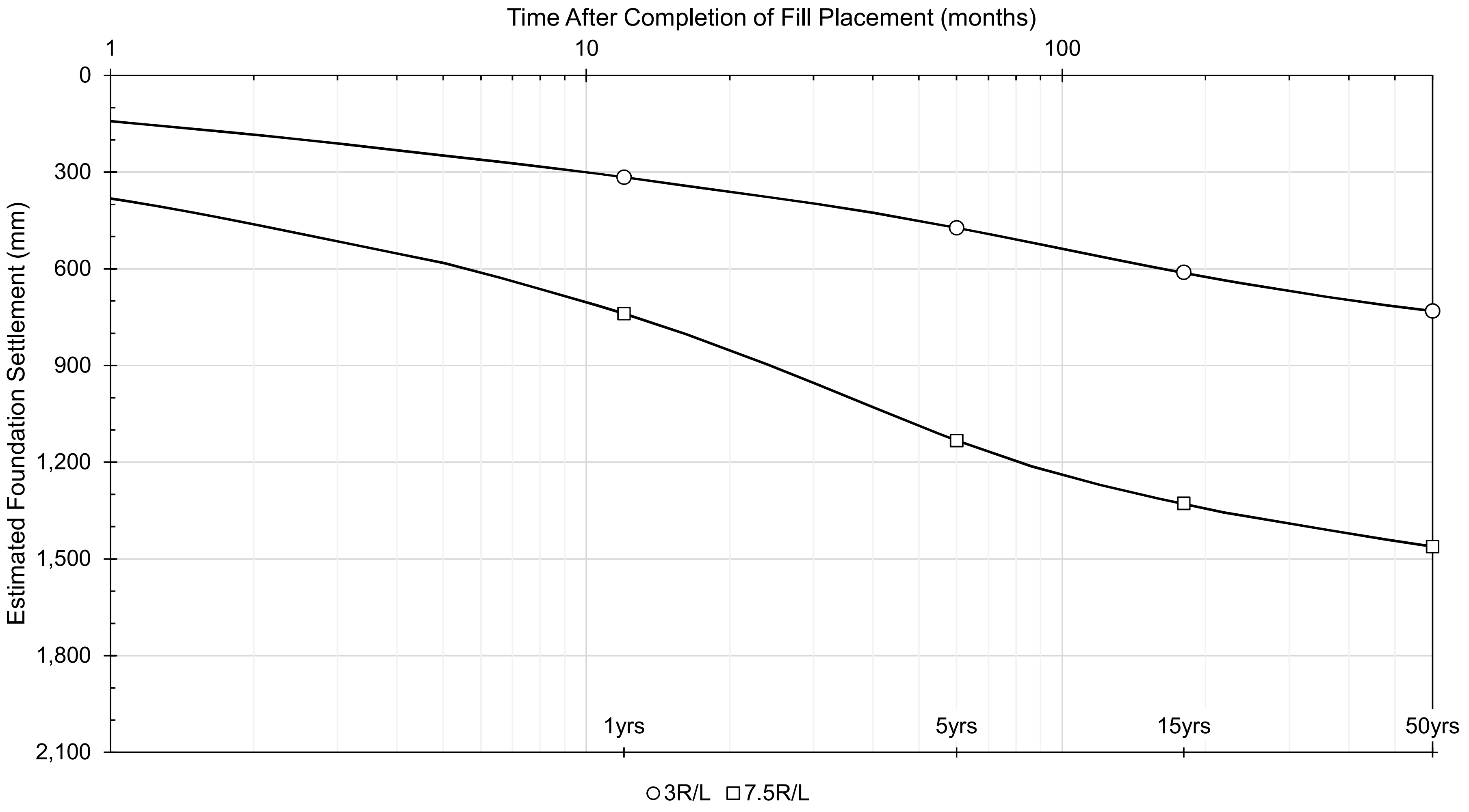


Figure I3

Rehabilitation of Highway 537

GWP 5134-14-00

Sta. 18+550, 3H:1V Side Slopes, 9m Road Width

