



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
BEAR BROOK BRIDGE REPLACEMENTS
HIGHWAY 417 FROM EIGHTH LINE TO OC 26
OTTAWA, ONTARIO
G.W.P. 455-98-00, SITES 3-266.1 & 3-266.2**

GEOCRES NO. 31G-248

Submitted

To

URS Canada Inc.

August 23, 2014

File: 19-4406-6

TABLE OF CONTENTS

SECTION	PAGE
PART 1	FACTUAL INFORMATION
1	INTRODUCTION.....1
2	SITE DESCRIPTION.....1
3	INVESTIGATION PROCEDURES2
3.1	Field Investigation 2
3.2	Laboratory Testing..... 3
4	DESCRIPTION OF SUBSURFACE CONDITIONS3
4.1	General 3
4.2	Rootmat..... 4
4.3	Fill Material 4
4.4	Silty Sand 5
4.5	Silty Clay 5
4.6	Clay 6
4.7	Glacial Till 7
4.8	Bedrock 8
4.9	Water Levels 8
4.10	Cone Penetration Testing..... 9
5	MISCELLANEOUS.....10
PART 2	ENGINEERING DISCUSSION AND RECOMMENDATIONS
6	DISCUSSION11
6.1	Proposed Structures and Embankments..... 11
6.2	Existing Structures and Embankments 12
7	SEISMIC CONSIDERATIONS.....13
8	APPROACH EMBANKMENTS.....14
8.1	Assessment of Settlement and Global Stability 14
8.2	Evaluation of Embankment Design Options..... 16
8.3	Recommendations for Embankment Design and Construction 17
9	ABUTMENT TYPE.....18
10	STRUCTURE FOUNDATIONS18
10.1	Steel Piles..... 19
10.2	Horizontal Resistance 20
10.3	Pile Tip..... 22
10.4	Pile Installation 22
10.5	Downdrag..... 22
10.6	Frost Protection..... 23
10.7	Erosion & Scour Protection 23
11	EXCAVATION.....23

12	DEWATERING	24
13	ABUTMENT BACKFILL	24
14	STRUCTURE INTERACTIONS.....	26
15	TEMPORARY PROTECTION SYSTEMS.....	27
16	CONSTRUCTION CONCERNS	27

APPENDICES

Appendix A	Borehole Location and Soil Strata Drawings General Arrangement Drawings
Appendix B	Record of Boreholes Summary of Groundwater Data
Appendix C	Geotechnical Laboratory Test Results
Appendix D	SCPTu Data
Appendix E	Historical Geotechnical Data
Appendix F	Table F1 – Comparison of Embankment Design Options Table F2 – Comparison of Foundation Options Soil Model Slope Stability Output L-Pile Analysis – HP 310 x 110 Steel Pile Soil Layer Information GSC Seismic Hazard Calculation EPS Typical Sections List of Special Provisions Suggested Text for NSSPs

**FOUNDATION INVESTIGATION AND DESIGN REPORT
BEAR BROOK BRIDGE REPLACEMENTS
HIGHWAY 417
FROM EIGHTH LINE TO OC 26
OTTAWA, ONTARIO
G.W.P. 455-98-00, SITES 3-266.1 & 3-266.2
GEOCRES NO. 31G-248**

PART 1 FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the design of replacement structures for the existing Highway 417 bridges over Bear Brook just west of Piperville Road (Eighth Line Road), near Ottawa, Ontario. Thurber has been retained by URS Canada Inc. to carry out this investigation on behalf of the Ministry of Transportation Ontario (MTO) under Agreement 4012-E-0001, Part A.

The purpose of this investigation was to determine the subsurface conditions at the site and, based on this data, to provide records of boreholes, laboratory test results and a written description of the subsurface conditions.

2 SITE DESCRIPTION

The site is located within a physiographic region known as the Russell and Prescott Sand Plains which are characterized by a sand deposit ranging from 3 to 9 m thick underlain by deep marine clay deposits.

In the vicinity of Highway 417, Bear Brook meanders through the floor of a valley with flow generally from south to north. The floor of the valley is approximately 70 to 80 m wide and approximately 8 m below the surrounding grades (elevation 68 to 69 m). Bear Brook has been incised within the valley floor by erosion and has a depth of approximately 2 m below the valley floor and width of 10 to 12 m.

Highway 417 has a rural freeway configuration with two lanes in each direction, separated by a vegetated median which is approximately 130 to 140 m wide at the Bear Brook crossings. The existing bridges consist of a five span structure with a total length of 97 m in the eastbound lanes and a six span structure with a total length of approximately 120 m in the westbound lanes.

The existing bridge abutments are located within slopes leading down to the valley floor. The highway embankment slopes extend down at approximately 2H:1V and tie into the existing valley slopes. The roadway platform does not present evidence of settlement or stability concerns at the four approaches. The embankment slopes are vegetated with long grasses and occasional shrubs. No evidence of instability was noted, however, significant erosion was evident within the valley and particularly evident at the east approach to the west bound structure where stormwater is being directed down the slope.

3 INVESTIGATION PROCEDURES

3.1 Field Investigation

Historical data available from the MTO GEOCREST library was reviewed prior to mobilization of the field investigation crews. The available data included Foundation Investigation Reports, general arrangement drawings and limited pile driving records for the existing bridge structures. The field investigation plan was finalized after discussion with the MTO Foundations Section. Approximate locations of test holes are shown on the Borehole Location and Soil Strata drawing in Appendix A. The locations and depths of the test holes are tabulated below.

Location	Test Hole #	Test Holes
Eastbound Bridge		
East approach	13-13	1 Borehole to 10.1 m
East abutment	SCPT13-12	1 Static cone penetration test to 30 m
East pier	13-11	1 Borehole to 34.2 m
West pier	13-10	1 Borehole to 32.1 m
West abutment	13-9	1 Borehole to 41.6 m
West approach	13-8	1 Borehole to 10.1 m
Westbound Bridge		
East approach	13-7	1 Borehole to 10.4 m
East abutment	13-6	1 Borehole to 38.6 m
Existing Bridge East abutment	13-5	1 Borehole to 10.8 m
East pier	13-4	1 Borehole to 35.8 m
West pier	13-3	1 Borehole to 35.7 m
West abutment	SCPT13-02	1 Static cone penetration test to 29.8 m
West approach	13-1	1 Borehole to 11.1 m
TOTAL		11 Boreholes 2 Static cone penetration tests

The geotechnical field investigation was carried out between September 16 and October 16, 2013.

The static cone penetration testing (CPT) was carried out by ConeTec using a track mounted CPT rig. Testing included the standard measurement of tip resistance, sleeve friction and pore pressure as well as pore pressure dissipation tests at selected depths and measurement of shear wave velocities at regular depth intervals.

The borehole drilling was carried out using a combination of truck and track-mounted drill rigs supplied and operated by a specialist drilling contractor.

Soil drilling was carried out using a combination of hollow stem augers and casing. Soil samples were obtained using a 50 mm outside diameter split spoon sampler advanced in accordance with the Standard Penetration Test (SPT). In-situ shear vane testing was carried out using an MTO N-vane within soft to stiff cohesive deposits. Thin-walled tube samples were collected at selected depth intervals within the clay deposit. Coring was carried out using NQ-size diamond coring gear to penetrate through boulders and into the underlying bedrock. A combination of vibrating wire piezometers and standpipe piezometers were installed to allow for measurement of groundwater levels.

The field work was supervised on a full-time basis by a member of our field staff who located the boreholes in the field, cleared borehole locations of underground utilities, directed the drilling, sampling and in-situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in appropriately labelled containers and transported back to Thurber's laboratory for further examination and testing.

It is noted that the locations of the boreholes and ground surface elevations at the borehole locations were surveyed by others and provided to Thurber.

3.2 Laboratory Testing

Geotechnical laboratory testing was carried out in the Thurber laboratory in Oakville, Ontario, and consisted of natural moisture content determination and visual identification of all soil samples in accordance with the current MTO standards. Grain size distribution analysis, Atterberg limit testing, specific gravity and oedometer testing were also carried out to MTO and ASTM standards.

The laboratory test results are presented on the records of boreholes in Appendix B and the figures in Appendix C.

4 DESCRIPTION OF SUBSURFACE CONDITIONS

4.1 General

Reference is made to the Record of Borehole sheets in Appendix B. Details of the encountered soil stratigraphy are presented in that appendix and on the Borehole Location and Soil Strata Drawings in Appendix A. Relevant factual data obtained from previous

investigations are included in Appendix E. An overall description of the stratigraphy is given in the following paragraphs however the factual data presented in the borehole logs governs any interpretation of the site conditions.

In general terms, the site was found to be underlain by a thick deposit of clay which in turn is underlain by glacial till ranging from sandy clayey till to silty sand till, over interbedded shale and limestone bedrock. Bear Brook has eroded a valley into the clay layer. The clay is overlain by thin deposits of sand and/or fill at some locations.

More detailed descriptions of the individual strata are presented below.

4.2 Rootmat

A rootmat was encountered at the ground surface in Boreholes 13-8, 13-9, 13-10 and 13-13. The thickness ranged from 30 to 50 mm. Further variations in thickness may occur between or beyond the boreholes and in other areas of the site.

4.3 Fill Material

An asphalt layer 120 mm in thickness was observed at ground surface in Borehole 13-5.

Fill was encountered at the surface in Boreholes 13-4, 13-6 and 13-7, just under the asphalt in Borehole 13-5 and below the rootmat in Boreholes 13-8, 13-9 and 13-10. Where encountered, the thickness of the fill layer ranged from 0.9 to 3.1 m. The underside elevation of the fill ranged from 65.4 to 73.9 m.

This soil is classified as very loose to compact having SPT 'N' values of weight of hammer (WH) to 24 blows for 0.3 m of penetration.

The measured natural moisture content ranged between 2% and 52 %.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure C1 in Appendix C. The gradation test results are summarized below.

Soil Particles	(%)
Gravel	0 to 2
Sand	58 to 88
Silt	11 to 33
Clay	0 to 9

This composition of the fill ranged from sand and gravel, some silt to sandy clay. Wood fragments and woody organic material was identified within the fill at some locations. A thin layer of fibrous peat (100 mm thick) was encountered at the base of the fill in Borehole 13-10.

4.4 Silty Sand

A deposit of silty sand was encountered at the ground surface in Borehole 13-1, 13-11 and at depths of 1.5 m and 3.1 m in Boreholes 13-9 and 13-10, respectively. The thickness of this layer ranged from 0.7 to 1.6 m. The base of the silty sand deposit ranged from elevation 64.6 to 74.3 m.

This soil is classified as very loose to compact having SPT 'N' values of 1 to 12 blows for 0.3 m of penetration.

The measured natural moisture content ranged between 15% and 42 %.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure C2 in Appendix C. The gradation test results are summarized below.

Soil Particles	(%)
Gravel	0
Sand	74 to 76
Silt	18 to 19
Clay	7 to 8

4.5 Silty Clay

A deposit of silty clay, sandy was encountered at the ground surface in Borehole 13-3. The thickness of this layer was 2.3 m. The base of the silty clay, sandy was at elevation 66.4 m.

This soil is classified as firm. The SPT 'N' values ranged from 2 to 7 blows for 0.3 m of penetration.

The measured natural moisture content ranged between 20% and 23 %.

The grain size distribution of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure C3 in Appendix C. The gradation test results are summarized below.

Soil Particles	(%)
Gravel	0
Sand	22 to 37
Silt	35
Clay	27 to 44

Atterberg Limit testing was carried out on one sample. The results are presented on the plasticity chart shown in Figure C10 (Appendix C) and summarized in the table below.

Liquid Limit	41
Plastic Limit	19
Plasticity Index	22

The results indicate that the material has intermediate plasticity and can be described as silty clay, sandy.

4.6 Clay

Underlying the above noted soils, a clay deposit was encountered in all boreholes. Where fully penetrated, the thickness of the clay layer ranged from 18.2 m to 29.6 m. The base of the clay layer ranges from Elevation 42.8 to 48.4 m.

The recorded SPT 'N' values in the clay layer ranged from 6 blows to less than 1 blow for 0.3 m of penetration. In many instances, the sampler sank into the clay under the self-weight of the hammer. In these instances the SPT 'N' has been recorded as WH for weight of hammer. Higher 'N' values were observed in the crust closer to the surface. The vane shear strengths measured in the deposit range from 15 to 90 kPa, indicating a soft to stiff consistency. Typically, the shear strength increased with depth. The sensitivity of the clay ranged from 3 to 34 but the deposit is typically of low to medium sensitivity.

The moisture content of the samples tested ranged from 20 to 86 %, typically between 45 and 80 %.

The grain size distribution of selected samples of this soil are provided on the Record of Borehole sheets and shown in Figures C4 to C8 in Appendix C. The gradation test results are summarized below.

Soil Particles	(%)
Gravel	0
Sand	0 to 8
Silt	17 to 76
Clay	24 to 83

Atterberg Limit testing was carried out on selected samples. The results are presented on the plasticity charts shown in Figures C11 through C15 (Appendix C) and summarized in

the table below. The results indicate that the material is typically high plasticity clay (CH) with zones of intermediate plasticity (CI).

Liquid Limit	37 to 71
Plastic Limit	19 to 34
Plasticity Index	21 to 42

The results of oedometer (one-dimensional consolidation) tests carried out on three undisturbed silty clay sample from different depths within Borehole 13-9 are provided in Appendix C. The sample locations and depths, and in-situ soil properties are summarized in the following table. The results of the tests indicate that the clay is slightly over-consolidated.

Borehole	13-9	13-9	13-9
Sample ID	TW-10	TW-15	TW-19
Depth/Elevation (m) (mid-sample)	7.9 / 67.0	15.5 / 59.4	23.2 / 51.7
Unit Weight (γ) kN/m³	18.5	15.7	17.0
Specific Gravity (G_s)	2.79	2.75	2.72
Initial Void Ratio (e_0)	1.052	2.008	1.396

4.7 Glacial Till

A glacial till (till) deposit was encountered below the clay in Boreholes 13-3, 13-4, 13-6, 13-9, 13-10 and 13-11. The composition of the till ranged from silty gravelly sand, some clay to silty sand, some clay, trace gravel. Cobbles and boulders are also present within the till deposit. Coring was required to get through the cobbles and boulders in some of the boreholes such as Borehole 13-9.

The thickness of this till layer varied from 3.9 to 11.1 m. The underside of the till ranges from elevation 37.3 to 40.0 m.

This soil is classified as compact to very dense having SPT 'N' values of 10 to 77 blows for 0.3 m of penetration.

The measured natural moisture ranged between 6 and 20 %.

The grain size distribution of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure C9 in Appendix C. The gradation test results are summarized below.

Soil Particles	(%)
Gravel	0 to 21
Sand	26 to 55
Silt	16 to 31
Clay	7 to 54

4.8 Bedrock

Six of the boreholes fully penetrated the glacial till deposit and were advanced into the underlying bedrock. The depths and elevations at which bedrock was encountered are summarized in the following table:

Table of Bedrock Depths and Elevations (in metres)

Location	Borehole	Depth (m)	Elevation (m)
Westbound Pier #1	13-3	31.4	37.3
Westbound Pier #2	13-4	30.3	38.2
Westbound east abutment	13-6	34.9	40.0
Eastbound west abutment	13-9	39.0	35.9
Eastbound Pier #1	13-10	28.7	39.7
Eastbound Pier #2	13-11	30.9	37.3

The bedrock consisted of black shale. The following properties were measured from the rock cores recovered at the abutment and pier boreholes:

Total core recovery (TCR)	30 - 100%
Solid core recovery (SCR)	0 - 98%
Rock Quality Designation (RQD)	0 – 100%

The RQD values are indicative of poor to excellent quality rock.

4.9 Water Levels

Piezometric pressures were measured in the vibrating wire piezometers (VWP) that were installed within selected boreholes on November 7, 2013 and on April 28, 2014. The measured piezometric pressures and equivalent elevations are summarized in Table 1 in Appendix B. The water levels vary from 3.4 m below ground surface to as much as 3.8 m

above ground surface. It is noted that artesian pressures were observed during drilling in Boreholes 13-4, 13-10 and 13-11. These piezometers are in the valley and the piezometric head is up to 3.8 m above the ground surface. The artesian conditions appear to originate within the glacial till or in the lower part of the clay.

The values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level will be influenced by Bear Brook and may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The bridge general arrangement drawings indicate a high water level in Bear Brook of 70.76 m and an observed water level of 66.30 m.

4.10 Cone Penetration Testing

Cone penetrometer testing was carried out in test holes SCPT13-2 and SCPT13-12. The testing was conducted by ConeTec utilizing an 18,000 kg, purpose built track-mounted CPT rigs. The CPT testing provides a near continuous depth profile of tip resistance, sleeve friction and pore pressure, which may identify the presence of thin layers (e.g. sand seams within clay) that may be missed with conventional drilling/sampling procedures and allows for in-situ measurement of shear wave velocity and pore pressure dissipation which can be used for seismic site characterization and assessment of consolidation characteristics, respectively.

The soil profile interpreted based on the CPT data indicates the presence of deep silt and clay deposits.

Shear wave velocities were measured at approximately 1 m intervals in piezocone soundings SCPT13-02 and SCPT13-12. The results indicate that the shear wave velocity within the upper 20 m is typically less than 150 m/s.

The CPT test results are provided in Appendix D.

5 MISCELLANEOUS

The borehole locations were marked in the field by Thurber. Borehole elevations and coordinates were surveyed by Callon Dietz. Thurber obtained utility clearances prior to drilling. Eastern Ontario Diamond Drilling Limited of Hawkesbury, Ontario supplied the drill rig and conducted the drilling, sampling and in-situ testing operations. CPT testing was conducted by ConeTec.

The drilling and sampling operations in the field were supervised on a full time basis by Ms. Gabrielle Marcotte, Ms. Katrina Young or Mr. Nick Weil of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved Oakville laboratory. Mr. Shawn Lapain directed the field operations and Mr. Paul Carnaffan, P.Eng. prepared this report.

Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

THURBER ENGINEERING LTD.



Paul Carnaffan, P.Eng.
Associate, Senior Geotechnical Engineer



Alastair Gorman, P.Eng.
Associate, Senior Geotechnical Engineer



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

**FOUNDATION INVESTIGATION AND DESIGN REPORT
BEAR BROOK BRIDGE REPLACEMENTS
HIGHWAY 417
FROM EIGHTH LINE TO OC 26
OTTAWA, ONTARIO
G.W.P. 455-98-00, SITES 3-266.1 & 3-266.2

GEOCRETS NO. 31G-248**

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6 DISCUSSION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the proposed structures and to specify geotechnical criteria for design and construction of the immediate approach fills.

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

6.1 Proposed Structures and Embankments

The preliminary General Arrangement (GA) drawings indicate that both the east bound and west bound replacement structures at this site will be three-span structures. Additional details regarding the proposed structures are as follows:

- The replacement structures are to be constructed on a permanent new alignment immediately adjacent to the existing structures on the median side. The spacing between the centreline of the existing structures to the centreline of the replacement structures is approximately 12.7 m to 13.5 m
- The proposed structures will consist of concrete decks supported by steel plate girders. The east bound structure will have a total length of 95.0 m with spans of 30.0 m, 35.0 m and 30.0 m. The west bound structure will have a total length of 121.0 m with spans of 38.0 m, 45.0 m and 38.0 m.
- The piers will be constructed within the valley with each structure having one pier on each side of Bear Brook.
- The replacement structures will each support two lanes plus shoulders. The design includes consideration of a possible future widening to support a third lane in each

direction with the third lane overlapping the current bridge structures. However, the current design does not include detailed design for the future widening.

- The profile grades and required embankment heights (maximum increase above existing grade) at the abutments are as follows:

Structure	Abutment	Profile Grade (m)	Maximum Required Embankment Height (m)
East Bound Structure	West	76.007	4.0
East Bound Structure	East	76.482	2.5
West Bound Structure	West	76.705	3.2
West Bound Structure	East	76.100	6.0

6.2 Existing Structures and Embankments

The existing bridge structures consist of five and six span structures with concrete decks supported on pre-stressed concrete girders. The total length of the existing east bound bridge is 345'0" (105.16 m) and the total length of the existing west bound bridge is 428'0" (130.45 m).

Both of the existing structures include piers on each side of Bear Brook. The piers and abutments of both existing bridges are supported on steel H-piles (12 BP 74) driven to practical refusal with a design load of 90 tons (800 kN) per pile. The piles at the piers are battered at 5 vertical to 1 horizontal; the piles supporting the abutments include both vertical piles and piles battered at 4 vertical to 1 horizontal.

Based on the General Plans from the historical contract drawings, the existing bridge abutments were constructed within the slopes leading down to the valley floor with the profile grade of the highway close to the existing grade of the surrounding land above the valley. Embankment slopes extend down from the highway and abutments at approximately 2H:1V and tie into the valley slopes. The embankment slopes are vegetated with long grasses and occasional shrubs. No evidence of slope instability was noted during an inspection prior to the start of the drilling investigation. Surface erosion was noted, particularly near the existing east approach to the west bound structure.

A review of the Foundation Investigation Report (dated March 11, 1968) for the existing structure indicates that the original design for these structures called for three span structures with total lengths of 210' (64.0 m) and 180' (54.9 m) for the west bound and east bound structures respectively. The proposed bridge geometry would have resulted in embankment fills as high as

38 feet (11.6 m) above the valley floor. The 1968 geotechnical analysis based on the original bridge geometry indicated that approach embankments with 2H:1V side slopes would have required mid-height berms up to 60 feet in width to ensure stability. In addition, total settlement of the approach embankments was estimated to be as much as 7 feet and 5 feet beneath the centre of the west bound and east bound approaches, respectively. The report recommended lengthening the proposed structures to minimize the length and height of the required approach fills in order to address both the slope stability and settlement issues.

Based on the contract drawings, it appears that the design for both structures was changed from three to five and six spans and that the total length of the east bound structure was increased from 180' (54.9 m) to 345'0" (105.16 m) and that the west bound structure was increased from 210' (64.0 m) to 428'0" (130.45 m).

A hand-written memo from the GEOCRE library (Review of Final Bridge Dwgs, WBL Structure, Bear Brook) dated January 13, 1969, included settlement calculations for the east approach of the west bound structure and indicated the following:

- The proposed grades at the east approach would result in a maximum stress increase of 1200 psf (approximately 57 kPa, or equivalent to about 2.7 m of granular fill)
- The proposed stress increase would not result in a stress in excess of the pre-consolidation stress
- The maximum settlement of the east approach due to recompression would be in the order of 4-6" (100 to 150 mm).

The available historical documents do not indicate any performance problems related to excessive settlement or global stability of the approach embankments.

7 SEISMIC CONSIDERATIONS

For design purposes, the site is treated as lying in Seismic Zone 4.

The following seismic parameters should be used for design:

- | | |
|-------------------------------------|------|
| • Velocity Related Seismic Zone | 2 |
| • Zonal Velocity Ratio | 0.10 |
| • Acceleration Related Seismic Zone | 4 |
| • Zonal Acceleration Ratio | 0.20 |
| • Peak Horizontal Acceleration | 0.2g |

The Soil Profile Type at this bridge site has been classified as Type IV based on the presence of over 12 m of soft clay (as characterized by a shear wave velocity of less than 150 m/s). Thus, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient “S” of 2.0 should be used in seismic design.

The potential for liquefaction of the clay deposits has been assessed using the criteria presented by Bray et al. (2004). Based on this criteria, the deposit is considered not susceptible to liquefaction due to its highly plastic nature.

8 APPROACH EMBANKMENTS

The proposed profile and bridge spans require a maximum grade raise at the four approaches of between 2.5 m and 6.0 m. The construction of embankments over the soft to firm clay deposit presents challenges with respect to both settlement and global stability.

8.1 Assessment of Settlement and Global Stability

An assessment of the time dependent settlement that would result from construction of the proposed approach fills using conventional granular fill with 2H:1V side slopes was carried out using Settle 3D modelling software. The soil model used for analysis is presented on Dwg No. 1 in Appendix F; it shows properties of the clay versus elevation. The design pre-consolidation pressure profile has been derived from the oedometer tests, both current and historic, as well as correlations with the undrained shear strength and plasticity. Compression characteristics have been modelled using C_c , C_r and C_α values from the current and historic oedometer test results. Values of $C_c = 2.4$, $C_r = 0.044$, $C_\alpha/C_c = 0.04$, $C_v = 4.73 \text{ m}^2/\text{yr}$ ($1.5 \times 10^{-3} \text{ cm}^2/\text{s}$) and $C_{vr} = 22.07 \text{ m}^2/\text{yr}$ ($7.0 \times 10^{-3} \text{ cm}^2/\text{s}$) have been used in the analysis. The results of the analysis are summarized in the table below.

Location	Maximum Settlement Beneath Centreline After 20 Years (mm)
East Bound Structure – West Abutment	130
East Bound Structure – East Abutment	70
West Bound Structure – West Abutment	190
West Bound Structure – East Abutment	480

The predicted settlement values reflect both the maximum embankment height as well as the aerial distribution of fill and fill height.

It is noted that the stresses associated with a conventional granular fill embankment would exceed the preconsolidation pressure for a portion of the depth profile at all but the east abutment of the east bound structure.

The estimated settlement of the approach embankments at all four abutments is in excess of the MTO Guidelines for post construction settlement over a period of 20 years after paving:

- 25 mm within 20 m behind bridge abutment
- 50 mm from 20 to 50 m from the bridge abutment
- 100 mm for greater than 50 m from the bridge abutment

In addition, the large settlement associated with construction of the embankments with conventional granular fill would have detrimental effects on the adjacent existing bridge structures and embankments including bending stresses on the existing battered piles and settlement of the existing approach fills.

The time rate of settlement has also been assessed. It is estimated that it would require a preload of several years to meet the MTO settlement guidelines for the east approach of the west bound structure.

The global stability of the proposed 2H:1V embankments was evaluated using a computer model (Slide ver 6.0) for limit equilibrium analysis. Input parameters for undrained analysis are based on the in-situ shear vane test results summarized in Drawing 1 in Appendix F. The values of cohesion and internal friction angle used in the drained analysis are based on empirical correlations developed for the Champlain Sea clay deposits present in the area (Tavenas and Leroueil, 1981). The analysis results are provided in Appendix F and are summarized in the table below.

Location	Global Stability Factor of Safety		
	Static Conditions		Seismic Conditions
	Undrained	Drained	
East Bound Structure – West Abutment	1.5	1.6	1.2
East Bound Structure – East Abutment	1.9	2.0	1.2
West Bound Structure – West Abutment	1.5	1.7	1.1
West Bound Structure – East Abutment	1.4	1.5	1.0

The results indicate a factor of safety of 1.4 under static undrained conditions for the slope at the east abutment of the west bound structure. A toe berm would need to be constructed to increase the factor of safety to greater than the target of 1.5, however, there is insufficient room for the required toe berm without impacting the creek. The remainder of the proposed slopes were found to be stable under both static and seismic conditions.

8.2 Evaluation of Embankment Design Options

Based on the initial assessment of the embankment constructed using conventional granular fill, additional embankment design options to address both settlement and global stability were developed and assessed. The embankment design options considered include:

Option	Description
1	Conventional granular fill embankment
2	Increase the length of the bridge to reduce the length and height of embankment fill
3	Ground improvement techniques
4	Structural support
5	Lightweight fill embankments
6	Accelerated settlement (surcharging either with or without wick drains)
7	Geogrid reinforcement
8	Staged construction

Option 7 (Geogrid Reinforcement) was ruled out since, although geogrid can form an artificial crust and spread out the load, it cannot prevent the settlement associated with the deep clay deposit, nor will it influence the settlement timing.

Option 8 (Staged Construction) was ruled out since the primary concern is longer term settlement. Staged construction offers advantages where short term stability is a primary concern but offers no real benefit in terms of mitigating long term settlement.

A summary of the advantages and disadvantages of the remaining options is provided in Table F-1 in Appendix F.

Several lightweight fill options, including slag, tire-derived aggregate (TDA), foamed concrete and expanded polystyrene (EPS) were considered. The unit weight of the EPS fill is significantly lower than all of the other lightweight fill options and was selected as the preferred type of lightweight fill as it is the only option that would allow for appropriate control of the anticipated settlement without excessive sub-excavation and replacement of native subgrade soil. EPS is also an MTO approved lightweight fill.

8.3 Recommendations for Embankment Design and Construction

It is recommended that the embankments be constructed using EPS lightweight fill (Option 5). This option addressed both settlement and stability concerns, avoids impacts to the existing structures due to settlement of the clay, and does not result in significant time delays to the project. It is noted that since the grade raise is generally limited to filling in the wedge between the bridge abutments, the valley slopes and the existing approach embankments, the volume of lightweight fill is relatively small. The EPS lightweight fill option is the preferred option from both a technical and risk management perspective.

Implementation of the EPS design option as described below will limit stress increases to approximately 5 kPa beneath the EPS and approximately 26 kPa in the adjacent sections with granular fill no more than 1.2 m thick. The resulting total settlement from 0 to 20 years is estimated to be approximately 15 mm beneath the EPS and 40 mm in the sections behind the EPS where granular fill is used. The global stability of the slope at the east abutment of the west bound structure will increase to greater than the target values of 1.5 and 1.1 under static and seismic conditions, respectively.

Location	Global Stability Factor of Safety		
	Static Conditions		Seismic Conditions
	Undrained	Drained	
West Bound Structure – East Abutment	1.5	1.5	1.2

The EPS fill treatment should be implemented in all areas where the proposed finished grade will be more than 1.2 m above current site grades. The proposed embankments will be keyed into the existing approach fill embankments. The limits of the EPS fill should be as follows:

- The bottom of the EPS should be stepped into the existing sloped ground surface such that the bottom of the EPS is always a minimum of 1.2 m below existing grades.
- The top surface of the EPS within the embankment side slopes should be covered with a 10mil sheet of polyethylene and stepped such that the minimum soil cover includes 300 mm of modified Select Subgrade Material under 600 mm of earth fill.
- The top surface of the EPS beneath the highway platform should be covered with a concrete slab. The top of the concrete slab should be at the underside of the pavement subbase layer. The recommended pavement structure in this location has a total thickness of 870 mm.

A granular levelling pad consisting of a 300 mm of compacted OPSS Granular A should be provided beneath the EPS. Due to the firm to soft clay conditions, it is recommended that a non-woven geotextile be placed horizontally beneath the granular levelling pad as a separation layer.

Guidelines for the design of EPS embankments can be found in NCHRP Report 529.

The contract must include an NSSP for the EPS embankment materials and construction. Both Type 22 and Type 29 EPS materials meet the geotechnical requirements. A draft version of suggested NSSP wording is provided in Appendix F.

The embankment design will need to take into consideration the potential for conflict between the EPS fill and foundations for signs, guiderails, utilities or other structures.

Based on the current General Arrangement drawings, it is anticipated that the base of the EPS will be no lower than elevation 69.3 m. This level is above the normal water level in Bear Brook but 1.5 m below the design high water level. Due to the weight of the concrete slab and granular fill that will be placed above the EPS, flotation is not a concern under long term conditions.

9 ABUTMENT TYPE

From a geotechnical perspective, the soil conditions at the site are considered suitable for an integral abutment design, as the clay soils offer a flexible foundation condition. A soil-structure interaction analysis to assess the response of a pile under lateral loading was carried out using commercially available software (LPile by Ensoft Inc.). A copy of the results in the form of load-deflection curves (p-y curves) and lateral load vs maximum bending moment are provided in Appendix F and were provided to the structural designers for their evaluation of the abutment design.

It is understood that structural requirements do not allow for use of a single row of piles at the abutments, and therefore, a semi-integral abutment design has been selected.

10 STRUCTURE FOUNDATIONS

The results of the field and laboratory investigation and historical data indicate that the site is underlain by a deep marine clay deposit, underlain by a glacial till deposit, which is underlain by shale bedrock. Key elevations are as follows:

Existing ground surface	66.2 to 69.3 m at piers 72.1 to 76.4 m at abutments
Top of glacial till deposit	42.8 to 48.4 m
Top of bedrock	35.9 to 40.0 m

The clay can generally be characterized as moderately sensitive with high plasticity. The clay is generally soft to firm within the upper portion with strength increasing gradually with depth.

The glacial till deposit generally consisted of silty sand with some clay, trace to some gravel and occasional to frequent cobbles and boulders. Rock coring techniques were used to penetrate the cobbles and boulders at some locations. Artesian groundwater conditions were noted in the till layer for three of the four boreholes drilled in the valley.

The clay deposit offers low bearing resistance and is susceptible to settlement under even moderate loads. The clay deposit has insufficient strength to support the foundation loads associated with the proposed abutments and piers. Deep foundations are required. The following deep foundation alternatives were considered:

- Micro-piles
- Steel pipe piles
- Steel H-piles
- Caissons (drilled shaft piles)

A comparison of the technical advantages and disadvantages of alternative foundation schemes is presented in Table F2 in Appendix F. Based on this comparison, steel H-piles are the recommended foundation support option from a geotechnical perspective. Design recommendations for driven steel H-piles are provided in the sections that follow.

10.1 Steel Piles

Due to the anticipated length of the piles and presence of boulders within the till deposit, it is recommended that the design use steel HP section piles driven to practical refusal. Interaction with the structural design team has indicated that HP 310 x 132 pile sections are required at the piers; HP 310 x 110 piles will be used at the abutments.

The design parameters for axial resistance of both HP 310 x 110 and HP 310 x 132 piles driven to practical refusal within the glacial till deposit can be taken as:

Factored geotechnical resistance at ULS	1800 kN
Axial resistance at SLS	1600 kN

The factored geotechnical resistance at ULS (ultimate limit states) includes a resistance factor of 0.5 as per the Canadian Highway Bridge Design Code (CHBDC).

The estimated pile tip elevations based on piles reaching practical refusal are as follows:

Estimated Pile Tip Elevation

Structure	Foundation Element	Underside of Pile Cap Elevation (m)	Estimated Pile Tip Elevation (m)
East Bound	West Abutment	69.4	38.0
	Pier #1	65.7	39.7
	Pier #2	65.9	40.0
	East Abutment	71.8	40.0
West Bound	West Abutment	71.0	40.0
	Pier #1	67.0	37.3
	Pier #2	64.5	38.2
	East Abutment	68.2	40.0

The geotechnical axial resistance was selected assuming that the piles meet refusal in the till layer above the bedrock. It is possible that some of the piles will fully penetrate the till layer and refuse on bedrock.

It is noted that the piles will penetrate through the deep clay deposit and into or through the glacial till deposit where artesian groundwater conditions have been observed. Due to the thickness of the clay, artesian flow up the pile shaft is not expected to be a concern. Furthermore, it is noted that the existing bridge structures are supported on steel H-Piles driven to similar depths and no problems with artesian flow up the pile shafts were noted in the review of the construction history.

10.2 Horizontal Resistance

The lateral load response of a single steel H-Pile (HP 310x110) embedded within the clay deposit at this site was assessed using an L-Pile analysis to determine lateral load versus pile head deflection and lateral load versus maximum bending moment within the pile. The results are presented in Appendix F.

Lateral resistance may also be developed through the inclusion of battered piles within the pile groups.

Pile spacing and group effects will need to be considered in assessing the overall lateral resistance of the piles at each foundation unit.

Soil layer information for use in an FB pier model at the pier and abutment locations, as requested by URS, is provided in the forms in Appendix F. The parameters have been developed based on the following methods:

- The shear modulus for the clay and till layers has been calculated based on the shear wave velocities measured as part of the CPT testing. Shear wave velocity data was not obtained for the upper fill deposit, therefore, the shear wave velocity has been calculated based on correlations to the SPT N-values.
- The undrained shear strength for cohesive deposits is based on in-situ shear vane testing.
- The unit weights for the clay are based on the average moisture content and specific gravity measured in lab tests and the assumption of 100% saturation below the groundwater level. The unit weights for non-cohesive soils have been estimated based on soil gradation and relative density.
- The major principal strain at 100% has been estimated based on a review of strain rates for quick triaxial tests completed as part of the investigation for the existing bridge structure.
- The major principal strain at 50% has been assigned based on typical values for clays (as presented in L-Pile Technical Manual)
- Poisson's ratio has been assigned based on typical values for the corresponding soil type
- Although uncorrected SPT N-values have been requested, we do not recommend that they be used for cohesive soils. Most correlations between clay properties and SPT N-values do not apply to the sensitive clay deposits in Eastern Canada, such as those present at this site.

Group effects should be considered when assessing the lateral load response of piles beneath a pier or abutment. Where detailed geometry regarding the pile spacing and layout is available, the pile group behaviour can be assessed using modelling software such as GROUP by Ensoft. Where simplified analysis is being carried out using soil springs, the coefficient of horizontal subgrade reaction can be reduced to account for group effects, by applying the factors provided in the table below, based on the pile spacing and direction of loading. Intermediate values may be obtained by linear interpolation.

Subgrade Reaction Factors for Pile Spacing

Condition	Pile Spacing, Centre to Centre*	Horizontal Subgrade Reaction Factor
Pile group oriented <i>perpendicular</i> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <i>parallel</i> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

(*) where D is the width of pile

10.3 Pile Tip

The tips of all driven piles must be fitted with Titus Steel Standard H-point or equivalent for protection.

10.4 Pile Installation

Driven piles must be installed in accordance with OPSS 903. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate geotechnical resistance of 3,600 kN per pile.”

10.5 Downdrag

Downdrag forces will develop along the length of the driven H-pile embedded in the clay deposit due to consolidation settlement induced by the approach embankment loads. Downdrag loads are not anticipated at the pier locations.

The downdrag loads have been assessed using static analysis and a β -value of 0.25 for the clay. For design purposes, an unfactored downdrag force of 570 kN per pile is recommended for both HP 310 x 110 and HP 310 x 132 sections to evaluate the impact of downdrag. This is based on an embedded pile length of 26 m.

This downdrag load should be multiplied by a load factor of 1.25 as per CHBDC Commentary Clause C8.6.4 to obtain a factored downdrag load. In accordance with Section 6.8.4 of the CHBDC and Clause C6.8.4 of the Commentary, in the structural design of a pile, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. In geotechnical analysis of downdrag, live load effects should not be considered.

The location of the neutral plane for a pile or group of piles should be determined by using unfactored loads and unfactored geotechnical parameters.

As indicated in Clause C.6.8.4 of the Commentary, the factored dead and downdrag load should not exceed the factored structural resistance of a pile.

Download drag loads can be avoided by increasing the amount of EPS fill used in the approach embankments in order to offset all stresses associated with embankment and avoid settlement of the clay deposit around the piles.

10.6 Frost Protection

The design depth of frost penetration at this site is 1.8 m. Accordingly, a minimum of 1.8 m of earth cover, or equivalent insulation, must be provided above the base of the pile caps to serve as frost protection.

10.7 Erosion & Scour Protection

The piers are located within the valley in relatively close proximity to the banks of Bear Brook. The tops of the pier pile caps are located below the high water level. The pile caps at the pier locations should be protected against erosion and scour. Rock protection should meet the requirements of OPSS 511 and OPSS.PROV 1004 and should be placed on a non-woven Class II geotextile. The requirements for erosion and scour protection should be assessed by the hydrology designers taking into account the anticipated flow velocities.

11 EXCAVATION

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the probable depth of excavation at this site may be classed as Type 3 soils. As per the OHSA, unsupported excavations in Type 3 soils should be constructed with side slopes no steeper than 1H:1V from the base of the excavation.

Due to the proximity of Bear Brook to the piers, control of surface water may be an issue, particularly during and following periods of rainfall. The Contractor must be made aware of the possibility that he may need to construct cofferdams (e.g. sheet pile cofferdams) at the piers to control surface water and to allow work to proceed in the dry. Groundwater control measures will be required in order to maintain a dry and stable excavation through overburden soils.

Excavations for the pile caps at the piers are expected to extend to depths of as much as 3.5 m below existing ground surface and up to 1 m below the reported water level in Bear Brook. Excavation base stability is not expected to be a concern for excavations extending no deeper than 4 m below ground surface.

12 DEWATERING

All excavations for foundations must be dewatered prior to the placement of concrete, as per OPSS 902 – Construction Specification for Excavating and Backfilling - Structures.

The design of any dewatering system that may be required must be the responsibility of the Contractor and the Contract Documents must alert him to this responsibility and the need to engage a dewatering specialist.

For foundation excavation close to Bear Brook, the design of the dewatering system should be coordinated with the design of the excavation support/cofferdam systems, where required. For excavations that do not extend below the high water level, the dewatering system may contain sumps at low points within the footing excavation from which accumulated water may be pumped. A permit to take water (PTTW) may be required for any foundation excavation that may encounter groundwater and collect surface water.

13 ABUTMENT BACKFILL

Due to the settlement and stability concerns associated with the approach fill embankments, the backfill behind the abutments will consist primarily of EPS material. A mechanism for drainage behind the abutment should be provided by either:

- a) A column of granular backfill, fully supported on the abutment pile cap, or
- b) A geosynthetic sheet drain which would avoid the need for compaction of a narrow trench of granular fill between the abutment wall and EPS or between the wingwall and EPS.

The backfill pressures acting on the back of the abutment should consider both:

- The gravity loads of the EPS backfill and overlying pavement structure pressing directly against the wall; and
- The active earth pressure from the soil behind the EPS backfill.

The methodology for assessing the pressures on the back of an abutment wall is described in Section 6 of NCHRP Report 529. The vertical load of EPS blocks will result in negligible active horizontal loading of the abutment wall. The horizontal pressure generated by the vertical stress imposed by the overlying pavement structure can be assumed to be equal to 0.1 times the vertical stress.

The earth pressure from the soil behind the EPS backfill may be calculated using the parameters provided in the following table for static conditions.

Earth Pressure Design Parameters – Static Conditions

Parameter	Soil Type			
	OPSS Granular A or Granular B Type II	OPSS Granular B Type I	OPSS SSM Fill	Silty Clay / Clay
Effective Friction Angle, ϕ	35°	32°	30°	27°
Unit Weight, γ (kN/m ³)	22.8	21.2	21.0	18.5
Interface Friction Angle, Soil to EPS, δ	35°	32°	30°	27°
Active Earth Pressure Coefficient, K_a (Unrestrained Wall)	0.27	0.31	0.33	0.38
At-rest Earth Pressure Coefficient, K_o (Restrained Wall)	0.43	0.47	0.50	0.55
Passive Earth Pressure Coefficient, K_p (Movement Towards Soil Mass)	3.7	3.3	3.0	2.7

In accordance with Clause C4.6.4 of the CHBDC and related commentary, retaining structures should be designed using earth pressure coefficients that include earthquake loading. The seismic component of the active earth pressure generated by the soil behind the EPS/soil interface can be calculated using the Mononobe-Okabe method with $k_h = A/2$ where A is the zonal acceleration ratio. The dynamic active earth pressure coefficients (K_{AE}) are provided in the following table:

Earth Pressure Design Parameters – Dynamic (Seismic) Conditions

Parameter	Soil Type			
	OPSS Granular A or Granular B Type II	OPSS Granular B Type I	OPSS SSM Fill	Silty Clay / Clay
Effective Friction Angle, ϕ	35°	32°	30°	27°
Unit Weight, γ (kN/m ³)	22.8	21.2	21.0	18.5
Interface Friction Angle, Soil to EPS, δ	35°	32°	30°	27°
Dynamic Active Earth Pressure Coefficient, K_{AE}	0.33	0.37	0.40	0.45

The K_{AE} values have been calculated based on Section 4.6.4 of the CHBDC for a yielding wall with a vertical back and horizontal backfill. The angle of friction between the wall and the soil has been set at 0 degrees to generate a conservative estimate. The application of amplification factors to the zonal acceleration ratio has not been included.

The horizontal coefficient of subgrade reaction of the EPS fill should be calculated based on the following equation:

- $K'_{EPS} = 0.14 * E_{EPS} / \{H * (1 - \nu_{EPS}^2)\}$ (units: kN/m³)

where: E_{EPS} = Young's Modulus of EPS Blocks (refer to Table 8 on Page 42 of NCHRP's Report 529 for different types of EPS blocks)
 ν_{EPS} = Poisson's Ratio of EPS Blocks (= 0.10)
 H = Thickness (vertical) of EPS behind wall

The horizontal pressure applied by the wall to the EPS fill must be smaller than the Elastic Limit Stress of the EPS.

14 STRUCTURE INTERACTIONS

The replacement bridge structures are to be constructed on permanent new alignments immediately adjacent to the existing structures on the median side. The spacing between the centreline of the existing structures to the centreline of the replacement structures is approximately 12.7 m to 13.5 m. The locations of the proposed piers are offset from the existing pier locations, as shown on the Borehole Location drawings in Appendix A. The close proximity between the existing and proposed structures presents additional considerations for both design and construction, including but not limited to the following:

- Roadway protection systems will be required to protect the existing abutments and approaches during excavation for construction of the new abutments.
- The structural engineer will need to check to ensure that there is no conflict between the existing and proposed piles supporting the piers and abutments (taking into account the projection of battered piles).
- Due to the length, removal of the existing piles would likely be challenging and costly. It is recommended that the existing piles and pile caps be left in place.
- The new approach fills will include EPS to limit settlement to within the MTO settlement criteria. As a result, settlement beyond the limits of the new fills will be small and is not expected to impact the existing structure.
- Installation of the new piles will result in vibrations in the surrounding area. The vibrations are likely to be perceptible on the existing structure and at the nearby

residence. Although the vibrations are not expected to have a detrimental impact on the capacity of the existing foundations, vibration monitoring should be carried out to ensure that vibration levels do not become excessive.

Although not included as part of the current design assignment, it is understood that planning studies have identified a possible future widening of Highway 417 and the new bridge structures by one lane in each direction. The future widenings would be constructed to the outside and would overlap with the existing structures. Since the piers of the new structures are offset from the existing piers, a conflict is not anticipated for widening of the piers in the future and it would likely be easier to construct the pier widenings once the existing superstructure has been removed. Widening of the abutments in the future is likely to be in conflict with the original bridge abutments and wingwalls. The pile caps from the original bridge structures will likely need to be removed at that time or incorporated into the design of the widening. In addition, the future widening would need to consider potential conflict with the piles from the original structures.

15 TEMPORARY PROTECTION SYSTEMS

Temporary protection systems will be required to protect the existing highway embankment and abutments during excavation for placement of the new bridge abutments and EPS backfill.

Sheet-piles or soldier pile & lagging walls are considered appropriate for protection systems at this site. It is noted that the cohesive soils will offer limited resistance for tie-back anchors and that the depth to bedrock is significant. Therefore the use of deadman anchors might be considered.

The temporary excavation support system should be designed and constructed in accordance with OPSS 539, November 2009. The lateral movement of the temporary shoring system should meet Performance Level 2.

16 CONSTRUCTION CONCERNS

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

- Adequate measures to control groundwater and to exclude surface water flow from the work area;
- The Contractor's selection of construction equipment and methodology must include assessment of the capability of the existing ground to support the proposed construction equipment and any temporary structures or fills (i.e. pads for crane support). Site conditions may limit the type of equipment suitable for use. The design and safety of any temporary works is the responsibility of the contractor;

- Excavation for construction of the new abutment pile caps and EPS backfill is expected to encroach within the existing approach embankments. Temporary protection systems and monitoring of movements of both the protection system and existing structure will be required.

This report was prepared by Mr. Paul Carnaffan, P.Eng., Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation projects, reviewed the report.

THURBER ENGINEERING LTD.



Paul Carnaffan, P.Eng.
Associate, Senior Geotechnical Engineer



Alastair Gorman, P.Eng.
Associate, Senior Geotechnical Engineer



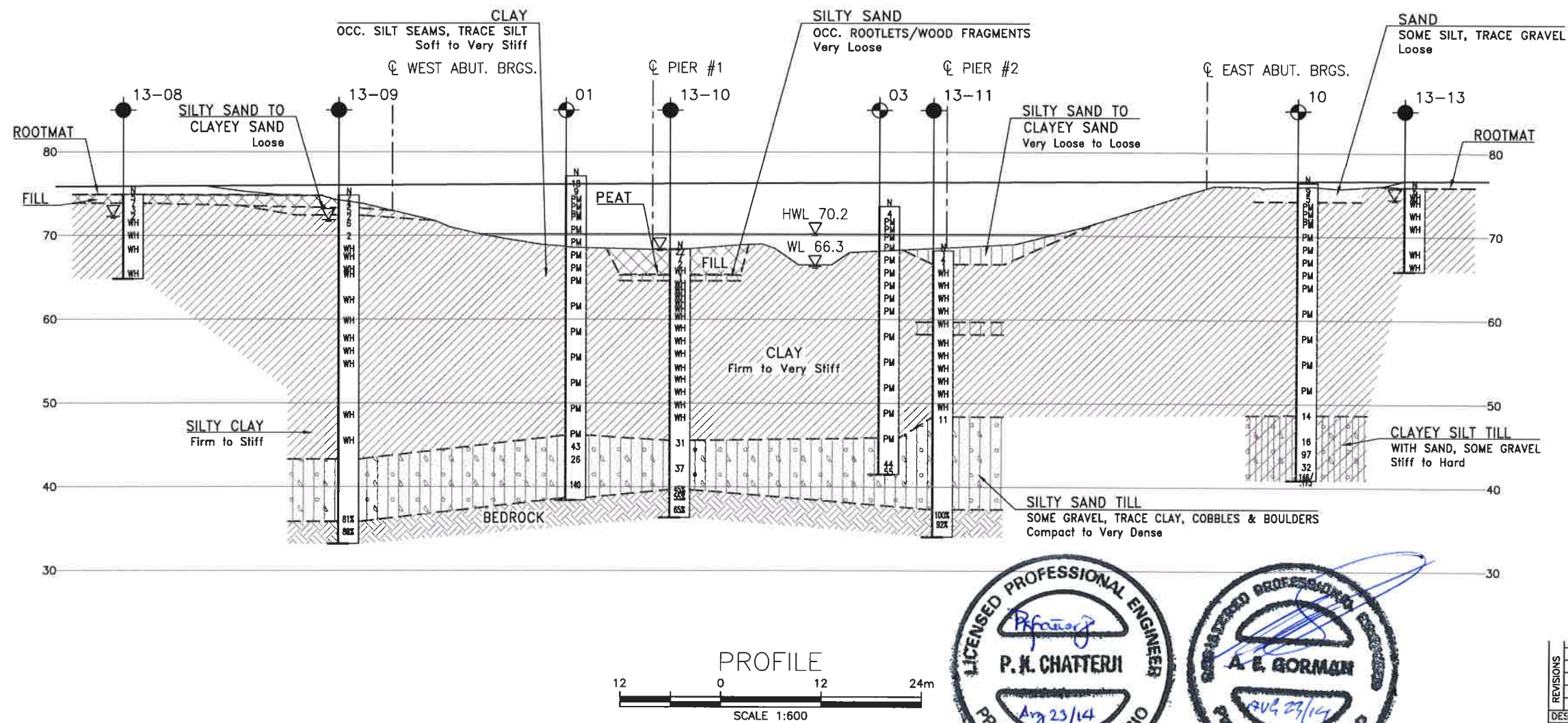
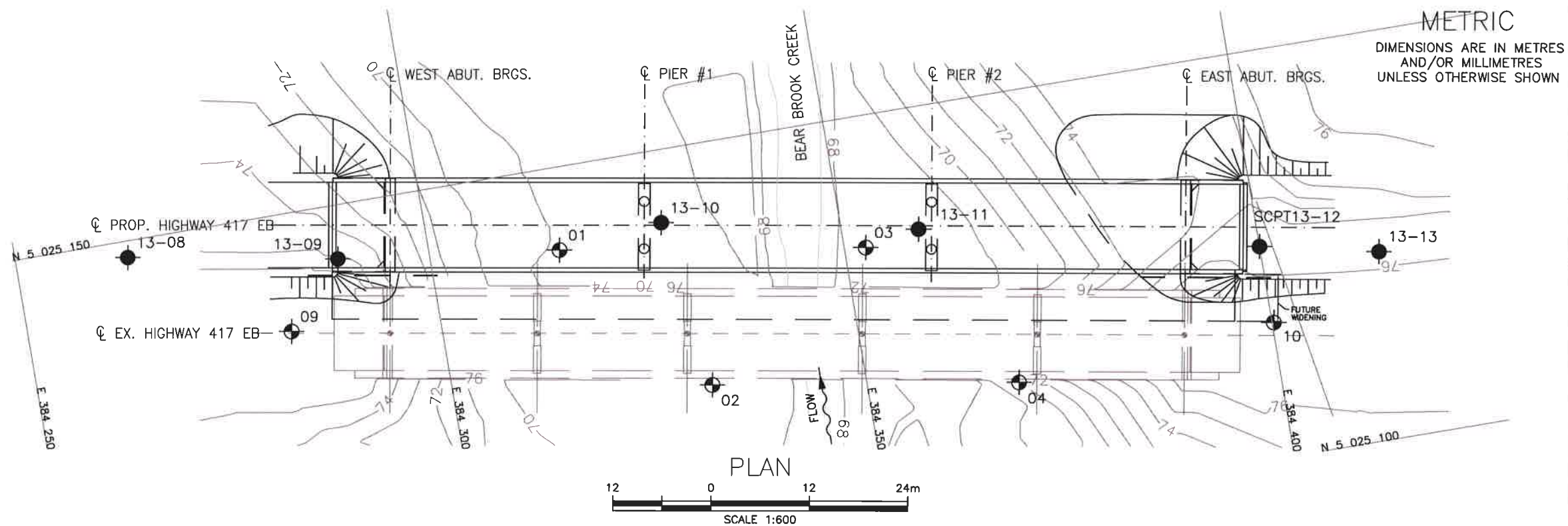
P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

h:\projects\19\4406\6 - hwy 417 ottawa\foundation\bridges\report\final\rev 1\fidr\final bridge rpt aug 7.doc

Appendix A

Borehole Location Drawings & Soil Profiles

Bridge General Arrangement Drawings



CONT No
GWP No 455-98-00

HIGHWAY 417
EASTBOUND LANES
BEAR BROOK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA

URS



THURBER ENGINEERING LTD.



SHEET



KEYPLAN

LEGEND

- ◆ Borehole (Current Investigation by Thurber)
- ◐ Borehole (Previous Investigation by Others)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
01	77.1	5 025 139.9	384 315.8
02	68.9	5 025 120.4	384 331.4
03	73.5	5 025 133.9	384 352.6
04	75.6	5 025 114.5	384 368.3
09	74.4	5 025 135.6	384 281.9
10	76.4	5 025 116.5	384 400.2
13-08	74.9	5 025 148.0	384 263.6
13-09	74.9	5 025 143.4	384 288.9
13-10	68.4	5 025 141.1	384 328.6
13-11	68.2	5 025 135.0	384 359.3
13-13	75.9	5 025 123.0	384 414.2

-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.

GEOCRES No. 31G-248



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	PC	CHK -	CODE
DRAWN	MFA	CHK PC	SITE 3-266.1
			STRUCT
			DWG 1
			DATE AUG 2014

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

CONT No
GWP No 455-98-00

HIGHWAY 417
WESTBOUND LANES
BEAR BROOK BRIDGE
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET

URS



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

- Borehole (Current Investigation by Thurber)
- ◆ Borehole (Previous Investigation by Others)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- ▽ Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

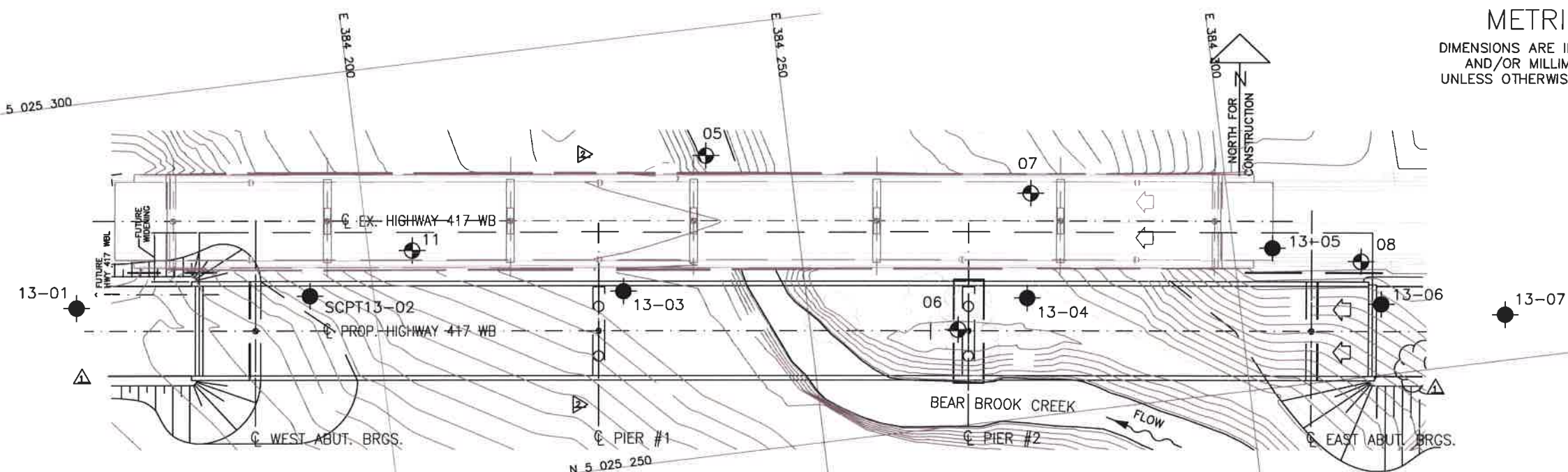
NO	ELEVATION	NORTHING	EASTING
05	66.2	5 025 285.0	384 240.3
06	67.9	5 025 261.2	384 267.0
07	68.5	5 025 276.0	384 277.3
08	76.4	5 025 263.4	384 314.6
11	69.3	5 025 278.1	384 205.0
13-01	75.9	5 025 276.2	384 165.4
13-03	68.7	5 025 270.4	384 228.9
13-04	68.5	5 025 263.9	384 275.4
13-05	76.1	5 025 266.2	384 304.5
13-06	75.0	5 025 258.2	384 316.3
13-07	75.2	5 025 255.2	384 330.5

-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.

