



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
REPLACEMENT OF THE ONTARIO NORTHLAND RAILWAY (ONR)
OVERHEAD BRIDGE
HIGHWAY 11 AT EARLTON
TOWNSHIP OF ARMSTRONG
G.W.P. 5101-17-00**

GEOCRES No. 31M-132

Latitude 47.713244°, Longitude -79.816590°

Report

to

WSP

Date: November 18, 2021

File: 28552



TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	SITE DESCRIPTION	1
3.	INVESTIGATIVE PROCEDURES	2
4.	LABORATORY TESTING	5
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	6
5.1	Replacement Structure	6
5.1.1	Asphalt	6
5.1.2	Sand and Gravel Fill	7
5.1.3	Sand to Silty Sand Fill	7
5.1.4	Silty Clay Fill	8
5.1.5	Topsoil	9
5.1.6	Silty Clay	9
5.1.7	Silty Sand Till	13
5.1.8	Bedrock	14
5.1.9	Groundwater Conditions	15
5.2	Detour Alignment	16
5.2.1	Topsoil	17
5.2.2	Silty Clay	17
5.2.3	Silty Sand Till	19
5.2.4	Groundwater Conditions	20
6.	CORROSIVITY AND SULPHATE ATTACK TEST RESULTS	20
7.	MISCELLANEOUS	21

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8.	INTRODUCTION	23
9.	FOUNDATION DESIGN	25
9.1	Driven H-Piles	27
9.1.1	Axial Resistance	27
9.1.2	Downdrag	28
9.1.3	H-Pile Installation	28
9.1.4	Lateral Resistances	29
9.2	Abutment Design Considerations	32
9.3	Frost Cover	32
10.	ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES	32

10.1	Granular Backfill	32
10.2	EPS Blocks	33
11.	EPS SUBGRADE PREPARATION AND INSTALLATION	34
12.	APPROACH EMBANKMENTS	34
12.1	Stability Analysis	35
12.2	Embankment Settlement	36
12.2.1	Foundation Settlement	36
12.2.2	Self-Compression.....	37
12.3	Embankment Construction	37
12.4	Erosion Protection	37
13.	EXCAVATION AND GROUNDWATER CONTROL.....	37
14.	SEISMIC CONSIDERATIONS	38
15.	EXISTING UTILITIES AND ADJACENT STRUCTURES	39
16.	CORROSIVITY AND SULPHATE ATTACK POTENTIAL;.....	40
17.	DEMOLITION OF EXISTING STRUCTURE	40
18.	ERECTION OF FALSEWORK	41
19.	DETOUR EMBANKMENT.....	41
20.	ONR TRACK SETTLEMENT	41
21.	GEOTECHNICAL MONITORING.....	42
22.	TEMPORARY PROTECTION SYSTEMS	42
23.	SUMMARY OF CONSTRUCTION CONCERNS	43
24.	CLOSURE	46

Appendices

Appendix A	Borehole Location and Soil Strata Drawings
Appendix B	Record of Borehole Sheets and Laboratory Test Results – Current Investigation
Appendix C	Record of Borehole Sheets and Laboratory Test Results – Previous Investigation
Appendix D	SCPT Plots and In-Situ Test Results
Appendix E	Summary of In-situ and Laboratory Test Results on Varved Silty Clay
	Figure E1 – From Beyond Embankment Footprint
	Figure E2 – Beneath Berm
	Figure E3 – Beneath Embankment Platform
Appendix F	Analytical Test Results
Appendix G	Foundation Comparison
Appendix H	Slope Stability Analysis Results
Appendix I	Settlement Analysis Figures
Appendix J	List of OPSS Documents and Nssp Wording
Appendix K	EPS Schematic
Appendix L	NBCC Seismic Hazard Values



**FOUNDATION INVESTIGATION REPORT
REPLACEMENT OF THE ONTARIO NORTHLAND RAILWAY (ONR)
OVERHEAD BRIDGE
HIGHWAY 11 AT EARLTON
TOWNSHIP OF ARMSTRONG
G.W.P. 5101-17-00**

GEOCRES NO. 31M-132

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the proposed replacement of the Ontario Northland Railway (ONR) overhead bridge in Earlton, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to WSP, under the Ministry of Transportation Ontario (MTO) Agreement Number 5019-E-0023.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site during the preliminary design phase:

- Geotechnical Report titled "Preliminary Foundation Investigation and Design Report, Replacement of ONR Overhead, Site 47-037, Highway 11, Earlton, Ontario, Ministry of Transportation, Ontario, GWP 5265-01-00", Report Number 11-1191-0025-1, GEOCRES 31-M99, prepared by Golder Associates, dated May 10, 2013 (Reference 1)

For the purposes of this report, a north-south orientation has been adopted for the bridge alignment. The same orientation has been adopted for the describing the location of the bridge relative to existing site features.

2. SITE DESCRIPTION

The existing ONR overhead structure is located about 800 m south of the intersection of Highway 11 and Highway 571 and 230 m east of the intersection of Rivard Road (formerly Government Road) and 10th Street in Earlton, Ontario. The existing 9-span structure is approximately 135 m long and 11 m wide and carries two lanes of Highway 11 over a ONR track and Rivard Road. The



approach embankments are approximately 9 m high and there are two levels of stabilizing berms which extend along the sides and front of the approach embankments. The lower berm is approximately 3 m high and 10 m wide, while the upper berm is approximately 6 m high and 17 m wide, with the width of the berms decreasing towards the north and south. The top of the existing approach embankments are at approximately Elevation 256.5 m at the north and south abutments, and the ONR tracks and Rivard Road underlying the bridge are at approximately Elevation 249 m and Elevation 250 m, respectively. The bridge is primarily surrounded by residential properties to the west and agricultural properties to the east.

It is noted that two failures occurred during original construction of the approach embankments at this site. In the 1930s, the south approach embankment failed after the embankment was constructed to a height of 8 m with 1.5H:1V side slopes. Then in 1959, a second failure of the south approach embankment occurred immediately or soon after the embankment was reconstructed to a height of 9 m. Further details on the embankment failures and site history are provided in Reference 1.

Quaternary mapping indicates that site is underlain by a glaciolacustrine deposit comprised of silt and clay. The deposit is part of a varved clay belt which extends from New Liskeard to Cochrane.

The bedrock in this area is mapped as sandstone, shale, dolostone and siltstone.

3. INVESTIGATIVE PROCEDURES

The site investigation was conducted in two phases (Phase I and II). The Phase I site investigation was carried out between November 17 and December 2, 2020, at which time eight (8) boreholes (20-01 to 20-03, 20-08, 20-21, and 20-25 to 20-27) and eight (8) Seismic Cone Penetration Tests (SCPTs) (SCPT20-01 to SCPT20-06, SCPT20-03B and SCPT20-06B) were advanced at the site. Subsequently, in May 2021, an additional seventeen (17) boreholes were drilled, of which, fourteen (14) boreholes were drilled at the piers of the proposed bridge, and three (3) boreholes were drilled along the detour alignment located east of the bridge. Four (4) boreholes were previously advanced at the site by Golder Associates in July 2012 as part of the preliminary investigation.

The approximate locations of the boreholes and piezocones are shown on the Borehole Location and Soil Strata Drawings included in Appendix A. The Records of Boreholes sheets and SCPTu profiles from the current investigation by Thurber are provided in Appendices B and D, respectively. The Record of Borehole sheets from the preliminary investigation by Golder are provided in Appendix C. The locations, coordinates, ground surface elevations, and depths of the boreholes completed during Phase I and II site investigations are provided in the table below.



Table 3.1 – Borehole/SCPTu Details

No.	Type	Location	Northing (m)	Easting (m)	Ground Elevation (m)	Borehole Depth (m)
20-01	Borehole	North Approach	5,286,752.0	393,509.0	256.3	24.3
20-02	Borehole	North Abutment	5,286,750.4	393,518.2	256.6	28.3
20-03	Borehole	North Abutment	5,286,745.5	393,517.7	256.6	24.7
20-04	Borehole	Pier #7	5,286,741.2	393,541.6	252.4	23.7
20-06	Borehole	Pier #7	5,286,723.2	393,537.6	252.6	24.0
20-08	Borehole	Pier #7	5,286,717.4	393,536.9	251.6	19.1
20-09	Borehole	Pier #6	5,286,728.2	393,554.6	249.9	20.8
20-10	Borehole	Pier #6	5,286,711.2	393,550.6	250.0	20.9
20-13	Borehole	Pier #5	5,286,714.2	393,572.6	248.2	17.0
20-14	Borehole	Pier #5	5,286,702.2	393,564.6	248.0	16.6
20-15	Borehole	Pier #4	5,286,696.2	393,589.6	248.4	16.5
20-16	Borehole	Pier #4	5,286,682.2	393,585.6	248.6	17.9
20-17	Borehole	Pier #3	5,286,689.2	393,596.6	249.0	17.8
20-18	Borehole	Pier #3	5,286,677.2	393,592.6	248.6	19.5
20-19	Borehole	Pier #2	5,286,678.2	393,609.6	249.9	18.0
20-20	Borehole	Pier #2	5,286,663.2	393,610.6	250.1	19.3
20-21	Borehole	Pier #1	5,286,667.6	393,627.9	252.3	15.9
20-23	Borehole	Pier #1	5,286,671.2	393,621.6	251.3	19.6
20-24	Borehole	Pier #1	5,286,651.2	393,619.6	252.6	21.0
20-25	Borehole	South Abutment	5,286,644.0	393,645.7	256.6	21.6
20-26	Borehole	South Abutment	5,286,641.1	393,642.6	256.6	25.4
20-27	Borehole	South Approach	5,286,634.1	393,658.2	256.1	20.5
20-28	Borehole	Detour Alignment	5,287,152.6	393,133.9	245.8	21.0
20-29	Borehole	Detour Alignment	5,286,820.2	393,566.6	247.5	13.7
20-30	Borehole	Detour Alignment	5,286,516.1	393,893.0	248.5	13.2
SCPT20-01	SCPT	Pier#7	5,286,722.1	393,536.7	252.8	19.7
SCPT20-02	SCPT	Pier #1	5,286,665.4	393,627.9	252.5	17.0
SCPT20-03	SCPT	North Abutment	5,286,743.8	393,519.4	256.7	4.4
SCPT20-03B	SCPT	North Abutment	5,286,742.3	393,521.1	256.8	24.7
SCPT20-04	SCPT	South of Pier#6	5,286,699.3	393,532.1	249.2	16.0
SCPT20-05	SCPT	North of Pier#2	5,286,684.2	393,630.7	249.9	13.7
SCPT20-06	SCPT	South Abutment	5,286,647.3	393,641.4	256.7	11.4
SCPT20-06B	SCPT	South Abutment	5,286,649.1	393,640.9	256.7	21.5



The coordinates of the boreholes were measured using a hand-held GPS device and measured relative to existing site features (e.g. piers, abutments). The ground surface elevations of the boreholes were provided by WSP and determined from the base plan. Prior to commencing the site investigation, utility clearances were obtained for all borehole locations.

All of the boreholes were drilled using LC55 and CME55 track-mounted drill rigs, supplied and operated by George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, with the exception of boreholes 20-08 and 20-21, which were drilled using a CPT Track Rig (M5TII), supplied and operated by Conetec Investigations Ltd. A combination of hollow stem auger and wash boring drilling techniques were used to advance the boreholes through the overburden and samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In the cohesive deposits, the undrained shear strength of the material was measured in-situ by means of field vane tests and undisturbed soil samples were collected using thin-walled Shelby tubes with a piston sampler. A Dynamic Cone Penetration Test (DCPT) was performed from the base of the sampled borehole 20-01.

The SCPTs were completed using a CPT Track Rig (M5TII) and involved pushing a piezocone, consisting of a metal rod equipped with electronic sensors at its tip, statically into the ground. Tip resistance, sleeve friction, and excess pore water pressure were continuously measured with depth using the electronic sensors. Pore pressure dissipation tests were performed at selected depths within the varved silty clay to obtain horizontal coefficient of consolidation values, and within the silty sand till layer underlying the silty clay. In addition, electric Vane Shear Testing (eVST) was performed to measure the undrained shear strength of the varved clay, and shear wave (V_s) and compression wave (V_p) velocity testing was performed in order to collect interval velocities. The results of the porewater pressure dissipation testing, eVST, and seismic testing are included in Appendix D.

NQ coring methods were used to advance Boreholes 20-02, 20-04, 20-06, 20-09, 20-10, 20-13 to 20-20, 20-23, 20-24, and 20-26, into bedrock and recover rock core samples. All remaining boreholes were advanced to auger refusal or DCPT refusal.

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

The groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in selected boreholes (20-03, 20-04, 20-10,



20-13, 20-16, 20-17, 20-20, 20-25, 20-29) to permit long-term water level monitoring. The piezometers consisted of either a 50 mm or a 25 mm Schedule 40 PVC pipe with a 3 m long slotted screen enclosed in a column of filter sand. Piezometer installation details and water level readings are shown on the Record of Borehole sheets in Appendix B. The piezometers were abandoned in general accordance with Ontario Regulation 903 (as amended by O. Reg. 372/07) upon completion of the field program.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. 25 mm and 50 mm diameter standpipe piezometers were installed and enclosed in filter sand in selected boreholes to permit longer term groundwater level monitoring. The details of the piezometers are shown in Table 3.2.

The boreholes in which no piezometers were installed were backfilled with bentonite holeplug to ground surface in general accordance with MOE Regulation 903. Asphalt cold patch was used at ground surface in the boreholes advanced through the road platform.

Table 3.2 – Standpipe Piezometer Details

Borehole	Piezometer Tip		Instrument Type	Slotted Screen Length (m)
	Depth (m)	Elevation (m)		
20-03	24.7	231.9	25 mm Piezometer	3
20-04	19.8	232.6	50 mm Piezometer	3
20-10	16.8	233.2	50 mm Piezometer	3
20-13	13.7	234.5	50 mm Piezometer	3
20-16	13.7	234.9	50 mm Piezometer	3
20-17	14.4	234.6	50 mm Piezometer	3
20-20	15.5	234.6	50 mm Piezometer	3
20-25	21.3	235.3	50 mm Piezometer	3
20-29	7.6	239.9	50 mm Piezometer	3

4. LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected soil samples were subjected to grain size analysis and Atterberg Limits testing. Point Load testing and Unconfined Compressive Strength (UCS) testing was carried out selected rock core samples.

Advanced testing was also carried out on recovered Shelby tube samples of the varved silty clay; One-dimensional consolidation testing was performed using incremental and controlled-strain



loading to determine the compressibility of the varved clay, and Consolidated Isotopically Undrained (CIU) and Unconsolidated Undrained (UU) triaxial testing was performed on undisturbed samples of the varved clay to assess soil strength under undrained loading. Direct Simple Shear (DSS) testing was also carried out to determine the shear strength horizontally along the clay varves.

The results of the index testing are shown on the Record of Borehole sheets and lab figures in Appendix B. The results of the rock and advanced soil testing are also included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference should be made to the Record of Borehole sheets in Appendix B. Details of the encountered soil stratigraphy are presented on the borehole sheets and on the Borehole Locations and Soil Strata drawings in Appendix A. Reference is also given to Appendix E which presents the graphical results of in-situ and laboratory tests performed on the varved clay deposit. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profiles are inferred from observations of during drilling and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

5.1 Replacement Structure

In general, the subsurface conditions at the site of the proposed replacement structure consist of asphalt (where present) overlying cohesionless fill (i.e. sand and gravel fill and sand to silty sand fill) above localized topsoil and silty clay fill layers overlying a relatively thick deposit of compressible varved silty clay. The upper portion of the clay is consistent with a weathered crust and the clay deposit is underlain by a deposit of silty sand till which in turn is underlain by sandstone/limestone bedrock.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

5.1.1 Asphalt

Asphalt was encountered at the ground surface in the boreholes advanced through the road platform (Boreholes 20-01 to 20-03, 20-25 to 20-27). A buried asphalt layer was also encountered in the boreholes advanced behind the abutments (Boreholes 20-02, 20-03, 20-15, 20-25, 20-26)



and two boreholes advanced close to the ONR tracks (Boreholes 20-14 and 20-15). The thickness of the asphalt ranged from 50 mm to 200 mm.

5.1.2 Sand and Gravel Fill

Brown sand and gravel fill containing trace to some silt was encountered in the boreholes advanced through the road platform (Boreholes 20-01 to 20-03, 20-25 to 20-27) underlying and/or between the asphalt layers. Trace asphalt was noted within the sand and gravel fill in Borehole 20-27. The thickness of this fill ranged from 0.6 m to 1.9 m and the base of this fill was encountered at depths between 0.8 m and 2.1 m (Elev. 255.8 m and 254.2 m).

SPT 'N' values obtained in the sand and gravel fill ranged from 64 blows per 0.3 m penetration to 100 blows per 0.15 m penetration, indicating a very dense relative density. Measured moisture contents ranged from 1 to 4%.

The results of a grain size distribution test carried out on a sample of the sand and gravel fill are shown on Figure B1 in Appendix B and summarized below:

Soil Particle	Percentage (%)
Gravel	37
Sand	50
Silt + Clay	13

5.1.3 Sand to Silty Sand Fill

Brown to grey sand to silty sand fill was encountered underlying the sand and gravel fill and/or asphalt in Boreholes 20-01 to 20-03, 20-25 to 20-27, at ground surface in Boreholes 20-04, 20-06, 20-09, 20-10, 20-13 to 20-20, 20-23 and 20-24, and underlying topsoil in Boreholes 20-08 and 20-21. The thickness of the sand to silty sand fill ranged from 0.3 m to 11.1 m and extended to depths between 0.3 m and 12.2 m below ground surface (Elev. 248.7 m and 244.4 m). Cobbles were noted in this fill in Borehole 20-20 and organic inclusions were noted in the fill in Borehole 20-21.

SPT 'N' values obtained in the sand to silty sand fill were highly variable and ranged from 0 blows per 0.3 m penetration to 100 blows per 0.2 m penetration, with an average 'N' value of about 25, indicating a very loose to very dense relative density. Measured moisture contents typically ranged from 5 to 10%. One moisture content was measured as high as 36% and is believed to be associated with the presence of organics within the fill.

The results of grain size distribution tests carried out on selected samples of the sand to silty sand fill are shown on Figures B2 to B4 in Appendix B and summarized below:



Soil Particle	Percentage (%)
Gravel	0 to 16
Sand	44 to 95
Silt	15 to 29
Clay	8 to 15
Silt + Clay	5 to 12

The results of an Atterberg Limits test carried out on a sample of the fine-grained portion of the sand to silty sand fill are shown on Figure B12 in Appendix B and summarized below:

Soil Property	Percentage (%)
Liquid Limit	18
Plastic Limit	13
Plasticity Index	5

The results of the Atterberg Limit tests indicate that the fine-grained portion of the fill has slight plasticity (CL-ML).

5.1.4 Silty Clay Fill

Grey silty clay fill was encountered underlying the sand to silty sand fill in Boreholes 20-01 to 20-03, 20-08, 20-25, and below topsoil in Borehole 20-27. The silty clay fill had varying amounts of sand, ranging from trace sand to with sand, and contained trace to some gravel. Trace rootlets and organics were also noted in the clay fill in Borehole 20-02, 20-25, and 20-27. The thickness of the silty clay fill ranged from 1.1 m to 3.6 m and the base of the fill was encountered at depths ranging from 5.6 m to 12.3 m (Elev. 246.0 m to 244.3 m).

SPT 'N' values obtained in the silty clay fill typically ranged from 3 to 15 blows per 0.3 m, indicating a soft to stiff consistency. Measured moisture contents ranged from 11 to 24%.

The results of grain size distribution tests carried out on selected samples of the silty clay fill are shown on Figure B5 in Appendix B and summarized below:

Soil Particle	Percentage (%)
Gravel	2 to 12
Sand	12 to 46
Silt	29 to 34
Clay	17 to 52

The results of Atterberg Limits testing carried out on samples of the silty clay fill are shown on Figure B13 in Appendix B and summarized below:



Soil Property	Percentage (%)
Liquid Limit	24 to 25
Plastic Limit	14
Plasticity Index	10 to 11

The results of the Atterberg Limit testing indicate that the silty clay fill has low plasticity (CL).

5.1.5 Topsoil

A layer of topsoil was encountered underlying and/or within the silty clay fill in Boreholes 20-01 to 20-03, and 20-25, below and/or within the sand to silty sand fill in Boreholes 20-04, 20-10, 20-14, 20-16, 20-26, and 20-27, and at ground surface in Boreholes 20-08 and 20-21. The thickness of the layer ranged from 25 mm to 1.4 m. Topsoil thickness may vary between boreholes and in other areas of the site.

Measured moisture contents on samples of the topsoil ranged from 7 to 93%.

5.1.6 Silty Clay

A relatively thick deposit of brown to grey varved silty clay was encountered in all boreholes underlying the fill and topsoil layers. Based on visual examination of the recovered samples, the varved silty clay is comprised of alternating clayey silt laminae and clay laminae, approximately 10 mm thick and 20 mm thick, respectively. The upper 1.5 m to 2 m of the clay is comprised of a weathered crust.

The surface of the varved clay deposit was encountered at depths between 0.3 m and 12.3 m (Elev. 248.0 m and 244.3 m). The base of this deposit was located at depths between 11.7 m and 22.6 m (Elev. 239.3 m and 233.2 m). The thickness of the deposit ranged from 4.5 m to 12.8 m, with the thickness generally decreasing towards the south.

SPT 'N' values obtained in the silty clay ranged from 0 (i.e. weight of hammer) to 22 blows per 0.3 m penetration with the majority of 'N' values equal to 0. Field shear vane tests performed in the silty clay measured undrained shear strengths ranging from 19 kPa to 88 kPa, with sensitivity values between approximately 2 and 18. The majority of the values were between 3 and 8, indicating typically medium sensitivity to sensitive. Electric vanes performed in the clay in Boreholes 20-08 and 20-21 measured undrained shear strengths from 29 to 72 kPa. The results of the electric vanes are included in Appendix D.

In general, the measured undrained shear strength of the unweathered silty clay varied depending on the amount of fill present, with higher undrained shear strengths measured for the clay beneath the existing embankment platform and lower shear strengths measured beyond the embankment



footprint. A summary of the average undrained shear strength of the unweathered silty clay measured in the field vane tests at various locations is provided in the following table.

Location	Average Undrained Shear Strength of Unweathered Silty Clay (kPa)
Beyond Embankment Footprint	31
Beneath Berm	45
Beneath Embankment Platform	63

The undrained shear strength of the crust was estimated from the results of cone penetration testing and generally ranged between approximately 100 and 200 kPa, with decreasing shear strength towards the bottom of the crust.

Based on the results of the vane testing, combined with the results of cone penetration testing, the weathered crust generally has a very stiff to stiff consistency, while the underlying unweathered silty clay has a soft to stiff consistency.

Measured moisture contents on the overall varved silty clay (combined clayey silt and clay laminae) typically ranged from 30 to 70%. Measured moisture contents on samples of the separated clay laminae and clayey silt laminae were 58% and 27%, respectively.

Grain size distribution tests were carried out on selected samples of the varved silty clay and individual clayey silt laminae and clay laminae. The results of the grain size tests on the varved silty clay are shown on Figures B6 to B8, and the results of the testing on the clay laminae and clayey silt laminae are shown on Figures B9 and B10, respectively. The results are also summarized in the table below.

Soil Particle	Varved Silty Clay	Clay Laminae	Clayey Silt Laminae
	Percentage (%)	Percentage (%)	Percentage (%)
Gravel	0 to 1	0	0
Sand	0 to 15	0	0
Silt	27 to 49	14 to 29	37 to 66
Clay	40 to 73	71 to 86	34 to 63

The results of Atterberg Limits tests carried out on the varved silty clay are presented on Figures B14 to B17 in Appendix B. The results of Atterberg Limits tests completed on samples of the clay



laminae and clayey silt laminae are shown on Figures B18 and B19, respectively. The results are also summarized below:

Soil Property	Varved Silty Clay	Clay Laminae	Clayey Silt Laminae
	Percentage (%)	Percentage (%)	Percentage (%)
Liquid Limit	38 to 53	49 to 59	31 to 44
Plastic Limit	19 to 28	22 to 27	19 to 22
Plasticity Index	17 to 31	27 to 35	12 to 22

The results of the Atterberg Limit tests indicate that the varved silty clay has intermediate to high plasticity (CI-CH), the clay laminae has high plasticity (CH), and the clayey silt laminae has low to intermediate plasticity (CL-CI).

The results of three incremental loading (IL) consolidation tests and three constant rate of strain (CRS) consolidation tests performed on samples of the varved silty clay are summarized in Tables 5.1 and 5.2, respectively, and included in Appendix B.

Table 5.1 – Summary of IL Consolidation Test Results for Replacement Structure

Borehole	20-08	20-21	20-26
Test Type	IL	IL	IL
Sample No.	ST3	ST4	ST2
Sample Location	Below North Berm	Below South Berm	Below South Approach
Depth (m)	11.6	13.1	15.5
Elevation (m)	240.1	239.2	241.1
Soil Type	Silty Clay	Silty Clay	Silty Clay
Initial moisture content	44.80	58.50	51.90
Unit Weight (kN/m ³)	17.4	15.9	16.8
e ₀ - Initial Void Ratio	1.23	1.67	1.41
P ₀ ' - In situ effective vertical stress (kPa)	140	143	184
P _c ' - Preconsolidation Pressure (kPa)	170	165	200
OCR - Overconsolidation Ratio	1.2	1.2	1.1
C _c - Compression Index	0.435	0.614	0.575
Cr - Recompression Index	0.033	0.052	0.045
C _v – Coefficient of Consolidation in NC range (m ² /yr)	2.8 - 9.4 (avg = 4.9)	1.4 - 1.7 (avg = 1.5)	1.7 - 6.6 (avg = 3.5)

Borehole	20-08	20-21	20-26
Test Type	IL	IL	IL
C_{vr} – Coefficient of Consolidation in OC range (m^2/yr)	6.9 - 10.5 (avg = 9.2)	7.5 - 12.7 (avg = 9.8)	6.5 - 16.9 (avg = 10.0)
C_c / C_r (%)	8%	9%	8%

Table 5.2 – Summary of CRS Consolidation Test Results for Replacement Structure

Borehole	20-08	20-21	20-21
Test Type	CRS	CRS	CRS
Sample No.	ST4	ST2	ST4
Sample Location	Below North Berm	Below South Berm	Below South Berm
Depth (m)	13.1	9.4	13.1
Elevation (m)	238.5	242.9	239.2
Soil Type	Silty Clay	Silty Clay	Silty Clay
Initial moisture content	45.80	39.90	49.20
Unit Weight (kN/m^3)	17.0	16.9	17.8
e_o - Initial Void Ratio	1.32	1.23	1.15
P'_0 - In situ effective vertical stress (kPa)	149	121	143
P'_c - Preconsolidation Pressure (kPa)	165	(*)	(*)
OCR - Overconsolidation Ratio	1.1	(*)	(*)
C_c - Compression Index	0.397	0.255	0.280
C_r - Recompression Index	0.045	0.040	0.028
C_c / C_r (%)	11%	16%	10%

(*) unable to estimate from test results

The results of three (3) Consolidated Isotropically Undrained (CIU) triaxial tests carried out on selected samples of the varved silty clay are presented in Appendix B and summarized below.

Table 5.3 – Summary of Triaxial Test Results

Borehole	20-03	20-08	20-23
Test Type	CIU	CIU	CIU
Sample No.	ST1	ST2	ST1
Sample Location	Below North Approach	Below North Berm	Below South Berm
Depth (m)	14.0	10.1	11.0
Elevation (m)	242.6	241.5	240.3
Soil Type	Silty Clay	Silty Clay	Silty Clay
Initial moisture content	39.9 – 40.5	43.8 – 46.0	48.2 – 48.6



Bulk Unit Weight (kN/m ³)	17.9 – 18.1	17.9	17.2
e _o - Initial Void Ratio (*)	1.10	1.20 – 1.27	1.33 – 1.34
P' ₀ - In situ effective vertical stress (kPa)	216	131	147
Effective Cohesion (kPa)	20	0	0
Friction Angle	29	28	28

(*) based on assumed specific gravity of 2.72

An Unconsolidated Undrained (UU) test was performed on one sample of the varved silty clay, sampled from below the south approach embankment, to assess the undrained shear strength of the clay. The results of the UU test are presented in Appendix B. A compressive strength of 75 kPa was measured in the test, which corresponds to an undrained shear strength of 37.5 kPa for the clay.

A direct simple shear (DSS) was also carried out on a sample of the varved silty clay, sampled from below the south stabilizing berm, to measure the strength of the clay in the horizontal direction (i.e. parallel to the varves). The results are presented in Appendix B. Based on the results, at a normal stress of 150 kPa, which is approximately equal to the estimated vertical in-situ effective stress, the peak and residual friction angle of the clay laminate in the horizontal direction is approximately 18 and 17 degrees, respectively.

5.1.7 Silty Sand Till

A deposit of grey silty sand till was encountered underlying the varved silty clay in all boreholes which penetrated the silty clay at this site. In general, the silty sand till contained trace to some gravel and clay.

The surface of the till was encountered at depths ranging from 11.7 m to 22.6 m (Elev. 239.8 m to 233.2 m) and the till ranged from 0.2 m to 4.8 m in thickness. Cobbles and boulders were encountered in the till in Borehole 20-24. Also, a granite boulder was noted within this till overlying bedrock in Borehole 20-04.

SPT 'N' values obtained in the till ranged from 0 blows (i.e. weight of hammer) per 0.3 m to 100 blows per 0.075 m, indicating highly variable very loose to very dense relative density. Measured moisture contents ranged from 6 to 32%.

The results of grain size distribution tests carried out on selected samples of the silty sand till are shown on Figure B11 in Appendix B and summarized below:

Soil Particle	Percentage (%)
Gravel	9 to 26
Sand	43 to 53



Soil Particle	Percentage (%)
Silt	23 to 29
Clay	8 to 12

The results of Atterberg Limits testing carried out on samples of the fine-grained portion of the silty sand till are shown on Figure B20 in Appendix B and summarized below:

Soil Property	Percentage (%)
Liquid Limit	14 to 16
Plastic Limit	11 to 12
Plasticity Index	2 to 5

The results of the Atterberg Limit testing indicate that the fine-grained portion of the silty sand till has slight plasticity (ML to CL-ML).

Glacial tills inherently contain cobbles and boulders.

5.1.8 Bedrock

Bedrock was confirmed below the silty sand till deposit in all boreholes in which coring was completed (i.e. Boreholes 20-02, 20-04, 20-06, 20-09, 20-10, 20-13 to 20-20, 20-23, 20-24, and 20-26). The table below summarizes the depth to bedrock and the bedrock surface elevations encountered in the boreholes

Table 5.4 – Approximate Bedrock Depth and Elevation

Foundation Element	Borehole No.	Depth to Bedrock Surface (m)	Bedrock Elevation (m)
North Abutment	20-02	24.6	232.0
Pier#7	20-04	19.9	232.5
	20-06	19.9	232.7
Pier #6	20-09	16.5	233.4
	20-10	16.8	233.2
Pier #5	20-13	13.9	234.3
	20-14	13.6	234.4
Pier #4	20-15	13.4	235.0
	20-16	13.9	234.7
Pier #3	20-17	14.5	234.5
	20-18	15.3	233.3



Foundation Element	Borehole No.	Depth to Bedrock Surface (m)	Bedrock Elevation (m)
Pier #2	20-19	14.4	235.5
	20-20	14.8	235.3
Pier #1	20-23	16.5	234.8
	20-24	18.0	234.6
South Abutment	20-26	21.8	234.8

The bedrock consists of interbedded sandstone, limestone and dolostone bedrock and is generally brown to grey in colour. The rock was described as fresh to moderately weathered. Photographs of the recovered rock cores are provided in Appendix B.

Total Core Recovery (TCR) and solid core recovery (SCR) in the core runs ranged from 65% to 100% and 43% to 100%, respectively. The Rock Quality Designation (RQD) determined from the cores recovered ranged from 17 to 100%, with most values greater than 50%, indicating typically fair to excellent rock quality. The Fracture Index (FI) of the rock, expressed as number of fractures per 0.3 m of core, ranged from 0 to greater than 10, but were typically between 0 and 3.

Twelve (12) unconfined compression tests performed on rock cores measured unconfined compressive strengths (UCS) ranging from 41 to 140 MPa, with an average UCS of 72 MPa. The UCS of the rock cores estimated from point load tests ranged from approximately 8 to 180 MPa, with an average UCS of 78 MPa. Based on the results, the rock is classified as weak to very strong, and generally medium strong to strong. The results of point load test results and unconfined compression tests are included in Appendix B.

5.1.9 Groundwater Conditions

Standpipe piezometers (25 mm and 50 mm diameter) were installed at the site to permit measurement of the groundwater level. The depth of the groundwater level was also inferred from porewater pressure response tests completed as part of the cone penetration testing. The groundwater depths and elevations measured in the monitoring wells and inferred from the porewater pressure response tests are summarized in the following table.

Table 5.5 – Summary of Groundwater Level Measurements at Replacement Structure

Location	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
	20-03	May 18, 2021	3.6	253.0	Piezometer



Location	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
North Abutment	SCPT20-03B	November 27, 2020	7.0	249.8	Inferred from CPT Porewater Pressure Response
Pier #7	20-04	May 15, 2021 May 27, 2021	5.2 5.3	247.2 247.1	Piezometer
	SCPT20-01	November 25, 2020	7.0	245.8	Inferred from CPT Porewater Pressure Response
Pier #6	20-10	May 15, 2021 May 27, 2021	2.6 3.0	247.4 247.0	Piezometer
Pier #5	20-13	May 7, 2021 May 15, 2021 May 27, 2021	0.8 1.6 1.7	247.4 246.6 246.5	Piezometer
Pier #4	20-16	May 15, 2021 May 27, 2021	1.9 1.8	246.7 246.8	Piezometer
Pier #3	20-17	May 15, 2021 May 27, 2021	2.5 2.6	246.5 246.4	Piezometer
Pier #2	20-20	May 15, 2021 May 27, 2021	1.7 2.5	248.4 247.6	Piezometer
Pier #1	SCPT20-02	November 27, 2020	1.5	251.0	Inferred from CPT Porewater Pressure Response
South Abutment	20-25	May 9, 2021	2.8	253.8	Piezometer
	SCPT20-06	November 29, 2020	7.0	249.7	Inferred from CPT Porewater Pressure Response
	SCPT20-06B	November 29, 2020	7.0	249.7	Inferred from CPT Porewater Pressure Response

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

5.2 Detour Alignment

In general, the subsurface conditions encountered in the three foundation boreholes advanced along the detour alignment (i.e. Boreholes 20-28 to 20-30) consist of topsoil overlying a relatively thick deposit of varved silty clay underlain by silty sand till.

A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.



5.2.1 Topsoil

A layer of topsoil was encountered at ground surface in the boreholes advanced along the detour alignment. The thickness of the topsoil ranged from 150 mm to 200 mm and the moisture contents on samples of the topsoil ranged from 27 to 35%. Topsoil thickness may vary between boreholes and in other areas of the site.

5.2.2 Silty Clay

A relatively thick deposit of varved silty clay was encountered underlying the topsoil in foundation boreholes advanced along the detour alignment. The varved clay is comprised of a very stiff to stiff weathered crust, approximately 1.5 to 2 m thick, which is underlain by soft to firm un-weathered clay. The thickness of the clay varied from 11.1 m to 18.2 m and the clay extended to depths ranging from 11.3 m to 18.4 m (Elev. 237.2 m and 227.4 m).

SPT 'N' values obtained in the silty clay ranged from 0 (i.e. weight of hammer) to 7 blows per 0.3 m penetration, with the higher 'N' values measured within the crust. Field shear vane tests performed in the un-weathered silty clay measured undrained shear strengths ranging from 16 kPa to 54 kPa, indicating a soft to stiff consistency (generally soft to firm). The sensitivity of the clay ranged from 3 to 12.

Measured moisture contents on samples of the silty clay ranged from 32 to 83%.

Grain size distribution tests were carried out on selected samples of the varved silty clay and a sample of the individual clayey silt laminae and clay laminae. The results of the grain size tests on the varved silty clay are shown on Figure B21, and the results of the testing on the clay laminae and clayey silt laminae are shown on Figures B22 and B23, respectively. The results are also summarized in the table below.

Soil Particle	Varved Silty Clay	Clay Laminae	Clayey Silt Laminae
	Percentage (%)	Percentage (%)	Percentage (%)
Gravel	0	0	0
Sand	0	0	0
Silt	37 to 57	58	19
Clay	43 to 63	42	81

The results of Atterberg Limits tests carried out on the varved silty clay are presented on Figures B25 and B26 in Appendix B. The results of Atterberg Limits tests completed on samples of the clay laminae and clayey silt laminae are shown on Figures B27 and B28, respectively. The results are also summarized below:

Soil Property	Varved Silty Clay	Clay Laminae	Clayey Silt Laminae
	Percentage (%)	Percentage (%)	Percentage (%)
Liquid Limit	37 to 83	63	37
Plastic Limit	18 to 26	26	21
Plasticity Index	16 to 60	37	16

The results of the Atterberg Limit tests indicate that the varved silty clay has intermediate to high plasticity (CI-CH), the clay laminae has high plasticity (CH), and the clayey silt laminae has low to intermediate plasticity (CL-CI).

The results of an incremental loading (IL) consolidation test and a constant rate of strain (CRS) consolidation test performed on samples of the varved silty clay are summarized in Tables 5.6 and 5.7 below, respectively, and included in Appendix B.

Table 5.6 – Summary of IL Consolidation Test Results for Detour Alignment

Borehole	20-29
Test Type	IL
Sample No.	ST1
Sample Location	Detour alignment and ONR track intersection
Depth (m)	1.98
Elevation (m)	245.5
Soil Type	Intact Clay
Initial moisture content	45.40
Bulk Unit Weight (kN/m ³)	17.1
e ₀ - Initial Void Ratio	1.28
P' ₀ - In situ effective vertical stress (kPa)	30
P' _c - Preconsolidation Pressure (kPa)	100
OCR - Overconsolidation Ratio	3.3
C _c - Compression Index	0.491
C _r - Recompression Index	0.034
C _v – Coefficient of Consolidation in NC range (m ² /yr)	4.2 - 8.3 (avg = 6.2)
C _{vr} – Coefficient of Consolidation in OC range (m ² /yr)	10.0 - 19.5 (avg = 12.7)
C _c / C _r (%)	7%

Table 5.7 – Summary of CRS Consolidation Test Results for Detour Alignment

Borehole Test Type	20-29 CRS
Sample No.	ST1
Sample Location	Detour alignment and ONR track intersection
Depth (m)	1.68
Elevation (m)	245.8
Soil Type	Intact Clay
Initial moisture content	56.30
Bulk Unit Weight (kN/m ³)	17.0
e _o - Initial Void Ratio	1.46
P' ₀ - In situ effective vertical stress (kPa)	28
P' _c - Preconsolidation Pressure (kPa)	210
OCR - Overconsolidation Ratio	7.5
C _c - Compression Index	0.650
C _r - Recompression Index	0.055
C _c / C _r (%)	8%

5.2.3 Silty Sand Till

A deposit of grey silty sand till was encountered underlying the varved silty clay in all foundation boreholes advanced along the detour alignment. In general, the silty sand till contained trace to some gravel and clay.

The surface of the till was encountered at depths ranging from 11.3 m to 18.4 m (Elev. 237.2 m to 227.4 m).

SPT 'N' values obtained in the till ranged from 2 to 12 blows per 0.3 m, indicating very loose to compact relative density. Measured moisture contents ranged from 5 to 11%.

The results of a grain size distribution test carried out on a sample of the silty sand till are shown on Figure B24 in Appendix B and summarized below:

Soil Particle	Percentage (%)
Gravel	14
Sand	46
Silt	29
Clay	11

Glacial tills inherently contain cobbles and boulders.

5.2.4 Groundwater Conditions

A standpipe piezometer (50 mm diameter) was installed in Borehole 20-29 to permit measurement of the groundwater level at the location of the detour alignment and ONR track intersection. The groundwater depths and elevations measured in the monitoring well are summarized in the following table.

Table 5.8 – Summary of Groundwater Level Measurements at Detour Alignment

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
20-29	May 15, 2021	6.5	241.0	Piezometer
	May 27, 2021	1.5	246.0	

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

6. CORROSIVITY AND SULPHATE ATTACK TEST RESULTS

Four (4) samples of the fill materials were submitted for laboratory testing to evaluate the potential for soil corrosion and sulphate attack on buried concrete structures. The results of the testing are provided in Appendix F and are summarized below.

Table 6.1 – Summary of Corrosivity Test Results

Parameter	Borehole / Sample Number			
	20-03 / SS6	20-08 / SS3	20-21 / SS3	20-25 / SS6
	Sandy to Silty Sand Fill	Silty Sand Fill	Silty Sand Fill	Sandy to Silty Sand Fill
	Depth = 4.6 m – 4.9 m	Depth = 1.5 m – 1.8 m	Depth = 1.5 m – 1.8 m	Depth = 4.6 m – 4.9m
Resistivity (ohm-cm)	3480	2310	5080	5680
pH	8.49	9.24	9.21	8.78
Redox Potential (mV)	260	249	248	230
Chlorides (µg/g)	200	220	92	190
Sulphates (µg/g)	39	50	16	22
Electrical Conductivity (mS/cm)	287	432	197	176
Sodium Absorption Ratio	1.0	7.3	1.4	1.3



7. MISCELLANEOUS

The coordinates of the boreholes were measured using a hand-held GPS device and measured relative to existing site features (e.g. piers, abutments). The ground surface elevations of the boreholes were provided by WSP and determined from the base plan. Prior to commencing the site investigation, utility clearances were obtained for all borehole locations.

George Downing Estate Drilling Ltd. of Hawkesbury, Ontario, supplied and operated drill rigs for the drilling, sampling and in-situ testing operations for the field investigation. All boreholes were completed using a track-mounted drill rig.

Conetec Investigations Ltd., of Richmond Hill, Ontario, supplied and operated the piezocone equipment.

Ontario National Railway (ONR) provided track flagging services required during the drilling of the boreholes near the railway track.

The borehole drilling was supervised on a full-time basis by Mr. Gregory Forrest, who logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing. Overall supervision of the field program was performed by Mr. Geoff Lay, P.Eng., and Mr. Joshua Alexander, E.I.T., of Thurber.

Routine soil classification testing and advanced laboratory testing was performed by Thurber. Additional triaxial testing and direct shear testing was performed by Golder.

Interpretation of the field data and preparation of the report was performed by Mr. Geoff Lay, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Thurber Engineering Ltd.



Geoff Lay, P.Eng.
Geotechnical Engineer



Jason Lee, P.Eng.
Principal, Senior Geotechnical Engineer



Dr. P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



**FOUNDATION INVESTIGATION AND DESIGN REPORT
REPLACEMENT OF THE ONTARIO NORTHLAND RAILWAY (ONR)
OVERHEAD BRIDGE
HIGHWAY 11 AT EARLTON
TOWNSHIP OF ARMSTRONG
G.W.P. 5101-17-00**

GEOCRES NO. 31M-132

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for the design and construction of the proposed replacement structure for Ontario Northland Railway (ONR) overhead bridge in Earlton, Ontario.

This foundation investigation and design report with the interpretations and recommendations is 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 contractors. Contractors must make their own interpretations 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 existing nine-span ONR overhead structure was constructed in 1961 and is supported on 14BP73 piles driven to bedrock. The existing concrete girder bridge is approximately 135 m long and 11 m wide and spans a single ONR track and Rivard Road (formerly Government Road). The approach embankments to the structure are in the order of 9 m high with two levels of stabilizing berms which extend along the sides and front of the approach embankments. The lower berm is approximately 3 m high and 10 m wide, while the upper berm is approximately 6 m high and 17 m wide, with the width of the berms decreasing towards the north and south.

It is noted that two failures occurred during original construction of the approach embankments at this site. In the 1930s, the south approach embankment failed after the embankment was constructed to a height of 8 m with 1.5H:1V side slopes. Then in 1959, a second failure of the south approach embankment occurred immediately or soon after the embankment was reconstructed to a height of 9 m.

As per the Golder Preliminary Report (Reference 1), a rehabilitation drawing for the existing structure dated March 1982 indicates settlement of the north approach embankment of about 350



mm immediately behind the abutment. Additionally, based on discussions with MTO Maintenance, it is understood that there have been a history of maintenance issues at the site which have reportedly necessitated repairs as follows:

- In 2017, the asphalt at the approaches to the overhead structure was milled and repaved to address pavement cracking.
- In 2018, grout was injected beneath the north approach slab immediately behind the north bridge abutment to fill several large voids beneath the approach slab.

Two bridge alternatives were initially considered for the proposed replacement structure as follows:

- Alternative 1: Replacement of the ONR Overhead bridge on the same alignment, with an eight (8) span structure, with the same total bridge length of approximately 140 m; and
- Alternative 2: Replacement of the ONR Overhead bridge on the same alignment, with a six (6) span structure, with a shorter bridge length of approximately 90 m.

Preliminary slope stability and settlement analyses were carried out by Thurber to assess the global stability of the embankments and the settlements of the foundation soils to be anticipated under the embankment loading. The results of the analyses were presented in Thurber's Technical Memorandum titled "Pre-Detailed Design Foundation Investigation", dated April 14, 2021. As per the memo, two options were considered for the 90m bridge alternative, with the first option involving staged embankment construction using stabilizing berms, wick drains, and surcharge, and the second option involving installation of lightweight EPS. However, while the 90m bridge alternative was determined to be feasible, the memo identified several concerns associated with the 90 m bridge option as follows:

- The foundations soils are expected to be partially disturbed given the previous embankment failures that occurred at the site. Placing new fill for the 90 m bridge approach embankments could potentially trigger another failure along a historic failure surface.
- Placement of new fill for berm construction has the potential to cause settlement of the existing ONR track.
- There is insufficient space between the forward embankment slopes and the railway track to construct the 25 m wide berms required.
- Removal of any existing fill could potentially destabilize the existing embankment.
- Potential difficulties installing wick drains through the very dense granular fills.



- Long-term settlement due to secondary consolidation may be higher than anticipated due to potential preloading/surcharge time constraints during construction.

In light of the above concerns, it was decided between MTO, WSP and Thurber that the 90m bridge was not a viable option at this site and that the 140m bridge option was preferable from a risk perspective. Consequently, it was agreed that the project would proceed with the 140m bridge option.

A preliminary General Arrangement (GA) drawing prepared by MTO, dated August 2021, indicates that the proposed 140 m long replacement structure will be an eight-span structure supported on piles driven to bedrock. The structure will be constructed along the same alignment as the existing nine-span bridge.

The GA drawing further indicates that the grade at the north and south approaches will be lowered approximately 0.5 m immediately behind the abutments and that new fill will be placed on the embankment side slopes to permit slight embankment widening. It is also understood that EPS will also be installed behind the abutments in order to reduce the lateral load on the abutments and that wing walls will be constructed from the ends of the abutments at all four quadrants of the bridge.

The existing bridge will be demolished and a temporary detour embankment will be constructed approximately 100 m east of the existing bridge to maintain the live traffic lanes on Highway 11 during construction of the proposed replacement structure. It is understood that the Highway 11 detour will cross the ONR track at the same grade.

The discussion and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of the investigation.

9. FOUNDATION DESIGN

In general, the subsurface conditions at the site of the proposed replacement structure consist of asphalt (where present) overlying cohesionless fill (i.e. sand and gravel fill and sand to silty sand fill) above localized topsoil and silty clay fill layers overlying a relatively thick deposit of compressible varved silty clay. The upper portion of the clay is consistent with a weathered crust and the clay deposit underlain by a deposit of silty sand till which in turn is underlain by sandstone/limestone bedrock.

The thickness of the clay ranges from about 4.5 m to 12.8 m and generally decreased towards the south. The surface of the bedrock was encountered approximately 13.4 m to 24.6 m below ground surface (Elev. 235.5 m to 232.0 m) and generally increased in elevation towards the south. The groundwater level in monitoring wells installed through the top of the north and south approach embankments was measured at depths of 3.6 m (Elev. 253.0 m) and 2.8 m (Elev. 253.8



m), respectively. The ground water level measured in wells installed beneath the bridge ranged from approximately 0.8 m to 5.3 m below ground surface (Elev. 248.4 m to 246.4 m).

The results of in-situ and laboratory tests performed on the varved silty clay deposit are summarized graphically in Appendix E.

Due to the presence and thickness of the varved clay deposit at this site, the potential for large settlements, and the excavation depth required to reach competent native soils, spread footings are not feasible at this site, and only deep foundations are considered suitable to support the replacement structure piers/abutments. Based on the subsurface conditions, initial consideration was given to the following deep foundation options:

- Driven steel H-piles
- Driven steel pipe piles
- Drilled shafts/Caissons

Steel H-piles driven to refusal on bedrock are considered feasible to support the replacement structure piers/abutments. This option would permit integral abutment design and is recommended.

Driven steel pipe piles are also considered feasible. However, there is generally higher risk with pipe piles getting caught on the cobbles and boulders in the till overlying the bedrock. Furthermore, they are not a suitable option for an abutment foundation for an integral abutment bridge. Consequently, this option has not been developed further.

Caissons socketed into bedrock are also considered feasible and would provide higher axial resistance relative to steel H-piles. The caissons would need to be installed through the cohesionless silty sand till below the groundwater table and would require use of liners and synthetic slurry. This option also is not compatible as an abutment foundation for an integral abutment bridge. Consequently, this option is not recommended and has not been developed further.

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix G. From a geotechnical and cost effectiveness perspective, the preferred foundation alternative for the new replacement structure is H-piles driven to bedrock. The subsurface conditions encountered at this site are considered suitable for use of integral abutments.



9.1 Driven H-Piles

The GA drawing indicates that the bridge abutments and piers will be supported on driven H-piles. Steel H-piles driven to refusal on bedrock are considered suitable for supporting the bridge abutments and piers.

9.1.1 Axial Resistance

For an HP 310x110 driven to dolostone bedrock, a factored geotechnical resistance at ULS of 2,000 kN per pile is recommended. For an HP 310x132 driven to dolostone bedrock, a factored geotechnical resistance at ULS of 2,400 kN per pile is recommended. The SLS condition will not govern for piles founded on the bedrock. The structural resistance of the pile must be checked by the structural designer.

The table below provides a summary of the approximate bedrock elevation and estimated pile length at each abutment/pier.

Table 9.1 – Approximate Bedrock Elevation and Estimated Pile Lengths at Each Foundation Element

Location (Reference Borehole)	Approximate Underside of Pile Cap (m)	Approximate Bedrock Elevation (m)	Estimated Pile Length (m)
North Abutment (20-02 & 20-03 & ONR-4)	252.5	232.0 – 231.8	20.5 – 20.7
Pier#7 (20-04 & 20-06 & 20-08)	251.0	232.7 – 232.5	18.3 – 18.5
Pier #6 (20-09 & 20-10 & ONR-3)	247.5	233.4 – 233.2	14.1 – 14.3
Pier #5 (20-13 & 20-14)	245.8	234.4 – 234.3	11.4 – 11.5
Pier #4 (20-15 & 20-16)	245.8	235.0 – 234.7	10.8 – 11.1
Pier #3 (20-17 & 20-18 & ONR-2)	246.8	234.5 – 233.3	12.3 – 13.5
Pier #2 (20-19 & 20-20)	247.5	235.5 – 235.3	12.0 – 12.2
Pier #1 (20-21 & 20-23 & 20-24)	250.2	234.8 – 234.6	15.4 – 15.6



Location (Reference Borehole)	Approximate Underside of Pile Cap (m)	Approximate Bedrock Elevation (m)	Estimated Pile Length (m)
South Abutment (20-25 & 20-26 & ONR-1)	252.7	235.0 – 234.8	17.7 – 17.9

9.1.2 Downdrag

In light of the minimum amount of additional fill proposed at this site, downdrag on the piles driven to bedrock is not expected to be an issue.

9.1.3 H-Pile Installation

Pile installation should be in accordance with OPSS.PROV 903 and SP 109F57.

The piles must be driven to bedrock. The appropriate pile driving note is “Piles to be driven to bedrock”.

Driven steel H-piles may encounter very dense zones and cobbles/boulders within the embankment fill and till deposit above the bedrock. The Contractor must employ suitable equipment and methods to penetrate any very dense zones and cobbles/boulders encountered during pile installation and advance the piles to bedrock.

Due to the presence of very dense zones and cobbles/boulders, pile tip protection is recommended for driven H-piles to prevent pile damage while driving the piles through the till and setting the piles on the bedrock. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent. The Contract Documents must contain a NSSP alerting the Bidders to the presence of very dense zones and cobbles/boulders. Suggested texts for the NSSP’s are included in Appendix J.

The new piles should be located such as to not interfere with the existing piles. It is recommended that piles in close proximity to new piles be exposed prior to new pile installation to confirm/verify the location of the existing piles.

Vibrations produced during pile driving may cause settlement of the existing ONR track. Vibration and settlement monitoring of the existing ONR track must be carried out during pile driving for Piers #4 and #5 near the ONR track. The energy chosen for pile driving should be selected such that vibrations at the track do not exceed the recommended vibration limits. Further details on geotechnical monitoring are provided in Section 20. NSSPs addressing vibration and settlement monitoring of the ONR track are included in Appendix J.



9.1.4 Lateral Resistances

The geotechnical lateral resistance in the cohesionless soils may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where: z = depth of embedment of pile (m)

D = pile width in metres (0.310 m for HP 310x110)

n_h = coefficient related to soil relative density (kN/m^3)

γ' = effective unit weight (kN/m^3)

K_p = passive earth pressure coefficient

The geotechnical lateral resistance acting on a pile in cohesive soils may be calculated using a value of the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = 67 s_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 s_u \quad (\text{kPa})$$

Where: s_u = undrained shear strength (kPa)

D = pile width in metres (0.310 m for HP 310x110)

The above equations and recommended parameters in the following table may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.



Table 9.2 – Soil Parameters for Lateral Pile Resistance

Layer	Top Level	Bot. Level	γ (kN/m ³)	nh (kN/m ³)	Kp	Su (kPa)
North Abutment (20-02 & 20-03 & ONR-4)						
Sand to Silty Sand Fill - Compact to Dense	252.5	249.5	21	4000	3.0	
Sand to Silty Sand Fill - Loose	249.5	248	20	2000	3.0	
Silty Clay Fill	248	245.5	8(*)			25
Clay Crust	245.5	243.7	8(*)			85
Varved Clay Upper	243.7	240.7	6(*)			45
Varved Clay Lower	240.7	234	6(*)			50
Till	234	232	10(*)	2000	3.0	
Pier #7 (20-04 & 20-06 & 20-08)						
Sand to Silty Sand Fill - Compact to Dense	251	248	21	4000	3.0	
Sand to Silty Sand Fill - Loose	248	247	20	2000	3.0	
Silty Clay Fill - Firm	247	246	8(*)			50
Clay Crust	246	245	8(*)			50
Varved Clay Upper	245	240.7	6(*)			35
Varved Clay Lower	240.7	235	6(*)			40
Till	235	232.5	10(*)	2000	3.0	
Pier #6 (20-09 & 20-10 & ONR-3)						
Silty Clay Fill	247.5	247	8(*)			30
Clay Crust	247	245.5	8(*)			45
Varved Clay Upper	245.5	243	6(*)			19
Varved Clay Lower	243	235	6(*)			25
Till	235	233.4	10(*)	1000	2.8	
Pier #5 (20-13 & 20-14)						
Clay Crust	245.8	245.5	8(*)			45
Varved Clay Upper	245.5	243	6(*)			19
Varved Clay Lower	243	235	6(*)			25
Till	235	234.4	10(*)	1000	2.8	
Pier #4 (20-15 & 20-16)						
Clay Crust	245.8	245.5	8(*)			45
Varved Clay Upper	245.5	243	6(*)			19



Layer	Top Level	Bot. Level	γ (kN/m ³)	nh (kN/m ³)	Kp	Su (kPa)
Varved Clay Lower	243	236.8	6(*)			25
Till	236.8	235	10(*)	1000	2.8	
Pier #3 (20-17 & 20-18 & ONR-2)						
Clay Crust	246.8	245.5	8(*)			45
Varved Clay Upper	245.5	243	6(*)			19
Varved Clay Lower	243	236.4	6(*)			25
Till	236.4	234.5	10(*)	1000	2.8	
Pier #2 (20-19 & 20-20)						
Clay Crust	247.5	245.5	8(*)			45
Varved Clay Upper	245.5	243	6(*)			19
Varved Clay Lower	243	235.7	6(*)			25
Till	235.7	235.5	10(*)	1000	2.8	
Pier #1 (20-21 & 20-23 & 20-24)						
Silty Sand Fill - Loose	250.2	245	10(*)	2000	3.0	
Clay Crust	245	244.5	8(*)			50
Varved Clay Upper	244.5	240.7	6(*)			35
Varved Clay Lower	240.7	237.5	6(*)			40
Till	237.5	236.4	10(*)	2000	3.0	
South Abutment (20-25 & 20-26 & ONR-1)						
Sand to Silty Sand - Compact	252.5	249.5	21	4000	3.0	
Sand to Silty Sand - Loose to Compact	249.5	244.4	10(*)	2000	3.0	
Clay Crust	244.4	243.7	8(*)			85
Varved Clay Upper	243.7	240.7	6(*)			45
Varved Clay Lower	240.7	239.3	6(*)			50
Till	239.3	235	10(*)	2000	3.0	

(*): Submerged unit weights

The spring constant, K_s , for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which the soil fails and will not support any additional load at greater pile displacement.



The modulus of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Section C6.11.3.4 of CHBDC Commentary (2019).

9.2 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system. Reference should be made to MTO's integral abutment manual for details of this system.

9.3 Frost Cover

The design depth of frost penetration for this site is 2.3 m as per OPSD 3090.100. The undersides of all pile caps/abutment stems must be provided with at least 2.3 m of soil cover as protection against frost action.

10. ABUTMENT BACKFILL AND LATERAL EARTH PRESSURES

10.1 Granular Backfill

Backfill to the abutments and retaining walls should consist of free-draining granular material conforming to OPSS.PROV 1010 Granular A. The granular material should be placed to the extents shown in OPSD 3101.150 where applicable. Compaction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501. Compaction effects should be considered in accordance with Clause 6.12.3 of the CHBDC.

Static earth pressures acting on the structures may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p = K (\gamma h + q)$$

Where:	p	=	horizontal earth pressure on the wall at depth h (kPa)
	K	=	lateral earth pressure coefficient (see table below)
	γ	=	unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

The static earth pressure coefficients depend on the material used as backfill. Recommended unfactored values are shown in Table 9.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls or unrestrained walls. Seismic earth pressure coefficients are provided in Section 14.

Table 9.1 – Static Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (K_a) (Unrestrained Wall)	0.27	0.39
At-rest (K_o) (Restrained Wall)	0.43	-
Passive (K_p)	3.7	-

The active and passive earth pressure coefficients in Table 9.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls. Reference should be made to OPSD 3101.150.

10.2 EPS Blocks

Should consideration be given to reducing lateral earth pressures on the abutment walls, lightweight EPS fill blocks may be installed behind the abutments. Horizontal stress from the EPS blocks is expected to be negligible provided the interface slope between the embankment fill and the EPS is inclined at 3H:1V.

For abutment walls with EPS backfill, reference should be made to the procedures in the TRB NCHRP Report 529 Section 6 Abutment Design for design purposes.



The design of the EPS blocks should be carried out by the structural designer based on the loading requirements on the abutment wall. Design considerations should include the thickness and grade of EPS, creep deformation and strength of the EPS blocks, installation of a polyethylene cover, and the like. It is understood that the pavement design has included the installation of a concrete cap above the EPS blocks and that recommended pavement designs have been provided separately under the Pavement Design Report based on the grade (density) of EPS to be used for this embankment.

A general sketch for a potential EPS configuration behind the abutments is attached in Appendix K.

It is recommended that drainage measures be provided, where applicable, to enhance positive drainage from the EPS blocks behind the abutment walls.

11. EPS SUBGRADE PREPARATION AND INSTALLATION

It is anticipated that the EPS blocks will have a founding subgrade of compact to very dense sand to silty sand fill. Any softened, loosened or deleterious materials at the EPS founding elevation must be subexcavated and replaced with OPSS.PROV 1010 Granular A material. The EPS subgrade must be free from deleterious, loose, or otherwise unsuitable soils. Embankment subgrade preparation must be carried out in accordance with OPSS.PROV 206.

Prior to placing the EPS blocks, it is recommended that a levelling pad be constructed on the existing fill subgrade by placing, levelling and compacting a 150 mm thick layer of OPSS.PROV 1010 Granular A material to 95% Standard Proctor Maximum Dry Density (SPMDD). Any granular fill placed above the EPS blocks must also consist of Granular A compacted in accordance with OPSS.PROV 501. The compaction efforts must not damage the EPS blocks.

An example NSSP for installation of EPS blocks are provided in Appendix J. It is noted that the technical requirements will depend on the adopted design for this site as well as requirements of the proprietary supplier, and are therefore subject to change.

12. APPROACH EMBANKMENTS

The existing approach embankments to the overhead structure are in the order of 10 m high. Based on the GA drawing, it is understood that the grade will be lowered about 0.5 m immediately behind the abutments and that up to 1 m of fill will be placed on the side slopes to permit slight embankment widening. Fill will also be placed on the forward slope in front of the north and south abutments as frost cover for the pile cap.



12.1 Stability Analysis

Stability analyses were carried out to assess the global stability of the existing approach embankments and the stability of the approaches following the proposed grade lowering and embankment widening. The stability analyses were carried out utilizing the commercially available slope stability program Slope/W (Version 10) of the GeoStudio software package developed by GEOSLOPE International Ltd using Morgenstern Price method of slices.

The global stability analyses were carried out for the existing, short-term (undrained), long term (drained), and seismic loading conditions. The analyses under seismic loading were performed using a pseudo-static slope stability analysis. A horizontal seismic coefficient, k_h of 0.103 g (i.e. half of the peak ground acceleration) was assumed for the seismic stability analysis.

The results of the stability analyses are presented on the stability figures included in Appendix H. The computed FOS are summarized in Table 12.1 below.

Table 12.1 – Summary of Stability Analysis Results

Location	Approximate Chainage	Slope Inclination	Condition	Factor of Safety	Figure
North Approach East Side	17+723	2H:1V	Existing	1.37	H1
			Short-Term	1.37	H2
			Long-Term (Drained)	1.38	H3
North Approach West Side	17+723	2H:1V	Short-Term	1.39	H4
			Long-Term (Drained)	1.39	H5
South Approach East Side	17+571	2H:1V	Existing	1.50	H6
			Short-Term	1.53	H7
			Long-Term (Drained)	1.53	H8
South Approach West Side	17+571	2H:1V	Short-Term	1.50	H9
			Long-Term (Drained)	1.50	H10
South Approach 45 Degree Section	17+565	2H:1V	Existing	1.52	H11
			Short-Term	1.54	H12
			Long-Term (Drained)	1.54	H13
South Approach Forward Slope	17+600	-	Existing	1.81	H14
			Short-Term	1.79	H15
			Long-Term (Drained)	1.79	H16
			Pseudo-Static	1.0	H17



FOS ranging from 1.37 to 1.81 were computed for the existing embankments indicating that the embankments are currently stable. The computed FOS under short-term and long-term conditions ranged from 1.37 to 1.79 indicating that the combined proposed grade lowering and fill placement will have minimal effect on the global stability of the approach embankments with most of the FOS increasing slightly following grade lowering and fill placement. For the pseudo-static condition, a FOS of 1.0 was computed, which exceeds the minimum FOS 1.0 for this condition. The computed FOS are considered acceptable indicating that the embankment widening and new forward slope may be constructed using Granular A at a 2H:1V side slope inclination.

12.2 Embankment Settlement

12.2.1 Foundation Settlement

Settlement analyses were carried out for the proposed grade raise along the approach embankments to assess the magnitudes and rates of foundation settlements during construction and post construction (long term) using the commercially available software Settle3D developed by Rocscience. The geotechnical parameters used in the settlement analyses were determined from the results of the consolidation tests and verified against empirical soil index correlations.

The currently applicable MTO embankment settlement criteria for design (July 2010) stipulates that the acceptable post-construction settlement are: 25 mm for the first 20 m behind the new abutments, and 50 mm between 20 m and 50 m behind the new abutments, 75 mm between 50 m and 75 m behind the new abutments, and 100 mm greater than 75 m behind the abutments. The maximum differential settlement must not exceed 200:1.

Based on the settlement analysis, the combined effect of the 0.5 m grade lowering and 1 m of fill placement on the embankment side slopes is estimated to produce approximately 10 to 30 mm of foundation settlement beneath the road platform and up to 40 mm at the side slope. Settlement is not expected to be an issue immediately behind the abutments where lightweight EPS will be installed. Ground settlements across the width of the embankment are shown in Appendix I.

Based on cross-sections provided by WSP, fill will also be placed on the forward slope in front of the north and south abutments as frost cover for the pile caps. However, the cross-sections indicate that the fill will be placed primarily within a cut and therefore foundation settlements due to the forward slope fill placement are expected to be negligible.



It is recommended that the proposed 1 m fill placement on side slopes be performed as early as possible to allow for settlement to take place during construction and limit post construction settlements to less than 25 mm.

12.2.2 Self-Compression

Self-compression of the compacted granular fill is estimated to be approximately 0.5% of the fill height. Post-construction settlement due to granular fill compression has been estimated at 0.25% of the embankment height. Given the small amount of new fill proposed, self-compression of the granular fill is expected to be negligible.

The creep deformation and required grade of the EPS blocks should be designed in accordance with TRB NCHRP Report 529.

12.3 Embankment Construction

Embankment subgrade preparation and embankment construction should be carried out in accordance with OPSS.PROV 206 and OPSS.PROV 501. The embankment widening and new forward slopes should be constructed using OPSS.PROV 1010 Granular A at a 2H:1V side slope inclination. The granular fill should be compacted to at least 98% SPMDD in maximum 200 mm thick lifts. Where new embankment fill is placed against existing embankment slopes or on a natural sloping ground surface, the existing slope must be benched in accordance with OPSD 208.010. All topsoil, organic materials, loose or soft fill or native soils, and any deleterious materials shall be removed within the footprint of new fill placement.

12.4 Erosion Protection

The new fill embankment slopes must be provided with erosion protection in accordance with OPSS.PROV 804. Design and implementation of the erosion protection works should include consideration of the surficial stability under heavy, prolonged rainfall and spring thaw conditions. Vegetation must be sufficiently established before the onset of winter. Asphalt curb and/or asphalt gutter may also be considered as per OPSD 601.010.

13. EXCAVATION AND GROUNDWATER CONTROL

The excavations for pile cap construction at abutments will extend primarily through compact to very dense sand to silty sand fill. The excavations at the piers will extend through sand to silty sand fill and locally into the underlying varved silty clay deposit. All excavations must be carried out in accordance with OPSS.PROV 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope requirements in compliance with the OHSA, the



compact to very dense sand to silty sand fill is classified as Type 2 soil above the water level and Type 3 soil below the water level. The stability of any temporary excavations within the varved clay must be assessed. Any temporary excavations within in the vicinity of the railway track must be supported by temporary shoring.

In general, the excavations at the abutments are expected to remain above the water level while the majority of excavations at the piers are expected to extend below the water level. Groundwater control measures such as perimeter ditches and pumping from filtered sumps are expected to be adequate to remove any accumulation of water from the excavations prior to placing concrete. Additional pumps may be required if localized zones of perched water are encountered with the fill materials. All pile caps must be constructed in the dry.

It is recommended that the depth of temporary excavations near the railway track be kept to a minimum to minimize the potential for track settlement due to groundwater drawdown. Temporary excavations must not cause settlement of the existing ONR track.

The selection of the method of excavation, temporary shoring, and dewatering is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions.

In light of the history of embankment instability at this site, and considering the soft nature of the varved clay, excavated soils and/or construction materials must not be stockpiled anywhere on the top or the sides of the north and south approach embankments, or near the crest of any temporary excavations to minimize the potential for embankment/excavation instability. An NSSP speaking to this is provided in Appendix J.

Large excavations into the existing stabilizing berms should be avoided and all excavations must be carried out in a manner that avoids destabilising the existing embankment, ONR tracks, and any buried utilities. Wherever possible, it is recommended that the existing bridge foundations and pile caps be left in place.

14. SEISMIC CONSIDERATIONS

The selection of the seismic site class is based on the soil conditions encountered in the upper 30 m of the stratigraphy. The site is predominantly underlain by a deposit of soft to stiff varved silty clay. This corresponds to a Seismic Site Class E in accordance with Table 4.1 of the CHBDC 2019. The peak ground acceleration, PGA, for a 2,475-year return period earthquake at this site is 0.114 g as per the National Building Code of Canada (NBCC) for Site Class C. The NBCC seismic hazard values for this site are included in Appendix L.

In accordance with Clause 6.14.7.2 of the CHBDC 2019, the increase in lateral earth pressure on abutments and retaining walls from seismic loading should be considered in the design. The



abutments and walls should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 10.1, plus the earthquake-induced dynamic earth pressure. The total pressure distribution (static plus seismic) may be determined as follows:

$$P_h(d) = K \gamma' d + (K_{AE} - K) \gamma' (H-d)$$

Where:

- $P_h(d)$ = Lateral earth pressure at depth d (kPa);
- K = Static at rest earth pressure coefficient, K_o to be used for restrained walls;
- K = Static active earth pressure coefficient, K_a to be used for non-restrained walls;
- K_{AE} = Seismic active earth pressure coefficient;
- γ' = Effective unit weight of the backfill soil (kN/m³);
- d = Depth below the top of the wall (m); and
- H = Total height of the wall above the toe (m).

For Site Class E and a reference PGA of 0.206 g, the coefficients of horizontal earth pressure for seismic loading presented in Table 14.1 below may be used:

Table 14.1 – Lateral Earth Pressure Coefficients during Earthquake (K_E)

Loading Condition	OPSS Granular A $\phi' = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$
Active (K_{AE})*	0.40
At-rest (K_{OE})**	0.84
Passive (K_{PE})	3.3

* After Mononobe and Okabe

** After Woods

In light of the properties of the clay and the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

15. EXISTING UTILITIES AND ADJACENT STRUCTURES

It is recommended that the exact locations of any existing utilities including railway utilities be established by the designer, and compared with the extent of the potential work zones related to the construction of the proposed structure and associated works. These utilities must not be damaged during construction. Wherever fill is to be placed over a buried utility, an assessment



of the impact of the fill placement on the settlement of the utility should be carried out. If necessary, protection and/or relocation of affected utilities may be required.

16. CORROSIVITY AND SULPHATE ATTACK POTENTIAL;

The results of the corrosivity and sulphate analytical tests indicate the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding fill and native soils is considered to be negligible due to the low concentration of sulphate and chloride in the samples.
- The potential for soil corrosion on metal is considered to be mild to moderate based on the low resistivity values measured on the samples.
- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should be also considered.

17. DEMOLITION OF EXISTING STRUCTURE

Demolition of the existing bridge abutment and piers must be performed carefully and must not destabilize the existing embankment slopes, ONR track, and any buried utilities. Wherever possible, it is recommended that the existing bridge foundations and pile caps be left in place.

The use of heavy construction equipment and in particular heavy lift cranes may be required during removal of the existing bridge girders and deck and may be required during erection of the new bridge. The impact of the heavy equipment loads on the existing embankment supported on soft varved clay and the existing bridge foundations must be considered during selection of the methodology and equipment employed for construction.

Prior to the commencement of construction, the Contractor must retain a Geotechnical Consultant to carry out a Geotechnical Assessment of the following:

- The impact of the proposed equipment loads and methodology
- The capability of the subgrade soils to support the proposed construction equipment and any temporary structures or fill (i.e. as a pad for crane support)
- The requirements and/or restrictions necessary to safely support the loads.

The design and safety of any temporary works is the responsibility of the Contractor. Recommended wording for an NSSP addressing this issue is provided in Appendix J.



18. ERECTION OF FALSEWORK

Temporary falsework may be required at this site to permit construction of the bridge superstructure. In light of the soft varved clays present at this site, falsework supported on shallow foundations may experience large differential settlements or foundation/bearing capacity failure. The falsework may also cause settlement of the existing ONR track.

The design and construction of temporary falsework is the responsibility of the Contractor. The actual load(s) acting on the soils is a function of the foundation type and construction sequence, and these factors should be taken into consideration when designing the temporary falsework. All temporary falsework should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate falsework system. Prior to the commencement of construction, the Contractor must also retain a Geotechnical Consultant to assess the stability and settlement impact of the proposed falsework loads and determine the means and methodology to safely support the falsework loads while avoiding foundation/bearing capacity failure and limiting settlement of the ONR track and bridge superstructure to tolerable limits. Suggested wording for an NSSP is provided in Appendix J.

19. DETOUR EMBANKMENT

A temporary detour embankment will be constructed to the east of the existing bridge to maintain the live traffic lanes of Highway 11 during construction of the proposed replacement structure. The detour will be approximately 1.5 km in length with fill sections up to approximately 1.5 m thick. It is understood that the detour embankment will be constructed with Granular B Type I and that the detour embankment will be removed following completion of the replacement structure.

Recommendations for the detour embankment are provided separately in the Thurber Draft Pavement Design Report titled "Highway 11 – ONR Overhead Structure Replacement", dated September 13, 2021.

20. ONR TRACK SETTLEMENT

Construction of the detour embankment east of the bridge may induce settlement of the ONR track. Provided drawings indicate that up to 1.5 m of fill will be placed adjacent to the railway embankment. A settlement analysis estimated that approximately 5 to 15 mm of ground settlement will occur at the railway track due to the construction of the 1.5 m high detour embankment over the 2 year service life of the Highway 11 detour. Away from the track, it is estimated that the detour fills will cause approximately 40 to 50 mm of foundation settlement. Ground settlements along the detour embankment centerline and ONR track centreline are shown



in Figures I1 and I2 included in Appendix I, respectively. The detour pavement should be maintained periodically to compensate for settlement and pavement cracking as necessary.

21. GEOTECHNICAL MONITORING

Given that foundation excavation and pile driving for Piers #4 and #5 will be carried out in close proximity to the existing ONR track, and considering that fill placement for the detour embankment may induce settlement of the track, geotechnical monitoring should be carried out to monitor vibrations and settlements at the ONR track during construction within the ONR right-of-way. The monitoring program should address types of settlement monitoring instruments, settlement data collection and interpretation, settlement and vibration threshold levels (review and alert) and corresponding plan of response actions. The response actions will address corrective measures, if necessary, in the event of exceedances. The settlement threshold levels are typically specified by the railway authority.

Two NSSPs (Supply and Installation of Railway Monitoring Equipment and Monitoring Program) addressing the geotechnical monitoring are included in Appendix J along with monitoring drawings.

22. TEMPORARY PROTECTION SYSTEMS

Depending on the depth of excavation, temporary protection systems may be required to support the ONR track during excavation and construction of Piers #4 and #5. The temporary protection systems must be implemented in accordance with OPSS.PROV 539 and designed for the Performance Level specified by the railway authority.

The design and construction of temporary protection system is the responsibility of the Contractor. The actual lateral pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors should be taken into consideration when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs, who will determine an appropriate support system. The temporary protection system must be designed to support the loading applied by the ONR train and any construction equipment. Monitoring of the temporary protection system for any movement should be carried out by the Contractor over its service life until the excavation is backfilled.

The soil parameters in the table below may be used for design of temporary protection systems with horizontal retained ground surface.

Table 22.1 – Design Parameters for Temporary Protection Systems

Soil Parameter	Sand Fill	Native Silty Clay
γ (total unit weight)	20 kN/m ³	16 kN/m ³
γ' (effective unit weight)	10 kN/m ³	6 kN/m ³
K_a	0.33	0.37
K_p	3.0	2.7

Hydrostatic pressure should be considered assuming a water level at the existing ground surface for the temporary protection design.

23. SUMMARY OF CONSTRUCTION CONCERNS

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

- Driven steel H-piles may encounter very dense zones and cobbles/boulders within the embankment fill and till deposit overlying the bedrock. The Contractor must employ suitable equipment and methods to penetrate any very dense zones and cobbles/boulders encountered during pile installation and advance the piles to bedrock.
- The site has a history of embankment instability. Large excavations into the existing stabilizing berms should be avoided and all excavations must be carried out in a manner that avoids destabilising the existing embankment, ONR tracks, and any buried utilities. Wherever possible, it is recommended that the existing bridge foundations and pile caps be left in place.
- Underground utilities may be present in the area which may be impacted by construction activities. The locations and elevations of any other underground utilities should be confirmed prior to construction, and protective measures and/or relocation carried out to avoid damage.
- The new piles will be installed in close proximity to the existing piles. The new piles should be located such as to not interfere with the existing piles. It is recommended that piles in close proximity to new piles be exposed prior to new pile installation to confirm/verify the location of the existing piles.
- Foundation excavation and pile driving for Piers #4 and #5 will be carried out in close proximity to the existing ONR track. Any temporary excavations within in the vicinity of the railway track must be supported by temporary shoring. Monitoring of the existing ONR track should be carried out before, during, and after any construction activities within the



ONR right-of-way including installation and removal of temporary protection, foundation excavation and pile driving for Piers #4 and #5, and construction of falsework. An NSSP for the Contractor (Supply and Installation of Railway Monitoring Equipment) and an NSSP for the Contract Administrator (Geotechnical Monitoring Program) addressing the geotechnical monitoring requirements are included in Appendix J along with monitoring drawings.

- Fill placement for the detour embankment east of the bridge may induce settlement of the ONR track. Monitoring of the existing track should be carried out over the service life of the detour embankment. It is understood that the detour embankment will be removed following completion of the replacement structure. The detour pavement should be maintained periodically to compensate for settlement and pavement cracking as necessary.
- In light of the history of embankment instability at this site, and considering the soft nature of the varved clay, excavated soils and/or construction materials must not be stockpiled anywhere on the top or the sides of the north and south approach embankments, or near the crest of any temporary excavations to minimize the potential for embankment/excavation instability.
- The use of heavy construction equipment and in particular heavy lift cranes may be required during removal of the existing bridge girders and deck and may be required during erection of the new bridge. In light of the history of embankment instability at this site, and considering the soft nature of the varved clay, consideration must be given to the sequence of bridge demolition and new bridge construction such as to not cause further instability of the approach embankments and berms or bearing capacity failure. Prior to the commencement of construction, the Contractor must retain a Geotechnical Consultant to carry out a Geotechnical Assessment of the following:
 - The impact of the proposed equipment loads and methodology
 - The capability of the subgrade soils to support the proposed construction equipment and any temporary structures or fill (i.e. as a pad for crane support)
 - The requirements and/or restrictions necessary to safely support the loads.

The design and safety of any temporary works is the responsibility of the Contractor. Recommended wording for an NSSP addressing this issue is provided in Appendix J.

- Temporary falsework may be required at this site to permit construction of the bridge superstructure. In light of the soft varved clays present at this site, falsework supported on shallow foundations may experience large differential settlements or foundation/bearing



capacity failure. The falsework may also cause settlement of the existing ONR track. Prior to the commencement of construction, the Contractor must retain a Geotechnical Consultant to assess the stability and settlement impact of the proposed falsework loads and determine the means and methodology to safely support the falsework loads while avoiding foundation/bearing capacity failure and limiting settlement of the ONR track and bridge superstructure to tolerable limits. Suggested wording for an NSSP is provided in Appendix J.



24. CLOSURE

Engineering analysis and preparation of the engineering part of this report were carried out by Mr. Geoff Lay, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



Geoff Lay, P.Eng.

Geotechnical Engineer



Jason Lee, P.Eng.

Principal, Senior Geotechnical Engineer



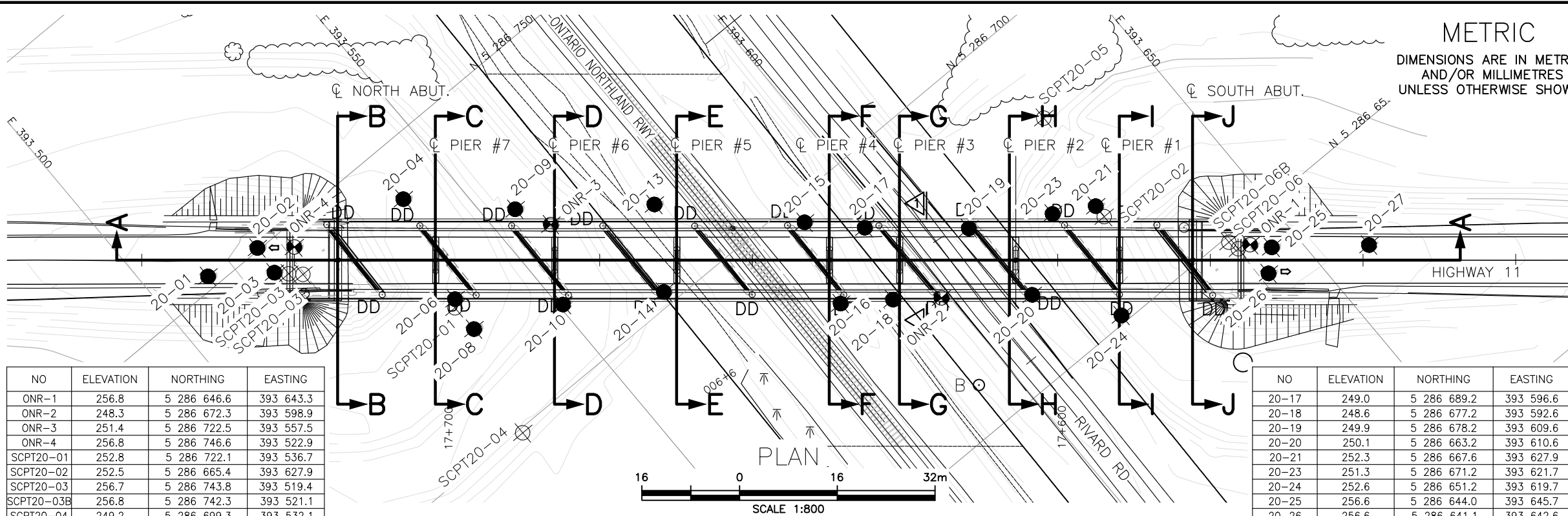
P.K. Chatterji, P.Eng.

Review Principal, Designated MTO Contact



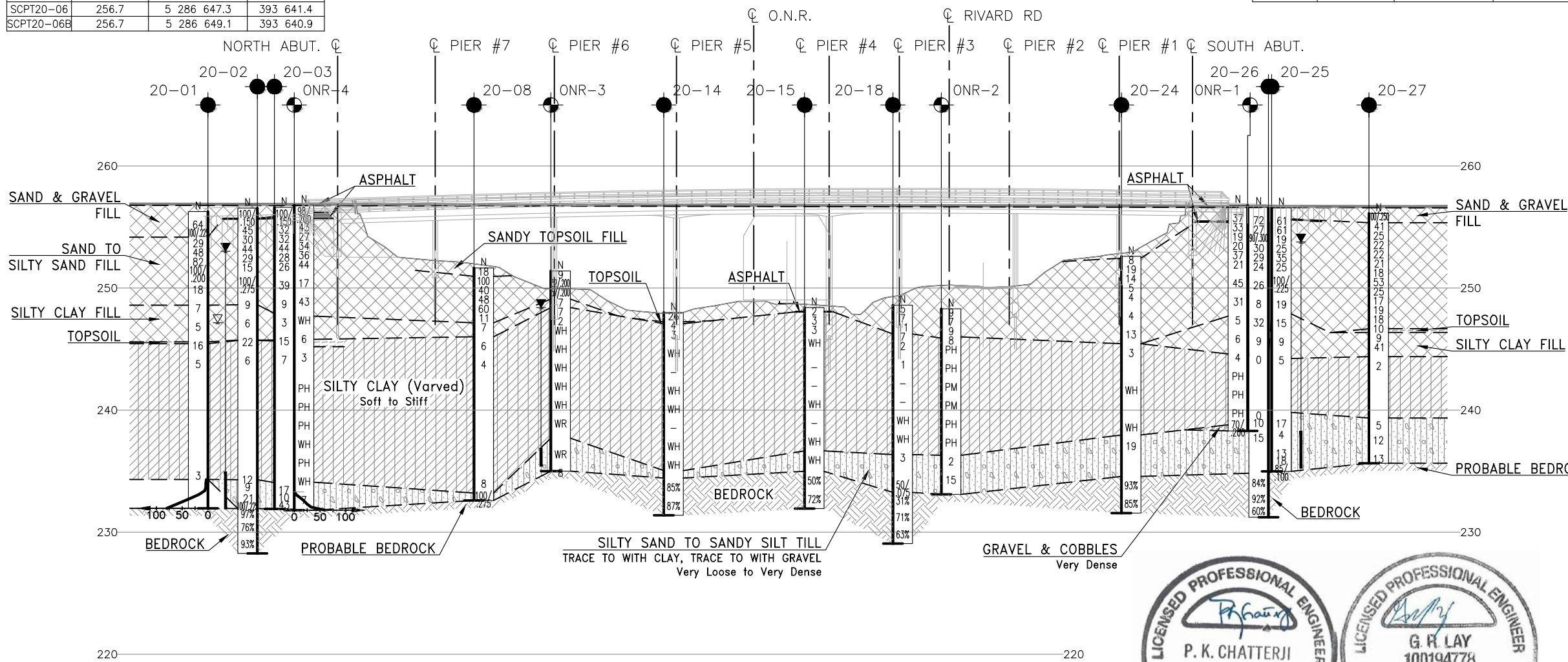
Appendix A

Borehole Location and Soil Strata Drawings

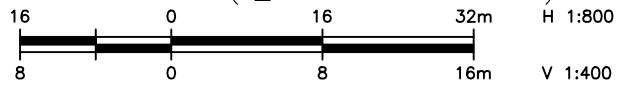


NO	ELEVATION	NORTHING	EASTING
ONR-1	256.8	5 286 646.6	393 643.3
ONR-2	248.3	5 286 672.3	393 598.9
ONR-3	251.4	5 286 722.5	393 557.5
ONR-4	256.8	5 286 746.6	393 522.9
SCPT20-01	252.8	5 286 722.1	393 536.7
SCPT20-02	252.5	5 286 665.4	393 627.9
SCPT20-03	256.7	5 286 743.8	393 519.4
SCPT20-03B	256.8	5 286 742.3	393 521.1
SCPT20-04	249.2	5 286 699.3	393 532.1
SCPT20-05	249.9	5 286 684.2	393 630.7
SCPT20-06	256.7	5 286 647.3	393 641.4
SCPT20-06B	256.7	5 286 649.1	393 640.9

NO	ELEVATION	NORTHING	EASTING
20-17	249.0	5 286 689.2	393 596.6
20-18	248.6	5 286 677.2	393 592.6
20-19	249.9	5 286 678.2	393 609.6
20-20	250.1	5 286 663.2	393 610.6
20-21	252.3	5 286 667.6	393 627.9
20-23	251.3	5 286 671.2	393 621.7
20-24	252.6	5 286 651.2	393 619.7
20-25	256.6	5 286 644.0	393 645.7
20-26	256.6	5 286 641.1	393 642.6
20-27	256.1	5 286 634.1	393 658.2



PROFILE A-A (CL HIGHWAY 11)



GRAVEL & COBBLES
Very Dense

SILTY SAND TO SANDY SILT TILL
TRACE TO WITH CLAY, TRACE TO WITH GRAVEL
Very Loose to Very Dense

PROBABLE BEDROCK

BEDROCK

PROBABLE BEDROCK

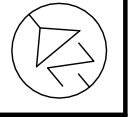
BEDROCK



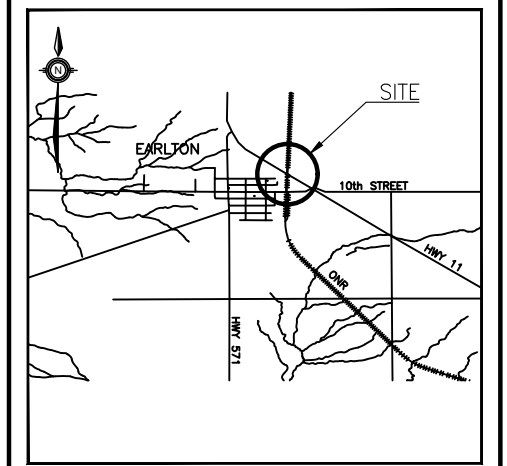
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GL	CHK PKC	CODE
DRAWN	MFA	CHK GL	SITE
LOAD			
STRUCT			
DWG			

CONT No
WP No 5101-17-00

HIGHWAY 11
ONTARIO NORTHLAND RAILWAY
OVERHEAD BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET
1



KEYPLAN

LEGEND

- Borehole / SCPT by Thurber (2020)
- Borehole by Others (2012)
- 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
20-01	256.3	5 286 752.0	393 509.0
20-02	256.6	5 286 750.4	393 518.2
20-03	256.6	5 286 745.5	393 517.7
20-04	252.4	5 286 741.2	393 541.6
20-06	252.6	5 286 723.2	393 537.6
20-08	251.6	5 286 717.4	393 536.9
20-09	249.9	5 286 728.2	393 554.6
20-10	250.0	5 286 711.2	393 550.6
20-13	248.2	5 286 714.2	393 572.6
20-14	248.0	5 286 702.2	393 564.6
20-15	248.4	5 286 696.2	393 589.6
20-16	248.6	5 286 682.2	393 585.6

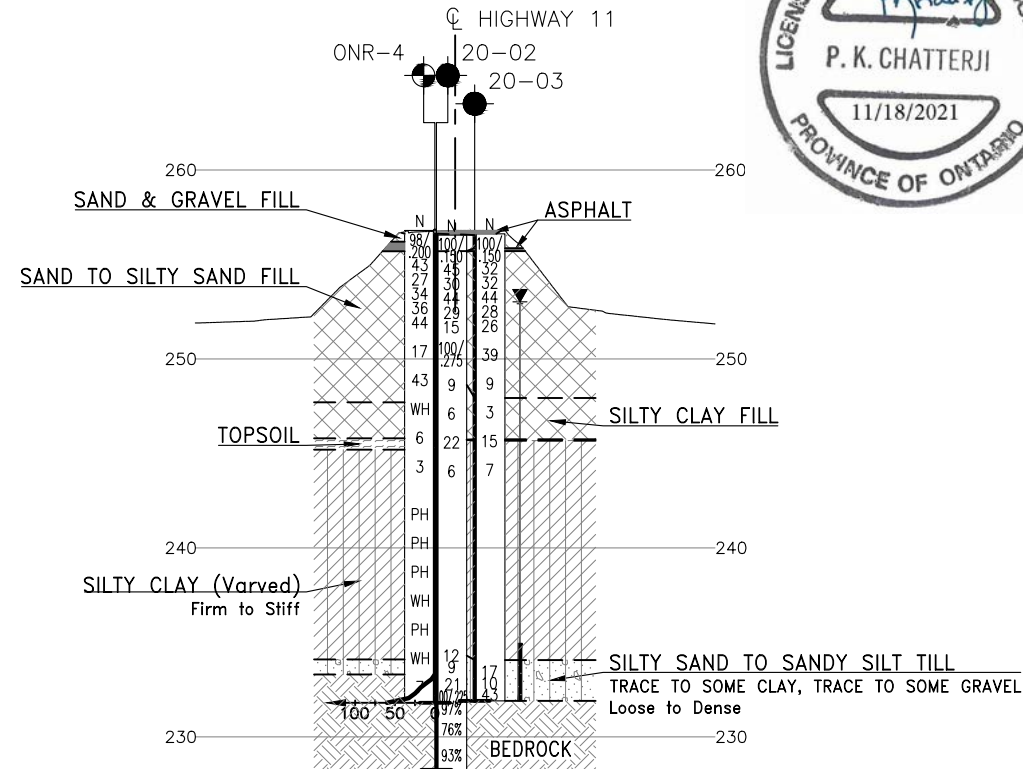
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 12.

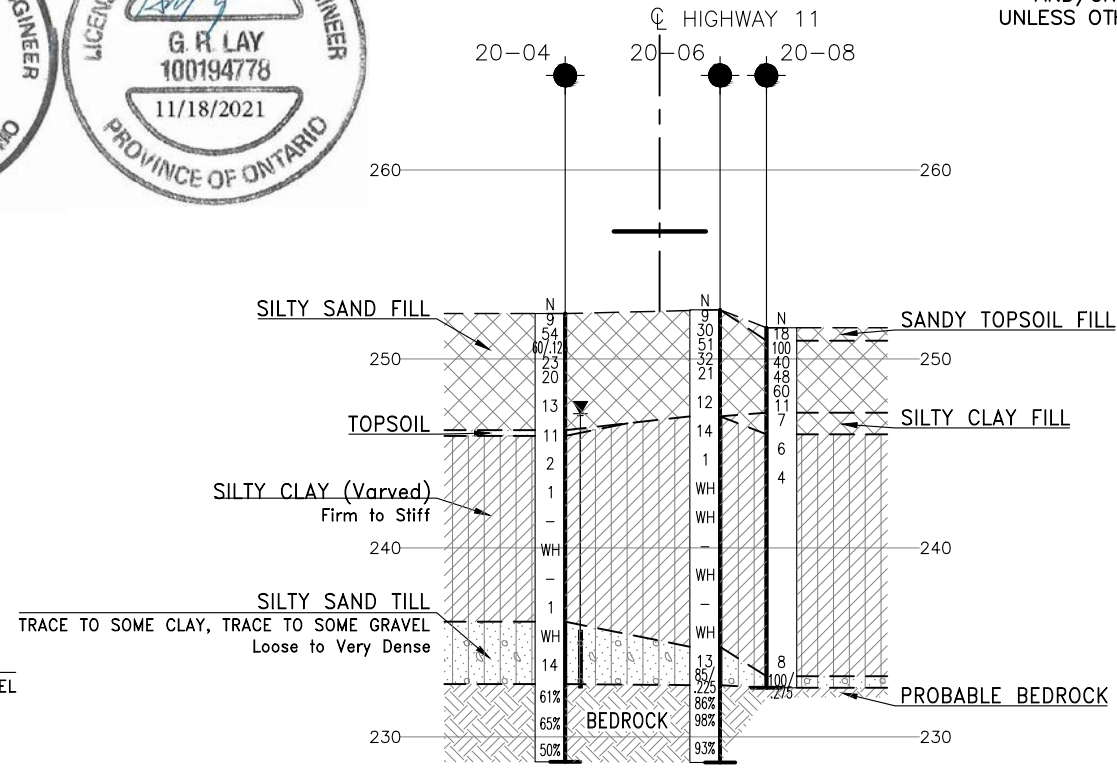
GEOCRES No. 31M-132



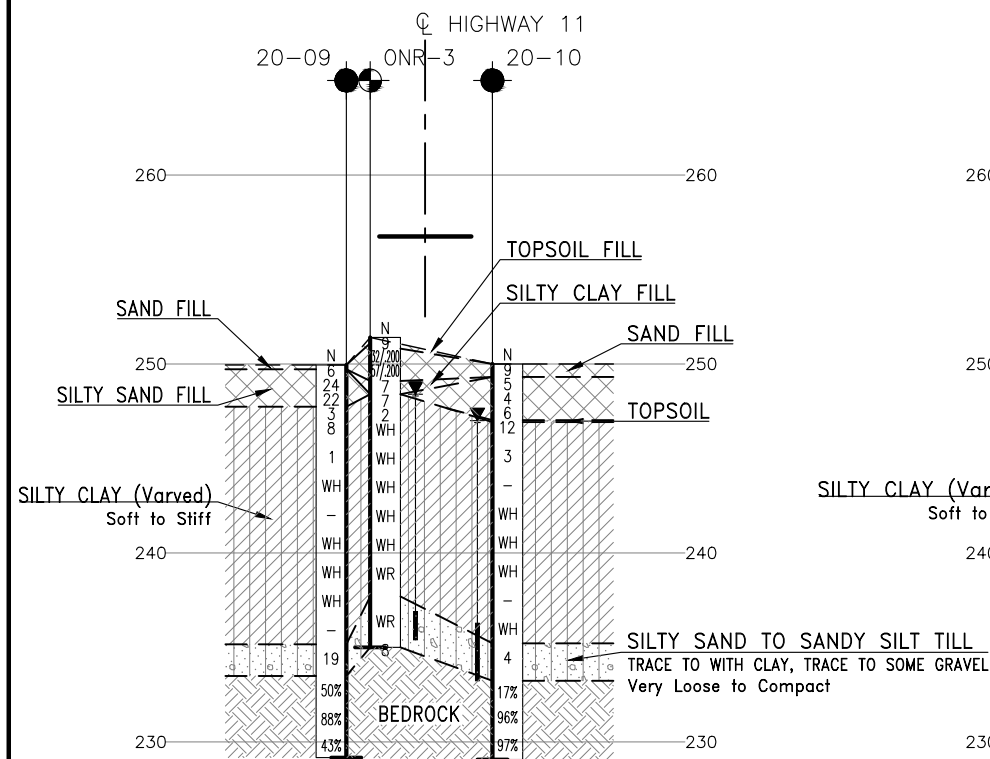
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



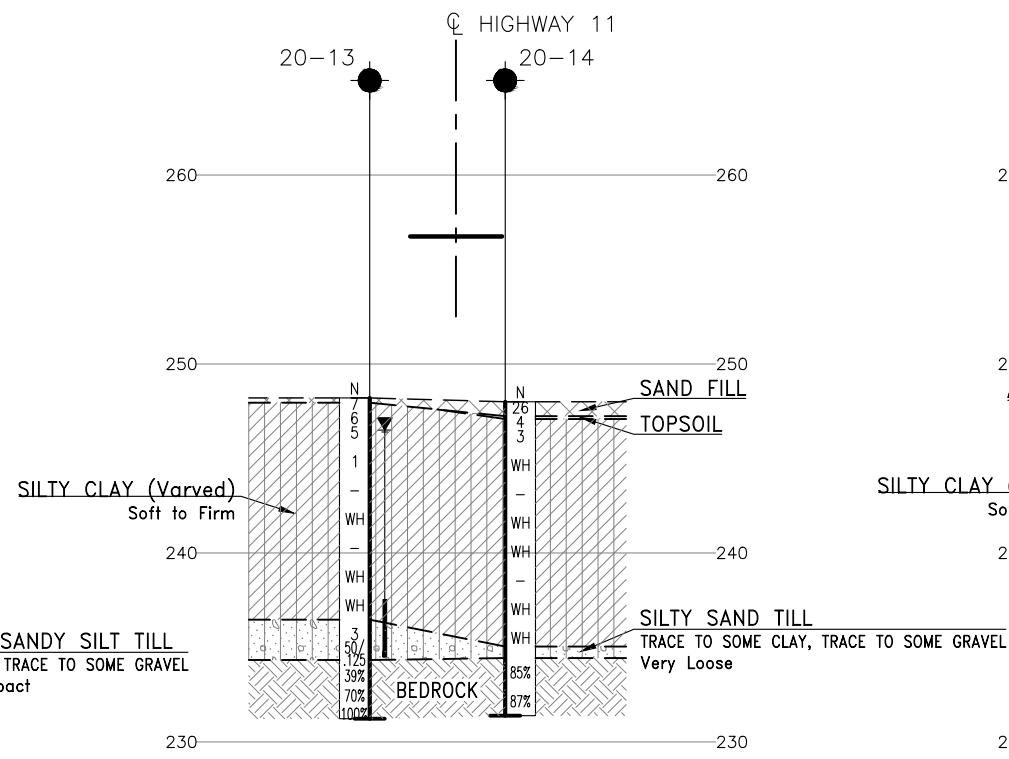
SECTION B-B (NORTH ABUT.)



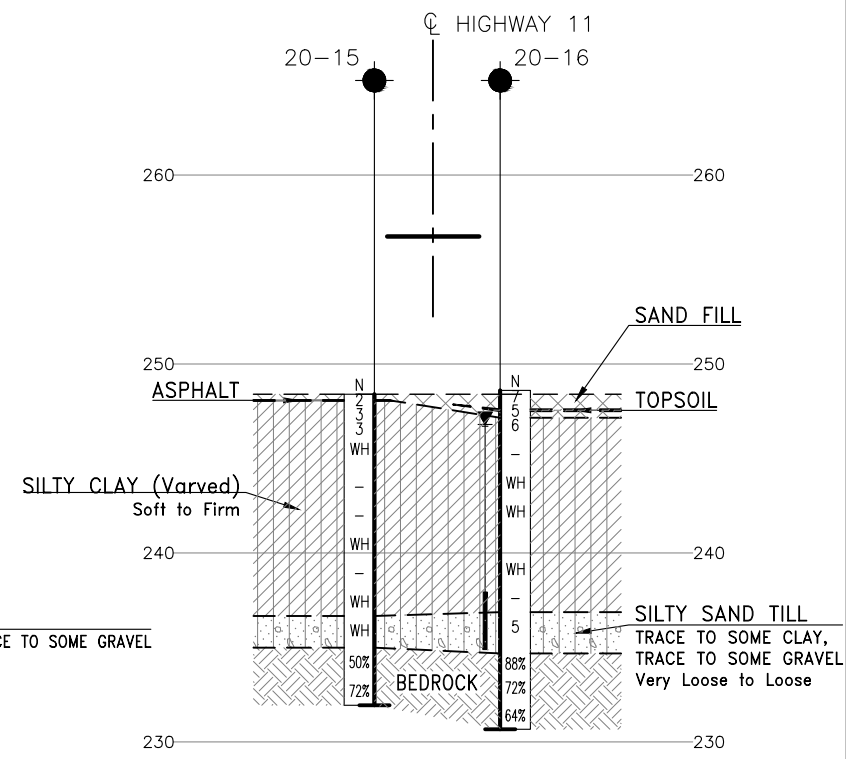
SECTION C-C (PIER #7)



SECTION D-D (PIER #6)



SECTION E-E (PIER #5)



SECTION F-F (PIER #4)

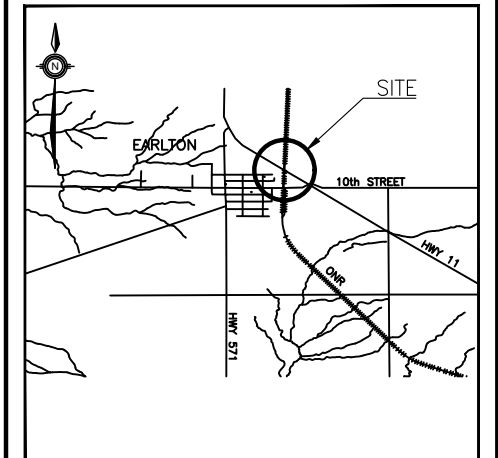
CONT No
WP No 5101-17-00

HIGHWAY 11
ONTARIO NORTHLAND RAILWAY
OVERHEAD BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
2



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole / SCPT by Thurber (2020)
	Borehole by Others (2012)
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

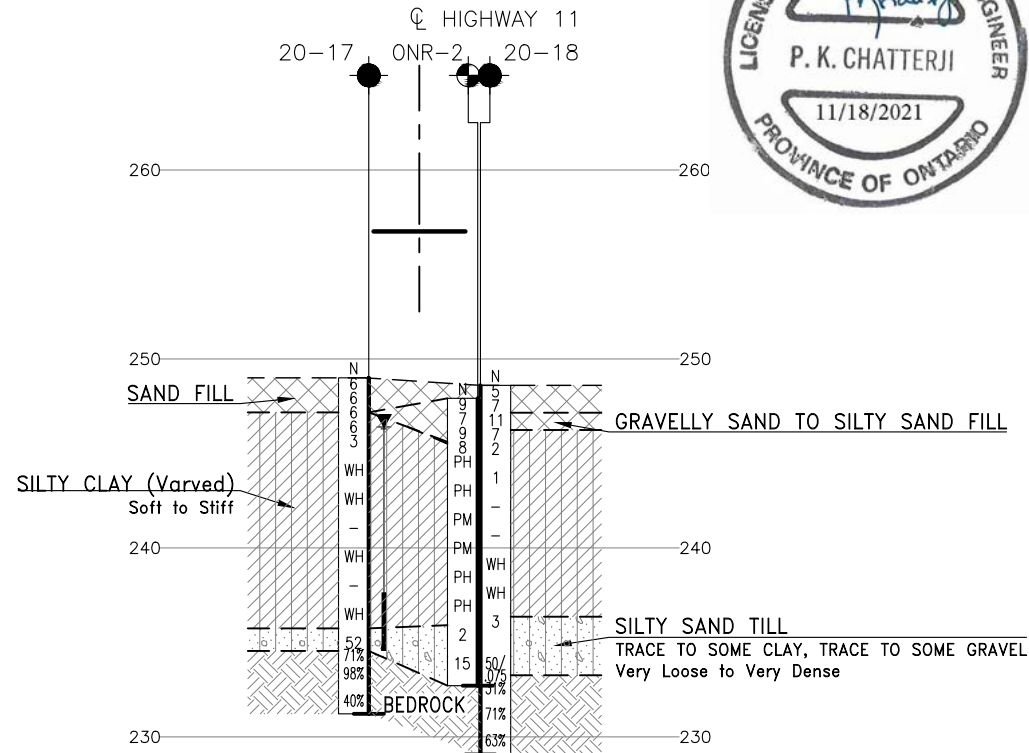
NO	ELEVATION	NORTHING	EASTING
20-03	256.6	5 286 745.5	393 517.7
20-04	252.4	5 286 741.2	393 541.6
20-06	252.6	5 286 723.2	393 537.6
20-08	251.6	5 286 717.4	393 536.9
20-09	249.9	5 286 728.2	393 554.6
20-10	250.0	5 286 711.2	393 550.6
20-13	248.2	5 286 714.2	393 572.6
20-14	248.0	5 286 702.2	393 564.6
20-15	248.4	5 286 696.2	393 589.6
20-16	248.6	5 286 682.2	393 585.6
ONR-3	251.4	5 286 722.5	393 557.5
ONR-4	256.8	5 286 746.6	393 522.9

-NOTES-

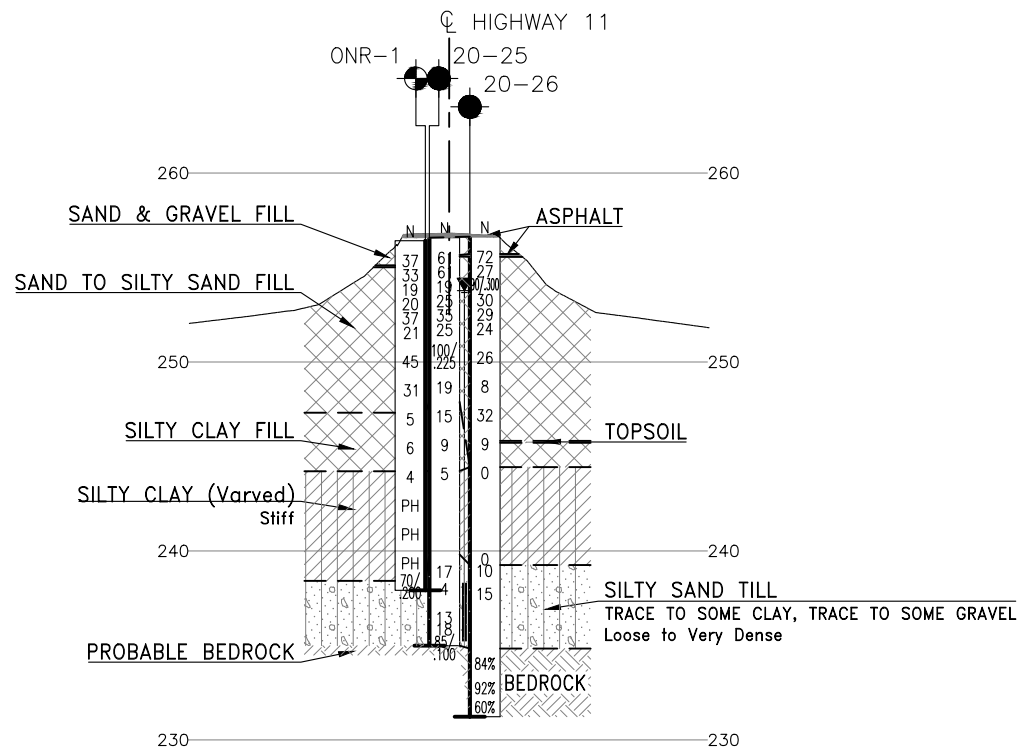
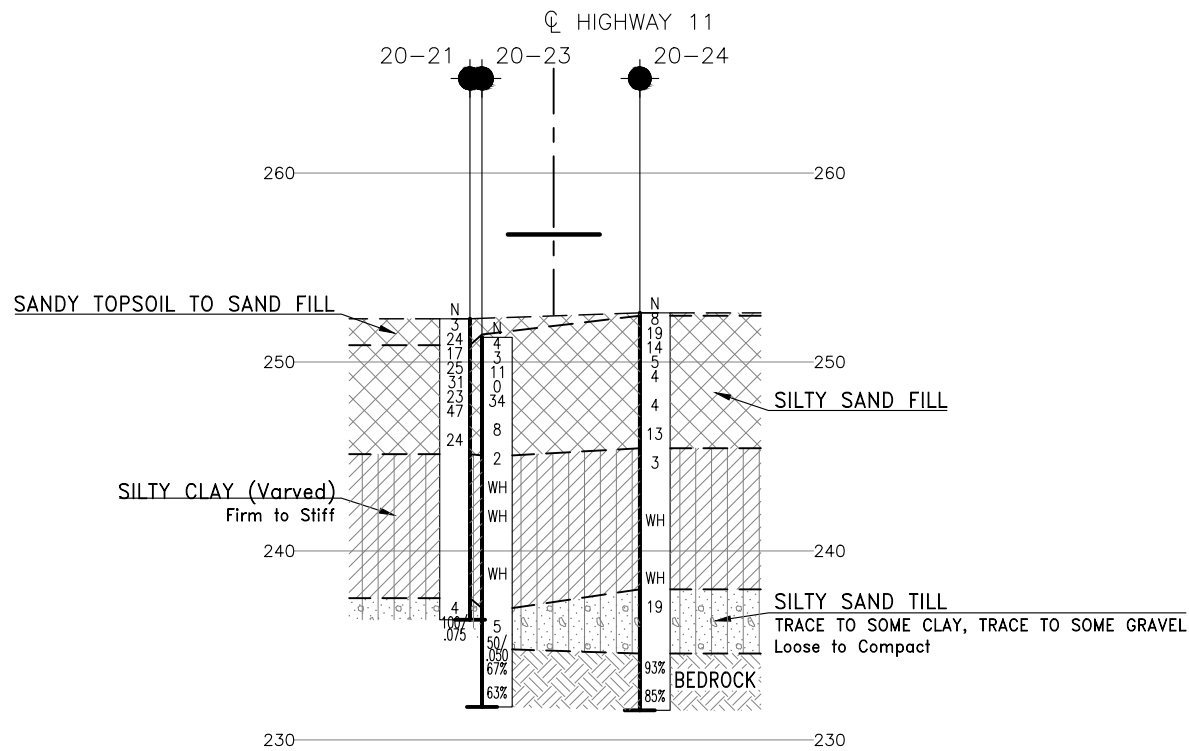
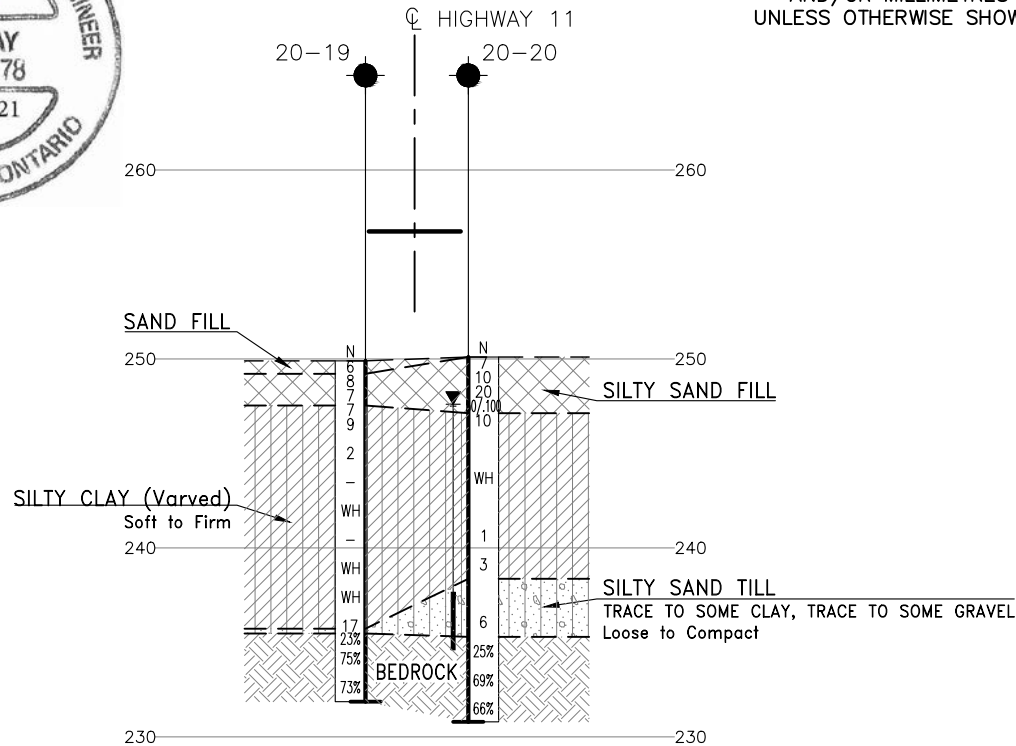
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 12.