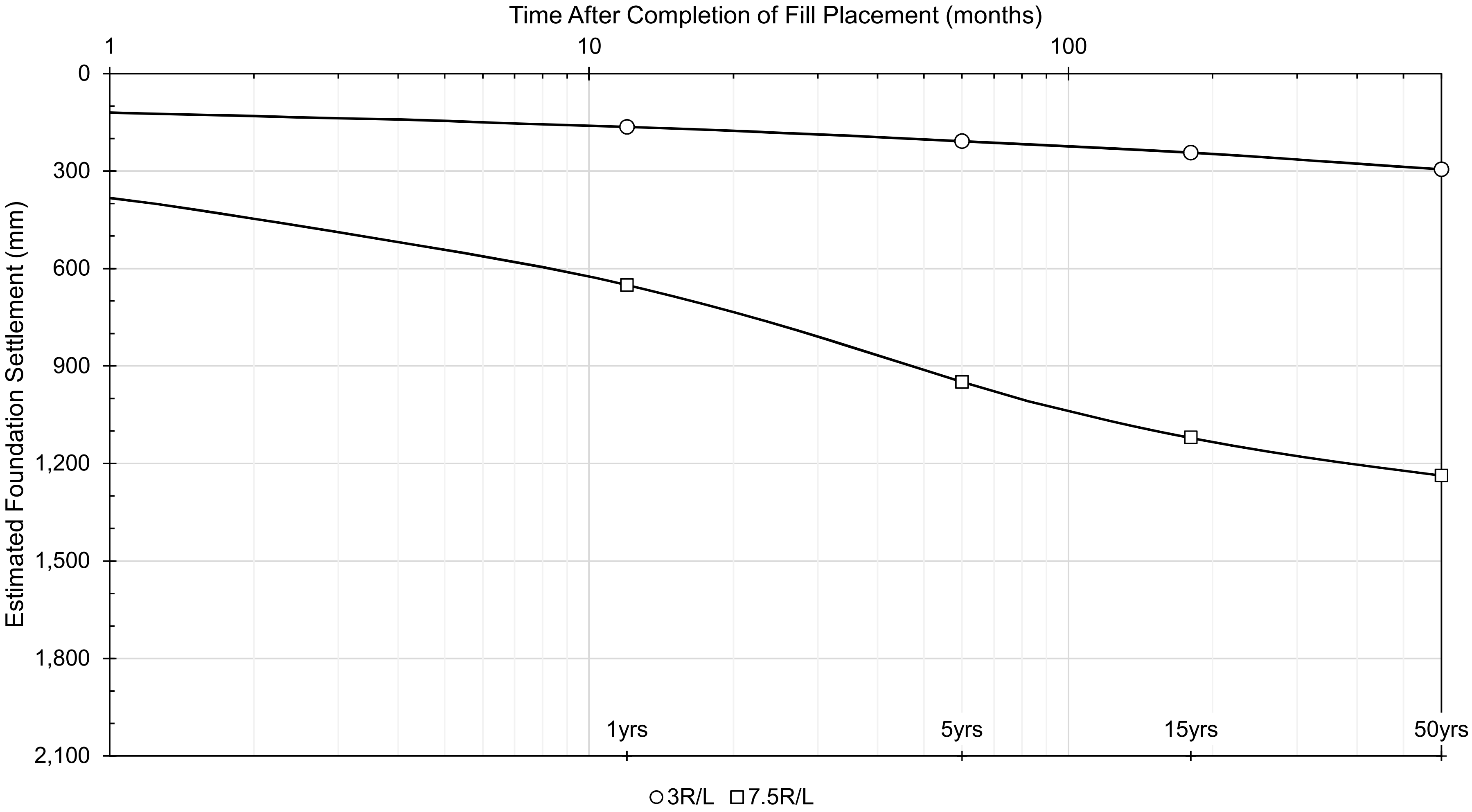


Figure I4

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+450, 3H:1V Side Slopes, 9m Road Width, With Top-Up