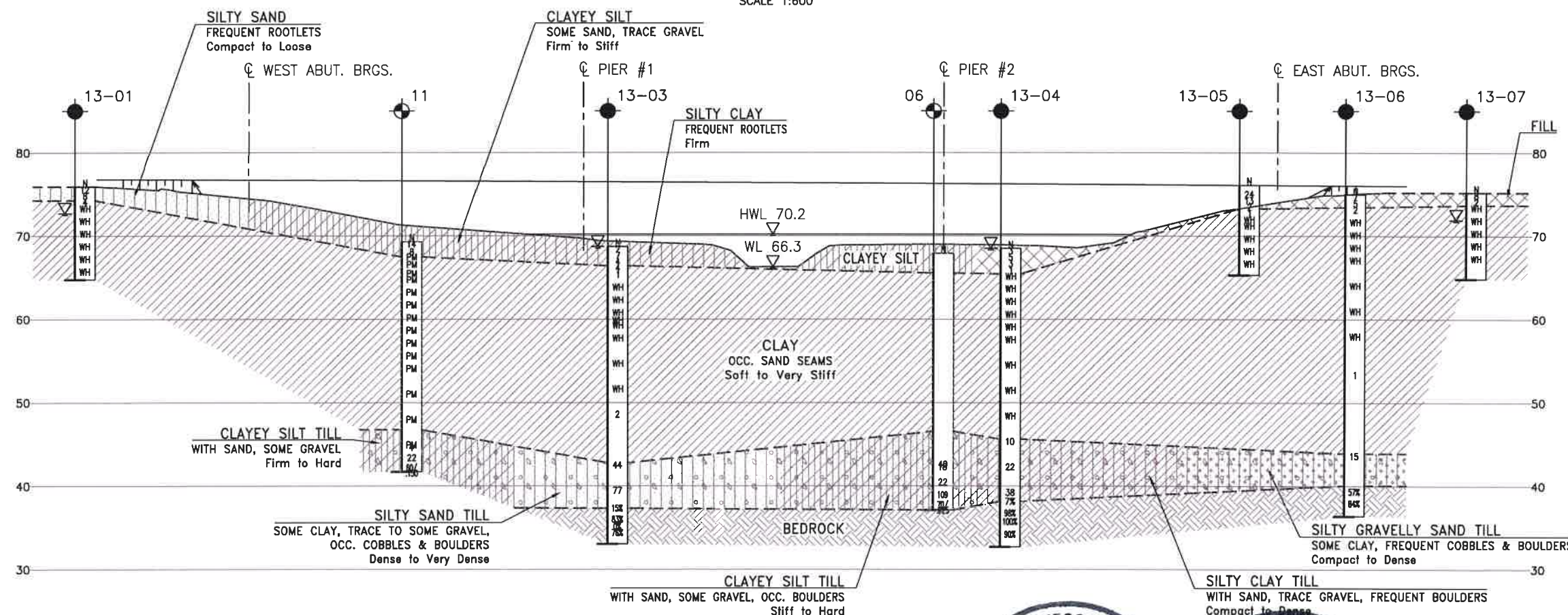
GEOCRES No. 31G-248

FILENAME: H:\Projects\455-98-00\455-98-00-BearBrookBridge(WBL).dwg
PLOTDATE: 8/1/2014 8:29 AM



PLAN

SCALE 1:600



PROFILE

SCALE 1:600



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	PC	CHK -	CODE
DRAWN	MFA	CHK PC	SITE 3-266.2
			STRUCT
			DWG 1
			DATE AUG 2014

DATE: 11/07/2014
CADD FILE NAME : T:\Projects\2-33017245 - Hwy 417 OC 26 to Images\03 Structural\CADD\Bearing Brook Bridge\EBL\01_EBL_GA.dgn

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

HWY 417
CONT No
WP 455-98-00



SHEET
S1

URS

GENERAL NOTES:

- CLASS OF CONCRETE.....30 MPa
UNLESS NOTED OTHERWISE
- CLEAR COVER TO REINFORCING STEEL:
FOOTINGS.....100±25
DECK - TOP.....70±20
DECK - BOTTOM.....40±10
REMAINDER.....70±20
UNLESS NOTED OTHERWISE.
- REINFORCING STEEL:
-REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
-BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS..
-STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa.
-BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS, ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1 UNLESS INDICATED OTHERWISE.
- UNLESS SHOWN OTHERWISE TENSION LAP SPLICES SHALL BE CLASS B.

CONSTRUCTION NOTES:

- THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESS FROM THE TOP OF BEARING ELEVATION, IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
- BACKFILL SHALL NOT BE PLACED BEHIND THE ABUTMENT DIAPHRAGMS UNTIL CONCRETE IN THE DECK SLAB HAS REACHED 25 MPa STRENGTH.
- PROTECTION SYSTEM SHALL MEET REQUIREMENTS FOR PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATICALLY ONLY. EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.

LIST OF DRAWINGS

- GENERAL ARRANGEMENT
- BOREHOLE LOCATIONS AND SOIL STRATA
- FOUNDATION LAYOUT AND FOOTING REINFORCEMENT
- ABUTMENTS
- WINGWALLS
- PIERS
- BEARINGS
- STRUCTURAL STEEL I
- STRUCTURAL STEEL II
- DECK LAYOUT AND SCREED ELEVATIONS
- DECK REINFORCEMENT
- BARRIER WALL W/O RAILING - PL3
- 6000mm APPROACH SLAB
- TYPE 'C' STRIP SEAL EXPANSION JOINT AND SLEEPER SLAB
- STRIP SEAL EXPANSION JOINT - TYPE 'C' DETAILS
- PILE DRIVING CONTROL
- EXISTING BRIDGE REMOVAL, STANDARD DETAILS

APPLICABLE STANDARD DRAWINGS

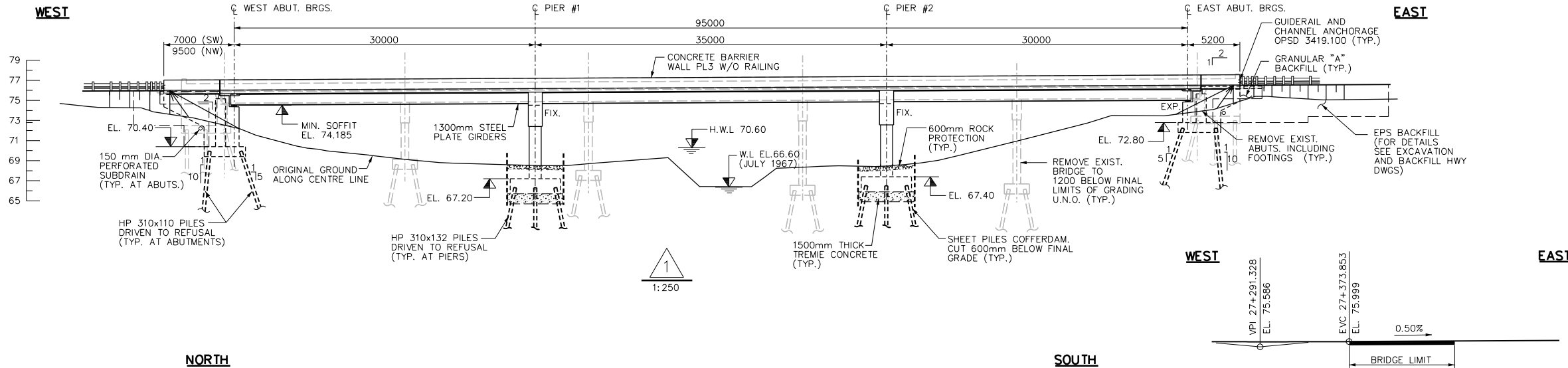
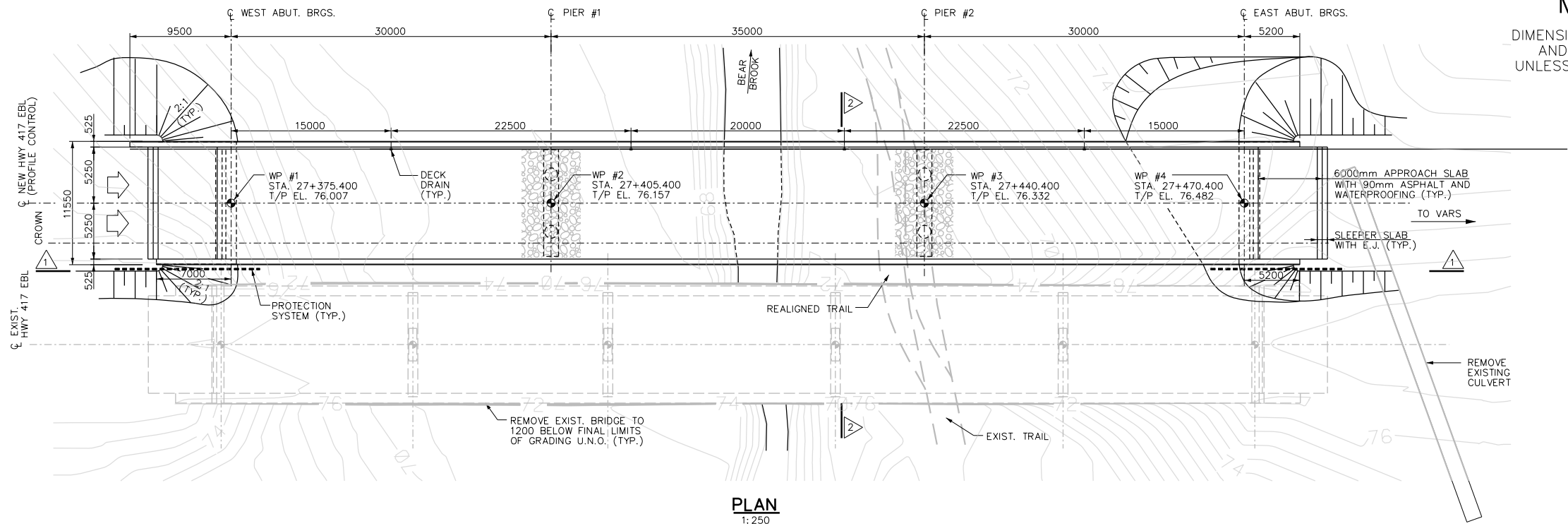
OPSD 3000.100	FOUNDATION, PILES, STEEL H-PILE DRIVING SHOE
OPSD 3000.150	FOUNDATION, PILES, STEEL H-PILE SPLICE
OPSD 3101.150	WALLS, ABUTMENT, BACKFILL, MINIMUM GRANULAR REQUIREMENT
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD 3390.100	DECK DRIP CHANNEL
OPSD 3419.100	BARRIERS AND RAILINGS, STEEL BEAM, GUIDE RAIL AND CHANNEL ANCHORAGE
OPSD 3950.100	JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE
OPSD 3941.200	FIGURES IN CONCRETE - SITE NUMBER AND DATE LAYOUT
OPSD 3340.150	DECK DRAINS WITH TRANSVERSE BAR OPENING

LIST OF ABBREVIATIONS

ABUT.	DENOTES ABUTMENT
BRGS.	DENOTES BEARING
DIA.	DENOTES DIAMETER
EBL	DENOTES EASTBOUND LANE
EL.	DENOTES ELEVATION
EXIST.	DENOTES EXISTING
E.J.	DENOTES EXPANSION JOINT
N.T.S.	DENOTES NOT TO SCALE
N.W.	DENOTES NORTHWEST
R.W.	DENOTES RETAINING WALL
SHLD.	DENOTES SHOULDER
STA.	DENOTES STATION
THK.	DENOTES THICKNESS
TYP.	DENOTES TYPICAL
U.N.O.	DENOTES UNLESS NOTED OTHERWISE
WP.	DENOTES WORKING POINT
T/P	DENOTES TOP OF PAVEMENT

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	L.X.	CHK	I.D.
DRAWN	F.P./V.A.	CHK	L.X.
CODE CAN/CSA 56-06	LOAD CL 625-ONT	DATE	JULY 2014
SITE	3-266.1	STRUCT	SCHEME
DWG	1		

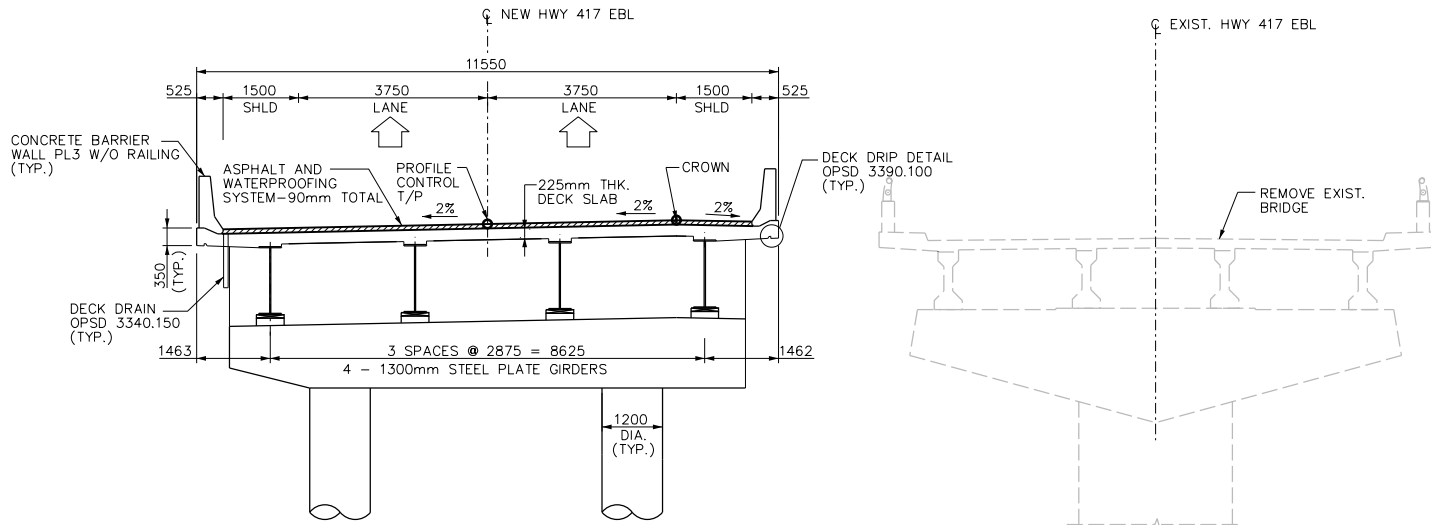


NORTH

SOUTH

PROFILE OF HWY 417 EBL

N.T.S.



2
1:75

1. CLASS OF CONCRETE.....30MPa
UNLESS NOTED OTHERWISE.
2. CLEAR COVER TO REINFORCING STEEL:
FOOTINGS.....100±25
DECK - TOP.....70±20
DECK - BOTTOM.....40±10
REMAINDER.....70±20
UNLESS NOTED OTHERWISE.
3. REINFORCING STEEL:
- REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
- BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
- STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa.
- BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.
- UNLESS SHOWN OTHERWISE TENSION LAP SPLICES SHALL BE CLASS B.

1. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESS FROM THE TOP OF BEARING ELEVATION, IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN IN THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
2. BACKFILL SHALL NOT BE PLACED BEHIND THE ABUTMENTS DIAPHRAGMS UNTIL CONCRETE IN DECK THE SLAB HAS REACHED 25 MPa STRENGTH.
3. PROTECTION SYSTEM SHALL MEET REQUIREMENTS FOR PERFORMANCE LEVEL 2. PROTECTION SYSTEM IS SHOWN SCHEMATICALLY ONLY. EXACT LIMITS SHALL BE DETERMINED BY THE CONTRACTOR.

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOUNDATION LAYOUT AND FOOTING REINFORCEMENT
4. ABUTMENTS
5. WINGWALLS
6. PIERS
7. BEARINGS
8. STRUCTURAL STEEL I
9. STRUCTURAL STEEL II
10. DECK LAYOUT AND SCREED ELEVATIONS
11. DECK REINFORCEMENT
12. BARRIER WALL W/O RAILING – PL3
13. 6000mm APPROACH SLAB
14. TYPE 'C' STRIP SEAL EXPANSION JOINT AND SLEEPER S
15. STRIP SEAL EXPANSION JOINT – TYPE 'C' DETAILS
16. PILE DRIVING CONTROL
17. EXISTING BRIDGE REMOVAL, STANDARD DETAILS

OPSD	3000.100	FOUNDATION, PILES, STEEL H--PILE DRIVING SHOE
OPSD	3000.150	FOUNDATION, PILES, STEEL H--PILE SPLICE
OPSD	3101.150	U.S. SUBTMENT, BACKFILL, MINIMUM GRANULAR REQUIREMENT
OPSD	3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD	3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD	3390.100	DECK DRIP CHANNEL
OPSD	3419.100	BARRIERS AND RAILINGS, STEEL BEAM,
OPSD	3950.100	GUIDE RAIL AND CHAIN-Link ANCHORAGE JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE
OPSD	3340.150	DECK DRAINS WITH TRANSVERSE BAR OPENING

[illegible]

ABUT.	DENOTES	ABUTMENT
BEGS.	DENOTES	BEARING
DIA.	DENOTES	DIAMETER
EBL.	DENOTES	EASTBOUND LANE
EL.	DENOTES	ELEVATION
EXIST.	DENOTES	EXISTING
EXP.	DENOTES	EXPANSION
FT.S.	DENOTES	NOT TO SCALE
N.W.	DENOTES	NORTHWEST
R.W.	DENOTES	RETAINING WALL
SHLD.	DENOTES	SHOULDER
STA.	DENOTES	STATION
THK.	DENOTES	THICKNESS
TYP.	DENOTES	TYPICAL
U.N.O.	DENOTES	UNLESS NOTED OTHERWISE
WP.	DENOTES	WORKING POINT



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

Appendix B
Record of Boreholes
Summary of Groundwater Data

19-4406-6

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

C_{pen}






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.
TERMS		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.				Indented by thumbnail
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	
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 13-1

1 OF 2

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Approach N 5 025 276.2 E 384 165.4 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 16.10.13 - 16.10.13 CHECKED BY PC

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 (%)	W _p	W	W _L		
75.9 0.0	Silty Sand , frequent rootlets near top Compact to loose Brown Moist		1	SS	12									
			2	SS	8									0 76 18 7
74.3 1.6	Clay with sand seams Very stiff to stiff Brown		3	SS	4									
73.8 2.1	Dry to moist Clay (CH) Firm to soft Grey and pink (mottled) Wet		4	SS	WH									0 0 44 56
			5	SS	WH									
			6	SS	WH									
			7	SS	WH									
			8	SS	WH									0 0 46 54

Continued Next Page


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

RECORD OF BOREHOLE No 13-1

2 OF 2

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Approach N 5 025 276.2 E 384 165.4 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 16.10.13 - 16.10.13 CHECKED BY PC

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							
0.0	Clay Soft Grey Wet		9	SS	WH															
64.8																				
11.1	End of Borehole Vibrating wire piezometer installed at 9.75 m Piezometric level on Nov. 7, 2013 = 72.7 m Elev.																			

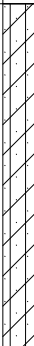
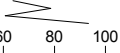
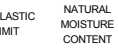
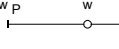
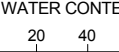
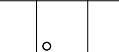
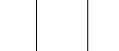


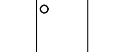
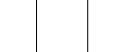
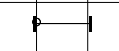
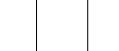


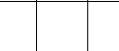


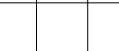
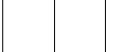
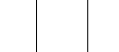
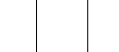

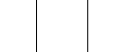
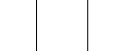
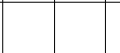
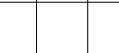
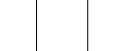

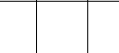

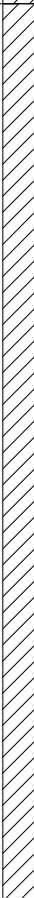


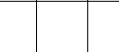
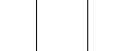


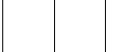
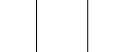

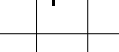
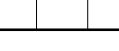
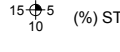
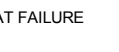

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-3

1 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Pier N 5 025 270.4 E 384 228.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 10.9.13 - 10.10.13 CHECKED BY PC

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																																																																																																																	
68.7 0.0	Silty Clay (CI) , sandy, frequent rootlets near top Firm Brown Moist		1	SS	2	 20 40 60 80 100	68	 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	0	37	35	27																																																																																																																			
			2	SS	7												 20 40 60 80 100	67	 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	0	22	35	44																																																																																																								
			3	SS	4																							 20 40 60 80 100	66	 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	0	22	35	44																																																																																													
66.4 2.3	4	SS	4	 20 40 60 80 100	65																																		 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	0	22	35	44																																																																																				
	5	SS	1																																													 20 40 60 80 100	64	 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	0	22	35	44																																																																									
64.9 3.8	Clay (CH) Firm Grey Wet																																																											 20 40 60 80 100	63	 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	0	22	35	44																																																													
			6																																																								SS												WH	 20 40 60 80 100	62	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																		
																																																																																		 20 40 60 80 100	61	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																								
			7																																																								SS												WH																					 20 40 60 80 100	60	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																														
																																																																																																						 20 40 60 80 100	59	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																				
			8																																																								SS												WH																																									 20 40 60 80 100	58	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44										
			9																																																								SS												WH																																																			 20 40 60 80 100	57	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44
			10																																																								SS												WH																																																												
						 20 40 60 80 100	55	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																																				
																 20 40 60 80 100	54	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																										
																										 20 40 60 80 100	53	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																
				 20 40 60 80 100	52																															 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																								
																																												 20 40 60 80 100	51	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																														
																																																						 20 40 60 80 100	50	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																				
																																																																 20 40 60 80 100	49	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																										
																																																																										 20 40 60 80 100	48	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																
						 20 40 60 80 100	47	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																																				
																 20 40 60 80 100	46	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																										
																										 20 40 60 80 100	45	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																																
				 20 40 60 80 100	44																															 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																																								
																																												 20 40 60 80 100	43	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																														
																																																						 20 40 60 80 100	42	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	35	44																																																																				
																																																																 20 40 60 80 100	41	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	 20 40 60 80 100	0	22	3																																																											

Continued Next Page


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

RECORD OF BOREHOLE No 13-3

2 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Pier N 5 025 270.4 E 384 228.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 10.9.13 - 10.10.13 CHECKED BY PC

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								
							20 40 60 80 100									
0.0	Clay (CH) Stiff Grey Wet															
			11	SS	WH										○	
			12	SS	WH										○	

Continued Next Page

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

RECORD OF BOREHOLE No 13-3

3 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Pier N 5 025 270.4 E 384 228.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 10.9.13 - 10.10.13 CHECKED BY PC

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 (%)				GR	SA	SI	CL
					○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					w _p w w _L										
0.0	Clay (CH) Stiff Grey Wet 																			

Continued Next Page

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

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-3

4 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - West Pier N 5 025 270.4 E 384 228.9 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 10.9.13 - 10.10.13 CHECKED BY PC

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													
							20	40	60	80	100												
0.0	Silty Sand , some clay, trace to some gravel, occasional cobbles and boulders Dense to very dense Grey (TILL)																						
37.3																							
31.4	BEDROCK , shale Weathered to fresh Black		18	NQ												5	RUN #18 TCR=30% SCR=15% RQD=15%						
			19	NQ												5	RUN #19 TCR=90% SCR=90% RQD=83%						
			20	NQ												20	RUN #20 TCR=92% SCR=52% RQD=0%						
			21	NQ												10	RUN #21 TCR=100% SCR=87% RQD=76%						
33.0																							
35.7	End of Borehole Vibrating wire piezometer installed at 10.64 m Piezometric level on Nov. 7, 2013 = 68.7 m Elev.																						



ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-4

1 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Pier N 5 025 263.9 E 384 275.4 ORIGINATED BY GM/NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 30.9.13 - 30.9.13 CHECKED BY PC

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 (%)				GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE				w _P w w _L								
								● QUICK TRIAXIAL × LAB VANE												
68.5 0.0							20	40	60	80	100									
	Silty sand , trace clay, frequent to occasional rootlets Very loose to loose Brown to grey Moist (FILL) - Frequent wood fragments		1	SS	3								○							
			2	SS	5									○						
			3	SS	3									○						
			4	SS	1									○						
65.5 3.1	Clay (CH) Firm to stiff Grey Wet		5	SS	WH															
			6	SS	WH										┌───┐○					
			7	SS	WH															
			8	SS	WH															
			9	SS	WH															

Continued Next Page

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

RECORD OF BOREHOLE No 13-4

2 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Pier N 5 025 263.9 E 384 275.4 ORIGINATED BY GM/NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 30.9.13 - 30.9.13 CHECKED BY PC

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	WATER CONTENT (%)						
								20 40 60 80 100							

Continued Next Page

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

RECORD OF BOREHOLE No 13-4

3 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Pier N 5 025 263.9 E 384 275.4 ORIGINATED BY GM/NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 30.9.13 - 30.9.13 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
							20 40 60 80 100	20 40 60	W _p W W _L					
0.0	Clay (CH) Stiff Grey Wet		13	SS	WH									
							48							
							47							
							46							
45.7														
22.9	Silty Clay with sand, trace gravel Compact to dense Grey (TILL)		14	SS	10									
							45							
							44							
							43							
			15	SS	22									
							42							
							41							
							40							
							39							
	- frequent boulders		16	SS	38									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-4

4 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Pier N 5 025 263.9 E 384 275.4 ORIGINATED BY GM/NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 30.9.13 - 30.9.13 CHECKED BY PC

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											
								20 40 60 80 100											
0.0																			
38.2																			
30.3	BEDROCK, shale Weathered to fresh Thinly laminated		17	RUN			38							FI	RUN #17 TCR=81% SCR=0% RQD=7%				
														>10					
				18	RUN			37						4		RUN #18 TCR=100% SCR=78% RQD=98%			
				19	RUN			36						3		RUN #19 TCR=100% SCR=98% RQD=100%			
				20	RUN			35						3		RUN #20 TCR=100% SCR=88% RQD=90%			
32.7							34												
35.8	End of Borehole Vibrating wire piezometer installed at 25.3 m Piezometric level on Nov. 7, 2013 = 72.3 m Elev.						33												

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-5

1 OF 2

METRIC

GWP# 455-98-00 LOCATION WB Structure - Existing East Abutment N 5 025 266.2 E 384 304.5 ORIGINATED BY NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 16.10.13 - 16.10.13 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20 40 60 80 100		w _P w w _L					
						○ UNCONFINED + FIELD VANE									
						● QUICK TRIAXIAL × LAB VANE									
76.1															
76.0	ASPHALT: 120 mm														
0.1	Sand and Gravel, some silt Brown Dry (FILL)		1	GS											
75.3															
0.8	Sand, some silt Compact to very loose Brown Moist (FILL)		1	SS	24										
			2	SS	13										
			3	SS	2										
73.2															
2.8	Clay (CH) Stiff to firm Brownish red														
			4	SS	1										
			5	SS	WH										
71.5															
4.6	Clay (CH) Soft to firm Grey Wet		6	SS	WH										
			7	SS	WH										
			8	SS	WH										
			9	SS	WH										

Continued Next Page

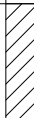
+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-5

2 OF 2

METRIC

GWP# 455-98-00 LOCATION WB Structure - Existing East Abutment N 5 025 266.2 E 384 304.5 ORIGINATED BY NW
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM
 DATUM Geodetic DATE 16.10.13 - 16.10.13 CHECKED BY PC

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													
								20	40	60	80	100						20	40	60	
0.0	Clay (CH) Soft to firm Grey Wet						66	7.0 +													
65.3								12.0 +													
10.8	End of Borehole																				

RECORD OF BOREHOLE No 13-6

1 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Abutment N 5 025 258.2 E 384 316.3 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 10.7.13 - 10.7.13 CHECKED BY PC

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								
75.0							20	40	60	80	100	20	40	60				
0.0	Silty sand , some gravel, frequent rootlets Loose Brown Dry (FILL)		1	SS	7													
74.2																		
0.8	Sandy Clay , occasional rootlets Firm Brownish grey (FILL)		2	SS	5		74											
73.4																		
1.5	Clay (CH) Stiff Brownish grey to grey Moist		3	SS	2		73								0 0 33 67			
72.5																		
2.4	Clay (CH) Firm Grey Wet																	
			4	SS	WH		72	5.0 4.3										
							71	6.0 8.0										
			5	SS	WH		70	10.7 7.5										
							69											
			6	SS	WH		68	12.0 8.7										
							67											
			7	SS	WH		66	9.0 32.0										
			8	TW			65											

Continued Next Page



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

RECORD OF BOREHOLE No 13-6

2 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Abutment N 5 025 258.2 E 384 316.3 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 10.7.13 - 10.7.13 CHECKED BY PC

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 (%)			GR	SA	SI	CL	
								○ UNCONFINED + FIELD VANE												
								● QUICK TRIAXIAL × LAB VANE												
							20	40	60	80	100		W _p	W	W _L					
0.0	Clay (CH) Firm Grey Wet																			
			9	SS	WH		64													
							63													
							62													
							61													
			10	SS	WH															
60.0							60													
15.0	Clay (CH) Stiff Grey Wet																			
							59													
							58													
							57													
							56													
			12	TW																
							55													

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 13-6

4 OF 4

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Abutment N 5 025 258.2 E 384 316.3 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 10.7.13 - 10.7.13 CHECKED BY PC

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				w _p w w _L				
								● QUICK TRIAXIAL × LAB VANE								
0.0	Clay (CH) Stiff Grey Wet															
43.9							44									
31.1	Silty Gravelly Sand, some clay, frequent cobbles and boulders Compact to dense Grey (TILL)		15	SS	15										21 37 30 12	
							43									
			16	RUN												
							42									
							41									
40.0			17	RUN												
							40									
34.9	BEDROCK, shale with clay seams Weathered to fresh Black		18	RUN			39									
			19	RUN											RUN #19 TCR=100% SCR=46% RQD=57%	
	occasional calcite and fossil seams						38									
			20	RUN			37								RUN #20 TCR=103% SCR=84% RQD=84%	
36.4																
38.6	End of Borehole Vibrating wire piezometers installed at 8.5 m (VWP1) and 30.4 m (VWP2) Piezometric levels on Nov. 7, 2013: VWP1 = 71.7 m Elev. VWP2 = 73.3 m Elev.															

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

METRIC

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT	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
75.2 0.0	Silty Sand, trace clay, frequent rootlets Loose Brown Moist (FILL)	[Pattern]	1	SS	8		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				0 69 22 9
74.4 0.8	Clayey sand, frequent wood fragments and rootlets, brown, moist Soft Brown Moist (FILL)	[Pattern]	2	SS	2						
73.7		[Pattern]									
1.5	Clay (CH) Soft to firm Grey Wet	[Pattern]	3	SS	WH						
		[Pattern]									
		[Pattern]	4	SS	WH						
		[Pattern]									
		[Pattern]	5	SS	WH						
		[Pattern]									
		[Pattern]	6	SS	WH						
		[Pattern]									
		[Pattern]									
		[Pattern]	7	SS	WH					0 0 23 7	
		[Pattern]									
		[Pattern]									
		[Pattern]	8	TW							
		[Pattern]									

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-7

2 OF 2

METRIC

GWP# 455-98-00 LOCATION WB Structure - East Approach N 5 025 255.2 E 384 330.5 ORIGINATED BY GM
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 10.8.13 - 10.8.13 CHECKED BY PC

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					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
0.0	Clay (CH) Firm Grey Wet End of Borehole Vibrating wire piezometer installed at 9.6 m Piezometric level on Nov. 7, 2013 = 71.9 m Elev.																
64.8																	
10.4																	





















ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-8

1 OF 2

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Approach N 5 025 148.0 E 384 263.6 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 24.9.13 - 25.9.13 CHECKED BY PC

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								
74.9								20	40	60	80	100								
74.8	Rootmat: 50 mm		1	SS	5															
0.1	Sand , occasional rootlets Loose Brown Moist to wet (FILL)																			
73.9			2	SS	7															
1.0	Clay (CH) Stiff Grey and pink (Mottled) Moist																			
			3	SS	3															
			4	SS	2															
			5	SS	WH															
			6	AS																
70.3																				
4.6	Clay (CH) Firm to stiff Grey Wet		7	SS	WH															
																				
			8	SS	WH															
																				
			9	TW																
																				
																				
			10	SS	WH															
																				
																				

Continued Next Page

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

RECORD OF BOREHOLE No 13-8

2 OF 2

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Approach N 5 025 148.0 E 384 263.6 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 24.9.13 - 25.9.13 CHECKED BY PC

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 (%)					
64.8 10.1	Clay (CH) Stiff Grey Wet End of Borehole Vibrating wire piezometer installed at 8.5 m Piezometric level on Nov. 7, 2013 = 72.3 m Elev.						20 40 60 80 100 9.6 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	20 40 60 15 5 10						

RECORD OF BOREHOLE No 13-9

1 OF 5

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Abutment N 5 025 143.4 E 384 288.9 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 19.9.13 - 24.9.13 CHECKED BY PC

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 (%)				GR	SA	SI	CL
								<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>	<div><div></div><div></div><div></div></div>					
74.9								20	40	60	80	100	W _P	W	W _L				
74.8	Rootmat: 50 mm																		
0.1	Silty Sand Very loose to loose Brown Dry (FILL)		1	SS	2		74											0	83 12 5
			2	SS	4														
73.3																			
1.5	Silty Sand to Clayey Sand Loose Brown Moist		3	SS	5		73												
72.5																			
2.4	Clay (CH) Very stiff to stiff Brown		4	SS	2		72												
			5	SS	6													0	0 30 70
							71												
69.9			6	SS	2		70												
5.0	Clay (CH) Firm to stiff Grey Wet																		
			7	AS			69												
			8	SS	WH		68												
			9	SS	WH													0	0 23 77
			10	TW			67											0	0 19 81

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-9

5 OF 5

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Abutment N 5 025 143.4 E 384 288.9 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 19.9.13 - 24.9.13 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
0.0	BEDROCK , shale Fresh Horizontally bedded Very thinly laminated Black		7	RUN		34									6	RUN #7 TCR=100% SCR=93% RQD=89%	
33.2																	
41.6	End of Borehole Vibrating wire piezometer installed at 29.0 m Piezometric level on Nov. 7, 2013 = 72.0 m Elev.																

RECORD OF BOREHOLE No 13-10

1 OF 4

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Pier N 5 025 141.1 E 384 328.6 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 16.9.13 - 16.9.13 CHECKED BY PC

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				
								20 40 60 80 100 20 40 60 80 100				20 40 60				
68.4																
68.0	Rootmat: 50 mm															
0.1	Clayey Silt Stiff Reddish brown Dry (FILL)		1	SS	22		68									
67.7																
0.8	Sand, some silt, trace clay Very loose Reddish brown to grey Moist to wet (FILL)		2	SS	7		67									
			3	SS	2										0 73 18 9	
			4	SS	WH		66									
65.4																
3.1	Peat, fibrous, soft, black, wet															
65.3	Silty Sand, occasional rootlets and wood fragments Very loose Greyish brown Wet		5	SS	1		65								0 74 19 8	
3.1																
64.6			6	SS	WH		64									
3.8	Clay (CH) Firm Grey Wet		7	SS	WH		63									
			8	SS	WH											
			9	SS	WH		62								0 0 21 79	
			10	SS	WH		61									
			11	SS	WH		60									
			12	SS	WH		59								0 0 24 76	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity



20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 13-10

2 OF 4

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Pier N 5 025 141.1 E 384 328.6 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 16.9.13 - 16.9.13 CHECKED BY PC

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	○ UNCONFINED + FIELD VANE	W _P W W _L	20 40 60	GR SA SI CL									
0.0	Clay (CH) Firm to stiff Grey Wet																				
			13	SS	WH																
			14	SS	WH																
			15	SS	WH																
			16	SS	WH																
			17	SS	WH																
	-Silty Clay (CI)																				
			18	SS	WH																
						</															

Continued Next Page

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

RECORD OF BOREHOLE No 13-10

3 OF 4

METRIC

GWP# 455-98-00 LOCATION EB Structure - West Pier N 5 025 141.1 E 384 328.6 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 16.9.13 - 16.9.13 CHECKED BY PC

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									WATER CONTENT (%)
0.0	Silty Clay (Cl) Firm to stiff Grey Wet		19	SS	WH		48										
45.6							47										
							46										
22.9	Silty Sand , some gravel, trace clay Dense Grey (TILL)		20	SS	31		45										
								44									
								43									
								42									
			21	SS	37												
							41										
							40										
39.7																	
28.7	BEDROCK shale Fine grained Thinly laminated Dark grey		22	RUN			39										

Continued Next Page

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

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

METRIC

[illegible]

RECORD OF BOREHOLE No 13-11

1 OF 4

METRIC

GWP# 455-98-00 LOCATION EB Structure - East Pier N 5 025 135.0 E 384 359.3 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 26.9.13 - 26.9.13 CHECKED BY PC

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									
68.2 0.0	Silty Sand to Clayey Sand Very loose to loose Brown Dry		1	SS	1			<div><div>20406080100</div><div>RESISTANCE PLOT</div><div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div><div>+ FIELD VANE</div><div>× LAB VANE</div></div><div><div>20406080100</div><div>WATER CONTENT (%)</div><div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div><div>w_p</div><div>w</div><div>w_L</div></div></div></div></div>					<div><div>204060</div><div>WATER CONTENT (%)</div><div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div><div>w_p</div><div>w</div><div>w_L</div></div></div></div>	<div>GR SA SI CL</div>			
					2			SS	4								
66.6 1.6	Clay (CH) Firm Grey Clay (CH)		3	SS	1								<div><div>204060</div><div>WATER CONTENT (%)</div><div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div><div>w_p</div><div>w</div><div>w_L</div></div></div></div>	<div>0 0 36 64</div>			
					4			SS	WH								
					5			SS	WH								
					6			SS	WH								
			7	SS	WH												
59.7 8.5	Silty Clay (CH) Stiff Grey Wet		8	SS	WH								<div><div>204060</div><div>WATER CONTENT (%)</div><div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div><div><div>w_p</div><div>w</div><div>w_L</div></div></div></div>	<div>0 0 20 80</div>			

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

ELEV DEPTH	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 (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa		WATER CONTENT (%)			
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W _P			W _L
							20 40 60 80 100		20 40 60				

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 13-11

4 OF 4

METRIC

GWP# 455-98-00 LOCATION EB Structure - East Pier N 5 025 135.0 E 384 359.3 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 26.9.13 - 26.9.13 CHECKED BY PC

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								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
								WATER CONTENT (%)								
							20	40	60	80	100		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
							20	40	60	80	100		W _P	W	W _L	
0.0	Silty Sand , some gravel, trace clay, frequent cobbles and boulders Compact to very dense Grey (TILL)		19	RUN												
37.3																
30.9	BEDROCK shale Weathered to fresh Black		20	RUN												
			21	RUN												
			22	RUN												
34.0																
34.2	End of Borehole Standpipe installed															

ONTMT4S 19-4406-6 BEARBROOK STRUCTURES.GPJ 2012TEMPLATE(MTO).GDT 6/6/14

RECORD OF BOREHOLE No 13-13

1 OF 2

METRIC

GWP# 455-98-00 LOCATION EB Structure - East Approach N 5 025 123.0 E 384 414.2 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 25.9.13 - 26.9.13 CHECKED BY PC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L			
75.9 76.8 0.0	Rootmat: 30 mm Clay (CH) Stiff to firm Brown Moist		1	SS	6									
75.0 0.9	Clay (CH) Soft Grey Wet		2	SS	WH									0 0 33 67
			3	SS	WH									
			4	SS	WH									
			5	SS	WH									
			6	TW										
			7	SS	WH									0 0 23 77
			8	SS	WH									
	- becomes firm													

Continued Next Page

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

RECORD OF BOREHOLE No 13-13

2 OF 2

METRIC

GWP# 455-98-00 LOCATION EB Structure - East Approach N 5 025 123.0 E 384 414.2 ORIGINATED BY KMY
 HWY 417 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SML
 DATUM Geodetic DATE 25.9.13 - 26.9.13 CHECKED BY PC

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 (%)					
65.8 10.1	Clay (CH) Firm Grey Wet End of Borehole Vibrating wire piezometer installed at 7.0 m Piezometric level on Nov. 7, 2013 = 74.4 m Elev.	///												

Table 1 – Piezometric Pressures and Elevations

Borehole	Ground Surface Elev. (m)	VWP Tip Location			Nov 7, 2013 data			April 28, 2014 data		
		Depth (m)	Pressure (kPa)	Pressure (kPa)	Pressure (kPa)	Equivalent Water Depth / Elev. (m)		Pressure (kPa)	Equivalent Water Depth / Elev. (m)	
						Depth*	Elev.		Depth*	Elev.
13-1	75.9	9.8	64.3	64.3	64.3	3.2	72.7	69.1	2.6	73.3
13-3	68.7	10.6	103.9	103.9	103.9	0.0	68.7	108.2	-0.4 (artesian)	69.1
13-4	68.5	25.3	285.3	285.3	285.3	- 3.8 (artesian)	72.3	277.6	-3.0 (artesian)	71.5
13-6 shallow	75.0	8.5	50.6	50.6	50.6	3.3	71.7	54.5	3.0	72.0
13-6 deep	75.0	30.4	281.1	281.1	281.1	1.7	73.3	266.4	3.3	71.7
13-7	75.2	9.6	61.8	61.8	61.8	3.3	71.9	60.5	3.4	71.8
13-8	74.9	8.5	57.8	57.8	57.8	2.6	72.3	62.2	2.1	72.8
13-9	74.9	29.0	255.7	255.7	255.7	2.9	72.0	253.8	3.2	71.7
13-10	68.4	21.5	244.4	244.4	244.4	-3.4 (artesian)	71.8	231.8	-2.2 (artesian)	70.6
13-13	75.9	7.0	54.1	54.1	54.1	1.5	74.4	55.8	1.3	74.6

* Depth is relative to existing ground surface at the borehole location.

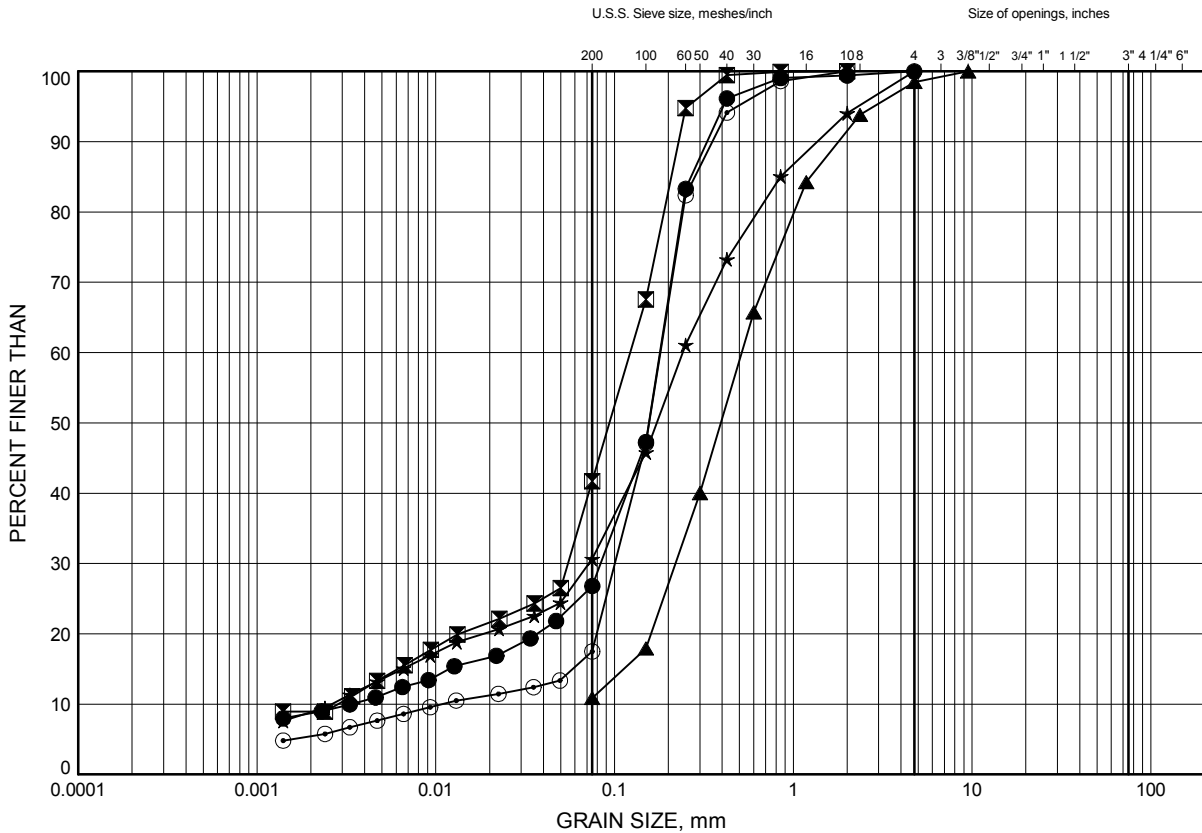
Appendix C
Geotechnical Laboratory Test Results

19-4406-6

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C1

Fill Material



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-10	1.83	66.57
⊠	13-4	1.83	66.67
▲	13-5	1.83	74.27
★	13-7	0.30	74.90
⊙	13-9	1.07	73.83

Date June 2014
 GWP# 455-98-00

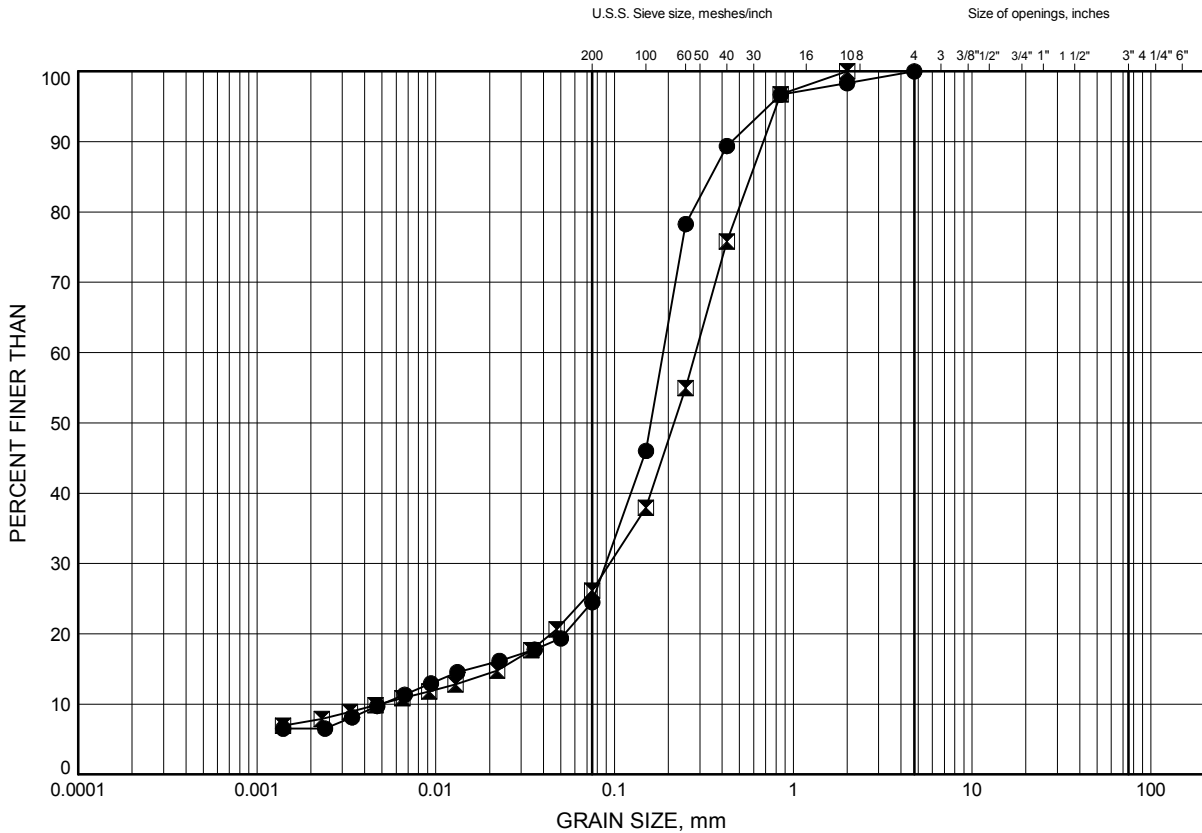


Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-1	1.07	74.83
⊠	13-10	3.37	65.03

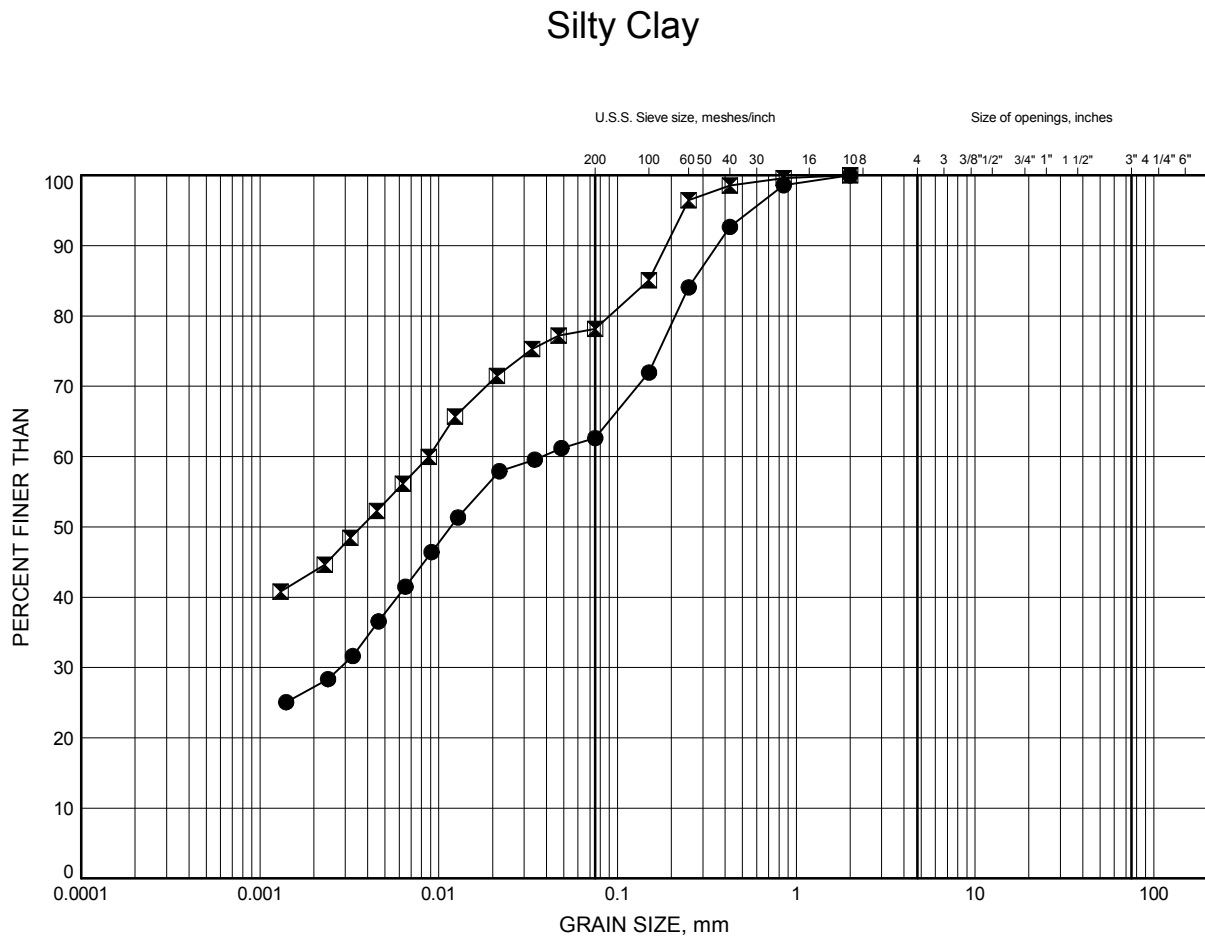
Date June 2014
 GWP# 455-98-00



Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-3	0.30	68.40
⊠	13-3	1.83	66.87

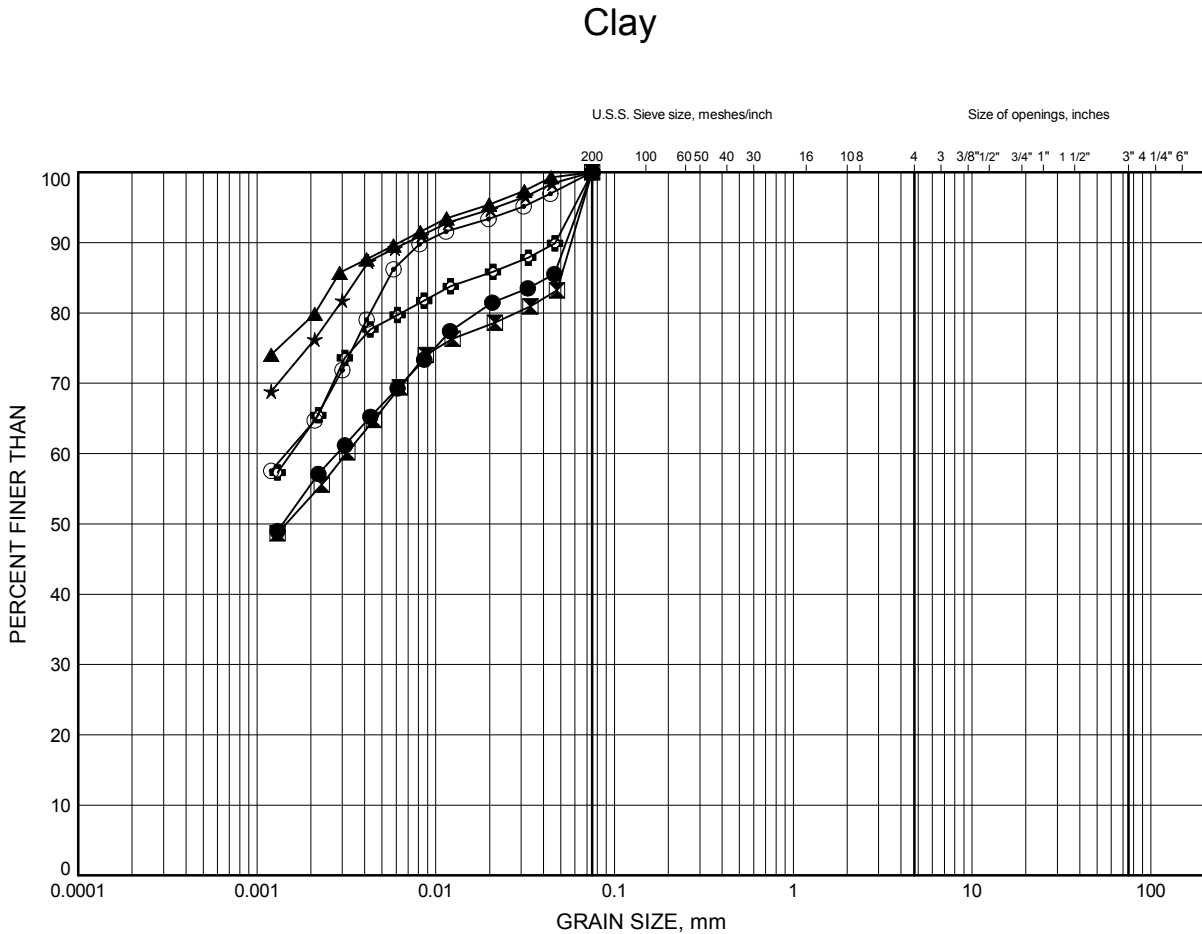
Date July 2014
 GWP# 455-98-00



Prep'd GM
 Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-1	2.59	73.31
⊠	13-1	8.69	67.21
▲	13-10	6.40	62.00
★	13-10	9.45	58.95
⊙	13-10	15.54	52.86
⊕	13-11	2.59	65.61

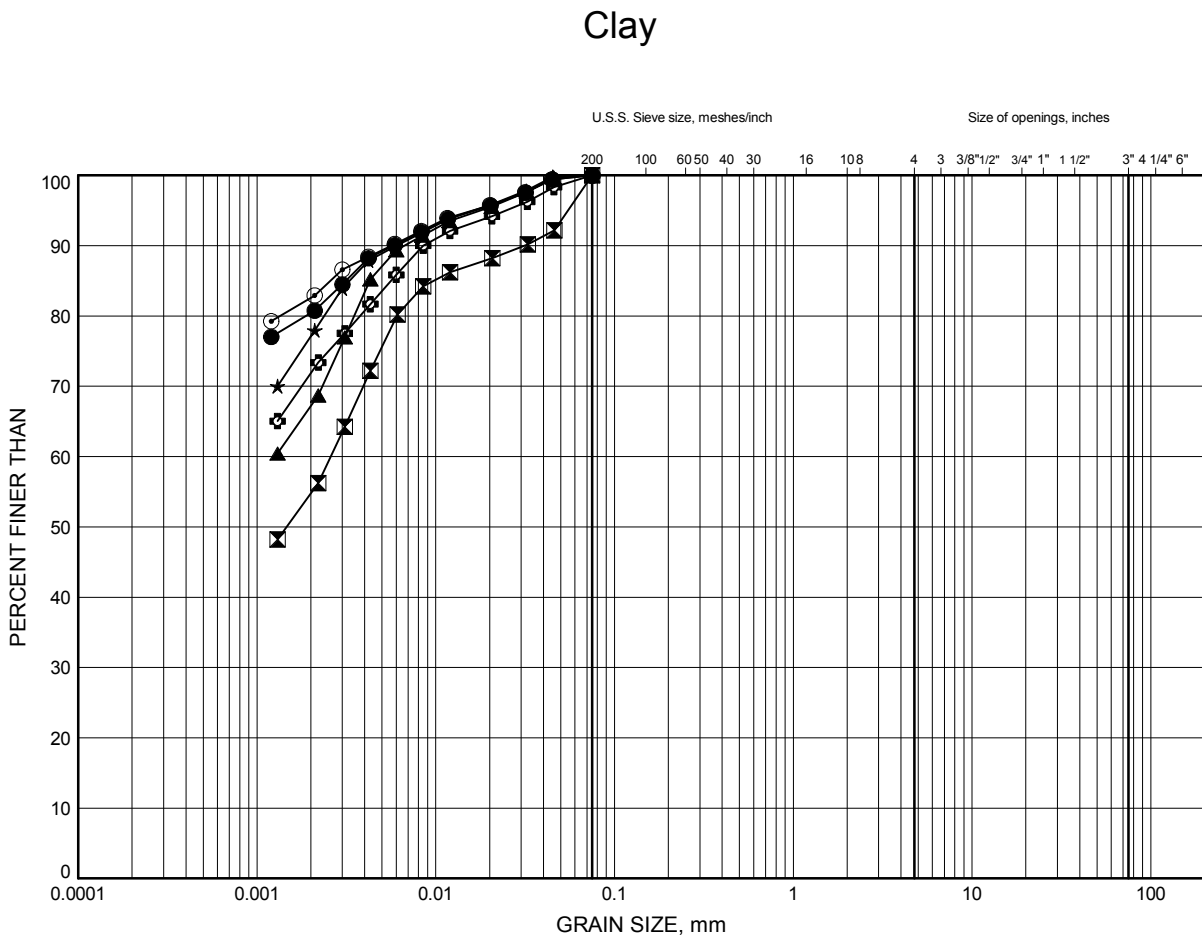
Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-11	8.69	59.51
⊠	13-11	15.54	52.66
▲	13-13	1.07	74.83
★	13-13	7.92	67.98
⊙	13-4	4.88	63.62
⊕	13-5	4.11	71.99