GEOCREs No. 31M-132

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GL	CHK	PKC
DRAWN	MFA	CHK	GL
CODE	LOAD	DATE	NOV 2021
SITE	STRUCT	DWG	2



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



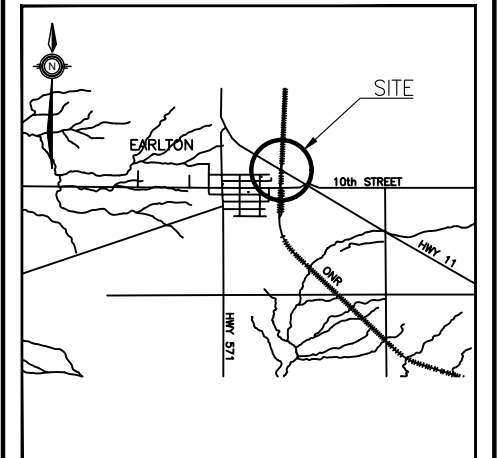
CONT No
WP No 5101-17-00

HIGHWAY 11
ONTARIO NORTHLAND RAILWAY
OVERHEAD BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
3



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole / SCPT by Thurber (2020)
	Borehole by Others (2012)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
WH	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
20-17	249.0	5 286 689.2	393 596.6
20-18	248.6	5 286 677.2	393 592.6
20-19	249.9	5 286 678.2	393 609.6
20-20	250.1	5 286 663.2	393 610.6
20-21	252.3	5 286 667.6	393 627.9
20-24	252.6	5 286 651.2	393 619.7
20-25	256.6	5 286 644.0	393 645.7
20-26	256.6	5 286 641.1	393 642.6

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 12.

GEOCRES No. 31M-132

SECTION I-I (PIER #1)

SECTION J-J (SOUTH ABUT.)



H 1:800

V 1:400

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GL	CHK PKC	CODE
DRAWN	MFA	CHK GL	SITE
LOAD	DATE	NOV 2021	
STRUCT	DWG	3	



Appendix B

Record of Borehole Sheets and Laboratory Test Results – Current investigation

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


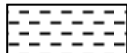



 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

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

RECORD OF BOREHOLE No 20-01

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 752.0 E 393 509.0 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/N-Casing/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2020.11.23 - 2020.11.24 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
256.3	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (150mm)		1	GS									
0.2	SAND and GRAVEL, some silt Brown Moist (FILL)						256						
255.3													
1.0	SAND and GRAVEL, some silt Very Dense Brown Moist (FILL)		1	SS	64		255						
			2	SS	100/ 0.225								
254.2													
2.1	SAND to Silty SAND, trace to some gravel, trace to some clay Compact to Very Dense Brown Moist (FILL)		3	SS	29		254						
			4	SS	48		253						
			5	SS	82		252						
			6	SS	100/ 0.200								
							251						
			7	SS	18		250						
							249						
248.6													
7.7	Silty CLAY, some sand, trace gravel Firm to Very Stiff Grey Moist to Wet (FILL)		8	SS	7		248						
							247						
			9	SS	5								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-01

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 752.0 E 393 509.0 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/N-Casing/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2020.11.23 - 2020.11.24 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
	Continued From Previous Page		5	ST									
234.4													
21.9	End of sampling and start DCPT		12	SS	3								
232.0													
24.3	END OF BOREHOLE AT 24.3m UPON DCPT REFUSAL ON PROBABLE BEDROCK. WATER LEVEL IN OPEN BOREHOLE AT 9.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m AND ASPHALT COLD PATCH TO SURFACE.												

RECORD OF BOREHOLE No 20-02

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 750.4 E 393 518.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.21 - 2020.11.23 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
256.6	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (120mm)							20 40 60 80 100				
0.1	SAND and GRAVEL, some silt Dark Brown Moist (FILL)		1	GS			256					
255.8			1	SS	100/							
255.7	ASPHALT: (75mm)				0.150							
0.9	SAND to Silty SAND, trace to some gravel, trace to some clay Compact to Very Dense Light Brown Moist (FILL)		2	SS	45		255					1 92 7 (SI+CL)
			3	SS	30		254					
			4	SS	44		253					
			5	SS	29		252					
			6	SS	15		251					
			7	SS	100/ 0.275		250					
							249					
248.7	Silty CLAY, some sand, trace gravel, trace rootlets, organics Firm to Very Stiff Grey Moist to Wet (FILL)		8	SS	9		248					
7.9			9	SS	6		247					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-02

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 750.4 E 393 518.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.21 - 2020.11.23 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
	Continued From Previous Page							20 40 60 80 100	20 40 60				kN/m ³	GR SA SI CL	
245.8							246								
248.8	TOPSOIL: (25mm)		10	SS	22										
10.8	Silty CLAY, varved Stiff Grey Wet														
			11	SS	6										
			1	ST											
			2	ST											
			3	ST											
			4	ST											
									</						

Continued Next Page

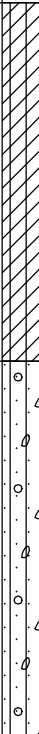

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-02

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 750.4 E 393 518.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.21 - 2020.11.23 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								20 40 60 80 100											
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _P w w _L WATER CONTENT (%) 20 40 60						
Continued From Previous Page																			
234.3 22.3	Silty SAND , some clay, trace to some gravel Loose to Compact Grey Wet (TILL)		5	ST			236										FI 1 1 0 4 6 2 1 1 2 2 1 0	RUN #1 TCR=97% SCR=97% RQD=97% UCS=61.7MPa (Average) RUN #2 TCR=98% SCR=86% RQD=76% UCS=42.8MPa (Average) RUN #3 TCR=98% SCR=98% RQD=93% UCS=103.4MPa (Average)	
			6	ST															
			12	SS	12														
			13	SS	9														
			14	SS	21														
			15	SS	100/														
232.0	SANDSTONE , interbedded with limestone, slightly weathered, strong to very strong, brown Horizontal fractures at 24.9m and 25.1m		1	RUN	0.225		231												
2			RUN																
26.0			LIMESTONE , interbedded with sandstone, moderately weathered, weak to very strong, brown Sub-vertical fractures (25mm) at 25.5m, 25.8m, 25.9m and 26.1m Horizontal fractures at 25.7m, 25.9m, 26.0m, 26.1m, 26.2m, 26.4m and 26.5m Vertical fracture from 25.9m to 26.1m Horizontal fractures at 27.0m, 27.2m and 27.8m Sub-horizontal fracture at 27.1m, 27.5m and 27.7m	3	RUN														
228.3	END OF BOREHOLE AT 28.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m AND ASPHALT COLD PATCH TO SURFACE.																		
28.3																			

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-03

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 745.5 E 393 517.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.28 - 2020.11.29 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
256.6	GROUND SURFACE														
0.0	ASPHALT: (200mm)														
0.2	SAND and GRAVEL, some silt Light Brown Moist (FILL)		1	GS			256								
255.8															
255.8	ASPHALT: (150mm)		1	SS	100/ 0.150										
0.9	SAND to Silty SAND, trace to some gravel, trace to some clay Dense to Loose Brown Moist (FILL)														
			2	SS	32		255								
			3	SS	32		254								
	Grey Wet		4	SS	44		253								8 66 15 11
			5	SS	28		252								
			6	SS	26		251								
							250								
							249								
			8	SS	9		248								
247.9															
8.7	Silty CLAY, with sand, trace gravel Soft to Stiff Grey Moist to Wet (FILL)														
			9	SS	3		247								

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-03

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 745.5 E 393 517.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.28 - 2020.11.29 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
								20 40 60 80 100				
245.7							246					
245.0	TOPSOIL: (75mm)		10	SS	15							
10.9	Silty CLAY, varved Stiff Grey Wet											
							245					
			11	SS	7		244					
								4.3				
			1	ST			243					
												0 0 17 83 0 0 66 34
							242	4.3				
								3.6				
			2	ST			241					
								3.9				
							240	4.1				
			3	ST								
							239	3.6				
								3.5				
			4	ST			238					
								3.3				
							237	3.5				

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-03

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 745.5 E 393 517.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.28 - 2020.11.29 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
			5	ST													
							236				3.4 +						
											3.7 +						
			6	ST			235										
											2.1 +						
234.0																	
22.6	Silty SAND , trace to some clay, trace to some gravel Compact to Dense Grey Wet (TILL)						234										
			12	SS	17												
			13	SS	10		233										
			14	SS	43												
231.9							232										
24.7	END OF BOREHOLE AT 24.7m UPON SPOON REFUSAL ON PROBABLE BEDROCK. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.18 3.6 253.0																




ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-04

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 741.2 E 393 541.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.09 - 2021.05.09 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
252.4	GROUND SURFACE						20	40	60	80	100						
0.0	Silty SAND , trace to some gravel, trace to some clay Loose to Very Dense Grey Moist (FILL)		1	SS	9								○				6 60 25 9
													○				
			2	SS	54								○				
			3	SS	60/ 0.125								○				
			4	SS	23								○				
			5	SS	20								○				
			6	SS	13								○				
246.2																	
6.2	TOPSOIL (300mm)		7	SS	11								○				
245.9																	
6.5	Silty CLAY , varved Firm Grey Moist														○	0 0 41 59	
			8	SS	2									○			
			9	SS	1									○			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-04

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 741.2 E 393 541.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.09 - 2021.05.09 LATITUDE LONGITUDE CHECKED BY GRL/JA

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

RECORD OF BOREHOLE No 20-06

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 723.2 E 393 537.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.07 - 2021.05.08 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
252.6 0.0	GROUND SURFACE		1	SS	9		252							
	Silty SAND , trace to some gravel, trace to some clay Loose to Very Dense Brown to Greyish Brown Moist (FILL)		2	SS	30		251							5 63 22 10
			3	SS	51		250							
			4	SS	32		249							
	Becoming Dense to Compact		5	SS	21		248							
			6	SS	12		247							9 51 28 12
247.0 5.6	Silty CLAY , occasional rootlets, Firm to Stiff Grey Wet		7	SS	14		246							
			8	SS	1		245							
			9	SS	WH		244							
							243							

Continued Next Page

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

RECORD OF BOREHOLE No 20-06

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 723.2 E 393 537.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.07 - 2021.05.08 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
								20 40 60 80 100		20 40 60		GR SA SI CL
								6.7				
			10	SS	WH		242					
							241	3.1				
			1	ST	-		240					
							239	6.6				
			11	SS	WH							0 0 37 63
							238	6.0				
			2	ST	-		237					0 0 35 65
							236	6.0				
			12	SS	WH							
							235	4.5				
234.8												
17.8	Silty SAND , trace to some gravel, trace to some clay Compact Grey Wet (TILL)											
			13	SS	13		234					
							233					
232.7												
19.9			14	SS	85/							FI

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity




20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-06

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 723.2 E 393 537.6 ORIGINATED BY GF
 DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
 DATUM Geodetic DATE 2021.05.07 - 2021.05.08 LATITUDE LONGITUDE CHECKED BY GRL/JA





SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100				W _P	W	W _L					
								SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
	Continued From Previous Page																		
231.6	SANDSTONE , slightly weathered		1	RUN	0.225										>10	RUN #1 TCR=100% SCR=91% RQD=86% UCS=170.5MPa (Average)			
	Horizontal fracture at 19.9m														0				
	Sub-horizontal fracture at 20.5m														2				
21.0	DOLOSTONE with sandstone seams, slightly weathered to fresh		2	RUN											0	RUN #2 TCR=100% SCR=100% RQD=98% UCS=76.3MPa (Average)			
	Sub-horizontal fracture at 21.6m, 21.8m and 22.1m														0				
															3				
															1				
															0				
228.6	Horizontal fracture at 23.1m, and 23.9m		3	RUN											0	RUN #3 TCR=100% SCR=100% RQD=93% UCS=102.3MPa (Average)			
	Sub-horizontal fracture at 23.7m and 23.9m														1				
															0				
24.0	END OF BOREHOLE AT 24.0m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.														3				

RECORD OF BOREHOLE No 20-08

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 717.4 E 393 536.9 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.12.02 - 2020.12.02 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE								
251.6	GROUND SURFACE						20	40	60	80	100								
0.0	TOPSOIL , sandy, trace silt, some organics Compact Brown Moist (FILL)		1	SS	18								○				16 53 23 8		
250.9														○					
0.7														○					
					2	SS	100								○				
			Silty SAND , trace to some gravel, trace to some clay Very Dense to Compact Brown to Grey Moist (FILL)												○				
																○			
					3	SS	40								○				
															○				
			4	SS	48								○				3 46 34 17		
													○						
			5	SS	60								○						
													○						
			6	SS	11								○						
													○						
247.1	Silty CLAY , trace sand, trace gravel Firm Grey Wet (FILL)																1.6 +		
4.5					7	SS	7								○				
246.0	Silty CLAY , varved Firm to Stiff Grey Wet																		
5.6															○				
					8	SS	6												
					9	SS	4									○			

Continued Next Page



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

RECORD OF BOREHOLE No 20-08

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 717.4 E 393 536.9 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.12.02 - 2020.12.02 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)						
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	w _p	w	w _L				
Continued From Previous Page							20 40 60 80 100	20 40 60								
			2	ST			241							0 0 16 84 0 0 58 42		
			3	ST												
			4	ST												
			5	ST												
			6	ST												
			10	SS	8		234									
233.2																
18.4	Silty SAND , trace to some gravel, trace to some clay Very Dense Brown Wet (TILL)						233									
232.5																
19.1			11	SS	100/ 0.275											
	END OF BOREHOLE AT 19.1m UPON SPOON REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

METRIC

[illegible]

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-09

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 728.2 E 393 554.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.08 - 2021.05.08 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					w _p w w _L			
								SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
	Continued From Previous Page							20 40 60 80 100						GR SA SI CL		
			9	SS	WH		239	4.5 +								
			10	SS	WH		238	4.5 +								
							237									
								5.0 +								
			2	ST	-		236									
235.1																
14.8	Silty SAND , trace to some gravel, trace to some clay Compact Grey Wet (TILL)						235									
			11	SS	19											
							234									
233.4																
16.5	SANDSTONE , moderately weathered, light brown Sub-horizontal fracture at 16.6m, 16.7m, 17.2m, 17.4m, 17.6m, and 17.8m Sub-vertical (25mm) at 16.8m, (25mm) at 17.5m, and (50mm) at 17.9m Horizontal fracture at 17.1m, 17.3m, 17.4m, 17.5m, and 17.9m		1	RUN			233									
							232									
231.7																
18.2	DOLOSTONE , interbed with sandstone, slightly to moderately weathered, grey Horizontal fracture at 18.2m and 18.8m Sub-horizontal fracture at 18.2m, 18.9m, and 19.3m Horizontal fracture at 19.6m, 19.9m, 20.0m, 20.3m, and 20.6m		2	RUN			231									
							230									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-10

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 711.2 E 393 550.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.06 - 2021.05.06 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
250.0	GROUND SURFACE												
0.0	SAND , some silt, trace gravel, trace clay, occasional wood fragments Loose Brown Moist (FILL)		1	SS	9								
249.3													
0.7													
	Silty SAND , trace to some gravel, trace to some clay Loose Brown Moist (FILL)		2	SS	5		249						
				3	SS	4		248					12 44 29 15
			4	SS	6								
247.0													
246.9	TOPSOIL (25mm)						247						
3.1	Silty CLAY , trace roots, varved Firm Grey Wet		5	SS	12								
			6	SS	3		245						0 0 41 59
							244						
			1	ST	-								
							243						
								4.3 +					
			7	SS	WH		242						
							241						
			8	SS	WH								

Continued Next Page

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

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

RECORD OF BOREHOLE No 20-10

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 711.2 E 393 550.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.06 - 2021.05.06 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL		
Continued From Previous Page								20 40 60 80 100				
235.2 												

Continued Next Page

+³ × 3 : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-10

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 711.2 E 393 550.6 ORIGINATED BY GF
 DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
 DATUM Geodetic DATE 2021.05.06 - 2021.05.06 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								<div><div></div><div></div><div></div><div></div><div></div></div> <div>20406080100</div>										<div><div></div><div></div><div></div></div> <div>204060</div>		
	Continued From Previous Page		3	RUN																
229.1	Horizontal fracture at 19.6m, 19.9m, and 20.2m																			
20.9	END OF BOREHOLE AT 20.9m. Monitroing Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.15 2.6 247.4 2021.05.27 3.0 247.0																			

RECORD OF BOREHOLE No 20-13

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 714.2 E 393 572.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.05 - 2021.05.05 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		SHEAR STRENGTH kPa		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			
248.2	GROUND SURFACE												
0.0 247.9	SAND , some silt, some gravel, trace rootlets Loose Brown Moist (FILL)		1	SS	7		248						
0.3													
	Silty CLAY , some sand, trace gravel Firm Grey to Brown Moist		2	SS	6		247						1 10 49 40
246.7													
1.4	Silty CLAY , varved Firm Grey Wet		3	SS	5		246						
			4	SS	1		245						0 0 41 59
							244	6.0					
			1	ST	-		243						
							242	6.0					
			5	SS	WH		241						
							240	7.0					0 0 27 73
			2	ST	-								
							239	9.0					
			6	SS	WH								

Continued Next Page

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

RECORD OF BOREHOLE No 20-13

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 714.2 E 393 572.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.05 - 2021.05.05 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page							20	40	60	80	100		
236.5			7	SS	WH			5.0						
11.7	Silty SAND , trace to some gravel, trace to some clay Very Loose Grey Wet (TILL)		8	SS	3			5.5						
234.3			9	SS	50/									
13.9	SANDSTONE , highly to slightly weathered Horizontal fracture at 13.9m, 14.0m, and 14.2m Sub-vertical fracture 14.1m, 14.5m, 14.7m, 14.9m and 15.0m Sub-vertical fracture (125mm) at 14.2m Sub-horizontal fractures at 15.2m, 15.3m, 15.5m, 15.6m, 15.7m, 15.8m, 15.9m, 16.1m, 16.2m and 16.3m Sub-vertical fractures (75mm) at 15.8m and (40mm) at 15.9m Sub-horizontal fracture at 16.8m Sub-vertical fracture (40mm) at 16.7m		1	RUN	0.125									
231.2			2	RUN										
17.0	END OF BOREHOLE AT 17.0m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.07 0.8 247.4 2021.05.15 1.6 246.6 2021.05.27 1.7 246.5		3	RUN										

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-14

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 702.2 E 393 564.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.04 - 2021.05.04 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
248.0	GROUND SURFACE											
0.0	SAND, some silt, trace gravel, trace rootlets Compact Brown Moist (FILL)		1	SS	26							
247.2												
247.8	TOPSOIL		2	SS	4		247					
0.9	Silty CLAY, varved Soft to Firm Grey Moist to Wet		3	SS	3		246					0 0 42 58
			4	SS	WH		245					
							244	4.0 +				
			1	ST	-		243					
							242					
			5	SS	WH		241	4.0 +				
			6	SS	WH		240					
							239	7.0 +				
			2	ST	-		238					

Continued Next Page

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

METRIC

[illegible]

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-15

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 696.2 E 393 589.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.10 - 2021.05.10 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
248.4	GROUND SURFACE											
0.0	SAND, some silt, trace gravel											
248.1	Compact		1	SS	2		248					
248.0	Brown											
0.4	Moist (FILL)											
	50mm thick asphalt layer at 0.3m											
	Silty CLAY, varved		2	SS	3		247					
	Firm											
	Brownish Grey to Grey		3	SS	3							
	Moist to Wet											
			4	SS	WH		246					
							245					
			1	ST	-		244					
							243					
			5	SS	-		242					
							241					
			6	SS	WH		240					
			2	ST	-		239					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-15

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 696.2 E 393 589.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.10 - 2021.05.10 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
236.7			7	SS	WH									
11.7	Silty SAND , trace to some gravel, trace to some clay Very Loose Grey Wet (TILL)		8	SS	WH									
235.0	Rock fragments													
13.4	SANDSTONE , moderate to slightly weathered, light brown to brown Sub-vertical fracture (25mm) at 13.4m, (50mm) at 13.8m, (100mm) 13.9m, and (75mm) at 14.2m Sub-horizontal fracture at 13.9m, 14.1m, 14.5m, 14.7m, and 14.8m Horizontal fracture 14.0m Horizontal fracture at 15.0m and 16.3m Sub-horizontal fracture 15.0m, 15.4m, 15.5m, 15.7m, and 15.9m Vertical fracture (25mm) at 15.7m		1	RUN										
231.9			2	RUN										
16.5	END OF BOREHOLE AT 16.5m.													

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-16

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 682.2 E 393 585.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.10 - 2021.05.11 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
248.6	GROUND SURFACE							20 40 60 80 100					
0.0	SAND , some silt, trace gravel Loose Brown Moist (FILL)		1	SS	7		248						
247.6													
247.6	TOPSOIL: (100mm)		2	SS	5								0 95 5 (SI+CL)
1.1													
247.1													
1.4	Silty CLAY , varved Soft to Firm Grey Moist to Wet		3	SS	6		247						
							246						
			1	ST	-		245						
			4	SS	WH		244						0 0 38 62
							243	12.0 +					
			5	SS	WH		242						
							241	+					
	Unable to take sample at 7.6m due to auger sinking and blowback												
							240						
			6	SS	WH		239						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-16

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 682.2 E 393 585.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.10 - 2021.05.11 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100									
Continued From Previous Page							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div> <div><div>204060</div><div>WATER CONTENT (%)</div></div>										
236.9	Silty SAND , trace to some gravel, trace to some clay Loose Light Grey Wet (TILL)		2	ST	-		238	6.4									
237																	
236			7	SS	5												
235																	
13.9	SANDSTONE , slightly weathered, light brown Sub-horizontal fracture at 14.8m Sub-vertical fracture (100mm) at 14.8m Sub-vertical fracture (175mm) at 15.0m and (50mm) at 15.5m Sub-horizontal fracture at 15.5m,15.8m, 16.0m, and 16.4m Sub-horizontal fracture (25mm) at 16.6m, 16.7m, 17.1m, 17.2m, and 17.4m		1	RUN			234										
			2	RUN													
			3	RUN													
230.7	END OF BOREHOLE AT 17.9m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.15 1.9 246.7 2021.05.27 1.8 246.8						231										
17.9																	



ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-17

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 689.2 E 393 596.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.12 - 2021.05.12 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE									
249.0	GROUND SURFACE						20	40	60	80	100									
0.0	SAND , some silt, trace gravel, trace rootlets Loose Dark Brown Moist (FILL)		1	SS	6								○				0 89 11 (SI+CL)			
														○						
			2	SS	6									○						
247.2			3	SS	6								○				0 0 41 59			
1.8	Silty CLAY , varved Soft to Firm Grey Wet													○						
															○					
																○				
																		○		
			5	SS	3													○		
				6	SS	WH													○	
			7	SS	WH												○			
			1	ST	-												○			
			8	SS	WH												○			

Continued Next Page

+³ × 3³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-17

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 689.2 E 393 596.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.12 - 2021.05.12 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
235.7	Stiff		2	ST	-		238	9.3						
							237	6.8						
			9	SS	WH		236							
13.3	Silty SAND , trace to some gravel, trace to some clay Very Dense Light Grey Wet (TILL)		10	SS	52		235	3.5						17 45 28 10
234.5	SANDSTONE , slightly to moderately weathered, light brown Sub-horizontal fracture at 14.5m Horizontal fracture at 14.6m Clay seams (25mm) at 15.3m and 16.0m Horizontal fracture at 15.3m Sub-horizontal fractures at 15.9m, 16.0m and 16.2m Sub-horizontal fractures at 16.4m, 16.7m, 16.8m, 16.9m, 17.0m, 17.1m and 17.7m Sub-vertical fracture from 17.4m to 17.8m		1	RUN			234							RUN #1 TCR=100% SCR=88% RQD=71% UCS=93.1MPa (Average)
			2	RUN			233							RUN #2 TCR=100% SCR=98% RQD=98% UCS=55.0MPa (Average)
			3	RUN			232							RUN #3 TCR=98% SCR=75% RQD=40% UCS=49.2MPa (Average)
231.2	END OF BOREHOLE AT 17.8m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.15 2.5 246.5 2021.05.27 2.6 246.4													
17.8														

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-18

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 677.2 E 393 592.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.11 - 2021.05.11 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
248.6	GROUND SURFACE					20	40	60	80	100	20	40	60			
0.0	SAND , some gravel, some silt Loose Brown Moist (FILL)		1	SS	5											
			2	SS	7											
247.1																
1.4	Silty SAND , trace to some gravel, trace to some clay Compact Brown Wet (FILL)		3	SS	11											
246.2																
2.4	Silty CLAY , varved, trace rootlets Soft to Stiff Brown to Grey Wet		4	SS	7											
			5	SS	2											
			6	SS	1											
			1	ST	-											
			2	ST	-											
			7	SS	WH											

Continued Next Page

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

RECORD OF BOREHOLE No 20-18

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 677.2 E 393 592.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.11 - 2021.05.11 LATITUDE LONGITUDE CHECKED BY GRL/JA

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

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-19

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 678.2 E 393 609.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.13 - 2021.05.13 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
249.9	GROUND SURFACE												
0.0	SAND , some silt, trace gravel, trace rootlets Loose Brown Moist (FILL)		1	SS	6								0 95 5 (SI+CL)
249.2													
0.7													
	Silty SAND , trace to some gravel, trace to some clay Loose Brown Moist (FILL)		2	SS	8								
				3	SS	7							
247.5													
2.4	Silty CLAY , varved, trace organics Firm Grey Moist to Wet		4	SS	7								0 15 35 50
				5	SS	9							
				6	SS	2							
				1	ST	-							
			7	SS	WH								
			2	ST	-								

Continued Next Page

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

RECORD OF BOREHOLE No 20-19

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 678.2 E 393 609.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY BH
DATUM Geodetic DATE 2021.05.13 - 2021.05.13 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
Continued From Previous Page							20	40	60	80	100	20	40	60	kN/m ³	GR	SA	SI	CL	
			8	SS	WH		239	4.0 +												
			9	SS	WH		238	6.0 +												
			10	SS	17		236													
235.7																				
14.2																				
235.5																				
14.4	Silty SAND , trace to some gravel, trace to some clay Compact Light Grey Moist to Wet (TILL)		1	RUN			235													
	SANDSTONE , slightly to highly weathered, light brown		2	RUN			234													
	Sub-vertical fracture (25mm) at 14.7m																			
	Sub-horizontal fracture at 14.8m and 14.9m																			
	Sub-horizontal fracture (25mm) a 15.5m, (75mm) at 16.2m, and (25mm) at 16.3m		3	RUN			233													
	Horizontal fracture at 15.5m																			
	Sub-horizontal fracture at 16.6m, 17.1m, 17.3m, 17.4m, and 17.5m																			
231.9							232													
18.0	END OF BOREHOLE 18.0m BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS.																			

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-20

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 663.2 E 393 610.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE COMPILED BY BH
DATUM Geodetic DATE 2021.05.13 - 2021.05.14 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
250.1	GROUND SURFACE												
0.0	Silty SAND , trace to some gravel, trace to some clay, trace rootlets Loose to Compact Brown to Grey Moist (FILL)		1	SS	7		250						
			2	SS	10		249						
			3	SS	20		248						
	Cobbles		4	SS	50/ 0.100								
247.1													
3.0	Silty CLAY , varved Soft to Firm Grey Wet		5	SS	10		247						0 0 41 59
							246						
			1	ST			245						
								4.0 +					
			6	SS	WH		244						0 0 42 58
							243						
			2	ST			242						
								5.1 +					
			7	SS	1		241						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-20

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 663.2 E 393 610.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE COMPILED BY BH
DATUM Geodetic DATE 2021.05.13 - 2021.05.14 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _P w w _L					
Continued From Previous Page							20	40	60	80	100	20	40	60	GR	SA	SI	CL
238.4 11.7 235.3 14.8	Silty SAND , trace to some gravel, trace to some clay Loose Grey Wet to Moist (TILL)		8	SS	3		240									0 0 41 59		
230.8 19.3	SANDSTONE , slightly to moderately weathered, light brown		1	RUN			235									RUN #1 TCR=65% SCR=65% RQD=25% UCS=85.1MPa (Average)		
	END OF BOREHOLE AT 19.3m. Monitoring Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.						231											

Continued Next Page





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

METRIC

[illegible]

METRIC

W.P.	5101-17-00	LOCATION	N 5 286 667.6 E 393 627.9		ORIGINATED BY	GF
DIST	HWY 11	BOREHOLE TYPE	Hollow Stem Augers		COMPILED BY	AN
DATUM	Geodetic	DATE	2020.12.01 - 2020.12.01	LATITUDE	LONGITUDE	CHECKED BY
						GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
252.3	GROUND SURFACE						20 40 60 80 100										
0.0	TOPSOIL, sandy, trace to some organics Very Loose to Compact Brown Moist (FILL)		1	SS	3												
			2	SS	24												
250.9																	
1.4	Silty SAND, trace to some gravel, trace to some clay Compact to Dense Brown to Grey Moist (FILL) Wet		3	SS	17												
			4	SS	25												
			5	SS	31												
			6	SS	23												
			7	SS	47												
	Some organics		8	SS	24												
245.1																	
7.2	Silty CLAY, varved Firm to Stiff Grey Wet																
			1	ST													
			2	ST													

RECORD OF BOREHOLE No 20-21

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 667.6 E 393 627.9 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.12.01 - 2020.12.01 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page													
237.5			3	ST			242			5.3				
							241							
							240			3.2				
			4	ST			239			2.8				
							238			2.9				
14.8	Silty SAND , trace to some gravel, trace to some clay Loose Grey Wet (TILL)		9	SS	4		237							
236.4			10	SS	100/									
15.9	END OF BOREHOLE AT 15.9m UPON SPOON AND AUGER REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.				0.075									

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	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
					WATER CONTENT (%)
					P W L
					NATURAL MOISTURE CONTENT
					Liquid Limit
					UNIT WEIGHT γ
					kN/m ³
					GR SA SI CL
Continued From Previous Page					
237.0	Silty SAND, trace to some gravel, trace to some clay Loose Light Grey Wet (TILL)		1	ST	
240					
239			10	SS	WH
238					
237			2	ST	
236					
234.8	SANDSTONE with dolostone interbeds, slightly to moderately weathered, light brown Sub-vertical fracture (125mm) at 16.5m Sub-horizontal fractures at 16.6m, 16.7m, 17.0m, 17.1m, 17.2m, 17.3m, 17.4m and 18.0m Clay seams (25mm) at 16.7m and (75mm) at 17.2m Gypsum layer at 16.9m Gypsum layer (75mm) at 18.1m and (50mm) at 19.1m Sub-horizontal fractures at 18.3m, 18.4m, 18.6m, 18.7m, 18.9m, 19.2m, 19.3m, 19.4m and 19.5m Clay seams (50mm) at 18.3m, (50mm) at 19.2m and (75mm) at 19.4m Rubble zone (25mm) at 19.4m		11	SS	5
235			12	SS	50/0.050
234			1	RUN	
233			2	RUN	
232					
END OF BOREHOLE AT 19.6m.					

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 20-24

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 651.2 E 393 619.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2021.05.15 - 2021.05.15 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
252.6	GROUND SURFACE															
0.0	SAND , some silt, trace gravel, trace roots (FILL) Silty SAND , trace to some gravel, trace to some clay Loose to Compact Brown Moist (FILL) <															

Continued Next Page

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

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-24

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 651.2 E 393 619.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2021.05.15 - 2021.05.15 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page											
238.0			9	SS	WH		242					
							241	4.0				
			2	ST			240	4.3				
			10	SS	WH		239					
238.0							238					
14.6	Silty SAND , trace to some gravel, trace to some clay Compact Light Grey Wet (TILL)		11	SS	19		237					
							236					
							235					
234.6	Cobbles and boulders from 17.4m to 18.0m						234					
18.0	SANDSTONE with dolostone interbeds, slightly to moderately weathered, light brown Sub-horizontal fractures at 18.1m, 18.3m and 19.1m Vertical fractures at 18.7m and 19.1m Horizontal fracture at 19.1m Gypsum layers (25mm) at 19.7m, (50mm) at 20.0m, (25mm) at 20.2m and (50mm) at 20.6m		1	RUN			233					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

ONTMT452 MTO-28552.GPJ 2017TEMPLATE(MTO).GDT 11/17/21

RECORD OF BOREHOLE No 20-24

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 651.2 E 393 619.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2021.05.15 - 2021.05.15 LATITUDE LONGITUDE CHECKED BY GRL/JA

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

RECORD OF BOREHOLE No 20-25

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 644.0 E 393 645.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.19 - 2020.11.21 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
256.6	GROUND SURFACE												
0.0	ASPHALT: (150mm)												
0.2	SAND and GRAVEL, some silt Brown Moist (FILL)		1	GS			256						
255.7													
255.0	ASPHALT: (75mm)		1	SS	61								
1.0	SAND to Silty SAND, trace to some gravel, trace to some clay Very Dense to Compact Brown to Grey Moist (FILL)		2	SS	61		255						
			3	SS	19		254						
			4	SS	25		253						
			5	SS	35								7 58 23 12
			6	SS	25		252						
							251						
			7	SS	100/ 0.225		250						
							249						
			8	SS	19								
247.9							248						
8.7	Silty CLAY, with sand, some gravel, trace organics Stiff Grey Moist (FILL)		9	SS	15		247						
	Topsoil at 9.4m												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-25

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 644.0 E 393 645.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.19 - 2020.11.21 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
244.3			10	SS	9		246					12 41 29 18
12.3	Silty CLAY , varved Stiff Grey Wet		11	SS	5		245					
							244					0 0 43 57
							243					
			1	ST			242					
							241					
			2	ST			240					
239.8							239					
16.8	Silty SAND , trace to some gravel, trace to some clay Loose to Compact Grey Wet (TILL)		3	ST			238					
			12	SS	17		237					
			13	SS	4							

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-25

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 644.0 E 393 645.7 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.19 - 2020.11.21 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)									
<p>Continued From Previous Page</p> <p>20 40 60 80 100</p> <p>○ UNCONFINED + FIELD VANE</p> <p>● QUICK TRIAXIAL × LAB VANE</p> <p>20 40 60 80 100</p>																						
235.0	Silty SAND , trace to some gravel, trace to some clay Compact to Very Dense Grey Wet (TILL)		14	SS	13		236									○					17 50 24 9	
			15	SS	18												○					
			16	SS	85/												○					
21.6	END OF BOREHOLE AT 21.6m UPON SPOON AND AUGER REFUSAL ON PROBABLE BEDROCK. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.09 2.8 253.8				0.100																	

RECORD OF BOREHOLE No 20-26

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 641.1 E 393 642.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.26 - 2020.11.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
256.6	GROUND SURFACE															
0.0	ASPHALT: (160mm)															
0.2	SAND and GRAVEL, some silt Brown Moist (FILL)		1	GS			256									37 50 13 (SI+CL)
255.7																
255.8	ASPHALT: (150mm)		1	SS	72											
1.1	SAND to Silty SAND, trace to some gravel, trace to some clay Compact Brown Moist (FILL)						255									
			2	SS	27											4 84 12 (SI+CL)
			3	SS	90/ 0.300		254									
			4	SS	30		253									
	Moist to Wet															
			5	SS	29											
							252									
			6	SS	24											7 59 23 11
	Grey						251									
			7	SS	26		250									
							249									
			8	SS	8		248									
							247									
	Loose															
			9	SS	32											

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-26

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 641.1 E 393 642.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.26 - 2020.11.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				
245.8							246					
245.9	TOPSOIL: (50mm)		10	SS	9							
10.9												
244.4							245					
12.2	Silty CLAY, varved Stiff Grey Wet		11	SS	0		244					
			1	ST			243					
			2	ST			242					
							241					
			12	SS	0		240					
239.2												
17.4	Silty SAND, trace to some gravel, trace to some clay Compact Grey Wet (TILL)		13	SS	10		239					
			14	SS	15		238					
							237					

Continued Next Page

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

RECORD OF BOREHOLE No 20-26

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 641.1 E 393 642.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2020.11.26 - 2020.11.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
	Continued From Previous Page							20 40 60 80 100							
							236								
							235								
234.8															
21.8	SANDSTONE , interbedded with limestone, slightly weathered, strong to very strong, brown Horizontal fractures at 21.9m, 22.0m and 22.4m Vertical fracture from 23.1m to 23.3m Sub-vertical fracture (25mm) at 23.2m		1	RUN										FI	RUN #1 TCR=100% SCR=87% RQD=84% UCS=94.4MPa (Average)
							234							0	
														2	
233.2														0	RUN #2 TCR=95% SCR=95% RQD=92% UCS=58.6MPa (Average)
23.4	LIMESTONE , interbedded with sandstone, moderately weathered, weak to very strong, grey/brown Horizontal fractures at 23.6m, 23.8m, 23.9m, 24.0m, 24.2m and 24.3m Sub-horizontal fracture at 24.3m Sub-vertical fractures from 24.9m to 25.0m and 25.2m to 25.3m Horizontal fractures at 25.0m, 25.2m and 25.3m		2	RUN			233							3	
														3	
							232							0	RUN #3 TCR=98% SCR=75% RQD=60% UCS=46.8MPa (Average)
														1	
231.2														3	
25.4	END OF BOREHOLE AT 25.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m AND ASPHALT COLD PATCH TO SURFACE.														

ONTMT4S2 MTO-28552.GPJ 2017TEMPLATE(MTO)_GDT 11/17/21

RECORD OF BOREHOLE No 20-27

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 634.1 E 393 658.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.17 - 2020.11.18 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
256.1	GROUND SURFACE															
0.0	ASPHALT: (140mm)						256									
0.1	SAND and GRAVEL, some silt, trace asphalt Very Dense Dark Grey Moist (FILL) SAND to Silty SAND, trace to some gravel, trace to some clay Dense to Compact Brown Moist (FILL)		1	SS	100/											
			1	GS	0.250											
255.3																
0.8			2	SS	41		255									
			3	SS	25											
			4	SS	22		254									
			5	SS	22											
		6	SS	21		252										
		7	SS	18												
		8	SS	53		251										
		9	SS	25		250										
		10	SS	17		249										
	Grey Moist to Wet															
		11	SS	19		248										
		12	SS	18												
							247									
246.6																
9.4	TOPSOIL: (300mm)		13	SS	10											
246.3																
9.8	Silty CLAY, with sand, trace gravel															

Continued Next Page

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

RECORD OF BOREHOLE No 20-27

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 634.1 E 393 658.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.17 - 2020.11.18 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
	Continued From Previous Page												
244.4	Silty CLAY , with sand, trace gravel, trace organics Stiff to Hard Grey Moist to Wet (FILL)		14	SS	9		246						
			15	SS	41		245						9 40 30 21
11.7	Silty CLAY , varved Stiff Grey Wet		16	SS	2		244						
			1	ST			243						
			2	ST			242						
239.3							241						
16.8	Silty SAND , gravelly, trace to some clay Compact Grey Wet (TILL)		3	ST			240						
			17	SS	5		239						
			18	SS	12		238						26 43 23 8
							237						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-27

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 286 634.1 E 393 658.2 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2020.11.17 - 2020.11.18 LATITUDE LONGITUDE CHECKED BY GRL/JA



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L WATER CONTENT (%)						
	Continued From Previous Page													
235.6	Switch to DCPT at 20.3m	○	19	SS	13		236							
20.5	END OF BOREHOLE AT 20.5m UPON DCPT REFUSAL. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.1m AND ASPHALT COLD PATCH TO SURFACE.													

RECORD OF BOREHOLE No 20-28

1 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 287 152.6 E 393 133.9 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.27 - 2021.05.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
245.8	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL: (150mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
0.2	Silty CLAY , varved Soft to Firm Brown Moist		1	SS	5		245						○ ○	
			2	SS	5								○	
	Grey Wet		3	SS	3		244						○	
							243	4.0 +						
			4	SS	1								○	0 0 57 43
							242							
								5.2 +						
			1	ST			241						○	
							240	12.0 +						
			5	SS	WH								○	
							239							
								6.0 +						
			2	ST			238						○	
							237	+						
			6	SS	WH								○	
							236							

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-28

2 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 287 152.6 E 393 133.9 ORIGINATED BY GF
 DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AN
 DATUM Geodetic DATE 2021.05.27 - 2021.05.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE		● QUICK TRIAXIAL × LAB VANE			w _P w w _L				
								20 40 60 80 100				20 40 60					
	Continued From Previous Page																
			3	ST			235	5.6 +									
							234	8.0 +									
			7	SS	WH		233										
							232	9.0 +									
			8	SS	2		231								0 0 53 47		
							230	5.3 +									
			9	SS	3		229										
							228										
			10	SS	2		227										
							226										
227.4																	
18.4	Silty SAND , trace to some gravel, trace to some clay Compact Grey Wet (TILL)		11	SS	7												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-28

3 OF 3

METRIC

W.P. 5101-17-00 LOCATION N 5 287 152.6 E 393 133.9 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.27 - 2021.05.27 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page		12	SS	8												
224.8							225										
21.0	END OF BOREHOLE AT 21.0m ON AUGER REFUSAL.																

RECORD OF BOREHOLE No 20-29

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 820.2 E 393 566.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.05 - 2021.05.06 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
247.5	GROUND SURFACE													
0.0	TOPSOIL: (150mm)													
0.2	Silty CLAY, varved Soft to Firm Dark Grey Moist		1	SS	7		247							
			2	SS	4		246							0 0 42 58
	Wet		1	ST			245							0 0 58 42
			3	SS	WH		244							0 0 19 81
							243							
			2	ST			242							
			4	SS	WH		241							
			3	ST			240							
							239							
			5	SS	WH		238							0 0 37 63
	Stiff													

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 20-29

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 820.2 E 393 566.6 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.05 - 2021.05.06 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
235.8			6	SS	1		237							
11.7	Silty SAND , trace to some gravel, trace to some clay Very Loose Grey Wet (TILL)		7	SS	2		236							
			8	SS	4		235							
233.8			9	SS	50/		234							
13.7	END OF BOREHOLE AT 13.7m ON SPOON AND AUGER REFUSAL. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.05.15 6.5 241.0 2021.05.27 1.5 246.0				0.025									

RECORD OF BOREHOLE No 20-30

1 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 516.1 E 393 893.0 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.26 - 2021.05.26 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
248.5	GROUND SURFACE												
0.0	TOPSOIL: (200mm)												
0.2	Silty CLAY, varved Firm Grey Moist		1	SS	7		248						
	Wet		2	SS	4		247						
			3	SS	3		246						
			1	ST			245						
			4	SS	WH		244						
			2	ST			243						
			5	SS	WH		242						
			3	ST			241						
							240						
							239						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

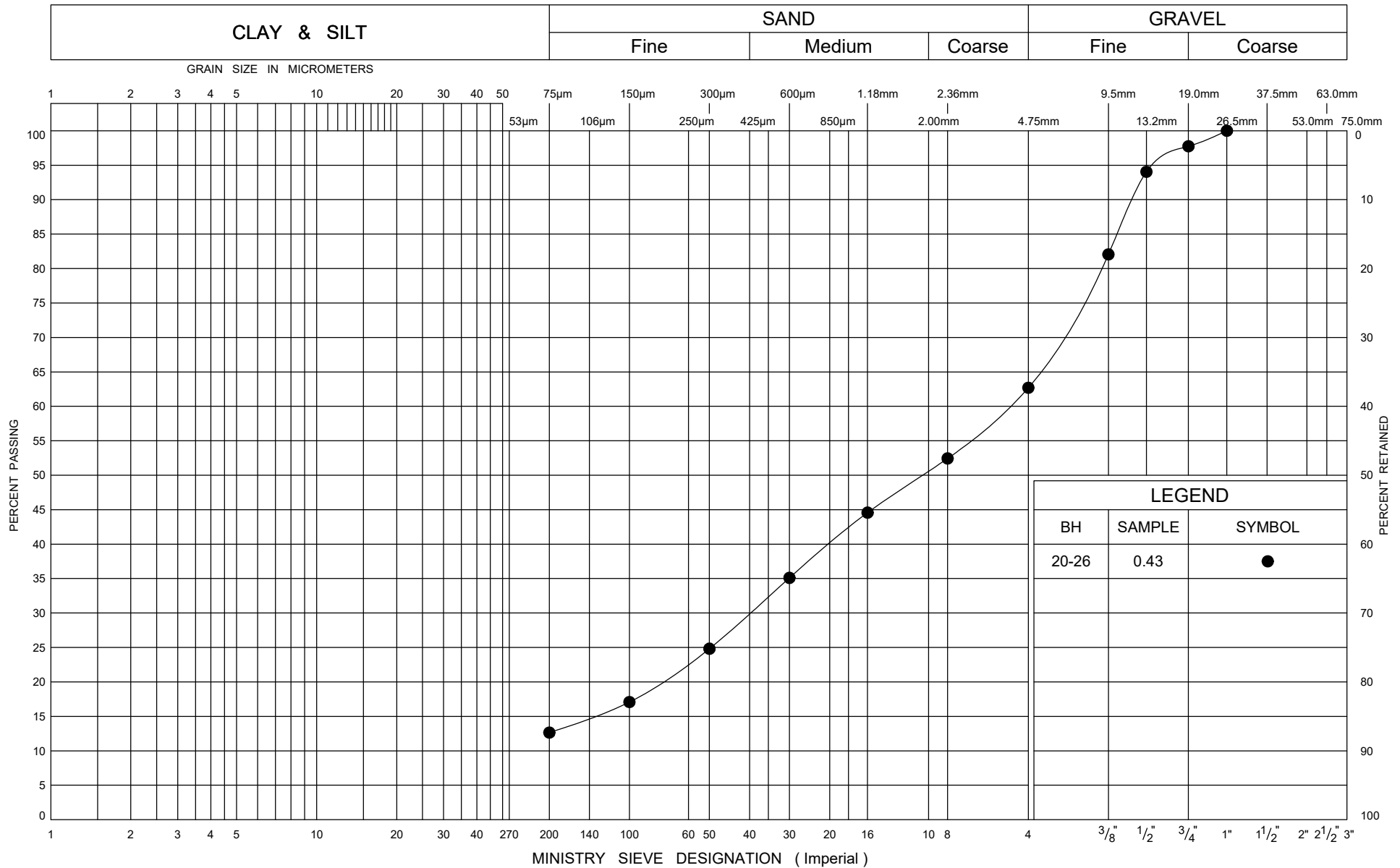
RECORD OF BOREHOLE No 20-30

2 OF 2

METRIC

W.P. 5101-17-00 LOCATION N 5 286 516.1 E 393 893.0 ORIGINATED BY GF
DIST HWY 11 BOREHOLE TYPE Hollow Stem Augers/Wash Boring COMPILED BY AN
DATUM Geodetic DATE 2021.05.26 - 2021.05.26 LATITUDE LONGITUDE CHECKED BY GRL/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100					20 40 60				
								○ UNCONFINED + FIELD VANE					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				
								● QUICK TRIAXIAL × LAB VANE					w P w w L				
								20 40 60 80 100					WATER CONTENT (%)				
237.2	Continued From Previous Page		6	SS	WH		238	10.5									
11.3	Silty SAND , trace to some gravel, trace to some clay Compact Grey Wet (TILL)						237										
235.3			7	SS	12		236										
13.2	END OF BOREHOLE AT 13.2m ON AUGER REFUSAL.																