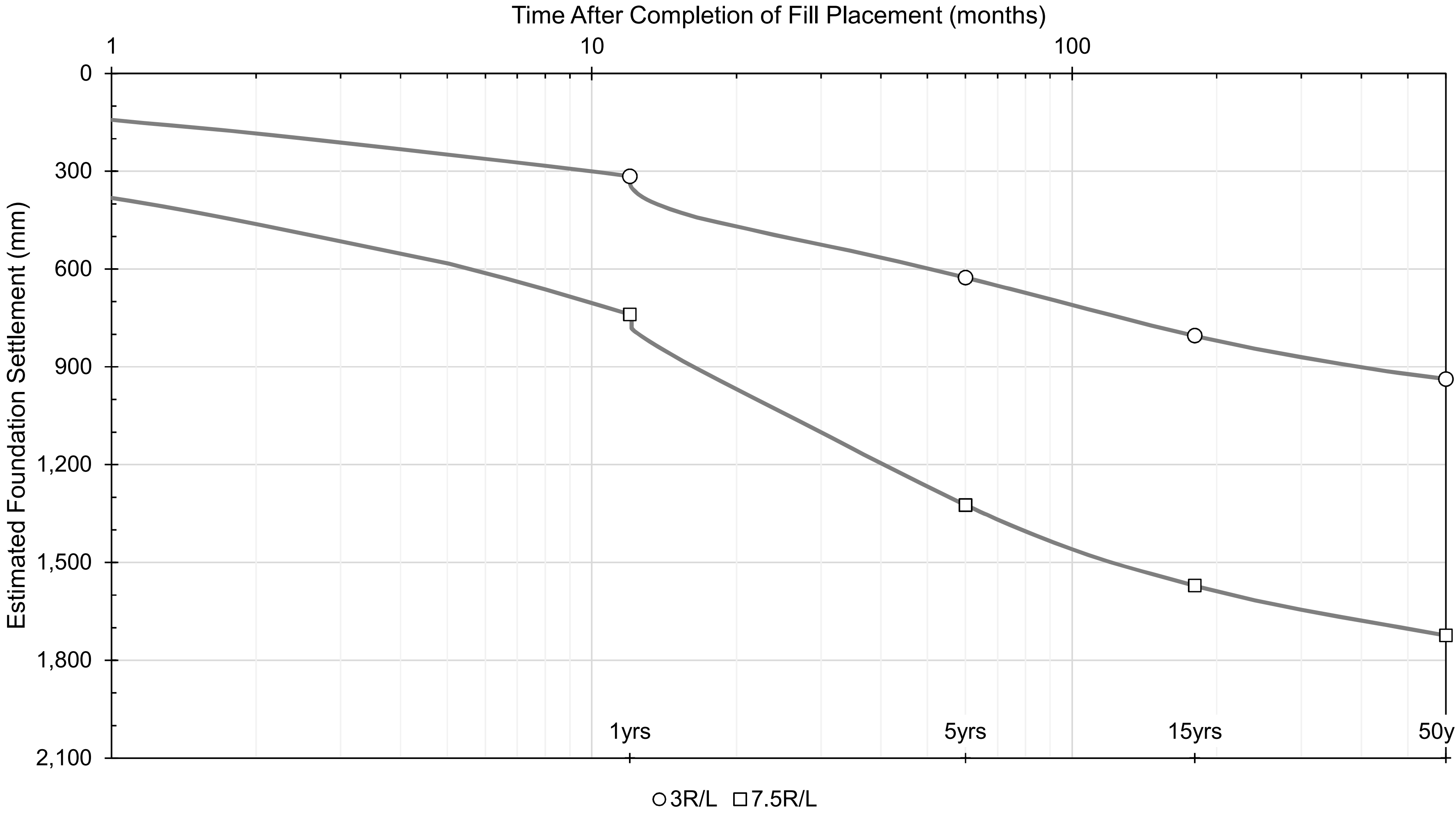


Figure I5

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+450, 4H:1V Side Slopes, 9m Road Width, With Top-Up