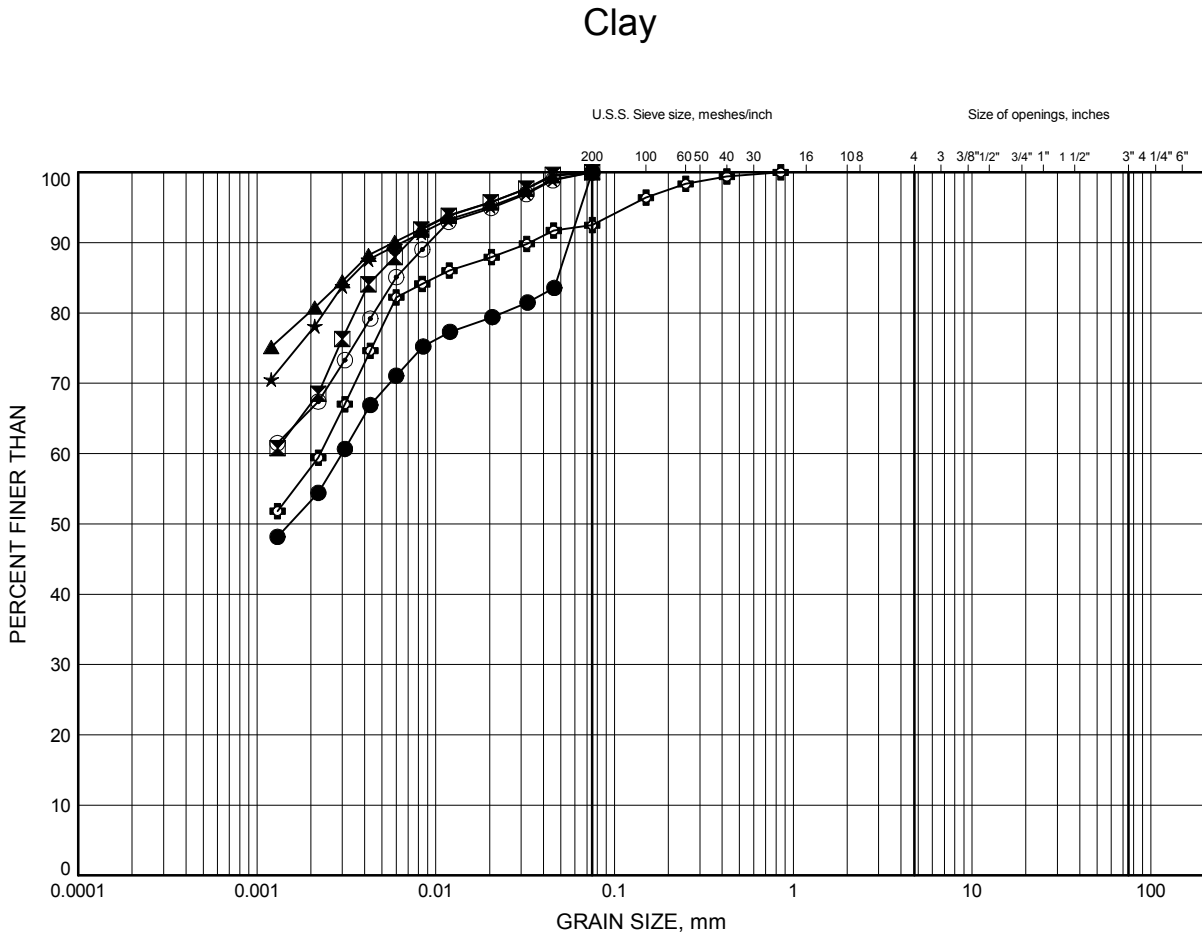
Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C6



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-5	7.92	68.18
⊠	13-6	1.83	73.17
▲	13-6	14.02	60.98
★	13-7	7.92	67.28
⊙	13-8	1.08	73.82
⊕	13-8	3.35	71.55

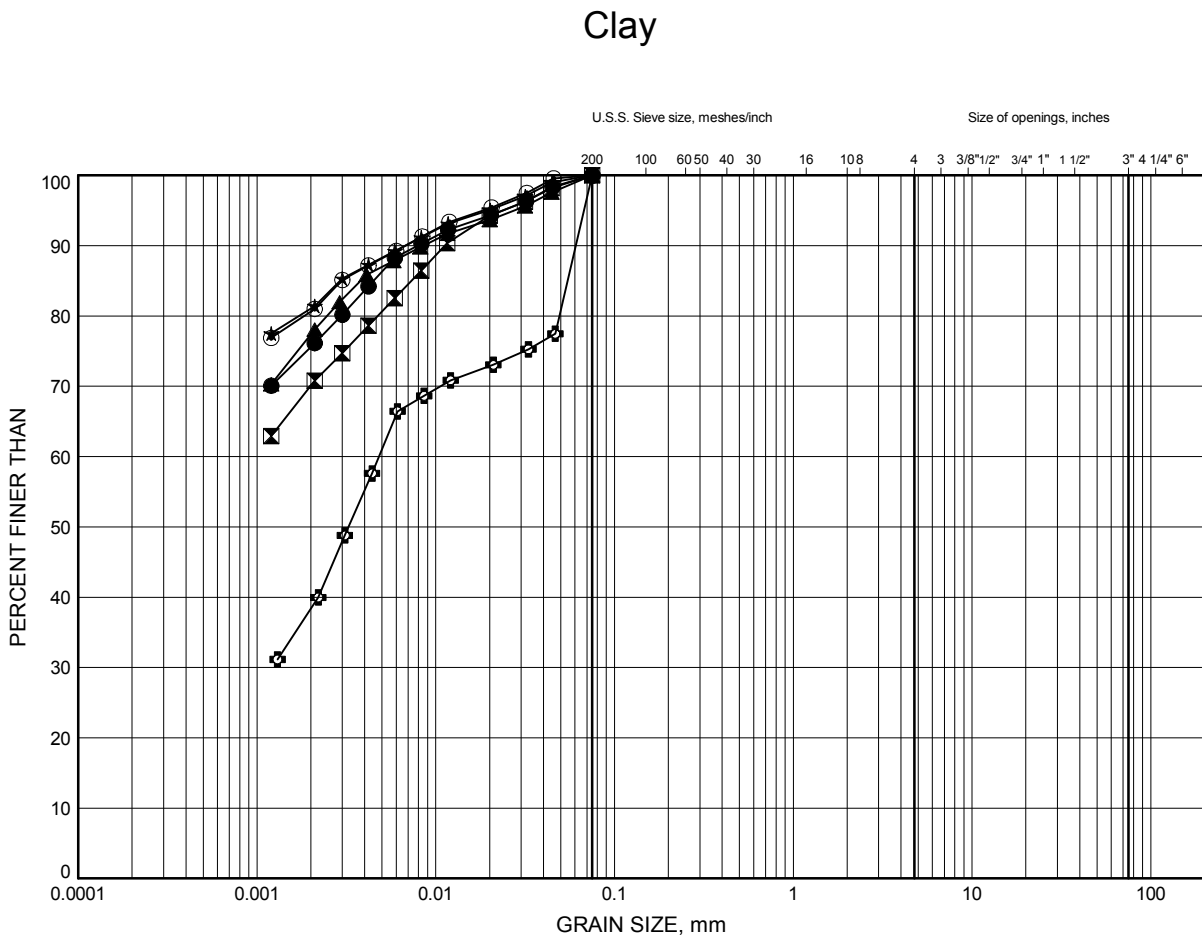
Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C7



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-8	9.45	65.45
⊠	13-9	3.35	71.55
▲	13-9	7.32	67.58
★	13-9	7.92	66.98
⊙	13-9	12.50	62.40
⊕	13-9	15.54	59.36

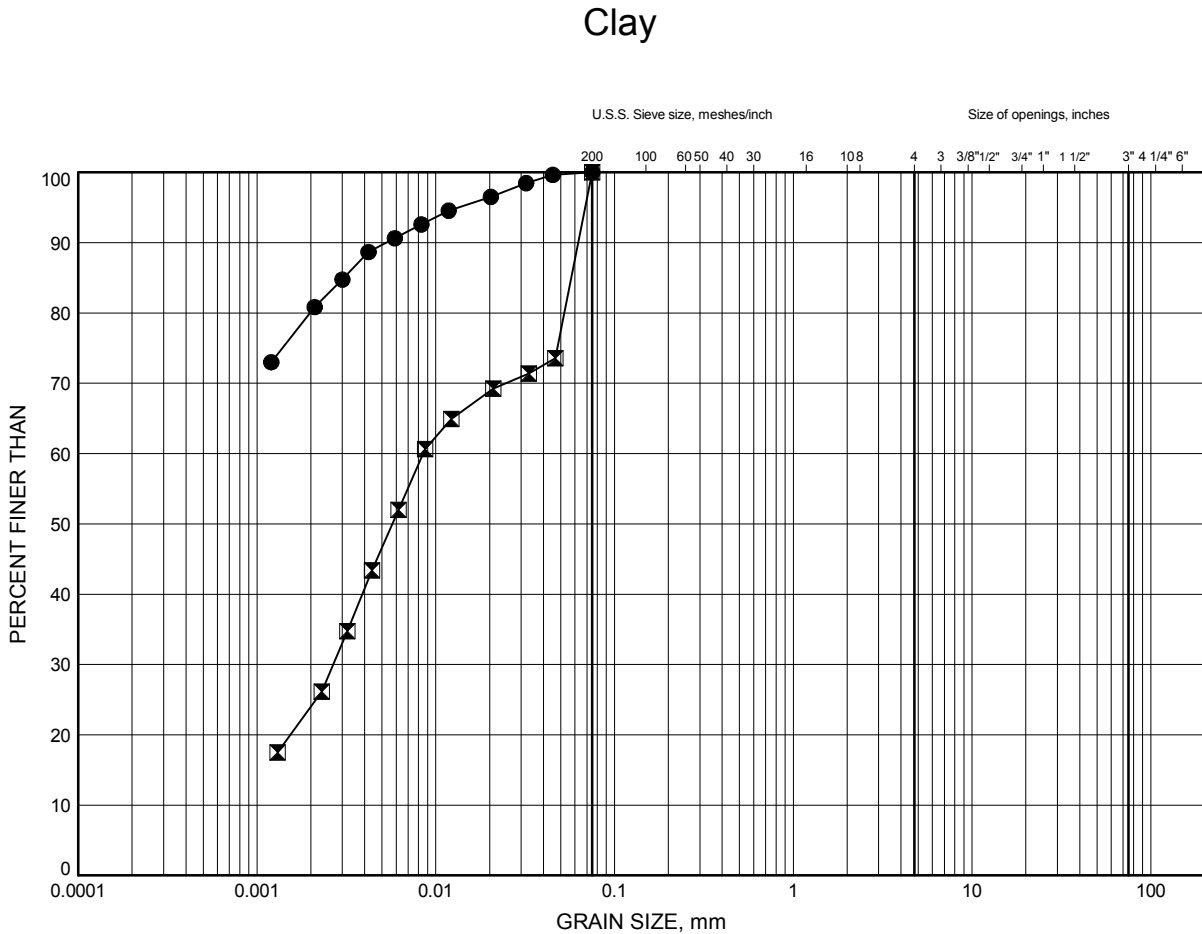
Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C8



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-9	20.12	54.78
⊠	13-9	23.16	51.74

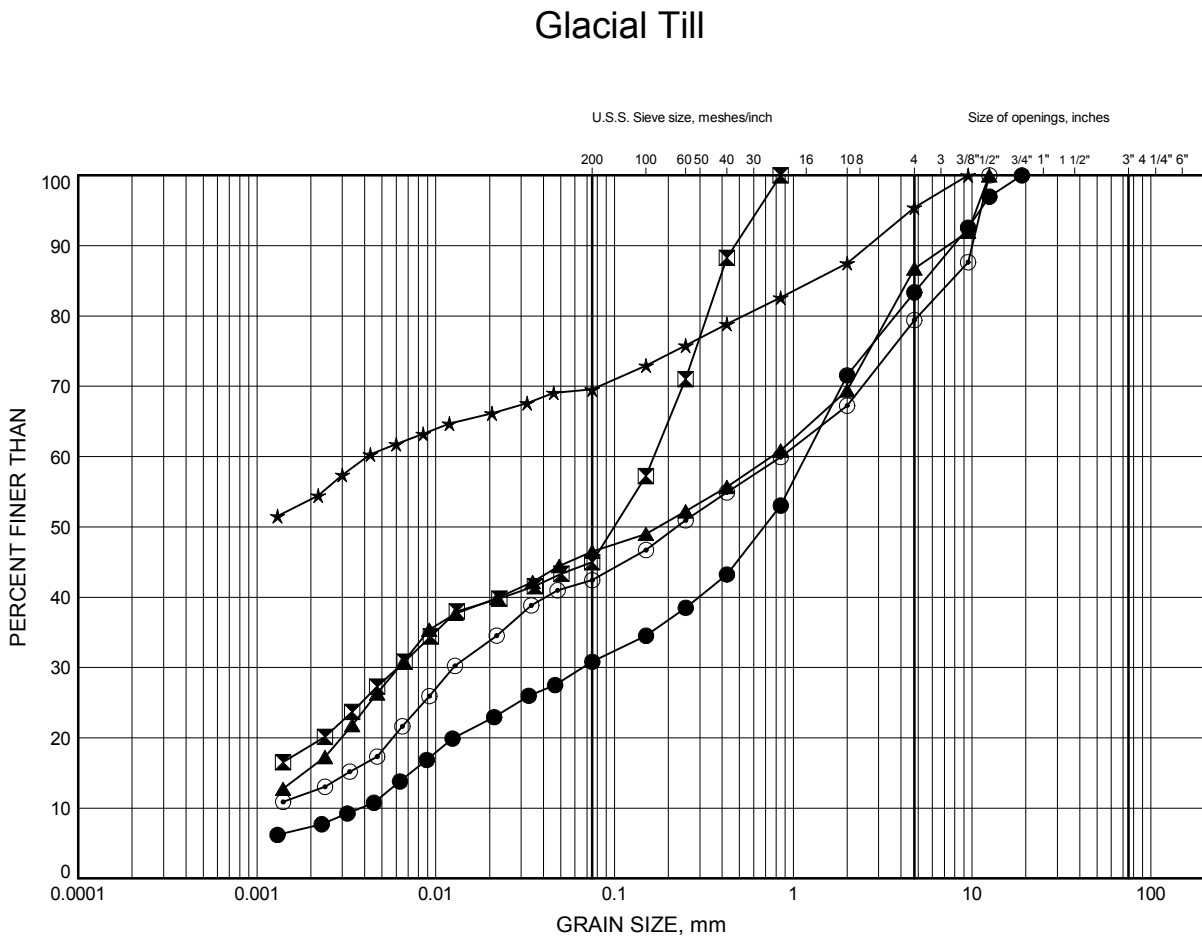
Date June 2014
 GWP# 455-98-00



Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment
GRAIN SIZE DISTRIBUTION

FIGURE C9



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-10	26.21	42.19
⊠	13-3	26.21	42.49
▲	13-3	29.26	39.44
★	13-4	26.21	42.29
⊙	13-6	31.28	43.72

Date June 2014
 GWP# 455-98-00



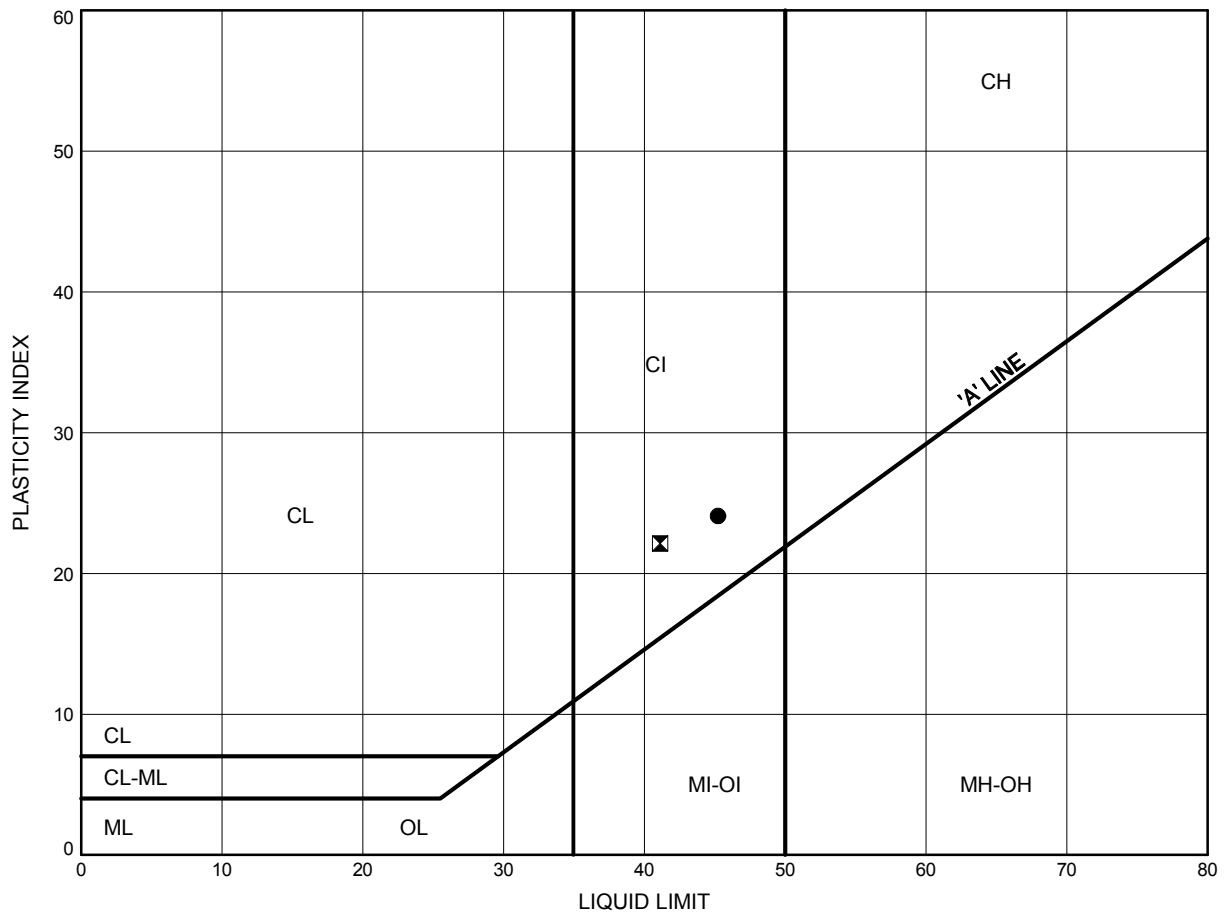
Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment

ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Sandy Silty Clay



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-10	15.54	52.86
⊠	13-3	1.83	66.87

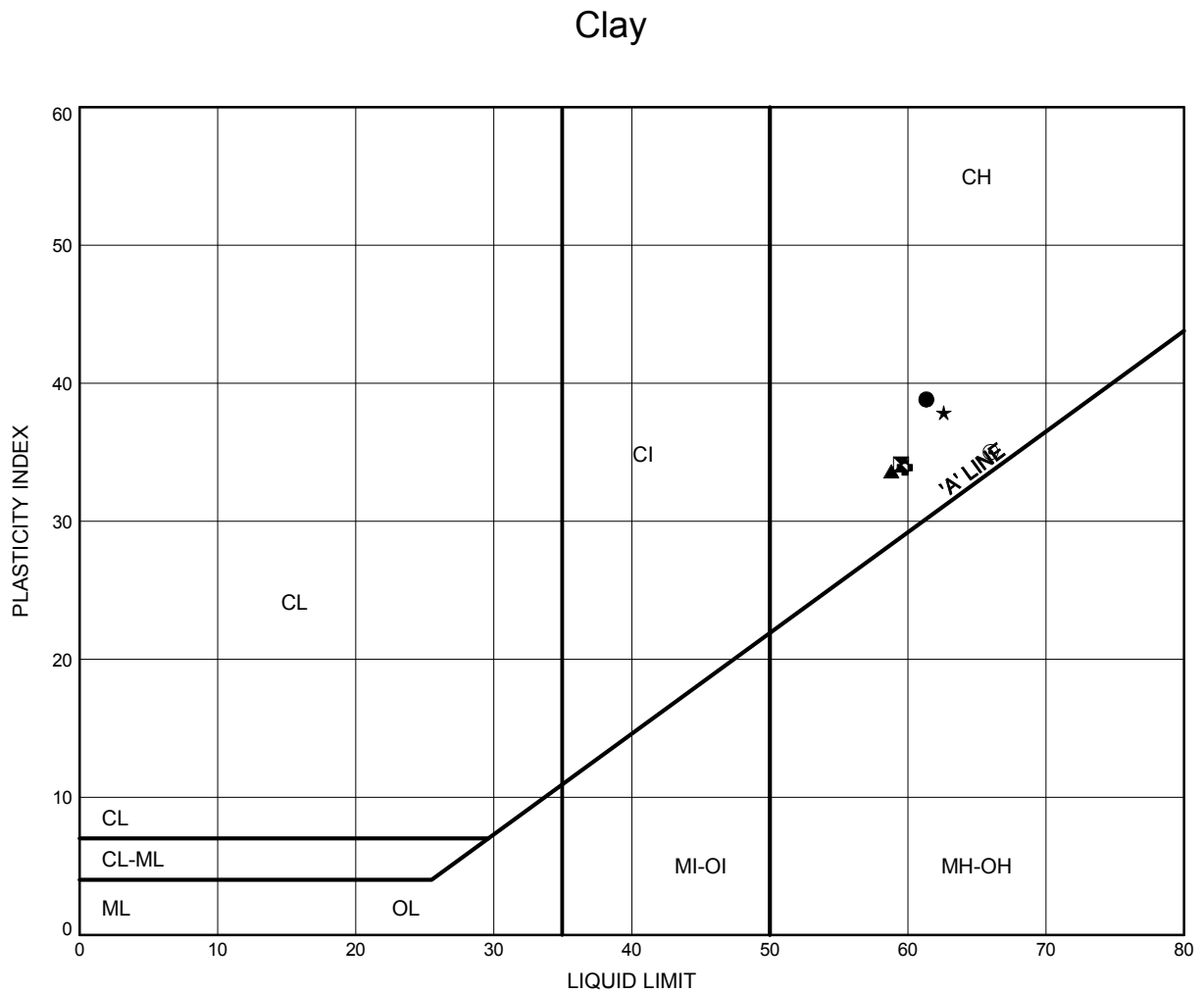
Date July 2014
GWP# 455-98-00



Prep'd GM
Chkd. PC

Part A: Bear Brook Structures Realignment
ATTERBERG LIMITS TEST RESULTS

FIGURE C11



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-1	8.69	67.21
⊠	13-10	6.40	62.00
▲	13-10	9.45	58.95
★	13-11	2.59	65.61
⊙	13-11	8.69	59.51
⊕	13-3	3.35	65.35

Date July 2014
 GWP# 455-98-00

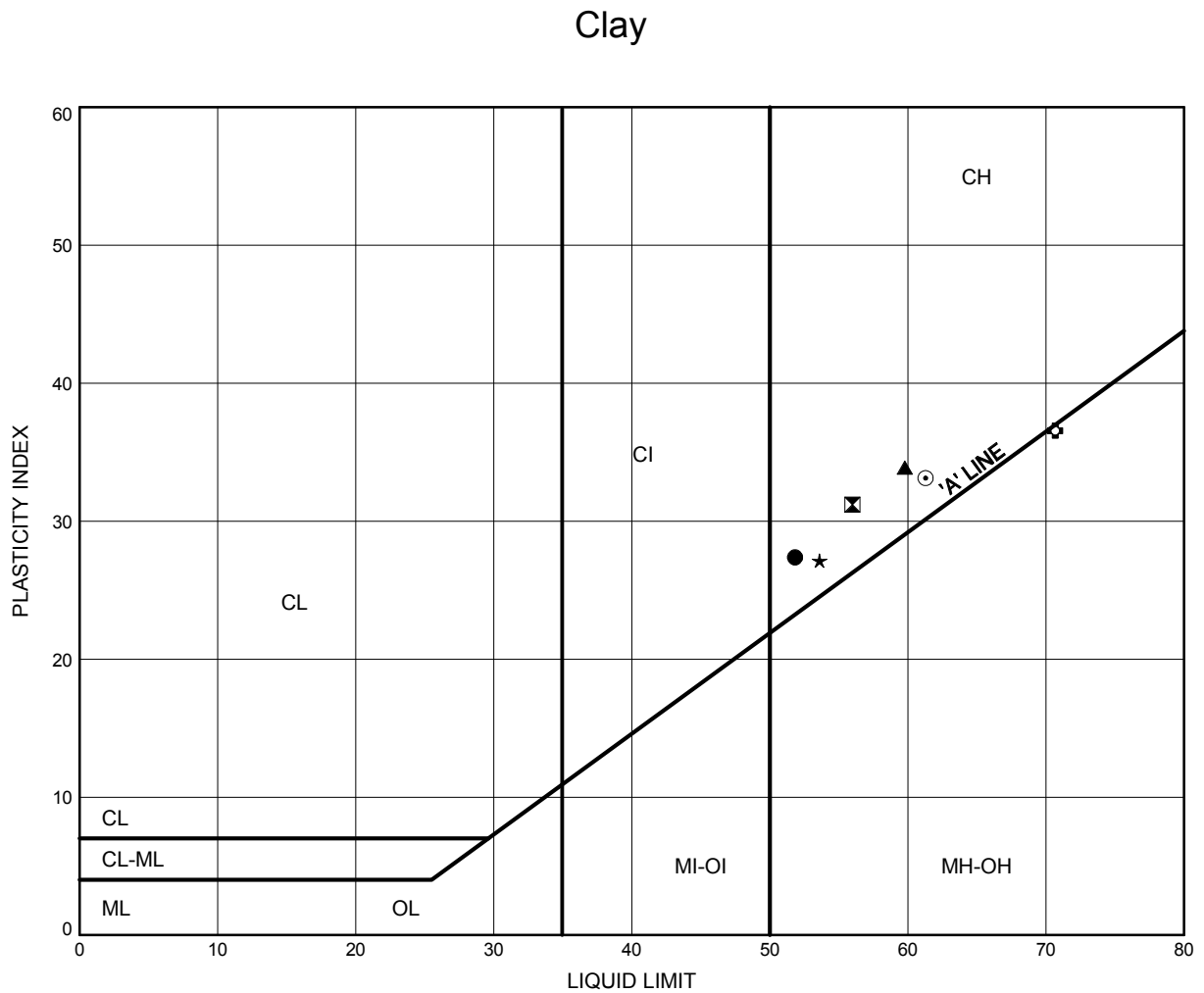


Prep'd GM
 Chkd. PC

Part A: Bear Brook Structures Realignment

ATTERBERG LIMITS TEST RESULTS

FIGURE C12



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-11	15.54	52.66
⊠	13-13	7.92	67.98
▲	13-3	3.35	65.35
★	13-3	9.45	59.25
⊙	13-4	4.88	63.62
⊕	13-4	14.02	54.48

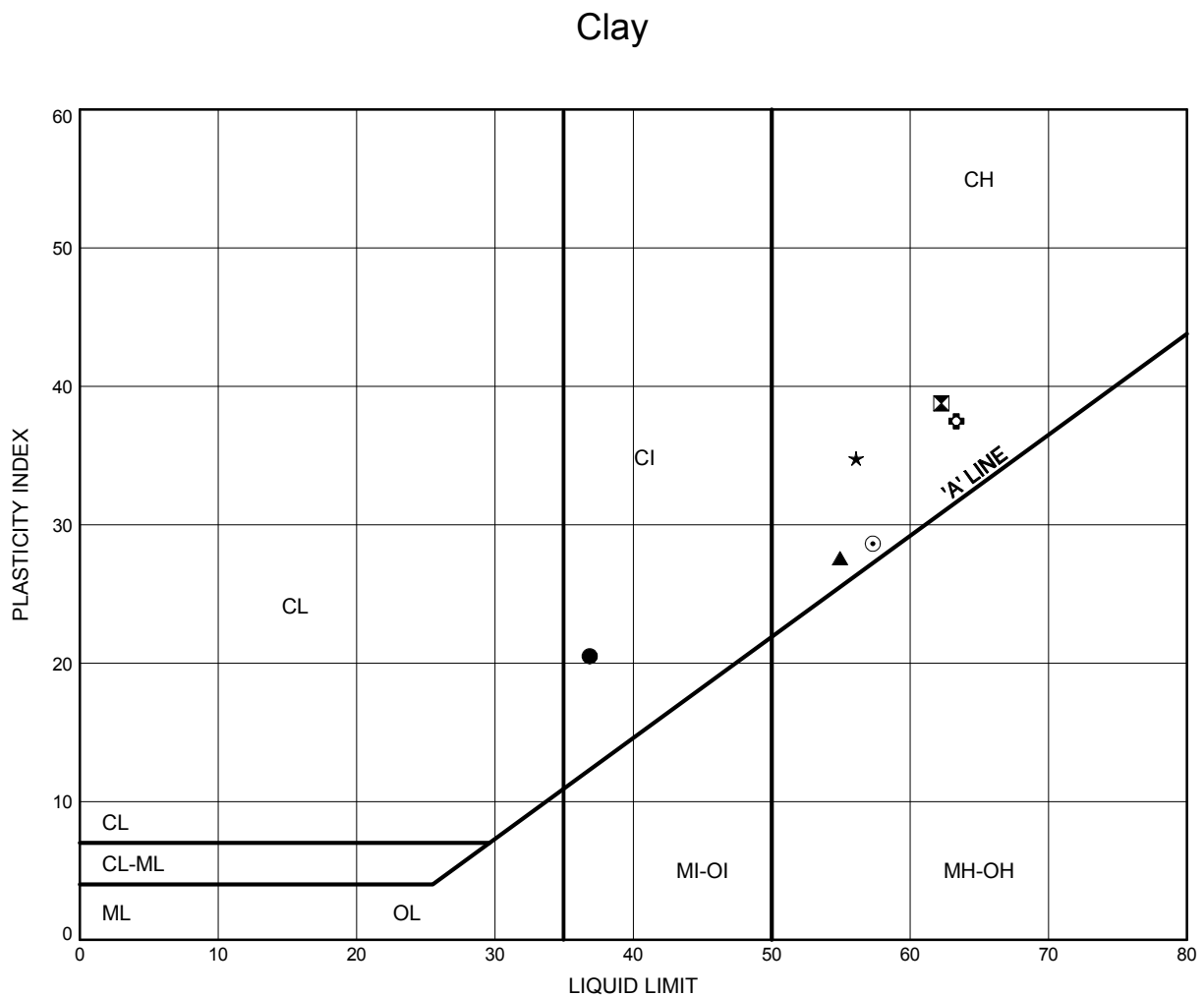
Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Part A: Bear Brook Structures Realignment
ATTERBERG LIMITS TEST RESULTS

FIGURE C13



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-4	26.21	42.29
⊠	13-5	4.11	71.99
▲	13-5	7.92	68.18
★	13-6	1.83	73.17
⊙	13-6	6.40	68.60
⊕	13-6	21.64	53.36

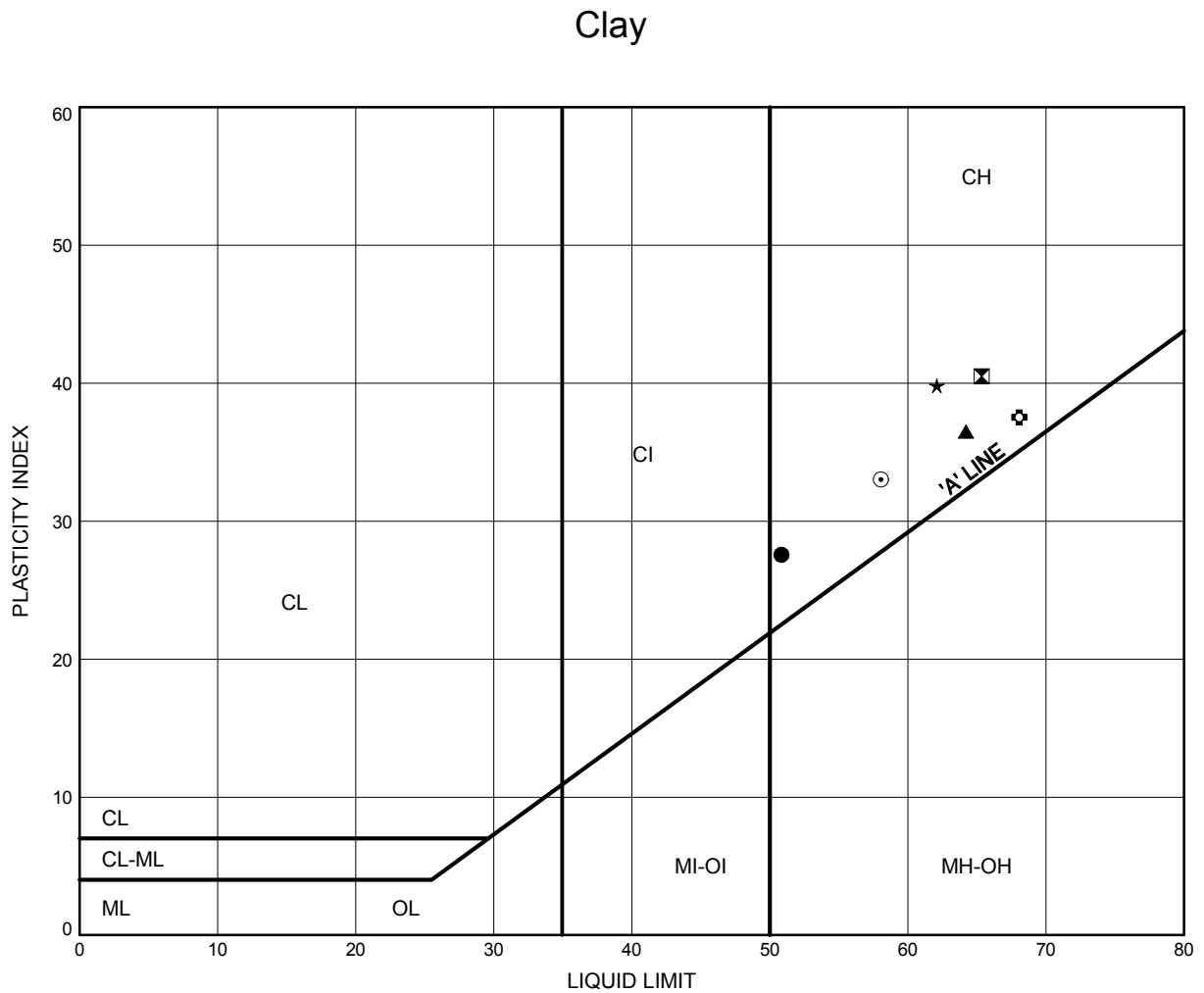
Date June 2014
 GWP# 455-98-00



Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment
ATTERBERG LIMITS TEST RESULTS

FIGURE C14



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-7	3.35	71.85
⊠	13-8	3.35	71.55
▲	13-8	9.45	65.45
★	13-9	3.35	71.55
⊙	13-9	7.32	67.58
⊕	13-9	7.92	66.98

Date June 2014
 GWP# 455-98-00

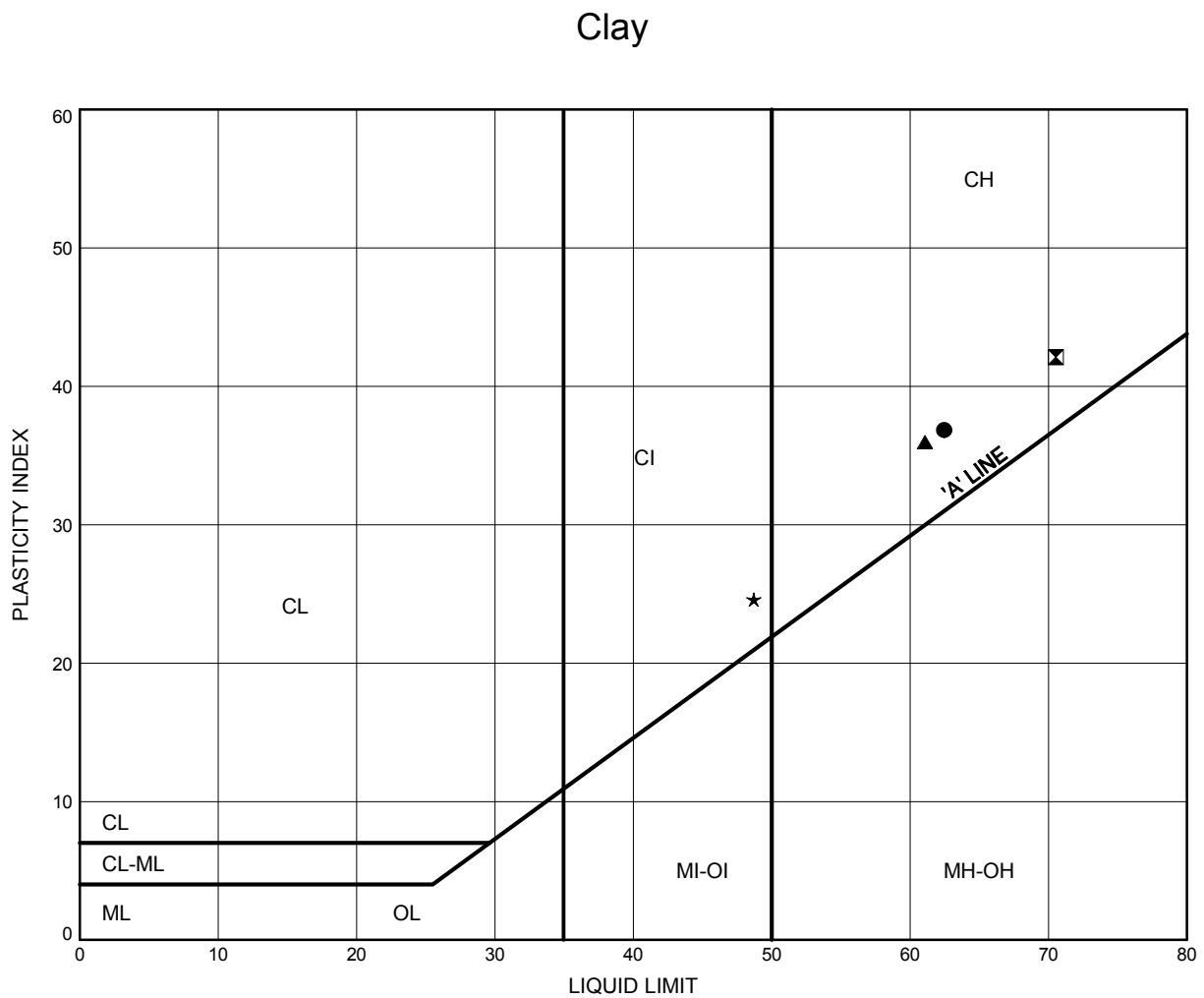


Prep'd CM
 Chkd. PC

Part A: Bear Brook Structures Realignment

ATTERBERG LIMITS TEST RESULTS

FIGURE C15



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	13-9	12.50	62.40
⊠	13-9	15.54	59.36
▲	13-9	20.12	54.78
★	13-9	23.16	51.74

Date June 2014
GWP# 455-98-00



Prep'd CM
Chkd. PC

Consolidation Test Report

CLIENT: **URS Canada**

FILE NUMBER: **19-4406-6**

PROJECT: **HWY 417 Bearbrook**

REPORT DATE: **20-Nov-13**

TEST DATES: **October 21, 2013 - November 01, 2013**

SAMPLE: **BH13-9-TW10 (25' - 27')**
Silty Clay, contains 19% Silt and 81% Clay, LL=68%, PL=31%

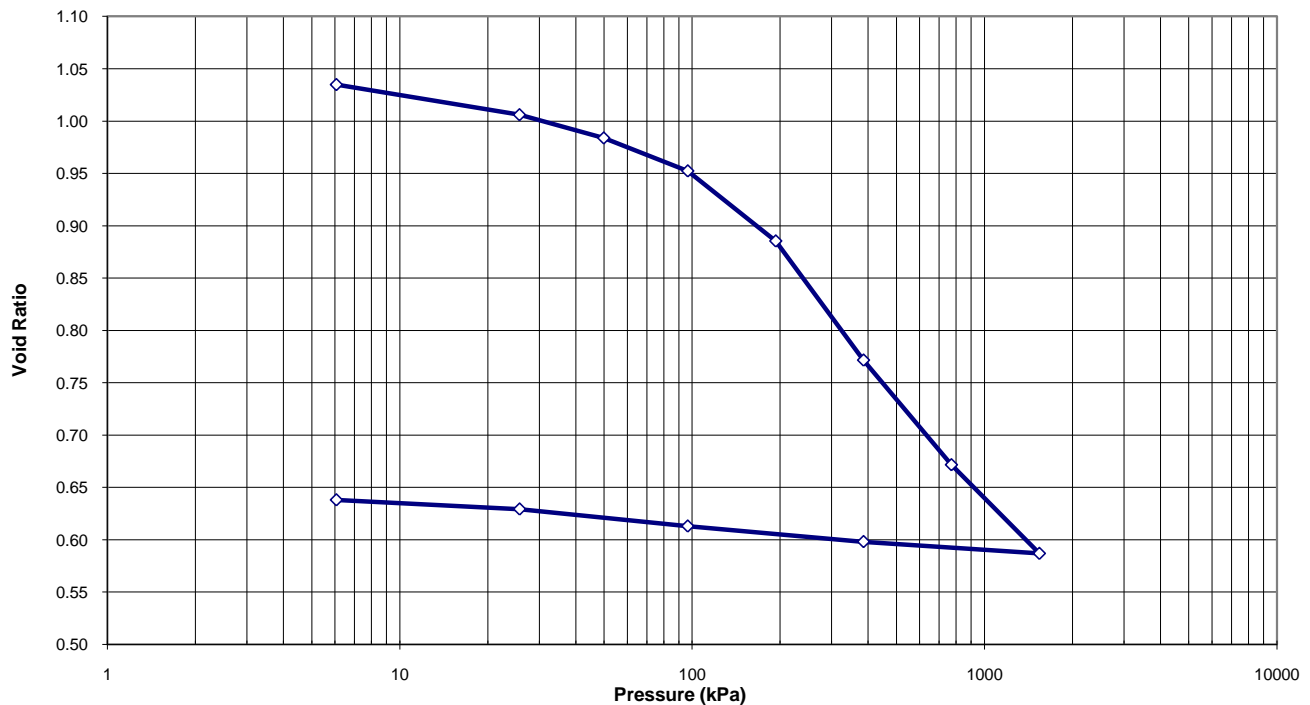
PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m ³)	1888.5	2113.2
Dry Dens. (kg/m ³)	1357.3	1700.3
Moisture Cont. (%)	39.1	24.3
Void Ratio	1.052	0.638

Note: A Specific Gravity of 2.79 was measured for the void ratio and saturation calculations.

Project #: 19-4406-6
 Client: URS Canada
 Project Name: HWY 417 Bearbrook
 Sample: BH13-9-TW10 (25' - 27')

Void Ratio vs. Pressure





Consolidation Test Report

HWY 417 Bearbrook
19-4406-6

BH13-9-TW10 (25' - 27')

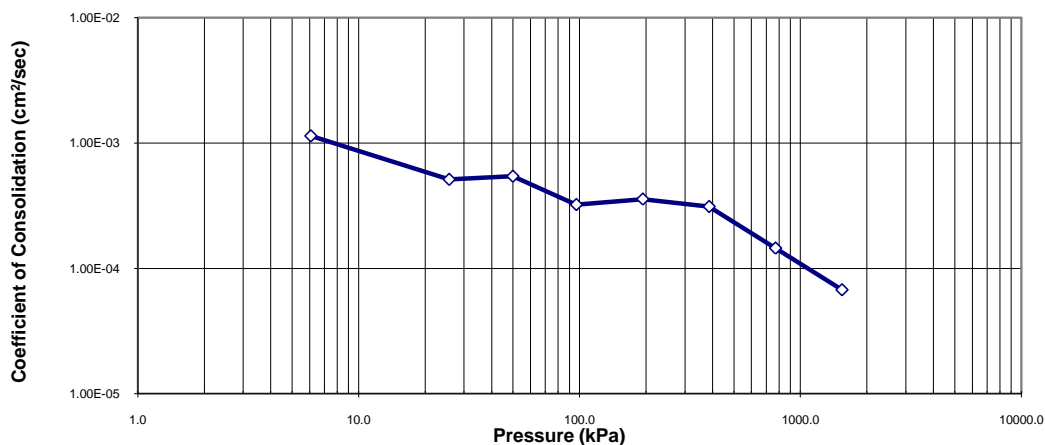
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer.

LOADING: A seating load of 6.1 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 100% primary consolidation was reached.

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	25.500					1.052		
6.1	25.324	25.412	-0.150	3.19	7.16E-03	1.038	1.14E-03	7.99E-07
25.7	25.070	25.197	-0.246	2.89	7.76E-03	1.017	5.12E-04	3.90E-07
49.9	24.741	24.906	-0.142	2.86	7.67E-03	0.991	5.43E-04	4.08E-07
96.6	24.368	24.555	-0.178	2.56	8.32E-03	0.961	3.22E-04	2.63E-07
193.2	23.529	23.949	-0.307	3.01	6.73E-03	0.893	3.56E-04	2.35E-07
385.7	22.121	22.825	-0.690	5.22	3.53E-03	0.780	3.11E-04	1.07E-07
770.7	20.887	21.504	-0.682	3.34	4.89E-03	0.681	1.45E-04	6.95E-08
1540.7	19.803	20.345	-0.594	2.25	6.50E-03	0.594	6.74E-05	4.30E-08
385.7	19.814	19.809				0.594		
96.6	19.998	19.906				0.609		
25.7	20.169	20.084				0.623		
6.1	20.257	20.213				0.630		

Coefficient of Consolidation vs. Pressure



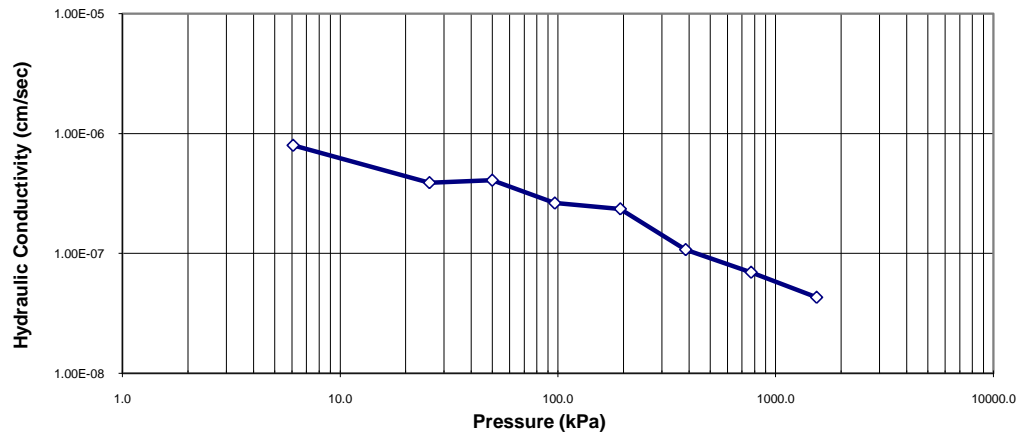
Notes: c_v and k calculated using t_{90} values

Consolidation Test Report

BH13-9-TW10 (25' - 27')

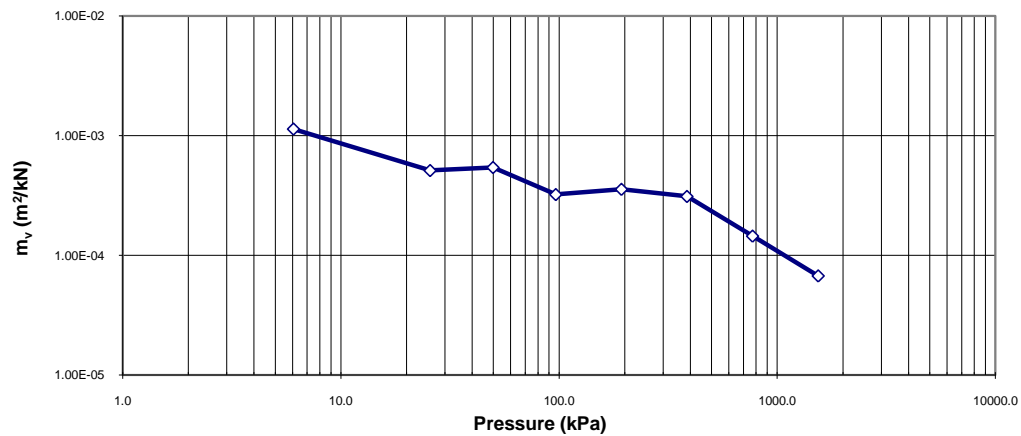
Project #: 19-4406-6
Client: URS Canada
Project Name: HWY 417 Bearbrook
Sample: BH13-9-TW10 (25' - 27')

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure

Project #: 19-4406-6
Client: URS Canada
Project Name: HWY 417 Bearbrook
Sample: BH13-9-TW10 (25' - 27')



Consolidation Test Report

CLIENT: **URS Canada**

FILE NUMBER: **19-4406-6**

PROJECT: **HWY 17 Bearbrook**

REPORT DATE: **20-Nov-13**

TEST DATES: **November 04, 2013 - November 15, 2013**

SAMPLE: **BH13-9-TW15 (50' - 52')**
Silty Clay, Grey, 62% Silt and 38% Clay, LL=70%, PL=29%

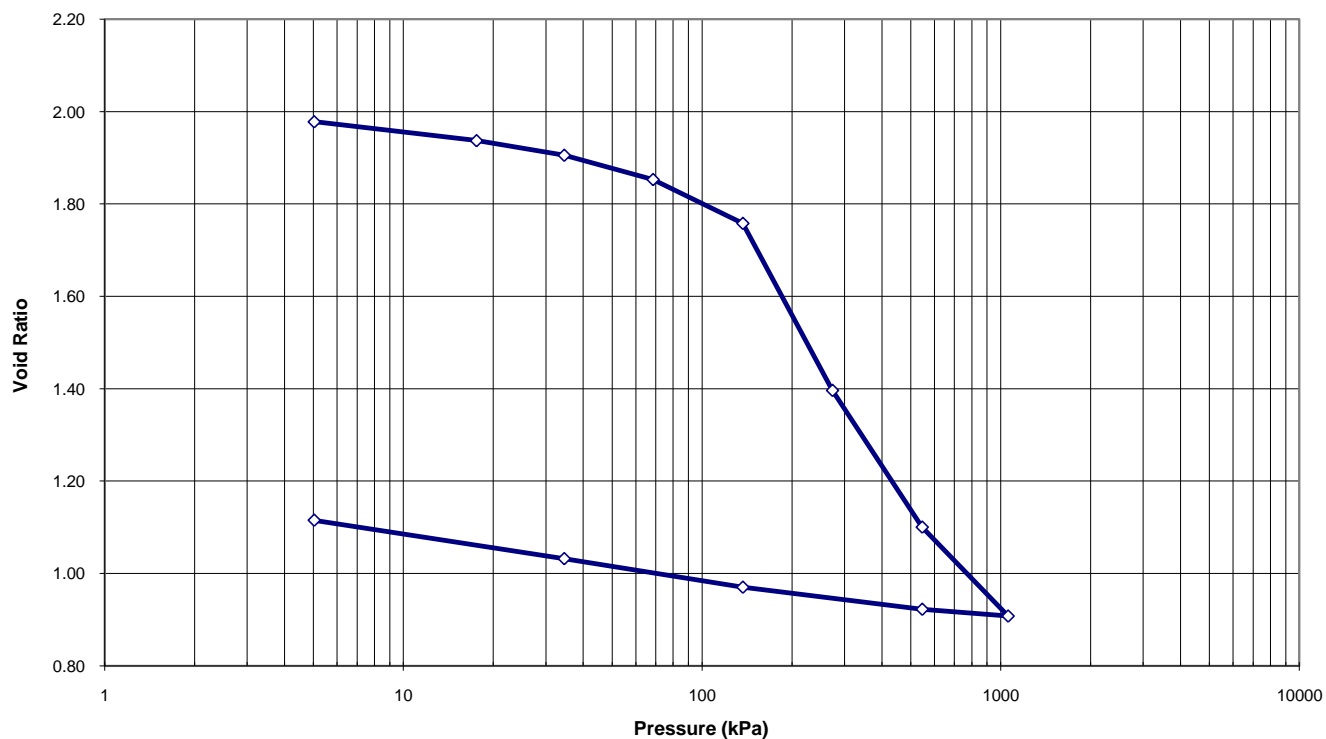
PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method A (constant load duration of 24 hrs)

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m ³)	1599.0	1911.3
Dry Dens. (kg/m ³)	915.2	1301.5
Moisture Cont. (%)	74.7	46.9
Void Ratio	2.008	1.115

Note: A Specific Gravity of 2.75 was measured for the void ratio and saturation calculations.

Void Ratio vs. Pressure

Project #: 19-4406-6
 Client: URS Canada
 Project Name: HWY 17 Bearbrook
 Sample: BH13-9-TW15 (50' - 52')



Consolidation Test Report

HWY 17 Bearbrook
19-4406-6

BH13-9-TW15 (50' - 52')

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer.

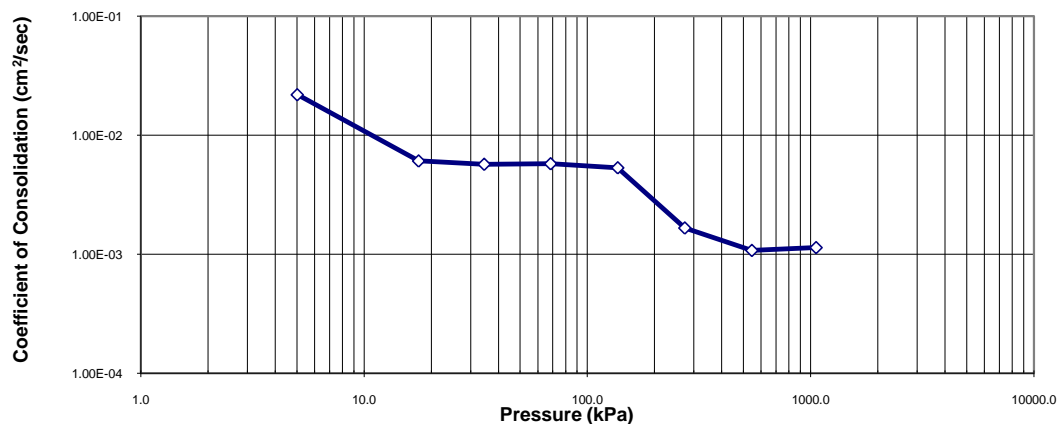
LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied after 100% primary consolidation was reached.

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					2.008		
5.0	19.801	19.901	-0.116	0.640	2.19E-02	1.978	1.98E-03	4.25E-06
17.6	19.529	19.665	-0.197	2.250	6.07E-03	1.937	1.10E-03	6.53E-07
34.5	19.319	19.424	-0.104	2.341	5.69E-03	1.906	6.34E-04	3.54E-07
68.5	18.969	19.144	-0.173	2.250	5.76E-03	1.853	5.34E-04	3.01E-07
136.9	18.338	18.654	-0.278	2.310	5.32E-03	1.758	4.87E-04	2.54E-07
273.2	15.933	17.136	-0.840	6.250	1.66E-03	1.396	9.62E-04	1.57E-07
545.5	13.964	14.949	-1.210	7.344	1.08E-03	1.100	4.54E-04	4.79E-08
1057.7	12.683	13.324	-0.785	5.523	1.14E-03	0.908	1.79E-04	1.99E-08
545.5	12.781	12.732				0.922		
136.9	13.099	12.940				0.970		
34.5	13.510	13.305				1.032		
5.0	14.064	13.787				1.115		

Coefficient of Consolidation vs. Pressure

Project #: 19-4406-6
Client: URS Canada
Project Name: HWY 17 Bearbrook
Sample: BH13-9-TW15 (50' - 52')



Notes: C_v and k calculated using t_{90} values

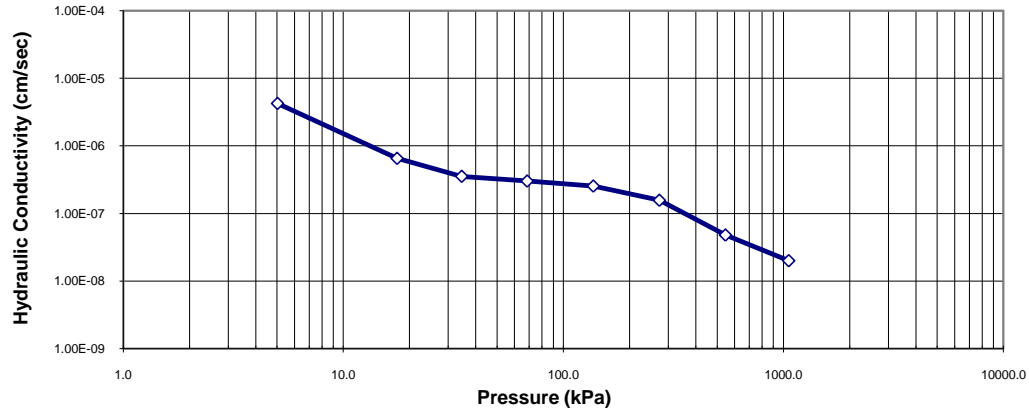
Consolidation Test Report

HWY 17 Bearbrook
19-4406-6

BH13-9-TW15 (50' - 52')

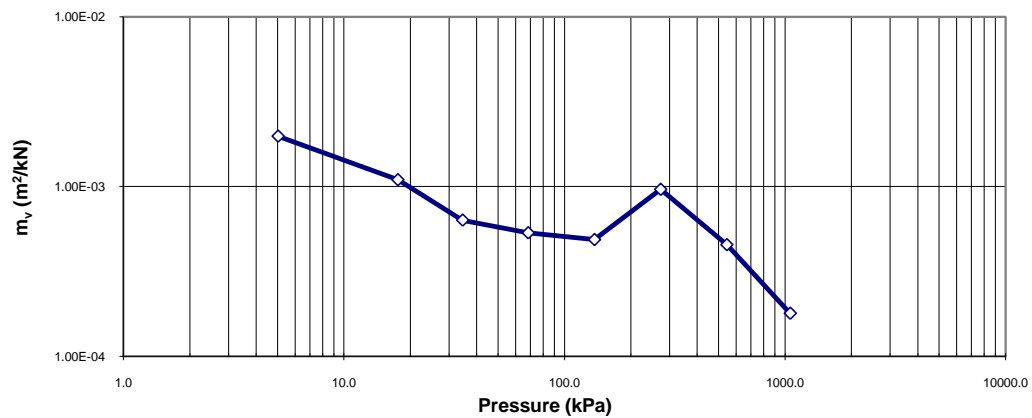
Hydraulic Conductivity vs. Pressure

Project #: 19-4406-6
Client: URS Canada
Project Name: HWY 17 Bearbrook
Sample: BH13-9-TW15 (50' - 52')



m_v vs. Pressure

Project #: 19-4406-6
Client: URS Canada
Project Name: HWY 17 Bearbrook
Sample: BH13-9-TW15 (50' - 52')



Consolidation Test Report

CLIENT: **URS Canada**

FILE NUMBER: **19-4406-6**

PROJECT: **HWY 417 Bearbrook**

REPORT DATE: **20-Nov-13**

TEST DATES: **November 04, 2013 - November 15, 2013**

SAMPLE: **BH13-9-TW19 (75' - 77')**
Silty Clay, contains 76% Silt and 24% Clay, LL=49%, PL=24%

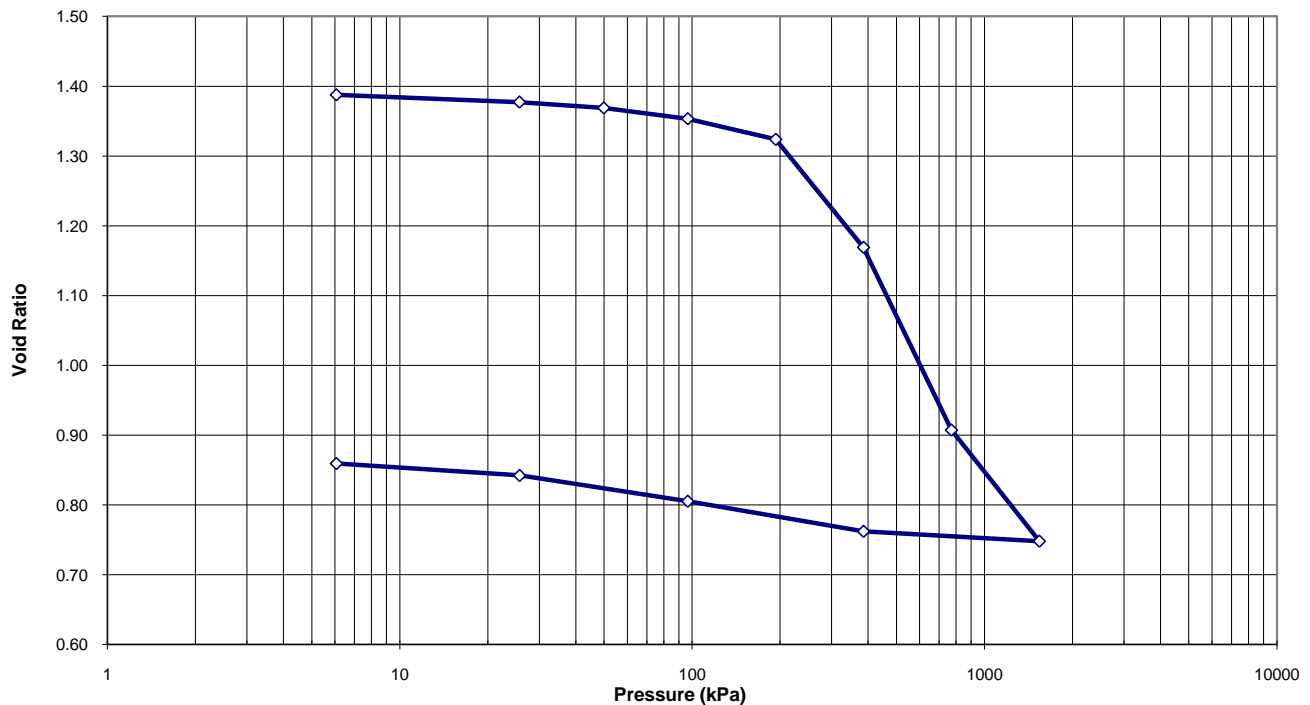
PROCEDURE: Test carried out in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	<u>Start of Test</u>	<u>End of Test</u>
Wet Dens. (kg/m ³)	1741.4	1987.0
Dry Dens. (kg/m ³)	1136.1	1464.1
Moisture Cont. (%)	53.3	35.7
Void Ratio	1.396	0.859

Note: A Specific Gravity of 2.72 was measured for the void ratio and saturation calculations.