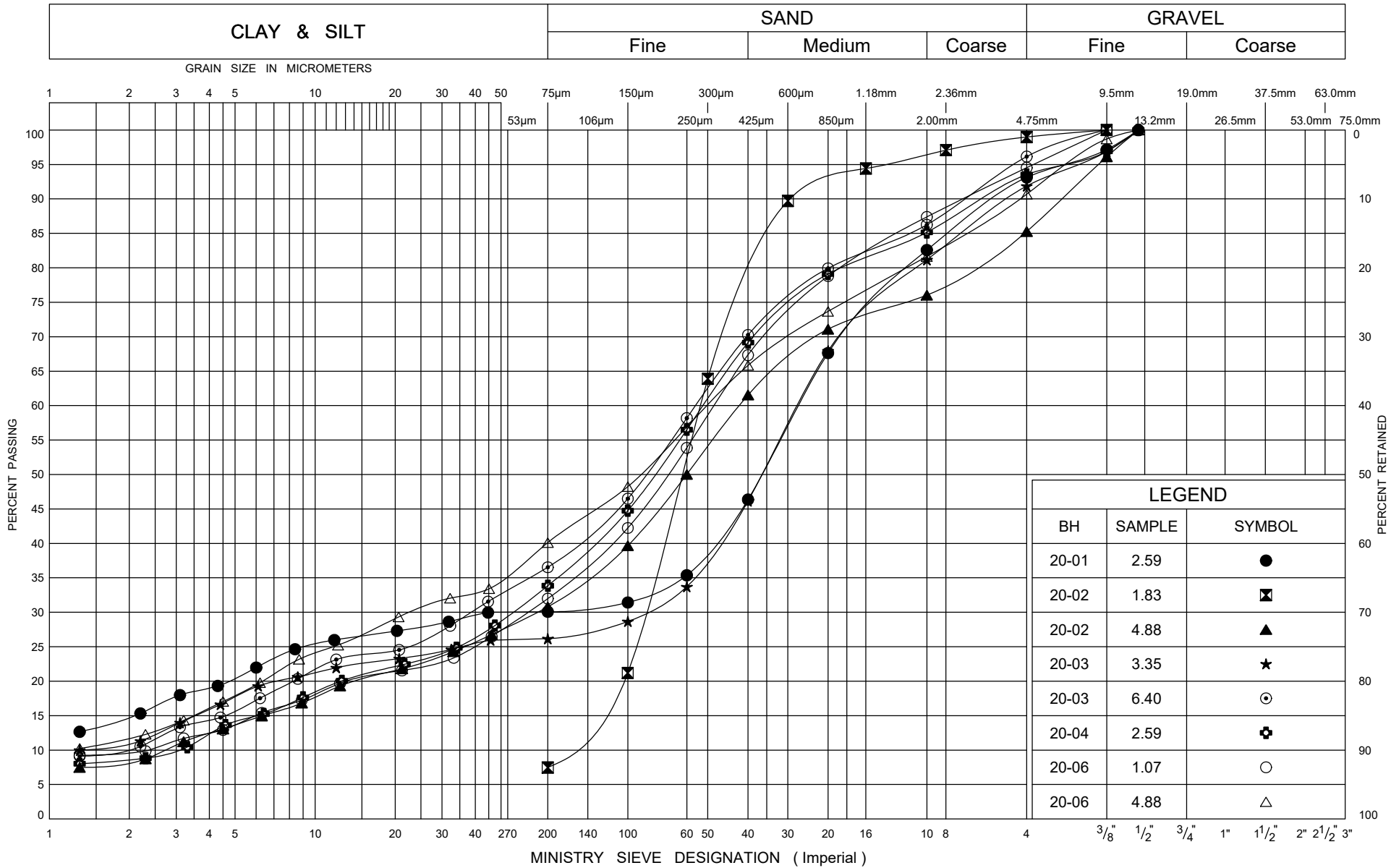
Ministry of
Transportation

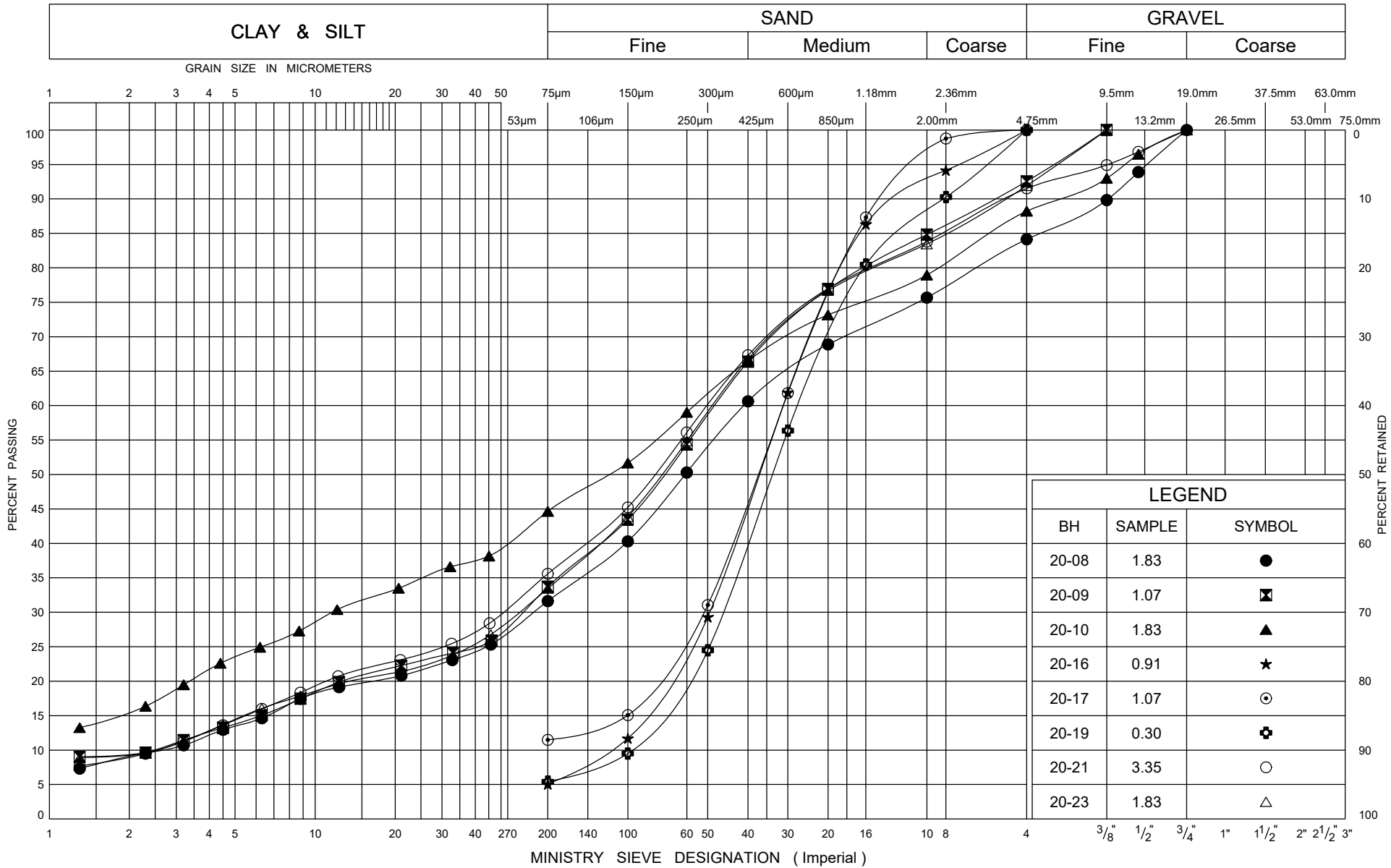
GRAIN SIZE DISTRIBUTION

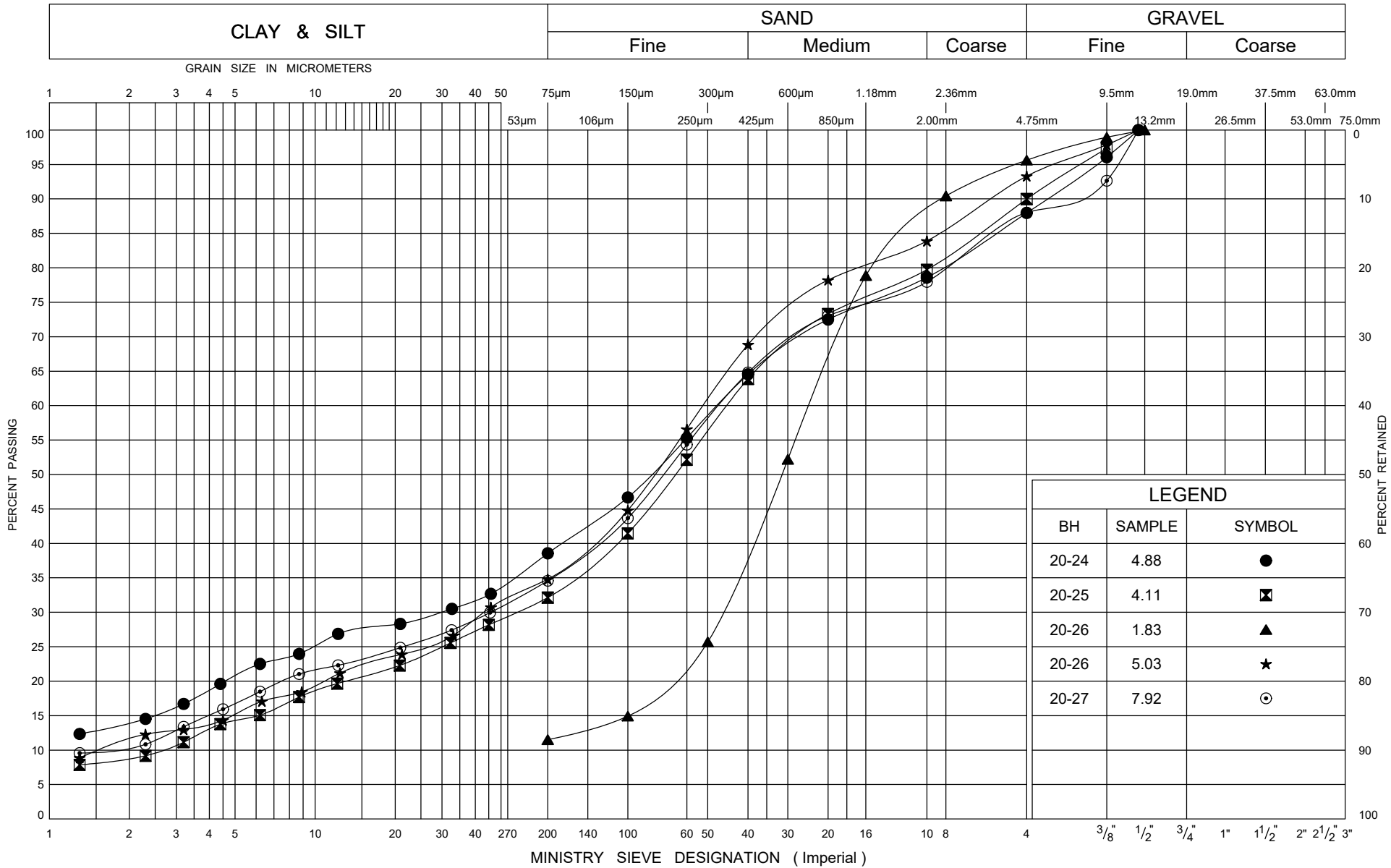
SAND and GRAVEL FILL

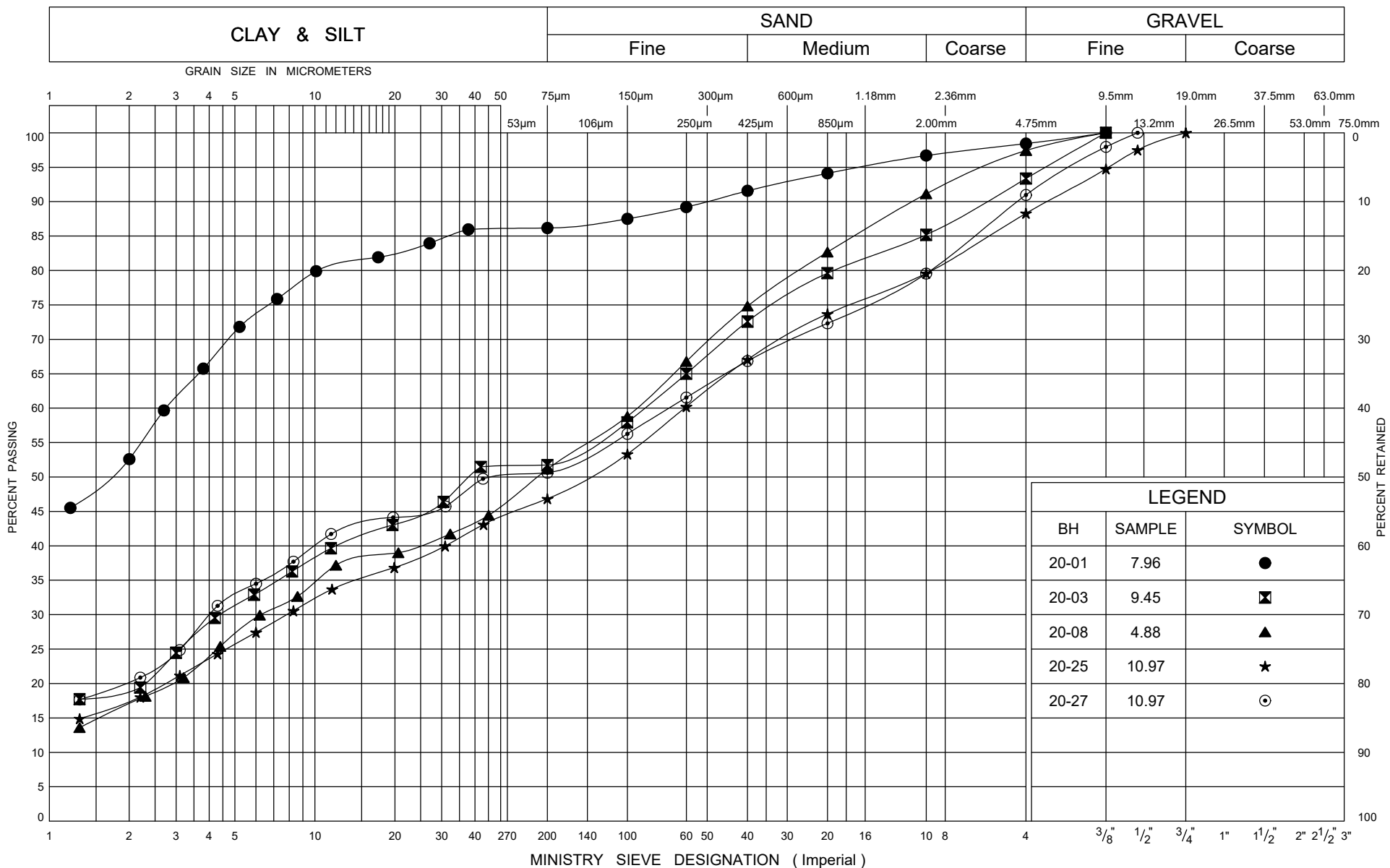
FIG No B1

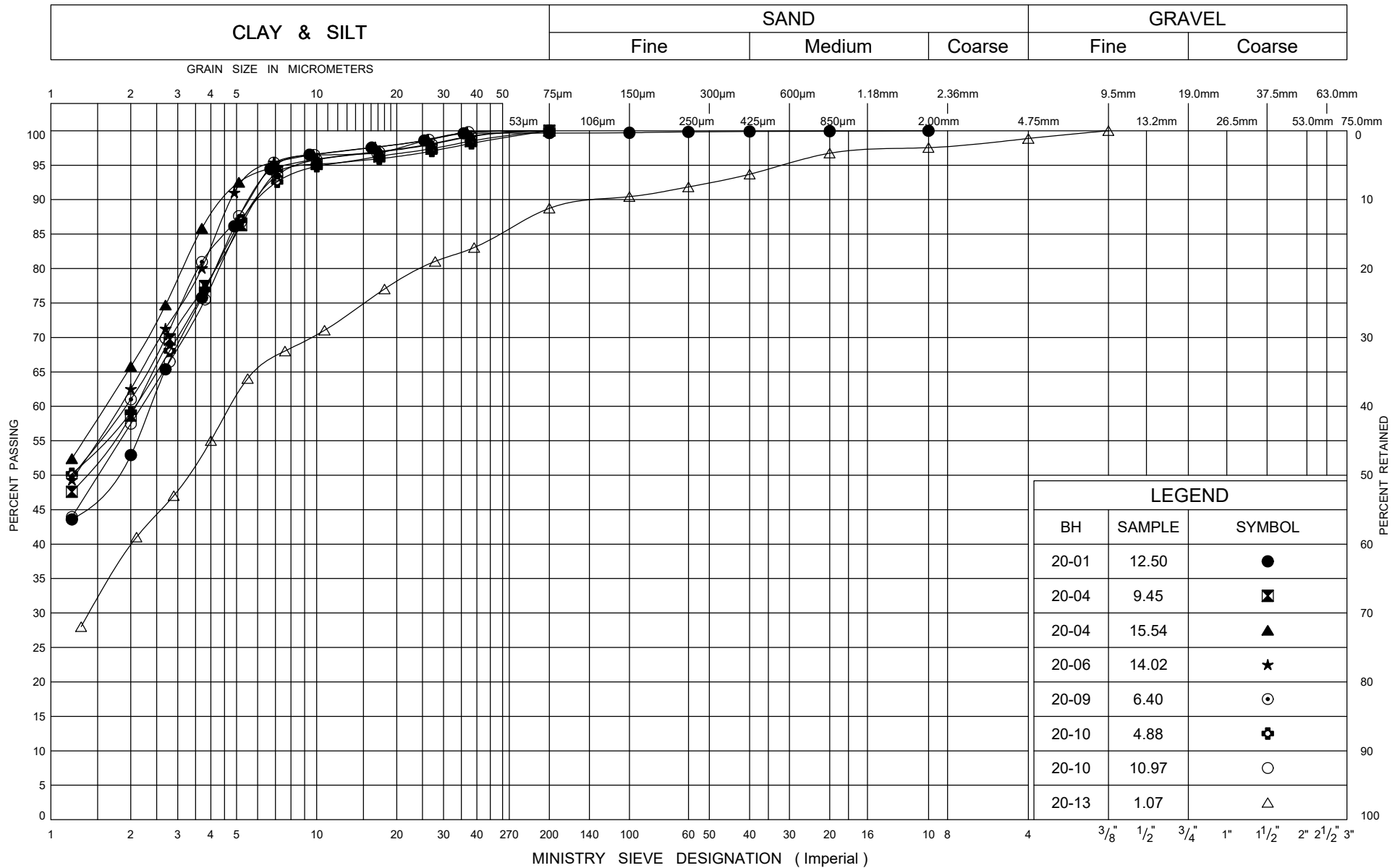
W P 5101-17-00











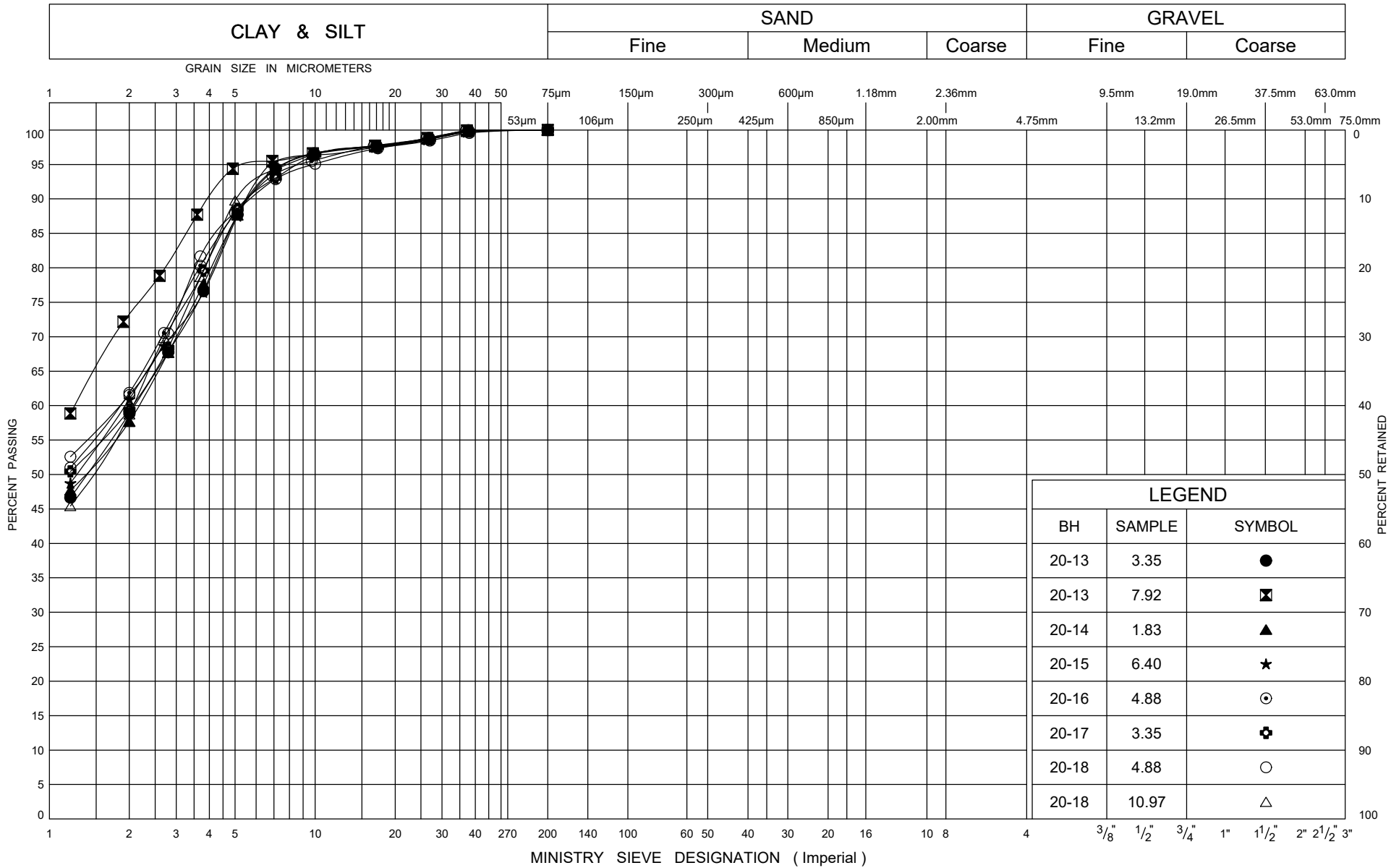
Ministry of
Transportation

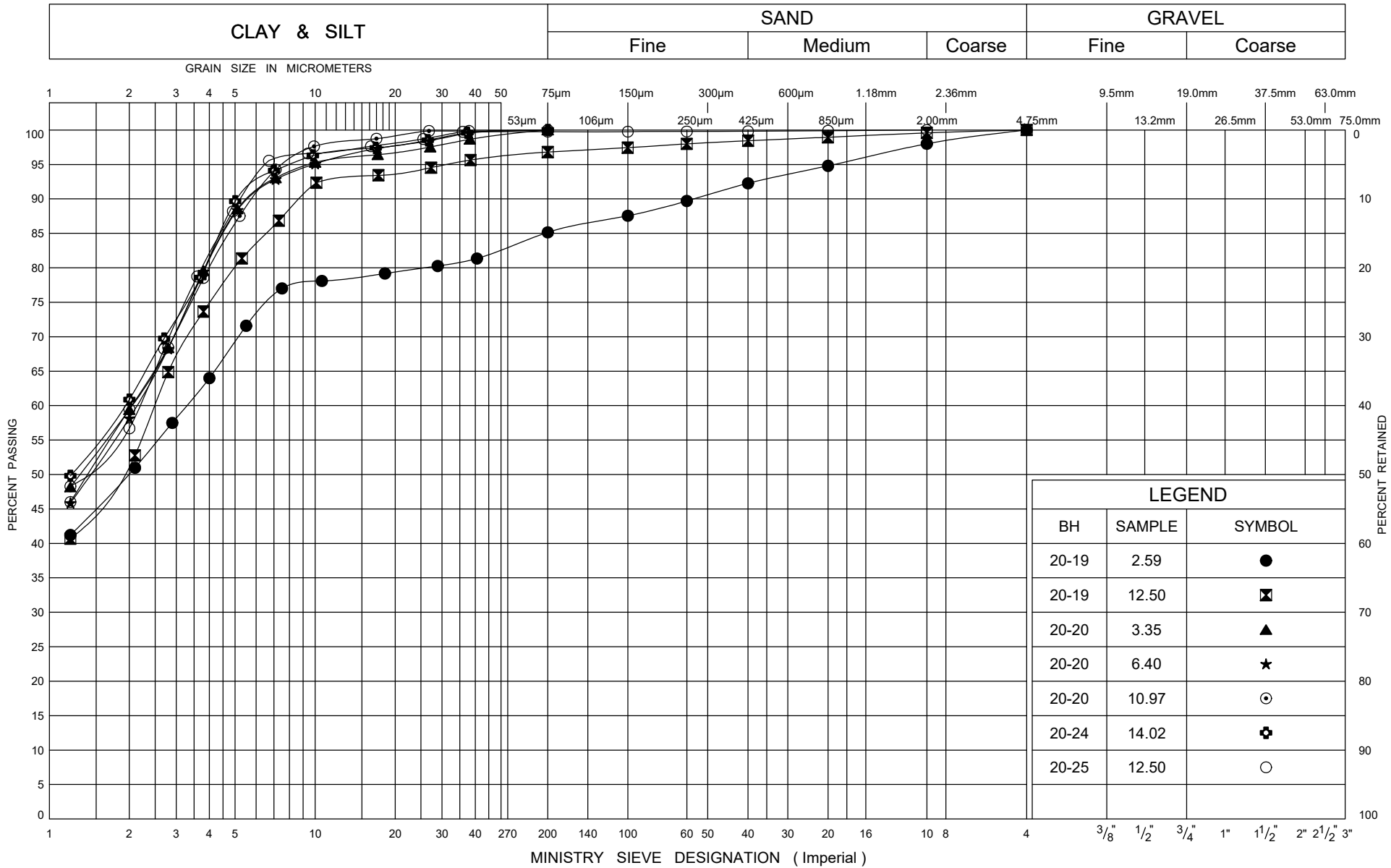
GRAIN SIZE DISTRIBUTION

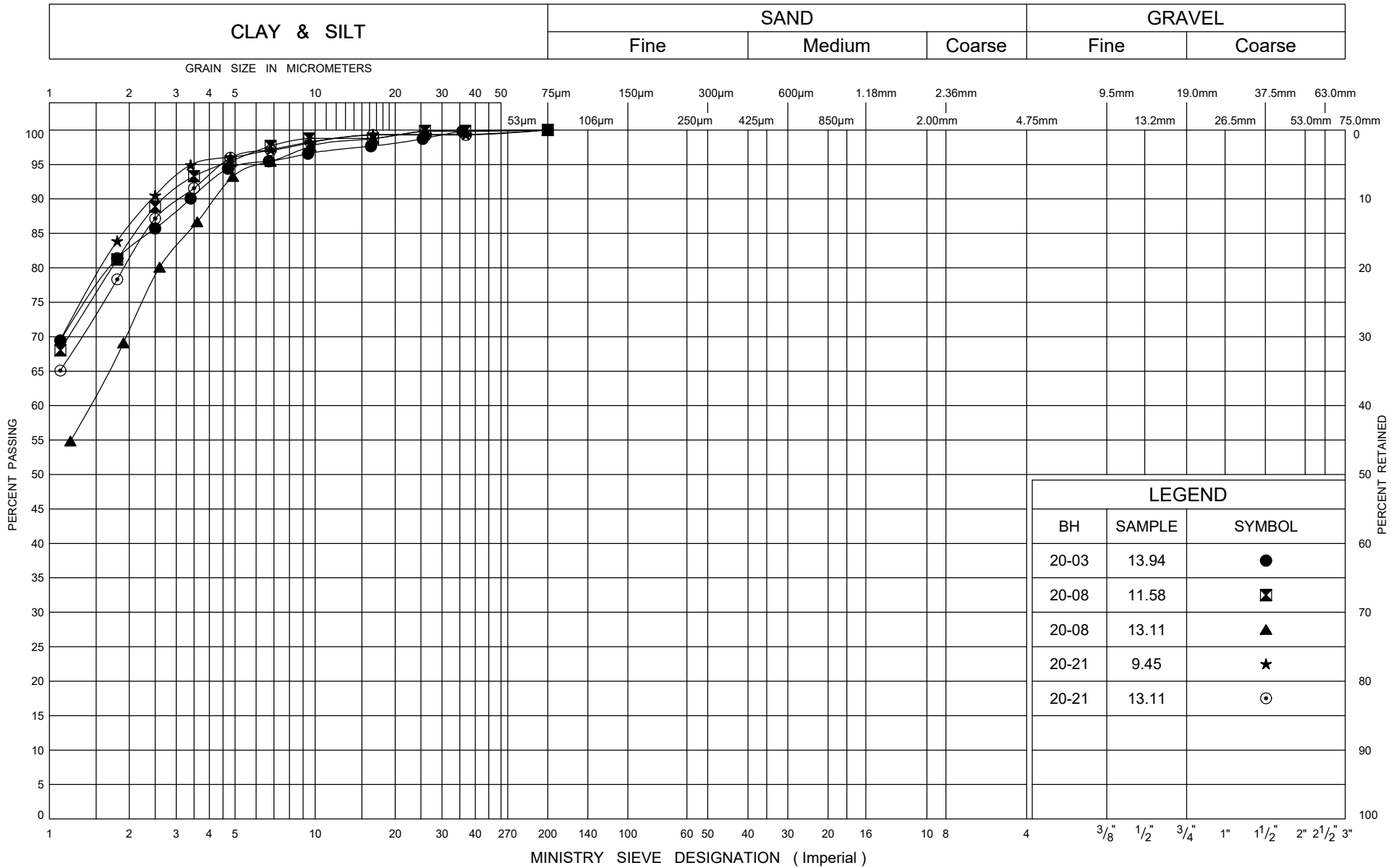
Varved Silty CLAY

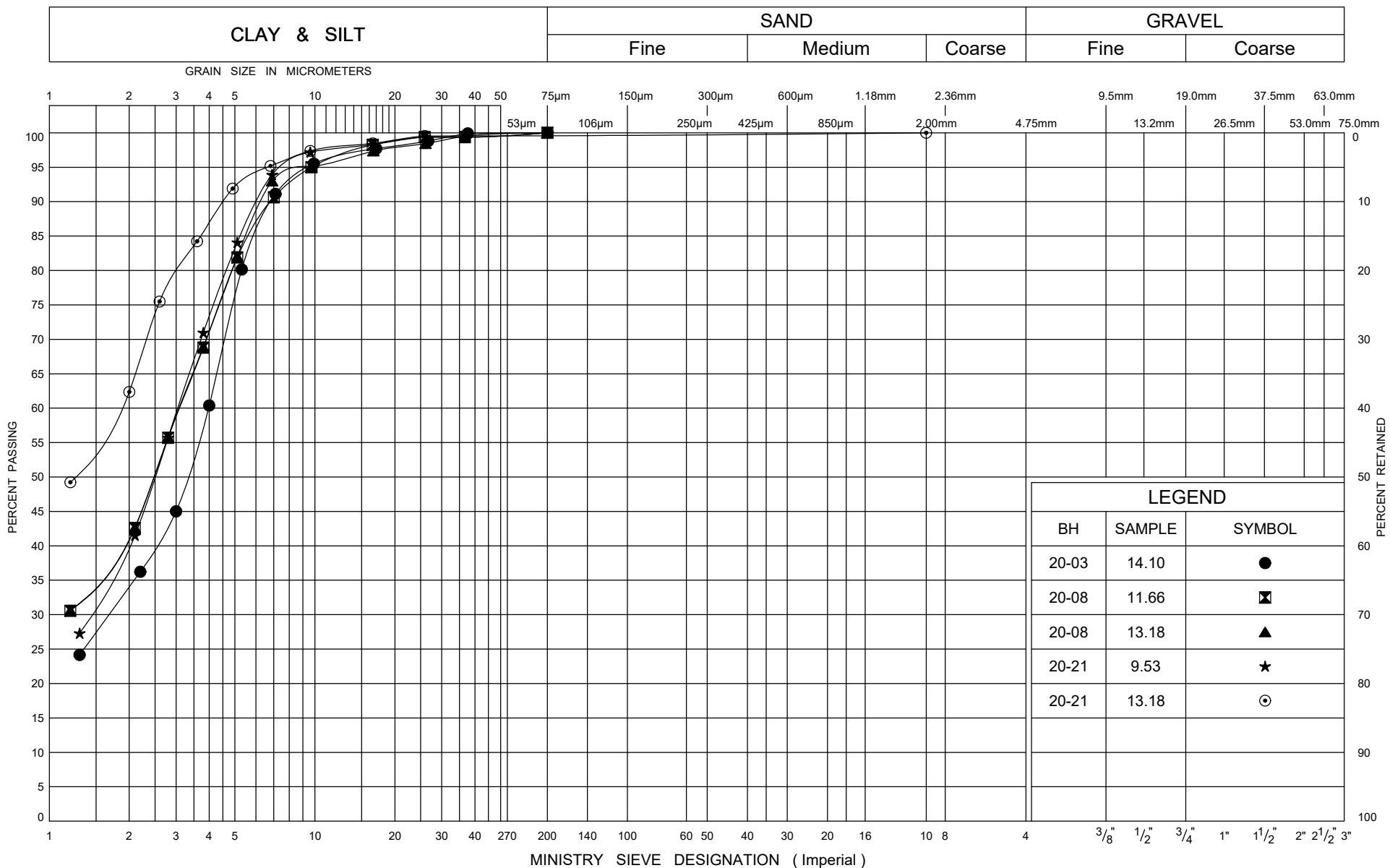
FIG No B6

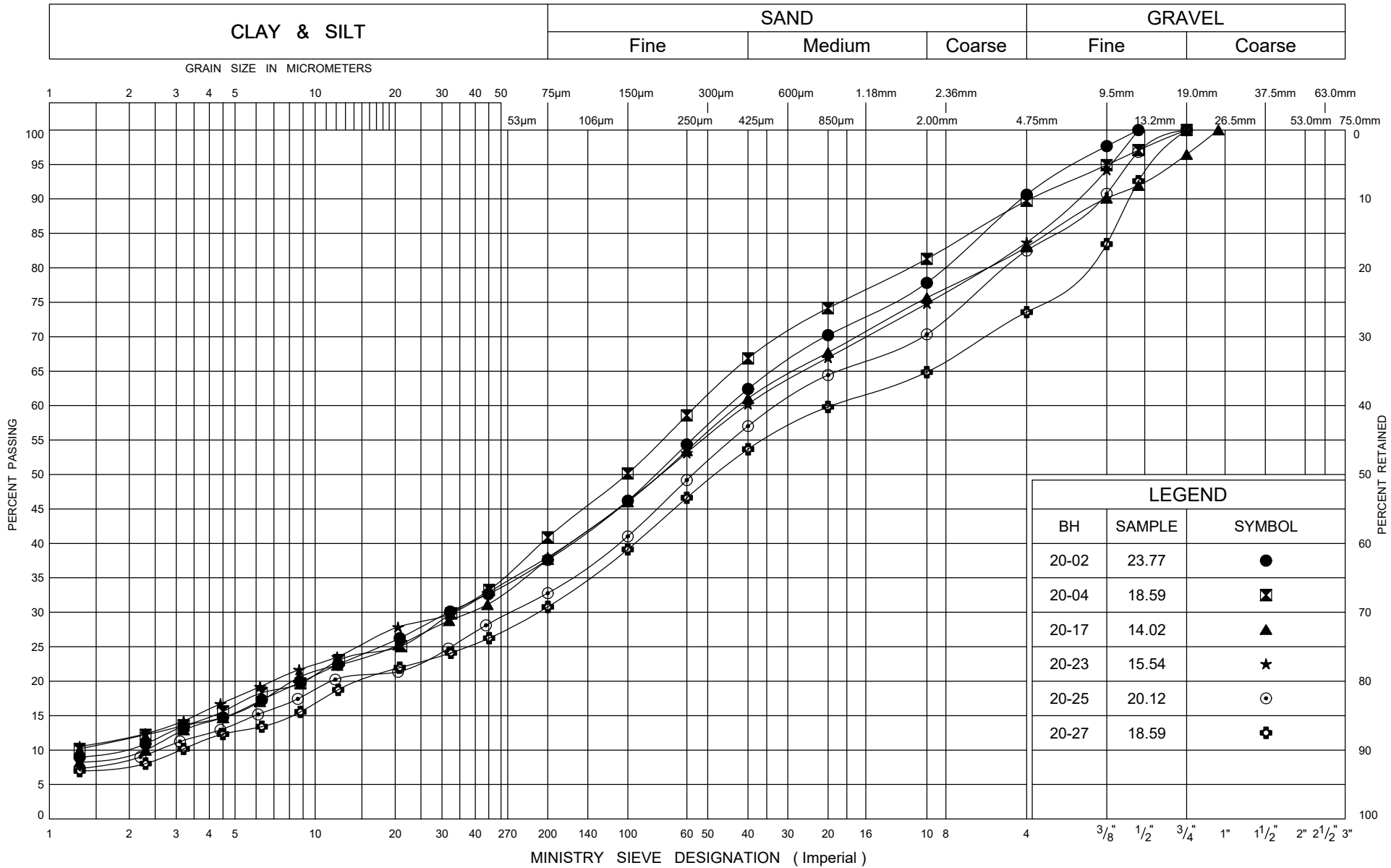
W P 5101-17-00

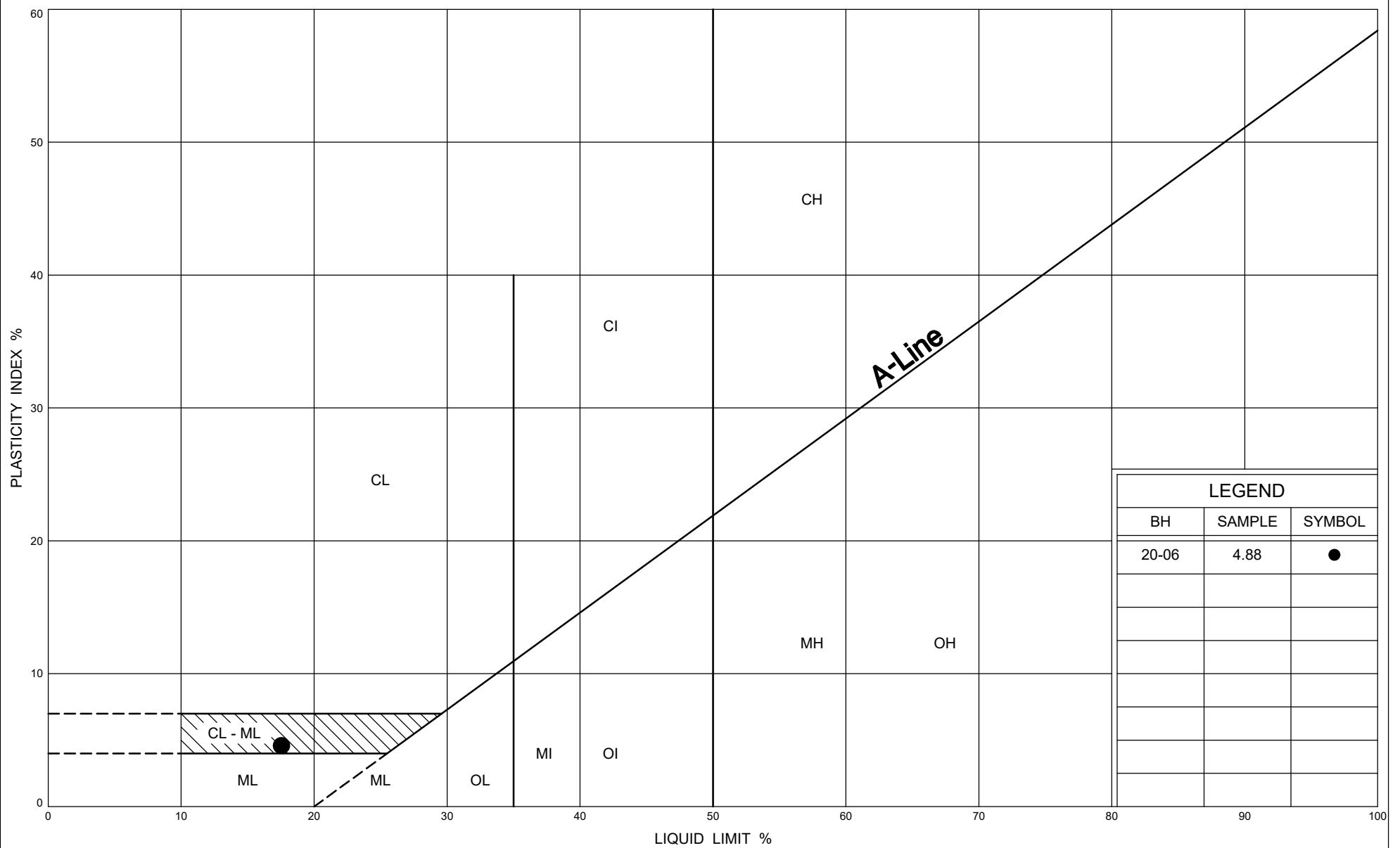






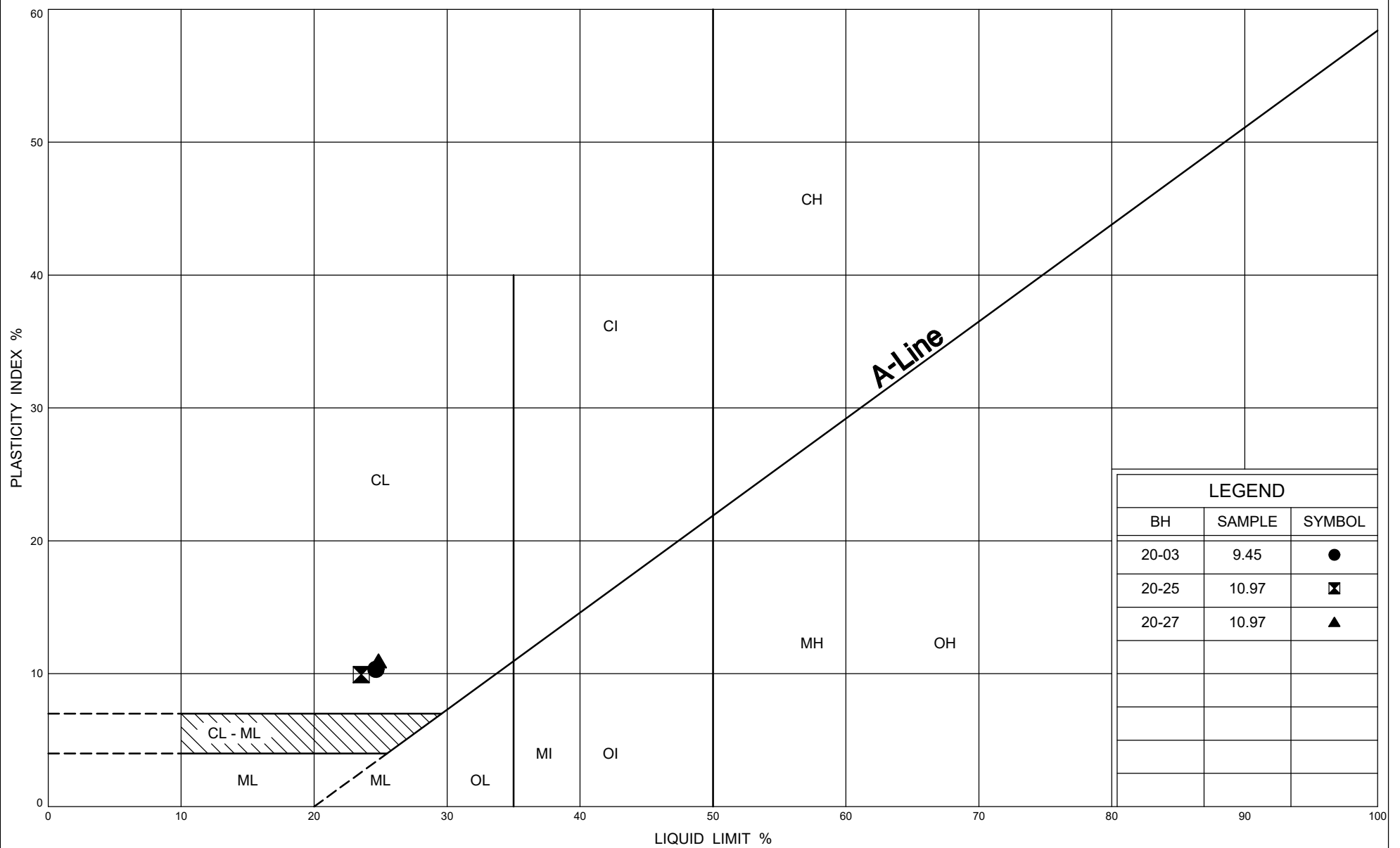


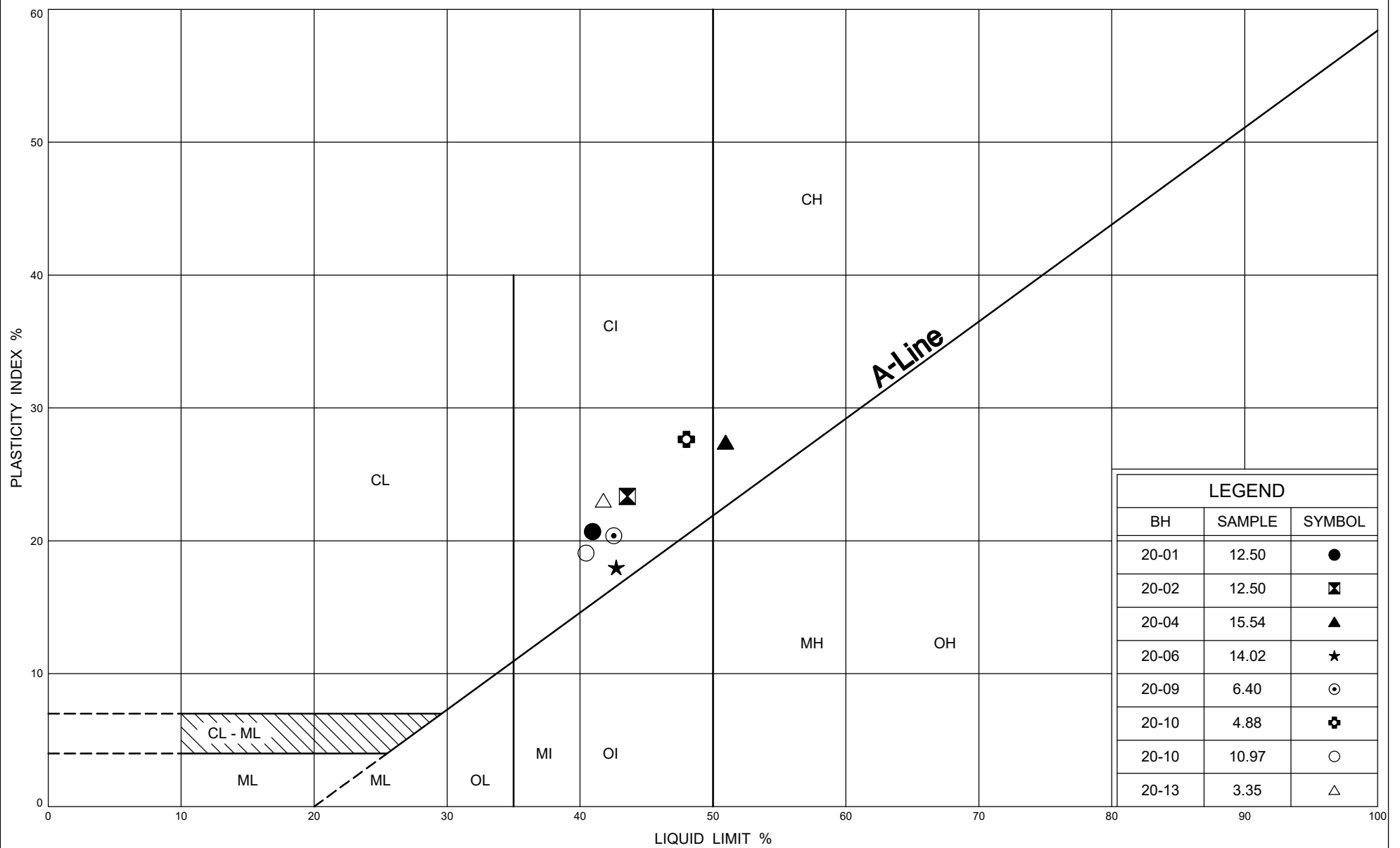




LEGEND		
BH	SAMPLE	SYMBOL
20-06	4.88	●

ONTARIO MOT PLASTICITY CHART MTO-28552.GPJ ONTARIO MOT.GDT 8/30/21





PLASTICITY CHART Varved Silty CLAY

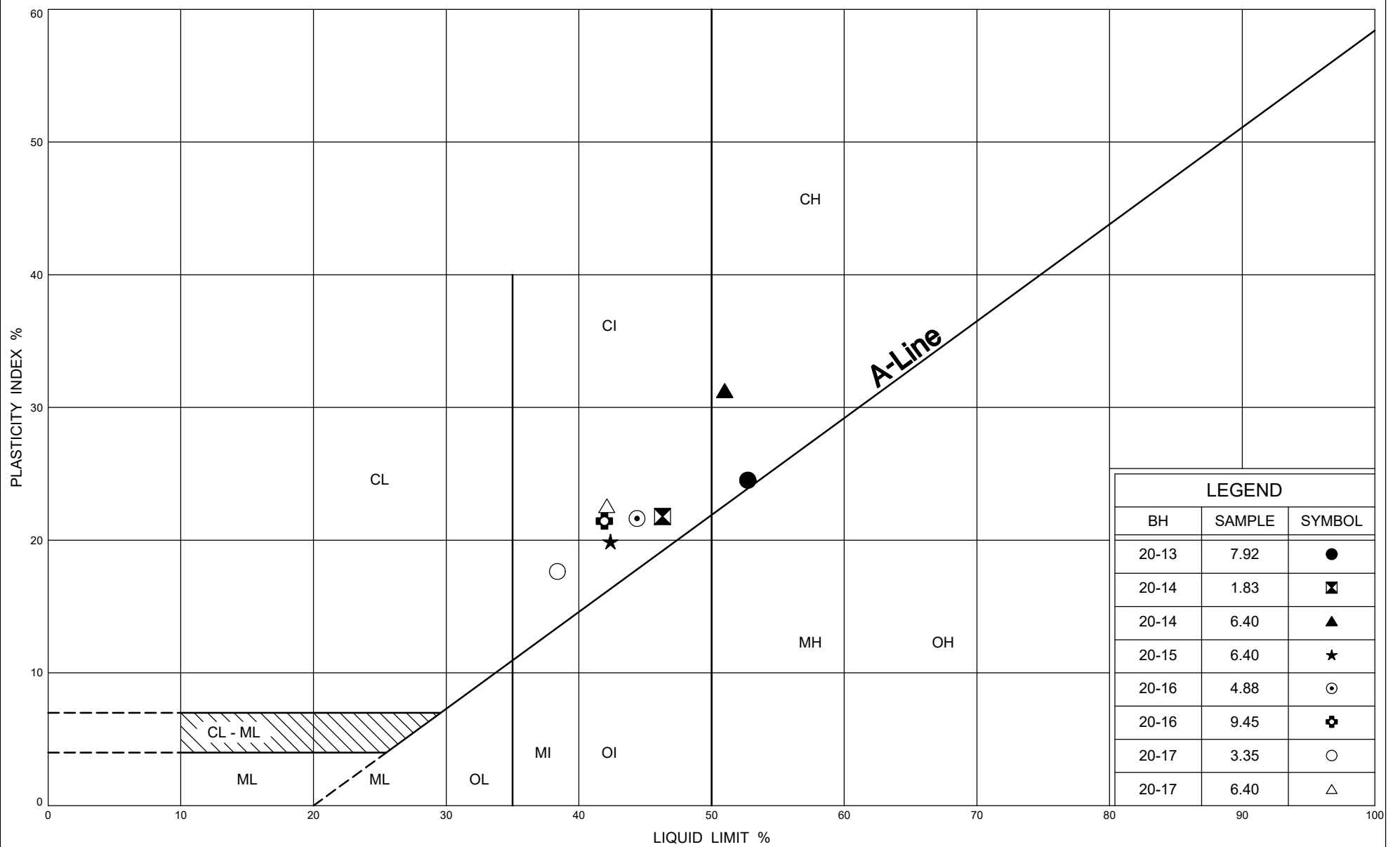
FIG No B14

W P 5101-17-00



Ministry of
Transportation

Ontario



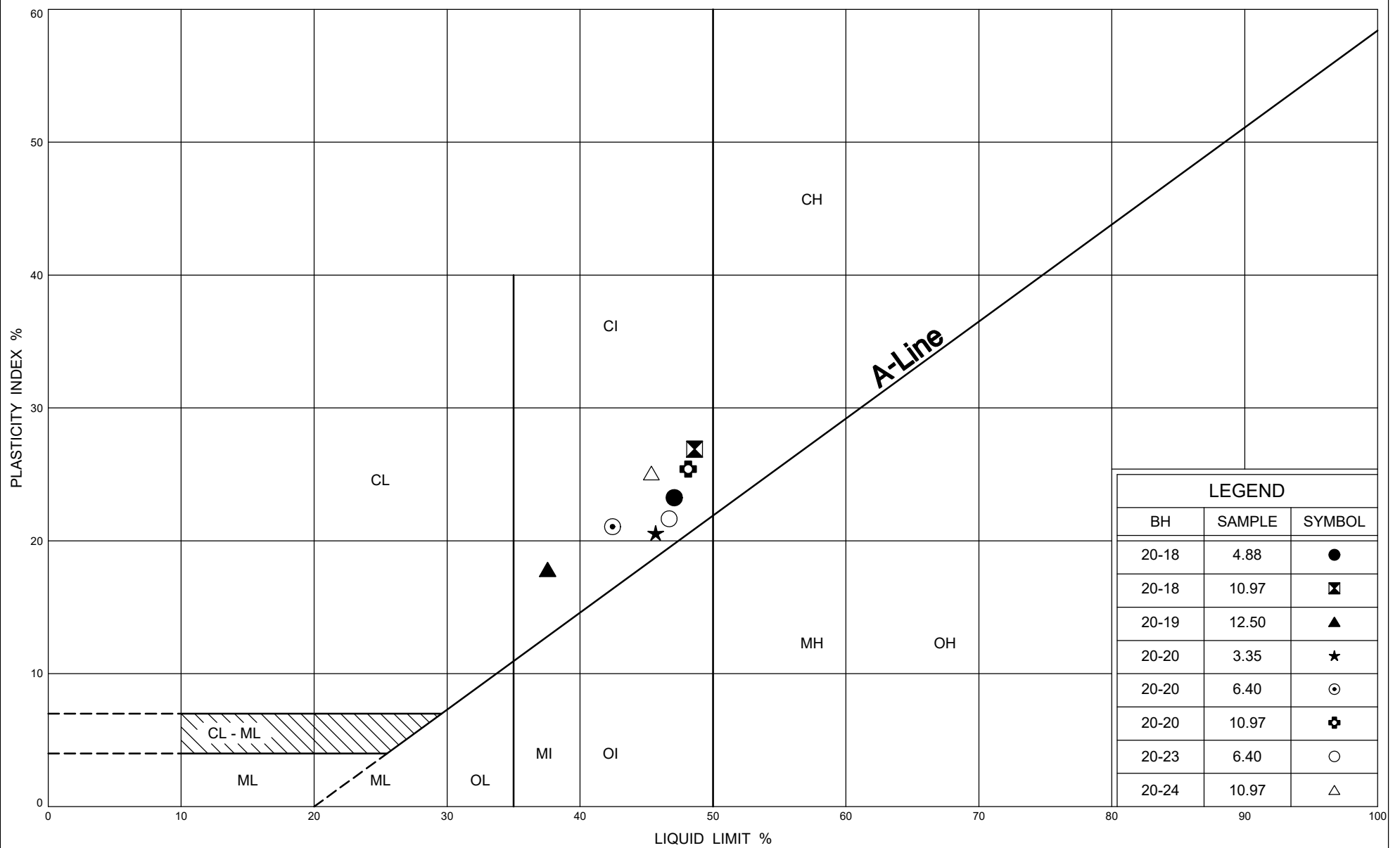
Ministry of
Transportation

PLASTICITY CHART

Varved Silty CLAY

FIG No B15

W P 5101-17-00



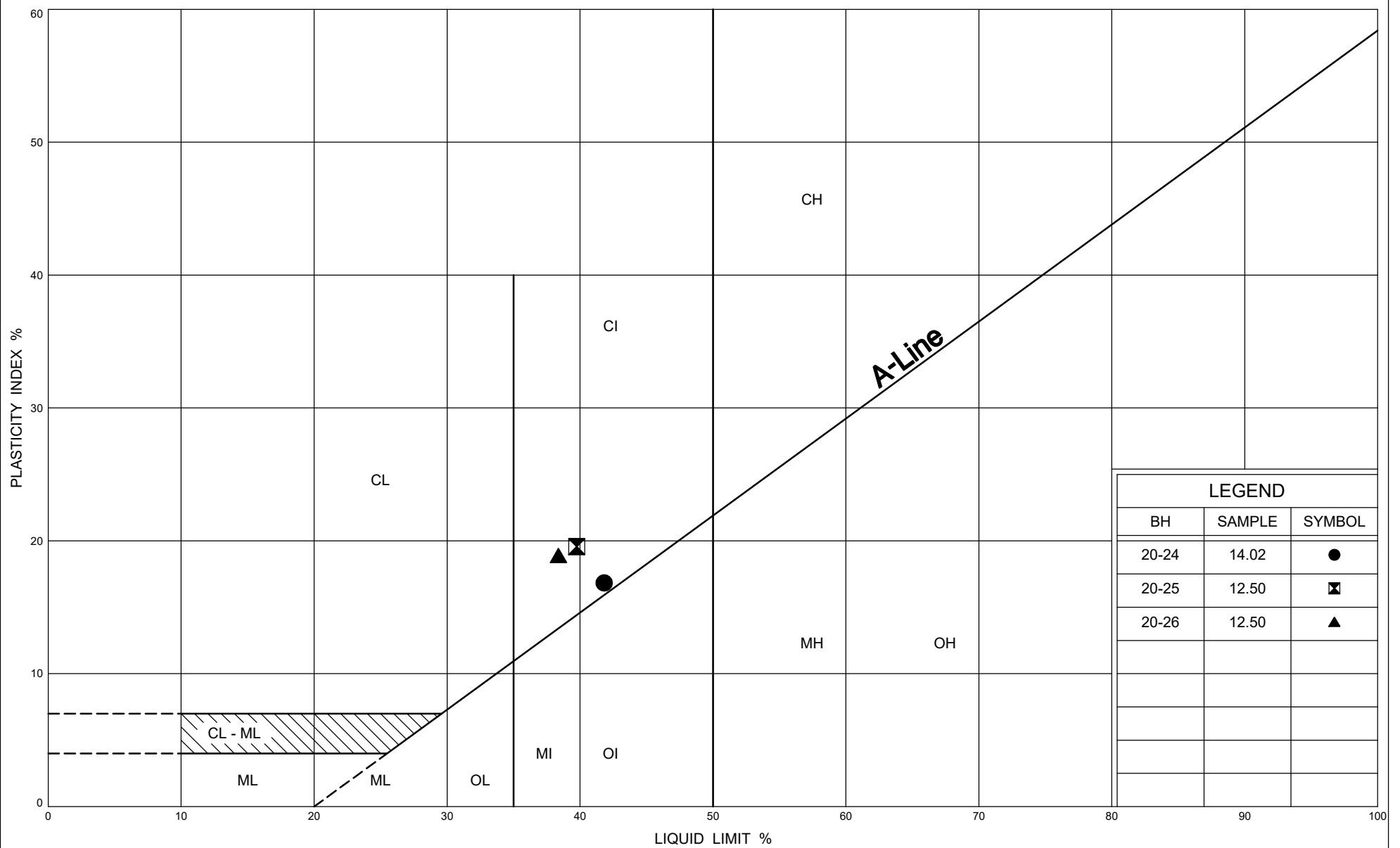
Ministry of
Transportation

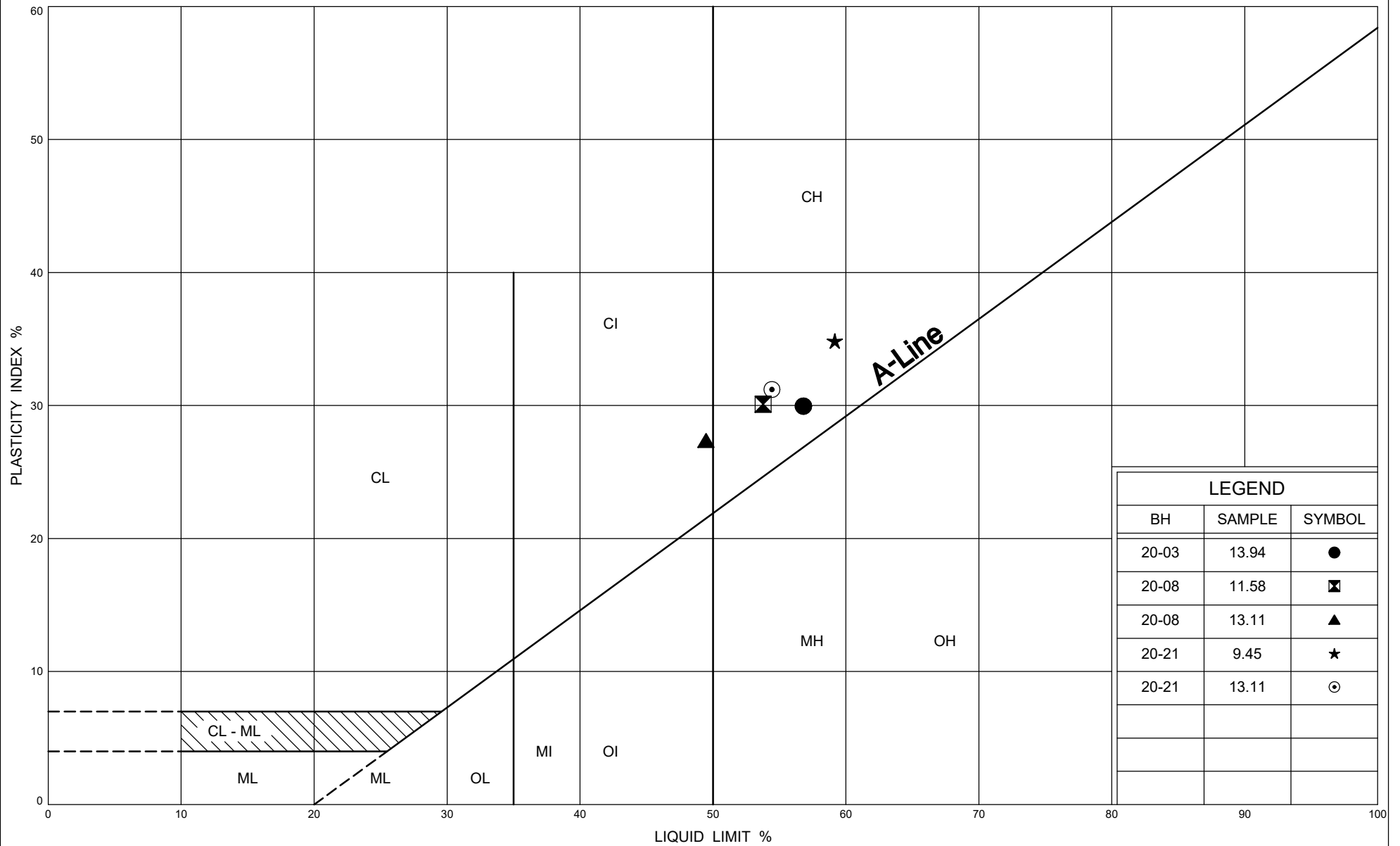
PLASTICITY CHART

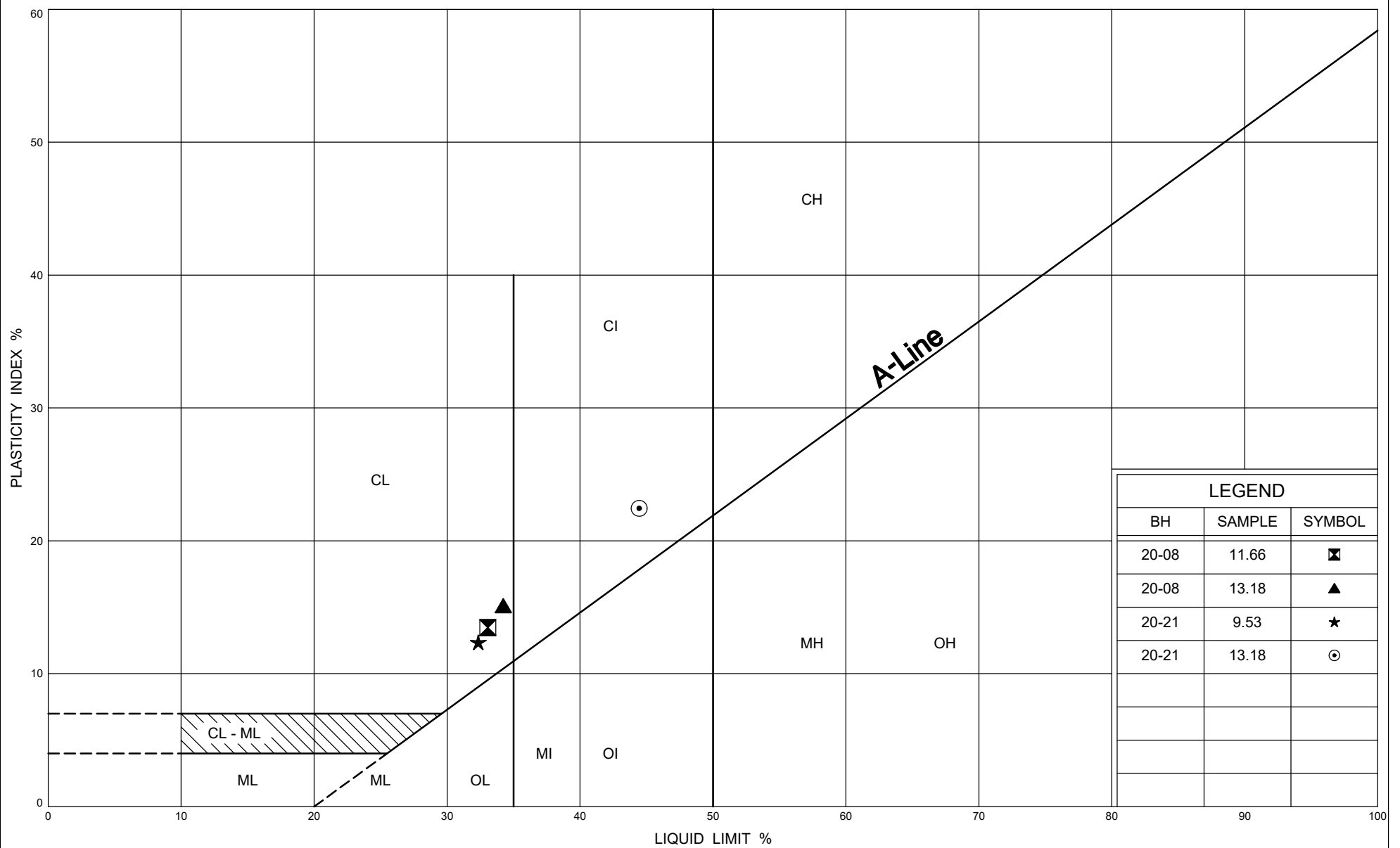
Varved Silty CLAY

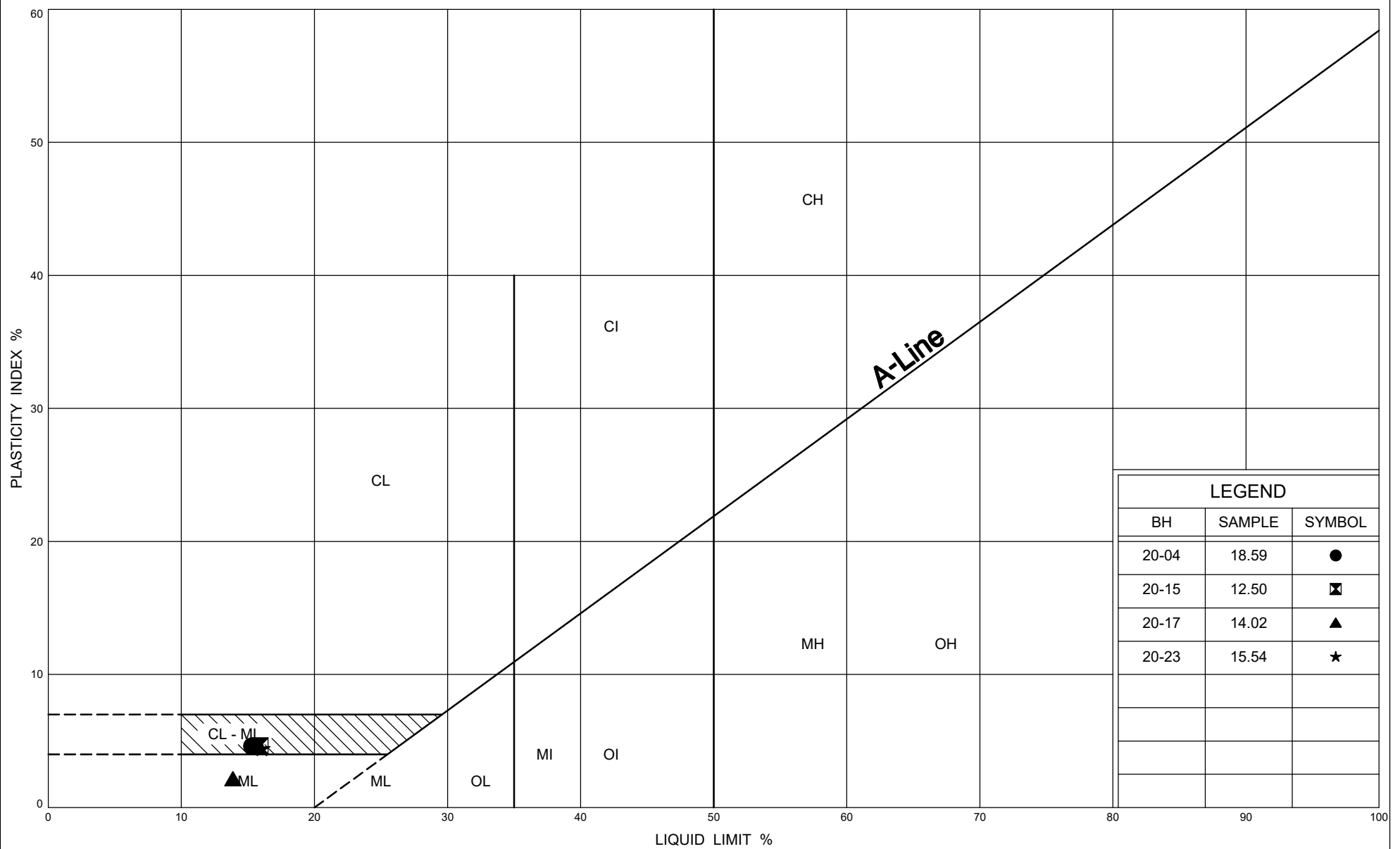
FIG No B16

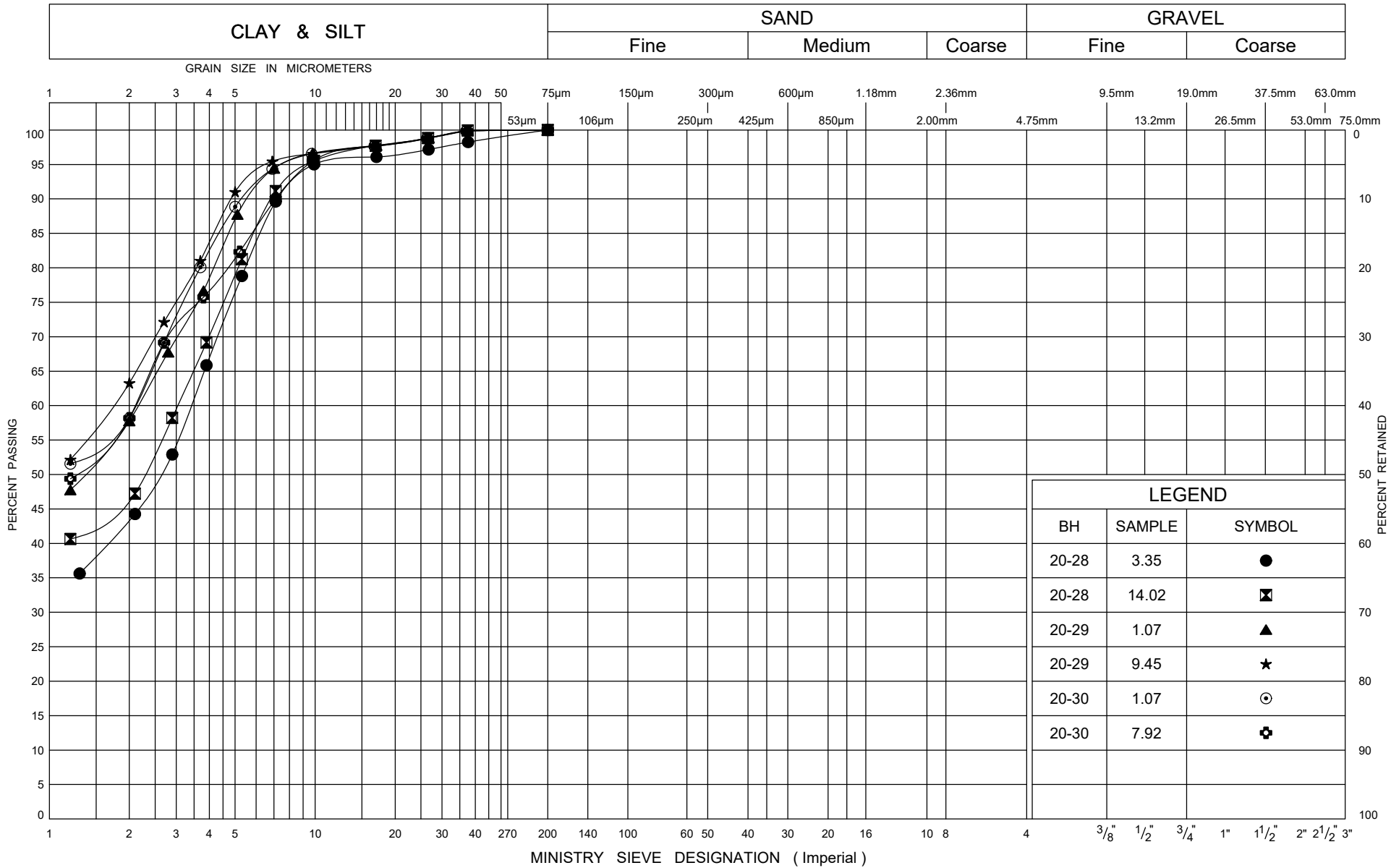
W P 5101-17-00

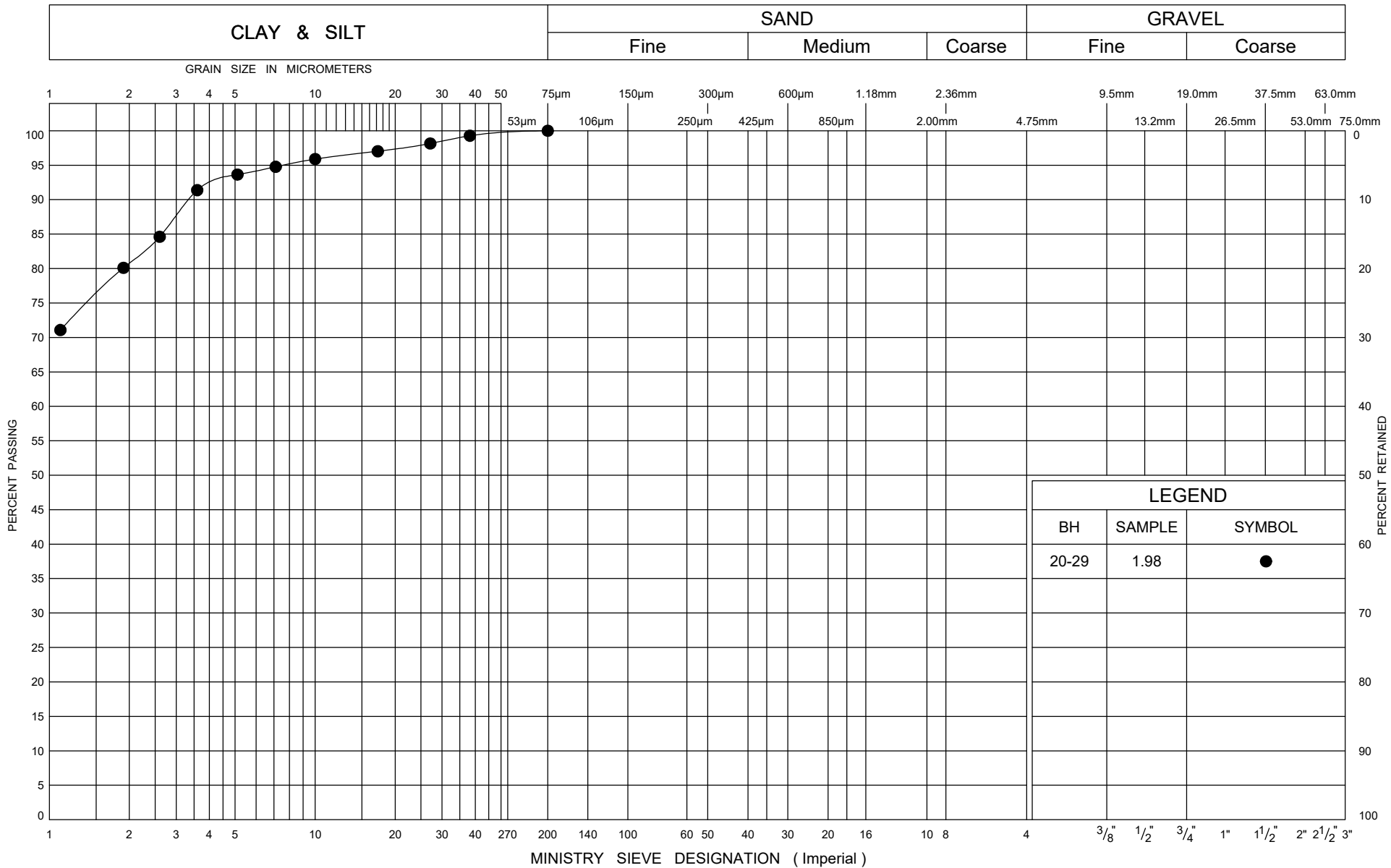


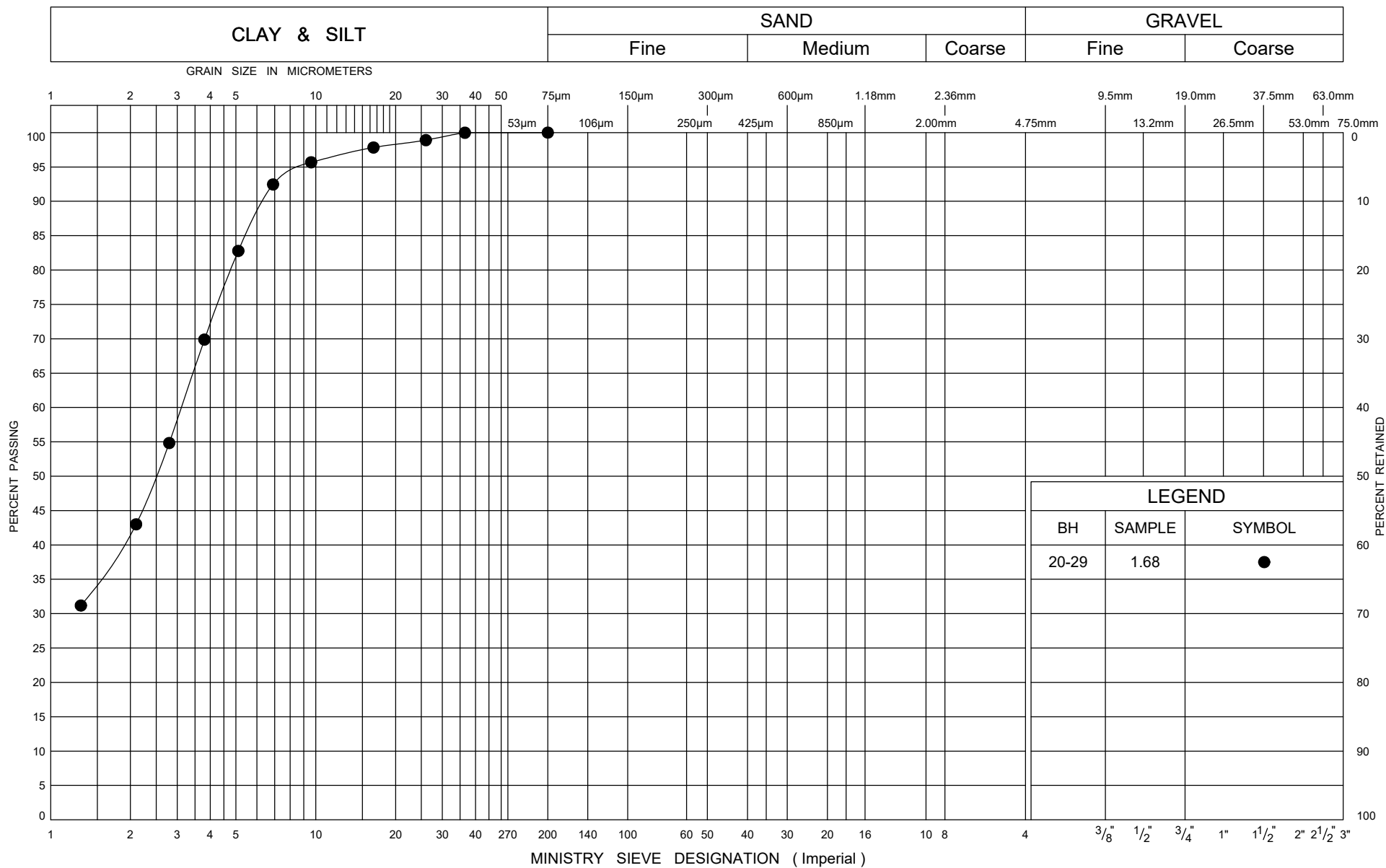












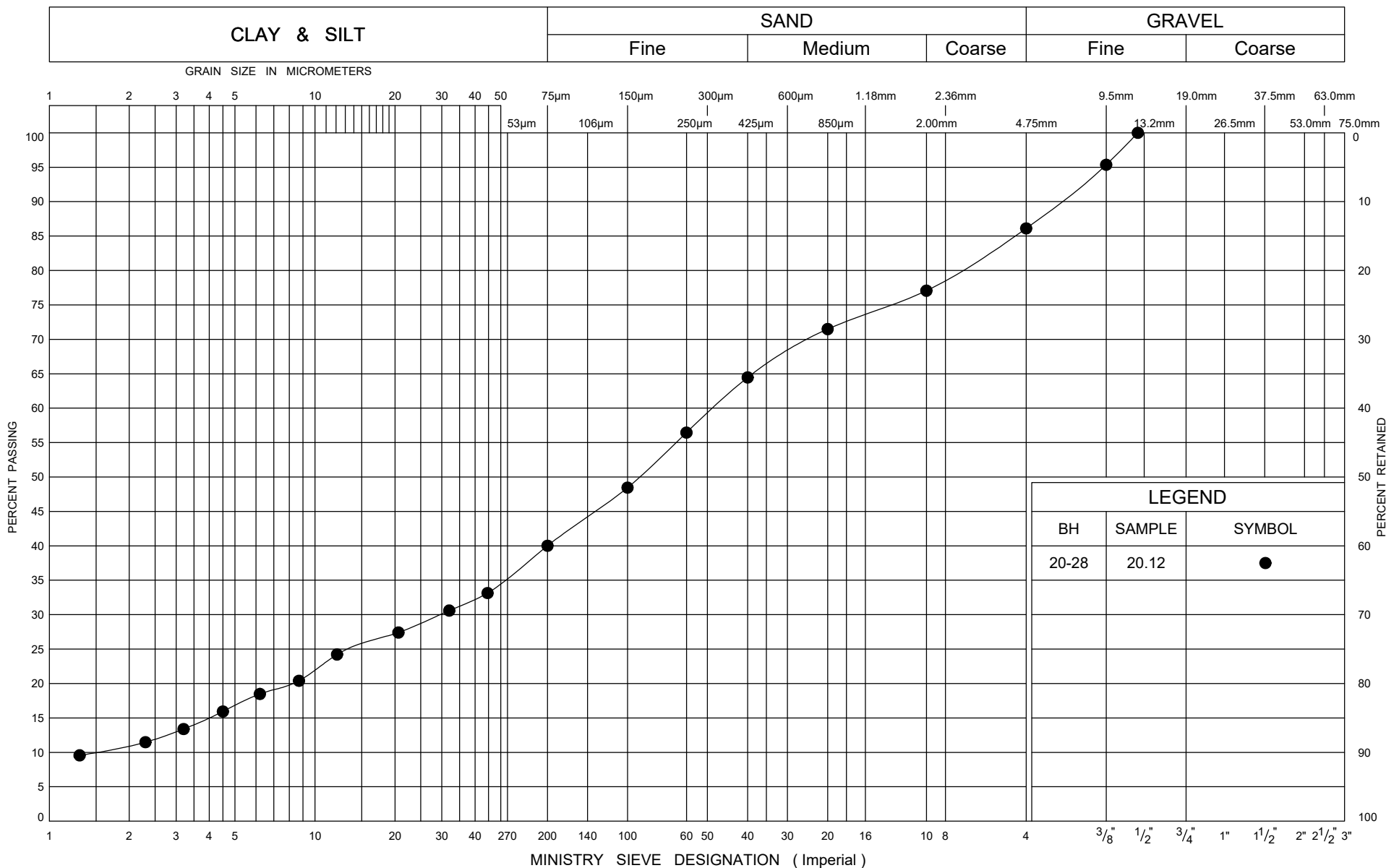
Ministry of
Transportation

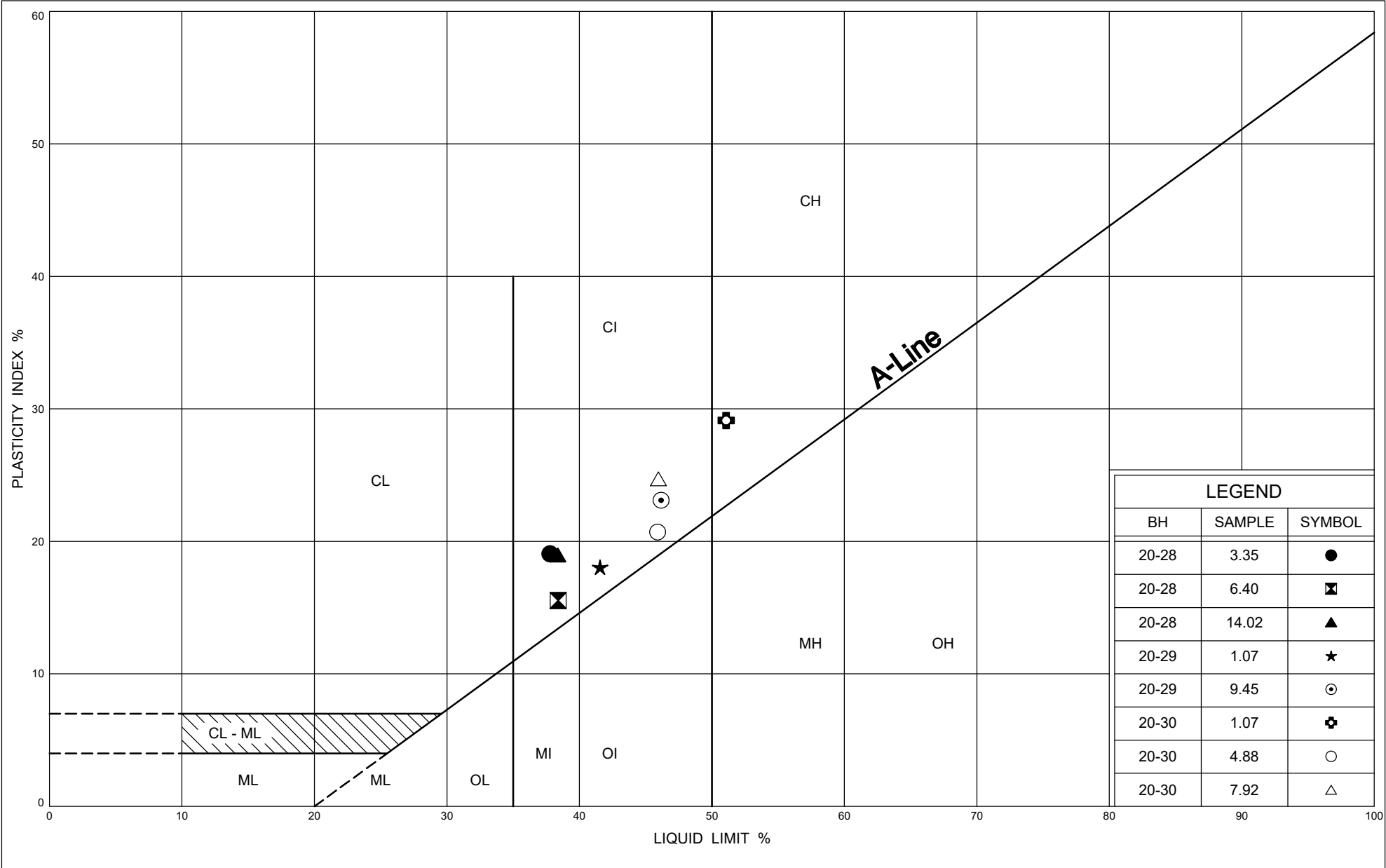
GRAIN SIZE DISTRIBUTION

Clayey SILT Laminae

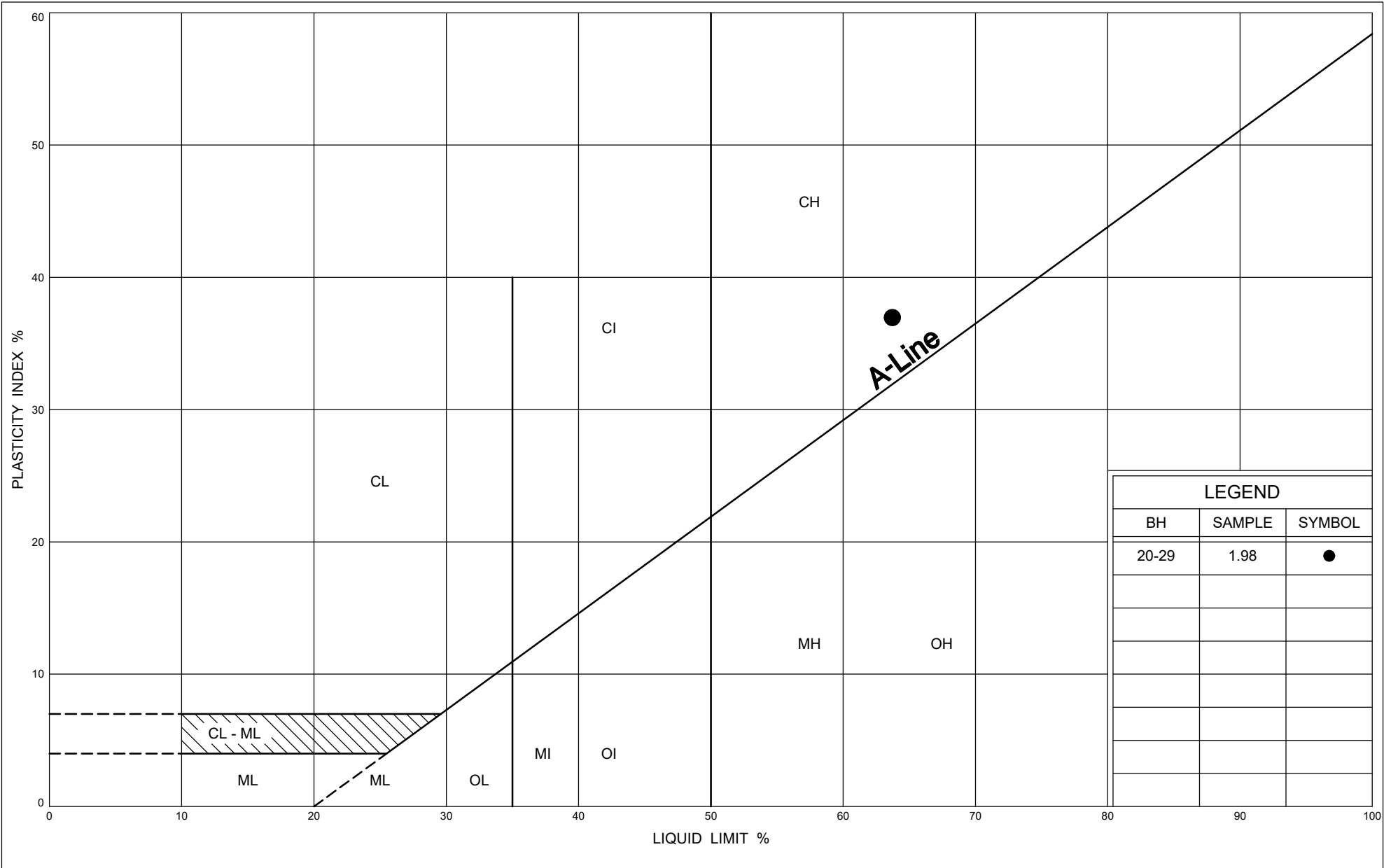
FIG No B23

W P 5101-17-00

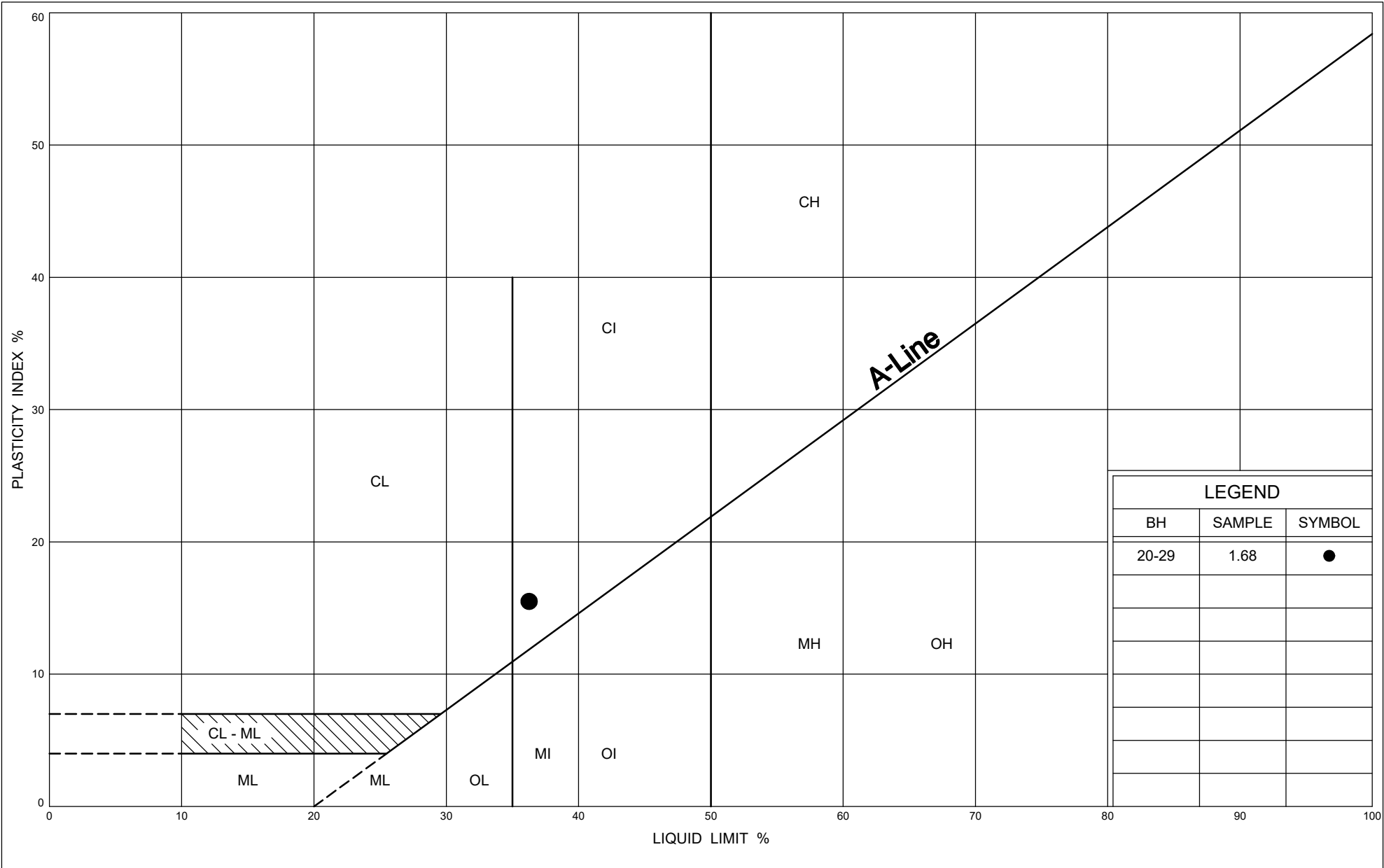




ONTARIO MOT PLASTICITY CHART MTO-28552.GPJ ONTARIO MOT.GDT 8/31/21



ONTARIO MOT PLASTICITY CHART MTO-28552.GPJ ONTARIO MOT.GDT 8/31/21



LEGEND		
BH	SAMPLE	SYMBOL
20-29	1.68	●

Consolidation Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: February 3, 2021

TEST DATES: December 19, 2020 - January 04, 2021

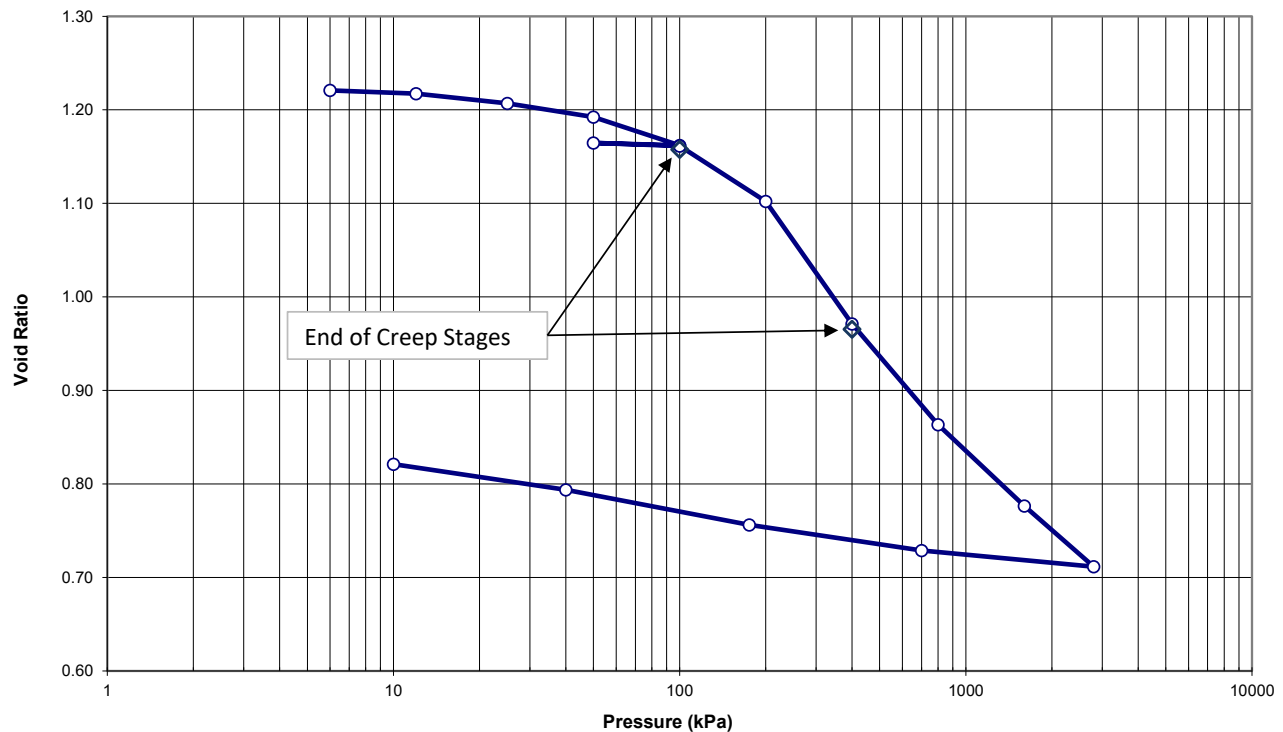
SAMPLE: 20-08 ST-3 37'-39'
 Silty clay, varved, grey, moist
 LL = 53.8, PL = 23.7, $I_p = 30.1$ (dark grey varves)
 LL = 33.1, PL = 19.6, $I_p = 13.5$ (light grey varves)

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	25.40	20.78
Wet Dens. (kg/m^3)	1775.4	1949.8
Dry Dens. (kg/m^3)	1226.3	1498.8
Moisture Cont. (%)	44.8	30.1
Void Ratio	1.226	0.821
Saturation (%)	99.7	100.0

Note: A Specific Gravity (Gs) of 2.73 was obtained for the void ratio and saturation calculations.

Void Ratio vs. Pressure



Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earltan

20-08 ST-3 37'-39'

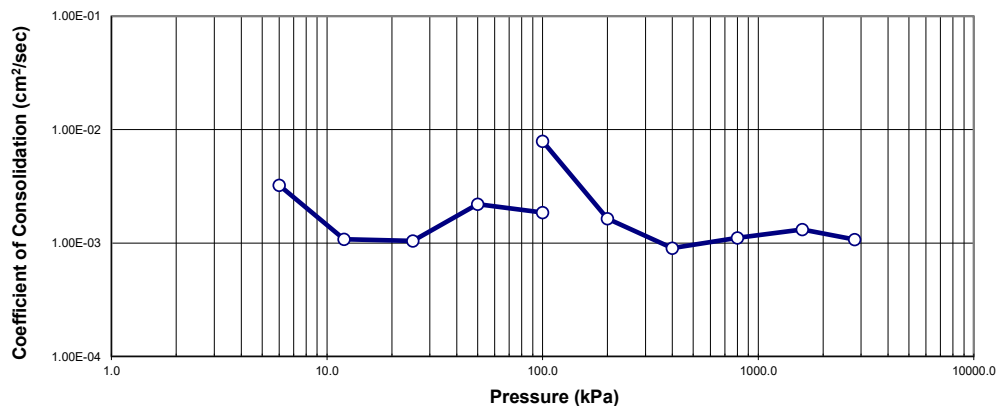
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 53.5%.

LOADING: A seating load of 6 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred under the seating load. Subsequent loads were applied after a constant load increment duration of 24 hours. Creep stages were conducted at 100 kPa and 400 kPa, and were maintained for an additional 48 hours each.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

	Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D ₉₀ (mm)	t ₉₀ (min)	c _v (cm ² /s)	Void Ratio	m _v (m ² /kN)	k (cm/s)
	0.0	25.400					1.226		
	6.0	25.341	25.371	-0.042	7.02	3.24E-03	1.221	3.87E-04	1.23E-07
	12.0	25.302	25.321	-0.052	20.98	1.08E-03	1.217	2.60E-04	2.75E-08
	25.0	25.181	25.241	-0.115	21.62	1.04E-03	1.207	3.66E-04	3.74E-08
	50.0	25.017	25.099	-0.138	10.11	2.20E-03	1.192	2.61E-04	5.64E-08
	100.0	24.671	24.844	-0.241	11.76	1.85E-03	1.162	2.76E-04	5.03E-08
	50.0	24.702	24.686				1.165		
	100.0	24.662	24.682	-0.045	2.72	7.91E-03	1.161	3.17E-05	2.46E-08
48hr Creep	100.0	24.624	24.643				1.158		
	200.0	23.987	24.305	-0.395	12.72	1.64E-03	1.102	2.58E-04	4.16E-08
	400.0	22.492	23.240	-0.997	21.16	9.02E-04	0.971	3.12E-04	2.76E-08
48hr Creep	400.0	22.430	22.461				0.966		
	800.0	21.262	21.846	-0.796	15.21	1.11E-03	0.863	1.30E-04	1.42E-08
	1600.0	20.272	20.767	-0.794	11.56	1.32E-03	0.777	5.82E-05	7.53E-09
	2800.0	19.530	19.901	-0.605	13.03	1.07E-03	0.711	3.05E-05	3.21E-09
	700.0	19.729	19.630				0.729		
	175.0	20.039	19.884				0.756		
	40.0	20.467	20.253				0.794		
	10.0	20.781	20.624				0.821		

Coefficient of Consolidation vs. Pressure



Note: C_v and k calculated using t₉₀ values (square root of time method)

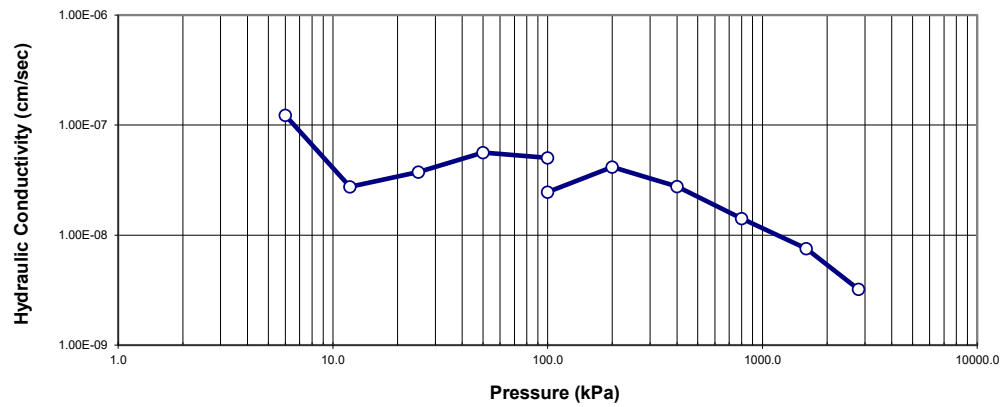
Consolidation Test Report

28552

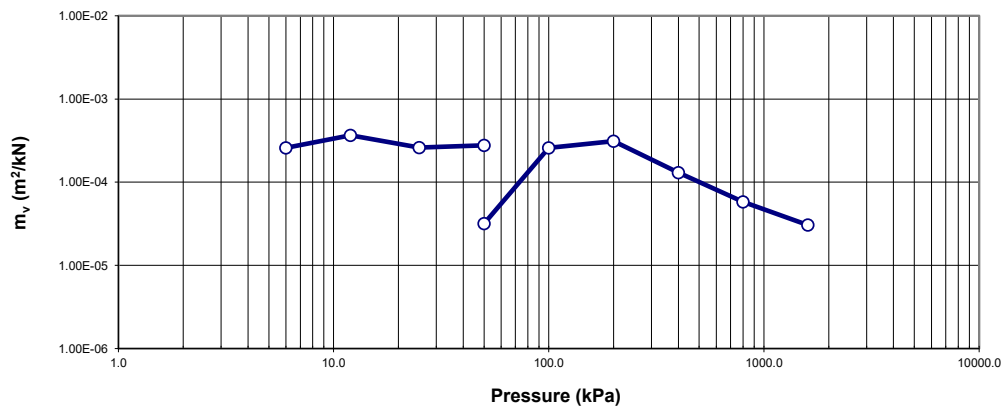
Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-08 ST-3 37'-39'

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure

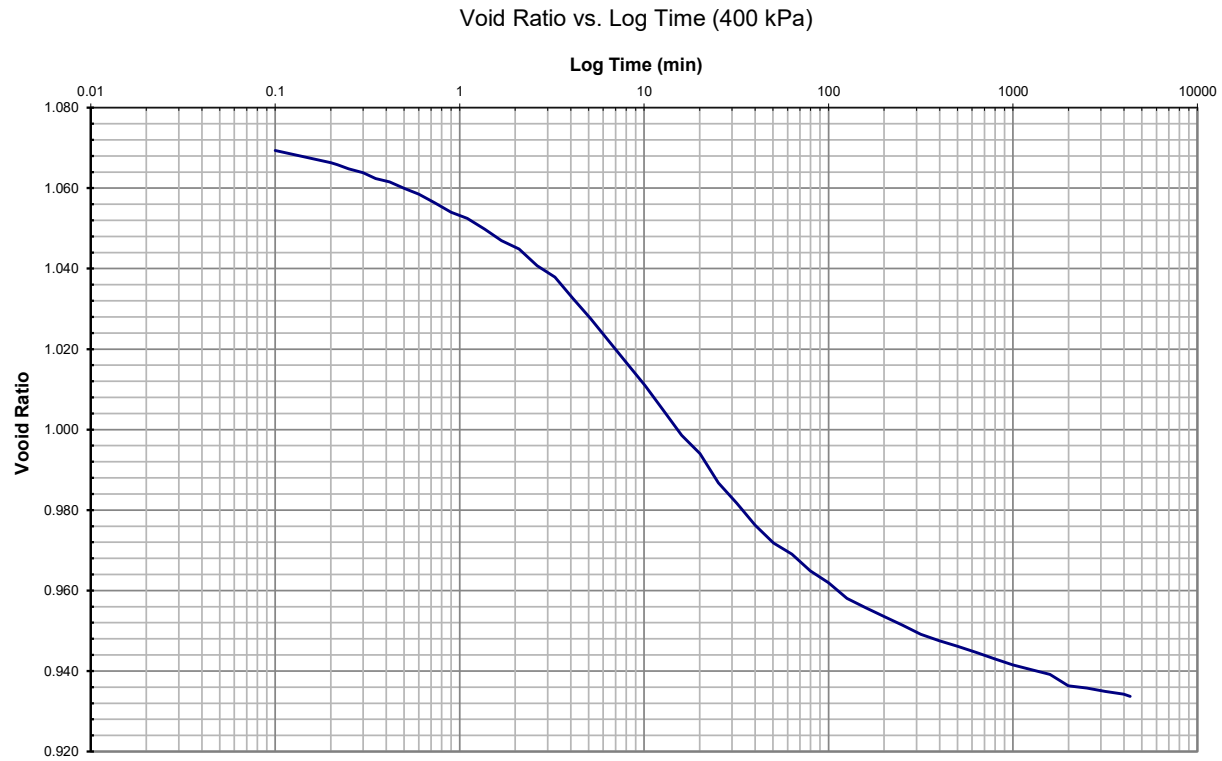


Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-08 ST-3 37'-39'



Consolidation Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: February 3, 2021

TEST DATES: December 19, 2020 - January 04, 2021

SAMPLE: 20-21 ST-4 42'-44'
 Silty clay, varved, grey, moist
 LL = 54.4, PL = 23.2, $I_p = 31.2$ (dark grey varves)
 LL = 44.4, PL = 22, $I_p = 22.4$ (light grey varves)

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	25.40	19.05
Wet Dens. (kg/m ³)	1620.3	1863.5
Dry Dens. (kg/m ³)	1022.1	1362.7
Moisture Cont. (%)	58.5	36.8
Void Ratio	1.671	1.004
Saturation (%)	95.6	100.0

Note: A Specific Gravity (Gs) of 2.73 was obtained for the void ratio and saturation calculations.

Void Ratio vs. Pressure



Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-21 ST-4 42'-44'

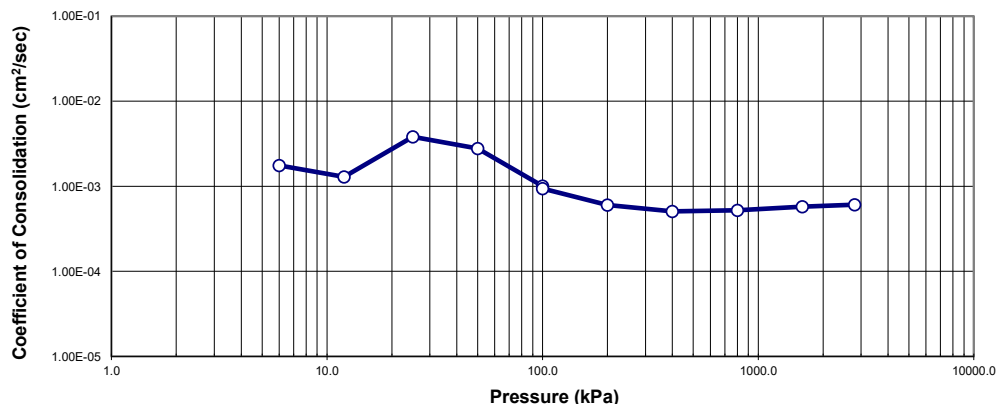
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 49.2%.

LOADING: A seating load of 6 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred under the seating load. Subsequent loads were applied after a constant load increment duration of 24 hours. Creep stages were conducted at 100 kPa and 400 kPa, and were maintained for an additional 48 hours each.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

	Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D ₉₀ (mm)	t ₉₀ (min)	c _v (cm ² /s)	Void Ratio	m _v (m ² /kN)	k (cm/s)
	0.0	25.400					1.671		
	6.0	25.388	25.394	-0.028	12.96	1.76E-03	1.670	8.16E-05	1.41E-08
	12.0	25.341	25.364	-0.057	17.64	1.29E-03	1.665	3.05E-04	3.86E-08
	25.0	25.172	25.256	-0.102	5.90	3.82E-03	1.647	5.15E-04	1.93E-07
	50.0	24.840	25.006	-0.184	7.95	2.78E-03	1.612	5.27E-04	1.44E-07
	100.0	24.206	24.523	-0.407	21.16	1.00E-03	1.545	5.10E-04	5.03E-08
	50.0	24.320	24.263				1.557		
	100.0	24.170	24.245	-0.123	22.09	9.40E-04	1.542	1.24E-04	1.14E-08
48hr Creep	100.0	24.139	24.154				1.538		
	200.0	22.926	23.533	-0.733	32.49	6.02E-04	1.411	5.03E-04	2.97E-08
	400.0	21.167	22.047	-1.250	33.87	5.07E-04	1.226	3.84E-04	1.91E-08
48hr Creep	400.0	21.094	21.131				1.218		
	800.0	19.627	20.361	-1.040	28.09	5.21E-04	1.064	1.74E-04	8.89E-09
	1600.0	18.294	18.961	-1.045	22.09	5.75E-04	0.924	8.49E-05	4.79E-09
	2800.0	17.355	17.825	-0.743	18.49	6.07E-04	0.825	4.28E-05	2.55E-09
	700.0	17.640	17.497				0.855		
	175.0	18.090	17.865				0.902		
	40.0	18.630	18.360				0.959		
	10.0	19.053	18.841				1.004		

Coefficient of Consolidation vs. Pressure



Note: C_v and k calculated using t₉₀ values (square root of time method)

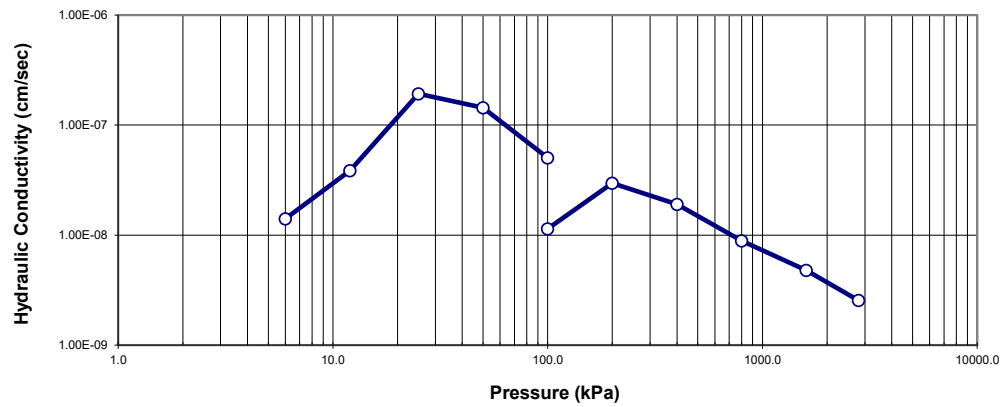
Consolidation Test Report

28552

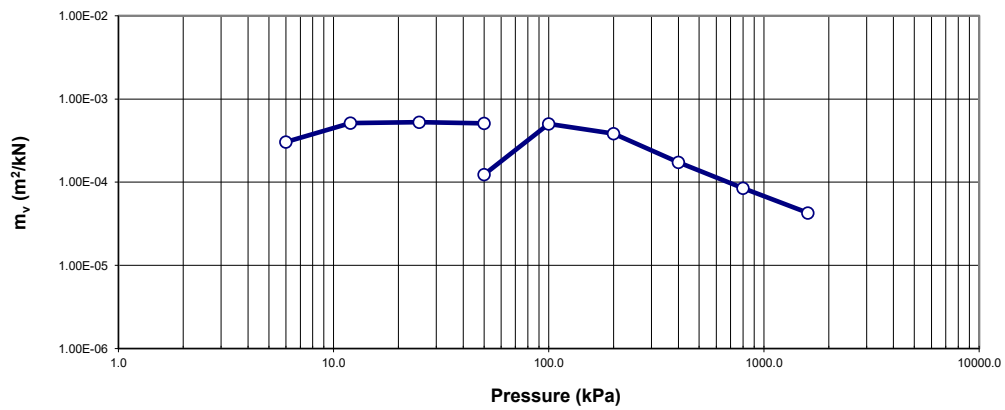
Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-21 ST-4 42'-44'

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure

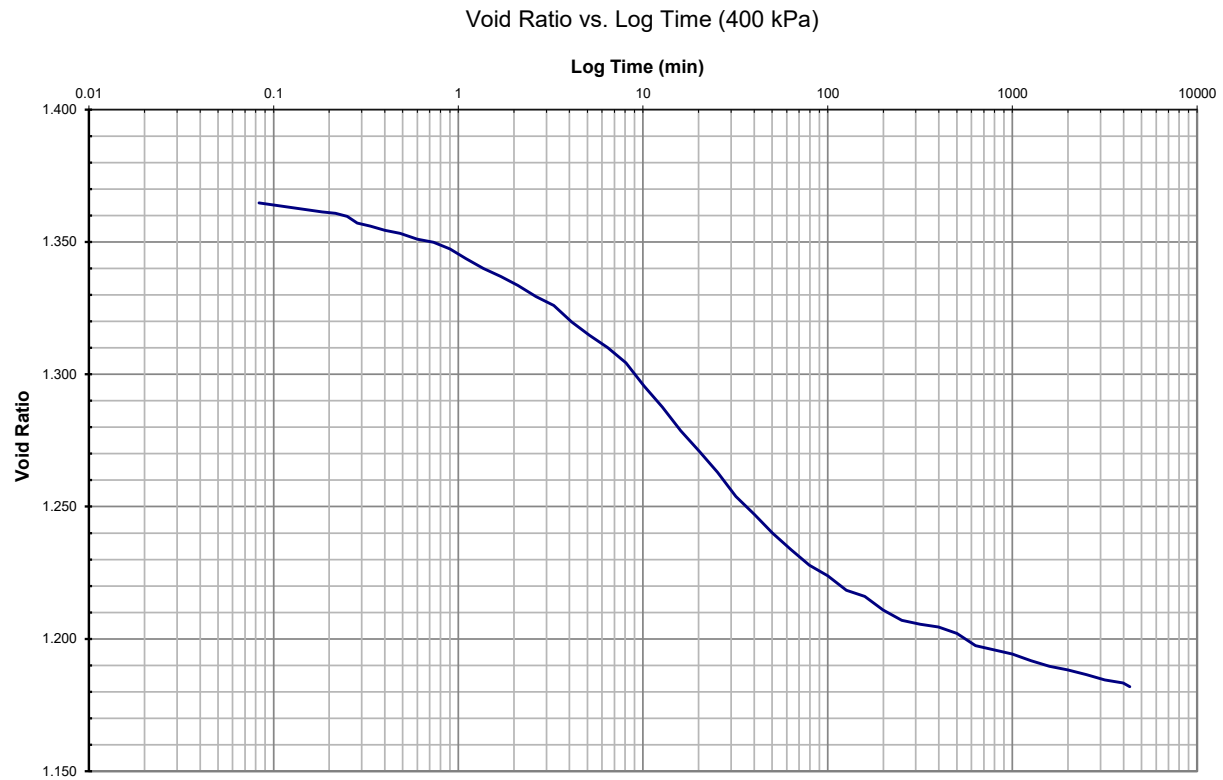


Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-21 ST-4 42'-44'



Consolidation Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: August 16, 2021

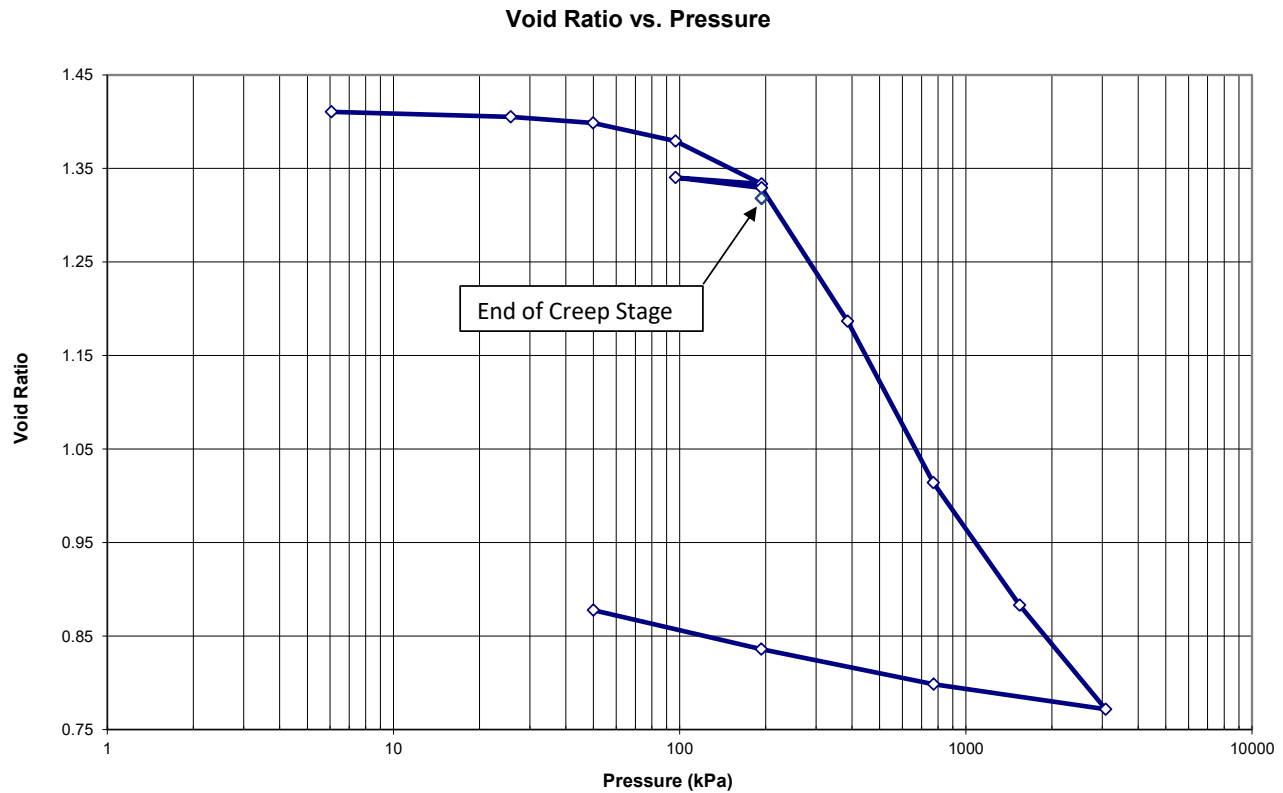
TEST DATES: June 22, 2021 - July 19, 2021

SAMPLE: 20-26 ST-2 50'-52'
Silty clay, grey, moist.
LL = 35.9, PL = 21.0, I_p = 14.9

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	25.40	19.81
Wet Dens. (kg/m ³)	1712.1	1913.1
Dry Dens. (kg/m ³)	1127.2	1445.5
Moisture Cont. (%)	51.9	32.3
Void Ratio	1.408	0.878
Saturation (%)	100.0	100.0

Note: A Specific Gravity (Gs) of 2.714 was obtained for the void ratio and saturation calculations.



Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-26 ST-2 50'-52'

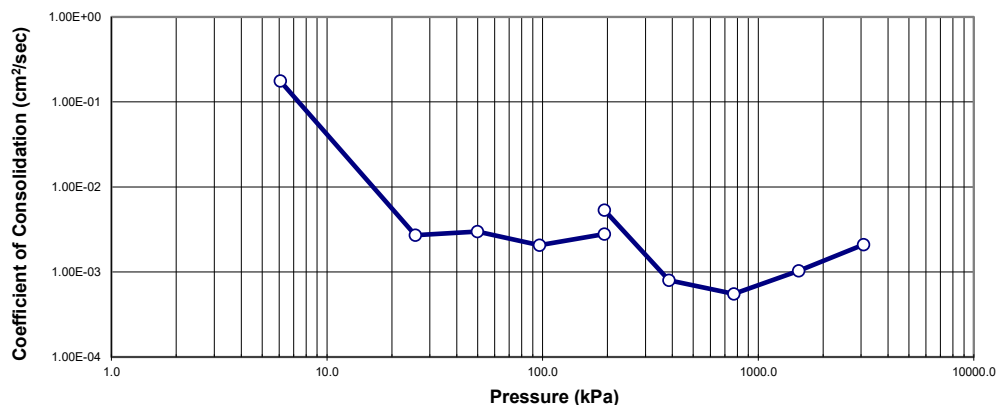
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 46.5%.

LOADING: A seating load of 6.07 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after a constant load increment duration of 24 hours; except for a creep stage which was conducted at 193.2 kPa and was maintained for 15 days.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D ₉₀ (mm)	t ₉₀ (min)	c _v (cm ² /s)	Void Ratio	m _v (m ² /kN)	k (cm/s)
0.0	25.400					1.408		
6.1	25.427	25.414	-0.017	0.13	1.76E-01	1.411		
25.7	25.370	25.399	-0.148	8.41	2.71E-03	1.405	1.14E-04	3.04E-08
49.9	25.300	25.335	-0.077	7.56	3.00E-03	1.399	1.14E-04	3.35E-08
96.6	25.096	25.198	-0.165	10.89	2.06E-03	1.379	1.72E-04	3.48E-08
193.2	24.614	24.855	-0.270	7.84	2.78E-03	1.333	1.99E-04	5.43E-08
96.6	24.687	24.651				1.340		
193.2	24.570	24.629	-0.082	4.00	5.36E-03	1.329	4.91E-05	2.58E-08
193.2 (Creep)	24.450	24.510				1.318		
385.7	23.065	23.758	-0.720	25.00	7.98E-04	1.187	2.94E-04	2.30E-08
770.7	21.243	22.154	-1.380	31.36	5.53E-04	1.014	2.05E-04	1.11E-08
1540.7	19.863	20.553	-0.920	14.44	1.03E-03	0.883	8.44E-05	8.55E-09
3081.0	18.688	19.276	-0.640	6.25	2.10E-03	0.772	3.84E-05	7.91E-09
771.0	18.971	18.830				0.799		
193.0	19.367	19.169				0.836		
50.0	19.806	19.587				0.878		

Coefficient of Consolidation vs. Pressure



Note: C_v and k calculated using t₉₀ values (square root of time method)

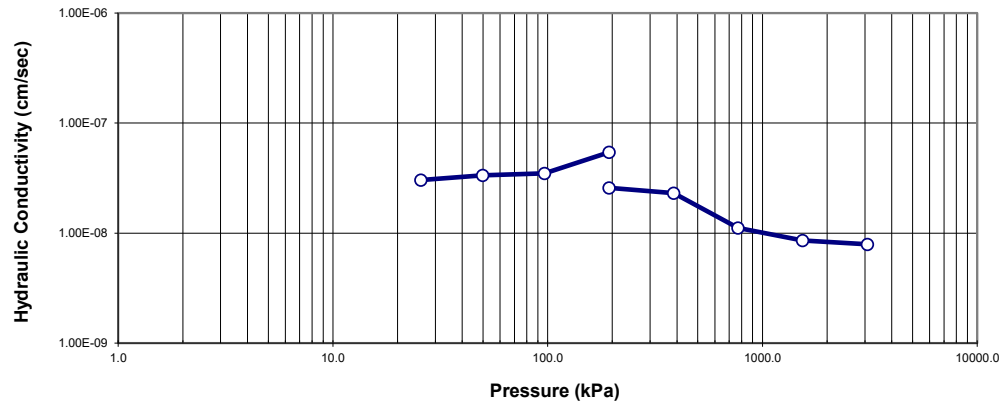
Consolidation Test Report

28552

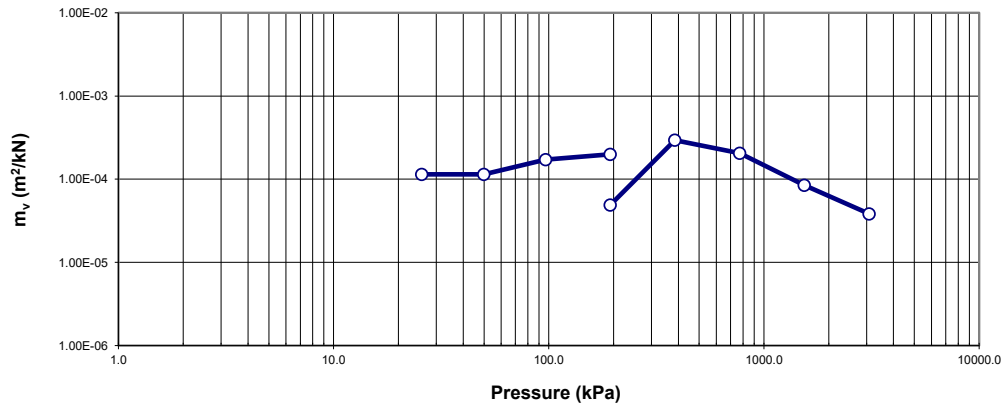
Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-26 ST-2 50'-52'

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure



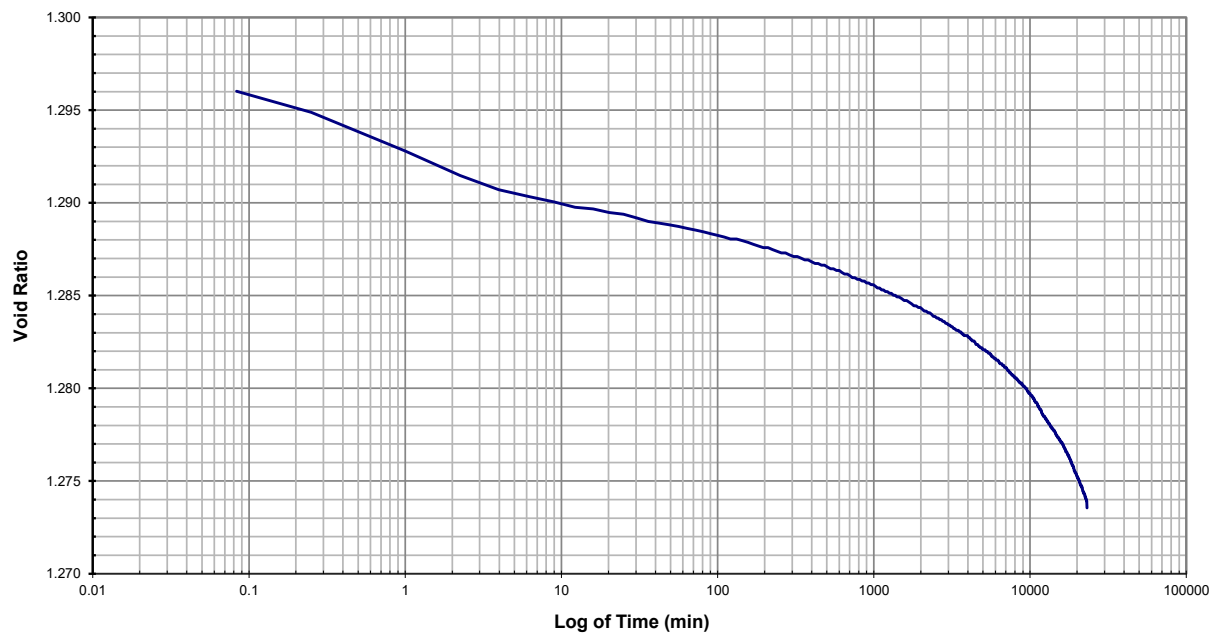
Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-26 ST-2 50'-52'

Void Ratio vs. Log Time at 193 kPa



Consolidation Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: August 20, 2021

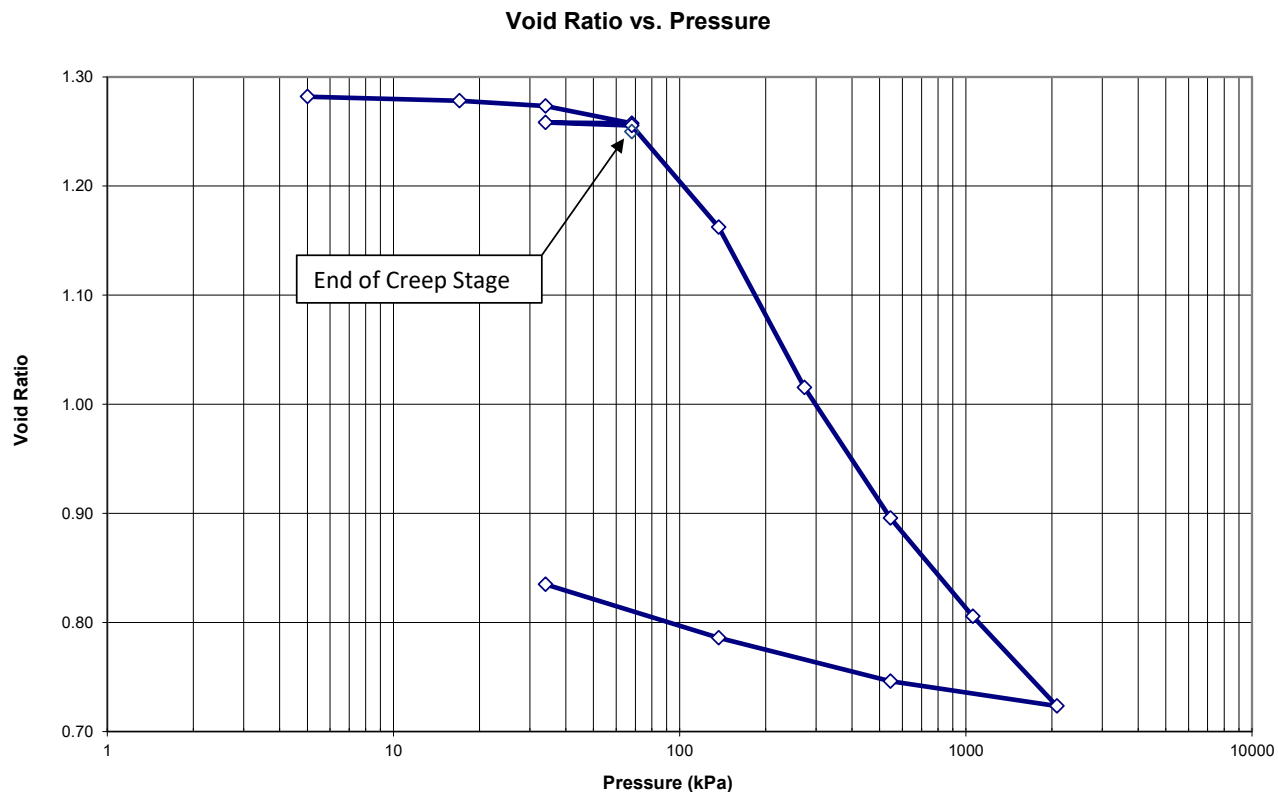
TEST DATES: June 23, 2021 - July 20, 2021

SAMPLE: 20-29 ST-1 5'-7'
Silty clay, grey, moist.
LL = 36.3, PL = 20.8, I_p = 15.5

PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-11, method B.

	Start of Test	End of Test
Sample Height (mm)	20.00	16.13
Wet Dens. (kg/m ³)	1740.0	1925.6
Dry Dens. (kg/m ³)	1196.6	1484.0
Moisture Cont. (%)	45.4	29.8
Void Ratio	1.276	0.835
Saturation (%)	97.0	97.0

Note: A Specific Gravity (Gs) of 2.724 was obtained for the void ratio and saturation calculations.



Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earltan

20-29 ST-1 5'-7'

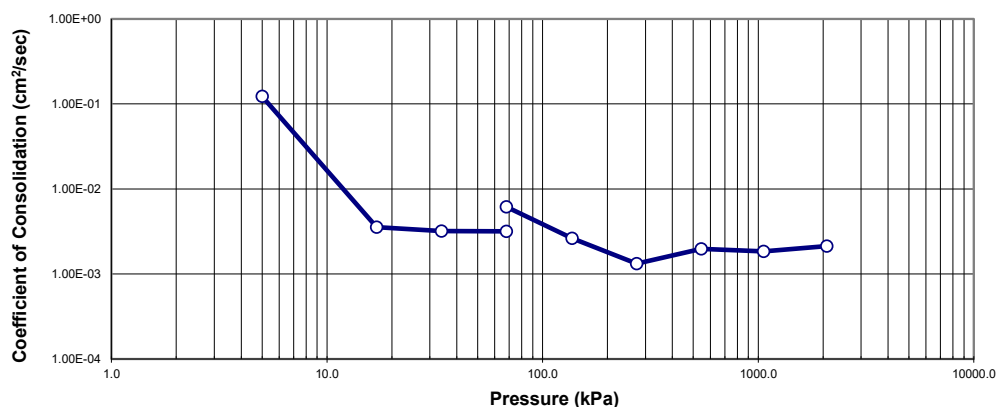
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer. The average moisture content of the trimmings was 43.1%.

LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after a constant load increment duration of 24 hours; except for a creep stage which was conducted at 68 kPa and was maintained for 15 days.

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. H. (mm)	Avg. H. (mm)	D ₉₀ (mm)	t ₉₀ (min)	c _v (cm ² /s)	Void Ratio	m _v (m ² /kN)	k (cm/s)
0.0	20.000					1.276		
5.0	20.052	20.026	-0.032	0.12	1.23E-01	1.282		
17.0	20.020	20.036	-0.122	4.00	3.55E-03	1.278	1.33E-04	4.63E-08
34.0	19.977	19.999	-0.070	4.41	3.20E-03	1.273	1.26E-04	3.97E-08
68.0	19.838	19.908	-0.125	4.41	3.18E-03	1.258	2.05E-04	6.37E-08
34.0	19.845	19.842				1.258		
68.0	19.819	19.832	-0.039	2.25	6.18E-03	1.255	3.85E-05	2.33E-08
68.0 (Creep)	19.770	19.795				1.250		
137.0	19.002	19.386	-0.500	5.06	2.62E-03	1.162	5.63E-04	1.45E-07
273.0	17.710	18.356	-0.920	9.00	1.32E-03	1.015	5.00E-04	6.49E-08
545.0	16.658	17.184	-0.680	5.29	1.97E-03	0.896	2.18E-04	4.23E-08
1058.0	15.867	16.263	-0.540	5.06	1.85E-03	0.806	9.26E-05	1.68E-08
2080.0	15.145	15.506	-0.480	4.00	2.12E-03	0.723	4.45E-05	9.28E-09
545.0	15.345	15.245				0.746		
137.0	15.695	15.520				0.786		
34.0	16.126	15.911				0.835		

Coefficient of Consolidation vs. Pressure



Note: C_v and k calculated using t₉₀ values (square root of time method)

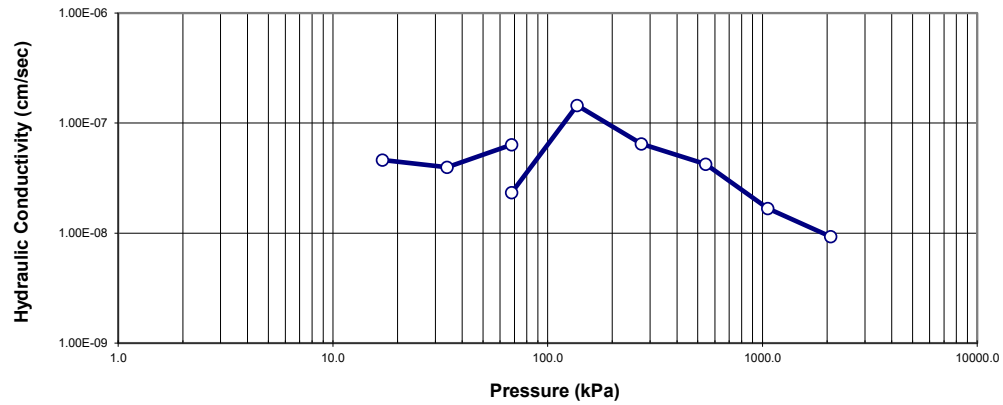
Consolidation Test Report

28552

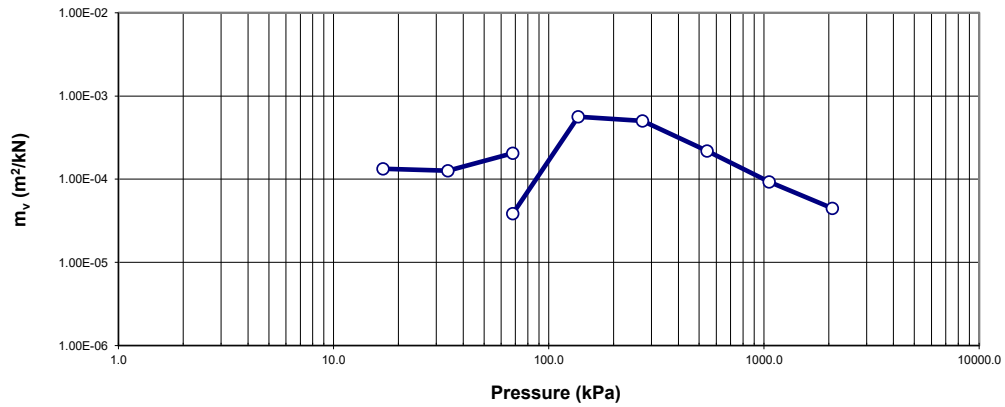
Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-29 ST-1 5'-7'

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure

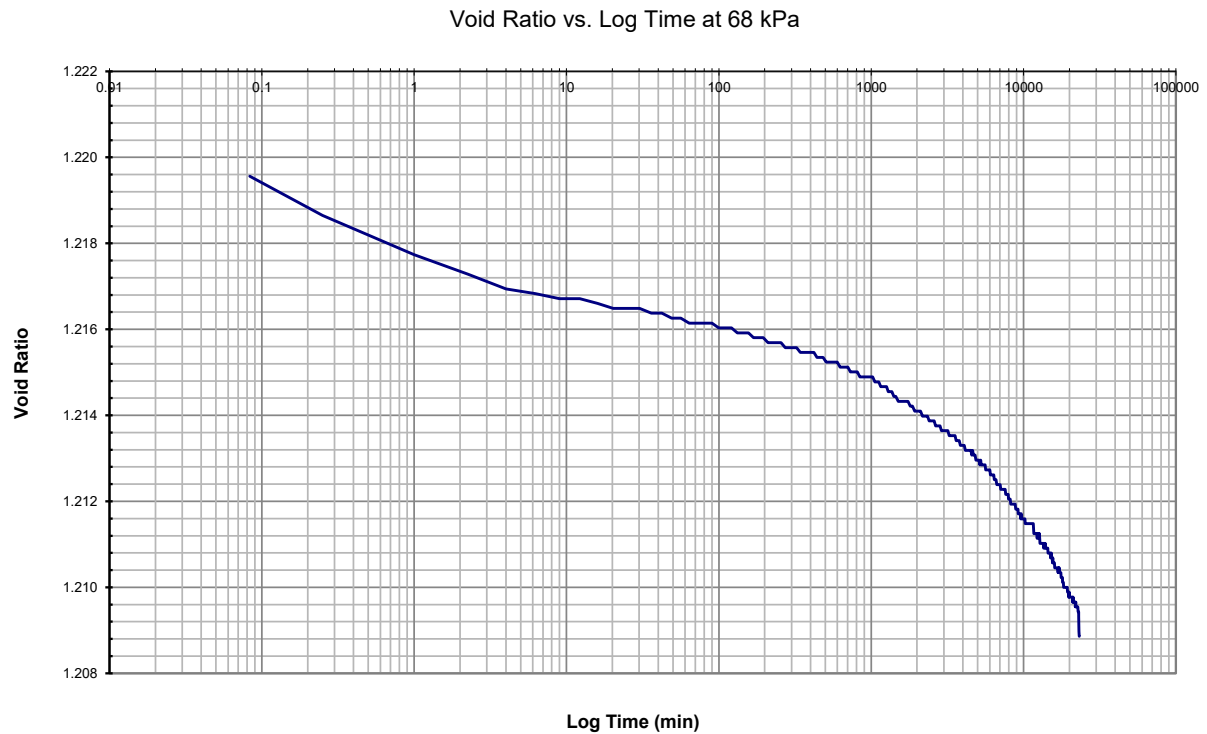


Consolidation Test Report

28552

Hwy 11 Replacement of ONR Overhead Bridge in Earleton

20-29 ST-1 5'-7'



Constant Rate of Strain (CRS) Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: 9/17/2021

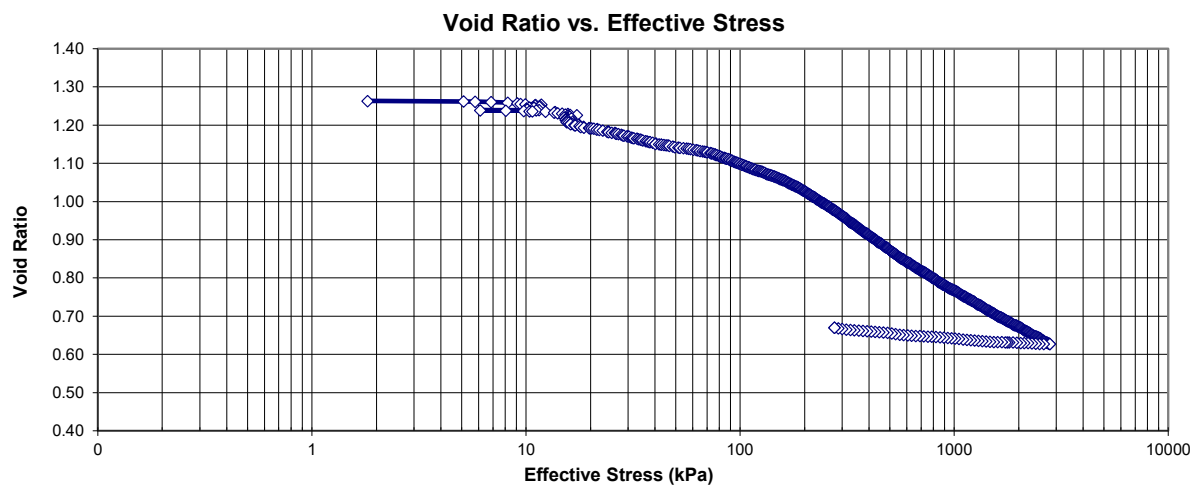
TEST DATES: January 4, 2021 - January 7, 2021

SAMPLE: 20-08 ST4 42-44'
Silty clay, grey, moist
LL = 34.2, PL = 19.1 (silt varve); LL = 49.5, PL=22.1 (clay varve)

PROCEDURE: Test carried out in general accordance with Standard Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading, ASTM

Sample Characteristics		
	Initial	Final
Sample Height (mm):	25.40	18.68
Sample Diameter (mm):	63.50	63.50
Wet Dens. (kg/m ³):	1755	2106
Dry Dens. (kg/m ³):	1202	1634
Moisture Content (%):	45.8	28.9
Void Ratio:	1.27	0.67

Test Conditions	
Back Pressure (kPa):	400
Seating Pressure (kPa):	1.83
Strain After Seating (%):	0.31
Strain Rate - Loading (%/hr):	0.7
Strain Rate - Unloading (%/hr):	0.1
R _u at end of loading:	0.02



Note: A Specific Gravity (G_s) of 2.724 was assumed for the void ratio calculations.

TESTED BY: BT

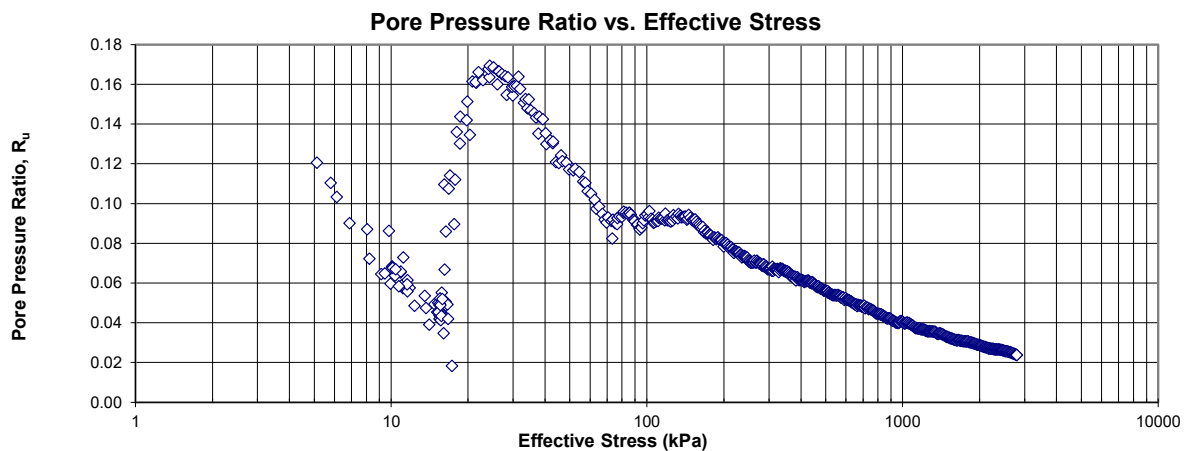
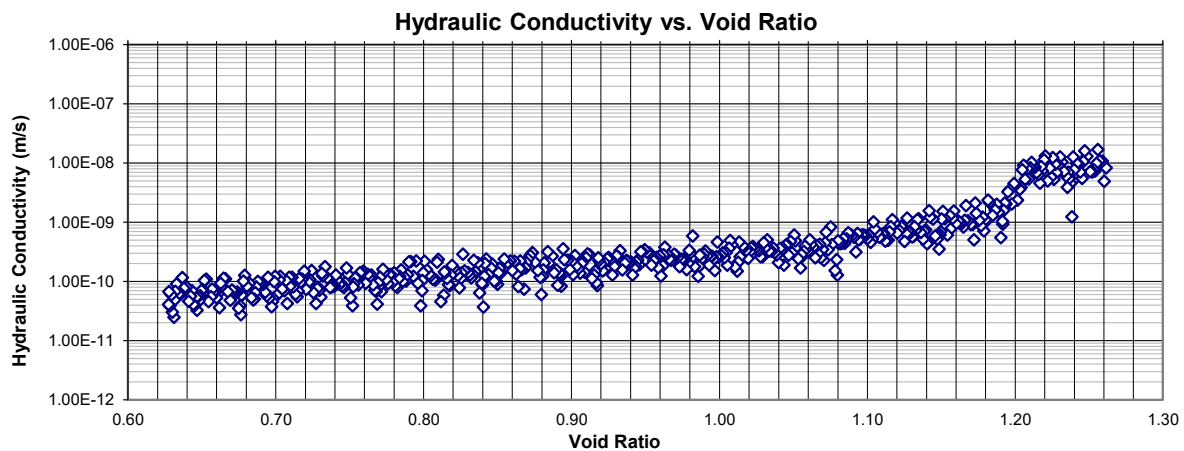
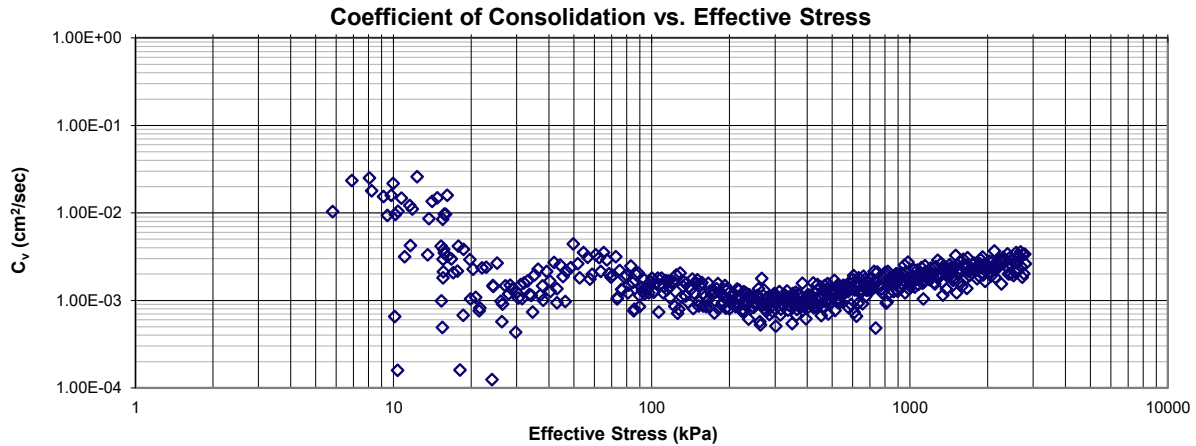
REVIEWED BY:

Constant Rate of Strain (CRS) Test Report

28552

20-08 ST4 42-44'

Hwy 11 Replacement of ONR Overhead Bridge in Earleton



Note: Only data from loading stage are shown in coefficient of consolidation vs. effective stress, and hydraulic conductivity vs. effective stress plots.

Constant Rate of Strain (CRS) Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earleton

REPORT DATE: 9/17/2021

TEST DATES: January 15, 2021 - January 17, 2021

SAMPLE: 20-21 ST4- 42-44

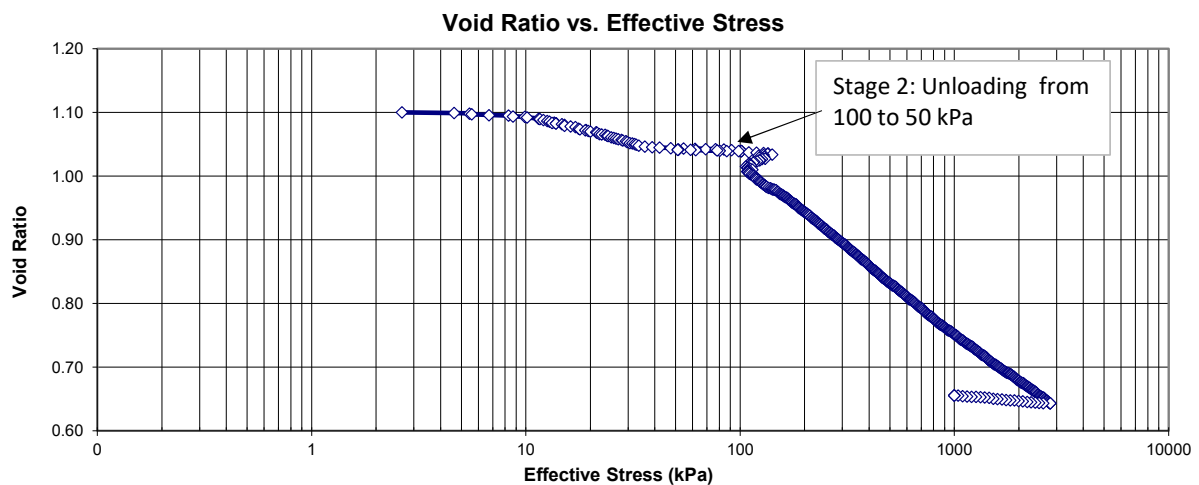
Silty clay, grey, moist

LL = 44.4, PL = 22 (silt varve); LL = 54.4, PL = 23.2 (clay varve)

PROCEDURE: Test carried out in general accordance with Standard Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading, ASTM

Sample Characteristics		
	Initial	Final
Sample Height (mm):	25.40	19.99
Sample Diameter (mm):	63.50	63.50
Wet Dens. (kg/m ³):	1818	2090
Dry Dens. (kg/m ³):	1297	1648
Moisture Content (%):	49.2	26.8
Void Ratio:	1.10	0.66

Test Conditions	
Back Pressure (kPa):	400
Seating Pressure (kPa):	2.65
Strain After Seating (%):	0.18
Strain Rate - Loading (%/hr):	0.6
Strain Rate - Unloading (%/hr):	0.1
R _u at end of loading:	0.002



Note: A Specific Gravity (Gs) of 2.724 was assumed for the void ratio calculations.

TESTED BY: BT

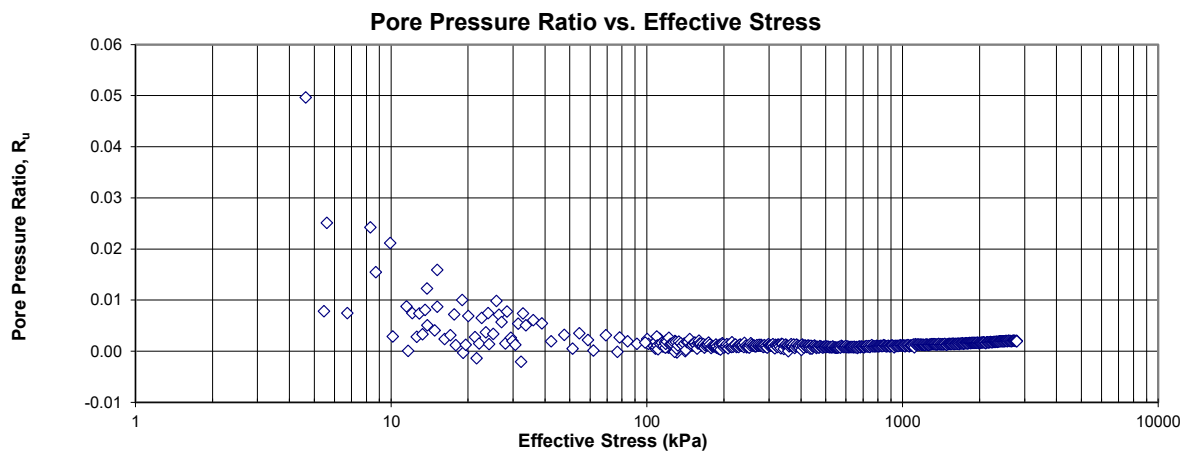
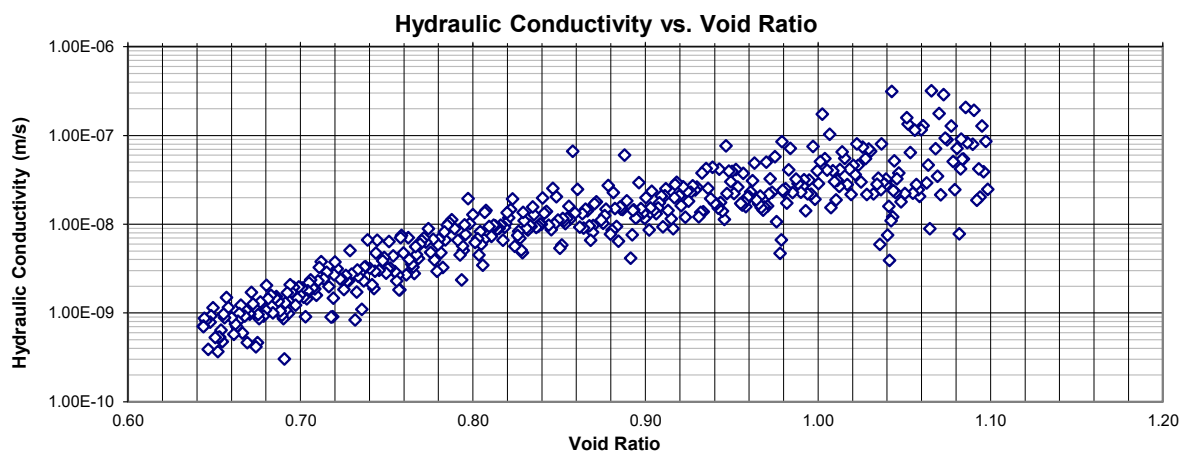
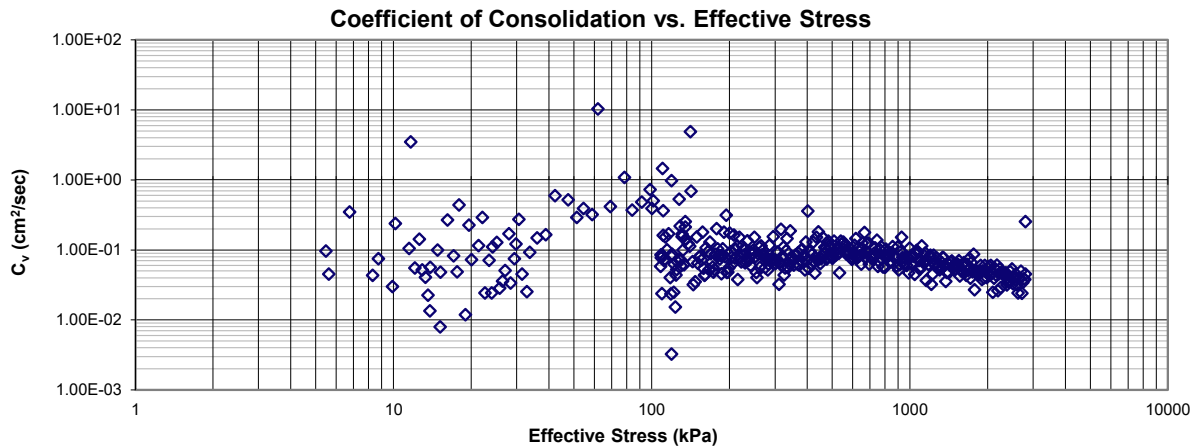
REVIEWED BY:

Constant Rate of Strain (CRS) Test Report

28552

20-21 ST4- 42-44

Hwy 11 Replacement of ONR Overhead Bridge in Earleton



Note: Only data from loading stage are shown in coefficient of consolidation vs. effective stress, and hydraulic conductivity vs. effective stress plots.

Constant Rate of Strain (CRS) Test Report

CLIENT: WSP

FILE NUMBER: 28552

PROJECT: Hwy 11 Replacement of ONR Overhead Bridge in Earltown

REPORT DATE: September 17, 2021

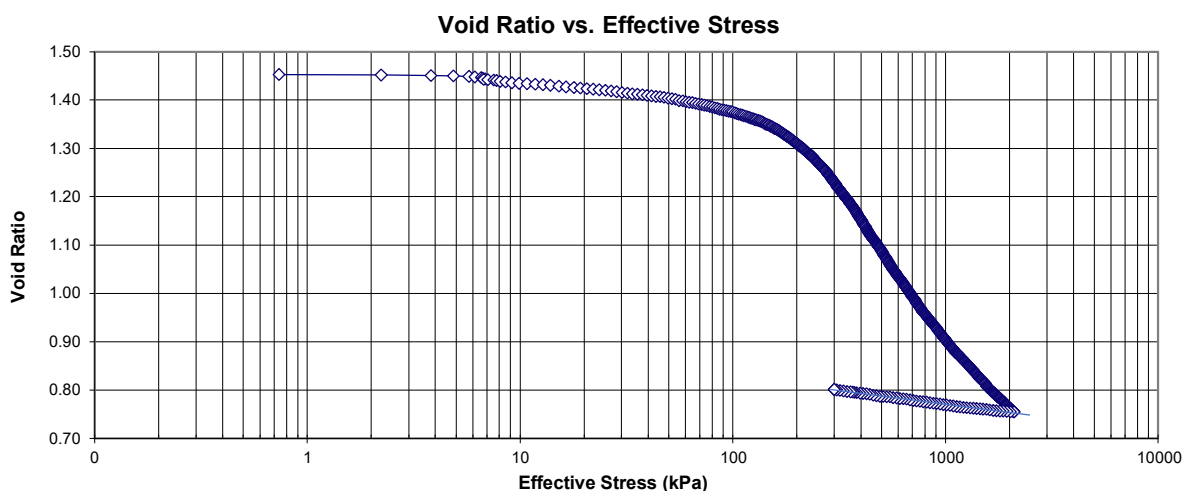
TEST DATES: June 25, 2021 - June 27, 2021

SAMPLE: 20-29 ST-1 5'-7'
Silty clay, grey, moist
LL = 36.3, PL = 20.8

PROCEDURE: Test carried out in general accordance with Standard Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading, ASTM D4186.

Sample Characteristics		
	Initial	Final
Sample Height (mm):	25.40	20.14
Sample Diameter (mm):	63.50	63.50
Wet Dens. (kg/m ³):	1679	1859
Dry Dens. (kg/m ³):	1109	1399
Moisture Content (%):	56.3	32.9
Void Ratio:	1.46	0.95

Test Conditions	
Back Pressure (kPa):	402.6
Seating Pressure (kPa):	0.74
Strain After Seating (%):	0.28
Strain Rate - Loading (%/hr):	0.7
Strain Rate - Unloading (%/hr):	0.35
R _u at end of loading:	0.05



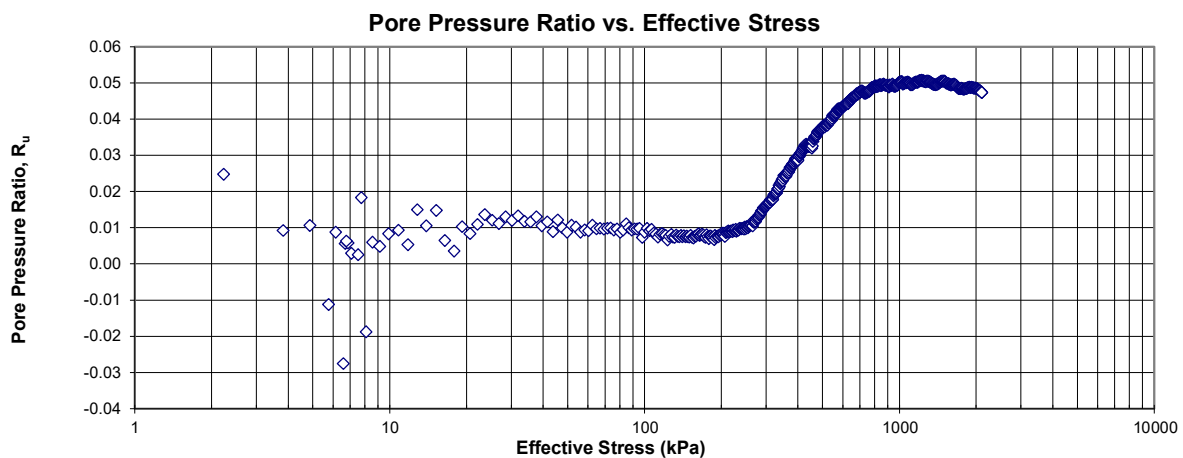
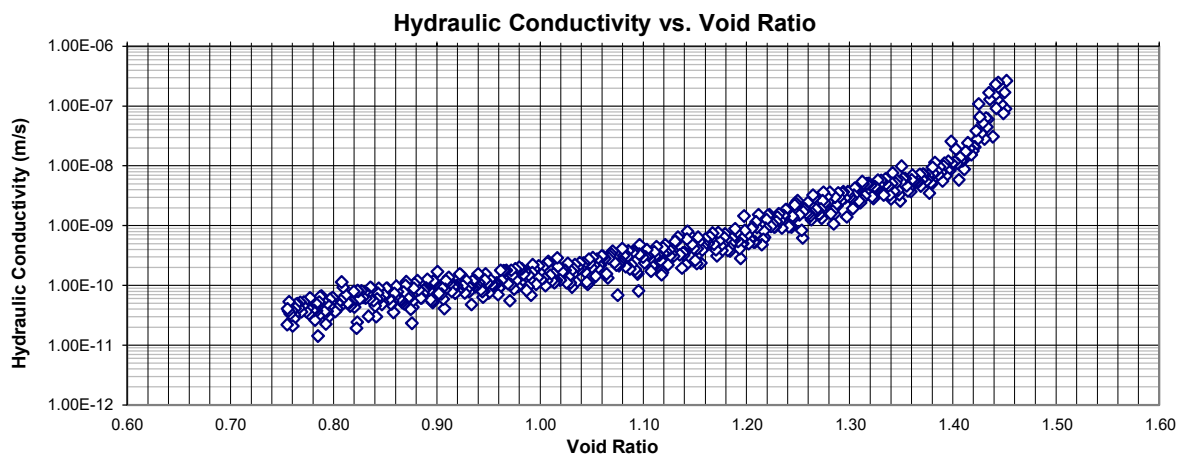
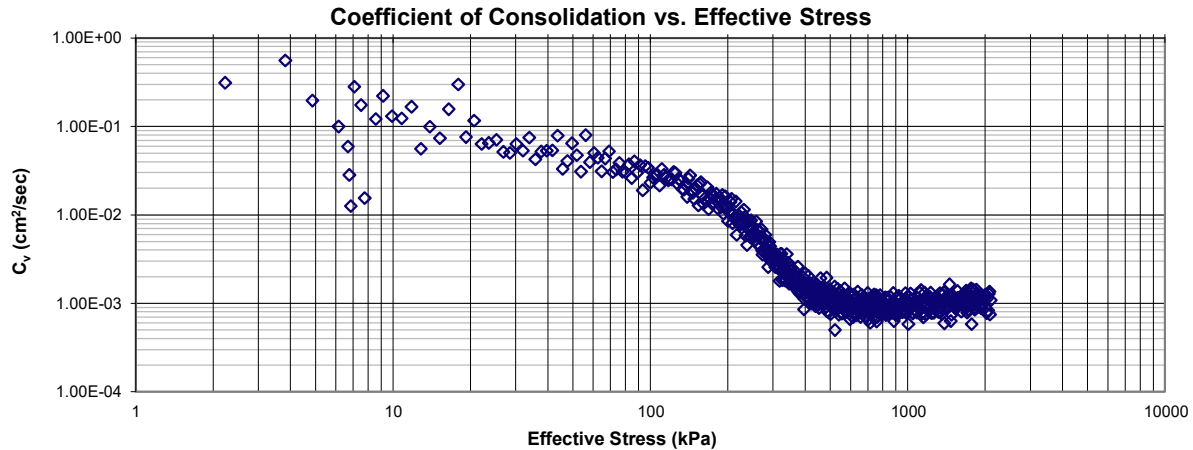
Note: A Specific Gravity (Gs) of 2.724 was measured for the void ratio calculations.

Constant Rate of Strain (CRS) Test Report

28552

20-29 ST-1 5'-7'

Hwy 11 Replacement of ONR Overhead Bridge in Earleton



Note: Only data from loading stage are shown in coefficient of consolidation vs. effective stress, and hydraulic conductivity vs. effective stress plots.
Coefficient of consolidation vs. effective stress is plotted from average of every 10 readings.