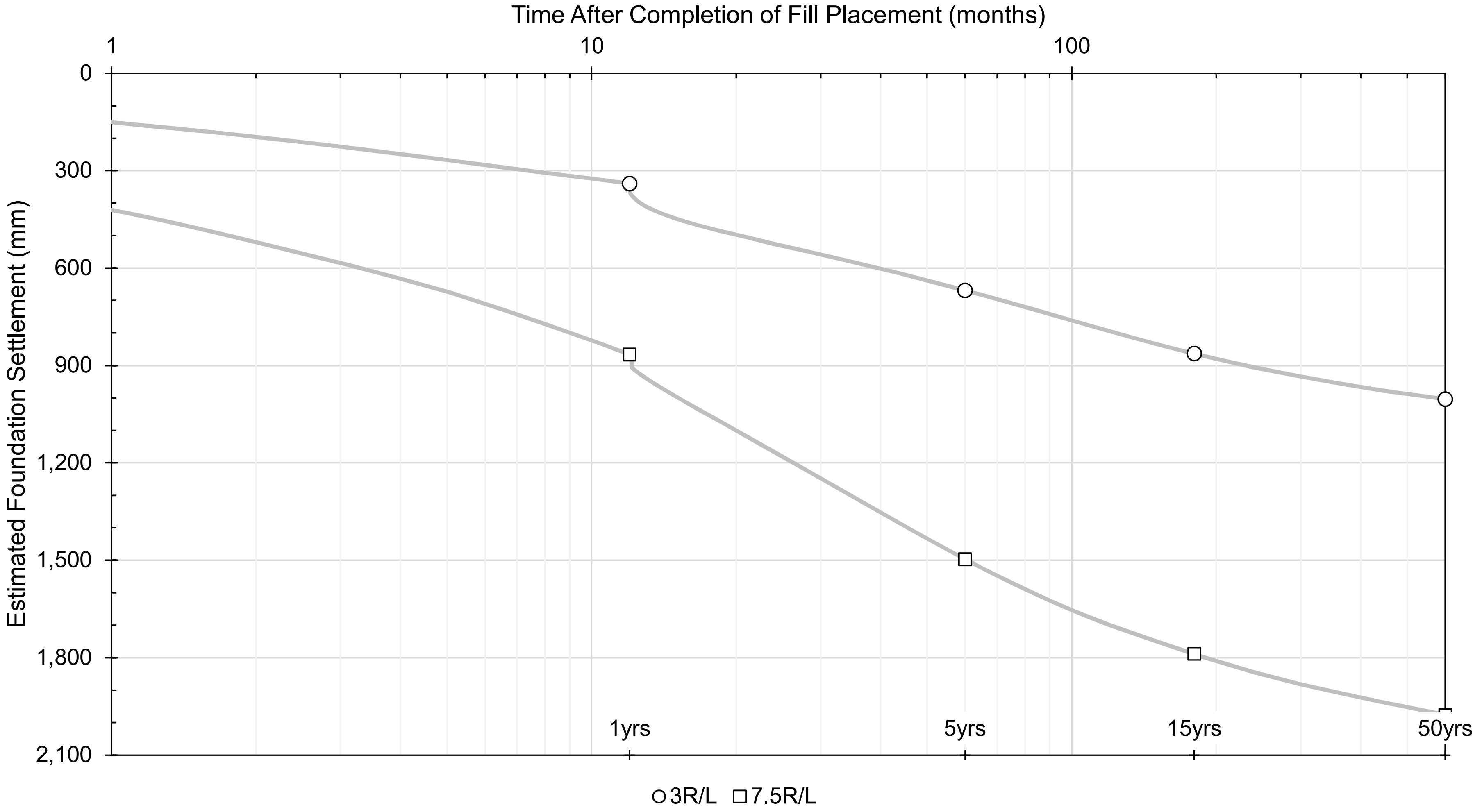


Figure I6

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+450, 3H:1V Side Slopes, 11m Road Width, With Top-Up