Project #: 19-4406-6
 Client: URS Canada
 Project Name: HWY 417 Bearbrook
 Sample: BH13-9-TW19 (75' - 77')

Void Ratio vs. Pressure





Consolidation Test Report

HWY 417 Bearbrook
19-4406-6

BH13-9-TW19 (75' - 77')

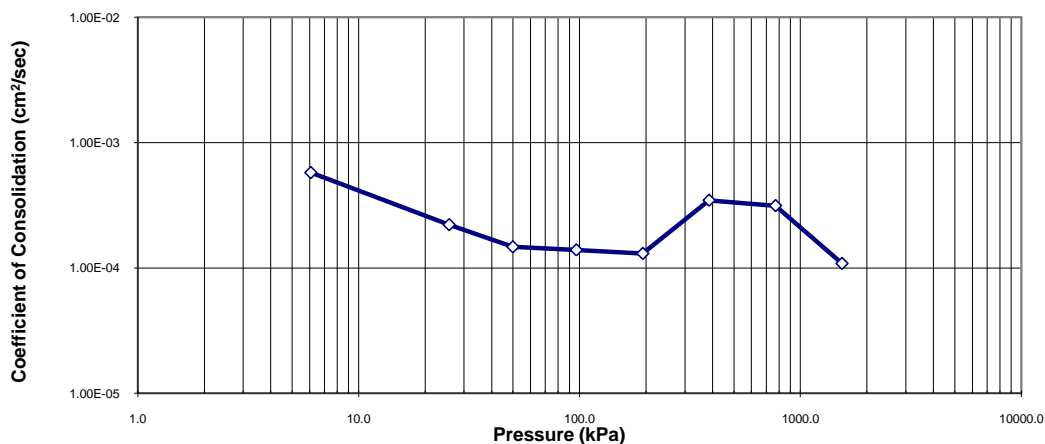
TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer.

LOADING: A seating load of 6.1 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 100% primary consolidation was reached.

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	25.500					1.396		
6.1	25.411	25.456	-0.038	0.416	5.50E-02	1.388	5.75E-04	3.10E-06
25.7	25.301	25.356	-0.087	1.563	1.45E-02	1.377	2.21E-04	3.15E-07
49.9	25.211	25.256	-0.052	1.664	1.35E-02	1.369	1.47E-04	1.95E-07
96.6	25.047	25.129	-0.092	1.716	1.30E-02	1.353	1.39E-04	1.77E-07
193.2	24.732	24.890	-0.164	1.742	1.26E-02	1.324	1.30E-04	1.60E-07
385.7	23.085	23.909	-0.440	3.331	6.06E-03	1.169	3.46E-04	2.06E-07
770.7	20.299	21.692	-1.716	12.250	1.36E-03	0.907	3.14E-04	4.17E-08
1540.7	18.604	19.452	-0.980	6.003	2.23E-03	0.748	1.08E-04	2.37E-08
385.7	18.754	18.679				0.762		
96.6	19.213	18.984				0.805		
25.7	19.606	19.410				0.842		
6.1	19.788	19.697				0.859		

Coefficient of Consolidation vs. Pressure



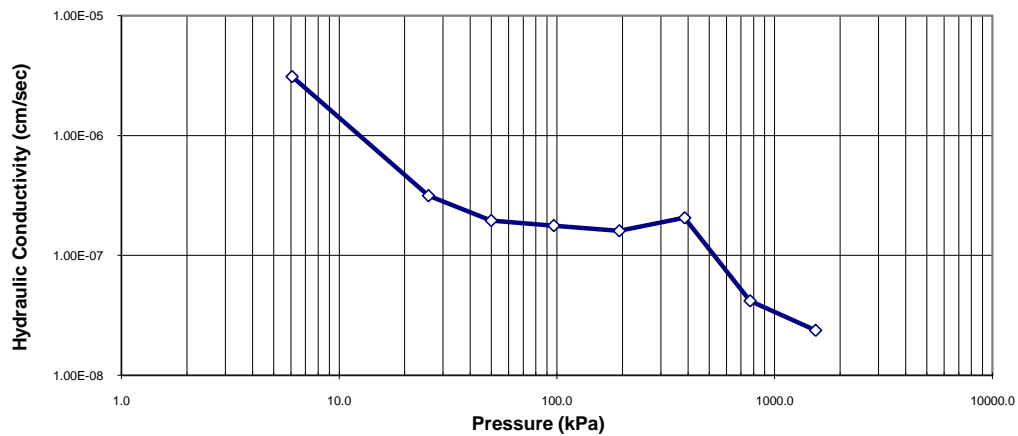
Notes: C_v and k calculated using t_{90} values



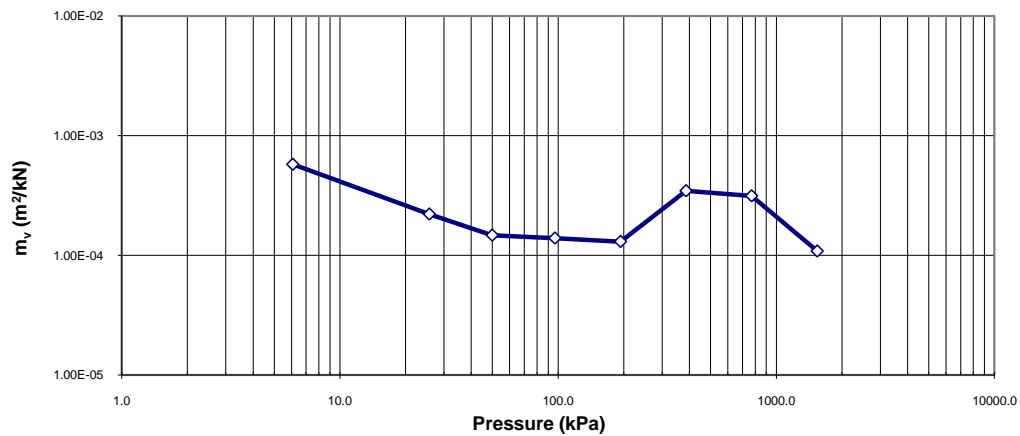
Consolidation Test Report

BH13-9-TW19 (75' - 77')

Hydraulic Conductivity vs. Pressure



m_v vs. Pressure



Appendix D
SCPTu Data

19-4406-6



Thurber Engineering

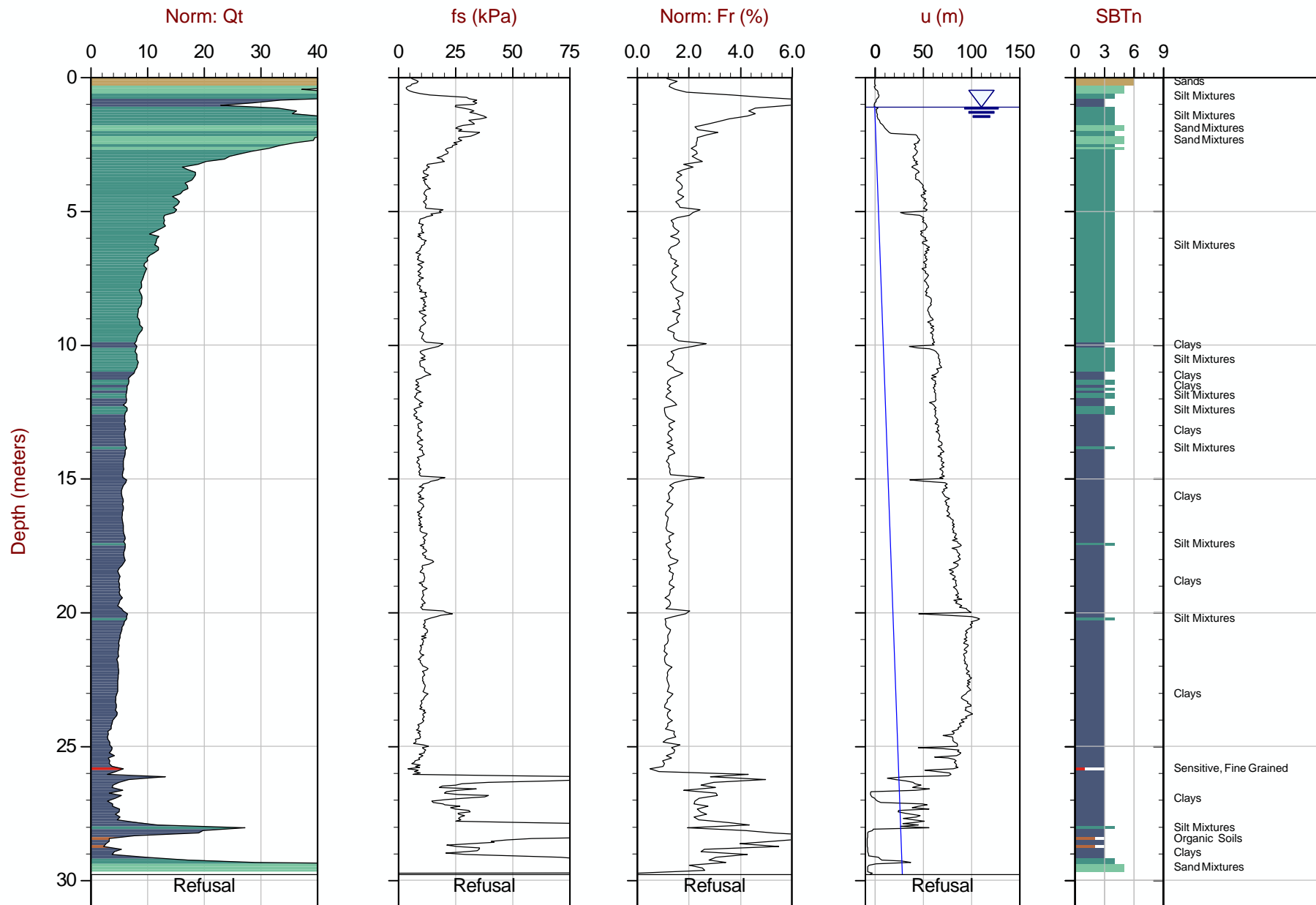
Job No: 13-05020

Date: 10:03:13 12:52

Site: HWY 417 Bear Brook Bridge, Ottawa, ON

Sounding: SCPT13-02

Cone: 374:T1500F15U500



Max Depth: 29.800 m / 97.77 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.100 m

File: 13-05020_SP13-02.COR

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM Zone 18 N: 5023375 E: 461897
Page No: 1 of 1



Thurber Engineering

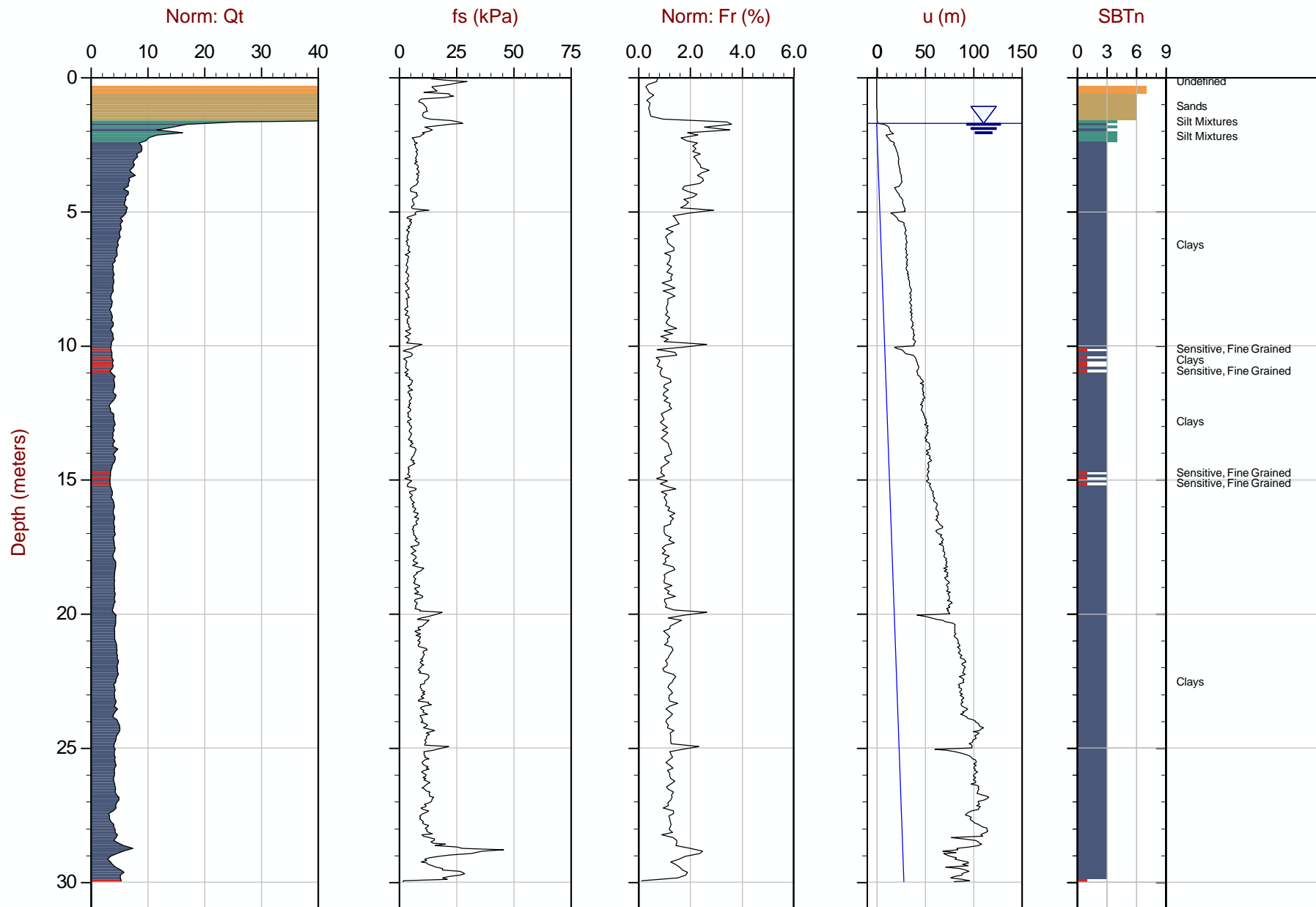
Job No: 13-05020

Date: 10:03:13 07:44

Site: HWY 417 Bear Brook Bridge, Ottawa, ON

Sounding: SCPT13-12

Cone: 374:T1500F15U500



Max Depth: 30.000 m / 98.42 ft
Depth Inc: 0.050 m / 0.164 ft
Avg Int: 0.100 m

File: 13-05020_SP13-12.COR

SBT: Lunne, Robertson and Powell, 1997
Coords: UTM Zone 18 N: 5023232 E: 462101
Page No: 1 of 1



Client: Thurber Engineering
Project: Hwy. 417 Bear Brook Bridge, Ottawa, ON
Sounding: SCPT13-02
Date: October 3, 2013

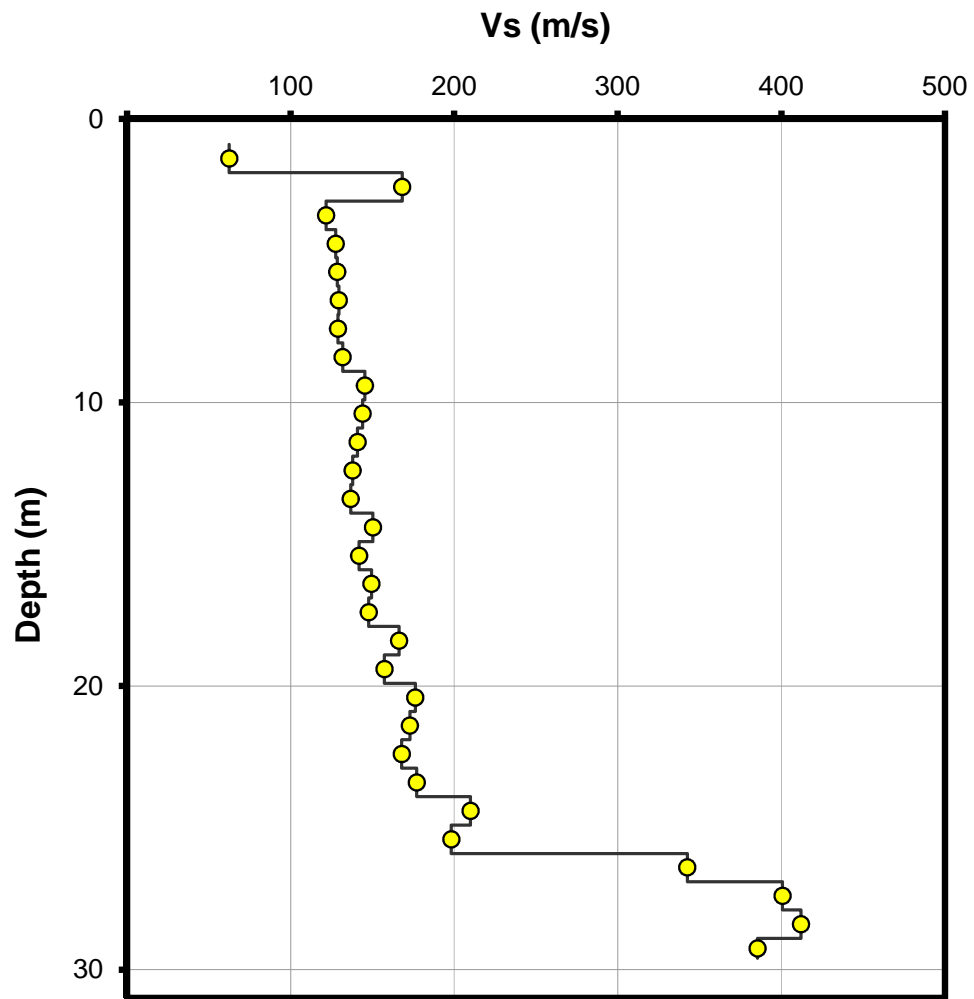
Seismic Source: Beam
Source Offset: 1.90 (m)
Source Depth: 0.00 (m)
Geophone Offset: 0.20 (m)

SEISMIC - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Mid-layer Depth (m)	Vs Interval Velocity (m/s)
1.10	0.90	2.10				
2.10	1.90	2.69	0.58	9.37	1.40	62
3.10	2.90	3.47	0.78	4.64	2.40	168
4.10	3.90	4.34	0.87	7.16	3.40	122
5.10	4.90	5.26	0.92	7.19	4.40	128
6.10	5.90	6.20	0.94	7.34	5.40	128
7.10	6.90	7.16	0.96	7.40	6.40	129
8.10	7.90	8.13	0.97	7.51	7.40	129
9.10	8.90	9.10	0.98	7.40	8.40	132
10.10	9.90	10.08	0.98	6.74	9.40	145
11.10	10.90	11.06	0.98	6.84	10.40	144
12.10	11.90	12.05	0.99	7.00	11.40	141
13.10	12.90	13.04	0.99	7.17	12.40	138
14.10	13.90	14.03	0.99	7.25	13.40	137
15.10	14.90	15.02	0.99	6.59	14.40	150
16.10	15.90	16.01	0.99	7.00	15.40	142
17.10	16.90	17.01	0.99	6.64	16.40	149
18.10	17.90	18.00	0.99	6.73	17.40	148
19.10	18.90	19.00	0.99	5.98	18.40	166
20.10	19.90	19.99	1.00	6.32	19.40	158
21.10	20.90	20.99	1.00	5.65	20.40	176
22.10	21.90	21.98	1.00	5.76	21.40	173
23.10	22.90	22.98	1.00	5.93	22.40	168
24.10	23.90	23.98	1.00	5.63	23.40	177
25.10	24.90	24.97	1.00	4.75	24.40	210
26.10	25.90	25.97	1.00	5.03	25.40	198
27.10	26.90	26.97	1.00	2.91	26.40	342
28.10	27.90	27.96	1.00	2.49	27.40	401
29.10	28.90	28.96	1.00	2.42	28.40	412
29.80	29.60	29.66	0.70	1.81	29.25	385



Client: Thurber Engineering
Location: Hwy. 417 Bear Brook Bridge, Ottawa, ON
CPT Sounding: SCPT13-02
Date: October 3, 2013





Client: Thurber Engineering
Project: Hwy. 417 Bear Brook Bridge, Ottawa, ON
Sounding: SCPT13-12
Date: October 3, 2013

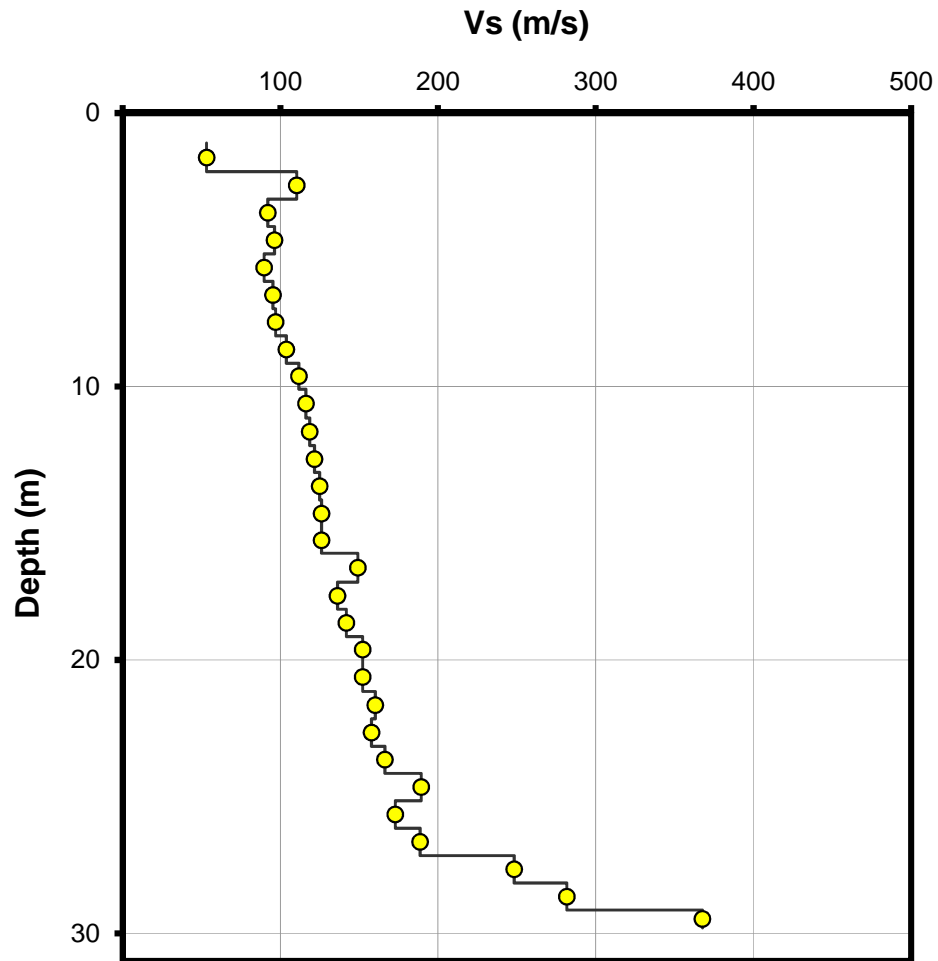
Seismic Source: Beam
Source Offset: 1.80 (m)
Source Depth: 0.00 (m)
Geophone Offset: 0.20 (m)

SEISMIC - Vs

Tip Depth (m)	Geophone Depth (m)	Ray Path (m)	Depth Interval (m)	Time Interval (ms)	Mid-layer Depth (m)	Vs Interval Velocity (m/s)
1.30	1.10	2.11				
2.35	2.15	2.80	0.69	13.05	1.62	53
3.35	3.15	3.63	0.82	7.46	2.65	110
4.35	4.15	4.52	0.90	9.73	3.65	92
5.35	5.15	5.46	0.93	9.68	4.65	96
6.35	6.15	6.41	0.95	10.62	5.65	90
7.35	7.15	7.37	0.97	10.13	6.65	95
8.35	8.15	8.35	0.97	10.04	7.65	97
9.35	9.15	9.33	0.98	9.43	8.65	104
10.30	10.10	10.26	0.93	8.35	9.63	112
11.35	11.15	11.29	1.04	8.91	10.63	116
12.35	12.15	12.28	0.99	8.33	11.65	119
13.35	13.15	13.27	0.99	8.13	12.65	122
14.35	14.15	14.26	0.99	7.93	13.65	125
15.35	15.15	15.26	0.99	7.87	14.65	126
16.30	16.10	16.20	0.94	7.49	15.63	126
17.35	17.15	17.24	1.04	6.99	16.63	149
18.35	18.15	18.24	0.99	7.30	17.65	136
19.35	19.15	19.23	1.00	7.02	18.65	142
20.30	20.10	20.18	0.95	6.22	19.63	152
21.35	21.15	21.23	1.05	6.87	20.63	152
22.35	22.15	22.22	1.00	6.22	21.65	160
23.35	23.15	23.22	1.00	6.31	22.65	158
24.35	24.15	24.22	1.00	5.99	23.65	166
25.35	25.15	25.21	1.00	5.27	24.65	189
26.35	26.15	26.21	1.00	5.77	25.65	173
27.35	27.15	27.21	1.00	5.29	26.65	189
28.35	28.15	28.21	1.00	4.02	27.65	248
29.35	29.15	29.21	1.00	3.54	28.65	282
30.00	29.80	29.85	0.65	1.76	29.48	368



Client: Thurber Engineering
Location: Hwy. 417 Bear Brook Bridge, Ottawa, ON
CPT Sounding: SCPT13-12
Date: October 3, 2013





Thurber Engineering

Job No: 13-05020

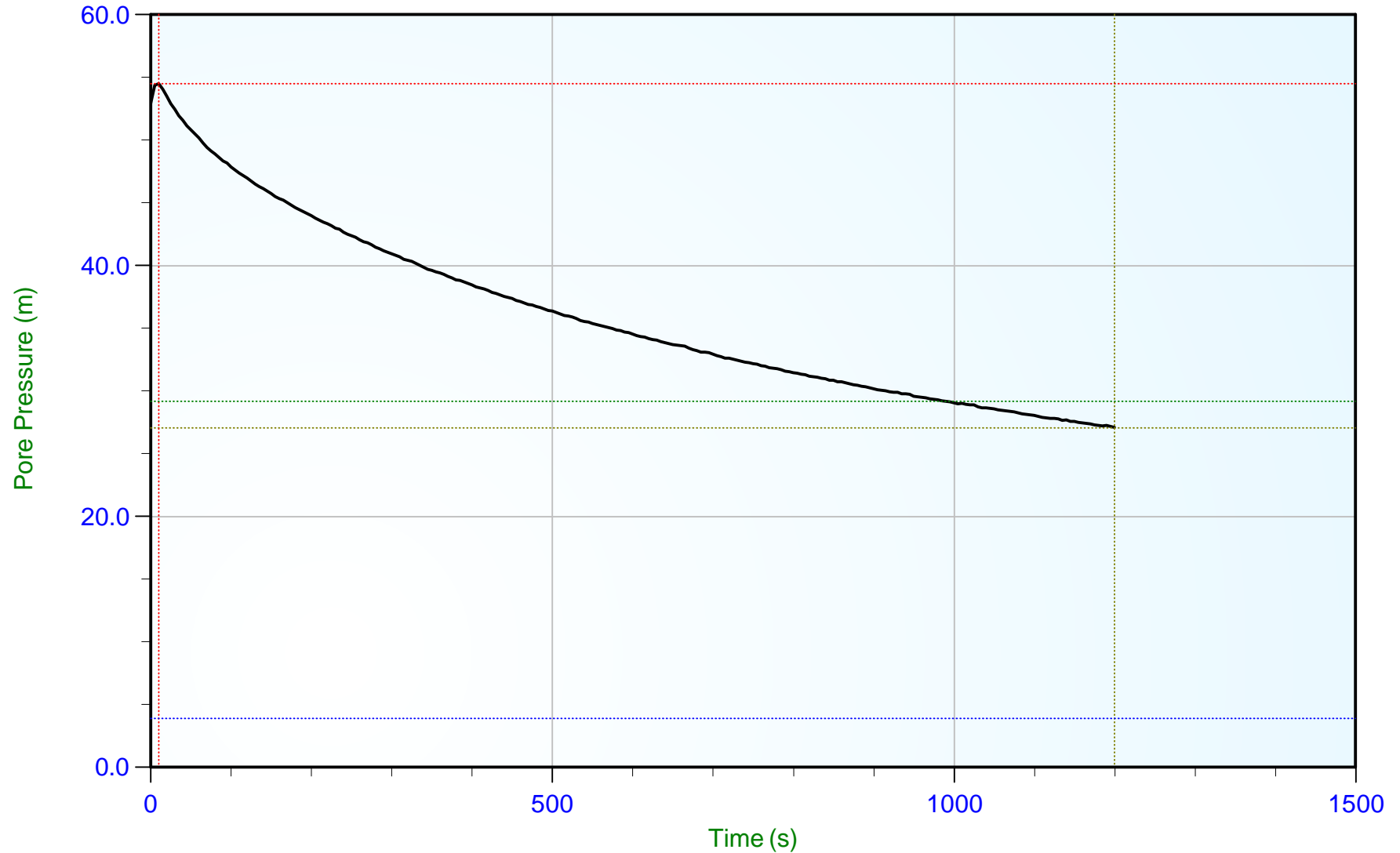
Date: 03-Oct-2013 12:52:58

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-02

Cone: AD374

Area: 15 sq cm



Trace Summary:

Filename: 13-05020_SP13-02.PPT
Depth: 5.000 m / 16.404 ft
Duration: 1200.0 s
PDM Min: 27.1 m
U Max: 54.5 m

WT: 1.100 m / 3.609 ft
Ueq: 3.9 m
U(50): 29.21 m

T(50): 976.9 s
Ir: 100
Ch: 0.7 sq cm/min



Thurber Engineering

Job No: 13-05020

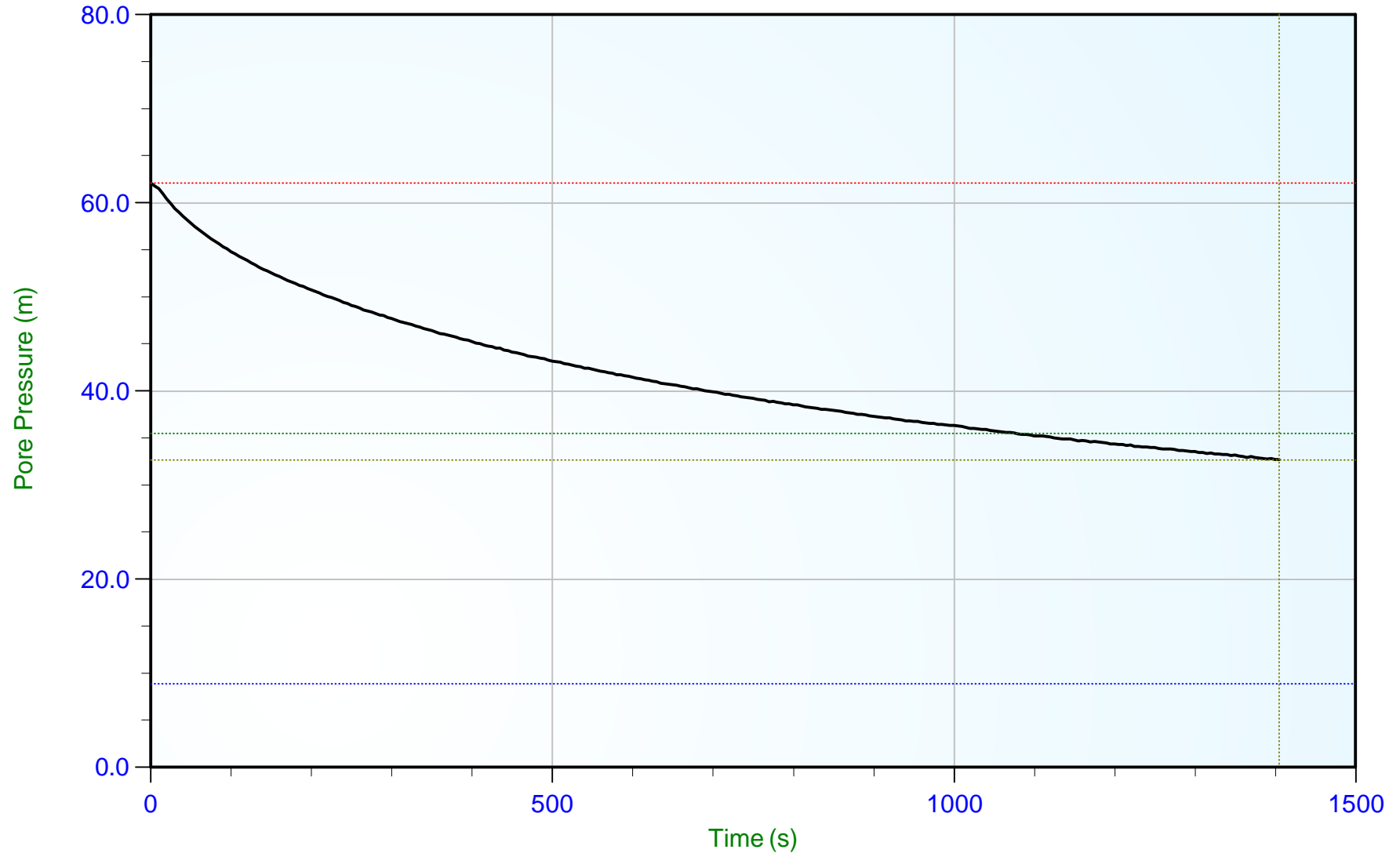
Date: 03-Oct-2013 12:52:58

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-02

Cone: AD374

Area: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-02.PRD Min: 32.7 m WT: 1.100 m / 3.609 ft T(50): 1077.3 s
Depth: 10.000 m / 32.808 ft U Max: 62.1 m Ueq: 8.9 m Ir: 100
Duration: 1405.0 s U(50): 35.51 m Ch: 0.7 sq cm/min



Thurber Engineering

Job No: 13-05020

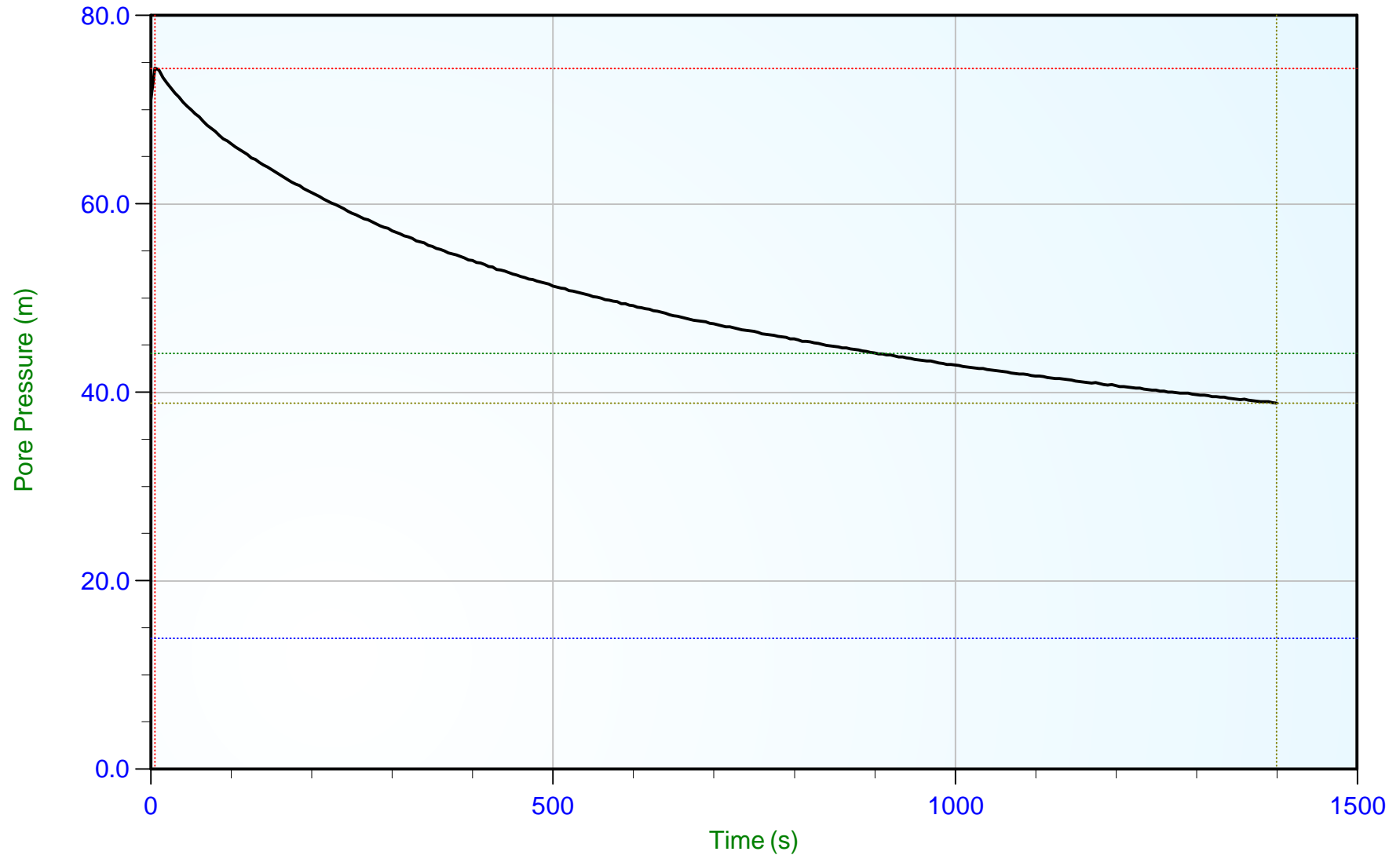
Date: 03-Oct-2013 12:52:58

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-02

Cone: AD374

Area: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-02.PRD Min: 38.9 m WT: 1.100 m / 3.609 ft T(50): 895.9 s
Depth: 15.000 m / 49.212 ft U Max: 74.4 m Ueq: 13.9 m Ir: 100
Duration: 1400.0 s U(50): 44.16 m Ch: 0.8 sq cm/min



Thurber Engineering

Job No: 13-05020

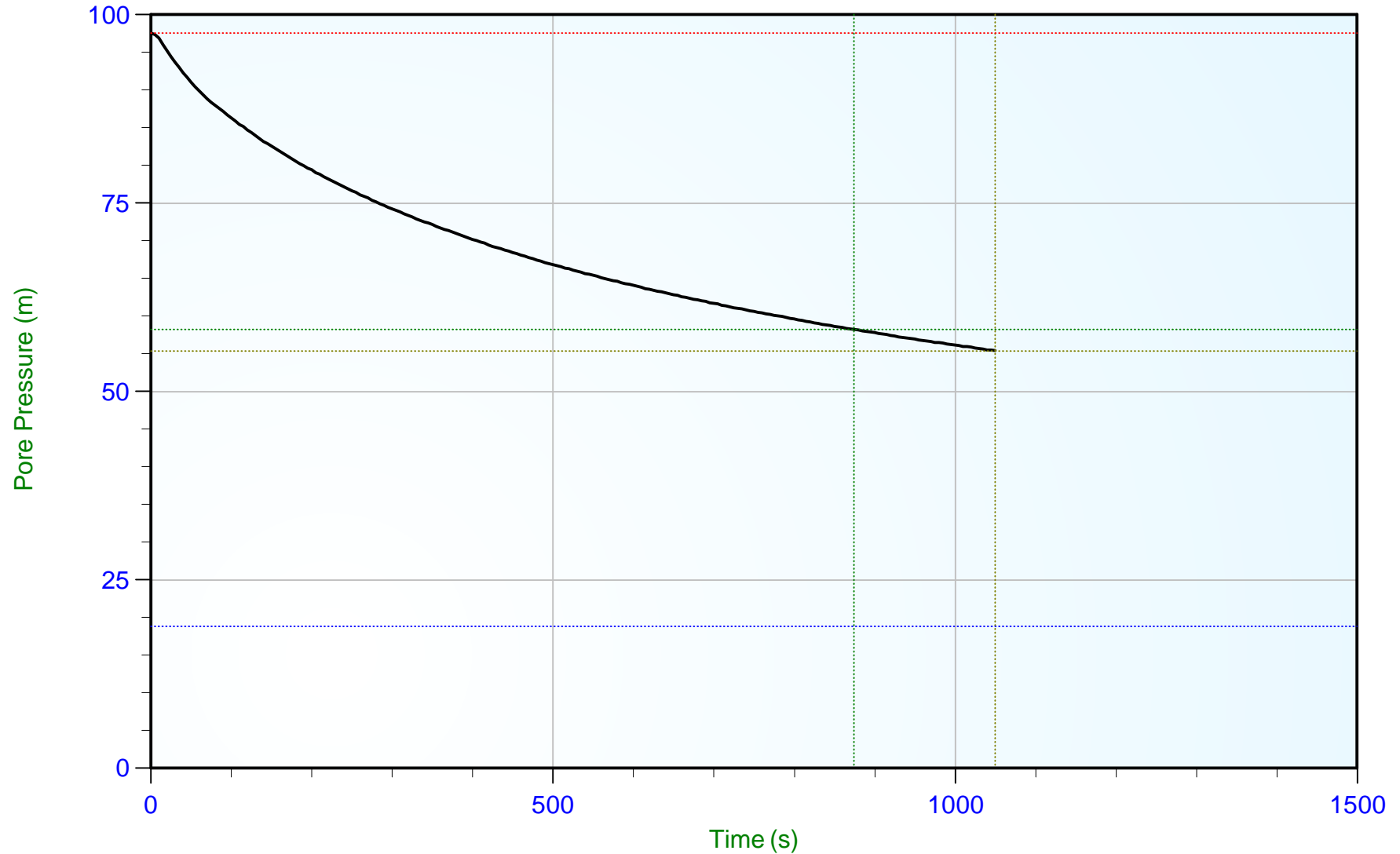
Date: 03-Oct-2013 12:52:58

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-02

Cone: AD374

CWA, Cb: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-02.PRD Min: 55.4 m WT: 1.100 m / 3.609 ft T(50): 874.4 s
Depth: 20.000 m / 65.616 ft U Max: 97.6 m Ueq: 18.9 m Ir: 100
Duration: 1050.0 s U(50): 58.24 m Ch: 0.8 sq cm/min



Thurber Engineering

Job No: 13-05020

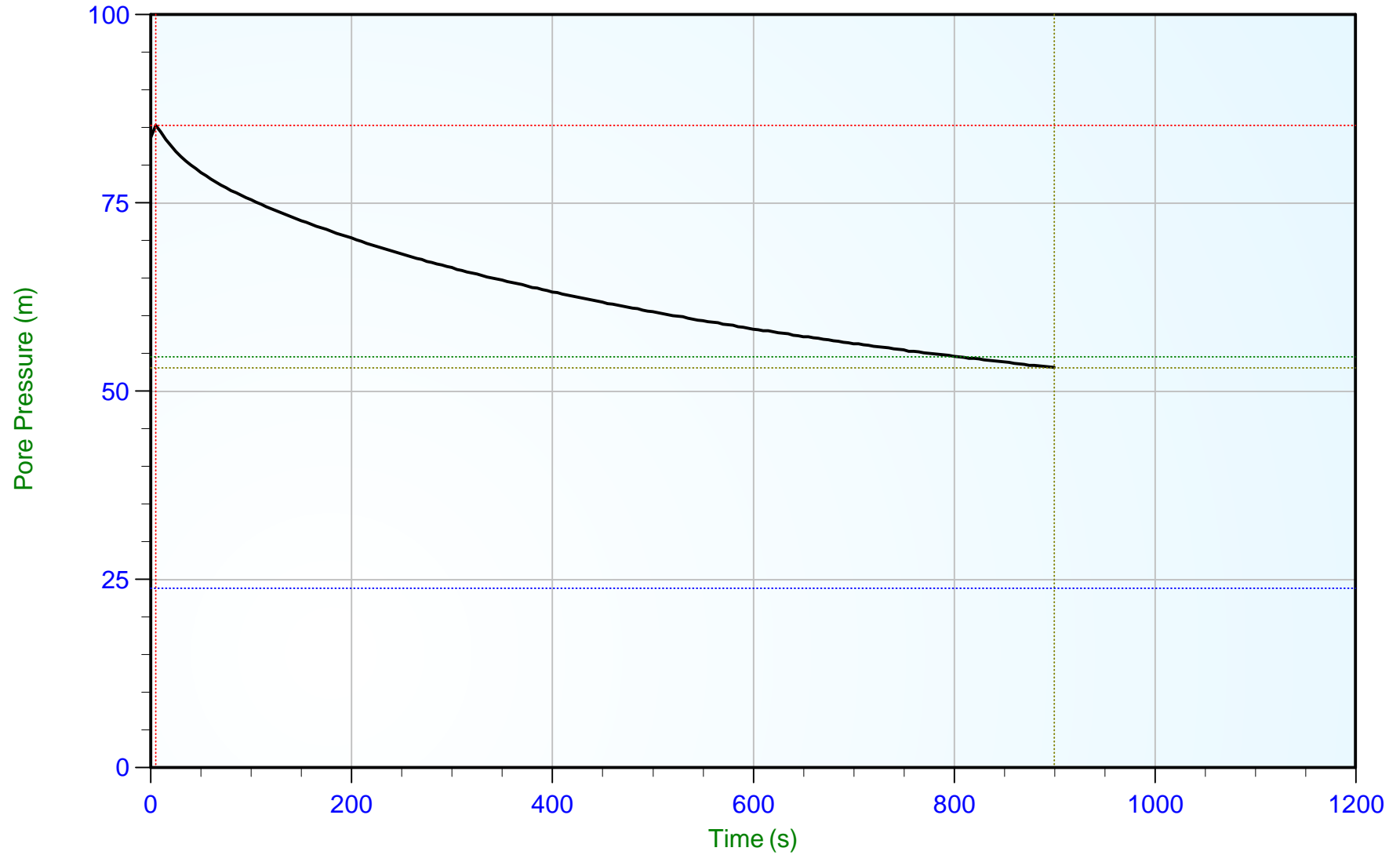
Date: 03-Oct-2013 12:52:58

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-02

Cone: AD374

Area: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-02.PRD Min: 53.1 m WT: 1.100 m / 3.609 ft T(50): 797.8 s
Depth: 25.000 m / 82.020 ft U Max: 85.3 m Ueq: 23.9 m Ir: 100
Duration: 900.0 s U(50): 54.61 m Ch: 0.9 sq cm/min



Thurber Engineering

Job No: 13-05020

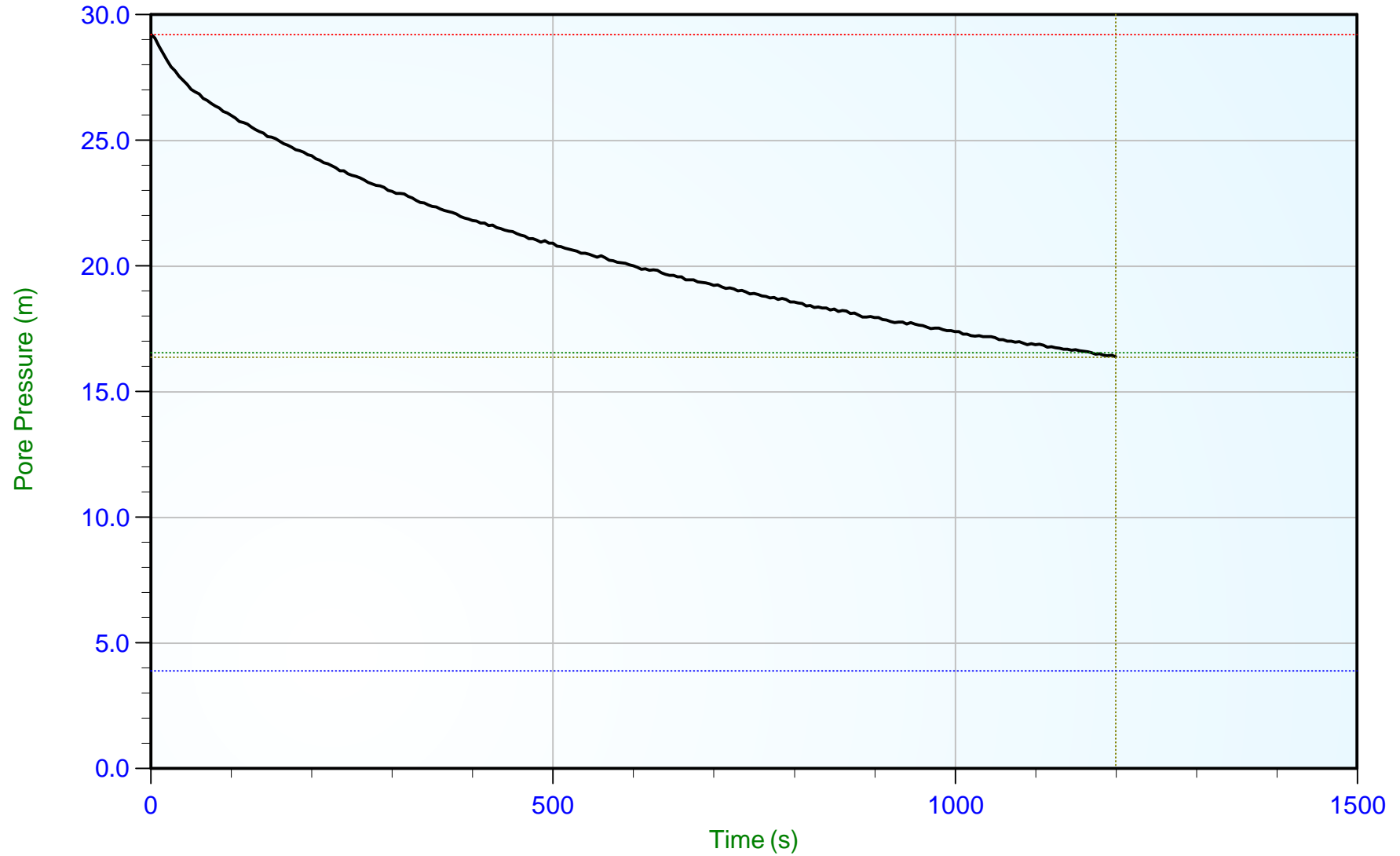
Date: 03-Oct-2013 07:44:50

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-12

Cone: AD374

Area: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-12.PRD Min: 16.4 m WT: 1.100 m / 3.609 ft T(50): 1169.0 s
Depth: 5.000 m / 16.404 ft U Max: 29.2 m Ueq: 3.9 m Ir: 100
Duration: 1200.0 s U(50): 16.56 m Ch: 0.6 sq cm/min



Thurber Engineering

Job No: 13-05020

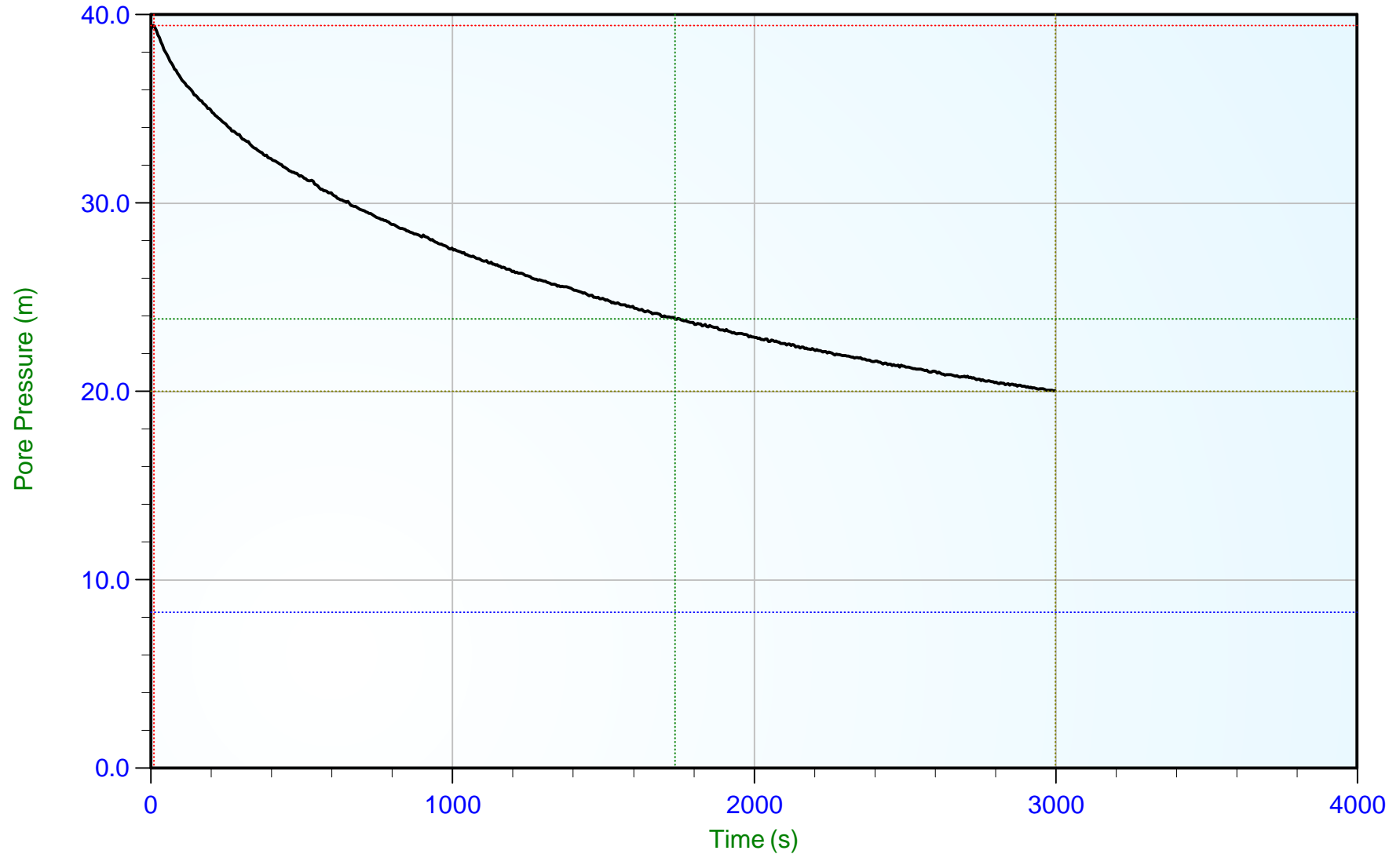
Date: 03-Oct-2013 07:44:50

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-12

Cone: AD374

Area: 15 sq cm



Trace Summary: Filename: 13-05020_SP13-12.PPTD Min: 20.0 m WT: 1.700 m / 5.577 ft T(50): 1728.8 s
Depth: 10.000 m / 32.808 ft U Max: 39.4 m Ueq: 8.3 m Ir: 100
Duration: 3000.0 s U(50): 23.87 m Ch: 0.4 sq cm/min



Thurber Engineering

Job No: 13-05020

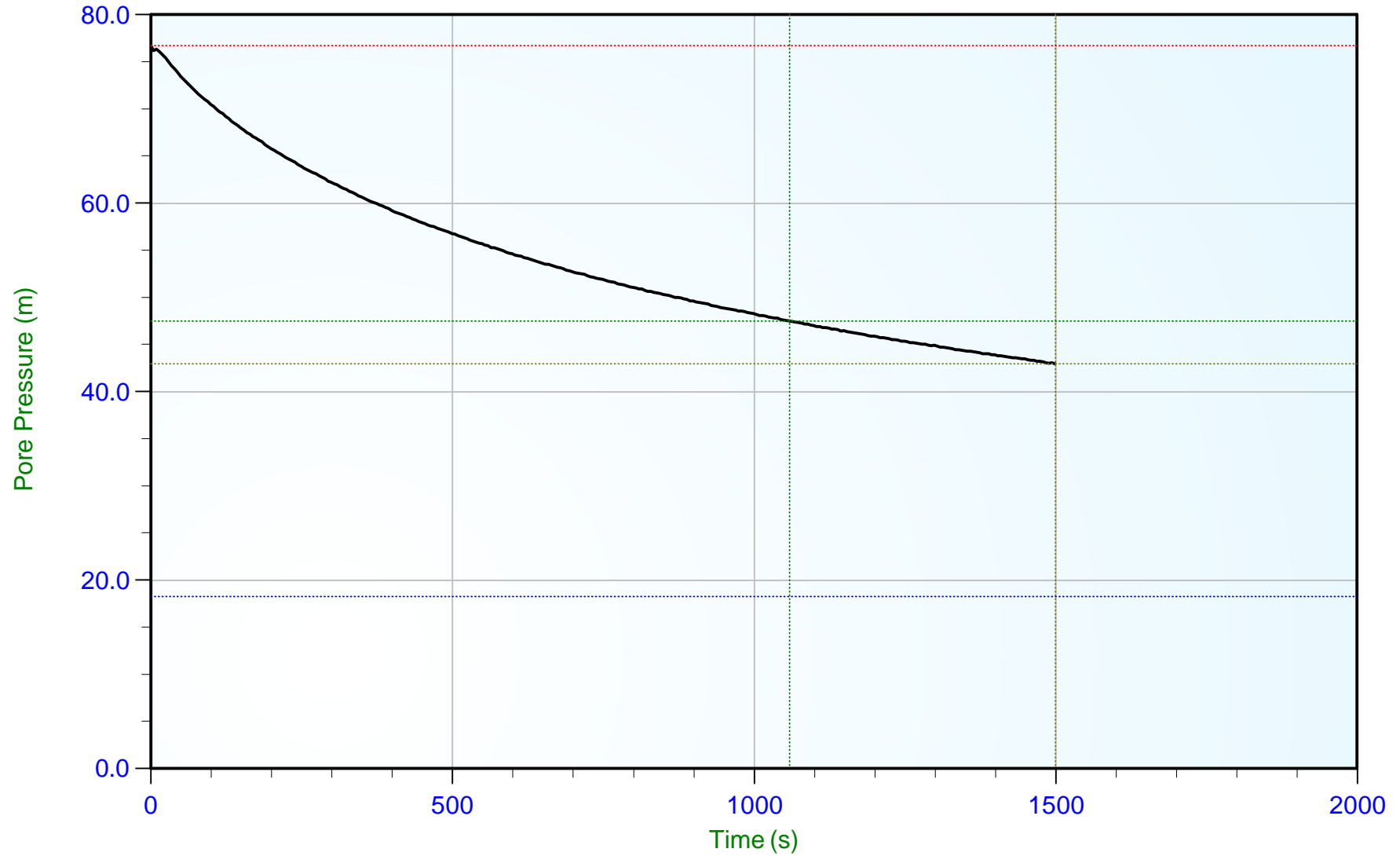
Date: 03-Oct-2013 07:44:50

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-12

Cone: AD374

Area: 15 sq cm



Trace Summary:

Filename: 13-05020_SP13-12.PPT
Depth: 20.000 m / 65.616 ft
Duration: 1500.0 s
U Min: 43.0 m
U Max: 76.7 m

WT: 1.700 m / 5.577 ft
Ueq: 18.3 m
U(50): 47.52 m

T(50): 1058.8 s
Ir: 100
Ch: 0.7 sq cm/min



Thurber Engineering

Job No: 13-05020

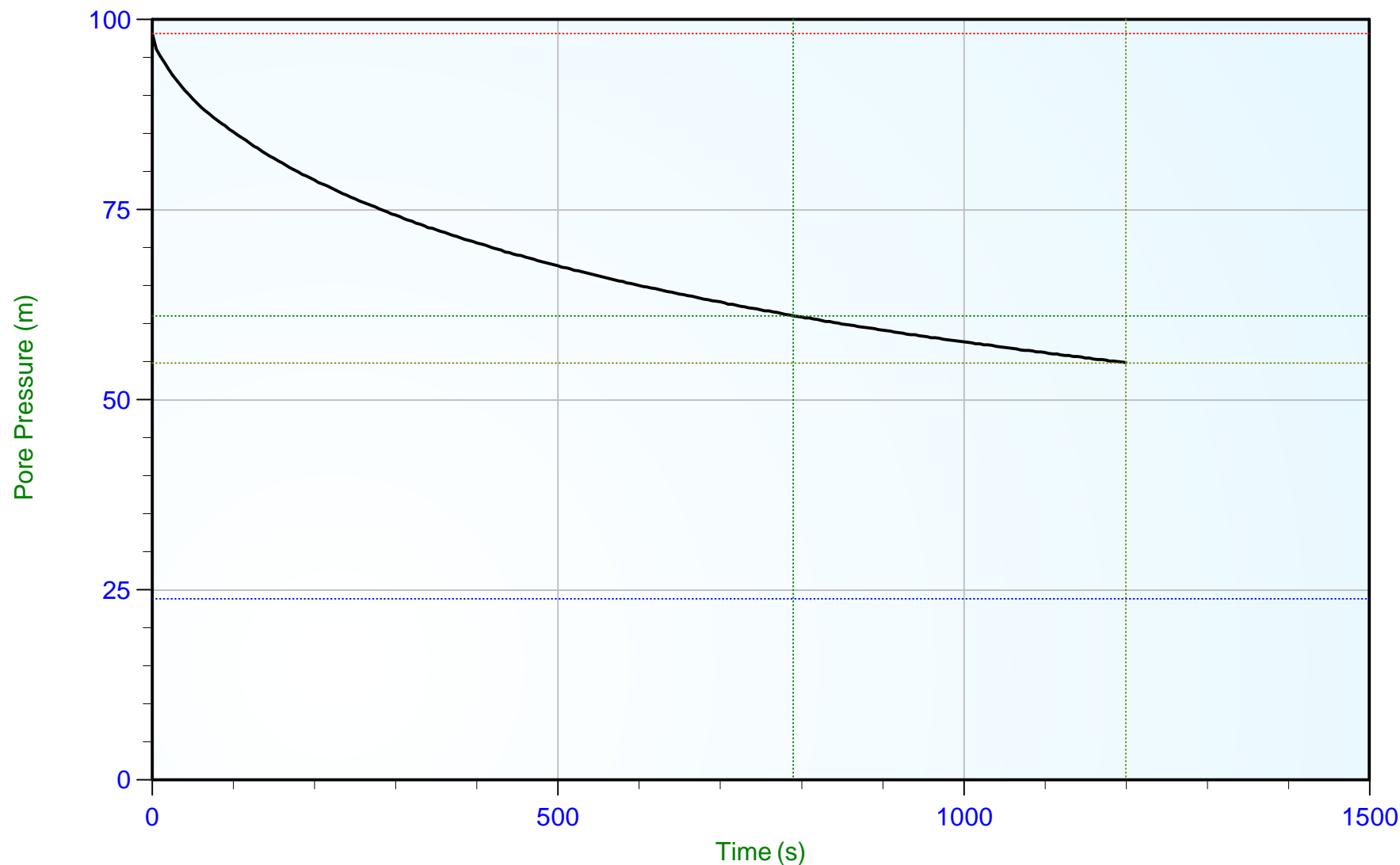
Date: 03-Oct-2013 07:44:50

Site: HWY 417 BEAR BROOK BRIDGE, OTTAWA, ON

Sounding: SCPT13-12

Cone: AD374

Area: 15 sq cm



Trace Summary:

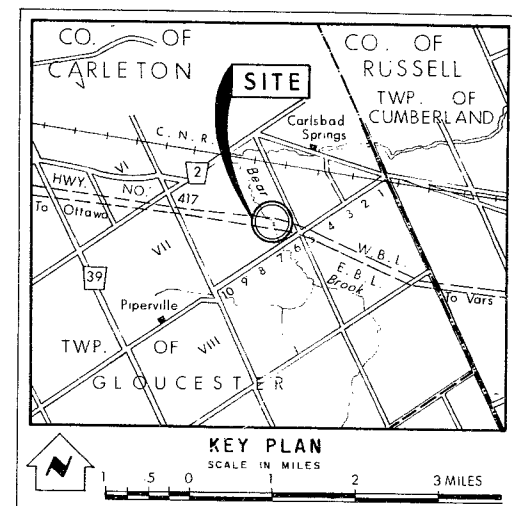
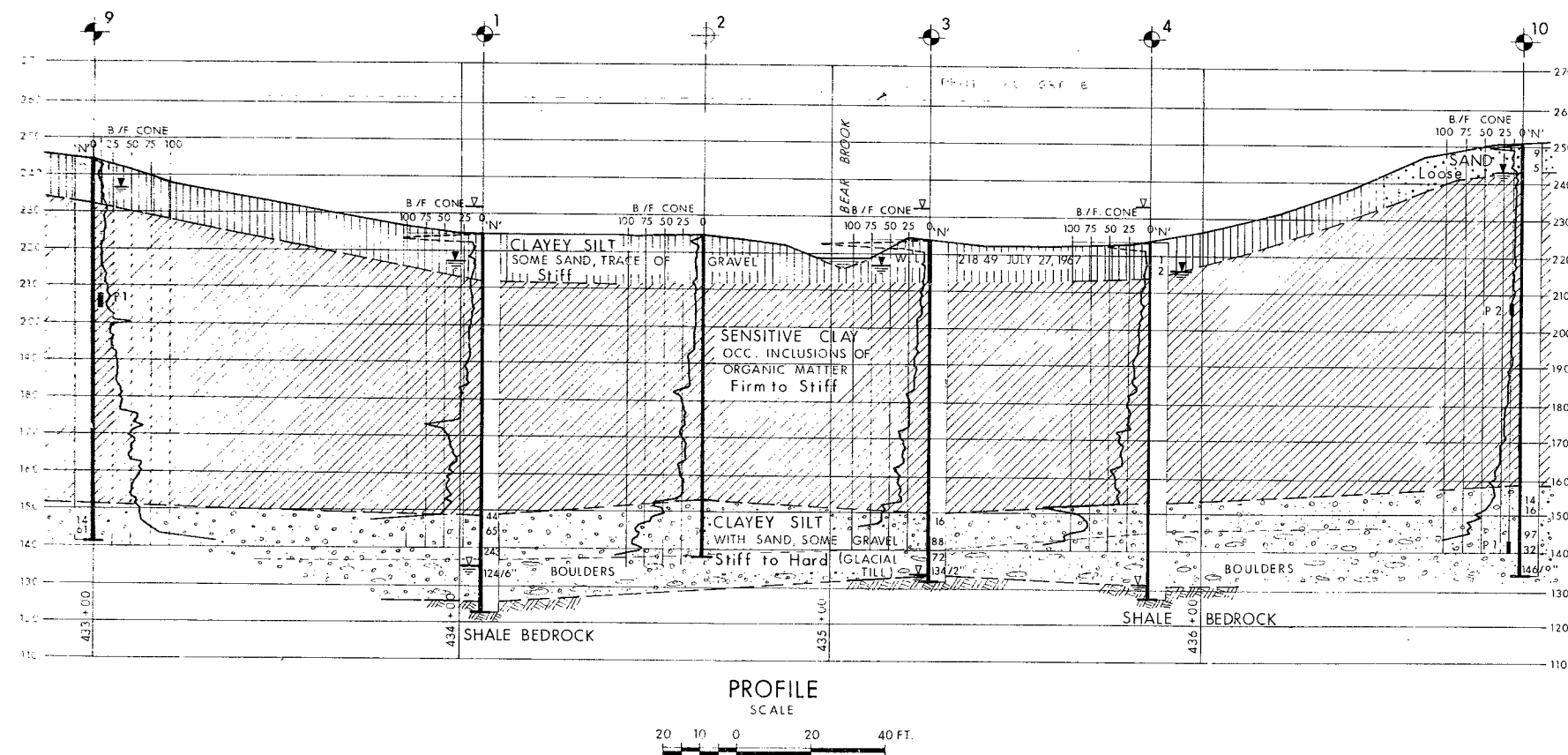
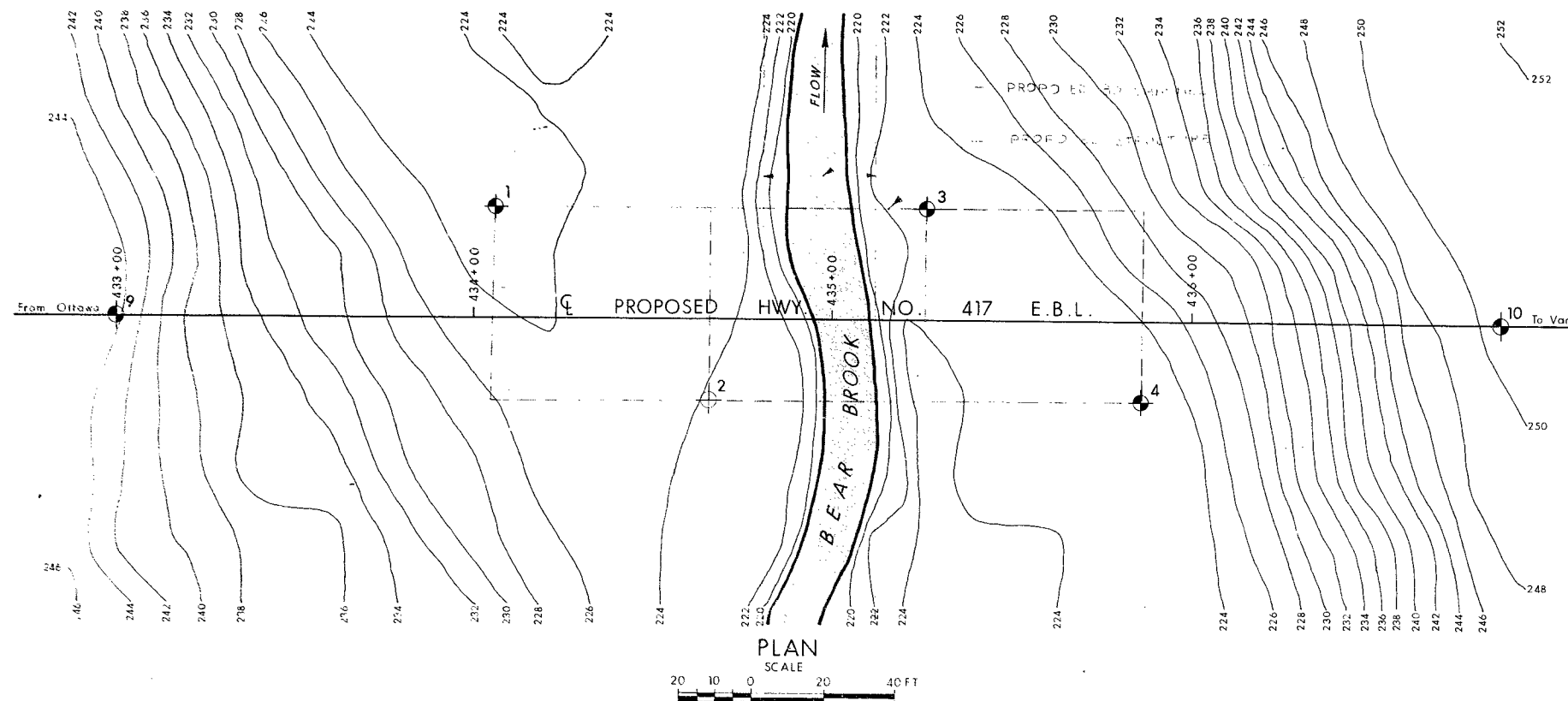
Filename: 13-05020_SP13-12.PRD
Depth: 25.000 m / 82.020 ft
Duration: 1200.0 s
U Min: 54.9 m
U Max: 98.2 m

WT: 1.100 m / 3.609 ft
Ueq: 23.9 m
U(50): 61.05 m

T(50): 790.1 s
Ir: 100
Ch: 0.9 sq cm/min

Appendix E
Historical Geotechnical Data

19-4406-6



LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation		
	Piezometer		Head
			Arterial Water
			Encountered
NO.	ELEVATION	STATION	OFFSET
1	223.5	434+06	31' LT
2	223.1	434+66	23' RT
3	223.9	435+26	31' LT
4	223.1	435+86	23' RT
9	244.0	433+00	CL
10	250.5	436+86	CL

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION - FOUNDATION SECTION

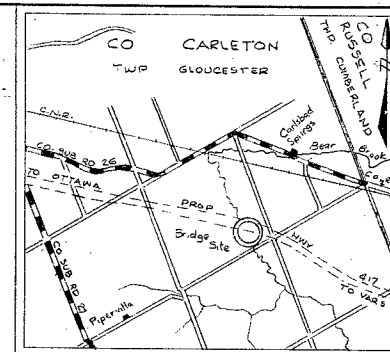
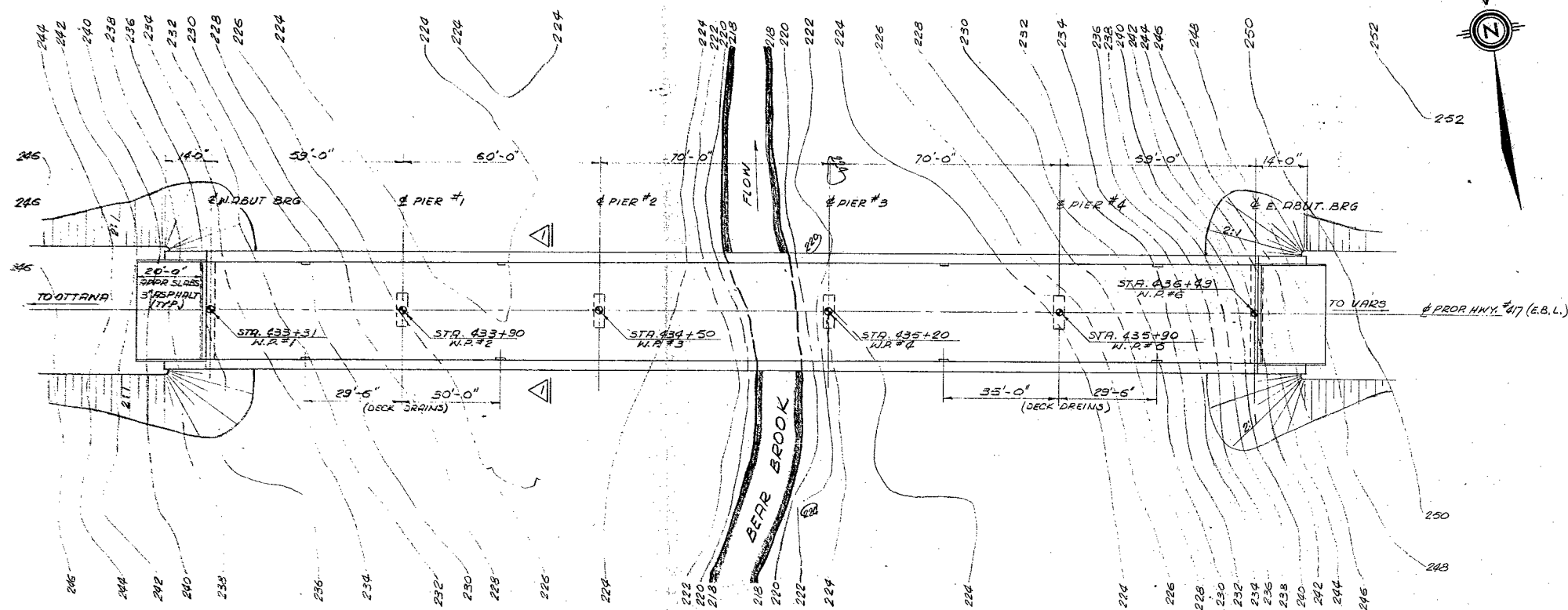
BEAR BROOK

KING'S HIGHWAY NO. 417 E.B.L. DIST. NO. 9
CO. CARLETON
TWP. GLOUCESTER LOT 6 CON. VII

BORE HOLE LOCATIONS & SOIL STRATA

SUBM'D B.D. CHECKED <input checked="" type="checkbox"/>	W.P. NO. 34 - 66-05	W.B.T. DRAWING NO.
DRAWN G.P. CHECKED <input checked="" type="checkbox"/>	JOB NO. 67 - F-111	67-F-111A
DATE FEB. 19 1968	SITE NO.	BRIDGE DRAWING NO.
APPROVED <i>A. Thomas</i>	CONT NO.	

REF. NO. E-4642-1



NOTES:

1. CLASS OF CONCRETE:

PRECAST MEMBERS - 5000 P.S.I.
DECK, CURBS & PARAPET WALLS - 4000 P.S.I.
REMAINDER - 3000 P.S.I.

2. CLEAR COVER ON REINFOR. STEEL:

FTS. ABUTS & PIERS	CURBS	PARAPET WALLS	DECK
3"	2"	1 1/2"	TOP - 1 1/2" BOT. - 1"

3. CONSTRUCTION NOTES:

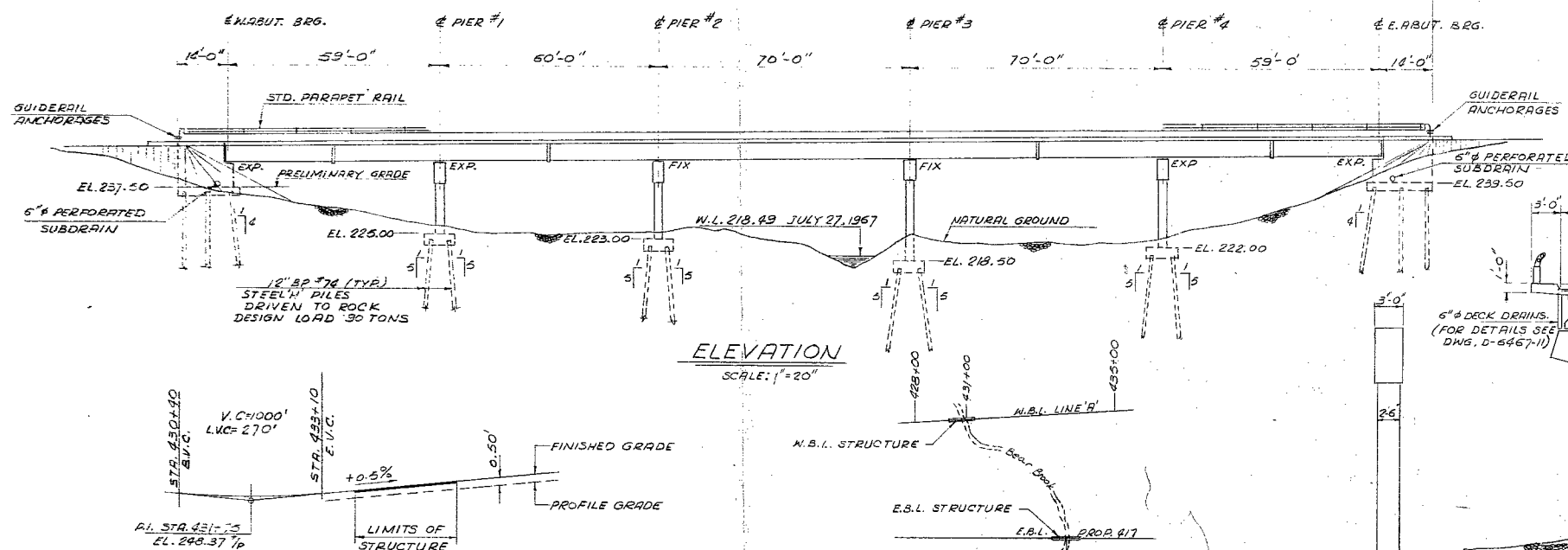
THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF $\pm 1/8"$.
NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED.

LIST OF DRAWINGS

1. GENERAL PLAN
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOOTING LAYOUT & REINFORCEMENT
4. ABUTMENTS & WINGWALLS
5. PIERS
6. PRESTRESSED GIRDERS & BEARINGS
7. DECK DETAILS & ELEVATIONS
8. PARAPET WALL DETAILS
9. STD. STEEL PARAPET RAIL
10. APPROACH SLABS
11. STANDARD DETAILS

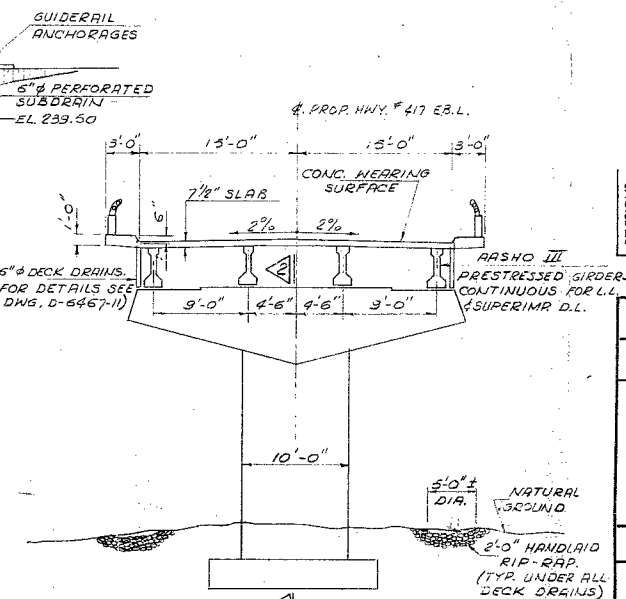
B.M. 245.34

GEOLOGIC DATUM
N. 44° W. IN W. ROOT OF 1' ELM
114' RT. OF 433+24 (E.B.L.)



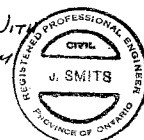
SITE PLAN

N.T.S.



SCALE: 1/8" = 1'-0"

PROTECT PILE CAP PIER 3 WITH
RIP RAP COVER ON STREAM
BANK



REVISIONS	DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO

BRIDGE DIVISION

67-F-111

BEAR BROOK BRIDGE

(E.B.L. STRUCTURE)

KING'S HIGHWAY No. 417 (E.B.L.)

DIST. No. 9

CO. CARLETON

LOT 5

CON. VII

GENERAL PLAN

APPROVED

SITE No. 3-255

W.P. No. 33-66-05

DESIGN J.S. CHECK S.B.D.

CONTRACT No.

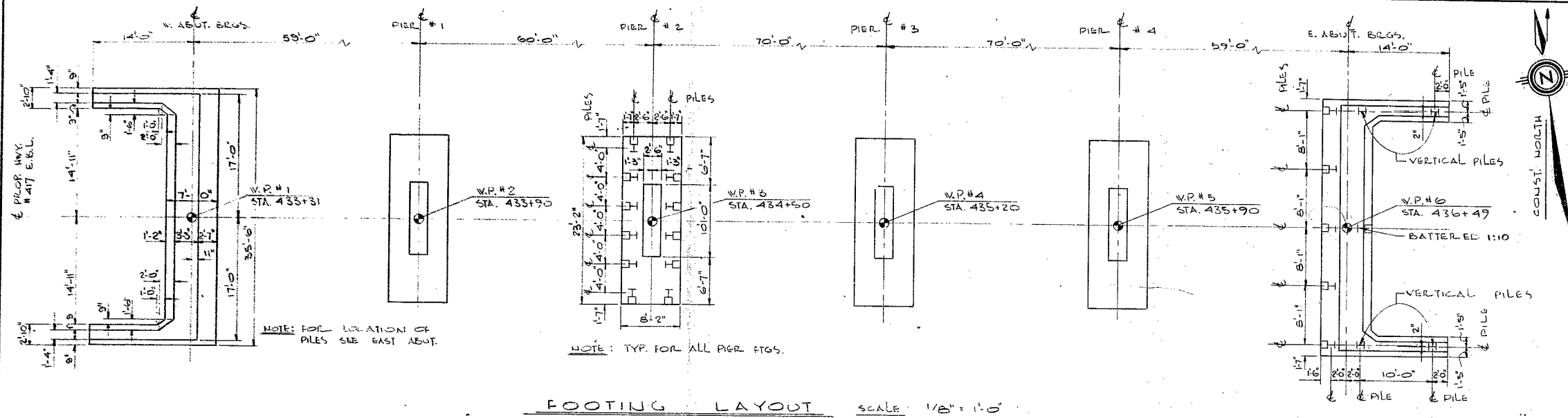
DRAWING B.S. CHECK S.B.D.

DRAWING No.

DATE NOV. 1968

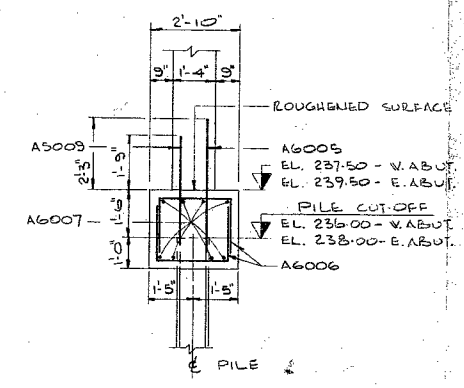
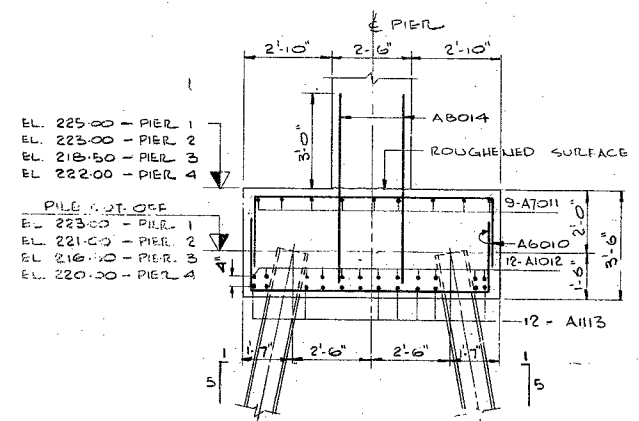
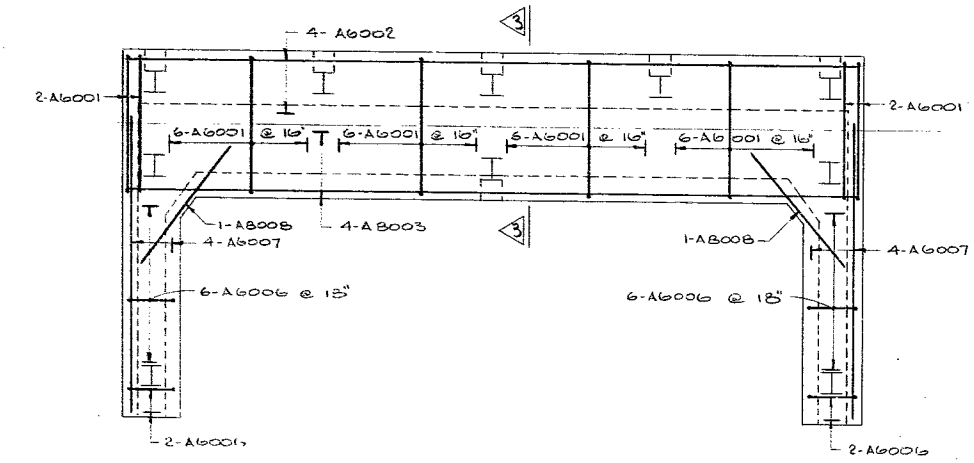
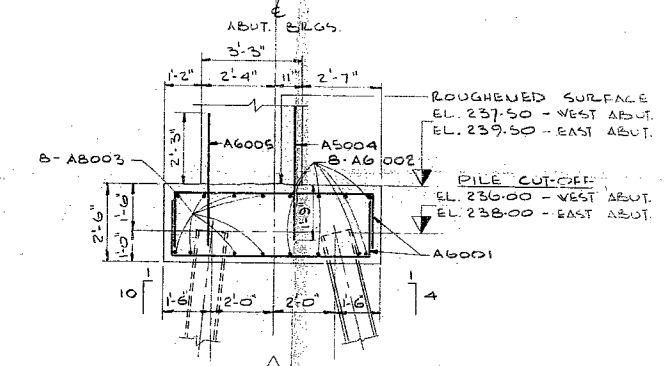
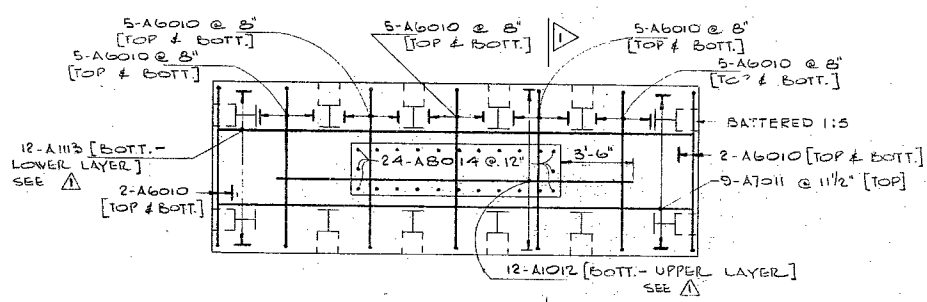
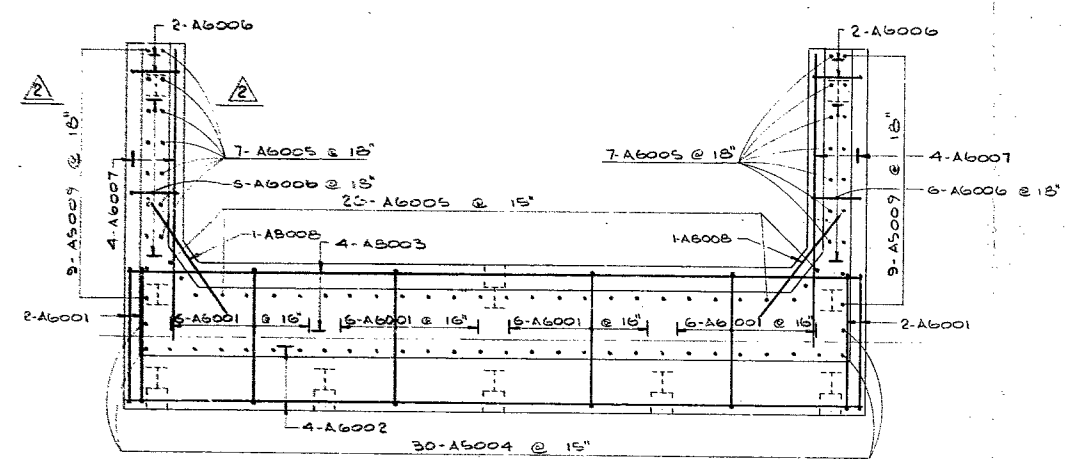
LOADING 1520-44

D-6467-1



STEEL H-PILE DATA			
LOCATION	NO.	LENGTH	TYPE
WEST ABUT.	10	114'-0"	
PIER 1	12	100'-0"	
PIER 2	12	97'-0"	H-PILES
PIER 3	12	88'-0"	12Bx74
PIER 4	12	92'-0"	
EAST ABUT.	10	111'-0"	
DESIGN LOAD - 90 TONS PER PILE			

NOTE:
ALL PILES TO BE DRIVEN TO PRACTICAL REFUSAL.



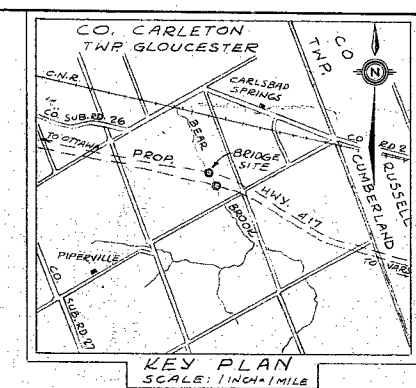
PLAN OF ABUTMENT FOOTINGS
SCALE: 1/4" = 1'-0"

SCALE: 3/8" = 1'-0"

SCALE: 3/8" = 1'-0"

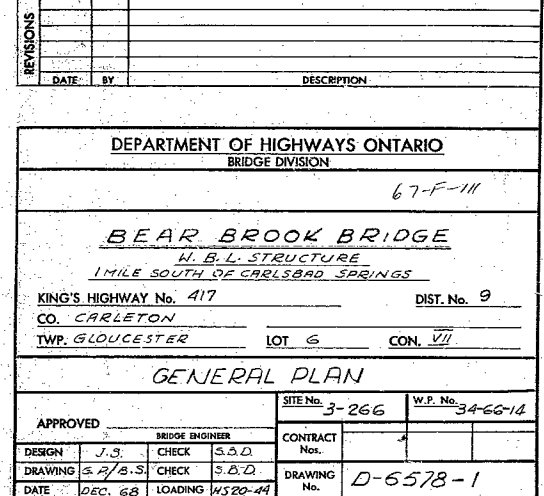


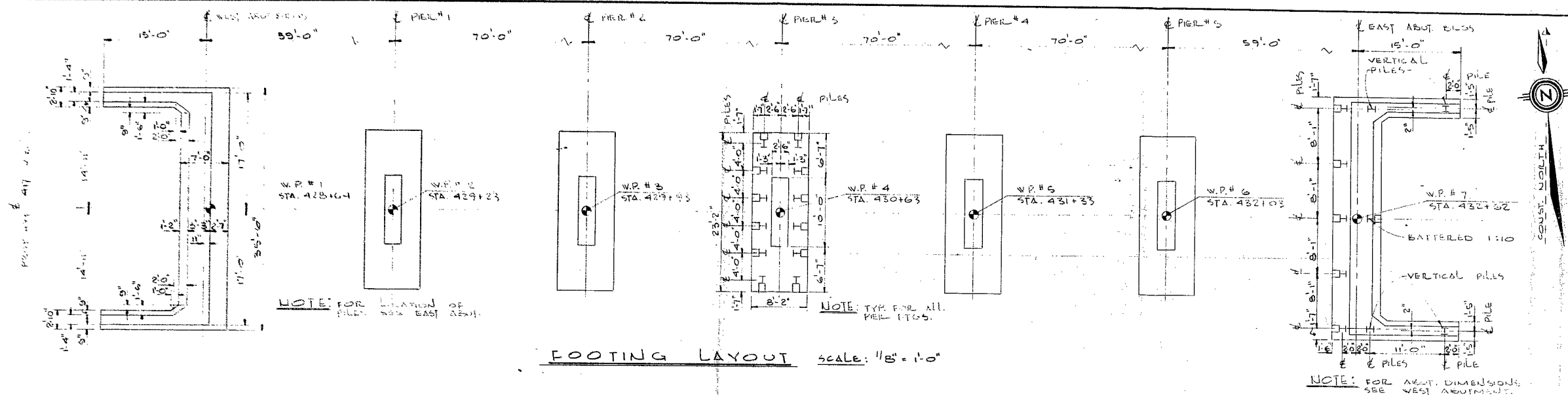
REVISIONS		DATE		BY		DESCRIPTION	
DEPARTMENT OF HIGHWAYS ONTARIO BRIDGE DIVISION 67-F-111 BEAR BROOK BRIDGE E.B.L. STRUCTURE KING'S HIGHWAY No. 417 E.B.L. DIST. No. 9 CO. CARLETON TWP. GLOUCESTER LOT 6 CON. VII							
FOOTING LAYOUT & REINFORCEMENT APPROVED _____ DESIGN J.S. CHECK S.B.D. CONTRACT No. _____ DRAWING P CHECK S.B.D. DRAWING No. D-6467-3 DATE NOV. 1965 LOADING H520-44							



LIST OF DRAWINGS

1. GENERAL PLAN
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOOTINGS LAYOUT & REINFORCEMENT
4. ABUTMENTS & WINGWALLS
5. PIERS
6. PRESTRESSED GIRDERS & BEARINGS
7. DECK DETAILS & ELEVATIONS
8. PARAPET WALL DETAILS
9. STD. STEEL PARAPET RAIL
10. APPROACH SLABS
11. STANDARD DETAILS

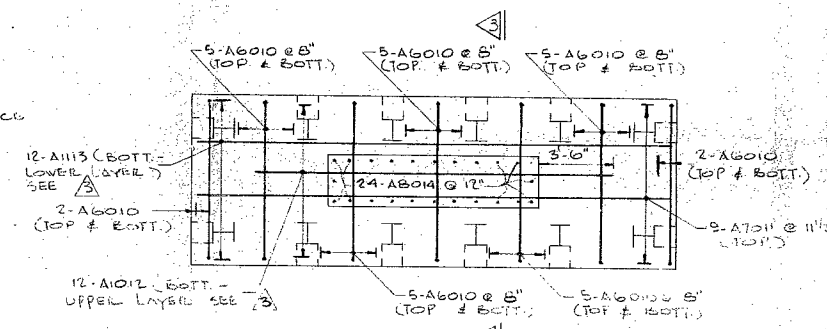
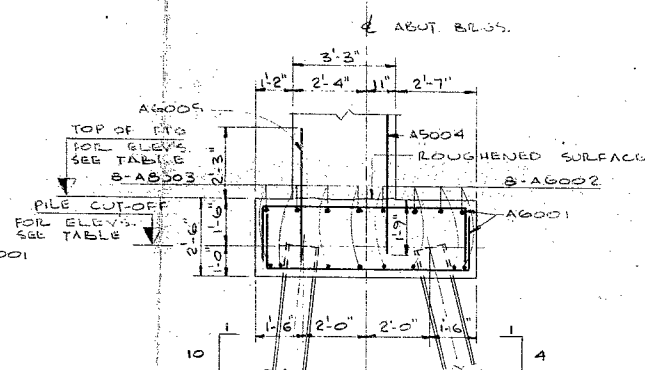
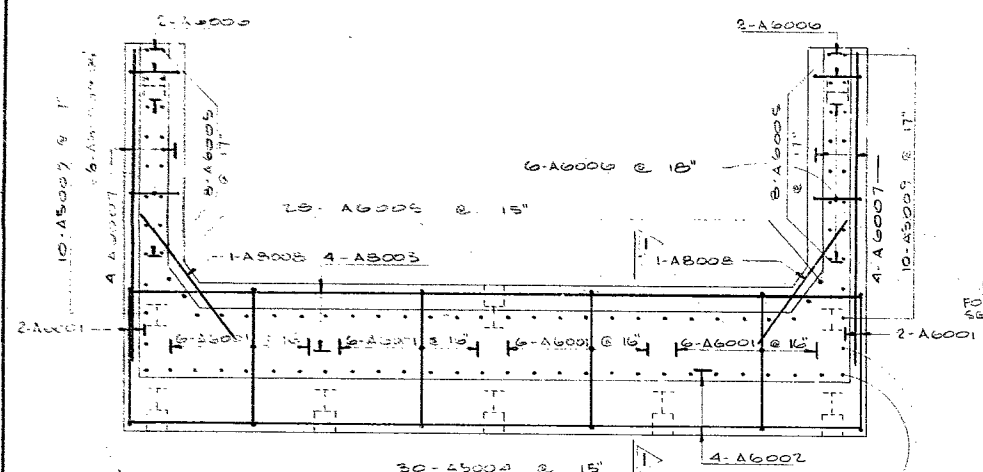




LOCATION	NO	LENGTH	TYPE
NEXT ABUT.	10	120'-0"	H-PILE 12-BF7
PIER # 1	12	107'-0"	
PIER # 2	12	101'-0"	
PIER # 3	12	95'-0"	
PIER # 4	12	102'-0"	
PIER # 5	12	102'-0"	H-PILE 12-BF7
PIER # 6	12	107'-0"	
NEXT ABUT.	10	113'-0"	

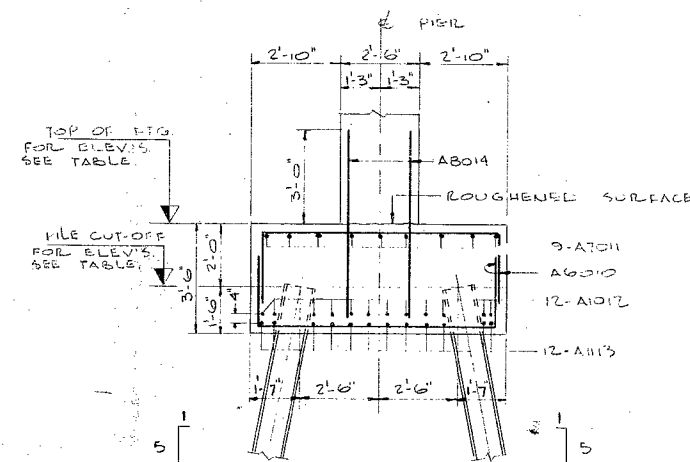
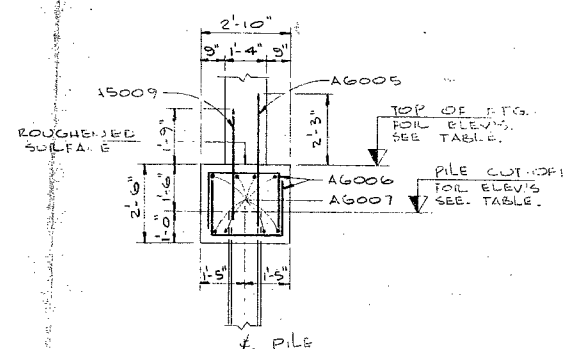
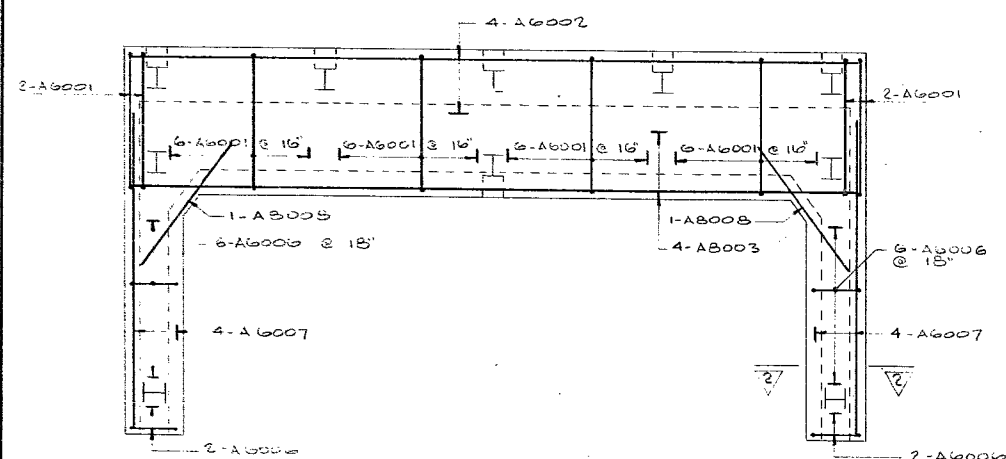
DESIGN LOAD - 90 TONS PER PILE

NOTE:
ALL FILES TO BE DELIVERED TO
PRACTICAL REFUSAL.



FOOTING ELEVATIONS		
LOCATION	TOP OF FTG. ELEVATIONS	PILE CUT-OFF ELEVATION
WEST ABUT.	240.00	235.00
PIER #1	228.00	235.00
PIER #2	222.00	235.00
PIER #3	215.50	213.50
PIER #4	221.00	219.00
PIER #5	223.00	221.00
EAST ABUT.	238.50	236.50

cler. does not agree
with that shown
on orig D-6578-1

[illegible][illegible]

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

67-F-111

BEAR BROOK BRIDGE

W.B.L. STRUCTURE

1 MILE SOUTH OF CARLSBAD SPRINGS

KING'S HIGHWAY No. 417 W.B.L.

DIST. No. 9

CO. CARLTON

TWP. CARLSBAD STER

LOT 6

CON. 51

FOOTING LAYOUT & REINFORCEMENT

APPROVED

BRIDGE ENGINEER

SITE No.

3-266

W.P. No.

34-66-14

CONTRACT

No.

DESIGN

J.S.

CHECK

S.B.D.

DRAWING

R

CHECK

S.B.D.

DATE

DEC. 1955

LOADING

4575-14

DRAWING No.

D-6578-3

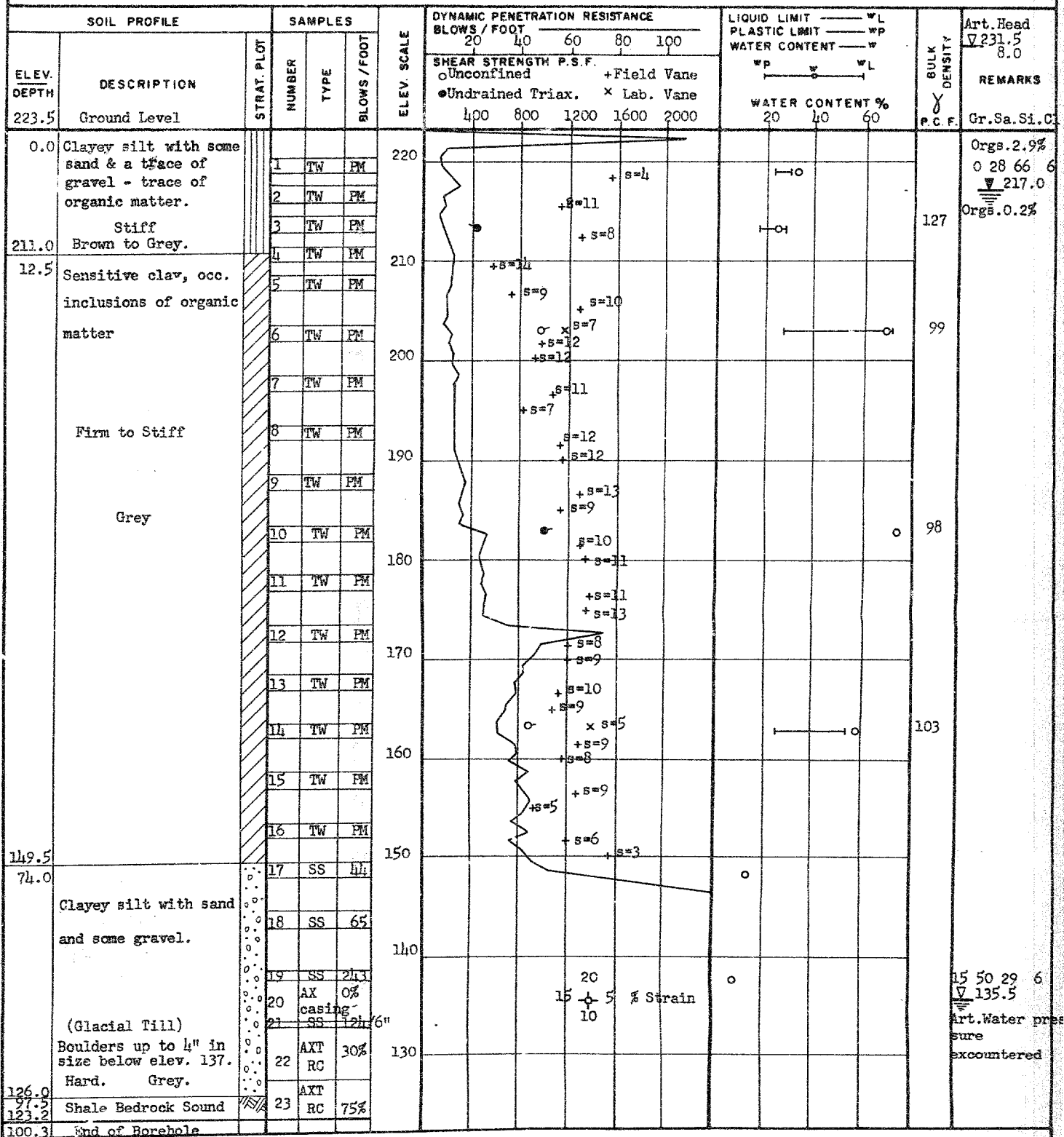
DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 67-F-111 LOCATION Sta. 434 + 06 @ Hwy. 417 EBL o/s 31' Lt. ORIGINATED BY CM
W.P. 34-66-05 BORING DATE Jan. 16-23, 1968 COMPILED BY WH
DATUM Geodetic BOREHOLE TYPE Diamond Drill, NX, BX Casing - AXT Core CHECKED BY WH



FOUNDATION SECTION

ORIGINATED BY CM

COMPILED BY _____ CM

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 67-F-111 LOCATION Sta. 435 + 26 @ Hwy. 417 EBL o/s 31' Lt. ORIGINATED BY CM
W.P. 34-66-05 BORING DATE Jan. 18 - 22, 1968 COMPILED BY WH
DATUM Geodetic BOREHOLE TYPE Diamond Drill NX BX CHECKED BY HL

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	20 40 60 80 100	WATER CONTENT %			
223.9	Ground Level							400 800 1200 1600 2000			▽ 232. Artes. Head
0.0	Probably clayey silt.										
214.											▽ 217.
	Probably Clay										
149.9											
74.0	Clayey silt with sand & some gravel. (Glacial Till) (occ. shale fragments below elev. 140) Stiff to hard. (gray)		1	SS	16						
			2	SS	88						
			3	SS	72						
133.6			4	SS	134.2"						
131.9	Shale Bedrock		5	MT RC	90%						▽ 133.9 90 Artesian water pressure encountered
92.0	End of Borehole										

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 67-F-111

LOCATION Sta. 435 + 86 @ Hwy. 417 EBL o/s 23' Rt.