Consolidated Undrained (CU) Triaxial Compression Test (ASTM D 4767)

Project Name	Replacement of ONR Overhead Bridge	Date	1/29/2021
Project No.	28552	BH No.	20-03
Client	Ministry of Transportation	Sample ID	ST1
Sample description	Silty clay, varved, grey, moist	Depth	45'-47'
Remarks:			
Sample Parameter Before Test			
	Specimen A	Specimen B	Specimen C
Specimen depth (m)	14.15-14.30	14.15-140.0	140-13.85
Ave diameter (mm)	68.63	68.65	68.91
Ave height (mm)	148.78	152.00	149.76
Wet mass (g)	1005	1037	1028.3
Dry mass (g)	718.28	740.71	732.11
Height-to-diameter ratio	2.17	2.21	2.17
Wet density (kg/m ³)	1826.23	1843.12	1841.03
Dry density (kg/m ³)	1305.22	1316.52	1310.74
Specific Gravity	2.73	2.73	2.73
Void Ratio	1.10	1.08	1.09
Moisture Content Before Test (%)	39.92	40.00	40.46
Piston Height (i) (mm)	140.43	146.3	143.69
Saturation			
Back pressure (kPa)	750	750	750
Cell pressure (kPa)	770	770	770
B-value Calculation			
Initial cell pressure (kPa)	770	770	770
Initial pore pressure (kPa)	750	750	750
Final cell pressure (kPa)	790	790	790
Final pore pressure (kPa)	770	770	770
B - value	0.99	0.99	1.00
Consolidation			
	Specimen A	Specimen B	Specimen C
Cell pressure (kPa)	850	950	1150
Back pressure (kPa)	750	750	750
Consolidation stress (kPa)	100	200	400
Piston height (ii) (mm)	139.65	143.21	137.07
Before Shearing			
Height of specimen (mm)	148.00	148.91	143.14
Total volume change (mL)	-12.2	-22.5	-43.3
Total Specimen Volume (cm ³)	538.1	540.2	515.3
Diameter (mm)	68.04	67.96	67.70
Wet mass (g)	992.80	1021.87	985.00



Consolidated Undrained (CU) Triaxial Compression Test (ASTM D 4767)

Project Name	Replacement of ONR Overhead Bridge	Date	1/29/2021
Project No.	28552	BH No.	20-03
Client	Ministry of Transportation	Sample ID	ST1
Sample description	Silty clay, varved, grey, moist	Depth	45'-47'

Before Shearing (Continued)

Moisture content (%)	38.22	37.96	34.54
Wet density (kg/m ³)	1845.07	1891.77	1911.61
Dry density (kg/m ³)	1334.89	1371.28	1420.83
Void Ratio	1.05	0.99	0.92
Saturation (%)	100	100	100

Shearing

Strain Rate (%/h)	0.85	0.56	0.42
Moisture Content After Test (%)	38.22	37.96	34.54
Failure Parameters			
Axial Strain (%)	7.24	3.04	10.11
Deviator Stress $\Delta\sigma$ (kPa)	125.55	166.34	234.68
Excess Pore Pressure u (kPa)	52.28	127.56	300.51
Total Major Principal Stress σ_1 (kPa)	215.96	361.94	623.50
Total Minor Principal Stress σ_3 (kPa)	90.83	195.75	389.02
$(\sigma_1 - \sigma_3)/2$ (kPa)	62.57	83.09	117.24
$(\sigma_1 + \sigma_3)/2$ (kPa)	153.39	278.84	506.26
Effec. Major Principal Stress σ_1' (kPa)	163.67	234.38	322.99
Effec. Minor Principal Stress σ_3' (kPa)	38.54	68.20	88.51
$(\sigma_1' - \sigma_3')/2$ (kPa)	62.57	83.09	117.24
$(\sigma_1' + \sigma_3')/2$ (kPa)	101.11	151.29	205.75

Specimen A



Specimen B



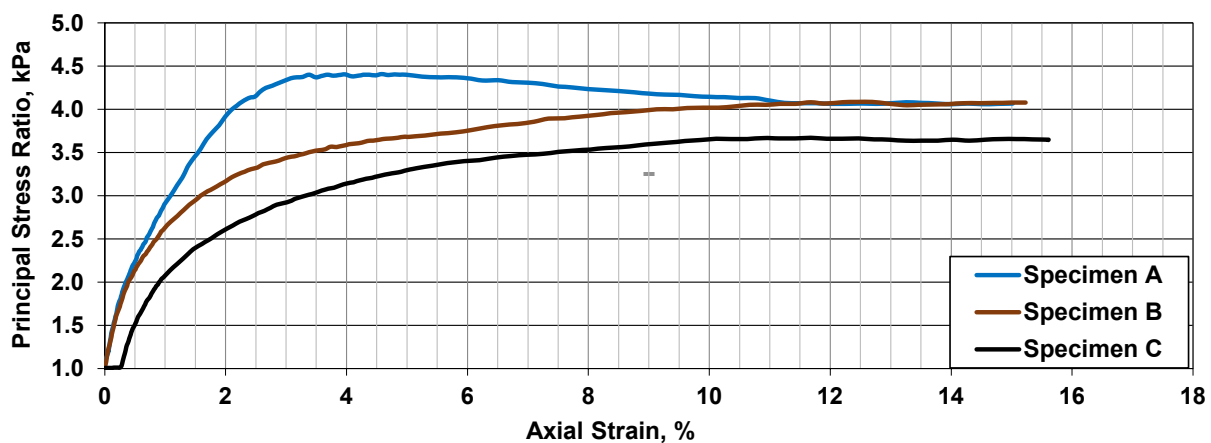
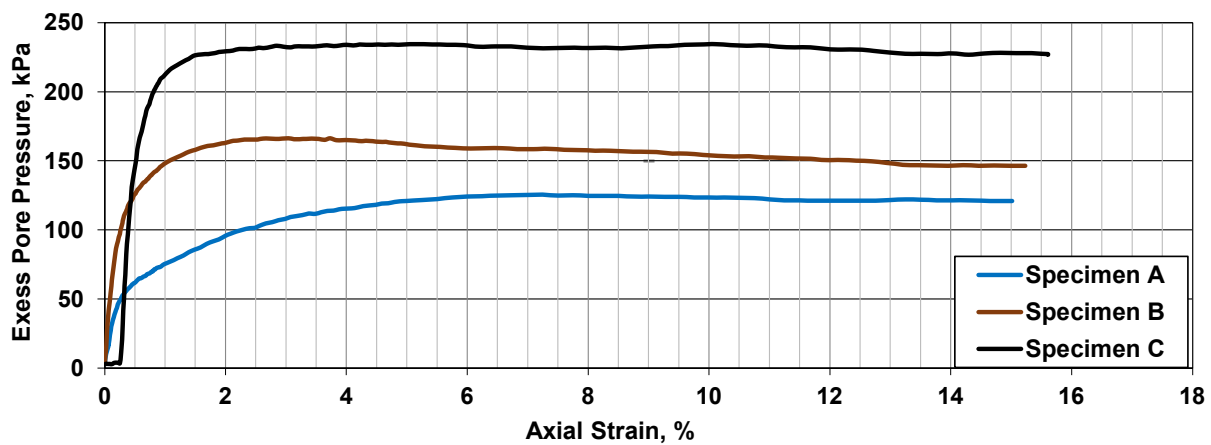
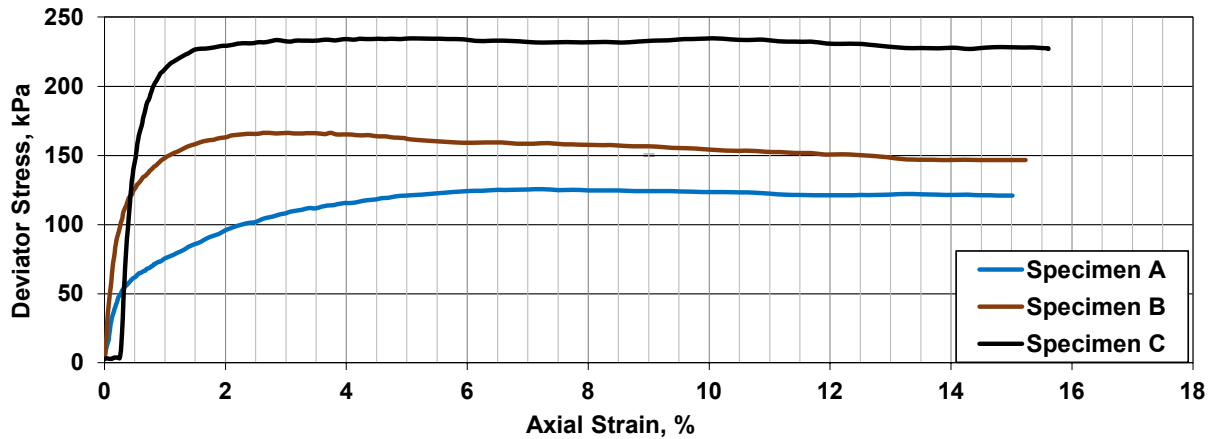
Specimen C





Consolidated Undrained (CU) Triaxial Compression Test (ASTM D 4767)

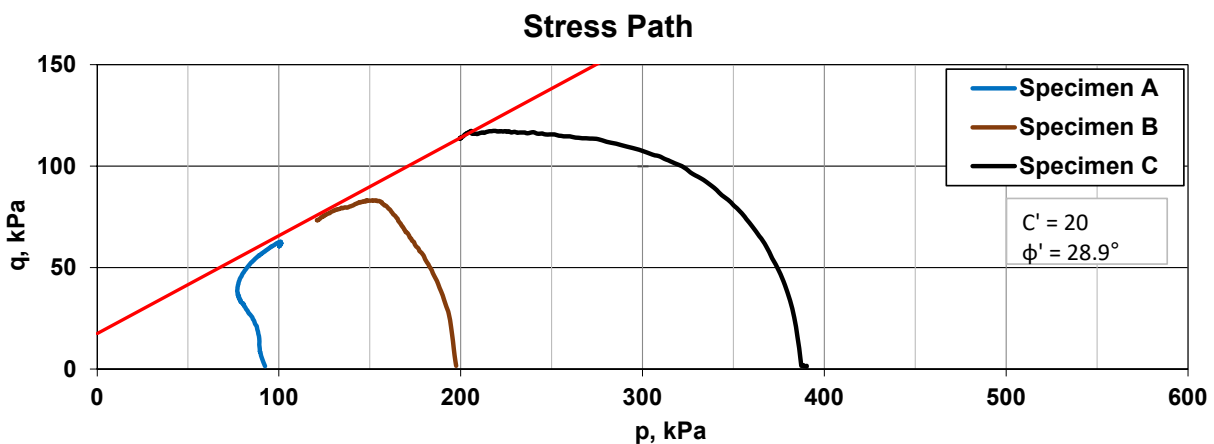
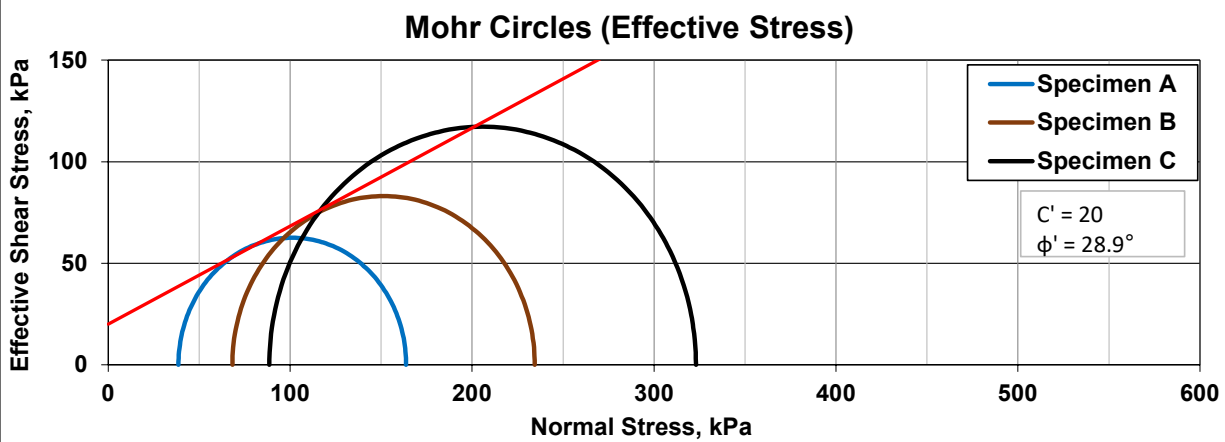
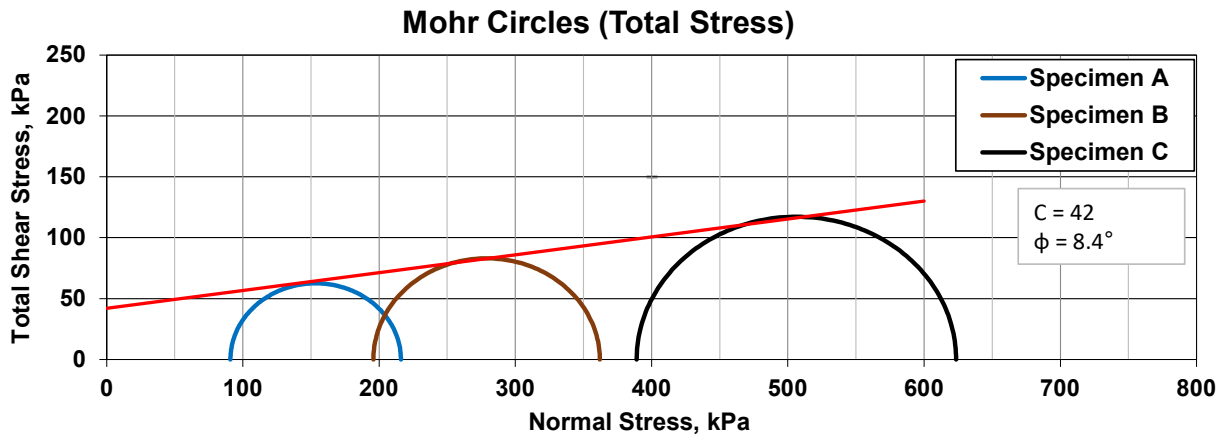
Project Name	Replacement of ONR Overhead Bridge	Date	1/29/2021
Project No.	28552	BH No.	20-03
Client	Ministry of Transportation	Sample ID	ST1
Sample description	Silty clay, varved, grey, moist	Depth	45'-47'





Consolidated Undrained (CU) Triaxial Compression Test (ASTM D 4767)

Project Name	Replacement of ONR Overhead Bridge	Date	1/29/2021
Project No.	28552	BH No.	20-03
Client	Ministry of Transportation	Sample ID	ST1
Sample description	Silty clay, varved, grey, moist	Depth	45'-47'





February 11 2021

21453742(2000)

Geoff Lay

Thurber Engineering Ltd.
Suite 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7

Dear Geoff,

This letter reports the results of laboratory testing carried out on the sample received at our office in Mississauga. The results of the tests are summarized in the attached tables and figures.

The testing services reported herein have been performed in accordance with the indicated recognized standard, unless noted otherwise. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability.

We trust that the results are sufficient for your current requirements. If you have any questions, please do not hesitate to call us.

Regards

Golder Associates Ltd.

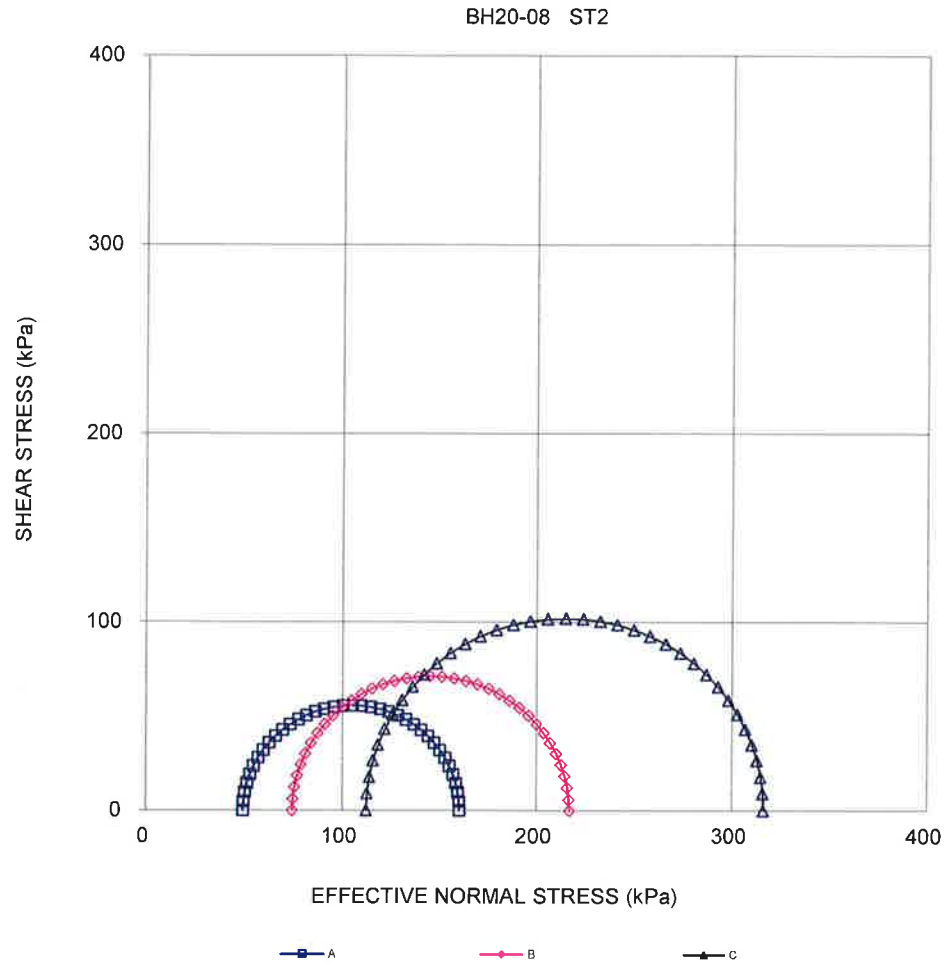
Marijana Manojlovic
Laboratory Manager

MM/lh

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS ASTM D4767 SHEET 1 OF 4		FIGURE	
TEST STAGE	A	B	C
BOREHOLE NUMBER		20-08	
SAMPLE		ST2	
SPECIMEN DIAMETER, cm	7.11	7.17	7.18
SPECIMEN HEIGHT, cm	13.95	13.97	14.05
NATURAL WATER CONTENT, %	44.8	43.8	46.0
DRY DENSITY, Mg/m ³	1.259	1.259	1.226
WATER CONTENT AFTER SATURATION, %	42.6	43.7	46.3
CELL PRESSURE, σ_3 , kPa	440.0	330.0	530.0
BACK PRESSURE, kPa	340.0	130.0	130.0
PORE PRESSURE PARAMETER "B"	0.96	0.99	0.96
EFFECTIVE CONSOLIDATION STRESS, σ_c , kPa	100.0	200.0	400.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	3.4	7.3	12.6
WATER CONTENT AFTER CONSOLIDATION, %	40.0	38.0	36.1
AVERAGE RATE OF STRAIN, %/hr	0.50	0.50	0.50
TIME TO FAILURE, HOURS	8.4	4.6	8.1
WATER CONTENT AFTER TEST, %	39.9	37.9	36.2
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$, kPa	111.3	142.5	203.9
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ maximum, %	4.2	2.3	4.0
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1 / σ'_3) maximum	3.6	3.9	3.4
DEVIATOR STRESS AT (σ'_1 / σ'_3) maximum, kPa	108.9	138.1	207.3
AXIAL STRAIN AT (σ'_1 / σ'_3) maximum, %	9.4	12.0	12.1
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ maximum	0.45	0.88	1.41
PORE PRESSURE PARAMETER, Af, AT (σ'_1 / σ'_3) maximum	0.53	1.10	1.51
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES: <div style="text-align: center;">Effective consolidation stresses are assigned by the client.</div>			
FAILURE PLANE NUMBER	-	-	-
ANGLE OF FAILURE, DEGREES	bulged	bulged	bulged
<div style="display: flex; justify-content: space-between; align-items: flex-end; padding-top: 20px;"> <div> Date: 02/08/2021 Project No. 21453742(2000) </div> <div style="text-align: center;"> Golder Associates </div> <div style="text-align: right;"> Prepared By LH Checked By: </div> </div>			

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

FIGURE



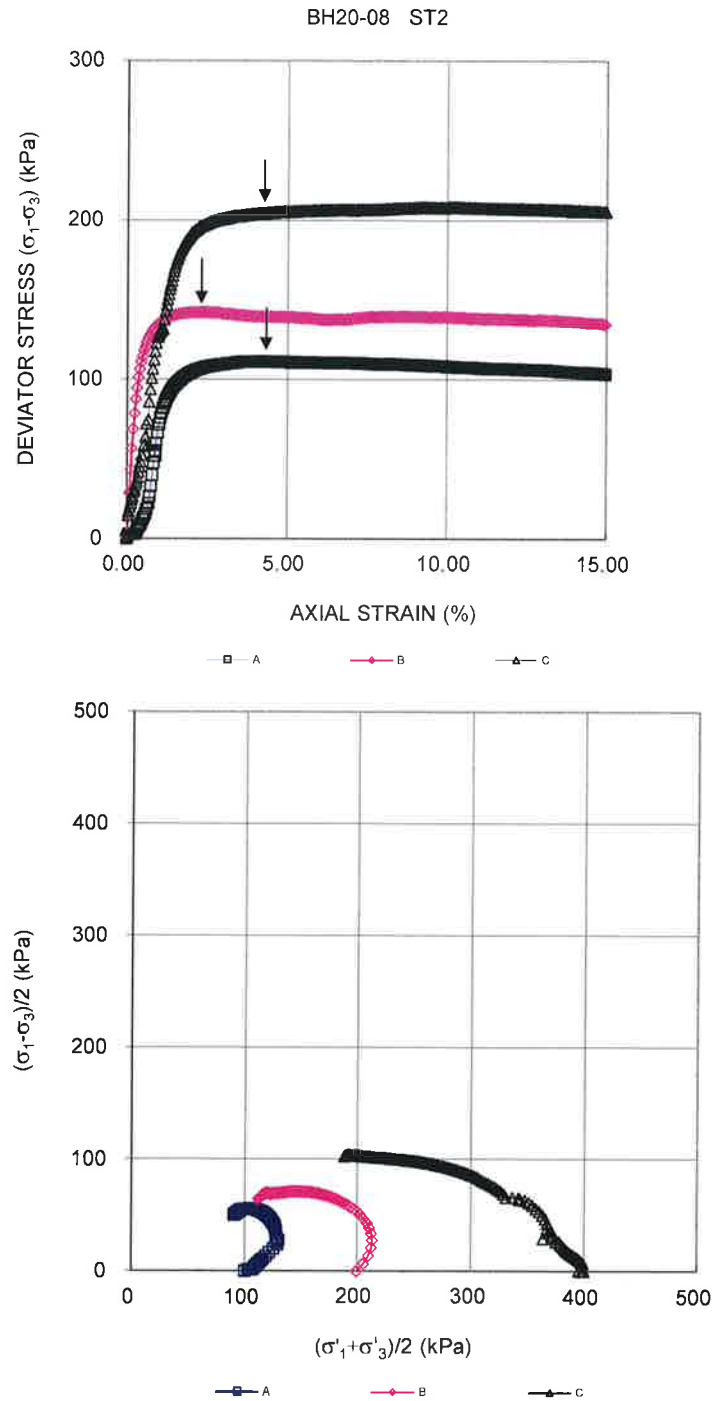
Date: 02/08/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: *[Signature]*

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

FIGURE



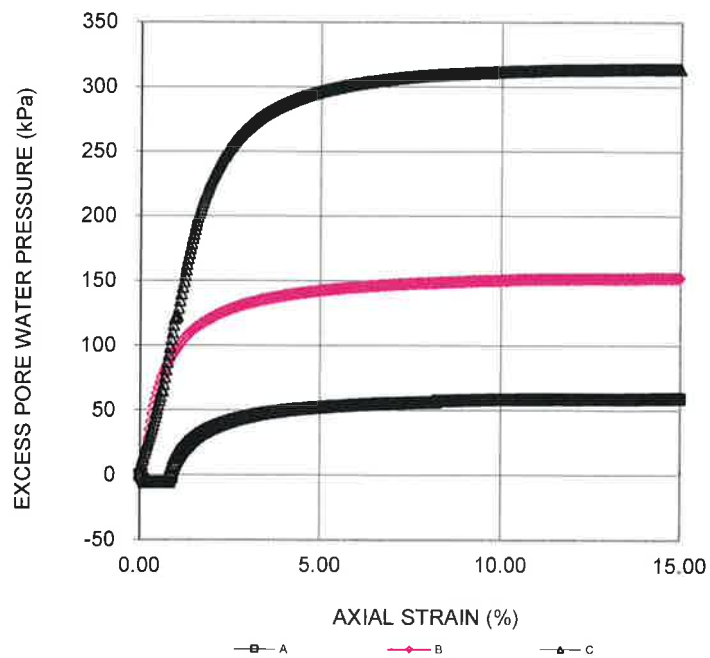
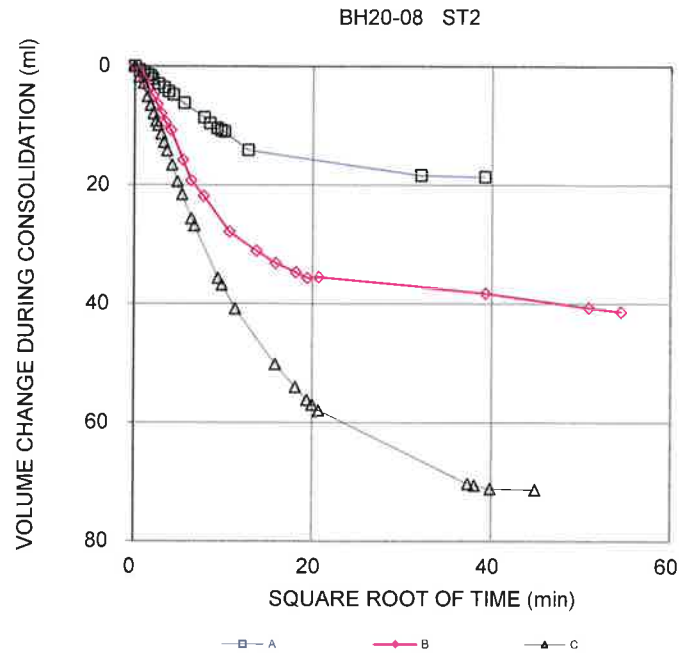
Date: 02/08/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: *[Signature]*

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

FIGURE



Date: 02/08/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: *[Signature]*

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

ASTM D 2850

SAMPLE IDENTIFICATION

PROJECT NUMBER	21453742(2000)	SAMPLE NUMBER	ST1
BOREHOLE NUMBER	BH20-26	SAMPLE DEPTH, m	13.72-14.33

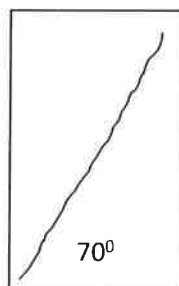
TEST CONDITIONS

MACHINE SPEED, mm/min	0.05	TYPE OF SPECIMEN	Intact
RATE OF AXIAL STRAIN, %/min	0.03	L/D	2.07
CELL PRESSURE, kPa	175		

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.30	WATER CONTENT, (specimen) %	45.97
SAMPLE DIAMETER, cm	6.91	UNIT WEIGHT, kN/m ³	17.38
SAMPLE AREA, cm ²	37.53	DRY UNIT WT., kN/m ³	11.90
SAMPLE VOLUME, cm ³	536.77	SPECIFIC GRAVITY, assumed	2.70
WET WEIGHT, g	951.44	VOID RATIO	1.22
DRY WEIGHT, g	651.81		

FAILURE SKETCH



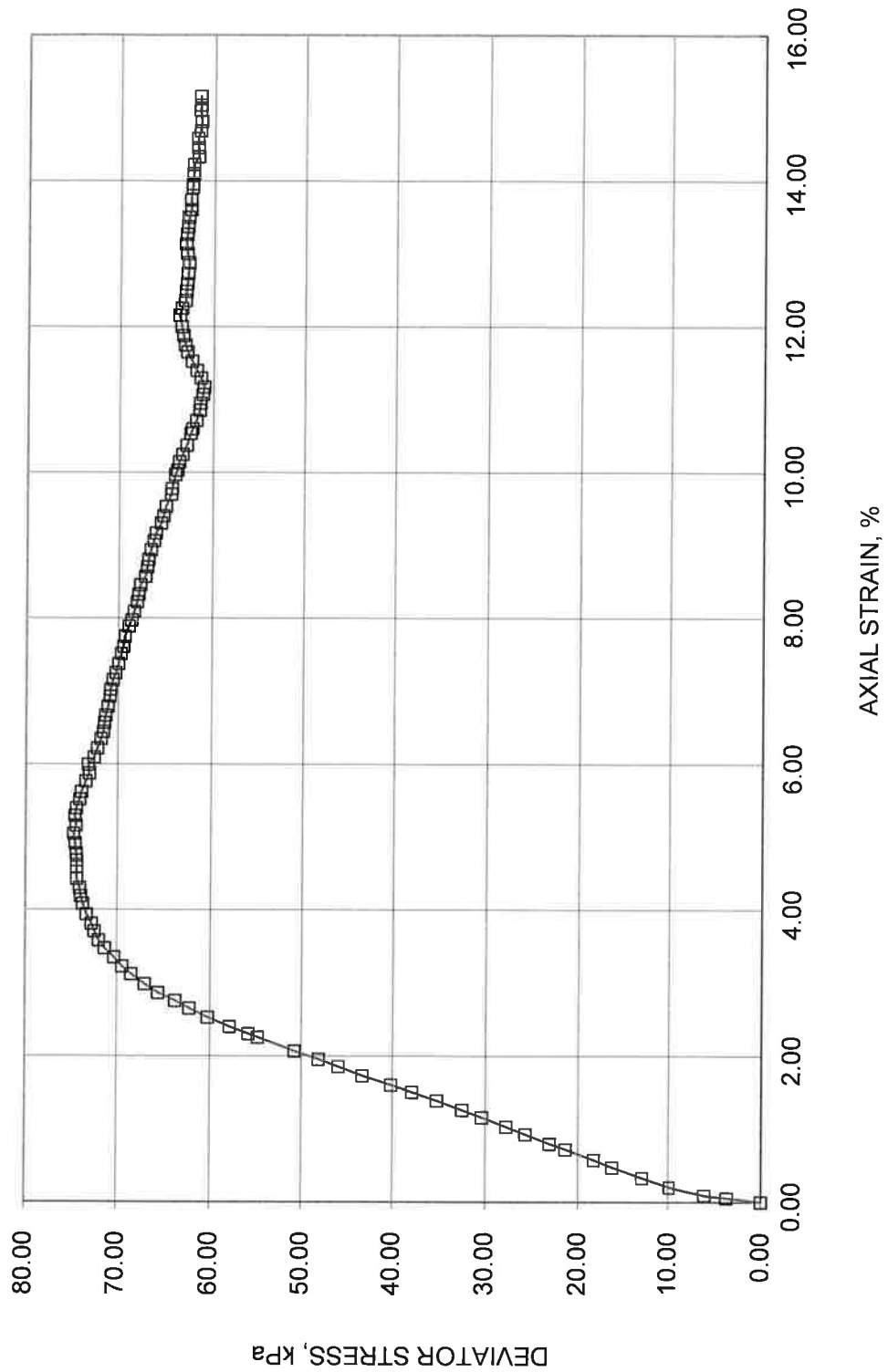
TEST RESULTS

STRAIN AT FAILURE, %	5.3	COMPRESSIVE STRENGTH, kPa	75
REMARKS:		DATE:	

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST (UU)

FIGURE

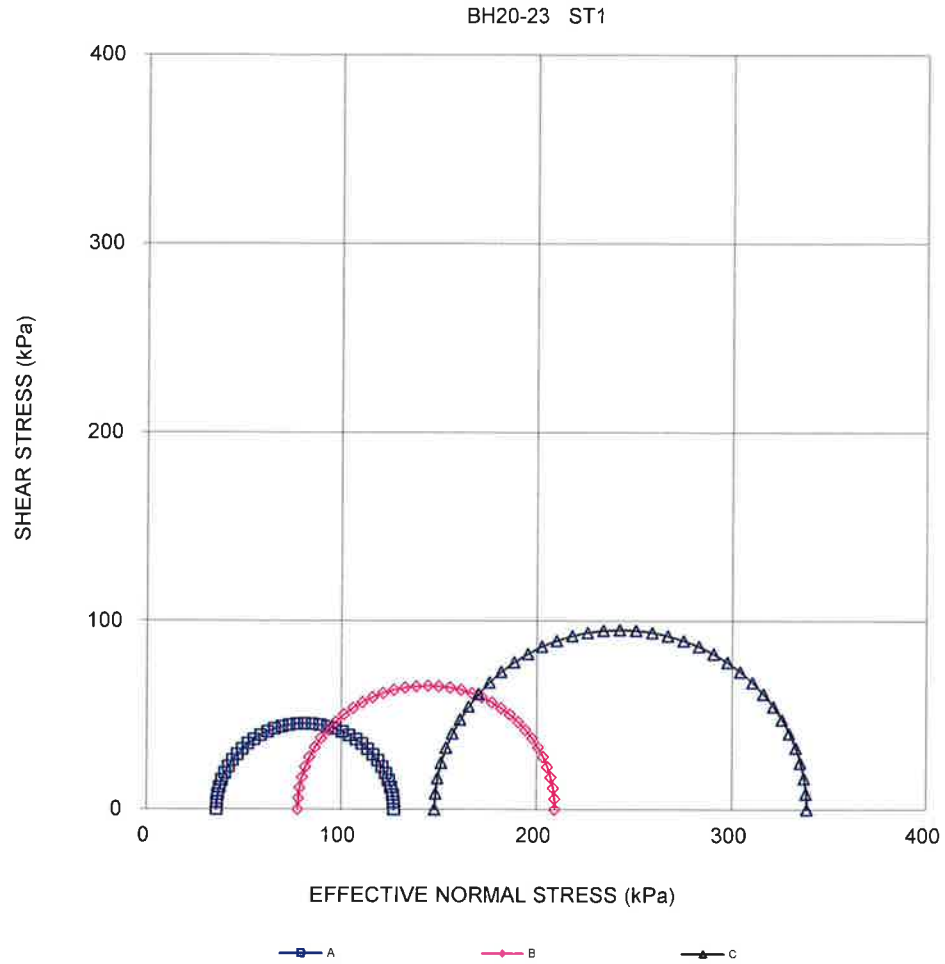
BH20-26 ST1 UU @ 175kPa



CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS ASTM D4767 SHEET 1 OF 4		FIGURE	
TEST STAGE	A	B	C
BOREHOLE NUMBER	20-23		
SAMPLE	ST1		
SPECIMEN DIAMETER, cm	6.96	6.97	6.94
SPECIMEN HEIGHT, cm	13.96	14.01	13.98
NATURAL WATER CONTENT, %	48.5	48.2	48.6
DRY DENSITY, Mg/m ³	1.180	1.178	1.177
WATER CONTENT AFTER SATURATION, %	49.1	48.8	48.8
CELL PRESSURE, σ_3 , kPa	230.0	330.0	530.0
BACK PRESSURE, kPa	130.0	130.0	130.0
PORE PRESSURE PARAMETER "B"	0.96	0.96	0.96
EFFECTIVE CONSOLIDATION STRESS, σ_c , kPa	100.0	200.0	400.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	4.4	7.6	12.3
WATER CONTENT AFTER CONSOLIDATION, %	45.3	42.4	38.3
AVERAGE RATE OF STRAIN, %/hr	0.50	0.50	0.50
TIME TO FAILURE, HOURS	7.3	4.0	9.3
WATER CONTENT AFTER TEST, %	44.6	43.2	37.9
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$, kPa	90.8	131.5	190.7
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ maximum, %	3.7	2.0	4.7
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ'_1 / σ'_3) maximum	3.7	3.5	2.4
DEVIATOR STRESS AT (σ'_1 / σ'_3) maximum, kPa	84.6	111.9	181.6
AXIAL STRAIN AT (σ'_1 / σ'_3) maximum, %	7.0	10.7	7.6
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ maximum	0.70	0.93	1.32
PORE PRESSURE PARAMETER, Af, AT (σ'_1 / σ'_3) maximum	0.81	1.38	1.48
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES: Effective consolidation stresses are assigned by the client. Specimen A taken 0-15cm from top of the tube. Specimen B taken 15-30cm from top of the tube. Specimen C taken 30-45cm from top of the tube.			
FAILURE PLANE NUMBER	-	-	1
ANGLE OF FAILURE, DEGREES	bulged	bulged	70
Date: 07/06/2021 Project No. 21453742(2000)			
Golder Associates		Prepared By LH Checked By: MM	

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

FIGURE



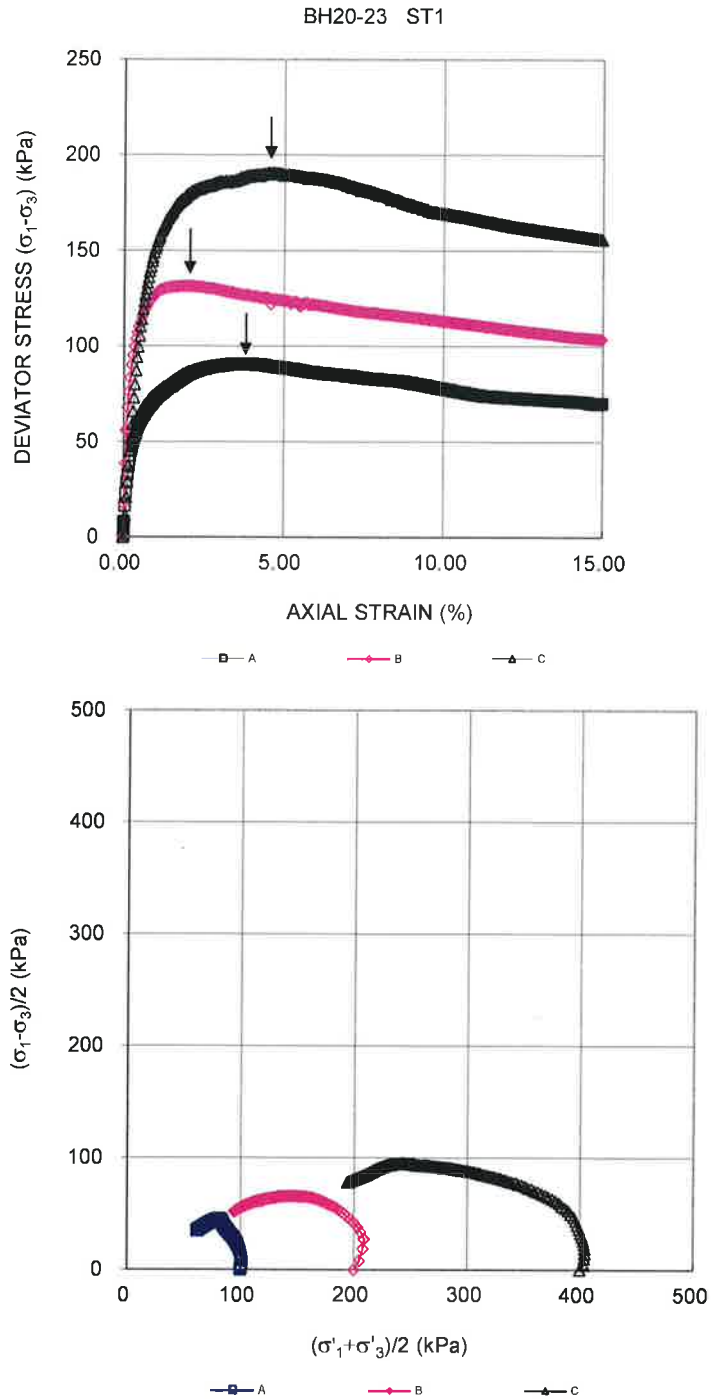
Date: 07/06/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: MM

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

FIGURE



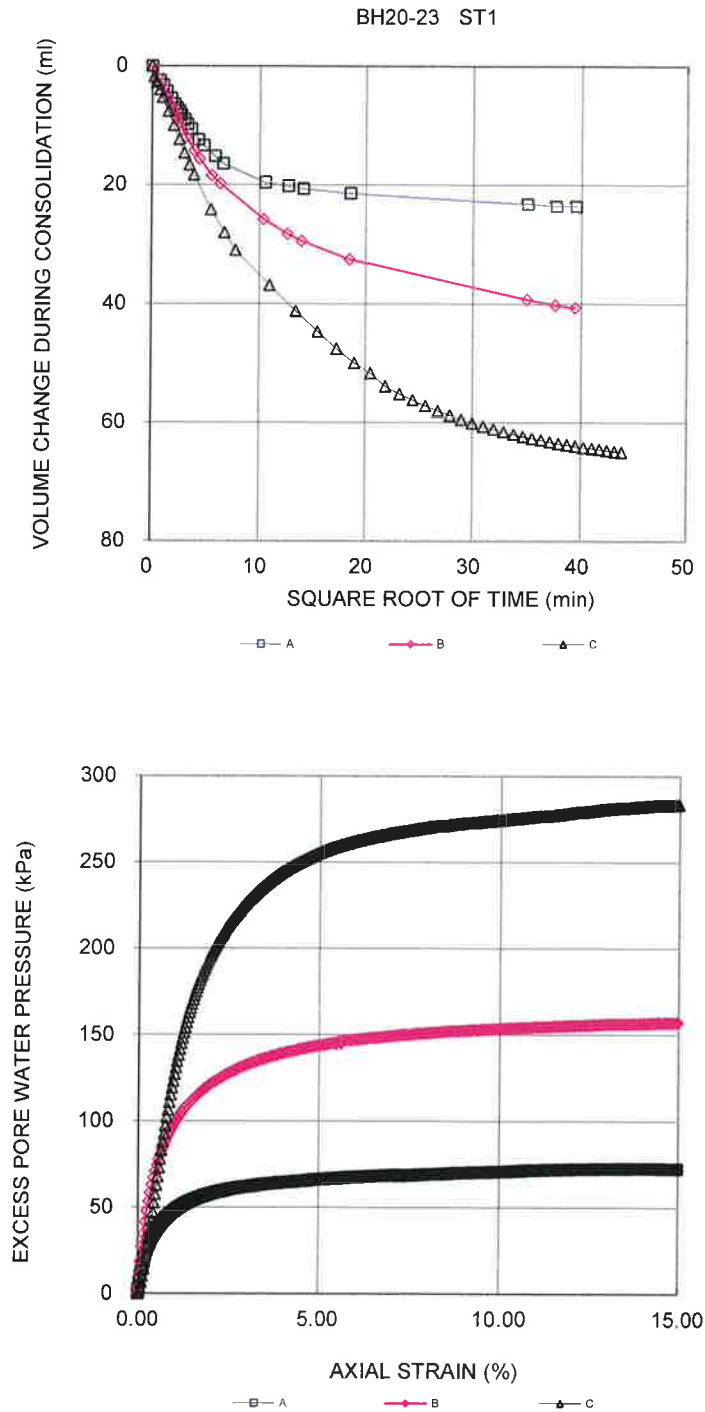
Date: 07/06/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: MM

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

FIGURE



Date: 07/06/2021
Project No. 21453742(2000)

Golder Associates

Prepared By LH
Checked By: MM

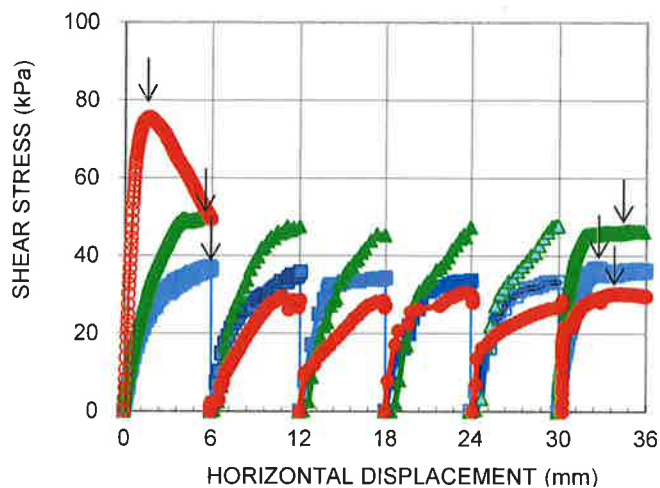
CONSOLIDATED DRAINED DIRECT SHEAR TEST ASTM D3080 SHEET 1 OF 3		FIGURE		
TEST STAGE	A	B	C	
BOREHOLE NUMBER		20-21		
SAMPLE		ST-3		
SAMPLE DEPTH, (m)		10.67-11.28		
SAMPLE HEIGHT, (mm)	26.70	25		27.1
SAMPLE LENGTH, (mm)	60.00	60.00		60.00
WATER CONTENT, BEFORE TEST, (%)	34.9	34.7		36.9
NORMAL (CONSOLIDATION) STRESS, (kPa)	75	150		300
WATER CONTENT, AFTER TEST, (%)	41.2	42.0		41.9
DISPLACEMENT RATE, mm/min	0.0048	0.0048		0.0048
TIME TO FAILURE, hours	20.3	20.6		6.1
PEAK SHEAR STRESS ¹ , (kPa)	37.1	50.4		75.6
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	5.9	5.9		1.8
RESIDUAL SHEAR STRESS, (kPa)	36.9	46.4		30.2
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	32.7	34.7		33.7
DRY DENSITY, initial, Mg/m ³	1.17	1.22		1.12
WET DENSITY, initial, Mg/m ³	1.58	1.64		1.54
TEST NOTES:				
¹ In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement (ASTM D3080).				
² Normal stresses assigned by the client				
³ Direct Shear Tests carried out submerged, per clients instruction.				
⁴ Test was performed following ASTM D3080 which is currently withdrawn with no replacement.				
Date:	3/15/2021	Prepared By:	LH	
Project No.	21453742(2000)	Checked By:	AH	
Golder Associates				

CONSOLIDATED DRAINED DIRECT SHEAR TEST
ASTM D3080
SHEET 2 OF 3

FIGURE

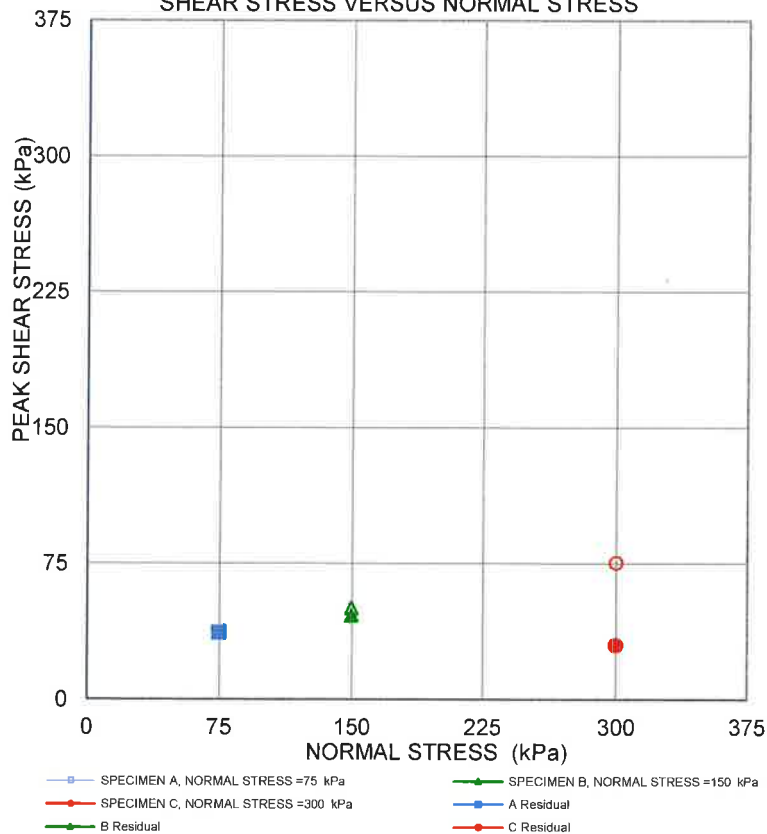
BH20-21 ST-3

SHEAR STRESS VERSUS HORIZONTAL DISPLACEMENT



BH20-21 ST-3

SHEAR STRESS VERSUS NORMAL STRESS



Date: 3/15/2021

Project No. 21453742(2000)

Golder Associates

Prepared By: LH

Checked By: AH

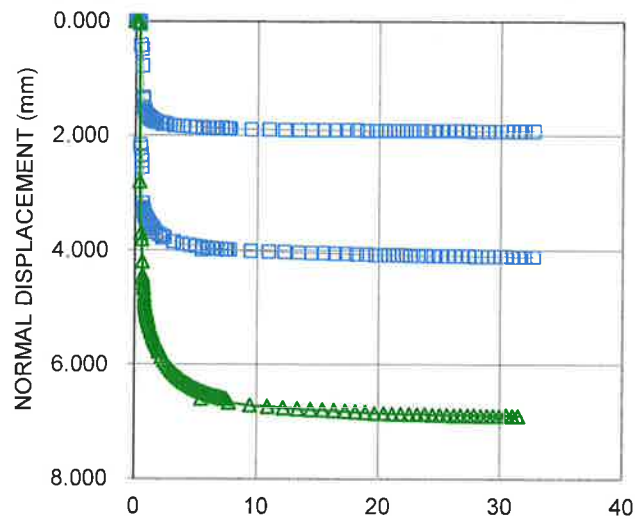
CONSOLIDATED DRAINED DIRECT SHEAR TEST

ASTM D3080
SHEET 3 OF 3

FIGURE

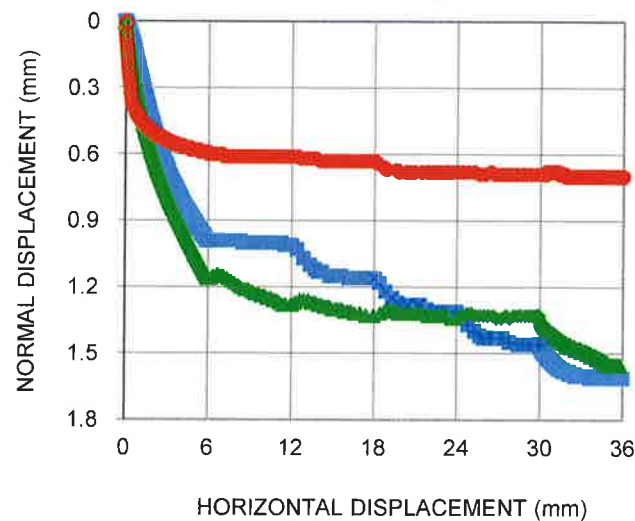
BH20-21 ST-3

NORMAL DISPLACEMENT VERSUS SQUARE ROOT OF TIME



BH20-21 ST-3

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



- | | |
|---------------------------------------|--|
| —●— SPECIMEN A, NORMAL STRESS =75 kPa | —●— SPECIMEN B, NORMAL STRESS =150 kPa |
| —●— SPECIMEN C, NORMAL STRESS=300 kPa | |
| —●— A Residual | —●— A Residual |
| —●— B Residual | —●— C Residual |
| —●— A 1st run | —●— A 2nd run |
| —●— B 1st Run | —●— B 2nd Run |
| —●— C 1st Run | —●— C 2nd run |
| —●— A 3 rd Run | —●— B 3rd run |
| —●— C 3rd Run | —●— A 4th run |
| —●— B 4th run | —●— C 4th run |

Date: 3/15/2021

Project No. 21453742(2000)

Golder Associates

Prepared By: LH

Checked By: AH

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-02 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: Nov 23, 2020

Run #	Depth (ft)	Depth (m)
1	80'9" – 83'9"	24.61 – 25.53
2	83'9" – 87'10"	25.53 – 26.77
3	87'10" – 92'10"	26.77 – 28.30

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-04 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 9, 2021

Run #	Depth (ft)	Depth (m)
1	64'4" – 68'8"	19.61 – 20.93
2	68'8" – 73'8"	20.93 – 22.45
3	73'8" – 77'10"	22.45 – 23.72

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-06 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 8, 2021

Run #	Depth (ft)	Depth (m)
1	65'2" – 68'8"	19.86 – 20.93
2	68'8" – 73'7"	20.93 – 22.43
3	73'7" – 78'7"	22.43 – 23.95

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-09 (Dry)

RUNS 1-3

BOTTOM



TOP

Date Drilled: May 8, 2021

Run #	Depth (ft)	Depth (m)
1	54'0" – 59'0"	16.46 – 17.98
2	59'0" – 64'0"	17.98 – 19.51
3	64'0" – 68'2"	19.51 – 20.78

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-10 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 7, 2021

Run #	Depth (ft)	Depth (m)
1	55'0" – 59'0"	16.76 – 17.98
2	59'0" – 63'8"	17.98 – 19.41
3	63'8" – 68'8"	19.41 – 20.93

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-13 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 5, 2021

Run #	Depth (ft)	Depth (m)
1	45'6" – 49'4"	13.87 – 15.04
2	49'4" – 54'0"	15.04 – 16.46
3	54'0" – 55'8"	16.46 – 16.97

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-14 (Dry)

TOP

RUNS 1-2



BOTTOM

Date Drilled: May 4, 2021

Run #	Depth (ft)	Depth (m)
1	44'6" – 49'6"	13.56 – 15.09
2	49'6" – 54'6"	15.09 – 16.61

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-15 (Dry)

RUNS 1-2

TOP



BOTTOM

Date Drilled: May 10, 2021

Run #	Depth (ft)	Depth (m)
1	44'0" – 49'0"	13.41 – 14.93
2	49'0" – 54'0"	14.93 – 16.46

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-16 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 11, 2021

Run #	Depth (ft)	Depth (m)
1	45'8" – 49'2"	13.92 – 14.99
2	49'2" – 54'0"	14.99 – 16.46
3	54'0" – 58'10"	16.46 – 17.93

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-17 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 12, 2021

Run #	Depth (ft)	Depth (m)
1	47'5" – 48'10"	14.45 – 14.88
2	48'10" – 53'9"	14.88 – 16.38
3	53'9" – 58'4"	16.38 – 17.78

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-18 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 11, 2021

Run #	Depth (ft)	Depth (m)
1	50'4" – 54'10"	15.34 – 16.71
2	54'10" – 59'2"	16.71 – 18.03
3	59'2" – 64'1"	18.03 – 19.53

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-19 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 13, 2021

Run #	Depth (ft)	Depth (m)
1	47'4" – 49'2"	14.43 – 14.99
2	49'2" – 54'2"	14.99 – 16.51
3	54'2" – 59'2"	16.51 – 18.03

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-20 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: May 14, 2021

Run #	Depth (ft)	Depth (m)
1*	48'7" – 53'7"	14.81 – 16.33
2	53'7" – 58'8"	16.33 – 17.88
3	58'8" – 63'4"	17.88 – 19.30

*Bedrock core starts at 50'4" (15.34 m)

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-23 (Dry)

TOP

RUNS 1-2



BOTTOM

Date Drilled: May 15, 2021

Run #	Depth (ft)	Depth (m)
1	54'2" – 59'2"	16.51 – 18.03
2	59'2" – 64'2"	18.03 – 19.56

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-24 (Dry)

TOP

RUNS 1-2



BOTTOM

Date Drilled: May 15, 2021

Run #	Depth (ft)	Depth (m)
1	59'2" – 64'0"	18.03 – 19.51
2	64'0" – 69'0"	19.51 – 21.03

PHOTOGRAPHS OF ROCK CORES – BOREHOLE 20-26 (Dry)

TOP

RUNS 1-3



BOTTOM

Date Drilled: Nov 27, 2021

Run #	Depth (ft)	Depth (m)
1	71'6" – 76'9"	21.79 – 23.32
2	76'9" – 80'0"	23.32 – 24.38
3	80'0" – 83'4"	24.38 – 25.40

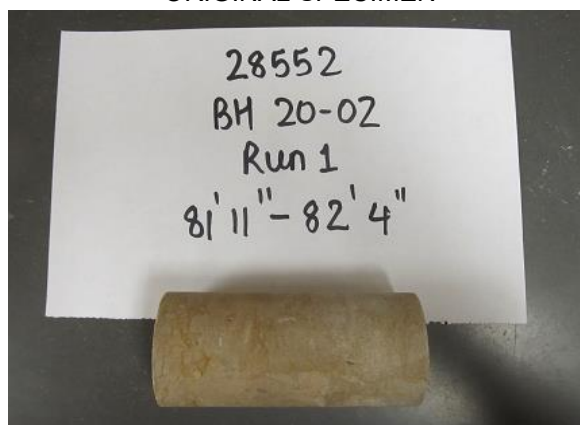
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

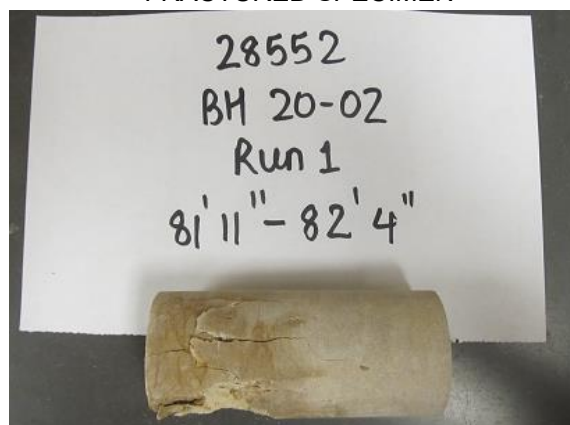
CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earleton	REPORT DATE:	25-Jan-21
BOREHOLE No.:	20-02	TEST DATE:	19-Jan-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	25.0-25.1 m		
DESCRIPTION:	Limestone/Sandstone		

Avg. Height (cm):	10.0	Weight (g):	442.4
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,550
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	173.49		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	124.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	71.8 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-02 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-04	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	20.0-20.1 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.2	Weight (g):	479.0
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,707
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	176.96		

ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-04

Run#: 1

Depth: 65'9" - 66'1"



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-04

Run#: 1

Depth: 65'9" - 66'1"



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	156.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	90.0 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-04 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-06	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	20.0-20.1 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.5	Weight (g):	499.1
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,740
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	182.17		

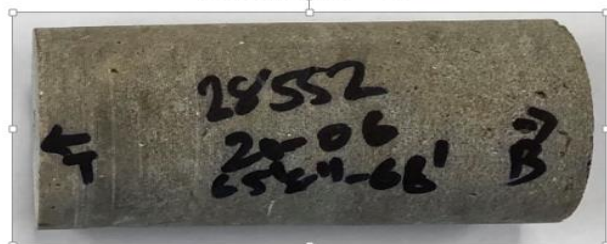
ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-06

Run#: 1

Depth: 65'8"-66'



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-06

Run#: 1

Depth: 65'8"-66'



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	242.0 kN
UNCONFINED COMPRESSIVE STRENGTH:	139.5 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-06 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-10	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	17.8-18.0 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.2	Weight (g):	461.4
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,607
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	176.96		

ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-10

Run#: 1

Depth: 58'6"-59'



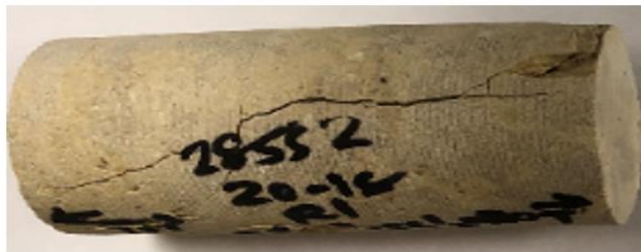
FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-10

Run#: 1

Depth: 58'6"-59'



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	117.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	67.7 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-10 Run 1

UNCONFINED COMPRESSION TEST REPORT

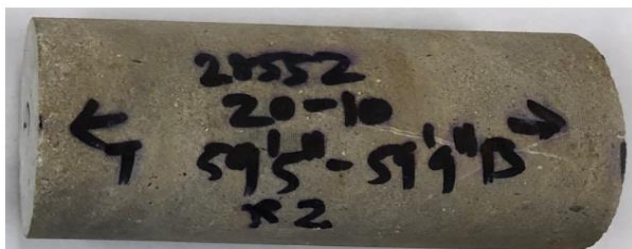
ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-10	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 2		
SAMPLE DEPTH:	18.1-18.2 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.7	Weight (g):	489.7
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,638
H. to Dia. Ratio*:	2.3:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	185.64		

ORIGINAL SPECIMEN

Project#: 28552
Bore-Hole#: 20-10
Run#: 2
Depth: 59'5" – 59'9"



FRACTURED SPECIMEN

Project#: 28552
Bore-Hole#: 20-10
Run#: 2
Depth: 59'5" – 59'9"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	71.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	41.4 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
 REVIEWED BY: WM

BH 20-10 Run 2

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-13	TEST DATE:	20-Jul-21
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	14.3-14.4 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.5	Weight (g):	477.5
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,621
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	182.17		

ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-13

Run#: 1

Depth: 47'-47'4"



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-13

Run#: 1

Depth: 47'-47'4"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	127.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	73.5 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-13 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-15	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	13.5-13.6 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.4	Weight (g):	475.0
Avg. Diameter (cm):	4.6	Wet Density (kg/m ³):	2,748
H. to Dia. Ratio*:	2.3:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	16.62	Moisture Content (%):	N/A
Sample Volume (cm ³):	172.84		

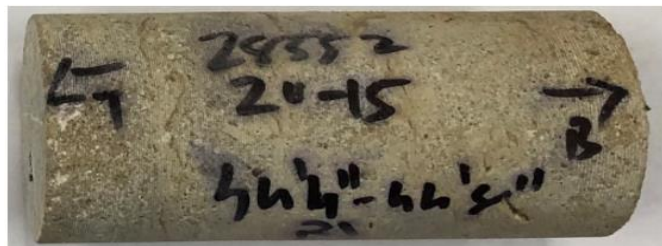
ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-15

Run#: 1

Depth: 44'4" - 44'8"



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-15

Run#: 1

Depth: 44'4" - 44'8"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	69.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	41.7 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-15 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-17	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	14.9-15.0 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.4	Weight (g):	468.6
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,597
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	180.43		

ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-17

Run#: 1

Depth: 48'11" - 49'3"



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-17

Run#: 1

Depth: 48'11" - 49'3"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	113.0 kN
UNCONFINED COMPRESSIVE STRENGTH:	65.1 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-17 Run 1

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-20	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 2		
SAMPLE DEPTH:	16.5-16.6 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.5	Weight (g):	480.3
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,636
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	182.17		

ORIGINAL SPECIMEN

Project#: 28552

Bore-Hole#: 20-20

Run#: 2

Depth: 54' - 54'4"



FRACTURED SPECIMEN

Project#: 28552

Bore-Hole#: 20-20

Run#: 2

Depth: 54' - 54'4"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	81.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	46.8 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-20 Run 2

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-23	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	13.5-13.6 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.3	Weight (g):	474.8
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,657
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	178.70		

ORIGINAL SPECIMEN

Project#: 28552
Bore-Hole#: 20-23
Run#: 1
Depth: 44'5" - 44'9"



FRACTURED SPECIMEN

Project#: 28552
Bore-Hole#: 20-23
Run#: 1
Depth: 44'5" - 44'9"



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	154.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	88.9 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
 REVIEWED BY: WM

BH 20-23 Run 1

UNCONFINED COMPRESSION TEST REPORT

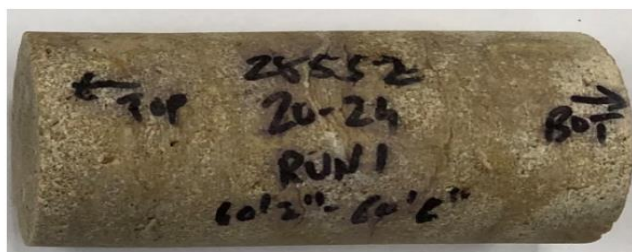
ASTM D7012-14

CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earlton	REPORT DATE:	30-Jul-21
BOREHOLE No.:	20-24	TEST DATE:	20-Jul-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	18.3-18.4 m		
DESCRIPTION:	Sandstone		

Avg. Height (cm):	10.4	Weight (g):	469.0
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,599
H. to Dia. Ratio*:	2.2:1	Dry Density (kg/m ³):	-
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	180.43		

ORIGINAL SPECIMEN

Project#: 28552
Bore-Hole#: 20-24
Run#: 1
Depth: 60'2" – 60'6"



FRACTURED SPECIMEN

Project#: 28552
Bore-Hole#: 20-24
Run#: 1
Depth: 60'2" – 60'6"



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	94.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	54.5 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
 REVIEWED BY: WM

BH 20-24 Run 1

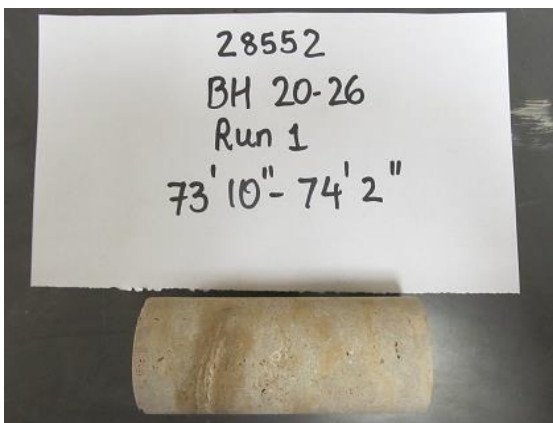
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

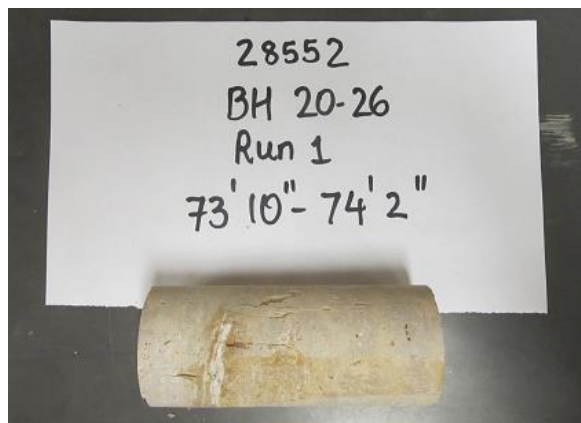
CLIENT:	Ministry Of Transportation, Ontario	FILE NUMBER:	28552
PROJECT NAME:	P-5019-Z-0023 NER Replacement of ONR Overhead Bridge, Hwy 11 at Earleton	REPORT DATE:	25-Jan-21
BOREHOLE No.:	20-26	TEST DATE:	19-Jan-21
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	22.5-22.6 m		
DESCRIPTION:	Limestone/Sandstone		

Avg. Height (cm):	10.6	Weight (g):	485.9
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,642
H. to Dia. Ratio*:	2.3:1	Dry Density (kg/m ³):	2,642
Cross Sectional Area (cm ²):	17.35	Moisture Content (%):	N/A
Sample Volume (cm ³):	183.90		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.4% / min
MAXIMUM COMPRESSIVE LOAD:	147.2 kN
UNCONFINED COMPRESSIVE STRENGTH:	84.8 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

BH 20-26 Run 1



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11 - ONR Replacement
 Core Size: NQ BH No : 20-02

Date Drilled: 02-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	24.9	D	4.22	47.30	66.33	1.7	41.9	Sandstone	Medium Strong
2	1	25.2	D	11.24	47.40	66.20	4.6	111.1	Sandstone	Very Strong
3	1	25.5	D	3.24	47.20	61.50	1.3	32.2	Sandstone	Medium Strong
4	2	25.8	D	5.46	47.40	54.50	2.2	54.0	Sandstone	Strong
5	2	26.1	D	3.96	47.40	60.00	1.6	39.1	Sandstone	Medium Strong
6	2	26.5	D	2.44	47.40	67.00	1.0	24.1	Sandstone	Weak
7	2	26.8	D	5.42	47.30	64.60	2.2	53.8	ndstone/Limestone	Strong
8	3	27.1	D	8.32	47.40	67.80	3.4	82.3	ndstone/Limestone	Strong
9	3	27.4	D	8.60	47.50	65.00	3.5	84.7	ndstone/Limestone	Strong
10	3	27.7	D	5.84	47.40	65.20	2.4	57.7	ndstone/Limestone	Strong
11	3	28.0	D	15.78	47.40	66.20	6.5	156.0	ndstone/Limestone	Very Strong
12	3	28.3	D	13.66	47.10	65.05	5.7	136.4	ndstone/Limestone	Very Strong
13										
14										
15										
16					RUN #1 AVERAGE (MPa):			61.7		Strong
17					RUN #2 AVERAGE (MPa):			42.8		Medium Strong
18					RUN #3 AVERAGE (MPa):			103.4		Very Strong
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1

Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have $0.7 \times D$ on either side of test point.

* Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11 - ONR Replacement
 Core Size: NQ BH No : 20-04

Date Drilled: 05-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	20.2	D	7.62	47.20	62.80	3.2	75.8	ndstone/Dolost	Strong
2	1	20.5	D	11.24	47.20	62.60	4.7	111.9	ndstone/Dolost	Very Strong
3	2	21.4	D	9.64	47.50	69.70	4.0	95.0	ndstone/Dolost	Strong
4	2	22.2	D	8.66	47.30	67.50	3.6	85.9	ndstone/Dolost	Strong
5	3	22.8	D	10.92	47.20	63.00	4.5	108.7	ndstone/Dolost	Very Strong
6	3	23.6	D	7.98	47.20	66.14	3.3	79.4	ndstone/Dolost	Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			93.8		Strong
11					RUN #2 AVERAGE (MPa):			90.4		Strong
12					RUN #3 AVERAGE (MPa):			94.0		Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11 - ONR Replacement
 Core Size: NQ BH No : 20-06

Date Drilled: 08-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	20.2	D	16.28	47.40	66.10	6.7	160.9	Sandstone	Very Strong
2	1	20.6	D	18.34	47.60	68.68	7.5	180.1	Sandstone	Very Strong
3	2	21.0	D	11.16	47.20	71.20	4.6	111.1	Sandstone	Very Strong
4	2	21.6	D	4.20	47.40	68.60	1.7	41.5	Sandstone	Medium Strong
5	3	22.5	D	14.46	47.20	71.40	6.0	143.9	ndstone/Dolost	Very Strong
6	3	23.1	D	6.10	47.20	68.35	2.5	60.7	ndstone/Dolost	Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			170.5		Very Strong
11					RUN #2 AVERAGE (MPa):			76.3		Strong
12					RUN #3 AVERAGE (MPa):			102.3		Very Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11 - ONR Replacement
 Core Size: NQ BH No : 20-09

Date Drilled: 02-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.9	D	4.02	47.40	69.30	1.7	39.7	ndstone/Dolostone	Medium Strong
2	1	20.6	D	13.50	47.20	69.80	5.6	134.3	Dolostone	Very Strong
3	2	21.1	D	15.18	47.20	70.70	6.3	151.1	Dolostone	Very Strong
4	2	21.9	D	13.92	47.20	67.10	5.8	138.5	Dolostone	Very Strong
5	3	22.7	D	7.62	47.20	69.50	3.2	75.8	Dolostone	Strong
6	3	23.7	D	1.98	46.90	70.00	0.8	19.9	Dolostone	Weak
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			87.0		Strong
11					RUN #2 AVERAGE (MPa):			144.8		Very Strong
12					RUN #3 AVERAGE (MPa):			47.9		Medium Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-10

Date Drilled: 07-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	17.1	D	1.80	47.10	67.30	0.7	18.0	Sandstone	Weak
2	1	17.3	D	4.44	47.20	67.20	1.8	44.2	Sandstone	Medium Strong
3	2	18.1	D	6.56	47.30	69.40	2.7	65.1	Sandstone	Strong
4	2	18.6	D	11.00	47.50	66.38	4.5	108.4	Sandstone	Very Strong
5	3	19.4	D	14.70	47.20	64.17	6.1	146.3	Dolostone	Very Strong
6	3	19.9	D	10.02	47.20	67.96	4.2	99.7	Dolostone	Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			31.1		Medium Strong
11					RUN #2 AVERAGE (MPa):			86.7		Strong
12					RUN #3 AVERAGE (MPa):			123.0		Very Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-13

Date Drilled: 05-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.1	D	9.16	47.20	70.00	3.8	91.2	Sandstone	Strong
2	1	14.8	D	8.44	47.20	63.35	3.5	84.0	Sandstone	Strong
3	2	15.4	D	2.70	47.20	68.50	1.1	26.9	Sandstone	Medium Strong
4	2	16.3	D	9.88	47.10	65.00	4.1	98.6	Sandstone	Strong
5	3	16.5	D	15.78	47.10	69.30	6.6	157.5	Sandstone	Very Strong
6	3	16.8	D	16.34	47.20	68.90	6.8	162.6	Sandstone	Very Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			87.6		Strong
11					RUN #2 AVERAGE (MPa):			62.8		Strong
12					RUN #3 AVERAGE (MPa):			160.1		Very Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11 - ONR Replacement
 Core Size: NQ BH No : 20-14

Date Drilled: 04-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	13.8	D	8.56	47.20	66.88	3.5	85.2	Sandstone	Strong
2	1	14.4	D	11.28	47.30	69.30	4.7	111.9	Sandstone	Very Strong
3	2	15.1	D	2.24	47.30	68.78	0.9	22.2	Sandstone	Weak
4	2	16.3	D	3.06	47.30	69.85	1.3	30.4	Sandstone	Medium Strong
5										
6										
7										
8					RUN #1 AVERAGE (MPa):			98.5		Strong
9					RUN #2 AVERAGE (MPa):			26.3		Medium Strong
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-15

Date Drilled: 10-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	13.5	D	9.16	47.20	60.50	3.8	91.2	Sandstone	Strong
2	1	14.5	D	2.82	47.10	68.90	1.2	28.2	Sandstone	Medium Strong
3	2	15.5	D	11.48	47.10	64.70	4.8	114.6	Sandstone	Very Strong
4	2	16.0	D	0.78	47.50	69.80	0.3	7.7	Sandstone	Weak
5	2	16.3	D	16.38	47.20	66.20	6.8	163.0	Sandstone	Very Strong
6										
7										
8										
9					RUN #1 AVERAGE (MPa):			59.7		Strong
10					RUN #2 AVERAGE (MPa):			95.1		Strong
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-16

Date Drilled: 11-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.0	D	8.84	47.20	70.10	3.7	88.0	Sandstone	Strong
2	1	14.7	D	10.56	47.40	67.80	4.3	104.4	Sandstone	Very Strong
3	2	15.2	D	4.46	47.20	64.00	1.8	44.4	Sandstone	Medium Strong
4	2	16.0	D	2.38	47.20	64.20	1.0	23.7	Sandstone	Weak
5	3	16.8	D	3.14	47.10	68.50	1.3	31.3	Sandstone	Medium Strong
6	3	17.5	D	9.74	47.20	65.70	4.0	96.9	Sandstone	Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			96.2		Strong
11					RUN #2 AVERAGE (MPa):			34.0		Medium Strong
12					RUN #3 AVERAGE (MPa):			64.1		Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-17

Date Drilled: 12-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.8	D	9.32	47.10	64.40	3.9	93.1	Sandstone	Strong
2	2	15.2	D	6.90	47.20	66.40	2.9	68.7	Sandstone	Strong
3	2	16.0	D	4.16	47.20	65.70	1.7	41.4	Sandstone	Medium Strong
4	3	16.5	D	4.00	47.40	67.00	1.6	39.5	Sandstone	Medium Strong
5	3	17.3	D	5.94	47.30	62.20	2.5	58.9	Sandstone	Strong
6										
7										
8										
9					RUN #1 AVERAGE (MPa):			93.1		Strong
10					RUN #2 AVERAGE (MPa):			55.0		Strong
11					RUN #3 AVERAGE (MPa):			49.2		Medium Strong
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-18

Date Drilled: 11-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	15.5	D	3.38	47.40	68.30	1.4	33.4	Sandstone	Medium Strong
2	1	16.6	D	8.80	47.20	65.83	3.6	87.6	Sandstone	Strong
3	2	17.0	D	4.72	47.20	67.80	2.0	47.0	Sandstone	Medium Strong
4	2	17.7	D	5.48	47.20	63.55	2.3	54.5	Sandstone	Strong
5	3	18.3	D	12.04	47.50	67.40	4.9	118.6	Sandstone	Very Strong
6	3	19.3	D	4.54	47.55	66.90	1.9	44.7	Dolostone	Medium Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			60.5		Strong
11					RUN #2 AVERAGE (MPa):			50.8		Strong
12					RUN #3 AVERAGE (MPa):			81.7		Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-19

Date Drilled: 13-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.8	D	8.26	47.20	66.50	3.4	82.2	Sandstone	Strong
2	1	15.0	D	6.96	47.20	61.80	2.9	69.3	Sandstone	Strong
3	2	15.4	D	8.32	47.20	67.00	3.4	82.8	Sandstone	Strong
4	2	16.1	D	4.10	47.20	67.70	1.7	40.8	Sandstone	Medium Strong
5	3	17.1	D	2.20	47.30	69.10	0.9	21.8	Sandstone	Weak
6	3	17.9	D	12.94	47.20	62.70	5.4	128.8	Sandstone	Very Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			75.7		Strong
11					RUN #2 AVERAGE (MPa):			61.8		Strong
12					RUN #3 AVERAGE (MPa):			75.3		Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-20

Date Drilled: 14-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	15.7	D	4.94	47.30	65.70	2.0	49.0	Sandstone	Medium Strong
2	1	16.3	D	12.10	47.00	64.60	5.1	121.2	Sandstone	Very Strong
3	2	16.7	D	8.70	47.20	67.40	3.6	86.6	Sandstone	Strong
4	2	17.1	D	1.86	47.10	65.50	0.8	18.6	Sandstone	Weak
5	3	18.2	D	6.88	47.30	69.00	2.8	68.2	Sandstone	Strong
6	3	18.9	D	12.98	47.40	67.80	5.3	128.3	Sandstone	Very Strong
7										
8										
9										
10					RUN #1 AVERAGE (MPa):			85.1		Strong
11					RUN #2 AVERAGE (MPa):			52.6		Strong
12					RUN #3 AVERAGE (MPa):			98.3		Strong
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-23

Date Drilled: 02-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	14.2	D	9.64	47.20	67.20	4.0	95.9	Sandstone	Strong
2	1	14.8	D	10.36	47.20	68.90	4.3	103.1	Sandstone	Very Strong
3	2	15.3	D	2.92	47.20	70.10	1.2	29.1	Sandstone	Medium Strong
4	2	16.3	D	4.62	47.20	66.50	1.9	46.0	Sandstone	Medium Strong
5										
6										
7										
8					RUN #1 AVERAGE (MPa):			99.5		Strong
9					RUN #2 AVERAGE (MPa):			37.5		Medium Strong
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-24

Date Drilled: 15-May-21
 Date Tested: 25-Jun-21
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	18.3	D	4.24	47.40	66.44	1.7	41.9	Sandstone	Medium Strong
2	1	19.1	D	7.40	47.40	60.00	3.0	73.2	Sandstone	Strong
3	2	19.9	D	9.86	47.20	60.00	4.1	98.1	Sandstone	Strong
4	2	20.8	D	3.84	47.30	65.10	1.6	38.1	Sandstone	Medium Strong
5										
6										
7										
8					RUN #1 AVERAGE (MPa):			57.5		Strong
9					RUN #2 AVERAGE (MPa):			68.1		Strong
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No: 28552
 Client: WSP
 Project Name: Hwy11-ONR Replacement
 Core Size: NQ BH No : 20-26

Date Drilled: 27-Nov-20
 Date Tested: 17-Dec-20
 Tester: MP
 Reviewed by:

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	I _{s(50)} (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	22.0	D	11.38	47.57	65.67	4.7	111.9	Sandst./Lime.	Very Strong
2	1	22.2	D	7.94	47.58	64.00	3.3	78.0	Sandst./Lime.	Strong
3	1	22.5	D	7.48	47.30	64.37	3.1	74.2	Sandst./Lime.	Strong
4	1	22.8	D	10.50	47.10	63.20	4.4	104.8	Sandst./Lime.	Very Strong
5	1	23.1	D	10.40	47.40	62.20	4.3	102.8	Sandst./Lime.	Very Strong
6	2	23.4	D	2.90	47.40	64.70	1.2	28.7	Sandst./Lime.	Medium Strong
7	2	23.7	D	13.38	47.40	66.40	5.5	132.3	Sandst./Lime.	Very Strong
8	2	24.0	D	1.52	47.70	66.23	0.6	14.9	Sandst./Lime.	Weak
9	3	24.4	D	8.72	47.11	64.76	3.6	87.0	Sandst./Lime.	Strong
10	3	24.7	D	2.18	47.20	63.23	0.9	21.7	Sandst./Lime.	Weak
11	3	25.1	D	3.20	47.40	65.20	1.3	31.6	Sandst./Lime.	Medium Strong
12										
13										
14										
15					RUN #1 AVERAGE (MPa):			94.4		Strong
16					RUN #2 AVERAGE (MPa):			58.6		Strong
17					RUN #3 AVERAGE (MPa):			46.8		Medium Strong
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33										
34										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
 Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.



Appendix C

Record of Borehole Sheets and Laboratory Test Results – Previous Investigation



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Percent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

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

JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

<u>Term</u>	<u>Size*</u>
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90° angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN Joint	PL Planar
FLT Fault	CU Curved
SH Shear	UN Undulating
VN Vein	IR Irregular
FR Fracture	K Slickensided
SY Stylolite	PO Polished
BD Bedding	SM Smooth
FO Foliation	SR Slightly Rough
CO Contact	RO Rough
AXJ Axial Joint	VR Very Rough
KV Karstic Void	
MB Mechanical Break	

PROJECT		11-1191-0025		RECORD OF BOREHOLE No ONR-1		1 OF 2 METRIC											
G.W.P.		5265-01-00		LOCATION		N 5286646.6; E 393643.3											
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. HOLLOW STEM AUGERS, NW CASING, WASH BORING											
DATUM		GEODETIC		DATE		JULY 17 and 18, 2012											
				ORIGINATED BY		EHS											
				COMPILED BY		JUL											
				CHECKED BY		AB											
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W _p W W _L	γ	GR SA SI CL					
256.8	GROUND SURFACE																
0.0	ASPHALT (200 mm)																
0.2	Sand and gravel to gravelly sand (FILL) Dense Brown Moist		1	AS	-		256										
255.5			2	SS	37												
1.4	ASPHALT (100 mm)						255										
	Sand to silty sand, trace to some clay (FILL) Compact to dense Brown to grey Moist to wet		3	SS	33												
			4	SS	19		254					5 87 (8)					
			5	SS	20												
			6	SS	37		253										
	Auger refusal at 3.9 m depth, switched to NW Casing. Cobble (200 mm) encountered.		7	SS	21		252					7 58 26 9					
							251										
			8	SS	45		250										
							249										
			9	SS	31		248										
247.7							247										
9.1	Silty clay, with sand, trace gravel (FILL) Firm Brown to grey Moist to wet		10	SS	5							5 30 30 35					
							246										
	Pockets of organics in Sample 11.		11	SS	6		245										
							244										
244.6							243										
12.2	SILTY CLAY, varved Firm Grey Wet		12	SS	4												
							242										
			13	TO	PH												

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>11-1191-0025</u>				RECORD OF BOREHOLE No ONR-1				2 OF 2 METRIC									
G.W.P. <u>5265-01-00</u>		LOCATION <u>N 5286646.6; E 393643.3</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. HOLLOW STEM AUGERS, NW CASING, WASH BORING</u>				COMPILED BY <u>JJL</u>											
DATUM <u>GEODETIC</u>		DATE <u>JULY 17 and 18, 2012</u>				CHECKED BY <u>AB</u>											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---																
	SILTY CLAY, varved Firm Grey Wet		14	TO	PH		241										
			15	TO	PH		240										
238.8							239										
18.0	GRAVEL and COBBLES Very dense																
238.3	Pink and grey		16	SS	70/0.2												
18.5	Wet																
	END OF BOREHOLE SPOON REFUSAL AND REFUSAL TO FURTHER CASING ADVANCE																
	Note: 1. Water level not measured upon completion of drilling.																

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

PROJECT 11-1191-0025			RECORD OF BOREHOLE No ONR-2			1 OF 2 METRIC								
G.W.P. 5265-01-00			LOCATION N 5286672.3; E 393598.9			ORIGINATED BY EHS								
DIST _____ HWY 11			BOREHOLE TYPE 108 mm I.D. HOLLOW STEM AUGERS			COMPILED BY JJL								
DATUM GEODETIC			DATE JULY 20, 2012			CHECKED BY AB								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
248.3	GROUND SURFACE													
0.0	Gravelly sand to silty sand, some clay (FILL) Loose Brown Moist to wet		1	SS	9									
			2	SS	7									
			3	SS	9									
246.0														
2.4	Clayey TOPSOIL Brown Moist SILTY CLAY, varved Soft to firm Grey Wet Light grey clayey silt laminae 10 mm thick Dark grey clay laminae 20 mm thick		4	SS	8									
			5	TO	PH									
			6	TO	PH									
			7	TO	PM									
			8	TO	PM									
			9	TO	PH									
			10	TO	PH									
236.3														
12.0	Sandy SILT to Silty SAND, some clay, some gravel Very loose to compact Grey Wet		11	SS	2									
			12	SS	15									

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>11-1191-0025</u>		RECORD OF BOREHOLE No ONR-2				2 OF 2 METRIC										
G.W.P. <u>5265-01-00</u>		LOCATION <u>N 5286672.3; E 393598.9</u>				ORIGINATED BY <u>EHS</u>										
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm I.D. HOLLOW STEM AUGERS</u>				COMPILED BY <u>JJL</u>										
DATUM <u>GEODETIC</u>		DATE <u>JULY 20, 2012</u>				CHECKED BY <u>AB</u>										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
	--- CONTINUED FROM PREVIOUS PAGE ---															
233.1																
15.2	END OF BOREHOLE AUGER REFUSAL Note: 1. Water level at a depth of 3.9 m below ground surface (Elev. 244.4 m) upon completion of drilling and rising slowly.															

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

PROJECT		11-1191-0025		RECORD OF BOREHOLE No ONR-3		1 OF 2 METRIC														
G.W.P.		5265-01-00		LOCATION		N 5286722.5; E 393557.5														
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. HOLLOW STEM AUGERS														
DATUM		GEODETIC		DATE		JULY 23 and 24, 2012														
ORIGINATED BY		EHS		COMPILED BY		JJL														
CHECKED BY		AB																		
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa			WATER CONTENT (%)			γ			GR SA SI CL		
251.4	0.0	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			W _p — W — W _L 20 40 60			kN/m ³					
251.1	0.3	Topsoil (FILL) Brown Moist		1	SS	9		251												
		Sand, some gravel, some silt, some clay with cobbles at 1.1 m and 1.6 m depths (FILL) Brown to grey Moist		2	SS	32/0.2		250												15 54 18 13
				3	SS	57/0.2														
249.1	2.3	Silty clay, organic pockets (FILL) Firm Brown Moist		4	SS	7		249												
248.4	3.0	SILTY CLAY, varved Soft to firm Grey Wet		5	SS	7		248												
				6	SS	2		247												
				7	SS	WH														
								246												
				8	SS	WH		245												
								244												
				9	SS	WH		243												
								242												
								241												
				10	SS	WH		240												
								239												
				11	SS	WH		238												
								237												
237.7	13.7	Sandy SILT, with clay, trace gravel, clay seams Very loose to loose Grey Wet		12	SS	WR														
				13	SS	WR														4 29 37 30

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT		RECORD OF BOREHOLE No ONR-3				2 OF 2 METRIC										
11-1191-0025																
G.W.P. 5265-01-00		LOCATION N 5286722.5; E 393557.5				ORIGINATED BY EHS										
DIST _____ HWY 11		BOREHOLE TYPE 108 mm I.D. HOLLOW STEM AUGERS				COMPILED BY JJJ										
DATUM GEODETIC		DATE JULY 23 and 24, 2012				CHECKED BY AB										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
235.0	Sandy SILT, with clay, trace gravel, clay seams Very loose to loose Grey Wet		14	SS	8		236									
16.4	END OF BOREHOLE AUGER REFUSAL Note: 1. Water level in piezometer at a depth of 7.0 m (Elev. 244.4 m) on August 1, 2012. 2. Water level in piezometer at a depth of 3.0 m below ground surface (Elev. 248.4 m) on September 27, 2012.						235									

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:

1 OF 2 **METRIC**

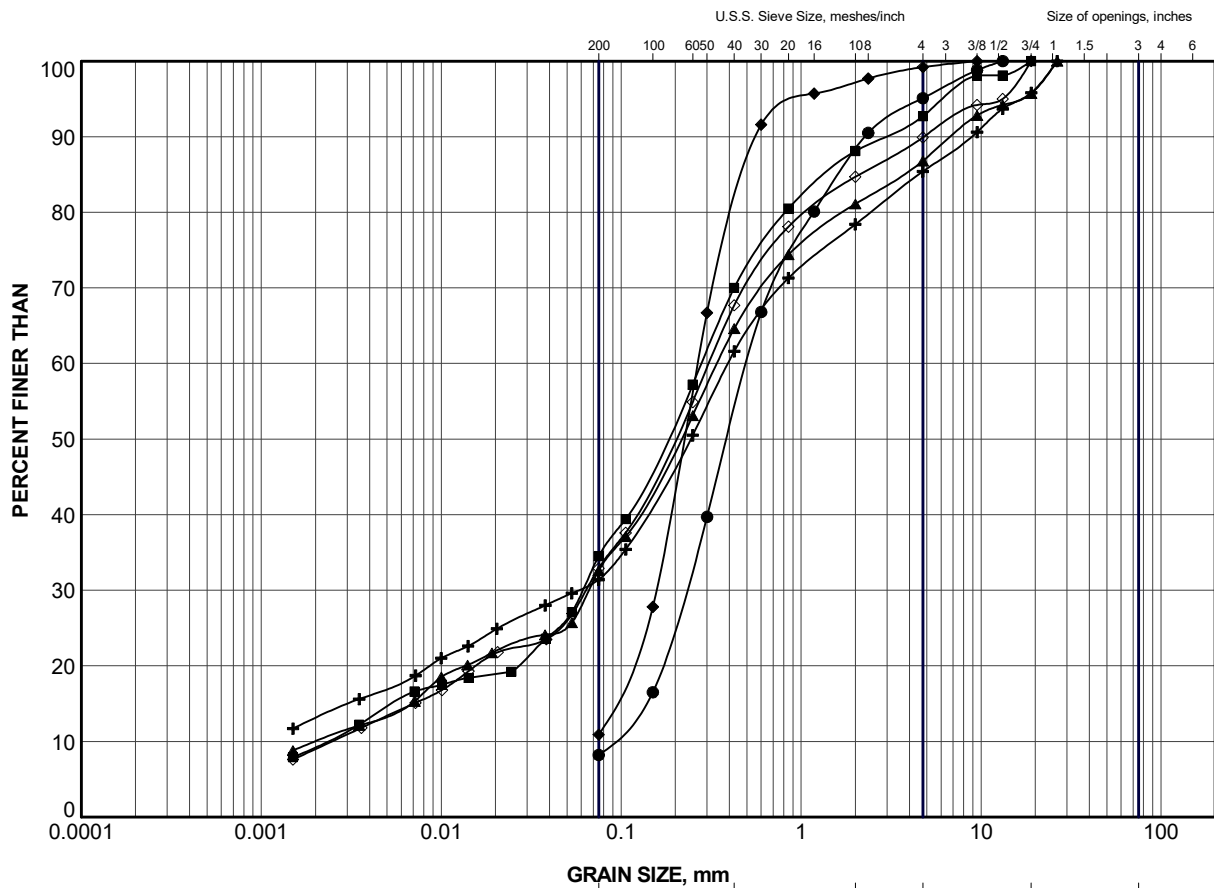
CHECKED BY AB

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT		11-1191-0025		RECORD OF BOREHOLE No ONR-4		2 OF 2 METRIC							
G.W.P.		5265-01-00		LOCATION		N 5286746.6; E 393522.9							
DIST		HWY 11		BOREHOLE TYPE		108 mm I.D. HOLLOW STEM AUGERS							
DATUM		GEODETIC		DATE		JULY 18 and 19, 2012							
				ORIGINATED BY		EHS							
				COMPILED BY		JJL							
				CHECKED BY		AB							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
--- CONTINUED FROM PREVIOUS PAGE ---													
	SILTY CLAY, varved Firm to stiff Grey Wet		14	TO	PH		241						
	Light grey clayey silt laminae 10 mm thick		15	TO	PH		240					18.4	0 0 81 19
	Dark grey clay laminae 20 mm thick						239						
			16	SS	WH		238						
							237						
			17	TO	PH		236						
							235						
234.1							234						
22.7	Sandy SILT to Silty SAND, some gravel, trace to some clay		19	SS	7		233						14 47 28 11
233.3	Loose Grey Wet						232						
23.5	START OF DCPT												
231.8													
25.0	END OF DCPT REFUSAL TO FURTHER PENETRATION (HAMMER BOUNCING) END OF BOREHOLE												
Note: 1. Water level not measured upon completion of drilling.													

SUD-MTO 001 11-1191-0025.GPJ GAL-MISS.GDT 22/10/12 DATA INPUT:



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ONR-1	4	254.2
■	ONR-1	7	251.9
▲	ONR-2	3	246.5
+	ONR-3	2	250.5
◆	ONR-4	3	255.0
◇	ONR-4	7	251.9

PROJECT

HIGHWAY 11
ONR OVERHEAD BRIDGE

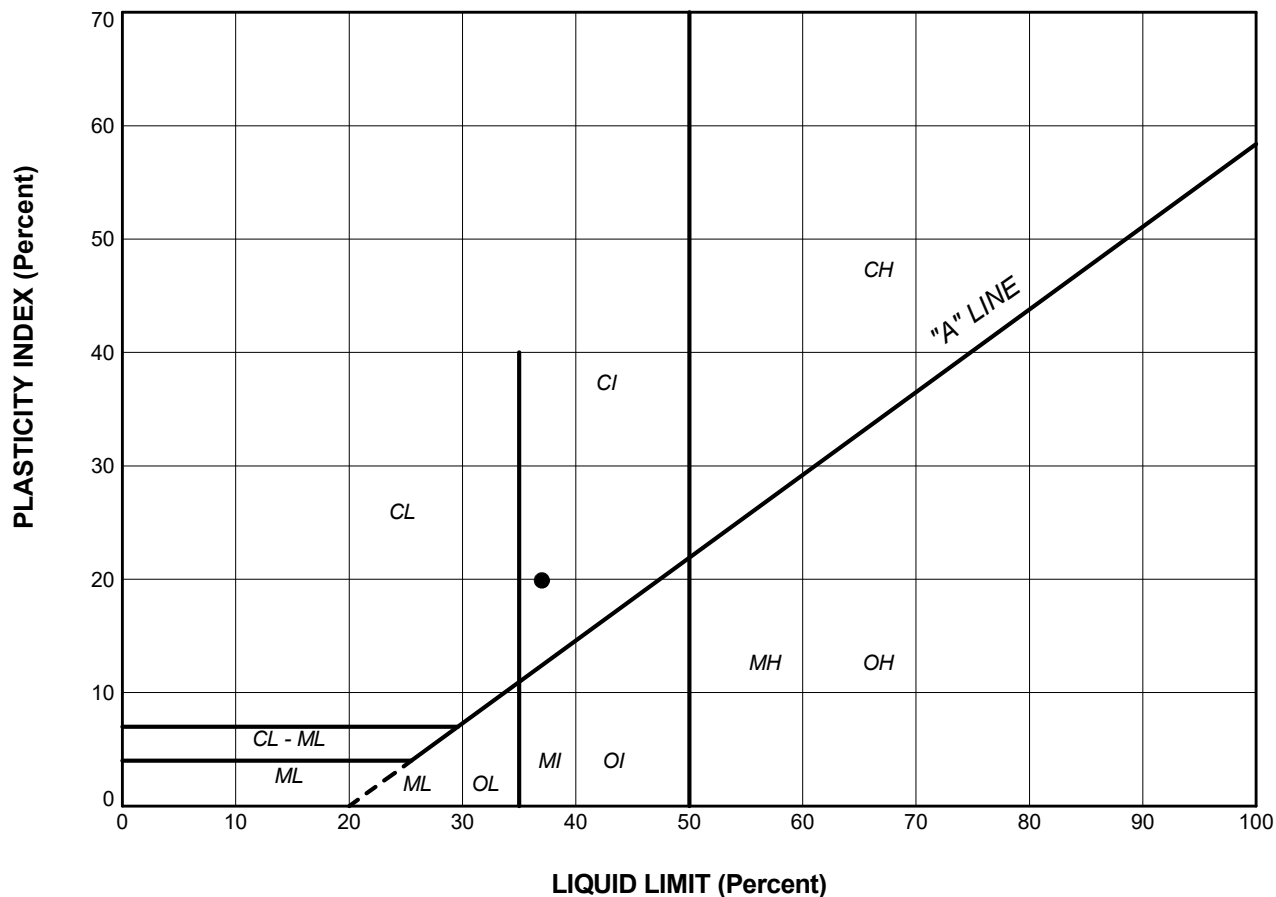
TITLE

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SAND (FILL)



PROJECT No.	11-1191-0025	FILE No.	11-1191-0025.GPJ
DRAWN	JJL	Oct 2012	SCALE N/A
CHECK	AB	Oct 2012	REV.
APPR	JMAC	Oct 2012	

FIGURE B1



SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

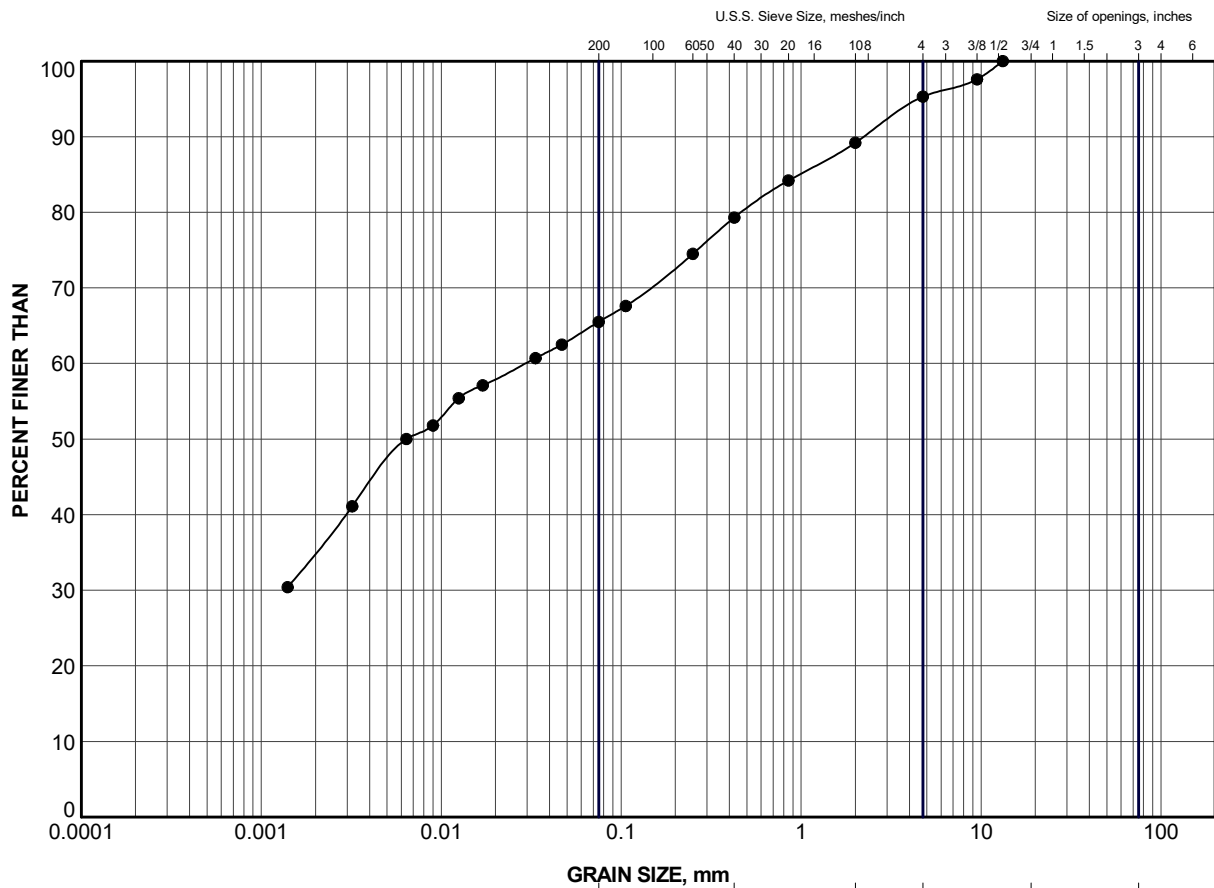
PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ONR-1	10	37	17	20

PROJECT					
HIGHWAY 11 ONR OVERHEAD BRIDGE					
TITLE					
PLASTICITY CHART SILTY CLAY (FILL)					
PROJECT No. 11-1191-0025			FILE No. 11-1191-0025.GPJ		
DRAWN	JJL	Oct 2012	SCALE	N/A	REV.
CHECK	AB	Oct 2012	FIGURE B2		
APPR	JMAC	Oct 2012			




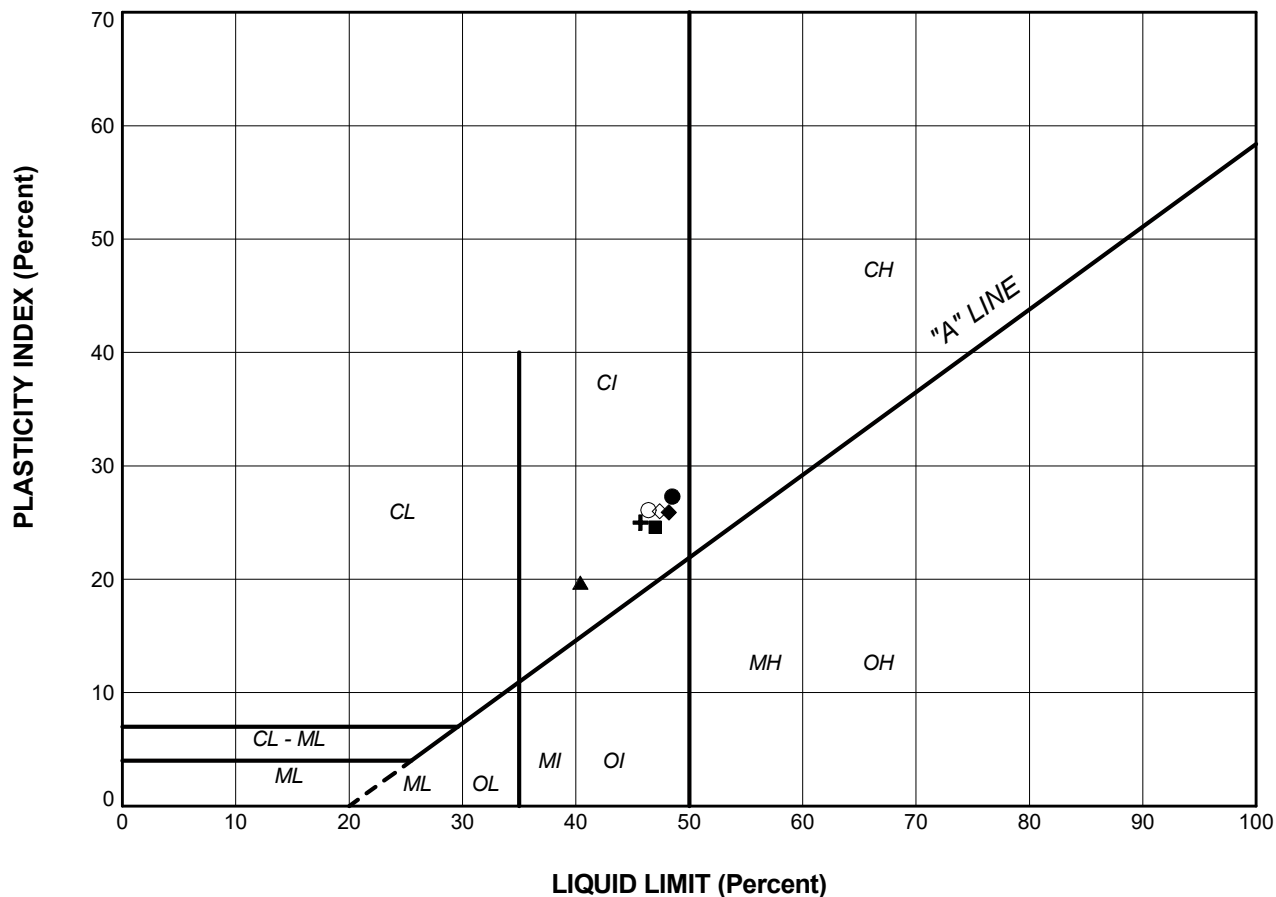


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

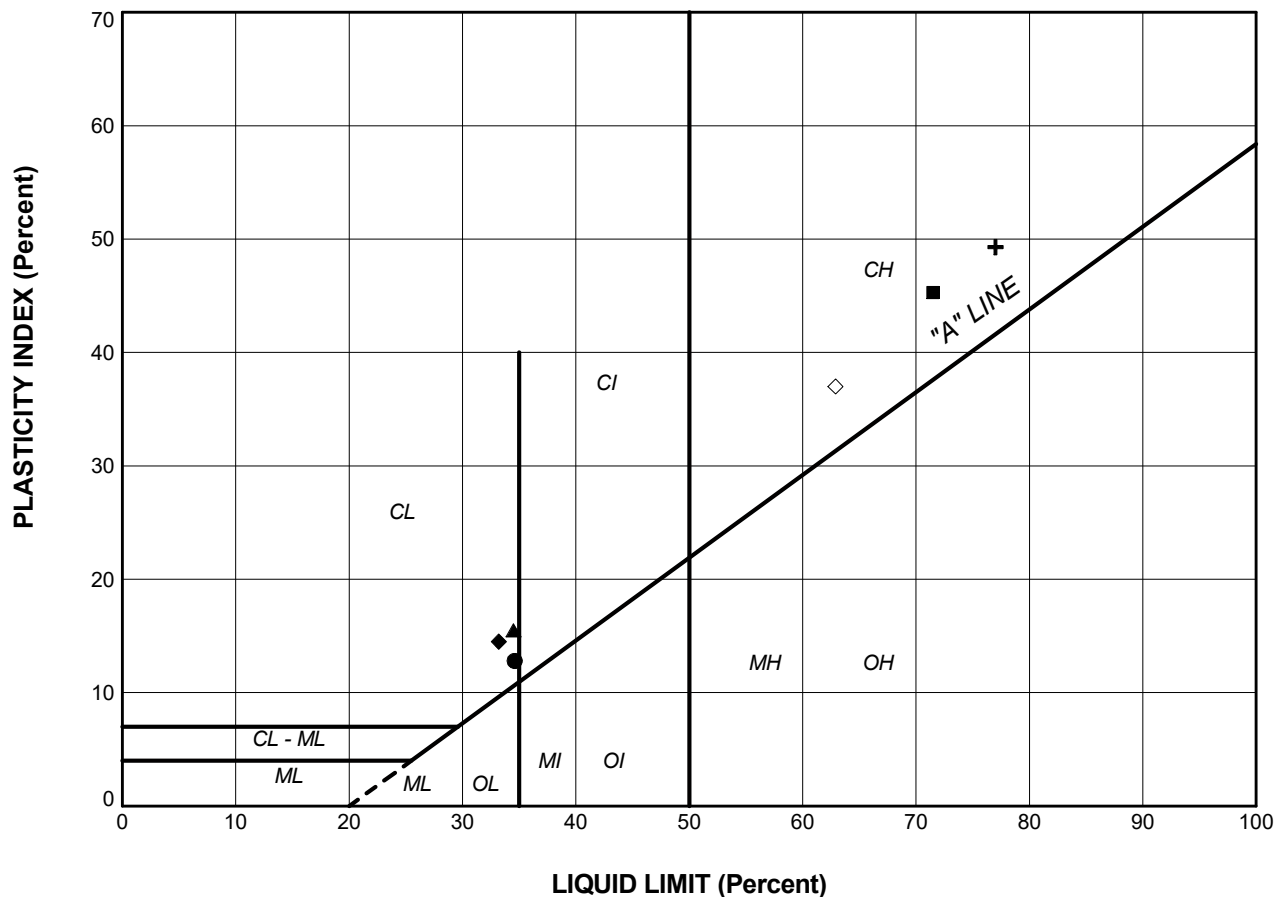
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ONR-1	10	247.4

PROJECT					
HIGHWAY 11 ONR OVERHEAD BRIDGE					
TITLE					
GRAIN SIZE DISTRIBUTION SILTY CLAY (FILL)					
PROJECT No.		11-1191-0025		FILE No. 11-1191-0025.GPJ	
DRAWN	JJL	Oct 2012	SCALE	N/A	REV.
CHECK	AB	Oct 2012			
APPR	JMAC	Oct 2012			
 Golder Associates SUDBURY, ONTARIO			FIGURE B3		



PROJECT					
HIGHWAY 11 ONR OVERHEAD BRIDGE					
TITLE					
PLASTICITY CHART SILTY CLAY					
PROJECT No.		11-1191-0025		FILE No. 11-1191-0025.GPJ	
DRAWN	JJL	Oct 2012	SCALE	N/A	REV.
CHECK	AB	Oct 2012	FIGURE B4-1		
APPR	JMAC	Oct 2012			






LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ONR-2	5(s)	35	22	13
■	ONR-2	5(c)	72	26	45
▲	ONR-2	7(s)	35	19	16
+	ONR-2	7(c)	77	28	49
◆	ONR-4	15(s)	33	19	15
◇	ONR-4	15(c)	63	26	37

Note:

(s) silt laminae

(c) clay laminae

PROJECT					HIGHWAY 11 ONR OVERHEAD BRIDGE				
TITLE					PLASTICITY CHART CLAYEY SILT AND CLAY LAMINAE				
PROJECT No. 11-1191-0025			FILE No. 11-1191-0025.GPJ						
DRAWN	JJL	Oct 2012	SCALE	N/A	REV.				
CHECK	AB	Oct 2012							
APPR	JMAC	Oct 2012							
 Golder Associates SUDBURY, ONTARIO			FIGURE B4-2						

CONSOLIDATION TEST SUMMARY**FIGURE B6****Pg. 1 of 4****SAMPLE IDENTIFICATION**

Project Number	11-1191-0025	Sample Number	7
Borehole Number	ONR-2	Sample Depth, m	6.3

TEST CONDITIONS

Test Type	Standard	Load Duration, hr	24
Oedometer Number	1		
Date Started	July 25/12		
Date Completed	August 13/12		

SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	2.544	Unit Weight, kN/m ³	16.40
Sample Diameter, cm	6.353	Dry Unit Weight, kN/m ³	10.28
Area, cm ²	31.70	Specific Gravity, assumed	2.70
Volume, cm ³	80.64	Solids Height, cm	0.988
Water Content, %	59.51	Volume of Solids, cm ³	31.32
Wet Mass, g	134.88	Volume of Voids, cm ³	49.32
Dry Mass, g	84.56	Degree of Saturation, %	102.0

TEST COMPUTATIONS

Pressure kPa	Primary Consolidation	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s	Total Work kJ/m ³
0	0.00	2.544	1.575	2.544					
9	0.03	2.540	1.572	2.542	217	0.0063	1.45E-04	9.00E-08	0.006
18	0.05	2.536	1.567	2.538	101	0.0135	2.11E-04	2.79E-07	0.031
35	0.10	2.526	1.557	2.531	240	0.0057	2.21E-04	1.23E-07	0.132
69	0.21	2.505	1.536	2.515	240	0.0056	2.42E-04	1.33E-07	0.565
143	0.88	2.417	1.447	2.461	1500	0.0009	4.69E-04	3.93E-08	4.292
285	1.75	2.242	1.269	2.330	2381	0.0005	4.84E-04	2.29E-08	19.778
571	0.96	2.146	1.173	2.194	866	0.0012	1.32E-04	1.52E-08	38.047
1140	0.69	2.077	1.102	2.112	375	0.0025	4.79E-05	1.18E-08	65.668
571	-0.07	2.084	1.110	2.081					
143	-0.30	2.114	1.140	2.099					
35	-0.32	2.146	1.172	2.130					
9	-0.32	2.178	1.205	2.162					

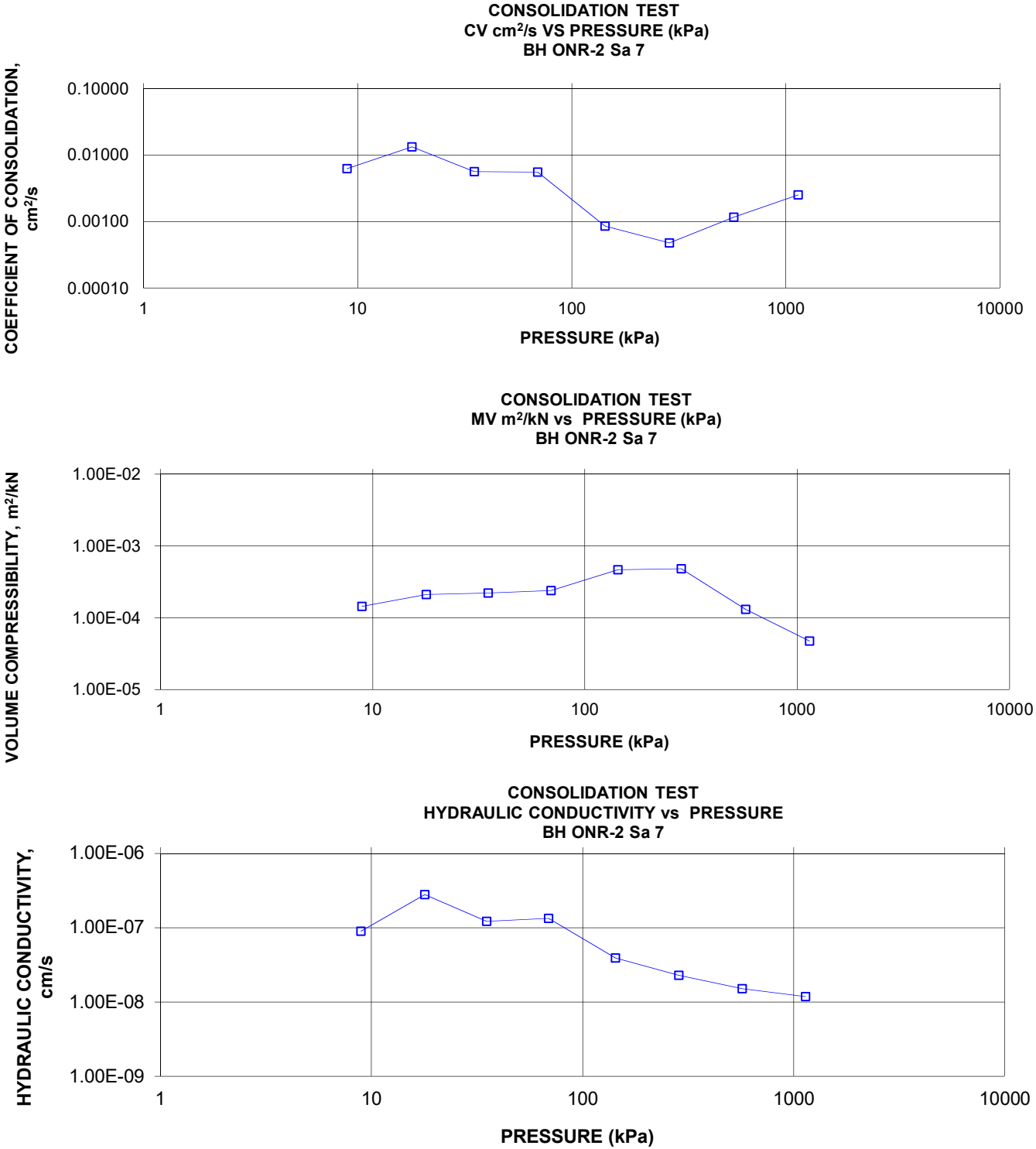
Note:

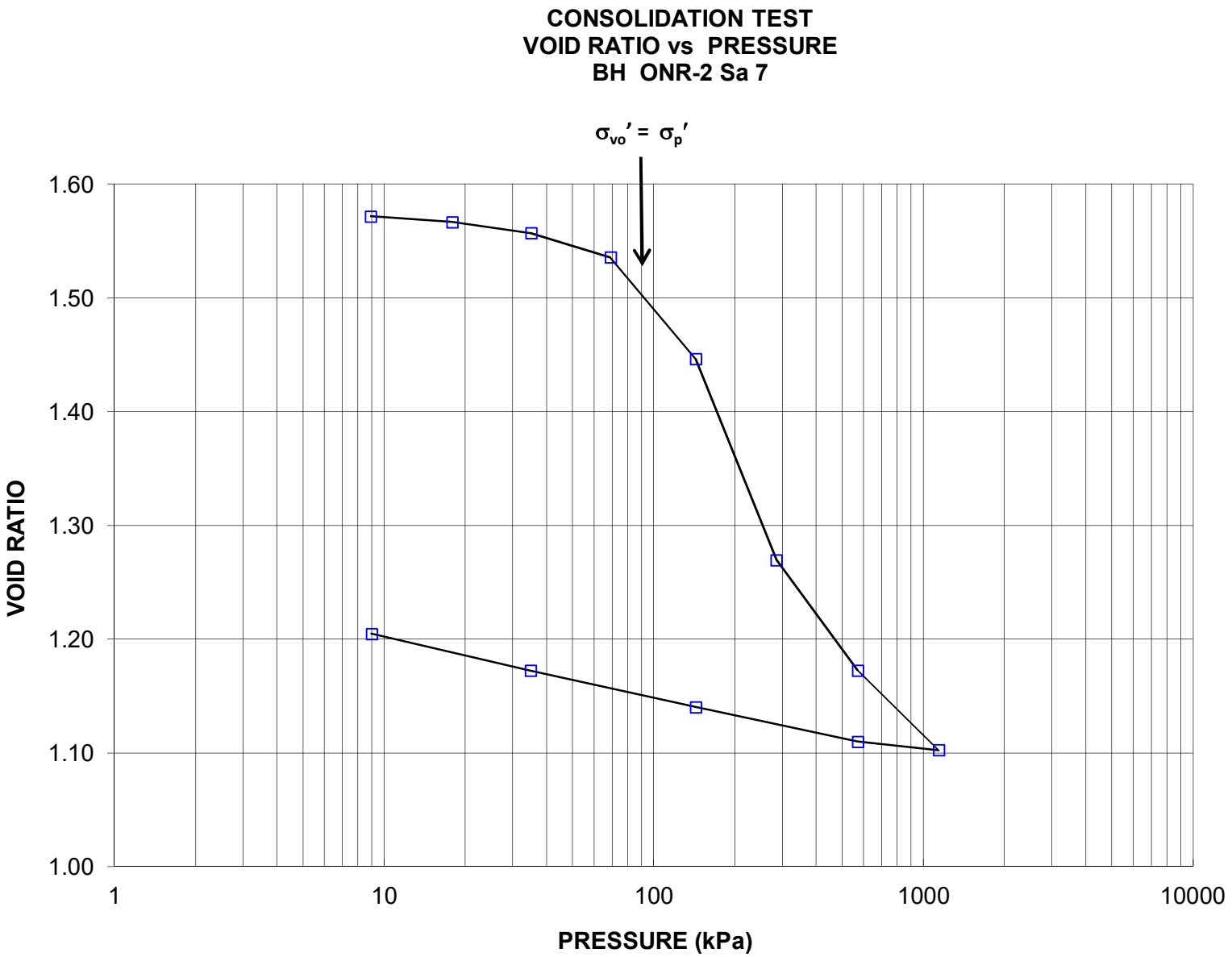
k calculated using α based on t₉₀ values.**SAMPLE DIMENSIONS AND PROPERTIES - FINAL**

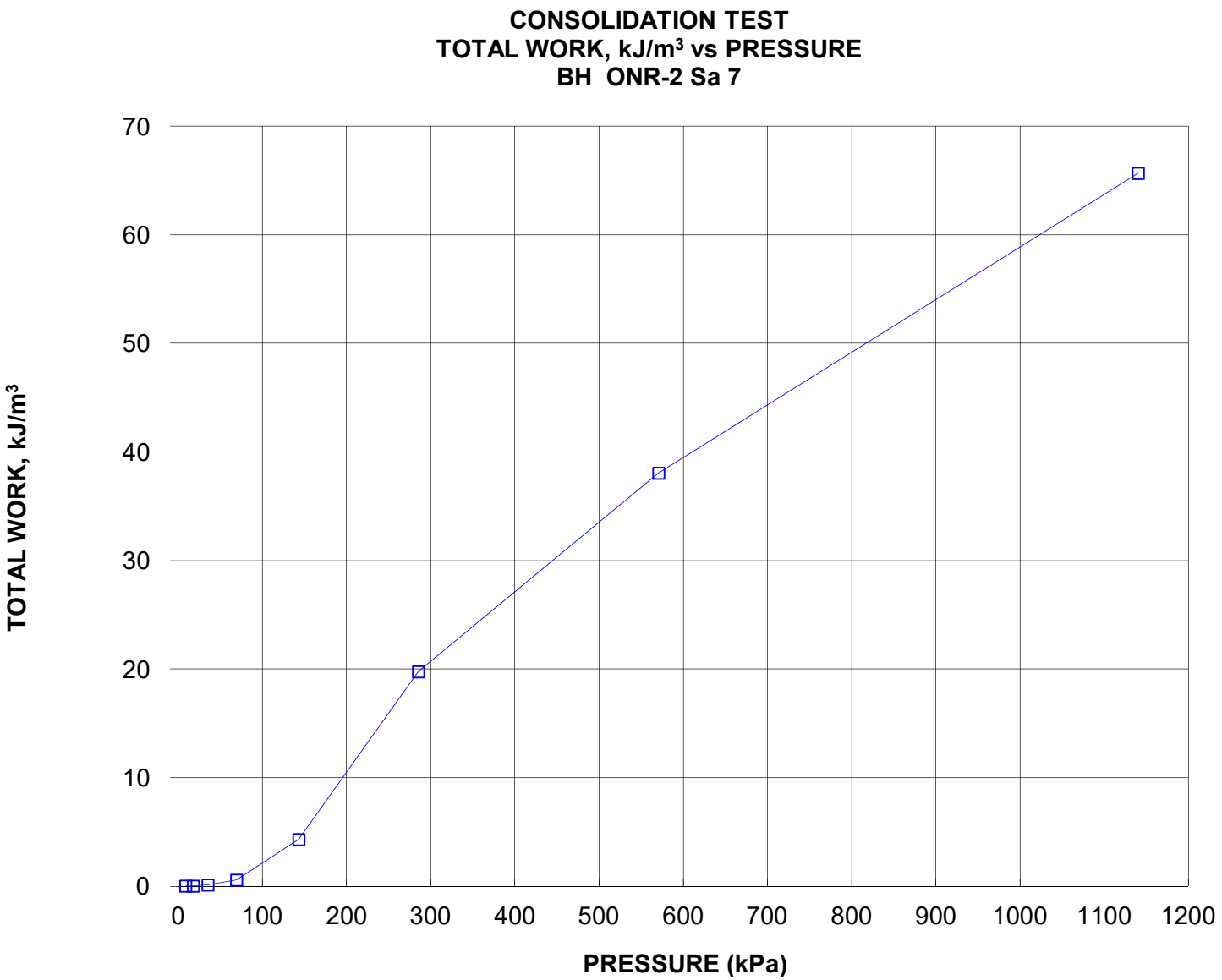
Sample Height, cm	2.178	Unit Weight, kN/m ³	16.35
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	12.01
Area, cm ²	31.70	Specific Gravity, assumed	2.70
Volume, cm ³	69.05	Solids Height, cm	0.988
Water Content, %	36.10	Volume of Solids, cm ³	31.32
Wet Mass, g	115.09	Volume of Voids, cm ³	37.73
Dry Mass, g	84.56		

CONSOLIDATION TEST SUMMARY

FIGURE B6
Pg. 2 of 4

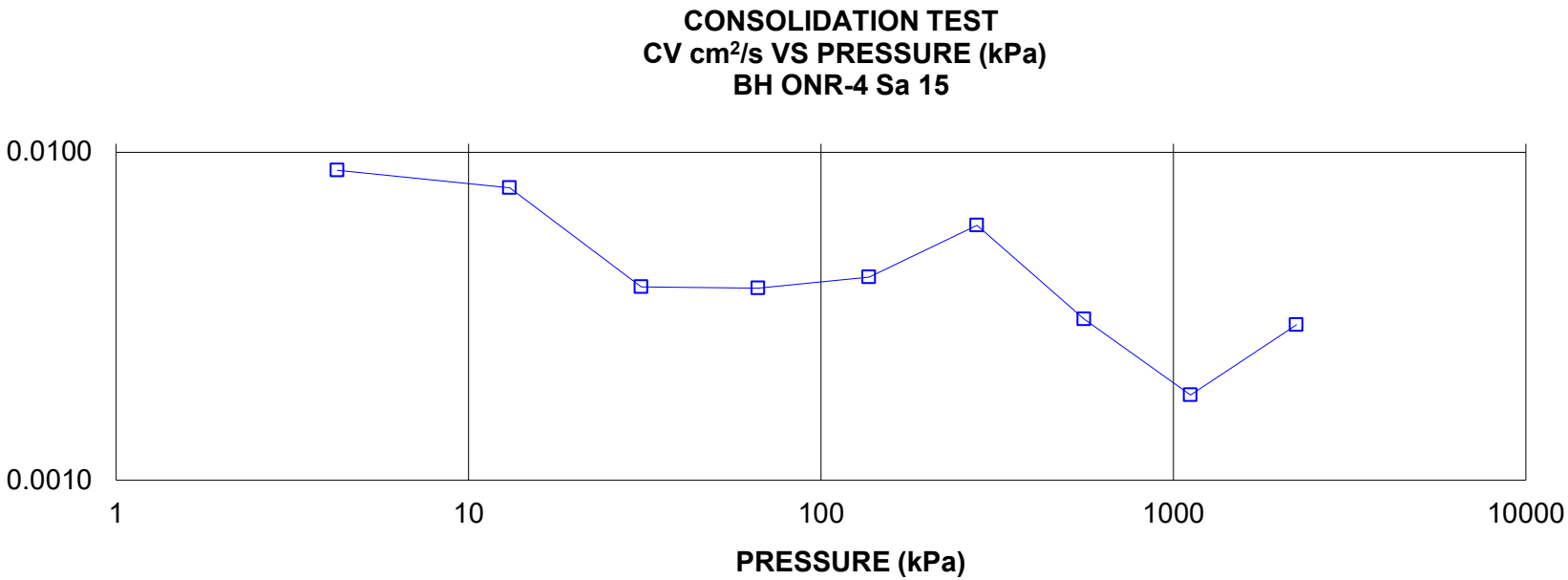




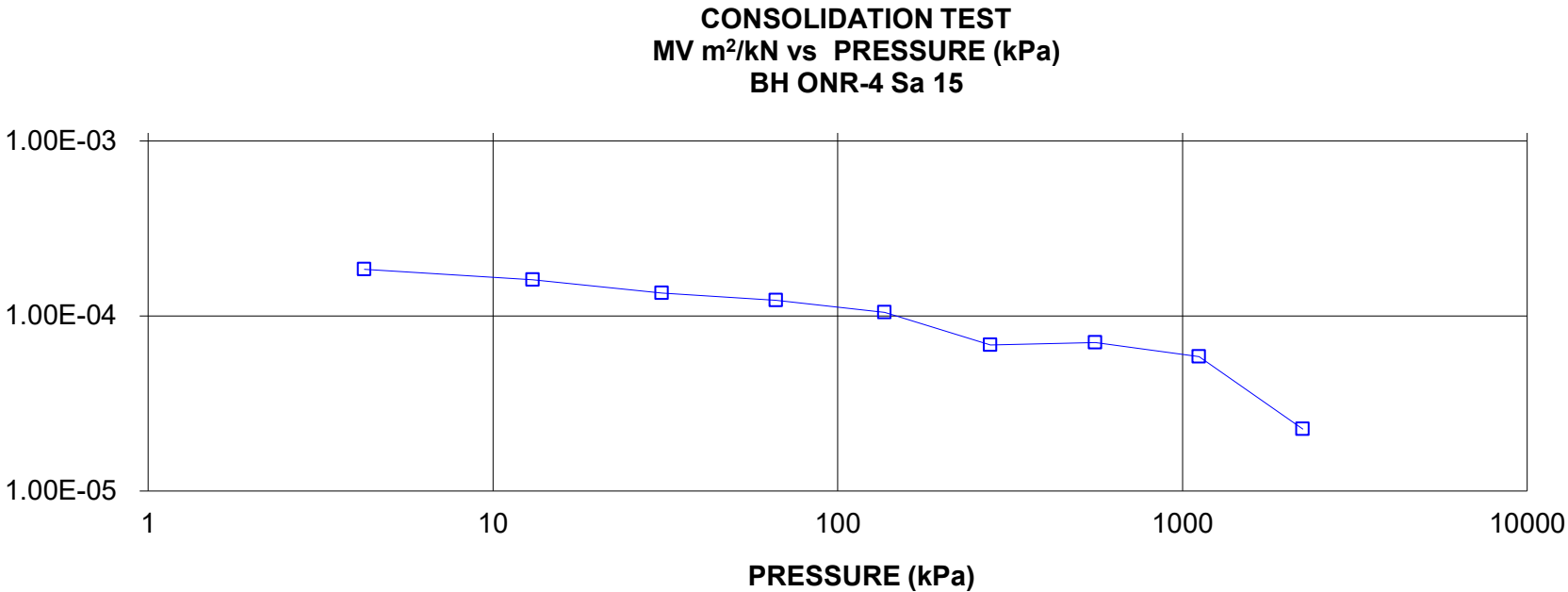


CONSOLIDATION TEST SUMMARY							FIGURE B7 Pg. 1 of 4		
SAMPLE IDENTIFICATION									
Project Number:		11-1191-0025				Sample Number:		15	
Borehole Number:		ONR-4				Sample Depth, m:		17.0	
TEST CONDITIONS									
Test Type		Standard				Load Duration, hr		24	
Oedometer Number		2							
Date Started		July 25/12							
Date Completed		August 13/12							
SAMPLE DIMENSIONS AND PROPERTIES - INITIAL									
Sample Height, cm		2.526				Unit Weight, kN/m ³		18.36	
Sample Diameter, cm		6.351				Dry Unit Weight, kN/m ³		13.08	
Area, cm ²		31.68				Specific Gravity, Assumed		2.70	
Volume, cm ³		80.02				Solids Height, cm		1.248	
Water Content, %		40.39				Volume of Solids, cm ³		39.53	
Wet Mass, g		149.84				Volume of Voids, cm ³		40.49	
Dry Mass, g		106.73				Degree of Saturation, %		106.5	
TEST COMPUTATIONS									
Pressure	Primary	Corr.		Average					Total
kPa	Consolidation	Height	Void	Height	t ₉₀	cv.	mv	k	Work
		cm	Ratio	cm	sec	cm ² /s	m ² /kN	cm/s	kJ/m3
0	0	2.526	1.024	2.526					
4	0.02	2.524	1.023	2.525	154	0.0088	1.85E-04	1.59E-07	0.002
13	0.04	2.520	1.020	2.522	173	0.0078	1.61E-04	1.23E-07	0.014
31	0.06	2.514	1.015	2.517	346	0.0039	1.36E-04	5.17E-08	0.067
66	0.11	2.503	1.006	2.509	346	0.0039	1.23E-04	4.65E-08	0.280
137	0.19	2.485	0.991	2.494	317	0.0042	1.05E-04	4.27E-08	1.039
277	0.24	2.460	0.972	2.473	217	0.0060	6.84E-05	4.73E-08	3.221
558	0.50	2.410	0.932	2.435	406	0.0031	7.04E-05	2.14E-08	11.705
1117	0.83	2.328	0.866	2.369	653	0.0018	5.84E-05	1.04E-08	40.370
2235	0.64	2.264	0.814	2.296	375	0.0030	2.26E-05	6.60E-09	86.303
1117	-0.09	2.273	0.821	2.268					
277	-0.28	2.301	0.844	2.287					
66	-0.33	2.334	0.870	2.317					
13	-0.33	2.367	0.897	2.350					
4	-0.13	2.380	0.907	2.374					
Note: k calculated using cv based on t ₉₀ values.									
SAMPLE DIMENSIONS AND PROPERTIES - FINAL									
Sample Height, cm		2.380				Unit Weight, kN/m ³		18.31	
Sample Diameter, cm		6.35				Dry Unit Weight, kN/m ³		13.88	
Area, cm ²		31.68				Specific Gravity, Assumed		2.70	
Volume, cm ³		75.40				Solids Height, cm		1.248	
Water Content, %		31.91				Volume of Solids, cm ³		39.53	
Wet Mass, g		140.79				Volume of Voids, cm ³		35.87	
Dry Mass, g		106.73							
Prepared By: SL				Golder Associates				Checked By: AB	

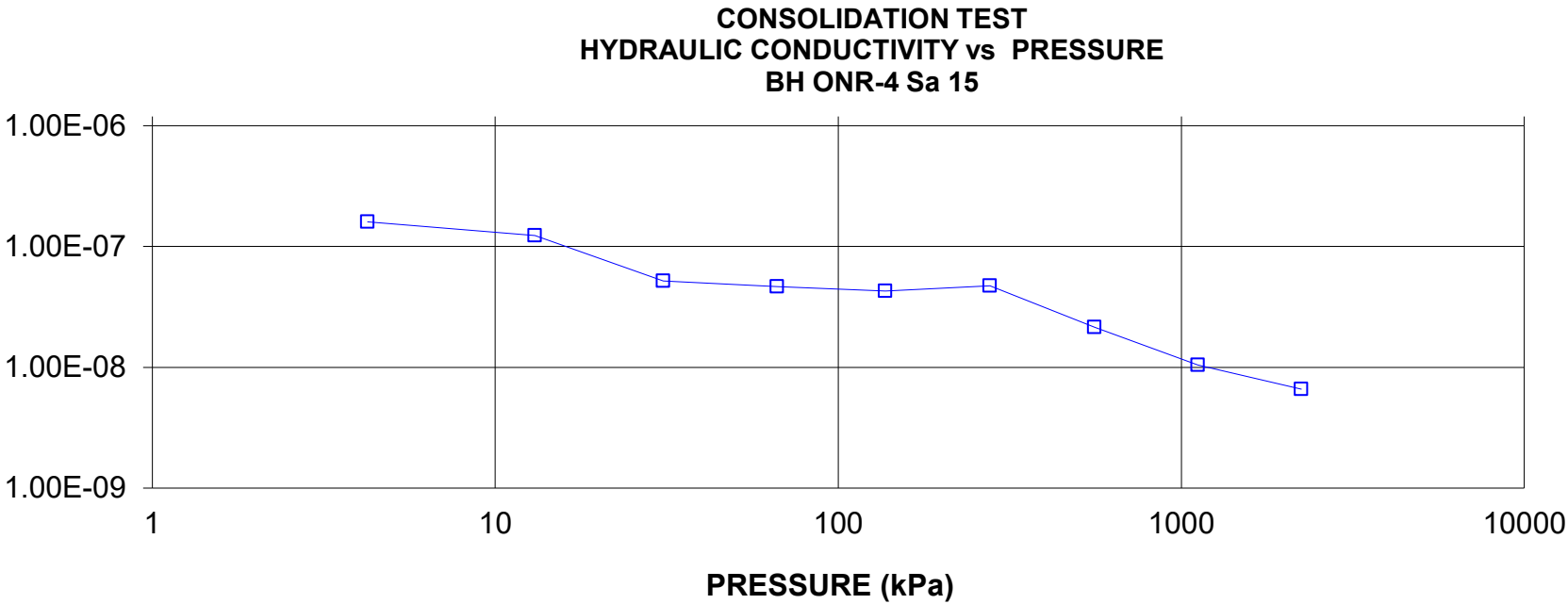
COEFFICIENT OF CONSOLIDATION,
cm²/s

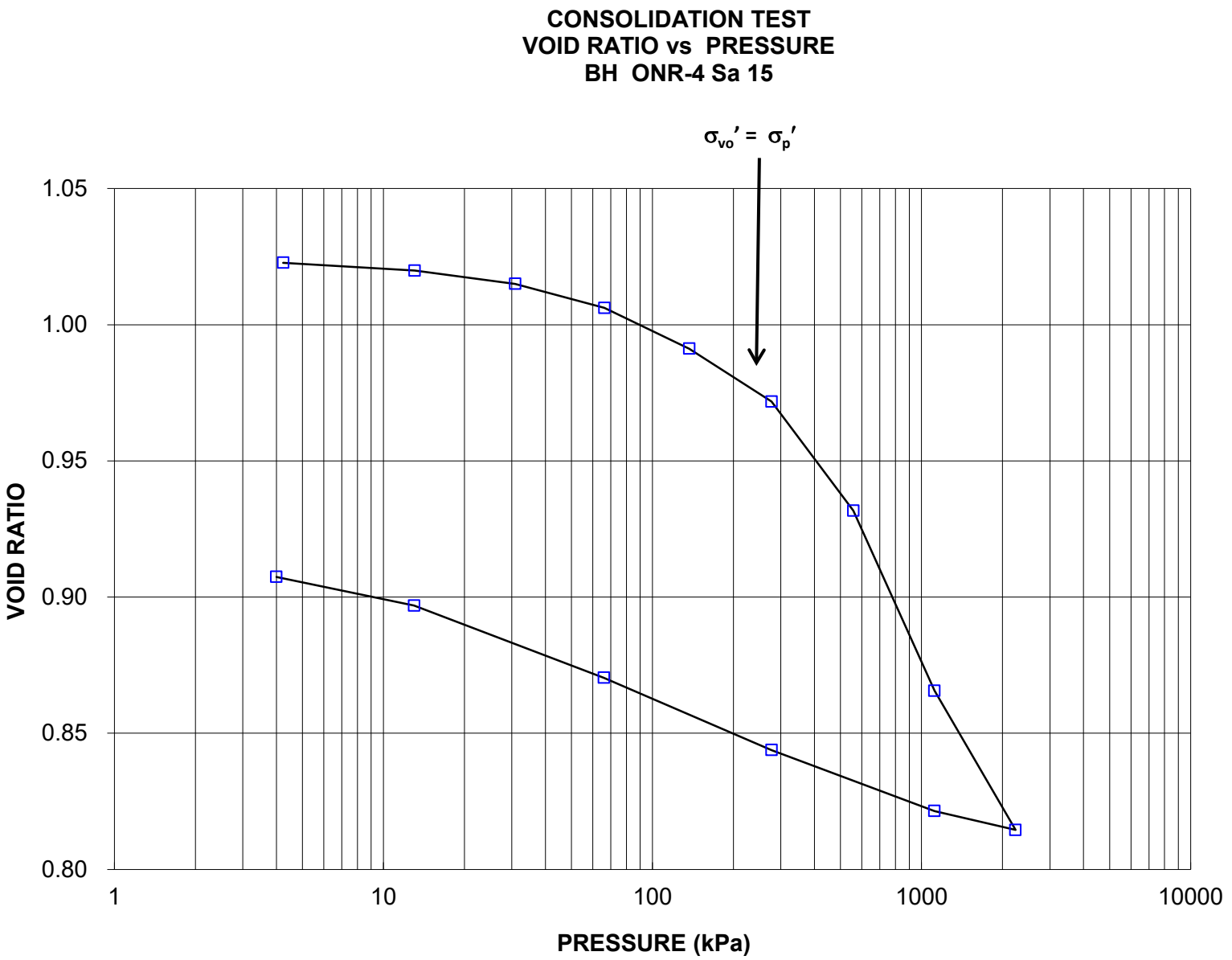


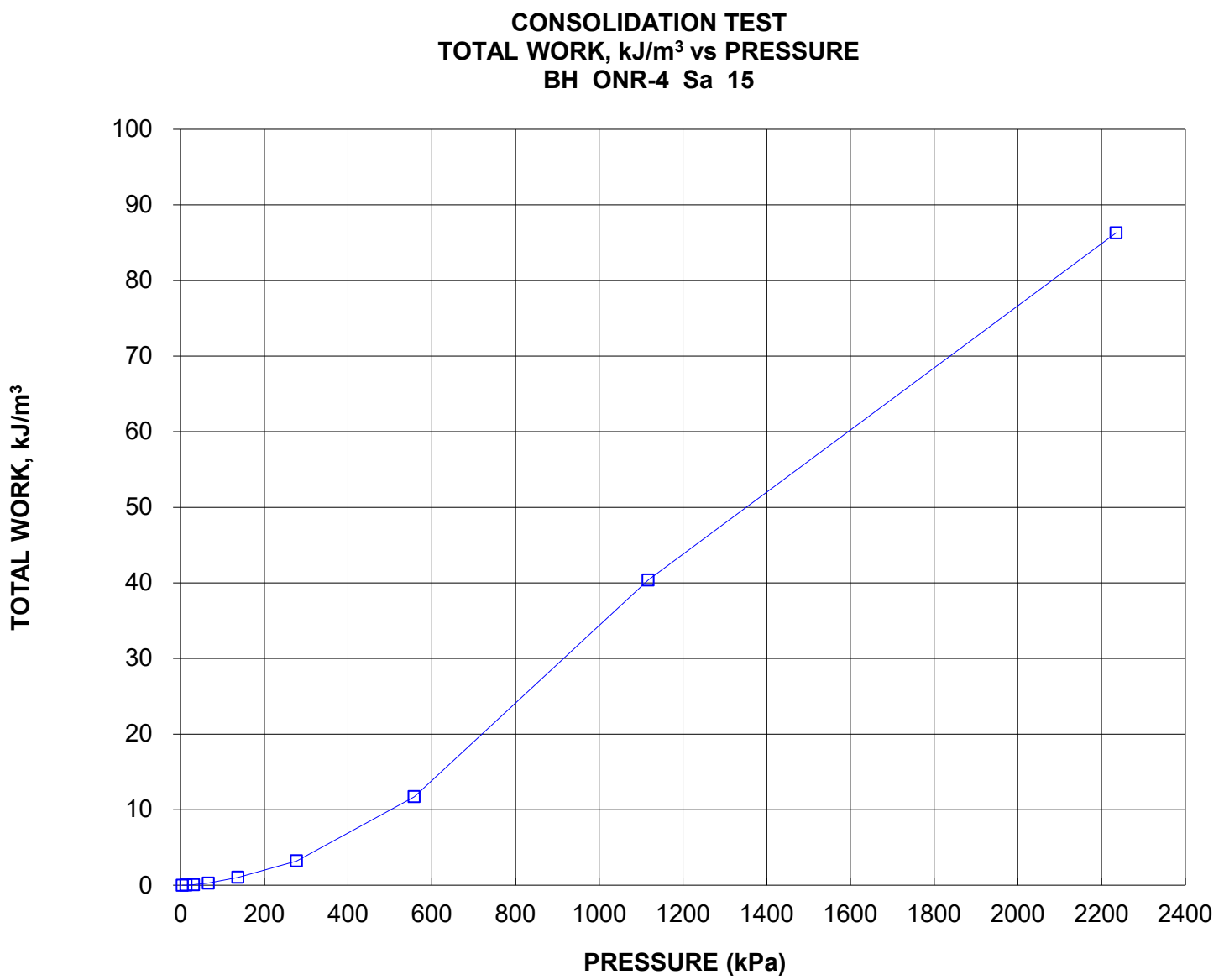
VOLUME COMPRESSIBILITY, m²/kN

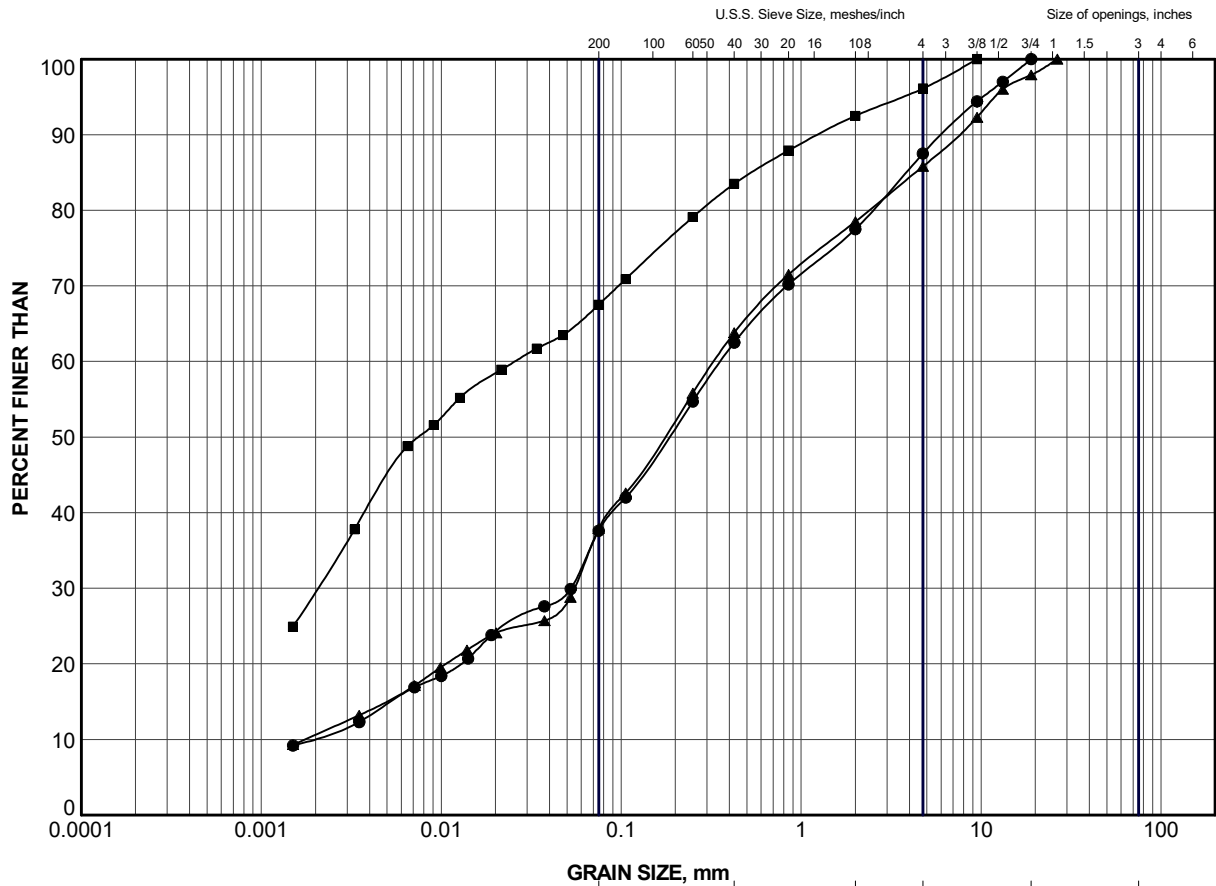


HYDRAULIC CONDUCTIVITY,
cm/s






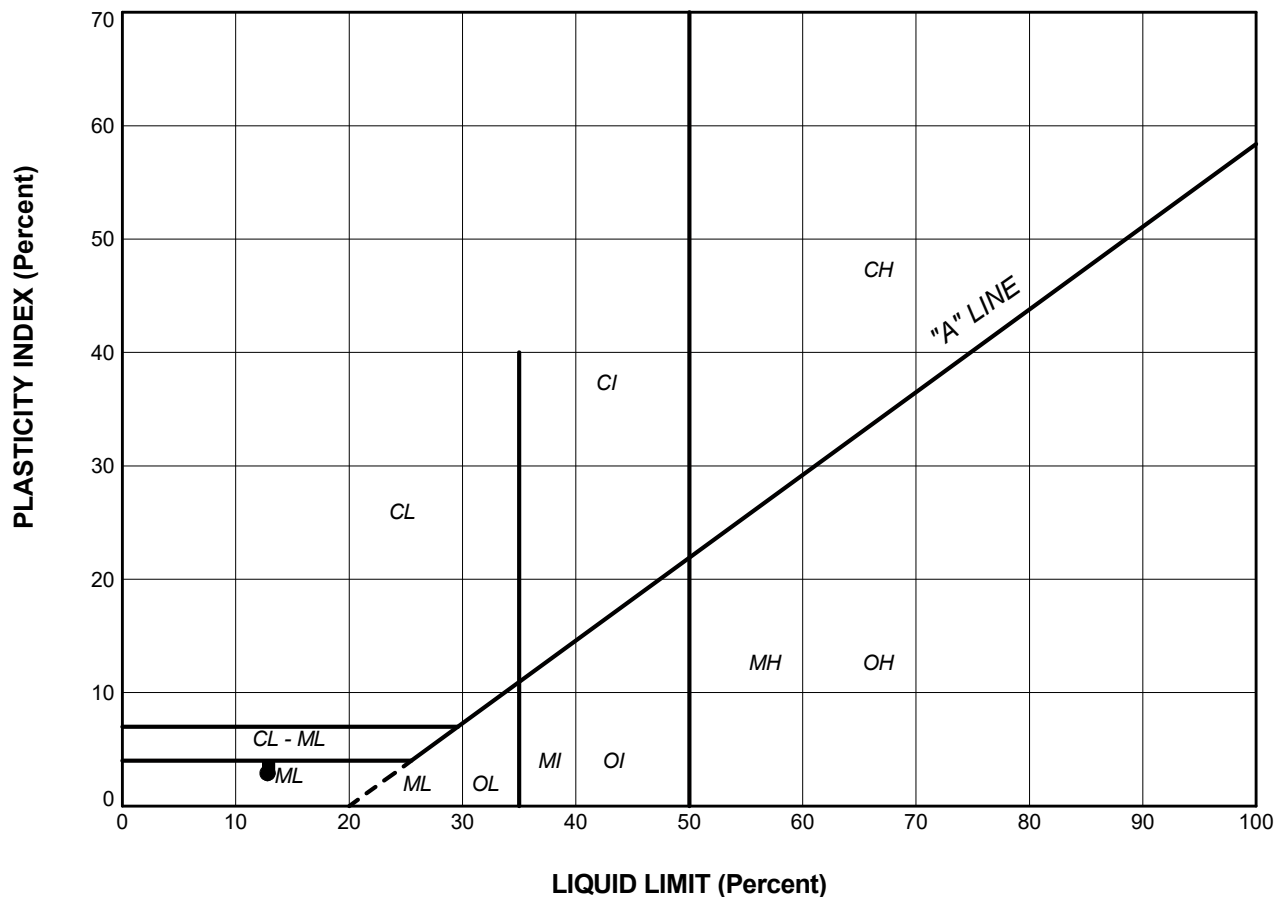




LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	ONR-2	11	235.8
■	ONR-3	13	237.4
▲	ONR-4	19	233.6

PROJECT						HIGHWAY 11 ONR OVERHEAD BRIDGE					
TITLE						GRAIN SIZE DISTRIBUTION SILTY SAND TO SANDY SILT					
PROJECT No.			11-1191-0025			FILE No.			11-1191-0025.GPJ		
DRAWN	JJL	Oct 2012	SCALE	N/A	REV.						
CHECK	AB	Oct 2012				FIGURE B8					
APPR	JMAC	Oct 2012									
 Golder Associates SUDBURY, ONTARIO											



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	ONR-2	11	13	10	3
■	ONR-4	19	13	10	3

PROJECT					
HIGHWAY 11 ONR OVERHEAD BRIDGE					
TITLE					
PLASTICITY CHART SILTY SAND					
PROJECT No.		11-1191-0025		FILE No.	
DRAWN		JJL		Oct 2012	
CHECK		AB		Oct 2012	
APPR		JMAC		Oct 2012	
SCALE		N/A		REV.	
 Golder Associates SUDBURY, ONTARIO				FIGURE B9	



Appendix D

SCPT Plots and In-Situ Test Results

Cone Penetration Test Summary and Standard Cone Penetration Test Plots



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Start Date: 24-Nov-2020
End Date: 01-Dec-2020

CONE PENETRATION TEST SUMMARY

Sounding ID	File Name	Date From	Date To	Cone	Cone Area (cm ²)	Assumed Phreatic Surface ¹ (m)	Final Depth (m)	Northing ² (m)	Easting ² (m)	Refer to Notation Number
SCPT20-01	20-05-21632_SP-01	25-Nov-2020	25-Nov-2020	414:T1000F10U500	10	7.0	19.720	5285147	588703	
SCPT20-02	20-05-21632_SP-02	27-Nov-2020	27-Nov-2020	414:T1000F10U500	10	1.5	17.040	5285082	588803	5
SCPT20-03	20-05-21632_SP-03	24-Nov-2020	24-Nov-2020	414:T1000F10U500	10		4.360	5285152	588689	3,4
SCPT20-03B	20-05-21632_SP-03B	26-Nov-2020	27-Nov-2020	414:T1000F10U500	10	7.0	24.700	5285142	588690	
SCPT20-04	20-05-21632_SP-04	26-Nov-2020	26-Nov-2020	414:T1000F10U500	10	1.5	15.970	5285109	588715	
SCPT20-05	20-05-21632_SP-05	01-Dec-2020	01-Dec-2020	377:T1000F10U500	10	1.5	13.660	5285098	588804	
SCPT20-06	20-05-21632_SP-06	29-Nov-2020	29-Nov-2020	377:T1000F10U500	10	7.0	11.410	5285063	588816	
SCPT20-06B	20-05-21632_SP-06B	29-Nov-2020	29-Nov-2020	377:T1000F10U500	10	7.0	21.510	5285065	588816	

1. The assumed phreatic surface was based on the dynamic pore pressure response, unless otherwise noted. Hydrostatic conditions were assumed for the calculated parameters.

2. Coordinates were collected with a consumer grade GPS device, datum: WGS84 / UTM Zone 17N.

3. The assumed phreatic surface was not detected.

4. There is no data between 2.560m - 2.700m due to the cone slipping through the material while advancing.

5. Cone AD414 was used for depth ranges 0.000m to 1.950m while Cone AD377 was used for depth ranges 3.000m to 17.040m



Thurber

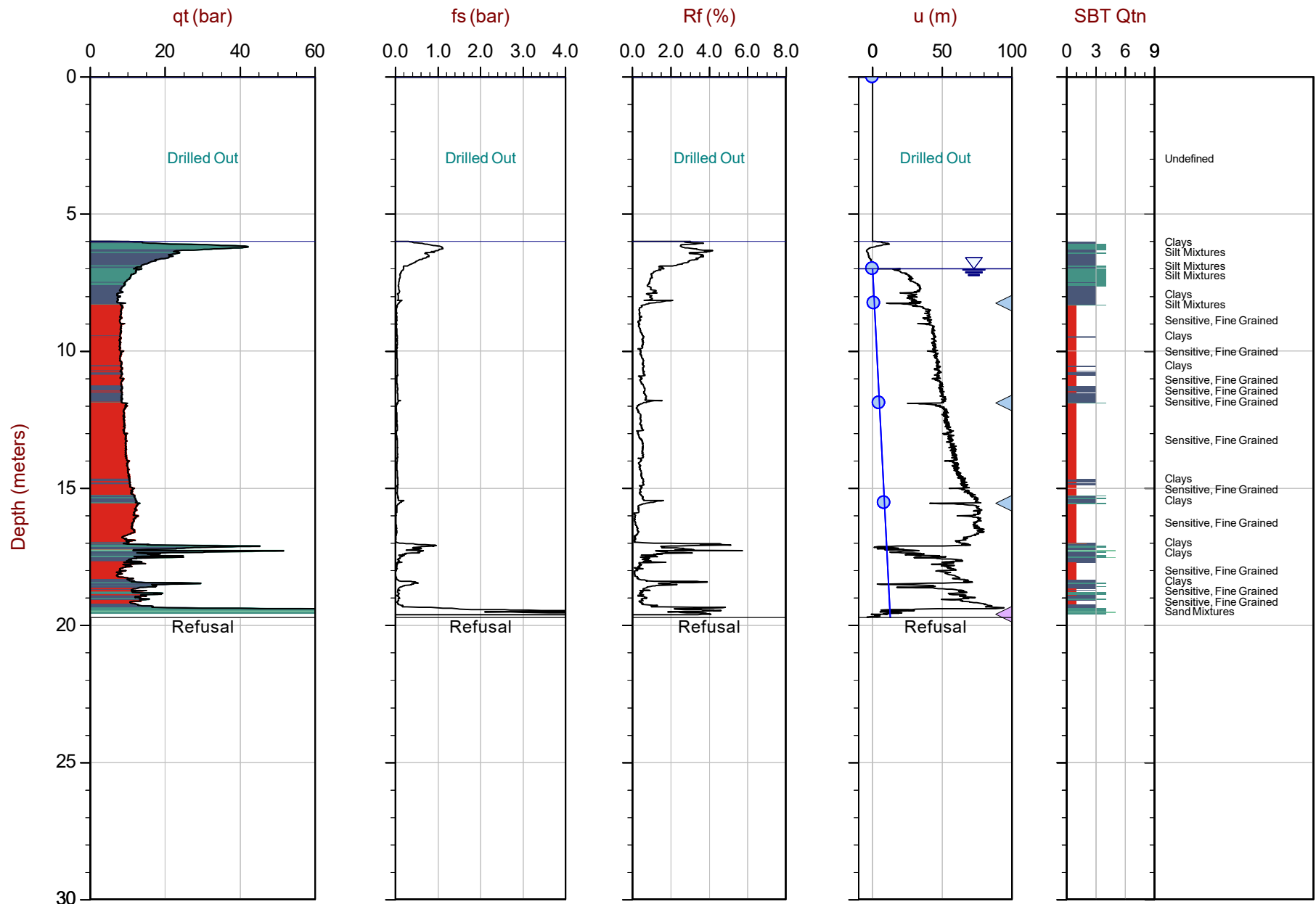
Job No: 20-05-21632

Date: 2020-11-25 11:35

Site: Highway 11/Government Road

Sounding: SCPT20-01

Cone: 414:T1000F10U500



Max Depth: 19.720 m / 64.70 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: Every Point

File: 20-05-21632_SP-01.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285147m E: 588703m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

Job No: 20-05-21632

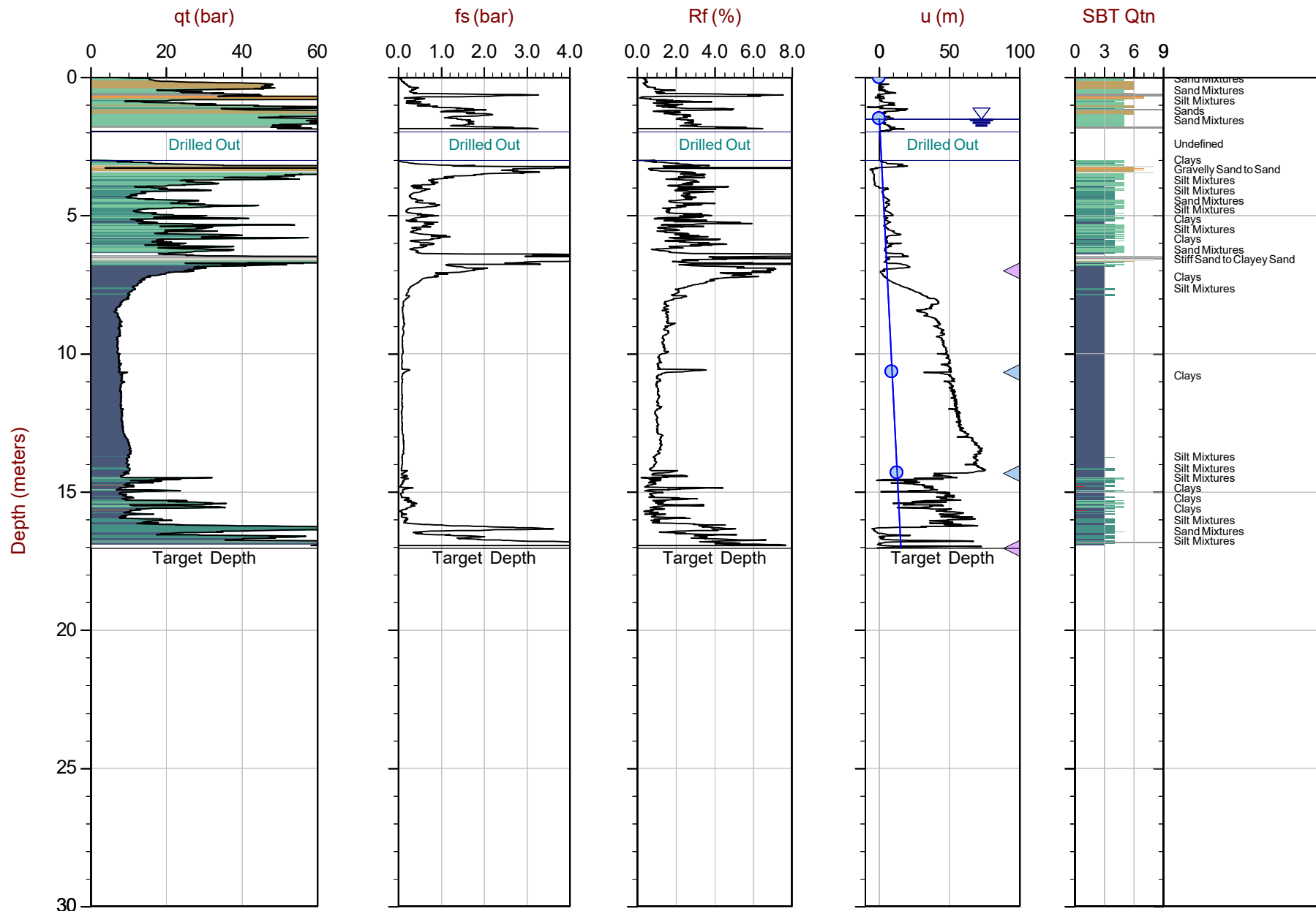
Date: 2020-11-27 12:20

Site: Highway 11/Government Road

Sounding: SCPT20-02

Cone: 414:T1000F10U500

377:T1000F10U500



Max Depth: 17.040 m / 55.90 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: Every Point

File: 20-05-21632_SP-02.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285082m E: 588803m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◀ Dissipation, Ueq achieved ◀ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

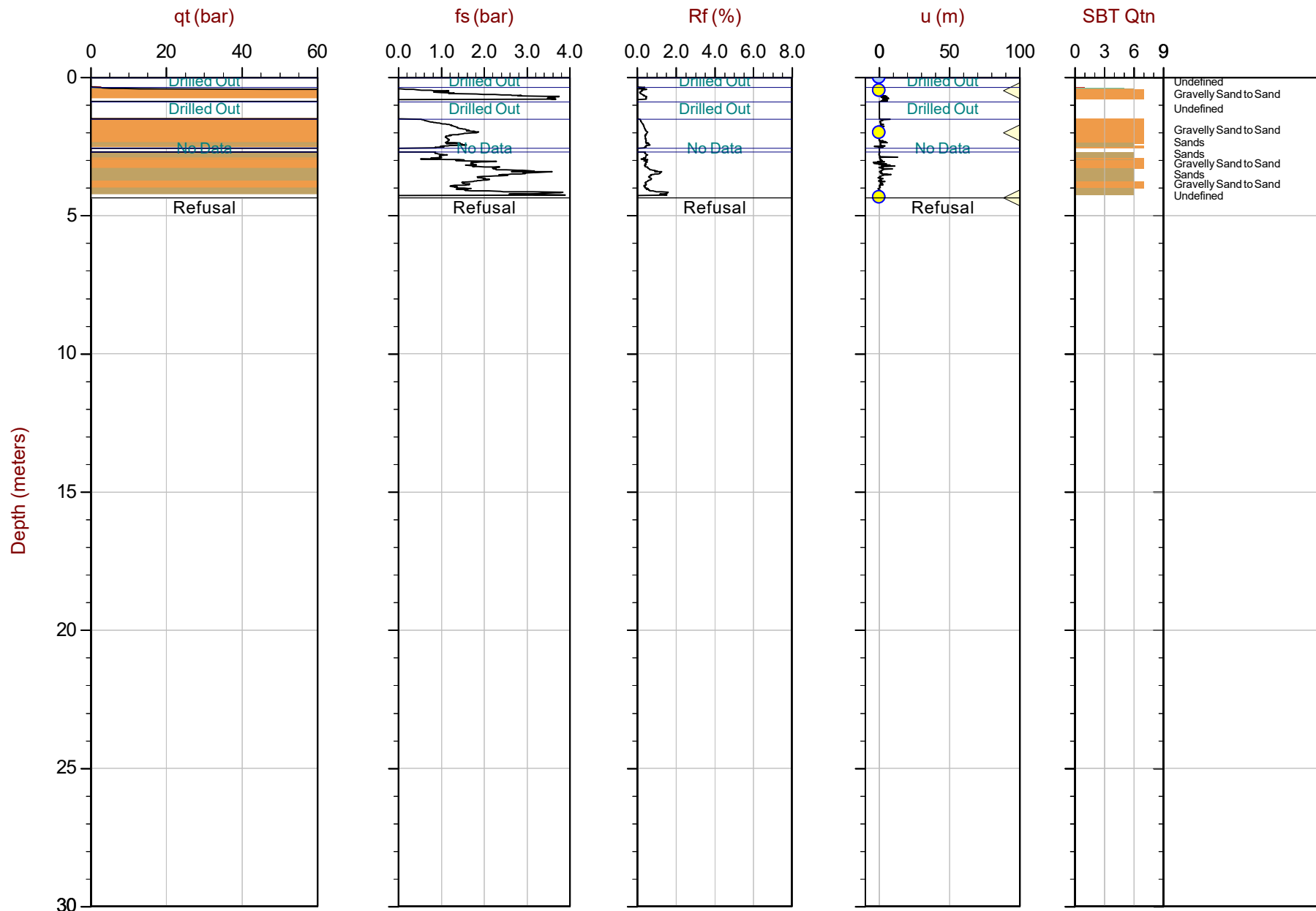
Job No: 20-05-21632

Date: 2020-11-24 10:20

Site: Highway 11/Government Road

Sounding: SCPT20-03

Cone: 414:T1000F10U500



Max Depth: 4.360 m / 14.30 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-03.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285152m E: 588689m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◀ Dissipation, Ueq achieved ◀ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

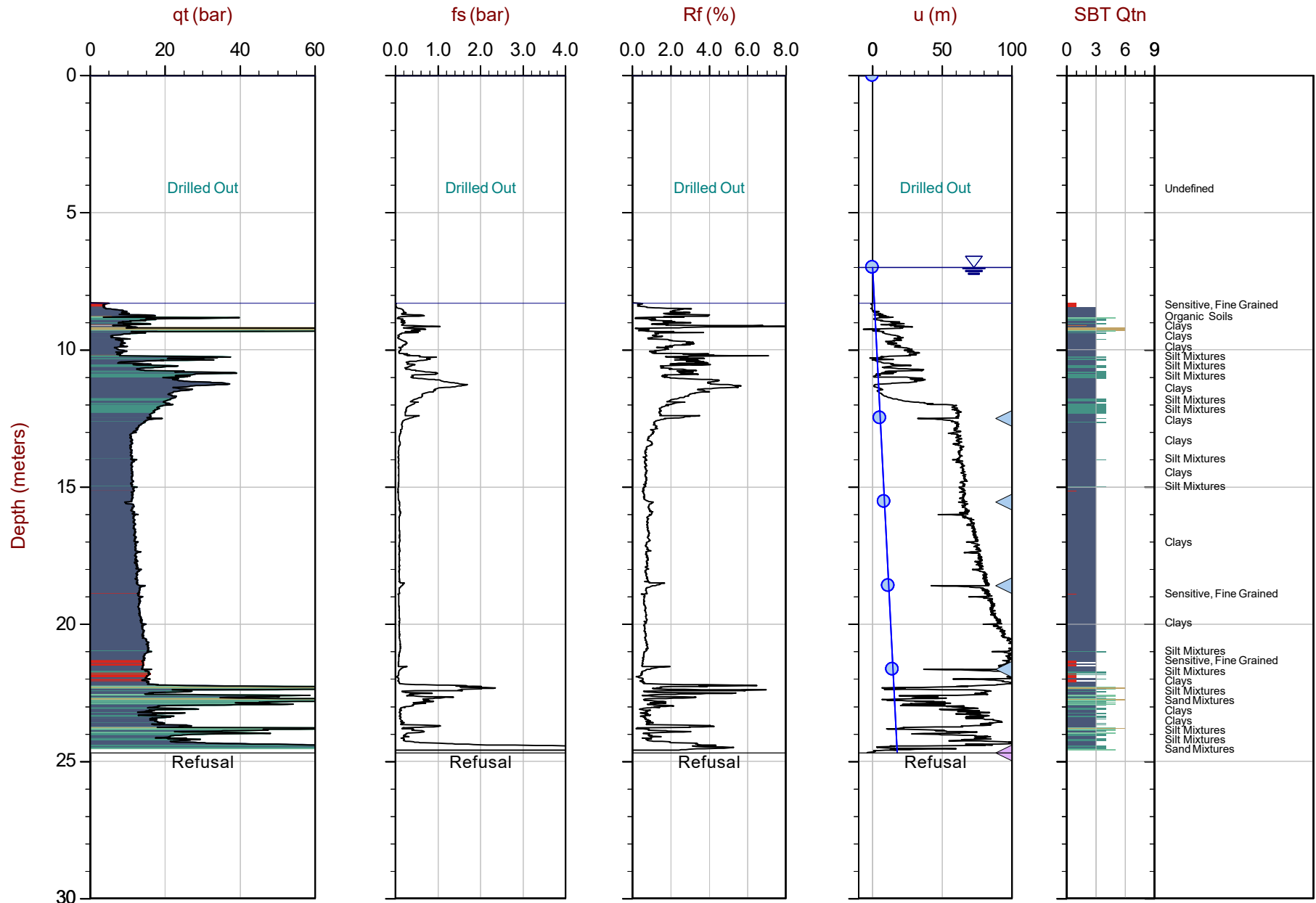
Job No: 20-05-21632

Date: 2020-11-26 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500



Max Depth: 24.700 m / 81.04 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: Every Point

File: 20-05-21632_SP-03B.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285142m E: 588690m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

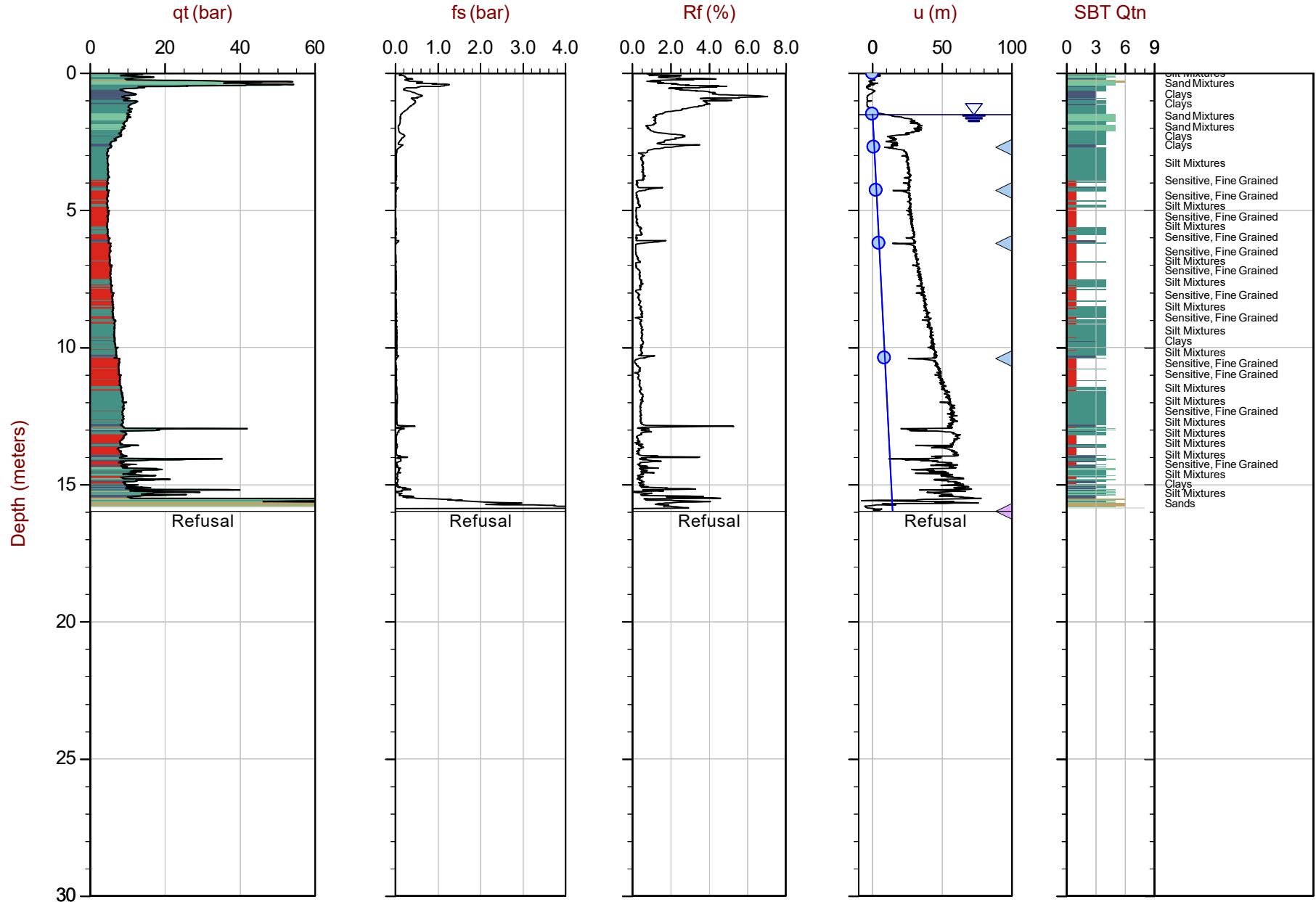
Job No: 20-05-21632

Date: 2020-11-26 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500



Max Depth: 15.970 m / 52.39 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: Every Point

File: 20-05-21632_SP-04.COR

Unit Wt: SBTQtn(PKR2009)

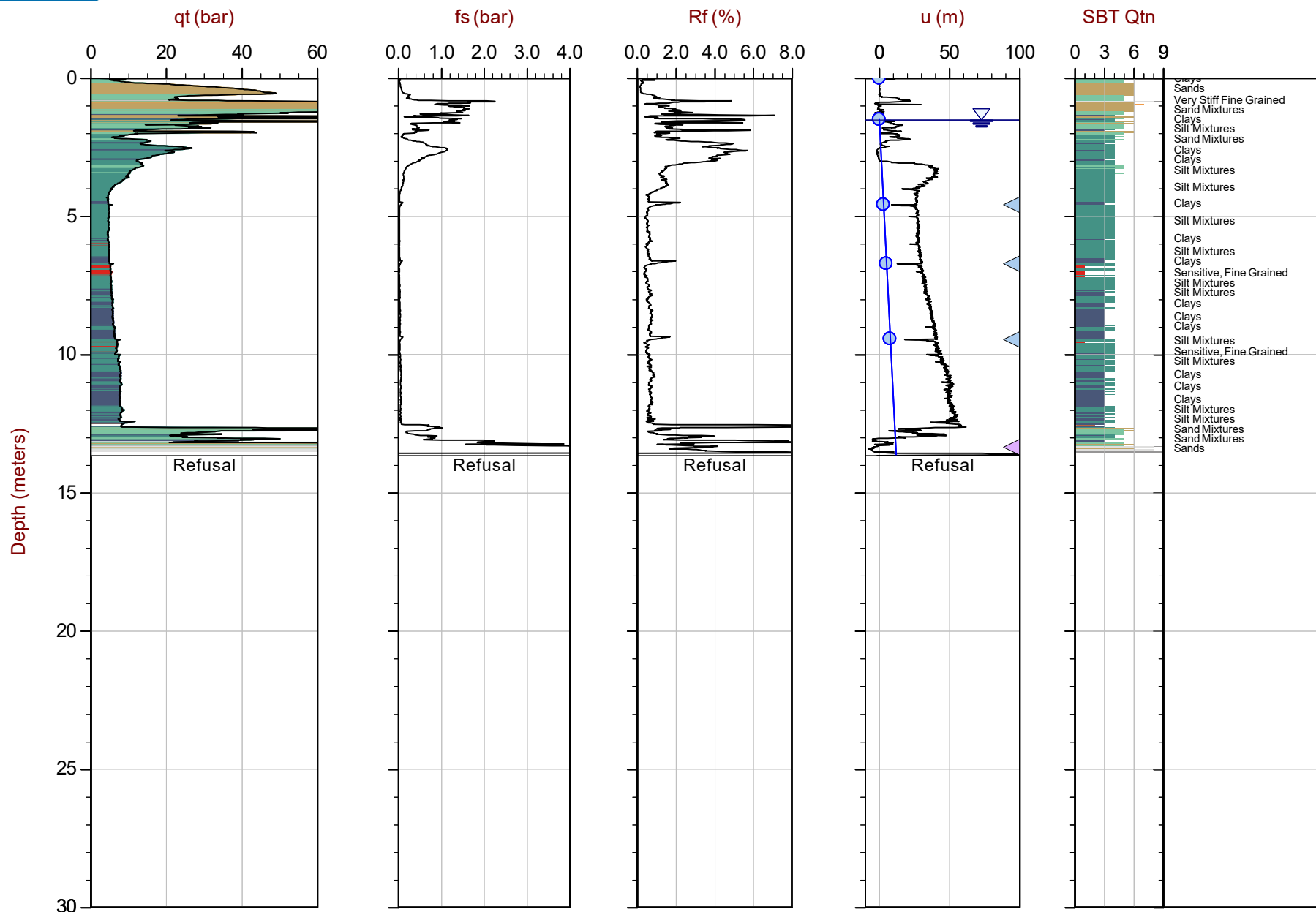
SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285109m E: 588715m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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.



Max Depth: 13.660 m / 44.82 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: Every Point

File: 20-05-21632_SP-05.COR

Unit Wt: SBTQtn(PKR2009)

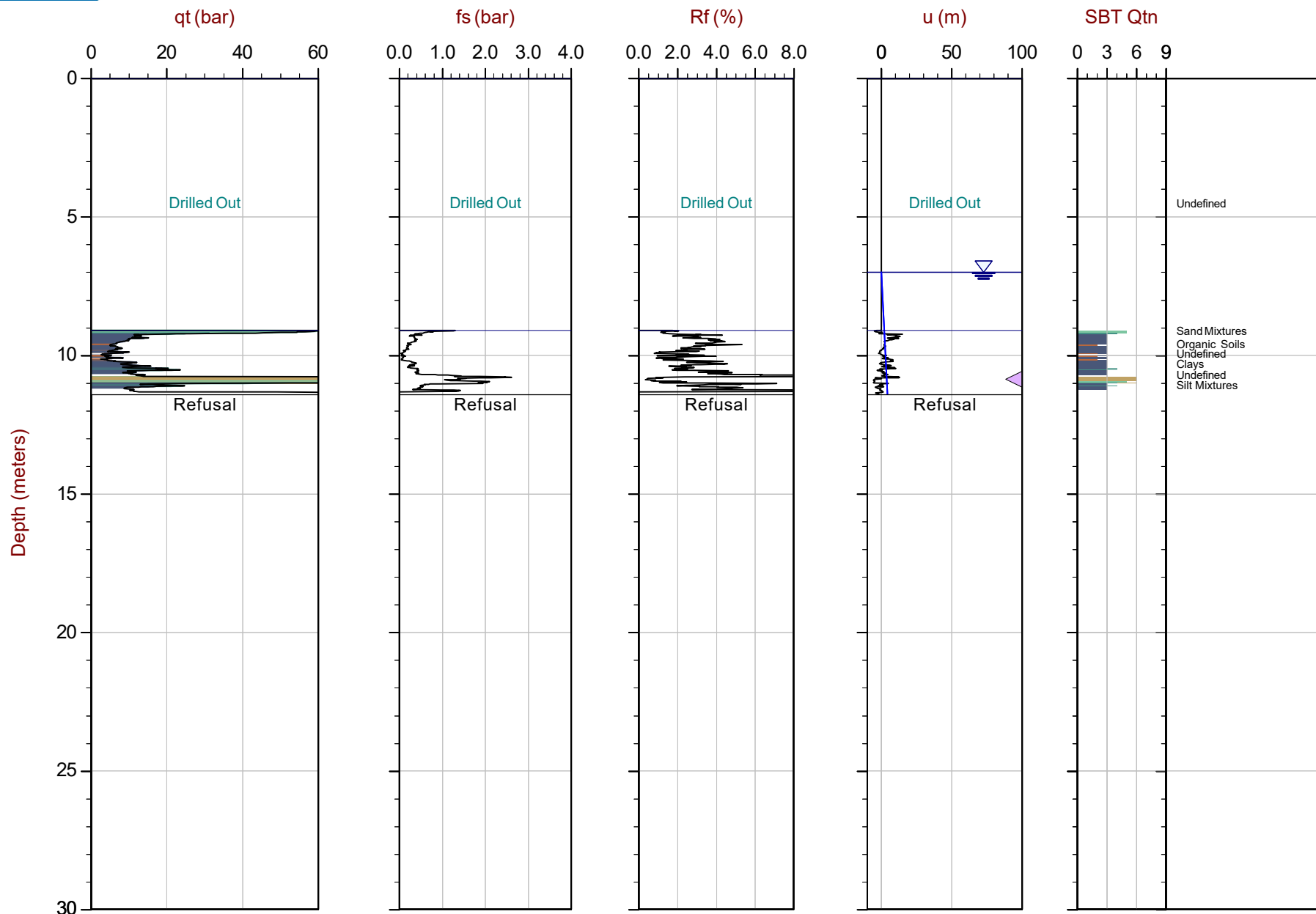
SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285098m E: 588804m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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.



Max Depth: 11.410 m / 37.43 ft
Depth Inc: 0.010 m / 0.033 ft
Avg Int: EveryPoint

File: 20-05-21632_SP-06.COR
UnitWt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010
 Coords: UTM17N:5285063mE:588816m
 SheetNo: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ◀ Dissipation, Ueq achieved ◀ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

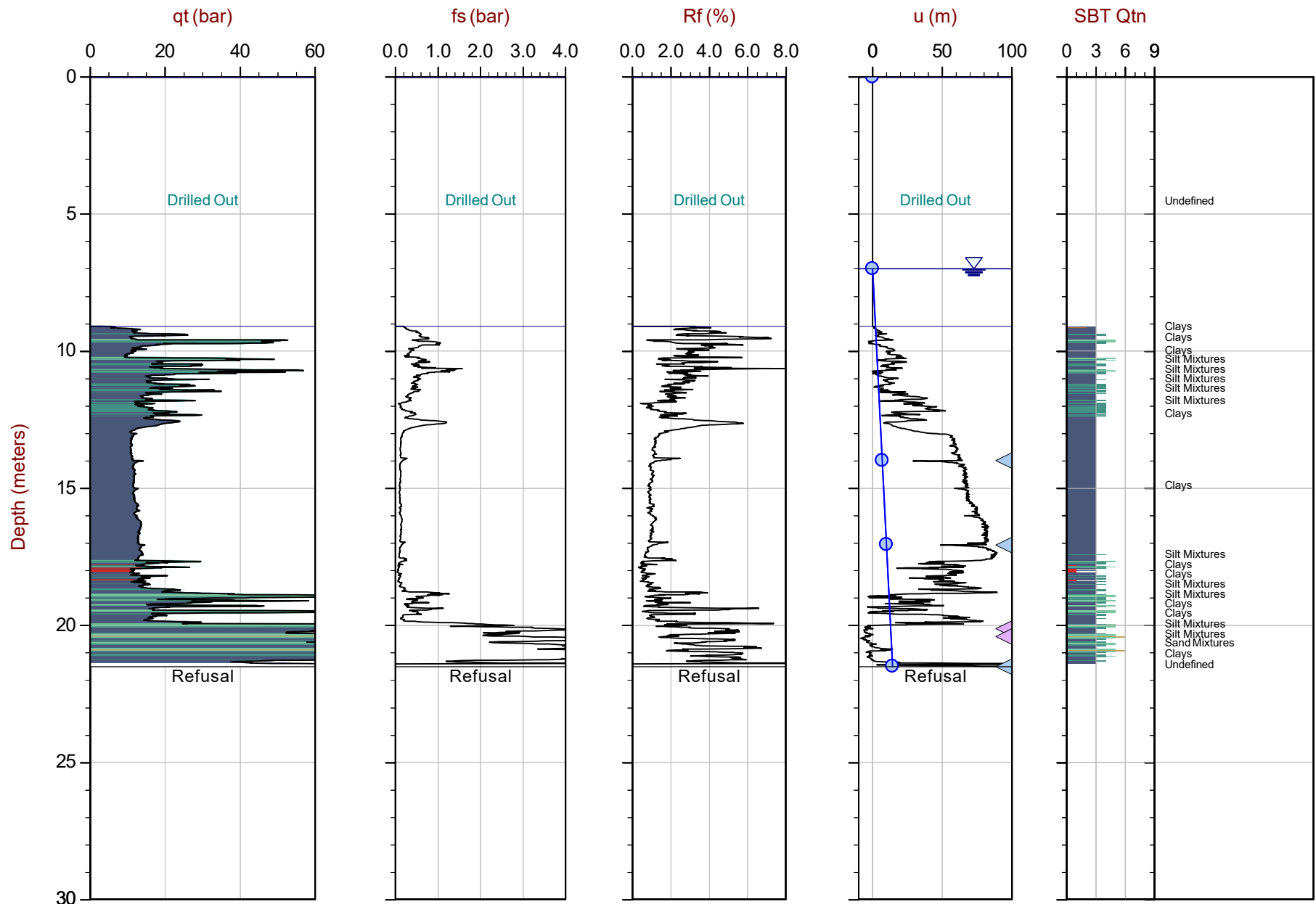
Job No: 20-05-21632

Date: 2020-11-29 10:29

Site: Highway 11/Government Road

Sounding: SCPT20-06B

Cone: 377:T1000F10U500



Max Depth: 21.510 m / 70.57 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-06B.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285065m E: 588816m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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



Thurber

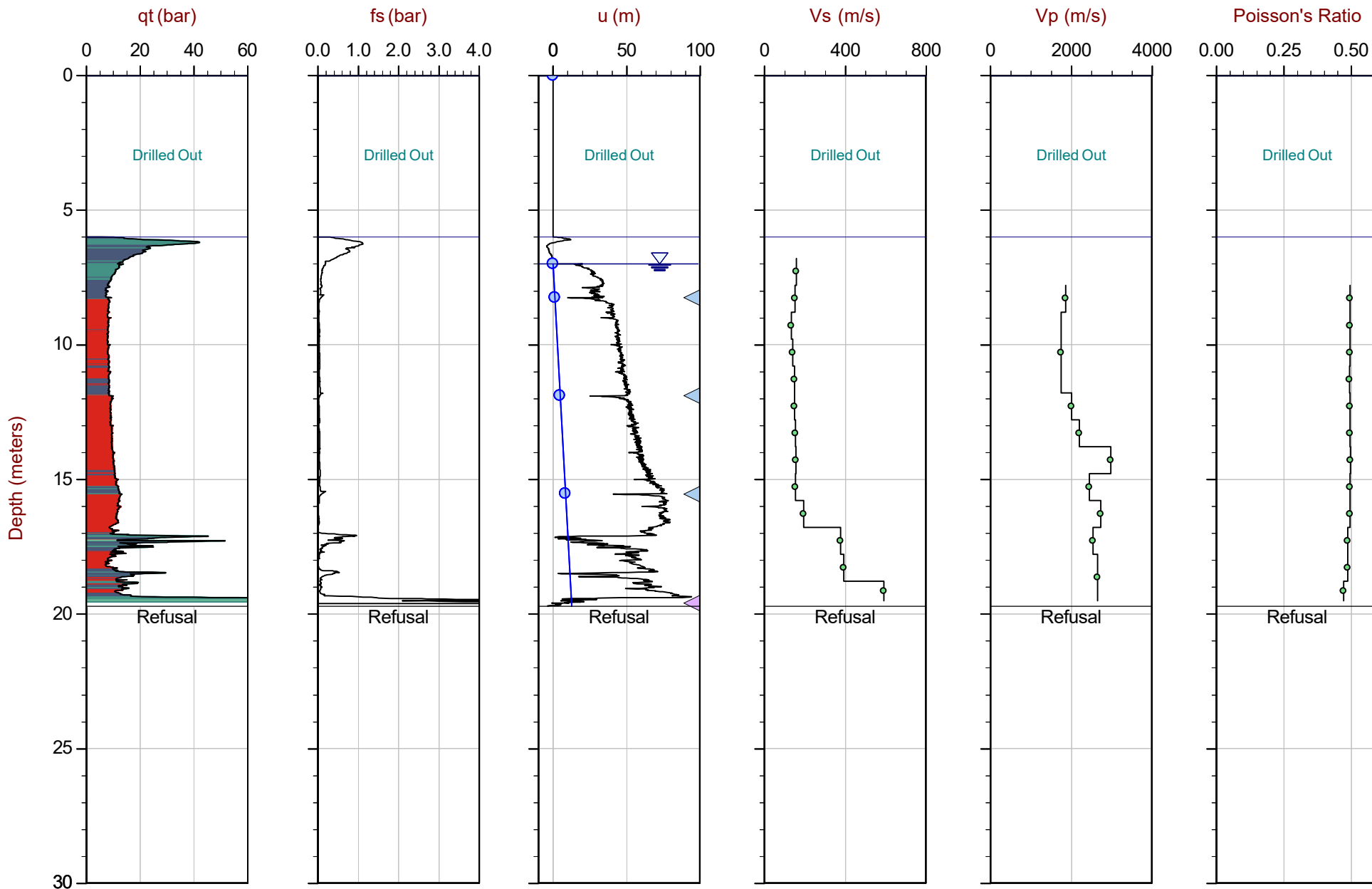
Job No: 20-05-21632

Date: 2020-11-25 11:35

Site: Highway 11/Government Road

Sounding: SCPT20-01

Cone: 414:T1000F10U500



Max Depth: 19.720 m / 64.70 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-01.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285147m E: 588703m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

Job No: 20-05-21632

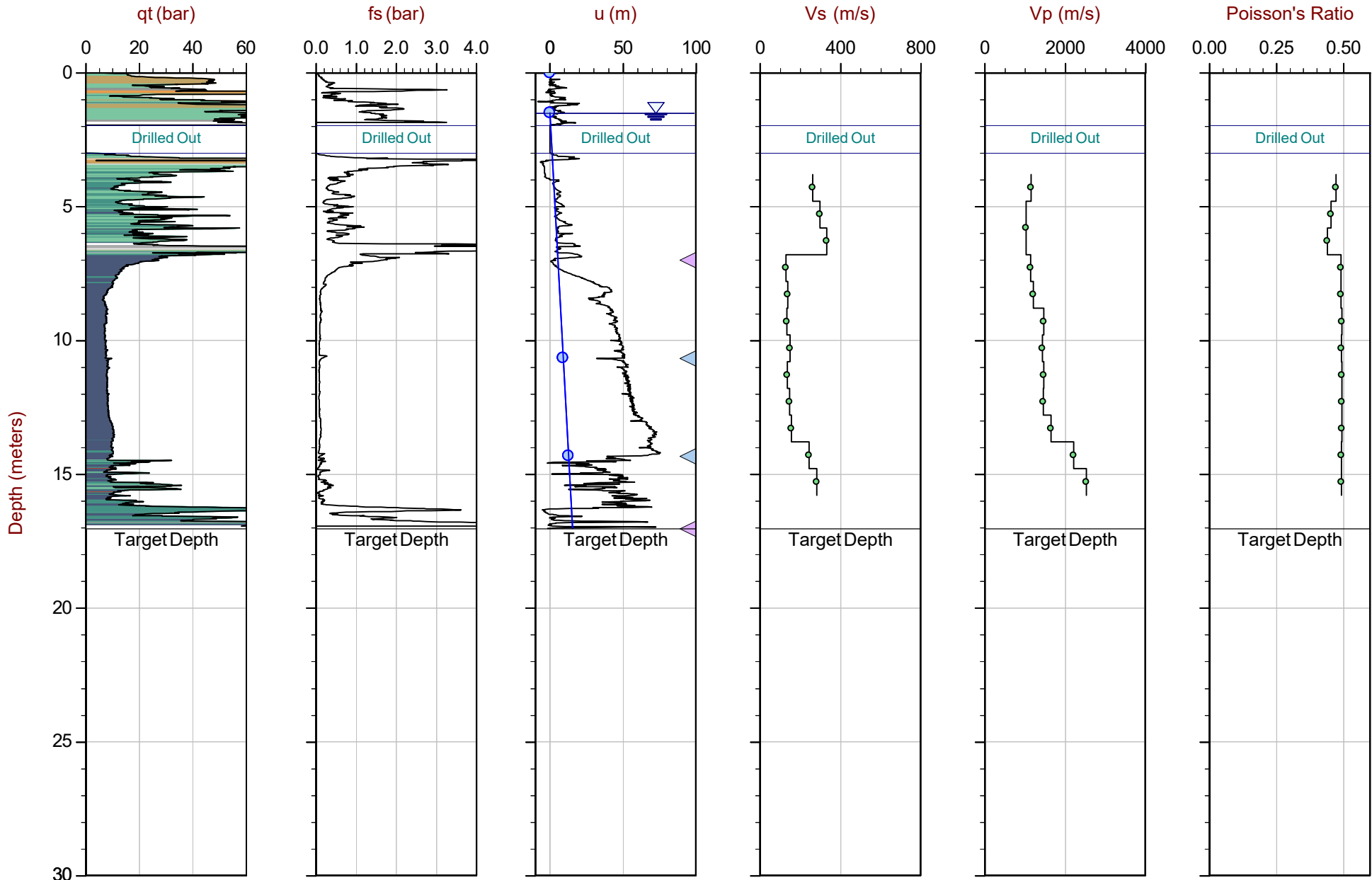
Date: 2020-11-27 12:20

Site: Highway 11/Government Road

Sounding: SCPT20-02

Cone: 414:T1000F10U500

377:T1000F10U500



Max Depth: 17.040 m / 55.90 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-02.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285082m E: 588803m

Sheet No: 1 of 1

Overplot Item: ● Ueq ○ Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

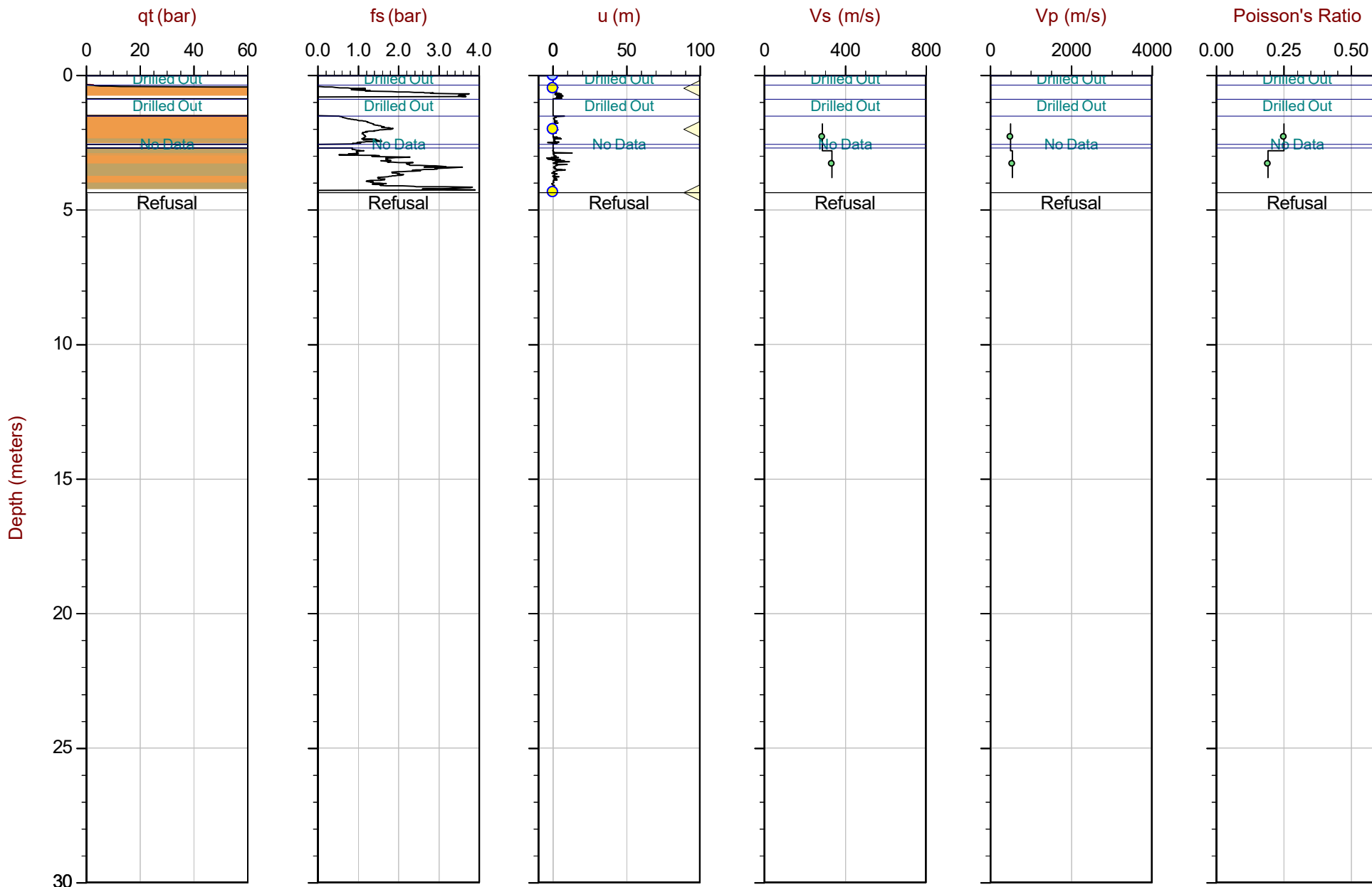
Job No: 20-05-21632

Date: 2020-11-24 10:20

Site: Highway 11/Government Road

Sounding: SCPT20-03

Cone: 414:T1000F10U500



Max Depth: 4.360 m / 14.30 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-03.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285152m E: 588689m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

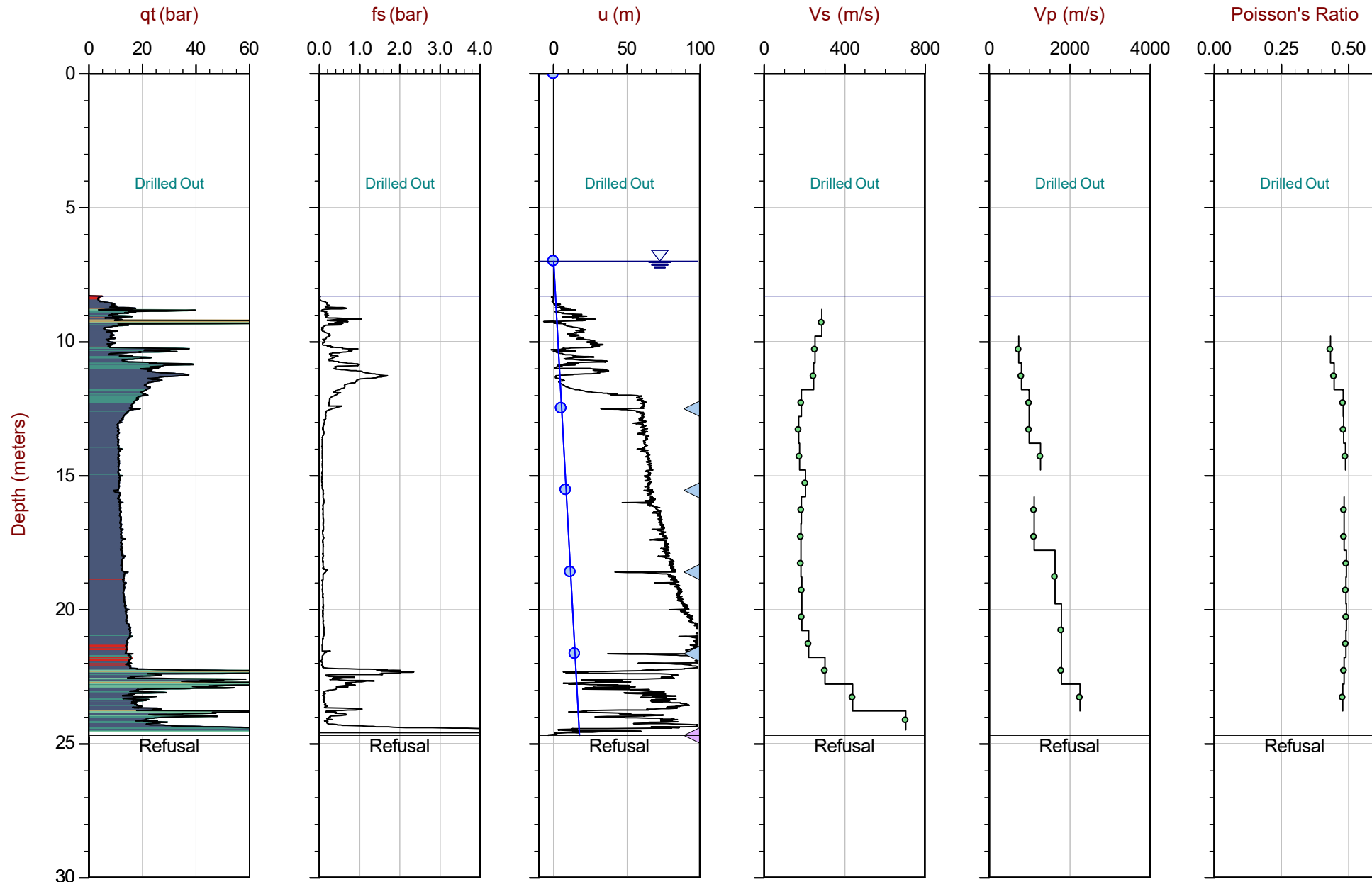
Job No: 20-05-21632

Date: 2020-11-26 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500



Max Depth: 24.700 m / 81.04 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-03B.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N: 5285142m E: 588690m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

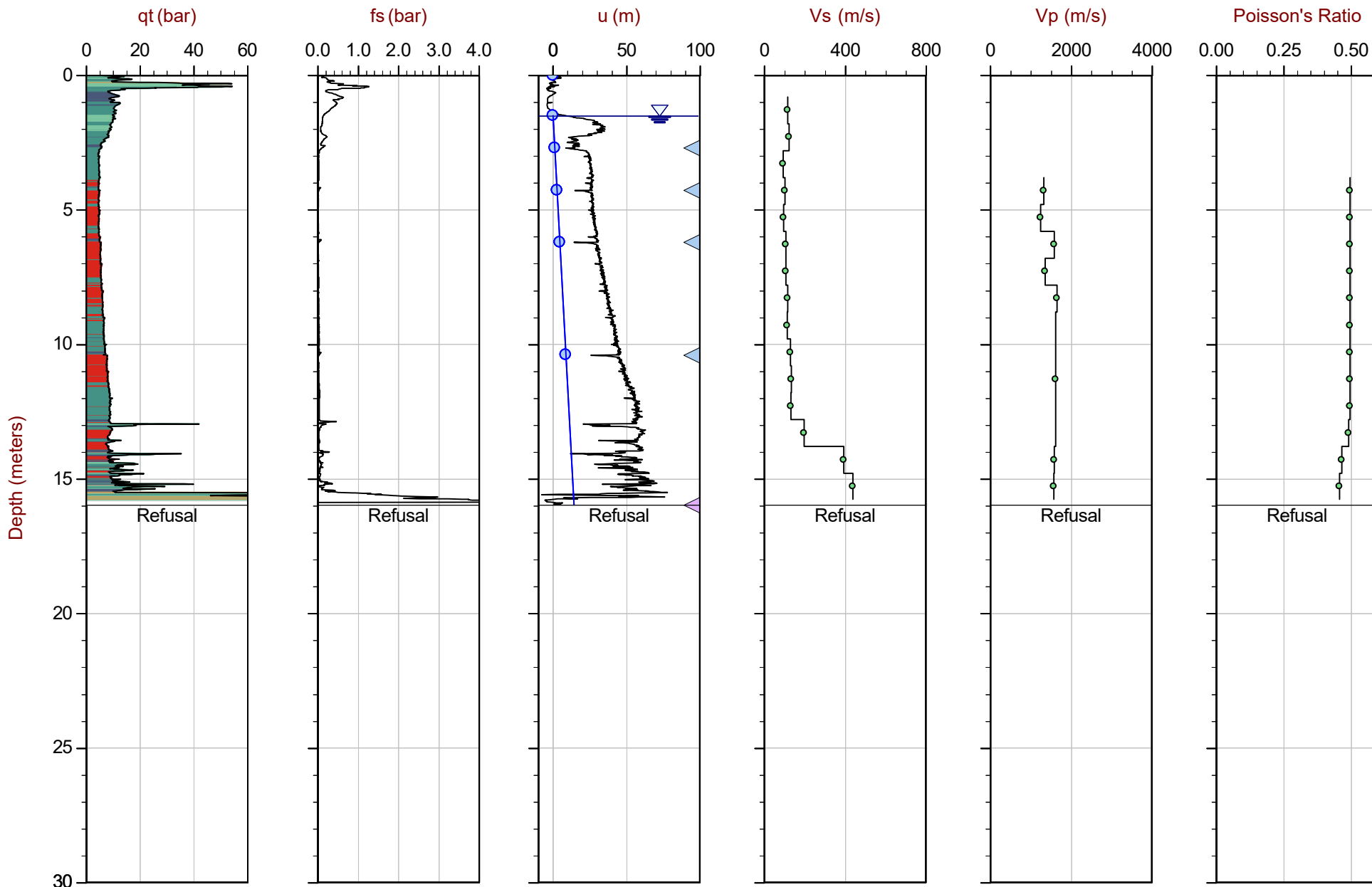
Job No: 20-05-21632

Date: 2020-11-26 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500



Max Depth: 15.970 m / 52.39 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-04.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285109m E: 588715m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

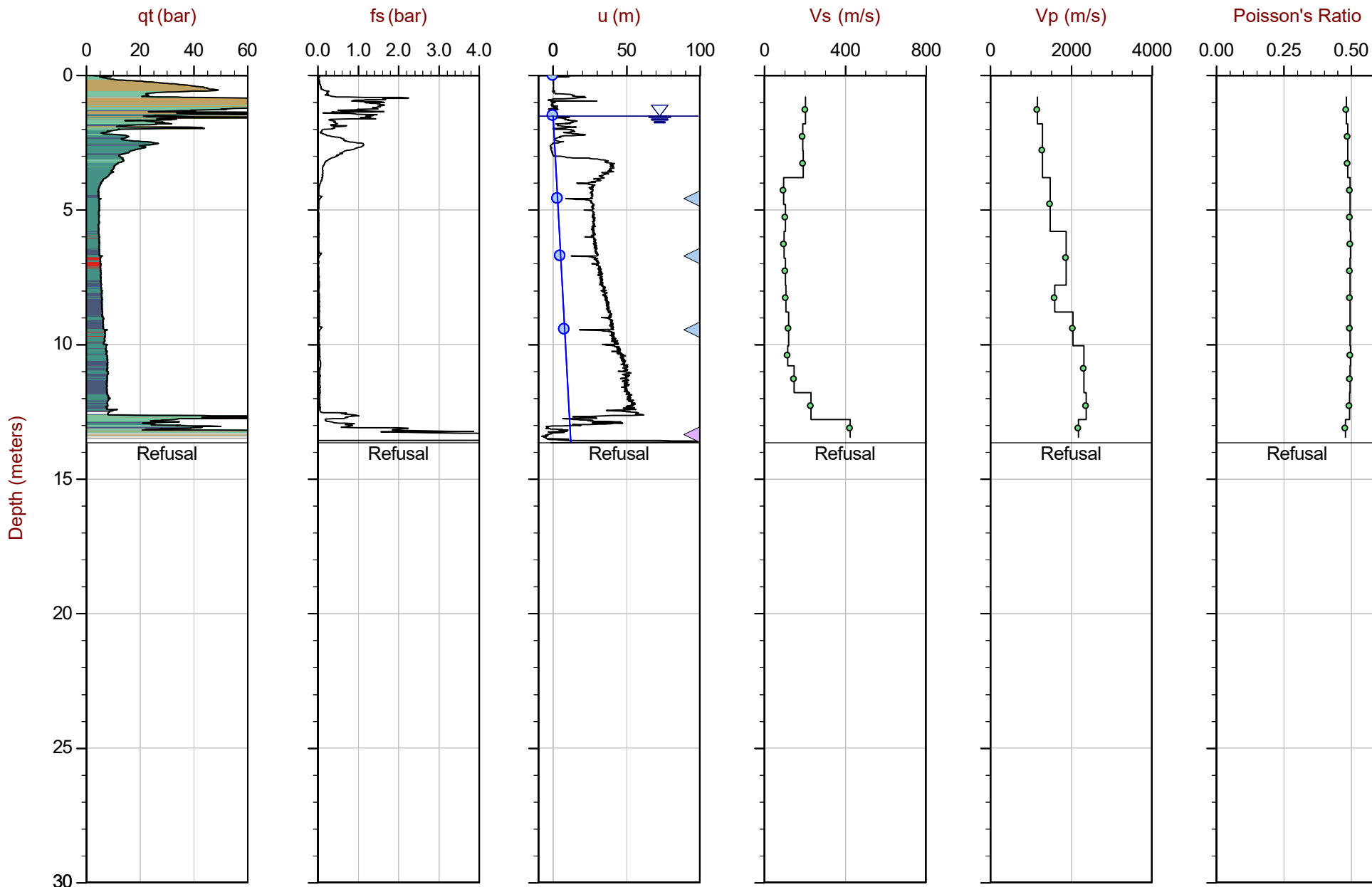
Job No: 20-05-21632

Date: 2020-12-01 11:38

Site: Highway 11/Government Road

Sounding: SCPT20-05

Cone: 377:T1000F10U500



Max Depth: 13.660 m / 44.82 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-05.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285098m E: 588804m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▲ Dissipation, Ueq not achieved ▲ Dissipation, Ueq assumed — 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

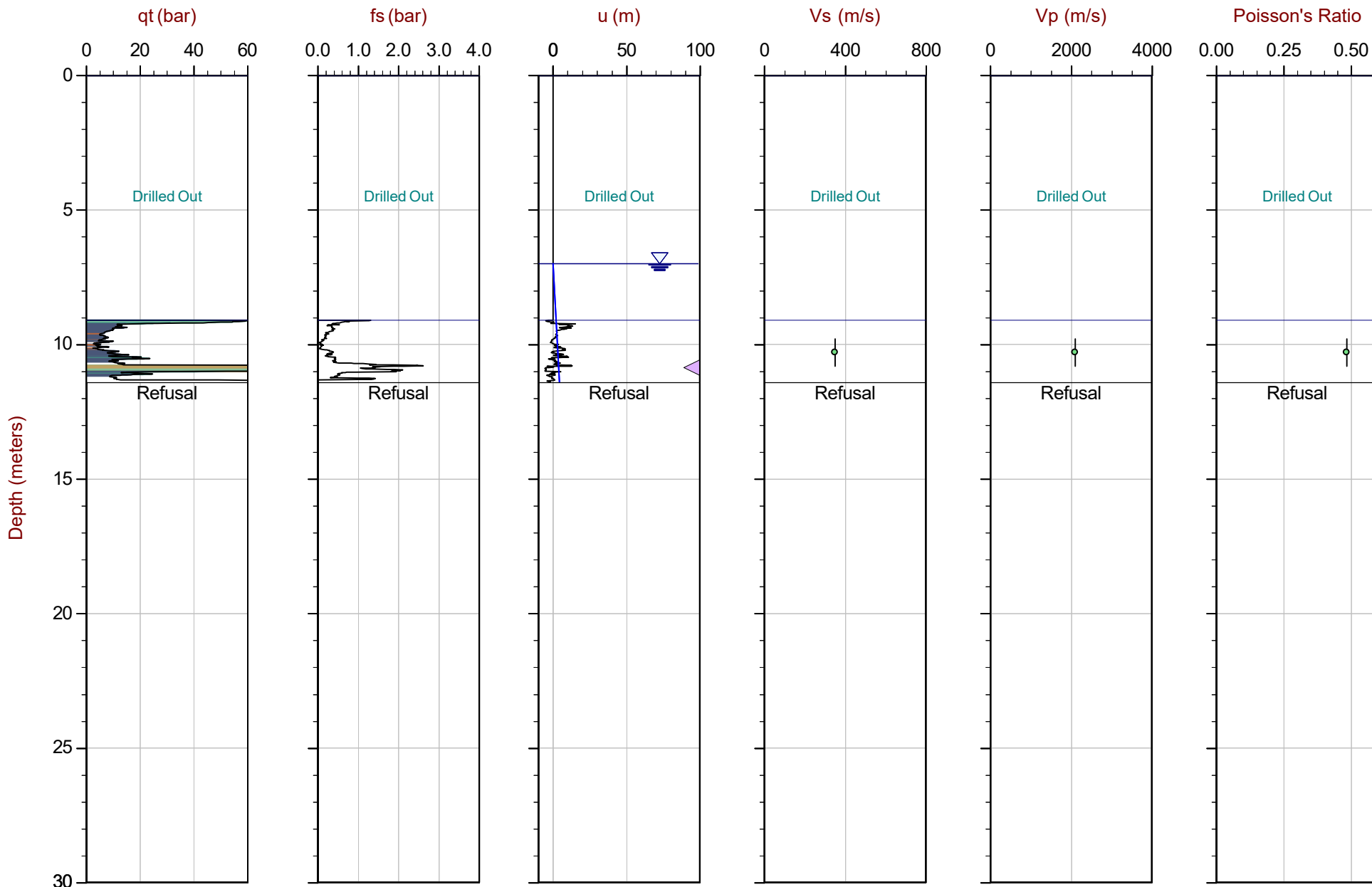
Job No: 20-05-21632

Date: 2020-11-29 08:56

Site: Highway 11/Government Road

Sounding: SCPT20-06

Cone: 377:T1000F10U500



Max Depth: 11.410 m / 37.43 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-06.COR

Unit Wt: SBTQtn(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285063m E: 588816m

Sheet No: 1 of 1

Overplot Item: ● Ueq ● Assumed Ueq ▲ Dissipation, Ueq achieved ▼ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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

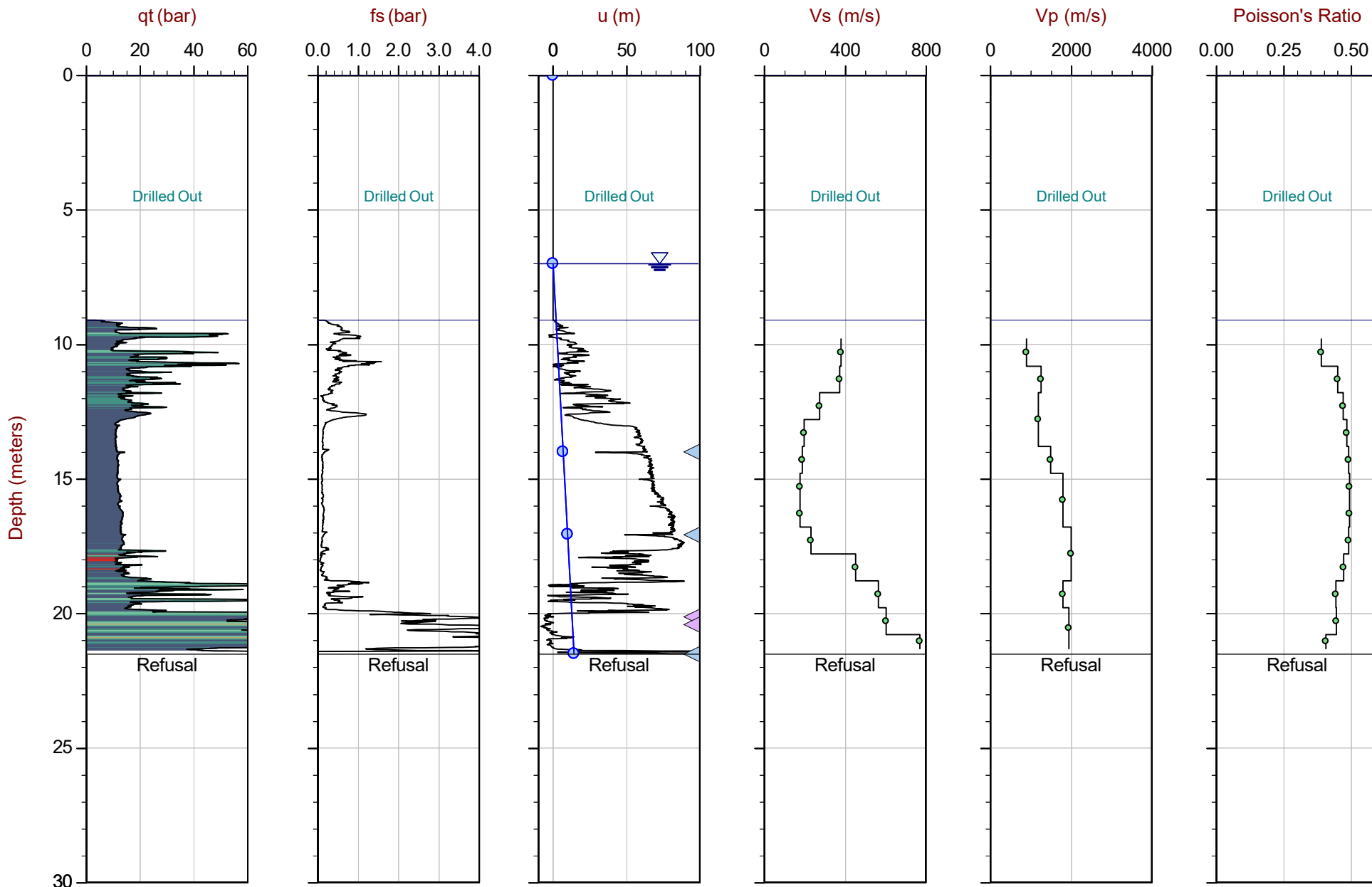
Job No: 20-05-21632

Date: 2020-11-29 10:29

Site: Highway 11/Government Road

Sounding: SCPT20-06B

Cone: 377:T1000F10U500



Max Depth: 21.510 m / 70.57 ft

Depth Inc: 0.010 m / 0.033 ft

Avg Int: EveryPoint

File: 20-05-21632_SP-06B.COR

Unit Wt: SBTQm(PKR2009)

SBT: Robertson, 2009 and 2010

Coords: UTM 17N N: 5285065m E: 588816m

Sheet No: 1 of 1

Overplot Item: ● Ueq ○ Assumed Ueq ◀ Dissipation, Ueq achieved ▶ Dissipation, Ueq not achieved ◀ Dissipation, Ueq assumed — 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 Shear Wave (V_s) Tabular Results



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-01
Date: 25-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u 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)
7.00	6.80	6.84			
8.00	7.80	7.84	1.00	6.23	160
9.00	8.80	8.83	1.00	6.56	152
10.00	9.80	9.83	1.00	7.42	134
11.00	10.80	10.83	1.00	7.02	142
12.00	11.80	11.82	1.00	6.69	149
13.00	12.80	12.82	1.00	6.69	149
14.00	13.80	13.82	1.00	6.42	156
15.00	14.80	14.82	1.00	6.36	157
16.00	15.80	15.82	1.00	6.49	154
17.00	16.80	16.82	1.00	5.13	195
18.00	17.80	17.82	1.00	2.64	378
19.00	18.80	18.82	1.00	2.53	394
19.72	19.52	19.53	0.72	1.21	594



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-02
Date: 27-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
3.00	2.80	2.90			
4.00	3.80	3.87	0.97	1.43	680
5.00	4.80	4.86	0.99	3.75	263
6.00	5.80	5.85	0.99	3.31	300
7.00	6.80	6.84	0.99	2.98	334
8.00	7.80	7.84	1.00	7.61	131
9.00	8.80	8.83	1.00	7.17	139
10.00	9.80	9.83	1.00	7.39	135
11.00	10.80	10.83	1.00	6.61	151
12.00	11.80	11.82	1.00	7.27	137
13.00	12.80	12.82	1.00	6.72	149
14.00	13.80	13.82	1.00	6.39	156
15.00	14.80	14.82	1.00	4.08	245
16.00	15.80	15.82	1.00	3.53	283



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-03
Date: 24-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
2.00	1.80	1.95			
3.00	2.80	2.90	0.95	3.28	289
4.00	3.80	3.87	0.97	2.89	337



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-03B
Date: 26-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
9.00	8.80	8.83			
10.00	9.80	9.83	1.00	3.45	289
11.00	10.80	10.83	1.00	3.94	253
12.00	11.80	11.82	1.00	4.04	247
13.00	12.80	12.82	1.00	5.33	187
14.00	13.80	13.82	1.00	5.76	173
15.00	14.80	14.82	1.00	5.64	177
16.00	15.80	15.82	1.00	4.84	206
17.00	16.80	16.82	1.00	5.36	186
18.00	17.80	17.82	1.00	5.42	184
19.00	18.80	18.82	1.00	5.45	183
20.00	19.80	19.81	1.00	5.27	190
21.00	20.80	20.81	1.00	5.30	189
22.00	21.80	21.81	1.00	4.48	223
23.00	22.80	22.81	1.00	3.29	304
24.00	23.80	23.81	1.00	2.26	443
24.70	24.50	24.51	0.70	0.99	706



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-04
Date: 26-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u 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)
1.00	0.80	1.10			
2.00	1.80	1.95	0.85	7.27	117
3.00	2.80	2.90	0.95	7.72	123
4.00	3.80	3.87	0.97	10.46	93
5.00	4.80	4.86	0.99	9.48	104
6.00	5.80	5.85	0.99	10.25	97
7.00	6.80	6.84	0.99	9.25	107
8.00	7.80	7.84	1.00	9.26	108
9.00	8.80	8.83	1.00	8.59	116
10.00	9.80	9.83	1.00	8.82	113
11.00	10.80	10.83	1.00	7.71	129
12.00	11.80	11.82	1.00	7.39	135
13.00	12.80	12.82	1.00	7.60	131
14.00	13.80	13.82	1.00	5.07	197
15.00	14.80	14.82	1.00	2.54	394
15.97	15.77	15.79	0.97	2.20	440



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-05
Date: 01-Dec-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
1.00	0.80	1.10			
2.00	1.80	1.95	0.85	4.19	204
3.00	2.80	2.90	0.95	4.96	191
4.00	3.80	3.87	0.97	5.07	192
5.00	4.80	4.86	0.99	10.25	96
6.00	5.80	5.85	0.99	9.37	106
7.00	6.80	6.84	0.99	10.14	98
8.00	7.80	7.84	1.00	9.37	106
9.00	8.80	8.83	1.00	9.26	108
10.25	10.05	10.08	1.25	10.36	120
11.00	10.80	10.83	0.75	6.39	117
12.00	11.80	11.82	1.00	6.73	148
13.00	12.80	12.82	1.00	4.30	232
13.66	13.46	13.48	0.66	1.54	427



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-06
Date: 01-Dec-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u SHEAR WAVE VELOCITY TEST RESULTS - V_s

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
10.00	9.80	9.83			
11.01	10.81	10.84	1.01	2.86	352



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-06B
Date: 29-Nov-2020

Seismic Source: Beam
Seismic Offset (m): 0.75
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u 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)
10.00	9.80	9.83			
11.01	10.81	10.84	1.01	2.64	381
12.00	11.80	11.82	0.99	2.65	374
13.00	12.80	12.82	1.00	3.64	275
14.00	13.80	13.82	1.00	5.07	197
15.00	14.80	14.82	1.00	5.29	189
16.00	15.80	15.82	1.00	5.62	178
17.00	16.80	16.82	1.00	5.62	178
18.00	17.80	17.82	1.00	4.30	233
19.00	18.80	18.82	1.00	2.20	453
20.00	19.80	19.81	1.00	1.76	567
21.00	20.80	20.81	1.00	1.65	605
21.51	21.31	21.32	0.51	0.66	771

Seismic Cone Penetration Test Compression Wave (Vp) Tabular Results



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-01
Date: 25-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
8.00	7.80	8.05			
9.00	8.80	9.02	0.97	0.52	1875
12.00	11.80	11.97	2.94	1.67	1759
13.00	12.80	12.96	0.99	0.49	2016
14.00	13.80	13.94	0.99	0.45	2212
15.00	14.80	14.94	0.99	0.33	2990
16.00	15.80	15.93	0.99	0.40	2454
17.00	16.80	16.92	0.99	0.36	2738
18.00	17.80	17.91	0.99	0.39	2544
19.72	19.52	19.62	1.71	0.64	2666



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-02
Date: 27-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
4.00	3.80	4.29			
5.00	4.80	5.20	0.91	0.78	1162
7.00	6.80	7.09	1.89	1.82	1039
8.00	7.80	8.05	0.96	0.84	1148
9.00	8.80	9.02	0.97	0.80	1211
10.00	9.80	10.00	0.98	0.66	1474
11.00	10.80	10.98	0.98	0.68	1440
12.00	11.80	11.97	0.98	0.67	1475
13.00	12.80	12.96	0.99	0.68	1463
14.00	13.80	13.94	0.99	0.60	1659
15.00	14.80	14.94	0.99	0.45	2221
16.00	15.80	15.93	0.99	0.39	2541



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-03
Date: 24-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
2.00	1.80	2.69			
3.00	2.80	3.44	0.75	1.49	502
4.00	3.80	4.29	0.85	1.56	545



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-03B
Date: 26-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
10.00	9.80	10.00			
11.00	10.80	10.98	0.98	1.32	742
12.00	11.80	11.97	0.98	1.21	812
13.00	12.80	12.96	0.99	0.99	995
14.00	13.80	13.94	0.99	0.99	997
15.00	14.80	14.94	0.99	0.77	1284
17.00	16.80	16.92	0.99	0.88	1126
18.00	17.80	17.91	0.99	0.88	1127
20.00	19.80	19.90	1.99	1.21	1641
22.00	21.80	21.89	1.99	1.10	1807
23.00	22.80	22.89	1.00	0.55	1808
24.00	23.80	23.88	1.00	0.44	2260



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-04
Date: 26-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
4.00	3.80	4.29			
5.00	4.80	5.20	0.91	0.68	1324
6.00	5.80	6.14	0.94	0.75	1251
7.00	6.80	7.09	0.95	0.60	1588
8.00	7.80	8.05	0.96	0.71	1363
9.00	8.80	9.02	0.97	0.59	1655
14.00	13.80	13.94	4.92	3.04	1621
15.00	14.80	14.94	0.99	0.62	1588
15.97	15.77	15.90	0.96	0.61	1576



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-05
Date: 01-Dec-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
1.00	0.80	2.15			
2.00	1.80	2.69	0.54	0.46	1175
4.00	3.80	4.29	1.60	1.24	1292
6.00	5.80	6.14	1.84	1.24	1484
8.00	7.80	8.05	1.92	1.02	1876
9.00	8.80	9.02	0.97	0.61	1602
10.25	10.05	10.25	1.22	0.60	2052
12.00	11.80	11.97	1.72	0.74	2324
13.00	12.80	12.96	0.99	0.42	2379
13.66	13.46	13.61	0.65	0.30	2188



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-06
Date: 01-Dec-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
10.00	9.80	10.00			
11.01	10.81	10.99	0.99	0.47	2111



Job No: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Sounding ID: SCPT20-06B
Date: 29-Nov-2020

Seismic Source: Plate
Seismic Offset (m): 2.00
Source Depth (m): 0.00
Geophone Offset (m): 0.20

SCPT_u COMPRESSION WAVE VELOCITY TEST RESULTS - V_p

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Ray Path Difference (m)	Travel Time Interval (ms)	Interval Velocity (m/s)
10.00	9.80	10.00			
11.01	10.81	10.99	0.99	1.10	900
12.00	11.80	11.97	0.98	0.77	1264
14.00	13.80	13.94	1.98	1.65	1195
15.00	14.80	14.94	0.99	0.66	1498
17.00	16.80	16.92	1.98	1.10	1801
19.00	18.80	18.91	1.99	0.99	2004
20.00	19.80	19.90	1.00	0.55	1805
21.51	21.31	21.40	1.50	0.77	1948

Pore Pressure Dissipation Summary and Pore Pressure Dissipation Plots



Job No: 20-05-21632
 Client: Thurber Engineering Ltd.
 Project: Highway 11 and Government Road Earlton
 Start Date: 24-Nov-2020
 End Date: 01-Dec-2020

CPT_u 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)
SCPT20-01	20-05-21632_SP-01	10	2600	8.250	1.3		7.0	1371	100	0.3
SCPT20-01	20-05-21632_SP-01	10	1800	11.900	4.9		7.0	1262	100	0.4
SCPT20-01	20-05-21632_SP-01	10	2500	15.550	8.6		7.0	1742	100	0.3
SCPT20-01	20-05-21632_SP-01	10	310	19.600	Not Achieved					
SCPT20-02	20-05-21632_SP-02	10	2830	7.000	Not Achieved					
SCPT20-02	20-05-21632_SP-02	10	1800	10.670	9.2		1.5	1054	100	0.4
SCPT20-02	20-05-21632_SP-02	10	1810	14.330	12.8		1.5	1534	100	0.3
SCPT20-02	20-05-21632_SP-02	10	470	17.040	Not Achieved					
SCPT20-03	20-05-21632_SP-03	10	465	0.480	0.0					
SCPT20-03	20-05-21632_SP-03	10	265	2.000	0.0					
SCPT20-03	20-05-21632_SP-03	10	570	4.350	0.0					
SCPT20-03B	20-05-21632_SP-03B	10	600	12.500	5.5		7.0	360	100	1.3
SCPT20-03B	20-05-21632_SP-03B	10	1250	15.550	8.6		7.0	851	100	0.6
SCPT20-03B	20-05-21632_SP-03B	10	1700	18.600	11.6		7.0	926	100	0.5
SCPT20-03B	20-05-21632_SP-03B	10	1300	21.650	14.7		7.0	333	100	1.4
SCPT20-03B	20-05-21632_SP-03B	10	700	24.700	Not Achieved					
SCPT20-04	20-05-21632_SP-04	10	1300	2.700	1.2		1.5	637	100	0.7
SCPT20-04	20-05-21632_SP-04	10	1600	4.270	2.8		1.5	1055	100	0.4
SCPT20-04	20-05-21632_SP-04	10	2500	6.200	4.7		1.5	1244	100	0.4



Job No: 20-05-21632
 Client: Thurber Engineering Ltd.
 Project: Highway 11 and Government Road Earlton
 Start Date: 24-Nov-2020
 End Date: 01-Dec-2020

CPT_u 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)
SCPT20-04	20-05-21632_SP-04	10	1700	10.400	8.9		1.5	873	100	0.5
SCPT20-04	20-05-21632_SP-04	10	1400	15.970	Not Achieved					
SCPT20-05	20-05-21632_SP-05	10	1600	4.580	3.1		1.5	764	100	0.6
SCPT20-05	20-05-21632_SP-05	10	2400	6.710	5.2		1.5	1198	100	0.4
SCPT20-05	20-05-21632_SP-05	10	2200	9.450	8.0		1.5	1051	100	0.5
SCPT20-05	20-05-21632_SP-05	10	285	13.340	Not Achieved					
SCPT20-06	20-05-21632_SP-06	10	540	10.860	Not Achieved					
SCPT20-06B	20-05-21632_SP-06B	10	1400	14.000	7.0		7.0	794	100	0.6
SCPT20-06B	20-05-21632_SP-06B	10	1200	17.070	10.1		7.0	712	100	0.7
SCPT20-06B	20-05-21632_SP-06B	10	2015	20.120	Not Achieved					
SCPT20-06B	20-05-21632_SP-06B	10	410	20.410	Not Achieved					
SCPT20-06B	20-05-21632_SP-06B	10	1565	21.510	14.5		7.0	853	100	0.6

a. Time is relative to where u_{max} occurred.

b. Houlsby and Teh, 1991.