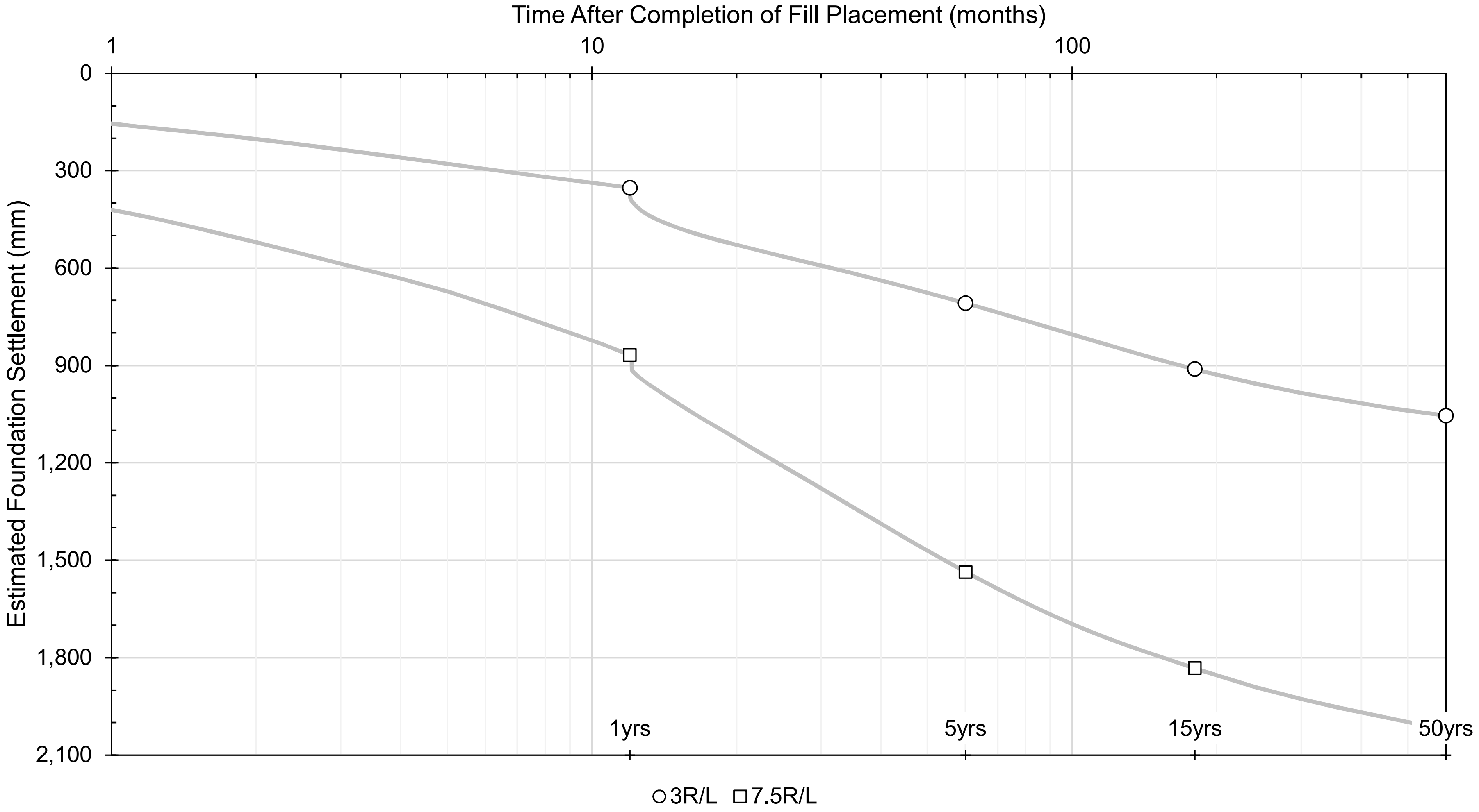


Figure I7

Rehabilitation of Highway 537
GWP 5134-14-00
Sta. 18+350, 3H:1V Side Slopes, 11m Road Width, With Top-Up