ORIGINATED BY CM

W.P. 34-66-05

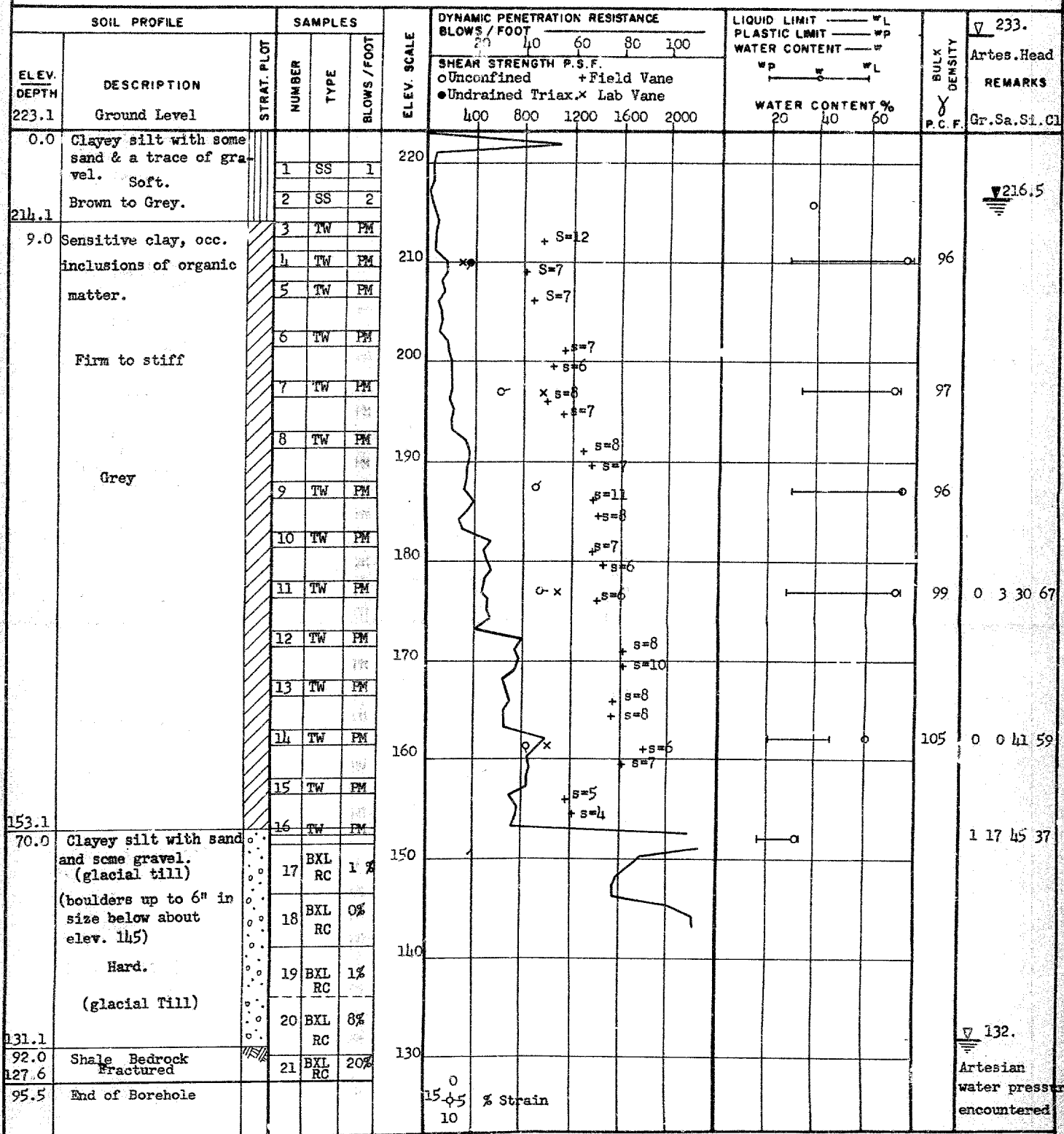
BORING DATE Jan. 10, 1968

COMPILED BY WH

DATUM Geodetic

BOREHOLE TYPE Diamond Drill NX - BX

CHECKED BY



DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO.5

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 67-F-111 LOCATION Sta. 430 + 75 @ Hwy. 417 W.B.L. o/s 38' Lt. ORIGINATED BY CM
W.P. 34-66-05 BORING DATE Jan. 4 - 17, 1968 COMPILED BY WH
DATUM Geodetic BOREHOLE TYPE Diamond Drill NX BX CHECKED BY WH

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT 20 40 60 80 100					SHEAR STRENGTH P.S.F. ○ Unconfined + Field Vane ● Undrained Triaxial Lab Vane 400 800 1200 1600 2000				WATER CONTENT % 20 40 60	
217.2	Water Level															Artes. Head	
215.5	Water															Gr. Sa. Si. Cl.	
1.7	Clayey silt or silty clay with some sand & a trace of gravel - trace of organic matter. Firm.		1	TW	PM											0 19 28 5	
			2	TW	PM											0 38 38 24	
208.2			3	TW	PM												
9.0	Sensitive clay, with occasional inclusions of organic matter (seams of sandy silt up to 1/2" thick below elev. 168)		4	TW	PM										95		
			5	TW	PM										95	0 2 28 70	
			6	TW	PM												
			7	TW	PM												
			8	TW	PM										96		
	Firm to stiff		9	TW	PM												
			10	TW	PM												
	Grey		11	TW	PM										94		
			12	TW	PM												
			13	TW	PM												
156.7			14	TW	PM										114		
60.5	Clayey silt with sand and some gravel (glacial till) (occasional seams & layers of sandy silt up to 6" thick throughout. Boulders up to 4" in size below elev. 130)		15	TW	PM											12 43 35 10	
			16	SS	30												
			17	SS	34												
	Stiff to hard.		18	SS	20											17 1 73 9	
	Grey		19	AXT	40%											Elev. 132.	
			20	RC	0%											Artesian	
			21	AXT	0%											Water	
122.4			22	RC	35%											Encountered	
94.8	Shale Bedrock																
116.9	Grey																
100.3	End of Borehole																

15.05 % Strain
10COPY WHEN DOCUMENTARY
WORK IS COMPLETED ON FILE

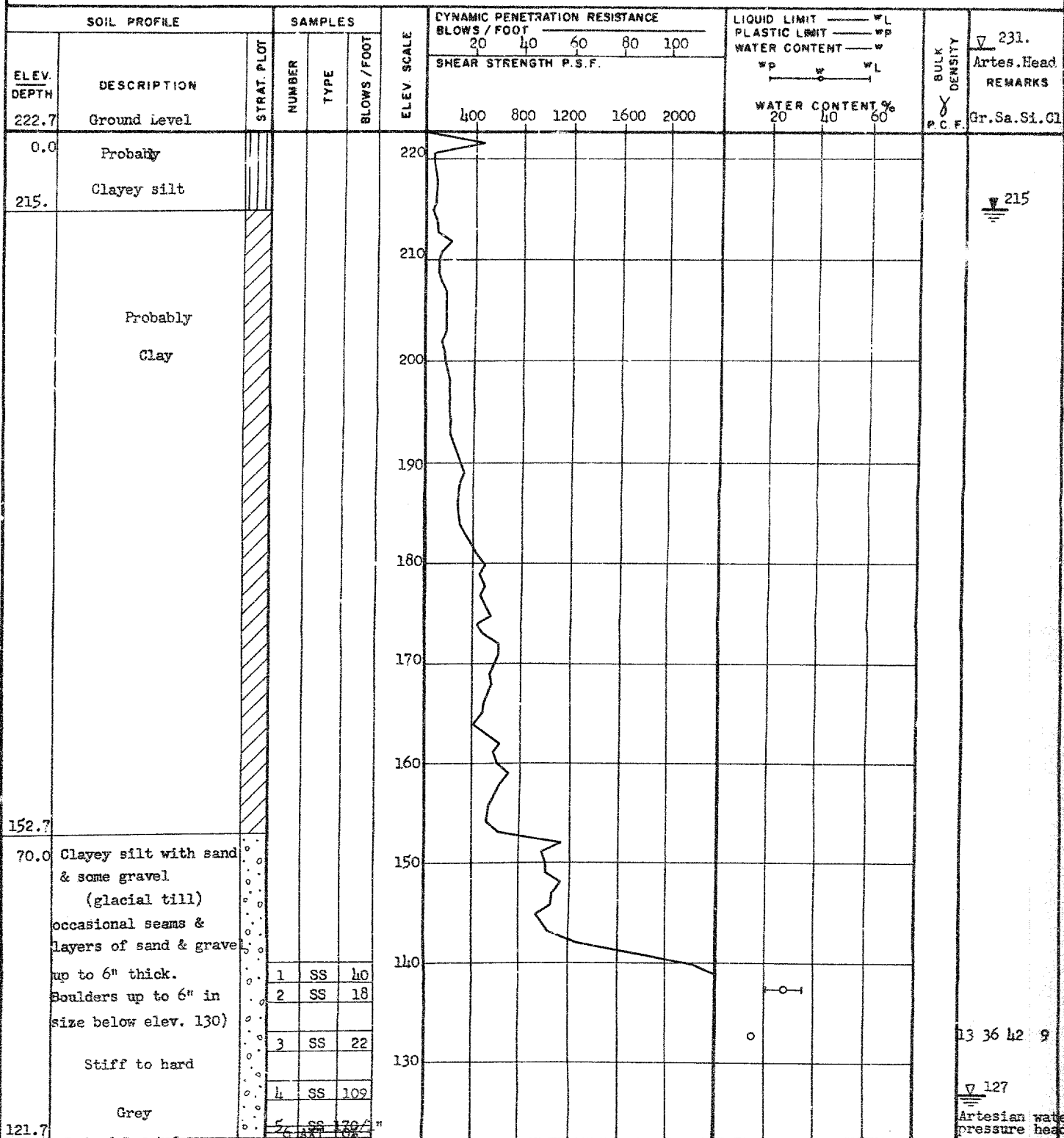
DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 67-F-111 LOCATION Sta. 431 + 75 @ Hwy. 417 WBL o/B 31' Rt. ORIGINATED BY CM
W.P. 34-66-05 BORING DATE Jan. 18 - 24, 1968 COMPILED BY WH
DATUM Geodetic BOREHOLE TYPE Diamond Drill NX BX Casing CHECKED BY [Signature]



13 36 42 9

127

Artesian water pressure head encountered

THIS DOCUMENT MAY BE REPRODUCED AS NOTIFIED ON FILM

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 67-F-111 LOCATION Sta. 432 + 02 @ Hwy. 417 WBL o/s 23' Lt. ORIGINATED BY CM
W.P. 34-66-05 BORING DATE Jan. 18, 1968 COMPILED BY WH
DATUM Geodetic BOREHOLE TYPE Diamond Drill CHECKED BY JK

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT ——— W _L		BULY DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT	BLOWS / FOOT		
224.9	Ground Level										
0.0	Probably										
217.	Clayey silt										
	Probably										
	Clay										
150.4	Probably										
74.5	Glacial Till										
144.6											
80.3	End of Cone Test										

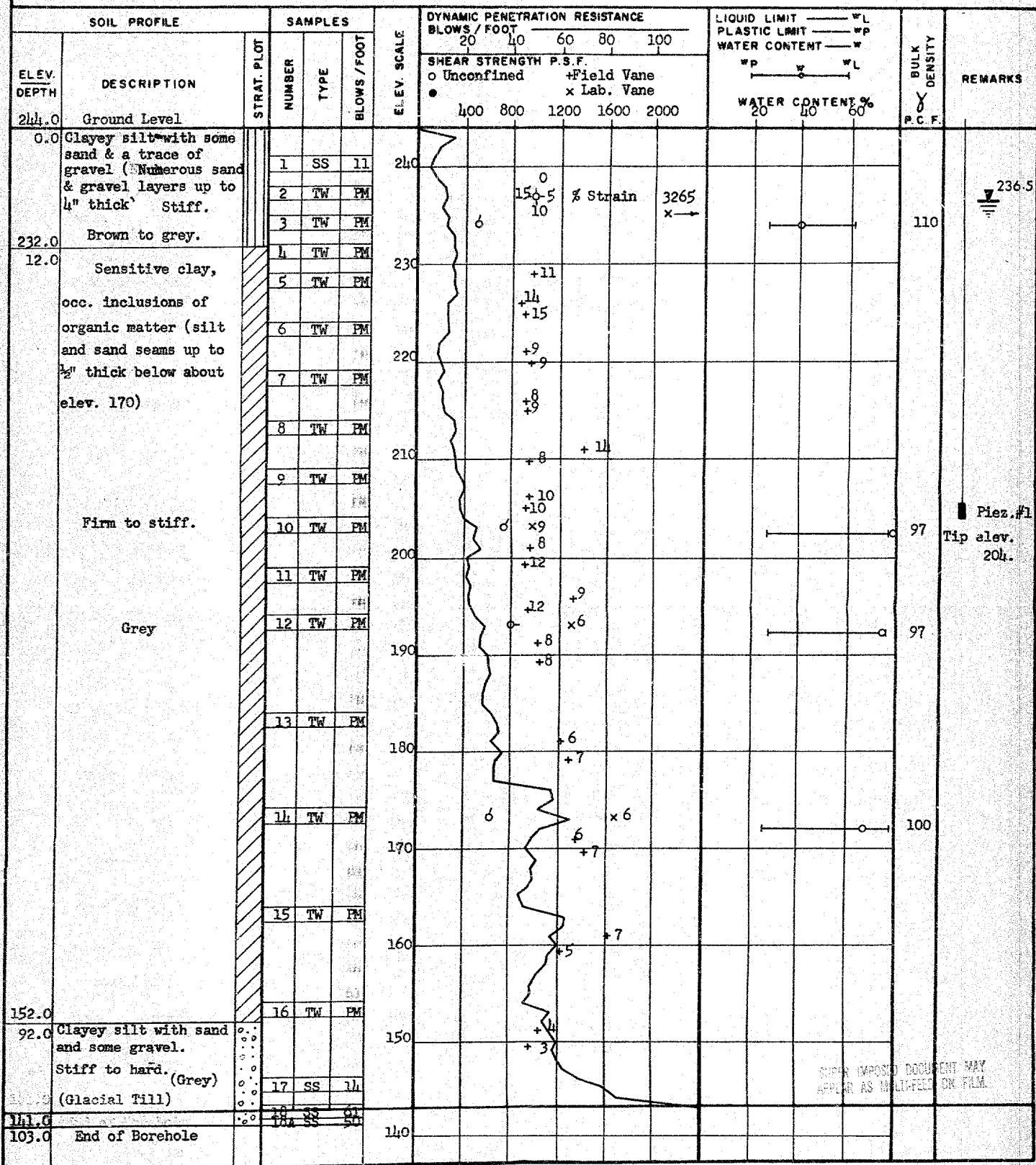
DEPARTMENT OF HIGHWAYS - ONTARIO				RECORD OF BOREHOLE NO. 8				FOUNDATION SECTION				
MATERIALS & TESTING DIVISION												
JOB 67-P-111				LOCATION Sta. 433 + 32 @ Hwy. 417 W. 1/2 s 3' Rt.				ORIGINATED BY CM				
W.P. 34-66-05				BORING DATE Jan. 3 - 4, 1968				COMPILED BY WH				
DATUM Geodetic				BOREHOLE TYPE Diamond Drill HX - BX casing - AXT Core				CHECKED BY <i>LL</i>				
SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — W _L		BULK DENSITY		REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	BLOWS / FOOT	WATER CONTENT — W _P	WATER CONTENT %	ρ _c F		
250.5	Ground Level											
0.0	Clayey silt with some sand & a trace of gra. occ. seams of silt. Brown to grey. Firm		1	SS	9							0 34 54 12
212.5			2	SS	6							242.9
8.0	Layered clay (alternate brown & red-brown layers up to 5" thick.		3	2" TW	PM							
216.5			4	2" TW	PM							0 0 30 70
14.0	Sensitive clay, occasional inclusions of organic matter.		5	2" TW	PM							
			6	2" TW	PM							
			7	2" TW	PM							0 1 35 64
	Firm to stiff		8	2" TW	PM							Plan #1 R Tip at Elev. 217.2
			9	2" TW	PM							
	Grey		10	2" TW	PM							
			11	2" TW	PM							
			12	2" TW	PM							
			13	2" TW	PM							
			14	2" TW	PM							
			15	2" TW	PM							
			16	2" TW	PM							
			17	2" TW	PM							
			18	2" TW	PM							
			19	2" TW	PM							
155.0			20	2" TW	PM							
95.5	Clayey silt with sand and some gravel (glacial till) (occasional seams of sandy silt up to 1/4" thick. Boulders up to 5" in size below elev. 114h)		21	SS	48							6 43 40 11
	Stiff to hard.		22	SS	169/20							
134.0	Grey		23	AXT	0%							
116.5	Shale Bedrock		24	AXT	85%							
128.5	Sound below elev. 130			RC	Rec.							
122.0	End of Borehole											

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 67-F-111 LOCATION Sta. 433 + 00 @ Hwy. 417 EBL ORIGINATED BY WH
W.P. 34-66-05 BORING DATE Jan. 25-30, 1966 COMPILED BY CM
DATUM Geodetic BOREHOLE TYPE Diamond Drill- NX BX Casing CHECKED BY AK



DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 67-P-111

LOCATION Sta. 436 + 86 & Hwy. 417 EBL

ORIGINATED BY CM

W.P. 34-66-05

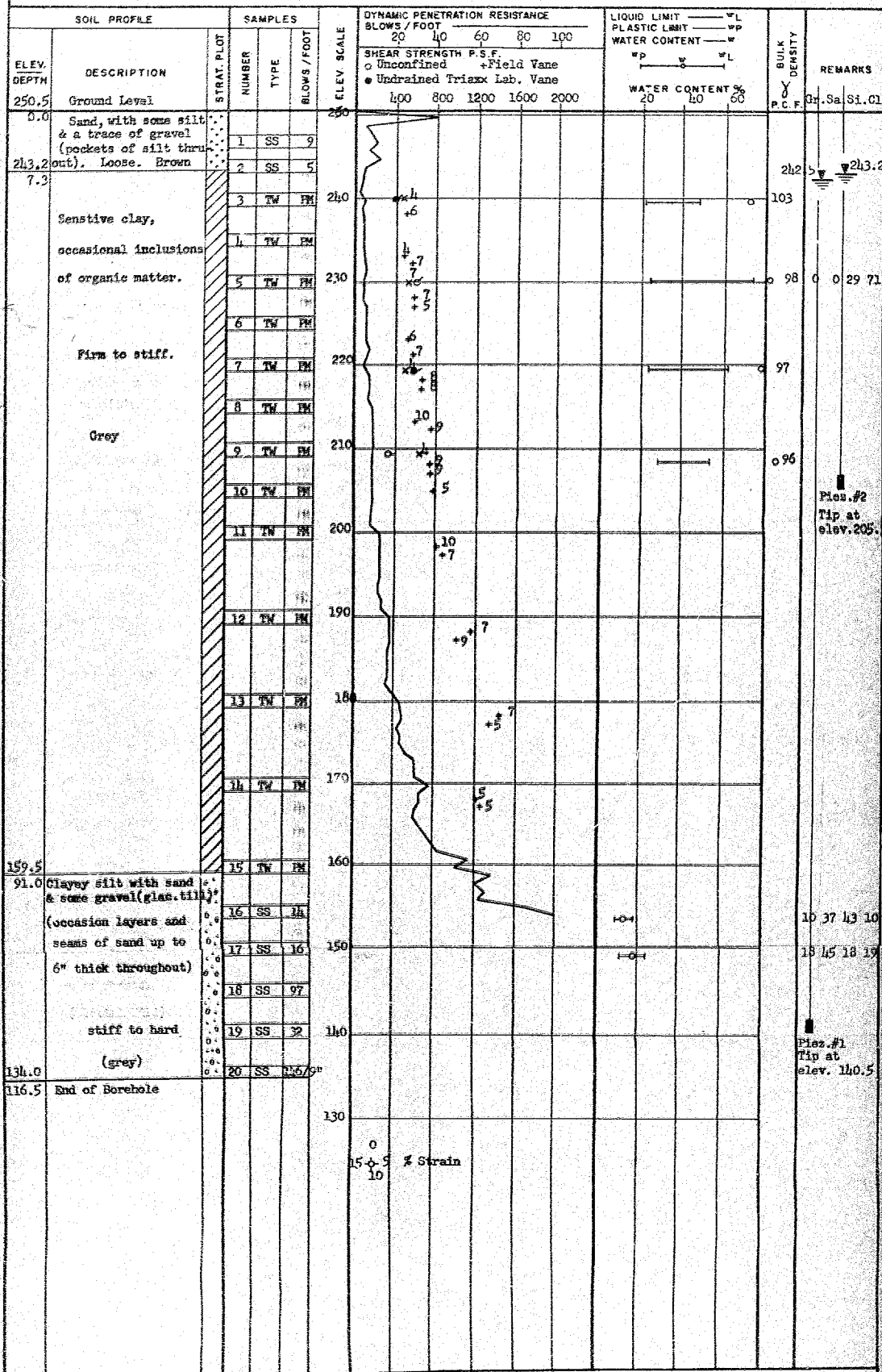
BORING DATE Jan. 23, 1968

COMPILED BY CM

DATUM Geodetic

BOREHOLE TYPE Diamond Drill

CHECKED BY



DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 67-F-111

LOCATION Sta. 429 + 60 @ Hwy. 417 WBL

ORIGINATED BY GEH

W.P. 34-66-05

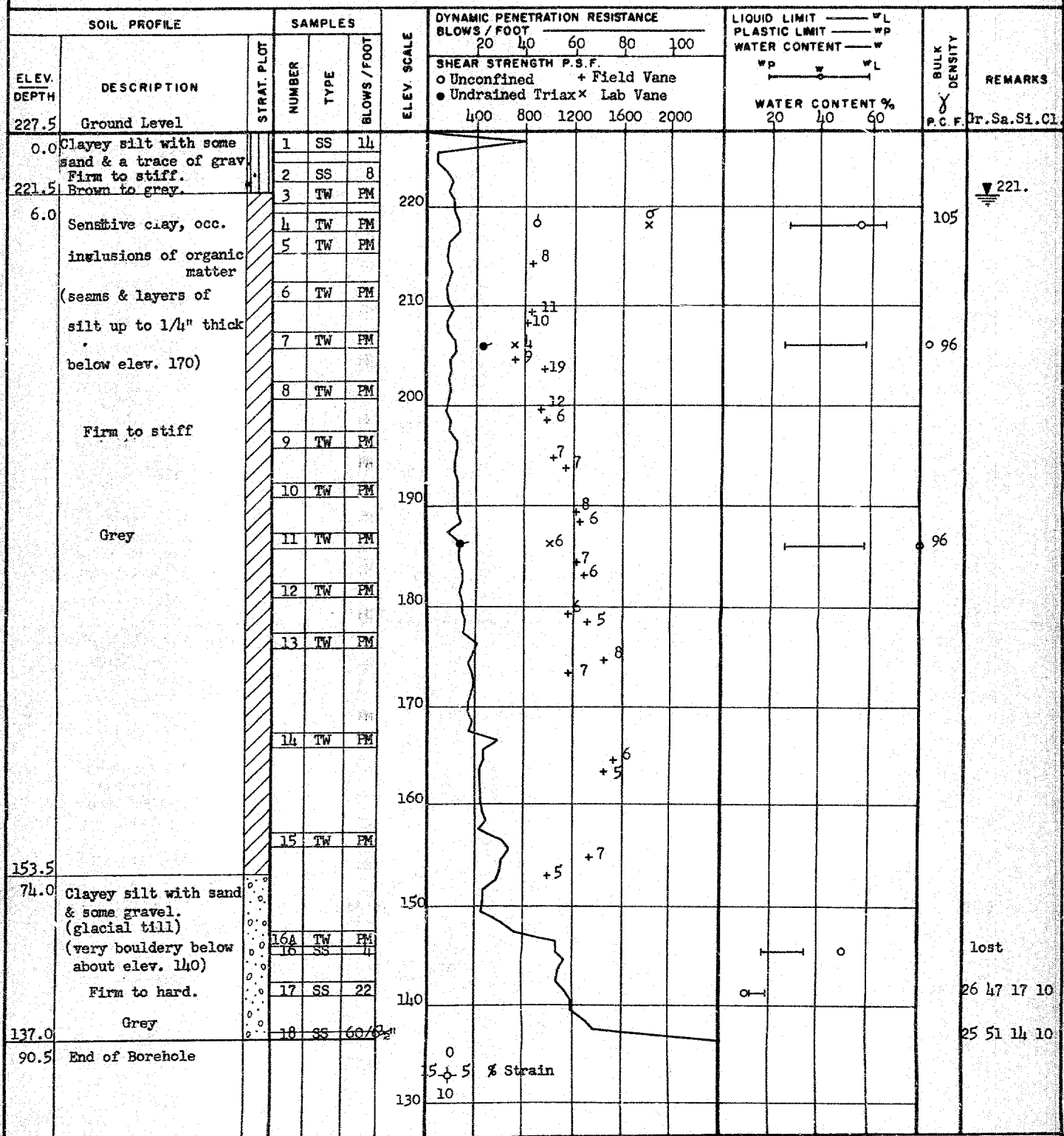
BORING DATE Jan. 25 - 29, 1968

COMPILED BY CM

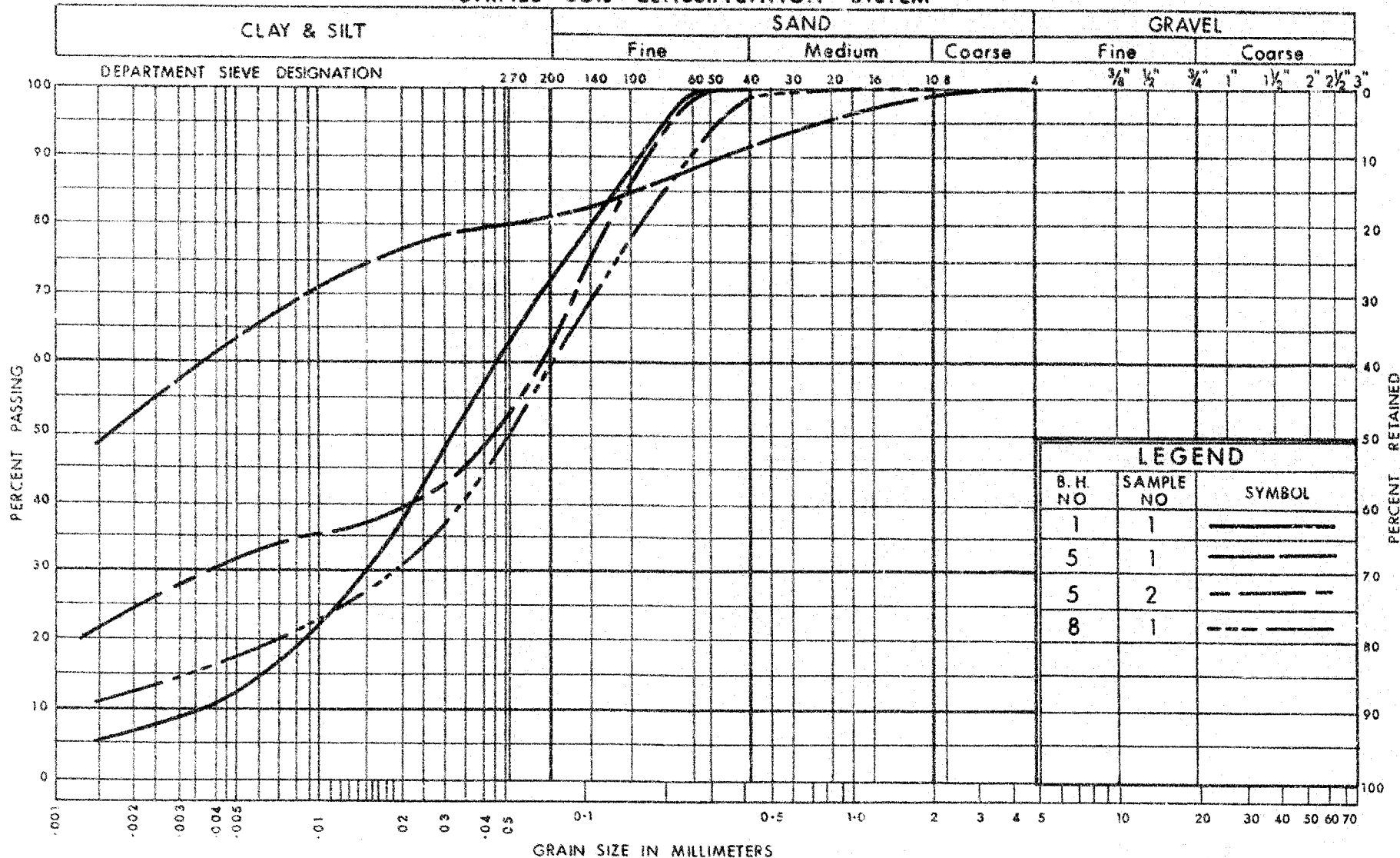
DATUM Geodetic

BOREHOLE TYPE Diamond Drill NX BX

CHECKED BY



UNIFIED SOIL CLASSIFICATION SYSTEM

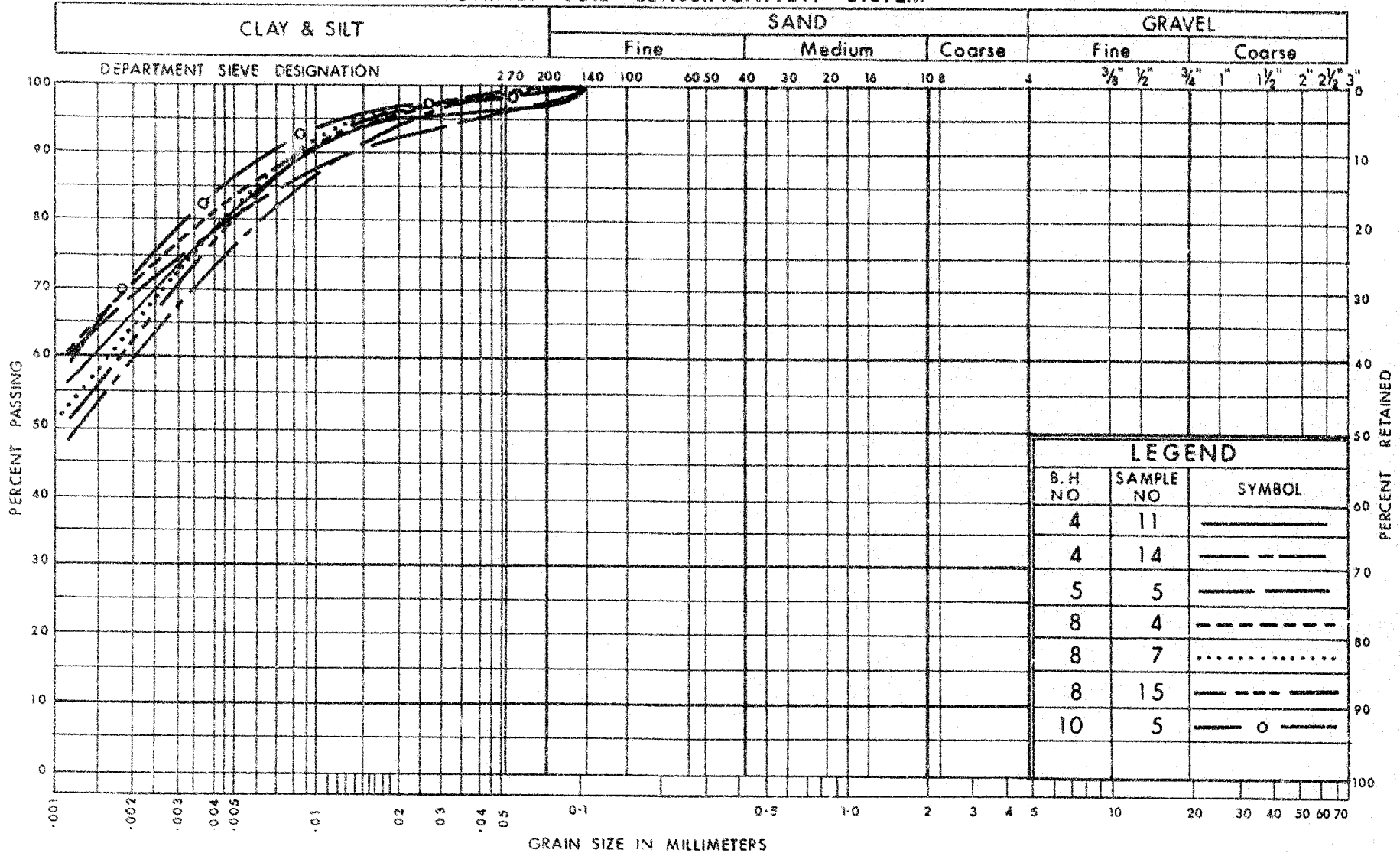


DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION CLAYEY SILT WITH SAND

W.P. No. 34 - 66 - 05
JOB No. 67 - F - 111
FIGURE NO. 6

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

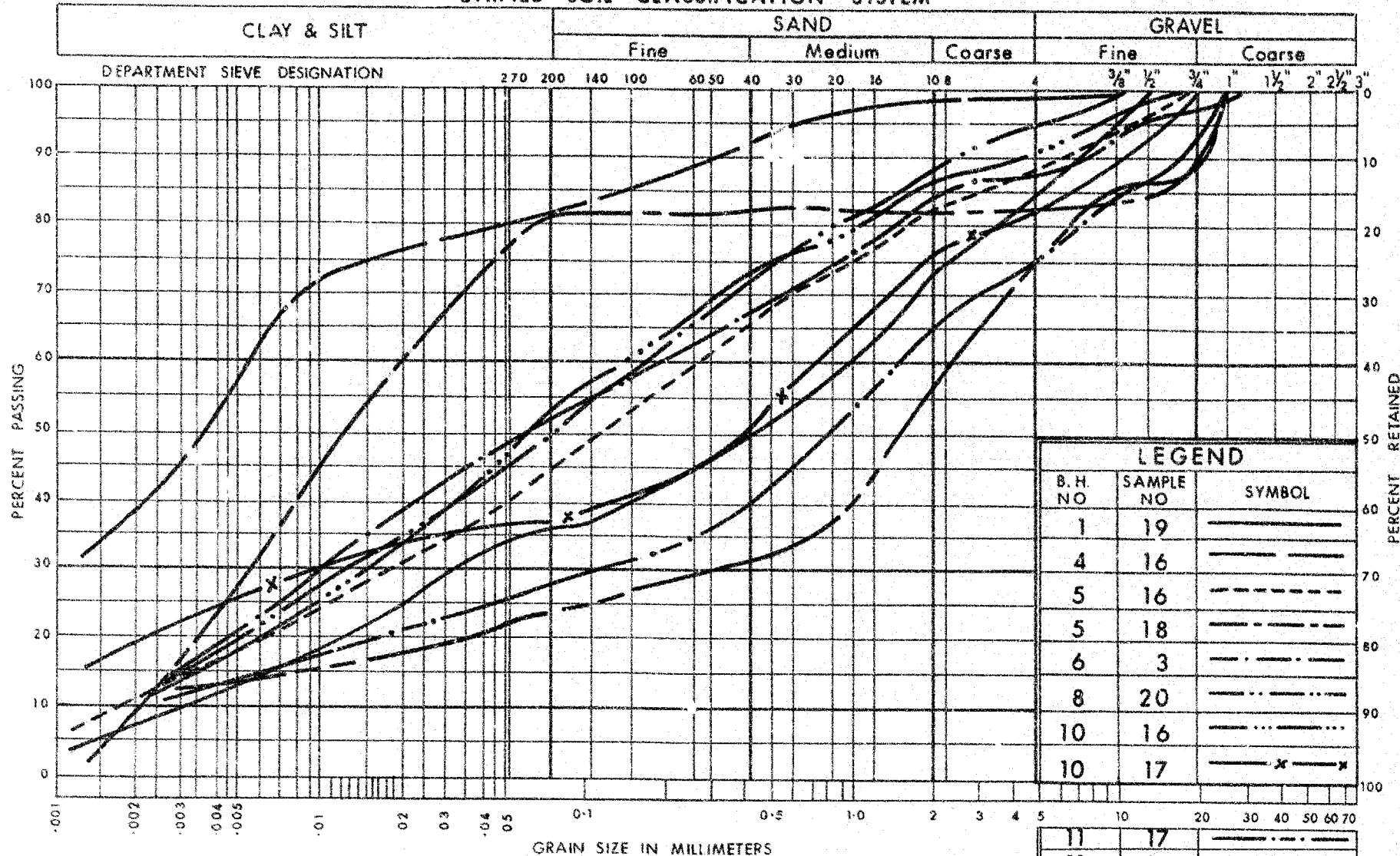
GRAIN SIZE DISTRIBUTION SENSITIVE CLAY

W.P. No. 34 - 66 - 05

JOB No. 67 - F - 111

FIGURE NO. 7

UNIFIED SOIL CLASSIFICATION SYSTEM



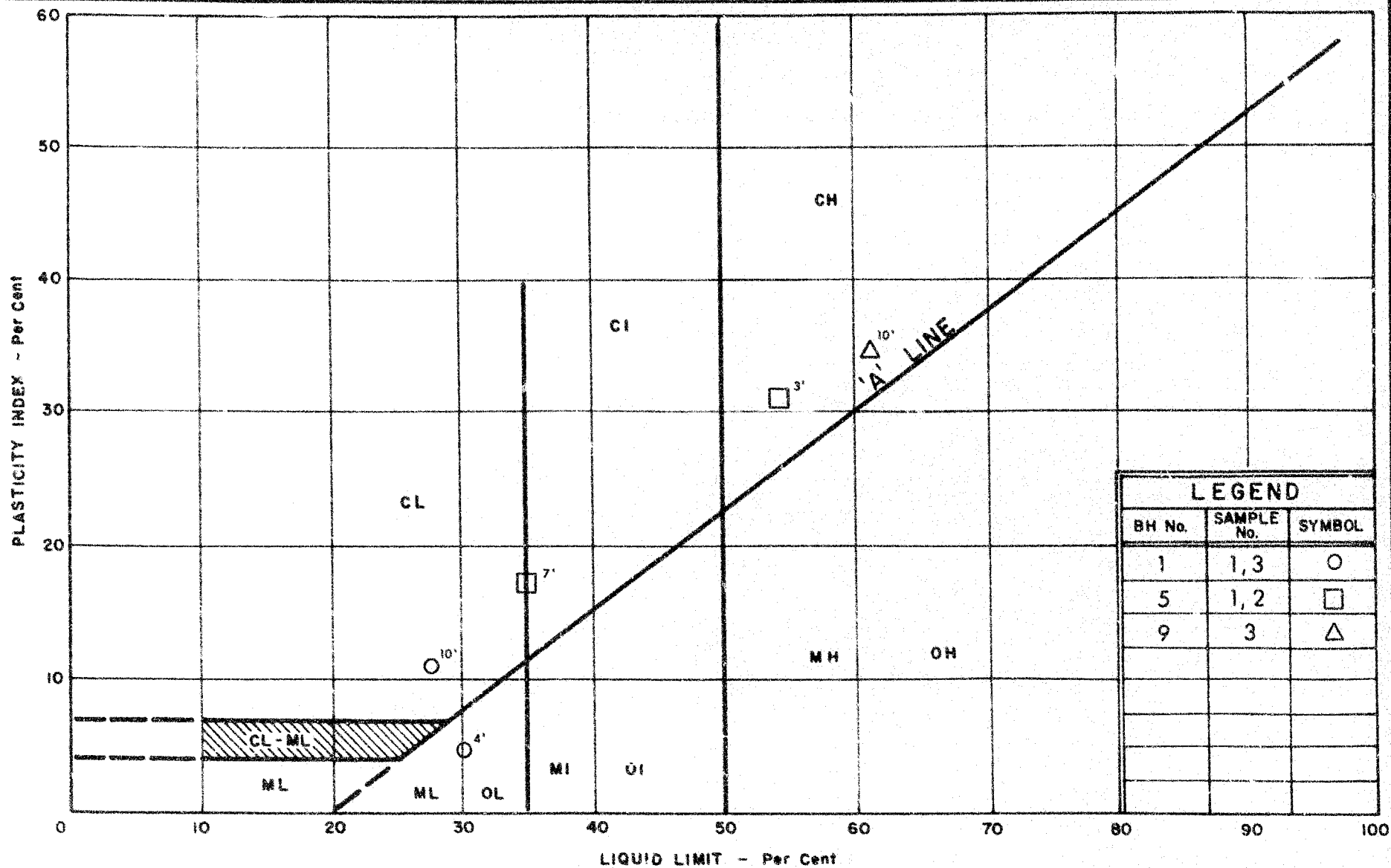
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH SAND & SOME GRAVEL
(GLACIAL TILL)

W.P. No. 34-66-05

JOB No. 67-F-111

FIGURE NO. 8



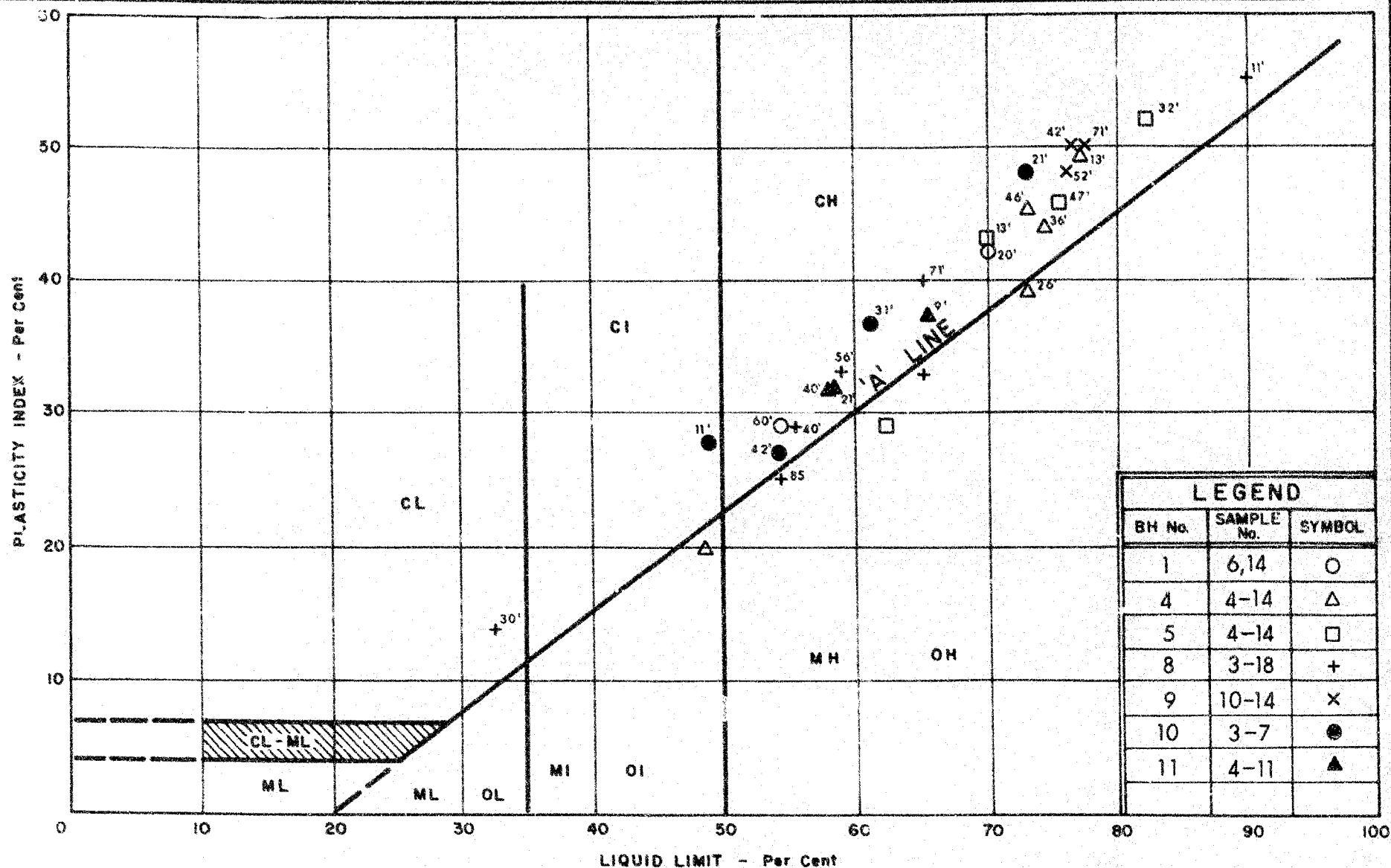
DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAYEY SILT WITH SAND

WP. No. 34-66-05

JOB No. 67-F-111

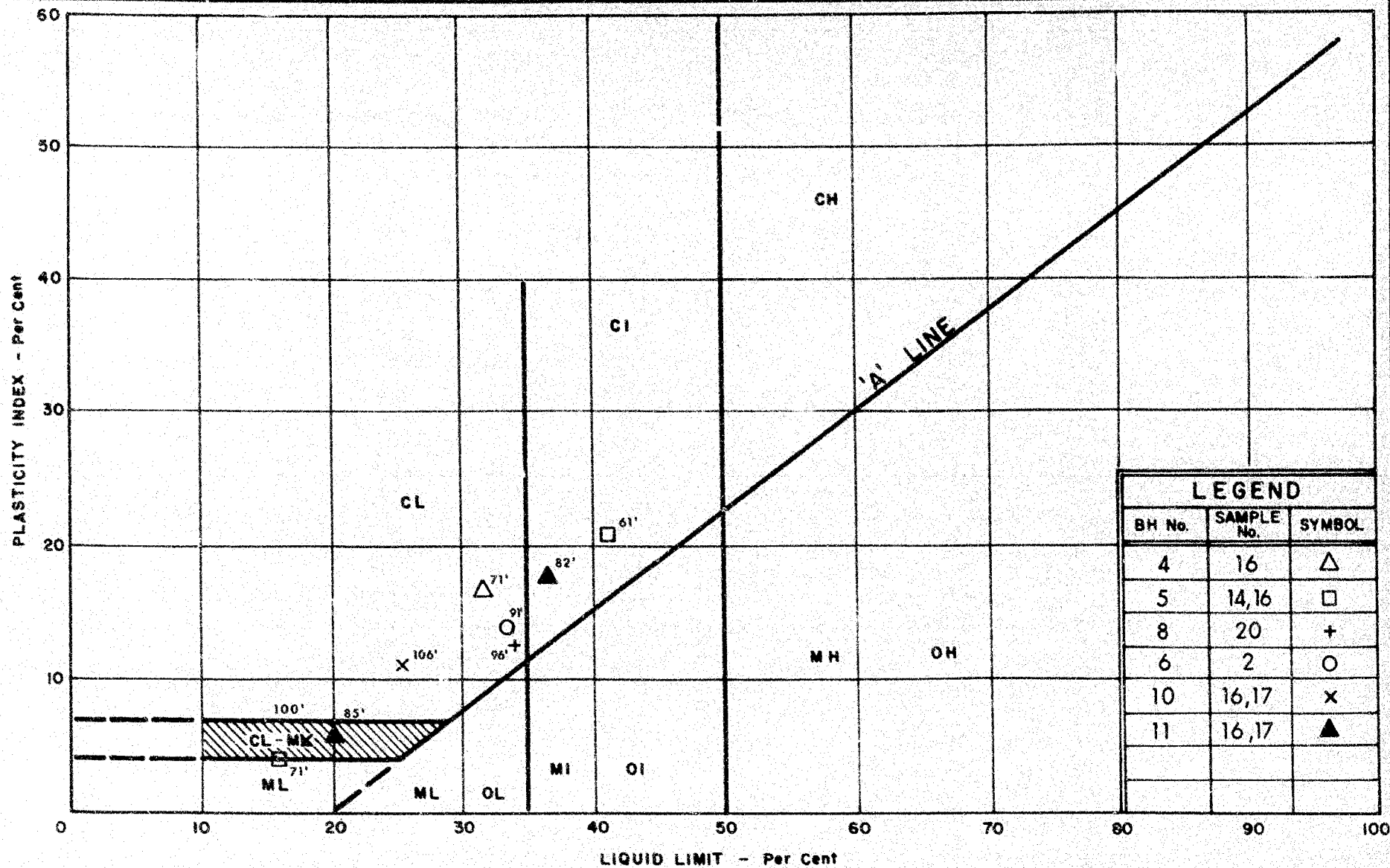
FIGURE NO. 9



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART GREY SENSITIVE CLAY

WP No. 34-66-05
JOB No. 67-F-111
FIGURE NO. 10



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

PLASTICITY CHART CLAYEY SILT WITH SAND & SOME GRAVEL (GLACIAL TILL)

W.P. No. 34 - 66 - 05

JOB No. 67 - F - 111

FIGURE NO. 11

VOID RATIO vs PRESSURE

$W_L = 72.7$
 $W_p = 27.6$
 $W = 71.3\%$
 $C_c = 2.16$

BORE HOLE 4
 SAMPLE 11
 DEPTH 46'2"
 ELEV. 117.4

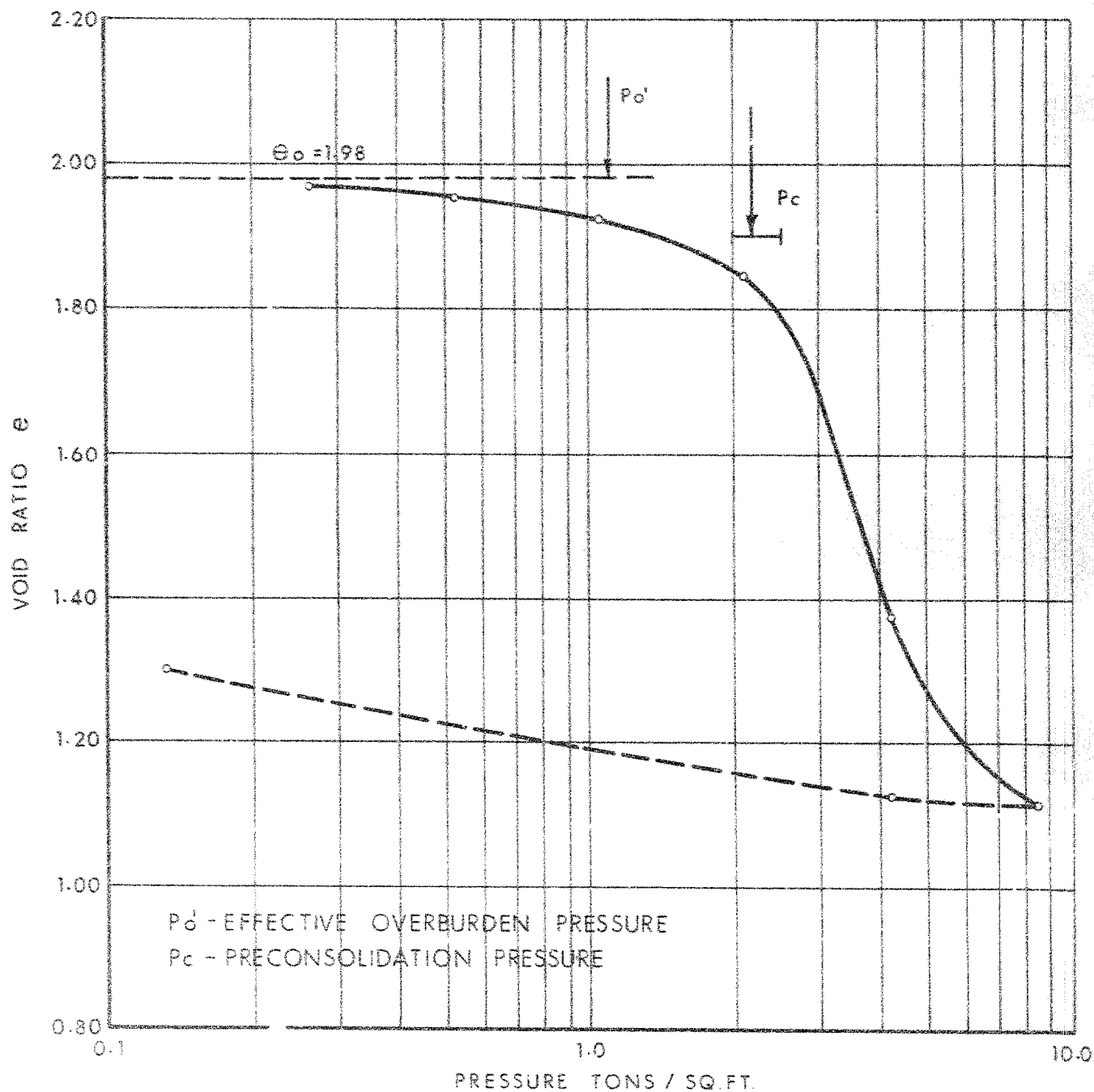


FIG. 12

VOID RATIO vs PRESSURE

$W_L = 48.3$
 $W_p = 19.6$
 $W = 61.4\%$
 $C_c = 0.93$

BORE HOLE 4
 SAMPLE 14
 DEPTH 61'3"
 ELEV. 161.8

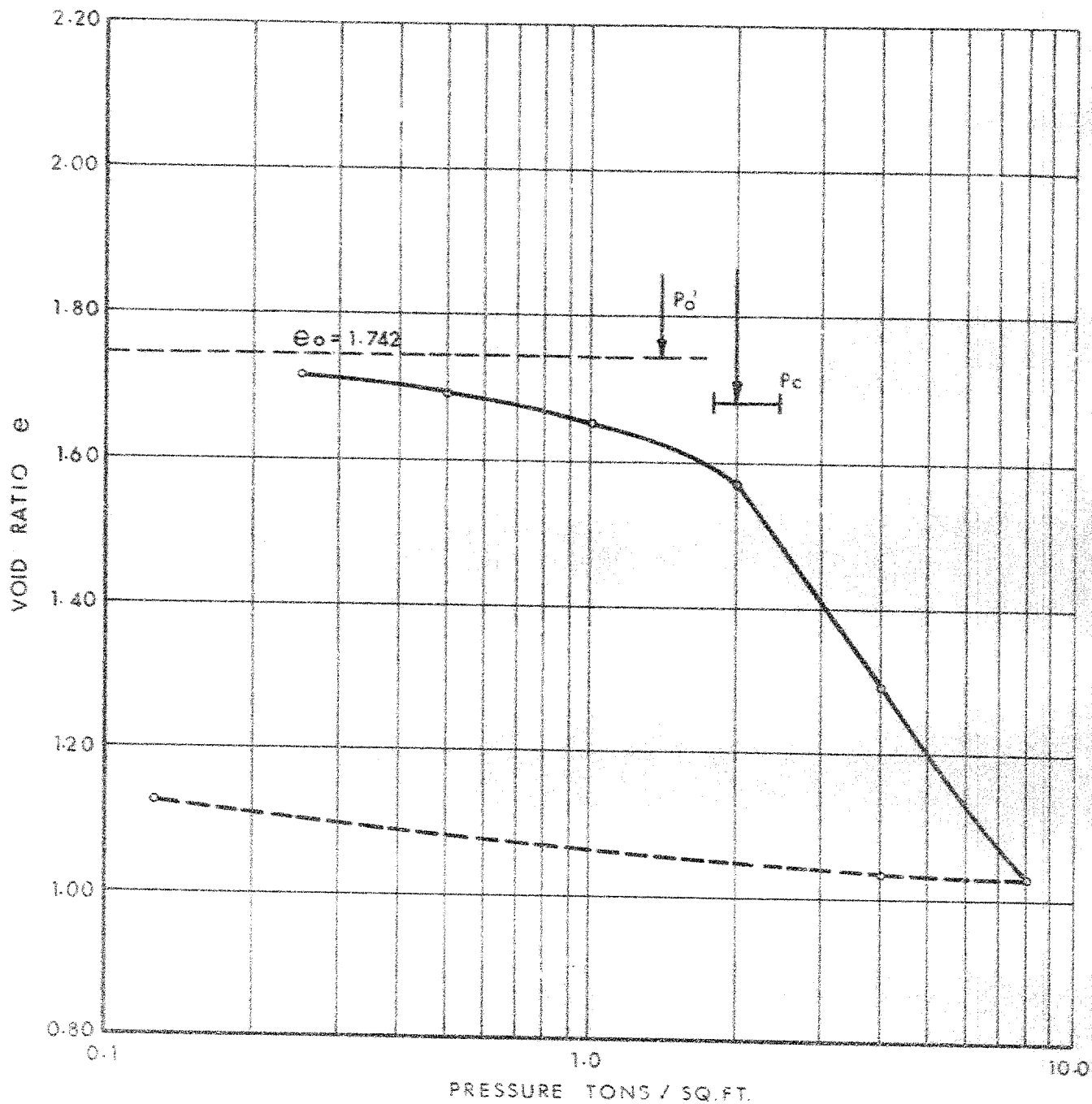


FIG. 13

VOID RATIO vs PRESSURE

$W_L = 62.6$

$W_p = 33.3$

$W = 80.8\%$

$C_c = 1.95$

BORE HOLE 5

SAMPLE 5

DEPTH 16 2"

ELEV. 201.1

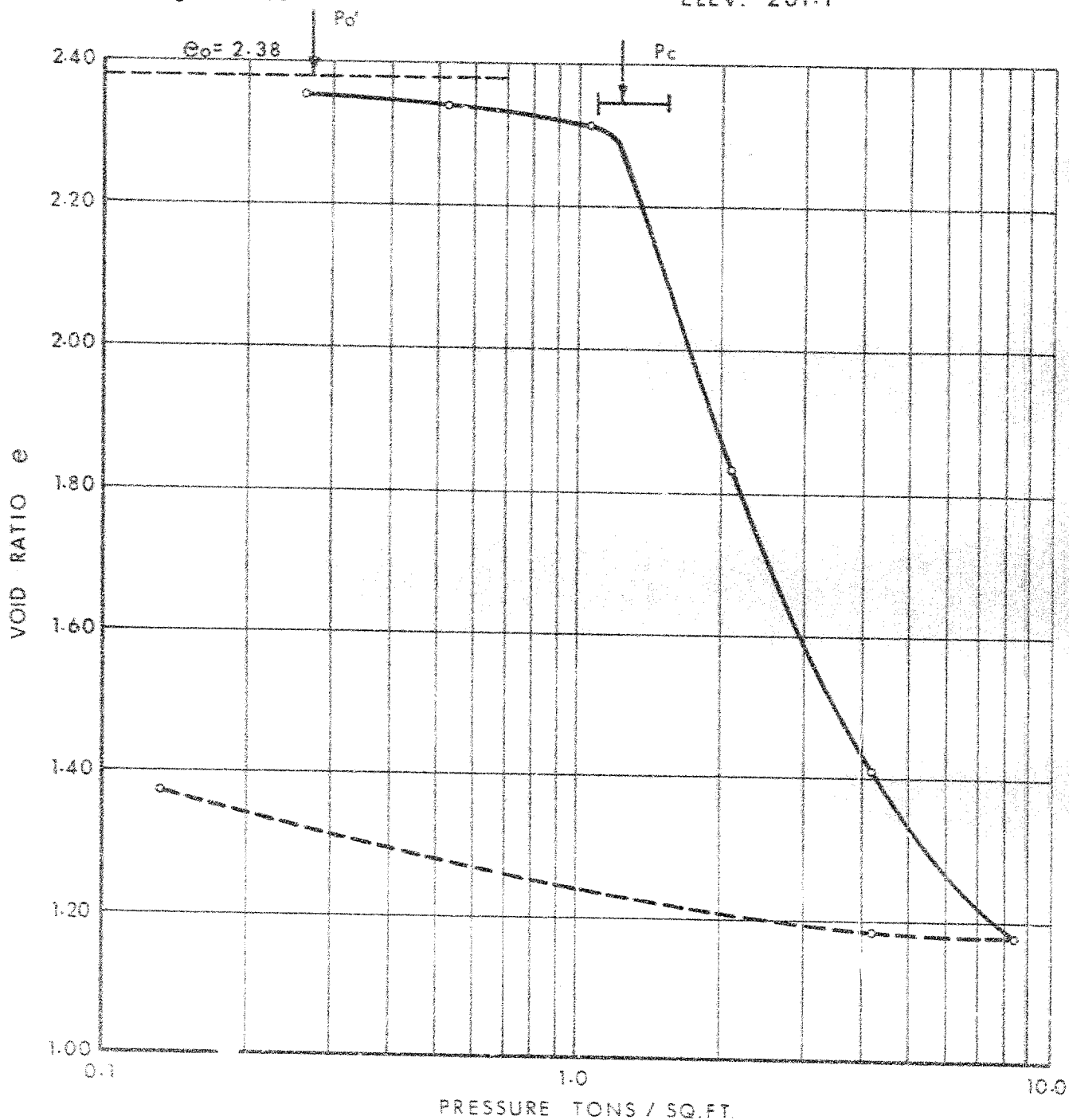


FIG. 14

VOID RATIO vs PRESSURE

$W_L = 65.0$

$W_p = 32.3$

$W = 84.6\%$

$C_c = 2.32$

BORE HOLE 8

SAMPLE 4

DEPTH 16' 0"

ELEV. 234.5

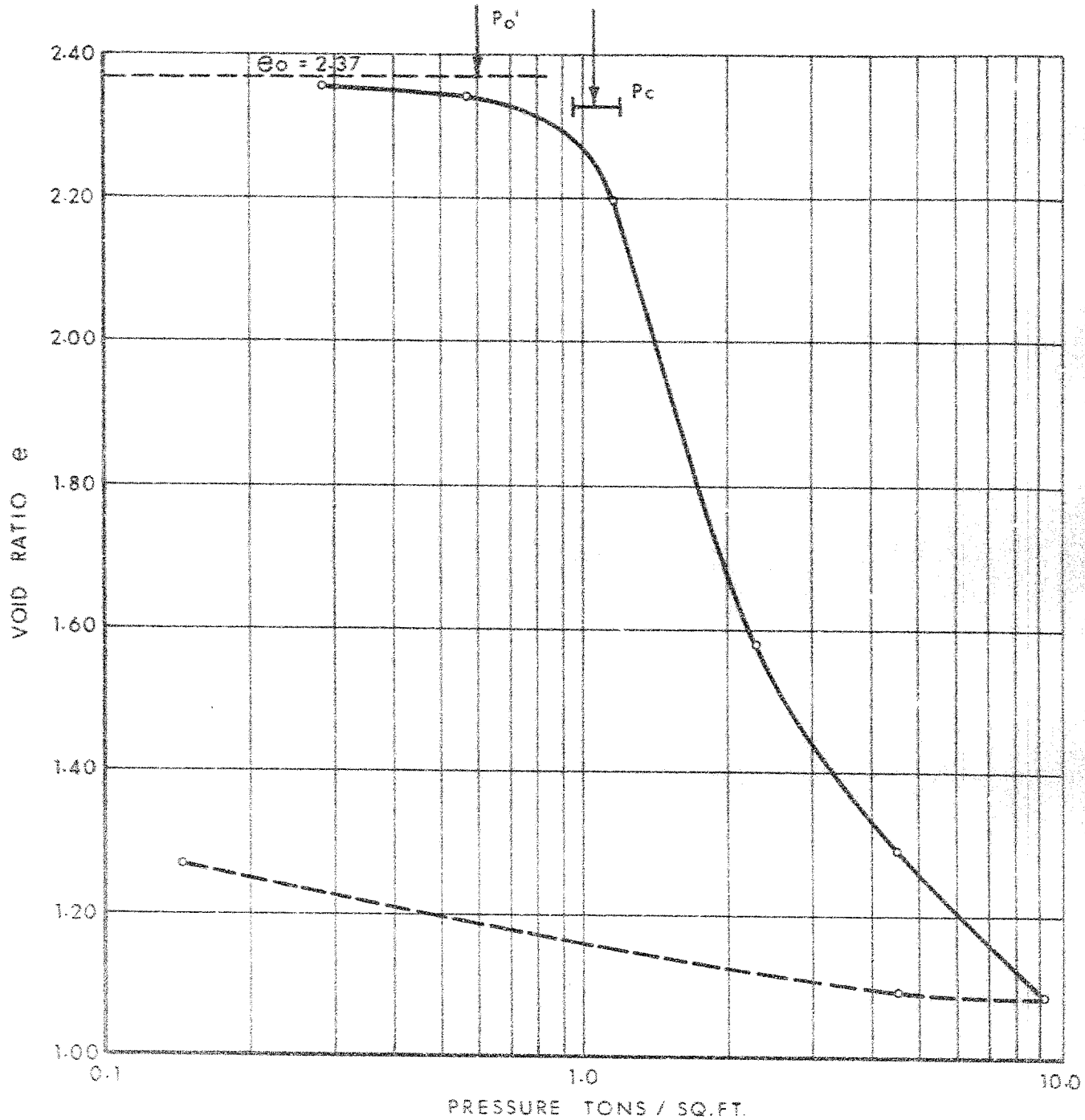


FIG. 15

VOID RATIO vs PRESSURE

$W_L = 32.2$

$W_p = 18.1$

$W = 73.3\%$

$C_c = 2.17$

BORE HOLE 8

SAMPLE 7

DEPTH 31' 3"

ELEV. 219.2

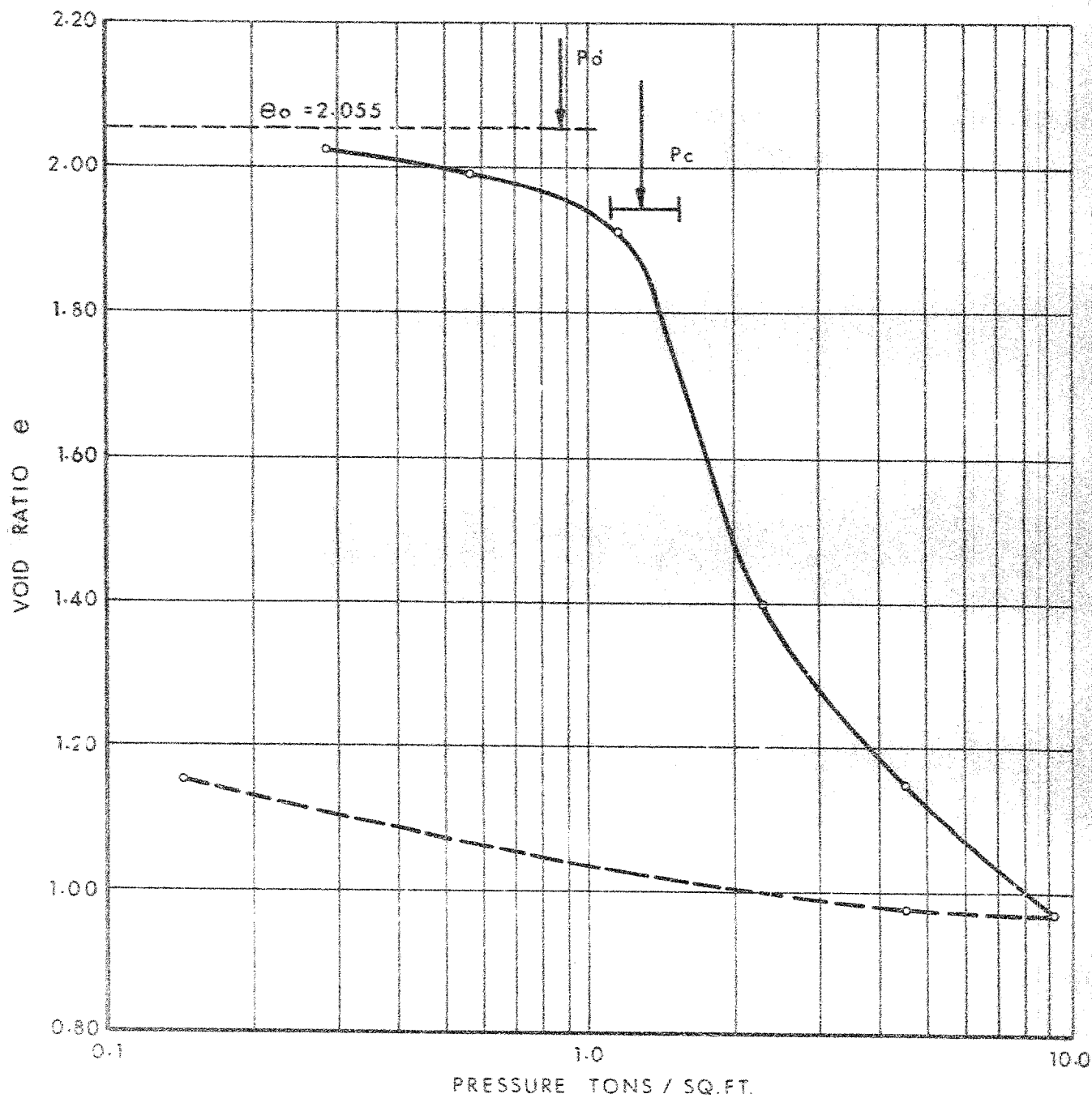


FIG. 16

Appendix F

Table F-1 Comparison of Embankment Design Options

Table F-2 Comparison of Foundation Options

Geotechnical Soil Model

Slope Stability Output

L-Pile Analysis for HP 310x110 Steel Piles

Soil Layer Information

GSC Seismic Hazard Calculation

List of Special Provisions

Suggested Wording for NSSPs

Table F-1 Evaluation of Embankment Design Options

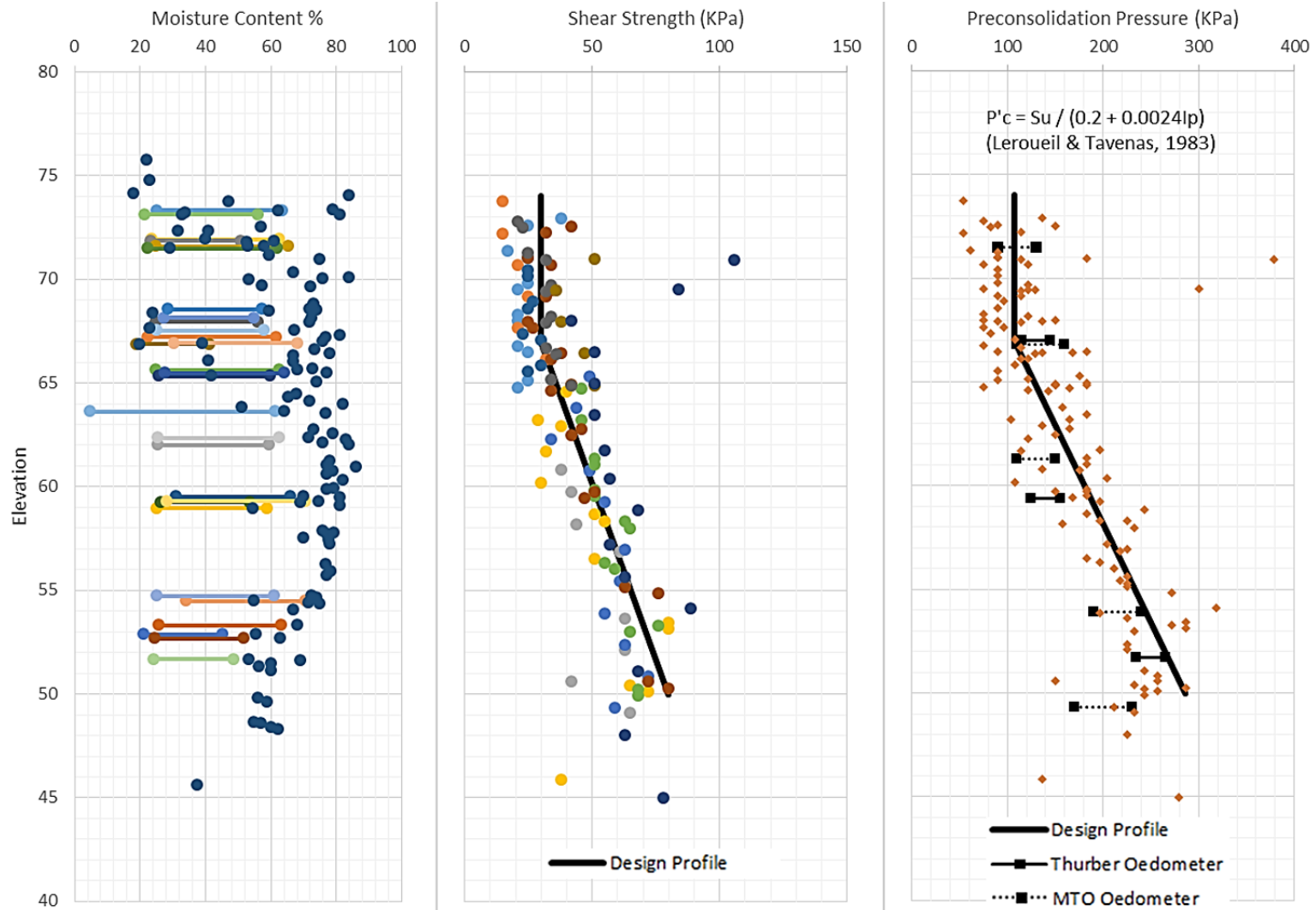
Option	Description	Advantages	Disadvantages	Risks/Consequences	Relative Cost	Comments
1	Granular Embankment Construction of embankment fills at 2H:1V using conventional construction techniques.	<ul style="list-style-type: none">Conventional constructionLow cost	<ul style="list-style-type: none">Pre-loading period of several years required to achieve sufficient degree of consolidationA toe berm is required at the east approach to the WB bridge to achieve minimum required safety factor for global stability of embankment which may impact on creek alignmentSettlement of existing approach fills and may result in bending stressed on existing abutment piles	<ul style="list-style-type: none">Settlement is slower than expected and pre-load period needs to be extended / further delays to project schedule	Low	Not Recommended
2	Lengthen Bridge Increase the length of the bridge so that the abutments do not extend beyond the top of the valley slopes.	<ul style="list-style-type: none">Avoids the need for placement of embankment fillAddresses both settlement and stability concerns	<ul style="list-style-type: none">Longer spans may require additional piles at piers and/or abutments	<ul style="list-style-type: none">None	High	Not Recommended
3	Ground Improvement Treatment of the ground to make it less compressible through methods such as deep soil mixing.	<ul style="list-style-type: none">Relatively fast constructionAddresses both settlement and stability concerns	<ul style="list-style-type: none">The sensitivity of the clay and thickness of the clay deposit means that very few ground improvement techniques are feasible and also increases the cost		High	Not Recommended
4	Structural Support Construction of a pile supported platform beneath the approach fills behind the abutments	<ul style="list-style-type: none">Relatively fast construction	<ul style="list-style-type: none">High cost	<ul style="list-style-type: none">None	High	Not Recommended
5	Lightweight Fill Use of lightweight material for embankment fill in order to limit stress increase. Can achieve zero stress increase by excavating and replacing some material beneath the embankment. Lightweight fill options include slag based aggregate, tire derived aggregate, expanded polystyrene and cellular concrete.	<ul style="list-style-type: none">Relatively fast constructionAddresses both settlement and stability concernsNo settlement to impact on existing structures			Medium	Recommended
6	Accelerated Settlement Acceleration of the settlement process by surcharging the site. Settlement could be further accelerated by inclusion of wick drains.	<ul style="list-style-type: none">Settlement timing can be controlled by wick drain spacing	<ul style="list-style-type: none">Does not address stability concernsSignificant delay to construction scheduleSettlement would result in increased bending stresses on existing piles and possibly differential settlement of existing approach fills.	<ul style="list-style-type: none">Settlement is slower than expected and surcharge period needs to be extended / further delays to project schedule	Low to Medium	Not Recommended

TABLE F-2

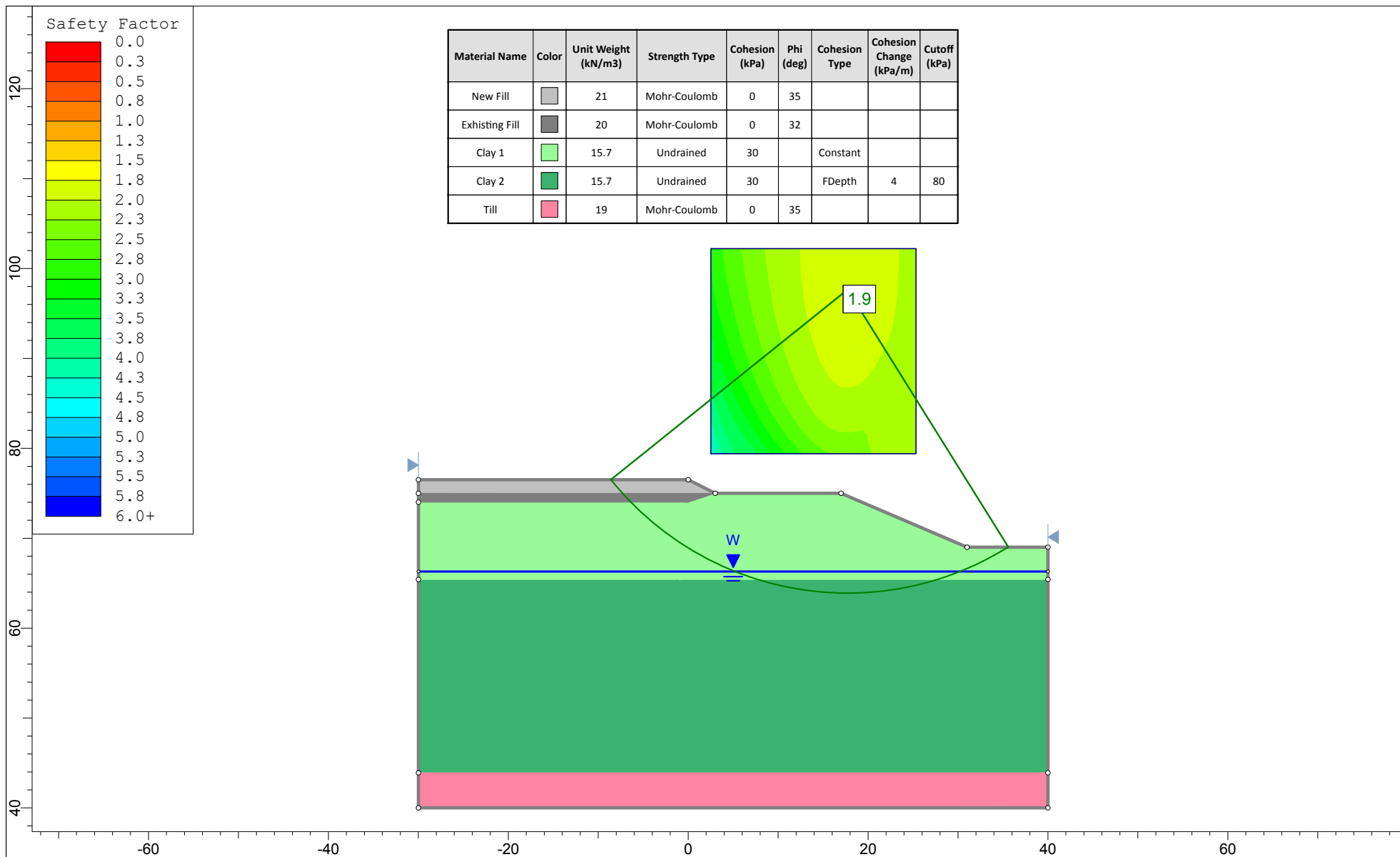
COMPARISON OF DEEP FOUNDATION ALTERNATIVES

Micro-Piles	Steel Pipe Piles	Steel H-Piles	Caissons
<p>Advantages:</p> <ul style="list-style-type: none"> • Can be installed beneath existing bridge structure to allow for over-building of piers for future bridge widening 	<p>Advantages:</p> <ul style="list-style-type: none"> • Quick installation procedure • Low cost 	<p>Advantages:</p> <ul style="list-style-type: none"> • Quick installation procedure • Low cost 	<p>Advantages:</p> <ul style="list-style-type: none"> • High axial and lateral resistance
<p>Disadvantages:</p> <ul style="list-style-type: none"> • High cost • Constructability concerns due to artesian groundwater conditions and boulders within glacial till • Low lateral resistance • Lower axial resistance than driven piles 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • Generally lower resistance than H-pile • Increased risk of damage during driving through glacial till deposit. • Increased risk of complications from artesian groundwater conditions. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • N/A 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • High cost • Constructability concerns due to artesian groundwater conditions and boulders within glacial till
NOT RECOMMENDED	FEASIBLE	RECOMMENDED	NOT RECOMMENDED

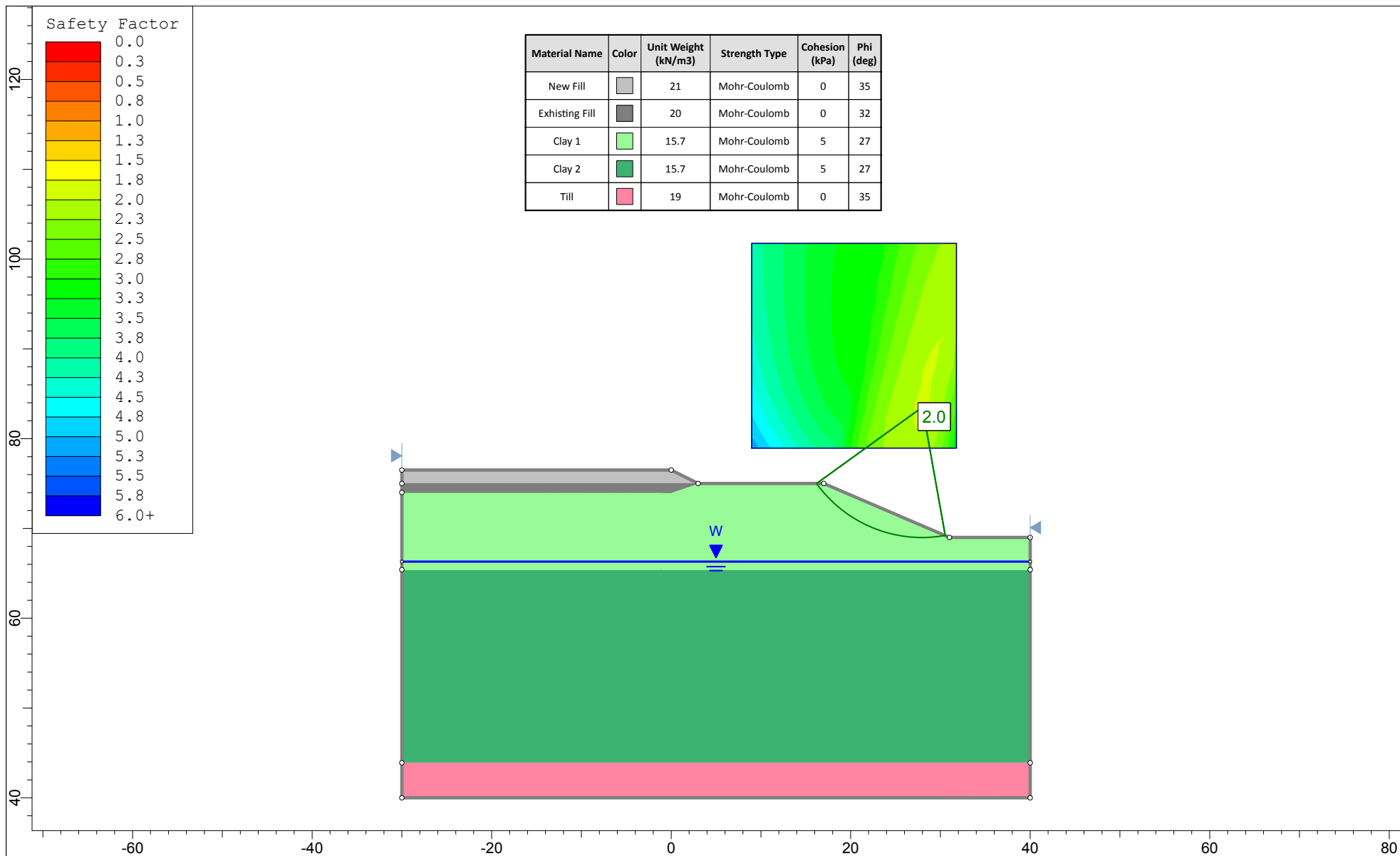




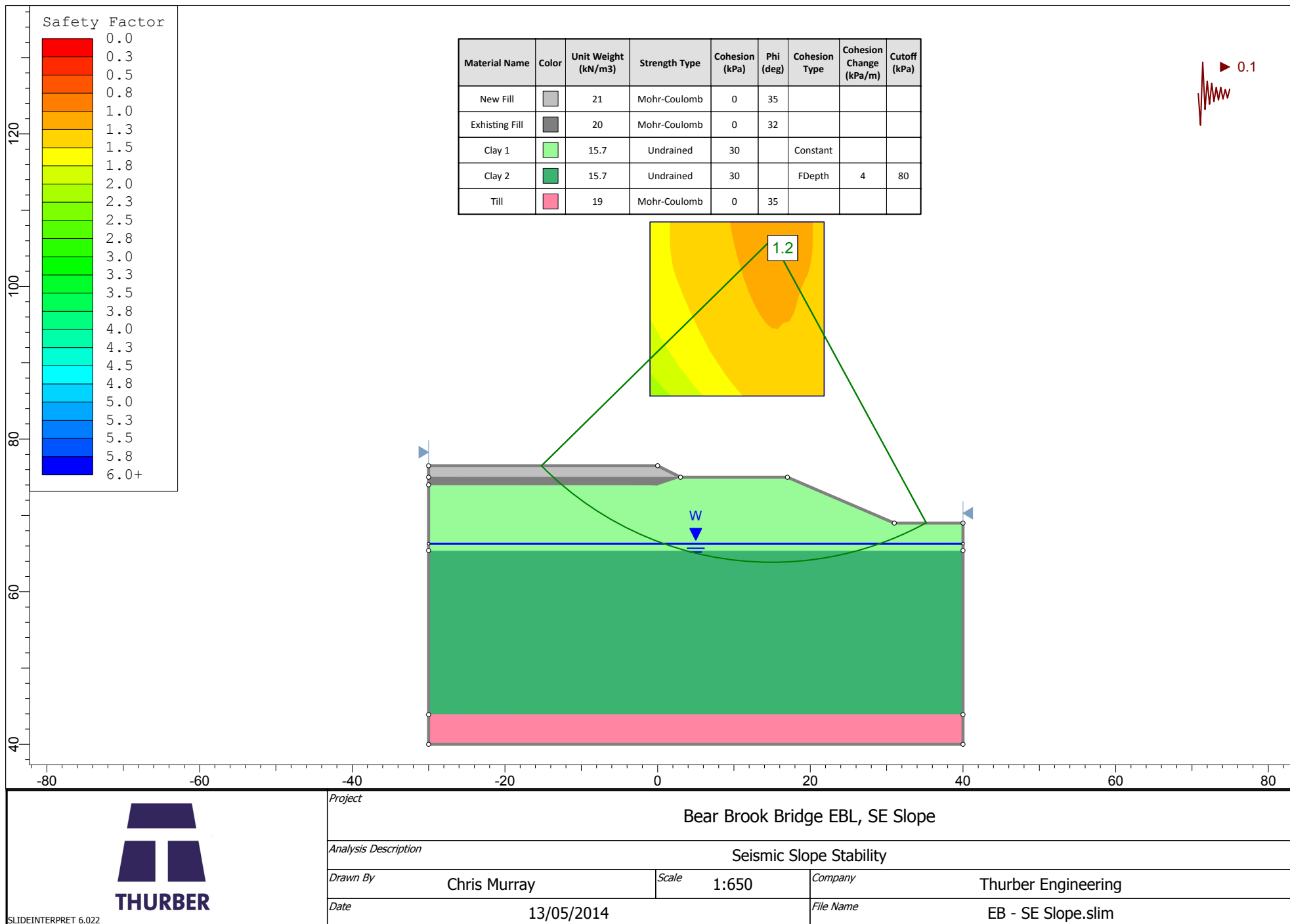
No.	Revision	Date	URS Canada Inc.		<div> THURBER ENGINEERING LTD.</div>		
			Bear Brook Bridges Soil Properties				
			19-4406-6	Highway 417	ENGINEER: PC	DRAWN CM	APPROVED: FJG
					DATE: 06/06/14	SCALE:	DRAWING NO: 1

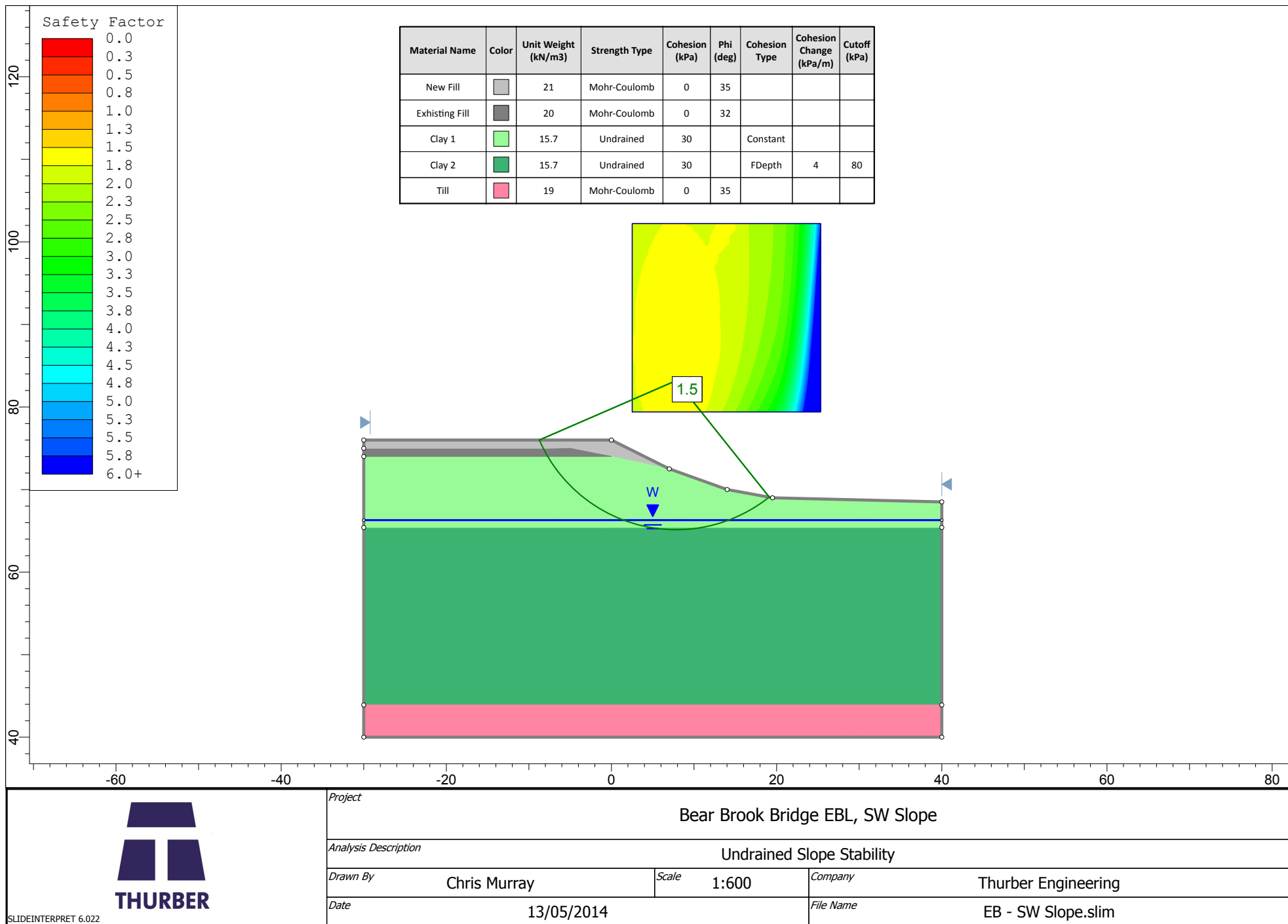


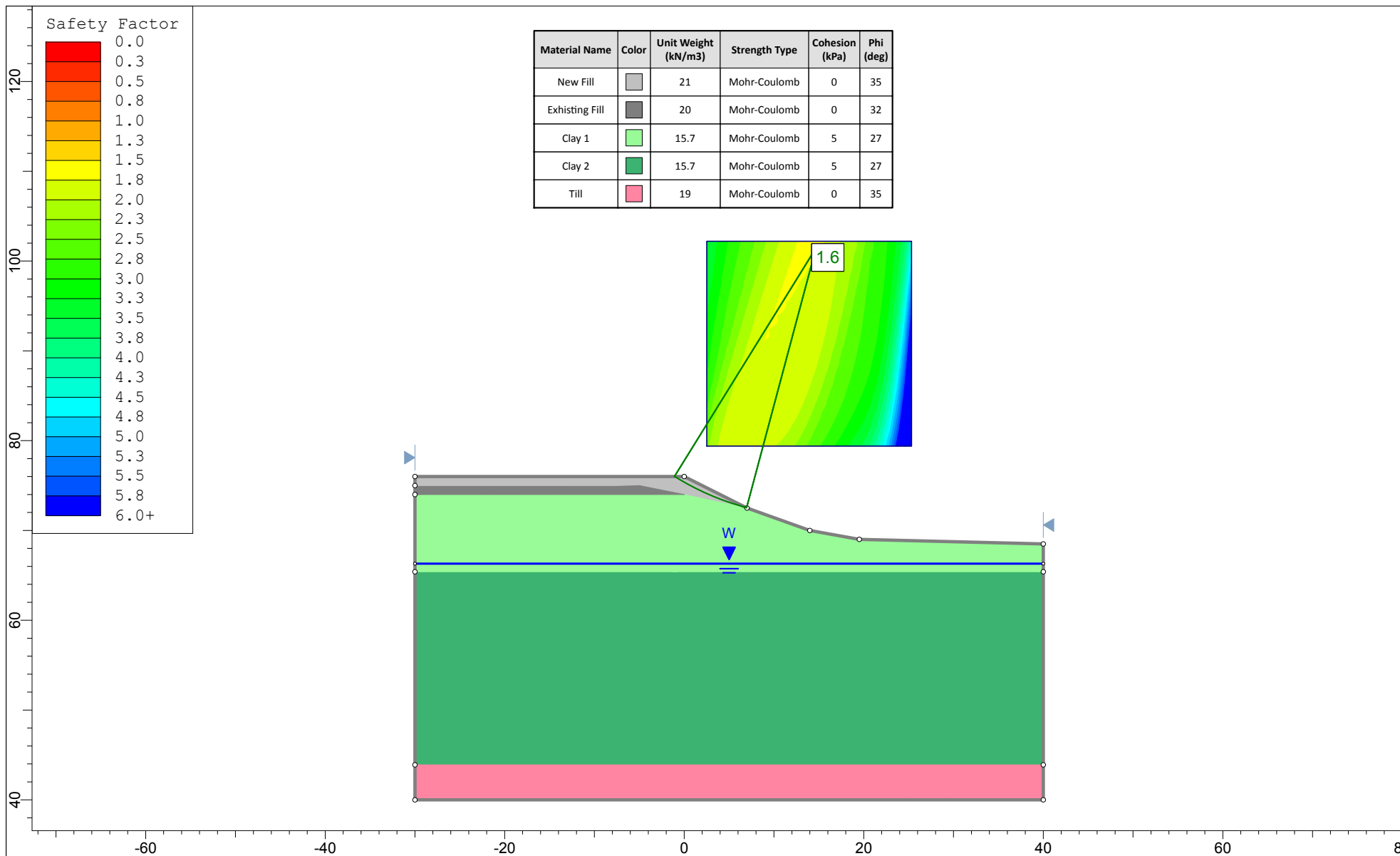
Project			
Bear Brook Bridge EBL, SE Slope			
Analysis Description			
Undrained Slope Stability			
Drawn By	Chris Murray	Scale	1:600
Company	Thurber Engineering		
Date	13/05/2014	File Name	EB - SE Slope.slim



Project			
Bear Brook Bridge EBL, SE Slope			
Analysis Description			
Drained Slope Stability			
Drawn By	Chris Murray	Scale	1:600
Company		Thurber Engineering	
Date	13/05/2014	File Name	EB - SE Slope.slim

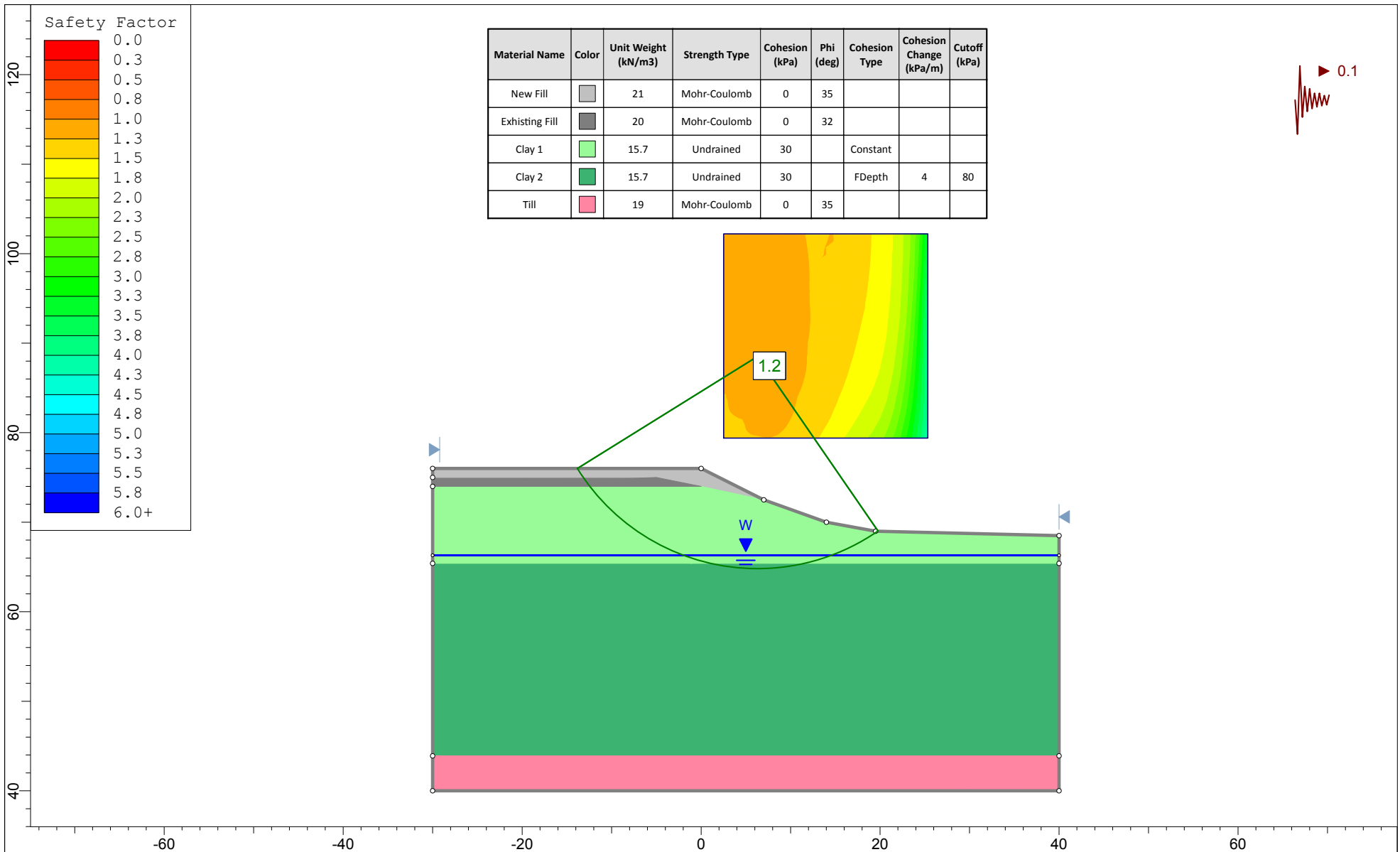




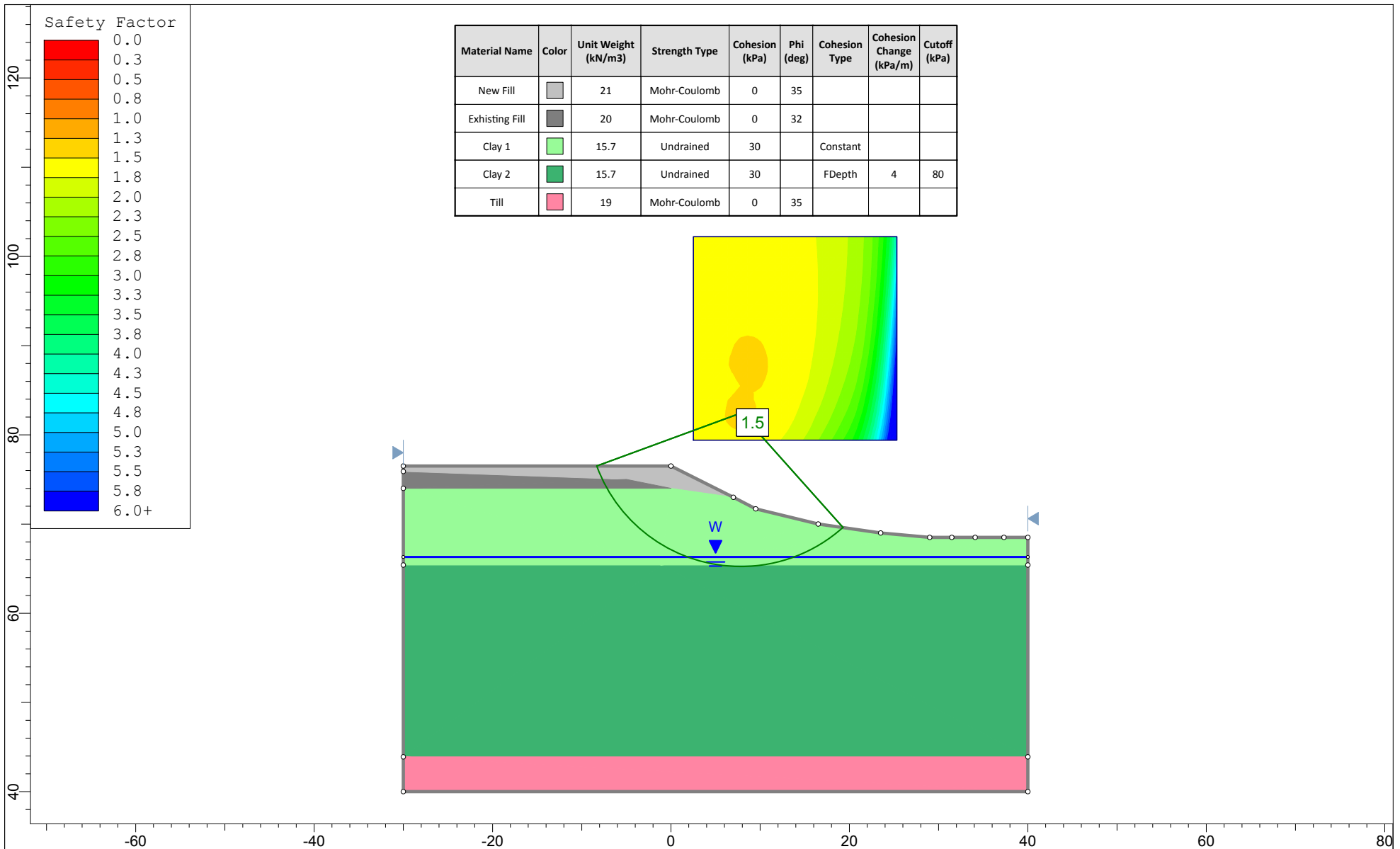


SLIDEINTERPRET 6.022

Project		Bear Brook Bridge EBL, SW Slope	
Analysis Description		Drained Slope Stability	
Drawn By	Chris Murray	Scale	1:600
Date		Company	Thurber Engineering
		File Name	EB - SW Slope.slim

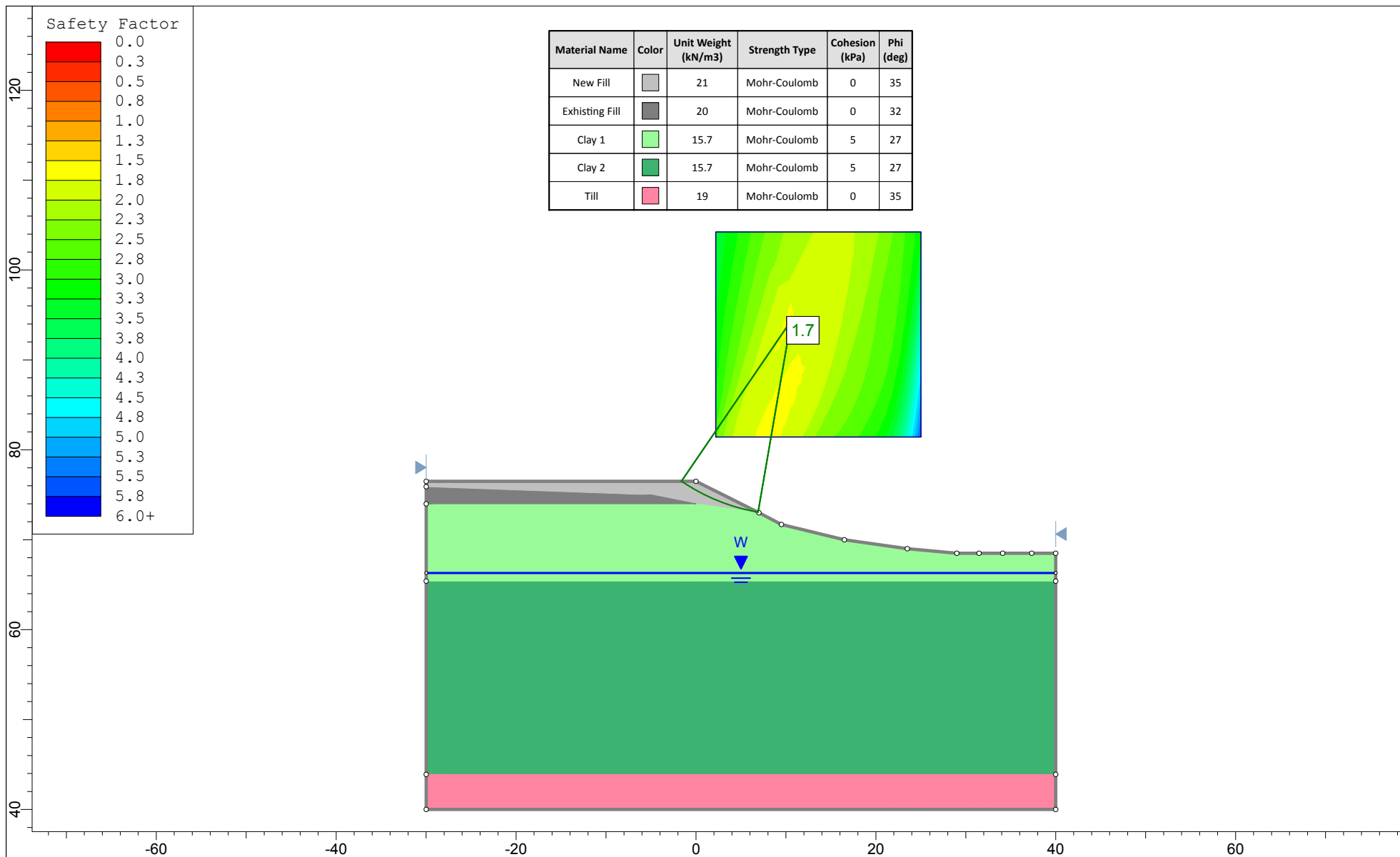


Project			
Bear Brook Bridge EBL, SW Slope			
Analysis Description			
Seismic Slope Stability			
Drawn By	Chris Murray	Scale	1:600
Company	Thurber Engineering		
Date	13/05/2014	File Name	EB - SW Slope.slim

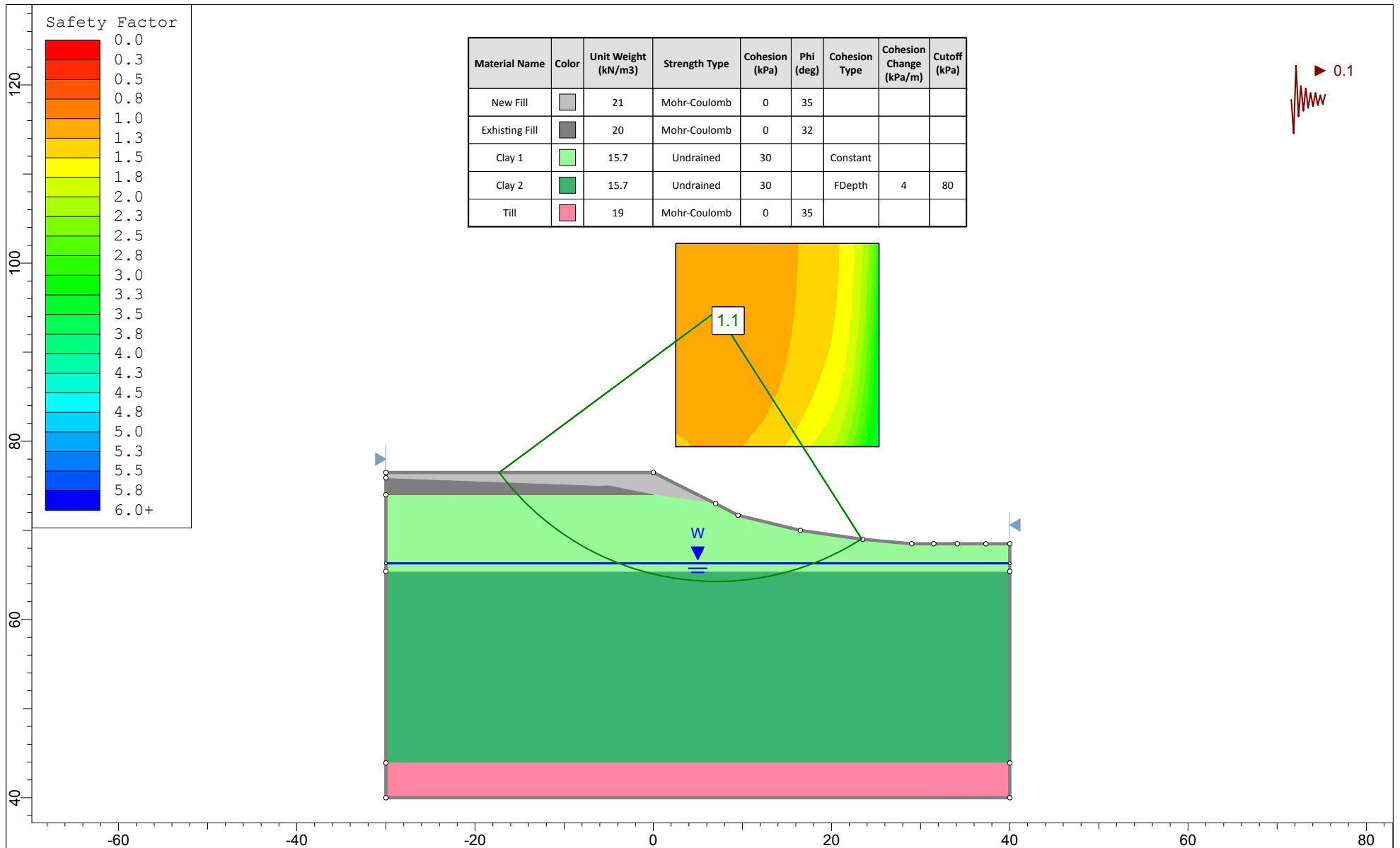


SLIDEINTERPRET 6.022

Project		Bear Brook Bridge WBL, NW Slope	
Analysis Description		Undrained Slope Stability	
Drawn By	Chris Murray	Scale	1:600
Date		Company	Thurber Engineering
13/05/2014		File Name	WB - NW Slope.slim

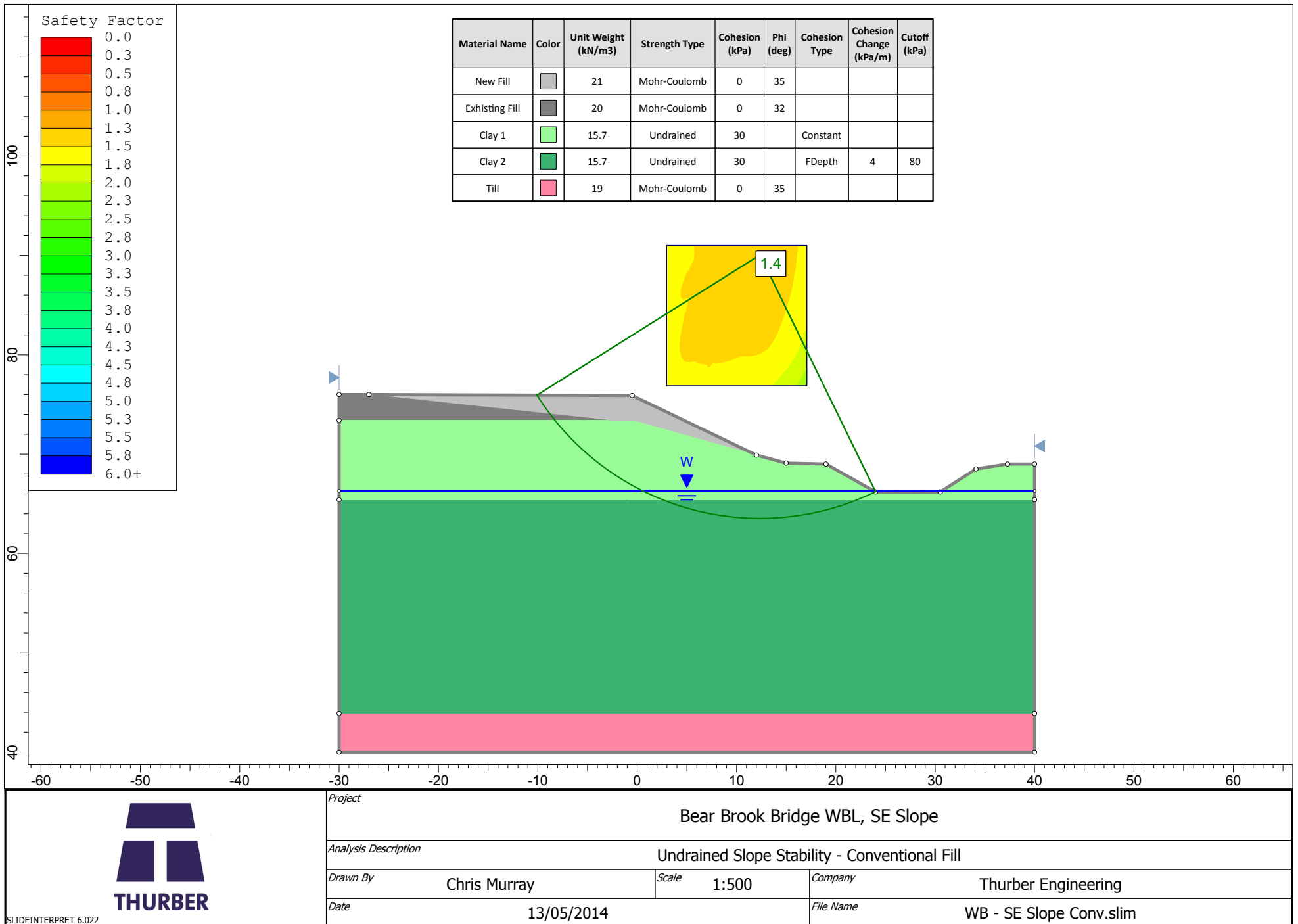


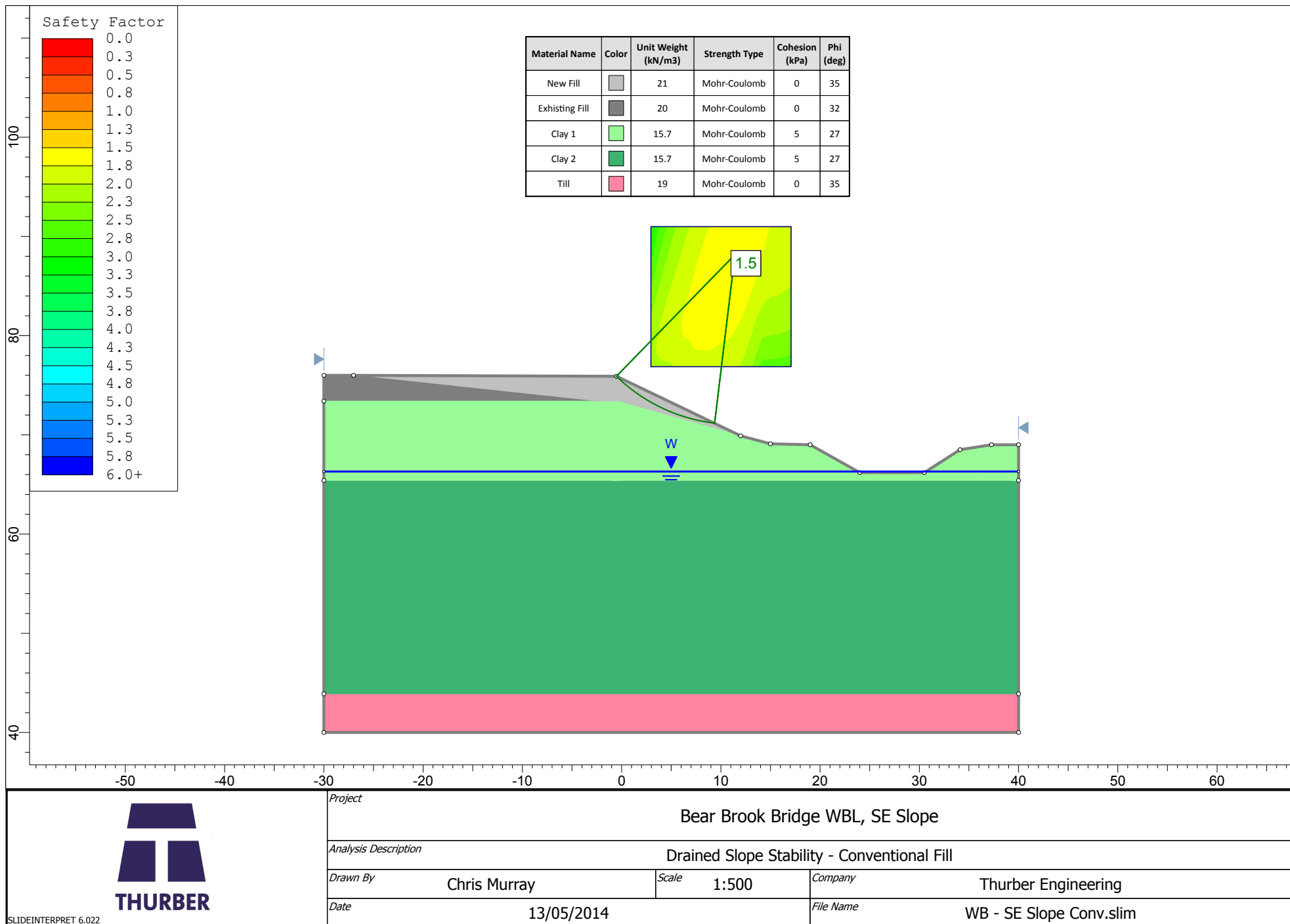
Project		Bear Brook Bridge WBL, NW Slope	
Analysis Description		Drained Slope Stability	
Drawn By	Chris Murray	Scale	1:600
Date		Company	Thurber Engineering
13/05/2014		File Name	WB - NW Slope.slim

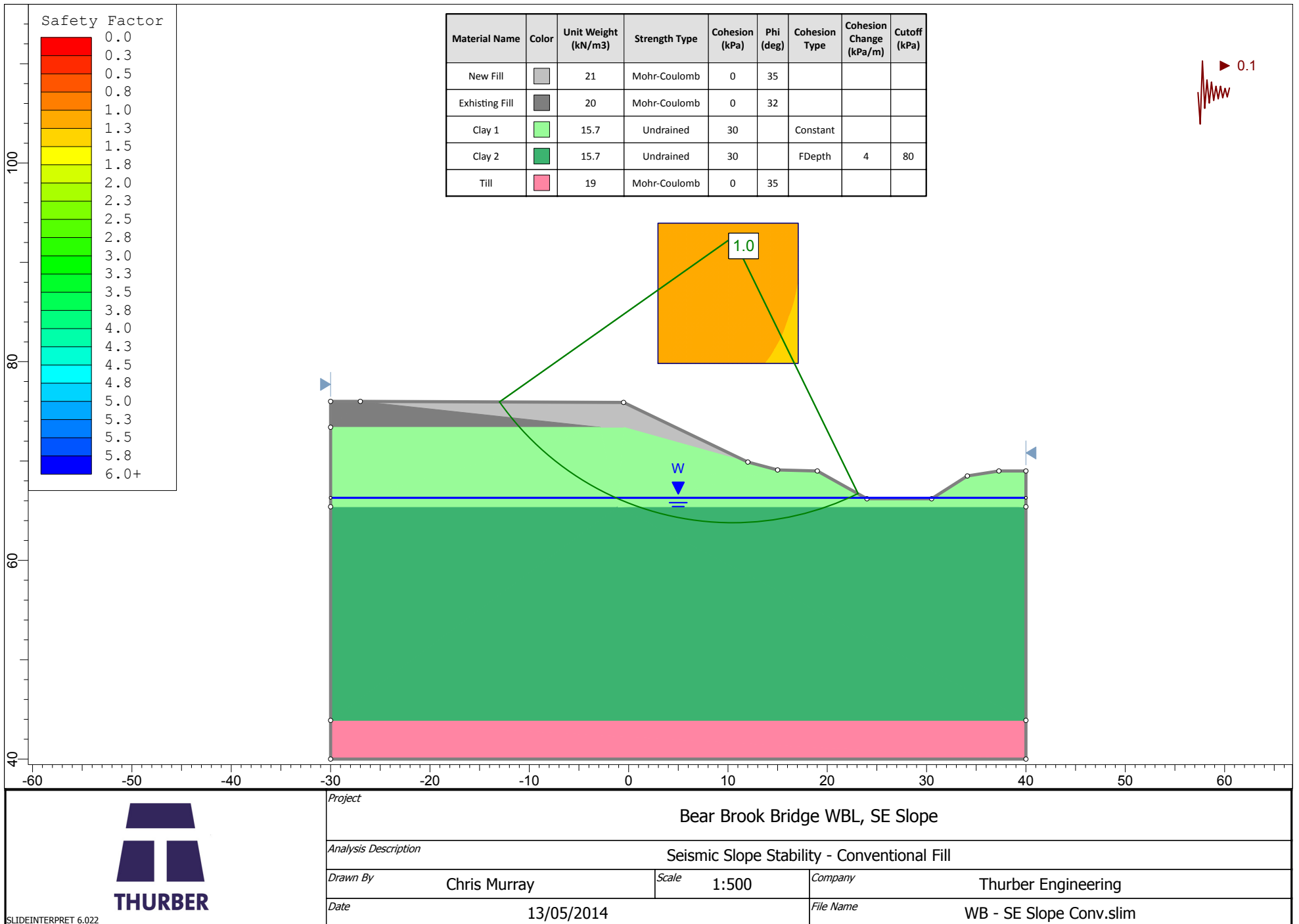


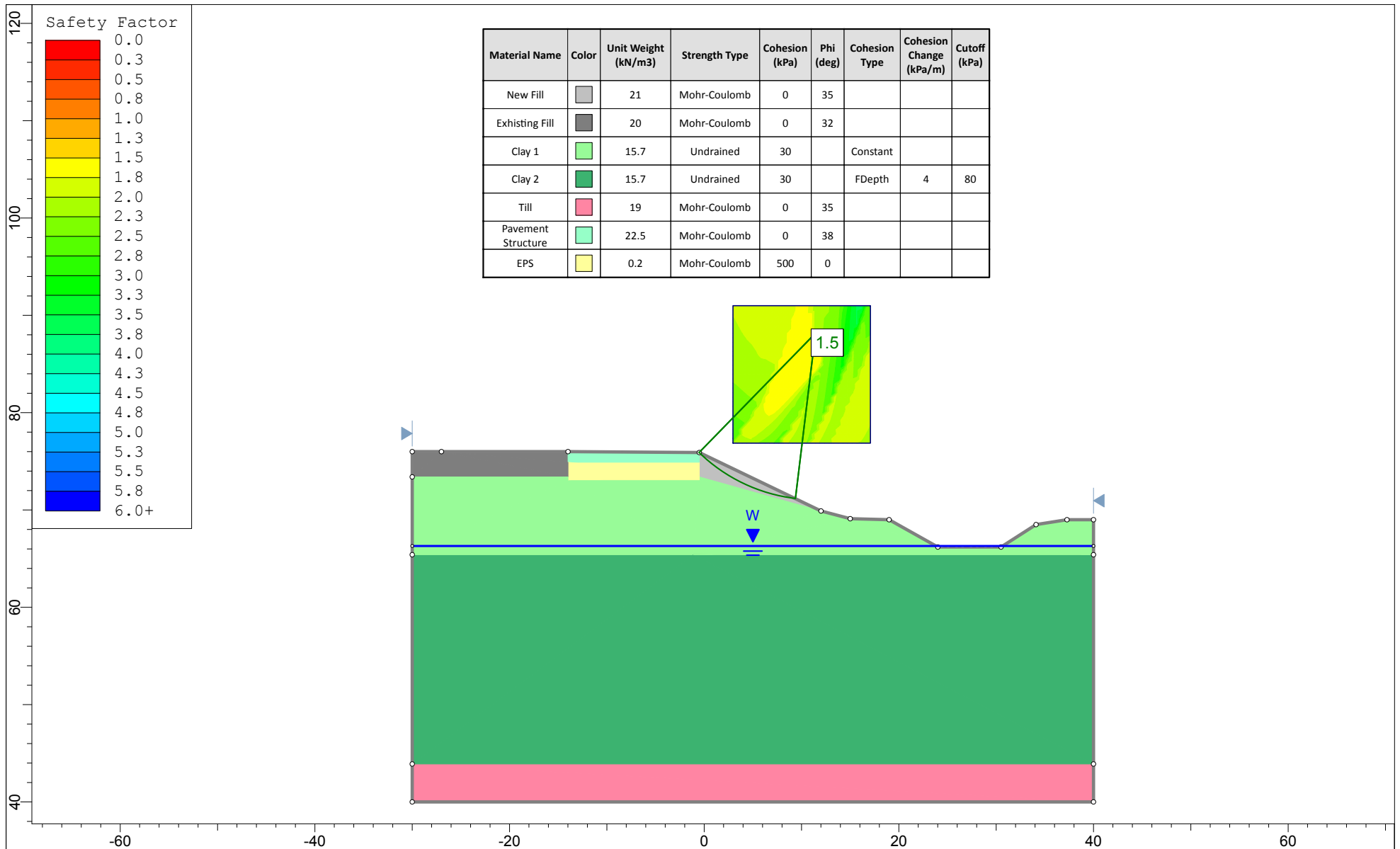
SLIDEINTERPRET 6.022

Project			
Bear Brook Bridge WBL, NW Slope			
Analysis Description			
Seismic Slope Stability			
Drawn By	Chris Murray	Scale	1:600
Company	Thurber Engineering		
Date	13/05/2014	File Name	WB - NW Slope.slim



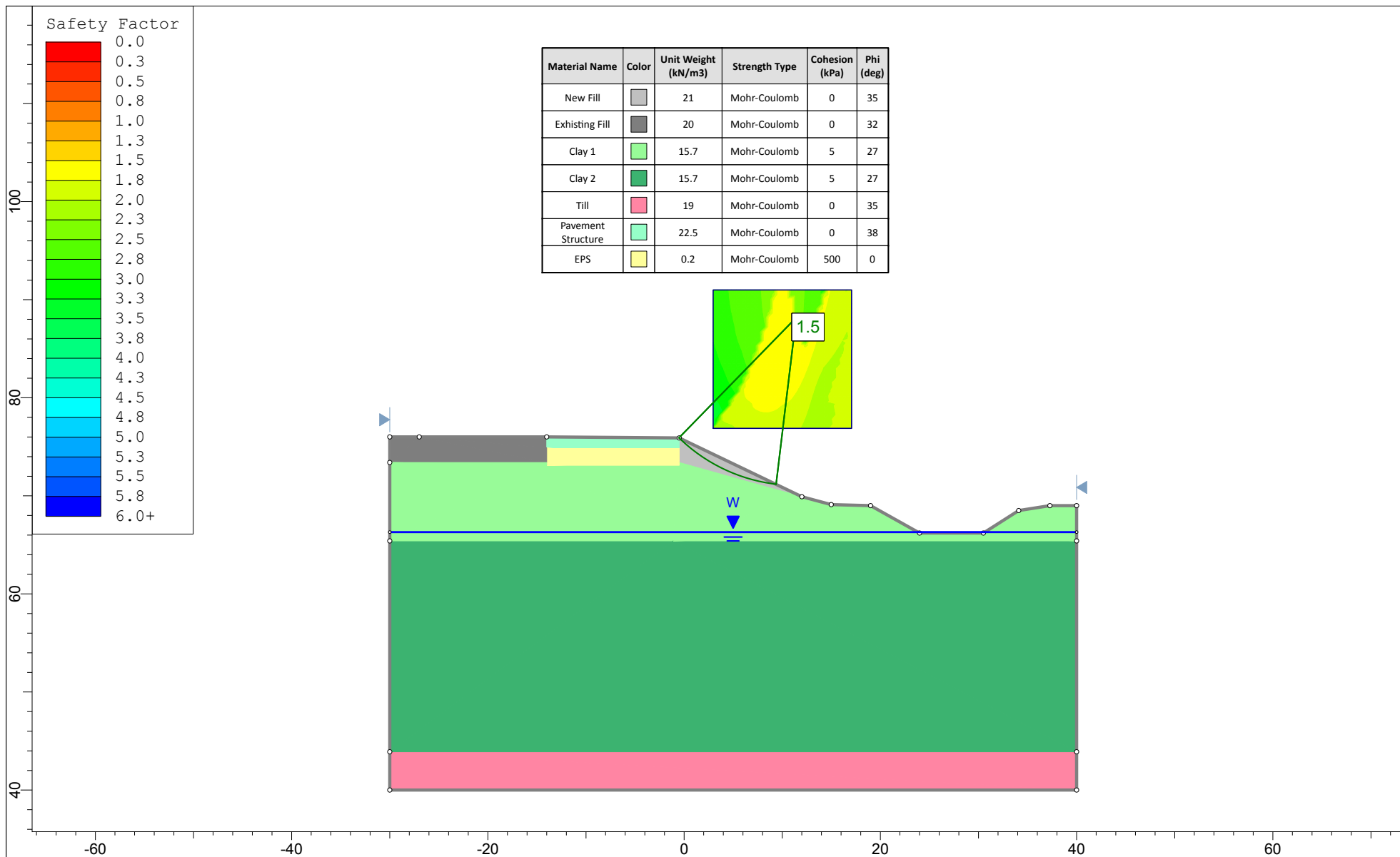






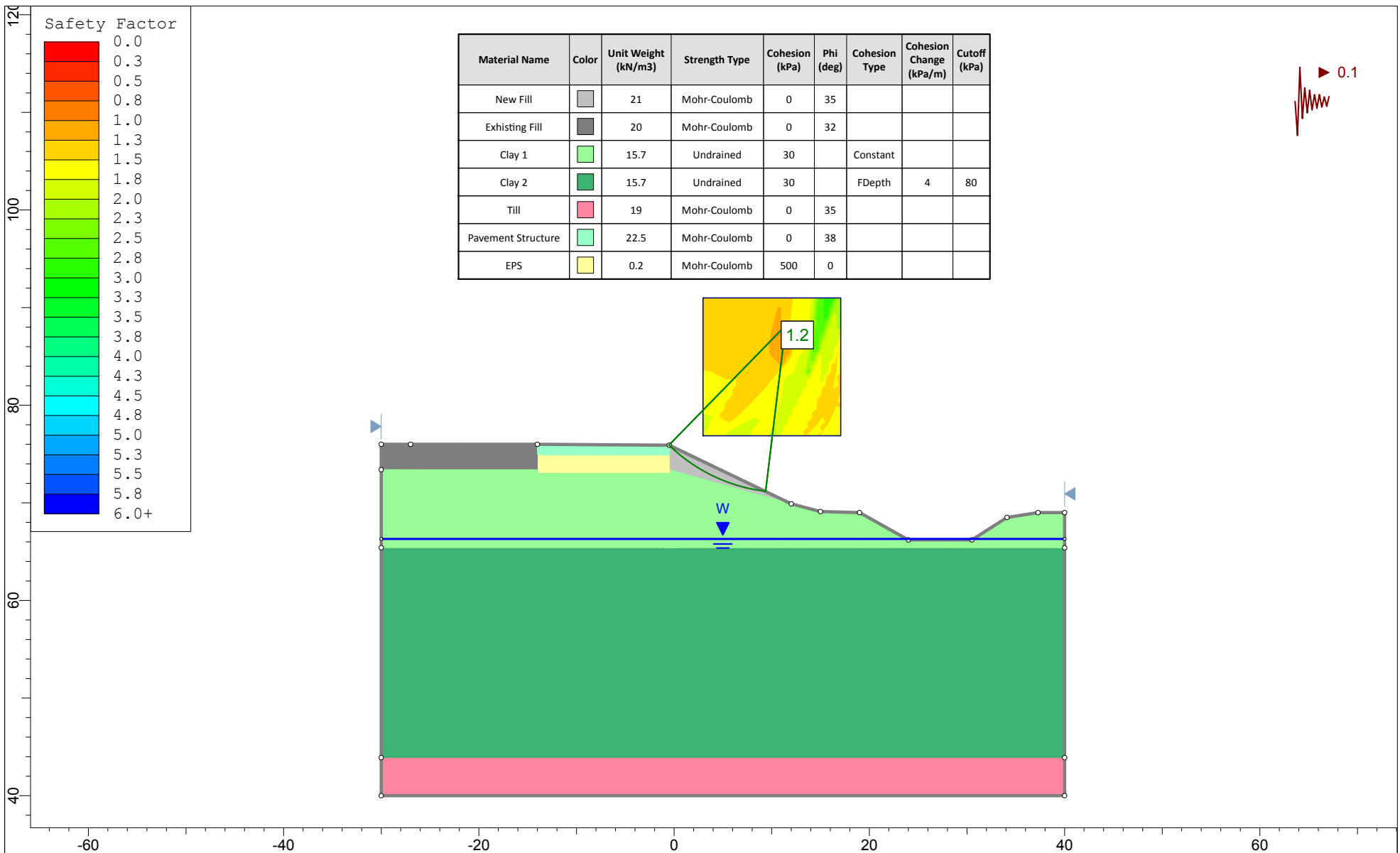
SLIDEINTERPRET 6.022

Project			
Bear Brook Bridge WBL, SE Slope			
Analysis Description			
Undrained Slope Stability - EPS Fill			
Drawn By	Chris Murray	Scale	1:550
Company	Thurber Engineering		
Date	13/05/2014	File Name	WB - SE Slope EPS.slim



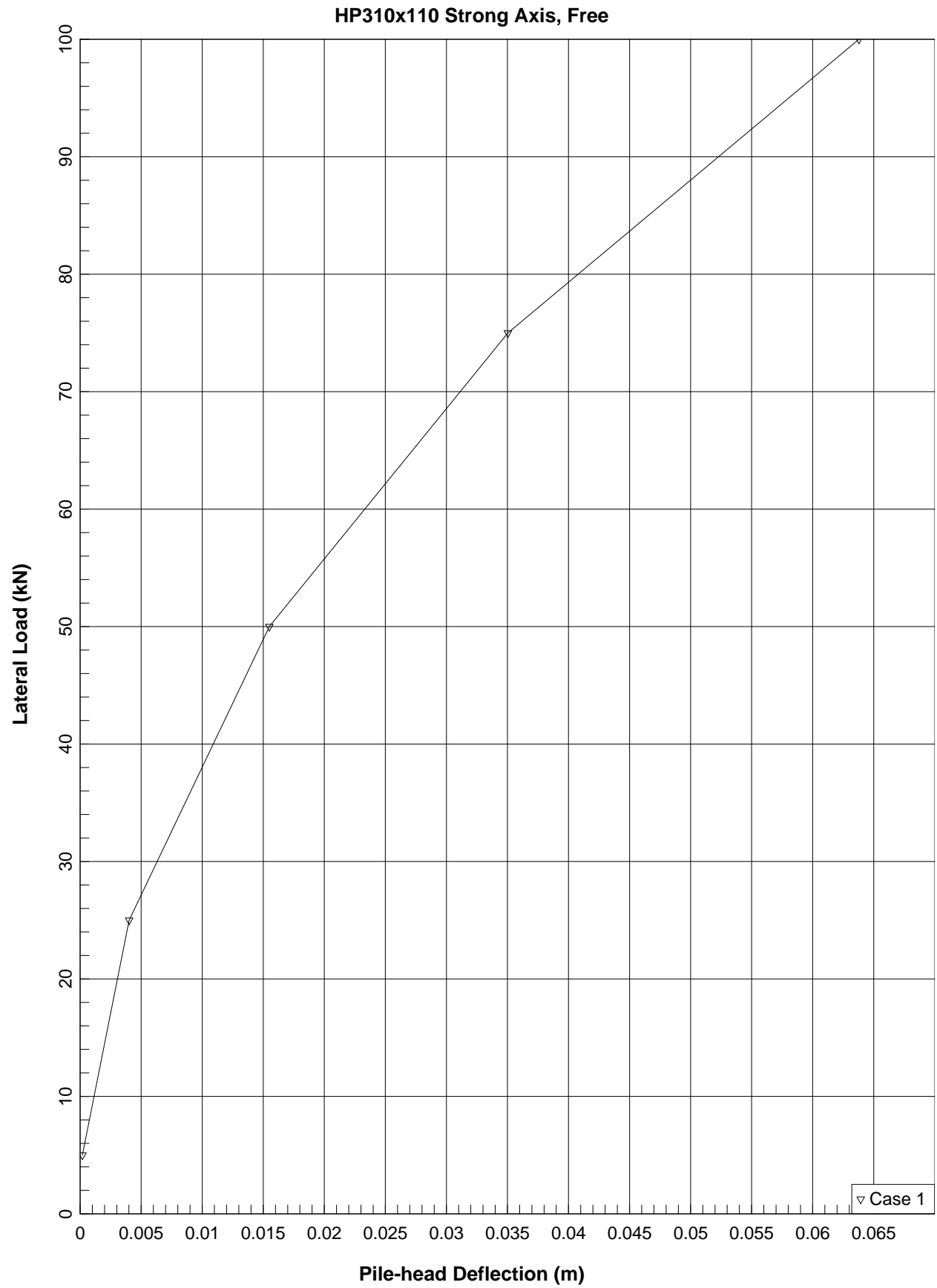
SLIDEINTERPRET 6.022

Project			
Bear Brook Bridge WBL, SE Slope			
Analysis Description			
Drained Slope Stability - EPS Fill			
Drawn By	Chris Murray	Scale	1:550
Company	Thurber Engineering		
Date	13/05/2014	File Name	WB - SE Slope EPS.slim

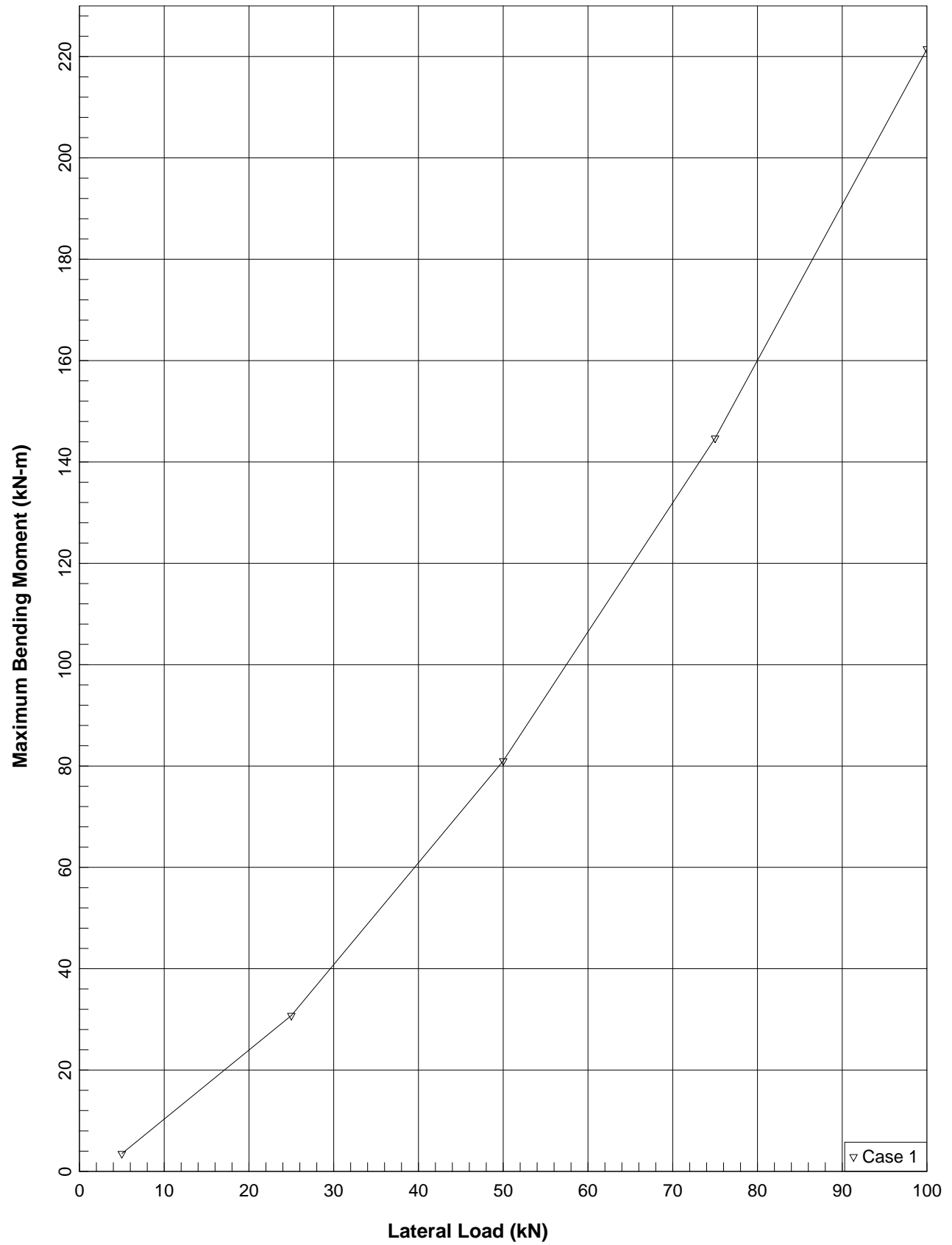


SLIDEINTERPRET 6.022

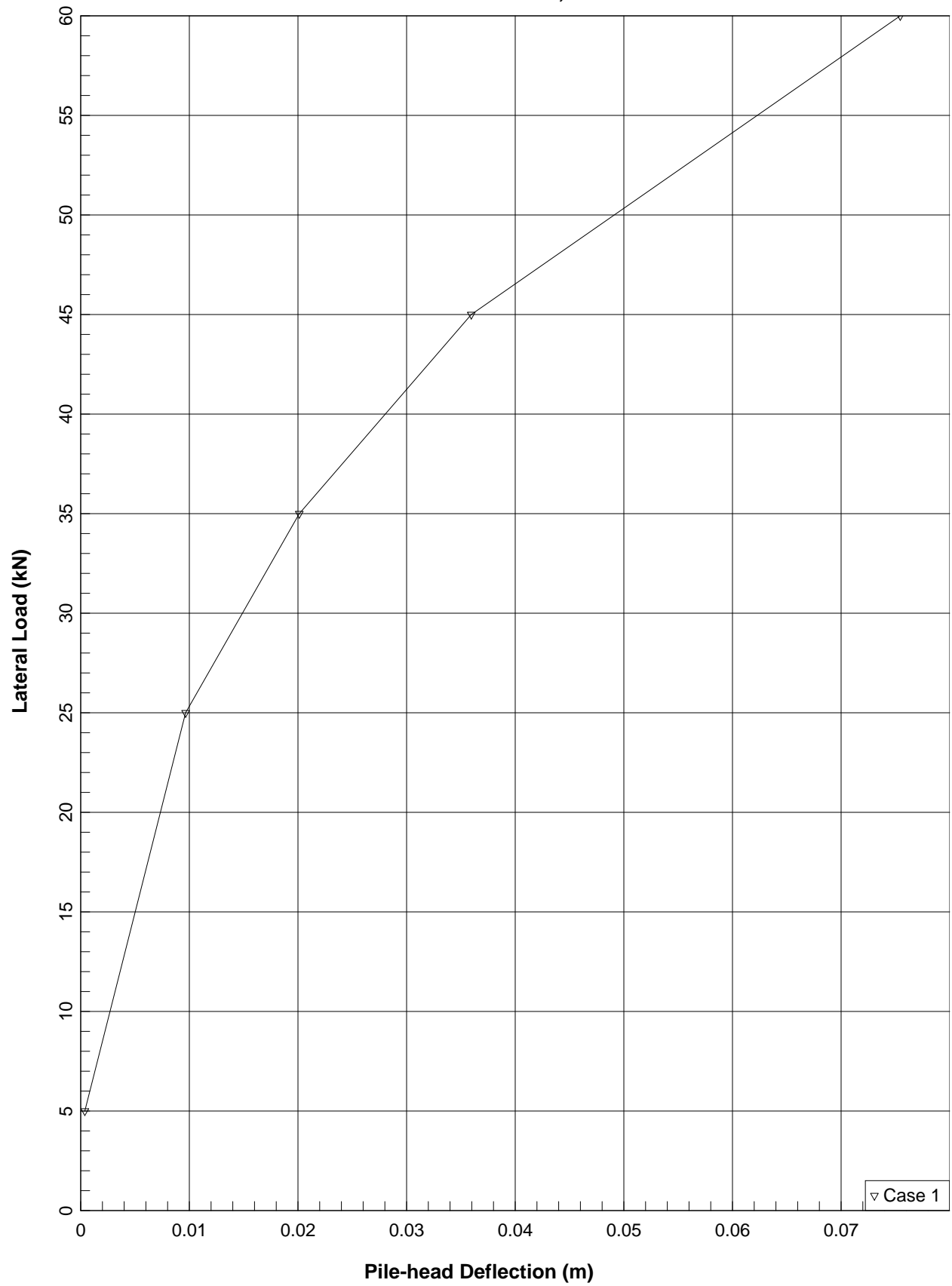
Project			
Bear Brook Bridge WBL, SE Slope			
Analysis Description			
Seismic Slope Stability - EPS Fill			
Drawn By	Chris Murray	Scale	1:550
Company	Thurber Engineering		
Date	13/05/2014	File Name	WB - SE Slope EPS.slim



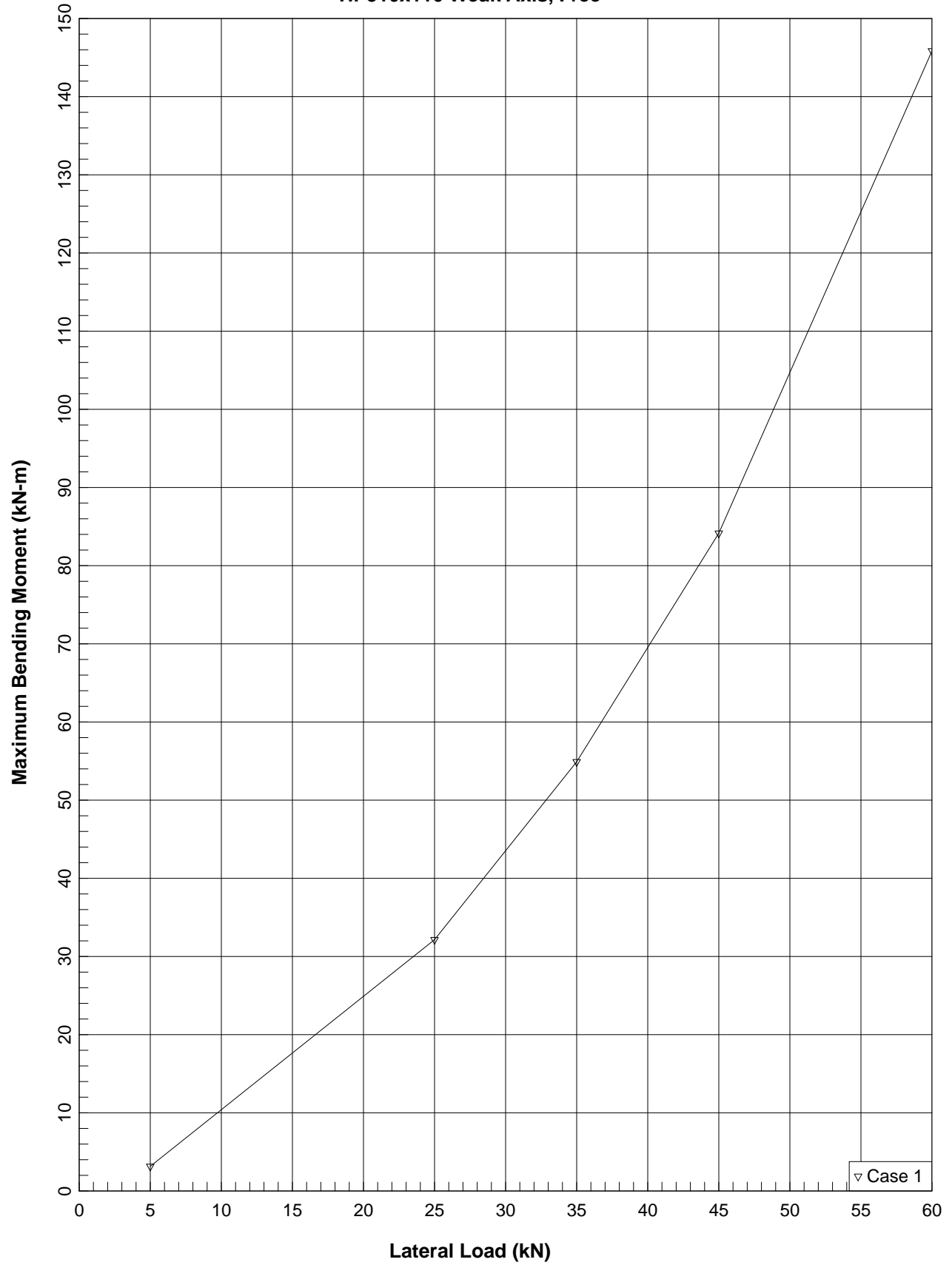
HP310x110 Strong Axis, Free



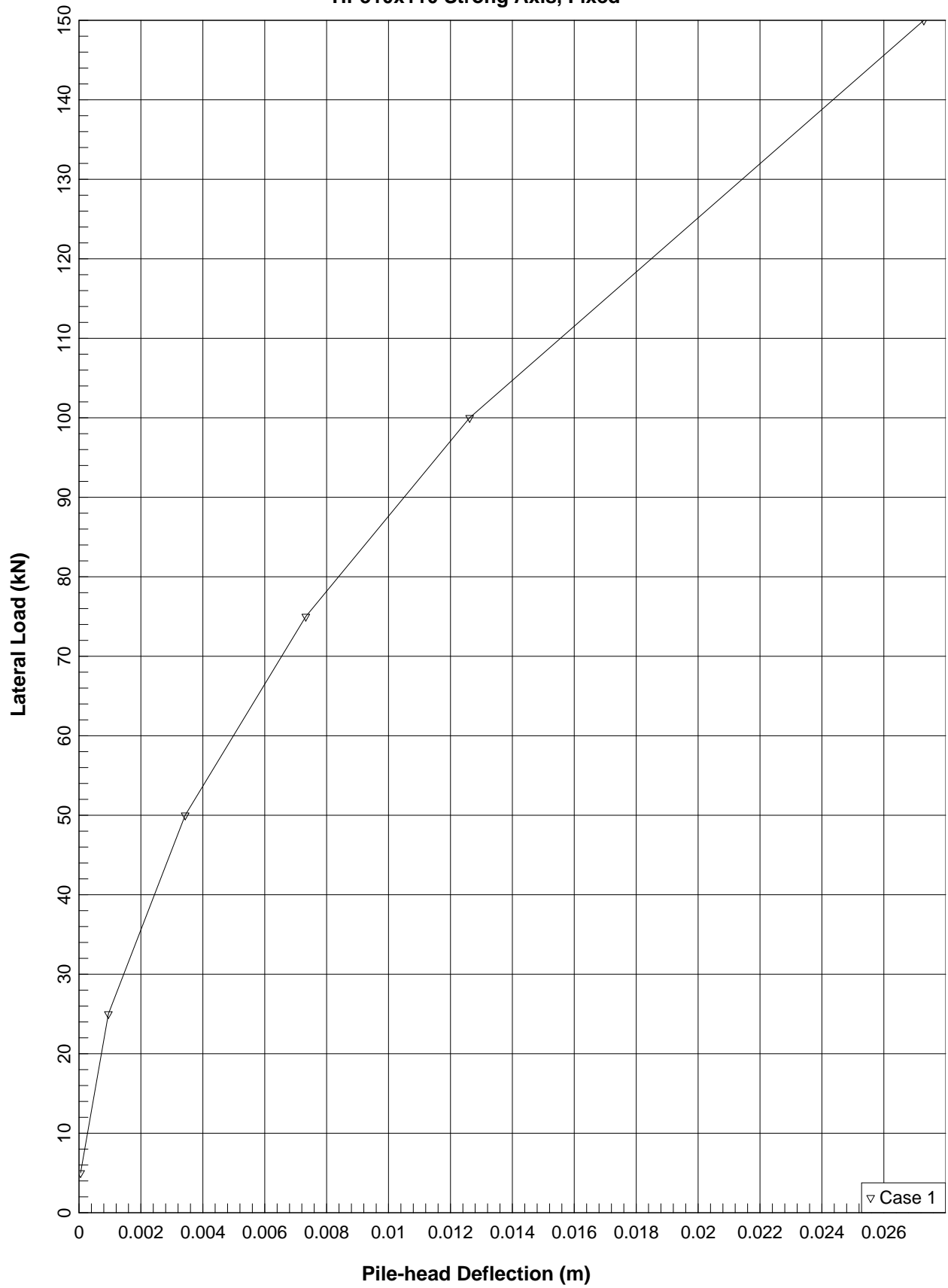
HP310x110 Weak Axis, Free



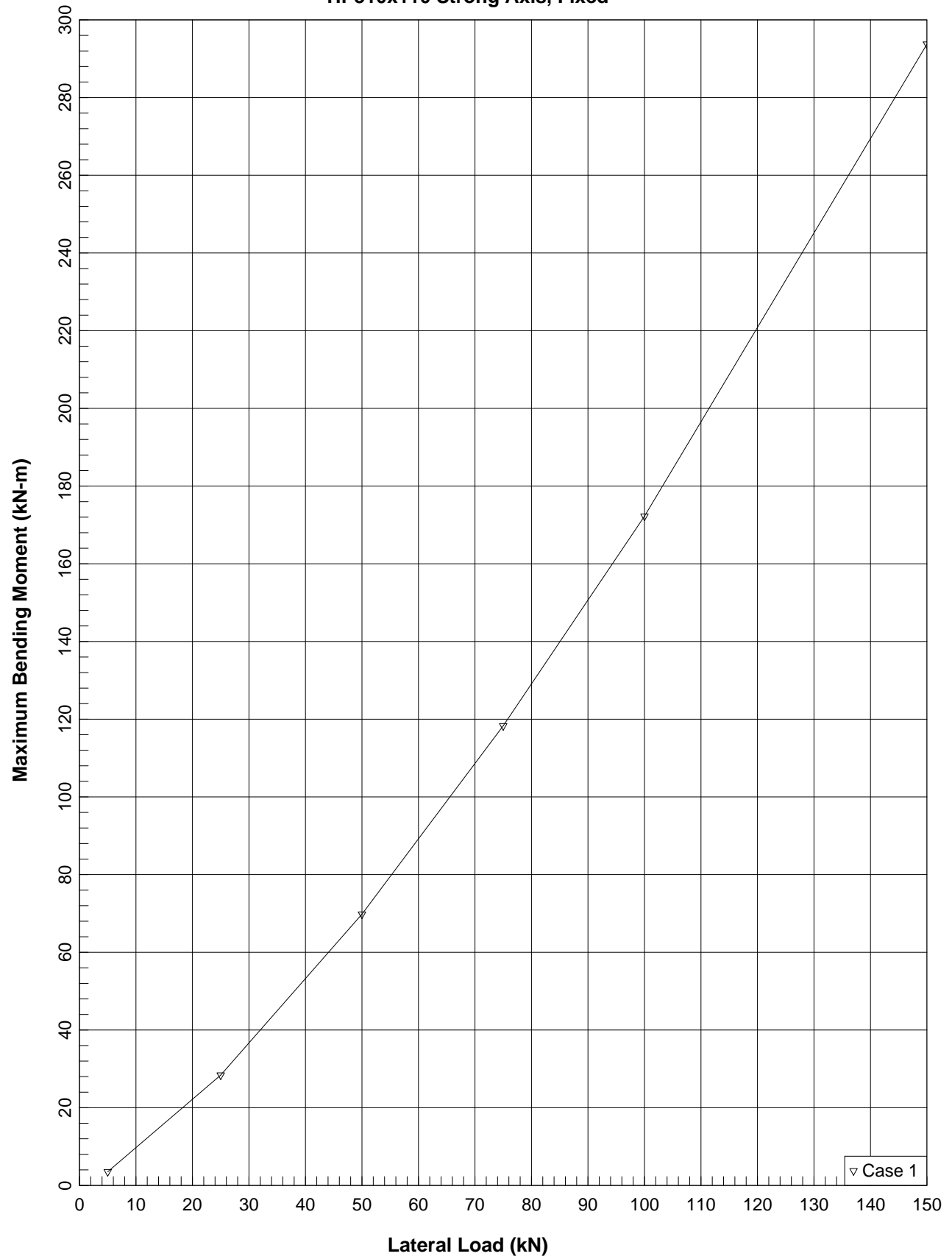
HP310x110 Weak Axis, Free



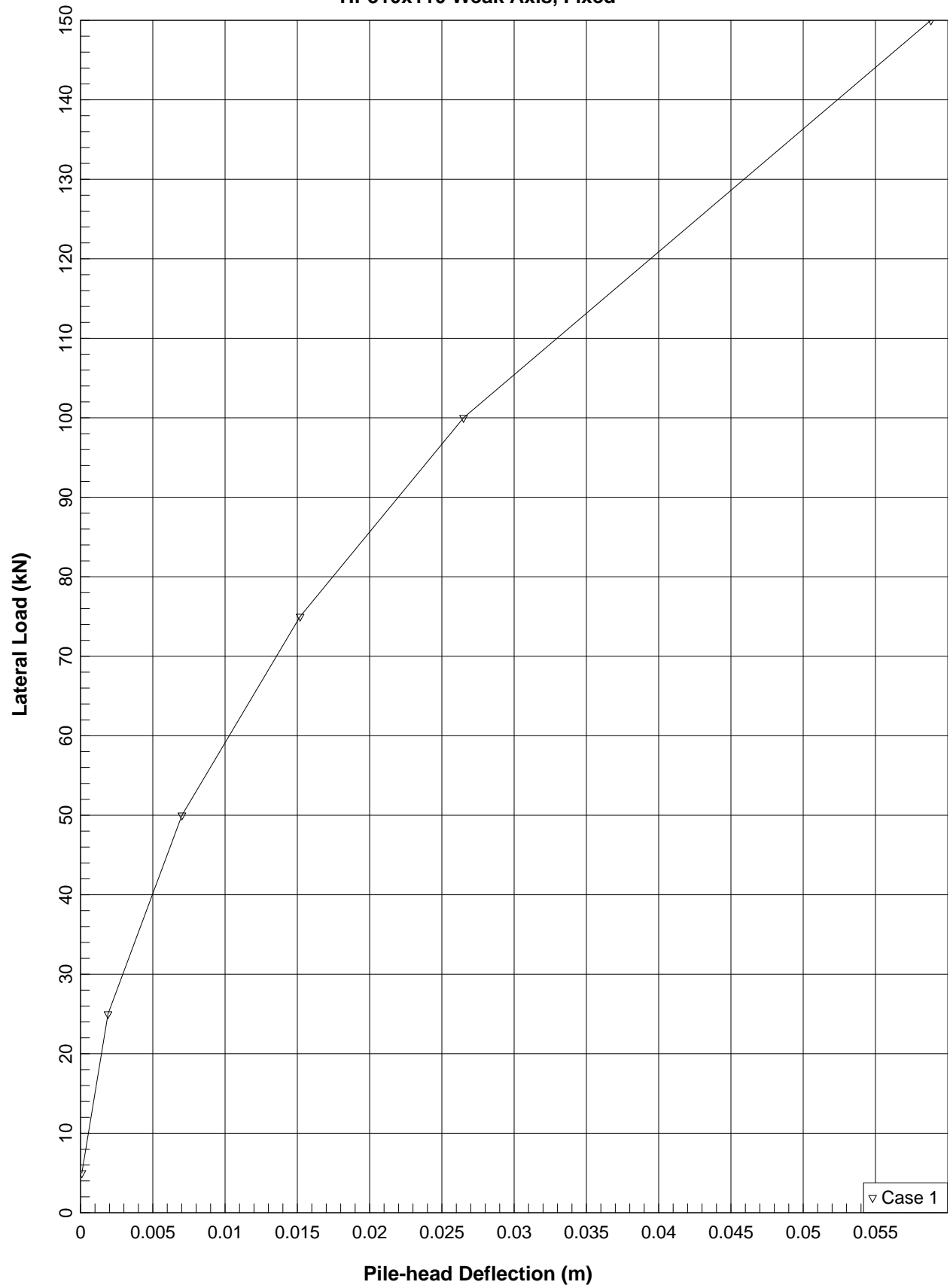
HP310x110 Strong Axis, Fixed



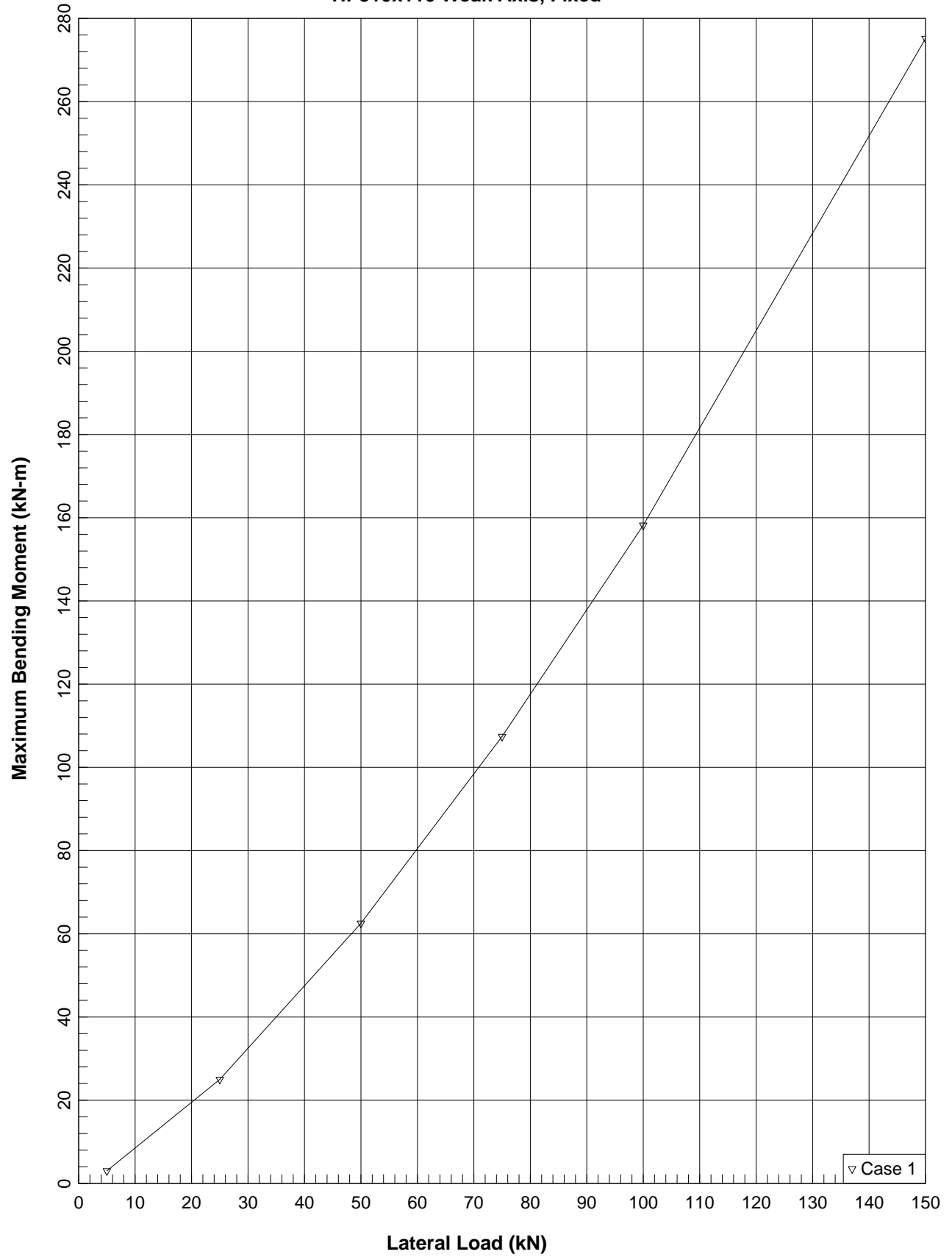
HP310x110 Strong Axis, Fixed



HP310x110 Weak Axis, Fixed



HP310x110 Weak Axis, Fixed



URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

EBL - West Abutment

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	74.9	72.5	43.4	35.9		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	32	32	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		2	5	No data	No data		

COHESIVE SOIL	Symbol	Units	Clay Crust		Clay		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	72.5	69.9	69.9	43.4		
Unit Weight	Gamma	kN/m3	17.5	17.5	15.5	15.5		
Undrained Shear Strength	Cu	kPa	110	80	40	80		
Major Principal Stain @50%	ϵ_{50}	%	0.5	0.5	1.0	0.5		
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8	5.8	5.8		
Shear Modulus	G	MPa	34	34	34	34		
Poisson's Ratio	ν		0.40	0.4	0.40	0.40		
Uncorrected SPT	N value		2	2	WH	WH		

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

EBL - Pier #1

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	68.4	64.6	45.6	39.7		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	32	32	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		22	1	31	37		

COHESIVE SOIL	Symbol	Units	Clay		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	64.6	45.6				
Unit Weight	Gamma	kN/m3	15.5	15.5				
Undrained Shear Strength	Cu	kPa	40	60				
Major Principal Stain @50%	ϵ_{50}	%	1.0	0.5				
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8				
Shear Modulus	G	MPa	34	34				
Poisson's Ratio	ν		0.40	0.4				
Uncorrected SPT	N value		WH	WH				

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

EBL - Pier #2

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	68.2	66.6	48.4	37.3		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	32	32	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		1	4	11	No data		

COHESIVE SOIL	Symbol	Units	Clay		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	66.6	48.4				
Unit Weight	Gamma	kN/m3	15.5	15.5				
Undrained Shear Strength	Cu	kPa	40	60				
Major Principal Stain @50%	ϵ_{50}	%	1.0	0.5				
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8				
Shear Modulus	G	MPa	34	34				
Poisson's Ratio	ν		0.40	0.4				
Uncorrected SPT	N value		WH	WH				

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

EBL - East Abutment

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	75.9	74.1	48.6	40		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	32	32	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		9	5	16	32		

COHESIVE SOIL	Symbol	Units	Clay		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	74.1	48.6				
Unit Weight	Gamma	kN/m3	15.5	15.5				
Undrained Shear Strength	Cu	kPa	40	60				
Major Principal Stain @50%	ϵ_{50}	%	1.0	0.5				
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8				
Shear Modulus	G	MPa	34	34				
Poisson's Ratio	ν		0.40	0.40				
Uncorrected SPT	N value		WH	WH				

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

WBL - West Abutment

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	75	71	47	38		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	32	32	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		12	8	No data	No data		

COHESIVE SOIL	Symbol	Units	Clay		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	71	47				
Unit Weight	Gamma	kN/m3	15.5	15.5				
Undrained Shear Strength	Cu	kPa	20	20				
Major Principal Stain @50%	ϵ_{50}	%	2.0	2.0				
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8				
Shear Modulus	G	MPa	34	34				
Poisson's Ratio	ν		0.40	0.4				
Uncorrected SPT	N value		WH	WH				

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

WBL - Pier #1

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Till		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	42.8	37.3				
Unit Weight	Gamma	kN/m3	21.5	21.5				
Angle of Internal Friction	ϕ	deg	35	35				
Subgrade Modulus	k	MPa/m	89	89				
Shear Modulus	G	MPa	235	235				
Uncorrected SPT	N value		44	77				

COHESIVE SOIL	Symbol	Units	Sandy Silty Clay		Clay Crust		Clay	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	68.7	66.4	66.4	64.9	64.9	42.8
Unit Weight	Gamma	kN/m3	17.0	17.0	17.5	17.5	15.5	15.5
Undrained Shear Strength	Cu	kPa	50	50	60	40	30	40
Major Principal Stain @50%	ϵ_{50}	%	0.5	0.5	0.5	1.0	1.0	1.0
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8	5.8	5.8	5.8	5.8
Shear Modulus	G	MPa	34	34	34	34	34	34
Poisson's Ratio	ν		0.40	0.40	0.40	0.40	0.40	0.40
Uncorrected SPT	N value		2	4	4	1	WH	WH

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

WBL - Pier #2

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	68.5	65.5	45.7	38.2		
Unit Weight	Gamma	kN/m3	20.0	20.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	30	30	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		3	1	10	38		

COHESIVE SOIL	Symbol	Units	Clay		Layer 2		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	65.5	45.7				
Unit Weight	Gamma	kN/m3	15.5	15.5				
Undrained Shear Strength	Cu	kPa	40	70				
Major Principal Stain @50%	ϵ_{50}	%	1.0	0.5				
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8				
Shear Modulus	G	MPa	34	34				
Poisson's Ratio	ν		0.40	0.40				
Uncorrected SPT	N value		WH	WH				

WH = weight of hammer (SPT N-value <1)

URS URS Canada Inc, Consulting Engineers 4th Floor, 30 Leek Crescent, Richmond Hill, ON	Project number:	33017345	Issue:	DETAILED DESIGN
	Project name:	Hwy 417 Bear Brook Bridges	Date of start:	
	Notes:	Abutments & Piers FOUNDATION DESIGN	Date of print:	
			Designed by:	
			Checked by:	

Soil Parameters Inquiry

WBL - East Abutment

Water Table EL: m

COHESIONLESS SOIL	Symbol	Units	Fill		Till		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	75.0	73.4	43.9	40.0		
Unit Weight	Gamma	kN/m3	21.0	21.0	21.5	21.5		
Angle of Internal Friction	ϕ	deg	30	30	35	35		
Subgrade Modulus	k	MPa/m	1.1	1.1	89	89		
Shear Modulus	G	MPa	1	1	235	235		
Uncorrected SPT	N value		7	5	15	15		

COHESIVE SOIL	Symbol	Units	Clay Crust		Clay		Layer 3	
			Top of Layer	Bott of Layer	Top of Layer	Bott of Layer	Top of Layer	Bott of Layer
Elevation	EL	m	73.4	72.5	72.5	43.9		
Unit Weight	Gamma	kN/m3	17.5	17.5	15.5	15.5		
Undrained Shear Strength	Cu	kPa	60	35	35	80		
Major Principal Stain @50%	ϵ_{50}	%	0.5	1.0	1.0	0.5		
Major Principal Stain @100%	ϵ_{100}	%	5.8	5.8	5.8	5.8		
Shear Modulus	G	MPa	34	34	34	34		
Poisson's Ratio	ν		0.40	0.40	0.40	0.40		
Uncorrected SPT	N value		2	2	WH	WH		

WH = weight of hammer (SPT N-value <1)

2010 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

Requested by: , Thurber Engineering Ltd.

November 27, 2013

Site Coordinates: 45.3622 North 75.486 West

User File Reference: Hwy 417 Bear Brook Bridges

National Building Code ground motions:

2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.635	0.309	0.138	0.046	0.322

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. 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 calculated values.*

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.090	0.249	0.386
Sa(0.5)	0.043	0.123	0.187
Sa(1.0)	0.017	0.056	0.088
Sa(2.0)	0.006	0.018	0.028
PGA	0.039	0.123	0.201

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3

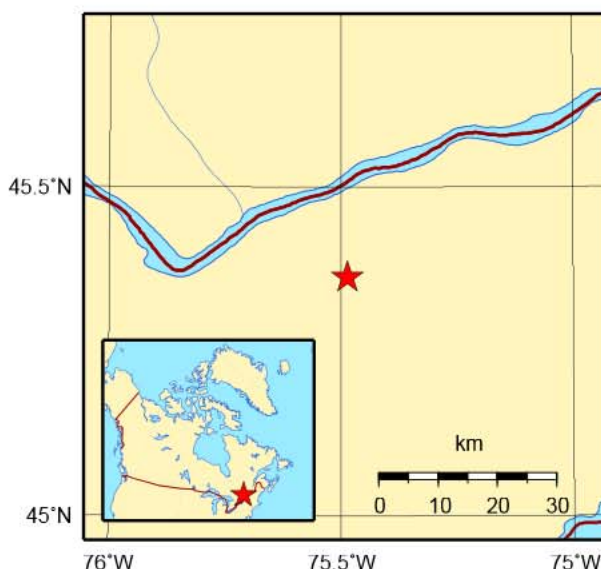
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

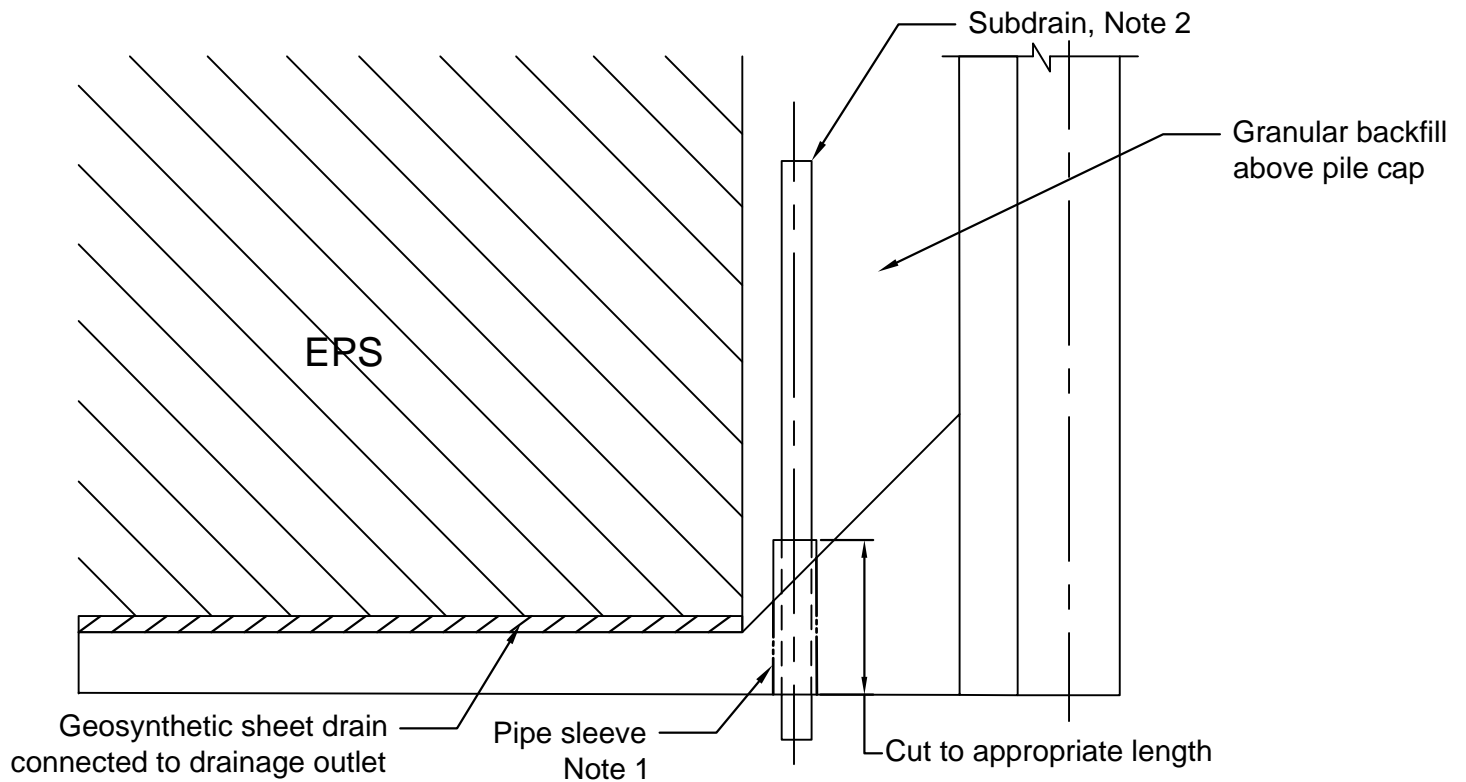
User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Aussi disponible en français

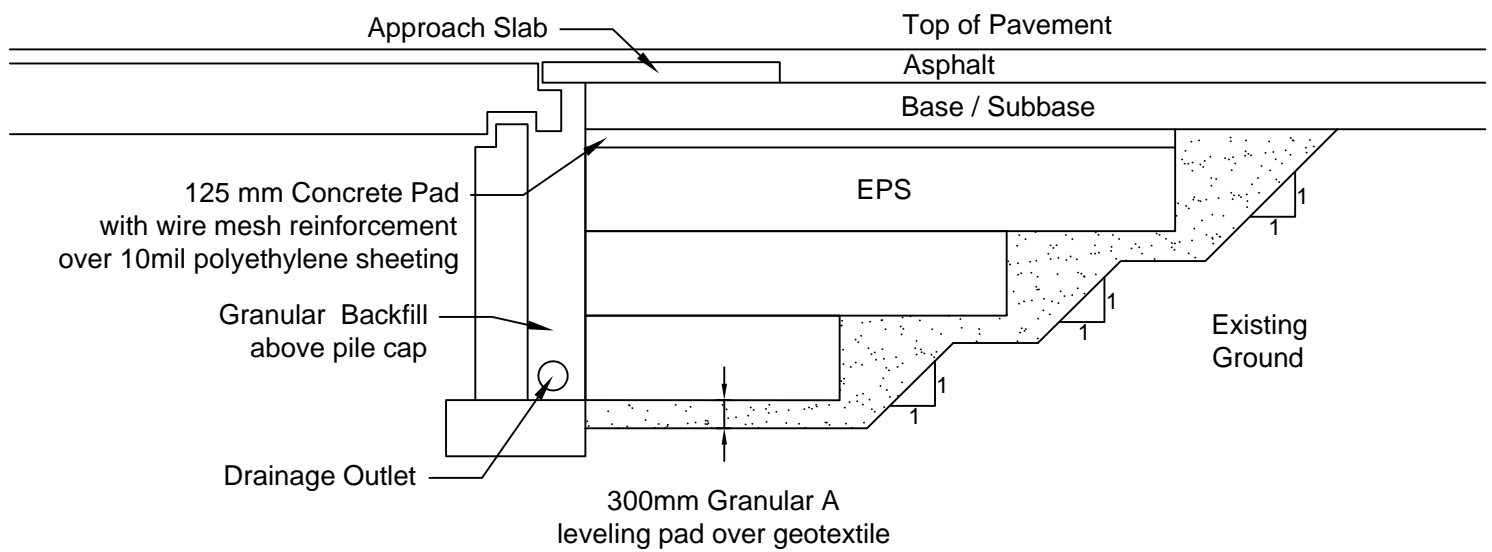




NOTE:

- 1 Height to be consistent with positive drainage of subdrain as specified.
 - 2 150mm dia perforated pipe subdrain wrapped with geotextile.
- A Subdrain shall be installed with a 2% gradient behind wall
- B Pipe sleeve may need to extend through EPS where EPS is required on outside of wing walls

Typical Detail - EPS and Drainage behind Abutment and Wingwalls



Typical Section - Transitions from Abutment to EPS Backfill to Soil

1. List of Special Provisions Referenced in this Report

OPSS 902

OPSS 903

OPSS 539

OPSS 511

OPSS.PROV 1004

2. Suggested Text for NSSP for Design of Crane Pad Supports

The contractor is advised that soft to firm sensitive clays are present at the site and that design and construction of temporary foundations and/or support pads may be required for crane pads. The evaluation and design of such measures shall be carried out by a qualified Professional Engineer.

EXPANDED POLYSTYRENE EMBANKMENT - Item No. **

Special Provision

1. Scope

This special provision covers the requirements for the supply and construction of the rigid expanded polystyrene embankment fill and associated works as shown on the contract drawings.

2. References

This special provision refers to the following standards, specifications or publications.

National Standards of Canada

CAN/CGSB - 51.20 M87

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

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

3. Subsurface Conditions

The subsurface conditions at the site are described in the Foundation Investigation Report for this Contract.

4. **Definitions**

For the purpose of this special provision, the following definitions apply:

Rigid Expanded Polystyrene

Molded 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: 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.

5. **Qualification**

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.

6. **Submission and Design Requirements**

6.1 **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 materials and construction procedure.

6.2 **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.

6.3 Construction

The contractor shall submit full details of the following.

- a) The method of foundation excavation and preparation.
- b) Construction of levelling pad.
- c) 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.
- d) The method and limits of placement of polyethylene sheeting.
- e) The method of placement of 125 mm reinforced concrete base pad (or equivalent).
- f) The method of placement of subbase material.
- g) The method of placement of side slope cover.

7. Materials

7.1 Granular Levelling Pad

The levelling pad shall consist of a Granular "A" or Granular "B" material with gradation and physical requirements as specified in OPSS 1010.

7.2 Rigid Expanded Polystyrene

7.2.1 General

7.2.1.1 The Contractor shall submit:

- 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.
- 7.2.1.2 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.

7.2.2 Detail Requirements

Requirements shall be as shown in Table 1 and as described below.

Table 1 – Material Properties

PROPERTY	UNIT	REQUIREMENTS	TEST PROCEDURE
Geometry	mm	1200 x 600 x 300	
- Linear		with tolerances \pm	
- Flatness		1%	
- Squareness		10 mm in 3 m \pm	

- Thickness		0.5%	
		-3, +5	
Compressive Strength	kPa (min)	110 (EPS Type 22)	ASTM D1621
	at 5% Deformation	170 (EPS Type 29)	(Procedure A)
Flexural Strength	kPa (min)	240 (EPS Type 22)	ASTM C203
		340 (EPS Type 29)	(Procedure B)
Dimensional Stability	% linear change (max)	1.5	ASTM D2126
Thermal Resistance	m ² .°C/W (min for 25 mm thickness)	0.7	ASTM C177 or C518
Flammability	Limiting Oxygen Index (min)	24	ASTM D2863
Water Absorption	% by Volume (max)	4 (EPS Type 22)	ASTM D2842
		2 (EPS Type 29)	

7.2.2.1 Geometry

The expanded polystyrene shall be supplied in the form of rectangular parallel blocks of minimum acceptable dimensions of 1200 mm x 600 mm x 300 mm .

The maximum deviation from the specified linear dimensions shall be $\pm 1\%$. The flatness of the block 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.

7.2.2.2 Compressive Strength

The minimum compressive strength, measured in accordance with ASTM D1621, Procedure A, shall be 110 kPa for EPS Type 22 and 170 kPa for EPS Type 29 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.

7.2.2.3 Flexural Strength

The minimum flexural strength of the polystyrene shall be 240 kPa for EPS Type 22 and 340 kPa for EPS Type 29. The flexural strength shall be determined in accordance to ASTM C203, method 1, Procedure B.

7.2.2.4 Dimensional Stability

Dimensional Stability shall be determined in accordance with ASTM D2126, Procedure G. A tolerance of 1.5% shall be satisfied.

7.2.2.5 Thermal Resistance

The thermal resistance shall be 0.7 m².°C/W for a 25 mm thickness using the following equation and using the average value from three specimens:

$$R_{25\text{mm}} = \frac{R_{\text{measured}}}{\text{thickness (mm)}} \times 25$$

The thermal resistance shall be measured in accordance with ASTM C177 or C518.

7.2.2.6 Flammability

The expanded polystyrene shall be classified as to surface burning characteristics in accordance with CAN/ULC - 51022 having a flame spread rating less than 500. The expanded polystyrene shall have a minimum limiting oxygen index measured in accordance with ASTM D2863

7.2.2.7 Water Absorption

The water absorption as measured by ASTM D2842 shall be limited to 4% for EPS Type 22 and 2% for EPS Type 29 by volume.

7.2.2.8 Chemical Resistance

The expanded polystyrene shall be resistant to common inorganic acids and alkalis. A table identifying the chemical resistance as either resistant, limited or not resistant shall be submitted.

7.2.2.9 Biological Resistance

The expanded polystyrene shall be resistant to biological degradation caused by organisms or enzymes.

7.2.2.10 Environmental

The expanded polystyrene shall be inert, non-nutritive and highly stable and shall not produce undesirable gases or leachate.

8.0 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.

9.0 Construction

9.1 Foundation Excavation

Foundation excavation shall be carried out to the design elevations shown on the drawings. Any softened, loosened or deleterious materials at the foundation footing elevation shall be subexcavated and replaced with Granular 'A' or Granular 'B' material.

9.2 Leveling Pad

Place, level and compact a layer of Granular 'A' or Granular 'B' material in accordance with OPSS 501 to within ± 30 mm of the design elevation. The leveling 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 leveling pad shall not be placed on frozen ground.

9.3 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.

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.

- (3) Sloping end adjustments at the abutments shall be accomplished by leveling terraces in the subsoil in accordance with the block thickness.
- (4) 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.
- (5) 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.
- (6) 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.

- (7) Exposed blocks shall be covered immediately to avoid possible burrowing by animals.
- (8) Individually marked blocks shall be fabricated and placed to ensure the top surface matches the elevation and crossfall shown on the drawings.
- (9) The top surface and side surfaces of the expanded polystyrene shall be covered with 10 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.
- (10) The contractor shall install the concrete base pad as detailed elsewhere in the contract.
- (11) The side slope of the rigid expanded polystyrene embankment shall be covered with Select Subgrade Material (SSM) as detailed elsewhere in this contract.
- (12) 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.
- (13) 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.***

10. 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.

11. Quality Assurance

Sampling and Testing

11.1.1 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.

11.1.2 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.

11.1.3 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.

12. Measurement for Payment

12.1 Actual Measurement

Measurement will be by volume in cubic metres measured in its original position and based on cross-sections.

13. Payment

13.1 Basis of Payment

The Concrete Base pad and granular leveling pad shall be paid for with the appropriate tender items as detailed elsewhere in the contract.

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.

14. Sheeting

14.1 Scope of Work

As part of the work of the above noted tender item the Contractor shall supply and install Polyethylene Sheeting as detailed elsewhere in the contract.

14.2 Basis of Payment

Payment at the contract price for the above tender item shall include full compensation for all labour, equipment and materials to install the Polyethylene Sheeting as detailed elsewhere in the contract and no extra payment will be made.