Thurber

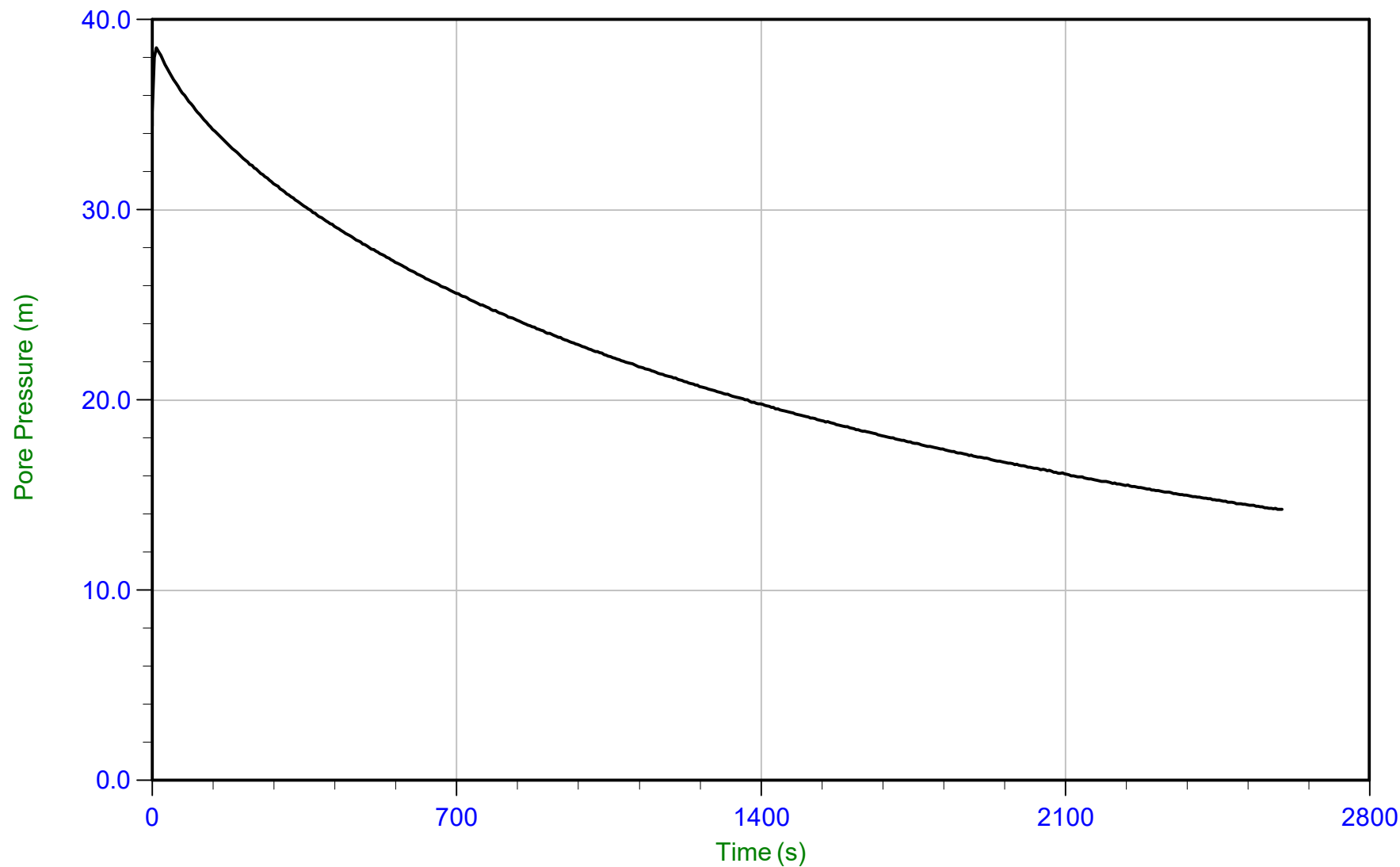
Job No: 20-05-21632

Date: 11/25/2020 11:35

Site: Highway 11/Government Road

Sounding: SCPT20-01

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-01.PPF

Depth: 8.250 m / 27.067 ft

Duration: 2600.0 s

u Min: 14.2 m

u Max: 38.5 m

u Final: 14.2 m

WT: 7.000 m / 22.966 ft

Ueq: 1.2 m

U(50): 19.89 m

T(50): 1370.8 s

Ir: 100

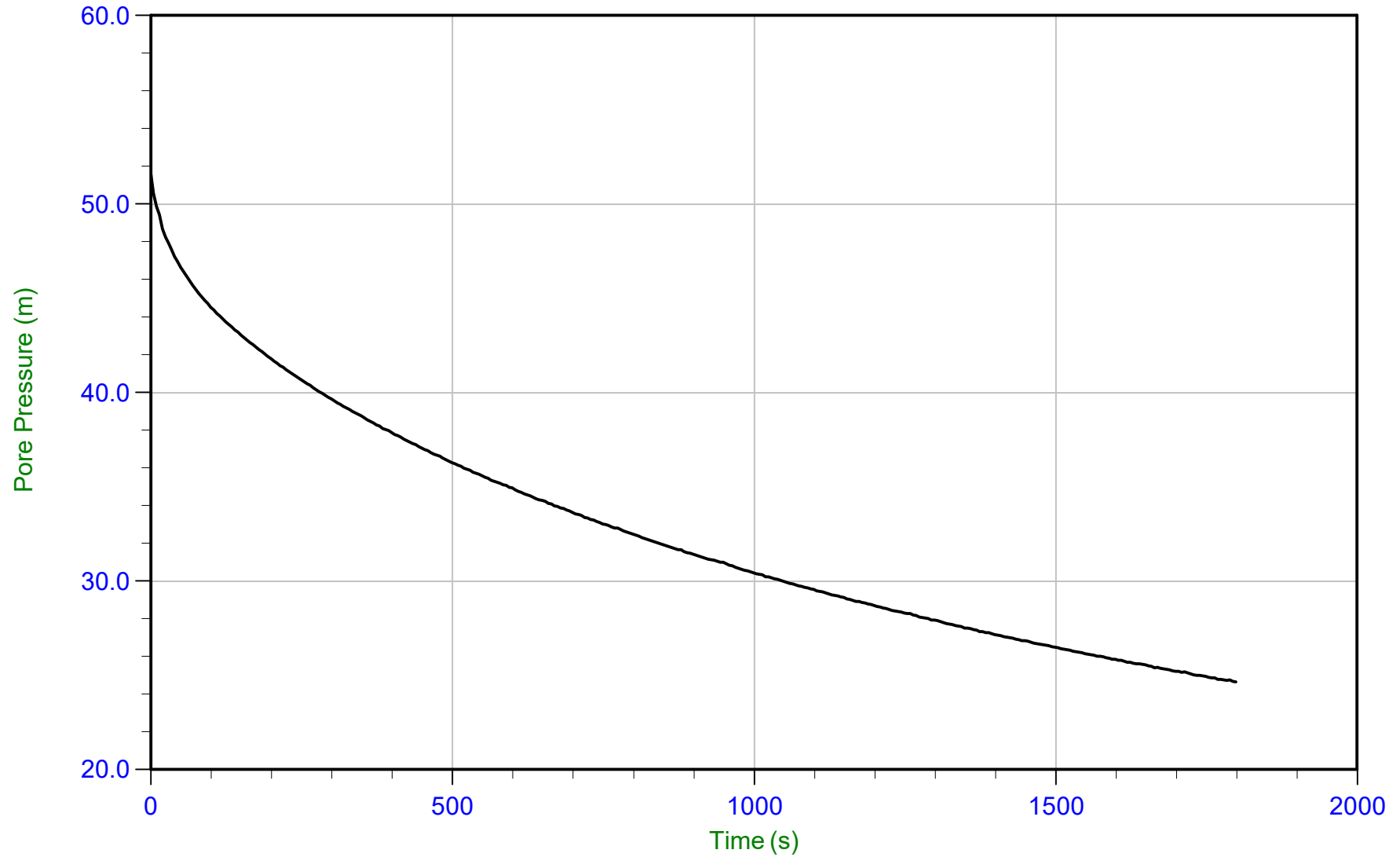
Ch: 0.3 cm²/min



Thurber

Job No: 20-05-21632
Date: 11/25/2020 11:35
Site: Highway 11/Government Road

Sounding: SCPT20-01
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-01.PPF
Depth: 11.900 m / 39.042 ft
Duration: 1800.0 s

u Min: 24.7 m
u Max: 51.6 m
u Final: 24.7 m

WT: 7.000 m / 22.966 ft
Ueq: 4.9 m
U(50): 28.24 m

T(50): 1262.4 s
Ir: 100
Ch: 0.4 cm²/min



Thurber

Job No: 20-05-21632
Date: 11/25/2020 11:35
Site: Highway 11/Government Road

Sounding: SCPT20-01
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-01.PPF
Depth: 15.550 m / 51.016 ft
Duration: 2500.0 s

u Min: 37.8 m
u Max: 77.3 m
u Final: 37.8 m

WT: 7.000 m / 22.966 ft
Ueq: 8.6 m
U(50): 42.91 m

T(50): 1741.7 s
Ir: 100
Ch: 0.3 cm²/min



Thurber

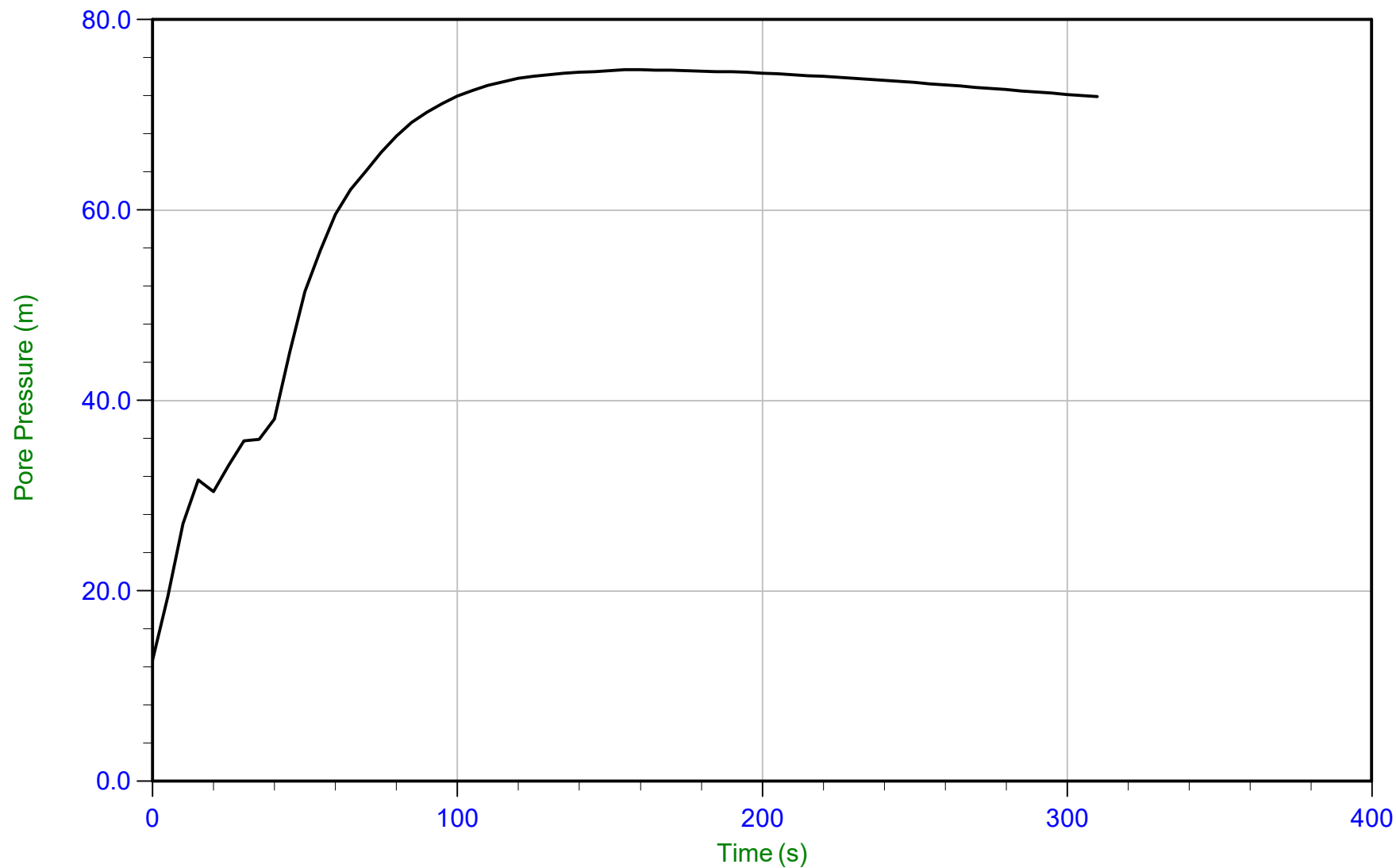
Job No: 20-05-21632

Date: 11/25/2020 11:35

Site: Highway 11/Government Road

Sounding: SCPT20-01

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-01.PPF

Depth: 19.600 m / 64.304 ft

Duration: 310.0 s

u Min: 12.7 m

u Max: 74.8 m

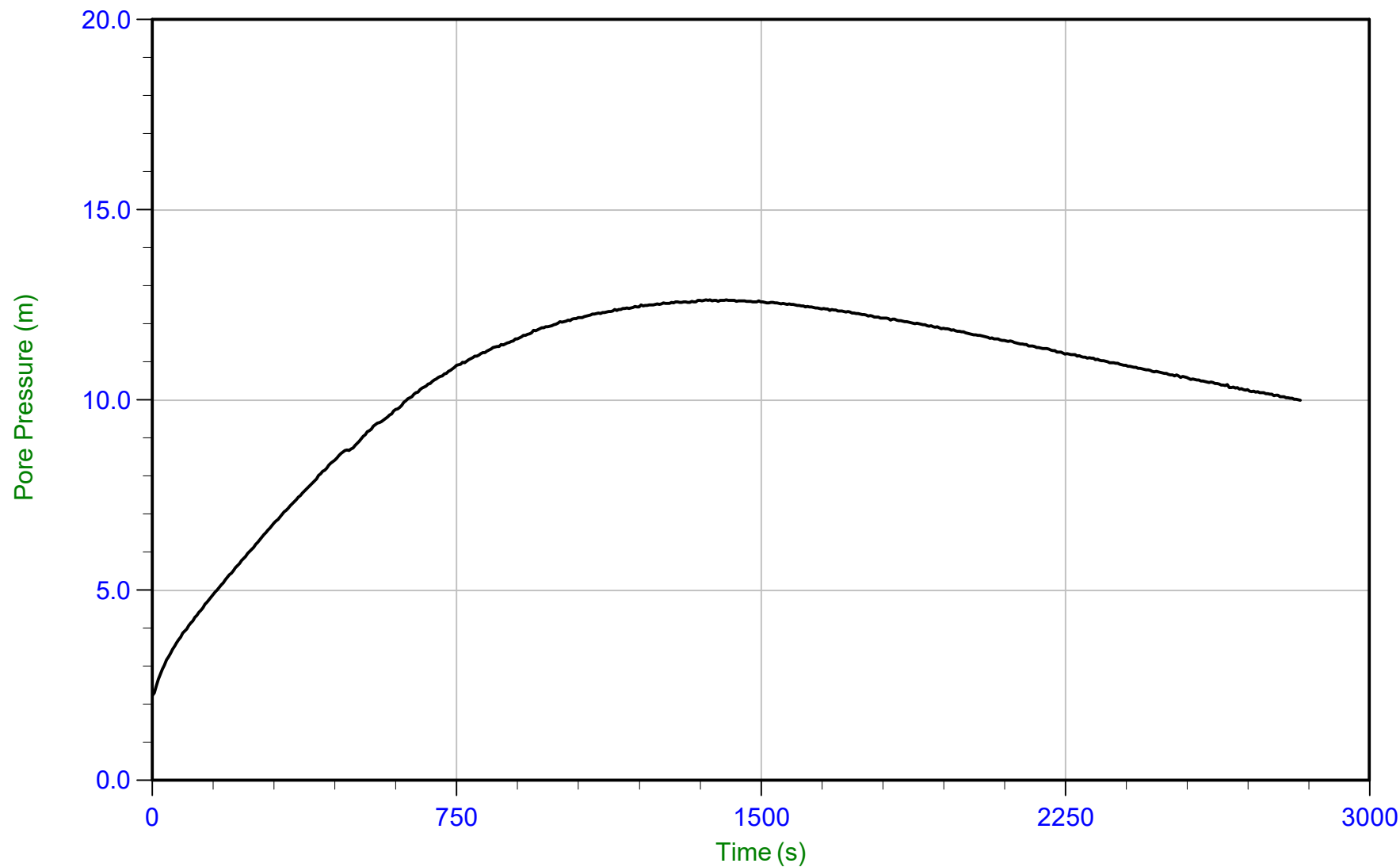
u Final: 71.9 m



Thurber

Job No: 20-05-21632
Date: 11/27/2020 12:20
Site: Highway 11/Government Road

Sounding: SCPT20-02
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-02.PPF
Depth: 7.000 m / 22.966 ft
Duration: 2830.0 s

u Min: 2.2 m
u Max: 12.6 m
u Final: 10.0 m



Thurber

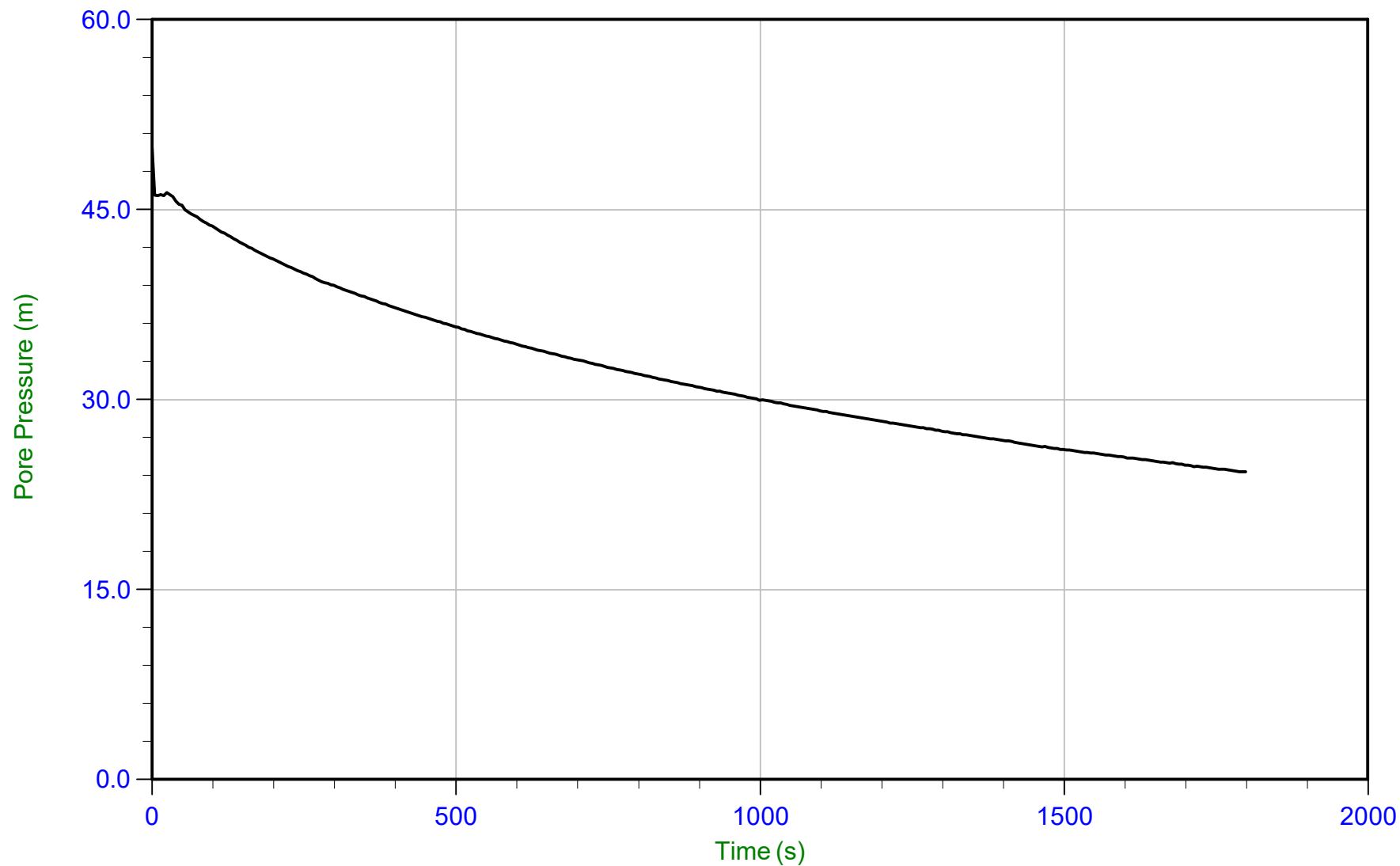
Job No: 20-05-21632

Date: 11/27/2020 12:20

Site: Highway 11/Government Road

Sounding: SCPT20-02

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-02.PPF

Depth: 10.670 m / 35.006 ft

Duration: 1800.0 s

u Min: 24.3 m

u Max: 49.9 m

u Final: 24.3 m

WT: 1.500 m / 4.921 ft

Ueq: 9.2 m

U(50): 29.52 m

T(50): 1054.4 s

Ir: 100

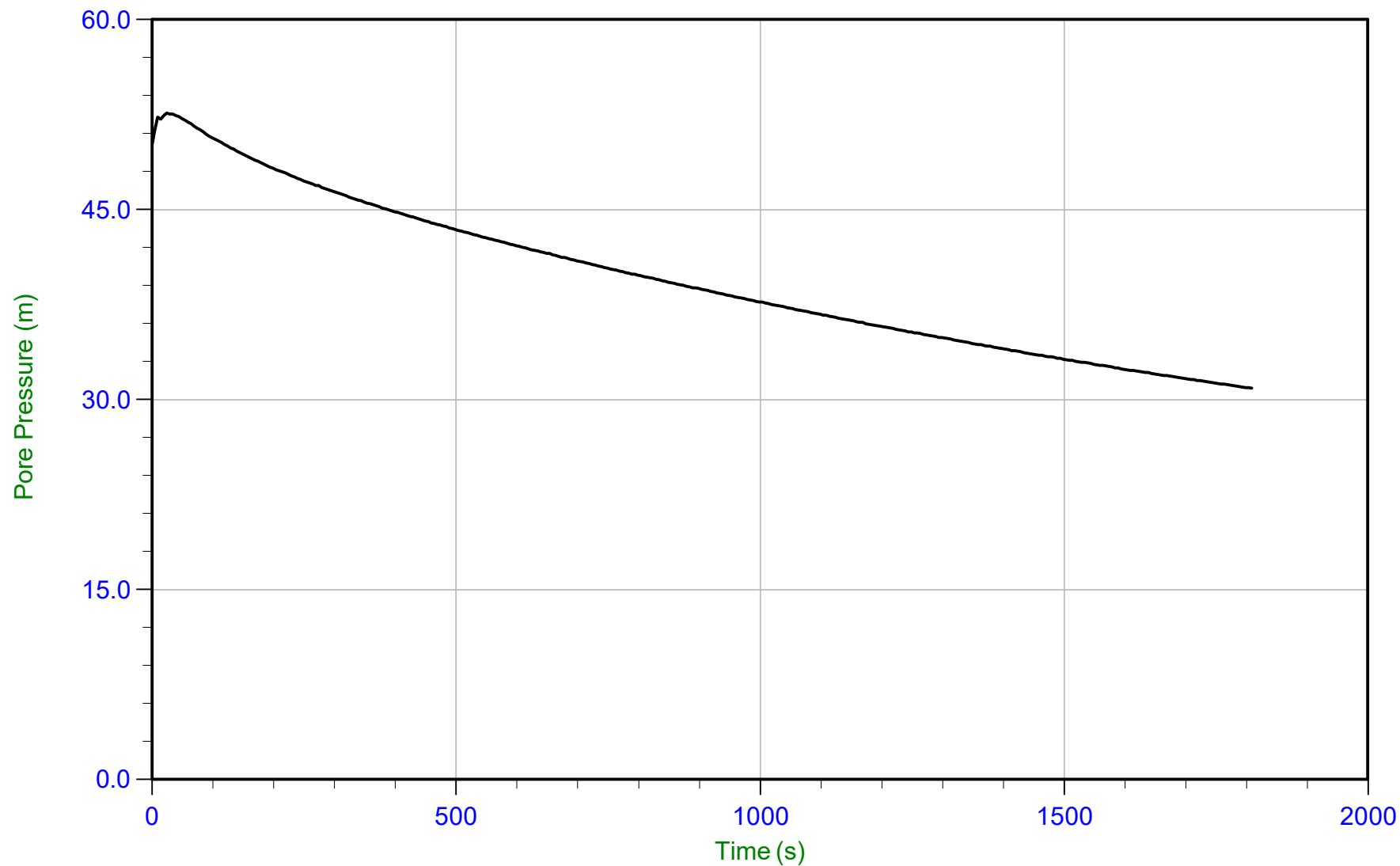
Ch: 0.4 cm²/min



Thurber

Job No: 20-05-21632
Date: 11/27/2020 12:20
Site: Highway 11/Government Road

Sounding: SCPT20-02
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-02.PPF
Depth: 14.330 m / 47.014 ft
Duration: 1810.0 s

u Min: 30.9 m
u Max: 52.6 m
u Final: 30.9 m

WT: 1.500 m / 4.921 ft
Ueq: 12.8 m
U(50): 32.72 m

T(50): 1533.5 s
Ir: 100
Ch: 0.3 cm²/min



Thurber

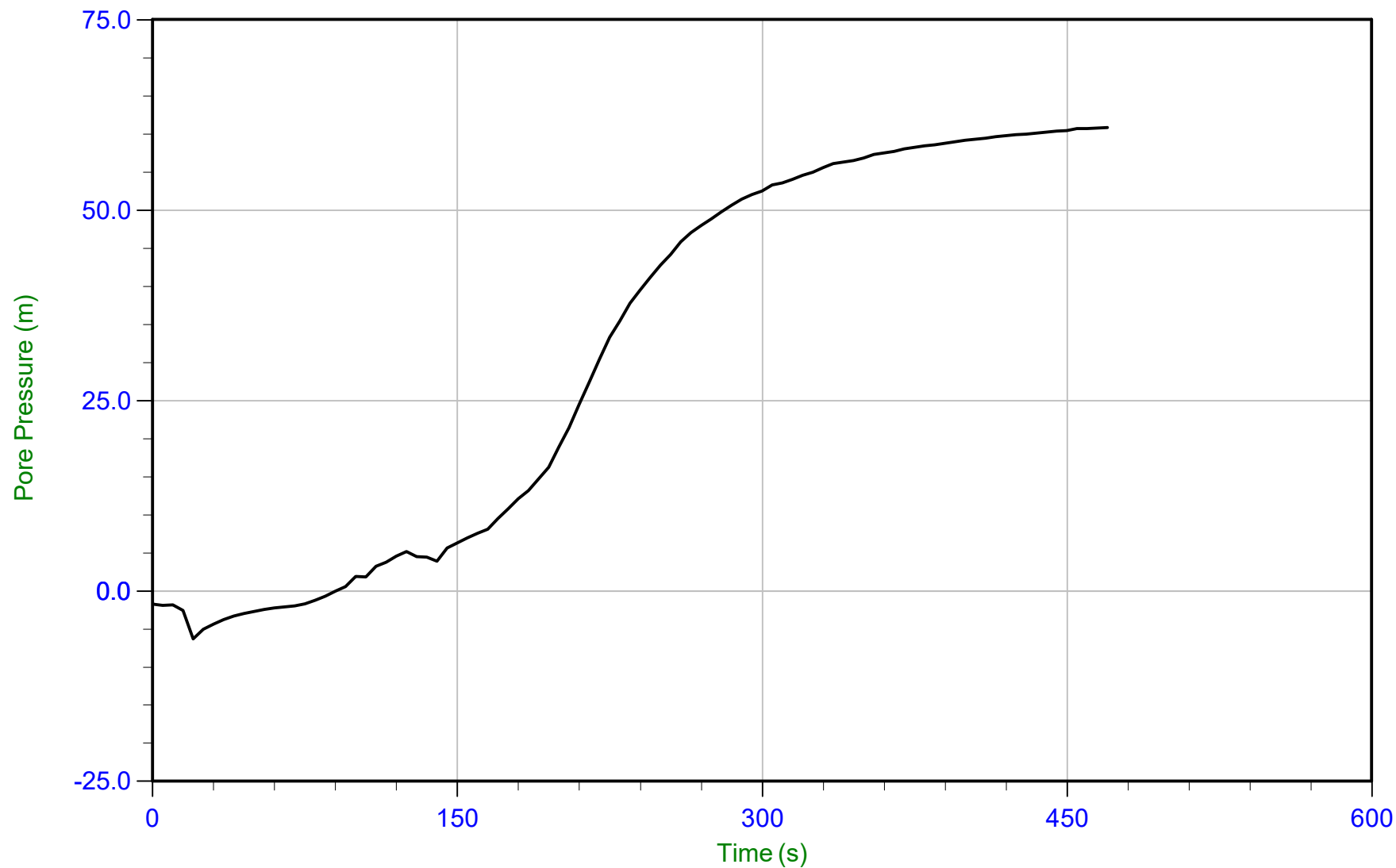
Job No: 20-05-21632

Date: 11/27/2020 12:20

Site: Highway 11/Government Road

Sounding: SCPT20-02

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-02.PPF

Depth: 17.040 m / 55.905 ft

Duration: 470.0 s

u Min: -6.3 m

u Max: 60.8 m

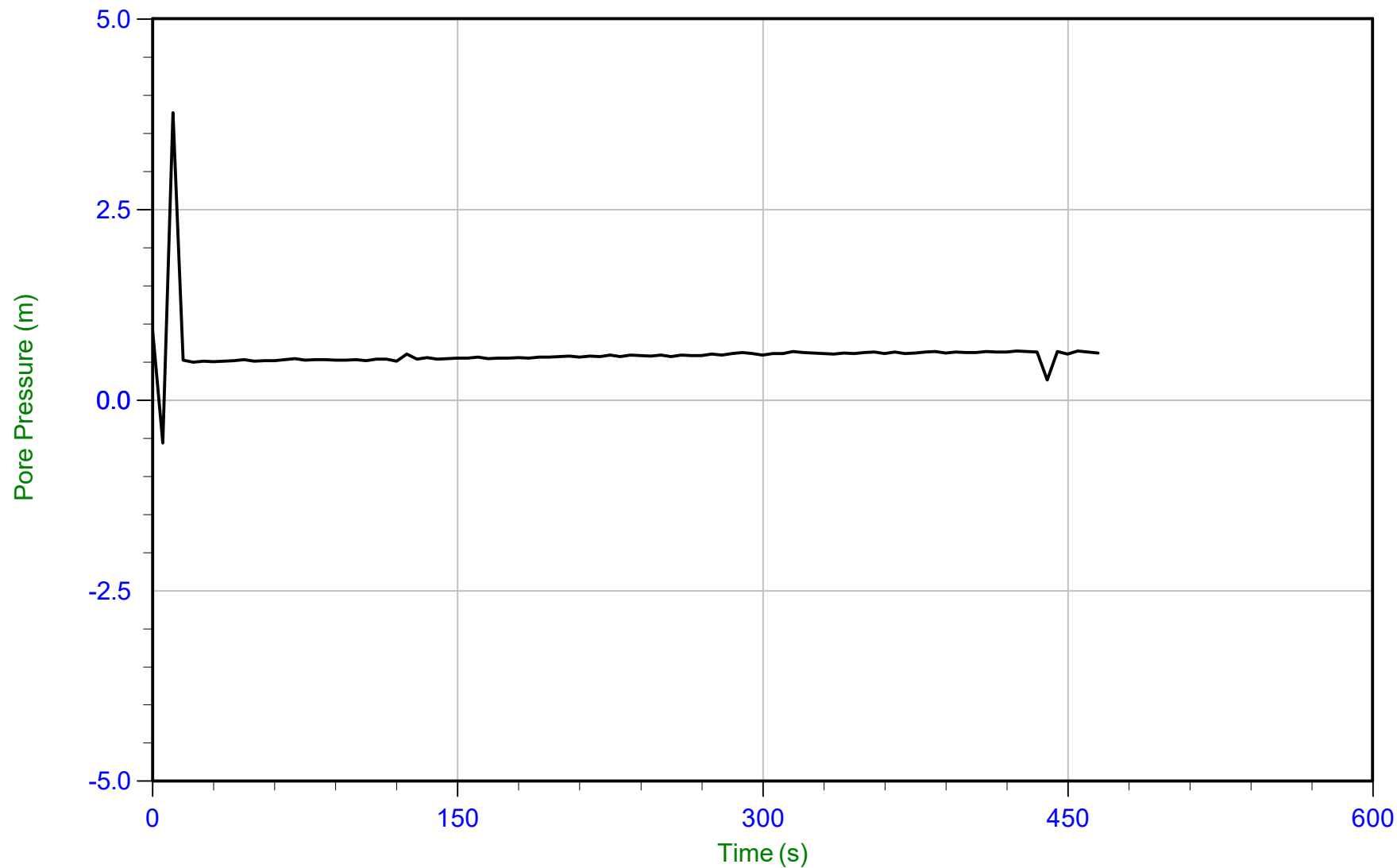
u Final: 60.8 m



Thurber

Job No: 20-05-21632
Date: 11/24/2020 10:20
Site: Highway 11/Government Road

Sounding: SCPT20-03
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03.PPF
Depth: 0.480 m / 1.575 ft
Duration: 465.0 s

u Min: -0.6 m
u Max: 3.8 m
u Final: 0.6 m

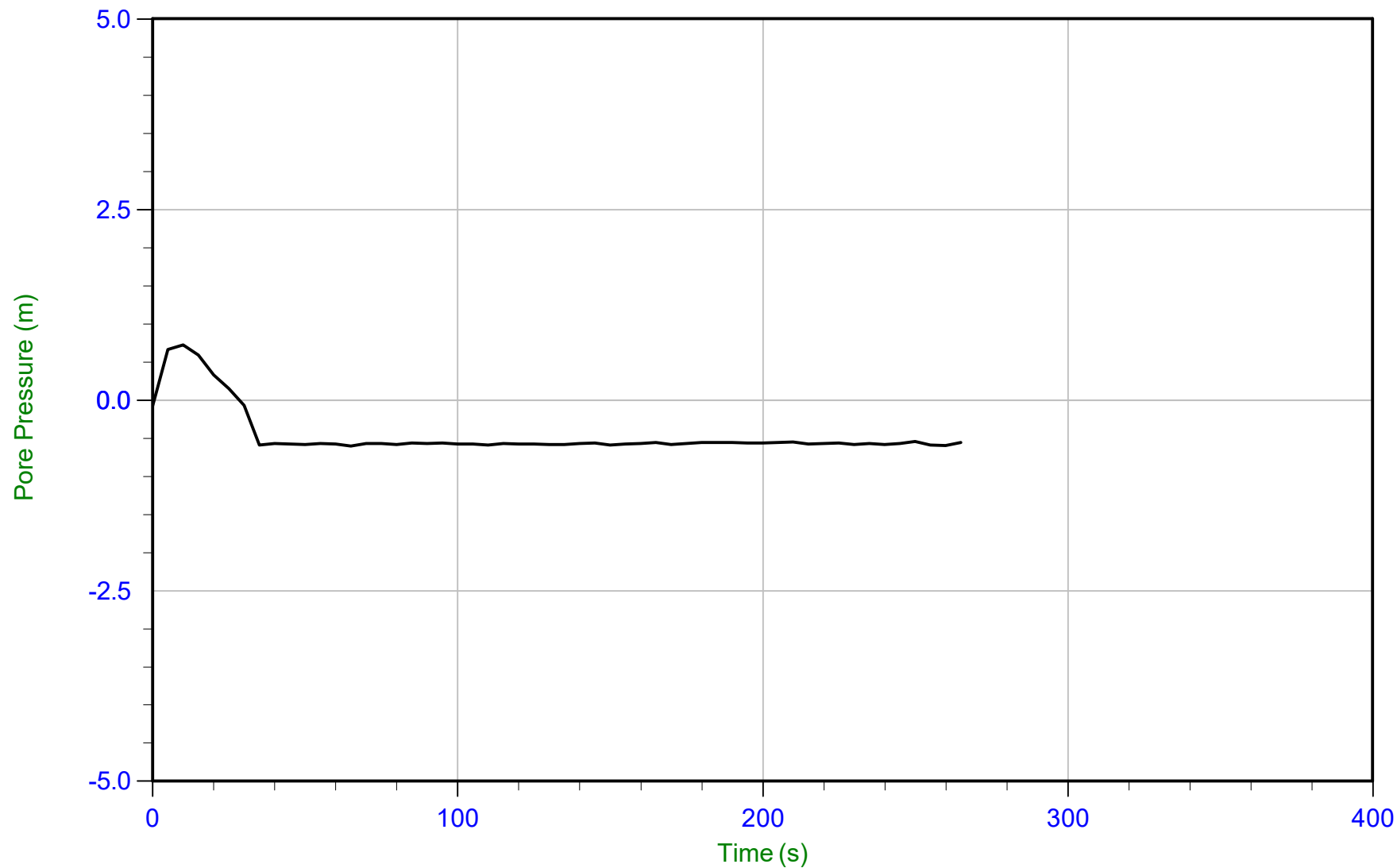
WT: 0.480 m / 1.575 ft
Ueq: 0.0 m



Thurber

Job No: 20-05-21632
Date: 11/24/2020 10:20
Site: Highway 11/Government Road

Sounding: SCPT20-03
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03.PPF
Depth: 2.000 m / 6.562 ft
Duration: 265.0 s

u Min: -0.6 m
u Max: 0.7 m
u Final: -0.6 m

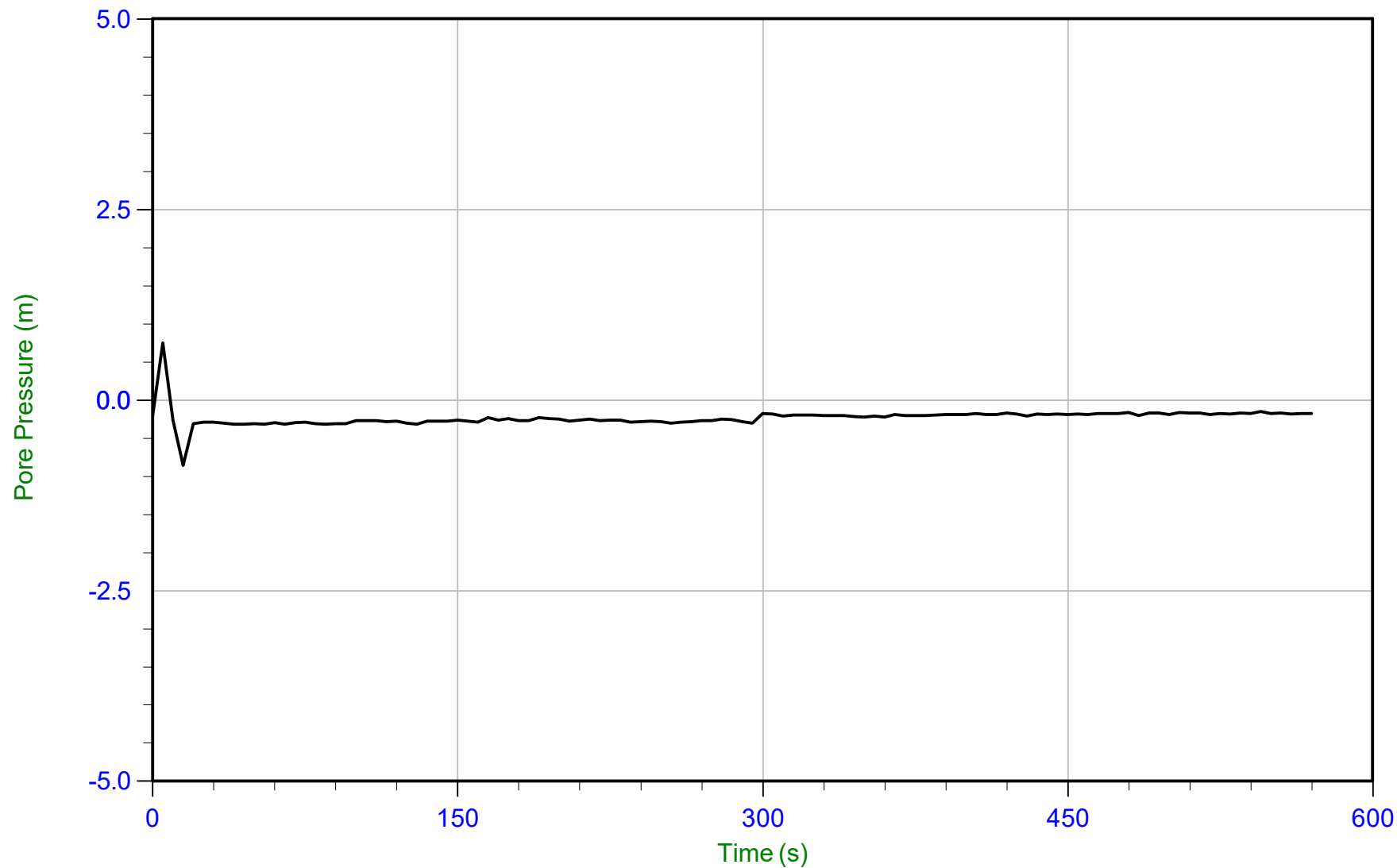
WT: 2.000 m / 6.562 ft
Ueq: 0.0 m



Thurber

Job No: 20-05-21632
Date: 11/24/2020 10:20
Site: Highway 11/Government Road

Sounding: SCPT20-03
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03.PPF
Depth: 4.350 m / 14.271 ft
Duration: 570.0 s

u Min: -0.9 m
u Max: 0.8 m
u Final: -0.2 m

WT: 4.350 m / 14.271 ft
Ueq: 0.0 m



Thurber

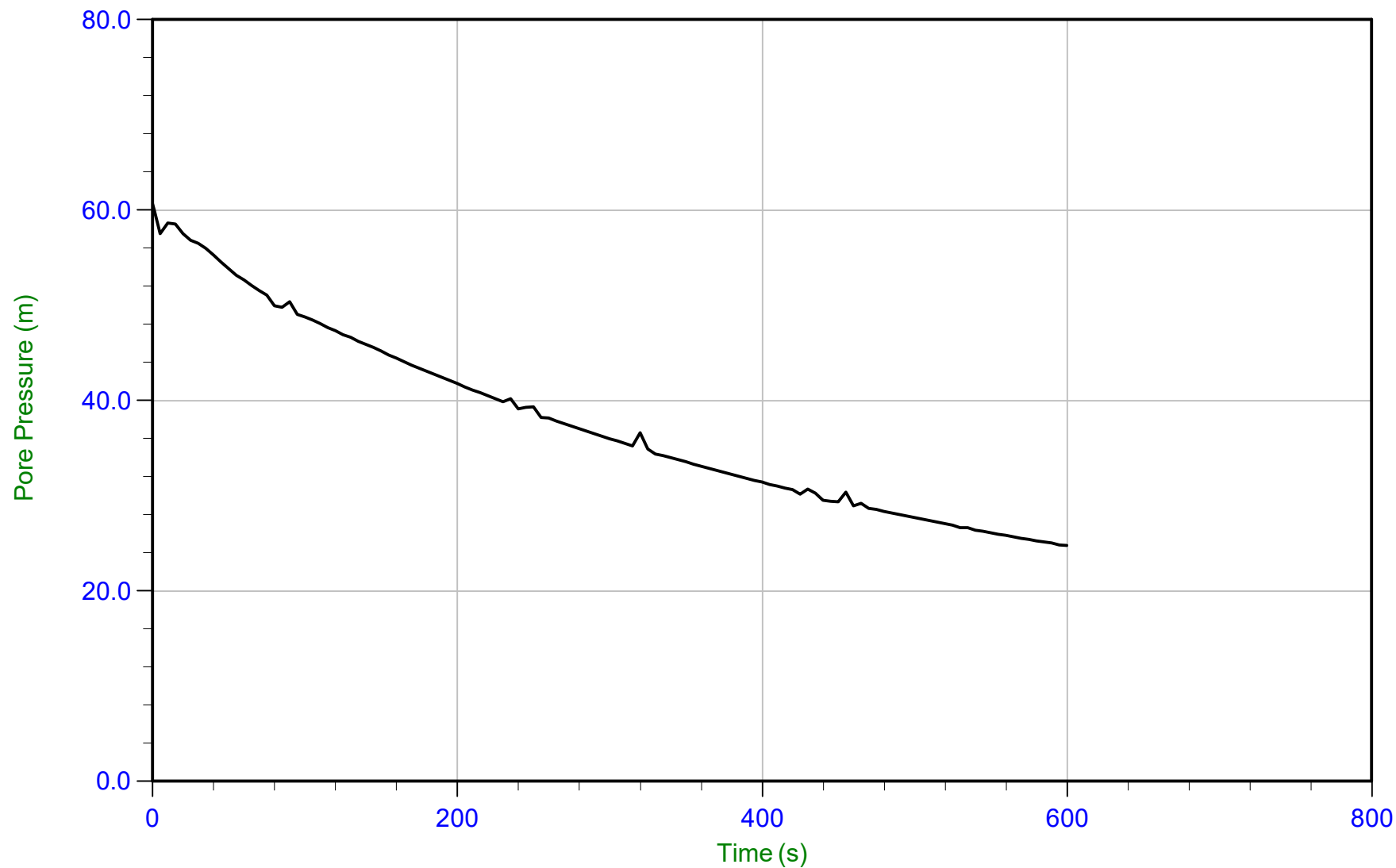
Job No: 20-05-21632

Date: 11/26/2020 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03B.PPF

Depth: 12.500 m / 41.010 ft

Duration: 600.0 s

u Min: 24.8 m

u Max: 60.7 m

u Final: 24.8 m

WT: 7.000 m / 22.966 ft

Ueq: 5.5 m

U(50): 33.09 m

T(50): 360.3 s

Ir: 100

Ch: 1.3 cm²/min



Thurber

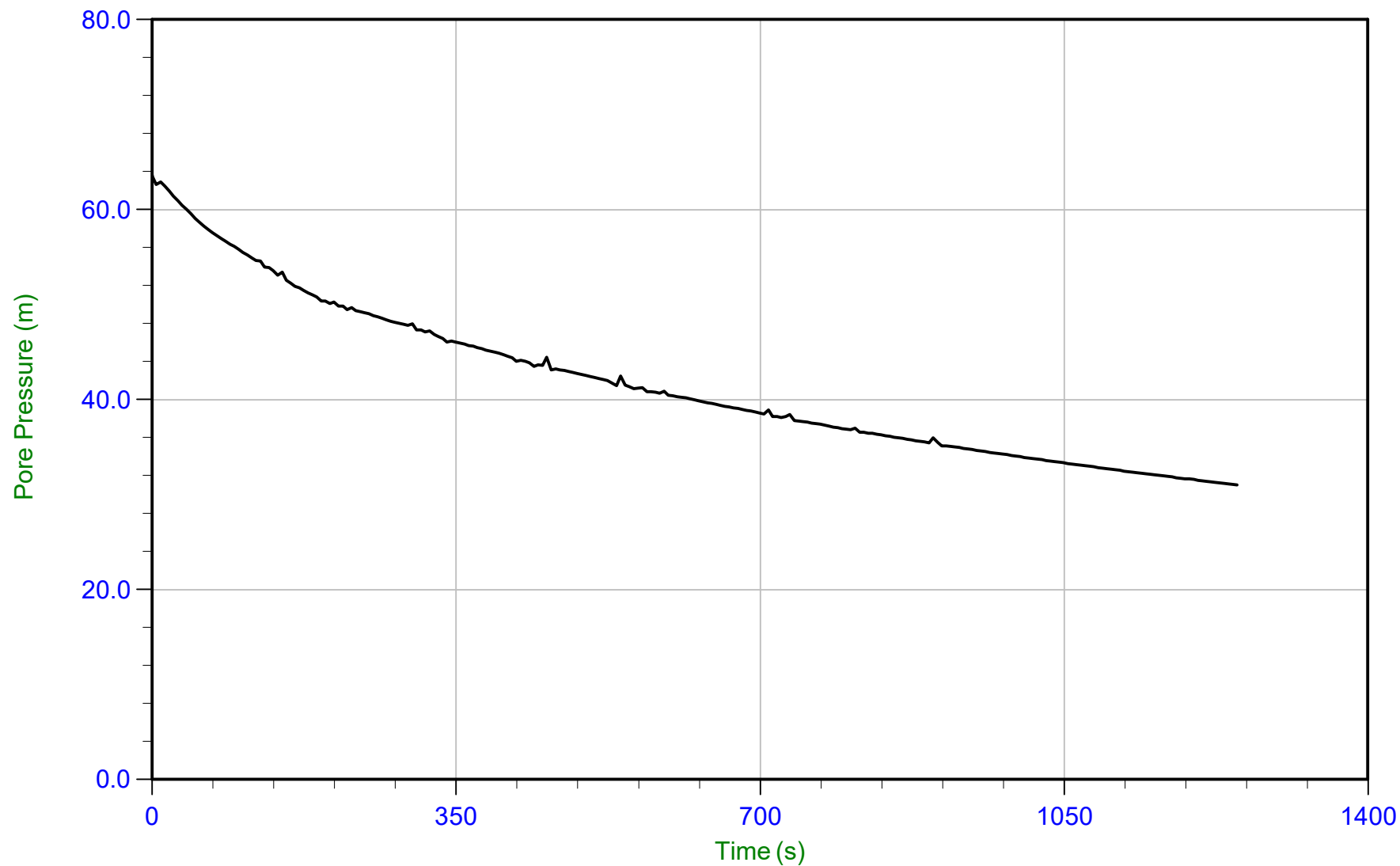
Job No: 20-05-21632

Date: 11/26/2020 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03B.PPF

Depth: 15.550 m / 51.016 ft

Duration: 1250.0 s

u Min: 31.0 m

u Max: 63.7 m

u Final: 31.0 m

WT: 7.000 m / 22.966 ft

Ueq: 8.6 m

U(50): 36.10 m

T(50): 850.7 s

Ir: 100

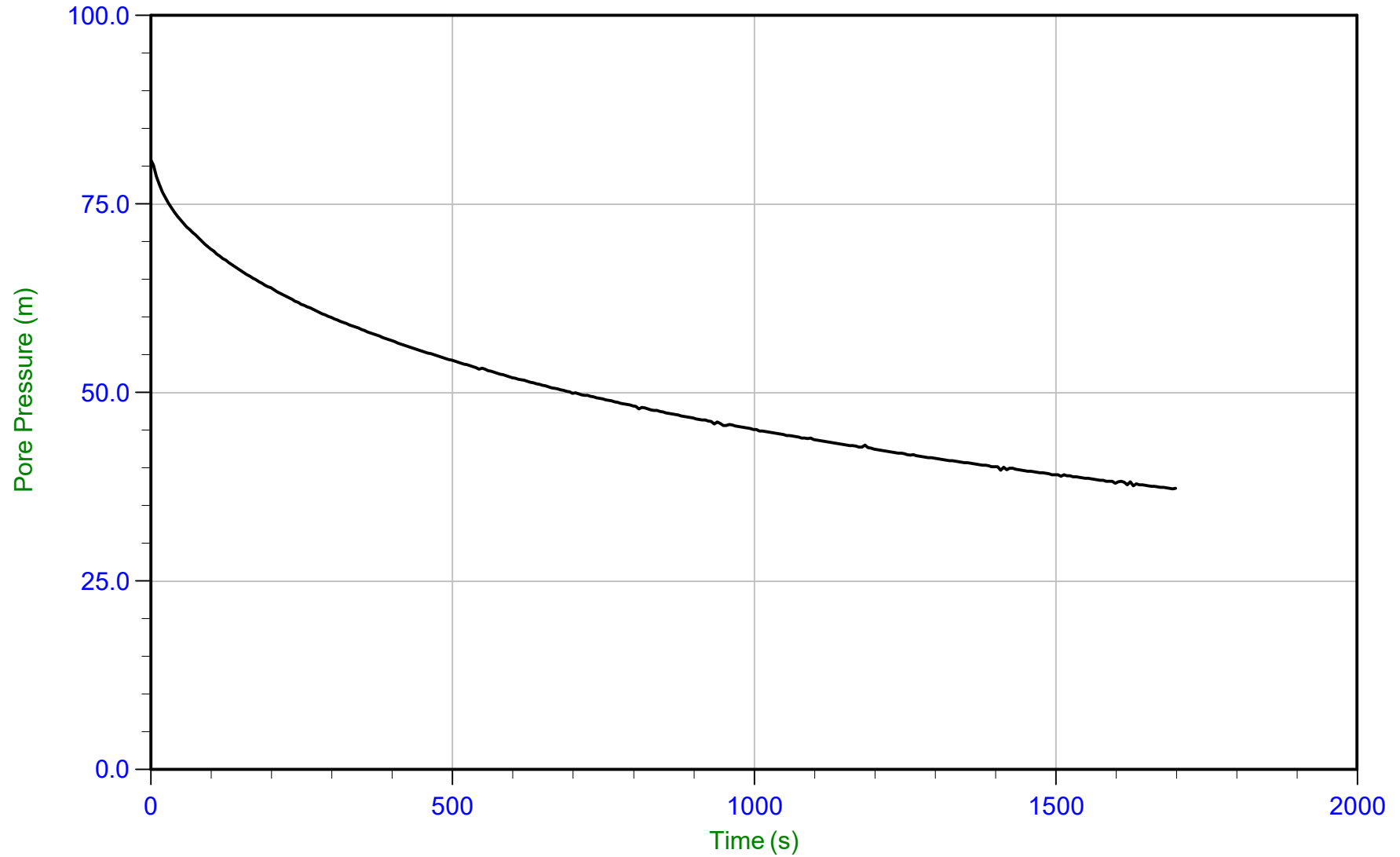
Ch: 0.6 cm²/min



Thurber

Job No: 20-05-21632
Date: 11/26/2020 08:50
Site: Highway 11/Government Road

Sounding: SCPT20-03B
Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03B.PPF
Depth: 18.600 m / 61.023 ft
Duration: 1700.0 s

u Min: 37.3 m
u Max: 80.9 m
u Final: 37.3 m

WT: 7.000 m / 22.966 ft
Ueq: 11.6 m
U(50): 46.23 m

T(50): 926.4 s
Ir: 100
Ch: 0.5 cm²/min



Thurber

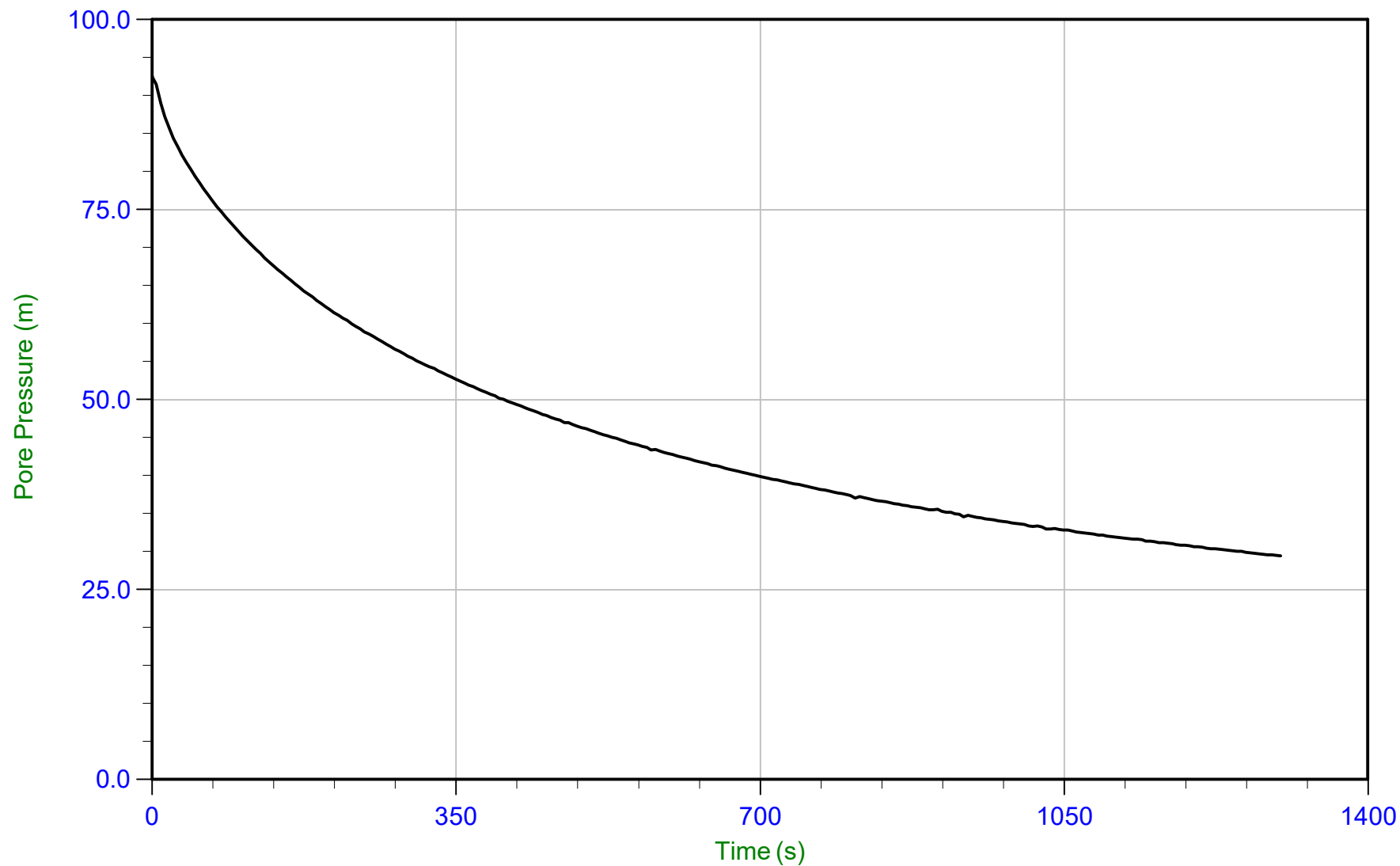
Job No: 20-05-21632

Date: 11/26/2020 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03B.PPF

Depth: 21.650 m / 71.029 ft

Duration: 1300.0 s

u Min: 29.4 m

u Max: 92.6 m

u Final: 29.4 m

WT: 7.000 m / 22.966 ft

Ueq: 14.7 m

U(50): 53.63 m

T(50): 332.6 s

Ir: 100

Ch: 1.4 cm²/min



Thurber

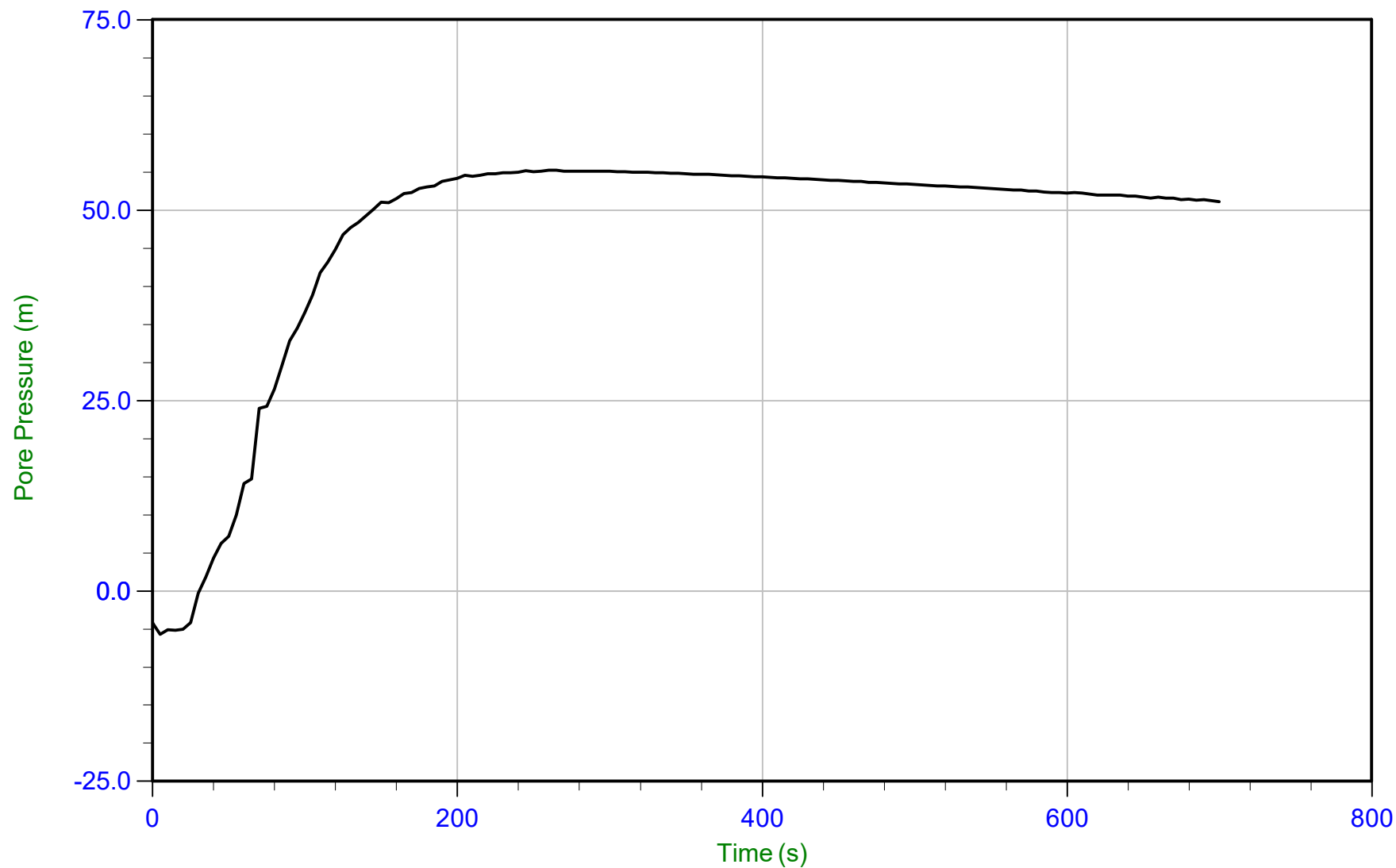
Job No: 20-05-21632

Date: 11/26/2020 08:50

Site: Highway 11/Government Road

Sounding: SCPT20-03B

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-03B.PPF

Depth: 24.700 m / 81.036 ft

Duration: 700.0 s

u Min: -5.7 m

u Max: 55.2 m

u Final: 51.1 m



Thurber

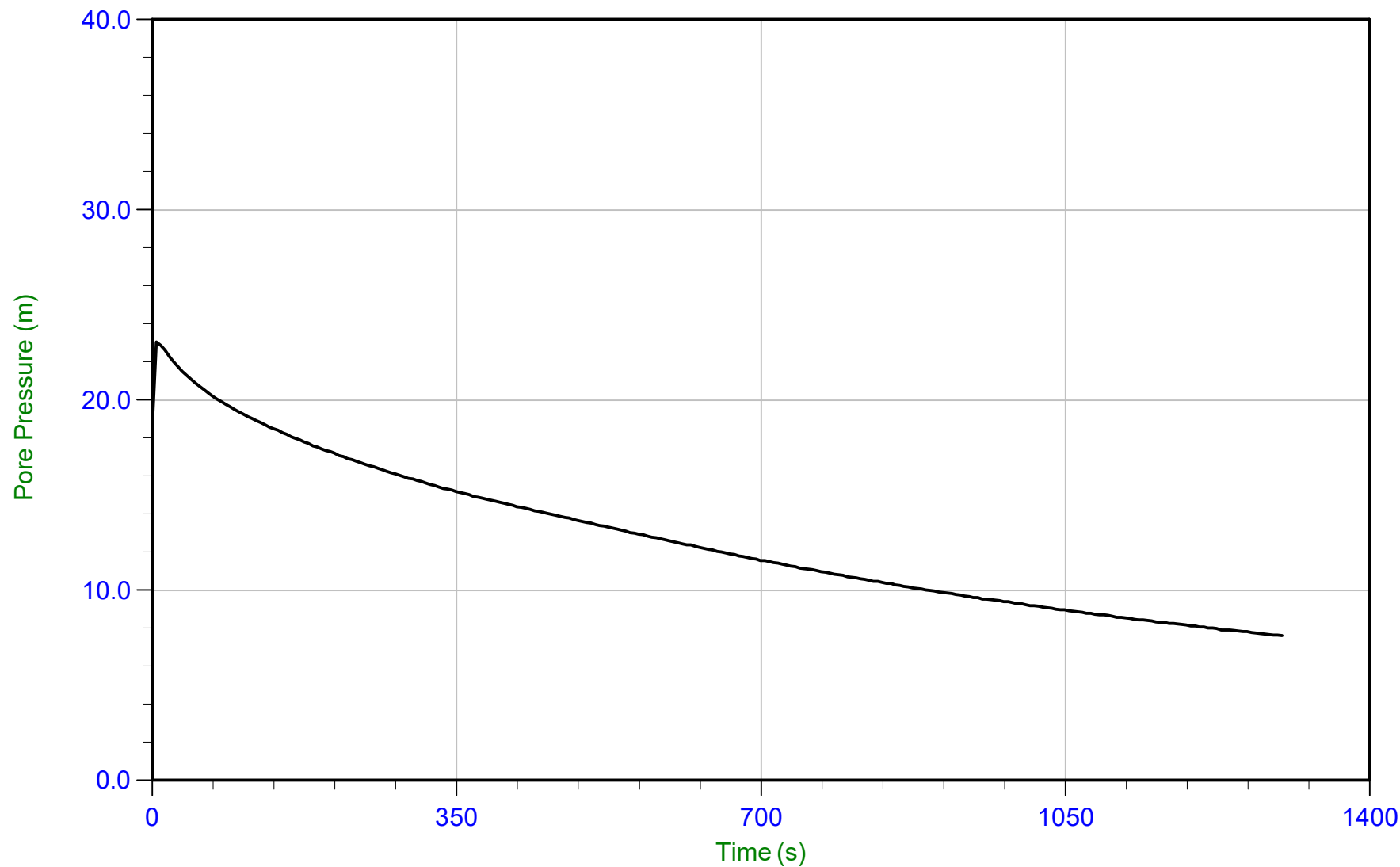
Job No: 20-05-21632

Date: 11/26/2020 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-04.PPF

Depth: 2.700 m / 8.858 ft

Duration: 1300.0 s

u Min: 7.6 m

u Max: 23.1 m

u Final: 7.6 m

WT: 1.500 m / 4.921 ft

Ueq: 1.2 m

U(50): 12.13 m

T(50): 637.2 s

Ir: 100

Ch: 0.7 cm²/min



Thurber

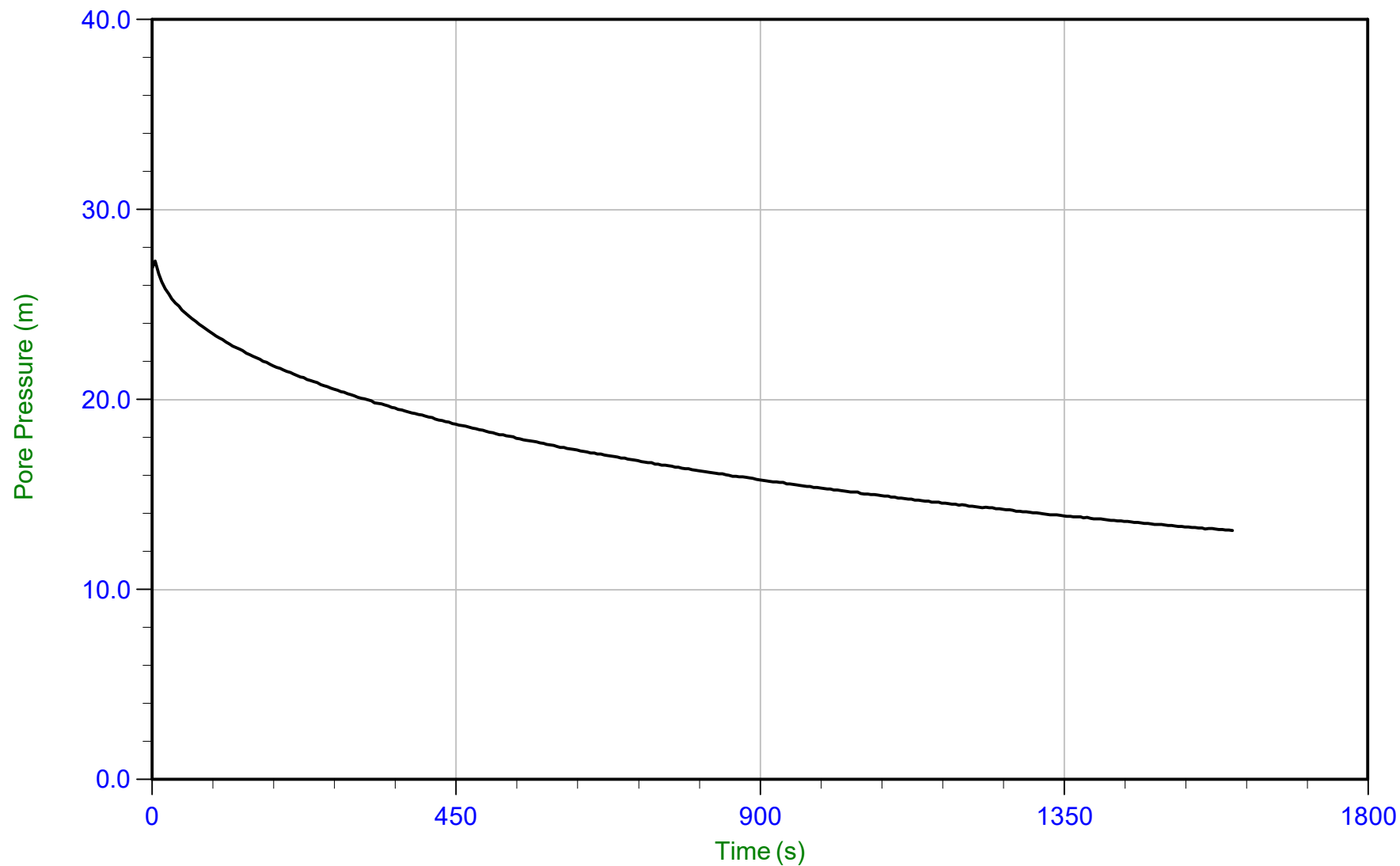
Job No: 20-05-21632

Date: 11/26/2020 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-04.PPF

Depth: 4.270 m / 14.009 ft

Duration: 1600.0 s

u Min: 13.1 m

u Max: 27.3 m

u Final: 13.1 m

WT: 1.500 m / 4.921 ft

Ueq: 2.8 m

U(50): 15.03 m

T(50): 1055.4 s

Ir: 100

Ch: 0.4 cm²/min



Thurber

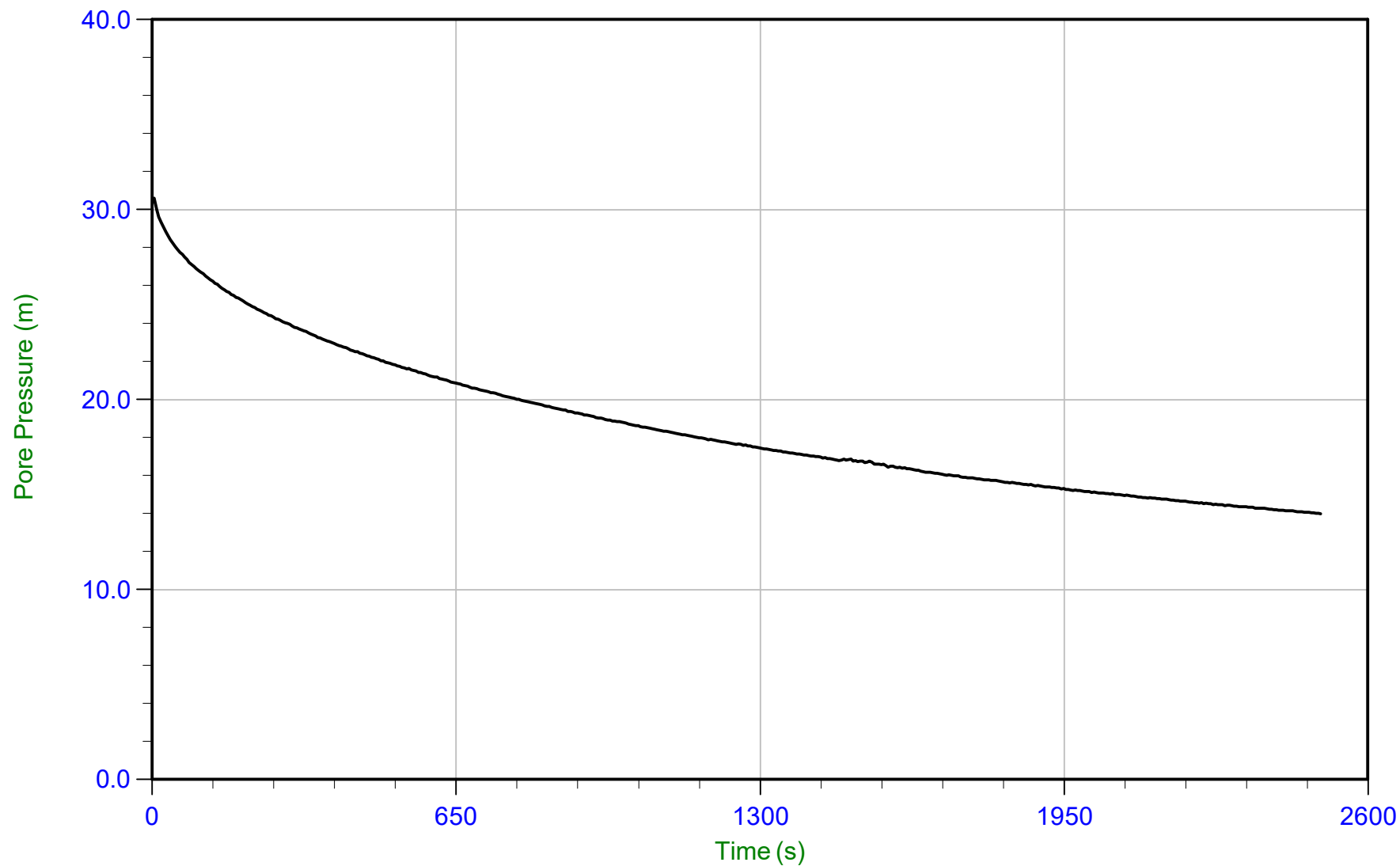
Job No: 20-05-21632

Date: 11/26/2020 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-04.PPF

Depth: 6.200 m / 20.341 ft

Duration: 2500.0 s

u Min: 14.0 m

u Max: 30.6 m

u Final: 14.0 m

WT: 1.500 m / 4.921 ft

Ueq: 4.7 m

U(50): 17.66 m

T(50): 1243.7 s

Ir: 100

Ch: 0.4 cm²/min



Thurber

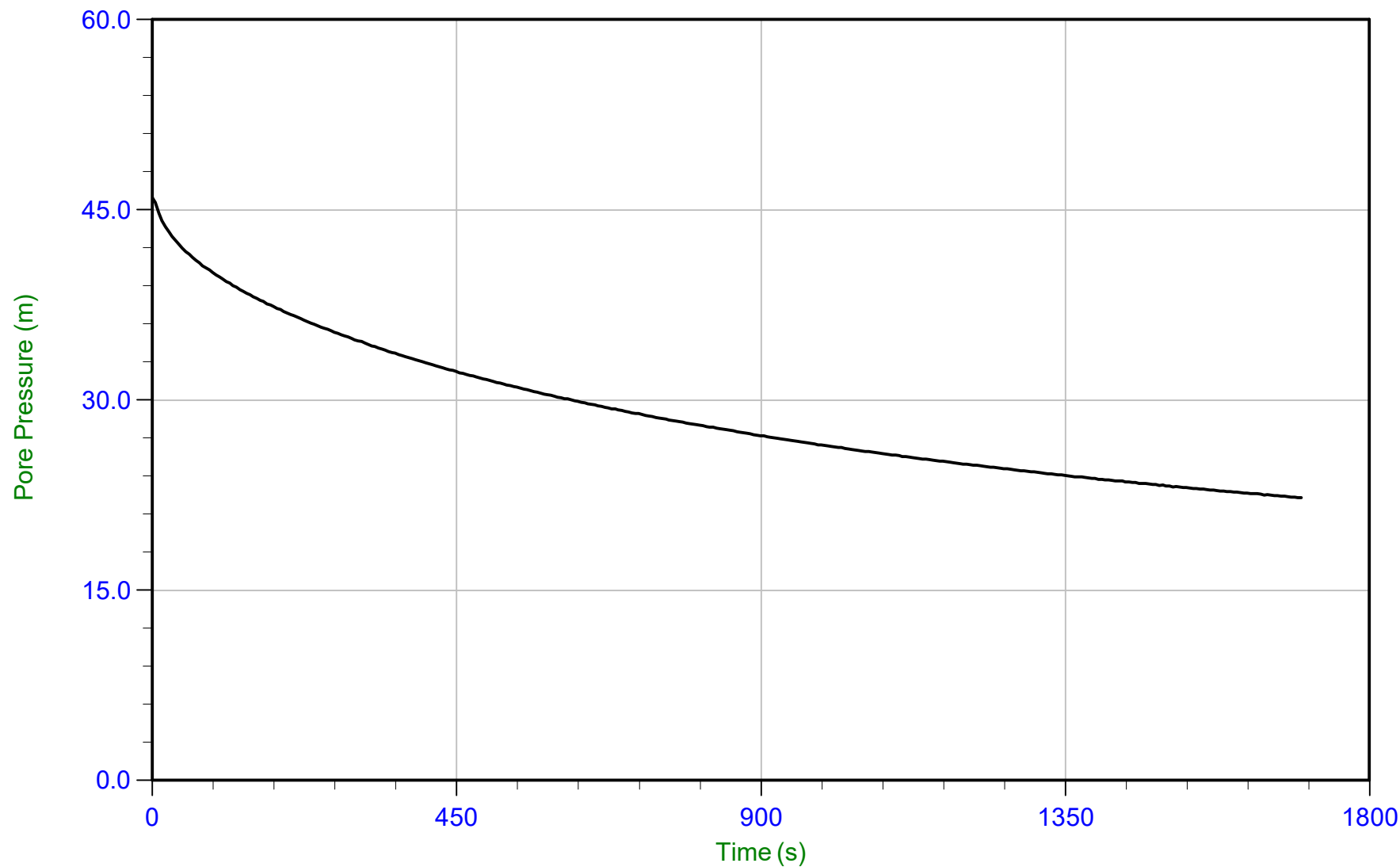
Job No: 20-05-21632

Date: 11/26/2020 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-04.PPF

Depth: 10.400 m / 34.120 ft

Duration: 1700.0 s

u Min: 22.3 m

u Max: 46.0 m

u Final: 22.3 m

WT: 1.500 m / 4.921 ft

Ueq: 8.9 m

U(50): 27.43 m

T(50): 873.3 s

Ir: 100

Ch: 0.5 cm²/min



Thurber

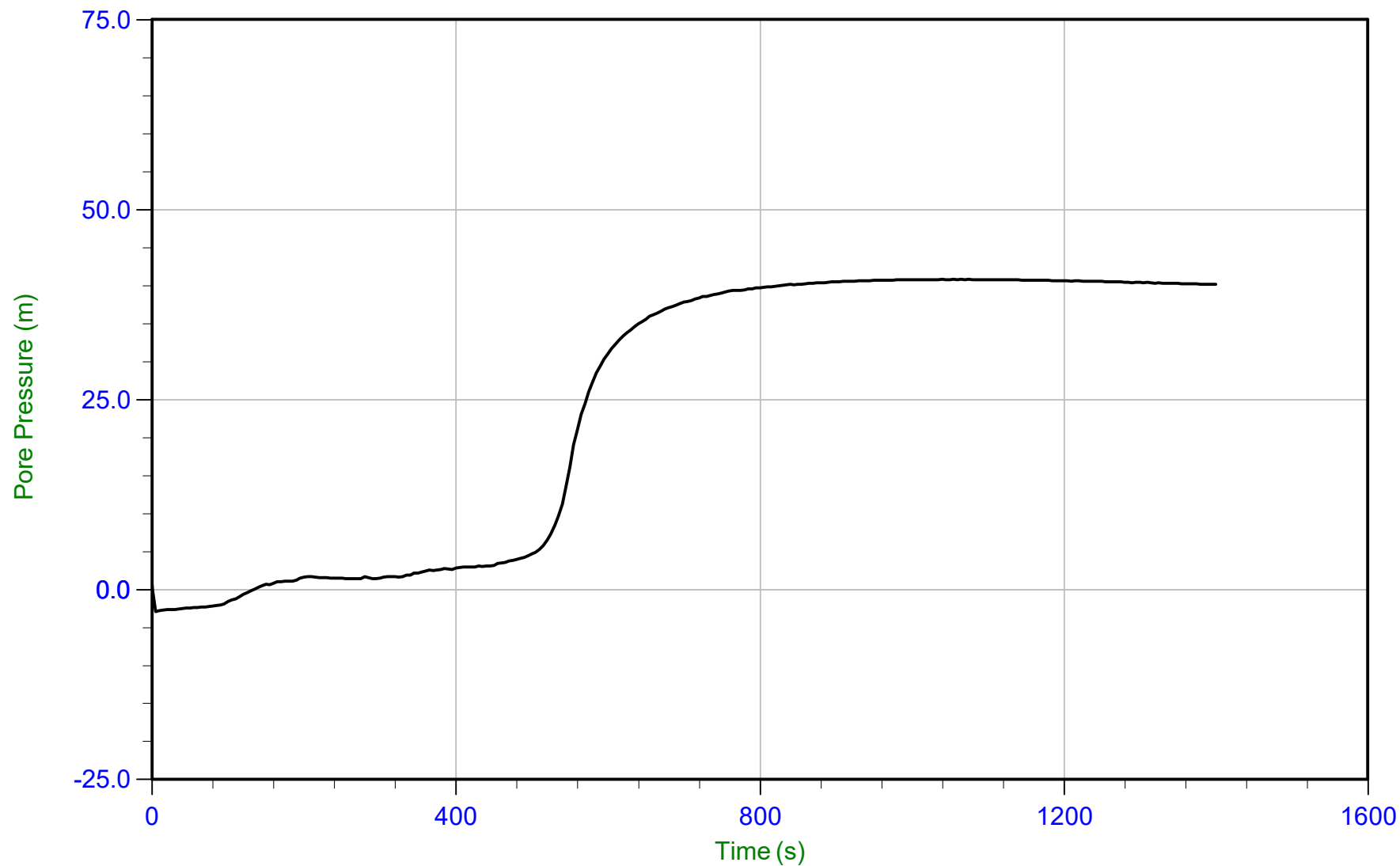
Job No: 20-05-21632

Date: 11/26/2020 11:26

Site: Highway 11/Government Road

Sounding: SCPT20-04

Cone: 414:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-04.PPF

Depth: 15.970 m / 52.394 ft

Duration: 1400.0 s

u Min: -2.9 m

u Max: 40.8 m

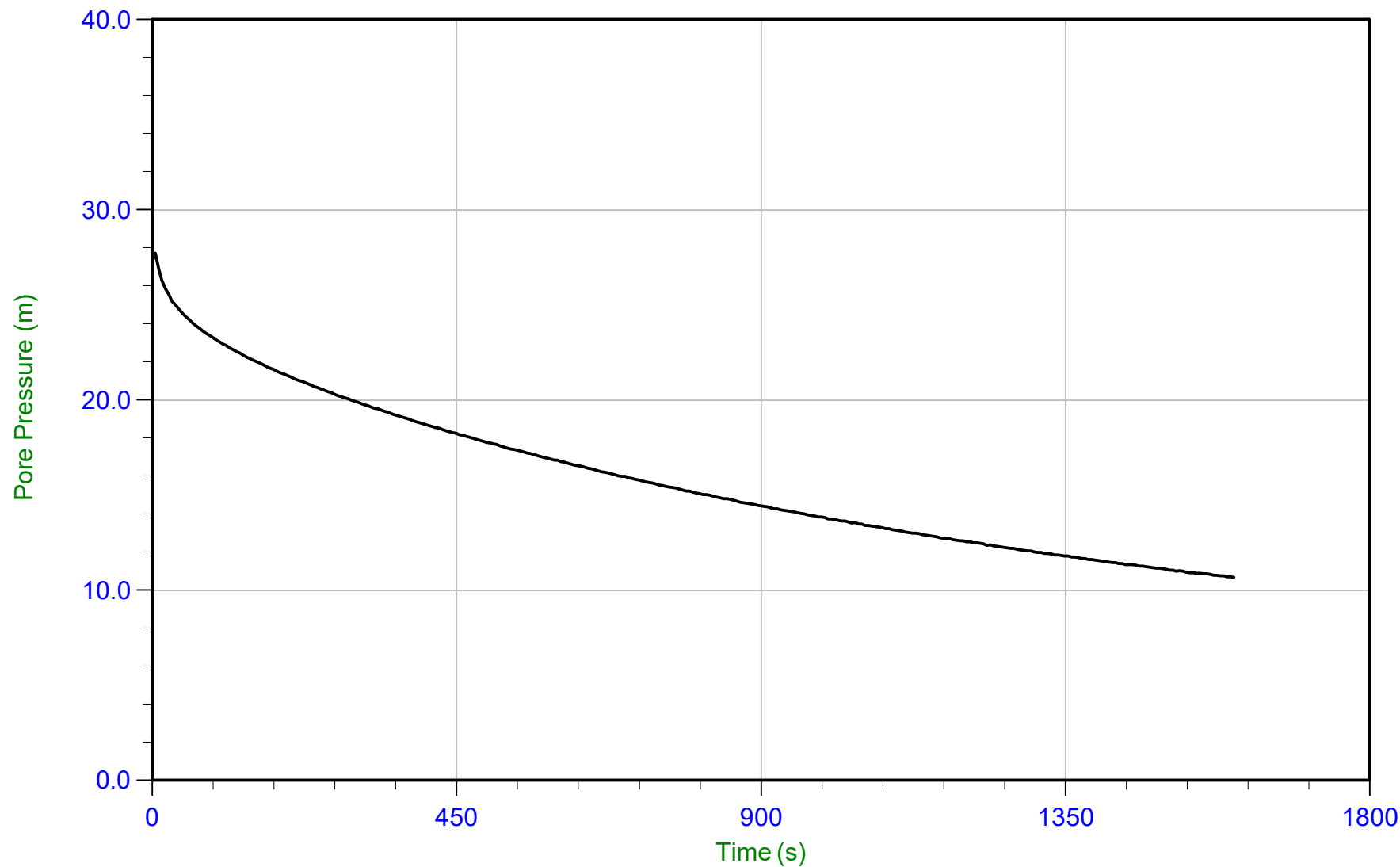
u Final: 40.1 m



Thurber

Job No: 20-05-21632
Date: 12/01/2020 11:38
Site: Highway 11/Government Road

Sounding: SCPT20-05
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-05.PPF
Depth: 4.580 m / 15.026 ft
Duration: 1600.0 s

u Min: 10.7 m
u Max: 27.7 m
u Final: 10.7 m

WT: 1.500 m / 4.921 ft
Ueq: 3.1 m
U(50): 15.41 m

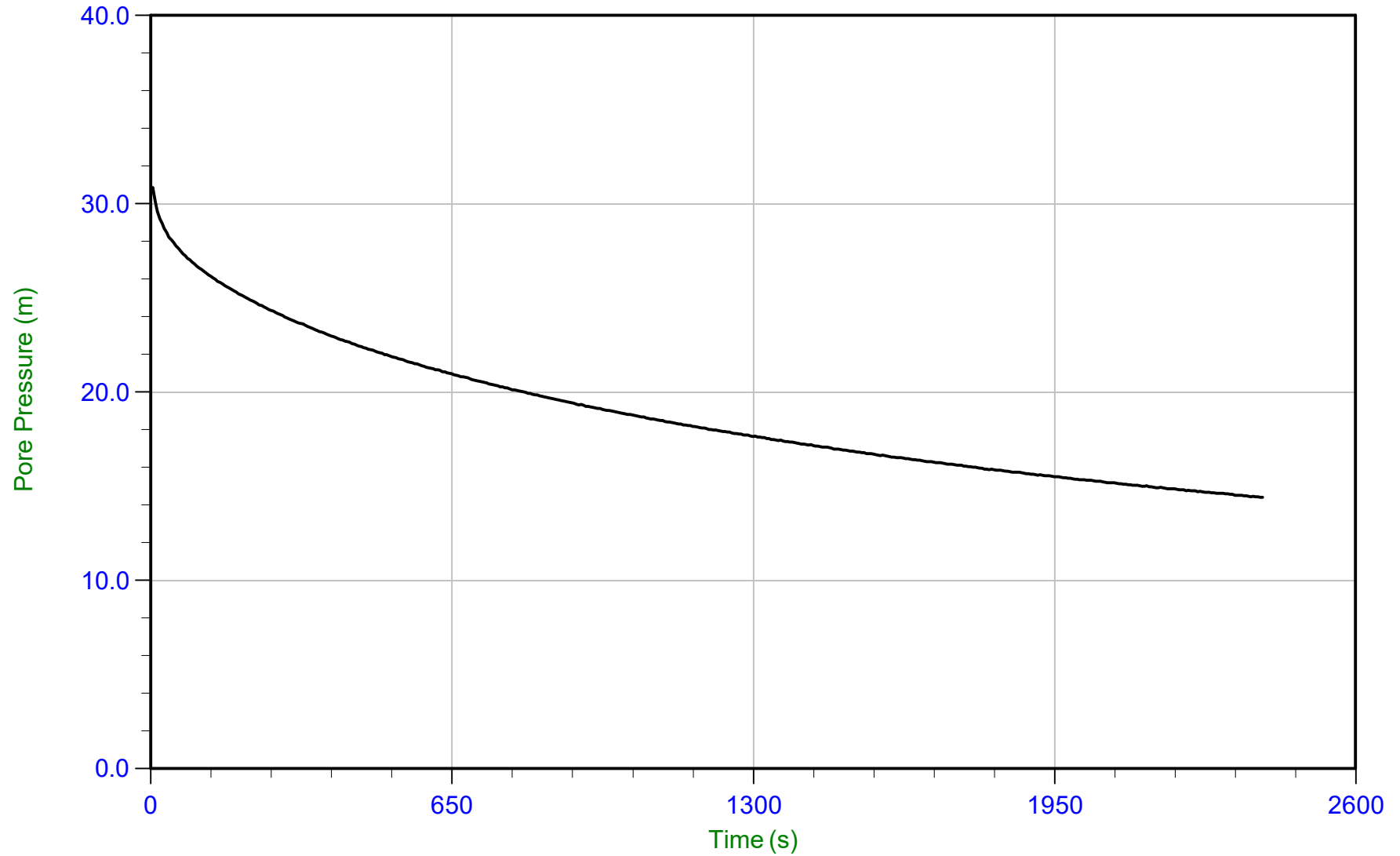
T(50): 763.5 s
Ir: 100
Ch: 0.6 cm²/min



Thurber

Job No: 20-05-21632
Date: 12/01/2020 11:38
Site: Highway 11/Government Road

Sounding: SCPT20-05
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-05.PPF
Depth: 6.710 m / 22.014 ft
Duration: 2400.0 s

u Min: 14.4 m
u Max: 30.9 m
u Final: 14.4 m

WT: 1.500 m / 4.921 ft
Ueq: 5.2 m
U(50): 18.04 m

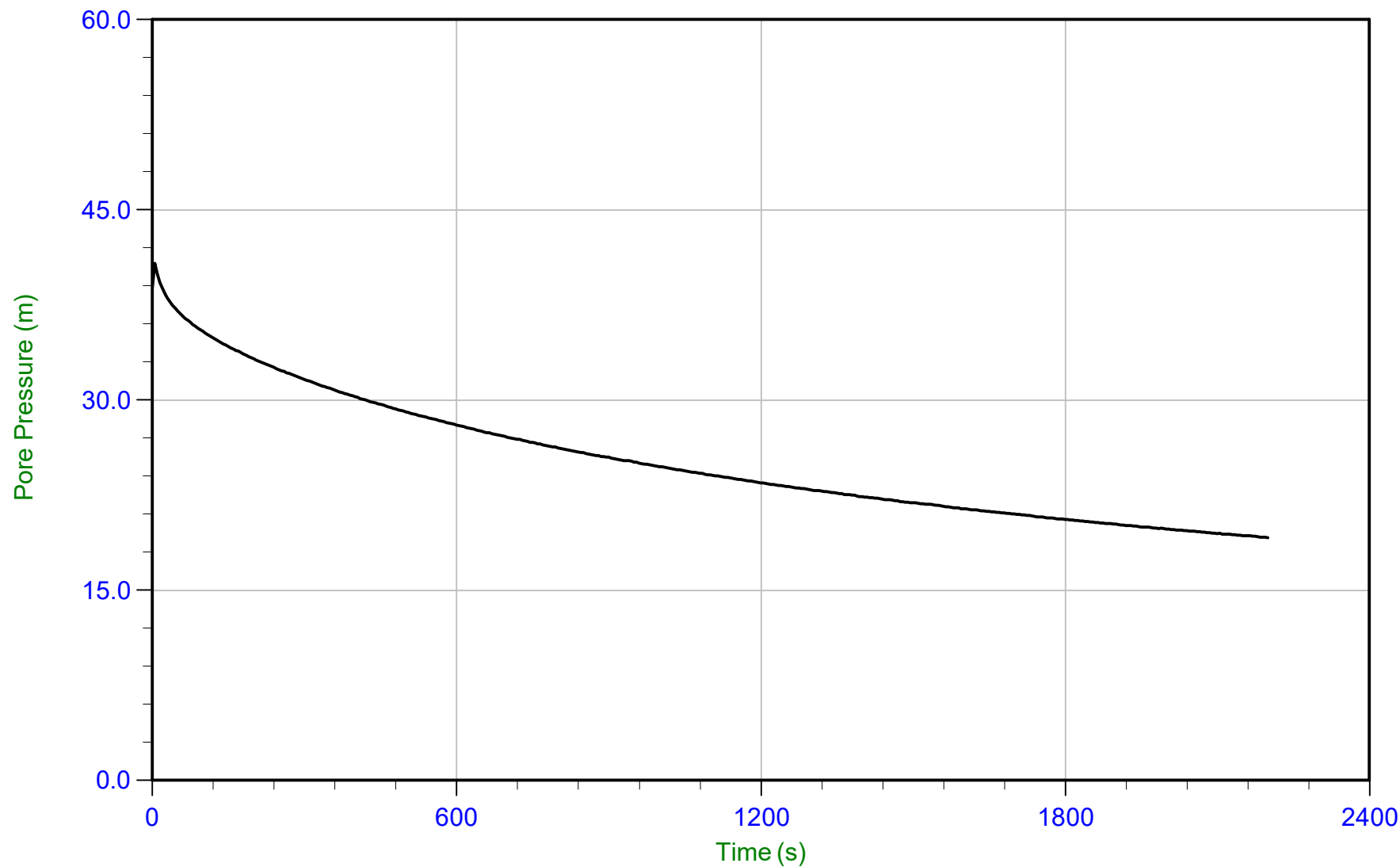
T(50): 1198.1 s
Ir: 100
Ch: 0.4 cm²/min



Thurber

Job No: 20-05-21632
Date: 12/01/2020 11:38
Site: Highway 11/Government Road

Sounding: SCPT20-05
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-05.PPF
Depth: 9.450 m / 31.004 ft
Duration: 2200.0 s

u Min: 19.1 m
u Max: 40.8 m
u Final: 19.1 m

WT: 1.500 m / 4.921 ft
Ueq: 8.0 m
U(50): 24.37 m

T(50): 1051.3 s
Ir: 100
Ch: 0.4 cm²/min



Thurber

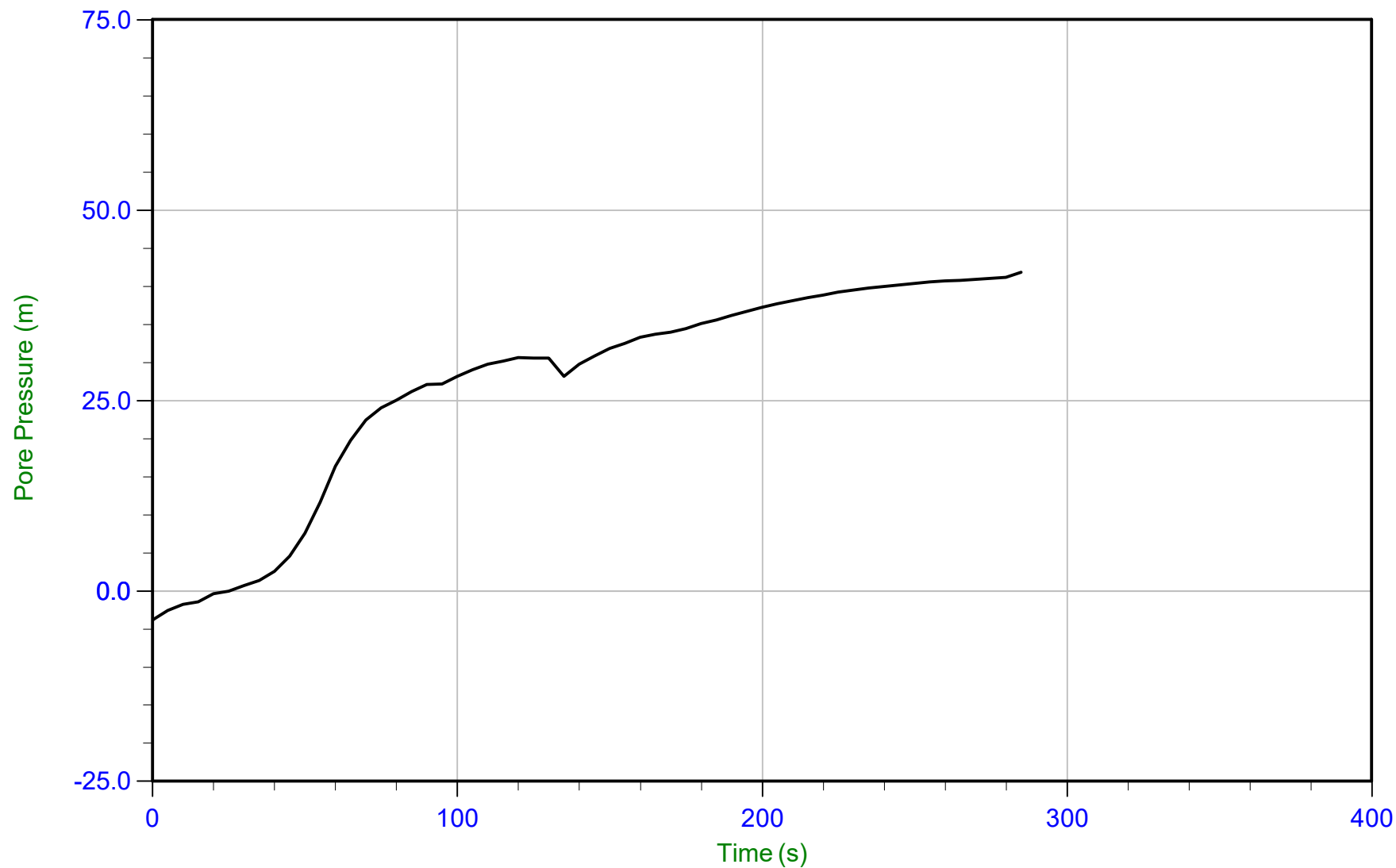
Job No: 20-05-21632

Date: 12/01/2020 11:38

Site: Highway 11/Government Road

Sounding: SCPT20-05

Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-05.PPF

Depth: 13.340 m / 43.766 ft

Duration: 285.0 s

u Min: -3.8 m

u Max: 41.9 m

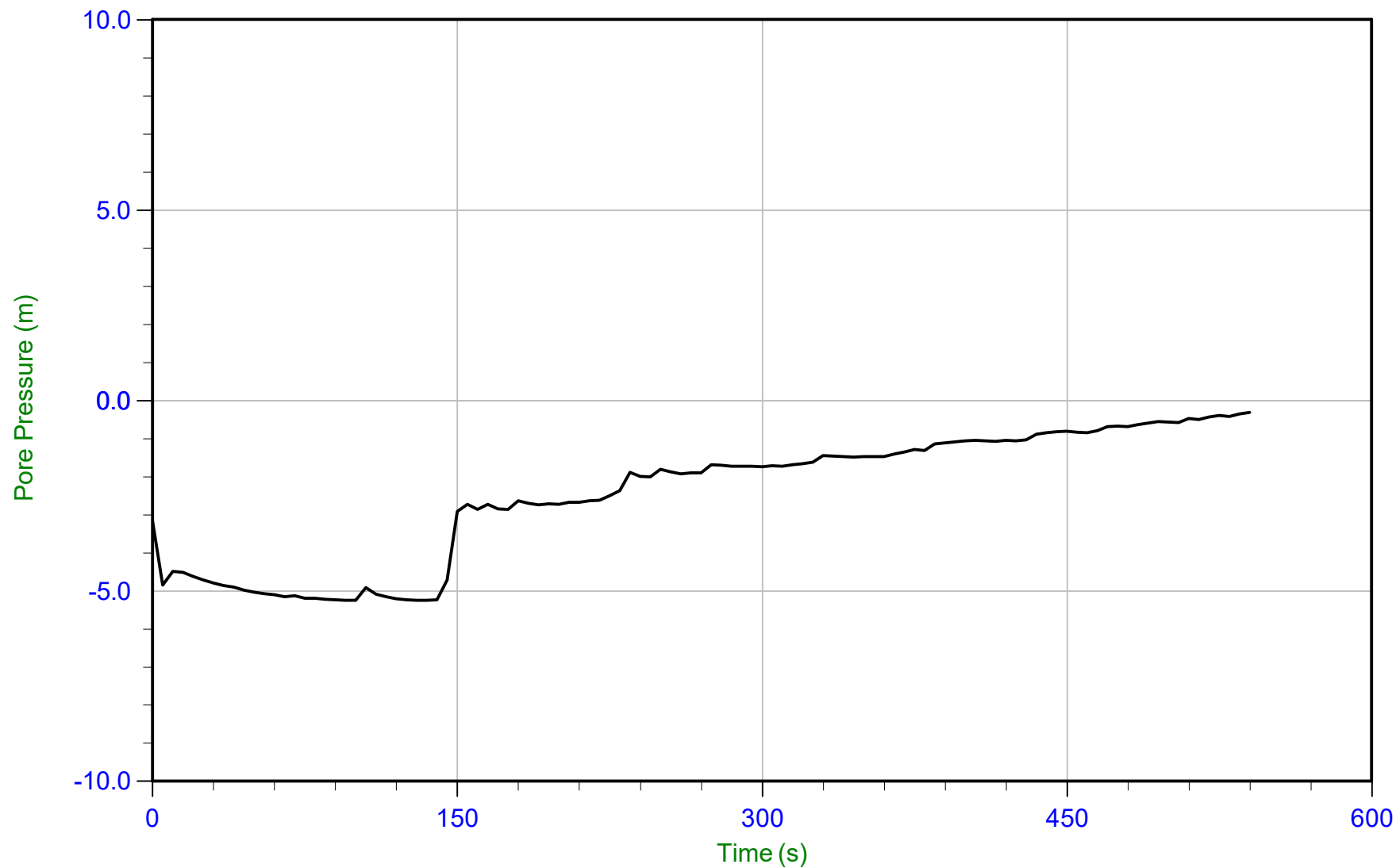
u Final: 41.9 m



Thurber

Job No: 20-05-21632
Date: 11/29/2020 08:56
Site: Highway 11/Government Road

Sounding: SCPT20-06
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06.PPF
Depth: 10.860 m / 35.629 ft
Duration: 540.0 s

u Min: -5.2 m
u Max: -0.3 m
u Final: -0.3 m



Thurber

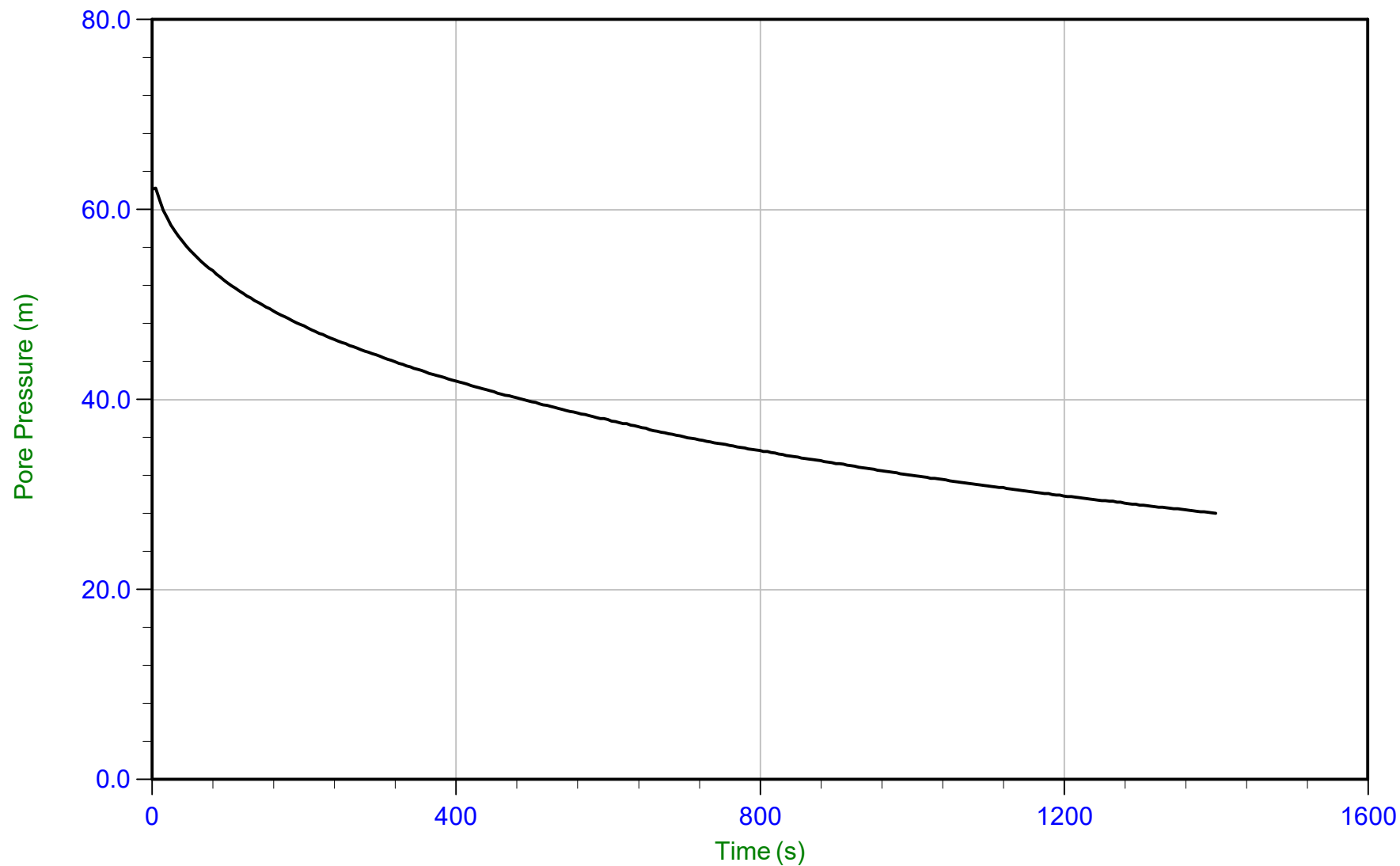
Job No: 20-05-21632

Date: 11/29/2020 10:29

Site: Highway 11/Government Road

Sounding: SCPT20-06B

Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06B.PPF

Depth: 14.000 m / 45.931 ft

Duration: 1400.0 s

u Min: 28.1 m

u Max: 62.3 m

u Final: 28.1 m

WT: 7.000 m / 22.966 ft

Ueq: 7.0 m

U(50): 34.64 m

T(50): 793.6 s

Ir: 100

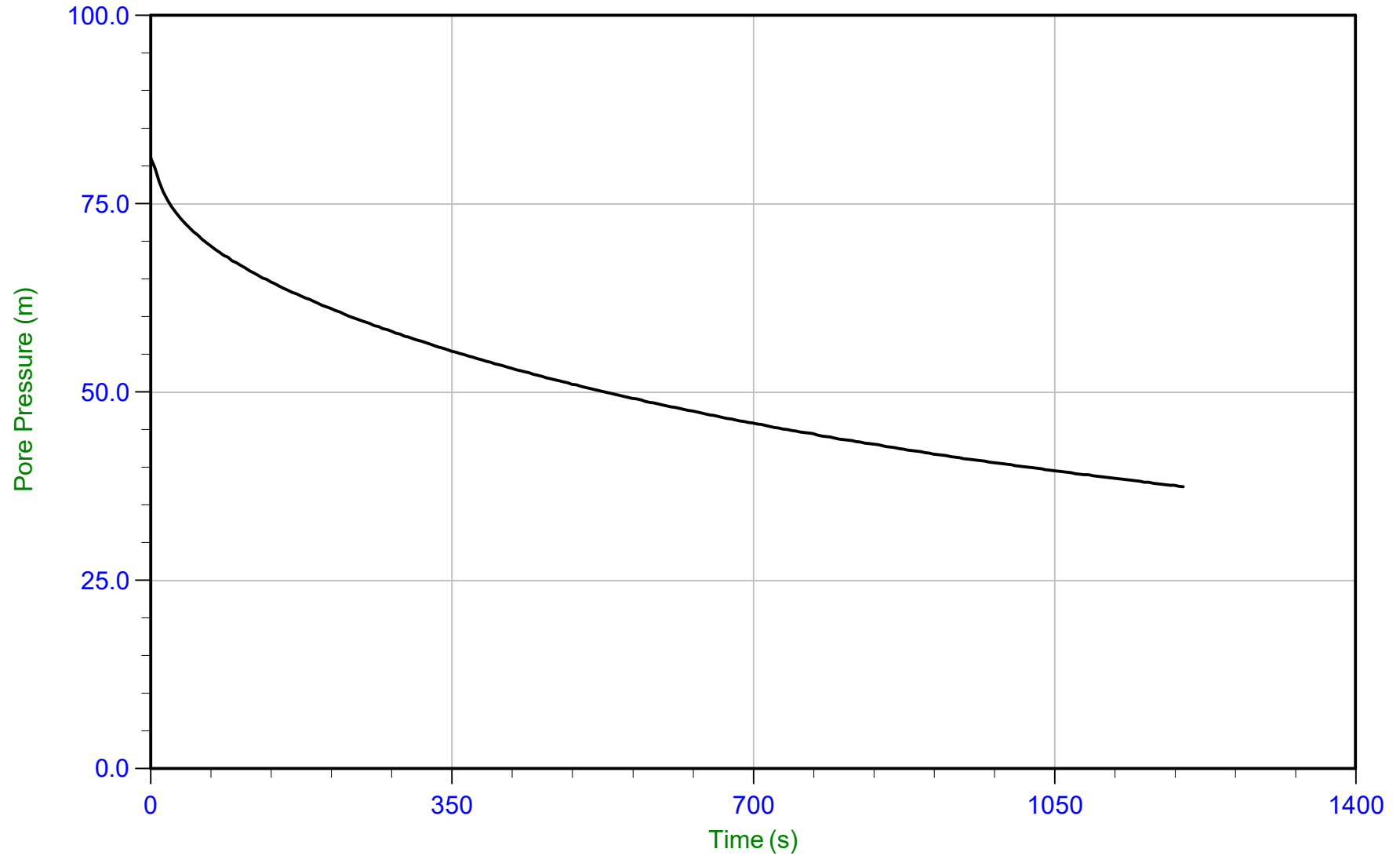
Ch: 0.6 cm²/min



Thurber

Job No: 20-05-21632
Date: 11/29/2020 10:29
Site: Highway 11/Government Road

Sounding: SCPT20-06B
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06B.PPF
Depth: 17.070 m / 56.003 ft
Duration: 1200.0 s

u Min: 37.4 m
u Max: 81.2 m
u Final: 37.4 m

WT: 7.000 m / 22.966 ft
Ueq: 10.1 m
U(50): 45.61 m

T(50): 712.4 s
Ir: 100
Ch: 0.7 cm²/min



Thurber

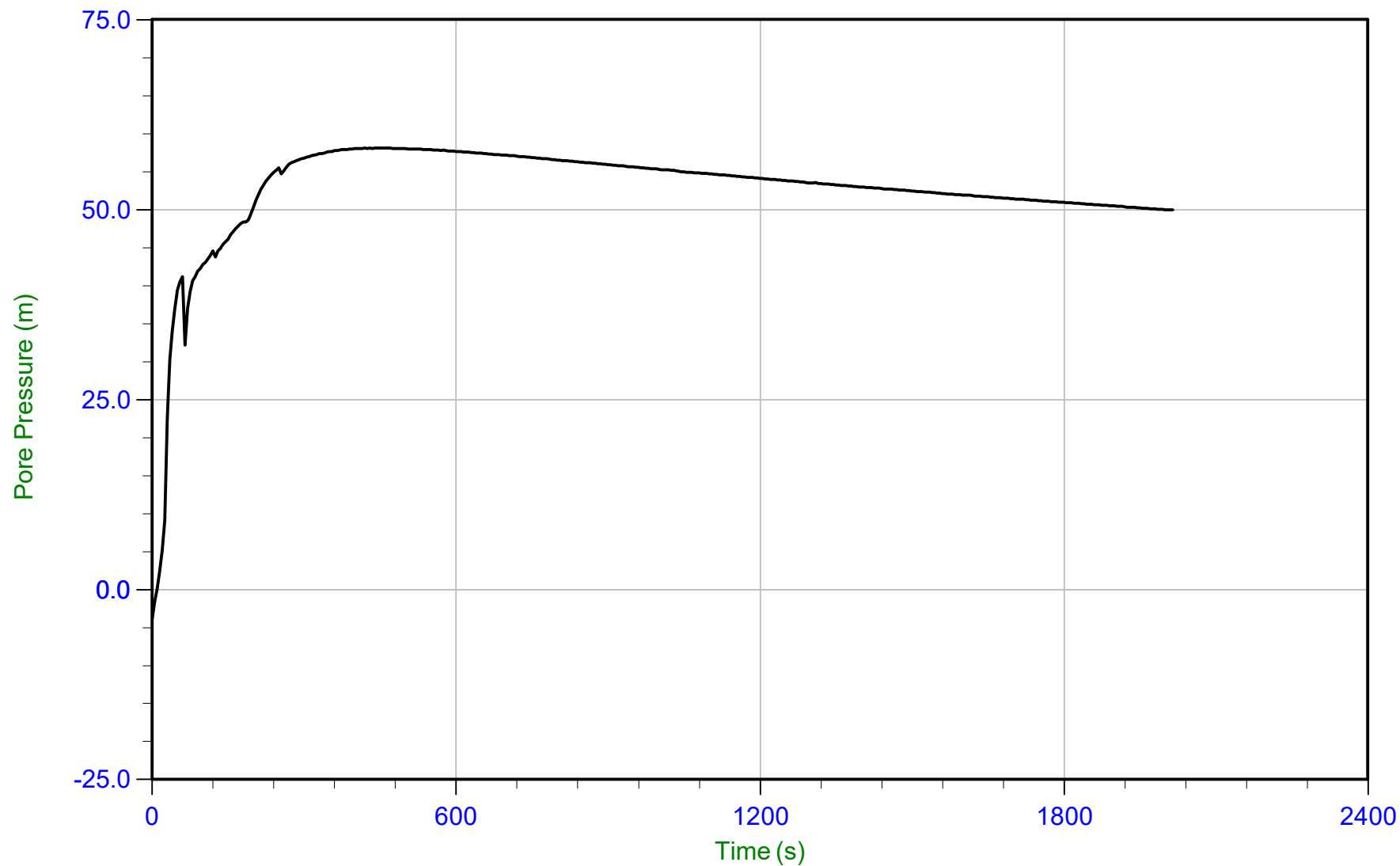
Job No: 20-05-21632

Date: 11/29/2020 10:29

Site: Highway 11/Government Road

Sounding: SCPT20-06B

Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06B.PPF

Depth: 20.120 m / 66.010 ft

Duration: 2015.0 s

u Min: -4.0 m

u Max: 58.1 m

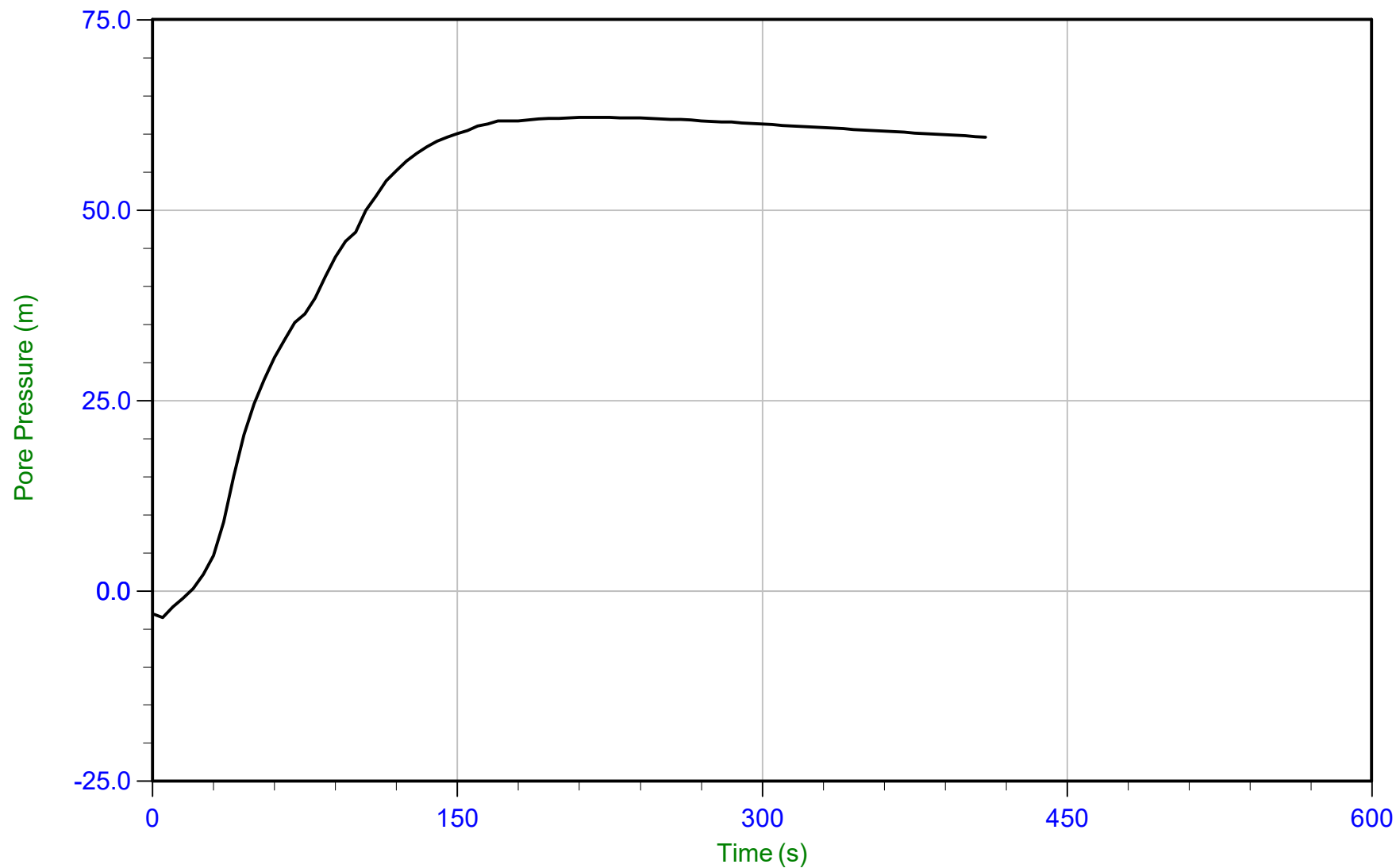
u Final: 49.9 m



Thurber

Job No: 20-05-21632
Date: 11/29/2020 10:29
Site: Highway 11/Government Road

Sounding: SCPT20-06B
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06B.PPF
Depth: 20.410 m / 66.961 ft
Duration: 410.0 s