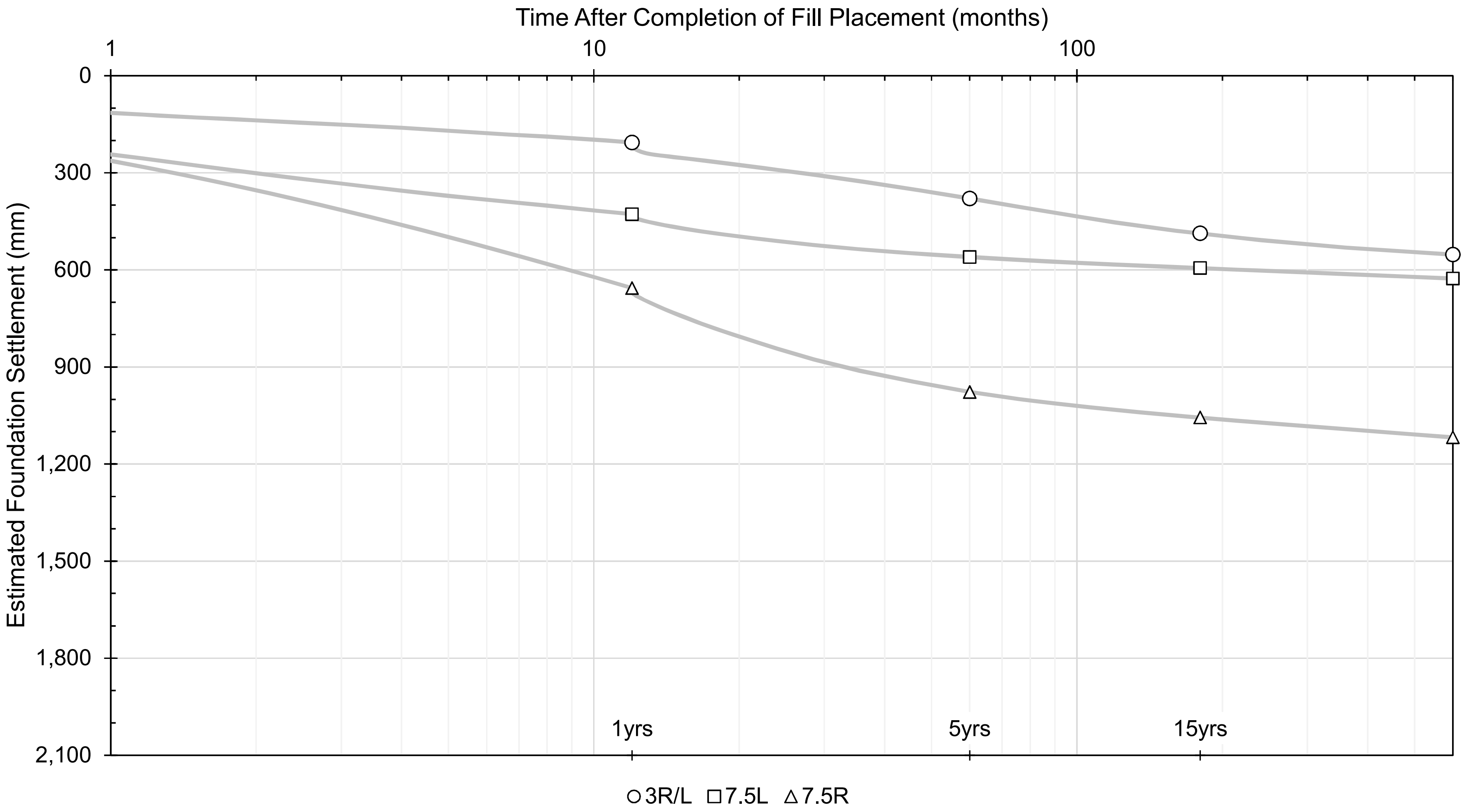


Figure I8

Appendix J.

Non-Standard Special Provisions (NSSP) and List of Special Provisions and OPSS Documents Referenced in this Report

The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 209	Construction Specification for Embankments over Swamps and Compressible Soils
OPSS 421	Construction Specification for Pipe Culvert Installation in Open Cut
OPSS 422	Construction Specification for Precast Reinforced Concrete Box Culverts in Open Cuts
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering of Pipeline, Utility and Associated Structure Excavation
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS 1860	Material Specification for Geotextile

OPSD 208.010	Benching of Earth Slopes
OPSD 203.020	Embankments Over Swamp
OPSD 203.030	Embankments Over Swamp
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 803.031	Frost Treatment – Pipe Culverts Frost Penetration Line Between Top of Pipe and Bedding Grade
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
SP 109S12	QVE, Backfilling, Compaction, and Certificate of Conformance
SP 517F01	Design Storm Return Period and Preconstruction Survey