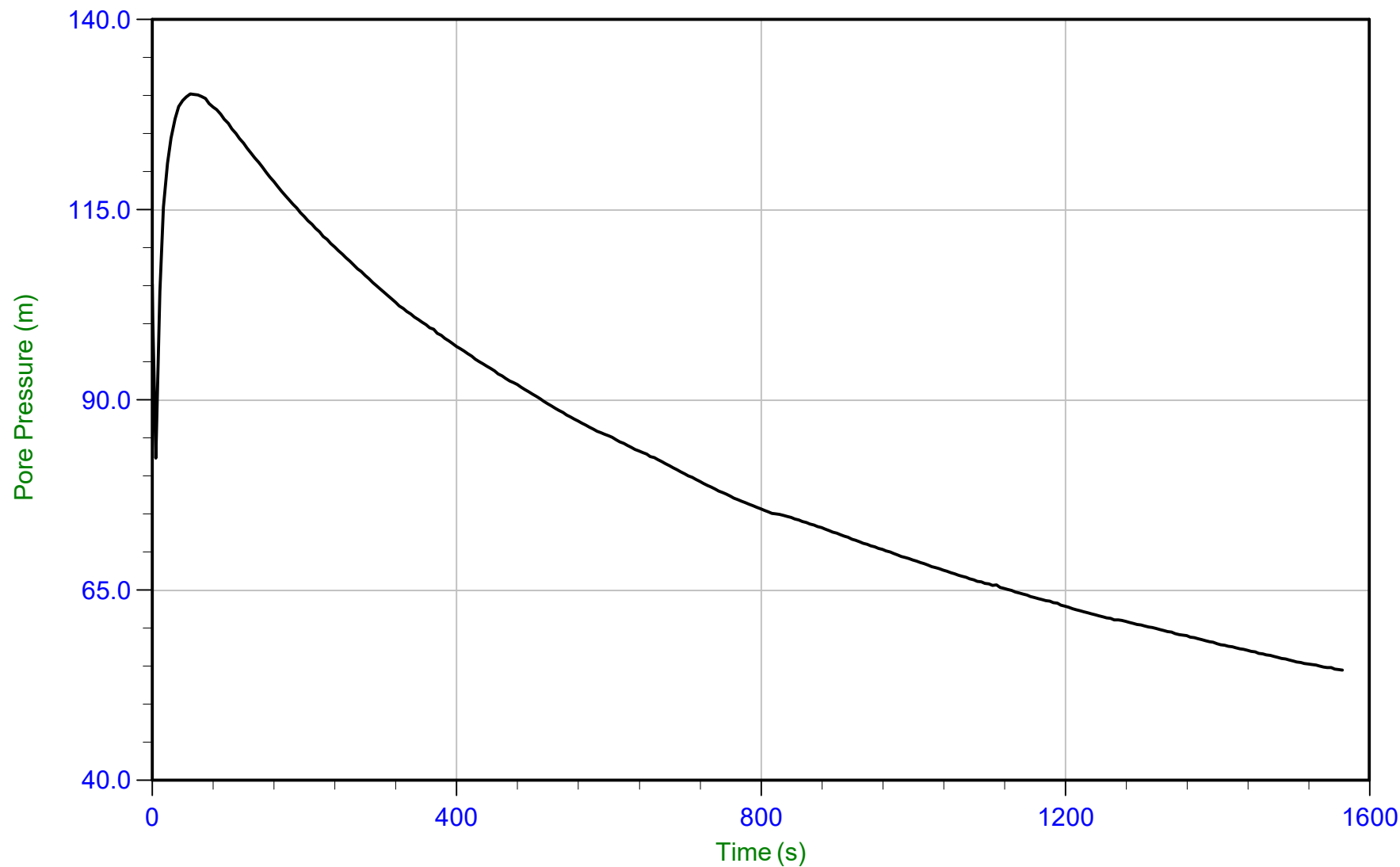
u Min: -3.5 m
u Max: 62.2 m
u Final: 59.6 m



Thurber

Job No: 20-05-21632
Date: 11/29/2020 10:29
Site: Highway 11/Government Road

Sounding: SCPT20-06B
Cone: 377:T1000F10U500 Area=10 cm²



Trace Summary:

Filename: 20-05-21632_SP-06B.PPF
Depth: 21.510 m / 70.570 ft
Duration: 1565.0 s

u Min: 54.5 m
u Max: 130.2 m
u Final: 54.5 m

WT: 7.000 m / 22.966 ft
Ueq: 14.5 m
U(50): 72.37 m

T(50): 853.3 s
Ir: 100
Ch: 0.5 cm²/min

Electric Field Vane Shear Test Profile Summary and Results



Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earlton
Start Date: 28-Nov-2020
End Date: 03-Dec-2020

ELECTRIC FIELD VANE SHEAR TEST SUMMARY

Sounding ID	File Name	Adjacent CPT Sounding ID	Rig	Date From	Date To	Northing ¹ (m)	Easting ¹ (m)	Refer to Notation Number
VST20-01	20-05-21632_VST01	SCPT20-01	M5T II	02-Dec-2020	03-Dec-2020	5285147	588701	
VST20-02	20-05-21632_VST02	SCPT20-02	M5T II	28-Nov-2020	30-Nov-2020	5285077	588798	

1. Coordinates were collected with a consumer grade GPS device, datum: WGS84 / UTM Zone 17N.



Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Start Date: 28-Nov-2020
End Date: 03-Dec-2020

ELECTRIC FIELD VANE SHEAR TEST RESULTS																						
Sounding ID	File Name	Date	Load Cell Serial Number	Load Cell Location	Casing/Drillout Depth (m)	Test Depth ¹ (m)	Test Elevation (m)	Vane Diameter D (mm)	Vane Height H (mm)	Top Taper Angle i _T (deg)	Bottom Taper Angle i _B (deg)	Vane Factor (kPa/Nm)	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
VST20-01	20-05-21632_VST01	02-Dec-2020	AVLC058	Surface	8.38	8.84		60	120	45	45	1.1926	29.30	17.10	34.95	20.39	5.99	1.93	28.96	18.46	1.57	
VST20-01	20-05-21632_VST01	02-Dec-2020	AVLC058	Surface	10.67	11.12		60	120	45	45	1.1926	43.91	11.32	52.37	13.50	4.95	0.96	47.42	12.54	3.78	
VST20-01	20-05-21632_VST01	03-Dec-2020	AVLC058	Surface	12.19	12.65		60	120	45	45	1.1926	44.09	12.13	52.58	14.47	5.09	3.09	47.49	11.38	4.17	
VST20-01	20-05-21632_VST01	03-Dec-2020	AVLC058	Surface	13.72	14.17		60	120	45	45	1.1926	54.41	13.90	64.88	16.57	4.96	1.87	59.93	14.70	4.08	
VST20-01	20-05-21632_VST01	03-Dec-2020	AVLC058	Surface	15.24	15.70		60	120	45	45	1.1926	52.33	14.21	62.40	16.95	3.10	4.89	59.30	12.06	4.92	
VST20-02	20-05-21632_VST02	28-Nov-2020	AVLC058	Surface	9.14	10.51		60	120	45	45	1.1926	45.88	14.72	54.72	17.55	5.15	8.26	49.56	9.29	5.34	
VST20-02	20-05-21632_VST02	30-Nov-2020	AVLC058	Surface	10.67	12.04		60	120	45	45	1.1926	50.75	17.83	60.52	21.27	6.91	4.23	53.62	17.04	3.15	
VST20-02	20-05-21632_VST02	30-Nov-2020	AVLC058	Surface	10.67	12.53		60	120	45	45	1.1926	49.19	18.17	58.67	21.67	6.71	3.30	51.95	18.38	2.83	
VST20-02	20-05-21632_VST02	30-Nov-2020	AVLC058	Surface	12.19	13.56		60	120	45	45	1.1926	45.00	16.08	53.66	19.17	4.62	2.34	49.04	16.84	2.91	
VST20-02	20-05-21632_VST02	30-Nov-2020	AVLC058	Surface	12.19	14.33		60	120	45	45	1.1926	62.56	30.70	74.61	36.61	2.25	11.76	72.36	24.85	2.91	

1. Test depths are referenced to the middle of the vane.



Job Number: 20-05-21632
 Client: Thurber Engineering Ltd.
 Project: Highway 11 and Government Road Earilton
 Start Date: 28-Nov-2020
 End Date: 03-Dec-2020

ELECTRIC FIELD VANE SHEAR TEST TIMING

Sounding ID	Date	Test Depth ¹ (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)	Refer to Notation Number
VST20-01	02-Dec-2020	8.84	08:35	08:38	3	304	0.09	09:00	09:02	3	0.09	
VST20-01	02-Dec-2020	11.12	12:00	12:01	2	396	0.09	12:24	12:25	2	0.39	
VST20-01	03-Dec-2020	12.65	08:28	08:31	3	375	0.09	08:56	08:57	2	0.40	
VST20-01	03-Dec-2020	14.17	09:23	09:25	2	589	0.08	10:51	10:52	2	0.42	
VST20-01	03-Dec-2020	15.70	11:05	11:09	4	341	0.09	11:31	11:34	3	0.42	
VST20-02	28-Nov-2020	10.51	12:28	12:31	3	636	0.08	12:51	12:52	2	0.10	
VST20-02	30-Nov-2020	12.04	07:36	07:40	5	926	0.11	08:05	08:09	4	0.10	
VST20-02	30-Nov-2020	12.53	08:23	08:25	3	410	0.10	09:09	09:11	3	0.10	
VST20-02	30-Nov-2020	13.56	10:31	10:36	5	284	0.09	11:01	11:03	2	0.10	
VST20-02	30-Nov-2020	14.33	11:33	11:36	4	652	0.09	12:01	12:02	1	0.09	

1. Test depths are referenced to the middle of the vane.

Electric Field Vane Shear Test Plots

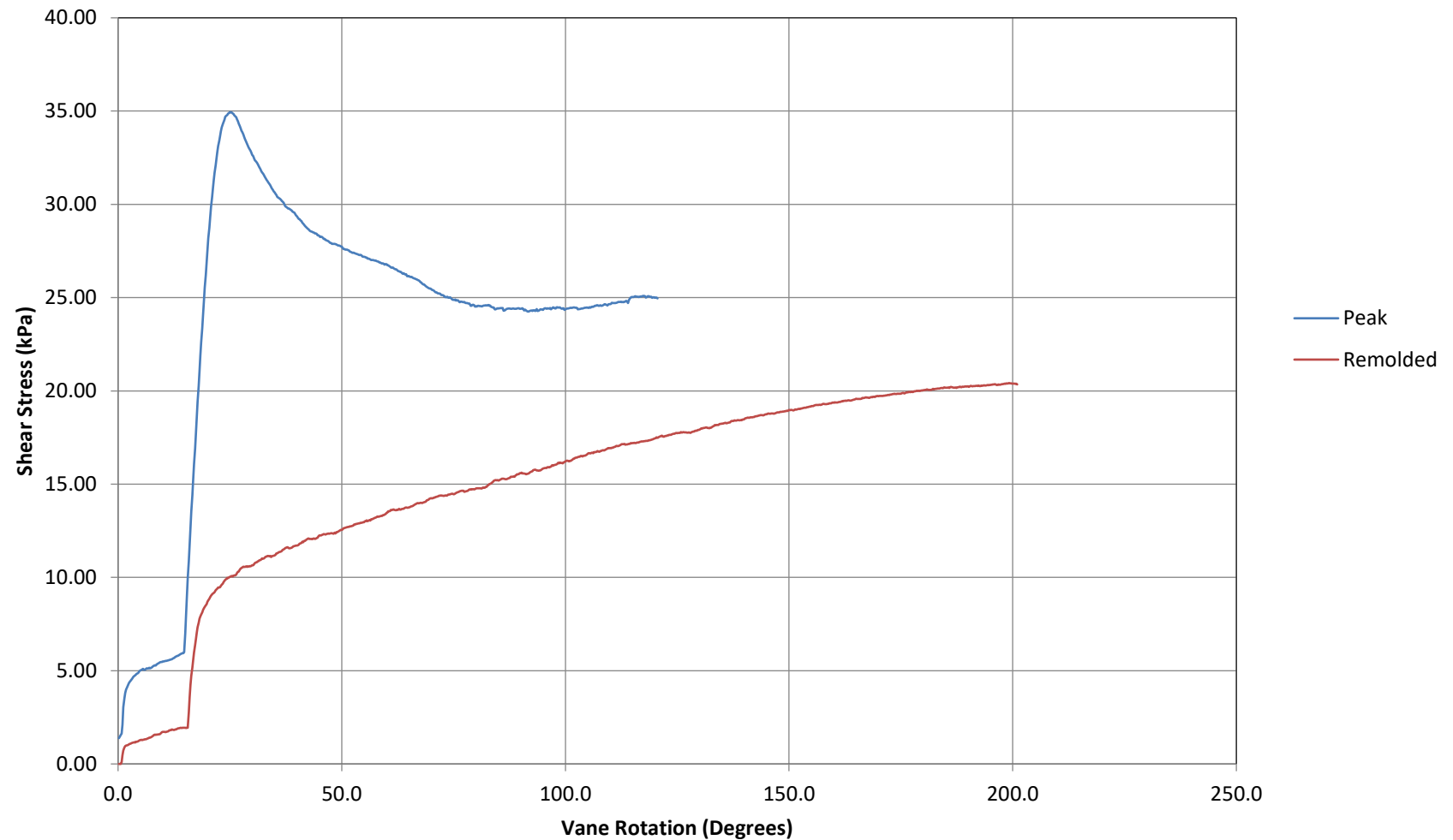


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-01

Test Date: 02-Dec-2020 08:38
Test Depth (m): 8.84
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285147
Easting (m): 588701

Vane Shear Test



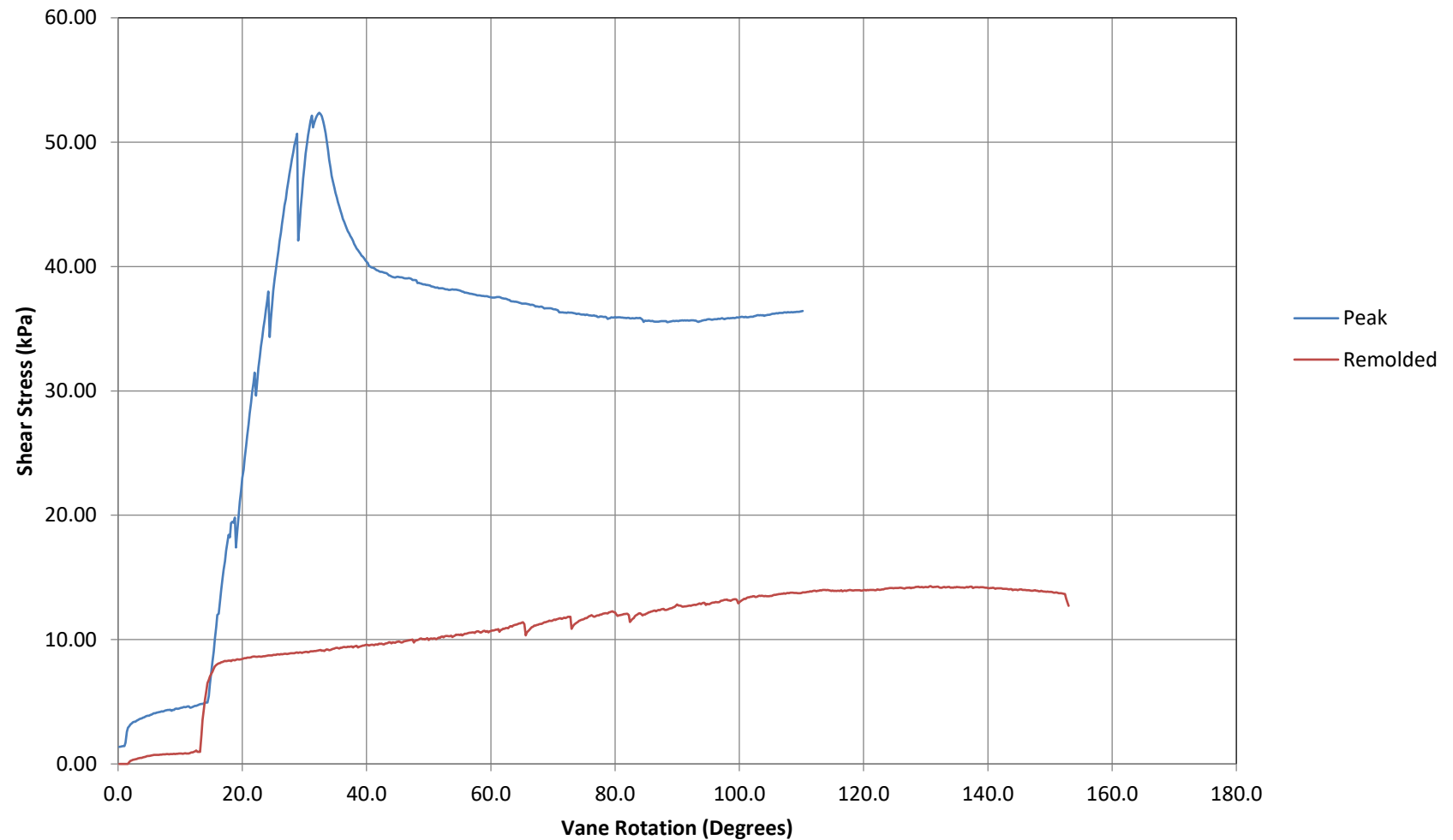


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-01

Test Date: 02-Dec-2020 12:01
Test Depth (m): 11.12
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285147
Easting (m): 588701

Vane Shear Test



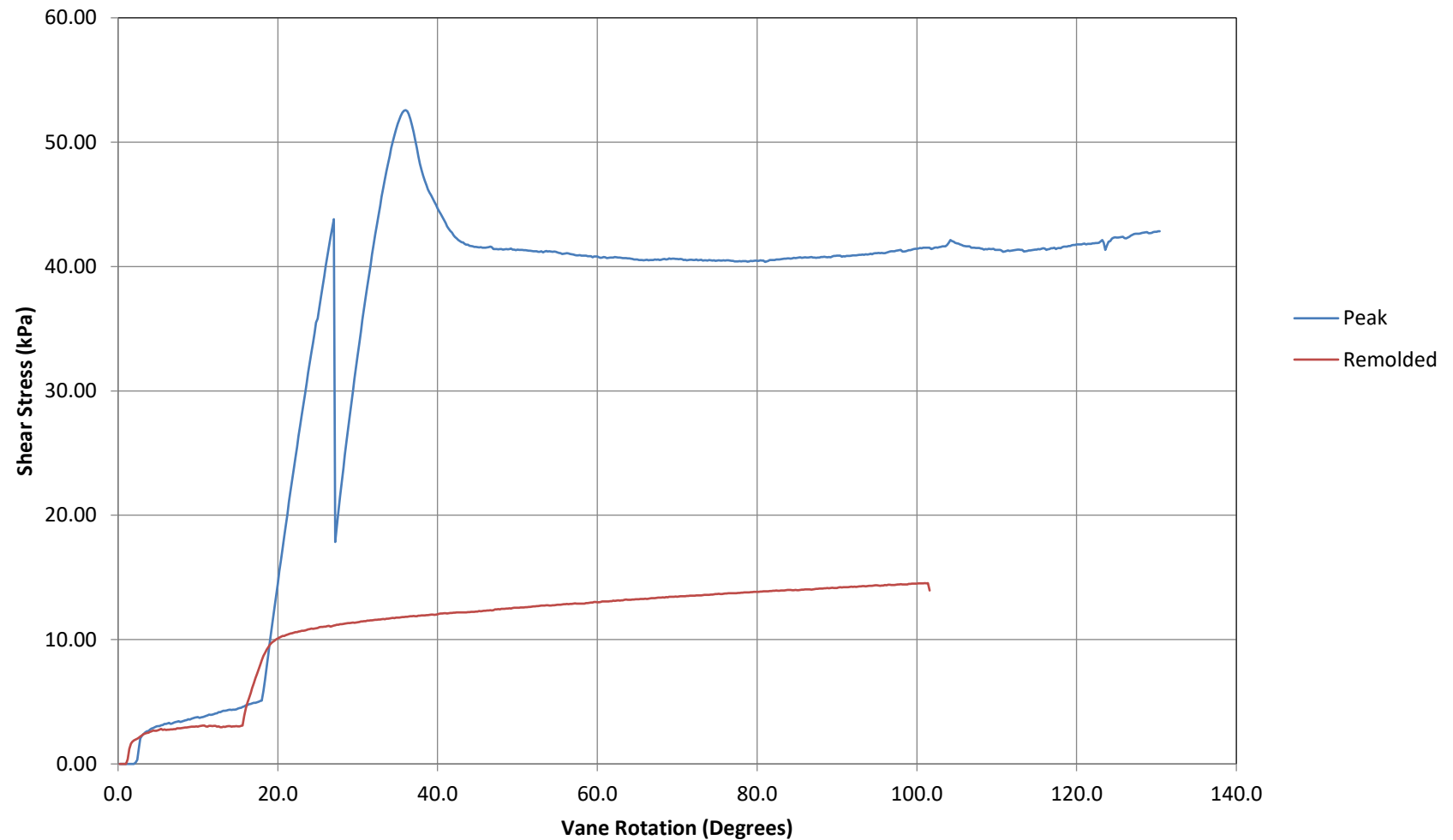


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earleton
Sounding: VST20-01

Test Date: 03-Dec-2020 08:31
Test Depth (m): 12.65
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285147
Easting (m): 588701

Vane Shear Test



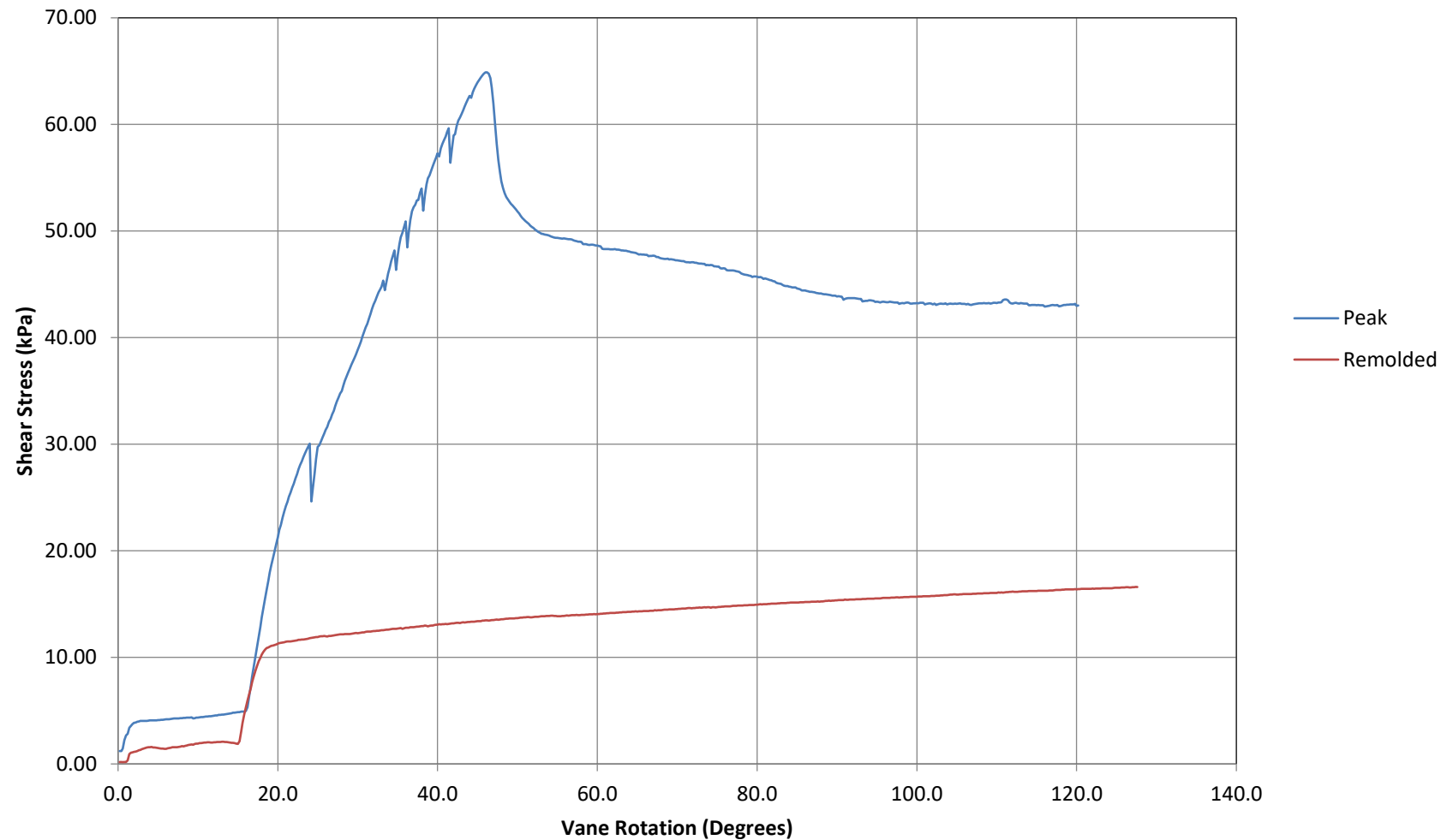


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-01

Test Date: 03-Dec-2020 09:25
Test Depth (m): 14.17
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285147
Easting (m): 588701

Vane Shear Test



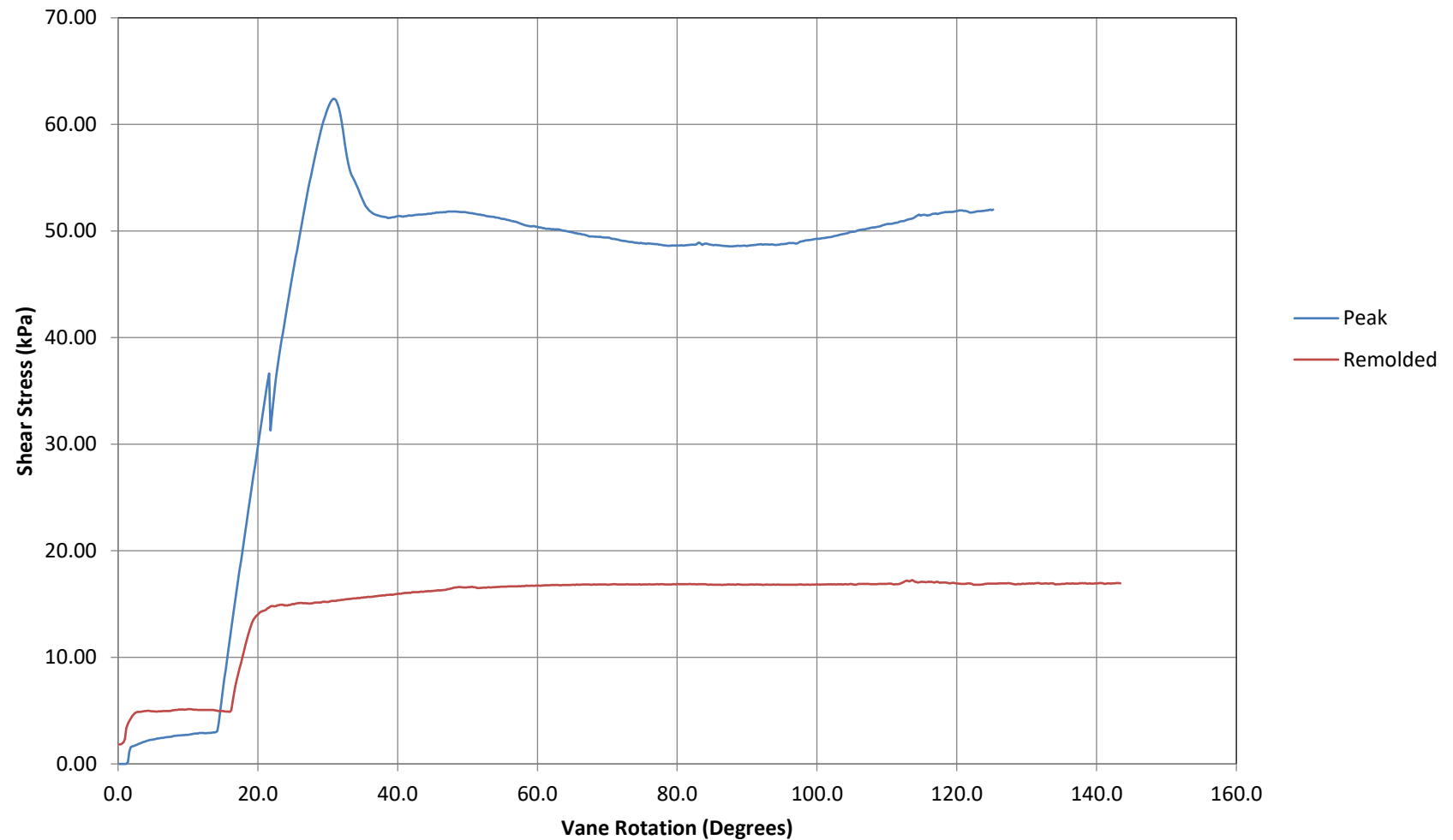


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-01

Test Date: 03-Dec-2020 11:09
Test Depth (m): 15.70
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285147
Easting (m): 588701

Vane Shear Test



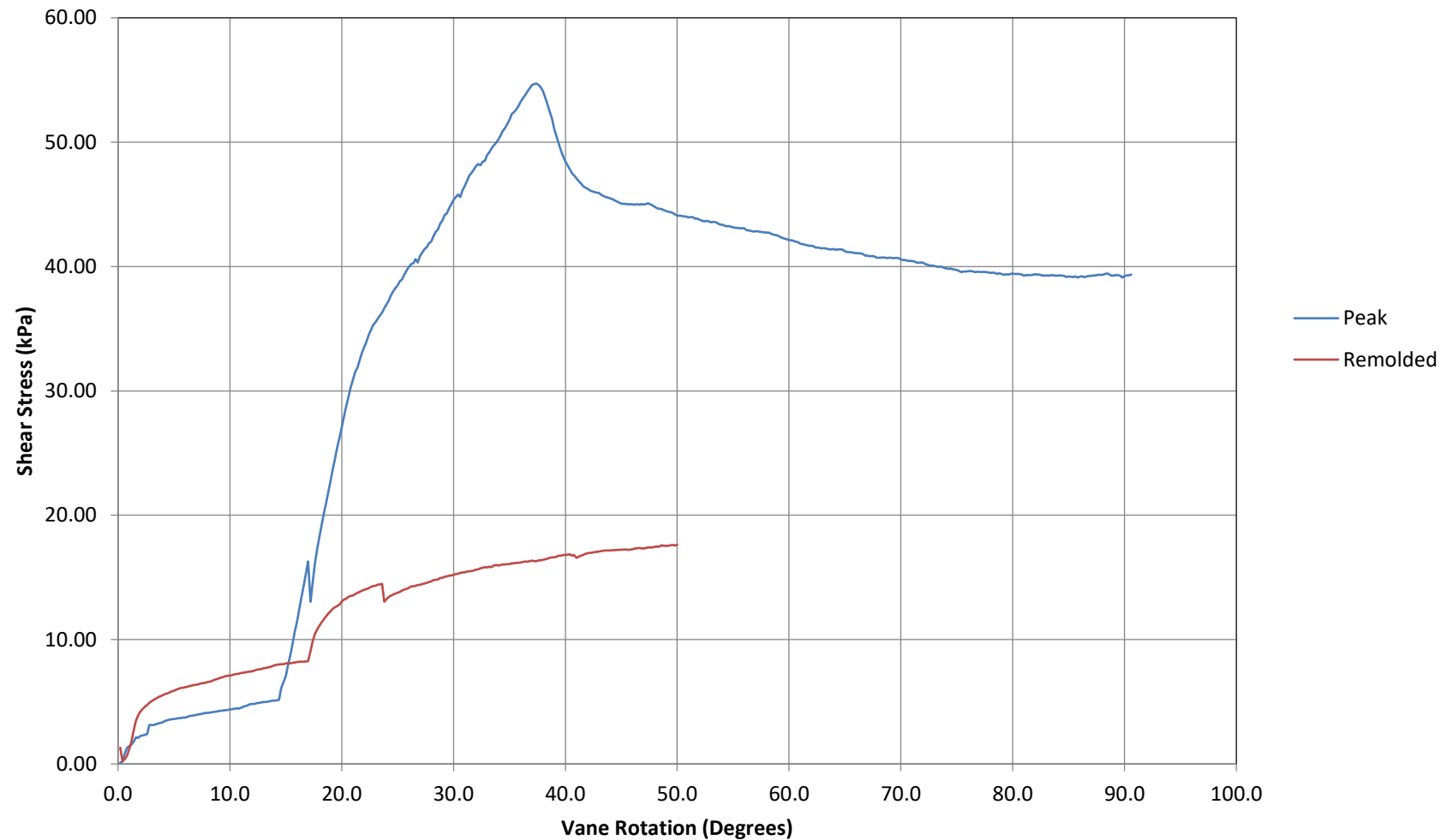


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-02

Test Date: 28-Nov-2020 12:31
Test Depth (m): 10.51
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285077
Easting (m): 588798

Vane Shear Test



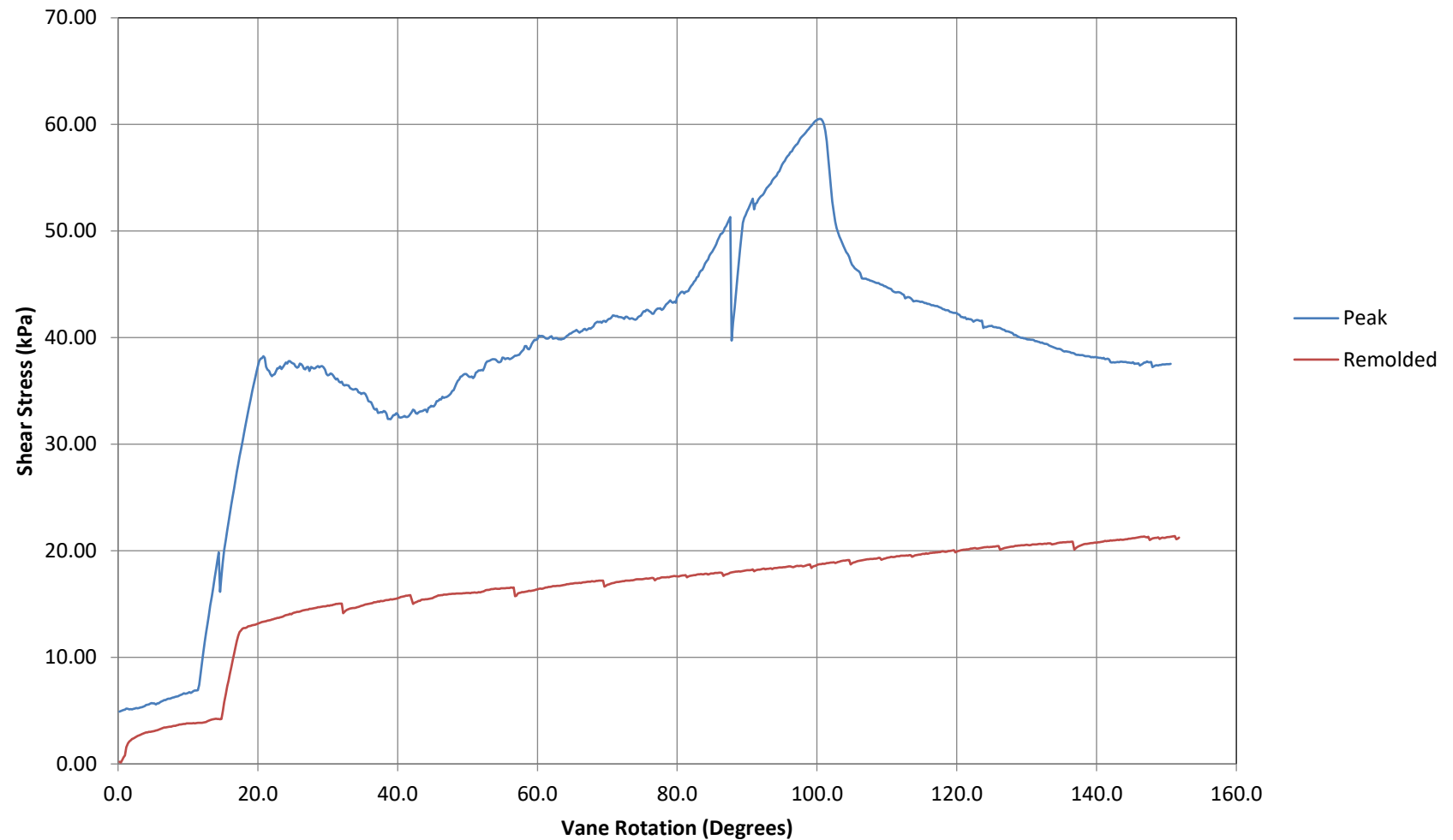


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-02

Test Date: 30-Nov-2020 07:40
Test Depth (m): 12.04
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285077
Easting (m): 588798

Vane Shear Test



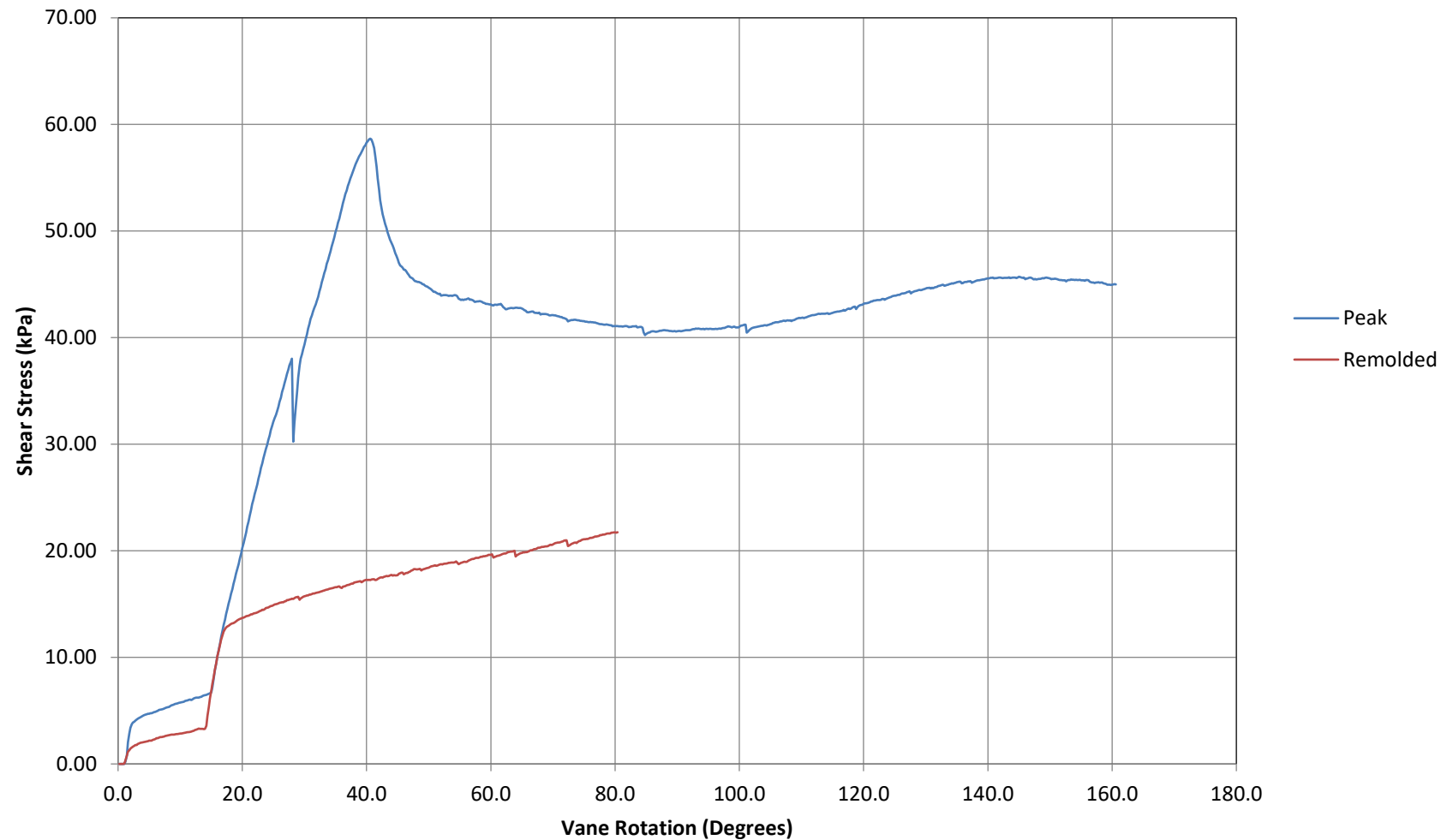


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-02

Test Date: 30-Nov-2020 08:25
Test Depth (m): 12.53
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285077
Easting (m): 588798

Vane Shear Test



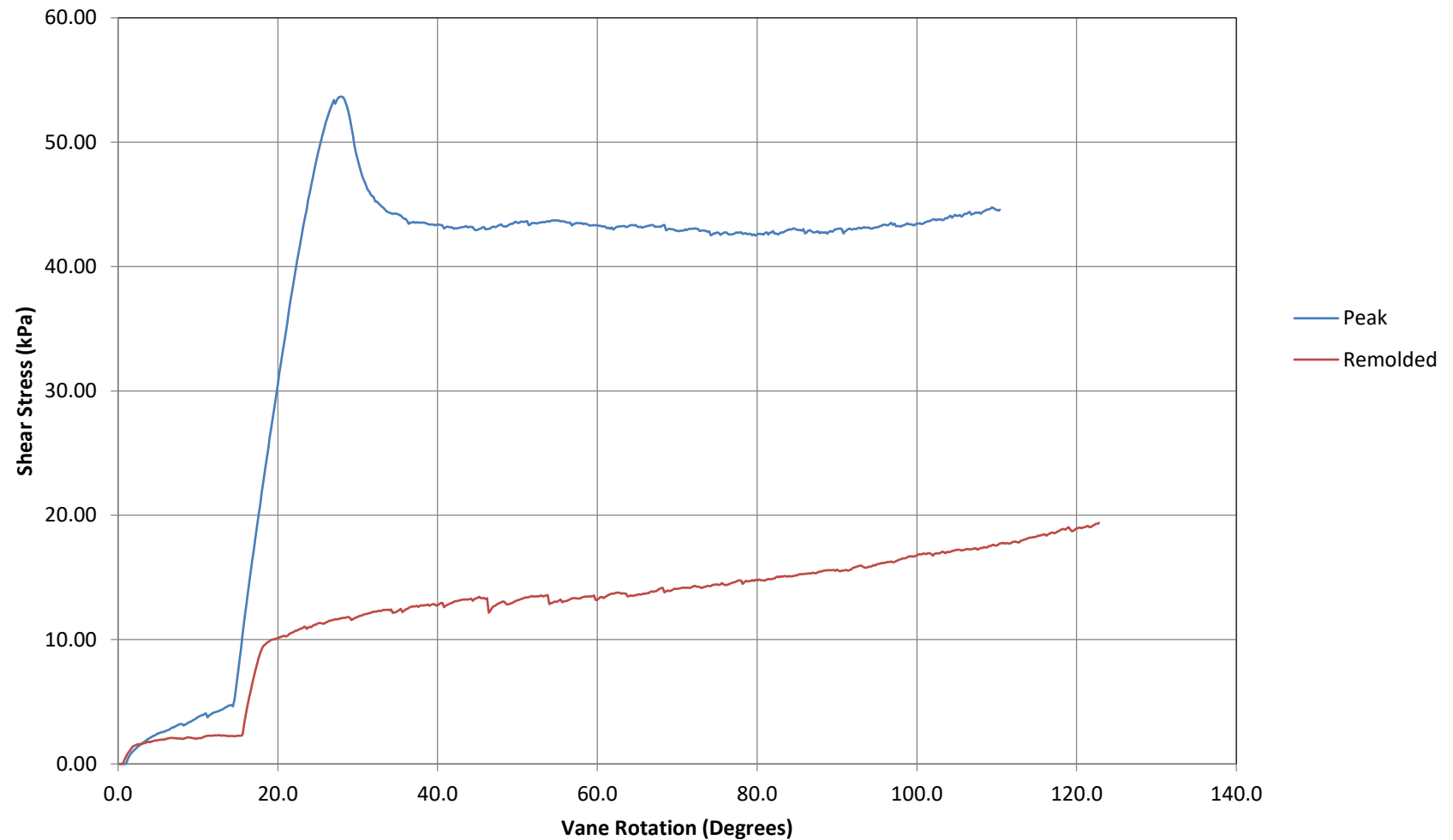


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-02

Test Date: 30-Nov-2020 10:36
Test Depth (m): 13.56
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285077
Easting (m): 588798

Vane Shear Test



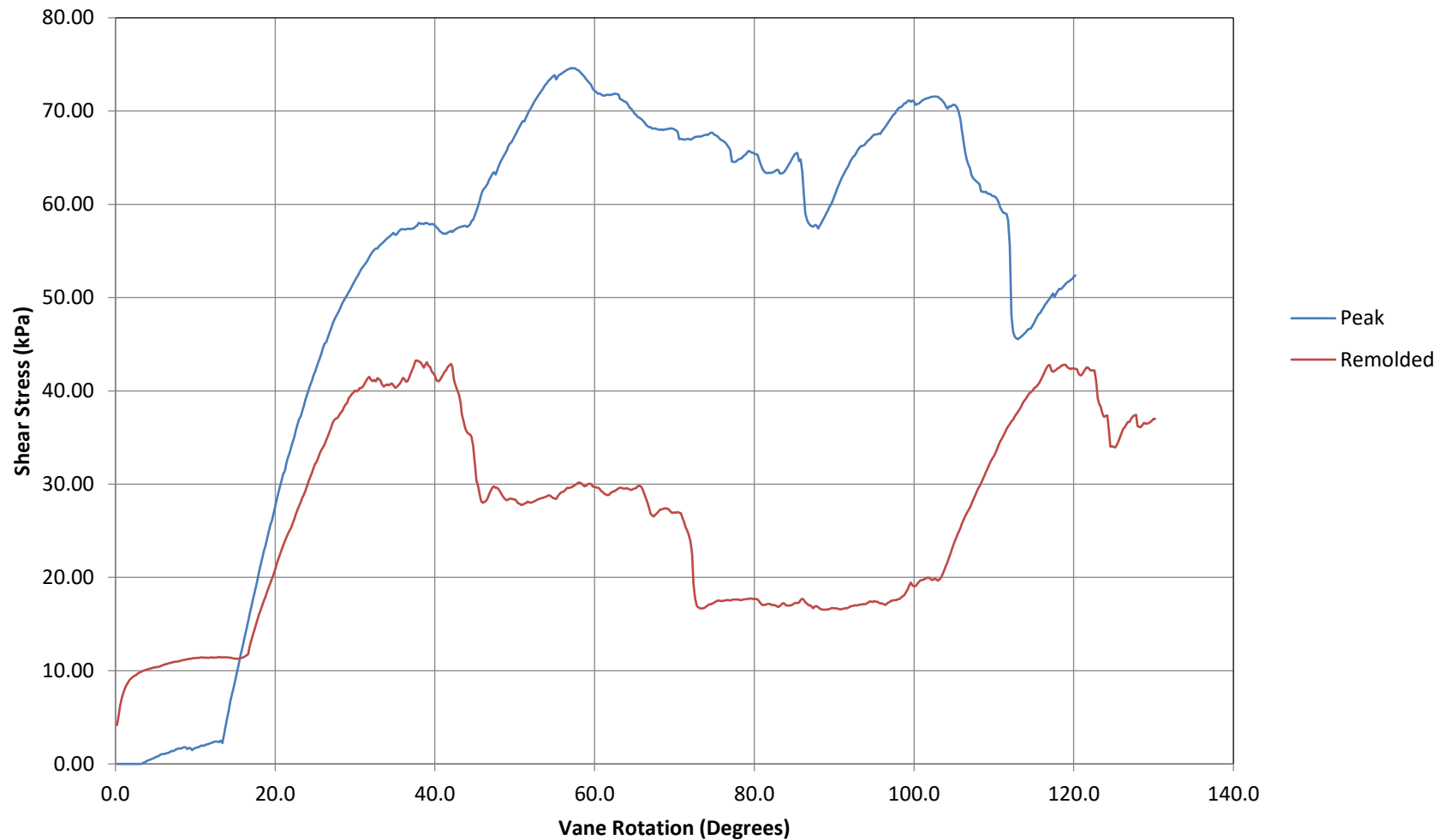


Job Number: 20-05-21632
Client: Thurber Engineering Ltd.
Project: Highway 11 and Government Road Earilton
Sounding: VST20-02

Test Date: 30-Nov-2020 11:36
Test Depth (m): 14.33
Vane Type: Adara solid double tapered 60 x 120
mm (45°, 45°)

Coordinate System: WGS 84 / UTM zone 17N
Northing (m): 5285077
Easting (m): 588798

Vane Shear Test



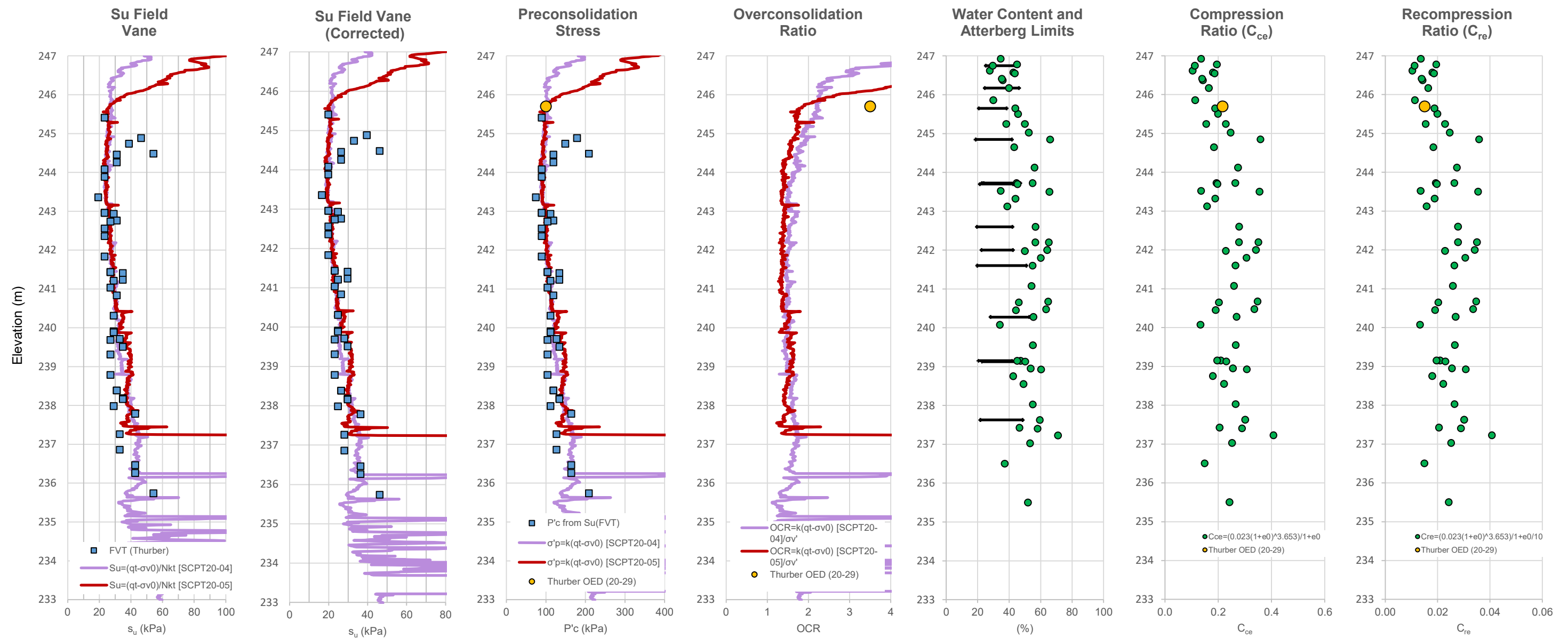


Appendix E

Summary of In-situ and Laboratory Test Results on Varved Silty Clay



SUMMARY OF IN-SITU AND LABRATORY TEST RESULTS ON VARVED SILTY CLAY FROM BEYOND EMBANKMENT FOOTPRINT

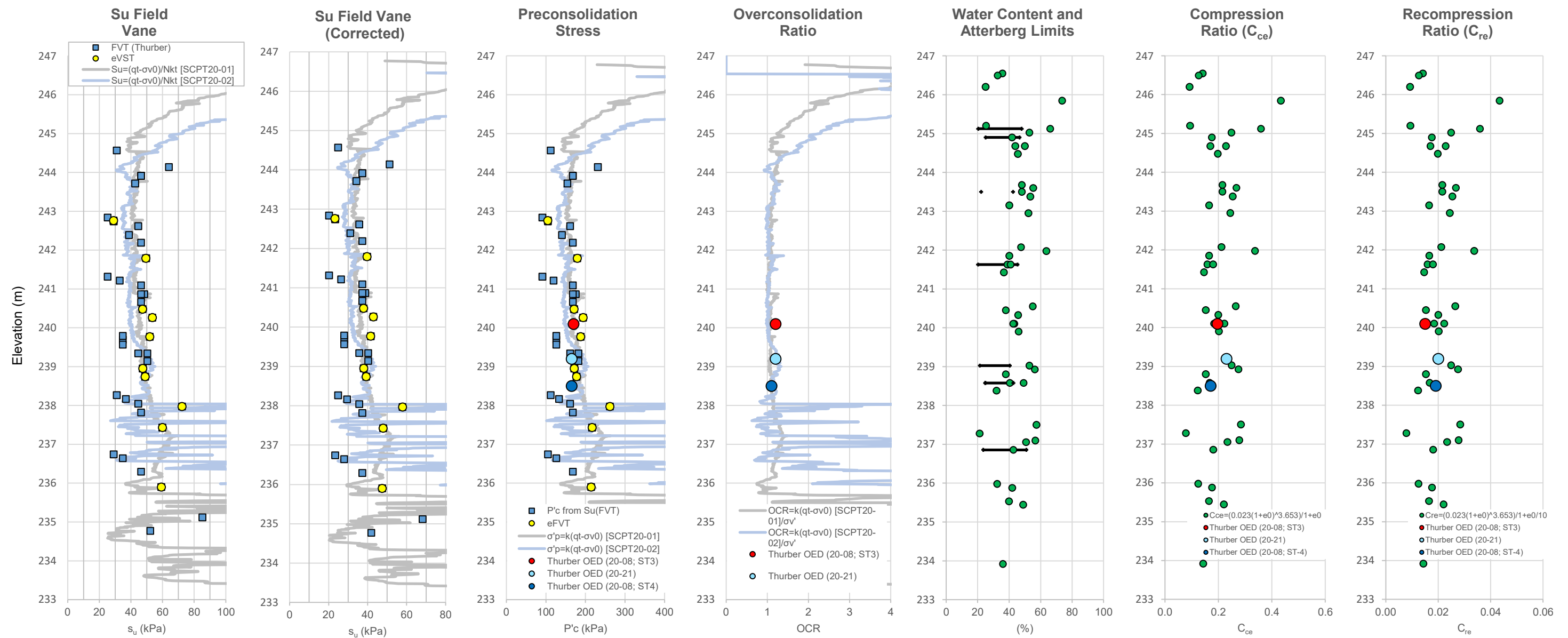


Project Name: ONR Overhead Replacement at Earlton
Project #: 28552
Location: Beyond Embankment Footprint
Relevant Boreholes: 20-13 to 20-20, 20-28 to 20-29

FIGURE E1



SUMMARY OF IN-SITU AND LABRATORY TEST RESULTS ON VARVED SILTY CLAY BENEATH BERM

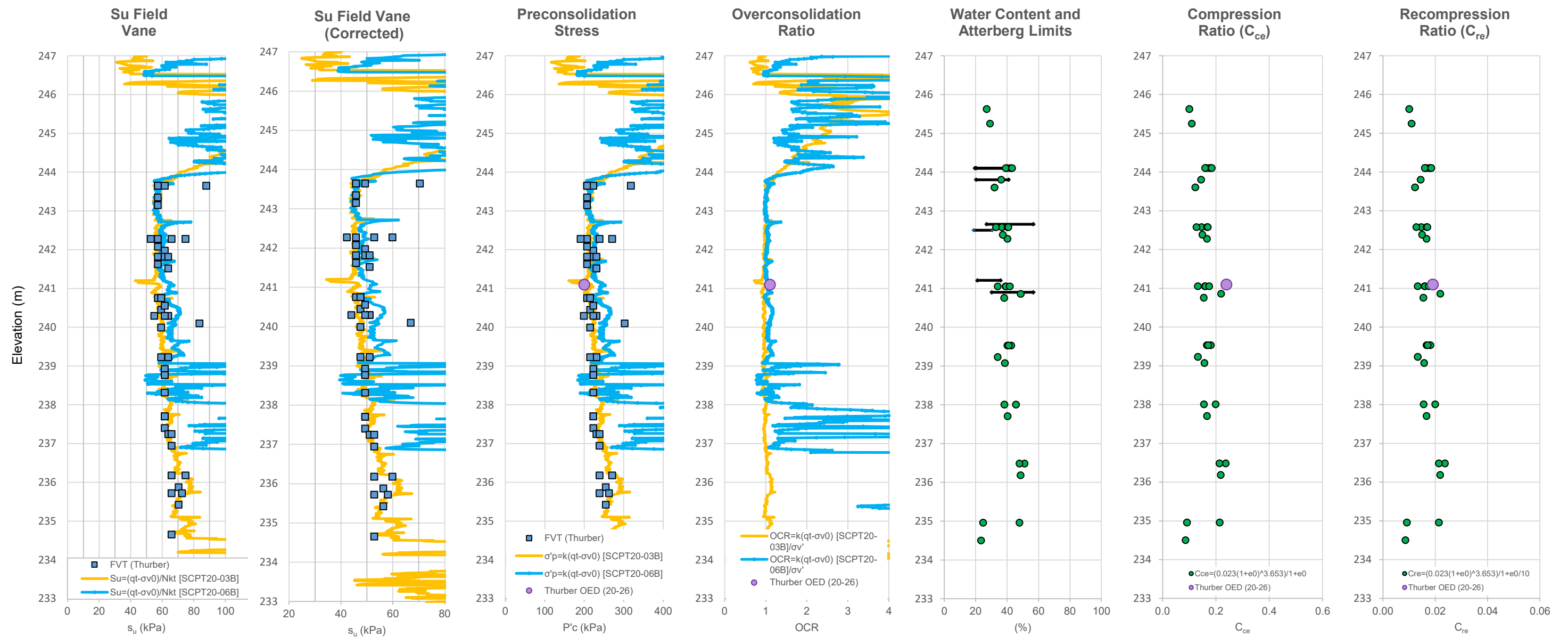


Project Name: ONR Overhead Replacement at Earlton
Project #: 28552
Location: Beneath Berm
Relevant Boreholes: 20-04, 20-06, 20-08 to 20-10, 20-21, 20-23, 20-24

FIGURE E2



SUMMARY OF IN-SITU AND LABRATORY TEST RESULTS ON VARVED SILTY CLAY BENEATH EMBANKMENT PLATFORM



Project Name: ONR Overhead Replacement at Earlton
Project #: 28552
Location: Beneath Embankment Platform
Relevant Boreholes: 20-01 to 20-03, 20-25 to 20-27

FIGURE E3



Appendix F

Analytical Test Results



FINAL REPORT

CA14649-DEC20 R1

28552

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client **Thurber Engineering Ltd.**

Address **103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada**

Contact **Geoff Lay**

Telephone **905-829-8666**

Facsimile

Email **glay@thurber.ca**

Project **28552**

Order Number

Samples **Soil (4)**

LABORATORY DETAILS

Project Specialist **Brad Moore Hon. B.Sc**

Laboratory **SGS Canada Inc.**

Address **185 Concession St., Lakefield ON, K0L 2H0**

Telephone **705-652-2143**

Facsimile **705-652-6365**

Email **brad.moore@sgs.com**

SGS Reference **CA14649-DEC20**

Received **12/18/2020**

Approved **12/24/2020**

Report Number **CA14649-DEC20 R1**

Date Reported **12/24/2020**

COMMENTS

Temperature of Sample upon Receipt: 6 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: 019644

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

SIGNATORIES

Brad Moore Hon. B.Sc

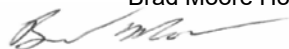




TABLE OF CONTENTS

First Page..... 1

Index..... 2

Results..... 3-4

QC Summary..... 5-7

Legend..... 8

Annexes..... 9



FINAL REPORT

CA14649-DEC20 R1

Client: Thurber Engineering Ltd.

Project: 28552

Project Manager: Geoff Lay

Samplers: N/A

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8
Sample Name	BH20-03, SS6	BH20-08, SS3	BH20-21, SS3	BH20-25, SS6
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	29/11/2020	02/12/2020	01/12/2020	19/11/2020

Parameter	Units	RL		Result	Result	Result	Result
Corrosivity Index							
Corrosivity Index	none	1		1	8	8	4
Soil Redox Potential	mV	-		260	249	248	230
Sulphide (Na ₂ CO ₃)	%	0.04		< 0.04	0.41	0.13	< 0.04
pH	pH Units	0.05		8.49	9.24	9.21	8.78
Resistivity (calculated)	ohms.cm	-9999		3480	2310	5080	5680

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8
Sample Name	BH20-03, SS6	BH20-08, SS3	BH20-21, SS3	BH20-25, SS6
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	29/11/2020	02/12/2020	01/12/2020	19/11/2020

Parameter	Units	RL		Result	Result	Result	Result
General Chemistry							
Conductivity	uS/cm	2		287	432	197	176

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8
Sample Name	BH20-03, SS6	BH20-08, SS3	BH20-21, SS3	BH20-25, SS6
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	29/11/2020	02/12/2020	01/12/2020	19/11/2020

Parameter	Units	RL		Result	Result	Result	Result
Metals and Inorganics							
Moisture Content	%	0.1		6.5	4.6	7.4	6.6
Sulphate	µg/g	0.4		39	50	16	22



FINAL REPORT

CA14649-DEC20 R1

Client: Thurber Engineering Ltd.

Project: 28552

Project Manager: Geoff Lay

Samplers: N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8
Sample Name	BH20-03, SS6	BH20-08, SS3	BH20-21, SS3	BH20-25, SS6
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	29/11/2020	02/12/2020	01/12/2020	19/11/2020

Parameter	Units	RL		Result	Result	Result	Result
Other (ORP)							
Chloride	µg/g	0.4		200	220	92	190
Sodium Adsorption Ratio	No unit	0.2		1.0	7.3	1.4	1.3
SAR Calcium	mg/L	0.09		44.7	15.3	85.8	39.8
SAR Magnesium	mg/L	0.02		9.4	4.8	27.2	8.7
SAR Sodium	mg/L	0.15		29.0	136	150	35.8
Conductivity	mS/cm	0.002		0.48	0.73	0.35	0.49



FINAL REPORT

CA14649-DEC20 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0383-DEC20	µg/g	0.4	<0.4	10	20	99	80	120	96	75	125
Sulphate	DIO0383-DEC20	µg/g	0.4	<0.4	18	20	98	80	120	93	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0055-DEC20	%	0.04	< 0.04	ND	20	102	80	120			



FINAL REPORT

CA14649-DEC20 R1

QC SUMMARY

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-ENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0323-DEC20	uS/cm	2	< 2	0	20	99	90	110	NA		
Conductivity	EWL0346-DEC20	mS/cm	0.002	<0.002	0	10	99	90	110	NA		

Metals in aqueous samples - ICP-OES
Method: MOE 4696e01/EPA 6010 | Internal ref.: ME-CA-ENVISPE-LAK-AN-003

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
SAR Calcium	ESG0071-DEC20	mg/L	0.09	<0.09	10	20	97	80	120	101	70	130
SAR Magnesium	ESG0071-DEC20	mg/L	0.02	<0.02	17	20	94	80	120	102	70	130
SAR Sodium	ESG0071-DEC20	mg/L	0.15	<0.15	10	20	98	80	120	109	70	130



FINAL REPORT

CA14649-DEC20 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0323-DEC20	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

No. 019644

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Chet Humber
Received Date: Feb 18, 20 (mm/dd/yy)
Received Time: 16:50 (hr : min)Received By (Signature): _____
Custody Seal Present: Yes ☒ No ☐
Custody Seal Intact: Yes ☒ No ☐Cooling Agent Present: Yes ☒ No ☐ Type: Ice
Temperature Upon Receipt (°C): 6.6LAB LIMS #: 01M649-Dece

REPORT INFORMATION

INVOICE INFORMATION

Company: Thurber☐ (same as Report Information)Contact: Geoff Lay

Company: _____

Address: 2010 W. 4th St. Rm 100

Contact: _____

Phone: 416-303-8668

Address: _____

Fax: _____

Phone: _____

Email: glay@thurber.caEmail: accounting@thurber.ca

REGULATIONS

☐ O.Reg 153/04☐ O.Reg 406/19

Other Regulations: _____

Sewer By-Law: _____

☐ Table 1 ☐ Res/Park ☐ Soil Texture: _____☐ Reg 347/558 (3 Day min TAT)☐ Sanitary☐ Table 2 ☐ Ind/Com ☐ Coarse☐ PW/QO ☐ MMER☐ Storm☐ Table 3 ☐ Agr/Other ☐ Medium/Fine☐ CCME ☐ Other: _____☐ Municipality: _____☐ Table _____ ☐ MISA☐ ODWS Not Reportable (See note)Soil Volume ☐ <350m3 ☐ >350m3

RECORD OF SITE CONDITION (RSC)

☐ YES ☐ NO

SAMPLE IDENTIFICATION

DATE SAMPLED

TIME SAMPLED

OF BOTTLES

MATRIX

1 BH20-03, SSC

Dec 28, 20

1

Soil

2 BH20-08, SSC

Dec 2, 20

1

Soil

3 BH20-21, SSC

Dec 1, 20

1

Soil

4 BH20-25, SSC

Nov 14, 20

1

Soil

5

6

7

8

9

10

11

12

Observations/Comments/Special Instructions

Sampled By (NAME): _____

Signature: _____

Relinquished by (NAME): _____

Signature: _____

Revision # 1.4
Date of Issue: 27 May, 2020Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. (2) Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). (3) Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

Please ensure SAR testing is not included in costativity package

ANALYSIS REQUESTED

M & I

SVOC

PCB

PHC

VOC

Pest

Other (please specify)

TCLP

Field Filtered (Y/N)

Metals & Inorganics

Full Metals Suite

ICP Metals only

PAHs only

SVOCs

PCBs

F1-F4 + BTEX

F1-F4 only

VOCs

BTEX only

Pesticides

Organochlorine or specify other

Appendix 2: 406/19 Leachate

Screening Levels Table:

Sewer Use:

Water Characterization Pkg

General

Extended

COMMENTS:

Quotation #: 28552Project #: 28552

TURNAROUND TIME (TAT) REQUIRED

Regular TAT (5-7 days)

RUSH TAT (Additional Charges May Apply):

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: _____

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

P.O. #: _____

Site Location/ID: Thur 11 ON Rockwell

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day.



Appendix G

Foundation Comparison



COMPARISON OF FOUNDATION ALTERNATIVES

Driven H-Piles	Driven Pipe Piles	Drilled Shafts/Caissons
<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Pile driving could continue in freezing weather. ii. Allows integral abutment design. iii. Generally less costly than drilled shafts/caissons. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. Higher lateral resistance relative to H-piles. ii. Liner is not required during installation to support excavation sidewalls. iii. Cleaning and inspection of the socket base is not required. 	<p><i>Advantages:</i></p> <ul style="list-style-type: none"> i. High geotechnical resistance available for caissons socketed into bedrock ii. Construction of caissons could continue in freezing weather. iii. Caissons could be structurally connected to the superstructure eliminating need for pile caps.
<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Potential for pile deflection or refusal on cobbles and boulders within till. ii. Potential for varying pile lengths within a foundation unit. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Possibly higher unit cost relative to driven H-piles. ii. Specialized installation. iii. Installation through cobbles and boulders will be difficult. iv. Not suitable for integral abutment design. 	<p><i>Disadvantages:</i></p> <ul style="list-style-type: none"> i. Higher unit cost compared to other foundation options such as driven piles. ii. Temporary liners and synthetic slurry will be required to install caissons below the water table. iii. Potential difficulty in cleaning and inspecting sockets. iv. Installation through cobbles and boulders will be difficult.
RECOMMENDED	FEASIBLE	FEASIBLE



Appendix H

Slope Stability Analysis Results

140 m BRIDGE NORTH APPROACH (STA. 17+723) EAST SIDE - EXISTING CONDITION

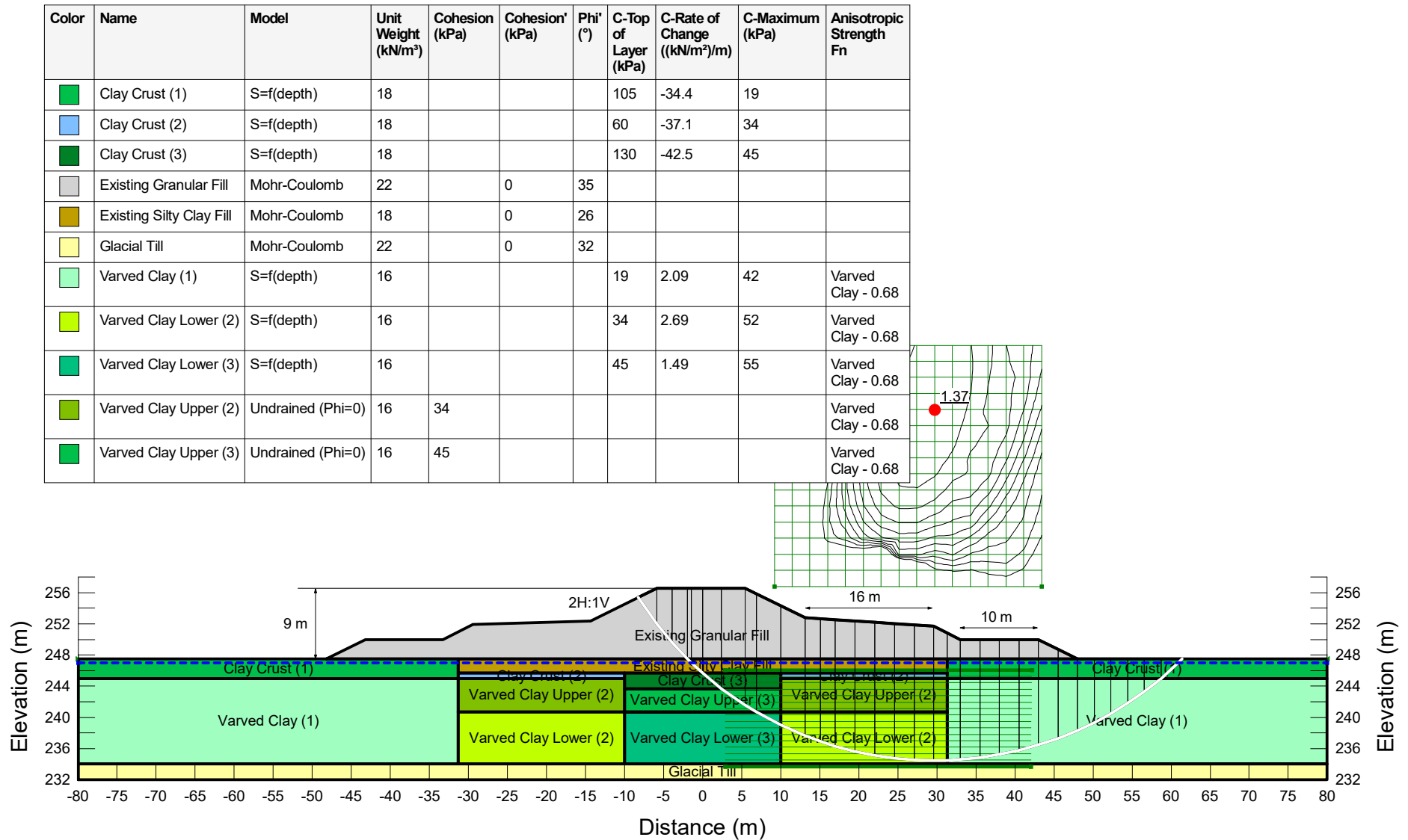


FIGURE H1

140 m BRIDGE NORTH APPROACH (STA. 17+723) EAST SIDE - UNDRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m ²)/m)	C-Maximum (kPa)	Anisotropic Strength F _n	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Lower (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Upper (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No

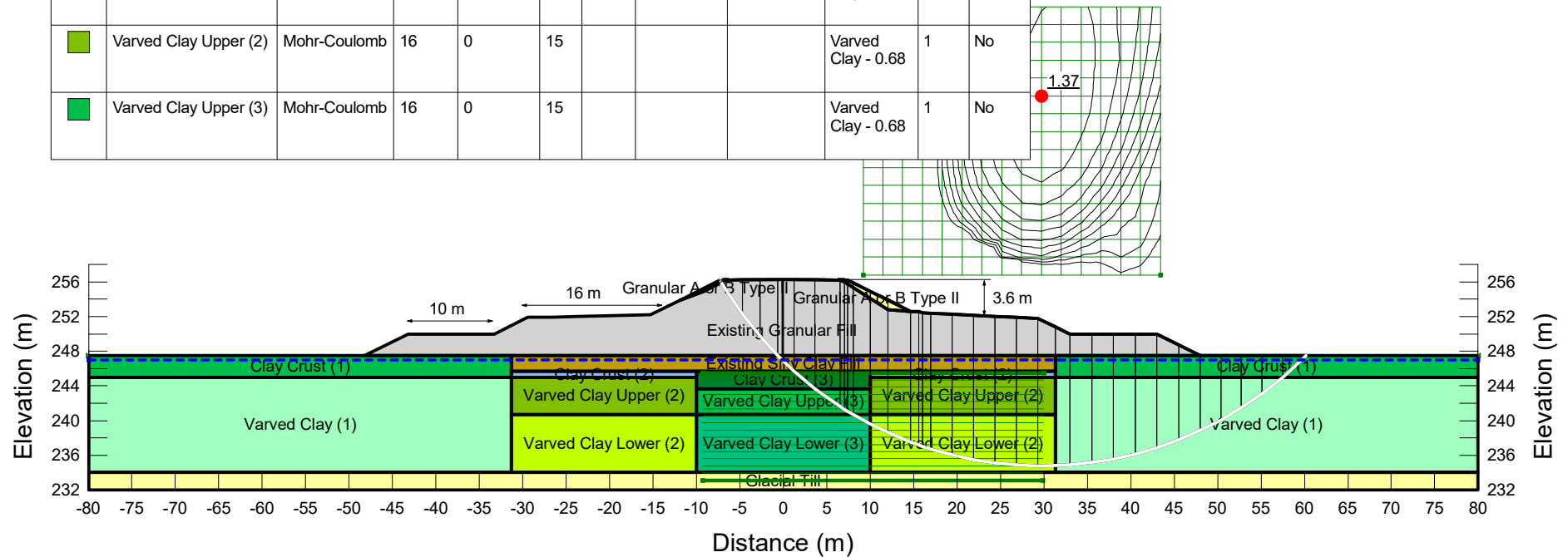


FIGURE H2

140 m BRIDGE NORTH APPROACH (STA. 17+723) EAST SIDE - DRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m ³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m ²)/m)	C-Maximum (kPa)	Anisotropic Strength F _n	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Lower (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Upper (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No

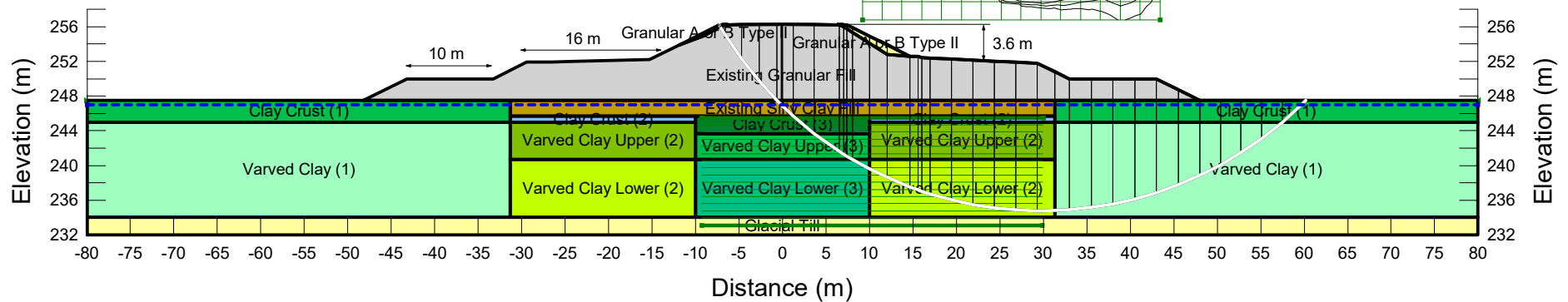
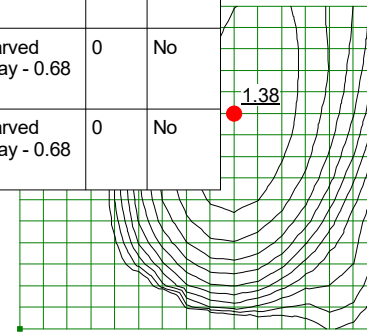














FIGURE H3

140 m BRIDGE NORTH APPROACH (STA. 17+723) WEST SIDE - UNDRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength F _n	B-bar	Add Weight
	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
	Glacial Till	Mohr-Coulomb	22	0	32					0	No
	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Lower (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Upper (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No

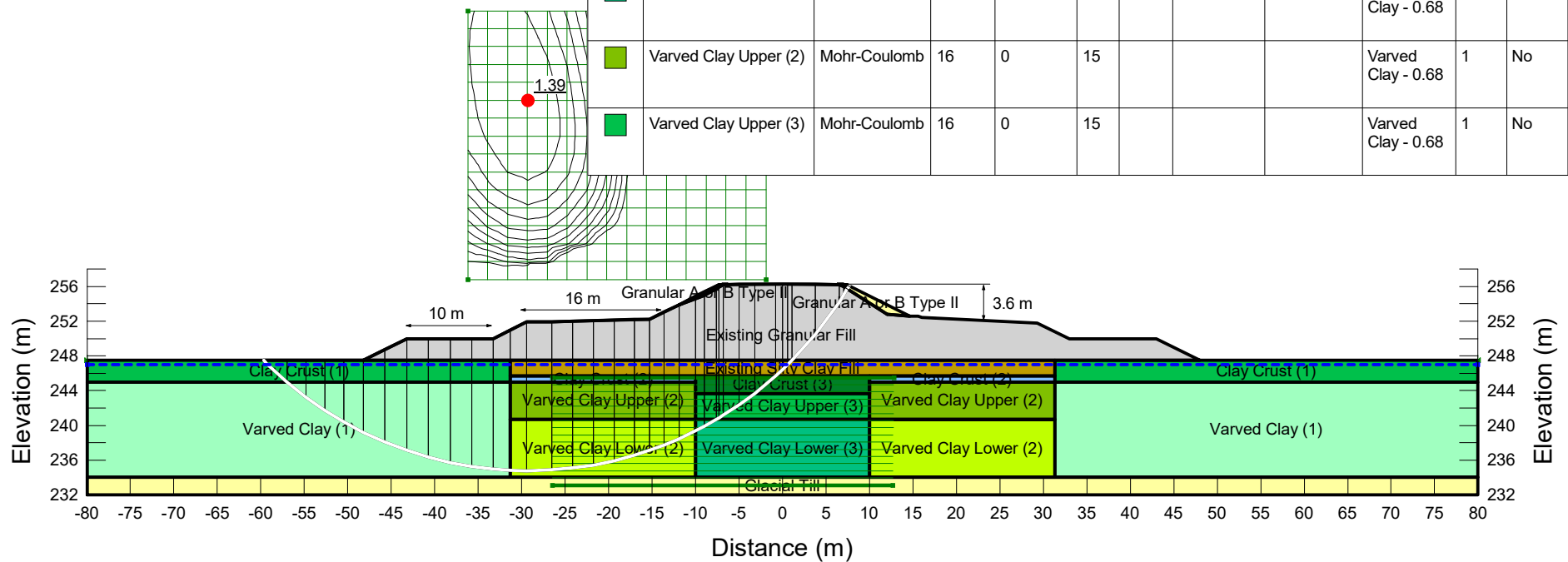


FIGURE H4

140 m BRIDGE NORTH APPROACH (STA. 17+723) WEST SIDE - DRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength F _n	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Lower (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Upper (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No

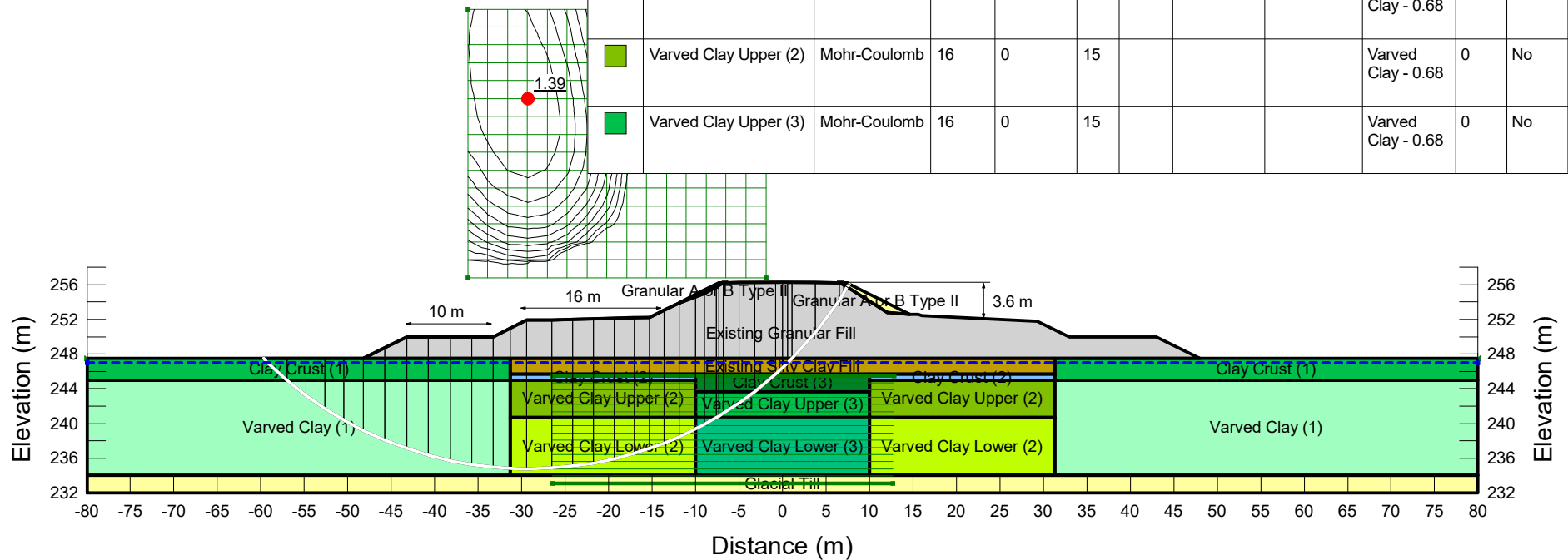


FIGURE H5

140 m BRIDGE SOUTH APPROACH (STA. 17+571) EAST SIDE - EXISTING CONDITION

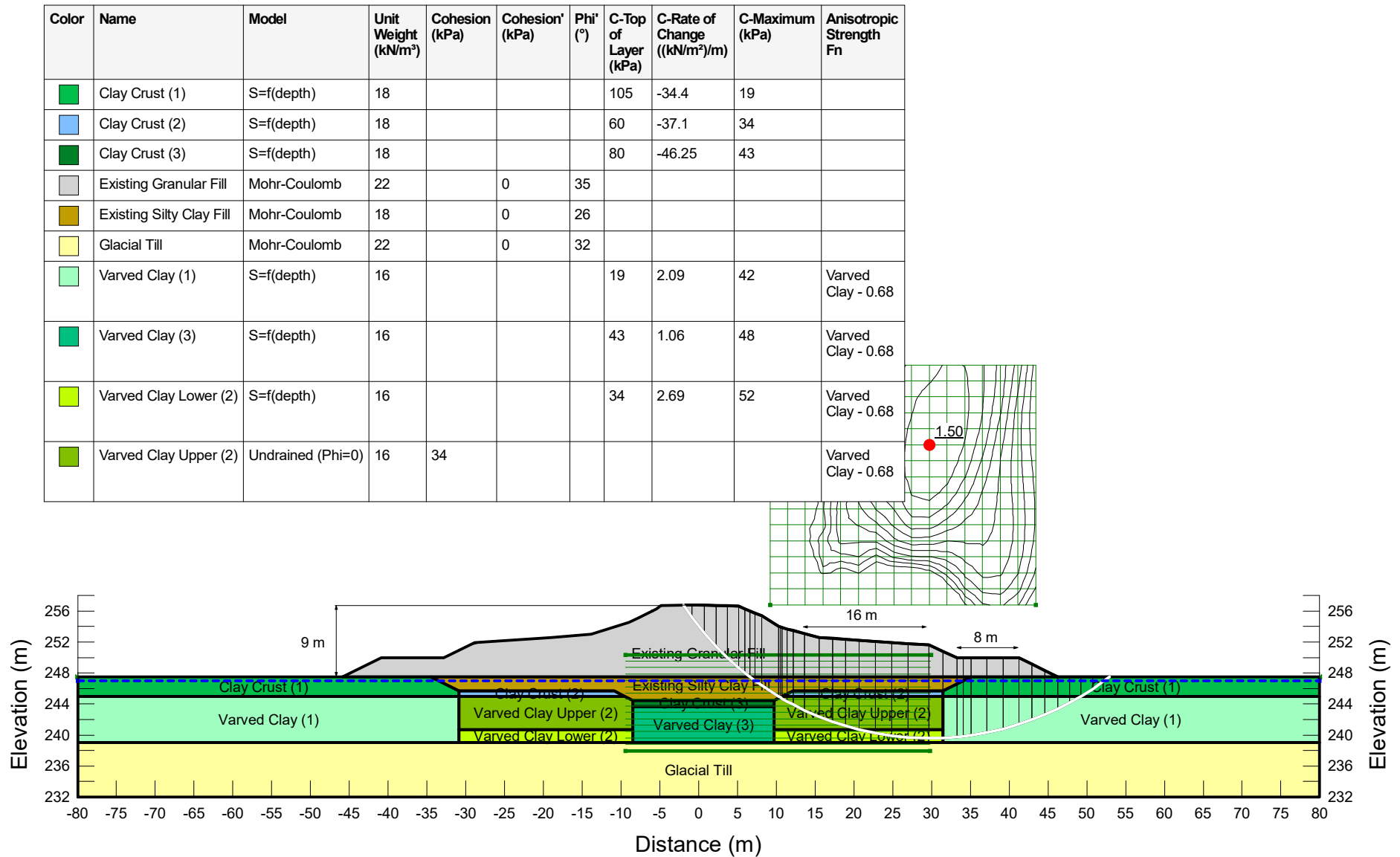













FIGURE H6

140 m BRIDGE SOUTH APPROACH (STA. 17+571) EAST SIDE - UNDRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
	Glacial Till	Mohr-Coulomb	22	0	32					0	No
	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No

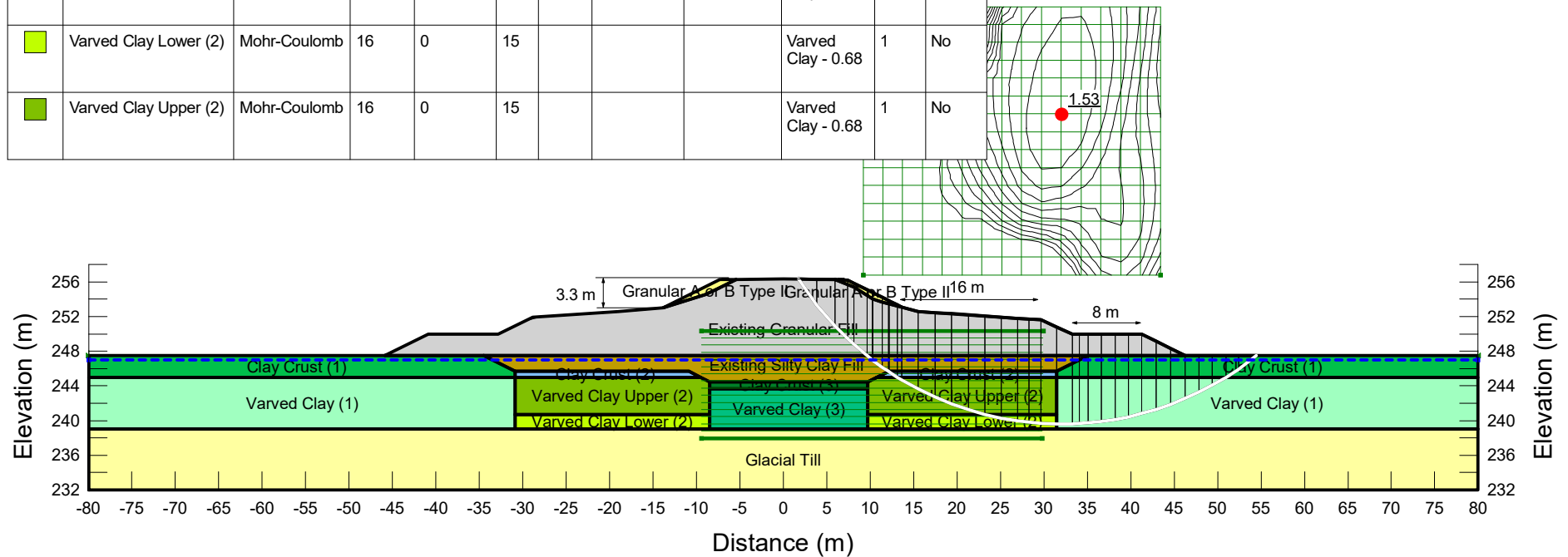













FIGURE H7

140 m BRIDGE SOUTH APPROACH (STA. 17+571) EAST SIDE - DRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Phi (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
	Glacial Till	Mohr-Coulomb	22	0	32					0	No
	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No

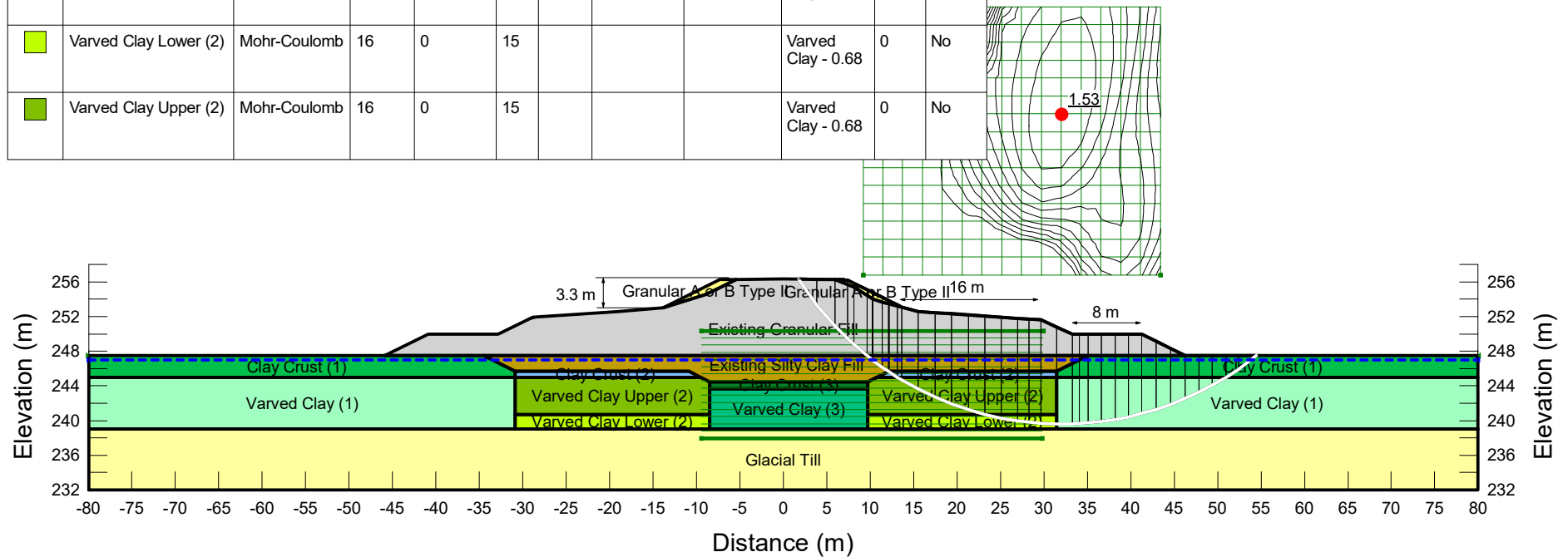


FIGURE **H8**

140 m BRIDGE SOUTH APPROACH (STA. 17+571) WEST SIDE - UNDRAINED CONDITION

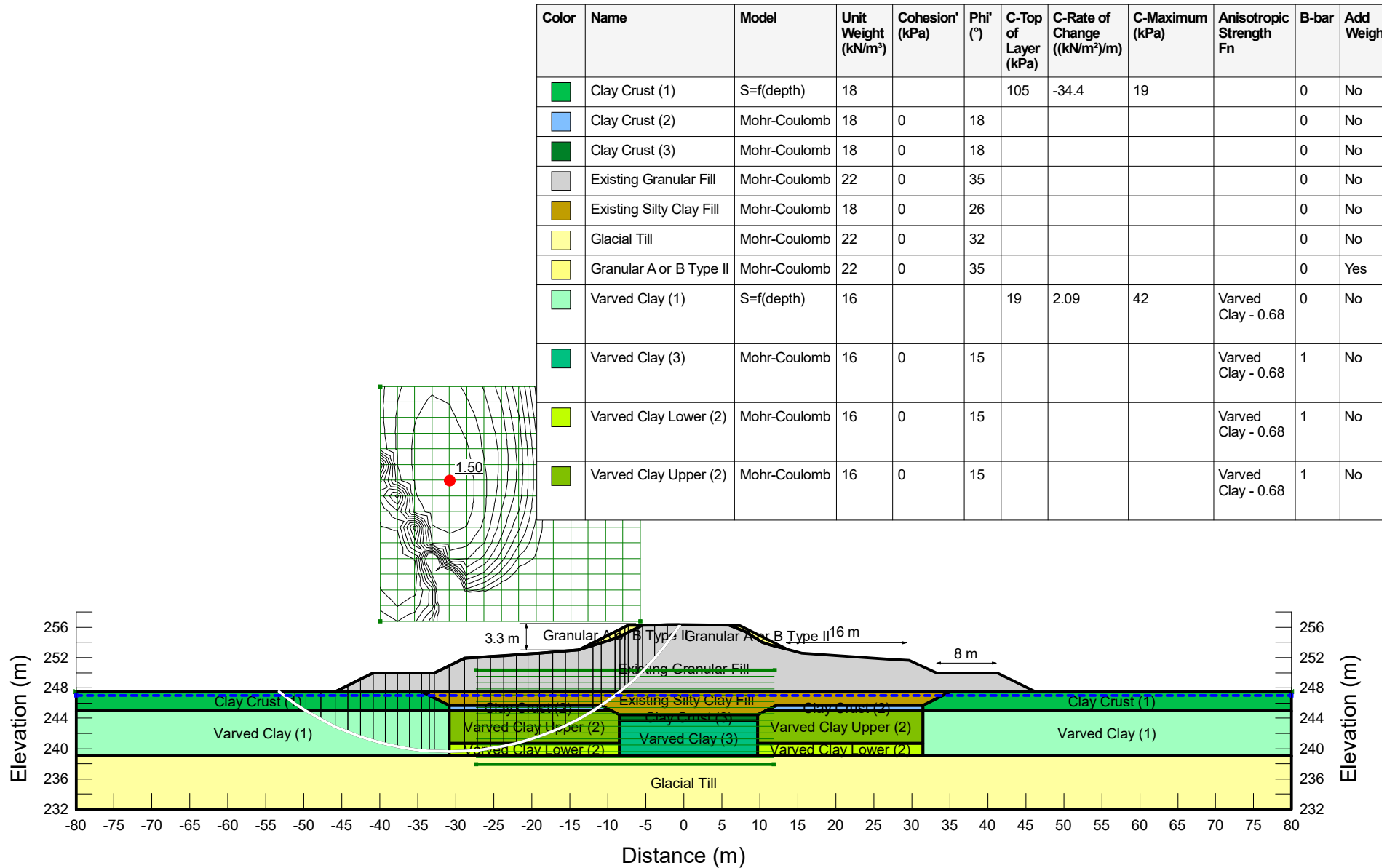


FIGURE H9

140 m BRIDGE SOUTH APPROACH (STA. 17+571) WEST SIDE - DRAINED CONDITION

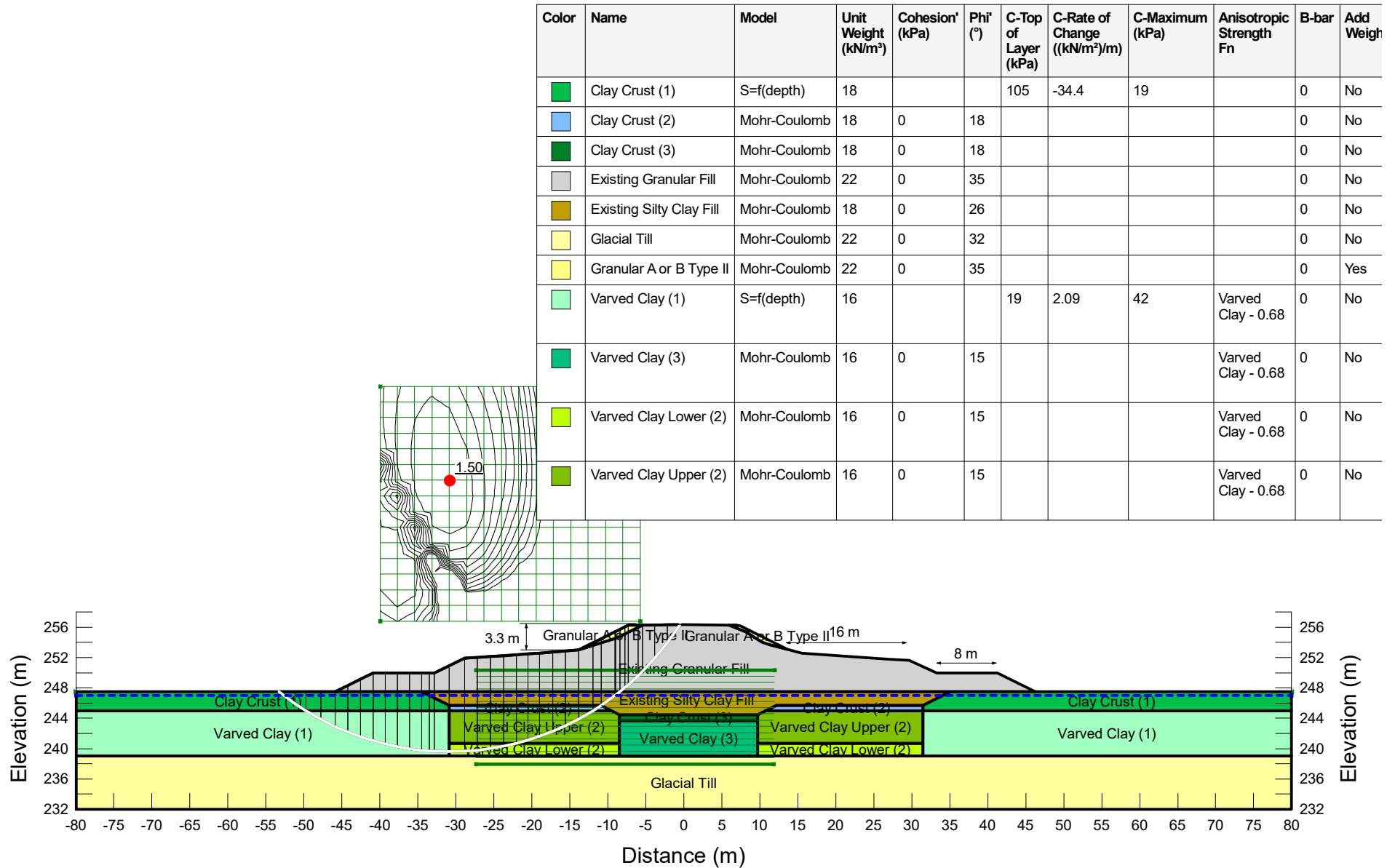


FIGURE H10

140 m BRIDGE SOUTH APPROACH (STA. 17+565) SW QUADRANT 45 DEGREES - EXISTING CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength F _n
Green	Clay Crust (1)	S=f(depth)	18				105	-34.4	19	
Blue	Clay Crust (2)	S=f(depth)	18				60	-37.1	34	
Dark Green	Clay Crust (3)	S=f(depth)	18				80	-46.25	43	
Grey	Existing Granular Fill	Mohr-Coulomb	22		0	35				
Brown	Existing Silty Clay Fill	Mohr-Coulomb	18		0	26				
Yellow	Glacial Till	Mohr-Coulomb	22		0	32				
Light Green	Varved Clay (1)	S=f(depth)	16				19	2.09	42	Varved Clay - 0.68
Dark Green	Varved Clay (3)	S=f(depth)	16				43	1.06	48	Varved Clay - 0.68
Light Yellow	Varved Clay Lower (2)	S=f(depth)	16				34	2.69	52	Varved Clay - 0.68
Dark Yellow	Varved Clay Upper (2)	Undrained (Phi=0)	16	34						Varved Clay - 0.68

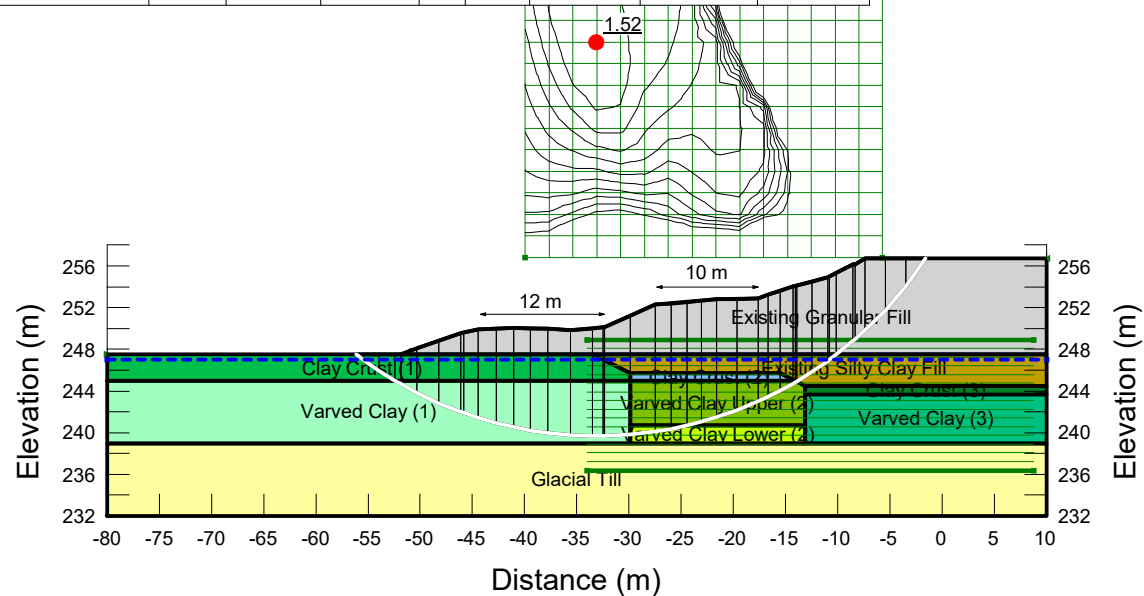













FIGURE H11

140 m BRIDGE SOUTH APPROACH (STA. 17+565) SW QUADRANT 45 DEGREES - UNDRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
	Glacial Till	Mohr-Coulomb	22	0	32					0	No
	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No

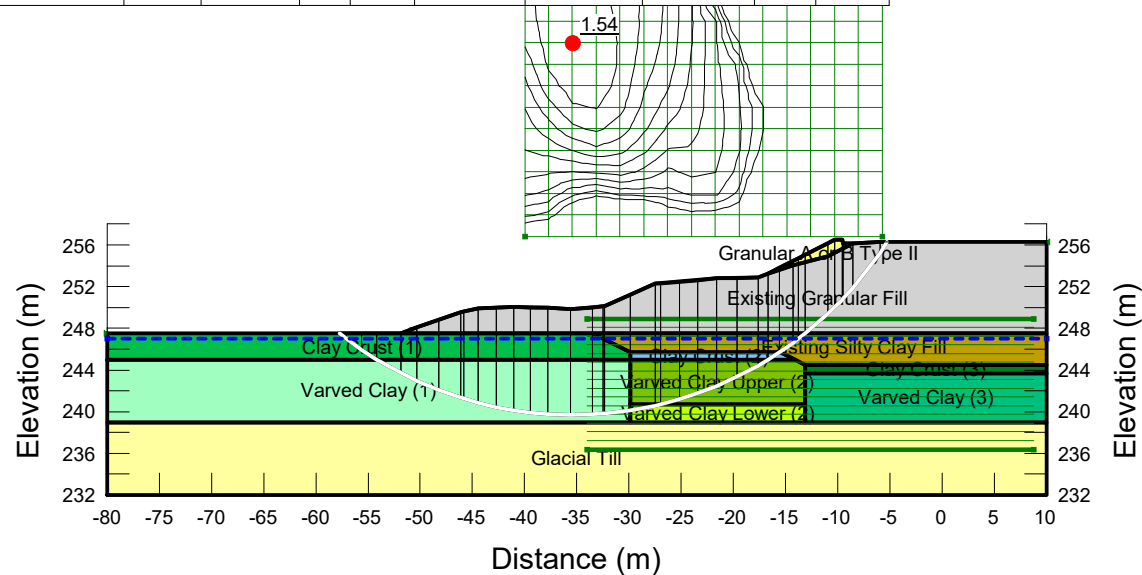













FIGURE H12

140 m BRIDGE SOUTH APPROACH (STA. 17+565) SW QUADRANT 45 DEGREES - DRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
	Glacial Till	Mohr-Coulomb	22	0	32					0	No
	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No

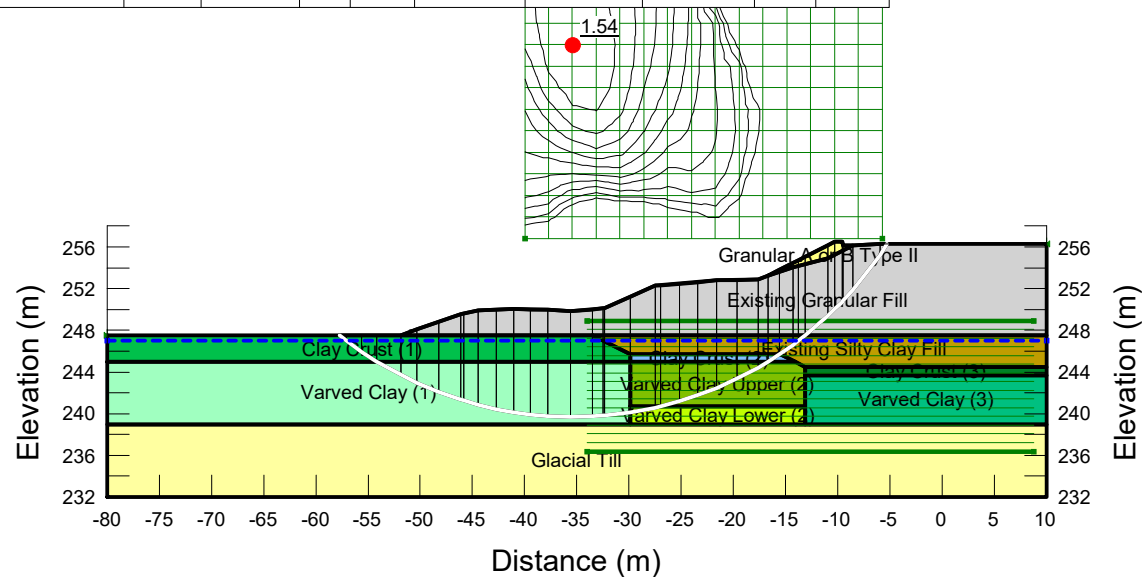


FIGURE H13

140 m BRIDGE SOUTH APPROACH (STA. 17+600) FORWARD SLOPE - EXISTING CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion (kPa)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn
■	Clay Crust (1)	S=f(depth)	18				105	-34.4	19	
■	Clay Crust (2)	S=f(depth)	18				60	-37.1	34	
■	Clay Crust (3)	S=f(depth)	18				80	-46.25	43	
■	Existing Granular Fill	Mohr-Coulomb	22		0	35				
■	Existing Silty Clay Fill	Mohr-Coulomb	18		0	26				
■	Glacial Till	Mohr-Coulomb	22		0	32				
■	Varved Clay (1)	S=f(depth)	16				19	2.09	42	Varved Clay - 0.68
■	Varved Clay (3)	S=f(depth)	16				43	1.06	48	Varved Clay - 0.68
■	Varved Clay Lower (2)	S=f(depth)	16				34	2.69	52	Varved Clay - 0.68
■	Varved Clay Upper (2)	Undrained (Phi=0)	16	34						Varved Clay - 0.68

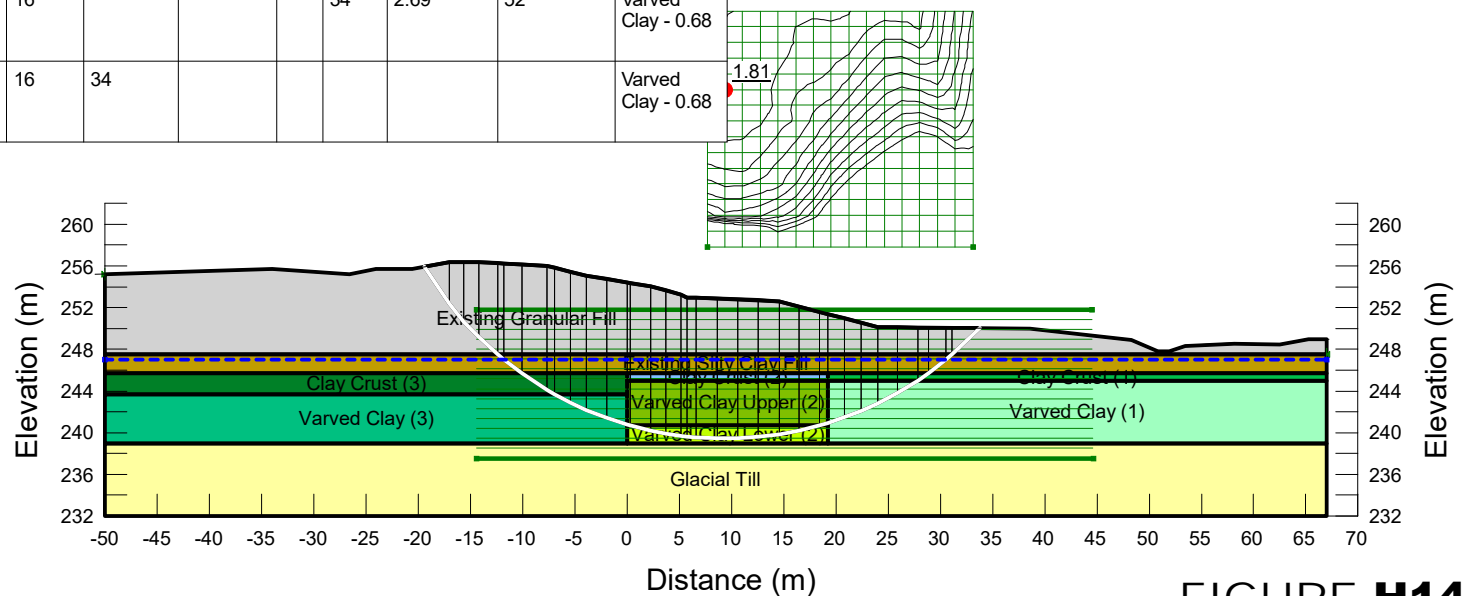
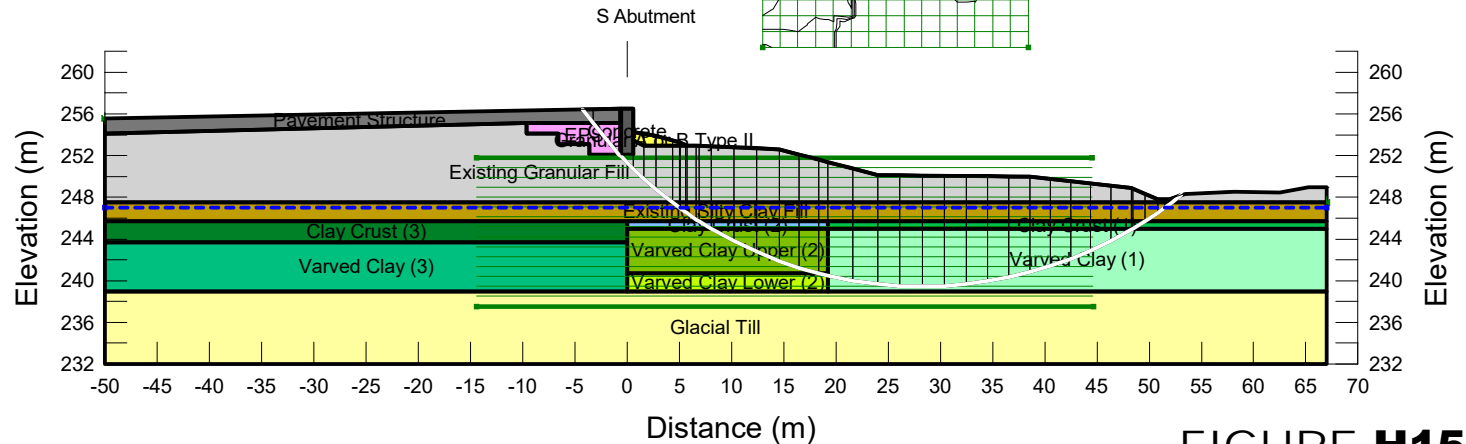


FIGURE H14

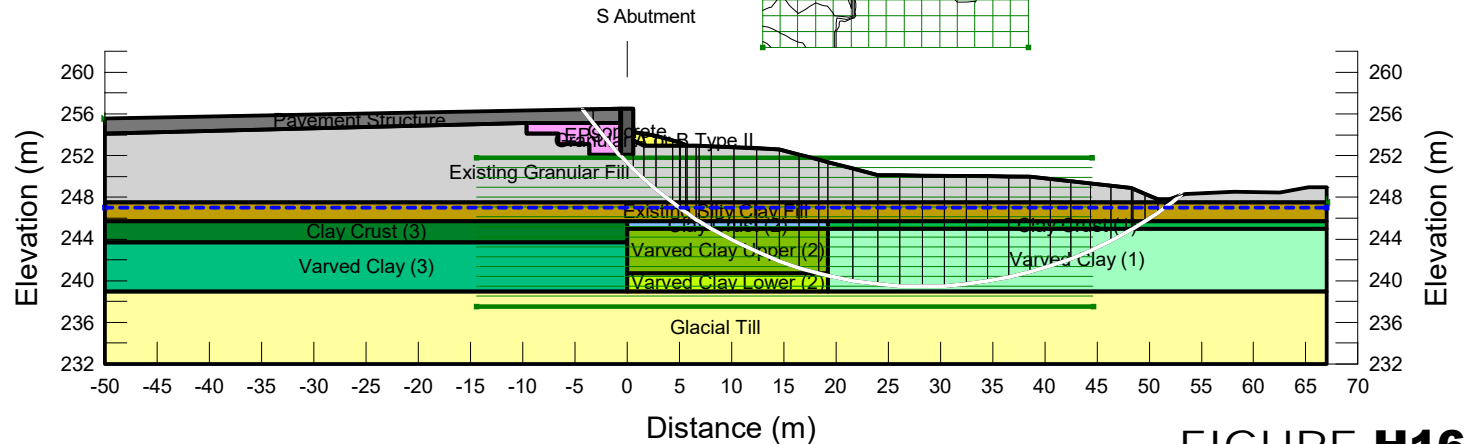
140 m BRIDGE SOUTH APPROACH (STA. 17+600) FORWARD SLOPE - UNDRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					1	No
■	Concrete	Mohr-Coulomb	24	1,000	0					0	No
■	EPS	Mohr-Coulomb	1	0	0					0	Yes
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Pavement Structure	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No



140 m BRIDGE SOUTH APPROACH (STA. 17+600) FORWARD SLOPE - DRAINED CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					0	No
■	Concrete	Mohr-Coulomb	24	1,000	0					0	No
■	EPS	Mohr-Coulomb	1	0	0					0	Yes
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Pavement Structure	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	0	No



140 m BRIDGE SOUTH APPROACH (STA. 17+600) FORWARD SLOPE - PSEUDO-STATIC CONDITION

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	C-Top of Layer (kPa)	C-Rate of Change ((kN/m²)/m)	C-Maximum (kPa)	Anisotropic Strength Fn	B-bar	Add Weight
■	Clay Crust (1)	S=f(depth)	18			105	-34.4	19		0	No
■	Clay Crust (2)	Mohr-Coulomb	18	0	18					0	No
■	Clay Crust (3)	Mohr-Coulomb	18	0	18					1	No
■	Concrete	Mohr-Coulomb	24	1,000	0					0	No
■	EPS	Mohr-Coulomb	1	0	0					0	Yes
■	Existing Granular Fill	Mohr-Coulomb	22	0	35					0	No
■	Existing Silty Clay Fill	Mohr-Coulomb	18	0	26					0	No
■	Glacial Till	Mohr-Coulomb	22	0	32					0	No
■	Granular A or B Type II	Mohr-Coulomb	22	0	35					0	Yes
■	Pavement Structure	Mohr-Coulomb	22	0	35					0	Yes
■	Varved Clay (1)	S=f(depth)	16			19	2.09	42	Varved Clay - 0.68	0	No
■	Varved Clay (3)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Lower (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No
■	Varved Clay Upper (2)	Mohr-Coulomb	16	0	15				Varved Clay - 0.68	1	No

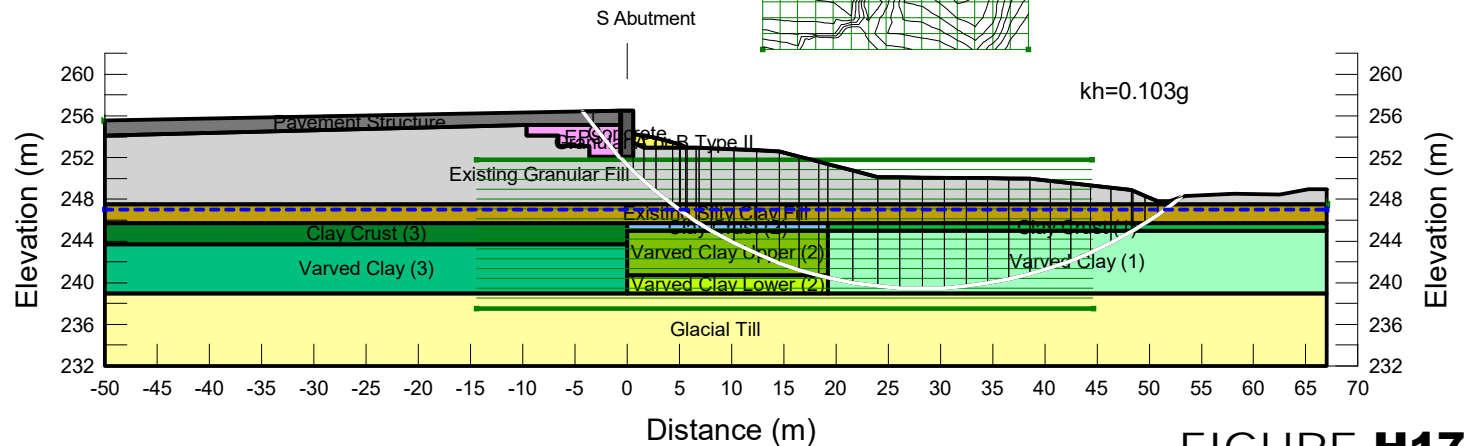
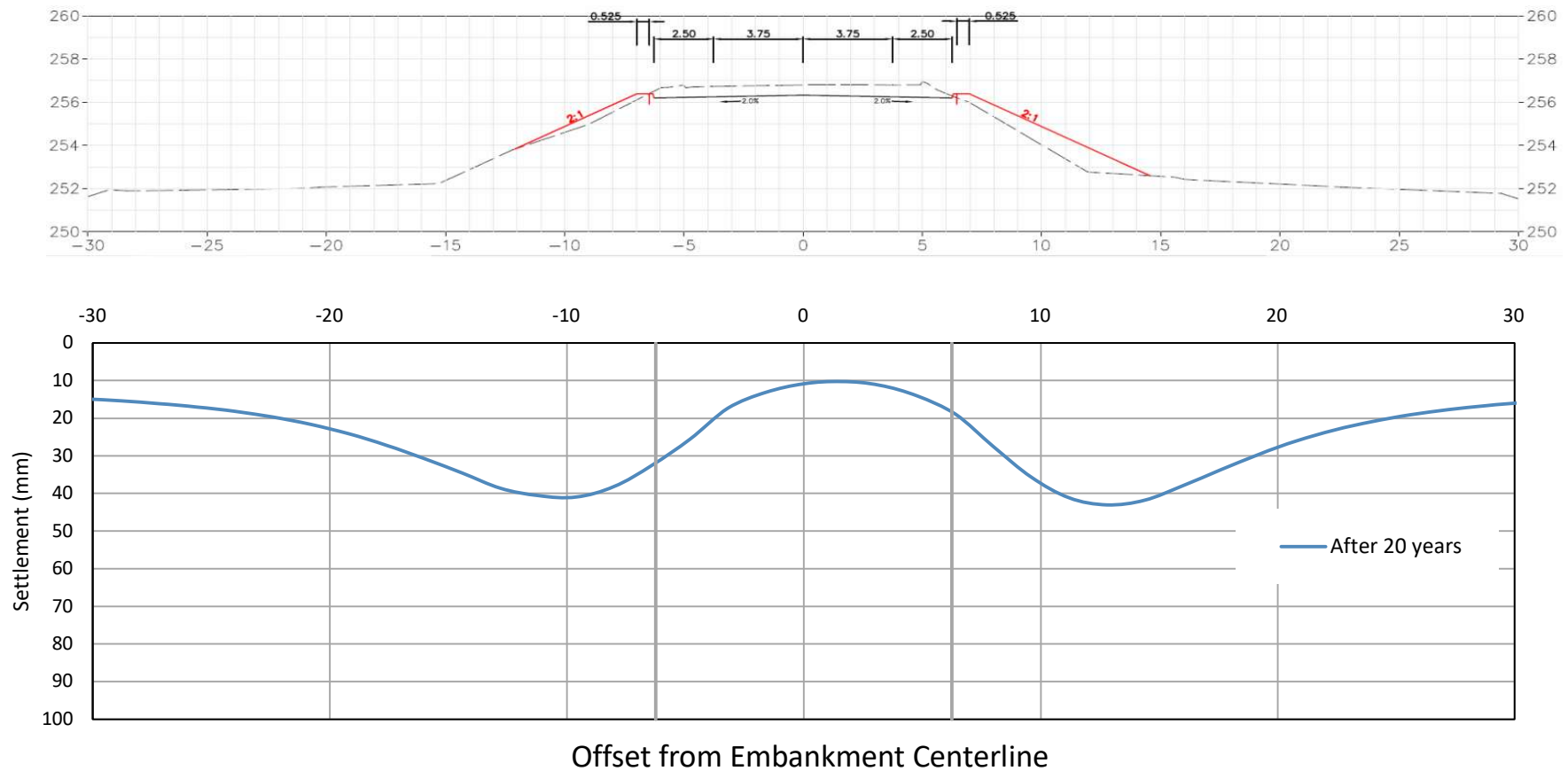


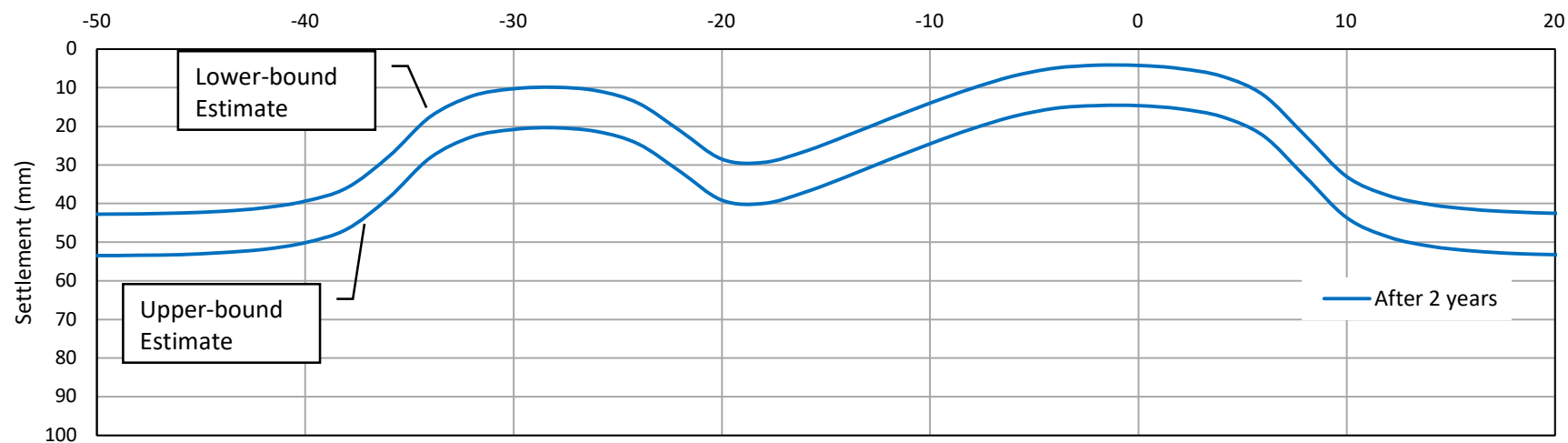
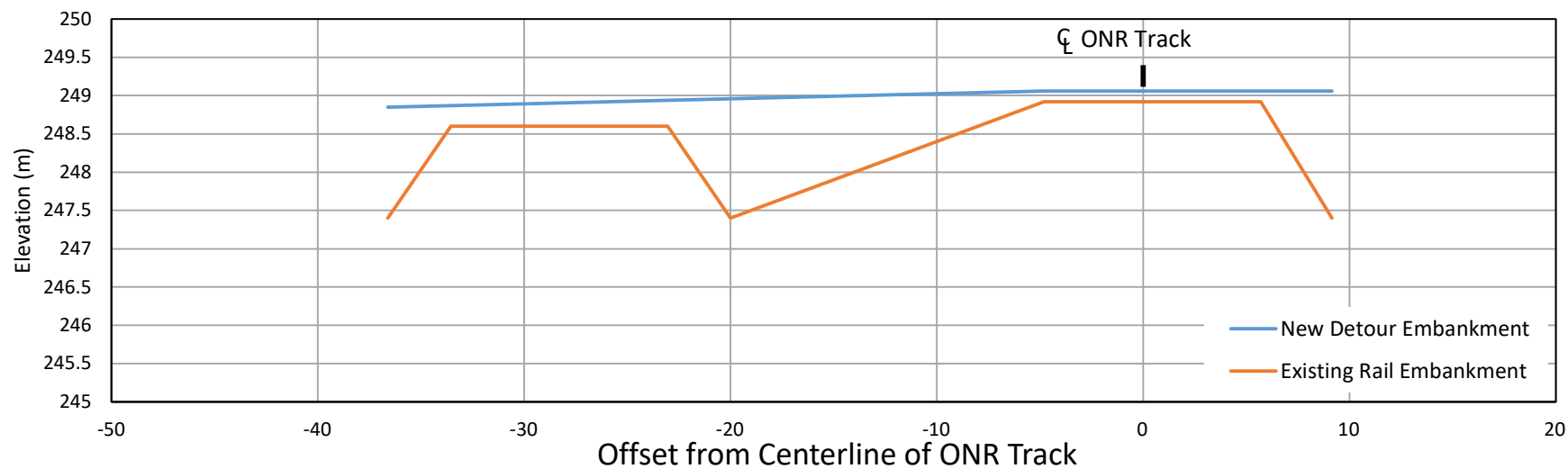
FIGURE H17

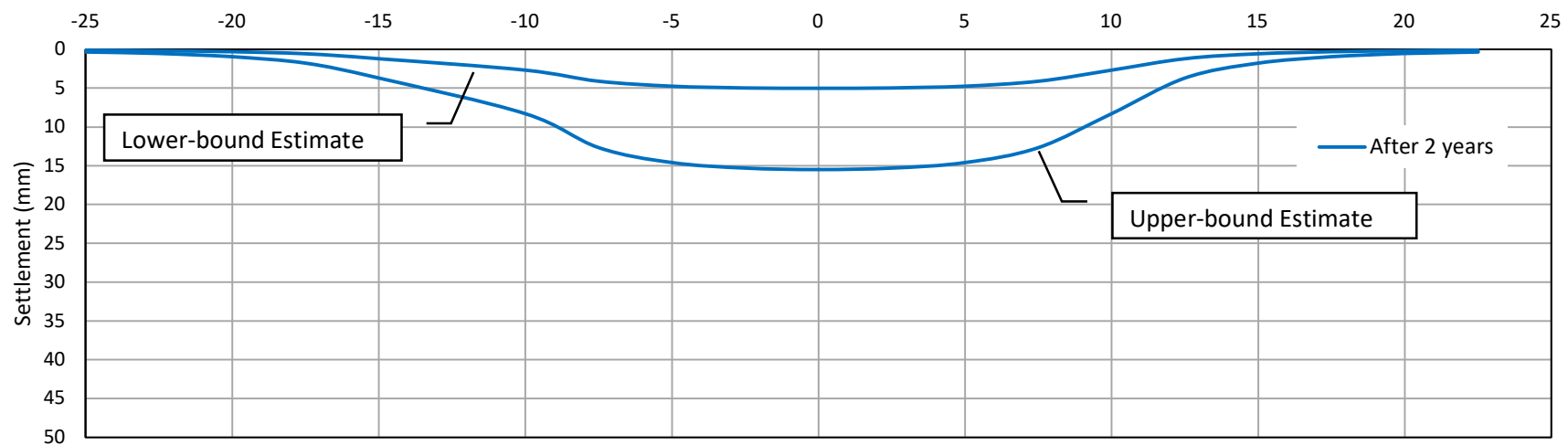
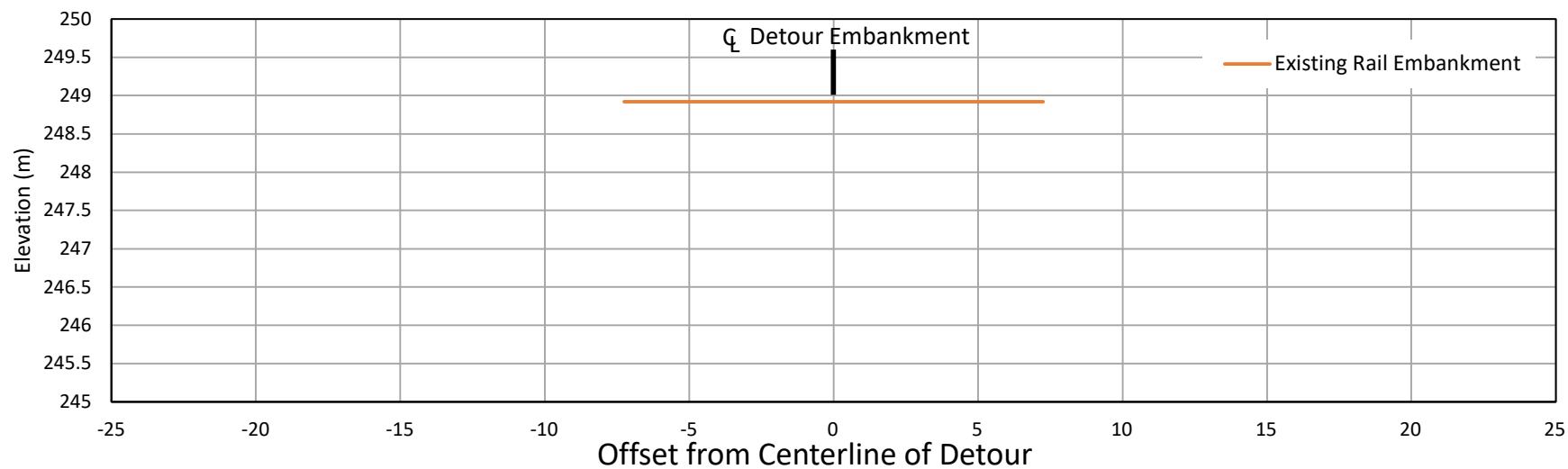


Appendix I

Settlement Analysis Figures









Appendix J

List of OPSS Documents and NSSP Wording



1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS.PROV 804
- OPSS.PROV 902
- OPSS.PROV 903
- OPSS.PROV 1010
- SP 109F57
- OPSD 208.010
- OPSD 601.010
- OPSD 3090.100
- OPSD 3101.150

2. Suggested Text for NSSP on “Pile Installation”

Pile installation should be in accordance with OPSS.PROV 903 and SP 109F57.

Driven steel H-piles may encounter very dense zones and cobbles/boulders within the embankment fill and till deposit above the bedrock. The Contractor must employ suitable equipment and methods penetrate any very dense zones and cobbles/boulders encountered during pile installation and advance the piles to bedrock.

Pile driving energy shall be carefully controlled for Piers #4 and #5 in order to not cause excessive vibrations and settlement of the ONR track. The peak particle velocity (PPV) levels produced by pile driving and setting piles on bedrock shall not exceed the following review and alert levels:

- Review Level: PPV = 8 mm/s
- Alert Level: PPV = 10 mm/s

3. Suggested Text for NSSP on “Pile Driven to Bedrock”

The piles must be driven to bedrock. The appropriate pile driving note is “Piles to be driven to bedrock”. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent. Pile driving shall be terminated before the pile is damaged by overdriving.



4. Suggested Text for NSSP on “Geotechnical Assessment - Use of Heavy Construction Equipment”

The use of heavy construction equipment and in particular heavy lift cranes may be required during removal of the existing bridge girders and deck and may be required during erection of the new bridge. The impact of the heavy equipment loads on the existing embankment supported on varved clay and the existing bridge foundations must be considered during selection of the methodology and equipment employed for construction.

Prior to the commencement of construction, the Contractor must retain a Geotechnical Consultant to carry out a Geotechnical Assessment of the following:

- The impact of the proposed equipment loads and methodology
- The capability of the subgrade soils to support the proposed construction equipment and any temporary structures or fill (i.e. as a pad for crane support)
- The requirements and/or restrictions necessary to safely support the loads.

The design and safety of any temporary works is the responsibility of the Contractor. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under MTO’s RAQS for providing services under the speciality of Geotechnical (Structures and Embankments) – High Complexity.

The assessment shall include, but not be limited to, the following:

- Determining appropriate setbacks for heavy equipment from the bridge abutments and crest of slope
- Determining the permissible ground pressure that may be applied to the foundation soils by the equipment; and
- Providing recommendations from crane pad design to distribute the crane loads without causing foundation/embankment failure.

The Contractor shall submit the findings of the Geotechnical Assessment and details of the proposed equipment and construction methodology to the Contract Administrator for information purposes a minimum of two weeks prior to the start of construction.

Heavy construction equipment such as dressed lifting cranes must not be permitted on the EPS embankments in order to avoid crushing or otherwise damaging the EPS blocks.



5. Suggested Text for NSSP on “Stockpiling of Material”

Stockpiling of excavated soils and/or construction materials including granular material shall not be permitted anywhere on the top or the sides of the north and south approach embankments and stabilizing berms, or near the crest of any temporary excavations to minimize the potential for embankment/excavation instability.

6. Suggested Text for NSSP on “Geotechnical Assessment - Temporary Falsework”

Temporary falsework may be required to permit construction of the bridge superstructure. In light of the soft varved clays present at this site, falsework supported on shallow foundations may experience large differential settlements or foundation/bearing capacity failure. The falsework may also cause settlement of the existing ONR track.

Prior to the commencement of construction, the Contractor shall retain a Geotechnical Consultant to assess the stability and settlement impact of the proposed falsework loads and determine the means and methodology to safely support the falsework loads while avoiding foundation/bearing capacity failure and limiting settlement of the ONR track and bridge superstructure to tolerable limits.

The design and safety of any temporary works is the responsibility of the Contractor. All Foundation Engineering services required for this project shall be performed by consultant(s) listed as accepted under MTO’s RAQS for providing services under the speciality of Geotechnical (Structures and Embankments) – High Complexity.

The assessment shall include, but not be limited to, the following:

- Assessing the impact of the proposed falsework loads on the existing ONR track
- Establishing appropriate setbacks for falsework foundations from the ONR track
- Determining the permissible ground pressure that may be applied to the foundation soils by the falsework
- Establishing the means and methods for safely supporting the falsework loads while minimizing track settlement and avoiding foundation/bearing capacity failure
- Assessing the impact of the falsework loads on the slope stability of the existing approach embankments and stabilizing berms
- Providing foundation recommendations for supporting the falsework while limiting settlement of the ONR track and bridge superstructure to tolerable levels.



The Contractor shall submit the findings of the Geotechnical Assessment and details of the proposed falsework and construction methodology to the Contract Administrator for information purposes a minimum of two weeks prior to the start of construction.

EXPANDED POLYSTYRENE EMBANKMENT

Special Provision

TABLE OF CONTENTS

1.0	SCOPE
2.0	REFERENCES
3.0	DEFINITIONS
4.0	DESIGN AND SUBMISSION REQUIREMENTS
5.0	MATERIALS
6.0	EQUIPMENT
7.0	CONSTRUCTION
8.0	QUALITY ASSURANCE
9.0	MEASUREMENT FOR PAYMENT
10.0	BASIS OF PAYMENT

1.0 SCOPE

This special provision covers the requirements for the supply and construction of the rigid expanded polystyrene (EPS) embankment fill and associated works as shown on the contract drawings.

As part of the work of the above noted tender item, the Contractor shall supply and install Geomembrane and Polyethylene Sheeting as detailed elsewhere in the Contract.

2.0 REFERENCES

This special provision refers to the following standards, specifications or publications.

National Standards of Canada

CAN/ULC – S102.2-10

CAN/ULC – S701-11

NCHRP

Report 529 Guideline and Recommended Standard for Geofoam Applications in Highway Embankments

ASTM

ASTM D1621	Test Method for Compressive Properties of Rigid Cellular Plastics
ASTM C203	Test Method for Breaking Load and Flexural Properties of Block Type Thermal Insulation
ASTM C177	Test Method for Steady State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Apparatus
ASTM D2842	Test Method for Water Absorption by Rigid Cellular Plastics
ASTM D2863	Test Method for Measuring the Minimum Oxygen Content
ASTM D2126	Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging
ASTM D6817	Standard Specification for Rigid Cellular Polystyrene Geofoam

OPSS - Ontario Provincial Standard Specification

OPSS 212	Borrow
OPSS 501	Compaction
OPSS 517	Dewatering
OPSS 1010	Aggregates – Granular A, B, M, and Selected Subgrade Material
OPSS 1605	Expanded Extruded Polystyrene Pavement Insulation
OPSS 1860	Geotextiles

Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Report for this Contract.

3.0 DEFINITIONS

For the purpose of this special provision, the following definitions apply:

Rigid Expanded Polystyrene: Moulded rigid blocks produced by a process of pre-expansion, aging and forming of petroleum based raw material.

Rigid Extruded Expanded Polystyrene: Rigid boards made by extrusion of expanded polystyrene beads.

Production Lot: The quantity of rigid polystyrene blocks produced in a continuous period of manufacturing the same grade and thickness of product within the same production day.

Quality Verification Engineer: Quality Verification Engineer means an Engineer with a minimum of five (5) years' experience related to the design and/or construction of expanded polystyrene systems of similar scope to that in the Contract, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to ensure conformance with the contract documents and issue of certificate(s) of conformance.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Submission of Shop Drawings

At least three weeks before the commencement of work, the Contractor shall submit to the Contract Administrator six copies of the shop drawings and method statement signed and sealed by the Quality Verification Engineer that provides full details of the construction procedure.

4.02 Delivery, Storage, Handling, and Protection

The Contractor shall submit the method of delivery, storage, handling and protection from damage by weather, traffic, construction staging and other causes as per the rigid expanded polystyrene manufacturer's requirement.

4.03 Construction

The contractor shall submit full details of the following.

- (1) The method of foundation excavation and preparation.
- (2) Construction of levelling pad.
- (3) The method of placement of expanded polystyrene blocks including temporary ballasting and protection of blocks during installation. The shop drawings shall indicate laying pattern and block dimensions on a layer-by-layer basis.
- (4) The method of placement of reinforced concrete slab (or equivalent, where applicable).
- (5) The method and limits of placement of polyethylene sheeting.
- (6) The method of placement of subbase material.

4.04 Quality Verification Engineer

The Contractor shall submit details of the sequence and method of installation to the Quality Verification Engineer for review. The submittals shall satisfy the specifications and at a minimum include a detailed description of proposed installation procedures. The details shall be submitted at least three weeks prior to the installation of the rigid expanded polystyrene embankments. The Contractor shall also submit to the Contract Administrator, for information purposes, details of the sequence and method of installation. The submittals shall satisfy the specifications and at a minimum contain the above information as provided to the Contractor's Quality Verification Engineer.

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the requirements and specifications of the contract documents. Upon completion of the Expanded Polystyrene Embankment the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer stating that the Expanded Polystyrene Embankment has been constructed in conformance with the installation procedures and specifications of the contract documents.

5.0 MATERIALS

5.01 Granular Levelling Pad and Backfill Between EPS and Sheet Pile Wall

The levelling pad shall consist of a OPSS .PROV 1010 Granular A material with gradation and physical requirements as specified in OPSS 1010.

Backfill in confined spaces between the sheet pile wall and EPS (such as within the sheet pile trough), shall comprise 9.5 mm clear stone meeting the requirements of OPSS 1004.

5.02 Polyethylene Geomembrane

The EPS shall be encapsulated with a polyethylene geomembrane with two coextruded textured surfaces such as [GSE HDT 30A000] or approved equivalent. A minimum 10mil smooth [black] polyethylene sheeting may be used on the sides only.

Polyethylene geomembrane shall be flexible and, by its own weight, shall cover and conform closely to 90 degree edges and corners of EPS blocks without additional heating of the Polyethylene geomembrane.

Polyethylene geomembrane shall be free from pin holes, tears, and any defects.

5.03 Rigid Expanded Polystyrene

5.03.01 General

The Contractor shall submit the following.

- (1) A general statement as to the type, composition, and method of production of the material.
- (2) The manufacturer's name, address, phone number, identification of a contact person and description of experience background in the manufacturing of the rigid expanded polystyrene.
- (3) Certification of compliance of physical and mechanical properties.
- (4) An identification of a laboratory accredited by the Standards Council of Canada to conduct the testing of the physical and mechanical properties of the rigid expanded polystyrene.
- (5) The physical and mechanical properties of the rigid expanded polystyrene including:
 - (1) Geometry
 - (2) Nominal Density
 - (3) Compressive Strength
 - (4) Flexural Strength
 - (5) Thermal Resistance
 - (6) Dimensional Stability
 - (7) Flammability
 - (8) Water Absorption
- (6) Aging and durability characteristics of the polystyrene including the chemical, biological and ultra-violet degradation resistance of the rigid polystyrene.
- (7) A sample of the expanded polystyrene material to the Quality Verification Engineer for review.
- (8) To the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The

Certificate shall state that the expanded polystyrene material is in conformance with the requirements and specifications of the contract documents.

Each block of the same production lot shall be stamped with the same production code showing plant identification, type and date of production. The polystyrene shall be free from defects affecting serviceability.

EPS blocks shall meet ASTM D6817 Standard Specification for rigid cellular polystyrene geofoam

5.03.02 Detail Requirements

Requirements shall be as shown in Table 1 and as described below.

Table 1 – Material Properties

PROPERTY	UNIT	REQUIREMENTS	TEST PROCEDUR
Geometry - Linear - Flatness - Squareness - Thickness	mm	2440 × 1220 × 338 with tolerances ± 1% 10mm in 3m ± 0.5% -3, +5	
Compressive Strength	kPa (min.) @ 1% Deformation	50 (EPS Type 22) 65 (EPS Type 24) 75 (EPS Type 29)	ASTM D1621 (Procedure A)
Compressive Strength	kPa (min.) @ 5% Deformation	110 (EPS Type 22) 140 (EPS Type 24) 170 (EPS Type 29)	ASTM D1621 (Procedure A)
Flexural Strength	kPa (min.)	240 (EPS Type 22) 276 (EPS Type 24) 345 (EPS Type 29)	ASTM C203 (Procedure B)
Dimensional Stability	% linear change (max.)	1.5	ASTM D2126
Thermal Resistance	m ² .°C/W (min. for 25mm thickness)	0.7	ASTM C177 or C518
Flammability	Limiting Oxygen Index (min.)	24	ASTM D2863
Water Absorption	% by Volume (max.)	4 (EPS Type 22) 3 (EPS Type 24) 2 (EPS Type 29)	ASTM D2842

5.03.02.01 Geometry

The expanded polystyrene shall be supplied in the form of rectangular parallel blocks of minimum acceptable dimensions of 2440 mm x 1220 mm x 338 mm.

The maximum deviation from the specified linear dimensions shall be $\pm 1\%$. The flatness of the lock faces shall be within ± 10 mm of a line formed by a 3 m straight edge.

The maximum difference in corner to corner dimensions (squareness) shall be 0.5%. The thickness shall be within -3 to $+5$ mm.

5.03.02.02 Compressive Strength

At no time shall the vertical stress on the EPS exceed the 1% strain limit. A Factor of Safety of 1.2 shall be applied to all loads, in accordance with NCHRP 529.

The minimum compressive strength, measured in accordance with ASTM D1621, Procedure A, shall be 110 kPa for EPS Type 22 at a strain of not more than 5%. The maximum permissible permanent stress level should not exceed 30% of the compressive strength of the material at 5% strain. The compressive strength for other grades of EPS are listed in Table 1.

5.03.02.03 Flexural Strength

The minimum flexural strength of the polystyrene shall be 240 kPa for EPS Type 22. The flexural strength shall be determined in accordance with ASTM C203, method 1, Procedure B. The flexural strength for other grades of EPS are listed in Table 1.

5.03.02.04 Dimensional Stability

Dimensional Stability shall be determined in accordance with ASTM D2126, Procedure G. A tolerance of 1.5% shall be satisfied.

5.03.02.05 Thermal Resistance

The thermal resistance shall be $0.7 \text{ m}^2 \cdot ^\circ\text{C} / \text{W}$ for a 25mm thickness using the following equation and using the average value from three specimens:

$$R_{25mm} = \frac{R_{measured}}{\text{Thickness (mm)}} \times 25$$

The thermal resistance shall be measured in accordance with ASTM C177 or C518.

5.03.02.06 Flammability

The expanded polystyrene shall be classified as to surface burning characteristics in accordance with CAN/ULC - S102.2-10 having a flame spread rating less than 500. The expanded polystyrene shall have a minimum limiting oxygen index measured in accordance with ASTM D2863.

5.03.02.07 Water Absorption

The water absorption as measured by ASTM D2842 shall be limited to 4% for EPS Type 22 by volume. The water absorption for other grades of EPS are listed in Table 1.

5.03.02.08 Chemical Resistance

The expanded polystyrene shall be resistant to common inorganic acids and alkalis. A table identifying the chemical resistance as resistant, limited or not resistant shall be submitted.

5.03.02.09 Biological Resistance

The expanded polystyrene shall be resistant to biological degradation caused by organisms or enzymes.

5.03.02.10 Environmental

The expanded polystyrene shall be inert, non-nutritive and highly stable and shall not produce undesirable gases or leachate.

6.0 EQUIPMENT

All cutting of polystyrene materials shall be by electric equipment or by hand.

Heavy equipment shall be limited in weight and size and restricted in operation to avoid damaging the expanded polystyrene as per the manufacturer's requirement.

7.0 CONSTRUCTION

7.01 Delivery, Storage and Handling

The product shall be suitably marked to identify its type, number and the manufacturer's name or trademark.

The Contractor shall protect the expanded polystyrene from exposure to sunlight to avoid ultraviolet degradation as per manufacturer's recommendation.

Protection of materials and works from damage by weather, traffic, construction staging, fire or vandalism and other causes shall be the responsibility of the Contractor.

EPS blocks shall be stored for a minimum 72 hours at ambient room temperature (20 to 25 degrees Celsius) after an EPS block is released from the mould.

EPS blocks shall be stored above ground. EPS blocks shall be protected from moisture and sunlight in accordance with manufacturer's recommendations.

EPS shall not be exposed to open flame or other ignition source. The constructor shall protect the EPS blocks from petroleum based products such as gasoline and diesel fuel and organic solvents such as acetone, benzene and paint thinner.

7.02 Supplier's Representative

The Contractor shall have on site at the commencement of the work, a representative of the supplier of the rigid expanded polystyrene to advise on recommended construction procedure.

The Contractor shall maintain liaison with the supplier throughout the construction of the embankment for advice and guidance as required. Periodic site visits by the supplier should be coordinated as required.

7.03 Foundation Excavation

Foundation excavation shall be carried out to the design elevations shown on the drawings. Any softened, loosened or deleterious materials at the EPS founding elevation shall be subexcavated and replaced with OPSS.PROV 1010 Granular A material.

Any unsuitable area as determined by the Engineer, shall be excavated and replaced with suitable compacted backfill. The EPS subgrade shall be free from deleterious, loose, or otherwise unsuitable soils.

7.04

Leveling Pad

Clear and grub site and remove any subgrade material unsuitable for EPS block placement as determined by the Engineer.

Dewater as required. There shall be no standing water or accumulated snow or ice on the subgrade within the area where the EPS blocks are placed. EPS blocks shall not be placed on a frozen subgrade.

Place, level and compact to 95% standard Proctor density, a 150mm layer of Granular 'A' material to within ± 30 mm of the design elevation. The levelling pad shall not deviate by more than 10 mm at any place on a 3 m straight edge over the limits of the bottom course of blocks. The levelling pad shall not be placed on frozen ground.

7.05

Installation of Blocks

- (1) The individually marked blocks shall be placed on the prepared leveling pad. The top surface of the first layer of blocks is to be set plane and level. Local trimming of the blocks may be necessary.
- (2) Subsequent successive layers shall be oriented with the long axis of blocks positioned at 90° to the previous layer in order to avoid continuous joints. Block joints shall be offset and staggered between layers.
- (3) A continuous check shall be kept to ensure the evenness of the blocks is satisfactory in each layer. Blocks shall be laid with joints with maximum opening of 10 mm between blocks. Differences in heights between adjacent blocks in the same layer should not exceed 5 mm.
- (4) Sloping end adjustments at the abutments shall be accomplished by leveling terraces in the subsoil in accordance with the block thickness.
- (5) Temporary ballast shall be provided as necessary to prevent movement of expanded polystyrene both in storage and as placed due to windy conditions. Timber fasteners or equivalent shall be used as necessary.
- (6) The expanded polystyrene embankment shall be protected from accidental ignition due to welding, smoking, grinding or cutting tools, etc. The Contractor shall take all necessary precautions to prevent ignition of the expanded polystyrene.
- (7) The expanded polystyrene shall be protected from organic solvents and other aggressive, harmful chemicals during construction. The proposed method of protection during construction shall be submitted to the Contractor's Quality Verification Engineer for review and to the Contract Administrator for information purposes.
- (8) Exposed blocks shall be covered immediately to avoid possible burrowing by animals.
- (9) Individually marked blocks shall be fabricated and placed to ensure the top surface matches the elevation and crossfall shown on the drawings.
- (10) The top surface and side surfaces of the expanded polystyrene shall be covered with 0.6 mil polyethylene sheeting extending onto adjacent work at the longitudinal ends of the embankment. All joints shall be lapped a minimum of 300 mm to provide a fully sealed enclosure.

- (11) No construction equipment shall be permitted to drive directly on the expanded polystyrene or polyethylene geomembrane. Damage to the geomembrane resulting from construction activities, equipment, or operations shall be repaired by the constructor as per manufacturer's recommendations.
- (12) The side slope of the rigid expanded polystyrene embankment shall be covered with clean sand salvaged from earth excavation operations. Alternatively, Granular B Type 1 to be used. The voids between the expanded polystyrene and sheet pile walls shall be filled with 9.5 mm clear stone.
- (13) The Contractor shall submit details of the sequence and method of installation to the Quality Verification Engineer for review. The submittals shall satisfy the specifications and at a minimum include a detailed description of proposed installation procedures. The details shall be submitted at least three weeks prior to the installation of the rigid expanded polystyrene embankments the Contractor shall also submit to the Contract Administrator, for information purposes, details of the sequence and method of installation. The submittals shall satisfy the specifications and at a minimum contain the above information as provided to the Contractor's Quality Verification Engineer.
- (14) The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the requirements and specifications of the contract documents. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation. Upon completion of the Expanded Polystyrene Embankment the Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer stating that the Expanded Polystyrene Embankment has been constructed in conformance with the installation procedures and specifications of the contract documents.

7.06 Drainage

Sub-drains (where specified on the design drawings) shall be 150 mm diameter perforated PVC drain pipe c/w 19mm clear crush 150mm all around wrapped in a non-woven geotextile.

7.07 Construction Loading

The pavement system includes all material placed above the EPS blocks within the limits of the roadway (including shoulders) unless noted otherwise. The pavement system shall be constructed above the concrete cap as shown on the design drawings.

No vehicles or construction equipment shall drive directly on the EPS blocks or the geomembrane. Bedding sand and crushed base course for the pavement system shall be pushed onto the embankment using appropriate light weight equipment. Vibratory equipment (e.g. vibrating drum roller) shall not be used to compact the first 300mm of granular material.

The bearing pressures at the surface of the EPS blocks due to construction loads (including any granular material) shall not exceed the 1% deformation compressive resistance values listed in Table 1. A factor of 1.2 shall be applied to all construction loads.

For the purposes of calculating EPS bearing pressures due to construction loads, use a load dispersion angle of 1H:1V through compacted material and 1H:2V through uncompacted material.

8.0 QUALITY ASSURANCE

8.01 Sampling and Testing

8.01.01 General

The Contract Administrator may undertake an independent testing program of the expanded polystyrene. Sampling and testing will be carried out in conformance with the relevant test procedure. The physical and thermal property testing identified in Table 1 will be conducted. The testing shall be conducted by a recognized testing laboratory accredited by the Standards Council of Canada.

8.01.02 Sampling Frequency

Sufficient sample material shall be obtained from blocks randomly selected by the Contract Administrator from each production lot as soon as the material arrives on site. As a minimum, three blocks shall be tested.

For each EPS grade produced by the block supplier, a minimum of one sample shall be tested per 500 m³ for the first 2000 m³. A minimum of one sample per 2000 m³ shall be tested thereafter.

8.01.03 Acceptance / Rejection

Failure of any one of the sample blocks to comply with any requirements of this special provision shall be cause for rejection of the production lot from which it was taken. Replacement of the blocks shall be at the Contractor's expense.

9.0 MEASUREMENT FOR PAYMENT

9.01 Actual Measurement

Measurement will be by volume in cubic metres measured in its original position and based on cross-sections.

10.0 BASIS OF PAYMENT

Payment at the contract price for the above tender item shall be full compensation for all labour, materials and equipment to do the work as described above and no extra payments will be made.

All dewatering required for EPS excavation shall be paid for under the Dewatering Structure Excavations item.

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT – Item No.

Special Provision

1.0 SCOPE

This special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Survey Benchmarks (BM)
- In-Ground Monitoring Points (IMP)
- Track Monitoring Points (TMP)

The purpose of these instruments is to monitor settlements at the existing Ontario Northland Railway (ONR) track during construction within or near the ONR right-of-way.

1.01 General Procedure

The benchmarks shall be installed prior to the embankment and foundation construction. The benchmark (BM) consists of a steel rod anchored into bedrock. Existing verified benchmarks monuments can be considered as a replacement for new benchmarks following approval by the Contract Administrator.

The Contractor shall install In-ground monitoring points as per the Monitoring Instrument Details drawing. The rod shall be embedded in the ground with a survey point on the top that can be clearly identified and returned to. The In-ground monitoring points shall be installed prior to any construction within or near the ONR right-of-way. The Contractor shall coordinate installation of the In-ground monitoring points with the Ontario Northland Railway/CA and obtain permit/track time with flagging protection as necessary.

The Contractor shall install track monitoring points as per the Monitoring Instrument Details drawing. The outer web surface of the rails shall be cleaned using sandpaper and wiped with a tack cloth. The reflective survey target shall be installed on the cleaned surface with epoxy glue. The Contractor shall coordinate installation of the track monitoring points with the Ontario Northland Railway and obtain permit/track time with flagging protection as necessary.

It is noted that vibration monitoring will be carried out by others to monitor vibrations at the existing ONR track during construction within or near the ONR right-of-way. The vibration monitoring program will provide input for the selection of appropriate pile driving equipment, hammer energy, and rate of pile driving. Pile driving energy shall be carefully controlled by the Contractor for Piers #4 and #5 in order to not cause excessive vibrations and settlement of the ONR track. The construction methodology shall be adjusted by the Contractor as necessary based on the results of the vibration and settlement monitoring program.

2.0 REFERENCES

2.01 Drawings

Reference shall be made to the following drawings:

- Monitoring Instrument Location Plan
- Monitoring Instrument Location Plan & Section
- Monitoring Instrument Details

2.02 Subsurface Conditions

Reference shall be made to the subsurface conditions described in the following report:

- Foundation Investigation Report, Replacement of The Ontario Northland Railway (ONR) Overhead Bridge, Highway 11 At Earleton, Township of Armstrong, G.W.P. 5101-17-00, Dated November 18, 2021 – Thurber Engineering Limited. (GEOCREs No. 31M-132)

3.0 DEFINITIONS

3.01 Personnel

The Contractor shall retain a Geotechnical Consultant who is approved for MTO RAQS category of “Geotechnical (Structures and Embankments) – Medium Complexity”, to undertake the supply and installation of the geotechnical instruments. Monitoring of the instruments shall be carried out by others.

The Contractor shall be understood to refer to the Contractor and his Geotechnical Consultant.

3.02 Or Equal

The term, “or equal”, shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

The Contractor shall submit details of proposed installation methods, including survey benchmarks, in-ground monitoring points and track monitoring points, and installation schedule to the Contract Administrator, a minimum of 15 days before the start of instrument installation.

5.0 MATERIALS

5.01 Survey Benchmarks (BM)

5.01.01 General

The Contractor shall supply all materials and equipment required for the installation of the benchmarks (BM).

5.01.02 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4 mm (1"), supplied in lengths as required to complete the installation as per Section 7.01.02.

The top end of each length of rod shall be threaded to receive a protective cap which is clearly identifiable and returned to.

5.01.03 Sand

The Contractor shall supply clean washed sand with the following gradation:

MTO Sieve Designation	Percentage Passing
4.5 mm - #4	100%
2 mm - #10	80% - 100%
850 µm - #20	20% - 100%
425 µm - #40	5% - 40%
150 µm - #100	0% - 5%

5.01.04 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 17.7 kg of bentonite (OPSS 1205), 284 litres of water and 42.6 kg of cement (Type 10 - OPSS 1301).

5.01.05 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

5.02 In-Ground Monitoring Point (IMP)

5.02.01 General

The Contractor shall supply all materials and equipment required for the installation of the In-ground monitoring points.

5.02.02 Rod

The Contractor shall supply a 1.2 m long steel pipe Schedule 40 with an outside diameter not less than 25.4 mm (1"), supplied in lengths as required to complete the installation.

The top end of each length of rod shall be threaded to receive a protective cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.03 Track Monitoring Points (TMP)

5.03.01 General

The Contractor shall supply all materials and equipment required for the installation of the track monitoring points.

5.03.02 Sticker

The contractor shall supply a self-adhesive reflective target with a dimension of 60 by 60 mm (e.g., Leica GZM, or equal). The reflective tape survey targets shall resist weather, dirt, and aging. The TMPs are to be installed on the outer web surface of both rails (directly opposite).

6.0 EQUIPMENT

6.01 Equipment Operation and Weather Conditions

All installation and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their locations within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range. The Contractor shall replace/repair non-functioning monitoring instruments as required at no cost to the Ministry.

7.0 CONSTRUCTION

7.01 Installation

7.01.01 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and mark the location of each instrument and obtain a ground surface elevation and northing/easting coordinates at each instrument location.

The quantities and locations of instruments are shown in Table 1.

Table 1 – Instrument Quantities and Locations

LOCATION	IMP	TMP
ONR Track at the location of new replacement structure (between Pier #4 and Pier #5)	7	14
ONR Track at the location of new detour embankment	7	14

7.01.02 Survey Benchmarks (BM)

The purpose of the benchmarks is to provide non-settling references for the surveying of In-ground Monitoring Points (IMP) and Track Monitoring Points (TMP).

7.01.02.01 Number and Location

A minimum of two non-yielding temporary survey benchmarks (BM) should be installed. The number and locations of benchmarks shall be adjusted in the field such that the benchmarks are at sufficient

distance from the embankments to remain non-yielding, not affected by the construction and direct sighting is possible from all In-ground monitoring points and track monitoring points to at least one benchmark. The locations of the temporary benchmarks are to be approved by the Contract Administrator prior to installation of the monitoring instruments.

7.01.02.02 Borehole Installation

The borehole shall be advanced to a depth of 1.5 m into bedrock using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, and rod anchor. The sides of the borehole shall be stable, and the borehole shall be free of drilling mud and debris.

7.01.02.03 Rod Couplings

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

7.01.02.04 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting on bedrock at the bottom of the borehole. The rod shall be grouted in place.

7.01.02.05 Installation Details

The elevation, easting and northing of the top of the benchmark rod shall be surveyed.

7.01.03 In-Ground Monitoring Points

The purposes of the In-ground monitoring points is to monitor settlement at the ONR track due to construction activities within or near the ONR right-of-way. Settlement is measured by surveying the top of rod with reference to stable non-settling benchmark.

7.01.03.01 General Procedure

In-ground monitoring points shall be installed between the rail ties along the centreline of ONR track at an approximately 4 m interval prior to any construction activity within or near the ONR right-of-way.

7.01.03.02 Location

The locations of the In-ground monitoring points are given in Tables 2a and 2b.

Table 2a – Approximate In-Ground Monitoring Point Locations at ONR Bridge

Location	Approx. Offset from ONR Track Centerline	Approx. Offset from Existing Highway 11 Centerline	No. of IMP
Along Existing ONR Track Centerline	0m	On CL	1
Along Existing ONR Track Centerline	0m	4 m North	1

Location	Approx. Offset from ONR Track Centerline	Approx. Offset from Existing Highway 11 Centerline	No. of IMP
Along Existing ONR Track Centerline	0m	On CL	1
Along Existing ONR Track Centerline	0m	8 m North	1
Along Existing ONR Track Centerline	0m	12 m North	1
Along Existing ONR Track Centerline	0m	4 m South	1
Along Existing ONR Track Centerline	0m	8 m South	1
Along Existing ONR Track Centerline	0m	12 m South	1

Table 2b – Approximate In-Ground Monitoring Point Locations at Detour Embankment

Location	Approx. Offset from ONR Track Centerline	Approx. Offset from Highway 11 Detour Embankment Centerline	No. of IMP
Along Existing ONR Track Centerline	0m	On CL	1
Along Existing ONR Track Centerline	0m	4 m North	1
Along Existing ONR Track Centerline	0m	8 m North	1
Along Existing ONR Track Centerline	0m	12 m North	1
Along Existing ONR Track Centerline	0m	4 m South	1
Along Existing ONR Track Centerline	0m	8 m South	1
Along Existing ONR Track Centerline	0m	12 m South	1

7.01.03.03 Installation

The Contractor shall install In-ground monitoring points as per the Monitoring Instrument Details drawing. The rod shall be embedded in the ground with a survey point on the top that can be clearly identified and returned to. The In-ground monitoring points shall be installed prior to any construction within or near the ONR right-of-way. The Contractor shall coordinate installation of the In-ground monitoring points with the Ontario Northland Railway/CA and obtain permit/track time with flagging protection as necessary.

7.01.04 Track Monitoring Points

The purpose of the track monitoring points is to monitor settlements at the ONR track due to construction activities within or near the ONR right-of-way. The track movements are measured by surveying the web of the rails with reference to stable non-settling benchmarks.

7.01.04.01 General Procedure

Track settlement points shall be installed on the outer web surface of both rails at a 4 m interval along the ONR track prior to any construction within or near the ONR right-of-way.

7.01.04.02 Location

The locations of the track monitoring points are given in Tables 3a and 3b.

Table 3a – Approximate Track Monitoring Point Locations at ONR Bridge

Location	Approx. Offset from Existing Highway 11 Centerline	No. of IMP
On Existing ONR Track Rails	On CL	2
On Existing ONR Track Rails	4 m North	2
On Existing ONR Track Rails	8 m North	2
On Existing ONR Track Rails	12 m North	2
On Existing ONR Track Rails	4 m South	2
On Existing ONR Track Rails	8 m South	2
On Existing ONR Track Rails	12 m South	2

Table 3b – Approximate Track Monitoring Point Locations at Detour Embankment

Location	Approx. Offset from Highway 11 Detour Embankment Centerline	No. of IMP
On Existing ONR Track Rails	On CL	2
On Existing ONR Track Rails	4 m North	2
On Existing ONR Track Rails	8 m North	2
On Existing ONR Track Rails	12 m North	2
On Existing ONR Track Rails	4 m South	2
On Existing ONR Track Rails	8 m South	2
On Existing ONR Track Rails	12 m South	2

7.01.05 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

7.01.06 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractor's work shall be repaired by the Contractor, at no cost to the Ministry.

7.01.07 Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic and track workers before, during and after construction. IMPs shall have florescent markers with blunt tops to protect track workers from injury.

Instruments shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for the duration of the monitoring program.

7.01.8 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at the Contractor's cost.

7.01.9 Installation Program

Instrument installation shall commence prior to existing bridge removal, pile driving, embankment fill placement and construction of any work. No material stockpiling shall be allowed within the bridge construction and embankment construction area during instrument installation. Table 4 gives a summary of the installation schedule requirements.

Table 4 – Installation Program

TYPE	START INSTALLATION	FINISH INSTALLATION
BM	-	Before installation of any monitoring instruments
IMP	-	Prior to any construction within or near the ONR right-of-way
TMP	-	Prior to any construction within or near the ONR right-of-way

7.02 Coordination with Monitoring

7.02.01 Survey Benchmarks (BM)

7.02.01.01 Notification

The Contractor shall notify the Contract Administrator no later than 7 days after installing a benchmark. At this time, the Contractor shall also supply the following information in a report to the Contract Administrator:

- Elevation, easting and northing of the top of the benchmark rod;
- Date(s) of installation;
- Stratigraphic log of subsurface conditions at the benchmark, including drilling method notes;
- Installation notes, sketches and photographs;
- Description of benchmarks.

The Contractor shall provide installation information as specified above and provide access to the benchmarks for monitoring including, but not limited to snow clearing in the winter. The Contractor shall provide electric power and general area lighting as needed.

7.02.02 In-Ground Monitoring Points

7.02.02.01 Notification

The Contractor shall notify the Contract Administrator no later than 7 days after installing an In-ground monitoring point. At this time, the Contractor shall also supply the following information in a report to the Contract Administrator.

- In-ground monitoring point location, easting and northing;
- Elevation of survey target of In-ground monitoring point;
- Dates of installation and datum readings;
- Installation notes, sketches and photographs.

7.02.02.02 Monitoring

Monitoring of the In-ground monitoring points shall be done by others. Monitoring shall be conducted during construction within or near the ONR right-of-way. Geotechnical monitoring shall be performed before, during and after the following activities:

- Installation and removal of temporary protection
- Foundation excavation and pile driving for Piers # 4 and #5
- Fill placement for the detour embankment

The Contractor shall provide installation information as specified above and provide access to the In-ground monitoring points for surveying.

7.02.02.03 Coordination

If the maximum movement measured exceeds the Review Level stipulated by ONR, the Contract Administrator (CA) will notify ONR and request the Contractor for a plan of action(s). The CA will review the plan of action(s) submitted by the Contractor to prevent the Alert Level from being reached and provide recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum movement measured exceeds the Alert Level stipulated by ONR, the CA will immediately notify ONR and instruct the Contractor to stop all construction activities within or near the ONR right-of-way. No construction shall take place within or near the ONR right-of-way until all the following conditions are satisfied:

- The CA has reviewed Contractor's plan of corrective action(s);
- Any corrective action(s) deemed necessary by ONR and CA has been implemented;
- ONR and the CA deem it is safe to proceed with the remainder of the construction works within or near the ONR right-of-way.

7.02.03 Track Monitoring Points

7.02.03.01 Notification

The Contractor shall notify the Contract Administrator no later than 7 days after installing a Track monitoring point. At this time, the Contractor shall also supply the following information in a report to the Contract Administrator.

- Track monitoring point location, easting and northing;

- Elevation of survey target of Track monitoring point;
- Dates of installation and datum readings;
- Installation notes, sketches and photographs.

7.02.03.02 Monitoring

Monitoring of the Track monitoring points shall be done by others. Monitoring shall be conducted during construction within or near the ONR right-of-way. Geotechnical monitoring shall be performed before, during and after the following activities:

- Installation and removal of temporary protection
- Foundation excavation and pile driving for Piers # 4 and #5
- Fill placement for the detour embankment

The Contractor shall provide installation information as specified above and provide access to the track monitoring points for surveying.

7.02.03.03 Coordination

If the maximum movement measured exceeds the Review Level stipulated by ONR, the Contract Administrator (CA) will notify ONR and request the Contractor for a plan of action(s). The CA will review the plan of action(s) submitted by the Contractor to prevent the Alert Level from being reached and provide recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum movement measured exceeds the Alert Level stipulated by ONR, the CA will immediately notify ONR and instruct the Contractor to stop all construction activities within or near the ONR right-of-way. No construction shall take place within or near the ONR right-of-way until all the following conditions are satisfied:

- The CA has reviewed Contractor's plan of corrective action(s);
- Any corrective action(s) deemed necessary by ONR and CA has been implemented;
- ONR and the CA deem it is safe to proceed with the remainder of the construction works within or near the ONR right-of-way.

7.03 Decommissioning of Instruments

The Contractor shall decommission all the In-Ground Monitoring Points (IMP) and Track Monitoring Points (TMP) at the end of the monitoring program unless advised otherwise by the Contract Administrator or ONR. The Benchmarks (BM) shall not be decommissioned unless advised otherwise by the Contract Administrator. Decommissioning of instrumentation shall be carried out according to the guidelines and standard regulations.

8.0 QUALITY ASSURANCE – Not Used

9.0 MEASUREMENT FOR PAYMENT

Measurement for Payment for the Supply and Installation of Embankment Monitoring Equipment shall be Lump Sum.

10.0 BASIS OF PAYMENT

Payment at contract price for this tender item shall be full compensation for all labour, equipment and materials to do the work.

MONITORING PROGRAM – Item No.

Special Provision

1.0 GENERAL

Requirements specified for Specialist Qualifications; Services, Deliverables and Records; and the Foundation Monitoring Plan apply to all the Instrumentation Monitoring. Instrumentation monitoring is required for the following items:

- Survey Benchmarks (BM)
- Track Monitoring Points (TMP)
- In-Ground Monitoring Points (IMP)
- Mobile Vibration Monitoring Station (MVM)

The instrumentation monitoring services include:

1. Data collection, data reduction and reporting;
2. Adherence to criteria used to assess the impact of foundation construction and fill placement on the existing Ontario Northland Railway (ONR) track based on the monitoring data collected from the instrumentation installed by others.
3. Interpretation of instrumentation readings.

1.0.1 Or equal

The term, “*or equal*”, shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

1.0.2 Specialist Qualifications

The Foundation Monitoring Consultant services required for this assignment have been categorized **Geotechnical** specialty – **High Complexity**.

The Foundation Engineering Consultants that are registered in MTO's consultant acquisition system (RAQS) at complexity ratings in the required specialty that meet or exceed the identified complexity requirement for this assignment are eligible to provide Foundation Engineering services for this project. The Contract Administrator shall retain a Foundation Monitoring Consultant to complete the instrumentation monitoring services. The Foundation Monitoring Consultant shall not be the same Geotechnical Consultant retained by the Contractor for the supply and installation of monitoring equipment.

1.0.3 Services, Deliverables and Records

The Foundation Monitoring Consultant shall:

- Review the Monitoring Program and, if deemed necessary, submit in writing to the Contract Administrator recommendations for modifications to the Monitoring Program;
- Establish the baseline readings. The Contract Administrator staff may take all other required readings after receiving training from the Foundation Monitoring Consultant.
- Calibrate and maintain monitoring equipment;
- Collect monitoring readings, reduce data, prepare reports;
- Provide transmittal of monitoring readings and reports to the Contract Administrator;
- Interpret monitoring readings as needed for the purposes of ongoing construction;
- Notify the Contract Administrator of required modifications to the construction procedures accordingly, if necessary. Interpretation shall include making correlations between survey data and specific construction activities;
- Notify the Contract Administrator within 24 hours if review measurement levels, as specified herein, for any instrumentation are reached;
- Discuss within 48 hours with the Contract Administrator response action(s), and submit a plan of actions, to prevent the critical instrument readings (i.e. review/alert levels) from being exceeded.
- Provide brief weekly updates and monthly progress reports to the Contract Administrator during the monitoring period.

1.1 PURPOSE

The purpose of these instruments is to monitor vibrations and settlements at the existing ONR track during construction within the ONR right-of-way. Geotechnical monitoring shall be performed before, during and after the following activities:

- Installation and removal of temporary protection (settlement monitoring)
- Foundation excavation and pile driving for Piers # 4 and #5 (vibration and settlement monitoring)
- Fill placement for the detour embankment (settlement monitoring)

1.2 DRAWINGS

Reference shall be made to the following drawings:

- Monitoring Instrument Location Plan
- Monitoring Instrument Location Plan & Section
- Monitoring Instrument Details

1.3 SUBSURFACE CONDITIONS

The subsurface conditions at the site are described in the following reports:

- Foundation Investigation Report, Replacement of The Ontario Northland Railway (ONR) Overhead Bridge, Highway 11 At Earlton, Township of Armstrong, G.W.P. 5101-17-00, Dated November 18, 2021 – Thurber Engineering Limited.

1.4 EQUIPMENT OPERATION

Monitoring equipment supplied by the Foundation Monitoring Consultant shall be maintained and rendered operational throughout the monitoring period.

1.5 READING SCHEDULE AND FREQUENCY

The Foundation Monitoring Consultant shall save and archive raw data in electronic and hard copy format.

The minimum monitoring frequencies along with the anticipated number of readings are given in the following sections. Instruments shall be read more or less frequently if determined to be required by the Foundation Monitoring Consultant.

It should be noted that the number of readings given in the following sections are approximate and may vary due to uncertainties associated with the construction schedule.

1.5.1 Minimum Monitoring Frequency

The minimum monitoring frequency for the instruments is summarized in the following section.

Table 1a – Minimum Settlement Monitoring Frequency for ONR bridge

STAGE	FREQUENCY	ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION (*)
Baseline Reading (***)	Once daily for TMPs and IMPs for 3 consecutive weekdays	3
Immediately prior to installation of temporary protection and start of foundation excavation for Pier #4	Once for all instruments	1
Immediately prior to installation of temporary protection and start of foundation excavation for Pier #5	Once for all instruments	1
During foundation excavation for Pier #4	Twice daily for TMPs and IMPs (one in morning and one in afternoon)	10 (Varies depending on construction schedule)
During foundation excavation for Pier #5	Twice daily for TMPs and IMPs (one in morning and	10 (Varies depending on construction schedule)

	one in afternoon)	
During pile driving for Pier #4	Twice daily for TMPs and IMPs (one in morning and one in afternoon)	20 (Varies depending on construction schedule)
During pile driving for Pier #5	Twice daily for TMPs and IMPs (one in morning and one in afternoon)	20 (Varies depending on construction schedule)
During temporary work installation (e.g. falsework construction)	Twice daily for TMPs and IMPs (one in morning and one in afternoon)	20 (Varies depending on construction schedule)
Following completion of all above activities	Once weekly for TMPs and IMPs for 4 consecutive weeks	4

Notes:

(*) Due to the uncertainty of the construction schedule, the number of readings may be greater than shown above.

(**) Additional monitoring may be needed for other temporary works within the ONR right-of-way

(***) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground.

Table 1b – Minimum Vibration Monitoring Frequency for ONR bridge

STAGE	FREQUENCY	ANTICIPATED NUMBER OF DAYS ON SITE (*)
Pre-Construction Measurements of Background Vibration (**)	Continuous for 2 consecutive weekdays	2 days
During installation and removal of temporary protection and pile driving for Piers #4 and #5	<ul style="list-style-type: none"> Continuous monitoring for the duration of the particular activity will be required The vibration monitoring can be terminated once such construction or extraction works are completed 	20 days

Notes:

(*) Due to the uncertainty of the construction schedule, the number of days on site may be greater than shown above.

(**) During vibration monitoring, the field technician should make note of on-site activities and time that each activity occurred (e.g. ONR train passing)

Table 1c – Minimum Settlement Monitoring Frequency for Detour Embankment

STAGE	FREQUENCY	ANTICIPATED NUMBER OF READINGS PER MONITORING SECTION (*)
Baseline Reading (**)	Once daily for TMPs and IMPs for 3 consecutive weekdays	3
Immediately prior to fill placement for detour embankment within the ONR right-of-way	Once	1
During fill placement for detour embankment within the ONR right-of-way	Twice daily for TMPs and IMPs (one in morning and one in afternoon)	10 (i.e. 5 days(***))
After end of detour embankment construction	Once weekly for 1 st two months	8
	Once every two weeks from 2 months to 4 months	4
	Once every month from 4 months to 24 months	20

Notes:

(*) Due to the uncertainty of the construction schedule, the number of readings may be greater than shown above.

(**) Baseline Readings: Value of instrumentation readings taken prior to construction to provide a baseline against which all subsequent readings are compared to assess movements of ground.

(***) Varies depending on amount of time required to construct detour embankment

2.0 INSTRUMENTATION SPECIFIC REQUIREMENT

2.1 MONITORING OF ONR TRACK: TRACK MONITORING POINTS (TMP)

2.1.1 Surveying

The northing, easting and elevation of the survey target of each track monitoring point (TMP) shall be surveyed to an accuracy of plus/minus two (+/- 2) mm or better and shall be reported to the nearest millimeter.

Surveying for vertical/horizontal movements monitoring shall be conducted by an experienced surveyor with appropriate equipment and experience. The surveying service shall be either

performed by the CA or a licensed surveyor retained by the CA. The CA shall coordinate surveying activities with ONR and obtain permit/track time with flagging protection as necessary.

2.1.2 Reporting

The Contract Administrator shall be notified within 24 hours if review level is reached at any track monitoring point (TMP) and a brief interpretation of the updated monitoring data shall be reported to the Contract Administrator within 24 hours after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

As a minimum the following shall be provided in the monthly progress report submitted to the Contract Administrator based on the readings collected from TMP instruments:

- A plot of vertical/horizontal movements versus time;
- Plan view showing location of the instrument being monitored.

2.1.3 Review and Alert Levels

The following vertical/horizontal movements measured at the TMPs relative to the baseline readings are to be observed. These monitoring response levels should be reviewed and approved by ONR based on the Class of Track.

Table 2 – Review and Alert Levels for Track Monitoring Points

Instrument Type	Vertical/Horizontal Movements Response Levels (mm)	
	Review	Alert
Track Monitoring Point (TMP)	10	19

If the maximum movement measured exceeds the Review Level in Table 2, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator will notify ONR and request the Contractor for a plan of action(s). The Foundation Monitoring Consultant will review the plan of action(s) submitted by the Contractor to prevent the Alert Level being reached and provide recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum movement measured exceeds the Alert Level in Table 2, the Foundation Monitoring Consultant / surveyor shall immediately inform the Contract Administrator and the Contract Administrator shall immediately notify ONR and instruct the Contractor to stop all construction activities within the ONR right-of-way. No construction shall take place within the ONR right-of-way until all the following conditions are satisfied:

- The cause of the excessive track settlement has been identified and analyzed by the Foundation Monitoring Consultant;
- Foundation Monitoring Consultant has reviewed Contractor's plan of corrective action and provided recommendations for corrective actions to the Contract Administrator;

- Any corrective action deemed necessary by ONR, Contract Administrator and the Foundation Monitoring Consultant has been implemented;
- ONR and the Contract Administrator deem it is safe to proceed with the remainder of the construction works within the ONR right-of-way.

2.2 MONITORING OF ONR TRACK: IN-GROUND MONITORING POINTS (IMP)

2.2.1 Surveying

The elevation of the survey target of each In-ground monitoring point (IMP) shall be surveyed to an accuracy of plus/minus two (+/- 2) mm or better and shall be reported to the nearest millimeter.

Surveying for vertical movements monitoring shall be conducted by an experienced surveyor with appropriate equipment and experience. The surveying service shall be either provided by the CA or a license surveyor retained by the CA. The CA shall coordinate surveying activities with ONR and obtain permit/track time with flagging protection as necessary.

2.2.2 Reporting

The Contract Administrator shall be notified within 24 hours if review level is reached at any In-ground monitoring point (IMP) and a brief interpretation of the updated monitoring data shall be reported to the Contract Administrator within 24 hours after each set of readings is obtained. A full set of up-to-date and processed monitoring data shall be presented in tabular and graphical form in the monthly progress report.

As a minimum the following shall be submitted in the monthly progress report based on the readings collected from IMP instruments:

- A plot of vertical movements versus time;
- Plan view showing location of the instrument being monitored.

2.2.3 Review and Alert Levels

The following vertical movements measured at the IMPs relative to the baseline readings are to be observed. These monitoring response levels should be reviewed and approved by ONR based on the Class of Track.

Table 3 – Review and Alert Levels for In-Ground Monitoring Points

Instrument Type	Vertical Movements Response Levels (mm)	
	Review	Alert
In-Ground Monitoring Point (IMP)	10	19

If the maximum movement measured exceeds the Review Level in Table 3, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator will notify ONR and request the Contractor for a plan of action(s). The Foundation Monitoring Consultant will review the plan of action(s) submitted by the Contractor to prevent the Alert Level being reached and provide recommendations to the Contract Administrator. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum movement measured exceeds the Alert Level in Table 3, the Foundation Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall immediately notify ONR and instruct the Contractor to stop all construction activities within the ONR Right-of-Way. No construction shall take place within the ONR right-of-way until all the following conditions are satisfied:

- The cause of the excessive track settlement has been identified and analyzed by the Foundation Monitoring Consultant;
- Foundation Monitoring Consultant has reviewed Contractor's plan of corrective action and provided recommendations for corrective actions to the Contract Administrator;
- Any corrective action deemed necessary by ONR, Contract Administrator and the Foundation Monitoring Consultant has been implemented;
- ONR and the Contract Administrator deems it is safe to proceed with the remainder of the construction works within the ONR right-of-way.

2.3 MOBILE VIBRATION MONITORING STATIONS (MVM)

2.3.1 General Procedure

Peak Particle Velocities (PPV) will be measured at the ONR track during pile driving at Piers #4 and #5 using a mobile vibration monitoring station (MVM) consisting of a geophone. The PPV will be correlated with Track Monitoring Point (TMP) and In-Ground Monitoring Point (IMP) readings, the timing of pile driving, and the pile driving hammer energy.

2.3.2 Equipment

One geophone shall be supplied by the Foundation Monitoring Consultant. The geophone shall be capable of measuring and recording vibration Peak Particle Velocities (PPV) up to 100 mm/s in the vertical, transverse and radial directions with an accuracy of 0.1 mm/s or better. The geophone shall be calibrated within 12 months prior to commencement of any pile driving operations.

2.3.3 Equipment Location

The mobile vibration monitoring station (MVM) shall be placed beside the ONR track (~0.5m from the end of closest rail tie) closest to the driven pile and between the ONR track and the pile driving operations. The MVM shall be present for the duration of pile driving and relocated as the work progresses. If track settlement is observed, the MVM shall be relocated to where the maximum track settlement occurs

2.3.4 Review and Alert Levels

The following PPV levels are recommended to be used as a guideline:

- Review Level: PPV = 8 mm/s
- Alert Level: PPV = 10 mm/s

These vibration levels shall be reviewed during pile driving operations and adjusted to be compatible with the Review and Alert Levels for vertical/horizontal movements provided in Tables 2 and 3.

2.3.5 Reporting

As a minimum the following shall be included in the report:

- Details of each pile installation (i.e. pile type, pile length, length of pile driven, piling energy, type of hammer, pile location, distance of the pile from the MVM and start/end time of pile driving)
- A plot of PPV versus time for the MVM instrument

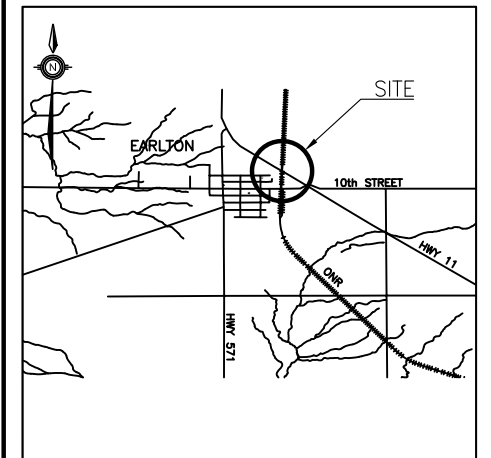
2.4 **CONTROL MONITORING LEVELS**

2.4.1 General



The monitoring program will provide input for the selection of appropriate pile driving equipment, hammer energy, and rate of pile driving. Pile driving energy shall be carefully controlled for Piers #4 and #5 in order to not cause excessive vibrations and settlement of the ONR track. The construction methodology shall be adjusted as necessary based on the results of the vibration and settlement monitoring program.

3.0 **FINAL REPORT**

At the completion of the monitoring program, a final monitoring report shall be issued to the Contract Administrator. The monitoring results shall be presented in tabular and graphical form as described above for each instrument type. Interpretation of the monitoring readings shall be included in the report.



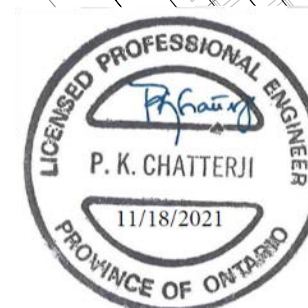
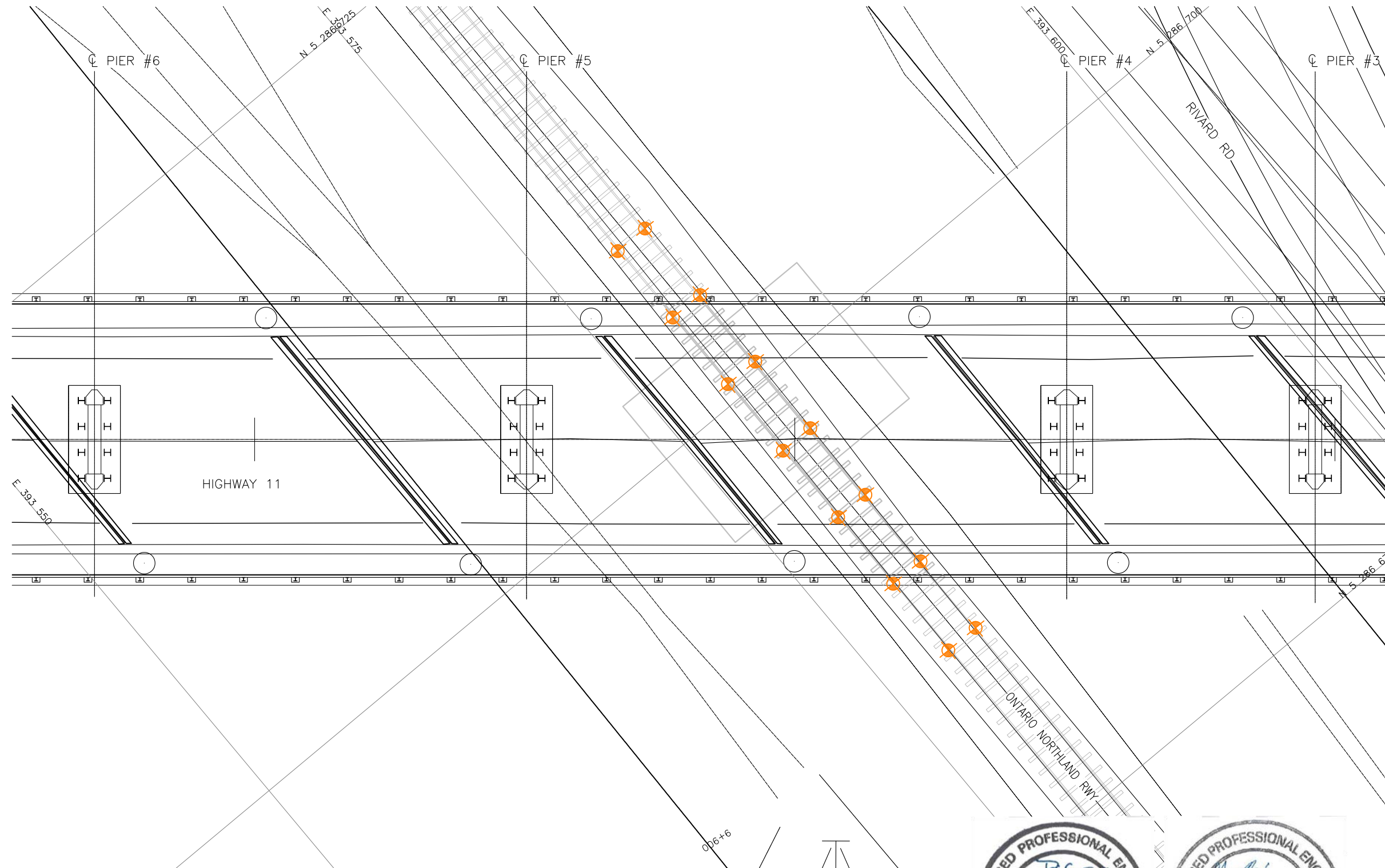
LEGEND

- | | |
|---|----------------------------------|
|  | TMP – Track Monitoring Point |
|  | IMP – In Ground Monitoring Point |

[illegible]

- 1) This drawing is schematic only. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment" for instrument locations.
- 2) Coordinate system is MTM NAD 83 Zone 12.

GEOCRES No. 31M-132



REVISIONS									
	DATE	BY					DESCRIPTION		
DESIGN	GL	CHK	PKC				LOAD		NOV 2021
DRAWN	MFA	CHK	GL		CODE		STRUCT	DWG 1	

CONT No
WP No

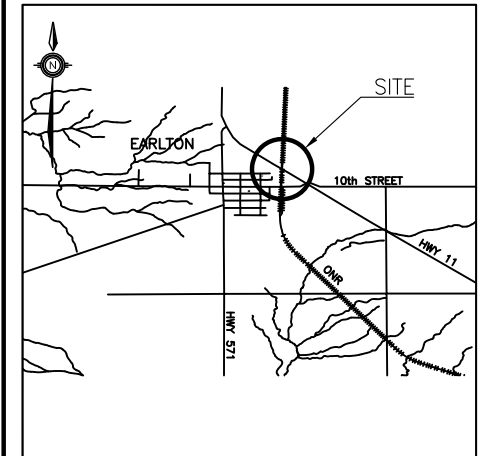


SHEET |

HIGHWAY 11 ONTARIO NORTHLAND RAILWAY DETOUR ALIGNMENT MONITORING INSTRUMENT LOCATION PLAN & SECTION



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND



TMP – Track Monitoring Point
IMP – In Ground Monitoring Point

[illegible]

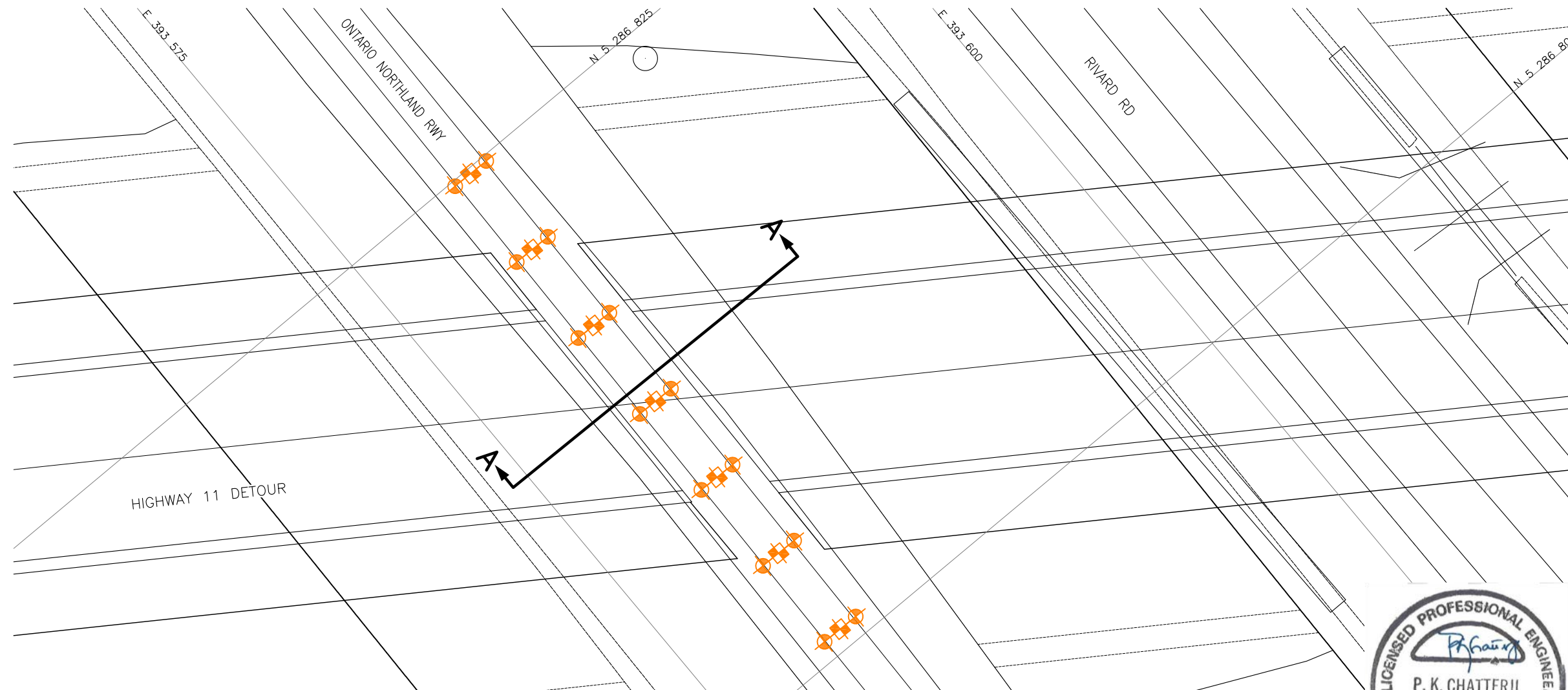
-NOTES-

- 1) This drawing is schematic only. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment" for instrument locations.
- 2) Coordinate system is MTM NAD 83 Zone 12.

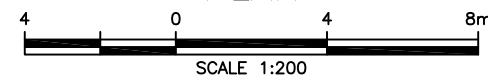
GEOCRES No. 31M-132

REVISIONS									
	DATE	BY	DESCRIPTION					DATE	NOV 2021
DESIGN	GL	CHK	PKC	CODE	LOAD				
DRAWN	MFA	CHK	GL	SITE	STRUCT	DWG	2		

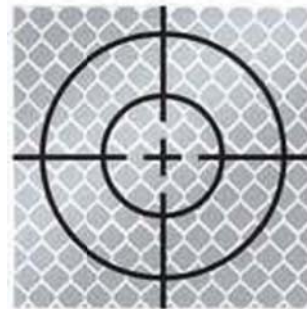
FILENAME: H:\Drafting\28000\28552\IED-28552-MOPL.dwg
PLOTDATE: 11/18/2021 4:09 PM



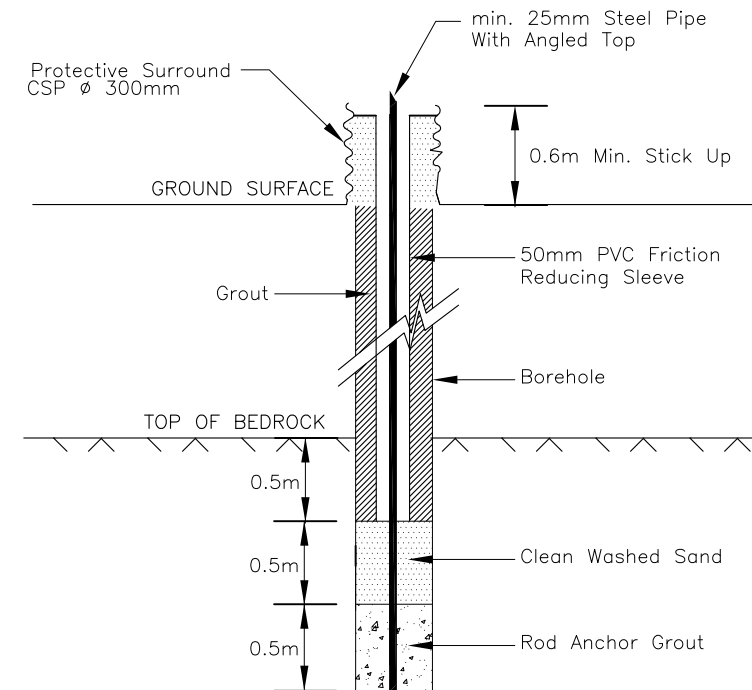
PLAN



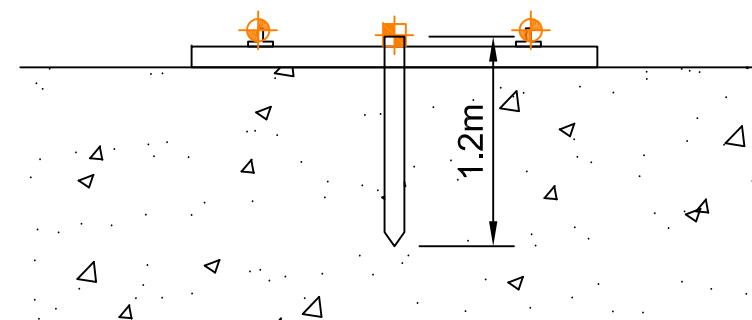
SECTION A-A (TYP.)
N.T.S.

Self-Adhesive
Reflective Target

TRACK MONITORING POINT (TMP)
N.T.S.



BENCHMARK (BM)
N.T.S.



TRACK AND IN-GROUND
MONITORING POINTS (TMP & IMP)
N.T.S.

EXAMPLE OF IN-GROUND MONITORING POINT INSTALLATION (IMP)

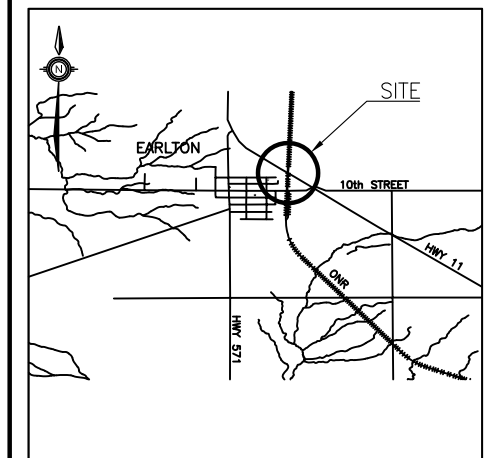
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

S CONT No
WP No

	HIGHWAY 11	
	ONTARIO-NORTHLAND RAILWAY	

SHEET |

MONITORING INSTRUMENT DETAILS



KEYPLAN

LEGEND



TMP – Track Monitoring Point
IMP – In Ground Monitoring Point

[illegible]

-NOTES-

- 1) This drawing is schematic only. Please refer to NSSP "Supply and Installation of Embankment Monitoring Equipment" for instrument locations.
- 2) Coordinate system is MTM NAD 83 Zone 12.

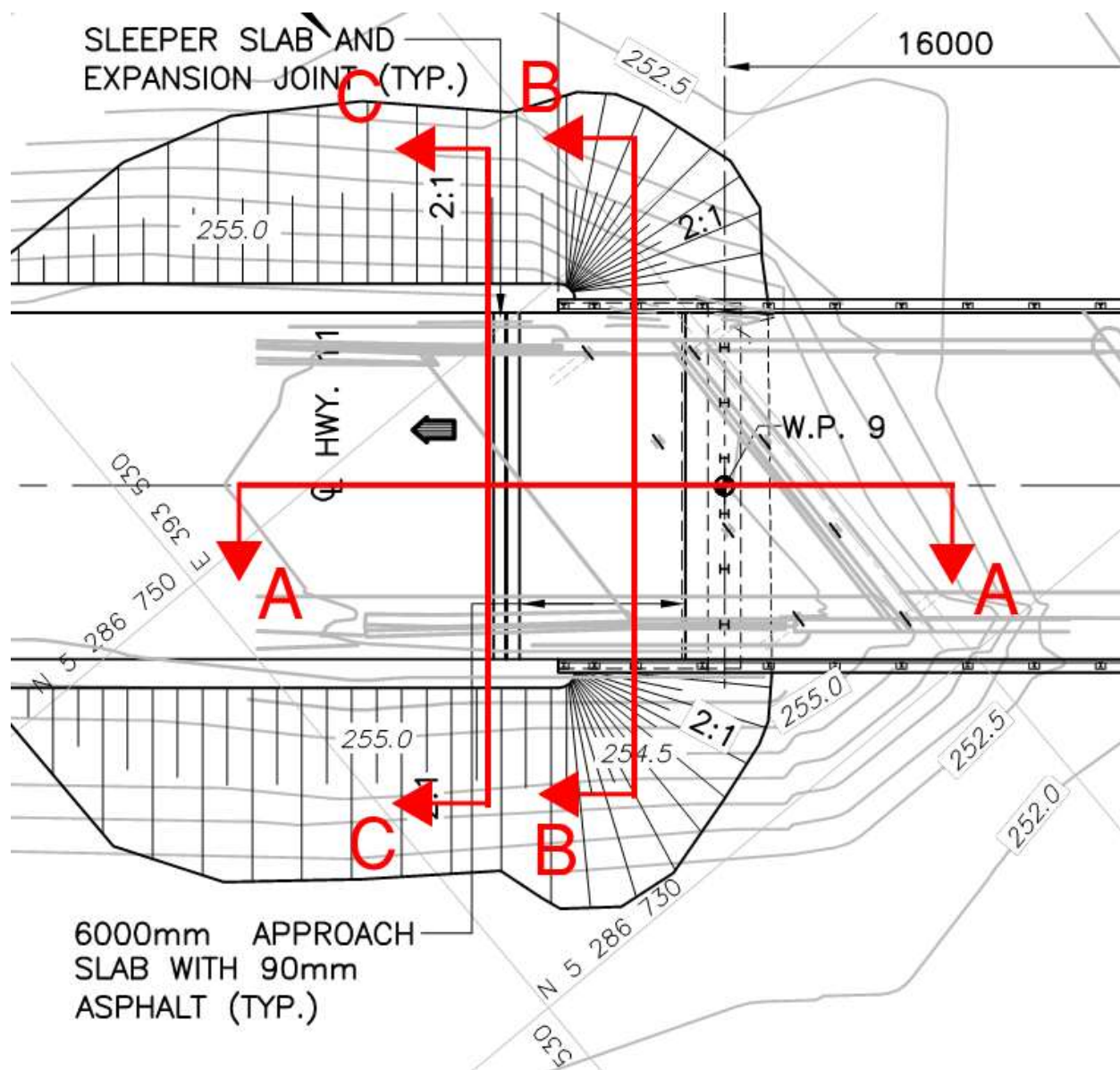
GEOCRES No. 31M-132

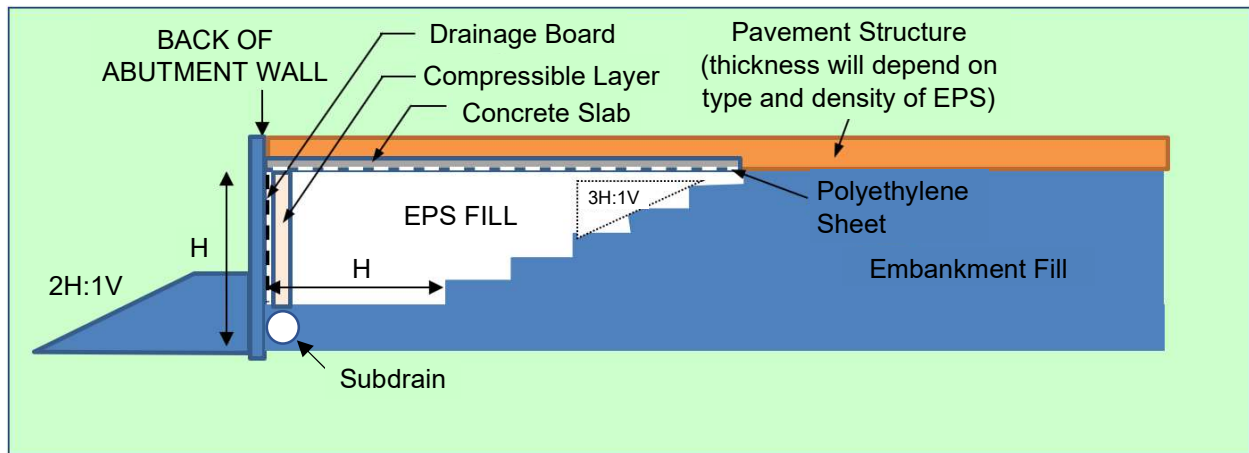
REVISIONS								
	DATE	BY				DESCRIPTION		
DESIGN	GL	CHK	PKC	CODE		LOAD	DATE	NOV 2021
DRAWN	MFA	CHK	GL	SITE		STRUCT	DWG	3



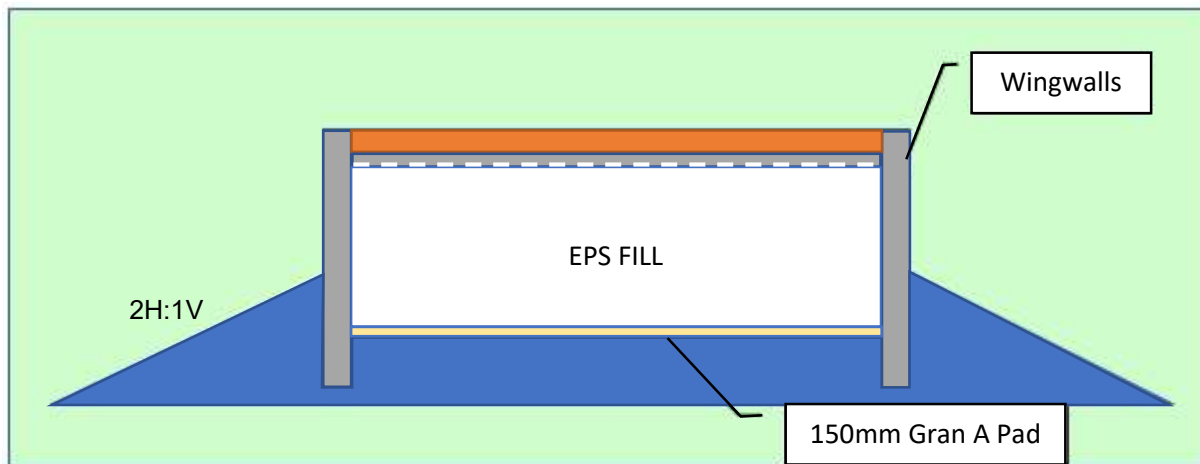
Appendix K

EPS Schematic

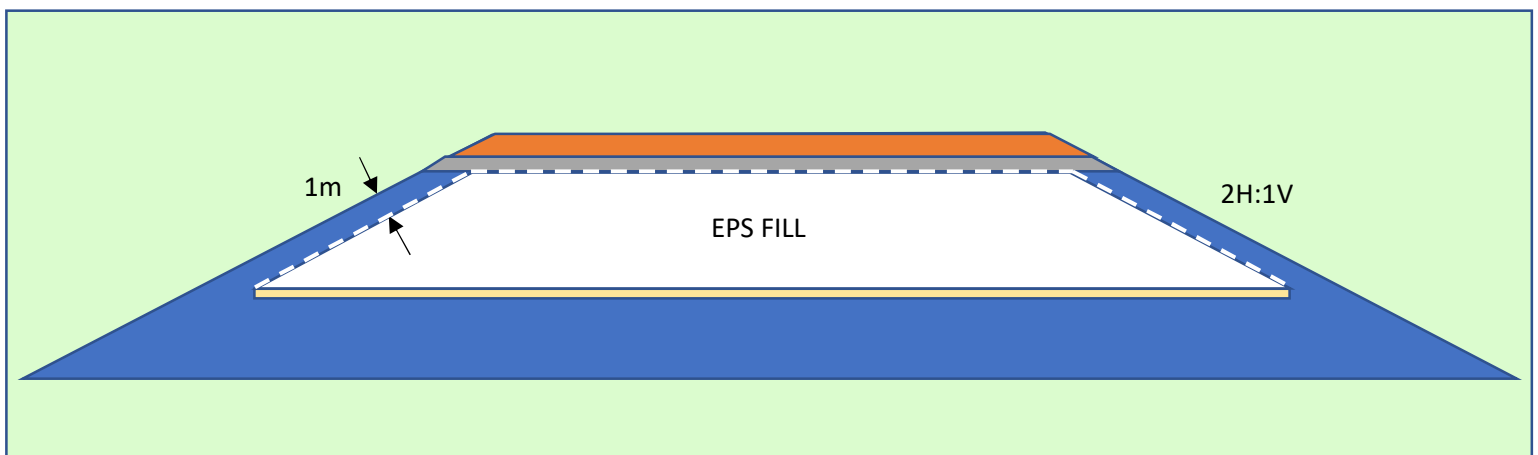




Section A-A



Section B-B



Section C-C



Appendix L

NBCC Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 47.713N 79.817W

User File Reference: Earlton

2021-09-17 13:21 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.160	0.089	0.052	0.014
Sa (0.1)	0.204	0.119	0.073	0.022
Sa (0.2)	0.182	0.109	0.069	0.022
Sa (0.3)	0.145	0.088	0.056	0.019
Sa (0.5)	0.108	0.066	0.043	0.015
Sa (1.0)	0.059	0.037	0.024	0.007
Sa (2.0)	0.029	0.018	0.011	0.003
Sa (5.0)	0.007	0.004	0.003	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.114	0.066	0.040	0.012
PGV (m/s)	0.088	0.051	0.032	0.009

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada