



## REPORT

# Foundation Investigation and Design Ramsayville Road Overpass Replacement Site No. 3-265/1 (EBL) and 3-265/2 (WBL) Highway 417 Ottawa, Ontario *GWP No. 4145-10-00*

Submitted to:

**WSP Canada Group Limited**

300 - 2611 Queensview Drive  
Ottawa, Ontario  
K2B 8K2

Submitted by:

**Golder Associates Ltd.**

1931 Robertson Road Ottawa, Ontario, K2H 5B7 Canada

Geocres Number: 31G5-284

Latitude: 45.373832 Longitude: -75.565307

1662565-1130

August 2018



## Distribution List

2 copies - WSP Canada Group Limited

1 copy - Ministry of Transportation, Kingston

1 copy - Ministry of Transportation, Downsview

1 e-copy - Golder



# Table of Contents

## PART A – FOUNDATION INVESTIGATION

<b>1.0 INTRODUCTION .....</b>	<b>1</b>
<b>2.0 SITE DESCRIPTION AND GEOLOGY .....</b>	<b>1</b>
2.1 General.....	1
2.2 Regional Geology.....	1
<b>3.0 INVESTIGATION PROCEDURES .....</b>	<b>2</b>
3.1 Current Investigation (2017).....	2
3.2 Previous Investigation (1968).....	4
<b>4.0 DESCRIPTION OF SUBSURFACE CONDITIONS .....</b>	<b>5</b>
4.1 Site Stratigraphy.....	5
4.2 Topsoil and Fill Material .....	5
4.3 Alluvium.....	6
4.4 Silty Clay to Clayey Silt .....	6
4.5 Silty Sand to Sandy Silt (Glacial Till).....	7
4.6 Bedrock .....	8
4.7 Groundwater Conditions .....	9
<b>5.0 CLOSURE .....</b>	<b>10</b>

## PART B – FOUNDATION DESIGN

<b>6.0 FOUNDATION ENGINEERING RECOMMENDATIONS .....</b>	<b>11</b>
6.1 General.....	11
6.2 Seismic Design .....	11
6.2.1 Seismic Zone and Importance Category .....	11
6.2.2 Seismic Site Classification .....	12
6.2.3 Spectral Response Values and Seismic Performance Category .....	12
6.2.4 Liquefaction Assessment.....	13
6.3 Bridge Foundations – General .....	14
6.3.1 Existing Foundations.....	14
6.3.2 Bridge Foundation Options .....	15
6.3.3 Feasibility of Integral and Semi-Integral Abutments .....	16
6.3.4 Consequence and Site Understanding Classification.....	17



6.4	Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations .....	17
6.4.1	Founding Elevation .....	17
6.4.2	Factored Geotechnical Axial Resistances .....	18
6.4.3	Downdrag Load (Negative Skin Friction) .....	19
6.4.4	Lateral Geotechnical Resistance .....	19
6.4.5	Lateral Soil-Structure Interaction Springs .....	20
6.5	Drilled Shaft (Caisson) Foundations .....	21
6.6	Lateral Earth Pressures for Design .....	21
6.6.1	Static Lateral Earth Pressures for Design .....	22
6.6.2	Seismic Lateral Earth Pressures for Design .....	23
6.7	Approach Embankment Design and Construction .....	24
6.7.1	Subgrade Preparation and Embankment Construction .....	24
6.7.2	Approach Embankment and Retaining Wall Stability .....	24
6.7.3	Approach Embankment Settlement .....	25
6.7.3.1	Allow Settlements to Occur .....	27
6.7.3.2	Preloading .....	27
6.7.3.3	Preloading and Surcharging .....	27
6.7.3.4	Wick Drains .....	28
6.7.3.5	Lightweight Fills .....	28
6.7.3.6	Settlement Monitoring .....	29
6.8	Construction Considerations .....	29
6.8.1	Excavations and Temporary Protection Systems .....	29
6.8.2	Groundwater and Surface Water Control .....	30
6.8.3	Vibration Monitoring During Pile Driving .....	30
6.9	Corrosion and Cement Type .....	30
<b>7.0</b>	<b>CLOSURE .....</b>	<b>31</b>

## TABLES

Table 1 - Comparison of Bridge Abutment and Pier Foundation Alternatives

Table 2 - Comparison of Settlement Mitigation Alternatives

## DRAWINGS

Drawing 1 - Ramsayville Creek Overpass, Site 3-265/2, Borehole Locations and Soil Strata

Drawing 2 - Ramsayville Creek Overpass, Site 3-265/1, Borehole Locations and Soil Strata



## **APPENDICES**

### **APPENDIX A**

#### **Borehole and Drillhole Records, Current Investigation**

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes 17-1301 to 17-1312

Bedrock Core Photographs, Figures A1 to A14

### **APPENDIX B**

#### **Laboratory Test Results, Current Investigation**

Figure B1 – Grain Size Distribution Test Results – Silt and Clay (FILL)

Figure B2 – Grain Size Distribution Test Results – Silty Sand (ALLUVIUM)

Figure B3 – Plasticity Chart – Silty Clay to Clay (WEATHERED CRUST)

Figure B4a to B4c – Plasticity Chart – Silty Clay to Clay

Figure B5 – Grain Size Distribution Test Results – Silty Clay to Clay

Figures B6 to B11 – Consolidation Test Results

Figure B12 – Plasticity Chart – Silty Sand to Sandy Silt (TILL)

Figure B13 – Grain Size Distribution Test Results – Silty Sand to Sandy Silt (TILL)

Figure B14 – Summary of Laboratory Compressive Strength Testing – Unconfined Compression Tests

Figure B15 – Summary of Engineering Properties

### **APPENDIX C**

#### **Borehole Record and Laboratory Test Results**

##### **(Previous Investigation, GEOCREC No. 31G05-071)**

Records of Previous Boreholes BH 1 to BH 10

Laboratory Test Results

### **APPENDIX D**

#### **Basic Chemical Analysis – Eurofins Report Number 1710192**

### **APPENDIX E**

#### **Results of MASW Testing**

### **APPENDIX F**

#### **Results of Analysis**

Figures F1 to F4 - Slope Stability Assessment

Figures F5 to F20 - P-Y Curves



## **APPENDIX G**

### **Non Standard Special Provisions**

Vibration Monitoring During Piling

Driving Piles Adjacent to Existing Piles

Placement of Working Slab – Structures

Obstructions During Piling

Settlement Monitoring During Grading

Excavating Through Obstructions - Structures

## **APPENDIX H**

### **Site Photographs**



**PART A**

Foundation Investigation Report  
Proposed Ramsayville Road Replacement  
Site No. 3-265/1 and 3-265/2  
Highway 417  
Ottawa, Ontario  
GWP 4145-10-00



## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations associated with numerous bridge and structural culvert rehabilitations and/or replacements on Highway 417 between the Aviation Parkway and Ramsayville Road as well as the widening of Highway 417 from Ottawa Road 174 to Hunt Club Road in Ottawa, Ontario (Assignment number 4016-E-0008).

This report presents the results of the foundation investigation carried out to provide foundation design recommendations of the proposed replacement of the Ramsayville Road Overpass, Sites No. 3-265/1 and 3-265/2 located on Highway 417 East Bound Lane (EBL) and West Bound Lane (WBL), respectively in Ottawa, Ontario (G.W.P. 4145-10-00 and W.P. 4145-10-01). The replacement of the existing structures are to be carried out in accordance with the current version of the Canadian Highway Bridge Design Code (CHBDC, S6-14).

The terms of reference and scope of work for the foundation investigation are outlined in the MTO's Request for Proposal (RFP), dated May 2016, and subsequent addenda. Golder's scope of work for foundation engineering services associated with the Highway 417 Ramsayville Road Overpass is contained in Table 17.8.3 of WSP's Technical Proposal for this assignment. The work has been carried out in accordance with Golder's Quality Control Plan for foundation engineering services for this project, dated March 13, 2017.

## 2.0 SITE DESCRIPTION AND GEOLOGY

### 2.1 General

The Ramsayville Road Overpass is located approximately 2.0 km south of Hunt Club Road in Ottawa, Ontario. At this location, Highway 417 is a divided highway with two travel lanes in each direction separated by a green area with an approximate width of 70 m.

The existing EBL bridge was constructed in 1970 and the existing WBL bridge was constructed in 1973. The bridges are five-span, 93.9 m long (18.0 m, 18.3 m, 21.3 m, 18.3 m, and 18.0 m), reinforced concrete slab on pre-stressed girder structures. The overall structure width is 11.0 m in the EBL and 12.6 m in the WBL. The structure is supported by four piers and conventional spill-through abutments. The bridge abutments are supported on "perched" foundations on vertical steel piles end bearing on bedrock. The front row of piles are battered in line with Highway 417. The pier foundations are supported on battered steel piles end bearing on bedrock.

### 2.2 Regional Geology

As delineated in *The Physiography of Southern Ontario*<sup>1</sup>, this section of Highway 417 lies on the boundary of the minor physiographic regions known as the Ottawa Valley Clay Plain and the Russell and Prescott Sand plain, which lies within the major physiographic region of the Ottawa-St. Lawrence Lowland.

The Ottawa Valley Clay Plain region is characterized by relatively thick deposits of sensitive marine clay, silt and silty clay that were deposited within the Champlain Sea basin. These deposits, known as the Champlain Sea clay or Leda clay, overlie relatively thin, commonly reworked glacial till and glaciofluvial deposits, that in turn overlie

---

<sup>1</sup> Chapman, L. J. and Putnam, D. F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey. Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000. Ontario Ministry of Natural Resources.



bedrock<sup>2</sup>. The Russell and Prescott Sand Plains are generally characterized by a sand mantle about 3 to 5 m thick overlying an extensive deposit of sensitive marine clay deposited within the Champlain Sea basin, underlain by glacial till and shale bedrock.

This region is underlain by a series of sedimentary rocks, consisting of sandstones, dolostones, limestones and shales that are, in turn, underlain at depth by bedrock of Carlsbad Formation.

The site falls within the Western Québec (WQ) seismic zone according to the Geological Survey of Canada. The WQ zone constitutes a large area which encompasses the urban areas of Montreal, Ottawa-Hull and Cornwall. Within the WQ zone recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montreal-Maniwaki axis. The two major earthquakes in the WQ zone includes the 1935 Témiscaming event which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2, and the 1944 Cornwall-Massena event which had a magnitude of 5.6.

## 3.0 INVESTIGATION PROCEDURES

### 3.1 Current Investigation (2017)

The subsurface investigation for the bridge replacement was carried out between May 7 and June 10, 2017. During that time, twelve boreholes (17-1301 to 17-1312, inclusive) were advanced within the median at the proposed locations of the piers and abutments. The borehole locations are shown on Drawings 1 and 2.

The boreholes were advanced using 108 mm inside diameter (200 mm outside diameter) continuous flight hollow stem augers on track mounted drill rigs, supplied and operated by Forage Grenville Drilling of Grenville, Québec. The boreholes were advanced to depths ranging from about 13.4 to 56.0 m below the existing ground surface.

Samples of the overburden were obtained at 0.8 m to 4.5 m intervals of depth using 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. In-situ vane testing (using an MTO “N”-sized vane) was carried out within the cohesive deposits, where possible. Boreholes 17-1301A, 17-1306A, and 17-1312B were advanced adjacent to 17-1301, 17-1306, and 17-1312, respectively, to retrieve relatively undisturbed 73 millimetre diameter thin-walled Shelby tube samples of the clay using a fixed piston sampler.

Upon reaching refusal to casing advancement in Boreholes 17-1302, 17-1303, 17-1305 and 17-1308 to 17-1311, the boreholes were advanced into the bedrock surface to depths of 3 to 3.4 m using rotary diamond drilling techniques while retrieving NQ sized core. A water truck was on site to supply the drill rigs with water for advancing the casing in the overburden and for the coring the bedrock. Traffic control required to allow the water truck and support vehicles to park adjacent to the site was supplied by Beacon Lite Ltd. of Ottawa, Ontario.

Monitoring wells were installed in Boreholes 17-1305, 17-1310, and 17-1311 to monitor the groundwater level at the site. The monitoring wells consisted of 31 and 50 mm outside diameter PVC tubing with a 1.5 to 3.0 m long screen. The groundwater levels was measured in the monitoring wells on June 16, 2017.

The remainder of the boreholes were backfilled with bentonite mixed with soil cuttings. The site conditions were restored following completion of the field work.

---

<sup>2</sup> Belanger, J.R. “Urban Geology of Canada’s National Capital Area”, in *Urban Geology of Canadian Cities*, Geological Association of Canada Special Paper 42, Ed. P.F. Karrow and O.L. White, 1998.



The field work was supervised on a full time basis by members of Golder's staff who located the boreholes in the field, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil and bedrock samples were identified in the field, placed in labelled containers, and transported to Golder's laboratory in Ottawa for further examination and to Golder's laboratories in Ottawa and Mississauga for testing. Index and classification tests consisting of water content determinations, Atterberg Limit tests, and grain size distribution analyses were carried out on selected soil samples at the Golder Ottawa laboratory. Unconfined compressive strength tests were carried out on selected rock core samples in the Golder Mississauga laboratory. Consolidation tests were performed on selected Shelby tube samples from Boreholes 17-1301A, 17-1305, 17-1307, 17-1311, and 17-1312B at Golder's Mississauga laboratory. The laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate.

Eight soil samples from Boreholes 17-1302, 17-1303, 17-1304, 17-1305, 17-1308, 17-1309, 17-1310, and 17-1311 were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack).

In addition to the borehole investigation, shear wave velocity profiling at the site was completed using the Multichannel Analysis of Surface Waves (MASW) technique and was conducted on May 9, 2017, by personnel from the Golder Associates' Mississauga and Ottawa offices. A series of 24 low frequency (4.5 Hz) geophones were laid out at 3 m intervals. A 9.9 kg sledge hammer and 45 kg weight drop were used as the seismic source. The source locations were offset at distances of 5, 10, and 15 m off the end and collinear with the geophone array.

The borehole elevation were surveyed by Golder using a Trimble R8 GPS unit. The borehole locations, including MTM NAD83 northing and easting coordinates, ground surface elevations referenced to geodetic datum, and drilled depths are summarized in the following table and are shown on Drawings 1 and 2.

Borehole Number	Borehole Location	MTM NAD83 Zone 9 Northing (m)	MTM NAD83 Zone 9 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
17-1301	EBL West Approach Embankment	5026398.4	377872.0	78.2	13.4
17-1301A	EBL West Approach Embankment	5026398.4	377872.0	78.2	5.9
17-1302	EBL West Abutment	5026398.8	377896.0	74.6	54.3
17-1303	EBL West Pier	5026388.9	377932.9	71.3	51.5
17-1304	EBL East Pier	5026379.0	377968.8	72.5	48.7
17-1305	EBL East Abutment	5026374.0	377994.5	76.6	56.1



Borehole Number	Borehole Location	MTM NAD83 Zone 9 Northing (m)	MTM NAD83 Zone 9 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
17-1306	EBL East Approach Embankment	5026368.5	378017.3	77.3	13.4
17-1306A	EBL East Approach Embankment	5026369.6	378017.2	77.1	6.1
17-1307	WBL East Approach Embankment	5026409.0	378035.5	77.7	13.4
17-1308	WBL East Abutment	5026420.5	378004.0	71.3	50.8
17-1309	WBL East Pier	5026421.8	377984.1	69.6	48.4
17-1310	WBL West Pier	5026428.4	377933.4	71.6	51.4
17-1311	WBL West Abutment	5026435.9	377914.0	75.3	54.6
17-1312	WBL West Approach Embankment	5026443.2	377899.3	77.5	14.3
17-1312B	WBL West Approach Embankment	5026443.2	377899.3	77.5	10.4

### 3.2 Previous Investigation (1968)

A previous investigation was carried out in 1968 by the MTO (then the Department of Highways, Ontario) for the design of the existing bridge. The results of that investigation are contained in the report titled *“Foundation Investigation Report for Eastbound Lane and West Bound Lane, Structures at the Crossing of Ramsay Creek and Proposed Hwy. #417, District No. 9 (Ottawa), W.J. 68-F-54 – W.P. 34-66-10-11”* dated September 26, 1968 (GEOCRE No. 31G05-071).

As part of the current assignment, this previously collected subsurface information pertinent to the site was reviewed and compiled.

Ten boreholes, each with an adjacent Dynamic Cone Penetration Test (DCPT), were put down at the site as part of the original investigation along the then-proposed bridge alignment. The approximate borehole and ground surface elevations are shown on the Record of Borehole sheets included in Appendix C and are also shown on Drawings 1 and 2. The locations of the previous boreholes and DCPTs should be considered approximate since the locations were referenced to an imperial borehole location plan rather than metric MTM coordinates.



The detailed subsurface soils and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records from the 1968 investigation.

## 4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

### 4.1 Site Stratigraphy

The Record of Borehole sheet from the current investigation is presented in Appendix A. The results of the laboratory testing carried out during the current investigation are presented on the Record of Boreholes sheets and on Figures B1 to B13 in Appendix B. The results of basic chemical analysis completed on select soil samples are provided in Appendix D. The borehole locations and the interpreted stratigraphic profile projected along the Ramsayville Road Overpass WBL and EBL are shown on Drawings 1 and 2, respectively. The stratigraphic boundaries shown on the Record of Borehole sheets and on the interpreted stratigraphic profile are inferred from observations of drilling progress and noncontinuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

The MASW test results and report are presented in Appendix E and include the calculated shear wave velocity profile measured from the field testing and a graphical representation of the shear wave velocity profile with depth.

In general, the subsurface conditions at the site consist of a layer of fill extending down to depths of about 0.4 to 2.0 metres (Elevations of about 69.2 to 76.7 m) over a deposit of alluvium extending down to a depth of about 1.8 m (Elevation of about 67.8 m). The fill and alluvium are underlain by a thick deposit of sensitive silty clay extending down to depths of about 33.8 to 42.1 m (Elevations of about 33.5 to 36.2 m) overlying a thin glacial till mantle extending to depths of about 45.0 to 53.0 m (Elevations of about 23.3 to 24.6 m) and shale bedrock. Shale bedrock was indicated to be present at depths ranging from 45 to 53 m (Elevations of about 23.3 to 24.6 m). The groundwater levels were encountered at depths ranging from about 3.0 m below the ground surface to 7.0 m above the ground surface (Elevations ranging from about 70.4 to 79.5 m).

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

### 4.2 Topsoil and Fill Material

Topsoil was encountered at the ground surface at Boreholes 17-1301, 17-1302, 17-1303, and 17-1309 to 17-1312. The topsoil ranges in thickness from about 100 to 300 millimetres.

A layer of fill exists at the ground surface, or below the topsoil where encountered, in Boreholes 17-1301, 17-1303 to 17-1308, and 17-1312 and extends to depths ranging from about 0.4 to 2.0 m below ground surface. The fill material generally consists of silty sand to silty clay to clayey silt with varying amounts of gravel. The fill also contains organic matter.

SPT 'N' values measured in the fill material generally range from about 4 to 12 blows per 0.3 m of penetration indicating the state of compactness is loose to compact.

The results of grain size distribution testing carried out on three samples of the fill are shown on the record of borehole logs and provided on Figure B1. The measured water content of the fill ranges from approximately 22 to 33 percent.



### 4.3 Alluvium

A deposit of alluvium was encountered below the topsoil in Borehole 17-1309 and consists of a mixture of silty clay, clayey silt and silty sand. The alluvium deposit extends down to a depth of about 1.8 m below the existing ground surface.

One SPT 'N' value of 8 blows per 0.3 m of penetration was measured in the alluvium, indicating the state of compactness is loose.

The results of grain size distribution testing carried out on one sample of the alluvium are shown on the record of borehole logs and provided in Figure B2. The measured water content on one sample of the alluvium deposit is approximately 24 percent.

### 4.4 Silty Clay to Clayey Silt

An extensive deposit of silty clay to clayey silt was encountered in the boreholes at this site. The deposit was proven to be about 32 m to 42 m in thickness, with the base of the deposit observed at depths of approximately 33.8 to 42.1 m below the existing ground surface (i.e. Elevation ranging from about 33.5 to 36.2 m). Much of the silty clay to clay deposit contained black organic mottling. Some silty sand layers were also noted.

The upper portion of the silty clay to clay deposit has been weathered to a grey-brown crust at all of the borehole locations except 17-1309. The weathered crust extends to depths ranging from about 1.4 to 4.3 m below the existing ground surface (i.e., Elevations ranging from 67.6 to 74.4 m).

SPT 'N' values measured in the weathered silty clay crust ranged from 2 to 12 blows per 0.3 m of penetration. In situ shear vane testing carried out within this deposit measured undrained shear strengths ranging from about 57 to greater than 96 kPa, indicating that the deposit has a stiff to very stiff consistency. In situ remold strengths from two shear vane tests were about 27 kPa, indicating a silty clay of medium sensitivity. A summary of the undrained shear strengths is shown in Figure B15.

The results of Atterberg limit testing on 10 samples of the weathered silty clay deposit gave plasticity index values ranging from about 32 and 58 percent and liquid limit values ranging from about 52 and 85 percent, indicating a deposit of high plasticity. The results of the Atterberg limit testing are provided on Figure B3 and Figure B15. The measured water content on 16 samples of the weathered silty clay deposit ranges from approximately 24 to 60 percent. The silty clay to clay below the depth of weathering is grey in colour. At depth, the grey silty clay to clay grades to clayey silt to silty clay. The grey silty clay to clayey silt, where fully penetrated, extends to depths ranging from about 33.8 to 42.1 m below the existing ground surface (Elevations ranging from about 33.5 to 36.2 m).

SPT 'N' values measured in the silty clay deposit ranged from "weight of rods" to 5 blows per 0.3 m of penetration. In situ shear vane testing carried out within the unweathered silty clay deposit measured undrained shear strengths ranging from about 19 to greater than 96 kPa, generally increasing with depth. Lower values of 19 and 22 kPa were measured at Boreholes 17-1301 and 17-1312, both at the western limit of the investigation, with the remainder of the boreholes showing values ranging from 26 to greater than 96 kPa. The results of the in situ testing indicate a soft to very stiff consistency. In situ remold strengths carried out within the unweathered silty clay gave remold shear strengths ranging from 2 to 27 kPa, indicating a medium sensitivity to quick silty clay. A summary of the undrained shear strengths is shown in Figure B15. The results of Atterberg limit testing on 37 samples of the silty clay deposit gave plasticity index values ranging from about 7 and 60 percent and liquid limit values ranging from about 23 and 85 percent, indicating a clay of low to high plasticity. One sample of the clayey



silt was found to be non-plastic. The results of the Atterberg limit testing are provided on Figure B4 and Figure B15. The measured water content on 71 samples of the weathered silty clay deposit ranges from approximately 24 to 94 percent.

The results of grain size distribution testing carried out on five samples of the silty clay to clay are shown on the record of borehole logs and provided on Figure B5. The results of the laboratory oedometer consolidation tests indicate vertical coefficient of consolidation values ( $c_v$ ) which range from about  $2 \times 10^{-5}$  cm<sup>2</sup>/s to  $3 \times 10^{-2}$  cm<sup>2</sup>/s for loads less than 125 kPa, and ranges from  $9 \times 10^{-6}$  cm<sup>2</sup>/s to  $1 \times 10^{-3}$  cm<sup>2</sup>/s for loads greater than 125 kPa. The values of the coefficient of consolidation ( $C_v$ ) for the silty clay to clay were calculated using the Taylor method (root-time method). It should be noted that the oedometer consolidation tests were carried out using a relatively low load increment ratio ('LIR' – which is the ratio of the magnitude of each load increment to the magnitude of the previous total load), which assists with defining the preconsolidation pressure for a sensitive and structured clay, such as present at this site, but can yield unrepresentative  $c_v$  values.

Laboratory oedometer consolidation testing was carried out on six samples of silty clay to clay selected from Boreholes 17-1301A, 17-1305, 17-1307, 17-1311, 17-1312B. The results of that testing are provided on Figures B6 to B11 and are summarized in the table below.

Borehole/ Sample Number	Sample Depth/ Elevation (m)	Unit Weight (kN/m <sup>3</sup> )	$\sigma_P'$ (kPa)	$\sigma_{VO}'^{(1)}$ (kPa)	$\sigma_P' - \sigma_{VO}'$ (kPa)	Cc	Cr	e <sub>o</sub>	OCR
17-1301A / 1	5.6 / 72.6	15.0	86 - 89	57	29 – 32	1.45	0.026	2.28	1.51 – 1.56
17-1305 / 8	7.9 / 68.7	15.2	188 - 200	60	128 – 140	2.66	0.019	2.11	3.13 – 3.33
17-1305 / 11	15.4 / 61.2	15.3	220 - 235	100	110 – 135	3.32	0.022	2.13	2.20 – 2.35
17-1307 / 7	6.4 / 71.3	15.1	140 - 146	51	89 – 95	1.75	0.024	2.16	2.75 – 2.86
17-1311 / 6	7.0 / 68.3	15.2	167 - 175	65	102 – 110	2.70	0.021	2.23	2.57 – 2.69
17-1312B / 1	10.1 / 67.4	14.5	182 – 185	80	102 – 105	4.03	0.013	2.52	2.28 – 2.31

**Notes:**

- $\sigma_P'$  - Apparent preconsolidation pressure
- $\sigma_{VO}'$  - Computed existing vertical effective stress
- Cc - Compression index
- Cr - Recompression index
- e<sub>o</sub> - Initial void ratio
- OCR - Overconsolidation ratio
- <sup>(1)</sup> - Based on typical range of grey clay unit weights of 16.25 to 17.25 kN/m<sup>3</sup>

## 4.5 Silty Sand to Sandy Silt (Glacial Till)

A deposit of glacial till was encountered below the silty clay to clayey silt in Boreholes 17-1302 to 17-1305, and 17-1308 to 17-1311. The glacial till deposit generally consists of gravel, cobbles, and boulders in a matrix of silty sand to sandy silt. The glacial till extends to depths ranging from about 45.0 to 53.0 m below the existing ground surface (i.e., Elevations ranging from about 23.3 to 24.6 m).



SPT 'N' values measured in the glacial till deposit ranges from 1 to greater than 50 blows per 0.3 m of penetration, but more generally ranging from 12 to 30 blows per 0.3 m of penetration, indicating the state of compactness is compact to dense. The higher blow counts could possibly reflect the presence of cobbles, boulders or the bedrock surface rather than the state of packing of the soil matrix.

The results of Atterberg limit testing on five samples of the glacial till deposit gave plasticity index values of about 3 percent and liquid limit values of about 15 percent, indicating a silt of low plasticity. Three of the samples of the glacial till were found to be non-plastic. The results of the Atterberg limit testing are provided on Figure B12 and Figure B15. The measured water content on 19 samples of the glacial till deposit ranges from approximately 5 to 19 percent.

The results of grain size distribution testing carried out on nine samples of the glacial till are shown on the borehole logs and provided on Figure B13.

## 4.6 Bedrock

Refusal to sampler advancement was encountered in Borehole 17-1304 at a depth of about 48.7 m below the existing ground surface (Elevation 23.8 m).

Bedrock was encountered beneath the glacial till in Boreholes 17-1302, 17-1303, 17-1305, and 17-1308 to 17-1311 at depths ranging from about 45.0 m to 53.0 m below the existing ground surface (i.e., Elevations ranging from about 23.3 to 24.6 m). The bedrock was cored between about 3.0 and 4.0 m using a NQ drill bit and rods.

The following table summarizes the bedrock surface or refusal depths and elevations as encountered at the borehole locations.

Borehole Number	Borehole Location with respect to Bridge Structure	Existing Ground Surface Elevation (m)	Depth to Bedrock/Refusal (m)	Bedrock Surface/Refusal Elevation (m)
17-1302	EBL West Abutment	74.6	51.3	23.3
17-1303	EBL West Pier	71.3	47.5	23.8
17-1304	EBL East Pier	72.5	48.7 <sup>1</sup>	23.8 <sup>1</sup>
17-1305	EBL East Abutment	76.6	53.0	23.6
17-1308	WBL East Abutment	71.3	47.4	23.9
17-1309	WBL East Pier	69.6	45.0	24.6
17-1310	WBL West Pier	71.6	47.9	23.7
17-1311	WBL West Abutment	75.3	51.2	24.1

**Note 1:** Refusal to sampler advancement.

Based on the bedrock surface elevations obtained where bedrock was proven, it is likely that the refusal to sampler advancement was encountered at the surface of the bedrock in Borehole 17-1304.

The bedrock encountered in these boreholes consist of weathered to fresh, thinly to medium bedded, grey, fine grained, porous shale. The Rock Quality Designation (RQD) values measured on recovered bedrock core samples ranged from about 0 to 100 percent, but more generally between 40 to 90 percent indicating a poor to excellent quality rock.



Results of unconfined compressive strength testing carried out on four bedrock core samples are presented in Figure B14. The results range from about 39 to 86 MPa and indicate a medium strong to strong bedrock.

## 4.7 Groundwater Conditions

Monitoring wells were installed in Boreholes 17-1305, 17-1310, and 17-1311 to monitor the groundwater level at the site. The water levels were measured in the monitoring wells on June 16, 2017 and are summarized in the following table.

Borehole	Ground Surface Elevation (m)	Screened Interval Material	Water Level Depth (m)	Water Level Elevation (m)	Date of Reading
17-1305A	76.6	Glacial Till	3.0	73.6	June 16, 2017
17-1305B	76.6	Weathered Crust / Grey Silty Clay	0.5	76.1	June 16, 2017
17-1310	71.6	Silty Clay	1.2	70.4	June 16, 2017
17-1311	75.3	Glacial Till	1.7	73.6	June 16, 2017

Artesian conditions were encountered at Boreholes 17-1303, 17-1304, 17-1308, and 17-1309 during the drilling operations. The water level elevations and depth of casing at the time of artesian conditions are listed in the following table.

Borehole	Ground Surface Elevation (m)	Depth of Casing (m)	Water Level Above Ground Surface (m)	Water Level Elevation (m)	Date
17-1303	71.3	47.5	2.4	73.7	May 19, 2017
17-1304	72.5	46.5	1.0	73.5	May 23, 2017
17-1308	71.3	48.5	1.9	73.2	June 5, 2017
17-1309	69.6	45.0	3.2	72.8	June 8, 2017

These combined groundwater level data indicate an apparent upward hydraulic gradient.

It is expected that these water levels will be subject to fluctuations both seasonally and as a result of precipitation events.



## 5.0 CLOSURE

This report was prepared by Mr. Alex Meacoe, P.Eng., and reviewed by Mr. Michael Snow P.Eng., a senior geotechnical engineer and Principal with Golder. Mr. Fintan Heffernan, P.Eng., a Senior Consultant with Golder and the Designated MTO Foundations Contact, conducted an independent quality control review of this report.

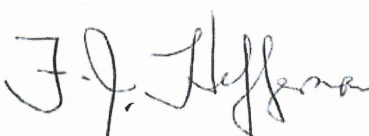
### Golder Associates Ltd.



Alex Meacoe, P.Eng.  
Geotechnical Engineer



Michael Snow, P.Eng.  
Principal, Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.  
Designated MTO Foundations Contact



WAM/MSS/FJH/mvrd

[https://golderassociates.sharepoint.com/sites/11263g/shared documents/01\\_foundations/6 - reports/1130 ramsayville road/final/1662565-1130-001-r-rev0-ramsayville road bridge-august 2018.docx](https://golderassociates.sharepoint.com/sites/11263g/shared%20documents/01_foundations/6%20-%20reports/1130%20ramsayville%20road/final/1662565-1130-001-r-rev0-ramsayville%20road%20bridge-august%202018.docx)

Golder and the G logo are trademarks of Golder Associates Corporation



**PART B**

Foundation Design Report  
Proposed Ramsayville Road Replacement  
Site No. 3-265/1 and 3-265/2  
Highway 417  
Ottawa, Ontario  
GWP 4145-10-00



## 6.0 FOUNDATION ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the replacement of the Ramsayville Road Overpass Bridge EBL, Site 3-265/1 and WBL, Site 3-265/2, of Highway 417 about 2.0 km south of Hunt Club Road in Ottawa, Ontario. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the current subsurface investigation as well as the available Geocres information for the site.

The foundation investigation report, discussion, and recommendations are intended for the use of the Ministry of Transportation, Ontario (MTO) and shall not be used or relied upon for any other purpose or by any other parties, including construction contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### 6.1 General

Golder Associates Ltd. (Golder) has been retained by WSP Canada Group Limited (WSP) on behalf of the MTO to provide recommendations on the foundation aspects for the design of the replacement structure of the Ramsayville Road Overpass bridges, on Highway 417 about 2.0 km south of Hunt Club Road in Ottawa, Ontario.

The existing bridges are shown on Drawings 1 and 2 and consists of five-span, 93.9 m long (18.0 m, 18.3 m, 21.3 m, 18.3 m, and 18.0 m) reinforced concrete slab on pre-stressed girder structures. The overall structure width is 11.0 m in the EBL and 12.6 m in the WBL. The structure is supported by four piers and conventional spill-through abutments. The bridge abutments are supported on “perched” foundations on vertical steel piles end bearing on bedrock. The front row of piles are battered in line with Highway 417. The pier foundations are supported on battered steel piles end bearing on bedrock.

It is understood that the existing bridges will be replaced with twin three-span structures. The new WBL and EBL bridge structures will have spans measuring 27.7 m, 39.6 m, and 33.7 m on an alignment shifted about 15.2 m to the south (for the WBL) and about 15.4 m to the north (for the EBL). It is also understood that the new bridges will be constructed while the existing bridges remain open, to provide a traffic detour, and that the existing bridge will not be demolished until the new bridges are open.

It is understood that the bridge is to be designed in accordance with the current Canadian Highway Bridge Design Code CAN/CSA-S6-14 (CHBDC).

### 6.2 Seismic Design

#### 6.2.1 Seismic Zone and Importance Category

The site falls within the Western Québec Seismic Zone (WQSZ) according to the Geological Survey of Canada. The WQSZ constitutes a large area that extends from Montréal to Témiscaming. Within the WQSZ, recent seismic activity has been concentrated in two subzones; one along the Ottawa River and another more active subzone along the Montréal-Maniwaki axis. Historical seismicity within the WQSZ includes the 1935 Témiscaming event which had a magnitude (i.e., a measure of the intensity of the earthquake) of 6.2 and the 1944 Cornwall-Massena event which had a magnitude of 5.6. In comparison to other seismically active areas in the world



(e.g., California, Japan, New Zealand), the frequency of earthquake activity within the WQSZ is significantly lower but there still exists the potential for significant earthquake events to be generated.

The CHBDC states that the seismic hazard values associated with the design earthquakes should be those established for the National Building Code of Canada (NBCC) by the Geological Survey of Canada (GSC). The GSC has developed a new set of seismic hazard maps (referred to as the 5th generation seismic hazard maps) that were made available for public use in December 2015.

In accordance with Section 4.4.2 of the CHBDC, and as specified by the MTO, the proposed bridge structure has been given an importance category of 'Major Route' bridge.

## 6.2.2 Seismic Site Classification

Multichannel Analysis of Surface Waves (MASW) geophysical testing was carried out within the Highway 417 median in the vicinity of the bridge to evaluate the average shear wave velocity of the upper 30 m of soil/bedrock at the site. The shear wave velocities measured at the site are presented in a technical memorandum (see results in Appendix E) and indicate that the average shear wave velocity in the upper 30 m of the subsurface stratigraphy at the two MASW locations were 126 m/s and 128 m/s. Based on these values, it is considered that a Site Class E would be applicable for the design of the structures.

However, table 4.1 of the CHBDC also specifies circumstances for which a Site Class of F is applicable and a site-specific response evaluation must be carried out; the presence of liquefiable soils is one of those conditions. As presented below in Section 6.2.6, this site is underlain by very localized horizons of soil which are considered to have a small probability to undergo liquefaction under the design earthquake event. This is not considered to have a material impact on the dynamic response of the site, and as such a Site Class E designation is considered appropriate for design.

## 6.2.3 Spectral Response Values and Seismic Performance Category

In accordance with Section 4.4.3.1 of the CHBDC and based on the location of the bridge (latitude 45.38 N and longitude -75.57 W), the following are the reference Site Class C (reference) peak seismic hazard values based on data obtained from Earthquakes Canada ([www.earthquakescanada.nrcan.gc.ca](http://www.earthquakescanada.nrcan.gc.ca)).

**Site Class C Spectral Values for Subject Site**

Seismic Hazard Values	Value at Given Probability of Exceedance in 50 Years		
	10% (475-year)	5% (975-year)	2% (2,475-year)
PGA	0.108 g	0.175 g	0.303 g
T ≤ 0.2 s	0.171 g	0.273 g	0.474 g
T = 0.5 s	0.092 g	0.146 g	0.252 g
T = 1.0 s	0.046 g	0.072 g	0.124 g
T = 2.0 s	0.021 g	0.034 g	0.058 g
T = 5.0 s	0.005 g	0.008 g	0.015 g
T ≥ 10.0 s	0.002 g	0.003 g	0.006 g



The values given above are for the reference ground condition Site Class C and must be modified to the site-specific seismic site classification given in Section 6.2.2 (Site Class E) in accordance with Section 4.4.3.3 of the CHBDC. As indicated in Section 4.4.3.3 of the CHBDC the value of  $PGA_{ref}$  for use with Tables 4.2 to 4.9 shall be taken as 80 percent of the PGA for Site Class C where  $S_a(0.2)/PGA$  is less than 2.0. Based on this requirement a  $PGA_{ref}$  value of 0.242 for the 2,475 year return was used. The corresponding site-specific seismic hazard values given in the table below can be used for design.

#### Site Class E Spectral Values for Subject Site

Seismic Hazard Values	Value at Given Probability of Exceedance in 50 Years		
	10% (475-year)	5% (975-year)	2% (2,475-year)
PGA	0.195 g	0.276 g	0.341 g
$T \leq 0.2$ s	0.280 g	0.404 g	0.550 g
$T = 0.5$ s	0.227 g	0.321 g	0.419 g
$T = 1.0$ s	0.129 g	0.181 g	0.240 g
$T = 2.0$ s	0.061 g	0.090 g	0.122 g
$T = 5.0$ s	0.014 g	0.023 g	0.034 g
$T \geq 10.0$ s	0.005 g	0.008 g	0.012 g

The fundamental period of the rehabilitated structure has yet to be confirmed and may depend on the design modifications to the superstructure. In consideration of the structure's "Major Route" importance category and the site specific seismic hazard values given above, the bridge would fall in Seismic Performance Category 2, if the fundamental period of the structure is greater than or equal to 0.5 s, or Seismic Performance Category 3, if the fundamental period of the structure is less than 0.5 s, in accordance with Table 4.10 of the CHBDC.

Based on the *regular* geometry of the bridge (since its skew angle is less than 20 degrees), it is understood that the structure will be designed using a "force-based approach" as defined in the CHBDC, depending on the Seismic Performance Category.

## 6.2.4 Liquefaction Assessment

Liquefaction is a phenomenon whereby seismically-induced shaking generates shear stresses within the soil under undrained conditions. These stresses tend to densify the soil (i.e., leading to potentially large surface settlements) and under undrained conditions generate excess pore pressures. The excess pore pressures also lead to sudden temporary losses in strength. Where existing static shear stresses are present, the loss of strength can lead to significant lateral movements (i.e., analogous to a slope failure) often referred to as "lateral spreading" or under certain conditions even catastrophic failure of the slope often referred to as "flow slides". Lateral spreading and flow slides often accompany liquefaction along rivers and other shorelines.

The liquefaction susceptibility of granular soils was evaluated by comparing the penetration resistance required to trigger liquefaction with the available penetration resistance. Liquefaction is predicted to occur when the available penetration resistance is less than the resistance required.



The methodology used to assess liquefaction potential at the site is consistent with that presented in the CHBDC Commentary. It involves comparing the cyclic shear stresses applied to the soil by the design earthquake, represented as the cyclic stress ratio (CSR), to the cyclic shear strength, represented as the cyclic resistance ratio (CRR) provided by the soil.

The liquefaction analysis was carried out using the in-situ testing data collected at the borehole locations. The design groundwater level was determined based on the measured artesian groundwater level in the standpipe piezometer installed in Boreholes 17-1305A and 17-1311 at Elevation 73.6 m. The CRR with depth was calculated at each borehole location using the parameter,  $(N_1)_{60CS}$ , that is based on the SPT N blow counts obtained in the field and corrected for overburden stress, rod length during sampling, hammer energy efficiencies, and fines content.

The methodology used to assess liquefaction potential at the site is consistent with the “simplified” approach outlined in the CHBDC and by Idriss and Boulanger (2008). It involves comparing the cyclic shear stresses applied to the soil by the design earthquake, represented as the cyclic stress ratio (CSR), to the cyclic shear strength, represented as the cyclic resistance ratio (CRR) provided by the soil. The results of the liquefaction assessment using the simplified method indicate that certain horizons of granular soils within the glacial tills at the site may be considered liquefiable during the 2,475-year design earthquake. Furthermore, certain siltier horizons of the clay deposit (i.e., lower portions of the deposit) and more plastic horizons within the glacial till, based on lab results from the original investigations for the current bridge, at the site can be expected to undergo some cyclic softening during the 2,475-year design earthquake as discussed by Bray et al (2004).

The liquefaction methodologies outlined in Idriss and Boulanger (2008) do not account for the additional cyclic resistance provided by the aging/cementation that may be a characteristic of the glacial tills at the site. Although aging of deposits is known to help resist seismic liquefaction, little research has been done in this area to quantify this. Based on Figure 9 presented in the work by Leon et al. (2006) a correction increase of about 30% in the CRR profile would appear appropriate. While such aging/cementation corrections would potentially reduce the risk of liquefaction at this site given the age of the till sheets present at the site of about 10,00 to 15,000 years (Gill, 1972), specific testing/assessment/research on the tills at this site is not available.

Work done by Harpin et al (2017) on the site response of sites in eastern Canada and the site-response analyses conducted by Golder Associates at the CR31 overpass (i.e., Site No. 31-204) would suggest that a site-specific response analysis would also reduce the CSR profile, when compared to the simplified methodology outlined in Idriss and Boulanger (2008), such that an approximately 20% reduction could be expected.

In consideration of the beneficial effects of aging and the anticipated lower cyclic stresses in eastern Canada, higher CRR and lower CSR respectively, the plasticity present in certain till horizons, and the depth of the potentially liquefiable horizons, the extent and probability of liquefaction at the site is considered to be very small to the point of having little impact on the dynamic response of the site (i.e., Site Class) and the performance of foundation elements.

## 6.3 Bridge Foundations – General

### 6.3.1 Existing Foundations

The existing Ramsayville Road Overpass structures are five-span structures with a reinforced concrete deck and non-integral abutments. The existing underpass bridge is understood to be in fair condition.



According to the available information, the existing five-span bridge structure abutments and wing walls are founded on “perched” foundations on HP310 x 110 steel H-piles end bearing on bedrock. The front row of abutment piles are battered towards Highway 417. The piers are founded on a combination of vertical and battered piles end bearing on bedrock

### 6.3.2 Bridge Foundation Options

Based on the subsurface conditions, only deep foundation options have been considered for the replacement of the existing Ramsayville Road Overpass structures, as shallow foundations would not provide sufficient bearing resistances or acceptable settlement performance for the structures. Using shallow foundations supported on the native silty clay soils, is not considered practical or appropriate for the abutments and piers since the very stiff to stiff weathered crust is of limited thickness and the underlying grey clay is of limited strength and high compressibility. These ground conditions would be insufficient to support the anticipated foundation loads and the settlement of the foundations would be excessive.

A summary of the advantages and disadvantages associated with each deep foundation option is provided below, and a comparison of the alternative foundation options based on advantages, disadvantages, constructability and relative costs is provided in Table 1 following the text of this report.

- **Driven steel H-piles:** Steel H-piles driven to refusal on the shale bedrock could be feasible for support of the replacement bridge structures. This option would provide relatively high geotechnical resistances and would permit the use of conventional, semi-integral or integral abutments or piers. The use of driving shoes is recommended to minimize damage while penetrating the glacial till deposit (which contain cobbles and boulders) and seating onto the shale bedrock.
- **Driven steel pipe (tube) piles:** Closed-ended steel tube (pipe) piles could also be considered as a deep foundation option for support of the abutments and central pier. This foundation option would have similar advantages to steel H-piles in terms of relatively high geotechnical resistances. This option would permit the use of conventional, semi-integral and potentially integral abutments and piers. Pipe piles are considered to have a higher risk than H-piles for “hanging up” or being deflected away from their vertical or battered orientation if cobbles and/or boulders are encountered within the till deposit during driving.
- **Auger-cast piles:** Auger-cast piles (ACPs also referred to as continuous flight auger piles) involve a continuous flight auger system drilled to a target depth. As the auger is removed, concrete or grout is injected through the hollow centre of the auger. Upon complete removal of the auger, reinforcing steel can then be inserted into the wet concrete/grout. Typical pile diameters are about 0.3 m to 0.6 m and can attain depths of about 25 m in Ontario. Diameters up to 0.9 m to depths of 30 m are available in North America. The number of foundation contractors able to install these in Ontario is smaller relative to more common foundation types and such foundations are not commonly used on highway bridge projects in Ontario. These foundation systems are not well-suited where uplift resistance is a key consideration, where cobbles/boulders can hinder auger drilling, where depths to competent bearing exceed 30 m, or where high lateral resistance is required. In light of these limitation, ACPs are not considered to be a preferred foundation alternative.
- **Rock socketed steel pipe (tube) piles:** Socketed steel pipe piles installed using the down-the-hole hammer method could also be considered as a deep foundation option for support of the abutments. This foundation option would also have similar advantages to those above of relatively high geotechnical resistances. This option would permit the use of conventional, semi-integral and potentially integral abutments and piers.



This foundation type would also penetrate any cobbles or boulders encountered within the glacial till deposit during installation. Socketed pipe piles would also have the required stiffness to resist the expected seismic lateral loads as well as provide toe 'fixity' at the interface with the bedrock surface.

- **Rock Socketed Drilled Concrete Caissons:** Caissons deriving their support from bearing within the shale bedrock are also feasible for this site. Caissons would require the use of temporary or permanent liners to mitigate the potential risks of ground squeezing in the clay deposits or ground loss from potential water-bearing cohesionless layers within the till soils during construction. This option would not permit the use of integral abutments or piers. In addition, the caissons would have to be socketed at least nominally into the bedrock to permit cleaning of the caisson bases, and such sockets would have to be advanced by rock coring and/or churn/chisel drilling into the competent shale bedrock. This foundation option is considered feasible at both the abutments and piers but installation at depths over 30 m is considered very challenging, and as a result rock socketed caissons are not considered a viable option for this site.

It is considered that the most feasible and cost-effective options for the new bridge abutments and piers are foundations supported on piles, founded on the bedrock. These options are also consistent with the existing bridge abutment and pier foundation construction. From the Geocres information it is understood that the existing bridge foundations are founded on driven steel H piles driven to refusal on the bedrock.

Support of the abutments on steel H piles driven to found on the bedrock is considered to be the most feasible, provided that the vibrations transmitted to the existing structures are monitored and kept to suitably low levels, below 100 mm/s, to minimize any detrimental effects on the existing structure. The use of uniform driven steel H piles through a thick deposit of sensitive silty clay deposit lessens the potential for artesian flow along the piles. As a precautionary measure, Granular A fill will be placed at the ground surface around the piles to guard against the loss of soil. Steel H piles driven through the dense till and to refusal on bedrock will mitigate the potential for heaving of adjacent piles during driving.

Steel H piles are preferred over steel pipe piles due to the much higher cost relative to driven pipe piles and lower structural efficiency relative to H-piles. Further, the toe fixity is not a critical element in this case given the depth of overburden, lack of liquefaction, and dense till present at depth.

Foundation recommendations for the design of foundations for the bridge abutments and piers are presented in the following sections. A summary comparison of the advantages, disadvantages, relative costs, and risks associated with the foundation options is presented in Table 1 following the text of this report.

### 6.3.3 Feasibility of Integral and Semi-Integral Abutments

As outlined in MTO's report SO-96-01, integral abutment bridges are single span or multiple span continuous deck type bridges with a movement system composed primarily of abutments on flexible integral foundations and approach slabs, in lieu of movable deck expansion joints and bearings at abutments. The feasibility of integral abutments or piers is influenced by a number of factors including geometry and subsurface conditions. The primary criterion is the need to support the abutments or piers on relatively flexible piles. Geometric constraints on the use of integral abutments are also applicable and include: overall bridge length less than 150 m; skew angle less than 35°; and abutment wall heights less than 6 m without a retained soil system.

As outlined in MTO's report BO-99-03, semi-integral abutment bridges are single or multiple span structures of less than 150 m in length with rigid foundations where the concrete deck is continuous with the approach slabs. Expansion joints are eliminated at the end of the deck and the superstructure is supported on movable bearings



and is almost independent of the abutment. An expansion joint is provided at the end of the approach slab that is detailed to slide between or over the wingwalls. Unlike integral abutments the geometric constraints for semi-integral abutments are less restrictive.

From a foundation perspective, either integral or semi-integral abutments are considered feasible at this location.

### 6.3.4 Consequence and Site Understanding Classification

In accordance with Section 6.5 of the CHBDC and its Commentary, the proposed overpass structure and foundation system may be classified as having large traffic volumes and its performance as having potential impacts on other transportation corridors, hence having a “typical” consequence level associated with exceeding limits states design. Given the level of foundation investigation completed to date as presented in Sections 3.0 and 4.0, in comparison to the degree of site understanding in Section 6.5 of *CHBDC*, the level of confidence for design is considered to be a “typical degree of site and prediction model understanding.” Accordingly, the appropriate corresponding ULS and SLS consequence factor,  $\Psi$  with a value of 1.0, and geotechnical resistance factors,  $\phi_{gu}$  with a value of 0.5 and  $\phi_{gs}$  with a value of 0.8, from Tables 6.1 and 6.2 of the CHBDC have been used for design, as indicated in Sections 6.4 to 6.7 below.

## 6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations

### 6.4.1 Founding Elevation

The abutments and piers for the new bridges, may be supported on steel H-piles or steel pipe (tube) piles driven to found on or within the shale bedrock. Based on the borehole results from the investigation, some nominal penetration of driven piles into the bedrock is expected up to about 0.1 m to allow for some weathering in the upper portion of the rock, the following pile tip elevations are recommended for design of steel H-piles:

Foundation Element	Borehole Numbers	Existing Ground Surface Elevation	Bedrock Surface Elevation	Design Pile Tip Elevation
WBL West Abutment	17-1311	75.3m	24.1 m	24.0 m
WBL West Pier	17-1310	71.6 m	23.7 m	23.6 m
WBL East Pier	17-1309	69.6 m	24.6 m	24.5 m
WBL East Abutment	17-1308	71.3 m	23.9 m	23.8 m
EBL West Abutment	17-1302	74.6 m	23.3 m	23.2 m
EBL West Pier	17-1303	71.3 m	23.8 m	23.7 m
EBL East Pier	17-1304	72.5 m	24.0 m	23.9 m
EBL East Abutment	17-1305	76.6 m	23.6 m	23.5 m



The pile caps should be constructed at a minimum depth of 1.8 m for frost protection purposes, per OPSD 3090.101 (*Foundation Frost Penetration Depths for Southern Ontario*).

At the foundation locations, the bedrock surface was encountered at depths of about 45 to 50 m. To provide suitable flexibility of steel H-piles for integral abutments, it is understood that the upper portion of the piles would be cased in a sand-filled, corrugated steel pipe (CSP) from about Elevation 73.6 to 74.5 m at the underside of the abutment stem.

For the installation of steel H-piles or steel pipe piles, consideration must be given to the potential presence of cobbles and boulders within the till deposit. In this regard, steel H-piles are preferred over steel pipe piles as pipe piles are considered to pose a higher risk of “hanging up” or being deflected away from their vertical or battered orientation during installation, due to their larger end area. A Non-Standard Special Provision has been provided in Appendix G to address the presence of obstructions (cobbles and boulders) in the till deposit.

The piles should be reinforced at the tip with standard bearing points to improve seating of the piles on the bedrock and to reduce the potential for damage to the piles during driving through soils that contain boulders, in accordance with OPSS.PROV 903 (*Deep Foundations*). In particular, any battered piles should be equipped with suitable bearing points (such as Titus Standard ‘H’ Bearing Pile Points or equivalent) to ensure adequate seating of the piles on the bedrock. If steel pipe piles are used, driving shoes should be in accordance with OPSD 3001.100 Type II (*Steel Tube Pile Driving Shoe*). A Non-Standard Special Provision has been provided in Appendix G to address the driving of piles adjacent to the existing battered piles.

#### 6.4.2 Factored Geotechnical Axial Resistances

The factored ultimate and serviceability geotechnical axial resistances (ULS) for new driven steel H-piles- and closed-end, concrete-filled 324 mm diameter steel pipe piles that are successfully driven to found on the shale bedrock are presented below.

Pile Type	Approximate Length of Driven Pile (m)	Factored Ultimate Geotechnical Axial Resistance (at ULS) (kN)
HP 310 x 110	50.0	1,500
HP 360 x 132	50.0	2,000
324 mm OD Close Ended Pipe Pile	50.0	1,300

Serviceability Limit States (SLS) resistances do not apply to new piles founded on the shale bedrock, since the SLS resistance for 25 mm of settlement is greater than the factored axial geotechnical resistance at ULS.

It should be noted that the factored axial resistance provided at ULS is limited by the geotechnical resistance of the shale bedrock. The axial resistance provided for the driven piles to refusal on bedrock will not be affected by the pile spacing.

The factored ULS axial capacities reflect available knowledge, experience and analytical tools for developing geotechnical capacity of these driven piles and, as such, a lower resistance factor was used. The undertaking of static pile load tests would allow for the ultimate geotechnical capacity to be validated more accurately (e.g.,



increased) under site-specific conditions and to support the use of higher geotechnical resistance factors allowed under the CHBDC when static load test results are available.

Pile installation should be in accordance with OPSS.PROV 903 (Deep Foundations). The drawings should incorporate the appropriate note stating that the piles should be equipped with bearing points and should be driven to bedrock. For piles driven to refusal on bedrock, and as described in OPSS.PROV 903, it is a generally accepted practice to reduce the hammer energy after abrupt peaking is met on the bedrock surface, and to then gradually increase the energy over a series of blows to seat the pile.

The pile termination or set criteria will be dependent on the pile driving hammer type, helmet, selected pile and length of pile; the criteria must therefore be established at the time of construction after the piling equipment is known. The pile capacity should then be verified in the field by the use of the Hiley formula (MTO's Standard Drawing SS103-11, *Pile Driving Control*) and/or Pile Dynamic Analyzer (PDA) testing during pile installation on selected piles to confirm the design capacity.

Vibration monitoring should be carried out in accordance with Section 6.8.3 below. The only structure in the vicinity of the new piers and abutments is the existing Ramsayville overpass structure, and as such, pre- and post-construction surveys will not be required.

#### 6.4.3 Downdrag Load (Negative Skin Friction)

A compressible clayey deposit was encountered below the embankment fill at the boreholes put down at the site. The additional loading imposed from the proposed grade raise of about 4 m would result in consolidation settlement of the underlying compressible silty clay deposit which could generate downdrag forces on the piles. Further discussion of the embankment settlement and proposed settlement mitigation options are provided in Section 6.7.3.

Based on the above, and assuming an underside of the pile cap ranging from about Elevation 67.6 to 74.5 m, the unfactored downdrag load acting on a single HP 310 x 110 pile over the length of pile within the compressible soils and overlying embankment fill is estimated to be up to about 300 kN for piles supporting the new abutments based on the neutral plane being at a depth of about 10 m and assuming a "soil plug" develops between the pile flanges (Prof. Jean-Louis Briaud, personal communication 2017).

The structural capacity of the piles must be checked for the factored dead and downdrag loads in accordance with Section 6.11.4.10 of the CHBDC.

However, if the settlement mitigation options outlined in Section 6.7.3, which include surcharging, are put in place some 6 months, subject to settlement monitoring, prior to driving the steel piles, then downdrag loads would not be mobilized and can be discounted.

#### 6.4.4 Lateral Geotechnical Resistance

The ULS *geotechnical* resistance to lateral loading may be calculated using passive earth pressure theory as outlined in Section C6.11.2.2.1 of the *Commentary to the CHBDC*, assuming that it acts over the the pile shaft to a depth equal to six pile diameters below the underside of the pile cap and an equivalent width equal to three pile diameters.

The ULS lateral resistance of a pile group may be estimated as the sum of the individual pile resistances across the face of the pile group, perpendicular to the direction of the applied lateral force.



For a HP 310 x 110 steel pile, the unfactored ULS lateral resistance is 180 kN at all locations except the EBL Piers (East and West) and the WBL East Pier and West Abutment where the value is 150 kN. The ULS resistances obtained using the above parameter represent unfactored values; in accordance with the *CHBDC*, a resistance factor of 0.5 is to be applied in calculating the horizontal resistance. This value provides a limit on the lateral geotechnical resistance offered using the p-y curves given in Section 6.4.5 below the pile cap under static conditions. The table below summarized the lateral geotechnical resistances.

Pile Location	Unfactored ULS lateral Resistance (kN)
WBL West Abutment	150
WBL West Pier	180
WBL East Pier	150
WBL East Abutment	180
EBL West Abutment	180
EBL West Pier	150
EBL East Pier	150
EBL East Abutment	180

#### 6.4.5 Lateral Soil-Structure Interaction Springs

The foundation lateral soil-structure interaction springs required for the static and dynamic analyses of the bridge abutments were computed based on the available subsurface information on the soil layers surrounding the foundations and the pile dimensions.

The soil-structure interaction between the bridge foundations and the surrounding soils was modeled using the load transfer method. The lateral load-displacement behaviour of the piles can be modeled using p-y curves (CFEM, 2006). P-y curves relate the lateral deflection of a single pile to the corresponding soil and bedrock reactions at any depth below ground surface.

The p-y curves were developed considering appropriate surcharge loads imposed by embankment fill loads (e.g., abutments) and artesian water conditions (e.g., in the deep glacial till deposits). The curves are considered appropriate for vertical piles as well as piles with batters of up to 1H:12V (horizontal to vertical). Where cyclic softening of certain siltier clay and till horizons was identified (see Section 6.2.4), the p values in the cyclic p-y curves were reduced by 25 per cent to reflect this condition under dynamic loading conditions.

The family of static and cyclic p-y curves calculated at 0.5 m increments of depth for a single, vertical 310X110 steel H-pile at the abutments are shown in tabular format and graphically in Figures F5 to F20 in Appendix F. The p-y curves were developed accounting for embankment surcharges and artesian pressures.

For piles arranged in closely spaced groups, the pile-soil-pile interaction causes the individual piles in a group to be less effective than a single pile. These “group effects” can be incorporated into the design using a method that modifies the single pile p-y curves by some factor (i.e., a p-reduction factor). Generalized multipliers (i.e., p-reduction factors) for a range of pile spacings are provided in Section C6.11.3.4 of CHBDC.



## 6.5 Drilled Shaft (Caisson) Foundations

Due to the relatively deep bedrock, caissons are not considered economical. With the artesian groundwater conditions encountered at depth, difficulty in socketing a liner into the bedrock, it may not be feasible to dewater and clean the base of the caisson and, as such, full end-bearing support may not be developed, and drilled caissons are not considered a preferred foundation type.

In order to complete the installation of drilled caissons in artesian conditions, the drilling must be completed with several meters of casing “stick-up” above grade to avoid upward flow which could undermine soils being penetrated during drilling and potentially release any confined gases: a critical issue at the lower pier locations. Furthermore, for end bearing drilled shafts, a clean bottom must be ensured which would be challenging to obtain and confirm at such depths below water. Finally drilled shafts at these depths would be substantially more expensive.

## 6.6 Lateral Earth Pressures for Design

The lateral earth pressures acting on the abutment walls and any associated wing walls (if required) will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls. Seismic (earthquake) loading must also be taken into account in the design.

The following recommendations are made concerning the design of the walls:

- Select, free draining, non-frost susceptible granular fill meeting the specifications of OPSS.PROV 1010 (*Aggregates*) Granular A or Granular B Type II, should be used as backfill behind the walls. Longitudinal drains or weep holes should be installed to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS.PROV 501 (*Compacting*). Other aspects of the granular backfill requirements with respect to sub-drains and frost taper should be in accordance with OPSD 3101.150 (*Walls, Abutment, Backfill, Minimum Granular Requirement*), OPSD 3121.150 (*Walls, Retaining, Backfill, Minimum Granular Requirement*), and 3190.100 (*Walls, Retaining and Abutment, Wall Drain*).
- A minimum compaction surcharge of 12 kPa should be included in the lateral earth pressures for the structural design of the walls, in accordance with CHBDC Section 6.12.3 and Figure 6.6. Care must be taken during the compaction operation not to overstress the wall. Heavy construction equipment should be maintained at a distance of at least 1 m away from the walls while the backfill soils are being placed. Handoperated- compaction equipment should be used to compact the backfill soils within a 1 m wide zone adjacent to the walls. Other surcharge loadings should be accounted for in the design, as required.
- For restrained walls, granular fill should be placed in a zone with the width equal to at least 1.8 m behind the back of the wall (Case (a) on Figure C6.20 of the *Commentary* to the CHBDC). For unrestrained walls, fill should be placed within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical (1.5H:1V) extending up and back from the rear face of the footing or pile cap (Case (b) on Figure C6.20 of the *Commentary* to the CHBDC).



### 6.6.1 Static Lateral Earth Pressures for Design

The following guidelines and recommendations are provided regarding the lateral earth pressures for static (i.e., not earthquake) loading conditions. These lateral earth pressures assume that the ground above the wall will be flat, not sloping. If the inclination of the slope above the wall changes then new lateral earth pressures will need to be calculated.

- For Case (a), the pressures are based on the proposed embankment fill and the following parameters (unfactored) may be used assuming the use of earth fill or Select Subgrade Material (SSM):

Material	Earth Fill or SSM
Soil Unit Weight:	20 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:	
Active, $K_a$	0.33
At rest, $K_o$	0.50
Passive, $K_P$	3.0

- For Case (b), the pressures are based on using engineered granular fill and the following parameters (unfactored) may be used:

Material	Granular A	Granular B Type II
Soil Unit Weight:	22 kN/m <sup>3</sup>	21 kN/m <sup>3</sup>
Coefficients of static lateral earth pressure:		
Active, $K_a$	0.27	0.27
At rest, $K_o$	0.43	0.43
Passive, $K_P$	3.7	3.7

- If the wall support and superstructure allow lateral yielding, active earth pressures may be used in the geotechnical design of the structure. The movement to allow active pressures to develop within the backfill, and thereby assume an unrestrained structure, may be taken as:
  - Rotation of approximately 0.002 about the base of a vertical wall (where the rotation is calculated as the horizontal displacement divided by the height of the wall);
  - Horizontal translation of 0.001 times the height of the wall; or,
  - A combination of both.
- If the wall does not allow lateral yielding (i.e., restrained structure where the rotational or horizontal movement is not sufficient to mobilize an active earth pressure condition), at rest-earth pressures (plus any compaction surcharge) should be assumed for geotechnical design.



## 6.6.2 Seismic Lateral Earth Pressures for Design

Seismic (earthquake) loading must be taken into account in the design in accordance with Section 4.6 of the CHBDC. In this regard, the following should be included in the assessment of lateral earth pressures:

- Seismic loading will result in increased lateral earth pressures acting on the wall. The wall should be designed to withstand the combined lateral loading for the appropriate static pressure conditions given in Section 6.6.1, above, plus the earthquake-induced dynamic earth pressure.
- In accordance with Sections 4.6.5 and C.4.6.5 of the CHBDC and its Commentary, for structures which do not allow lateral yielding, the horizontal seismic coefficient ( $k_h$ ) used in the calculation of the seismic active pressure coefficient is taken as 1.0 times the PGA. For structures which allow lateral yielding, ( $k_h$ ) is taken as 0.5 times the PGA.
- The following seismic active pressure coefficients ( $K_{AE}$ ) for the two backfill cases (Case (a) and Case (b)) may be used in design. It should be noted that these seismic earth pressure coefficients assume that the back of the wall is vertical and the ground surface behind the wall is flat. Where sloping backfill is present above the top of the wall, the lateral earth pressures under seismic loading conditions should be calculated by treating the weight of the backfill located above the top of the wall as a surcharge.
- Seismic Active Pressure Coefficients,  $K_{AE}$

	Design Earthquake	Site PGA	Granular A	Granular B Type II	SSM
Yielding Wall	2,475 Yr	0.34	0.37	0.37	0.46
Non-Yielding Wall	2,475 Yr	0.34	0.52	0.52	0.62

- The earthquake-induced dynamic pressure distribution, which is to be added to the static earth pressure distribution, is a linear distribution with maximum pressure at the top of the wall and minimum pressure at its toe (i.e., an inverted triangular pressure distribution). The total pressure distribution (static plus seismic) may be determined as follows:

$$\sigma_h(d) = K_a \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ yielding walls}$$

$$\sigma_h(d) = K_o \gamma d + (K_{AE} - K_a) \gamma (H-d), \text{ non-yielding walls}$$

Where:  $\sigma_h(d)$  is the (static plus seismic) lateral earth pressure at depth,  $d$ , (kPa);

$K_a$  is the static active earth pressure coefficient;

$K_o$  is the static at-rest earth pressure coefficient;

$K_{AE}$  is the seismic active earth pressure coefficient;

$\gamma$  is the unit weight of the backfill soil ( $\text{kN/m}^3$ ), as given previously;

$d$  is the depth below the top of the wall (m); and,

$H$  is the total height of the wall (m).



## 6.7 Approach Embankment Design and Construction

Embankment construction beyond the ends of the retaining walls will likely be accomplished using conventional 2H:1V embankment side slopes.

Based on the borehole results, the embankment subgrade soils will generally consist of stiff to very stiff weathered silty clay crust which is underlain by firm to stiff silty clay to clayey silt, which is in turn underlain by loose to very dense silty sand till.

### 6.7.1 Subgrade Preparation and Embankment Construction

In preparation of the foundations for the abutments and piers, all existing embankment fill, topsoil, alluvium, and soft or loose soils should be removed from below the proposed founding elevations and wasted or reused as landscaping fill, as required. Subgrade preparation should be performed and monitored in accordance with OPSS 902 (*Construction Specification for Excavating and Backfilling – Structures*).

The silty clay that will be exposed at the foundation subgrade level will be susceptible to disturbance from construction traffic, ponded water, and groundwater conditions. To limit this degradation, it is recommended that a concrete working slab be placed on the subgrade within four hours after preparation, inspection and approval of the footing subgrade. A Non-Standard Special Provision has been provided in Appendix G to address this requirement.

Any new embankment fill for the approach embankments should be placed and compacted in accordance with OPSS.PROV 206 (*Grading*) and OPSS.PROV 501 (*Compacting*). Benching of the existing embankment side slopes should be carried out to “key in” the new fill materials in areas where the embankment is widened, in accordance with OPSS 208.010 (*Benching of Earth Slopes*).

To reduce erosion of the embankment side slopes due to surface water runoff, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of the embankments. The erosion protection should be in accordance with OPSS.PROV 804 (*Seed and Cover*).

### 6.7.2 Approach Embankment and Retaining Wall Stability

“Limit equilibrium” stability analyses were carried out to assess the factor of safety against deep-seated global instability of the approach embankments and retaining walls (based on a rotational shear failure through the underlying silty clay). Those analyses were carried out for the critical ‘undrained’ conditions which would exist during and immediately following construction, the ‘drained’ conditions that would exist in the long term, and also possible seismic loading conditions. The Slope/W commercial software was used to determine the factor of safety based on the Morgenstern-Price methodology.

With appropriate subgrade preparation and proper placement of earth or granular soils, the up to 2 to 4 m high approach embankments, with side slopes maintained at 2 horizontal to 1 vertical, founded on the existing fill materials and native soils, will have a factor of safety greater than 1.3 against deep seated slope instability (as shown on Figures F1 to F4 in Appendix F) and a factor of safety greater than 1.1 against deep-seated global instability under seismic loading, based on an acceleration of 0.17g (which corresponds to half the PGA, as per the CHBDC). The results do however indicate that some shallow sloughing (with factors of safety less than 1.1) could occur of the embankment side slopes during seismic loading. That sloughing would not however impair the short term use of the structure and is mainly a maintenance/repair issue. The potential for sloughing could be reduced by providing well vegetated side slopes, as mentioned above in Section 6.7.1.



The following soil parameters were used in the stability analysis:

Material	Bulk Unit Weight (kN/m <sup>3</sup> )	Effective Friction Angle (degrees)	Undrained Shear Strength (kPa)
New Granular Embankment Fill	21	32	-
Existing Silty Clay and Silty Sand Fill	18	30	-
Weathered Silty Clay (Drained)	18	35	5
Weathered Silty Clay (Undrained)	18	-	80
Silty Clay (Drained)	15.2	28.7 – 34.7	7.4 – 7.7
Silty Clay (Undrained)	15.2	-	30 – 80
Till	22.6	35	-
Bedrock		Impenetrable	

The preliminary assessment of the stability of the approach embankments and retaining walls should be reviewed and confirmed based on the design drawings and subsoil conditions encountered within the proposed approach embankment and retaining wall footprints.

### 6.7.3 Approach Embankment Settlement

Settlement of the existing embankments has likely fully occurred over time since the original bridge construction in 1970 and 1973. Settlement of the new approach embankment widenings, and where new fills are overlain over the existing embankments, will occur as a result of compression of the new embankment fill itself, compression of the existing fill material, compression and consolidation of the clayey soils on which the embankments are founded.

Provided that the new embankment fill material consists of granular fill, Select Subgrade Material or clean earth fill, the settlement of the new embankment fill itself is expected to be less than about 15 to 30 mm depending on the fill used, and will occur during construction.

The use of granular fill for the new embankment construction would reduce the magnitude of post-construction settlement (likely to less than 15 mm), since the majority of settlement of granular fills will occur during construction.

The settlements due to compression of the existing embankment fills are considered to be comparable to or less than those for the new embankment materials, provided these soils are proof rolled prior to placing new fill materials.

The additional loading imposed by the proposed new embankment fills of up to 3 to 4 m would result in further consolidation settlement of the underlying compressible soils. Estimates of future re-compression consolidation settlements were developed based on the indicated embankment geometry, existing stress levels, and preconsolidation pressure profile in the silty clay soils using the software SETTLE3D.

Additional settlements induced by the new embankment fills along the existing piles are expected to be more than 15 mm and as such are expected to generate downdrag loads on those piles. Such downdrag should be assessed as indicated in Section 6.4.3 and similar values would be generated under settlements generated under the short-term surcharge loading outlined below in Section 6.7.3.2.



Additional settlements induced by the new embankment fills at the centreline of pavement of the existing embankments are expected to range from less than 15 mm at the abutments to about 50 to 70 mm along the edge of pavement and shoulder closest to the new embankment at a distance of about 50 m from the abutment, and about 25 mm along the existing pavement centreline at a distance of about 50 m from the abutment. No material additional settlements induced by the new embankment fills are expected at the edge of pavement furthest from the new embankments.

Settlements induced by the new embankment fills on the underlying native soils are largely a result of recompression and consolidation of the underlying silty clay soils. Up to an additional 100 to 200 mm of recompression and primary consolidation settlement within the grey silty clay deposit over a period of about 10 years with an additional 10-20 mm of secondary compression to occur subsequently. Over 90% of the consolidation settlements is expected to occur over a period of about 2 to 3 years (without surcharge), depending on embankment height and location.

The above settlements would be entirely differential relative to the structures (which would be supported on deep foundations on bedrock). These settlement values exceed the usual values accepted by MTO for the approaches to bridges, as shown in the following table:

Distance from Abutment (m)	Tolerable Settlement (mm)
0 to 20	<25
20 to 50	<50
50 to 75	<75
>75	<100

Within 10 m of the abutments of these particular bridges, it is understood that essentially negligible settlements are desired (less than 10 mm), in part to avoid road grade differences with the pile supported abutment structure. It should be noted that pavement boreholes near the existing abutments indicate asphalt thicknesses approaching 300 mm to 375 mm, potentially indicating that some longer term settlements may have been mitigated by re-paving in this area. There is some remaining settlement existing adjacent to the existing abutments, notably on the EBL bridge, probably the result of secondary compression.

The following mitigation options have therefore been considered:

- 1) Allow the settlements to occur and periodically pad and overlay to correct the profile.
- 2) Pre-loading only.
- 3) Pre-load and surcharge the widening.
- 4) Installation of vertical wick drains.
- 5) Use of lightweight fills such as Expanded Polystyrene (EPS) and Lightweight Cellular Concrete (LCC).

Recommendations for the above options are provided in the following sections.



### 6.7.3.1 Allow Settlements to Occur

This option would involve allowing the roadway to settle and to accept the short-term potential impacts of the expected settlements on the roadway performance. It would be planned to pad and overlay the roadway periodically to reinstate the roadway profile. This option is considered to be technically feasible but is probably not appropriate considering the high volumes of traffic over these bridges. Downdrag loads on the abutment piles would also need to be considered.

### 6.7.3.2 Preloading

Preload site preparation treatment involves the placement of the permanent loads (typically permanent grade fills) in advance of the completion of the embankment and roadway construction to allow the subgrade soils to compress under the weight of the applied fills, thus reducing the potential post-construction settlement. Preloading treatment reduces, but does not entirely eliminate, settlement effects. Some residual, post-treatment settlement is inevitable due to the long-term secondary consolidation of the fine-grained subgrade soils.

For this option, the footprint of the new embankments would be preloaded with fill and allowed to settle in advance of the new lanes being paved and put in-service.

As described above, time will be required for the pore water to be expelled and the settlements to occur. Time-settlement analyses have therefore been carried out and the results of those analyses are indicated in the following table:

Residual Settlement (mm)	Preload Duration (months)
< 50 mm at 20 to 50 m < 25 mm at 0 to 20 m	24 to 36

The results shown in the above table indicate that if these long-term post-construction settlements can be tolerated, then approximately 24 to 36 months of preload time would be required. These preload times are however only estimates. The actual duration of the preload will need to be determined based on monitoring of the ground settlements under the preload/surcharge. Given the time required to achieve acceptable settlement performance of the embankment, this option is not considered feasible due to the overall project schedule constrains as we understand them.

In the event that a preloading mitigation approach is retained, the installation of the abutment piles should be delayed 24 months, subject to settlement monitoring results, such that significant settlements are no longer occurring. Otherwise downdrag loads on the piles may be mobilized as described in Section 6.4.3.

### 6.7.3.3 Preloading and Surcharging

Preload and surcharging involves the placement of a temporary fill load (in addition to the permanent fill load) to accelerate consolidation of the subgrade soils, and thus accelerate site preparation treatment. The thickness of the applied temporary surcharge varies depending on the degree to which the soil consolidation process (and thus the construction schedule) needs to be accelerated. A trade-off exists between the height or thickness of the applied preload and temporary surcharge fills, and the desired timeframe to complete site preparation treatment; a greater thickness of applied surcharge results in a shorter preload duration, but at increased cost.

For this option, the footprint of the new embankments would be preloaded/surcharged with fill and allowed to settle in advance of the new lanes being paved and put in-service.



As described above, time will be required for the pore water to be expelled and the settlements to occur. This option is therefore not feasible without surcharging the preload to accelerate the settlements. Additional time-settlement analyses have therefore been carried out on the basis of a 1.5 m surcharge above the design pavement level. The results of those analyses are indicated in the following table:

Surcharge Height (m)	Residual Settlement (mm)	Surcharge Duration (months)
1.5	< 50 mm at 20 to 50 m < 25 mm at 0 to 20 m	6 to 9 months

The results shown in the above table indicate that these long-term post-construction settlements can be tolerated, then approximately 6 to 9 months of preload and surcharge time would be required. These preload and surcharge times are however only estimates. The actual duration of the preload will need to be determined based on monitoring of the ground settlements under the preload/surcharge.

In the event that a preloading/surcharging mitigation approach is retained, the installation of the abutment piles should be delayed by 6 months, subject to settlement monitoring results, such that significant settlements are no longer occurring following removal of the surcharge. Otherwise downdrag loads on the piles may be mobilized as described in Section 6.4.3. This option is considered the preferred mitigation approach to the embankment settlements.

An important feature of this option is the need to place the selected surcharge for the duration of the preload time. The feasibility of that option, from a drainage and roadway geometry perspective, will need to be evaluated by the designers.

Stability analyses were carried out to evaluate the stability of the embankments with the proposed surcharge, and the resulting factors of safety were found to meet the requirements under static conditions presented in Section 6.7.2.

#### **6.7.3.4 Wick Drains**

The installation of vertical wick drains, in combination with preloading and surcharging, can be considered to further reduce the settlement times of the embankment under the preloading and surcharging option. A typical wick drain layout would have them spaced on about 1.5 m and extend to depths of 8 to 10 m at this site. Given the limited depth of the clay layer that is undergoing consolidation, the relatively short preload and surcharge durations discussed above, and the higher cost of a wick drain installation, this option while feasible is not considered to provide advantages to a more economical preloading and surcharging mitigation approach.

#### **6.7.3.5 Lightweight Fills**

The use of lightweight fills such as expanded polystyrene (EPS) and lightweight cellular concrete (LCC) can be considered to further reduce the settlements of the embankments for the proposed abutments. In such a mitigation approach, such lightweight fills are used to replace a portion of the embankment fills and thus reduce stresses imposed on underlying compressible soil layers to levels that essentially eliminate primary and secondary consolidation settlements. About 1.5 m to 2 m of lightweight fill would be required to essentially eliminate consolidation settlements at this site. Given the relatively short preload and surcharge durations discussed above and the much higher cost of a lightweight fill mitigation, this option while feasible is not considered to provide advantages to a more economical preloading and surcharging mitigation approach.



### 6.7.3.6 Settlement Monitoring

Settlement monitoring of the embankments during construction should be carried out by means of settlement plates. The settlement plates should be installed along the centreline of the Highway 417 at distances of about 5, 15, 30, and 50 m from each abutment along the embankments. The settlement plates should consist of 6.35 mm thick steel plates with plan dimensions of at least 0.5 m by 0.5 m with a 25 mm diameter steel pipe installed in the centre of the plate. The settlement plates should be surveyed at regular intervals including baseline readings before construction, daily readings during construction, and twice per week for one month following construction, and every second week up to two months after completion of embankment construction.

The installation and monitoring should be as per the Non-Standard Special Provision for the settlement monitoring provided in Appendix G.

## 6.8 Construction Considerations

The following sections identify future construction considerations that may impact the future design and construction.

### 6.8.1 Excavations and Temporary Protection Systems

Excavations for the pile caps are expected to extend up to about 2 to 3 m below the existing ground surface. The excavations will extend through the existing fill and alluvium deposit into the weathered silty clay crust.

Where space permits, open-cut excavations into these materials should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act (OHSA) for Construction Activities. The existing fill material and weathered silty clay crust above the water table would be classified as Type 3 soil, based on OHSA. According to OHSA excavations in excavations that extend to, or into, Type 3 soils should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V). The fill material, alluvium, and silty clay below the water table would be classified as Type 4 soil, based on OSHA and excavations in these materials should be sloped no steeper than 3H:1V.

It is anticipated that temporary protection systems would likely be required to facilitate the excavation to foundation or pile cap level for the new abutments and construction of the approach embankments. The temporary excavation support system shall be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*). The lateral movement of the temporary protection system should meet Performance Level 2 as specified in OPSS.PROV 539.

It is considered that soldier pile and lagging or an interlocking sheetpile system would be feasible at this site. Interlocking sheetpiling is considered to be a feasible shoring option at the abutment and pier locations, where the sheetpiling would extend through the native silty clay deposit where boulders aren't expected. Soldier pile and lagging is also considered a feasible shoring option. Pre-augering through the embankment fill may also be required prior to the installation of the soldier piles for the protection system to limit the vibration impacts on the existing bridge structure.

The soldier pile and lagging or sheetpiling could be supported against lateral movement using walers, tie backs and/or internal struts/braces. To reduce potential disturbance of the existing bridge, sheetpiling or pre-augered soldier piles should be installed at a minimum offset of 2 m from the piled foundations of the existing structure. Where soldier piles are to be driven, the protection system should be installed at a minimum offset of 5 m from the existing piled foundations.



## 6.8.2 Groundwater and Surface Water Control

The groundwater level, at the new abutment and pier locations, is about 1 to 3 m depth below the existing ground surface. Excavations for the construction of the abutment and pier foundations on bedrock will likely involve minimal groundwater and surface water control. It should be possible to handle ground and surface water inflows by pumping from well filtered sumps established in the floor of the excavations.

## 6.8.3 Vibration Monitoring During Pile Driving

The proposed staged construction is to include construction of the new the structures while the existing structures remain in service. It is recommended that vibration monitoring be carried out during installation of piles or driven protection systems to assist in maintaining vibration levels within tolerable ranges for the existing portions of the bridge, or for any temporary modular structure if used at the site.

A maximum peak particle velocity of 100 mm/s is recommended at the existing abutments and piers. The piles furthest from the existing structure should be driven first, in order to check the vibration level at the existing structure and, if necessary, alter the installation procedures for the remaining piles.

## 6.9 Corrosion and Cement Type

Eight soil samples from Boreholes 17-1302, 17-1303, 17-1304, 17-1305, 17-1308, 17-1309, 17-1310, and 17-1311 were submitted to Eurofins Environment Testing for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on buried concrete elements (corrosion and sulphate attack). The results of the testing are attached in Appendix D, and are summarized in the table below.

The results indicate a low potential for concrete degradation due to the presence of sulphates, and that concrete made with Type GU Portland cement should be acceptable for substructures. However, the results also indicate a high potential for corrosion of exposed ferrous metal which should be considered in the design.

**Summary of Corrosivity of Sample**

Borehole / Sample No.	Sample Depth (m)	Sample Type	Chloride (%)	pH	Electrical Conductivity (mS/cm)	Resistivity (ohm-cm)	Sulphate (%)
17-1302 / 3	1.5 – 2.1	Soil	0.041	7.5	1.20	833	0.01
17-1303 / 11	13.7 – 14.3	Soil	0.390	8.5	5.60	179	0.02
17-1304 / 3	1.5 – 2.1	Soil	0.034	8.2	0.74	1350	0.01
17-1305 / 14	25.8 – 26.4	Soil	0.294	8.7	4.31	232	0.03
17-1308 / 3	1.5 – 2.1	Soil	0.058	7.0	1.41	709	0.03
17-1309 / 11	15.2 – 15.8	Soil	0.468	8.4	5.82	172	0.03
17-1310 / 3	2.3 – 2.9	Soil	0.060	7.6	1.74	575	0.03
17-1311 / 15	39.6 – 40.2	Soil	0.055	9.0	1.38	725	0.04




## 7.0 CLOSURE

This report was prepared by Mr. Alex Meacoe, P.Eng., and was reviewed by Mr. Michael Snow, P.Eng., a senior geotechnical engineer and Principal of Golder. Mr. Murty Devata, P.Eng, provided technical input and Mr. Fintan Heffernan, P.Eng., Designated MTO Foundations Contact, conducted an independent quality control review of this report.

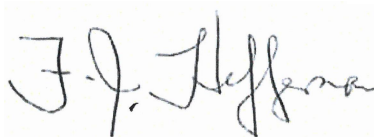
### Golder Associates Ltd.



Alex Meacoe, P.Eng.  
Geotechnical Engineer



Michael Snow, P.Eng.  
Principal, Senior Geotechnical Engineer



Fintan J. Heffernan, P.Eng.  
Designated MTO Foundations Contact



WAM/MSS/FJH/mvrd

[https://golderassociates.sharepoint.com/sites/11263g/shared documents/01\\_foundations/6 - reports/1130 ramsayville road/final/1662565-1130-001-r-rev0-ramsayville road bridge-august 2018.docx](https://golderassociates.sharepoint.com/sites/11263g/shared%20documents/01_foundations/6%20-%20reports/1130%20ramsayville%20road/final/1662565-1130-001-r-rev0-ramsayville%20road%20bridge-august%202018.docx)

Golder and the G logo are trademarks of Golder Associates Corporation



Table 1: Comparison of Bridge Abutment and Pier Foundation Alternatives

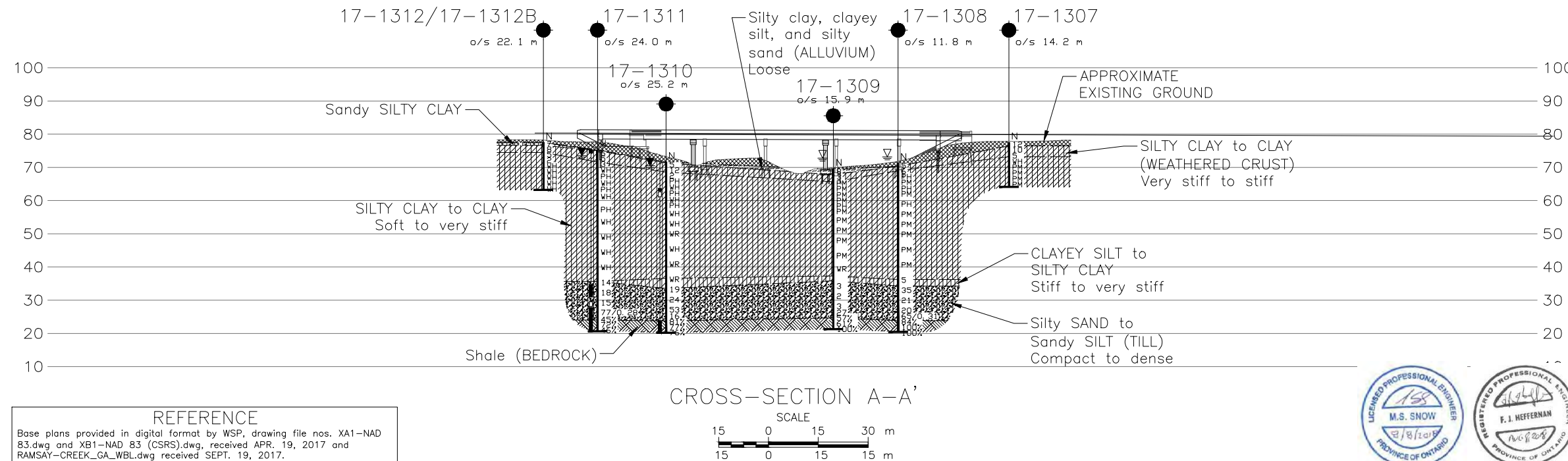
Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/ Risks
1. Steel H-piles founded on the bedrock	<ul style="list-style-type: none"><li>Feasible for the support of new abutments with pile cap “perched” within the approach embankments and for support of piers.</li></ul>	<ul style="list-style-type: none"><li>High bearing resistance.</li><li>Negligible settlement.</li><li>Compatible with existing bridge foundations.</li><li>Conventional construction methods for H-pile or steel pipe pile foundations.</li><li>Steel H-piles allow for integral abutment configuration.</li></ul>	<ul style="list-style-type: none"><li>Piles may interfere with existing battered piles.</li></ul>	<ul style="list-style-type: none"><li>Less expensive than caisson option.</li></ul>	<ul style="list-style-type: none"><li>Minor potential for pile damage / deflection if cobbles and boulders are encountered during pile driving.</li></ul>
2. Steel pipe piles	<ul style="list-style-type: none"><li>Feasible for piles driven to bedrock or refusal.</li></ul>	<ul style="list-style-type: none"><li>High bearing resistance.</li><li>Negligible settlement.</li><li>Pipe piles allow potentially for integral abutments or for semi-integral abutments</li></ul>	<ul style="list-style-type: none"><li>Pipe piles more likely to meet refusal in boulder till.</li></ul>	<ul style="list-style-type: none"><li>Comparable to steel H-piles</li></ul>	<ul style="list-style-type: none"><li>Higher risk that pipe piles can be deflected in boulder till.</li></ul>
3. Rock socketed steel pipe piles	<ul style="list-style-type: none"><li>Feasible using down the hole hammer method.</li></ul>	<ul style="list-style-type: none"><li>High bearing resistance.</li><li>Negligible settlement.</li><li>Provides stiffness to resist seismic lateral loads.</li></ul>	<ul style="list-style-type: none"><li>Need to balance hydrostatic head incorporative techniques such as mud drilling.</li></ul>	<ul style="list-style-type: none"><li>More expensive than steel H-pile or pipe piles with rock socket costs.</li></ul>	<ul style="list-style-type: none"><li>May not be able to dewater socket for cleaning and inspection.</li></ul>
4. Rock socketed drilled concrete caissons	<ul style="list-style-type: none"><li>Not feasible in deep cohesionless granular soil with artesian conditions</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>
5. Auger cast piles	<ul style="list-style-type: none"><li>Not feasible in deep cohesionless granular soil with artesian conditions.</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>
5. Spread/strip footings supported on native soil	<ul style="list-style-type: none"><li>Not Feasible.</li><li>Inadequate bearing and excessive settlement for footings on clay subsoil.</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>	<ul style="list-style-type: none"><li>N/A</li></ul>



Table 2 – Comparison of Settlement Mitigation Alternatives

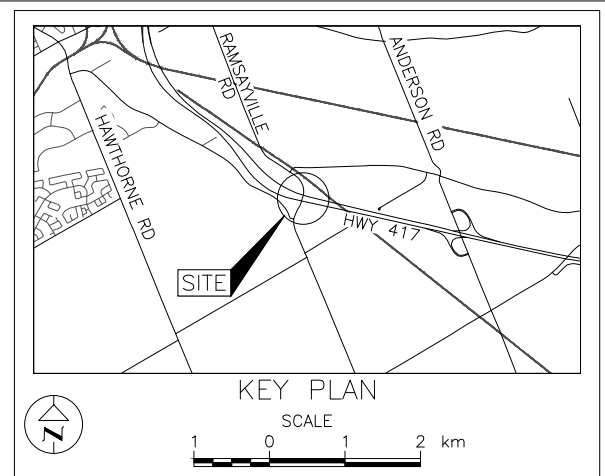
Foundation Option	Feasibility	Advantages	Disadvantages	Relative Costs	Constructability/ Risks
1. Allow embankments to settle and plan to periodically pad/overlay roadway	<ul style="list-style-type: none"><li>Probably not feasible given high traffic volumes</li></ul>	<ul style="list-style-type: none"><li>No impact on construction schedule</li></ul>	<ul style="list-style-type: none"><li>Required post-construction maintenance</li><li>Possible interim safety issue, between overlays, due to settlements</li></ul>	<ul style="list-style-type: none"><li>Relatively low costs, but must consider post-construction maintenance costs</li></ul>	<ul style="list-style-type: none"><li>Excessive roadway settlement in short term</li></ul>
2. Preloading only	<ul style="list-style-type: none"><li>Feasible</li></ul>	<ul style="list-style-type: none"><li>Little post-construction maintenance required</li></ul>	<ul style="list-style-type: none"><li>Delays paving for 2 years</li></ul>	<ul style="list-style-type: none"><li>Slightly less expensive than surcharging, and significantly less expensive than wick drains or lightweight fill</li></ul>	<ul style="list-style-type: none"><li>Some uncertainty about schedule, since cannot complete roadway construction until monitoring indicates sufficient settlement has occurred.</li></ul>
3. Preloading and surcharge	<ul style="list-style-type: none"><li>Feasible</li></ul>	<ul style="list-style-type: none"><li>Little post-construction maintenance required</li><li>Less delay for paving than simple preload</li></ul>	<ul style="list-style-type: none"><li>Delays paving for 6 months</li></ul>	<ul style="list-style-type: none"><li>Significantly less expensive than wick drains or lightweight fills</li></ul>	<ul style="list-style-type: none"><li>Some uncertainty about schedule, since cannot complete roadway construction until monitoring indicates sufficient settlement has occurred.</li></ul>
4. Preloading and surcharge with wick-drains	<ul style="list-style-type: none"><li>Feasible</li></ul>	<ul style="list-style-type: none"><li>Little post-construction maintenance required</li><li>Reduces the preloading and surcharging time with only nominal delay to paving</li></ul>	<ul style="list-style-type: none"><li>Mobilizing specialty subcontractor for small amount of work</li></ul>	<ul style="list-style-type: none"><li>Higher cost than preloading and surcharging, with only a few months gain in ability to pave</li></ul>	<ul style="list-style-type: none"><li>Some uncertainty about schedule, since cannot complete roadway construction until monitoring indicates sufficient settlement has occurred.</li></ul>
4. Lightweight fill	<ul style="list-style-type: none"><li>Feasible</li></ul>	<ul style="list-style-type: none"><li>No post-construction maintenance required</li><li>Minimal impact on schedule</li></ul>	<ul style="list-style-type: none"><li>Expensive</li></ul>	<ul style="list-style-type: none"><li>Likely most expensive option</li></ul>	<ul style="list-style-type: none"><li>Low risk option, but contractor may successfully propose one of other options as change order</li></ul>











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

# RAMSAYVILLE ROAD OVERPASS (WBL) HIGHWAY 417 BOREHOLE LOCATIONS AND SOIL STRATA



- | LEGEND  |  |
|---|--|
|    | Borehole – Current Investigation                                   |
|    | Borehole – Previous Investigation<br>(Geocres No. 31G5–71)         |
|    | Seal   |
|   | Piezometer   |
| N   | Standard Penetration Test Value                                    |
| 16  | Blows/0.3m unless otherwise stated<br>(Std. Pen. Test, 475 j/blow) |
| 100%  | Rock Quality Designation (RQD)                                     |
|  | WL in piezometer, measured on JUN. 16, 2017                        |
|  | WL upon completion of drilling                                     |

BOREHOLE CO-ORDINATES (MTM ZONE 9)			
No.	ELEVATION	NORTHING	EASTING
17-1301	78.2	5026398.4	377872.0
17-1301A	78.2	5026398.4	377872.0
17-1302	74.6	5026398.8	377896.0
17-1303	71.3	5026388.9	377932.9
17-1304	72.5	5026379.0	377968.8
17-1305	76.6	5026374.0	377994.5
17-1306	77.3	5026368.5	378017.3
17-1306A	77.1	5026369.6	378017.2
17-1307	77.7	5026409.0	378035.5
17-1308	71.3	5026420.5	378004.0
17-1309	69.6	5026421.8	377984.1
17-1310	71.6	5026428.4	377933.4
17-1311	75.3	5026435.9	377914.0
17-1312	77.5	5026443.2	377899.3
17-1312B	77.5	5026424.2	377899.3

**NOTES**

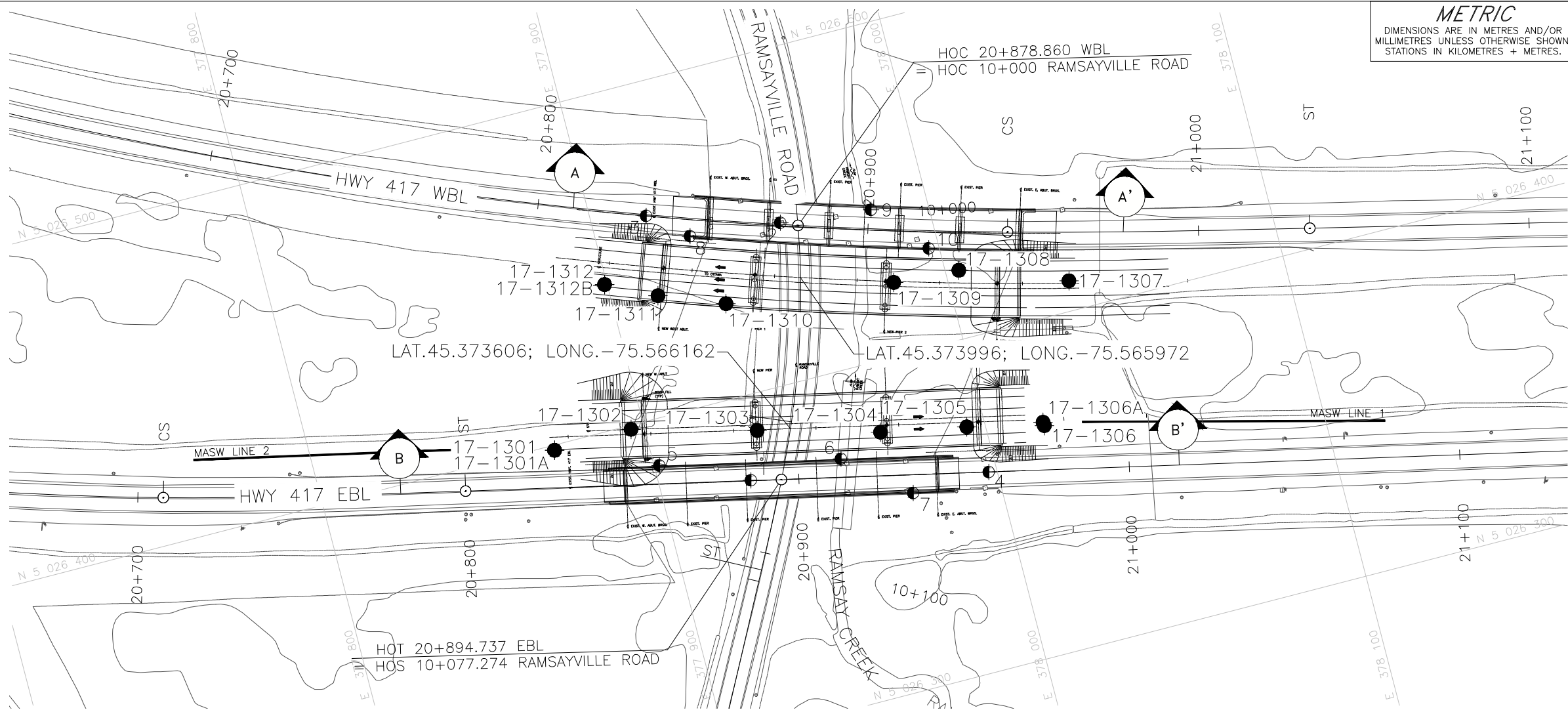
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

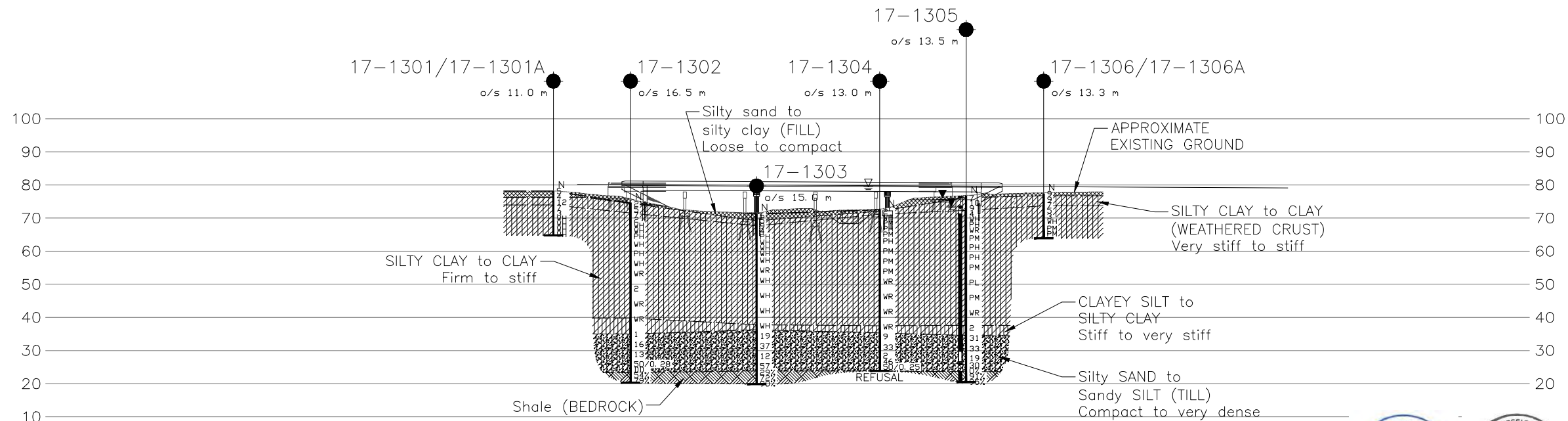
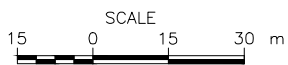
Cross-section B-B' shown on Drawing 2.

	-	-	-	-	-
NO.	DATE	BY	REVISION		
<b>Geocres No. 31G5-284</b>					
HWY. 417		PROJECT NO. 1662565		DIST. EASTERN	
SUBM'D. SAT	CHKD. SAT	DATE: 8/18/2017		SITE: 3-265/2	
DRAWN: JM	CHKD. FJH	APPD. FJH		DWG. 1	

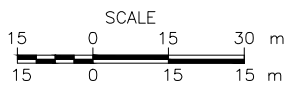




PLAN



CROSS-SECTION B-B'



REFERENCE

Base plans provided in digital format by WSP, drawing file nos. XA1-NAD 83.dwg and XB1-NAD 83 (CSRS).dwg, received APR. 19, 2017 and RAMSAY-CREEK\_GA\_EBL.dwg received SEPT. 19, 2017.

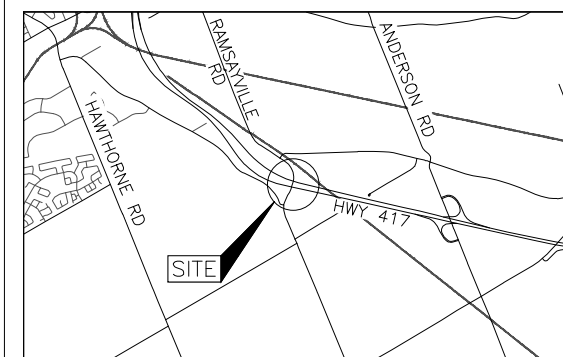
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
WP No. 4145-10-00

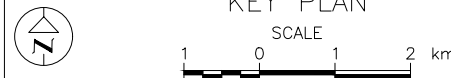
RAMSAYVILLE ROAD OVERPASS (EBL)  
HIGHWAY 417  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEY PLAN



LEGEND

- Borehole - Current Investigation
- Borehole - Previous Investigation (Geocres No. 31G5-71)
- ⬮ Seal
- ⬮ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Rock Quality Designation (RQD)
- ⬮ WL in piezometer, measured on JUN. 16, 2017
- ⬮ WL upon completion of drilling

BOREHOLE CO-ORDINATES (MTM ZONE 9)

No.	ELEVATION	NORTHING	EASTING
17-1301	78.2	5026398.4	377872.0
17-1301A	78.2	5026398.4	377872.0
17-1302	74.6	5026398.8	377896.0
17-1303	71.3	5026388.9	377932.9
17-1304	72.5	5026379.0	377968.8
17-1305	76.6	5026374.0	377994.5
17-1306	77.3	5026368.5	378017.3
17-1306A	77.1	5026369.6	378017.2
17-1307	77.7	5026409.0	378035.5
17-1308	71.3	5026420.5	378004.0
17-1309	69.6	5026421.8	377984.1
17-1310	71.6	5026428.4	377933.4
17-1311	75.3	5026435.9	377914.0
17-1312	77.5	5026443.2	377899.3
17-1312B	77.5	5026424.2	377899.3

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Cross-section A-A' shown on Drawing 1.

NO.	DATE	BY	REVISION

Geocres No. 31G5-284

HWY. 417	PROJECT No. 1662565	DIST. EASTERN
SUBM'D. SAT	CHKD. SAT	DATE: 8/18/2017
DRAWN: JM	CHKD. FJH	APPD. FJH
		SITE: 3-265/1
		DWG. 2





**APPENDIX A**

# Borehole and Drillhole Records, Current Investigation

Lists of Abbreviations and Symbols

Lithological and Geotechnical Rock Description Terminology

Records of Boreholes 17-1301 to 17-1312

Bedrock Core Photographs, Figures A1 to A14



## LIST OF SYMBOLS

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

<b>I. GENERAL</b>		<b>(a) Index Properties (continued)</b>	
$\pi$	3.1416	w	water content
$\ln x$ ,	natural logarithm of x	$w_l$ or LL	liquid limit
$\log_{10}$	x or log x, logarithm of x to base 10	$w_p$ or PL	plastic limit
g	acceleration due to gravity	$I_p$ or PI	plasticity index = $(w_l - w_p)$
t	time	$w_s$	shrinkage limit
FoS	factor of safety	$I_L$	liquidity index = $(w - w_p) / I_p$
		$I_C$	consistency index = $(w_l - w) / I_p$
		$e_{max}$	void ratio in loosest state
		$e_{min}$	void ratio in densest state
		$I_D$	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)
<b>II. STRESS AND STRAIN</b>		<b>(b) Hydraulic Properties</b>	
$\gamma$	shear strain	h	hydraulic head or potential
$\Delta$	change in, e.g. in stress: $\Delta \sigma$	q	rate of flow
$\varepsilon$	linear strain	v	velocity of flow
$\varepsilon_v$	volumetric strain	i	hydraulic gradient
$\eta$	coefficient of viscosity	k	hydraulic conductivity (coefficient of permeability)
$\nu$	Poisson's ratio	j	seepage force per unit volume
	total stress		
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )	<b>(c) Consolidation (one-dimensional)</b>	
$\sigma'_{vo}$	initial effective overburden stress	C	compression index (normally consolidated range)
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, minor)	$C_r$	recompression index (over-consolidated range)
$\sigma_{oct}$	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$	$C_s$	swelling index
$\tau$	shear stress	$C_\alpha$	secondary compression index
u	porewater pressure	$m_v$	coefficient of volume change
E	modulus of deformation	$c_v$	coefficient of consolidation (vertical direction)
G	shear modulus of deformation	$C_h$	coefficient of consolidation (horizontal direction)
K	bulk modulus of compressibility	$T_v$	time factor (vertical direction)
		U	degree of consolidation
<b>III. SOIL PROPERTIES</b>		$\sigma'_p$	pre-consolidation stress
<b>(a) Index Properties</b>		OCR	over-consolidation ratio = $\sigma'_p / \sigma'_{vo}$
$\rho(\gamma)$	bulk density (bulk unit weight)*	<b>(d) Shear Strength</b>	
$\rho_d(\gamma_d)$	dry density (dry unit weight)	$\tau_p, \tau_r$	peak and residual shear strength
$\rho_w(\gamma_w)$	density (unit weight) of water	$\phi'$	effective angle of internal friction
$\rho_s(\gamma_s)$	density (unit weight) of solid particles	$\delta$	angle of interface friction
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )	$\mu$	coefficient of friction = $\tan \delta$
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )	$c'$	effective cohesion
e	void ratio	$C_u, S_u$	undrained shear strength ( $\phi = 0$ analysis)
n	porosity	p	mean total stress $(\sigma_1 + \sigma_3)/2$
S	degree of saturation	$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
		q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
		$q_u$	compressive strength $(\sigma_1 - \sigma_3)$
		$S_t$	sensitivity

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

Notes: 1  
2

$\tau = c' + \sigma' \tan \phi'$   
shear strength = (compressive strength)/2



## LIST OF ABBREVIATIONS

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

### I. SAMPLE TYPE

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

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

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

#### Dynamic Cone Penetration Resistance; N<sub>d</sub>:

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

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

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

### III. SOIL DESCRIPTION

#### (a) Non-Cohesive (Cohesionless) Soils

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

#### (b) Cohesive Soils Consistency

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

### IV. SOIL TESTS

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

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

### V. MINOR SOIL CONSTITUENTS

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



## LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

### WEATHERINGS STATE

**Fresh:** no visible sign of weathering

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

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

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

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

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

### BEDDING THICKNESS

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

### JOINT OR FOLIATION SPACING

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

### GRAIN SIZE

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

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

### CORE CONDITION

#### Total Core Recovery (TCR)

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

#### Solid Core Recovery (SCR)

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

#### Rock Quality Designation (RQD)

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

### DISCONTINUITY DATA

#### Fracture Index

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

#### Dip with Respect to Core Axis

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

#### Description and Notes

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

#### Abbreviations

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



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1301</b>		SHEET 1 OF 2		<b>METRIC</b>						
W.P.		4145-10-00		LOCATION		N 5026398.4; E 377872.0 MTM ZONE 9 (LAT. 45.373718; LONG. -75.567063)		ORIGINATED BY						
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)		COMPILED BY						
DATUM		Geodetic		DATE		May 8, 2017		CHECKED BY						
								WAM						
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa		WATER CONTENT (%)		γ	
78.2	0.0	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100	25 50 75			
0.2	0.2	(SM) Silty sand (TOPSOIL) Dark brown Moist		1	SS	5		78	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED			○		c
77.3	0.9	(SM) Silty sand, contains rootlets (FILL) Loose Grey to grey-brown Moist		2	SS	4		77				○		0 17 19 64
76.2	2.0	(CL/ML/SM) Silty clay to clayey silt and silty sand (FILL) Loose Grey-brown Wet		3	SS	12		76						
75.9	2.3	(CL/CI) SILTY CLAY, contains organic matter (WEATHERED CRUST) Dark brown Moist		4	SS	7		75						
		(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown moist		5	SS	3		74						
73.9	4.3	(CI/CH) SILTY CLAY to CLAY Soft to firm Grey with black organic mottling Wet		6	SS	WH		73						
				7	SS	WH		72						
				8	SS	WH		71						
				9	SS	WH		70						
								69						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT		RECORD OF BOREHOLE				No 17-1301A		SHEET 1 OF 1		METRIC				
W.P.		LOCATION		BOREHOLE TYPE		ORIGINATED BY		COMPILED BY		CHECKED BY				
DIST		DATE		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
DATUM		ELEVATION		ELEVATION		ELEVATION		ELEVATION		ELEVATION				
1662565-1130		N 5026398.4; E 377872.0 MTM ZONE 9 (LAT. 45.373718; LONG. -75.567063)		Power Auger, 200 mm Diam. (Hollow Stem)		DG		ZS		WAM				
4145-10-00		May 11, 2017												
Eastern HWY 417														
Geodetic														
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
78.2	0.0	GROUND SURFACE												
0.2	0.2	(SM) Silty sand (TOPSOIL) Dark brown Moist												
77.3	0.9	(SM) Silty sand, rootlets (FILL) Loose Grey to grey-brown Moist												
76.2	2.0	(CL/ML/SM) Silty clay to clayey silt and silty sand (FILL) Loose Grey-brown Wet												
75.9	2.3	(CL/CI) SILTY CLAY, contains organic matter (WEATHERED CRUST) Dark brown Moist												
73.9	4.3	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Very stiff to stiff Grey-brown moist												
72.3	5.9	(CI/CH) SILTY CLAY Soft to firm Grey with black organic mottling Wet												
END OF BOREHOLE														
Note(s):														
1. Soil stratigraphy is inferred from Record of Borehole 17-1301														



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1302</b>		SHEET 1 OF 7		<b>METRIC</b>						
W.P.		4145-10-00		LOCATION		N 5026398.8; E 377896.0 MTM ZONE 9 (LAT. 45.373718; LONG. -75.566757)		ORIGINATED BY						
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		COMPILED BY						
DATUM		Geodetic		DATE		May 8, 2017		CHECKED BY						
								WAM						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
74.6	GROUND SURFACE													
0.0	(SM) Silty sand (TOPSOIL)													
0.2	Dark brown Moist		1	SS	2									
73.8	(CI/CH) SILTY CLAY to CLAY, some sand, contains rootlets (Weathered Crust)													
0.8	Grey-brown Moist		2	SS	5									
	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST)													
	Very stiff to stiff													
	Grey-brown Moist		3	SS	7									
			4	SS	5									
71.5	(CI/CH) SILTY CLAY to CLAY													
3.1	Firm to stiff		5	SS	2									
	Grey Wet													
			6	TP	PH									
			7	SS	WH									
			8	SS	WH									
66.7	(CI/CH) SILTY CLAY to CLAY													
7.9	Stiff													
	Grey Wet													
			9	TP	PH									
			10	TP	PH									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT		RECORD OF BOREHOLE No 17-1302				SHEET 6 OF 7		METRIC									
W.P. 4145-10-00		LOCATION N 5026398.8; E 377896.0 MTM ZONE 9 (LAT. 45.373718; LONG. -75.566757)				ORIGINATED BY DG											
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS											
DATUM Geodetic		DATE May 8, 2017				CHECKED BY WAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
23.3	(SM/ML) Silty SAND to Sandy Silt, contains cobbles and boulders (TILL) Very dense Brown Wet		22	NQ	DD												
51.3	Shale (BEDROCK)  Bedrock cored from depths 51.3 m to 54.3 m  For bedrock coring details refer to Record of Drillhole 17-1302		1	RC	REC 100%												RQD = 54%
			2	RC	REC 100%												RQD = 79%
20.3	END OF BOREHOLE																
54.3																	

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTOWHY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1302**

SHEET 7 OF 7

LOCATION: N 5026398.8 ;E 377896.0

DRILLING DATE: May 8, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
							TOTAL CORE % 000000 000000 000000	SOLID CORE % 000000 000000 000000				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 <sup>-9</sup> 10 <sup>-8</sup> 10 <sup>-7</sup> 10 <sup>-6</sup>	10 <sup>-9</sup> 10 <sup>-8</sup> 10 <sup>-7</sup> 10 <sup>-6</sup>	W1 W2 W3 W4 W5 W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		BEDROCK SURFACE		23.32																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: DG

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1303</b>		SHEET 1 OF 7		<b>METRIC</b>															
W.P.		4145-10-00		LOCATION		N 5026388.9; E 377932.9 MTM ZONE 9 (LAT. 45.373625; LONG. -75.566288)		ORIGINATED BY															
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		COMPILED BY															
DATUM		Geodetic		DATE		May 16, 2017		CHECKED BY															
								WAM															
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)								
ELEV	DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ			GR SA SI CL			
71.3	0.0	GROUND SURFACE							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> — W — W <sub>L</sub>			25 50 75						
71.1	0.2	(SM) Silty sand (TOPSOIL) Dark brown Moist						71															
		(CL/CI) Sandy silty clay, trace gravel (FILL) Grey-brown Moist		1	SS	6		70															
				2	SS	5																	
69.2	2.1	(CI/CH) SILTY CLAY to CLAY, contains sand seams (WEATHERED CRUST) Stiff to very stiff Grey-brown Moist		3	SS	9		69															
				4	SS	4		68															
67.7	3.7	(CI/CH) SILTY CLAY to CLAY Firm to stiff Grey Wet		5	TP	PH		67															
				6	SS	-		66															
								65															
				7	TP	PH		64															
				8	SS	WH		63															
								62															
				9	SS	WH																	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT 1662565-1130		<b>RECORD OF BOREHOLE No 17-1303</b>				SHEET 4 OF 7		<b>METRIC</b>	
W.P. 4145-10-00		LOCATION N 5026388.9; E 377932.9 MTM ZONE 9 (LAT. 45.373625; LONG. -75.566288)				ORIGINATED BY DG			
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS			
DATUM Geodetic		DATE May 16, 2017				CHECKED BY WAM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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		
	--- CONTINUED FROM PREVIOUS PAGE ---																
37.8	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black organic mottling Wet						41										
33.5	(ML-CI/CH) CLAYEY SILT to SILTY CLAY, trace sand Stiff Grey Wet		16	SS	WH												
36.3							37										
35.1	(SM) Silty SAND, some gravel, contains cobbles and boulders (TILL) Compact Dark grey Wet						36										
							35										
34.1			17	SS	19												
37.2	(SM-ML/SP) Silty SAND to SAND and SILT, some gravel, contains organic matter, cobbles and boulders (TILL) Compact to very dense Grey Wet						34										
							33										
							32										
			18	SS	37												

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS




GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02 DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

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



PROJECT		RECORD OF BOREHOLE No 17-1303				SHEET 6 OF 7		METRIC										
W.P. 4145-10-00		LOCATION N 5026388.9; E 377932.9 MTM ZONE 9 (LAT. 45.373625; LONG. -75.566288)				ORIGINATED BY DG												
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS												
DATUM Geodetic		DATE May 16, 2017				CHECKED BY WAM												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)	
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100							
	Shale (BEDROCK)		3	RC	REC 100%		21											RQD = 90%
	Bedrock cored from depths 47.5 m to 51.5 m  For bedrock coring details refer to Record of Drillhole 17-1303						20											
19.9	END OF BOREHOLE																	
51.5	NOTES:  1. Water level at 2.4 m above ground surface (Elev. 73.7), measured on May 19, 2017																	

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1303**

SHEET 7 OF 7

LOCATION: N 5026388.9 ;E 377932.9

DRILLING DATE: May 16, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY																		FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA				HYDRAULIC CONDUCTIVITY K, cm/sec			WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							TOTAL CORE %	SOLID CORE %			DIP W/L CORE AXIS	TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 <sup>0</sup>	10 <sup>1</sup>	10 <sup>2</sup>	10 <sup>3</sup>	W1	W2	W3		W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		BEDROCK SURFACE		23.84																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: DG

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS





N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

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



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1304</b>		SHEET 2 OF 5		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026379.0; E 377968.8 MTM ZONE 9 (LAT. 45.373533; LONG. -75.565830)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash boring</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 16, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)				GR	SA	SI	CL	
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100	25		50	75			
	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black mottling Wet							+											
								+											
			9	SS	PM														
								+											
								+											
			10	SS	PM														
									+										
																</			

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTOWHY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1304</b>		SHEET 3 OF 5		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026379.0; E 377968.8 MTM ZONE 9 (LAT. 45.373533; LONG. -75.565830)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash boring</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 16, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---							○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×		REMOULDED	W <sub>p</sub>	W	W <sub>L</sub>			
	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black mottling Wet																			
			12	SS	WR															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTOWHY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1304</b>		SHEET 4 OF 5		<b>METRIC</b>					
W.P.		4145-10-00		LOCATION		N 5026379.0; E 377968.8 MTM ZONE 9 (LAT. 45.373533; LONG. -75.565830)		ORIGINATED BY PAH					
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash boring		COMPILED BY ZS					
DATUM		Geodetic		DATE		May 16, 2017		CHECKED BY WAM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	25 50 75		
	--- CONTINUED FROM PREVIOUS PAGE ---												
	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black mottling Wet		14	SS	WR		42						0 0 40 60
							41						
							40						
							39						
							38						
37.5 35.1	(CI/CH-ML) SILTY CLAY and CLAYEY SILT, layered Stiff to very stiff Grey Wet		15	SS	WR		37						
							36						
35.3 37.2	(ML-SM) Sandy SILT, some gravel to Gravelly Silty SAND, contains cobbles, boulders and clayey silt seams (TILL) Very loose to dense Grey Wet		16	SS	9		35						
							34						
							33						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&WIDENING\02\_DATA\GIN\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MT0\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&WIDENING\02\_DATA\GIN\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

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



+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT		RECORD OF BOREHOLE				No 17-1305		SHEET 6 OF 7		METRIC							
W.P. 4145-10-00		LOCATION				N 5026374.0; E 377994.5 MTM ZONE 9 (LAT. 45.373485; LONG. -75.565503)				ORIGINATED BY PAH							
DIST Eastern HWY 417		BOREHOLE TYPE				Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS							
DATUM Geodetic		DATE				May 8, 2017				CHECKED BY WAM							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
25.1	(ML/SP) Sandy SILT to SAND and SILT, trace to some clay and gravel, contains clayey silt seams, cobbles and boulders (TILL) Dense Grey Wet						26										
51.5	(SM/GM) Silty SAND and GRAVEL, contains cobbles and boulders (TILL) Dense Grey Wet		21	SS	30		25										
23.6							24										
53.0	Shale (BEDROCK)  Bedrock cored from depths 53.0 m to 56.1 m  For bedrock coring details refer to Record of Drillhole 17-1305		1	RC	REC 88%		23										RQD = 0%
			2	RC	REC 100%		22										RQD = 91%
			3	RC	REC 100%		21										RQD = 95%
20.5	END OF BOREHOLE																
56.1	NOTES:  1. Water level in deep well at a depth of 3.0 m below ground surface (Elev. 73.6), measured on June 16, 2017.  2. Water level in shallow well at a depth of 0.5 m below ground surface (Elev. 76.1), measured on June 16, 2017.																

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1305**

SHEET 7 OF 7

LOCATION: N 5026374.0 ;E 377994.5

DRILLING DATE: May 8, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
							TOTAL CORE % 000000 999999	SOLID CORE % 000000 999999				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 <sup>-4</sup> 10 <sup>-3</sup> 10 <sup>-2</sup> 10 <sup>-1</sup>	10 <sup>-4</sup> 10 <sup>-3</sup> 10 <sup>-2</sup> 10 <sup>-1</sup>	W1 W2 W3 W4 W5 W6	W1 W2 W3 W4 W5 W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
53		BEDROCK SURFACE		23.64																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1306</b>		SHEET 1 OF 2		<b>METRIC</b>						
W.P.		4145-10-00		LOCATION		N 5026368.5; E 378017.3 MTM ZONE 9 (LAT. 45.373433; LONG. -75.565213)		ORIGINATED BY PAH						
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring		COMPILED BY ZS						
DATUM		Geodetic		DATE		May 8-7, 2017		CHECKED BY WAM						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
77.3	GROUND SURFACE													
0.0	(CL,ML,SM) Silty clay, clayey silt and silty sand (FILL) Loose Grey-brown Moist		1	SS	9									
76.8														
0.6	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Very stiff Grey-brown Moist		2	SS	9									
			3	SS	7									
			4	SS	5									
			5	SS	3									
73.7														
3.7	(CI/CH) SILTY CLAY to CLAY Firm Grey with black mottling Wet													
			6	SS	WH									
			7	TP	PH									
			8	SS	PM									
			9	SS	PM									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMT\Hwy417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1306</b>				SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026368.5; E 378017.3 MTM ZONE 9 (LAT. 45.373433; LONG. -75.565213)</u>				ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring</u>				COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 8-7, 2017</u>				CHECKED BY <u>WAM</u>			

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100					W <sub>p</sub> W W <sub>L</sub> 25 50 75					
	--- CONTINUED FROM PREVIOUS PAGE ---															
	(CI/CH) SILTY CLAY to CLAY Firm Grey with black mottling Wet															
			10	SS	PM											
			11	SS	PM											
63.9																
13.4	END OF BOREHOLE															

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMT\OHWWY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE				No 17-1306A		SHEET 1 OF 1		METRIC							
W.P. 4145-10-00		LOCATION				N 5026369.6; E 378017.2 MTM ZONE 9 (LAT. 45.373443; LONG. -75.565214)				ORIGINATED BY PAH							
DIST Eastern HWY 417		BOREHOLE TYPE				Power Auger, 200 mm Diam. (Hollow Stem)				COMPILED BY ZS							
DATUM Geodetic		DATE				May 24, 2017				CHECKED BY WAM							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
77.1	GROUND SURFACE							20	40	60	80	100					
0.0	(CL,ML,SM) Silty clay, clayey silt and silty sand (FILL) Loose Grey-brown Moist						77										
76.5	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Very stiff Grey-brown Moist						76										
0.6							75										
							74										
							73										
73.4	(CI/CH) SILTY CLAY to CLAY Firm Grey with black mottling Wet						72										
3.7							71										
			1	TP	PH												
71.0	END OF BOREHOLE																
6.1	Note(s): 1. Soil stratigraphy inferred from Record of Borehole 17-1306																

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02 DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1307</b>				SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026409.0; E 378035.5 MTM ZONE 9 (LAT. 45.373796; LONG. -75.564975)</u>				ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring</u>				COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 23-24, 2017</u>				CHECKED BY <u>WAM</u>			

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W		
						○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	20	40	60	80	100					
	--- CONTINUED FROM PREVIOUS PAGE ---															
	(CI/CH) SILTY CLAY to CLAY Firm Grey with black mottling Wet						X		+							
			10	SS	PM		67									
							66		+							
									+							
			11	SS	PM		65							○		
64.3									+							
13.4	END OF BOREHOLE								+							

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1308</b>		SHEET 1 OF 7		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026420.5; E 378004.0 MTM ZONE 9 (LAT. 45.373902; LONG. -75.565374)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 25-June 5, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
71.3	GROUND SURFACE													
0.0	(CI/CH) Silty clay to clay, some sand and gravel (FILL) Grey-brown Moist		1	GRAB	-									
70.4														
0.9	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Very stiff Grey-brown Moist		2	SS	5									
			3	SS	6									
69.0														
2.3	(CI/CH) SILTY CLAY to CLAY Firm to stiff Grey with black organic mottling Wet		4	SS	WH									
			5	TP	PH									
			6	SS	PM									
			7	SS	PM									
			8	TP	PH									
			9	SS	PM									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1308</b>		SHEET 2 OF 7		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026420.5; E 378004.0 MTM ZONE 9 (LAT. 45.373902; LONG. -75.565374)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 25-June 5, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	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	×	REMOULDED		W <sub>p</sub>	W	W <sub>L</sub>				
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	(CI/CH) SILTY CLAY to CLAY Firm to stiff Grey with black organic mottling Wet																			
			10	TP	PH															
			11	SS	PM															
			12	SS	PM															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMT\OHVY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1308</b>		SHEET 4 OF 7		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026420.5; E 378004.0 MTM ZONE 9 (LAT. 45.373902; LONG. -75.565374)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 25-June 5, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   LIQUID CONTENT   LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED	WATER CONTENT (%)					
							20   40   60   80   100				25   50   75			
	--- CONTINUED FROM PREVIOUS PAGE ---													
	(CI/CH) SILTY CLAY to CLAY Firm to stiff Grey with black organic mottling Wet						41							
			15	SS	PM									
							40							
							39							
							38							
							37							
36.2														
35.1	(ML) CLAYEY SILT Loose Grey Moist		16	SS	5		36							
							35							
34.3														
37.0	(ML/SP) Sandy SILT to SAND and SILT, some gravel, trace to some clay, contains silty sand seams, cobbles and boulders (TILL) Compact to dense Grey Wet						34							
			17	SS	35		33							
							32							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE No 17-1308				SHEET 5 OF 7		METRIC								
W.P. 4145-10-00		LOCATION N 5026420.5; E 378004.0 MTM ZONE 9 (LAT. 45.373902; LONG. -75.565374)				ORIGINATED BY PAH										
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS										
DATUM Geodetic		DATE May 25-June 5, 2017				CHECKED BY WAM										
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100				
	(ML/SP) Sandy SILT to SAND and SILT, some gravel, trace to some clay, contains silty sand seams, cobbles and boulders (TILL) Compact to dense Grey Wet		18	SS	21											18 41 33 8
23.9			20	SS	65/0.31											
47.4	Shale (BEDROCK)  Bedrock cored from depths 47.4 m to 50.8 m  For bedrock coring details refer to Record of Drillhole 17-1308		1	RC	REC 97%											RQD = 84%
			2	RC	REC 100%											RQD = 100%

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1308**

SHEET 7 OF 7

LOCATION: N 5026420.5 ;E 378004.0

DRILLING DATE: May 25-June 5, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	FLUSH RETURN	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
							RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr		Ja	W1	W2	W3	W4	W5		W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
							000000 000000 000000 000000 000000	000000 000000 000000 000000 000000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
		BEDROCK SURFACE		23.87																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1309</b>		SHEET 1 OF 6		<b>METRIC</b>								
W.P.		4145-10-00		LOCATION		N 5026421.8; E 377984.1 MTM ZONE 9 (LAT. 45.373917; LONG. -75.565629)		ORIGINATED BY PAH								
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		COMPILED BY ZS								
DATUM		Geodetic		DATE		June 5-6, 2017		CHECKED BY WAM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
69.6	GROUND SURFACE															
0.0	(CL) Silty clay (TOPSOIL/FILL) Grey-brown Moist		1	GRAB	-											
69.3	(CL, CL-ML, SM) Mixture of Silty clay, clayey silt and silty sand, contains organic matter (ALLUVIUM) Loose Grey-brown Thinly to thickly laminated Wet		2	SS	8											
67.8	(CL/CH) SILTY CLAY to CLAY Firm Grey Wet		3	SS	3											
65.7	(CL/CH) SILTY CLAY to CLAY Stiff Grey with black organic mottling Wet		4	SS	PH											
4.0			5	SS	PM											
			6	SS	PM											
			7	SS	PM											
			8	SS	PM											

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1309</b>		SHEET 2 OF 6		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026421.8; E 377984.1 MTM ZONE 9 (LAT. 45.373917; LONG. -75.565629)</u>		ORIGINATED BY <u>PAH</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>June 5-6, 2017</u>		CHECKED BY <u>WAM</u>			

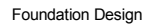
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL   LIQUID LIMIT   MOISTURE   LIMIT CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20   40   60   80   100	○ UNCONFINED   + FIELD VANE	● QUICK TRIAXIAL   × REMOULDED	W <sub>p</sub> W   W <sub>L</sub>						
	--- CONTINUED FROM PREVIOUS PAGE ---							20   40   60   80   100			25   50   75		GR   SA   SI   CL				
	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black organic mottling Wet								+								
			9	TP	PH		59		+								
							58		+								
			10	SS	PM		57					○					
							56		>96 + +								
							55										
			11	SS	PM		54										
							53		+	+							
							52										
			12	SS	PM		51					○					
							50		+								

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMITO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS






+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTO\HWY417\REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		1662565-1130		<b>RECORD OF BOREHOLE No 17-1309</b>		SHEET 4 OF 6		<b>METRIC</b>						
W.P.		4145-10-00		LOCATION		N 5026421.8; E 377984.1 MTM ZONE 9 (LAT. 45.373917; LONG. -75.565629)		ORIGINATED BY PAH						
DIST		Eastern HWY 417		BOREHOLE TYPE		Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		COMPILED BY ZS						
DATUM		Geodetic		DATE		June 5-6, 2017		CHECKED BY WAM						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>	25 50 75			
--- CONTINUED FROM PREVIOUS PAGE ---														
	(CI/CH) SILTY CLAY to CLAY Stiff Grey with black organic mottling Wet		15	SS	WR		39							
								38						
37.3														
32.3	Probable (CL-ML) CLAYEY SILT Grey Wet						37							
35.8							36							
33.8	(ML/SP) Sandy SILT to SILT and SAND, some gravel, contains cobbles and boulders (TILL) Very Loose Grey Wet		16	SS	3		35							
							34							
							33							
							32							
			17	SS	2		31							
							30							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE				No 17-1309		SHEET 5 OF 6		METRIC						
W.P. 4145-10-00		LOCATION				N 5026421.8; E 377984.1 MTM ZONE 9 (LAT. 45.373917; LONG. -75.565629)				ORIGINATED BY PAH						
DIST Eastern HWY 417		BOREHOLE TYPE				Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS						
DATUM Geodetic		DATE				June 5-6, 2017				CHECKED BY WAM						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
26.8	(ML/SP) Sandy SILT to SILT and SAND, some gravel, contains cobbles and boulders (TILL) Very Loose Grey Wet		18	SS	3											18 37 37 8
42.8	(SM) Gravelly Silty SAND, contains cobbles and boulders (TILL) Compact Grey Wet		19	SS	27											
24.7	Shale (BEDROCK)		1	RC	REC 89%											RQD = 57%
45.0	Bedrock cored from depths 45.0 m to 48.4 m  For bedrock coring detail refer to Record of Drillhole 17-1309		2	RC	REC 87%											RQD = 61%
			3	RC	REC 100%											RQD = 100%
21.3	END OF BOREHOLE															
48.4	NOTES:  1. Water level at 3.2 m above ground surface (Elev. 72.8 m), measured on June 8, 2017															

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1309**

SHEET 6 OF 6

LOCATION: N 5026421.8 ;E 377984.1

DRILLING DATE: June 5-6, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
						FLUSH RETURN	RECOVERY		R.Q.D. %	FRACT. INDEX PER	DIP w.r.t CORE AXIS °	DISCONTINUITY DATA		HYDRAULIC CONDUCTIVITY K, cm/sec		WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							TOTAL CORE %	SOLID CORE %				TYPE AND SURFACE DESCRIPTION	Jr	Ja	10 <sup>-9</sup>	10 <sup>-8</sup>	10 <sup>-7</sup>	10 <sup>-6</sup>	W1		W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
		BEDROCK SURFACE		24.65																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: PAH

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS



<b>PROJECT</b> 1662565-1130		<b>RECORD OF BOREHOLE No 17-1310</b>		SHEET 1 OF 7		<b>METRIC</b>	
<b>W.P.</b> 4145-10-00		<b>LOCATION</b> N 5026428.4; E 377933.4 MTM ZONE 9 (LAT. 45.373981; LONG. -75.566276)		<b>ORIGINATED BY</b> DG			
<b>DIST</b> Eastern HWY 417		<b>BOREHOLE TYPE</b> Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		<b>COMPILED BY</b> ZS			
<b>DATUM</b> Geodetic		<b>DATE</b> May 23-25, 2017		<b>CHECKED BY</b> WAM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
71.6	GROUND SURFACE																
0.0	(SM) Silty sand (TOPSOIL) Dark brown Moist																
71.3																	
0.3	(CI/CH) SILTY CLAY to CLAY, trace sand (WEATHERED CRUST) Stiff to very stiff Grey-brown Moist		1	SS	5												
			2	SS	12												
			3	SS	7												
68.6			4	SS	2												
3.1	(CI/CH) SILTY CLAY to CLAY Firm to stiff Grey with black organic mottling Wet																
			5	TP	PH												
			6	SS	WH												
			7	SS	PH												
			8	SS	PH												

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMT\Hwy417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





GTA-MTO 001 N:\ACTIVE\SPATIAL\_JM\MTOWHWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE





GTA-MTO 001 N:\ACTIVE\SPATIAL\_JM\MTOWHWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02 DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1310</b>				SHEET 5 OF 7		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026428.4; E 377933.4 MTM ZONE 9 (LAT. 45.373981; LONG. -75.566276)</u>				ORIGINATED BY <u>DG</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>				COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 23-25, 2017</u>				CHECKED BY <u>WAM</u>			


SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					W <sub>p</sub>	W			W <sub>L</sub>			
						20	40	60	80	100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)				
						20	40	60	80	100						25	50	75		
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	(SM/GM) Silty SAND and GRAVEL, trace clay, contains cobbles and boulders (TILL) Compact to very dense Grey Wet		18	SS	24															
			19	SS	53															
			20	SS	16															
23.8	Shale (BEDROCK)		1	RC	REC 100%														40 34 22 4	
47.9	Bedrock cored from depths 47.9 m to 51.4 m For bedrock coring details refer to Record of Drillhole 17-1310		2	RC	REC 99%														RQD = 81%	
																			RQD = 77%	
			3	RC															RQD = 76%	

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE				No 17-1310		SHEET 6 OF 7		METRIC							
W.P. 4145-10-00		LOCATION				N 5026428.4; E 377933.4 MTM ZONE 9 (LAT. 45.373981; LONG. -75.566276)				ORIGINATED BY DG							
DIST Eastern HWY 417		BOREHOLE TYPE				Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS							
DATUM Geodetic		DATE				May 23-25, 2017				CHECKED BY WAM							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa									WATER CONTENT (%)
	--- CONTINUED FROM PREVIOUS PAGE ---						20	40	60	80	100						
	Shale (BEDROCK)  Bedrock cored from depths 47.9 m to 51.4 m  For bedrock coring details refer to Record of Drillhole 17-1310		3	RC	REC 100%												RQD = 76%
20.2	END OF BOREHOLE																
51.4	NOTES:  1. Water level in well at a depth of 1.2 m below ground surface (Elev. 70.4 m), measured on June 16, 2017  2. NP = Non-plastic																

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMITO\HWY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT: 1662565-1130

**RECORD OF DRILLHOLE: 17-1310**

SHEET 7 OF 7

LOCATION: N 5026428.4 ;E 377933.4

DRILLING DATE: May 23-25, 2017

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---

DRILL RIG: CME 55

DRILLING CONTRACTOR: Grenville Drilling

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY														FEATURES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
						RECOVERY		R.Q.D. %	FRACT. INDEX PER	DISCONTINUITY DATA			HYDRAULIC CONDUCTIVITY K, cm/sec	WEATH- ERING INDEX																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
						TOTAL CORE %	SOLID CORE %			TYPE AND SURFACE DESCRIPTION	Jr	Ja		W1	W2	W3	W4	W5	W6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
						800000	800000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
		BEDROCK SURFACE		23.76																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

DEPTH SCALE

1 : 50

**GOLDER**

LOGGED: DG

CHECKED: WAM

GTA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS



<b>PROJECT</b> 1662565-1130		<b>RECORD OF BOREHOLE No 17-1311</b>		SHEET 1 OF 7		<b>METRIC</b>	
<b>W.P.</b> 4145-10-00		<b>LOCATION</b> N 5026435.9; E 377914.0 MTM ZONE 9 (LAT. 45.374050; LONG. -75.566521)		<b>ORIGINATED BY</b> DG			
<b>DIST</b> Eastern HWY 417		<b>BOREHOLE TYPE</b> Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core		<b>COMPILED BY</b> ZS			
<b>DATUM</b> Geodetic		<b>DATE</b> May 31, 2017		<b>CHECKED BY</b> WAM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
												20	40	60	80					
75.3	GROUND SURFACE																			
0.0	(SM) Silty sand (TOPSOIL)																			
75.1	Dark brown																			
0.2	Moist																			
	(CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST) Stiff to very stiff Grey-brown Moist		1	SS	6															
			2	SS	6															
			3	SS	5															
			4	SS	3															
71.6	(CI/CH) SILTY CLAY to CLAY																			
3.6	Stiff Grey with black organic mottling Wet		5	SS	WH															
			6	TP	PH															
			7	SS	WH															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





GTA-MTO 001 N:\ACTIVE\SPATIAL\_JM\MTOWHWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

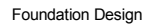




+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_JM\MTOWHWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS





+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1311</b>		SHEET 5 OF 7		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026435.9; E 377914.0 MTM ZONE 9 (LAT. 45.374050; LONG. -75.566521)</u>		ORIGINATED BY <u>DG</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>May 31, 2017</u>		CHECKED BY <u>WAM</u>			

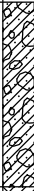

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100	25	50	75					
	--- CONTINUED FROM PREVIOUS PAGE ---																			
	(SM/GM) Silty SAND and GRAVEL, trace to some clay, contains cobbles and boulders (TILL) Compact to very dense Dark grey Wet																			
			16	SS	18															
			17	SS	15															
			18	SS	77/0.28															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTD\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE No 17-1311				SHEET 6 OF 7		METRIC									
W.P. 4145-10-00		LOCATION N 5026435.9; E 377914.0 MTM ZONE 9 (LAT. 45.374050; LONG. -75.566521)				ORIGINATED BY DG											
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)/Wash Boring/Rotary Drill, NQ Core				COMPILED BY ZS											
DATUM Geodetic		DATE May 31, 2017				CHECKED BY WAM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	--- CONTINUED FROM PREVIOUS PAGE ---							20	40	60	80	100					
24.0	(SM/GM) Silty SAND and GRAVEL, trace to some clay, contains cobbles and boulders (TILL) Compact to very dense Dark grey Wet																
51.2	Shale (BEDROCK)  Bedrock cored from depths 51.2 m to 54.6 m  For bedrock coring details refer to Record of Drillhole 17-1311		1	RC	REC 100%												RQD = 45%
			2	RC	REC 100%												RQD = 72%
			3	RC	REC 100%												RQD = 46%
20.7	END OF BOREHOLE																
54.6	NOTES:  1. Water level in well at a depth of 1.7 m below ground surface (Elev. 73.6), measured on June 16, 2017																



SHEET 7 OF 7

DATUM: Geodetic

DRILLING CONTRACTOR: Grenville Drilling

STA-RCK 031 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02\_DATA\GINT\1662565.GPJ GAL-MISS.GDT 8/9/18 ZS

LOGGED: DG  
CHECKED: WAM



GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&WIDENING\02 DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



PROJECT <u>1662565-1130</u>		<b>RECORD OF BOREHOLE No 17-1312</b>		SHEET 2 OF 2		<b>METRIC</b>	
W.P. <u>4145-10-00</u>		LOCATION <u>N 5026443.2; E 377899.3 MTM ZONE 9 (LAT. 45.374117; LONG. -75.566709)</u>		ORIGINATED BY <u>SN</u>			
DIST <u>Eastern</u> HWY <u>417</u>		BOREHOLE TYPE <u>Power Auger, 200 mm Diam. (Hollow Stem)</u>		COMPILED BY <u>ZS</u>			
DATUM <u>Geodetic</u>		DATE <u>June 7-8, 2017</u>		CHECKED BY <u>WAM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---							○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × REMOULDED	20	40	60	80	100	w <sub>p</sub>	w		w <sub>L</sub>			
	(CI/CH) SILTY CLAY to CLAY Soft to firm Grey with black organic mottling Wet						×	+												
							×	+												
			10	SS	WH															
							×		+											
							×		+											
			11	SS	WH															
							×		+											
							×		+											
			12	SS	WH															
63.2																				
14.3	END OF BOREHOLE																			

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT 1662565-1130		<b>RECORD OF BOREHOLE No 17-1312B</b>				SHEET 1 OF 2		<b>METRIC</b>	
W.P. 4145-10-00		LOCATION N 5026443.2; E 377899.3 MTM ZONE 9 (LAT. 45.374117; LONG. -75.566709)				ORIGINATED BY SN			
DIST Eastern HWY 417		BOREHOLE TYPE Power Auger, 200 mm Diam. (Hollow Stem)				COMPILED BY ZS			
DATUM Geodetic		DATE June 8, 2017				CHECKED BY WAM			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					WATER CONTENT (%)									
						20	40	60	80	100	20	40	60	80	100	25	50	75		
77.5	GROUND SURFACE																			
0.0	(SM) Silty sand (TOPSOIL)																			
0.1	Moist																			
	(CL/CI) Sandy silty clay, trace to some gravel, contains rootlets (FILL)																			
76.6	Brown																			
	Moist																			
0.9	(CI/CH) SILTY CLAY to CLAY, trace sand (WEATHERED CRUST)																			
	Very stiff to stiff																			
	Grey-brown																			
	Moist																			
74.5	(CI/CH) SILTY CLAY to CLAY, trace sand																			
3.1	Soft to firm																			
	Grey-brown																			
	Wet																			
73.0	(CI/CH) SILTY CLAY to CLAY																			
4.6	Firm to stiff																			
	Grey with black organic mottling																			
	Wet																			
67.8																				
9.8																				

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IM\MTOWHY417REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



PROJECT		RECORD OF BOREHOLE				No 17-1312B		SHEET 2 OF 2		METRIC						
W.P. 4145-10-00		LOCATION				N 5026443.2; E 377899.3 MTM ZONE 9 (LAT. 45.374117; LONG. -75.566709)				ORIGINATED BY SN						
DIST Eastern HWY 417		BOREHOLE TYPE				Power Auger, 200 mm Diam. (Hollow Stem)				COMPILED BY ZS						
DATUM Geodetic		DATE				June 8, 2017				CHECKED BY WAM						
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
67.2	(CI/CH) SILTY CLAY to CLAY Soft to firm Grey with black organic mottling Wet		1	SH	-											
10.4	END OF BOREHOLE															
	NOTES:  1. For soil stratigraphy refer to Record of Borehole 17-1312.															

GTA-MTO 001 N:\ACTIVE\SPATIAL\_IMMTO\HWY417\REHAB&amp;WIDENING\02\_DATA\GINT\1662565.GPJ GAL-GTA.GDT 8/9/18 ZS



**BH 17-1302 (Wet)**  
**Cored Length of 51.26 to 54.31 metres**  
**Core Box 1 and 2 of 2**

51.26 m Top of Bedrock



54.31 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A1**



**BH 17-1302 (Dry)**  
**Cored Length of 51.26 to 54.31 metres**  
**Core Box 1 and 2 of 2**

51.26 m Top of Bedrock



54.31 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565/1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A2**



**BH 17-1303 (Wet)**  
**Cored Length of 47.47 to 51.45 metres**  
**Core Box 1 and 2 of 2**

47.47 m Top of Bedrock



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A3**



**BH 17-1303 (Dry)**  
**Cored Length of 47.47 to 51.45 metres**  
**Core Box 1 and 2 of 2**

47.47 m Top of Bedrock



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

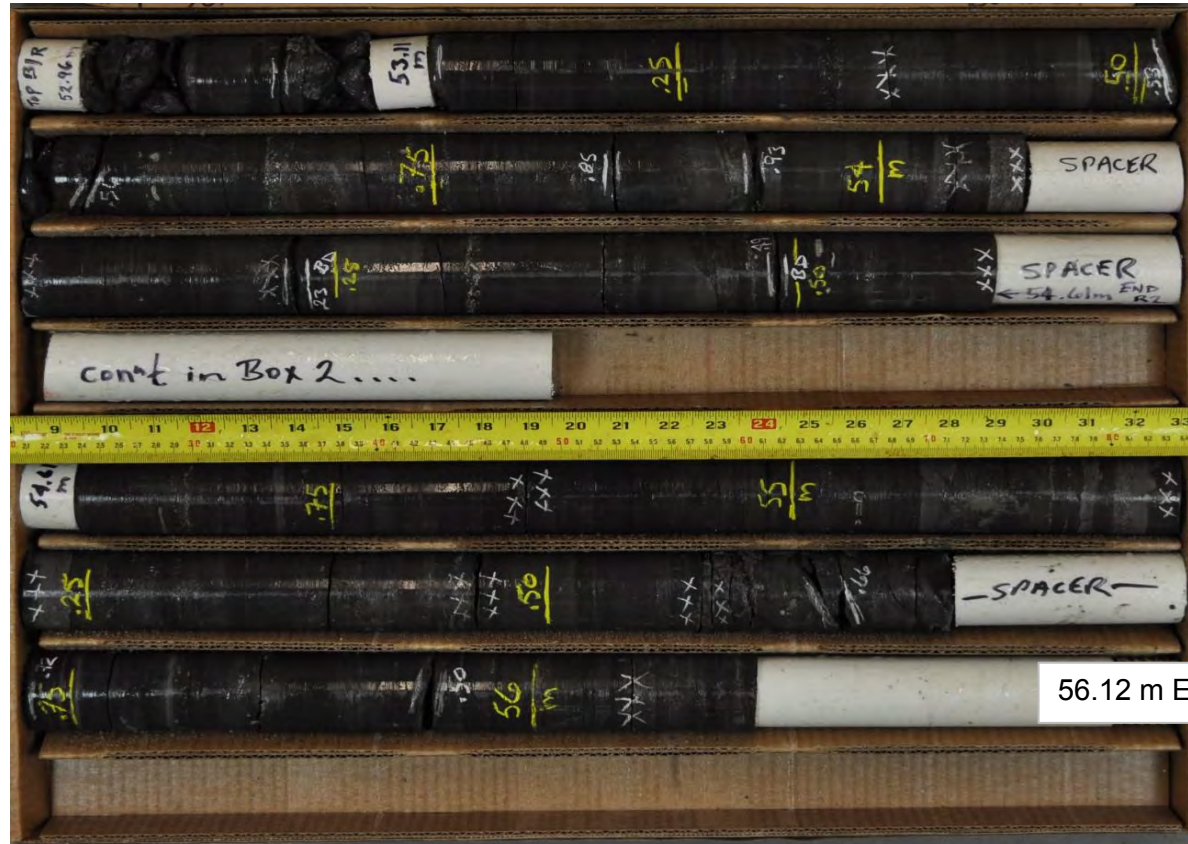
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A4**



**BH 17-1305 (Wet)**  
**Cored Length of 52.96 to 56.12 metres**  
**Core Box 1 and 2 of 2**

52.96 m Top of Bedrock



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A5**



**BH 17-1305 (Dry)**  
**Cored Length of 52.96 to 56.12 metres**  
**Core Box 1 and 2 of 2**

52.96 m Top of Bedrock



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

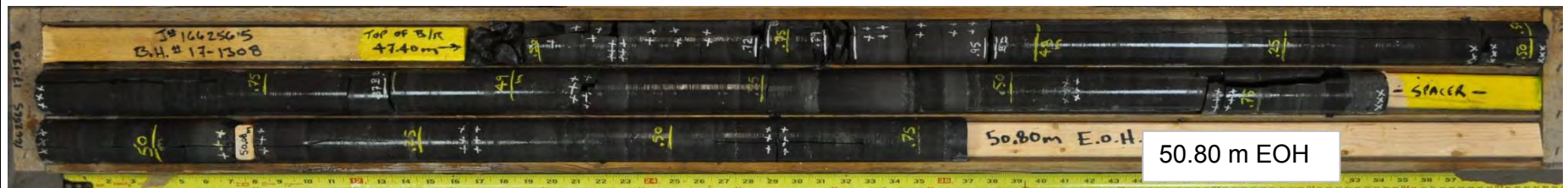
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A6**



**BH 17-1308 (Wet)**  
**Cored Length of 47.40 to 50.80 metres**  
**Core Box 1 of 1**

47.40 m Top of Bedrock



50.80 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

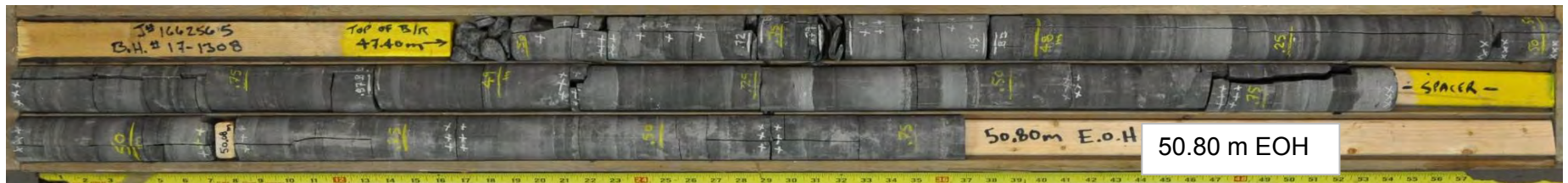
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A7**



BH 17-1308 (Dry)  
Cored Length of 47.40 to 50.80 metres  
Core Box 1 of 1

47.40 m Top of Bedrock



50.80 m EOH



Geotechnical Investigation  
Ramsayville Road Overpass  
Ottawa, Ontario

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

Figure A8



**BH 17-1309 (Wet)**  
**Cored Length of 44.96 to 48.36 metres**  
**Core Box 1 of 1**

44.96 m Top of Bedrock



48.36 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A9**



**BH 17-1309 (Dry)**  
**Cored Length of 44.96 to 48.36 metres**  
**Core Box 1 of 1**

44.96 m Top of Bedrock



48.36 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A10**



**BH 17-1310 (Wet)**  
**Cored Length of 47.83 to 51.44 metres**  
**Core Box 1 and 2 of 2**

47.83 m Top of Bedrock



51.44 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

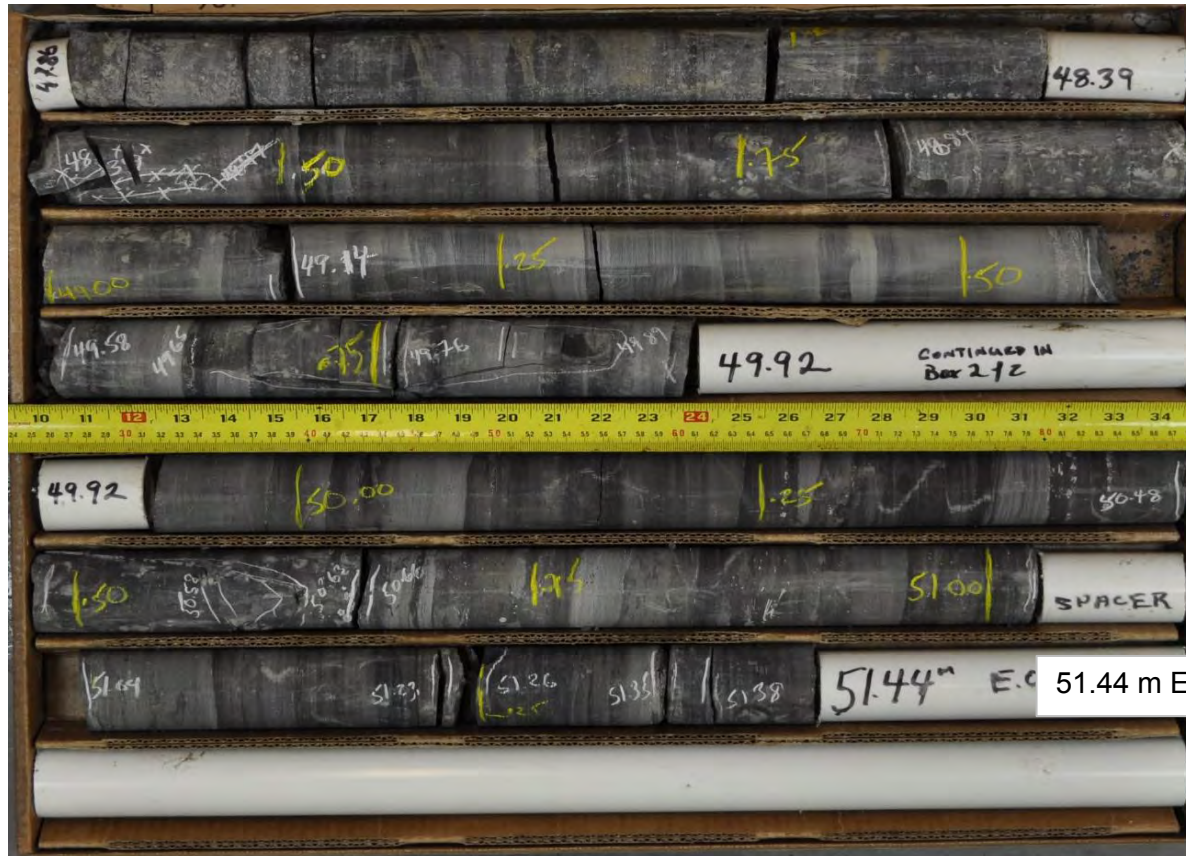
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A11**



**BH 17-1310 (Dry)**  
**Cored Length of 47.83 to 51.44 metres**  
**Core Box 1 and 2 of 2**

47.83 m Top of Bedrock



51.44 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

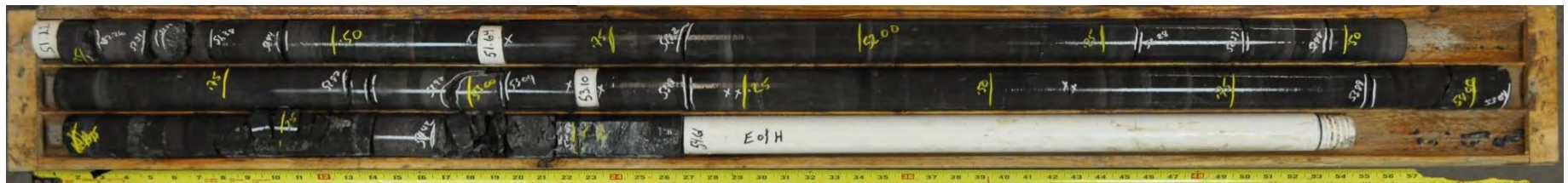
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A12**



**BH 17-1311 (Wet)**  
**Cored Length of 51.22 to 54.61 metres**  
**Core Box 1 of 1**

51.22 m Top of Bedrock



54.61 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

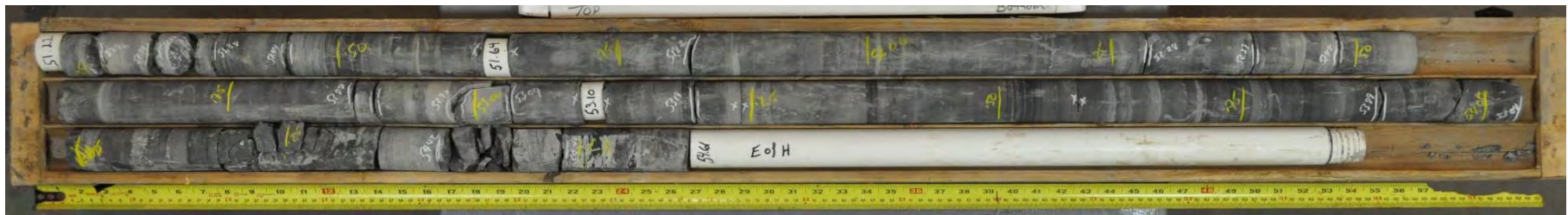
Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A13**



**BH 17-1311 (Dry)**  
**Cored Length of 51.22 to 54.61 metres**  
**Core Box 1 of 1**

51.22 m Top of Bedrock



54.61 m EOH



**Geotechnical Investigation**  
**Ramsayville Road Overpass**  
**Ottawa, Ontario**

Project No.	1662565 / 1130
Drawn:	KS
Date:	2017-09-01
Checked:	WAM
Review:	MSS

**Figure A14**



## **APPENDIX B**

# Laboratory Test Results, Current Investigation

Figure B1 – Grain Size Distribution Test Results – Silt and Clay (FILL)

Figure B2 – Grain Size Distribution Test Results – Silty Sand (ALLUVIUM)

Figure B3 – Plasticity Chart – Silty Clay to Clay (WEATHERED CRUST)

Figure B4a to B4c – Plasticity Chart – Silty Clay to Clay

Figure B5 – Grain Size Distribution Test Results – Silty Clay to Clay

Figures B6 to B11 – Consolidation Test Results

Figure B12 – Plasticity Chart – Silty Sand to Sandy Silt (TILL)

Figure B13 – Grain Size Distribution Test Results – Silty Sand to Sandy Silt (TILL)

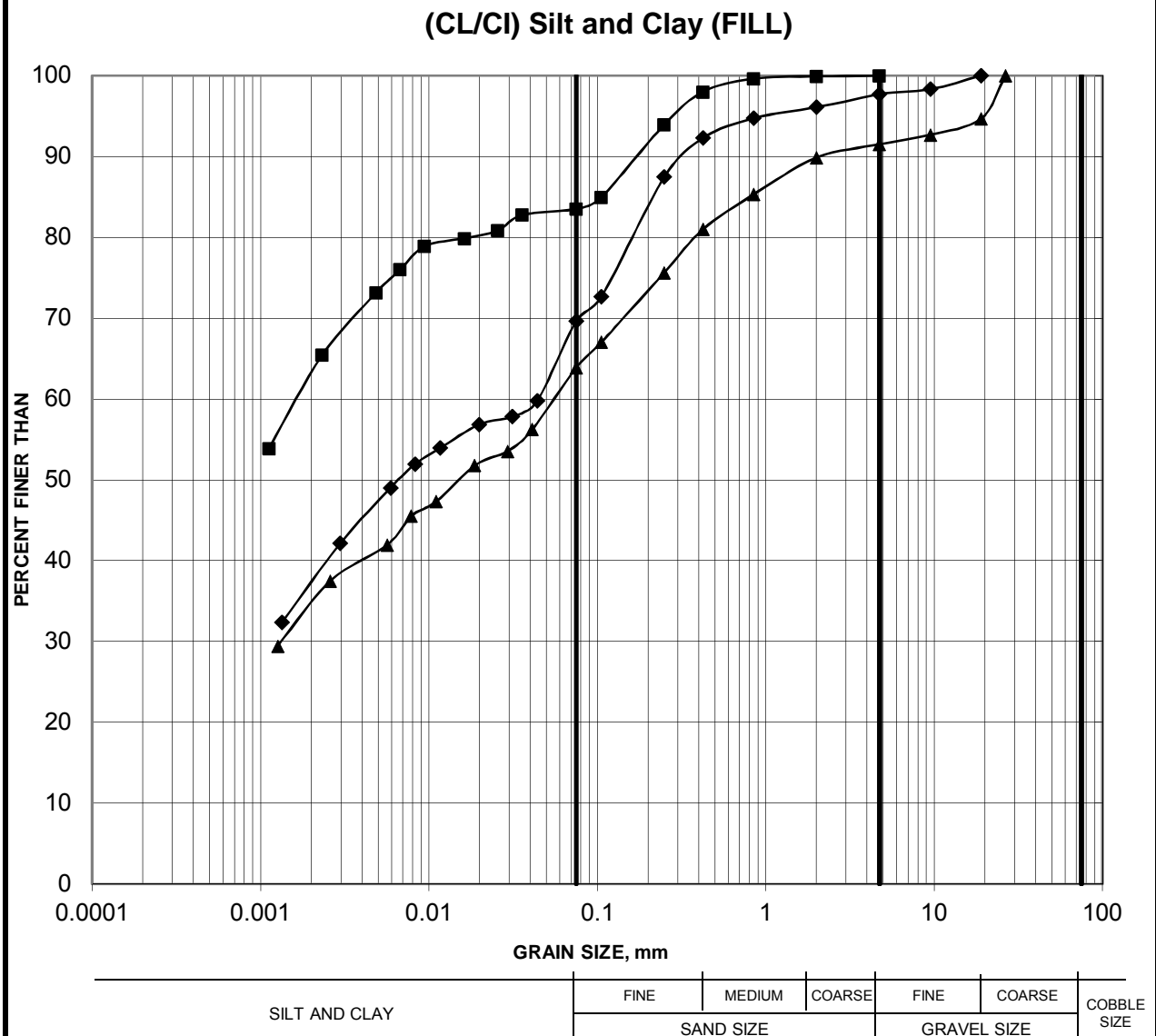
Figure B14 – Summary of Laboratory Compressive Strength Testing – Unconfined Compression Tests

Figure B15 – Summary of Engineering Properties



# GRAIN SIZE DISTRIBUTION

FIGURE B1



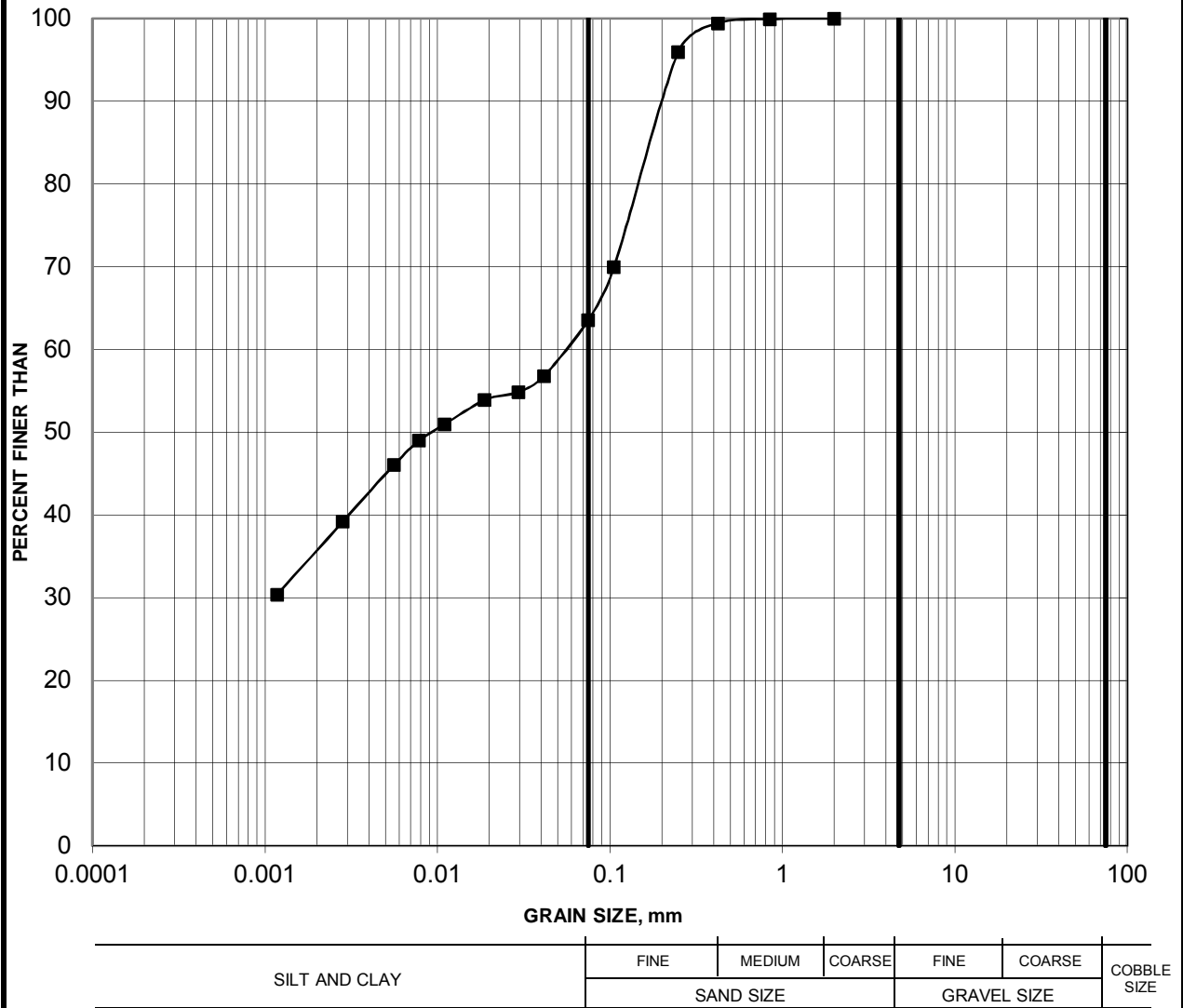
Borehole	Sample	Depth (m)
17-1301	2B	0.91-1.37
17-1303	2	0.76-1.37
17-1312	1	0.09-0.70



# GRAIN SIZE DISTRIBUTION

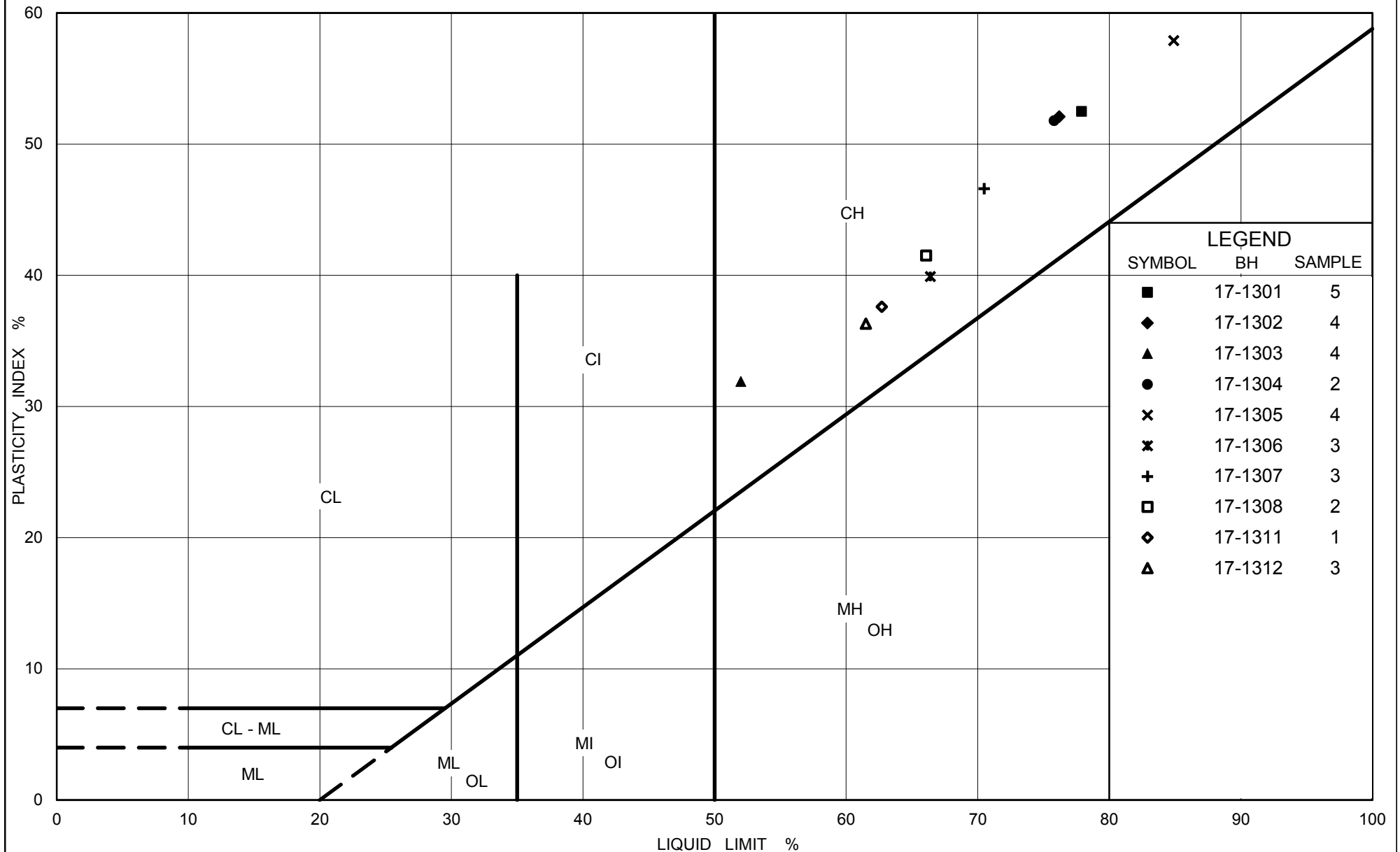
FIGURE B2

(SM) Silty Sand (ALLUVIUM)



Borehole	Sample	Depth (m)
17-1309	2	0.76-1.37





Ontario

Ministry of Transportation

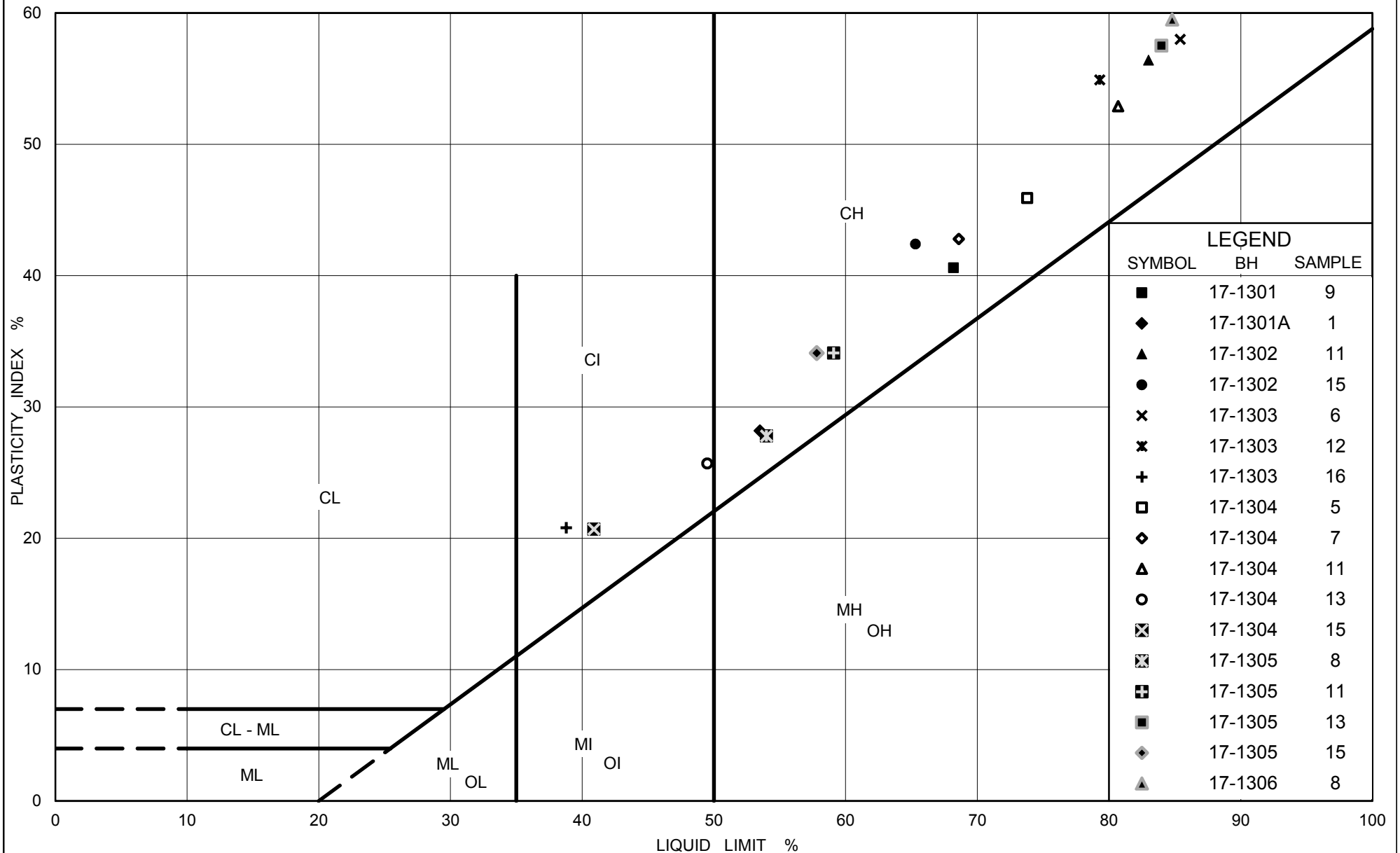
## PLASTICITY CHART (CI/CH) SILTY CLAY to CLAY (WEATHERED CRUST)

FIG No. B3

Project No. 1662565 /1130

Compiled By : MI    Checked By : CNM





Ontario

Ministry of Transportation

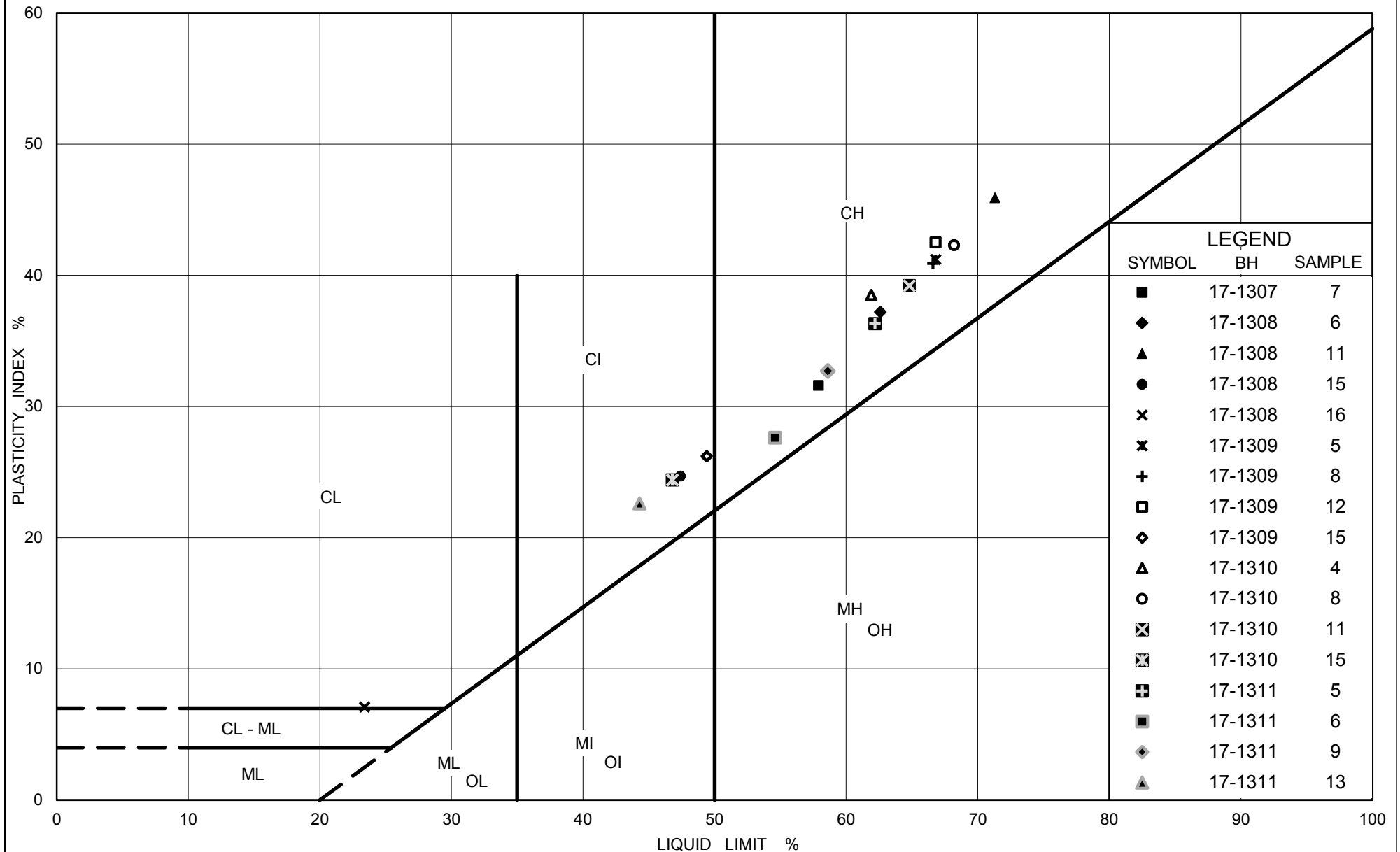
# PLASTICITY CHART (CI/CH) SILTY CLAY to CLAY

FIG No. B4a

Project No. 1662565 /1130

Compiled By : MI      Checked By : CNM





Ontario

Ministry of Transportation

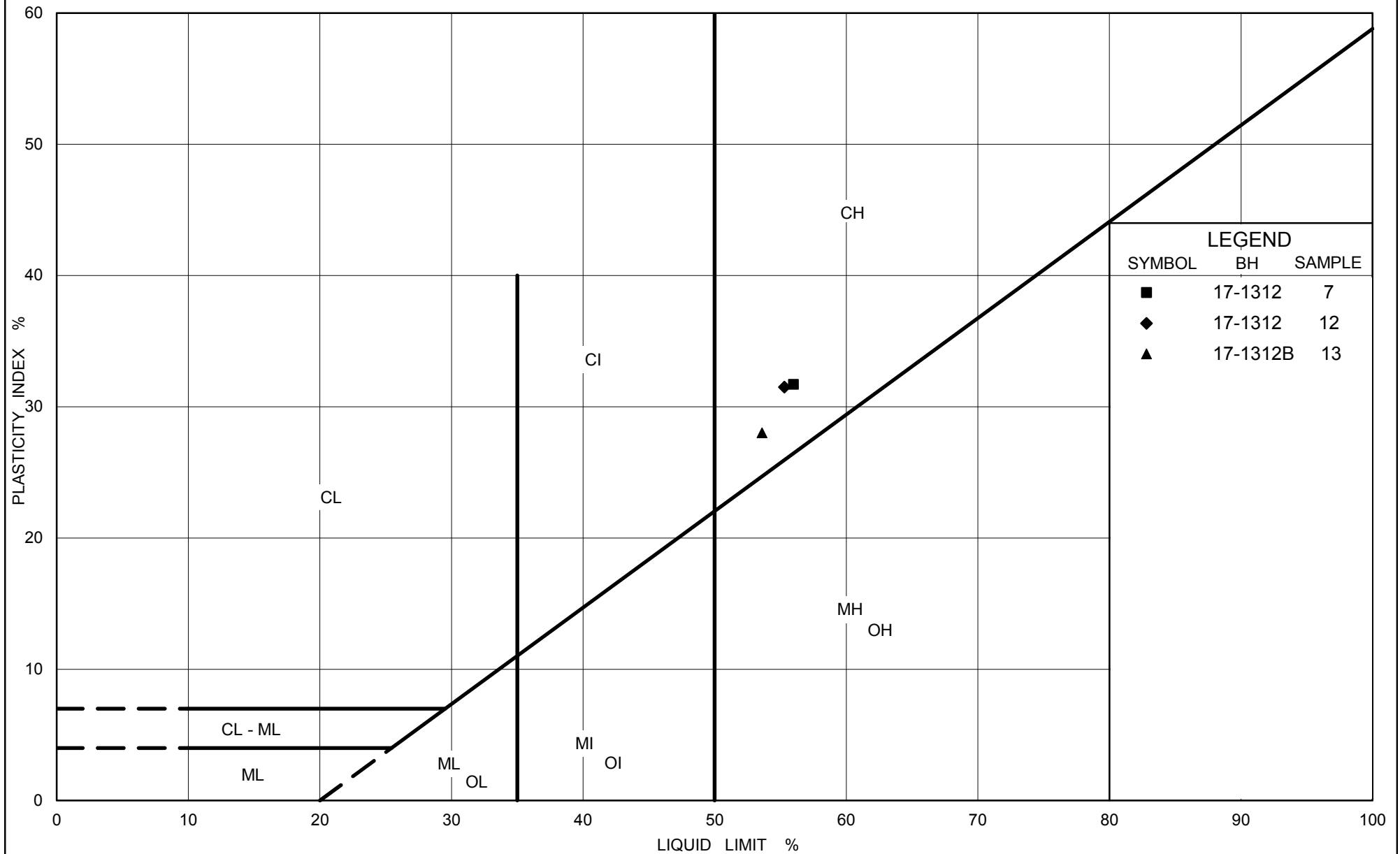
# PLASTICITY CHART (CI/CH) SILTY CLAY to CLAY

FIG No. B4b

Project No. 1662565 /1130

Compiled By : MI    Checked By : CNM





Ontario

Ministry of Transportation

# PLASTICITY CHART (CI/CH) SILTY CLAY to CLAY

FIG No. B4c

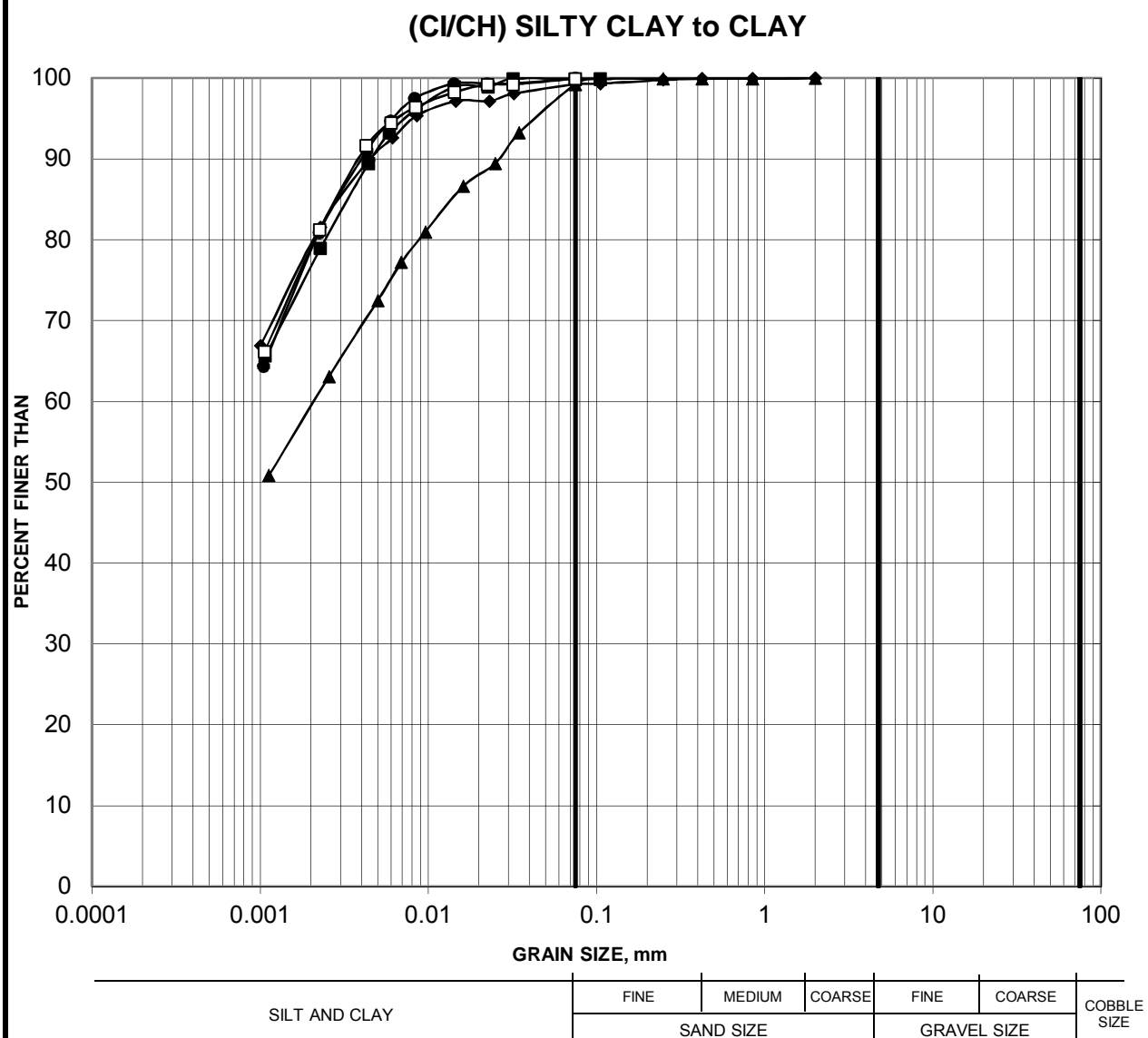
Project No. 1662565 /1130

Compiled By : MI      Checked By : CNM



# GRAIN SIZE DISTRIBUTION

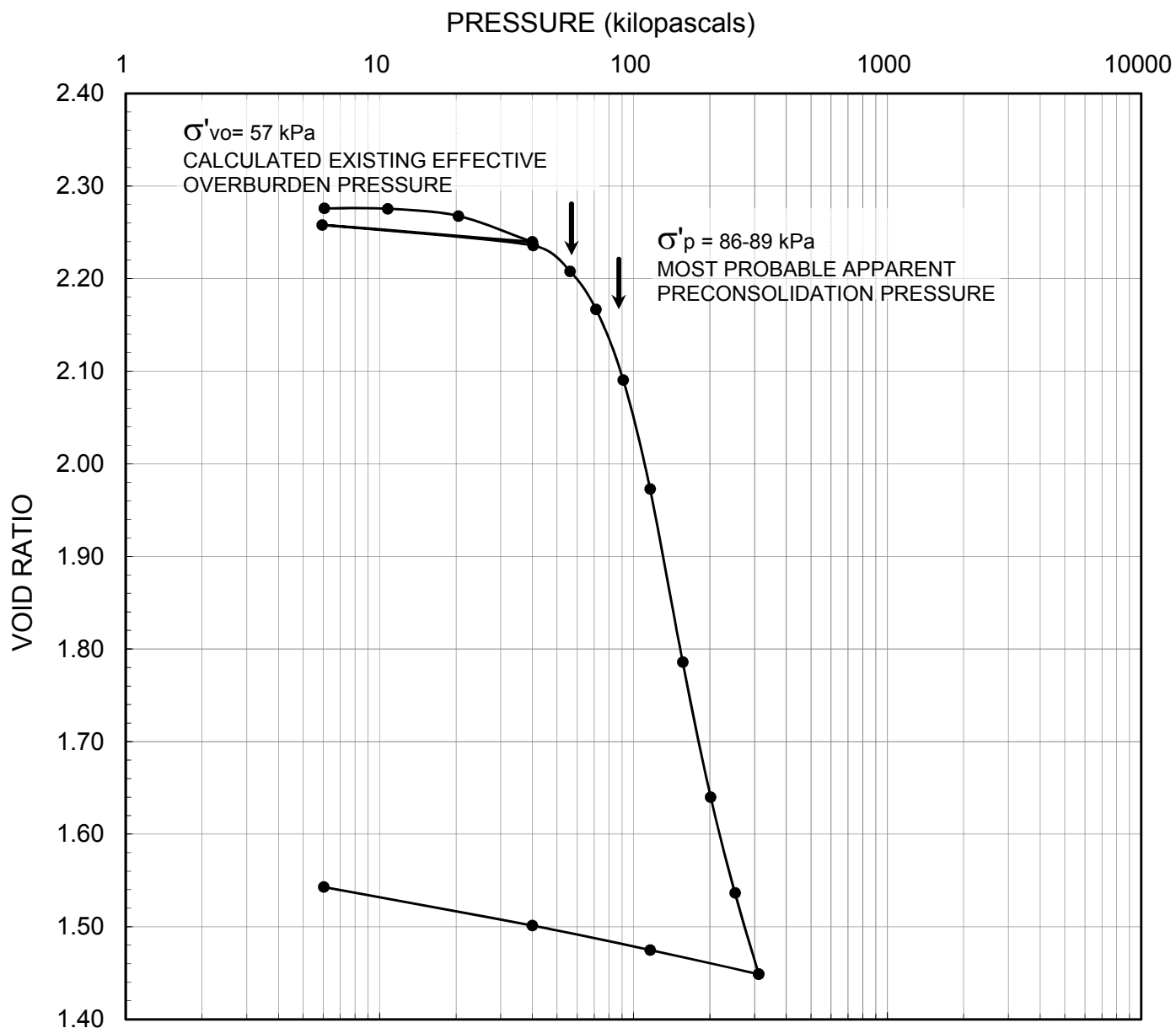
FIGURE B5



Borehole	Sample	Depth (m)
17-1302	7	6.10-6.71
17-1303	8	7.62-8.23
17-1304	14	30.48-31.09
17-1306	11	12.19-12.80
17-1310	6	6.86-7.47







#### LEGEND

Borehole:	17-1301A	$w_i = 83\%$	$S_o = 100\%$	$\gamma = 15 \text{ kN/m}^3$
Sample:	1	$w_f = 55\%$	$e_o = 2.28$	$G_s = 2.75$
Depth (m):	5.8	$w_l = 54\%$	$C_c = 1.45$	
Elevation (m):	72.6	$w_p = 25\%$	$C_r = 0.026$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

CHECK CNM

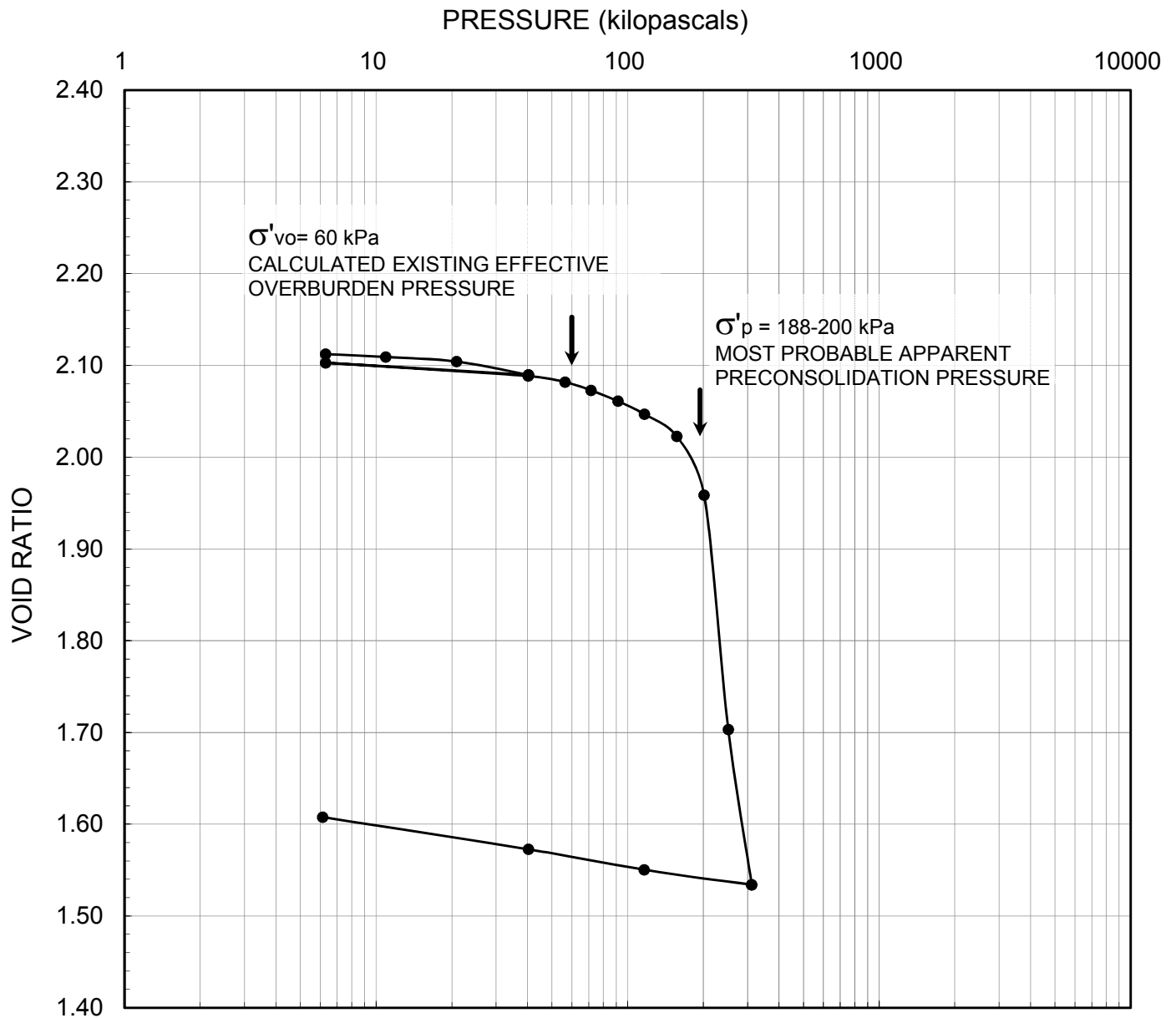
PROJECT No. 1662565 / 1130 REV. 1

REVIEW WAM

FIGURE

**B6**





#### LEGEND

Borehole:	17-1305	$w_i = 78\%$	$S_o = 100\%$	$\gamma = 15.2 \text{ kN/m}^3$
Sample:	8	$w_f = 62\%$	$e_o = 2.11$	$G_s = 2.71$
Depth (m):	8.1	$w_l = 54\%$	$C_c = 2.66$	
Elevation (m):	68.7	$w_p = 26\%$	$C_r = 0.019$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

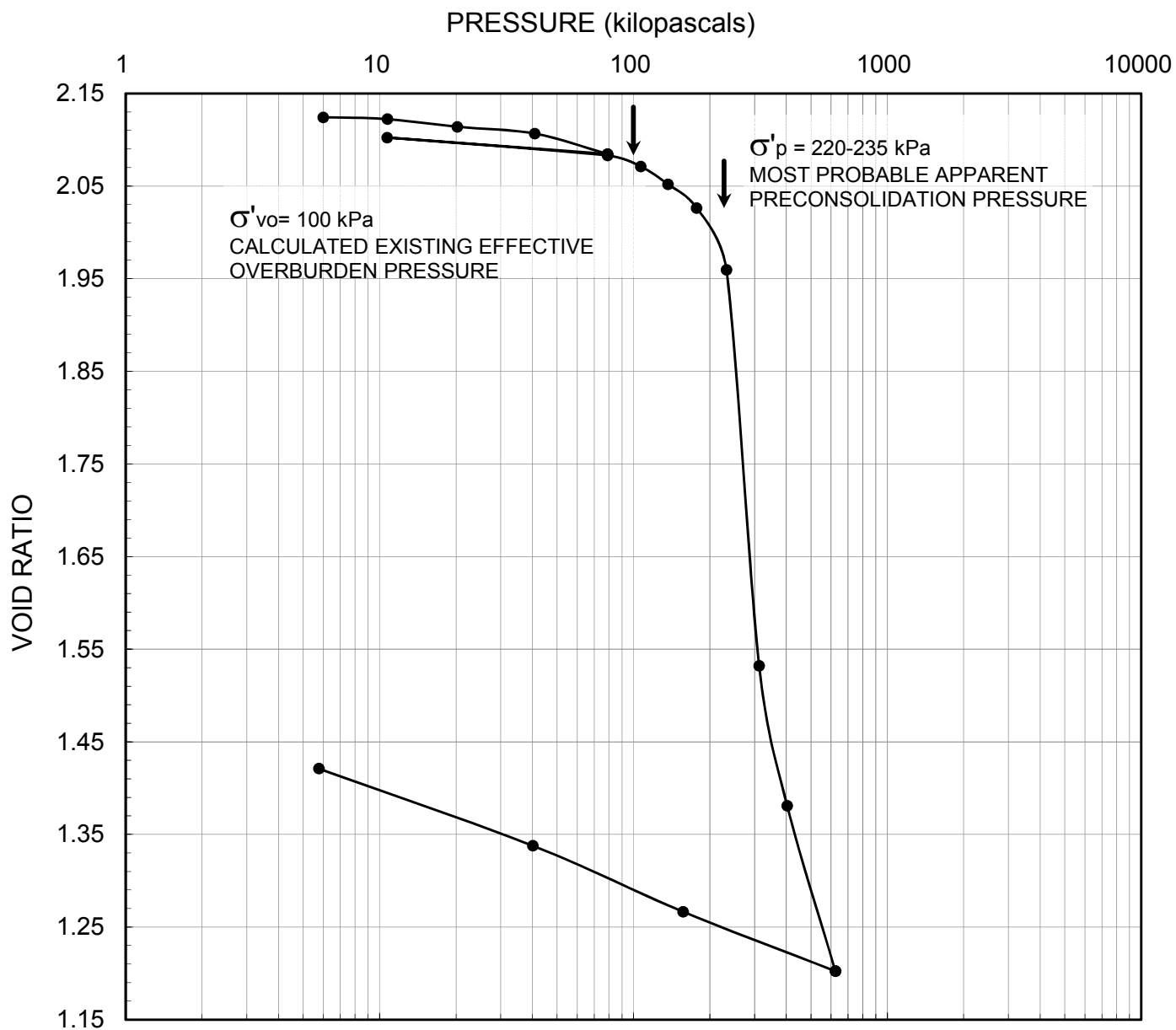
FILE No.	Consolidation summary
PROJECT No.	1662565 / 1130
REV.	1

CHECK	CNM
REVIEW	WAM

FIGURE

**B7**





### LEGEND

Borehole:	17-1305	$w_i = 76\%$	$S_o = 99\%$	$\gamma = 15.3 \text{ kN/m}^3$
Sample:	11	$w_f = 54\%$	$e_o = 2.13$	$G_s = 2.77$
Depth (m):	15.6	$w_l = 59\%$	$C_c = 3.32$	
Elevation (m):	61.2	$w_p = 25\%$	$C_r = 0.022$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

CHECK CNM

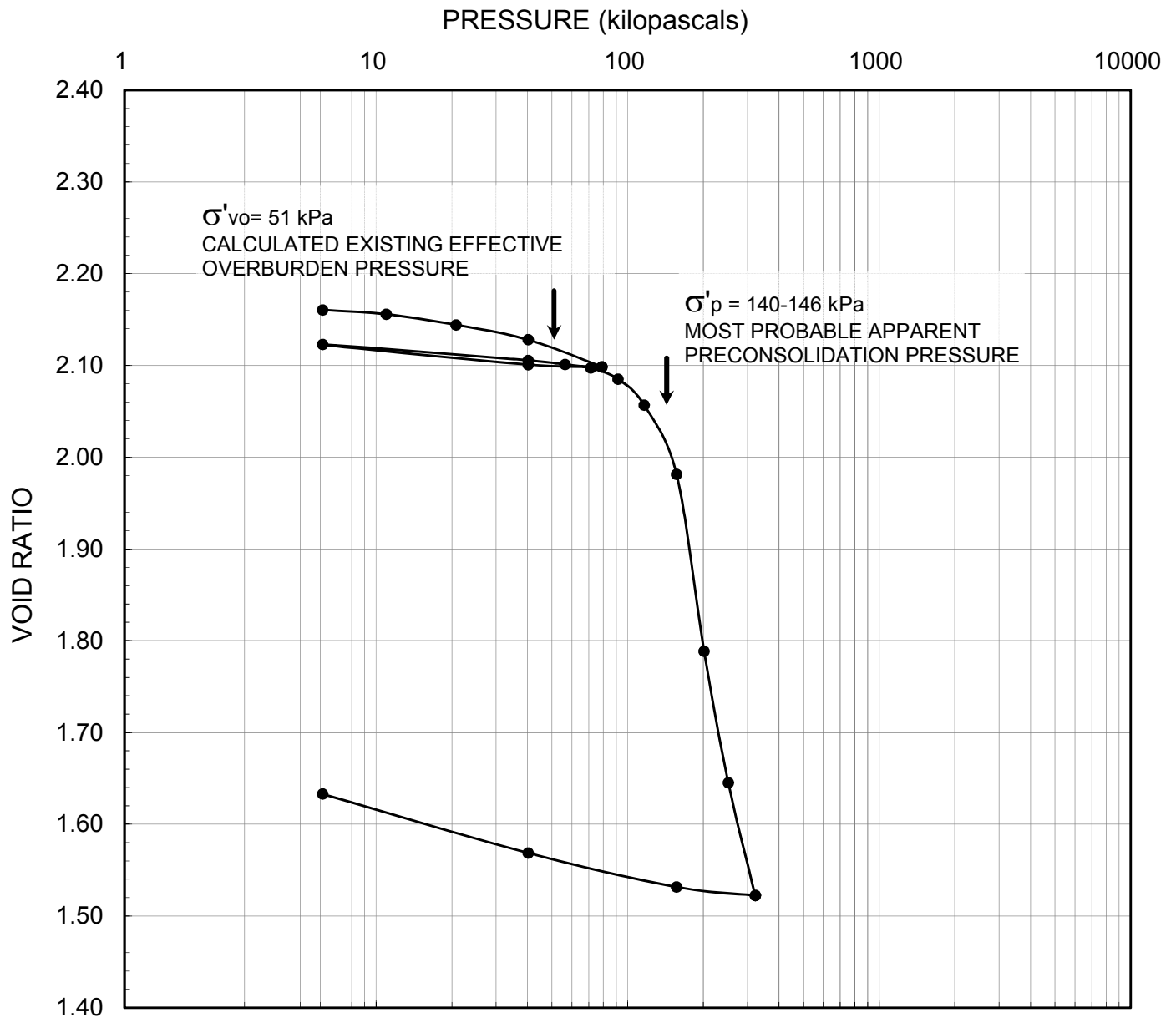
PROJECT No. 1662565 /1130 REV. 1

REVIEW WAM

FIGURE

**B8**





#### LEGEND

Borehole: 17-1307	$w_i = 80\%$	$S_o = 100\%$	$\gamma = 15.1 \text{ kN/m}^3$
Sample: 7	$w_f = 59\%$	$e_o = 2.16$	$G_s = 2.70$
Depth (m): 6.5	$w_l = 58\%$	$C_c = 1.75$	
Elevation (m): 71.3	$w_p = 26\%$	$C_r = 0.024$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

CHECK CNM

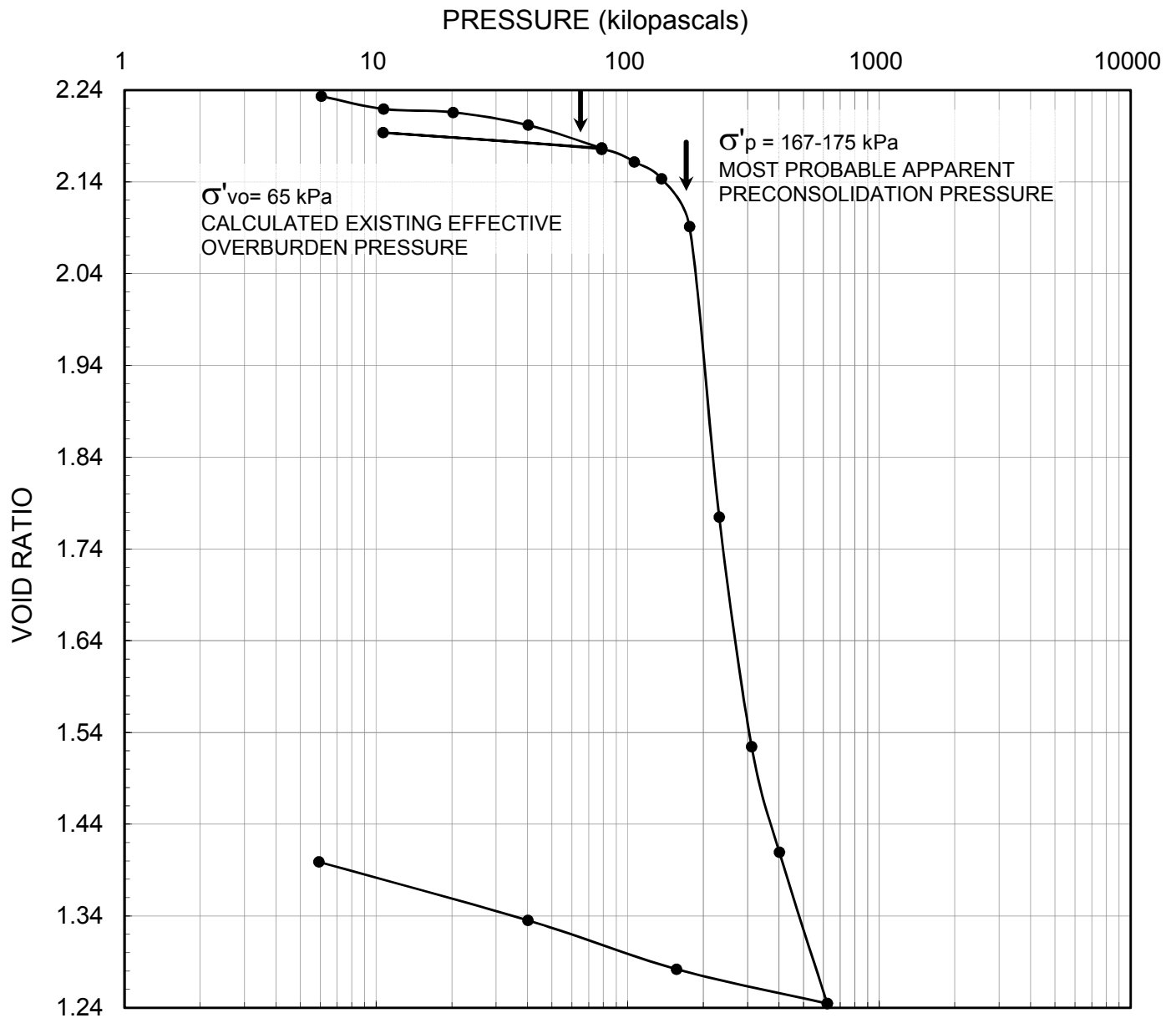
PROJECT No. 1662565 /1130 REV. 1

REVIEW WAM

FIGURE

**B9**





### LEGEND

Borehole: 17-1311	$w_i = 80\%$	$S_o = 100\%$	$\gamma = 15.2 \text{ kN/m}^3$
Sample: 6	$w_f = 53\%$	$e_o = 2.23$	$G_s = 2.77$
Depth (m): 7.1	$w_l = 55\%$	$C_c = 2.70$	
Elevation (m): 68.3	$w_p = 27\%$	$C_r = 0.021$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

CHECK CNM

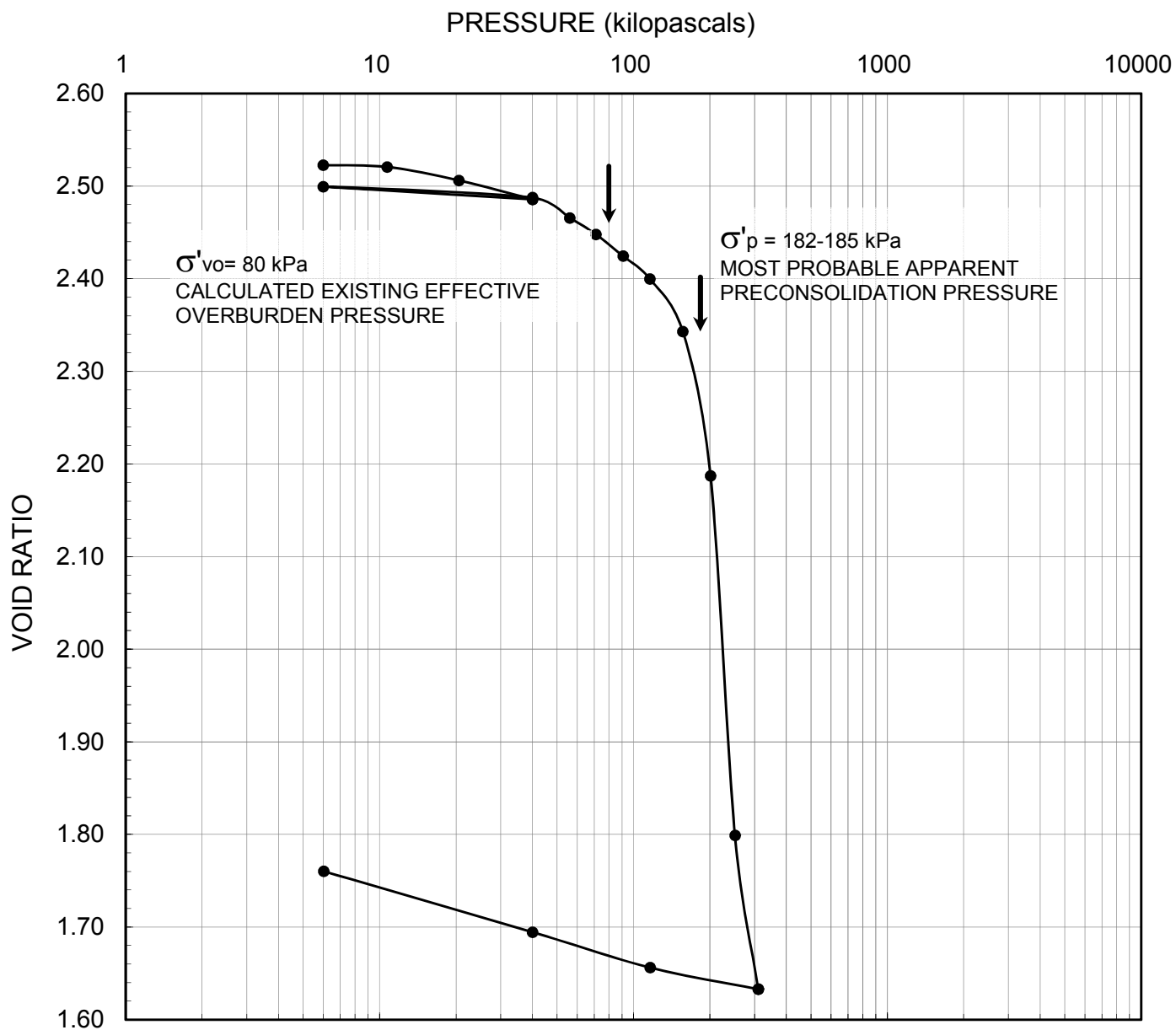
PROJECT No. 1662565 /1130 REV. 1

REVIEW WAM

FIGURE

**B10**





#### LEGEND

Borehole:	17-1312B	$w_i = 90\%$	$S_o = 98\%$	$\gamma = 14.5 \text{ kN/m}^3$
Sample:	1	$w_f = 64\%$	$e_o = 2.52$	$G_s = 2.75$
Depth (m):	10.3	$w_l = 54\%$	$C_c = 4.03$	
Elevation (m):	64.5	$w_p = 26\%$	$C_r = 0.013$	



**GOLDER**

SCALE	AS SHOWN
DATE	09/15/17
CADD	N/A
ENTERED	MI

TITLE

## CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary

CHECK CNM

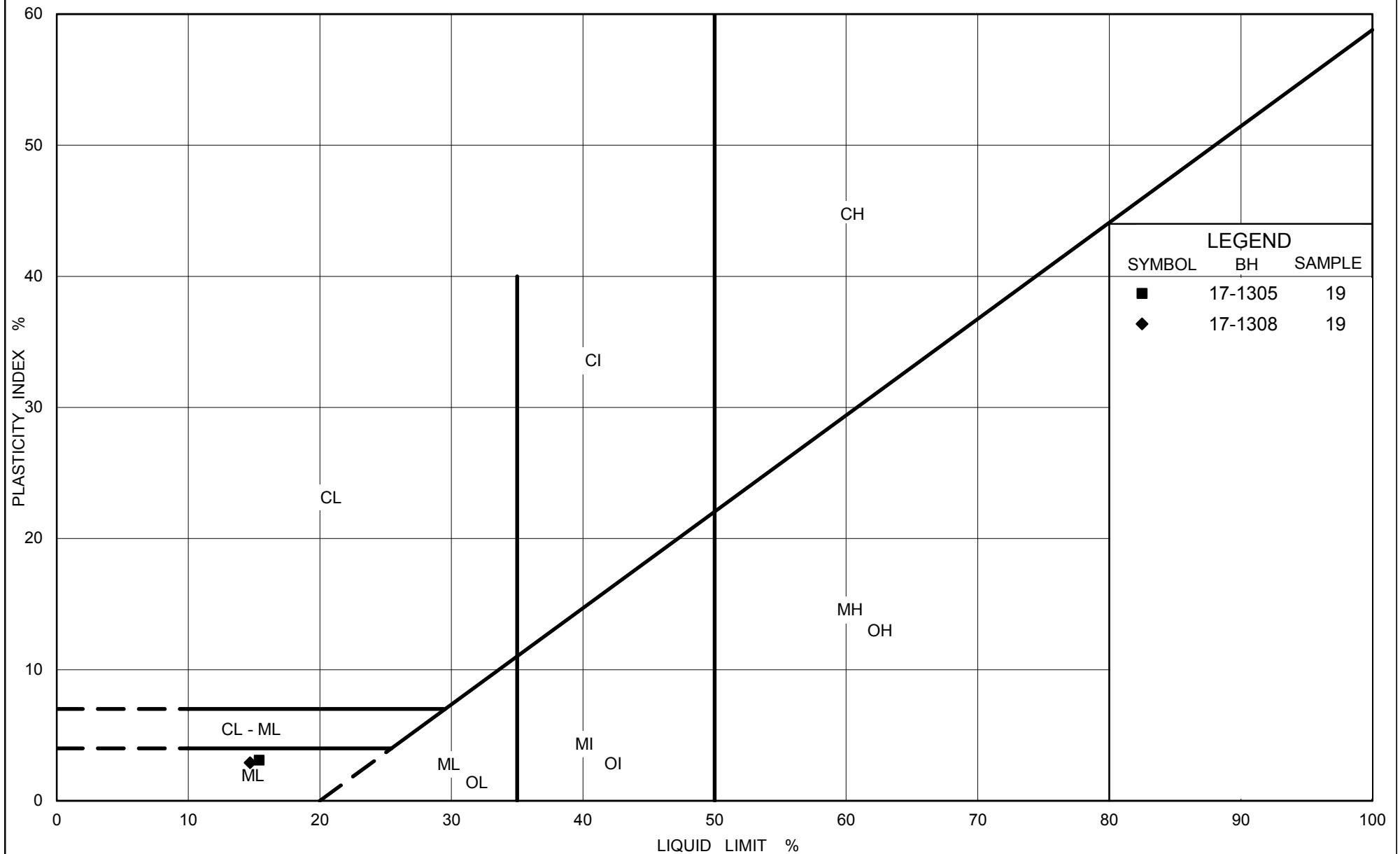
PROJECT No. 1662565 / 1130 REV. 1

REVIEW WAM

FIGURE

**B11**





Ontario

Ministry of Transportation

## PLASTICITY CHART (SM-ML) SILTY SAND to Sandy SILT (TILL)

FIG No. B12

Project No. 1662565 /1130

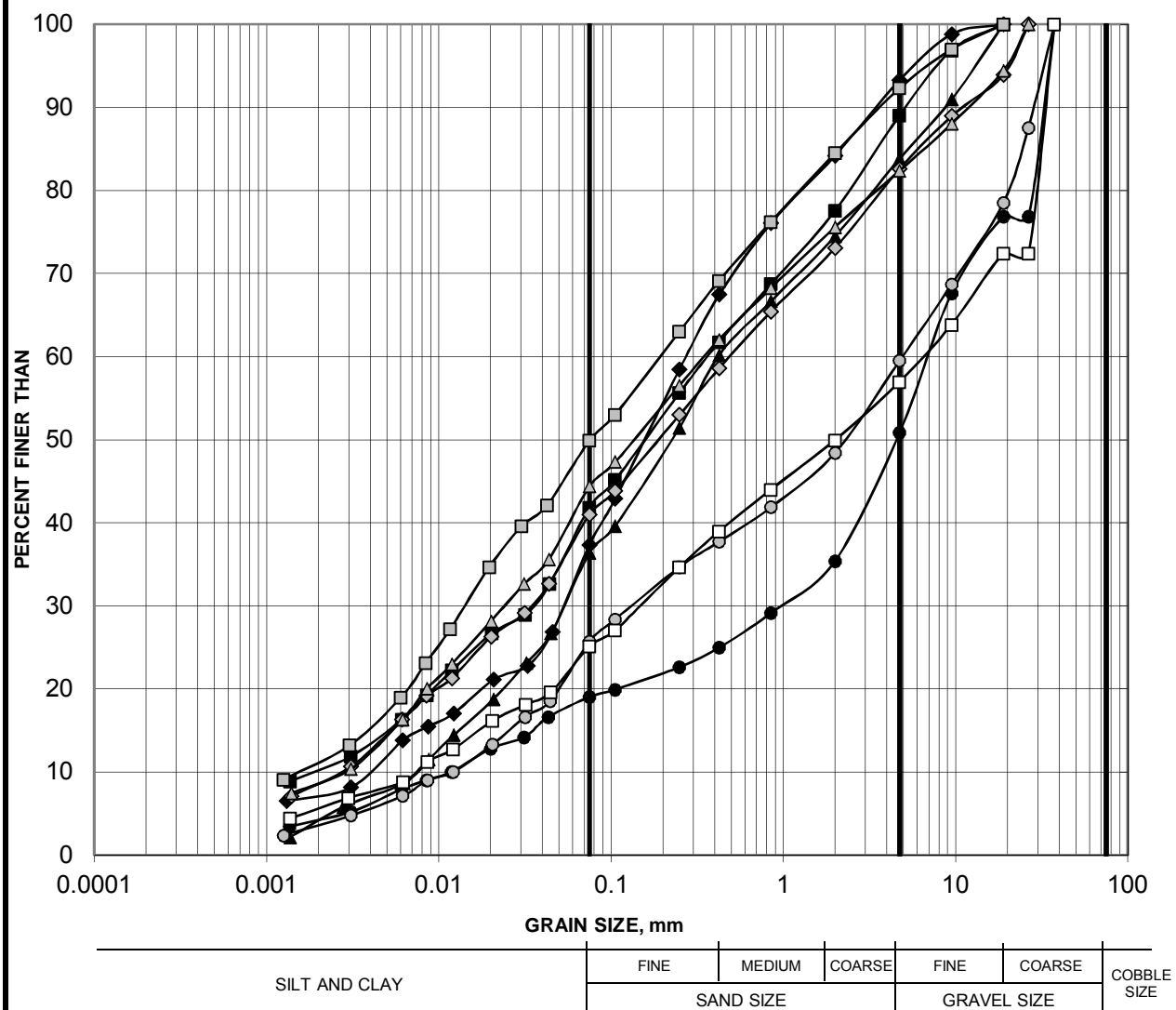
Compiled By : MI      Checked By : CNM



# GRAIN SIZE DISTRIBUTION

FIGURE B13

(SM-ML) SILTY SAND to Sandy SILT (TILL)



Borehole	Sample	Depth (m)
17-1302	18	39.32-39.93
17-1302	19	42.37-42.98
17-1303	20	45.72-46.33
17-1304	20	48.40-48.56
17-1305	19	45.72-46.33
17-1308	18	41.00-41.61
17-1309	18	41.15-41.76
17-1310	20	47.24-47.85
17-1311	17	45.72-46.33



GOLDER

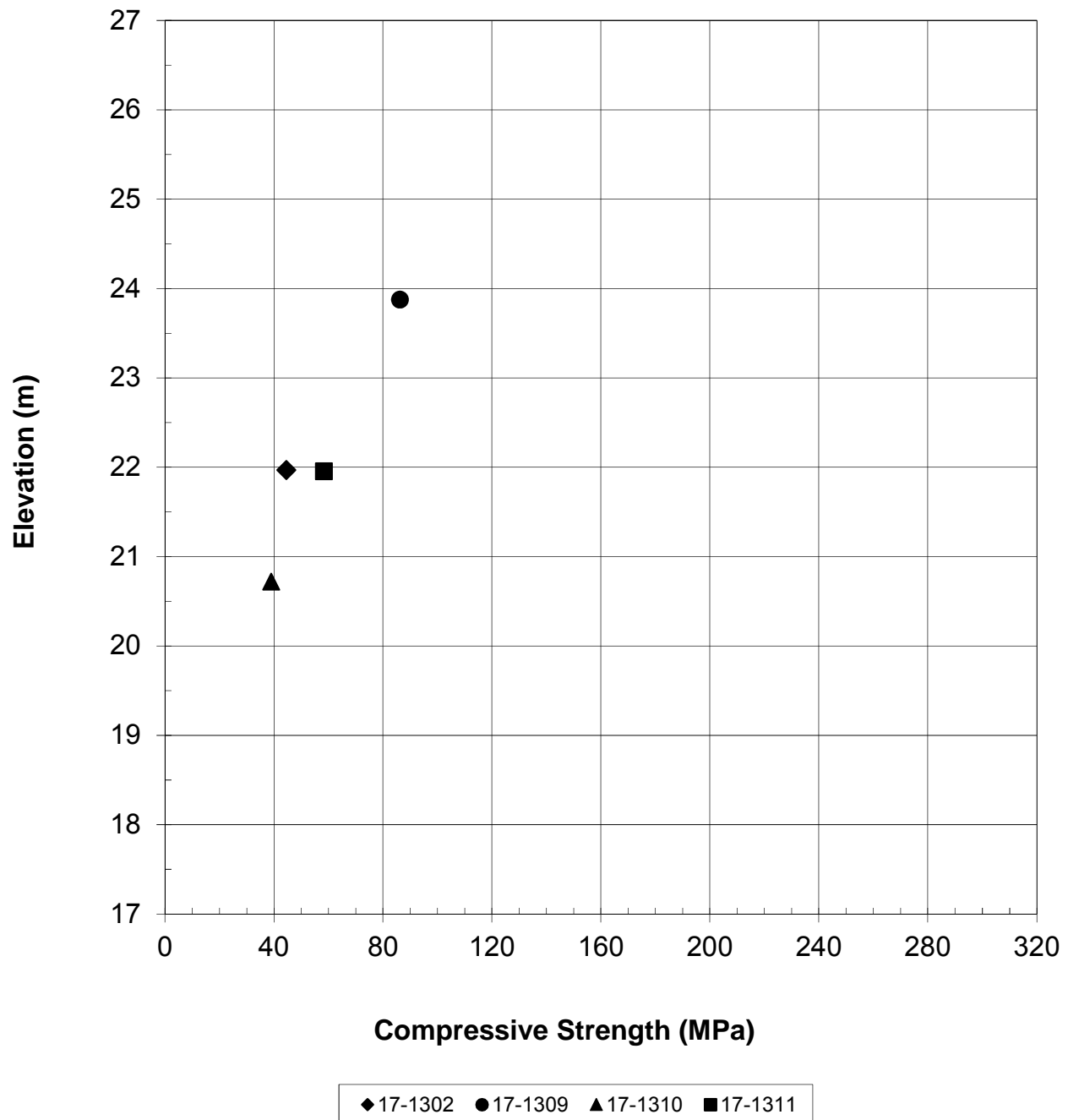
Project: 1662565 /1130

Created by: MI  
Checked by: CNM



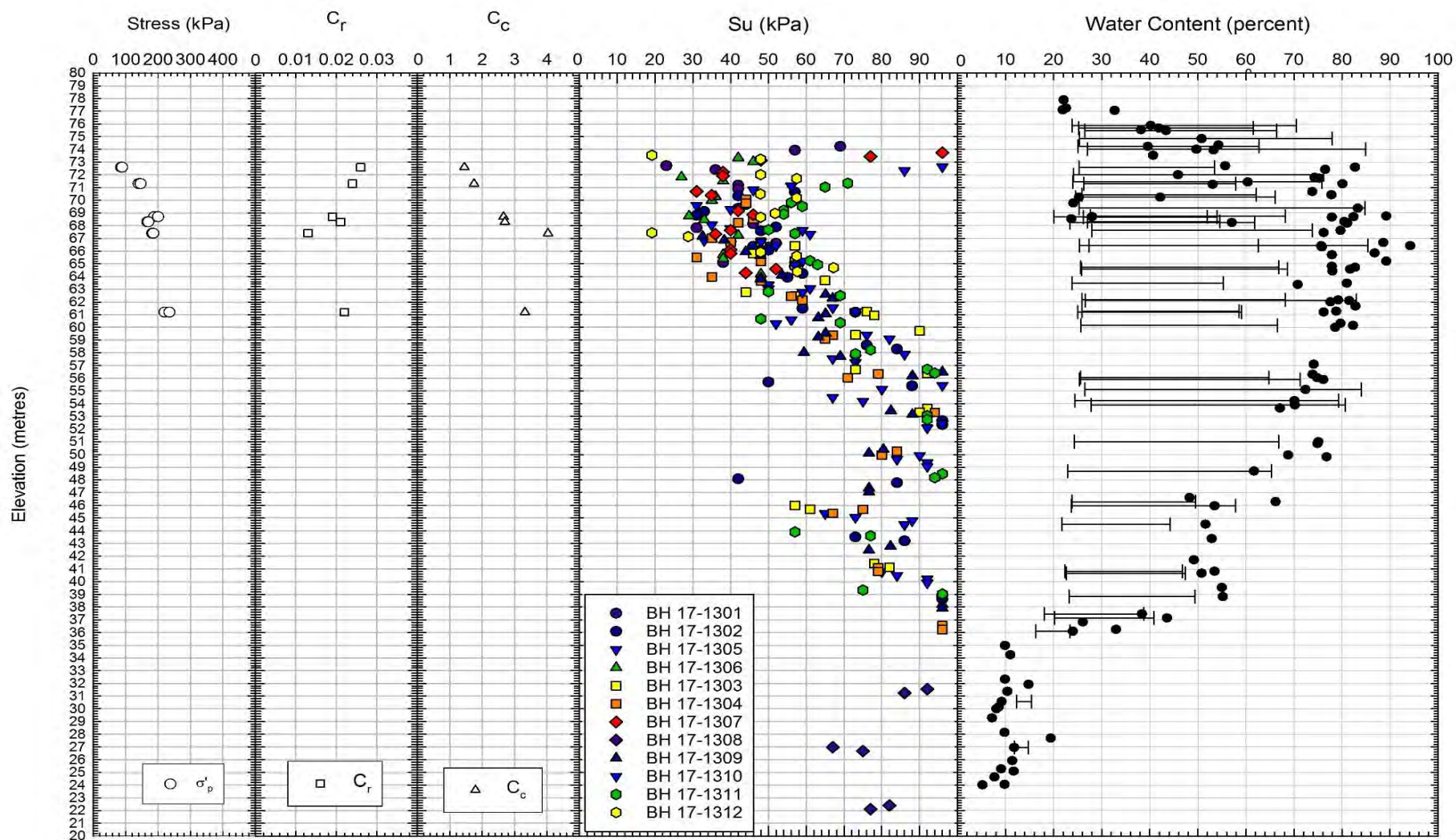
**SUMMARY OF LABORATORY COMPRESSIVE STRENGTH  
UNCONFINED COMPRESSION TESTS**

**FIGURE B14**





## SUMMARY OF ENGINEERING PROPERTIES



**RAMSAYVILLE ROAD OVERPASS**  
**SITE NOS. 3-265/1 AND 3-265/2**  
**HIGHWAY 417, OTTAWA, ONTARIO**

Project No.	1662565 / 1130
Drawn:	WAM
Date:	03/05/2018
Checked:	MSS
Review:	FJH

**Figure B15**



**APPENDIX C**

**Borehole Record and Laboratory Test Results  
(Previous Investigation, GEOCRES No. 31G05-071)**

Records of Previous Boreholes BH 1 to BH 10

Laboratory Test Results



## RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

MATERIALS &amp; TESTING DIVISION

JOB 68-F-54

LOCATION Hwy. 417, Sta. 220 + 40 EBL

ORIGINATED BY PBS

W.P. 34-66-01

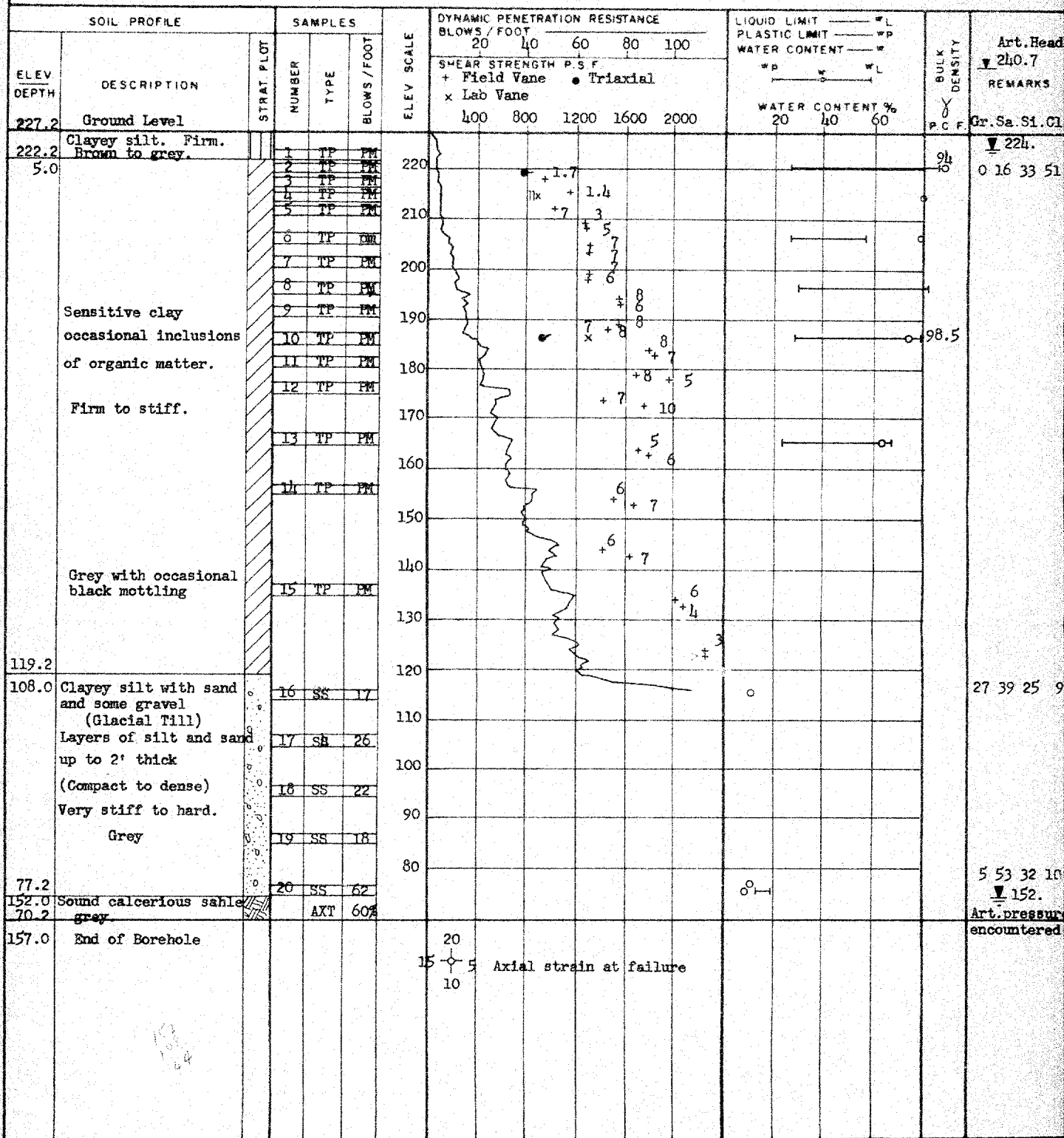
BORING DATE June 26 - July 3, 1968

COMPILED BY PBS

DATUM Geodetic

BOREHOLE TYPE Diamond Drill, NX - BX Casing, AXT Core

CHECKED BY





DEPARTMENT OF HIGHWAYS - ONTARIO

## MATERIALS &amp; TESTING DIVISION

JOB 68-F-54

W.P. 34-66-01

DATUM Geodetic

## RECORD OF BOREHOLE NO. 2

LOCATION Hwy. 417 Sta. 221 + 30 WBL

BORING DATE July 4-9, 1968

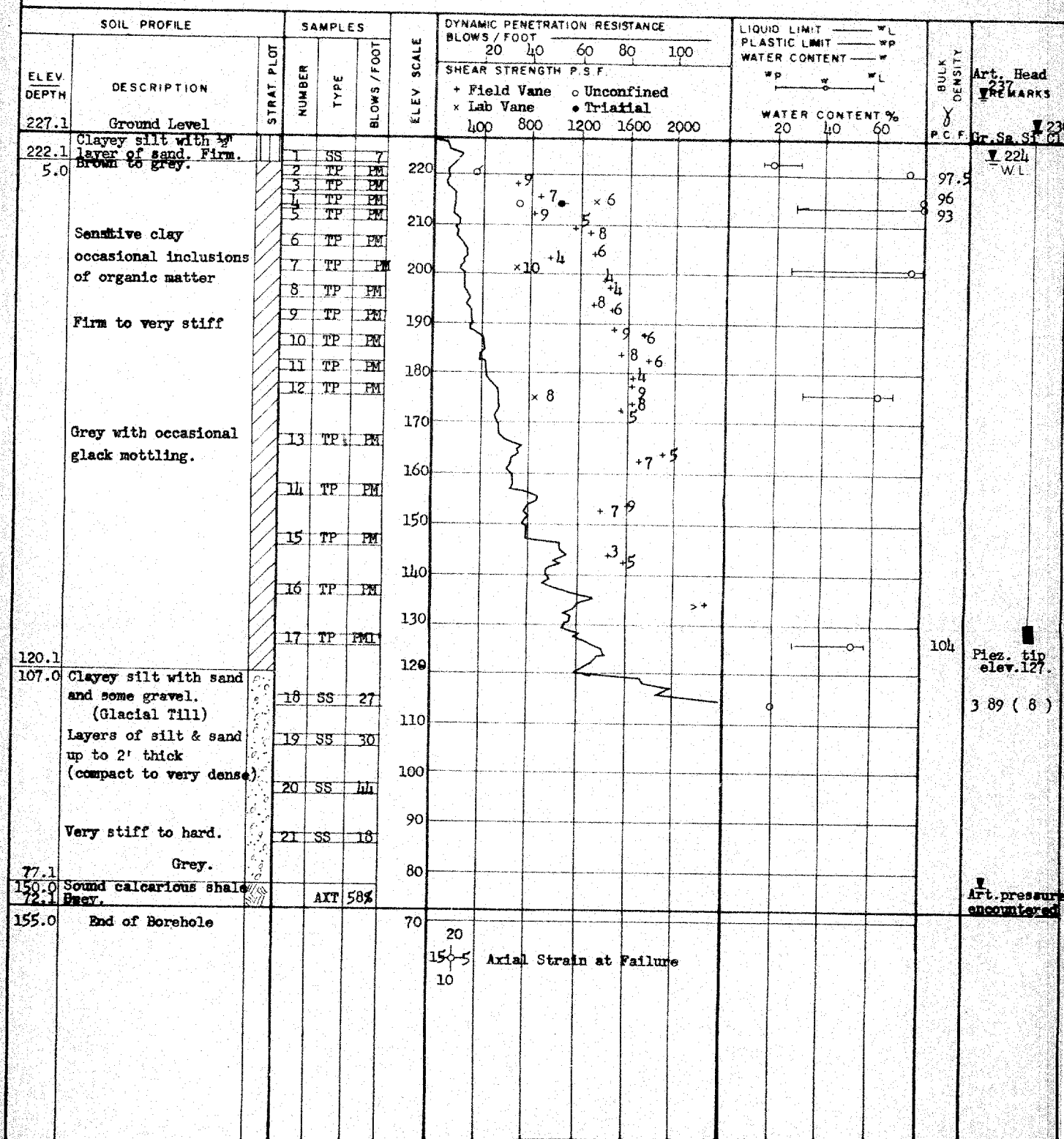
BOREHOLE TYPE Diamond Drill, NX, BX Casing, AXT Core

FOUNDATION SECTION

ORIGINATED BY BHL

COMPILED BY PS

CHECKED BY





DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 68-F-54 LOCATION Hwy. 417 Sta. 219 + 95 WBL

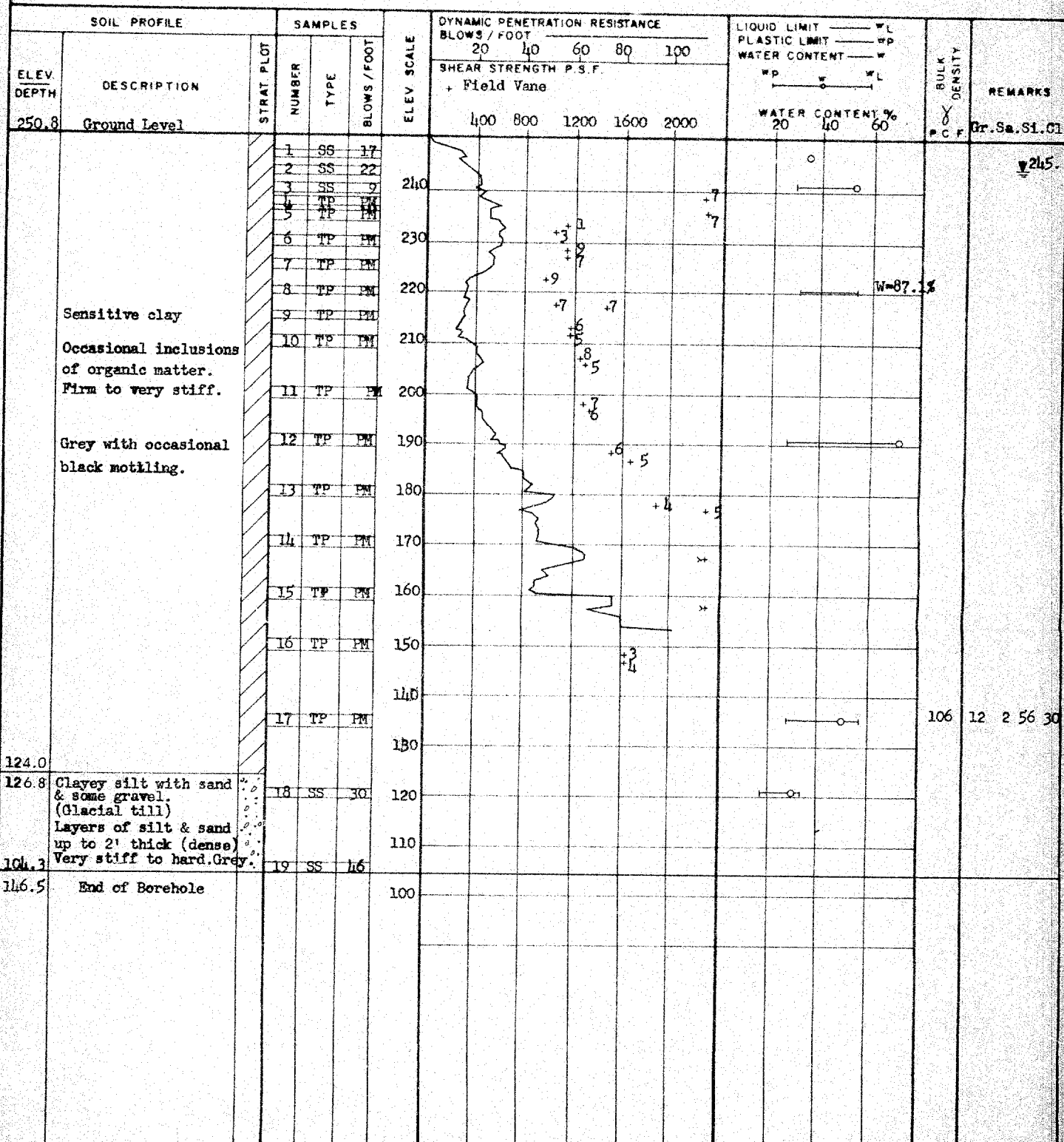
ORIGINATED BY FBS

W.P. 34-66-01 BORING DATE July 10-11, 1968

COMPILED BY FBS

DATUM Geodetic BOREHOLE TYPE Diamond Drill, NX Casing

CHECKED BY



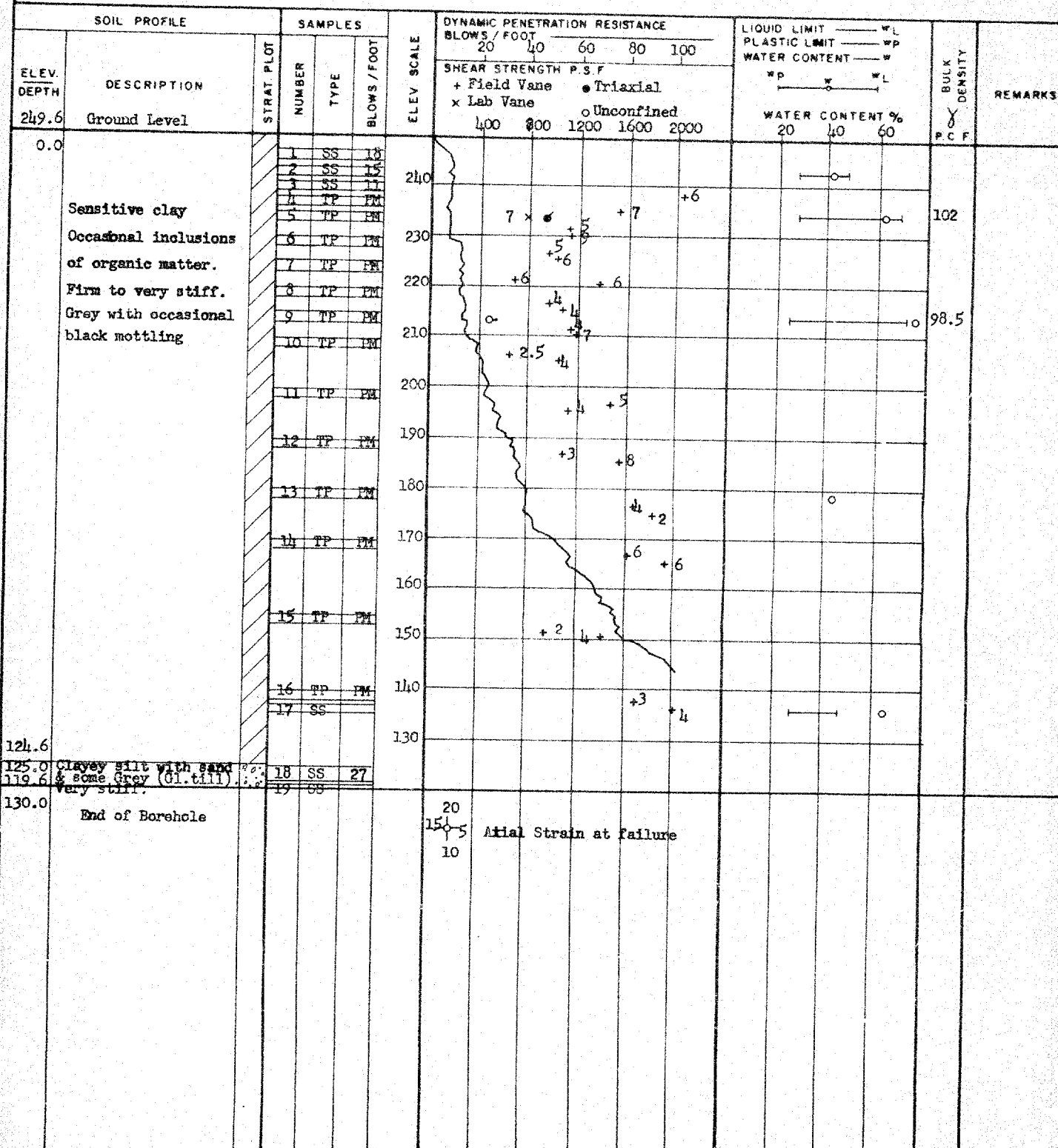


DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 68-F-54 LOCATION Hwy. 417 Sta. 222 + 75 EBL ORIGINATED BY BHL  
W.P. 34-66-01 BORING DATE July 15-17, 1968 COMPILED BY PBS  
DATUM Geodetic BOREHOLE TYPE Diamond Drill, NX Casing CHECKED BY LS





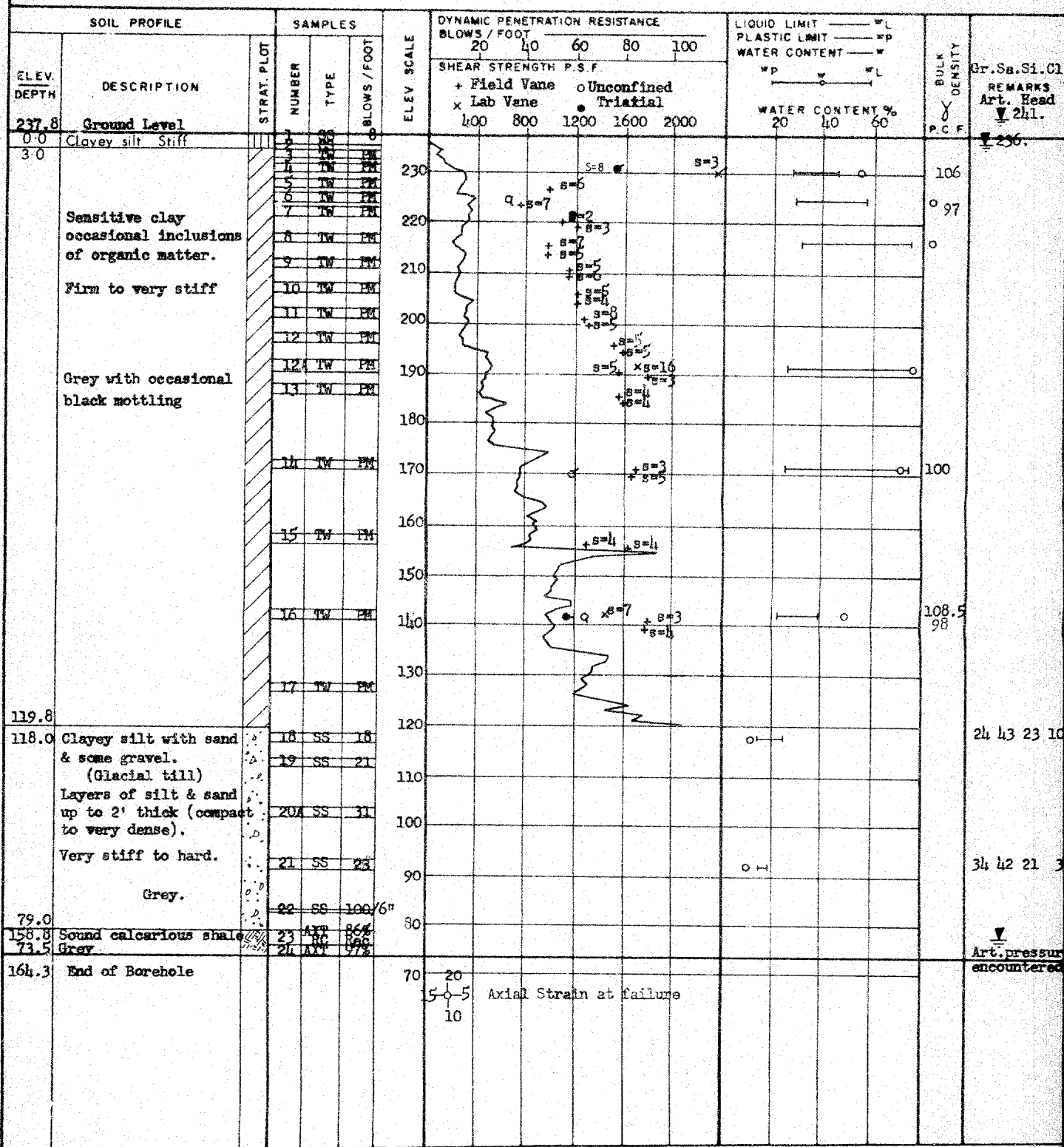
DEPARTMENT OF HIGHWAYS - ONTARIO

## MATERIALS &amp; TESTING DIVISION

## RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 68-F-54 LOCATION Sta. 219 + 50 @ Hwy. 417 EBL o/s 18' Lt. ORIGINATED BY WH  
 W.P. 34-66-01 BORING DATE Aug. 7-15, 1968 COMPILED BY WH  
 DATUM Geodetic BOREHOLE TYPE Diamond Drill - Washboring CHECKED BY WH





DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING DIVISION

## RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 68-F-54

LOCATION Sta. 221 + 30 @ Hwy. 417 EBL o/s 18' Lt.

ORIGINATED BY WH

W.P. 34-66-01

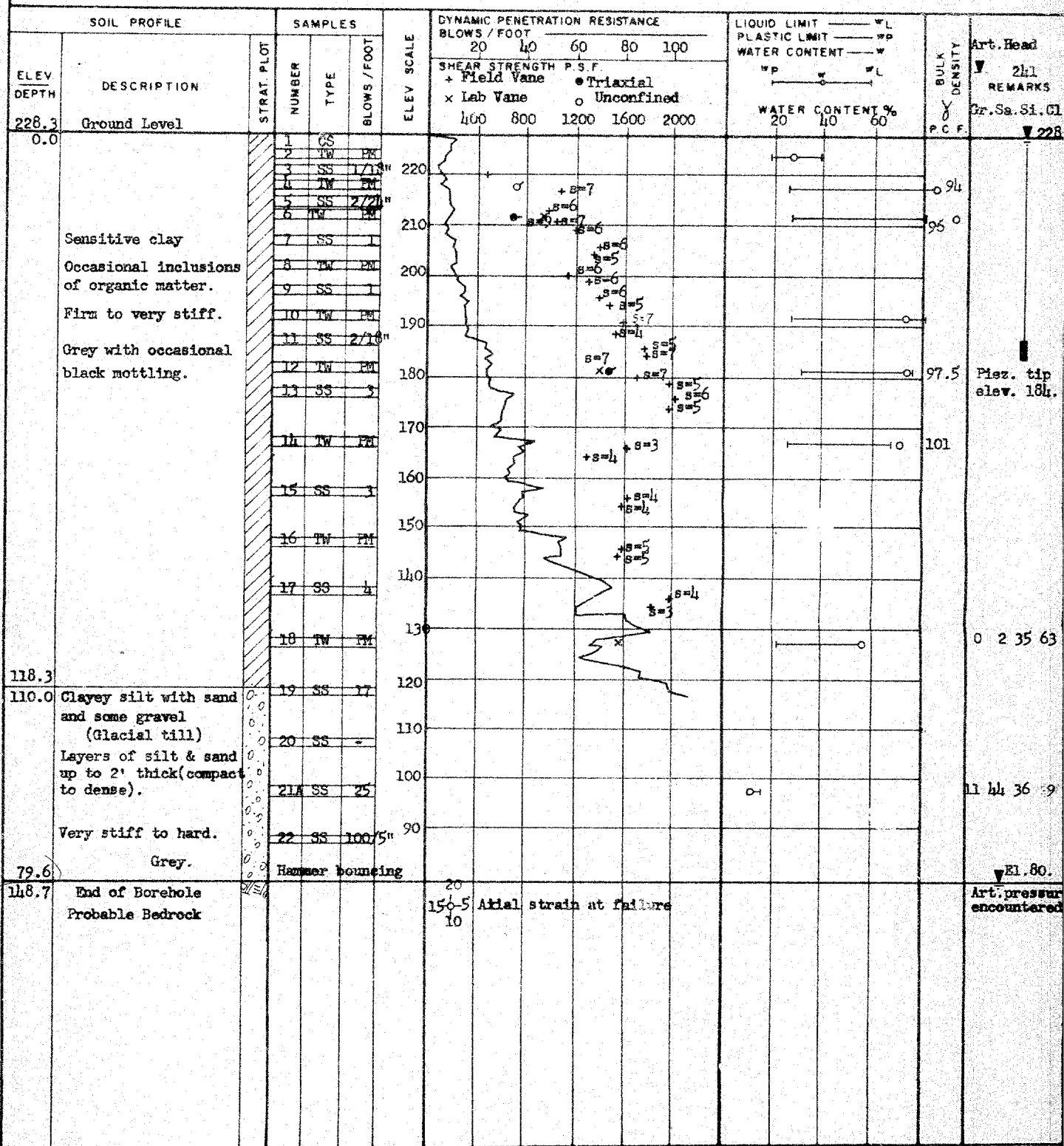
BORING DATE August 16 - 21, 1968

COMPILED BY WH

DATUM Geodetic

BOREHOLE TYPE Diamond Drill - Washboring

CHECKED BY





DEPARTMENT OF HIGHWAYS - ONTARIO

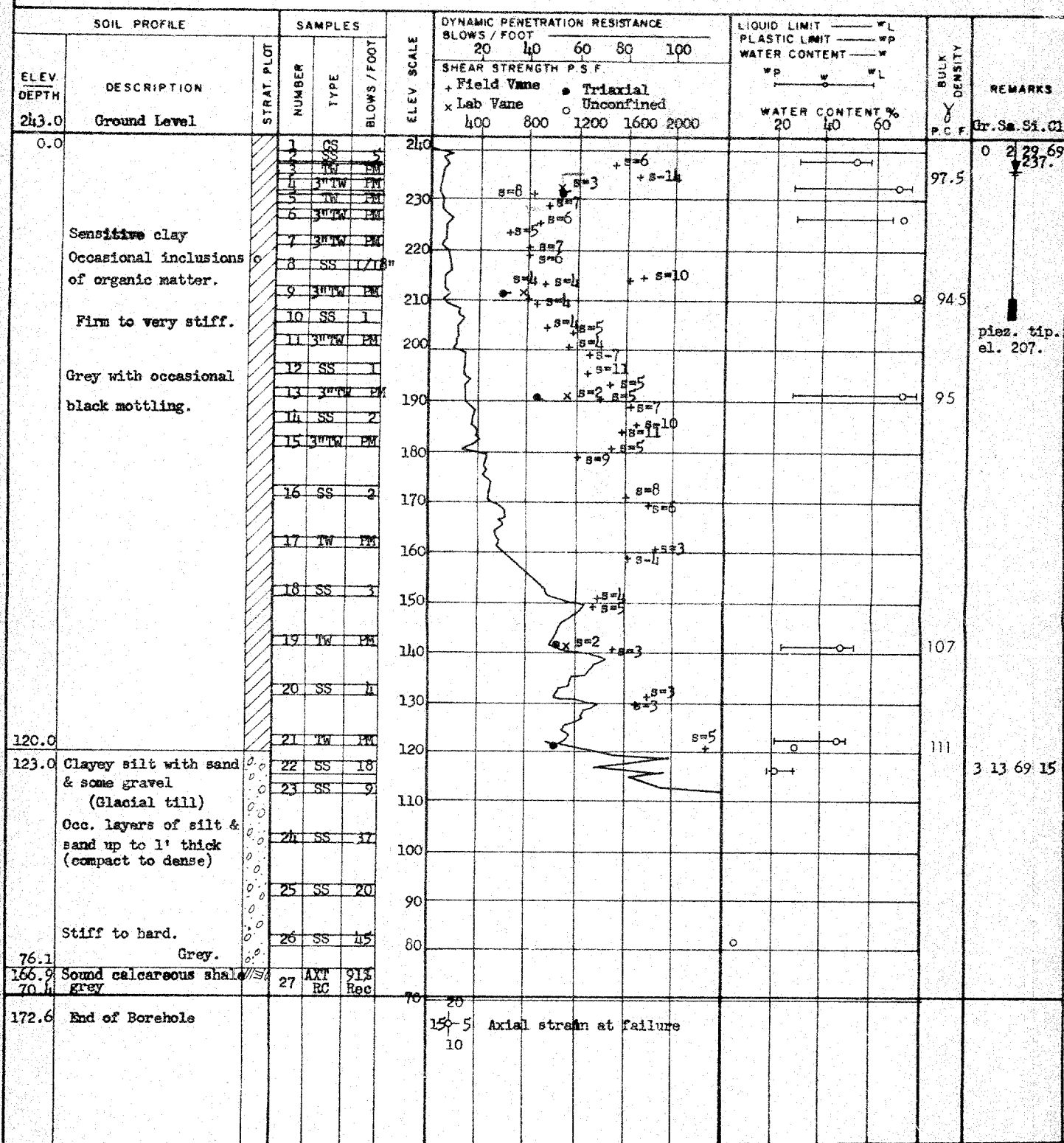
## MATERIALS &amp; TESTING DIVISION

## RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 68-F-54 LOCATION Sta. 222 + 00 @ Hwy. 417 EBL o/s 18' Rt.  
W.P. 24-66-01 BORING DATE August 12 - 19, 1968  
DATUM Geodetic BOREHOLE TYPE Diamond Drill - Washboring

ORIGINATED BY WH  
COMPILED BY WH  
CHECKED BY JK





## RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

MATERIALS &amp; TESTING DIVISION

JOB 68-F-54

LOCATION Sta. 220 + 40 @ Hwy. 417 WBL o/s 18' Rt.

ORIGINATED BY WH

W.P. 34-66-01

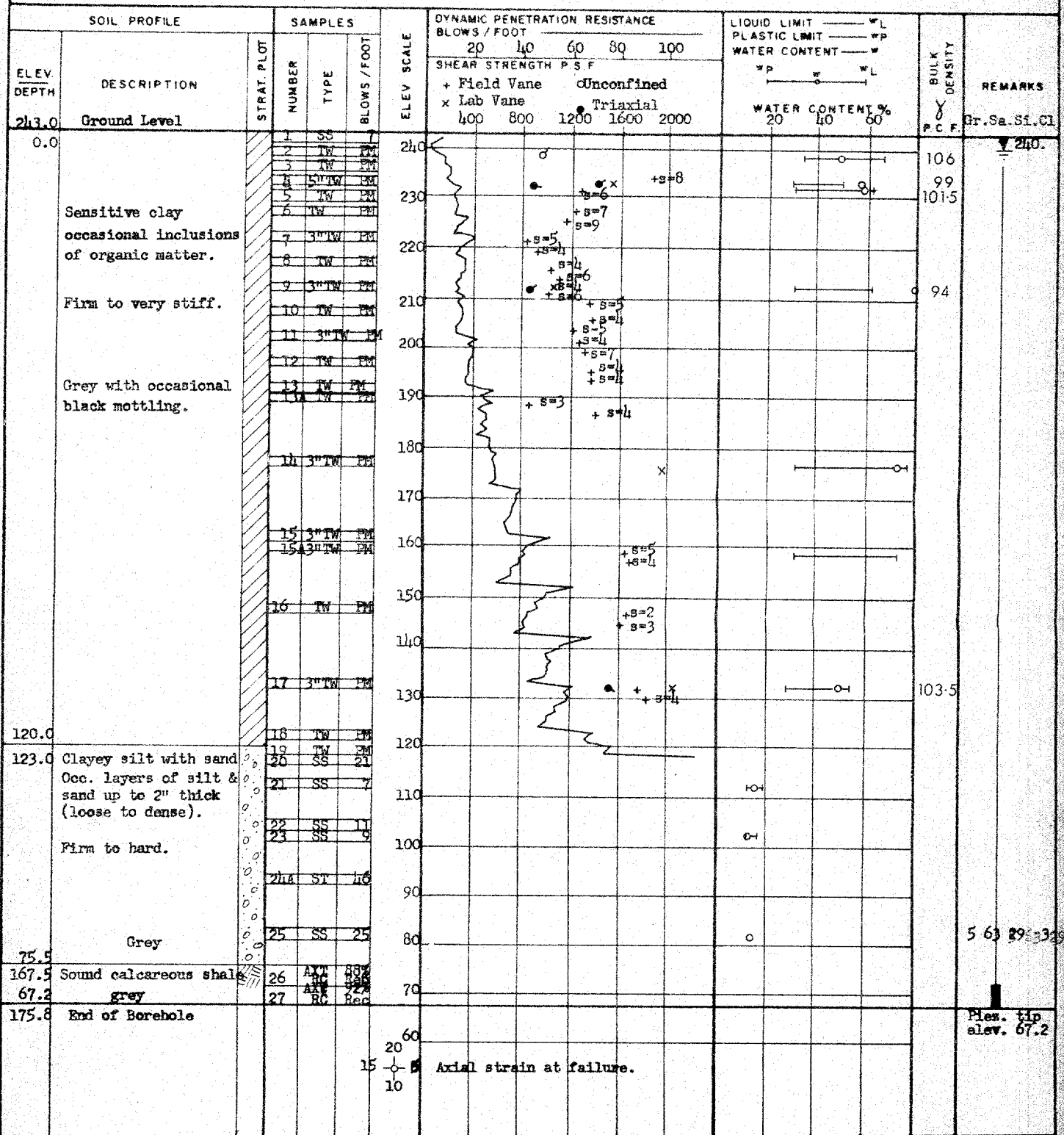
BORING DATE August 7, 14, 1968

COMPILED BY SW

DATUM Geodetic

BOREHOLE TYPE Diamond Drill, Washboring

CHECKED BY JH





## MATERIALS &amp; TESTING DIVISION

## RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 68-F-54

LOCATION Sta. 222 + 20 @ Hwy. 417 WBL o/s 18<sup>th</sup> Lt.

ORIGINATED BY WH

W.P. 34-66-01

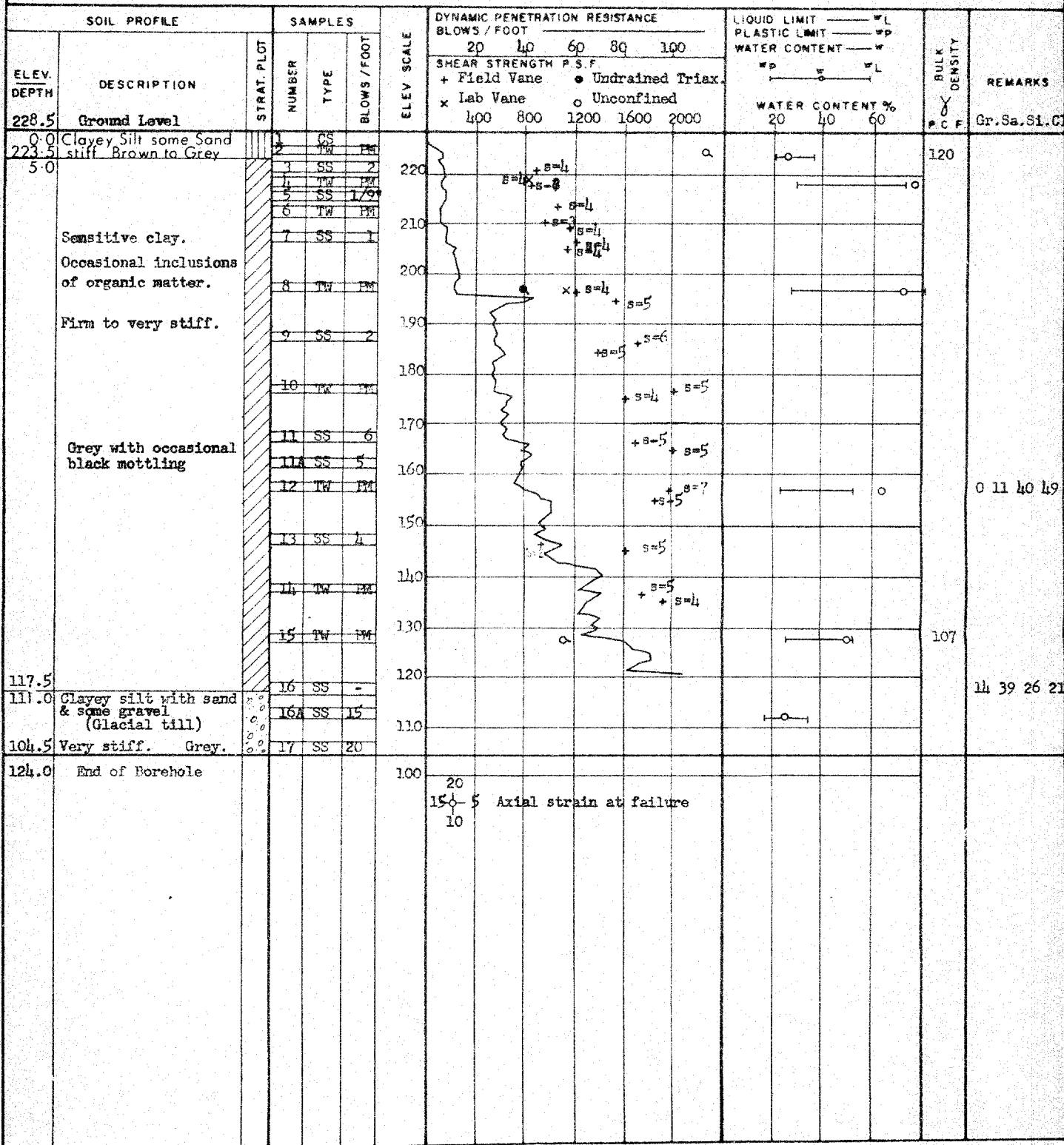
BORING DATE Aug. 21-23, 1968

COMPILED BY WH

DATUM Geodetic

BOREHOLE TYPE Diamond Drill, Washboring

CHECKED BY





## MATERIALS &amp; TESTING DIVISION

## RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

JOB 68-F-54

LOCATION Sta. 222 + 80 @ Hwy. 417 EBL o/s 18' Rt.

ORIGINATED BY WH

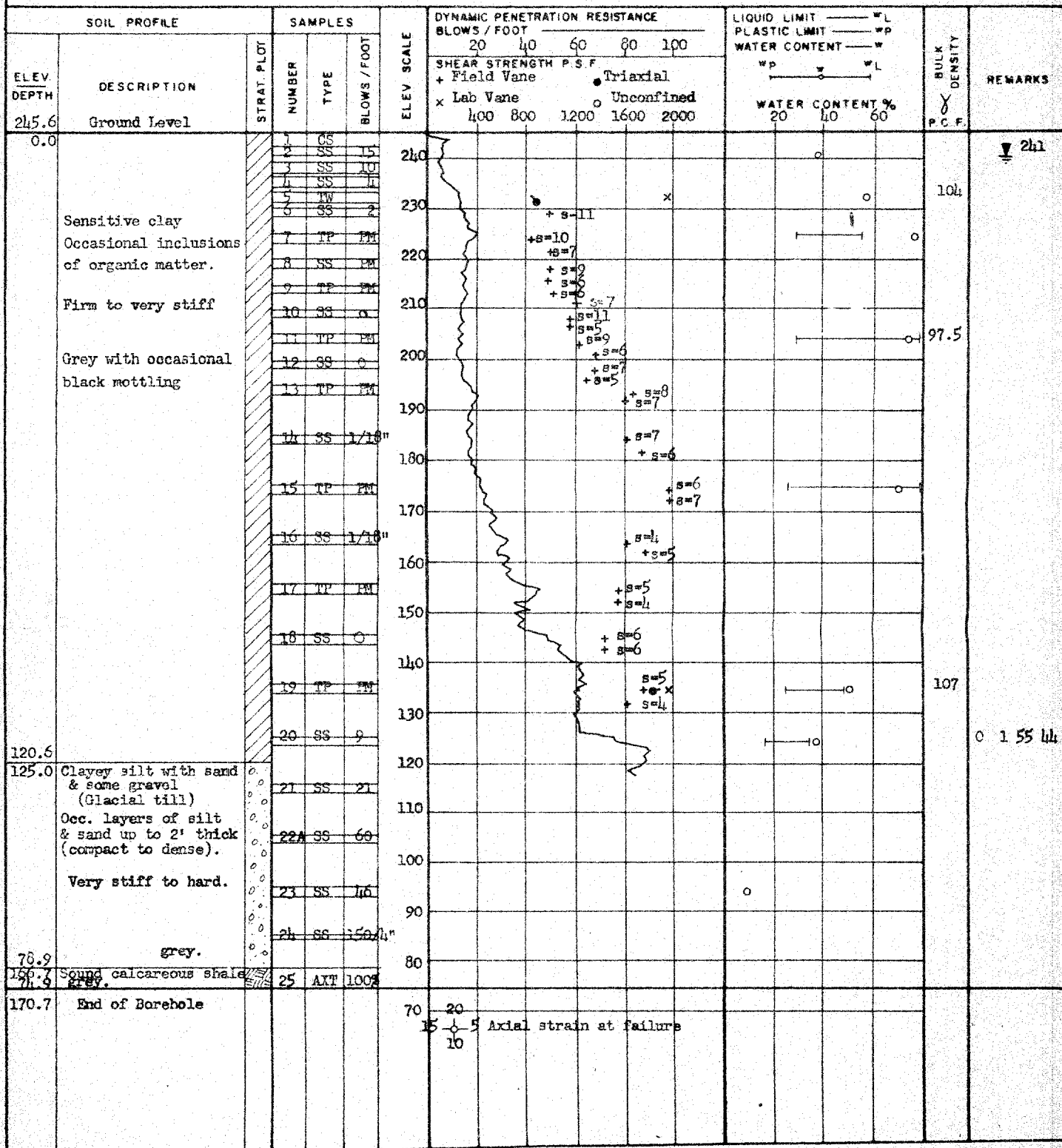
W. P. 34-66-01

BORING DATE Aug. 15-22, 1968

COMPILED BY WH

DATUM Geodetic

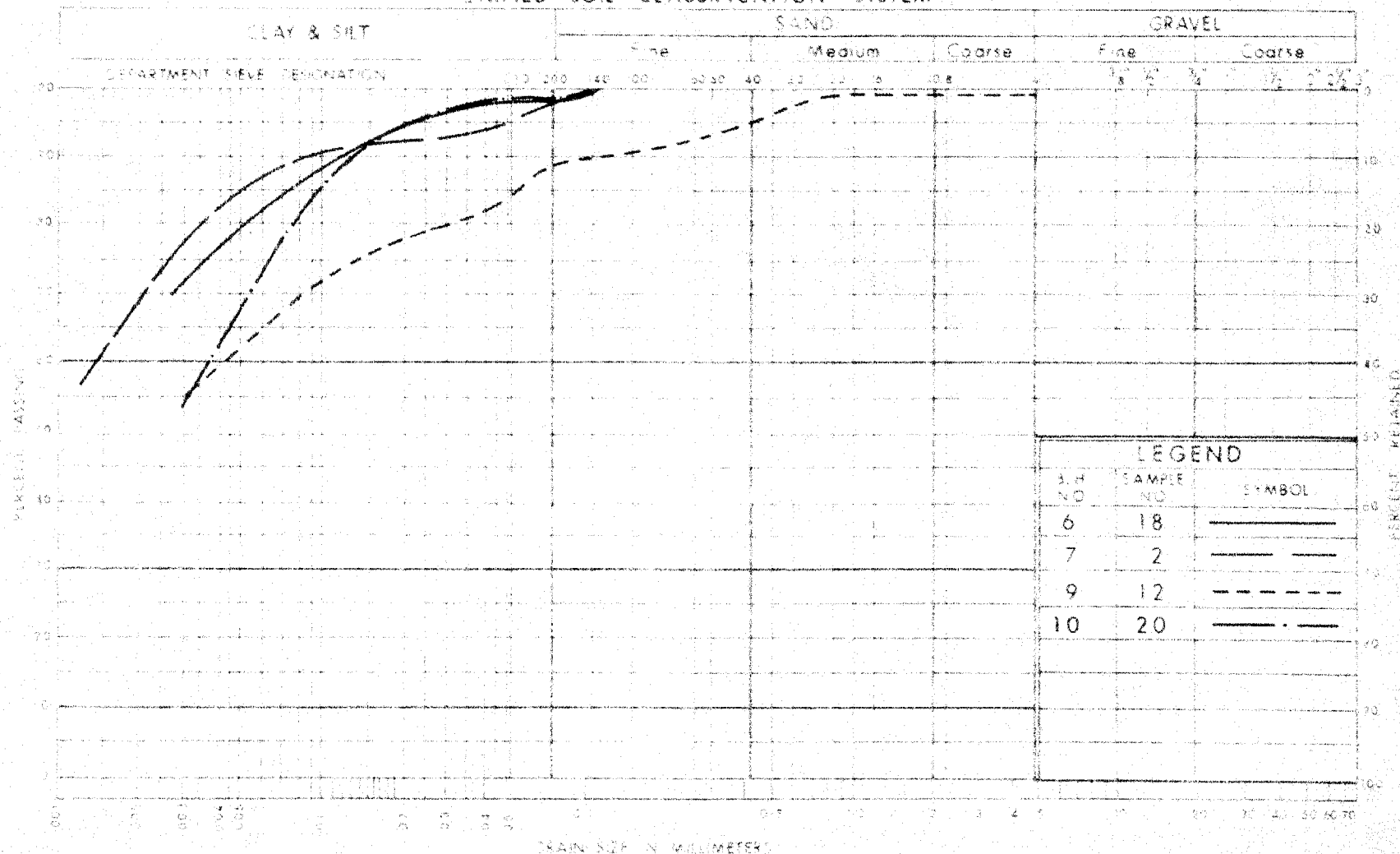
BOREHOLE TYPE Diamond Drill, Washboring

CHECKED BY *HL*



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
SENSITIVE CLAY

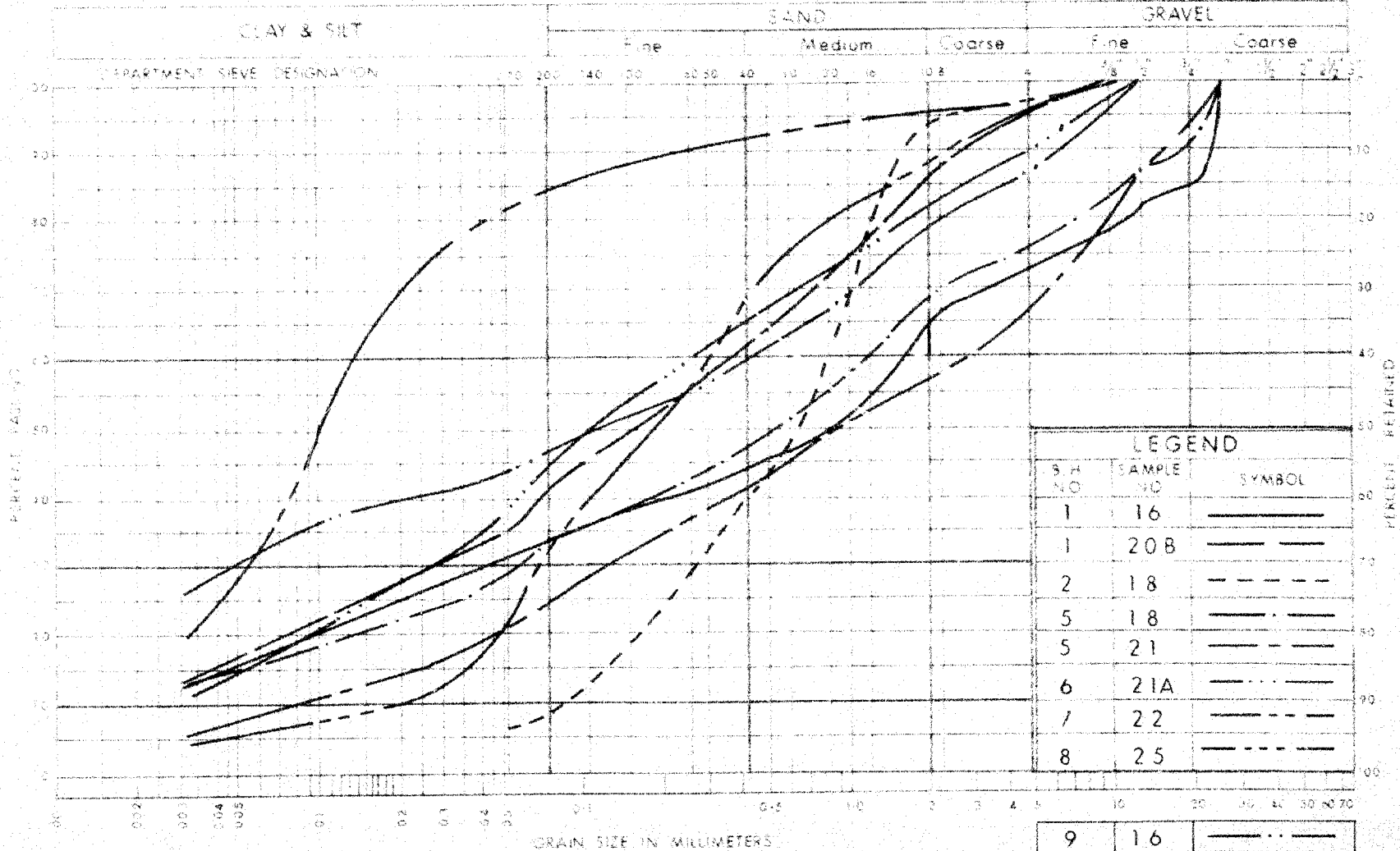
W.P. No 34-66-01  
JOB No 68-F-54

FIG. 3



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT

# UNIFIED SOIL CLASSIFICATION SYSTEM



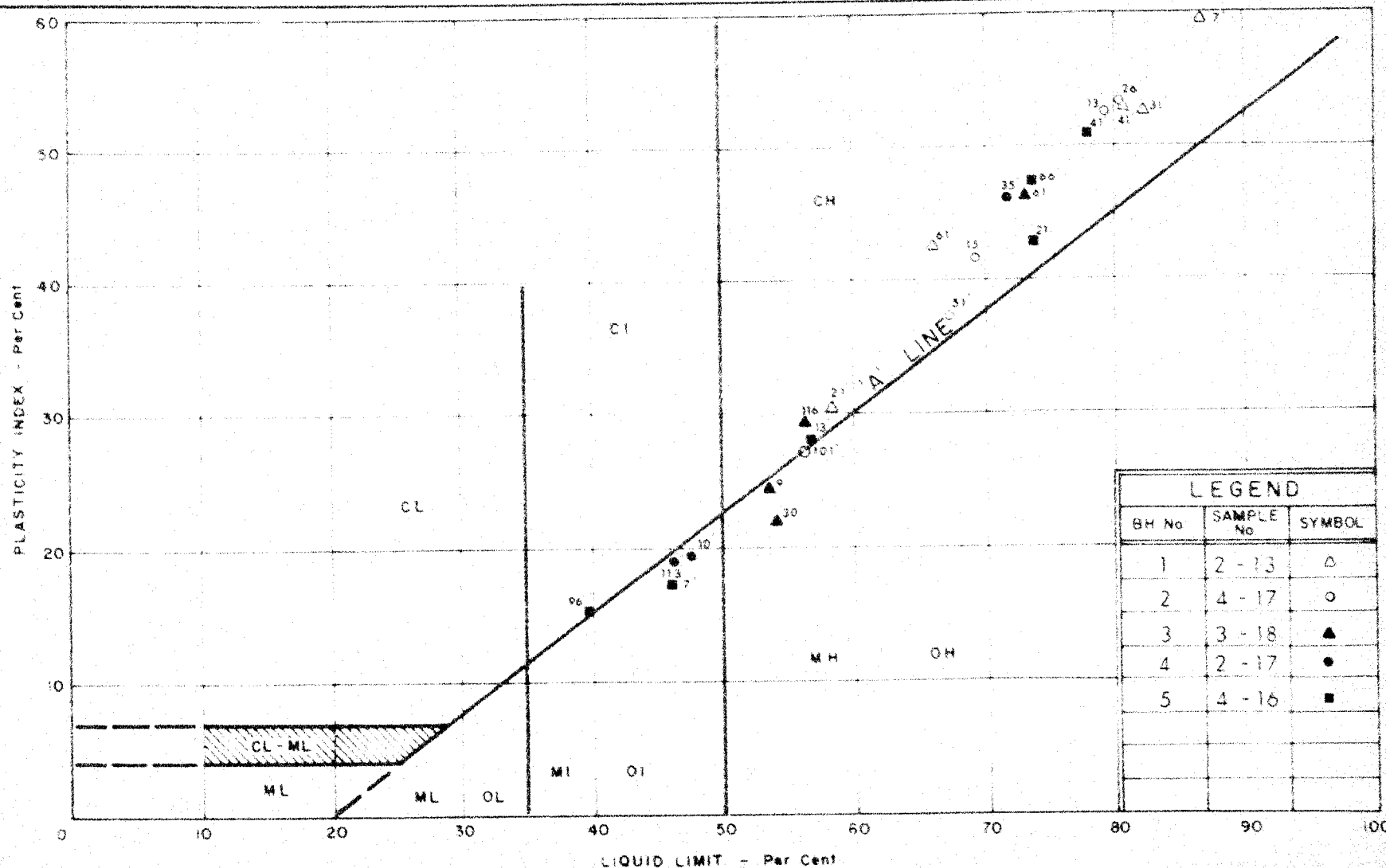
DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

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

WP No. 34 - 66 - 01  
JOB No. 68 - F - 54  
FIG. 4



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT



PLASTICITY CHART  
SENSITIVE CLAY

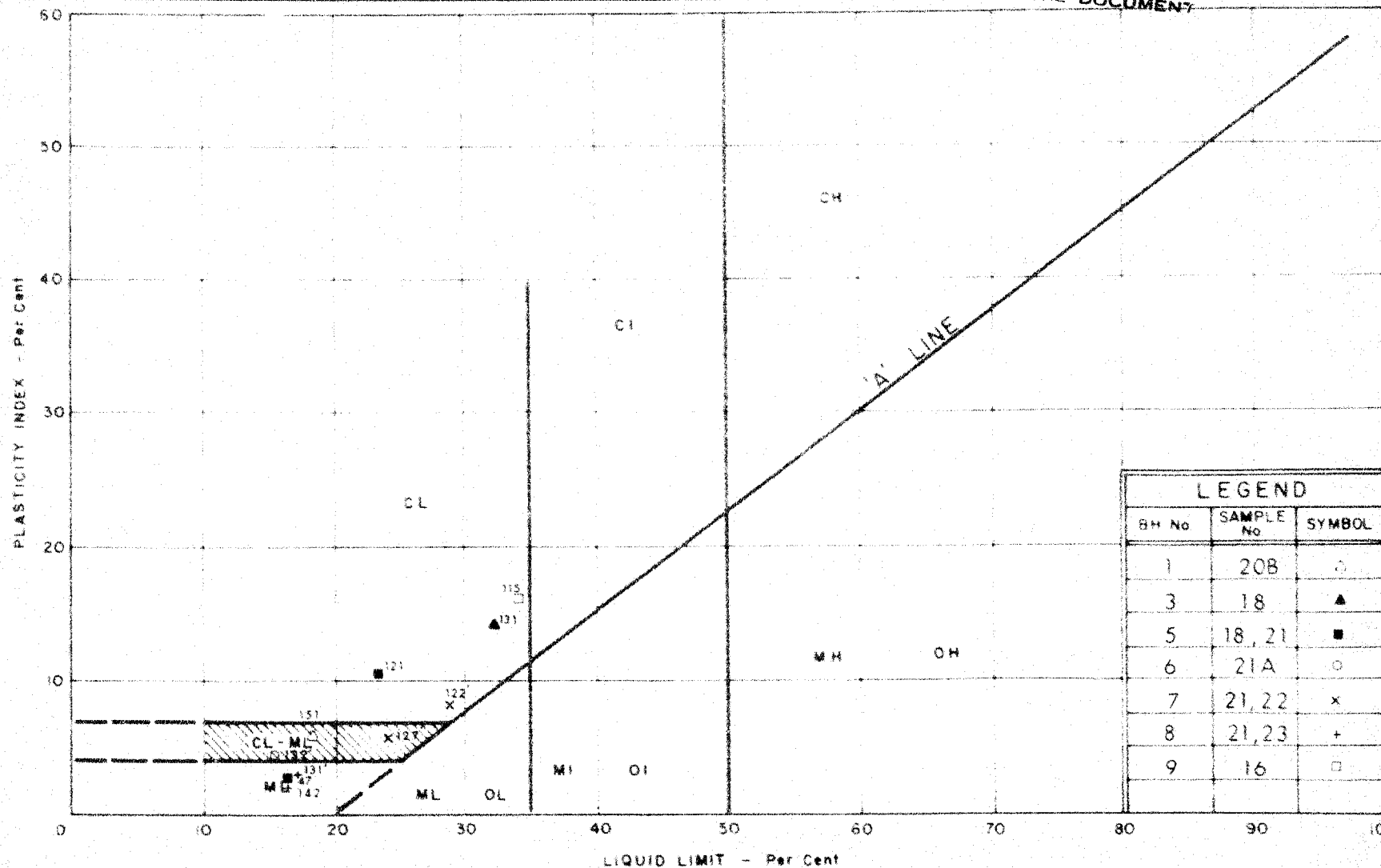
WP No. 34-66-01  
JOB No. 68-F-54  
FIG. No. 5



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION



DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT



DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# PLASTICITY CHART

CLAYEY SILT  
WITH SAND, SOME GRAVEL  
(GLACIAL TILL)

WP No. 34-66-01

JOB No. 68-F-54

FIG. No. 7



# VOID RATIO vs PRESSURE

$W_L = 79.0$

$W_p = 26.9$

$W = 78.7$

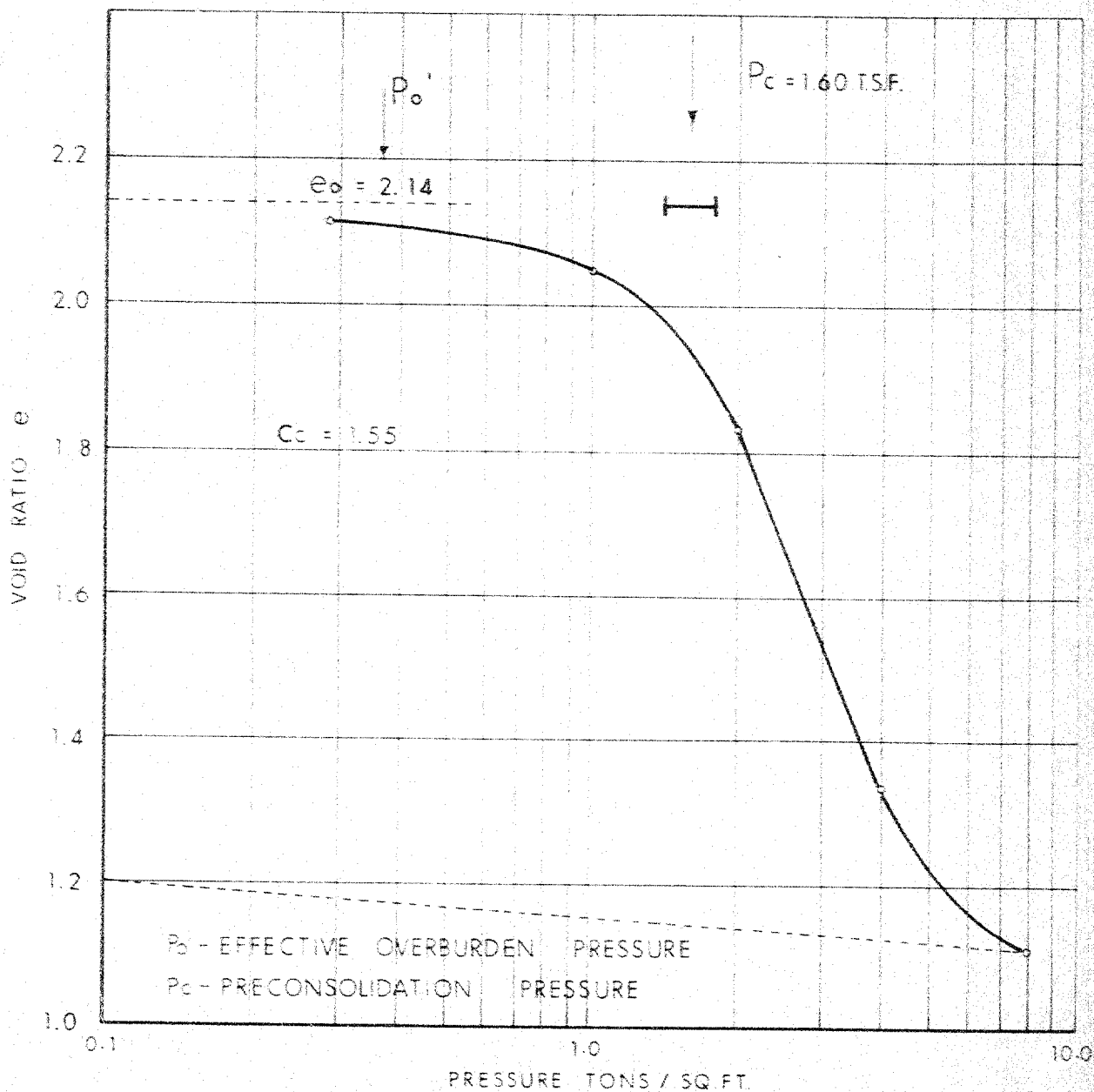
$C_c = 1.55$

BORE HOLE 2

SAMPLE 4

DEPTH 12' - 11"

ELEV. 214.0



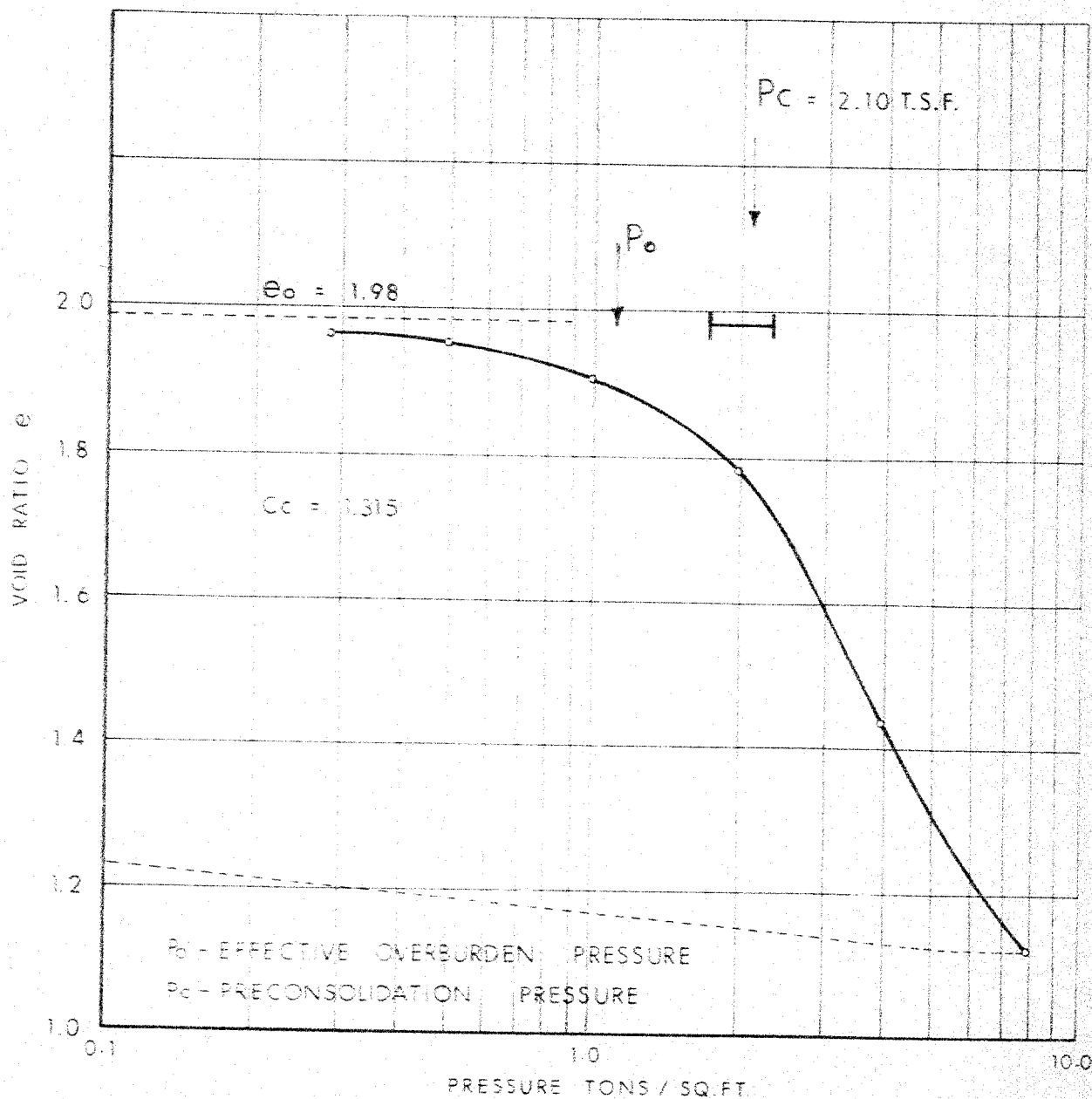
DEFECTS IN NEGATIVE DUE TO  
CONDITION OF ORIGINAL DOCUMENT



# VOID RATIO vs PRESSURE

$W_L = 67.4$   
 $W_p = 30.2$   
 $W = 61.2$   
 $C_c = 1.315$

BORE HOLE 2  
 SAMPLE 12  
 DEPTH 51'  
 ELEV. 176.0





**APPENDIX D**

**Basic Chemical Analysis – Eurofins Report Number 1710192**



# Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)  
1931 Robertson Road  
Ottawa, ON  
K2H 5B7  
Attention: Ms. Susan Trickey  
PO#:  
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1710192  
Date Submitted: 2017-06-22  
Date Reported: 2017-06-28  
Project: 1662565/1130  
COC #: 819239

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1300006 Soil  2017-05-08 17-1302 sa3 5-7	1300007 Soil  2017-05-15 17-1303 sa11 45-47	1300008 Soil  2017-05-16 17-1304 sa3 5-7	1300009 Soil  2017-05-09 17-1305 sa14 84.5-86.5
Agri. - Soil	pH	2.0				7.5	8.5	8.2	8.7
	SO4	0.01	%			0.01	0.02	0.01	0.03
General Chemistry	Cl	0.002	%			0.041	0.392	0.034	0.294
	Electrical Conductivity	0.05	mS/cm			1.20	5.60	0.74	4.31
	Resistivity	1	ohm-cm			833	179	1350	232

Group	Analyte	MRL	Units	Guideline	Lab I.D. Sample Matrix Sample Type Sampling Date Sample I.D.	1300010 Soil  2017-05-23 17-1310 sa3 7.5-9.5	1300011 Soil  2017-05-25 17-1308 sa3 5-7	1300012 Soil  2017-06-07 17-1309 sa11 50-52	1300013 Soil  2017-06-05 17-1311 sa15 130-132
Agri. - Soil	pH	2.0				7.6	7.0	8.4	9.0
	SO4	0.01	%			0.03	0.03	0.03	0.04
General Chemistry	Cl	0.002	%			0.060	0.058	0.468	0.055
	Electrical Conductivity	0.05	mS/cm			1.74	1.41	5.82	1.38
	Resistivity	1	ohm-cm			575	709	172	725

## **Guideline = \* = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by \*\* which indicates analysis was completed in Mississauga, Ontario).  
Results relate only to the parameters tested on the samples submitted.  
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range



**APPENDIX E**

# Results of MASW Testing



**DATE** May 24, 2017**PROJECT No.** 1662565**TO** Susan Trickey  
Golder Associates Ltd.**FROM** Stephane Sol, Christopher Phillips**EMAIL** ssol@golder.com;cphillips@golder.com**CHBDC SEISMIC SITE CLASS TESTING RESULTS  
RAMSAYVILLE RD AND HWY 417  
OTTAWA, ONTARIO**

This technical memorandum presents the results of two Multichannel Analysis of Surface Waves (MASW) test performed for the Canadian Highway Bridge Design Code (CHBDC 2014) Seismic Site Classification for a bridge investigation (Figure1). The tests are located on each side of the Ramsayville Rd at the intersection with the HWY417 in Ottawa. The geophysical testing was performed by Golder Associates Ltd. (Golder) personnel on April 27, 2017.



*Figure 1: MASW Location Site Map (MASW Line in red)*

**Golder Associates Ltd.**6925 Century Avenue, Suite #100, Mississauga, Ontario, Canada L5N 7K2  
Tel: +1 (905) 567 4444 Fax: +1 (905) 567 6561 www.golder.com**Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America**

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation.





## Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium, surface waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that particular wavelength of surface wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledge hammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors, and water-wave action (in near-shore environments).

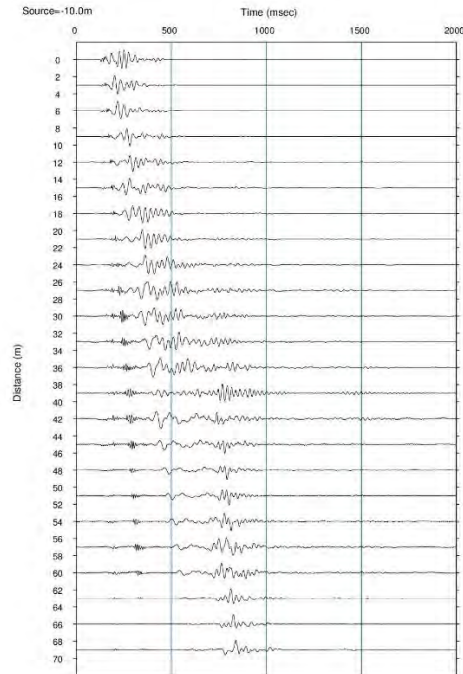
The geophone receivers measure the wave-train associated with the surface wave travelling from a seismic source at different distances from the source.

The participation of surface waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the 'dispersion curve') is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear-modulus of the medium as a function of depth.

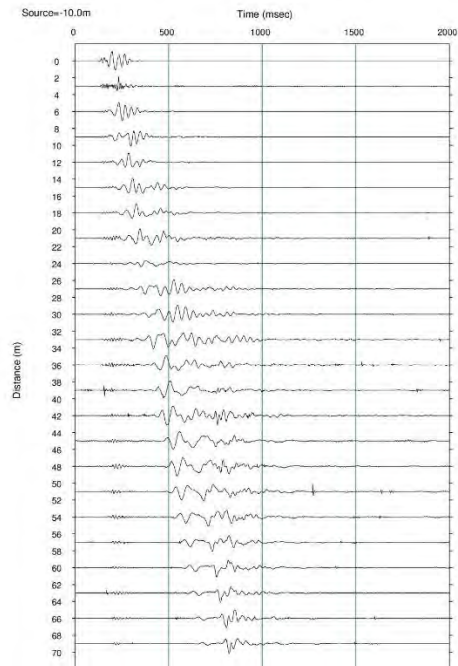
## Field Work

The MASW field work was conducted on April 27, 2017, by personnel from the Golder Mississauga and Ottawa offices. For the MASW line, a series of 24 low frequency (4.5 Hz) geophones were laid out at 3 metre intervals. Both active and passive readings were recorded along the MASW line. For the active investigation, a seismic drop of 45 kg and a 9.9 kg sledge hammer were used as seismic sources. Active seismic records were collected with seismic sources located 5, 10, and 15 metres from and collinear to the geophone array. An example of active seismic records collected at each line are shown in Figures 2 and 3, below.





*Figure 2: Typical seismic record collected at the site of MASW Line 1.*



*Figure 3: Typical seismic record collected at the site of MASW Line 2.*



## Data Processing

Processing of the MASW test results consisted of the following main steps:

- 1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;
- 2) Calculation of the phase for each frequency component;
- 3) Linear regression to calculate phase velocity for each frequency component;
- 4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient ( $r^2$ ) between the data and the linear regression best fit line used to calculate phase velocity;
- 5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and,
- 6) Combining the best active record and all the passive readings into one dispersion curve; and
- 7) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figures 4 and 5 for Line 1 and Figures 6 and 7 for Line 2. The dispersion curves from the active and passive data sets were combined to increase the analyzable frequency range. Shear wave velocity profiles were generated through inverse modelling to best fit the calculated dispersion curves. The active survey of Line 1 provided a dispersion curve with a suitable frequency range (5-21 Hz). The Line 1 passive survey was able to resolve the dispersion trend at lower frequency (as low as 1.5 Hz) and provided a better resolve dispersion curve from 1.5 to 21 Hz. The active survey of Line 2 provided a dispersion curve with a suitable frequency range (4-20 Hz). The Line 1 passive survey was able to resolve the dispersion trend at lower frequency (as low as 1.5 Hz) and provided a better resolve dispersion curve from 1.5 to 20 Hz. At both lines the minimum measured surface wave frequency with sufficient signal-to-noise ratio to accurately measure phase velocity was approximately 1.5 Hz.



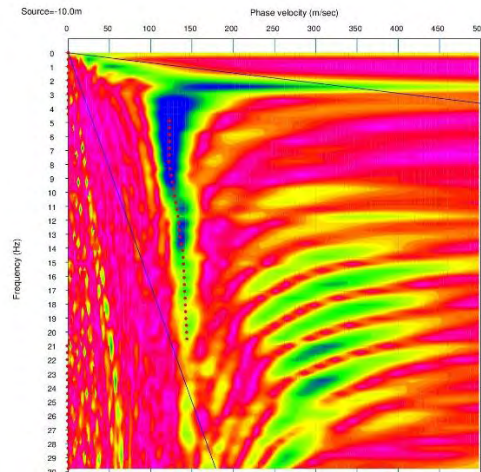


Figure 4: Active MASW Dispersion Curve Picks (red dots) along MASW Line 1

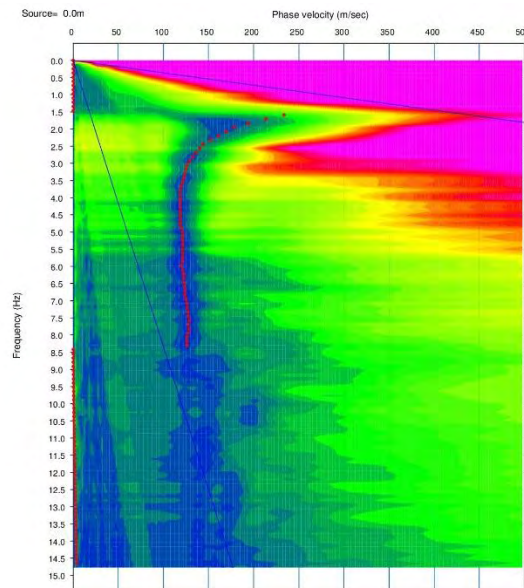


Figure 5: Passive MASW Dispersion Curve Picks (red dots) along MASW Line 1



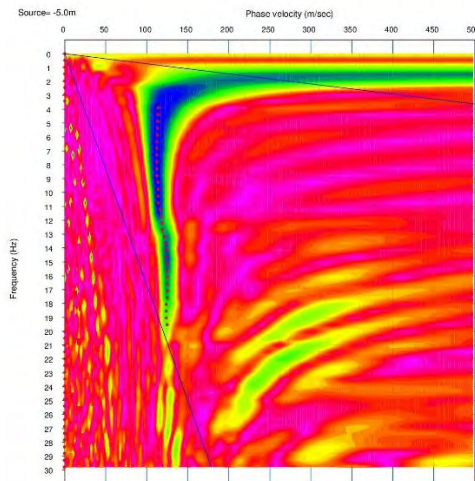


Figure 6: Active MASW Dispersion Curve Picks (red dots) along MASW Line 2

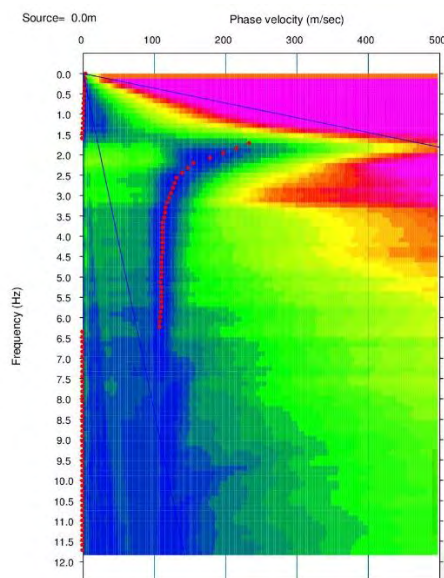


Figure 7: Passive MASW Dispersion Curve Picks (red dots) along MASW Line 2

## Results

The MASW test results are presented in Figures 8 and 9, which present the calculated shear wave velocity profile derived from the field testing along MASW Lines 1 and 2, respectively. The results along MASW Line 1 have been calculated using weight-drop located at 10 metres from the last geophone. The results along MASW Line 1 have been calculated using weight-drop located at 5 metres from the last geophone. The field collected dispersion curves are compared with the model generated dispersion curves on Figures 10 and 11 for MASW Lines 1 and 2, respectively. There is a satisfactory correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 2% along both lines.



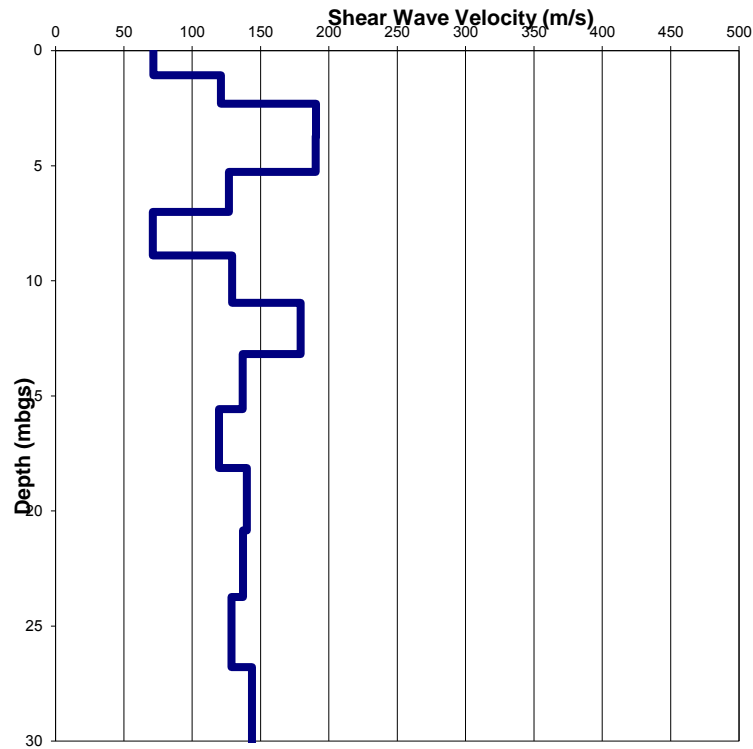


Figure 8: MASW Modelled Shear-Wave Velocity Depth profile along MASW Line 1

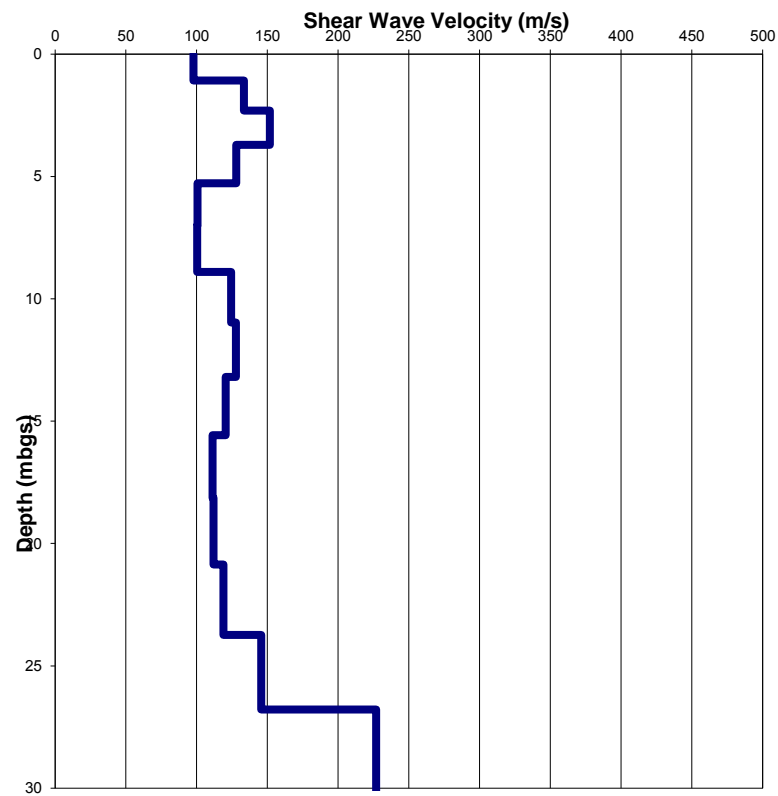


Figure 9: MASW Modelled Shear-Wave Velocity Depth profile along MASW Line 2



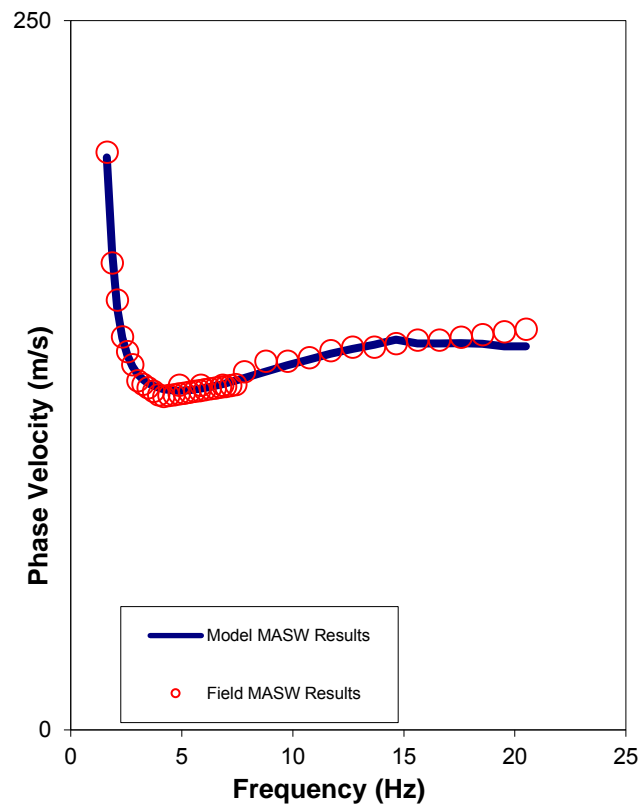


Figure 10: Comparison of Field (red dots) vs. Modelled Data (blue line) along MASW Line 1

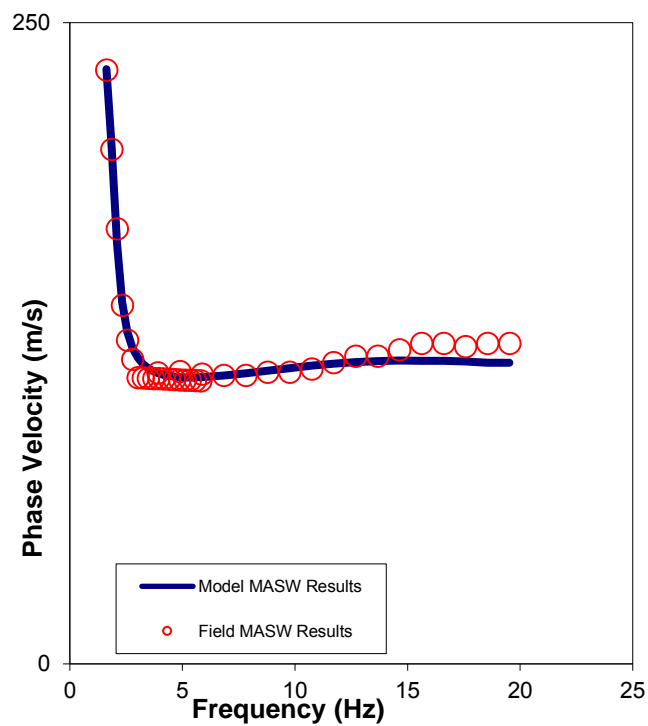


Figure 11: Comparison of Field (red dots) vs. Modelled Data (blue line) along MASW Line 2



To calculate the average shear-wave velocity as required by the CHBDC 2014, the results were modelled to 30 metres below ground surface. The average shear-wave velocity along MASW Line 1 was found to be 128 m/s (Table 1). The average shear-wave velocity along MASW Line 2 was found to be 126 m/s (Table 2).

**Table 1: Shear-Wave Velocity Profile along MASW Line 1**

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	71	0.014988
1.07	2.31	1.24	121	0.010220
2.31	3.71	1.40	191	0.007350
3.71	5.27	1.57	190	0.008226
5.27	7.01	1.73	127	0.013642
7.01	8.90	1.90	71	0.026645
8.90	10.96	2.06	129	0.015960
10.96	13.19	2.23	179	0.012411
13.19	15.58	2.39	137	0.017462
15.58	18.13	2.55	120	0.021358
18.13	20.85	2.72	140	0.019438
20.85	23.74	2.88	137	0.021031
23.74	26.79	3.05	129	0.023695
26.79	30.00	3.21	144	0.022365
<b>Vs Average to 30 mbgs (m/s)</b>			<b>128</b>	



**Table 2: Shear-Wave Velocity Profile along MASW Line 2**

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	98	0.010964
1.07	2.31	1.24	133	0.009272
2.31	3.71	1.40	152	0.009236
3.71	5.27	1.57	128	0.012238
5.27	7.01	1.73	101	0.017199
7.01	8.90	1.90	100	0.018887
8.90	10.96	2.06	124	0.016563
10.96	13.19	2.23	128	0.017435
13.19	15.58	2.39	121	0.019818
15.58	18.13	2.55	111	0.022950
18.13	20.85	2.72	112	0.024295
20.85	23.74	2.88	119	0.024259
23.74	26.79	3.05	146	0.020946
26.79	30.00	3.21	227	0.014175
<b>Vs Average to 30 mbgs (m/s)</b>			<b>126</b>	

The CHBDC 2014 requires special site specific evaluation if certain soil types are encountered on the site, so the site classification stated here should be reviewed, and modified if necessary, according to borehole stratigraphy, standard penetration resistance results, and undrained shear strength measurements, if available for this site.

## Limitations

This technical memorandum is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.



The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

## Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

### **GOLDER ASSOCIATES LTD.**



Stephane Sol, Ph.D, P. Geo  
Senior Geophysicist



Christopher Phillips, M. SC., P. Geo  
Senior Geophysicist, Principal

SS/CRP/jl

[https://golderassociates.sharepoint.com/sites/11263g/shared documents/09\\_field work/geophysics/ramsayville masw/report/tech memo\\_1662565 mto ramsayville.docx](https://golderassociates.sharepoint.com/sites/11263g/shared%20documents/09_field%20work/geophysics/ramsayville%20masw/report/tech%20memo_1662565%20to%20ramsayville.docx)



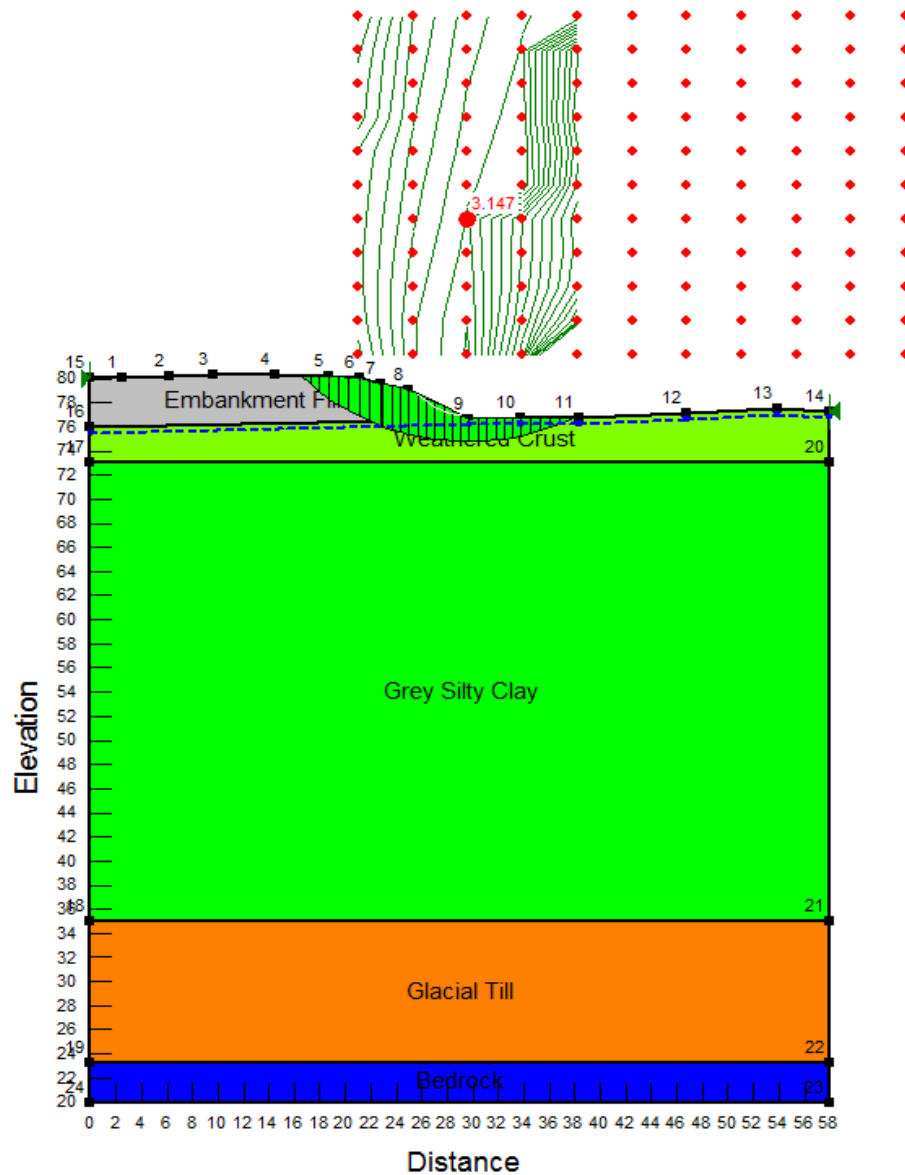
**APPENDIX F**

## Results of Analysis

Figures F1 to F4 - Slope Stability Assessment

Figures F5 to F20 - P-Y Curves





File Name: 1662565-1130 Ramsayville EBL 20+830.gsz  
 Title: Ramsayville Road Overpass EBL West Approach (BH17-1302)  
 Name: 1.1 Static Drained  
 Method: Morgenstern-Price  
 Direction of movement: Left to Right  
 Horz Seismic Load: 0

Name: Embankment Fill  
 Model: Mohr-Coulomb  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 30 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Weathered Crust  
 Model: Mohr-Coulomb  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 5 kPa  
 Phi: 35 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Grey Silty Clay  
 Model: Mohr-Coulomb  
 Unit Weight: 15.2 kN/m<sup>3</sup>  
 Cohesion: 7.5 kPa  
 Phi: 28.7 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Glacial Till  
 Model: Mohr-Coulomb  
 Unit Weight: 22.6 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 35 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Bedrock  
 Model: Bedrock (Impenetrable)  
 Piezometric Line: 1



## Slope Stability Assessment - Static Drained

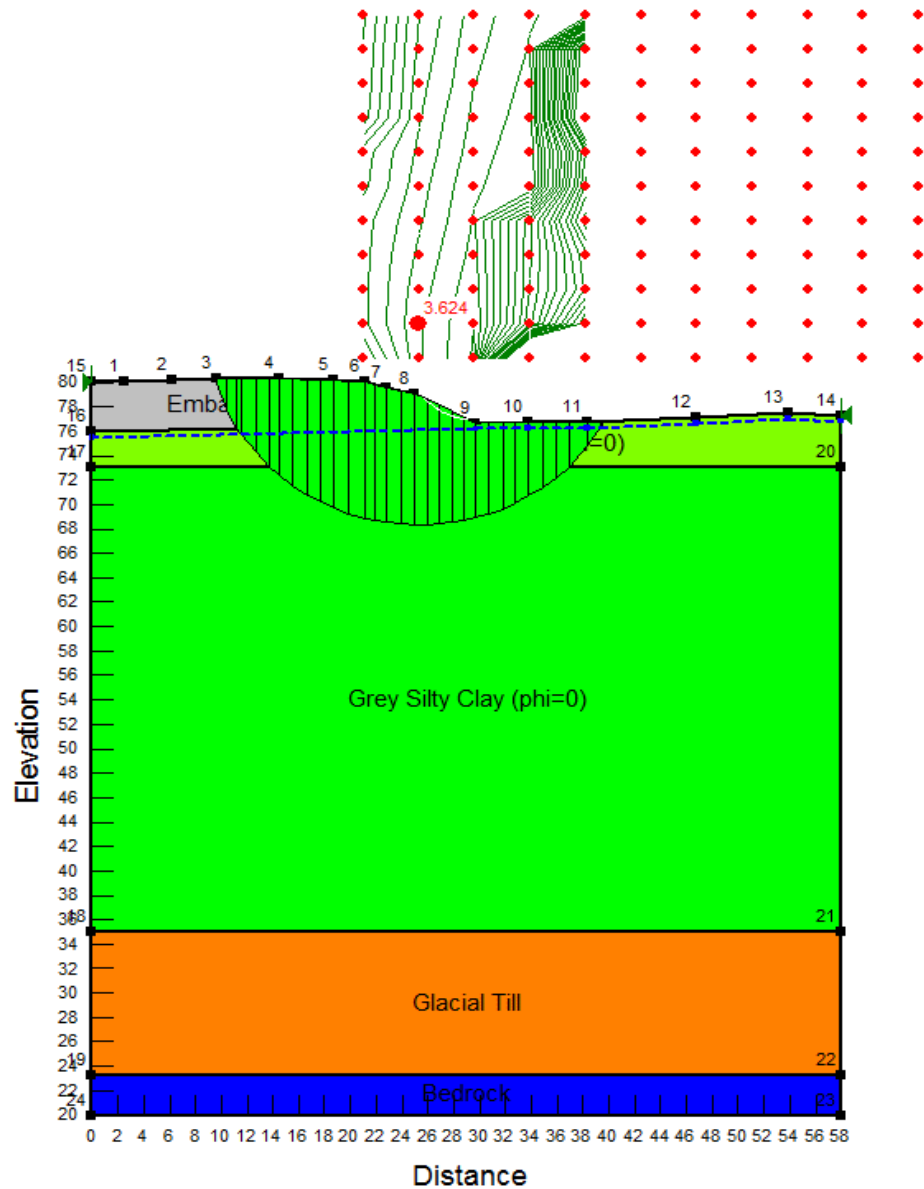
Ramsayville Road Overpass

Ottawa, Ontario

Project No.	1662565 / 1130
Drawn:	WAM
Date:	2017-09-25
Checked:	MSS
Review:	FJH

Figure F1





File Name: 1662565-1130 Ramsayville EBL 20+830.gsz  
 Title: Ramsayville Road Overpass EBL West Approach (BH17-1302)  
 Name: 1.2 Static Undrained  
 Method: Morgenstern-Price  
 Direction of movement: Left to Right  
 Horz Seismic Load: 0

Name: Embankment Fill  
 Model: Mohr-Coulomb  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 30 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Weathered Crust (phi=0)  
 Model: Undrained (Phi=0)  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 80 kPa  
 Piezometric Line: 1

Name: Grey Silty Clay (phi=0)  
 Model: S=f(depth)  
 Unit Weight: 15.2 kN/m<sup>3</sup>  
 C-Top of Layer: 30 kPa  
 C-Rate of Change: 3.5 kPa/m  
 Limiting C: 80 kPa  
 Piezometric Line: 1

Name: Glacial Till  
 Model: Mohr-Coulomb  
 Unit Weight: 22.6 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 35 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Bedrock  
 Model: Bedrock (Impenetrable)  
 Piezometric Line: 1



## Slope Stability Assessment - Static Undrained

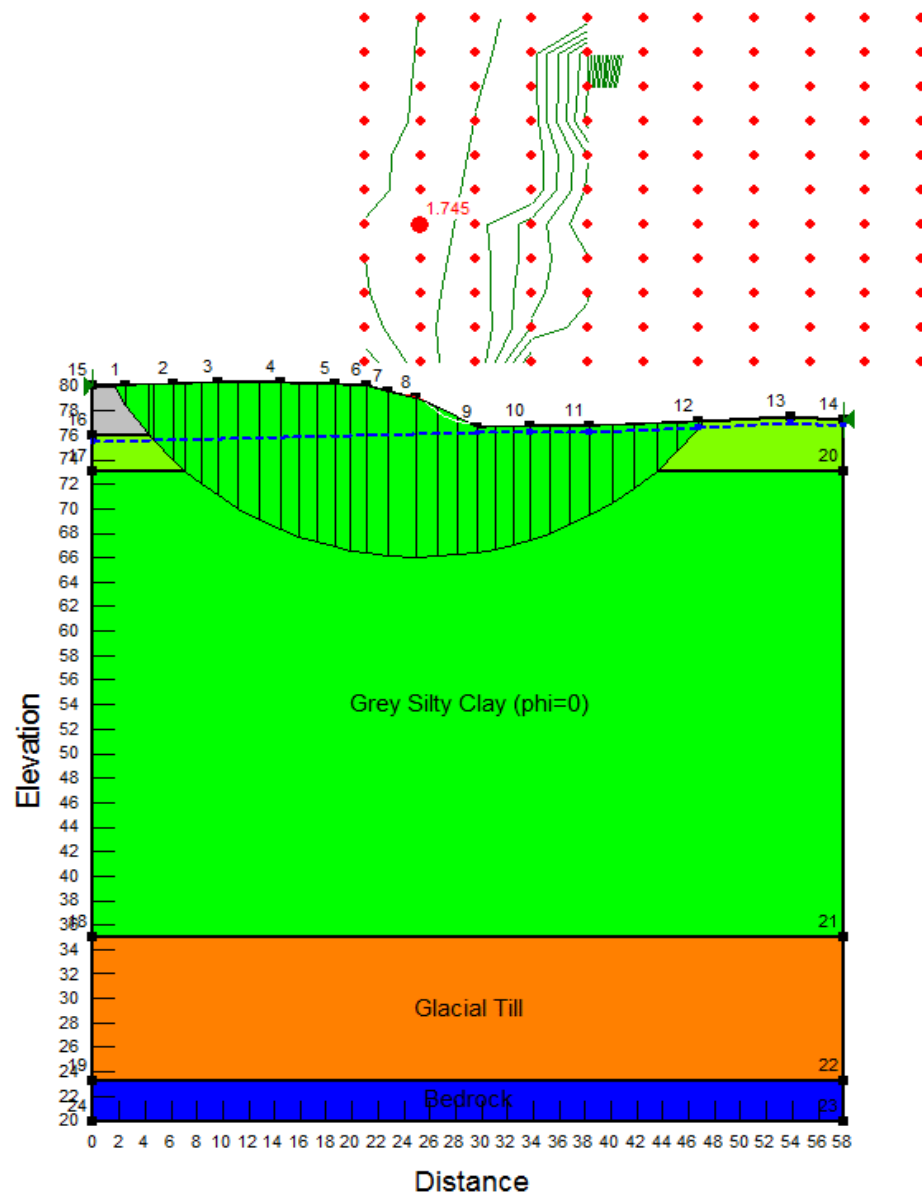
Ramsayville Road Overpass

Ottawa, Ontario

Project No.	1662565 / 1130
Drawn:	WAM
Date:	2017-09-25
Checked:	MSS
Review:	FJH

Figure F2





File Name: 1662565-1130 Ramsayville EBL 20+830.gsz  
 Title: Ramsayville Road Overpass EBL West Approach (BH17-1302)  
 Name: 1.3 Seismic Undrained  
 Method: Morgenstern-Price  
 Direction of movement: Left to Right  
 Horz Seismic Load: 0.171

Name: Embankment Fill  
 Model: Mohr-Coulomb  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 30 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Weathered Crust (phi=0)  
 Model: Undrained (Phi=0)  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 80 kPa  
 Piezometric Line: 1

Name: Grey Silty Clay (phi=0)  
 Model: S=f(depth)  
 Unit Weight: 15.2 kN/m<sup>3</sup>  
 C-Top of Layer: 30 kPa  
 C-Rate of Change: 3.5 kPa/m  
 Limiting C: 80 kPa  
 Piezometric Line: 1

Name: Glacial Till  
 Model: Mohr-Coulomb  
 Unit Weight: 22.6 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 35 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Bedrock  
 Model: Bedrock (Impenetrable)  
 Piezometric Line: 1



## Slope Stability Assessment - Seismic Undrained

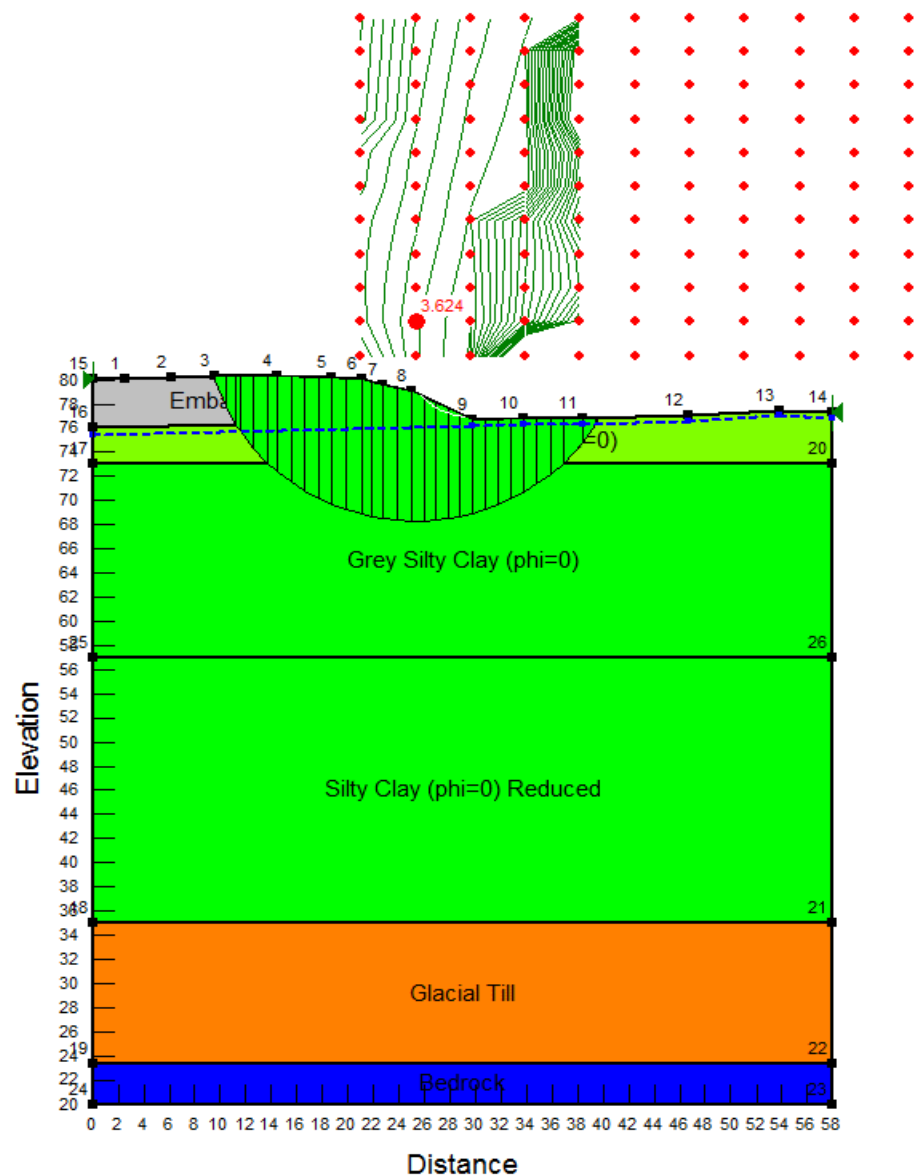
Ramsayville Road Overpass

Ottawa, Ontario

Project No.	1662565 / 1130
Drawn:	WAM
Date:	2017-09-25
Checked:	MSS
Review:	FJH

Figure F3





File Name: 1662565-1130 Ramsayville EBL 20+830 Post Earthquake.gsz  
 Title: Ramsayville Road Overpass EBL West Approach (BH17-1302)  
 Name: 1.4 Static Undrained  
 Method: Morgenstern-Price  
 Direction of movement: Left to Right  
 Horz Seismic Load: 0

Name: Embankment Fill  
 Model: Mohr-Coulomb  
 Unit Weight: 21 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 30 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Weathered Crust (phi=0)  
 Model: Undrained (Phi=0)  
 Unit Weight: 18 kN/m<sup>3</sup>  
 Cohesion: 80 kPa  
 Piezometric Line: 1

Name: Grey Silty Clay (phi=0)  
 Model: S=f(depth)  
 Unit Weight: 15.2 kN/m<sup>3</sup>  
 C-Top of Layer: 30 kPa  
 C-Rate of Change: 3.5 kPa/m  
 Limiting C: 80 kPa  
 Piezometric Line: 1

Name: Glacial Till  
 Model: Mohr-Coulomb  
 Unit Weight: 22.6 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 35 °  
 Phi-B: 0 °  
 Piezometric Line: 1

Name: Bedrock  
 Model: Bedrock (Impenetrable)  
 Piezometric Line: 1

Name: Silty Clay (phi=0) Reduced  
 Model: S=f(depth)  
 Unit Weight: 15.2 kN/m<sup>3</sup>  
 C-Top of Layer: 37.5 kPa  
 C-Rate of Change: 3.5 kPa/m  
 Limiting C: 60 kPa  
 Piezometric Line: 1



## Slope Stability Assessment - Post Liquefaction

Ramsayville Road Overpass

Ottawa, Ontario

Project No.	1662565 / 1130
Drawn:	WAM
Date:	2017-09-25
Checked:	MSS
Review:	FJH

Figure F4



SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - EBL WEST ABUTMENT

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand								W/hrd SC Crust		Grey Silty Clay																										
	z= 1.0 m		z= 1.5 m		z= 2.0 m		z= 2.5 m		z= 3.0 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m		
	Elev. 73.7 m		Elev. 73.2 m		Elev. 72.7 m		Elev. 72.2 m		Elev. 71.7 m		Elev. 71.2 m		Elev. 70.2 m		Elev. 69.2 m		Elev. 68.2 m		Elev. 67.2 m		Elev. 66.2 m		Elev. 65.2 m		Elev. 64.2 m		Elev. 63.2 m		Elev. 62.2 m		Elev. 61.2 m		Elev. 60.2 m		Elev. 59.2 m		
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.002	7.368	0.002	14.820	0.003	24.784	0.004	37.259	0.000	14.880	0.000	5.580	0.000	6.233	0.000	6.885	0.000	7.538	0.000	8.191	0.000	8.843	0.000	9.497	0.000	10.153	0.000	10.810	0.000	11.466	0.000	12.123	0.000	12.779	0.000	13.436	
	0.004	14.203	0.005	28.567	0.006	47.772	0.007	71.818	0.000	29.760	0.000	11.160	0.000	12.465	0.000	13.771	0.000	15.076	0.000	16.381	0.000	17.686	0.000	18.994	0.000	20.307	0.000	21.620	0.000	22.933	0.000	24.246	0.000	25.559	0.000	26.872	
	0.005	20.114	0.007	40.456	0.009	67.654	0.011	101.708	0.000	44.640	0.000	16.740	0.000	18.698	0.000	20.656	0.000	22.614	0.000	24.572	0.000	26.529	0.000	28.491	0.000	30.460	0.000	32.430	0.000	34.399	0.000	36.368	0.000	38.338	0.000	40.307	
	0.007	24.926	0.010	50.133	0.012	83.836	0.014	126.036	0.000	59.520	0.001	22.320	0.001	24.931	0.001	27.541	0.001	30.152	0.001	32.762	0.001	35.373	0.000	37.988	0.000	40.614	0.000	43.240	0.000	45.865	0.000	48.491	0.000	51.117	0.000	53.743	
	0.009	28.651	0.012	57.627	0.015	96.368	0.018	144.876	0.001	74.400	0.002	27.900	0.002	31.163	0.002	34.426	0.002	37.689	0.002	40.953	0.002	44.216	0.001	47.485	0.001	50.767	0.001	54.049	0.001	57.332	0.001	60.614	0.001	63.896	0.001	67.179	
0.011	31.427	0.014	63.209	0.018	105.704	0.022	158.911	0.002	89.280	0.004	33.480	0.004	37.396	0.004	41.312	0.004	45.227	0.004	49.143	0.004	53.059	0.002	56.982	0.002	60.920	0.002	64.859	0.002	68.798	0.002	72.737	0.002	76.676	0.002	80.615		
0.012	33.436	0.017	67.250	0.021	112.460	0.025	169.068	0.004	104.160	0.006	39.060	0.006	43.628	0.006	48.197	0.006	52.765	0.006	57.334	0.006	61.902	0.004	66.479	0.004	71.074	0.004	75.669	0.004	80.264	0.004	84.860	0.004	89.455	0.004	94.050		
0.014	34.859	0.019	70.113	0.024	117.248	0.029	176.266	0.007	119.040	0.009	44.640	0.009	49.861	0.009	55.082	0.009	60.303	0.009	65.524	0.009	70.745	0.007	75.976	0.007	81.227	0.007	86.479	0.007	91.731	0.007	96.983	0.007	102.234	0.007	107.486		
0.016	35.853	0.021	72.111	0.027	120.590	0.032	181.290	0.011	133.920	0.013	50.220	0.013	56.094	0.013	61.967	0.013	67.841	0.013	73.715	0.013	79.588	0.011	85.472	0.011	91.381	0.011	97.289	0.011	103.197	0.011	109.105	0.011	115.014	0.011	120.922		
0.018	36.540	0.024	73.492	0.030	122.899	0.036	184.761	0.017	148.800	0.018	55.800	0.018	62.326	0.018	68.853	0.018	75.379	0.018	81.905	0.018	88.432	0.017	94.969	0.017	101.534	0.017	108.099	0.017	114.664	0.017	121.228	0.017	127.793	0.017	134.358		
0.020	37.010	0.026	74.439	0.033	124.482	0.040	187.142	0.025	163.680	0.024	61.380	0.024	68.559	0.024	75.738	0.024	82.917	0.024	90.096	0.024	97.275	0.025	104.466	0.025	111.688	0.025	118.909	0.025	126.130	0.025	133.351	0.025	140.572	0.025	147.793		
0.021	37.332	0.029	75.085	0.036	125.563	0.043	188.766	0.036	178.560	0.032	66.960	0.032	74.792	0.032	82.623	0.032	90.455	0.032	98.286	0.032	106.118	0.036	113.963	0.036	121.841	0.036	129.719	0.036	137.596	0.036	145.474	0.036	153.352	0.036	161.229		
0.023	37.550	0.031	75.524	0.039	126.298	0.047	189.871	0.049	193.440	0.040	72.540	0.040	81.024	0.040	89.508	0.040	97.993	0.040	106.477	0.040	114.961	0.049	123.460	0.049	131.994	0.049	140.528	0.049	149.063	0.049	157.597	0.049	166.131	0.049	174.665		
0.025	37.698	0.033	75.822	0.042	126.796	0.050	190.620	0.066	208.320	0.050	78.120	0.050	87.257	0.050	96.394	0.050	105.531	0.050	114.667	0.050	123.804	0.066	132.957	0.066	142.148	0.066	151.338	0.066	160.529	0.066	169.720	0.066	178.910	0.066	188.101		
0.027	37.799	0.036	76.024	0.045	127.134	0.054	191.128	0.087	223.200	0.062	83.700	0.062	93.489	0.062	103.279	0.062	113.068	0.062	122.858	0.062	132.647	0.087	142.454	0.087	152.301	0.087	162.148	0.087	171.995	0.087	181.842	0.087	191.689	0.087	201.536		
0.028	37.867	0.038	76.161	0.048	127.363	0.058	191.472	0.109	223.200	0.066	83.700	0.066	93.489	0.066	103.279	0.066	113.068	0.066	122.858	0.066	132.647	0.109	142.454	0.109	152.301	0.109	162.148	0.109	171.995	0.109	181.842	0.109	191.689	0.109	201.536		
Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)								Glacial Till																												
	z= 16.5 m		z= 17.5 m		z= 18.5 m		z= 38.5 m		z= 40.5 m		z= 42.5 m		z= 44.5 m		z= 46.5 m		z= 48.5 m		z= 50.5 m																		
	Elev. 58.2 m		Elev. 57.2 m		Elev. 56.2 m		Elev. 36.2 m		Elev. 34.2 m		Elev. 32.2 m		Elev. 30.2 m		Elev. 28.2 m		Elev. 26.2 m		Elev. 24.2 m																		
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)																	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000																	
	0.000	14.092	0.000	14.749	0.000	14.880	0.000	14.880	0.001	935.841	0.001	1010.327	0.001	1095.985	0.001	1159.298	0.001	1233.783	0.001	1308.269	0.001																
	0.000	28.184	0.000	29.497	0.000	29.760	0.000	29.760	0.002	1803.886	0.002	1947.461	0.002	2112.572	0.002	2234.611	0.002	2378.186	0.002	2521.761	0.002																
	0.000	42.277	0.000	44.246	0.000	44.640	0.000	44.640	0.003	2554.657	0.003	2757.987	0.003	2991.817	0.003	3164.648	0.003	3367.979	0.003	3571.309	0.003																
	0.000	56.369	0.000	58.995	0.000	59.520	0.000	59.520	0.004	3165.711	0.004	3417.676	0.004	3707.437	0.004	3921.608	0.004	4173.573	0.004	4425.539	0.004																
	0.001	70.461	0.001	73.744	0.001	74.400	0.001	74.400	0.005	3638.917	0.005	3928.546	0.005	4261.620	0.005	4507.804	0.005	4797.433	0.005	5087.063	0.005																
0.002	84.553	0.002	88.492	0.002	89.280	0.002	89.280	0.006	3991.451	0.006	4309.139	0.006	4674.480	0.006	4944.514	0.006	5262.202	0.006	5579.890	0.006																	
0.004	98.646	0.004	103.241	0.004	104.160	0.004	104.160	0.007	4246.578	0.007	4584.572	0.007	4973.265	0.007	5260.560	0.007	5598.554	0.008	5936.548	0.008																	
0.007	112.738	0.007	117.990	0.007	119.040	0.007	119.040	0.008	4427.363	0.008	4779.746	0.008	5184.987	0.008	5484.513	0.008	5836.896	0.009	6189.279	0.009																	
0.011	126.830	0.011	132.738	0.011	133.920	0.011	133.920	0.009	4553.565	0.009	4915.993	0.009	5332.785	0.009	5640.849	0.009	6003.276	0.010	6365.704	0.010																	
0.017	140.922	0.017	147.487	0.017	148.800	0.017	148.800	0.009	4640.746	0.010	5010.112	0.010	5434.884	0.010	5748.846	0.011	6118.212	0.011	6487.579	0.011																	
0.025	155.015	0.025	162.236	0.025	163.680	0.025	163.680	0.010	4700.535	0.011	5074.660	0.011	5504.905	0.011	5822.911	0.012	6197.037	0.012	6571.162	0.012																	
0.036	169.107	0.036	176.984	0.036	178.560	0.036	178.560	0.011	4741.335	0.012	5118.708	0.012	5552.687	0.012	5873.454	0.013	6250.827	0.013	6628.199	0.013																	
0.049	183.199	0.049	191.733	0.049	193.440	0.049	193.440	0.012	4769.084	0.013	5148.665	0.013	5585.183	0.013	5907.827	0.014	6287.409	0.014	6666.990	0.014																	
0.066	197.291	0.066	206.482	0.066	208.320	0.066	208.320	0.013	4787.911	0.014	5168.991	0.014	5607.233	0.014	5931.151	0.015	6312.230	0.015	6693.310	0.015																	
0.087	211.384	0.087	221.231	0.087	223.200	0.087	223.200	0.014	4800.666	0.015	5182.761	0.015	5622.170	0.015	5946.951	0.016	6329.046	0.016	6711.141	0.016																	



## P-Y CURVES

**Ramsayville Road Overpass  
H-Pile 310x110 - EBL West Pier (Borehole 17-1303)**

**Figure F6**

### SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - EBL WEST PIER

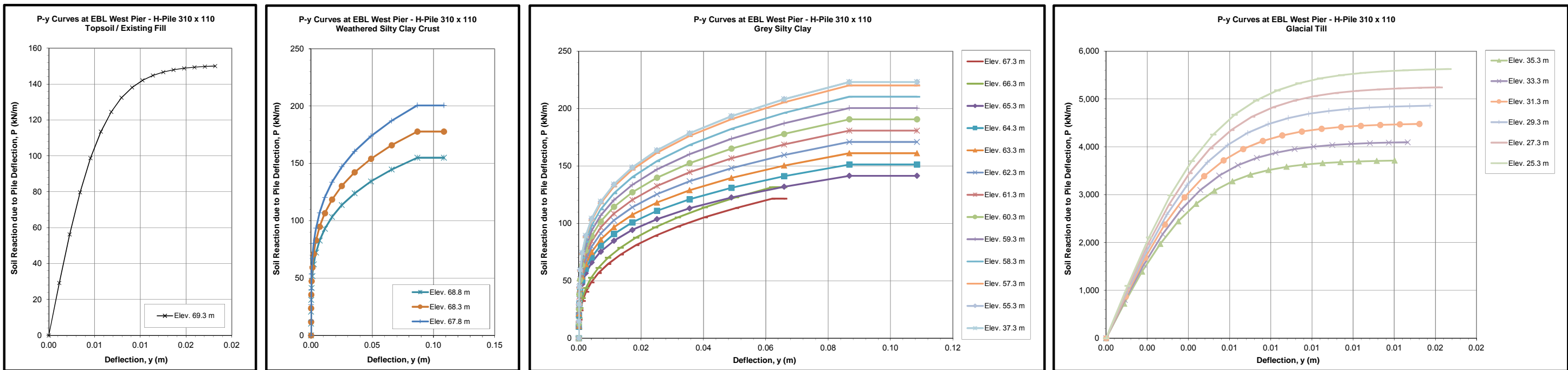
Description Depth (z) * Elevation P-y Curves	TS / Exist. Fill		Weathered Silty Clay Crust								Grey Silty Clay																								
	z= 2.0 m		z= 2.5 m		z= 3.0 m		z= 3.5 m		z= 4.0 m		z= 5.0 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 14.0 m		z= 16.0 m		z= 34.0 m		
	Elev. 69.3 m		Elev. 68.8 m		Elev. 68.3 m		Elev. 67.8 m		Elev. 67.3 m		Elev. 66.3 m		Elev. 65.3 m		Elev. 64.3 m		Elev. 63.3 m		Elev. 62.3 m		Elev. 61.3 m		Elev. 60.3 m		Elev. 59.3 m		Elev. 58.3 m		Elev. 57.3 m		Elev. 55.3 m		Elev. 37.3 m		
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.001	29.208	0.000	10.334	0.000	11.853	0.000	13.373	0.000	8.104	0.000	8.769	0.000	9.431	0.000	10.088	0.000	10.744	0.000	11.401	0.000	12.057	0.000	12.714	0.000	13.370	0.000	14.027	0.000	14.683	0.000	14.880	0.000	14.880	0.000	14.880
0.002	56.300	0.000	20.668	0.000	23.707	0.000	26.745	0.000	16.209	0.000	17.537	0.000	18.863	0.000	20.176	0.000	21.488	0.000	22.801	0.000	24.114	0.000	25.427	0.000	26.740	0.000	28.053	0.000	29.366	0.000	29.760	0.000	29.760	0.000	29.760
0.003	79.732	0.000	31.002	0.000	35.560	0.000	40.118	0.000	24.313	0.000	26.306	0.000	28.294	0.000	30.263	0.000	32.233	0.000	34.202	0.000	36.172	0.000	38.141	0.000	40.110	0.000	42.080	0.000	44.049	0.000	44.640	0.000	44.640	0.000	44.640
0.005	98.804	0.000	41.336	0.000	47.413	0.000	53.491	0.001	32.417	0.001	35.074	0.000	37.725	0.000	40.351	0.000	42.977	0.000	45.603	0.000	48.229	0.000	50.855	0.000	53.480	0.000	56.106	0.000	58.732	0.000	59.520	0.000	59.520	0.000	59.520
0.006	113.573	0.001	51.670	0.001	59.267	0.001	66.863	0.002	40.521	0.002	43.843	0.001	47.156	0.001	50.459	0.001	53.721	0.001	57.004	0.001	60.286	0.001	63.568	0.001	66.851	0.001	70.133	0.001	73.415	0.001	74.400	0.001	74.400	0.001	74.400
0.007	124.575	0.002	62.004	0.002	71.120	0.002	80.236	0.004	48.626	0.004	52.611	0.002	56.588	0.002	60.527	0.002	64.465	0.002	68.404	0.002	72.343	0.002	76.282	0.002	80.221	0.002	84.160	0.002	88.098	0.002	89.280	0.002	89.280	0.002	89.280
0.008	132.538	0.004	72.338	0.004	82.973	0.004	93.609	0.006	56.730	0.006	61.380	0.004	66.019	0.004	70.614	0.004	75.210	0.004	79.805	0.004	84.400	0.004	88.996	0.004	93.591	0.004	98.186	0.004	102.781	0.004	104.160	0.004	104.160	0.004	104.160
0.009	138.180	0.007	82.672	0.007	94.827	0.007	106.982	0.009	64.834	0.009	70.149	0.007	75.450	0.007	80.702	0.007	85.954	0.007	91.206	0.007	96.457	0.007	101.709	0.007	106.961	0.007	112.213	0.007	117.464	0.007	119.040	0.007	119.040	0.007	119.040
0.010	142.119	0.011	83.006	0.011	96.680	0.011	120.354	0.013	72.939	0.013	78.917	0.011	84.882	0.011	90.790	0.011	96.698	0.011	102.606	0.011	108.515	0.011	114.423	0.011	120.331	0.011	126.239	0.011	132.148	0.011	133.920	0.011	133.920	0.011	133.920
0.011	144.840	0.017	103.340	0.017	118.534	0.017	133.727	0.018	81.043	0.018	87.686	0.017	94.313	0.017	100.878	0.017	107.442	0.017	114.007	0.017	120.572	0.017	127.136	0.017	133.701	0.017	140.266	0.017	146.831	0.017	148.800	0.017	148.800	0.017	148.800
0.013	146.706	0.025	113.674	0.025	130.387	0.025	147.100	0.024	89.147	0.024	96.454	0.025	103.744	0.025	110.965	0.025	118.187	0.025	125.408	0.025	132.629	0.025	139.850	0.025	147.071	0.025	154.292	0.025	161.514	0.025	163.680	0.025	163.680	0.025	163.680
0.014	147.980	0.036	124.008	0.036	142.240	0.036	160.472	0.032	97.251	0.032	105.223	0.036	113.176	0.036	121.053	0.036	128.931	0.036	136.808	0.036	144.686	0.036	152.564	0.036	160.441	0.036	168.319	0.036	176.197	0.036	178.560	0.036	178.560	0.036	178.560
0.015	148.846	0.049	134.342	0.049	154.094	0.049	173.845	0.040	105.356	0.040	113.991	0.049	122.607	0.049	131.141	0.049	139.675	0.049	148.209	0.049	156.743	0.049	165.277	0.049	173.812	0.049	182.346	0.049	190.880	0.049	193.440	0.049	193.440	0.049	193.440
0.016	149.433	0.066	144.676	0.066	165.947	0.066	187.218	0.050	113.460	0.050	122.760	0.066	132.038	0.066	141.229	0.066	150.419	0.066	159.610	0.066	168.800	0.066	177.991	0.066	187.182	0.066	196.372	0.066	205.563	0.066	208.320	0.066	208.320	0.066	208.320
0.017	149.831	0.087	155.010	0.087	177.800	0.087	200.590	0.062	121.564	0.062	131.529	0.087	141.469	0.087	151.316	0.087	161.164	0.087	171.011	0.087	180.858	0.087	190.705	0.087	200.552	0.087	210.399	0.087	220.246	0.087	223.200	0.087	223.200	0.087	223.200
0.018	150.101	0.109	155.010	0.109	177.800	0.109	200.590	0.066	121.564	0.066	131.529	0.109	141.469	0.109	151.316	0.109	161.164	0.109	171.011	0.109	180.858	0.109	190.705	0.109	200.552	0.109	210.399	0.109	220.246	0.109	223.200	0.109	223.200	0.109	223.200

Description Depth (z) * Elevation P-y Curves	Glacial Till											
	z= 36.0 m		z= 38.0 m		z= 40.0 m		z= 42.0 m		z= 44.0 m		z= 46.0 m	
	Elev. 35.3 m		Elev. 33.3 m		Elev. 31.3 m		Elev. 29.3 m		Elev. 27.3 m		Elev. 25.3 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.001	722.801	0.001	797.286	0.001	871.772	0.001	946.257	0.001	1020.743	0.001	1095.229	
0.002	1393.239	0.002	1536.814	0.002	1680.389	0.002	1823.964	0.002	1967.539	0.002	2111.114	
0.003	1973.100	0.003	2176.430	0.003	2379.761	0.003	2583.091	0.003	2786.422	0.003	2989.752	
0.004	2445.050	0.004	2697.016	0.004	2948.981	0.004	3200.947	0.004	3452.912	0.004	3704.878	
0.004	2810.533	0.005	3100.162	0.005	3389.791	0.005	3679.420	0.005	3969.049	0.005	4258.678	
0.005	3082.814	0.006	3400.502	0.006	3718.189	0.006	4035.877	0.006	4353.565	0.006	4671.253	
0.006	3279.862	0.006	3617.856	0.007	3955.850	0.007	4293.844	0.007	4631.838	0.007	4969.832	
0.007	3419.493	0.007	3771.876	0.008	4124.259	0.008	4476.642	0.008	4829.025	0.008	5181.408	
0.008	3516.965	0.008	3879.393	0.009	4241.821	0.009	4604.249	0.009	4966.676	0.009	5329.104	
0.009	3584.299	0.009	3953.666	0.010	4323.033	0.010	4692.399	0.010	5061.766	0.010	5431.133	
0.010	3630.478	0.010	4004.603	0.010	4378.729	0.011	4752.854	0.011	5126.979	0.011	5501.105	
0.011	3661.990	0.011	4039.363	0.011	4416.736	0.012	4794.109	0.012	5171.482	0.012	5548.854	
0.011	3683.422	0.012	4063.003	0.012	4442.584	0.013	4822.166	0.013	5201.747	0.014	5581.328	
0.012	3697.963	0.013	4079.043	0.013	4460.123	0.014	4841.203	0.014	5222.283	0.015	5603.362	
0.013	3707.814	0.014	4089.909	0.014	4472.004	0.015	4854.099	0.015	5236.194	0.016	5618.290	
0.014	3714.481	0.015	4097.263	0.015	4480.045	0.016	4862.827	0.016	5245.609	0.017	5628.391	

**NOTES:** \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 69.8 m.

Please note the following assumptions:

1. P-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Static loading condition is considered. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.



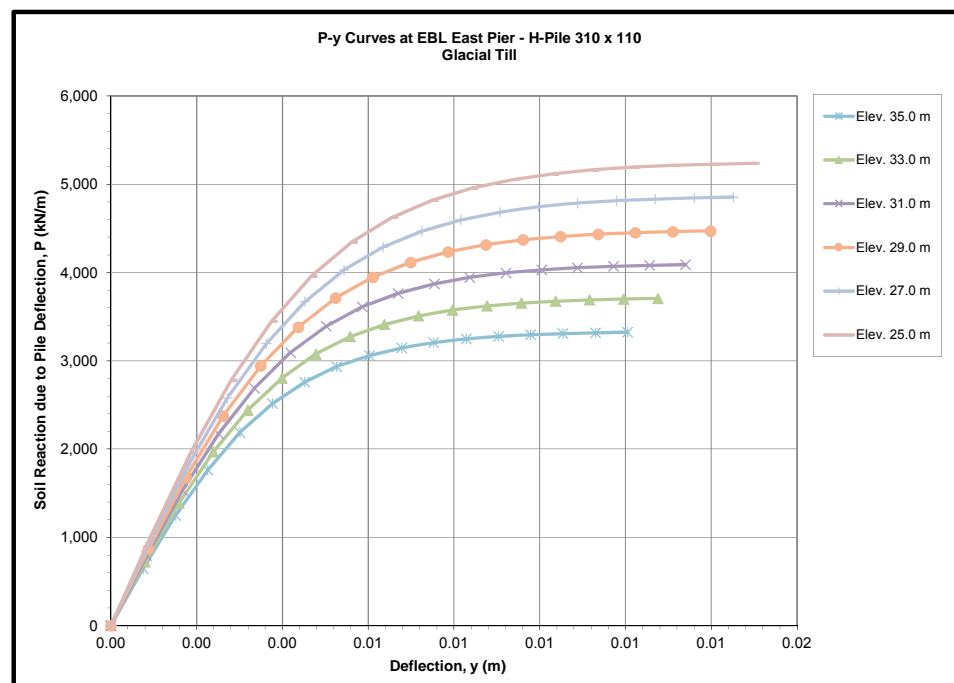
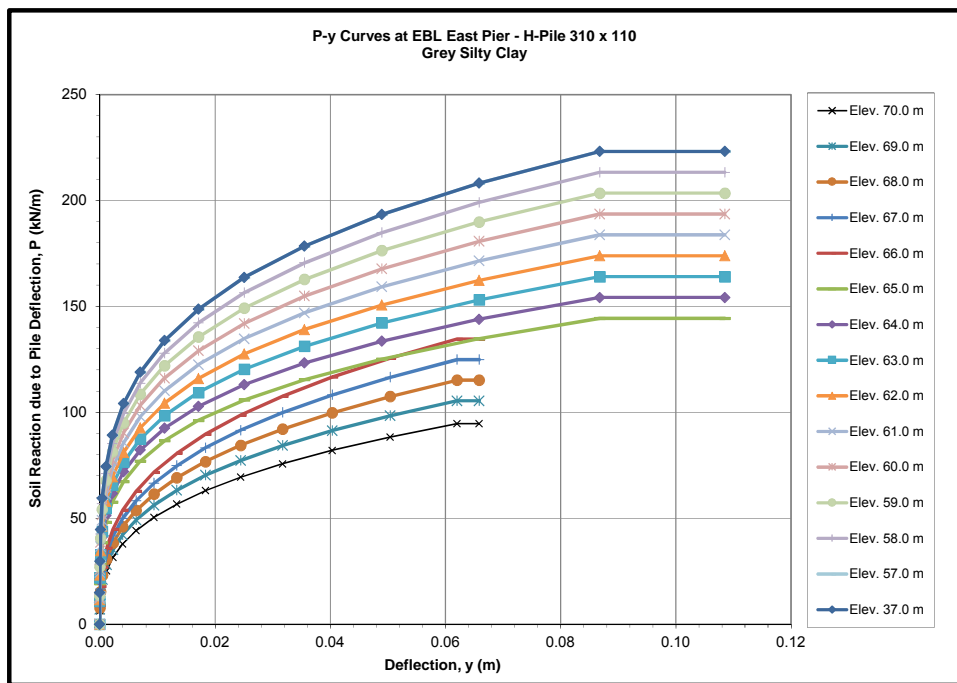


### SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - EBL EAST PIER

Description Depth (z) * Elevation P-y Curves		Grey Silty Clay																															
		z= 2.5 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m		z= 35.5 m			
		Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m		Elev. 61.0 m		Elev. 60.0 m		Elev. 59.0 m		Elev. 58.0 m		Elev. 57.0 m		Elev. 37.0 m			
		y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.000	6.313	0.000	7.033	0.000	7.681	0.000	8.328	0.000	8.976	0.000	9.628	0.000	10.285	0.000	10.941	0.000	11.598	0.000	12.254	0.000	12.911	0.000	13.567	0.000	14.224	0.000	14.880	0.000	14.880	0.000	14.880	0.000	14.880
0.000	12.625	0.000	14.066	0.000	15.362	0.000	16.657	0.000	17.952	0.000	19.256	0.000	20.569	0.000	21.882	0.000	23.195	0.000	24.508	0.000	25.821	0.000	27.134	0.000	28.447	0.000	29.760	0.000	29.760	0.000	29.760	0.000	29.760
0.000	18.938	0.000	21.099	0.000	23.042	0.000	24.985	0.000	26.928	0.000	28.885	0.000	30.854	0.000	32.824	0.000	34.793	0.000	36.762	0.000	38.732	0.000	40.701	0.000	42.671	0.000	44.640	0.000	44.640	0.000	44.640	0.000	44.640
0.001	25.250	0.001	28.133	0.001	30.723	0.001	33.314	0.001	35.905	0.000	38.513	0.000	41.139	0.000	43.765	0.000	46.391	0.000	49.016	0.000	51.642	0.000	54.268	0.000	56.894	0.000	59.520	0.000	59.520	0.000	59.520	0.000	59.520
0.002	31.563	0.002	35.166	0.002	38.404	0.002	41.642	0.002	44.881	0.001	48.141	0.001	51.424	0.001	54.706	0.001	57.988	0.001	61.271	0.001	64.553	0.001	67.835	0.001	71.118	0.001	74.400	0.001	74.400	0.001	74.400	0.001	74.400
0.004	37.875	0.004	42.199	0.004	46.085	0.004	49.971	0.004	53.857	0.002	57.769	0.002	61.708	0.002	65.647	0.002	69.586	0.002	73.525	0.002	77.464	0.002	81.402	0.002	85.341	0.002	89.280	0.002	89.280	0.002	89.280	0.002	89.280
0.006	44.188	0.006	49.232	0.006	53.766	0.006	58.299	0.006	62.833	0.004	67.398	0.004	71.993	0.004	76.588	0.004	81.184	0.004	85.779	0.004	90.374	0.004	94.969	0.004	99.565	0.004	104.160	0.004	104.160	0.004	104.160	0.004	104.160
0.009	50.500	0.009	56.265	0.009	61.446	0.009	66.628	0.009	71.809	0.007	77.026	0.007	82.278	0.007	87.529	0.007	92.781	0.007	98.033	0.007	103.285	0.007	108.536	0.007	113.788	0.007	119.040	0.007	119.040	0.007	119.040	0.007	119.040
0.013	56.813	0.013	63.298	0.013	69.127	0.013	74.956	0.013	80.785	0.011	86.654	0.011	92.562	0.011	98.471	0.011	104.379	0.011	110.287	0.011	116.195	0.011	122.104	0.011	128.012	0.011	133.920	0.011	133.920	0.011	133.920	0.011	133.920
0.018	63.126	0.018	70.331	0.018	76.808	0.018	83.285	0.018	89.762	0.017	96.282	0.017	102.847	0.017	109.412	0.017	115.976	0.017	122.541	0.017	129.106	0.017	135.671	0.017	142.235	0.017	148.800	0.017	148.800	0.017	148.800	0.017	148.800
0.024	69.438	0.024	77.364	0.024	84.498	0.024	91.613	0.024	98.738	0.025	105.911	0.025	113.132	0.025	120.353	0.025	127.574	0.025	134.795	0.025	142.016	0.025	149.238	0.025	156.459	0.025	163.680	0.025	163.680	0.025	163.680	0.025	163.680
0.032	75.751	0.032	84.398	0.032	92.170	0.032	99.942	0.032	107.714	0.036	115.539	0.036	123.416	0.036	131.294	0.036	139.172	0.036	147.049	0.036	154.927	0.036	162.805	0.036	170.682	0.036	178.560	0.036	178.560	0.036	178.560	0.036	178.560
0.040	82.063	0.040	91.431	0.040	99.850	0.040	108.270	0.040	116.690	0.049	125.167	0.049	133.701	0.049	142.235	0.049	150.769	0.049	159.304	0.049	167.838	0.049	176.372	0.049	184.906	0.049	193.440	0.049	193.440	0.049	193.440	0.049	193.440
0.050	88.376	0.050	98.464	0.050	107.531	0.050	116.599	0.050	125.666	0.066	134.795	0.066	143.986	0.066	153.176	0.066	162.367	0.066	171.558	0.066	180.748	0.066	189.939	0.066	199.129	0.066	208.320	0.066	208.320	0.066	208.320	0.066	208.320
0.062	94.688	0.062	105.497	0.062	115.212	0.062	124.927	0.062	134.642	0.087	144.424	0.087	154.271	0.087	164.118	0.087	173.965	0.087	183.812	0.087	193.659	0.087	203.506	0.087	213.353	0.087	223.200	0.087	223.200	0.087	223.200	0.087	223.200
0.066	94.688	0.066	105.497	0.066	115.212	0.066	124.927	0.066	134.642	0.109	144.424	0.109	154.271	0.109	164.118	0.109	173.965	0.109	183.812	0.109	193.659	0.109	203.506	0.109	213.353	0.109	223.200	0.109	223.200	0.109	223.200	0.109	223.200

Description Depth (z) * Elevation P-y Curves		Glacial Till											
		z= 37.5 m		z= 39.5 m		z= 41.5 m		z= 43.5 m		z= 45.5 m		z= 47.5 m	
		Elev. 35.0 m		Elev. 33.0 m		Elev. 31.0 m		Elev. 29.0 m		Elev. 27.0 m		Elev. 25.0 m	
		y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.001	646.977	0.001	721.462	0.001	795.948	0.001	870.433	0.001	944.919	0.001	1019.405	0.001	1094.959
0.002	1247.084	0.002	1390.659	0.002	1534.234	0.002	1677.809	0.002	1821.384	0.002	1964.959	0.002	2108.534
0.002	1766.116	0.002	1969.446	0.003	2172.777	0.003	2376.107	0.003	2579.438	0.003	2782.768	0.003	2986.099
0.003	2188.557	0.003	2440.523	0.003	2692.488	0.003	2944.454	0.004	3196.419	0.004	3448.385	0.004	3699.350
0.004	2515.700	0.004	2805.329	0.004	3094.958	0.004	3384.587	0.005	3674.216	0.005	3963.845	0.005	4253.174
0.005	2759.417	0.005	3077.105	0.005	3394.793	0.005	3712.481	0.005	4030.169	0.006	4347.857	0.006	4664.745
0.005	2935.795	0.006	3273.789	0.006	3611.783	0.006	3949.777	0.006	4287.771	0.007	4625.765	0.007	4961.759
0.006	3060.778	0.006	3413.161	0.007	3765.544	0.007	4117.927	0.007	4470.310	0.008	4822.693	0.008	5137.666
0.007	3148.025	0.007	3510.453	0.008	3872.881	0.008	4235.308	0.008	4597.736	0.008	4960.164	0.009	5322.598
0.008	3208.296	0.008	3577.662	0.008	3947.029	0.009	4316.396	0.009	4685.762	0.009	5055.129	0.010	5384.601
0.008	3249.630	0.009	3623.755	0.009	3997.881	0.010	4372.006	0.010	4746.131	0.010	5120.257	0.011	5449.086
0.009	3277.837	0.010	3655.209	0.010	4032.582	0.010	4409.955	0.011	4787.328	0.011	5164.701	0.012	5499.556
0.010	3297.020	0.010	3676.601	0.011	4056.182	0.011	4435.764	0.012	4815.345	0.012	5194.926	0.013	5529.981
0.011	3310.036	0.011	3691.116	0.012	4072.195	0.012	4453.275	0.013	4834.355	0.013	5215.435	0.014	5560.036
0.011	3318.854	0.012	3700.949	0.013	4083.044	0.013	4465.139	0.014	4847.234	0.014	5229.329	0.015	5590.091
0.012	3324.821	0.013	3707.603	0.013	4090.385	0.014	4473.167	0.015	4855.949	0.015	5238.731	0.016	5620.146

**NOTES:** \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 70.6 m.  
Please note the following assumptions:





SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - EBL EAST ABUTMENT

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand																Grey Silty Clay															
	z= 4.0 m		z= 4.5 m		z= 5.0 m		z= 5.5 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 14.0 m		z= 15.0 m					
	Elev. 73.0 m		Elev. 72.5 m		Elev. 72.0 m		Elev. 71.5 m		Elev. 71.0 m		Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m					
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)		
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	0.002	7.368	0.002	14.820	0.003	24.784	0.004	37.259	0.000	5.720	0.000	6.371	0.000	7.022	0.000	7.673	0.000	8.324	0.000	8.975	0.000	9.628	0.000	10.285	0.000	10.941	0.000	11.598	0.000	12.254	0.000	12.911
0.004	14.203	0.005	28.567	0.006	47.772	0.007	71.818	0.000	11.439	0.000	12.741	0.000	14.043	0.000	15.345	0.000	16.647	0.000	17.949	0.000	19.256	0.000	20.569	0.000	21.882	0.000	23.195	0.000	24.508	0.000	25.821	
0.005	20.114	0.007	40.456	0.009	67.654	0.011	101.708	0.000	17.159	0.000	19.112	0.000	21.065	0.000	23.018	0.000	24.971	0.000	26.924	0.000	28.885	0.000	30.854	0.000	32.824	0.000	34.793	0.000	36.762	0.000	38.732	
0.007	24.926	0.010	50.133	0.012	83.836	0.014	126.036	0.001	22.878	0.001	25.482	0.001	28.086	0.001	30.690	0.001	33.294	0.001	35.898	0.000	38.513	0.000	41.139	0.000	43.765	0.000	46.391	0.000	49.016	0.000	51.642	
0.009	28.651	0.012	57.627	0.015	96.368	0.018	144.876	0.002	28.598	0.002	31.853	0.002	35.108	0.002	38.363	0.002	41.618	0.002	44.873	0.001	48.141	0.001	51.424	0.001	54.706	0.001	57.988	0.001	61.271	0.001	64.553	
0.011	31.427	0.014	63.209	0.018	105.704	0.022	158.911	0.004	34.317	0.004	38.223	0.004	42.129	0.004	46.035	0.004	49.941	0.004	53.847	0.002	57.769	0.002	61.708	0.002	65.647	0.002	69.586	0.002	73.525	0.002	77.464	
0.012	33.436	0.017	67.250	0.021	112.460	0.025	169.068	0.006	40.037	0.006	44.594	0.006	49.151	0.006	53.708	0.006	58.265	0.006	62.822	0.004	67.398	0.004	71.993	0.004	76.588	0.004	81.184	0.004	85.779	0.004	90.374	
0.014	34.859	0.019	70.113	0.024	117.248	0.029	176.266	0.009	45.756	0.009	50.964	0.009	56.172	0.009	61.380	0.009	66.588	0.009	71.796	0.007	77.026	0.007	82.278	0.007	87.529	0.007	92.781	0.007	98.033	0.007	103.285	
0.016	35.853	0.021	72.111	0.027	120.590	0.032	181.290	0.013	51.476	0.013	57.335	0.013	63.194	0.013	69.053	0.013	74.912	0.013	80.771	0.011	86.654	0.011	92.562	0.011	98.471	0.011	104.379	0.011	110.285	0.011	116.195	
0.018	36.540	0.024	73.492	0.030	122.899	0.036	184.761	0.018	57.195	0.018	63.705	0.018	70.215	0.018	76.725	0.018	83.235	0.018	89.745	0.017	96.282	0.017	102.847	0.017	109.412	0.017	115.976	0.017	122.541	0.017	129.106	
0.020	37.010	0.026	74.439	0.033	124.482	0.040	187.142	0.024	62.915	0.024	70.076	0.024	77.237	0.024	84.398	0.024	91.559	0.024	98.720	0.025	105.911	0.025	113.132	0.025	120.353	0.025	127.574	0.025	134.795	0.025	142.016	
0.021	37.332	0.029	75.085	0.036	125.563	0.043	188.766	0.032	68.634	0.032	76.446	0.032	84.258	0.032	92.070	0.032	99.882	0.032	107.694	0.036	115.539	0.036	123.416	0.036	131.294	0.036	139.172	0.036	147.049	0.036	154.927	
0.023	37.550	0.031	75.524	0.039	126.298	0.047	189.871	0.040	74.354	0.040	82.817	0.040	91.280	0.040	99.743	0.040	108.206	0.040	116.669	0.049	125.167	0.049	133.701	0.049	142.235	0.049	150.769	0.049	159.304	0.049	167.838	
0.025	37.698	0.033	75.822	0.042	126.796	0.050	190.620	0.050	80.073	0.050	89.187	0.050	98.301	0.050	107.415	0.050	116.529	0.050	125.643	0.066	134.795	0.066	143.986	0.066	153.176	0.066	162.367	0.066	171.558	0.066	180.748	
0.027	37.799	0.036	76.024	0.045	127.134	0.054	191.128	0.062	85.793	0.062	95.558	0.062	105.323	0.062	115.088	0.062	124.853	0.062	134.618	0.087	144.424	0.087	154.271	0.087	164.118	0.087	173.965	0.087	183.812	0.087	193.659	
0.028	37.867	0.038	76.161	0.048	127.363	0.058	191.472	0.066	85.793	0.066	95.558	0.066	105.323	0.066	115.088	0.066	124.853	0.066	134.618	0.109	144.424	0.109	154.271	0.109	164.118	0.109	173.965	0.109	183.812	0.109	193.659	

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)																Glacial Till																																																																																																																																																																																																																																																																																																																																																													
	z= 16.0 m		z= 17.0 m		z= 18.0 m		z= 19.0 m		z= 20.0 m		z= 41.0 m		z= 43.0 m		z= 45.0 m		z= 47.0 m		z= 49.0 m		z= 51.0 m		z= 53.0 m																																																																																																																																																																																																																																																																																																																																																							
	Elev. 61.0 m		Elev. 60.0 m		Elev. 59.0 m		Elev. 58.0 m		Elev. 57.0 m		Elev. 56.0 m		Elev. 55.0 m		Elev. 54.0 m		Elev. 53.0 m		Elev. 52.0 m		Elev. 51.0 m		Elev. 50.0 m		Elev. 49.0 m		Elev. 48.0 m		Elev. 47.0 m		Elev. 46.0 m		Elev. 45.0 m		Elev. 44.0 m		Elev. 43.0 m		Elev. 42.0 m		Elev. 41.0 m		Elev. 40.0 m		Elev. 39.0 m		Elev. 38.0 m		Elev. 37.0 m		Elev. 36.0 m		Elev. 35.0 m		Elev. 34.0 m																																																																																																																																																																																																																																																																																																																							
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)</



SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - WBL EAST ABUTMENT

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand								Grey Silty Clay																									
	z= 1.0 m		z= 1.5 m		z= 2.0 m		z= 2.5 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m	
	Elev. 74.0 m		Elev. 73.5 m		Elev. 73.0 m		Elev. 72.5 m		Elev. 71.5 m		Elev. 70.5 m		Elev. 69.5 m		Elev. 68.5 m		Elev. 67.5 m		Elev. 66.5 m		Elev. 65.5 m		Elev. 64.5 m		Elev. 63.5 m		Elev. 62.5 m		Elev. 61.5 m		Elev. 60.5 m		Elev. 59.5 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.002	7.368	0.002	14.820	0.003	24.784	0.004	37.259	0.000	10.230	0.000	6.037	0.000	6.689	0.000	7.342	0.000	7.995	0.000	8.647	0.000	9.300	0.000	9.956	0.000	10.613	0.000	11.269	0.000	11.926	0.000	12.582	0.000	13.239	0.000
0.004	14.203	0.005	28.567	0.006	47.772	0.007	71.818	0.000	20.460	0.000	12.074	0.000	13.379	0.000	14.684	0.000	15.989	0.000	17.295	0.000	18.600	0.000	19.913	0.000	21.226	0.000	22.539	0.000	23.852	0.000	25.165	0.000	26.478	0.000
0.005	20.114	0.007	40.456	0.009	67.654	0.011	101.708	0.000	30.690	0.000	18.111	0.000	20.068	0.000	22.026	0.000	23.984	0.000	25.942	0.000	27.900	0.000	29.869	0.000	31.839	0.000	33.808	0.000	35.778	0.000	37.747	0.000	39.716	0.000
0.007	24.926	0.010	50.133	0.012	83.836	0.014	126.036	0.001	40.920	0.001	24.147	0.001	26.758	0.001	29.368	0.001	31.979	0.001	34.589	0.001	37.200	0.000	39.826	0.000	42.452	0.000	45.078	0.000	47.704	0.000	50.329	0.000	52.955	0.000
0.009	28.651	0.012	57.627	0.015	96.368	0.018	144.876	0.002	51.150	0.002	30.184	0.002	33.447	0.002	36.711	0.002	39.974	0.002	43.237	0.001	46.500	0.001	49.782	0.001	53.065	0.001	56.347	0.001	59.629	0.001	62.912	0.001	66.194	0.001
0.011	31.427	0.014	63.209	0.018	105.704	0.022	158.911	0.003	61.380	0.004	36.221	0.004	40.137	0.004	44.053	0.004	47.968	0.004	51.884	0.003	55.800	0.002	59.739	0.002	63.678	0.002	67.616	0.002	71.555	0.002	75.494	0.002	79.433	0.002
0.012	33.436	0.017	67.250	0.021	112.460	0.025	169.068	0.005	71.610	0.006	42.258	0.006	46.826	0.006	51.395	0.006	55.963	0.006	60.532	0.005	65.100	0.004	69.695	0.004	74.291	0.004	78.886	0.004	83.481	0.004	88.076	0.004	92.672	0.004
0.014	34.859	0.019	70.113	0.024	117.248	0.029	176.266	0.008	81.840	0.009	48.295	0.009	53.516	0.009	58.737	0.009	63.958	0.009	69.179	0.009	74.400	0.007	79.652	0.007	84.904	0.007	90.155	0.007	95.407	0.007	100.659	0.007	105.911	0.007
0.016	35.853	0.021	72.111	0.027	120.590	0.032	181.290	0.011	92.070	0.013	54.332	0.013	60.205	0.013	66.079	0.013	71.953	0.013	77.826	0.014	83.700	0.011	89.608	0.011	95.516	0.011	101.425	0.011	107.333	0.011	113.241	0.011	119.149	0.011
0.018	36.540	0.024	73.492	0.030	122.899	0.036	184.761	0.016	102.300	0.018	60.368	0.018	66.895	0.018	73.421	0.018	79.947	0.018	86.474	0.021	93.000	0.017	99.565	0.017	106.129	0.017	112.694	0.017	119.259	0.017	125.824	0.017	132.388	0.017
0.020	37.010	0.026	74.439	0.033	124.482	0.040	187.142	0.021	112.530	0.024	66.405	0.024	73.584	0.024	80.763	0.024	87.942	0.024	95.121	0.030	102.300	0.025	109.521	0.025	116.742	0.025	123.964	0.025	131.185	0.025	138.406	0.025	145.627	0.025
0.021	37.332	0.029	75.085	0.036	125.563	0.043	188.766	0.027	122.760	0.032	72.442	0.032	80.274	0.032	88.105	0.032	95.937	0.032	103.768	0.043	111.600	0.036	119.478	0.036	127.355	0.036	135.233	0.036	143.111	0.036	150.988	0.036	158.866	0.036
0.023	37.550	0.031	75.524	0.039	126.298	0.047	189.871	0.034	132.990	0.040	78.479	0.040	86.963	0.040	95.447	0.040	103.932	0.040	112.416	0.059	120.900	0.049	129.434	0.049	137.968	0.049	146.502	0.049	155.036	0.049	163.571	0.049	172.105	0.049
0.025	37.698	0.033	75.822	0.042	126.796	0.050	190.620	0.043	143.220	0.050	84.516	0.050	93.653	0.050	102.789	0.050	111.926	0.050	121.063	0.080	130.200	0.066	139.391	0.066	148.581	0.066	157.772	0.066	166.962	0.066	176.153	0.066	185.344	0.066
0.027	37.799	0.036	76.024	0.045	127.134	0.054	191.128	0.053	153.450	0.062	90.553	0.062	100.342	0.062	110.132	0.062	119.921	0.062	129.711	0.105	139.500	0.087	149.347	0.087	159.194	0.087	169.041	0.087	178.888	0.087	188.735	0.087	198.582	0.087
0.028	37.867	0.038	76.161	0.048	127.363	0.058	191.472	0.056	153.450	0.066	90.553	0.066	100.342	0.066	110.132	0.066	119.921	0.066	129.711	0.132	139.500	0.109	149.347	0.109	159.194	0.109	169.041	0.109	178.888	0.109	188.735	0.109	198.582	0.109

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)								Glacial Till									
	z= 16.5 m		z= 17.5 m		z= 18.5 m		z= 40.5 m		z= 41.5 m		z= 43.5 m		z= 45.5 m		z= 47.5 m		z= 49.5 m	
	Elev. 58.5 m		Elev. 57.5 m		Elev. 56.5 m		Elev. 34.5 m		Elev. 33.5 m		Elev. 31.5 m		Elev. 29.5 m		Elev. 27.5 m		Elev. 25.5 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.000	13.895	0.000	14.552	0.000	14.880	0.000	14.880	0.001	952.077	0.001	1026.562	0.001	1101.048	0.001	1175.533	0.001	1250.019	0.001
0.000	27.791	0.000	29.104	0.000	29.760	0.000	29.760	0.002	1835.181	0.002	1978.756	0.002	2122.331	0.002	2265.906	0.002	2409.481	0.002
0.000	41.686	0.000	43.655	0.000	44.640	0.000	44.640	0.003	2598.976	0.003	2802.307	0.003	3005.637	0.003	3208.968	0.003	3412.298	0.003
0.000	55.581	0.000	58.207	0.000	59.520	0.000	59.520	0.004	3220.632	0.004	3472.597	0.004	3724.563	0.004	3976.528	0.004	4228.494	0.004
0.001	69.476	0.001	72.759	0.001	74.400	0.001	74.400	0.005	3702.047	0.005	3991.676	0.005	4281.305	0.005	4570.935	0.005	4860.564	0.005
0.002	83.372	0.002	87.311	0.002	89.280	0.002	89.280	0.006	4060.697	0.006	4378.385	0.006	4696.073	0.006	5013.760	0.006	5331.448	0.006
0.004	97.267	0.004	101.862	0.004	104.160	0.004	104.160	0.007	4320.250	0.007	4658.244	0.007	4996.238	0.007	5334.232	0.007	5672.226	0.007
0.007	111.162	0.007	116.414	0.007	119.040	0.007	119.040	0.008	4504.172	0.008	4856.555	0.008	5208.938	0.008	5561.321	0.008	5913.704	0.008
0.011	125.058	0.011	130.966	0.011	133.920	0.011	133.920	0.009	4632.563	0.009	4994.991	0.009	5357.419	0.009	5719.847	0.009	6082.274	0.009
0.017	138.953	0.017	145.518	0.017	148.800	0.017	148.800	0.009	4721.256	0.010	5090.623	0.010	5459.989	0.010	5829.356	0.010	6198.723	0.010
0.025	152.848	0.025	160.069	0.025	163.680	0.025	163.680	0.010	4782.083	0.011	5156.208	0.011	5530.333	0.011	5904.459	0.012	6278.584	0.012
0.036	166.744	0.036	174.621	0.036	178.560	0.036	178.560	0.011	4823.591	0.012	5200.964	0.012	5578.337	0.012	5955.709	0.013	6333.082	0.013
0.049	180.639	0.049	189.173	0.049	193.440	0.049	193.440	0.012	4851.820	0.013	5231.402	0.013	5610.983	0.013	5990.564	0.014	6370.146	0.014
0.066	194.534	0.066	203.725	0.066	208.320	0.066	208.320	0.013	4870.975	0.014	5252.054	0.014	5633.134	0.014	6014.214	0.015	6395.294	0.015
0.087	208.429	0.087	218.276	0.087	223.200	0.087	223.200	0.014	4883.951	0.015	5266.046	0.015	5648.141	0.015	6030.236	0.016	6412.331	0.016
0.109	208.429	0.109	218.276	0.109	223.200	0.109	223.200	0.015	4892.732	0.016	5275.514	0.016	5658.296	0.016	6041.078	0.017	6423.860	0.017



SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - WBL EAST PIER

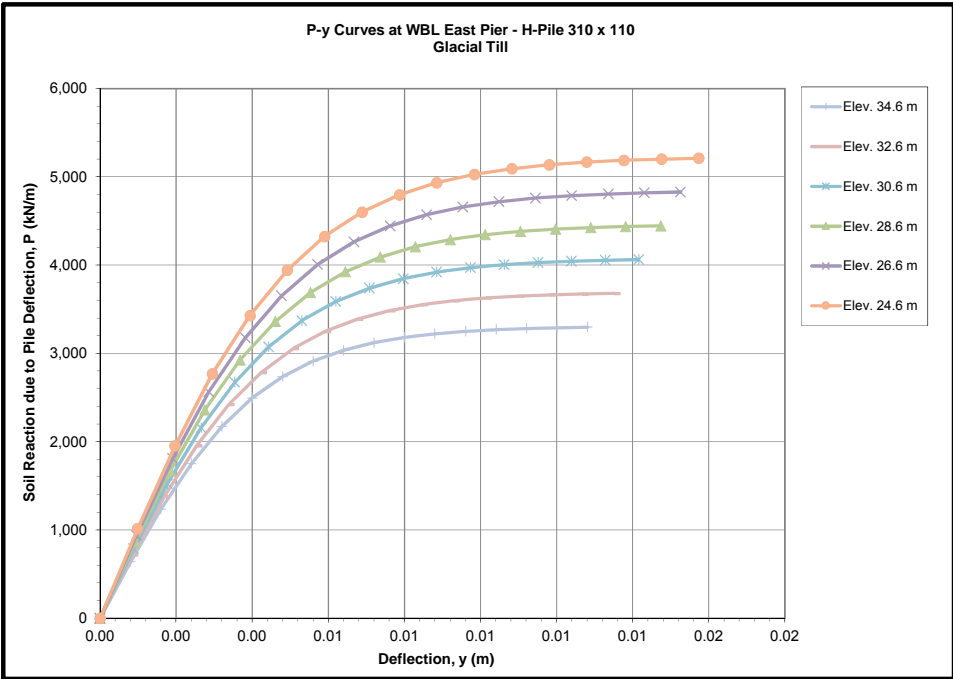
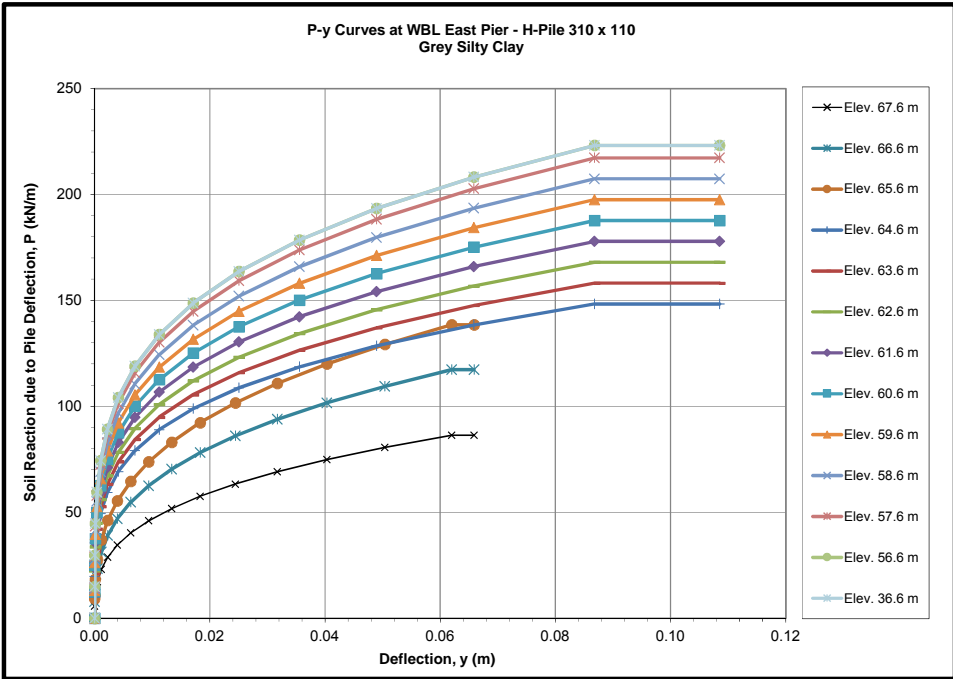
Description Depth (z) * Elevation P-y Curves	Grey Silty Clay																																
	z= 2.0 m		z= 3.0 m		z= 4.0 m		z= 5.0 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 15.0 m		z= 17.0 m		z= 33.0 m				
	Elev. 67.6 m		Elev. 66.6 m		Elev. 65.6 m		Elev. 64.6 m		Elev. 63.6 m		Elev. 62.6 m		Elev. 61.6 m		Elev. 60.6 m		Elev. 59.6 m		Elev. 58.6 m		Elev. 57.6 m		Elev. 56.6 m		Elev. 54.6 m		Elev. 52.6 m		Elev. 36.6 m				
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.000	5.760	0.000	7.824	0.000	9.235	0.000	9.891	0.000	10.547	0.000	11.204	0.000	11.860	0.000	12.517	0.000	13.173	0.000	13.830	0.000	14.486	0.000	14.880	0.000	14.880	0.000	14.880	0.000	14.880	0.000	14.880	0.000	14.880
0.000	11.521	0.000	15.648	0.000	18.471	0.000	19.782	0.000	21.095	0.000	22.408	0.000	23.720	0.000	25.033	0.000	26.346	0.000	27.659	0.000	28.972	0.000	29.760	0.000	29.760	0.000	29.760	0.000	29.760	0.000	29.760	0.000	29.760
0.000	17.281	0.000	23.472	0.000	27.706	0.000	29.672	0.000	31.642	0.000	33.611	0.000	35.581	0.000	37.550	0.000	39.520	0.000	41.489	0.000	43.458	0.000	44.640	0.000	44.640	0.000	44.640	0.000	44.640	0.000	44.640	0.000	44.640
0.001	23.041	0.001	31.296	0.001	36.941	0.000	39.563	0.000	42.189	0.000	44.815	0.000	47.441	0.000	50.067	0.000	52.693	0.000	55.319	0.000	57.944	0.000	59.520	0.000	59.520	0.000	59.520	0.000	59.520	0.000	59.520	0.000	59.520
0.002	28.802	0.002	39.120	0.002	46.177	0.001	49.454	0.001	52.736	0.001	56.019	0.001	59.301	0.001	62.584	0.001	65.866	0.001	69.148	0.001	72.431	0.001	74.400	0.001	74.400	0.001	74.400	0.001	74.400	0.001	74.400	0.001	74.400
0.004	34.562	0.004	46.944	0.004	55.412	0.002	59.345	0.002	63.284	0.002	67.223	0.002	71.161	0.002	75.100	0.002	79.039	0.002	82.978	0.002	86.917	0.002	89.280	0.002	89.280	0.002	89.280	0.002	89.280	0.002	89.280	0.002	89.280
0.006	40.322	0.006	54.768	0.006	64.647	0.004	69.236	0.004	73.831	0.004	78.426	0.004	83.022	0.004	87.617	0.004	92.212	0.004	96.808	0.004	101.403	0.004	104.160	0.004	104.160	0.004	104.160	0.004	104.160	0.004	104.160	0.004	104.160
0.009	46.082	0.009	62.592	0.009	73.882	0.007	79.127	0.007	84.378	0.007	89.630	0.007	94.882	0.007	100.134	0.007	105.385	0.007	110.637	0.007	115.889	0.007	119.040	0.007	119.040	0.007	119.040	0.007	119.040	0.007	119.040	0.007	119.040
0.013	51.843	0.013	70.415	0.013	83.118	0.011	89.017	0.011	94.926	0.011	100.834	0.011	106.742	0.011	112.650	0.011	118.559	0.011	124.467	0.011	130.375	0.011	133.920	0.011	133.920	0.011	133.920	0.011	133.920	0.011	133.920	0.011	133.920
0.018	57.603	0.018	78.239	0.018	92.353	0.017	98.908	0.017	105.473	0.017	112.038	0.017	118.602	0.017	125.167	0.017	131.732	0.017	138.296	0.017	144.861	0.017	148.800	0.017	148.800	0.017	148.800	0.017	148.800	0.017	148.800	0.017	148.800
0.024	63.363	0.024	86.063	0.024	101.588	0.025	108.799	0.025	116.020	0.025	123.241	0.025	130.463	0.025	137.684	0.025	144.905	0.025	152.126	0.025	159.347	0.025	163.680	0.025	163.680	0.025	163.680	0.025	163.680	0.025	163.680	0.025	163.680
0.032	69.124	0.032	93.887	0.032	110.824	0.036	118.690	0.036	126.568	0.036	134.445	0.036	142.323	0.036	150.200	0.036	158.078	0.036	165.956	0.036	173.833	0.036	178.560	0.036	178.560	0.036	178.560	0.036	178.560	0.036	178.560	0.036	178.560
0.040	74.884	0.040	101.711	0.040	120.059	0.049	128.581	0.049	137.115	0.049	145.649	0.049	154.183	0.049	162.717	0.049	171.251	0.049	179.785	0.049	188.320	0.049	193.440	0.049	193.440	0.049	193.440	0.049	193.440	0.049	193.440	0.049	193.440
0.050	80.644	0.050	109.535	0.050	129.294	0.066	138.472	0.066	147.662	0.066	156.853	0.066	166.043	0.066	175.234	0.066	184.424	0.066	193.615	0.066	202.806	0.066	208.320	0.066	208.320	0.066	208.320	0.066	208.320	0.066	208.320	0.066	208.320
0.062	86.405	0.062	117.359	0.062	138.530	0.087	148.362	0.087	158.209	0.087	168.056	0.087	177.904	0.087	187.751	0.087	197.598	0.087	207.445	0.087	217.292	0.087	223.200	0.087	223.200	0.087	223.200	0.087	223.200	0.087	223.200	0.087	223.200
0.066	86.405	0.066	117.359	0.066	138.530	0.109	148.362	0.109	158.209	0.109	168.056	0.109	177.904	0.109	187.751	0.109	197.598	0.109	207.445	0.109	217.292	0.109	223.200	0.109	223.200	0.109	223.200	0.109	223.200	0.109	223.200	0.109	223.200

Description Depth (z) * Elevation P-y Curves	Glacial Till											
	z= 35.0 m		z= 37.0 m		z= 39.0 m		z= 41.0 m		z= 43.0 m		z= 45.0 m	
	Elev. 34.6 m		Elev. 32.6 m		Elev. 30.6 m		Elev. 28.6 m		Elev. 26.6 m		Elev. 24.6 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.001	641.740	0.001	716.225	0.001	790.711	0.001	865.196	0.001	939.682	0.001	1014.167	
0.002	1236.989	0.002	1380.564	0.002	1524.139	0.002	1667.714	0.002	1811.289	0.002	1954.864	
0.002	1751.819	0.003	1955.150	0.003	2158.480	0.003	2361.811	0.003	2565.141	0.003	2768.471	
0.003	2170.841	0.003	2422.806	0.004	2674.772	0.004	2926.737	0.004	3178.703	0.004	3430.668	
0.004	2495.335	0.004	2784.964	0.004	3074.593	0.005	3364.222	0.005	3653.851	0.005	3943.480	
0.005	2737.080	0.005	3054.768	0.005	3372.456	0.006	3690.144	0.006	4007.831	0.006	4325.519	
0.006	2912.030	0.006	3250.024	0.006	3588.018	0.006	3926.012	0.007	4264.006	0.007	4602.000	
0.006	3036.001	0.007	3388.384	0.007	3740.767	0.007	4093.150	0.008	4445.533	0.008	4797.916	
0.007	3122.542	0.008	3484.970	0.008	3847.397	0.008	4209.825	0.009	4572.253	0.009	4934.681	
0.008	3182.325	0.008	3551.691	0.009	3921.058	0.009	4290.424	0.010	4659.791	0.010	5029.158	
0.009	3223.324	0.009	3597.450	0.010	3971.575	0.010	4345.700	0.010	4719.826	0.011	5093.951	
0.010	3251.303	0.010	3628.675	0.011	4006.048	0.011	4383.421	0.011	4760.794	0.012	5138.167	
0.010	3270.330	0.011	3649.912	0.012	4029.493	0.012	4409.074	0.012	4788.656	0.013	5168.237	
0.011	3283.241	0.012	3664.321	0.012	4045.401	0.013	4426.481	0.013	4807.560	0.014	5188.640	
0.012	3291.988	0.013	3674.083	0.013	4056.178	0.014	4438.273	0.014	4820.368	0.015	5202.463	
0.013	3297.907	0.014	3680.689	0.014	4063.471	0.015	4446.253	0.015	4829.035	0.016	5211.817	

NOTES: \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 67.6 m.

Please note the following assumptions:

1. P-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Static loading condition is considered. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - WBL WEST PIER

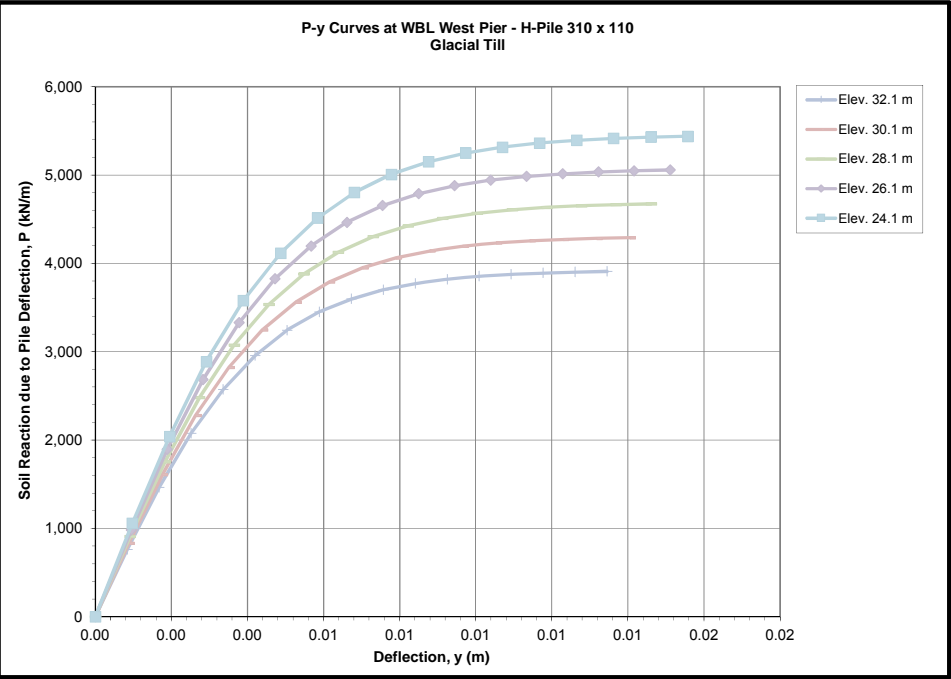
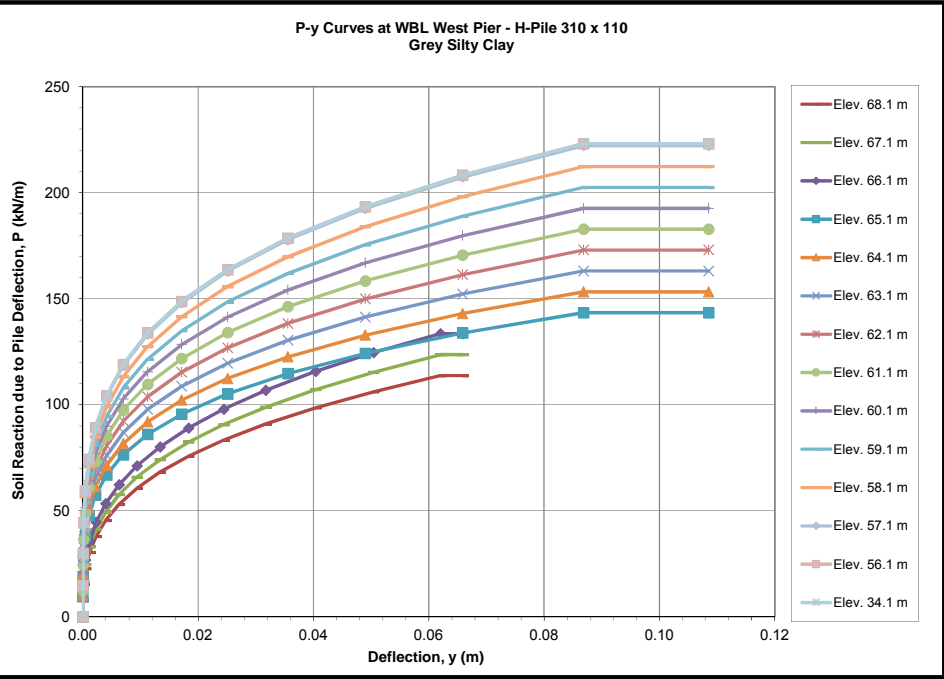
Description Depth (z) * Elevation P-y Curves	Grey Silty Clay																																	
	z= 3.0 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m		z= 37.5 m					
	Elev. 68.6 m		Elev. 68.1 m		Elev. 67.1 m		Elev. 66.1 m		Elev. 65.1 m		Elev. 64.1 m		Elev. 63.1 m		Elev. 62.1 m		Elev. 61.1 m		Elev. 60.1 m		Elev. 59.1 m		Elev. 58.1 m		Elev. 57.1 m		Elev. 56.1 m		Elev. 34.1 m					
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)				
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
	0.000	10.755	0.000	7.584	0.000	8.244	0.000	8.904	0.000	9.563	0.000	10.219	0.000	10.876	0.000	11.532	0.000	12.188	0.000	12.845	0.000	13.501	0.000	14.158	0.000	14.814	0.000	14.880	0.000	14.880				
	0.000	21.510	0.000	15.168	0.000	16.488	0.000	17.808	0.000	19.125	0.000	20.438	0.000	21.751	0.000	23.064	0.000	24.377	0.000	25.690	0.000	27.003	0.000	28.316	0.000	29.629	0.000	29.760	0.000	29.760				
	0.000	32.265	0.000	22.752	0.000	24.732	0.000	26.712	0.000	28.688	0.000	30.657	0.000	32.627	0.000	34.596	0.000	36.565	0.000	38.535	0.000	40.504	0.000	42.474	0.000	44.443	0.000	44.640	0.000	44.640				
	0.001	43.020	0.001	30.336	0.001	32.976	0.001	35.616	0.000	38.250	0.000	40.876	0.000	43.502	0.000	46.128	0.000	48.754	0.000	51.380	0.000	54.006	0.000	56.632	0.000	59.257	0.000	59.520	0.000	59.520				
	0.002	53.775	0.002	37.920	0.002	41.220	0.002	44.520	0.001	47.813	0.001	51.095	0.001	54.378	0.001	57.660	0.001	60.942	0.001	64.225	0.001	67.507	0.001	70.789	0.001	74.072	0.001	74.400	0.001	74.400				
	0.003	64.530	0.004	45.504	0.004	49.464	0.004	53.424	0.002	57.376	0.002	61.314	0.002	65.253	0.002	69.192	0.002	73.131	0.002	77.070	0.002	81.008	0.002	84.947	0.002	88.886	0.002	89.280	0.002	89.280				
	0.005	75.285	0.006	53.088	0.006	57.708	0.006	62.328	0.004	66.938	0.004	71.533	0.004	76.129	0.004	80.724	0.004	85.319	0.004	89.915	0.004	94.510	0.004	99.105	0.004	103.700	0.004	104.160	0.004	104.160				
	0.008	86.040	0.009	60.672	0.009	65.952	0.009	71.232	0.007	76.501	0.007	81.752	0.007	87.004	0.007	92.256	0.007	97.508	0.007	102.760	0.007	108.011	0.007	113.263	0.007	118.515	0.007	119.040	0.007	119.040				
	0.011	96.795	0.013	68.256	0.013	74.196	0.013	80.136	0.011	86.063	0.011	91.972	0.011	97.880	0.011	103.788	0.011	109.696	0.011	115.604	0.011	121.513	0.011	127.421	0.011	133.329	0.011	133.920	0.011	133.920				
	0.016	107.550	0.018	75.840	0.018	82.440	0.018	89.040	0.017	95.626	0.017	102.191	0.017	108.755	0.017	115.320	0.017	121.885	0.017	128.449	0.017	135.014	0.017	141.579	0.017	148.144	0.017	148.800	0.017	148.800				
	0.021	118.305	0.024	83.424	0.024	90.684	0.024	97.944	0.025	105.188	0.025	112.410	0.025	119.631	0.025	126.852	0.025	134.073	0.025	141.294	0.025	148.516	0.025	155.737	0.025	162.958	0.025	163.680	0.025	163.680				
	0.027	129.060	0.032	91.008	0.032	98.928	0.032	106.848	0.036	114.751	0.036	122.629	0.036	130.506	0.036	138.384	0.036	146.262	0.036	154.139	0.036	162.017	0.036	169.895	0.036	177.772	0.036	178.560	0.036	178.560				
	0.034	139.815	0.040	98.592	0.040	107.172	0.040	115.752	0.049	124.314	0.049	132.848	0.049	141.382	0.049	149.916	0.049	158.450	0.049	166.984	0.049	175.518	0.049	184.052	0.049	192.587	0.049	193.440	0.049	193.440				
	0.043	150.570	0.050	106.176	0.050	115.416	0.050	124.656	0.066	133.876	0.066	143.067	0.066	152.257	0.066	161.448	0.066	170.639	0.066	179.829	0.066	189.020	0.066	198.210	0.066	207.401	0.066	208.320	0.066	208.320				
	0.053	161.325	0.062	113.760	0.062	123.660	0.062	133.560	0.087	143.439	0.087	153.286	0.087	163.133	0.087	172.980	0.087	182.827	0.087	192.674	0.087	202.521	0.087	212.368	0.087	222.215	0.087	223.200	0.087	223.200				
	0.056	161.325	0.066	113.760	0.066	123.660	0.066	133.560	0.109	143.439	0.109	153.286	0.109	163.133	0.109	172.980	0.109	182.827	0.109	192.674	0.109	202.521	0.109	212.368	0.109	222.215	0.109	223.200	0.109	223.200				

Description Depth (z) * Elevation P-y Curves	Glacial Till									
	z= 39.5 m		z= 41.5 m		z= 43.5 m		z= 45.5 m		z= 47.5 m	
	Elev. 32.1 m		Elev. 30.1 m		Elev. 28.1 m		Elev. 26.1 m		Elev. 24.1 m	
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.001	760.742	0.001	835.227	0.001	909.713	0.001	984.198	0.001	1058.684
	0.002	1466.372	0.002	1609.947	0.002	1753.522	0.002	1897.097	0.002	2040.673
	0.003	2076.671	0.003	2280.002	0.003	2483.332	0.003	2686.663	0.003	2889.993
	0.003	2573.395	0.004	2825.361	0.004	3077.326	0.004	3329.292	0.004	3581.257
	0.004	2958.063	0.004	3247.692	0.005	3537.321	0.005	3826.950	0.005	4116.579
	0.005	3244.636	0.005	3562.324	0.005	3880.012	0.006	4197.700	0.006	4515.388
	0.006	3452.028	0.006	3790.022	0.006	4128.016	0.007	4466.010	0.007	4804.004
	0.007	3598.988	0.007	3951.371	0.007	4303.754	0.008	4656.137	0.008	5008.520
	0.008	3701.577	0.008	4064.005	0.008	4426.432	0.009	4788.860	0.009	5151.288
	0.008	3772.445	0.009	4141.812	0.009	4511.179	0.009	4880.545	0.010	5249.912
	0.009	3821.048	0.010	4195.173	0.010	4569.299	0.010	4943.424	0.011	5317.550
	0.010	3854.215	0.011	4231.587	0.011	4608.960	0.011	4986.333	0.012	5363.706
	0.011	3876.771	0.011	4256.352	0.012	4635.933	0.012	5015.515	0.013	5395.096
	0.012	3892.076	0.012	4273.156	0.013	4654.235	0.013	5035.315	0.014	5416.395
	0.013	3902.444	0.013	4284.539	0.014	4666.634	0.014	5048.729	0.015	5430.824
	0.013	3909.461	0.014	4292.243	0.015	4675.025	0.015	5057.807	0.016	5440.589

NOTES: \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 68.6 m.

Please note the following assumptions:

1. P-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Static loading condition is considered. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





SUMMARY OF P-Y CURVES FOR H-PILE 310x110 - WBL WEST ABUTMENT

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand																Grey Silty Clay																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	z= 3.0 m				z= 3.5 m				z= 4.0 m				z= 4.5 m				z= 5.0 m				z= 6.0 m				z= 7.0 m				z= 8.0 m				z= 9.0 m				z= 10.0 m				z= 11.0 m				z= 12.0 m				z= 13.0 m				z= 14.0 m				z= 15.0 m				z= 16.0 m				z= 17.0 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	Elev. 74.0 m		Elev. 73.5 m		Elev. 73.0 m		Elev. 72.5 m		Elev. 72.0 m		Elev. 71.0 m		Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m		Elev. 61.0 m		Elev. 60.0 m																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



**SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - EBL WEST ABUTMENT**

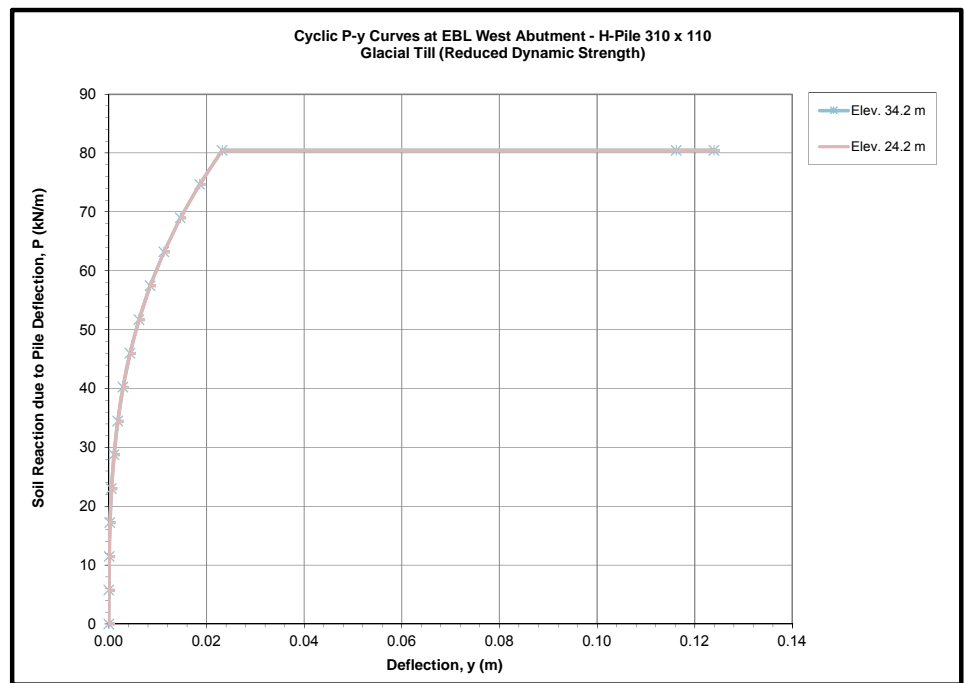
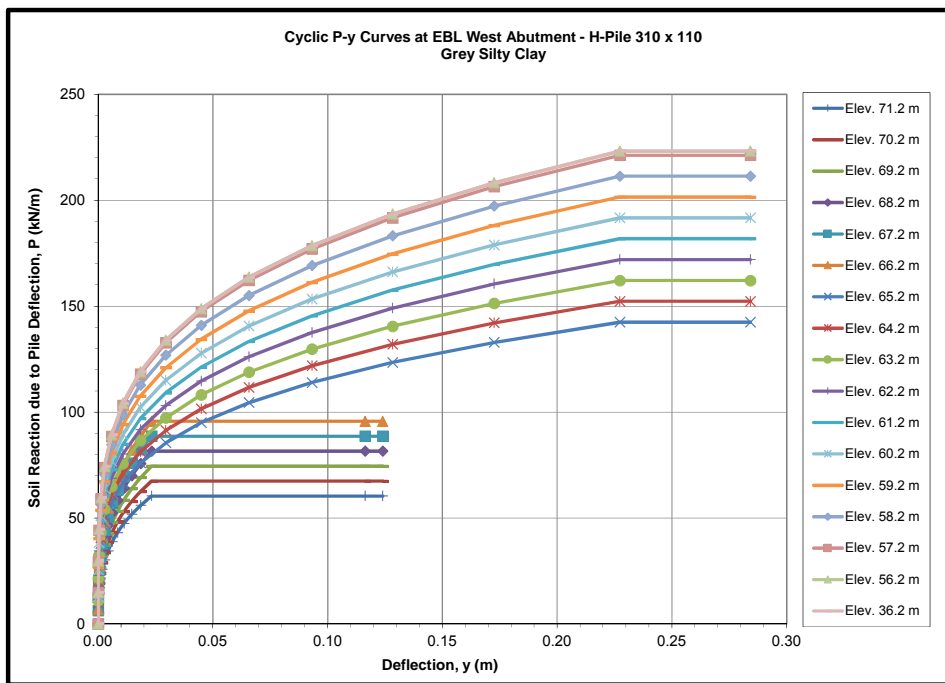
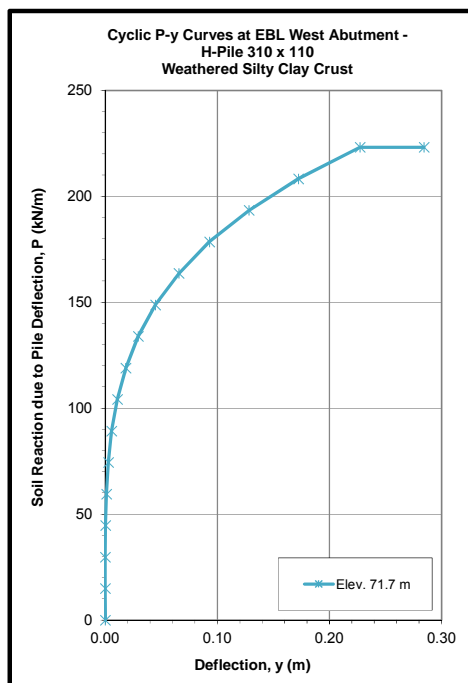
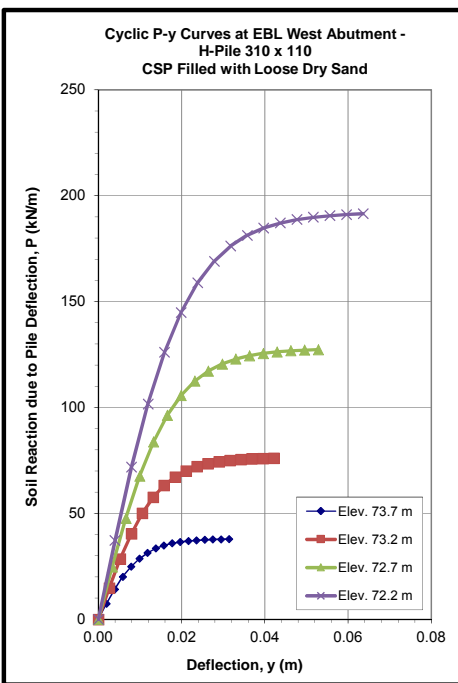
Description		CSP Filled with Loose Dry Sand								Wrhrd SC Crust		Grey Silty Clay																								
Depth (z) *	Elevation	z= 1.0 m		z= 1.5 m		z= 2.0 m		z= 2.5 m		z= 3.0 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		
P-y Curves		Elev. 73.7 m		Elev. 73.2 m		Elev. 72.7 m		Elev. 72.2 m		Elev. 71.7 m		Elev. 71.2 m		Elev. 70.2 m		Elev. 69.2 m		Elev. 68.2 m		Elev. 67.2 m		Elev. 66.2 m		Elev. 65.2 m		Elev. 64.2 m		Elev. 63.2 m		Elev. 62.2 m		Elev. 61.2 m		Elev. 60.2 m		
		y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	0.002	7.368	0.003	14.820	0.003	24.784	0.004	37.259	0.000	14.880	0.000	4.311	0.000	4.816	0.000	5.320	0.000	5.824	0.000	6.328	0.000	6.833	0.000	7.337	0.000	7.842	0.000	8.347	0.000	8.852	0.000	9.357	0.000	9.862	0.000	10.367
	0.004	14.203	0.005	28.567	0.007	47.772	0.008	71.818	0.000	29.760	0.000	8.623	0.000	9.631	0.000	10.640	0.000	11.648	0.000	12.657	0.000	13.665	0.000	14.673	0.000	15.681	0.000	16.689	0.000	17.697	0.000	18.705	0.000	19.713	0.000	20.721
	0.006	20.114	0.008	40.456	0.010	67.854	0.012	101.708	0.000	44.640	0.000	12.934	0.000	14.447	0.000	15.959	0.000	17.472	0.000	18.985	0.000	20.498	0.000	22.011	0.000	23.524	0.000	25.037	0.000	26.550	0.000	28.063	0.000	29.576	0.000	31.089
	0.008	24.926	0.011	50.133	0.013	83.836	0.016	126.036	0.001	59.520	0.001	17.245	0.001	19.262	0.001	21.279	0.001	23.296	0.001	25.313	0.001	27.330	0.001	29.347	0.001	31.364	0.001	33.381	0.001	35.398	0.001	37.415	0.001	39.432	0.001	41.449
	0.010	28.651	0.013	57.627	0.017	96.368	0.020	144.876	0.003	74.400	0.001	21.556	0.001	24.078	0.001	26.599	0.001	29.120	0.001	31.641	0.001	34.163	0.003	36.684	0.003	39.205	0.003	41.726	0.003	44.247	0.003	46.768	0.003	49.289	0.003	51.810
	0.012	31.427	0.016	63.209	0.020	105.704	0.024	158.911	0.006	89.280	0.002	25.868	0.002	28.893	0.002	31.919	0.002	34.944	0.002	37.970	0.002	40.995	0.006	44.020	0.006	47.045	0.006	50.070	0.006	53.095	0.006	56.120	0.006	59.145	0.006	62.170
	0.014	33.436	0.018	67.250	0.023	112.460	0.028	169.068	0.011	104.160	0.003	30.179	0.003	33.709	0.003	37.239	0.003	40.768	0.003	44.298	0.003	47.828	0.011	51.358	0.011	54.888	0.011	58.418	0.011	61.948	0.011	65.478	0.011	69.008	0.011	72.538
	0.016	34.859	0.021	70.113	0.026	117.248	0.032	176.266	0.018	119.040	0.004	34.490	0.004	38.524	0.004	42.558	0.004	46.592	0.004	50.626	0.004	54.660	0.018	58.694	0.018	62.728	0.018	66.762	0.018	70.796	0.018	74.829	0.018	78.862	0.018	82.895
	0.018	35.853	0.024	72.111	0.030	120.590	0.036	181.290	0.029	133.920	0.006	38.802	0.006	43.340	0.006	47.878	0.006	52.416	0.006	56.954	0.006	61.493	0.029	66.031	0.029	70.569	0.029	75.107	0.029	79.645	0.029	84.183	0.029	88.721	0.029	93.259
	0.020	36.540	0.026	73.492	0.033	122.899	0.040	184.761	0.045	148.800	0.008	43.113	0.008	48.155	0.008	53.198	0.008	58.240	0.008	63.283	0.008	68.325	0.045	73.367	0.045	78.409	0.045	83.451	0.045	88.493	0.045	93.535	0.045	98.577	0.045	103.619
	0.022	37.010	0.029	74.439	0.036	124.882	0.044	187.142	0.066	163.680	0.011	47.424	0.011	52.971	0.011	58.518	0.011	64.064	0.011	69.611	0.011	75.158	0.066	80.705	0.066	85.747	0.066	90.789	0.066	95.831	0.066	100.873	0.066	105.915	0.066	110.957
	0.024	37.332	0.032	75.085	0.040	125.563	0.048	188.766	0.093	178.560	0.015	51.736	0.015	57.786	0.015	63.837	0.015	69.888	0.015	75.939	0.015	81.990	0.093	87.041	0.093	92.092	0.093	97.143	0.093	102.194	0.093	107.245	0.093	112.296	0.093	117.347
	0.026	37.550	0.034	75.524	0.043	126.298	0.052	189.871	0.128	193.440	0.019	56.047	0.019	62.602	0.019	69.157	0.019	75.712	0.019	82.267	0.019	88.822	0.128	93.873	0.128	98.924	0.128	103.975	0.128	109.026	0.128	114.077	0.128	119.128	0.128	124.179
	0.027	37.698	0.037	75.822	0.046	126.796	0.056	190.620	0.173	208.320	0.023	60.368	0.023	67.418	0.023	74.477	0.023	81.536	0.023	88.596	0.023	95.655	0.173	100.706	0.173	105.757	0.173	110.808	0.173	115.859	0.173	120.910	0.173	125.961	0.173	131.012
	0.029	37.799	0.040	76.024	0.050	127.134	0.060	191.128	0.227	223.200	0.116	60.358	0.116	67.418	0.116	74.477	0.116	81.536	0.116	88.596	0.116	95.655	0.227	100.706	0.227	105.757	0.227	110.808	0.227	115.859	0.227	120.910	0.227	125.961	0.227	131.012
	0.031	37.867	0.042	76.161	0.053	127.363	0.064	191.472	0.284	223.200	0.124	60.358	0.124	67.418	0.124	74.477	0.124	81.536	0.124	88.596	0.124	95.655	0.284	100.706	0.284	105.757	0.284	110.808	0.284	115.859	0.284	120.910	0.284	125.961	0.284	131.012

Description		Grey Silty Clay (continued)								Glacial Till				Zone of reduced dynamic strength from elevation 35.0 m to 23.3 m.			
Depth (z) *	Elevation	z= 15.5 m		z= 16.5 m		z= 17.5 m		z= 18.5 m		z= 38.5 m		z= 40.5 m				z= 50.5 m	
P-y Curves		Elev. 59.2 m		Elev. 58.2 m		Elev. 57.2 m		Elev. 56.2 m		Elev. 56.2 m		Elev. 34.2 m				Elev. 24.2 m	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	0.000	13.436	0.000	14.092	0.000	14.749	0.000	14.880	0.000	14.880	0.000	5.748	0.000	5.748	0.000		
	0.000	26.872	0.000	28.184	0.000	29.497	0.000	29.760	0.000	29.760	0.000	11.497	0.000	11.497	0.000		
	0.000	40.307	0.000	42.277	0.000	44.246	0.000	44.640	0.000	44.640	0.000	17.245	0.000	17.245	0.000		
	0.001	53.743	0.001	56.369	0.001	58.995	0.001	59.520	0.001	59.520	0.001	22.994	0.001	22.994	0.001		
	0.003	67.179	0.003	70.461	0.003	73.744	0.003	74.400	0.003	74.400	0.003	28.742	0.001	28.742	0.001		
	0.006	80.615	0.006	84.553	0.006	88.492	0.006	89.280	0.006	89.280	0.006	34.490	0.002	34.490	0.002		
	0.011	94.050	0.011	98.646	0.011	103.241	0.011	104.160	0.011	104.160	0.011	40.239	0.003	40.239	0.003		
	0.018	107.486	0.018	112.738	0.018	117.990	0.018	119.040	0.018	119.040	0.018	45.987	0.004	45.987	0.004		
	0.029	120.922	0.029	126.830	0.029	132.738	0.029	133.920	0.029	133.920	0.029	51.736	0.006	51.736	0.006		
	0.045	134.358	0.045	140.922	0.045	147.487	0.045	148.800	0.045	148.800	0.045	57.484	0.008	57.484	0.008		
	0.066	147.793	0.066	155.015	0.066	162.236	0.066	163.680	0.066	163.680	0.066	63.232	0.011	63.232	0.011		
	0.093	161.229	0.093	169.107	0.093	176.984	0.093	178.560	0.093	178.560	0.093	68.981	0.015	68.981	0.015		
	0.128	174.665	0.128	183.199	0.128	191.733	0.128	193.440	0.128	193.440	0.128	74.729	0.019	74.729	0.019		
	0.173	188.101	0.173	197.291	0.173	206.482	0.173	208.320	0.173	208.320	0.173	80.478	0.023	80.478	0.023		
	0.227	201.536	0.227	211.384	0.227	221.231	0.227	223.200	0.227	223.200	0.227	80.478	0.116	80.478	0.116		
	0.284	201.536	0.284	211.384	0.284	221.231	0.284	223.200	0.284	223.200	0.284	80.478	0.124	80.478	0.124		

**NOTES:** \* Depth (z) is measured to be positive below the existing ground surface. A surcharge load equal to half of the proposed embankment height is assumed. Underside of abutment wall at Elev. 74.2 m.

Please note the following assumptions:

1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Cyclic loading condition is considered and 500 cycles of loading are assumed. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





**SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - EBL WEST PIER**

Zone of reduced  
dynamic strength from  
elevation 29.3 m to  
27.3 m.

Please note the following assumptions:

1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Cyclic loading condition is considered and 500 cycles of loading are assumed. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - EBL EAST PIER

SUMMARY OF CYCLIC P-Y CURVES FOR HP-PILE 310X110 - EBL EAST PIER																																
Description Depth (z) * Elevation P-y Curves	Grey Silty Clay																															
	z= 2.5 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m		z= 35.5 m			
	Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m		Elev. 61.0 m		Elev. 60.0 m		Elev. 59.0 m		Elev. 58.0 m		Elev. 57.0 m		Elev. 37.0 m			
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	4.934	0.000	5.434	0.000	5.934	0.000	6.435	0.000	6.935	0.000	9.628	0.000	10.285	0.000	10.941	0.000	11.598	0.000	12.254	0.000	12.911	0.000	13.567	0.000	14.224	0.000	14.880	0.000	14.880	0.000	14.880
	0.000	9.867	0.000	10.868	0.000	11.869	0.000	12.870	0.000	13.871	0.000	19.256	0.000	20.569	0.000	21.882	0.000	23.195	0.000	24.508	0.000	25.821	0.000	27.134	0.000	28.447	0.000	29.760	0.000	29.760	0.000	29.760
	0.000	14.801	0.000	16.302	0.000	17.803	0.000	19.305	0.000	20.806	0.000	28.885	0.000	30.854	0.000	32.824	0.000	34.793	0.000	36.762	0.000	38.732	0.000	40.701	0.000	42.671	0.000	44.640	0.000	44.640	0.000	44.640
	0.001	19.734	0.001	21.736	0.001	23.738	0.001	25.739	0.001	27.741	0.001	38.513	0.001	41.139	0.001	43.765	0.001	46.391	0.001	49.016	0.001	51.642	0.001	54.268	0.001	56.894	0.001	59.520	0.001	59.520	0.001	59.520
	0.001	24.668	0.001	27.170	0.001	29.672	0.001	32.174	0.001	34.676	0.003	48.141	0.003	51.424	0.003	54.706	0.003	57.988	0.003	61.271	0.003	64.553	0.003	67.835	0.003	71.118	0.003	74.400	0.003	74.400	0.003	74.400
	0.002	29.602	0.002	32.604	0.002	35.607	0.002	38.609	0.002	41.612	0.006	57.769	0.006	61.708	0.006	65.647	0.006	69.586	0.006	73.525	0.006	77.464	0.006	81.402	0.006	85.341	0.006	89.280	0.006	89.280	0.006	89.280
	0.003	34.535	0.003	38.038	0.003	41.541	0.003	45.044	0.003	48.547	0.011	67.398	0.011	71.993	0.011	76.588	0.011	81.184	0.011	85.779	0.011	90.374	0.011	94.969	0.011	99.565	0.011	104.160	0.011	104.160	0.011	104.160
	0.004	39.469	0.004	43.472	0.004	47.476	0.004	51.479	0.004	55.482	0.018	77.026	0.018	82.278	0.018	87.529	0.018	92.781	0.018	98.033	0.018	103.285	0.018	108.536	0.018	113.788	0.018	119.040	0.018	119.040	0.018	119.040
	0.006	44.403	0.006	48.906	0.006	53.410	0.006	57.914	0.006	62.418	0.029	86.654	0.029	92.562	0.029	98.471	0.029	104.379	0.029	110.287	0.029	116.195	0.029	122.104	0.029	128.012	0.029	133.920	0.029	133.920	0.029	133.920
	0.008	49.336	0.008	54.340	0.008	59.344	0.008	64.349	0.008	69.353	0.045	96.282	0.045	102.847	0.045	109.412	0.045	115.976	0.045	122.541	0.045	129.106	0.045	135.671	0.045	142.235	0.045	148.800	0.045	148.800	0.045	148.800
	0.011	54.270	0.011	59.774	0.011	65.279	0.011	70.784	0.011	76.288	0.066	105.911	0.066	113.132	0.066	120.353	0.066	127.574	0.066	134.795	0.066	142.016	0.066	149.238	0.066	156.459	0.066	163.680	0.066	163.680	0.066	163.680
	0.015	59.203	0.015	65.208	0.015	71.213	0.015	77.218	0.015	83.223	0.093	115.539	0.093	123.416	0.093	131.294	0.093	139.172	0.093	147.049	0.093	154.927	0.093	162.805	0.093	170.682	0.093	178.560	0.093	178.560	0.093	178.560
	0.019	64.137	0.019	70.642	0.019	77.148	0.019	83.653	0.019	90.159	0.128	125.167	0.128	133.701	0.128	142.235	0.128	150.769	0.128	159.304	0.128	167.838	0.128	176.372	0.128	184.906	0.128	193.440	0.128	193.440	0.128	193.440
	0.023	69.071	0.023	76.076	0.023	83.082	0.023	90.088	0.023	97.094	0.173	134.795	0.173	143.986	0.173	153.176	0.173	162.367	0.173	171.558	0.173	180.748	0.173	189.939	0.173	199.129	0.173	208.320	0.173	208.320	0.173	208.320
	0.116	69.071	0.116	76.076	0.116	83.082	0.116	90.088	0.116	97.094	0.227	144.424	0.227	154.271	0.227	164.118	0.227	173.965	0.227	183.812	0.227	193.659	0.227	203.506	0.227	213.353	0.227	223.200	0.227	223.200	0.227	223.200
	0.124	69.071	0.124	76.076	0.124	83.082	0.124	90.088	0.124	97.094	0.284	144.424	0.284	154.271	0.284	164.118	0.284	173.965	0.284	183.812	0.284	193.659	0.284	203.506	0.284	213.353	0.284	223.200	0.284	223.200	0.284	223.200
Description Depth (z) * Elevation P-y Curves	Glacial Till												Zone of reduced dynamic strength from elevation 35.3 m to 32.5 m.																			
	z= 37.5 m		z= 39.5 m		z= 41.5 m		z= 43.5 m		z= 45.5 m		z= 47.5 m																					
	Elev. 35.0 m		Elev. 33.0 m		Elev. 31.0 m		Elev. 29.0 m		Elev. 27.0 m		Elev. 25.0 m																					
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)																				
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000																				
	0.000	5.748	0.000	5.748	0.001	795.948	0.001	870.433	0.001	944.919	0.001	1019.405																				
	0.000	11.497	0.000	11.497	0.002	1534.234	0.002	1677.809	0.002	1821.384	0.002	1964.959																				
	0.000	17.245	0.000	17.245	0.003	2172.777	0.003	2376.107	0.003	2579.438	0.003	2782.768																				
	0.001	22.994	0.001	22.994	0.003	2692.488	0.003	2944.454	0.004	3196.419	0.004	3448.385																				
	0.001	28.742	0.001	28.742	0.004	3094.958	0.004	3384.587	0.005	3674.216	0.005	3963.845																				
	0.002	34.490	0.002	34.490	0.005	3394.793	0.005	3712.481	0.005	4030.169	0.006	4347.857																				
	0.003	40.239	0.003	40.239	0.006	3611.783	0.006	3949.777	0.006	4287.771	0.007	4625.765																				
	0.004	45.987	0.004	45.987	0.007	3765.544	0.007	4117.927	0.007	4470.310	0.008	4822.693																				
	0.006	51.736	0.006	51.736	0.008	3872.881	0.008	4235.308	0.008	4597.736	0.008	4960.164																				
	0.008	57.484	0.008	57.484	0.008	3947.029	0.009	4316.396	0.009	4685.762	0.009	5055.129																				
	0.011	63.232	0.011	63.232	0.009	3997.881	0.010	4372.006	0.010	4746.131	0.010	5120.257																				
	0.015	68.981	0.015	68.981	0.010	4032.582	0.010	4409.955	0.011	4787.328	0.011	5164.701																				
	0.019	74.729	0.019	74.729	0.011	4056.182	0.011	4435.764	0.012	4815.345	0.012	5194.926																				
	0.023	80.478	0.023	80.478	0.012	4072.195	0.012	4453.275	0.013	4834.355	0.013	5215.435																				
	0.116	80.478	0.116	80.478	0.013	4083.044	0.013	4465.139	0.014	4847.234	0.014	5229.329																				
	0.124	80.478	0.124	80.478	0.013	4090.385	0.014	4473.167	0.015	4855.949	0.015	5238.731																				

NOTES: \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 70.6 m.  
Please note the following assumptions:

1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.



SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - EBL EAST ABUTMENT

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand								Grey Silty Clay																						
	z= 4.0 m		z= 4.5 m		z= 5.0 m		z= 5.5 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 14.0 m		z= 15.0 m				
	Elev. 73.0 m		Elev. 72.5 m		Elev. 72.0 m		Elev. 71.5 m		Elev. 71.0 m		Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m				
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.002	7.368	0.003	14.820	0.003	24.784	0.004	37.259	0.000	4.419	0.000	4.922	0.000	5.425	0.000	5.928	0.000	6.431	0.000	6.934	0.000	7.437	0.000	7.940	0.000	8.443	0.000	8.946	0.000	9.449	0.000	9.952
0.004	14.203	0.005	28.567	0.007	47.772	0.008	71.818	0.000	8.838	0.000	9.844	0.000	10.850	0.000	11.856	0.000	12.862	0.000	13.868	0.000	14.874	0.000	15.880	0.000	16.886	0.000	17.892	0.000	18.898	0.000	19.904
0.006	20.114	0.008	40.456	0.010	67.654	0.012	101.708	0.000	13.257	0.000	14.766	0.000	16.275	0.000	17.784	0.000	19.293	0.000	20.802	0.000	22.311	0.000	23.820	0.000	25.329	0.000	26.838	0.000	28.347	0.000	29.856
0.008	24.926	0.011	50.133	0.013	83.836	0.016	126.036	0.001	17.676	0.001	19.688	0.001	21.700	0.001	23.712	0.001	25.724	0.001	27.736	0.001	29.748	0.001	31.760	0.001	33.772	0.001	35.784	0.001	37.796	0.001	39.808
0.010	28.651	0.013	57.627	0.017	96.368	0.020	144.876	0.001	22.095	0.001	24.610	0.001	27.125	0.001	29.640	0.001	32.155	0.001	34.670	0.003	37.185	0.003	39.710	0.003	42.235	0.003	44.760	0.003	47.285	0.003	49.810
0.012	31.427	0.016	63.209	0.020	105.704	0.024	158.911	0.002	26.514	0.002	29.532	0.002	32.550	0.002	35.568	0.002	38.586	0.002	41.604	0.006	44.622	0.006	47.640	0.006	50.658	0.006	53.676	0.006	56.694	0.006	59.712
0.014	33.436	0.018	67.250	0.023	112.460	0.028	169.068	0.003	30.934	0.003	34.454	0.003	37.975	0.003	41.496	0.003	45.017	0.003	48.538	0.011	52.059	0.011	55.101	0.011	58.143	0.011	61.185	0.011	64.227	0.011	67.269
0.016	34.859	0.021	70.113	0.026	117.248	0.032	176.266	0.004	35.353	0.004	39.377	0.004	43.400	0.004	47.424	0.004	51.448	0.004	55.472	0.018	59.496	0.018	63.519	0.018	67.542	0.018	71.565	0.018	75.588	0.018	79.611
0.018	35.853	0.024	72.111	0.030	120.590	0.036	181.290	0.006	39.772	0.006	44.299	0.006	48.825	0.006	53.352	0.006	57.879	0.006	62.406	0.029	66.933	0.029	71.459	0.029	75.986	0.029	80.513	0.029	85.040	0.029	89.567
0.020	36.540	0.026	73.492	0.033	122.899	0.040	184.761	0.008	44.191	0.008	49.221	0.008	54.250	0.008	59.280	0.008	64.310	0.008	69.340	0.045	74.370	0.045	79.400	0.045	84.430	0.045	89.460	0.045	94.490	0.045	99.520
0.022	37.010	0.029	74.439	0.036	124.482	0.044	187.142	0.011	48.610	0.011	54.143	0.011	59.676	0.011	65.208	0.011	70.741	0.011	76.274	0.066	81.807	0.066	87.339	0.066	92.872	0.066	98.404	0.066	103.937	0.066	109.470
0.024	37.332	0.032	75.085	0.040	125.563	0.048	188.766	0.015	53.029	0.015	59.065	0.015	65.101	0.015	71.136	0.015	77.172	0.015	83.208	0.093	89.244	0.093	95.280	0.093	101.316	0.093	107.352	0.093	113.388	0.093	119.424
0.026	37.550	0.034	75.524	0.043	126.298	0.052	189.871	0.019	57.448	0.019	63.987	0.019	70.526	0.019	77.064	0.019	83.603	0.019	89.642	0.128	95.680	0.128	101.718	0.128	107.756	0.128	113.794	0.128	119.832	0.128	125.870
0.027	37.698	0.037	75.822	0.046	126.796	0.056	190.620	0.023	61.867	0.023	68.909	0.023	75.951	0.023	82.992	0.023	90.034	0.023	97.076	0.173	104.118	0.173	111.160	0.173	118.202	0.173	125.244	0.173	132.286	0.173	139.328
0.029	37.799	0.040	76.024	0.050	127.134	0.060	191.128	0.116	61.867	0.116	68.909	0.116	75.951	0.116	82.992	0.116	90.034	0.116	97.076	0.227	104.118	0.227	111.160	0.227	118.202	0.227	125.244	0.227	132.286	0.227	139.328
0.031	37.867	0.042	76.161	0.053	127.363	0.064	191.472	0.124	61.867	0.124	68.909	0.124	75.951	0.124	82.992	0.124	90.034	0.124	97.076	0.284	104.118	0.284	111.160	0.284	118.202	0.284	125.244	0.284	132.286	0.284	139.328

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)																Glacial Till						Zone of reduced dynamic strength from elevation 29.6 m to 23.6 m.			
	z= 16.0 m		z= 17.0 m		z= 18.0 m		z= 19.0 m		z= 20.0 m		z= 41.0 m		z= 43.0 m		z= 45.0 m		z= 47.0 m		z= 49.0 m		z= 53.0 m					
	Elev. 61.0 m		Elev. 60.0 m		Elev. 59.0 m		Elev. 58.0 m		Elev. 57.0 m		Elev. 56.0 m		Elev. 54.0 m		Elev. 52.0 m		Elev. 50.0 m		Elev. 48.0 m		Elev. 46.0 m					
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)				
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
0.000	12.254	0.000	12.911	0.000	13.567	0.000	14.224	0.000	14.880	0.000	15.536	0.000	16.192	0.001	16.848	0.001	17.504	0.001	18.160	0.001	18.816	0.001	19.472	0.001	20.128	
0.000	24.508	0.000	25.821	0.000	27.134	0.000	28.447	0.000	29.760	0.000	31.073	0.000	32.386	0.002	33.699	0.002	35.012	0.002	36.325	0.002	37.638	0.002	38.951	0.002	40.264	
0.000	36.762	0.000	38.732	0.000	40.701	0.000	42.671	0.000	44.640	0.000	46.610	0.000	48.580	0.003	50.550	0.003	52.520	0.003	54.490	0.003	56.460	0.003	58.430	0.003	60.400	
0.001	49.016	0.001	51.642	0.001	54.268	0.001	56.894	0.001	59.520	0.001	62.146	0.001	64.772	0.004	67.398	0.004	70.024	0.004	72.650	0.004	75.276	0.004	77.902	0.004	80.528	
0.003	61.271	0.003	64.553	0.003	67.835	0.003	71.117	0.003	74.400	0.003	77.682	0.003	80.964	0.005	84.246	0.005	87.528	0.005	90.810	0.005	94.092	0.005	97.374	0.005	100.656	
0.006	73.525	0.006	77.464	0.006	81.402	0.006	85.341	0.006	89.280	0.006	93.219	0.006	97.158	0.006	101.097	0.006	105.036	0.006	108.975	0.006	112.914	0.006	116.853	0.006	120.792	
0.011	85.779	0.011	90.374	0.011	94.969	0.011	99.565	0.011	104.160	0.011	108.755	0.011	113.350	0.007	117.945	0.007	122.540	0.007	127.135	0.007	131.730	0.007	136.325	0.007	140.920	
0.018	98.033	0.018	103.285	0.018	108.536	0.018	113.788	0.018	119.040	0.018	124.292	0.018	129.544	0.008	134.796	0.008	140.048	0.008	145.300	0.008	150.552	0.008	155.804	0.008	161.056	
0.029	110.287	0.029	116.195	0.029	122.104	0.029	128.012	0.029	133.920	0.029	139.828	0.029	145.736	0.009	151.644	0.009	157.552	0.009	163.460	0.009	169.368	0.009	175.276	0.009	181.184	
0.045	122.541	0.045	129.106	0.045	135.671	0.045	142.235	0.045	148.800	0.045	155.365	0.045	161.930	0.010	168.495	0.010	175.060	0.010	181.625	0.010	188.190	0.010	194.755	0.010	201.320	
0.066	134.795	0.066	142.016	0.066	149.238	0.066	156.459	0.066	163.680	0.066	170.902	0.066	178.124	0.011	185.346	0.011	192.568	0.011	199.790	0.012	207.012	0.012	214.234	0.012	221.456	
0.093	147.049	0.093	154.927	0.093	162.805	0.093	170.682	0.093	178.560	0.093	186.438	0.093	194.316	0.012	202.194	0.012	210.072	0.013	217.950	0.013	225.828	0.013	233.706	0.013	241.584	
0.128	159.304	0.128	167.838	0.128	176.372	0.128	184.906	0.128	193.440	0.128	201.974	0.128	210.508	0.013	219.042	0.013	227.576	0.014	236.110	0.014	244.644	0.014	253.178	0.014	261.712	
0.173	171.558	0.173	180.748	0.173	189.939	0.173	199.129	0.173	208.320	0.173	217.510	0.173	226.700	0.014	235.890	0.014	245.080	0.015	254.270	0.015	263.460	0.015	272.650	0.015	281.840	
0.227	183.812	0.227	193.659	0.227	203.506	0.227	213.353	0.227	223.200	0.227	233.047	0.227	242.894	0.015	252.741											

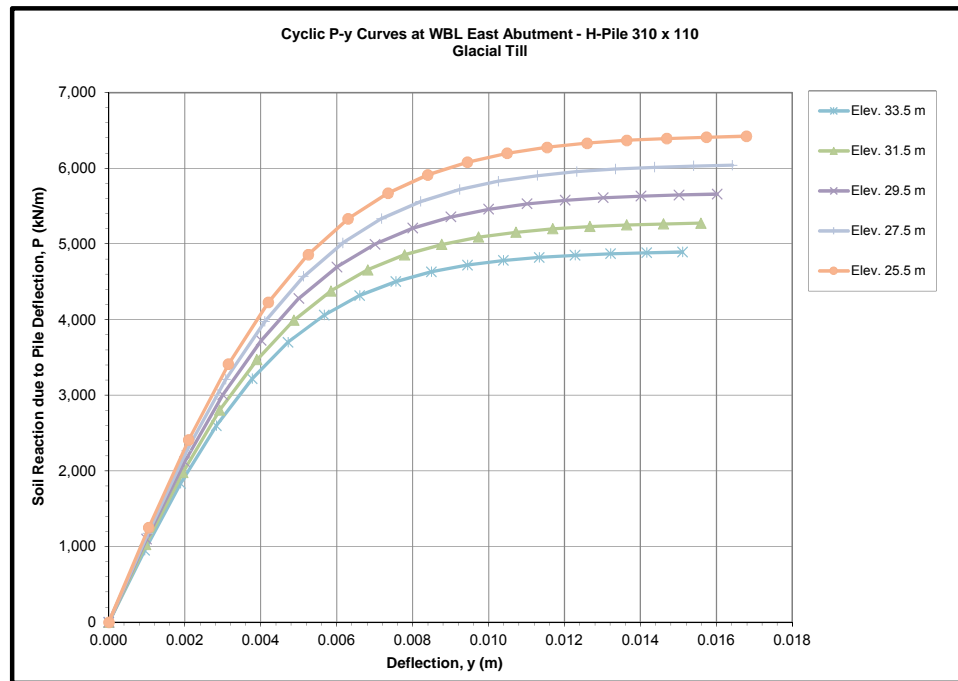
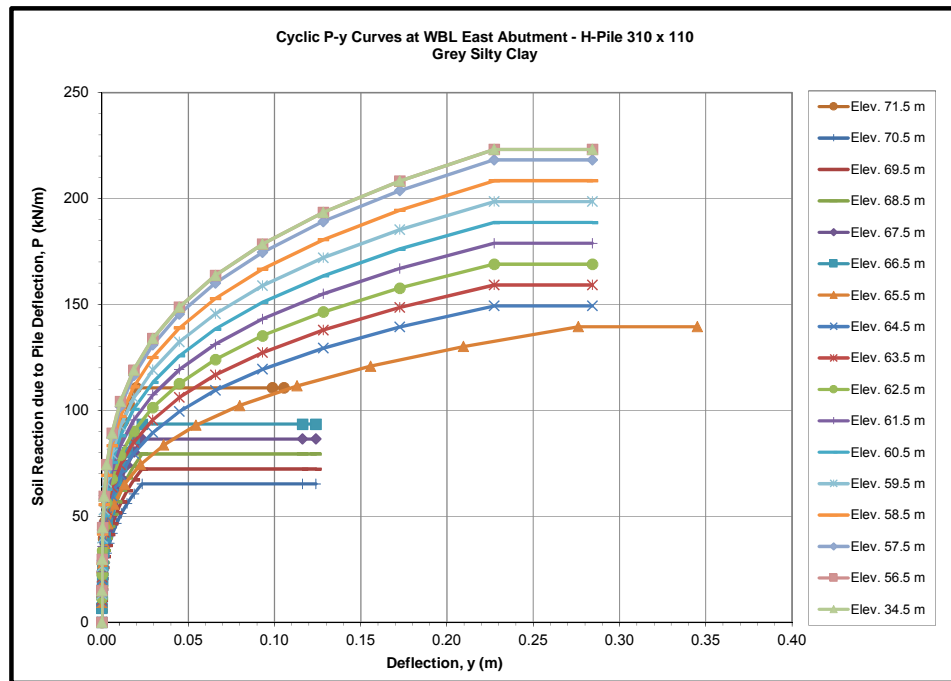
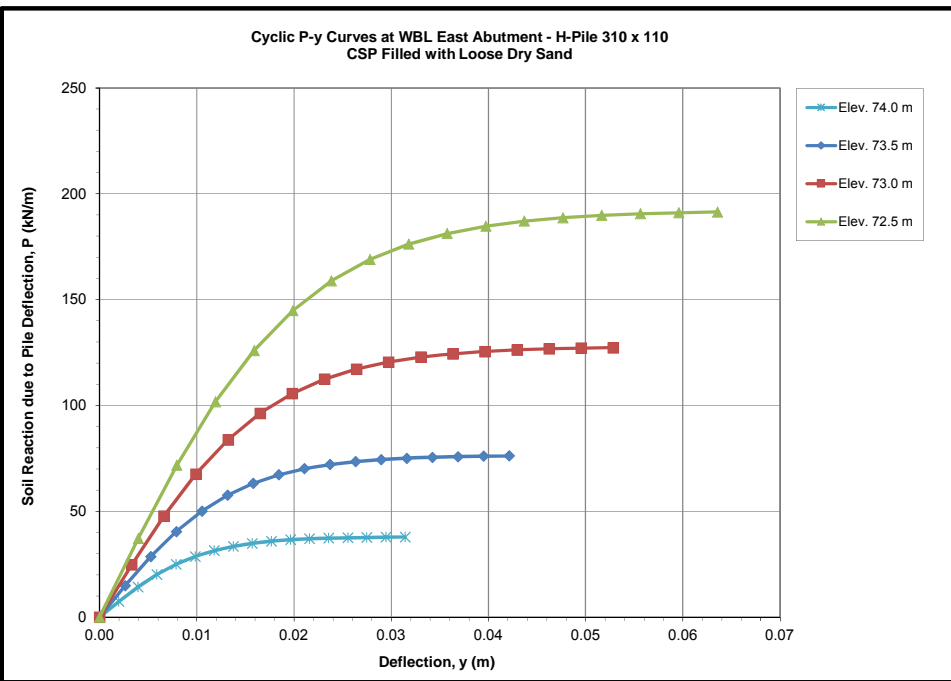


**SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - WBL EAST ABUTMENT**

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand								Grey Silty Clay																									
	z= 1.0 m		z= 1.5 m		z= 2.0 m		z= 2.5 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m	
	Elev. 74.0 m		Elev. 73.5 m		Elev. 73.0 m		Elev. 72.5 m		Elev. 71.5 m		Elev. 70.5 m		Elev. 69.5 m		Elev. 68.5 m		Elev. 67.5 m		Elev. 66.5 m		Elev. 65.5 m		Elev. 64.5 m		Elev. 63.5 m		Elev. 62.5 m		Elev. 61.5 m		Elev. 60.5 m		Elev. 59.5 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.002	7.368	0.003	14.820	0.003	24.784	0.004	37.259	0.000	7.904	0.000	4.664	0.000	5.169	0.000	5.673	0.000	6.177	0.000	6.681	0.000	9.300	0.000	9.956	0.000	10.613	0.000	11.269	0.000	11.926	0.000	12.582	0.000	13.239
0.004	14.203	0.005	28.567	0.007	47.772	0.008	71.818	0.000	15.808	0.000	9.329	0.000	10.337	0.000	11.346	0.000	12.354	0.000	13.363	0.000	18.600	0.000	19.913	0.000	21.226	0.000	22.539	0.000	23.852	0.000	25.165	0.000	26.478	
0.006	20.114	0.008	40.456	0.010	67.654	0.012	101.708	0.000	23.712	0.000	13.993	0.000	15.506	0.000	17.018	0.000	18.531	0.000	20.044	0.000	27.900	0.000	29.869	0.000	31.839	0.000	33.808	0.000	35.778	0.000	37.747	0.000	39.716	
0.008	24.926	0.011	50.133	0.013	83.836	0.016	126.036	0.000	31.616	0.001	18.657	0.001	20.674	0.001	22.691	0.001	24.708	0.001	26.725	0.001	37.200	0.001	39.826	0.001	42.452	0.001	45.078	0.001	47.704	0.001	50.329	0.001	52.955	
0.010	28.651	0.013	57.627	0.017	96.368	0.020	144.876	0.001	39.520	0.001	23.321	0.001	25.843	0.001	28.364	0.001	30.885	0.001	33.406	0.003	46.500	0.003	49.782	0.003	53.065	0.003	56.347	0.003	59.629	0.003	62.912	0.003	66.194	
0.012	31.427	0.016	63.209	0.020	105.704	0.024	158.911	0.002	47.424	0.002	27.986	0.002	31.011	0.002	34.037	0.002	37.062	0.002	40.087	0.007	55.800	0.006	59.739	0.006	63.678	0.006	67.616	0.006	71.555	0.006	75.494	0.006	79.433	
0.014	33.436	0.018	67.250	0.023	112.460	0.028	169.068	0.002	55.328	0.003	32.650	0.003	36.180	0.003	39.309	0.003	43.339	0.003	46.769	0.013	65.100	0.011	69.695	0.011	74.291	0.011	78.886	0.011	83.481	0.011	88.076	0.011	92.672	
0.016	34.859	0.021	70.113	0.026	117.248	0.032	176.266	0.004	63.232	0.004	37.314	0.004	41.348	0.004	45.382	0.004	49.416	0.004	53.450	0.022	74.400	0.018	79.652	0.018	84.904	0.018	90.155	0.018	95.407	0.018	100.659	0.018	105.911	
0.018	35.853	0.024	72.111	0.030	122.482	0.036	181.290	0.005	71.136	0.006	41.978	0.006	46.517	0.006	51.055	0.006	55.593	0.006	60.131	0.036	83.700	0.029	89.608	0.029	95.516	0.029	101.425	0.029	107.333	0.029	113.241	0.029	119.149	
0.020	36.540	0.026	73.492	0.033	122.899	0.040	184.761	0.007	79.040	0.008	46.643	0.008	51.685	0.008	56.728	0.008	61.770	0.008	66.812	0.055	93.000	0.045	99.565	0.045	106.129	0.045	112.694	0.045	119.259	0.045	125.824	0.045	132.388	
0.022	37.010	0.029	74.439	0.036	124.482	0.044	187.142	0.010	86.944	0.011	51.307	0.011	56.854	0.011	62.400	0.011	67.947	0.011	73.494	0.080	102.300	0.066	109.521	0.066	116.742	0.066	123.964	0.066	131.185	0.066	138.406	0.066	145.627	
0.024	37.332	0.032	75.085	0.040	125.563	0.048	188.766	0.012	94.849	0.015	55.971	0.015	62.022	0.015	68.073	0.015	74.124	0.015	80.175	0.113	111.600	0.093	119.478	0.093	127.355	0.093	135.233	0.093	143.111	0.093	150.988	0.093	158.866	
0.026	37.550	0.034	75.524	0.043	126.298	0.052	189.871	0.016	102.753	0.019	60.635	0.019	67.191	0.019	73.746	0.019	80.301	0.019	86.856	0.156	120.900	0.128	129.434	0.128	137.968	0.128	146.502	0.128	155.036	0.128	163.571	0.128	172.105	
0.027	37.698	0.037	75.822	0.046	126.796	0.056	190.620	0.020	110.657	0.023	65.300	0.023	72.359	0.023	79.419	0.023	86.478	0.023	93.537	0.210	130.200	0.173	139.391	0.173	148.581	0.173	157.772	0.173	166.962	0.173	176.153	0.173	185.344	
0.029	37.799	0.040	76.024	0.050	127.134	0.060	191.128	0.099	110.657	0.116	65.300	0.116	72.359	0.116	79.419	0.116	86.478	0.116	93.537	0.276	139.500	0.227	149.347	0.227	159.194	0.227	169.041	0.227	178.888	0.227	188.735	0.227	198.582	
0.031	37.867	0.042	76.161	0.053	127.363	0.064	191.472	0.105	110.657	0.124	65.300	0.124	72.359	0.124	79.419	0.124	86.478	0.124	93.537	0.345	139.500	0.284	149.347	0.284	159.194	0.284	169.041	0.284	178.888	0.284	188.735	0.284	198.582	

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)								Glacial Till								
	z= 16.5 m		z= 17.5 m		z= 18.5 m		z= 40.5 m		z= 41.5 m		z= 43.5 m		z= 47.5 m		z= 49.5 m		
	Elev. 58.5 m		Elev. 57.5 m		Elev. 56.5 m		Elev. 34.5 m		Elev. 33.5 m		Elev. 31.5 m		Elev. 29.5 m		Elev. 25.5 m		
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	0.000	13.895	0.000	14.552	0.000	14.880	0.000	14.880	0.001	952.077	0.001	1026.562	0.001	1101.048	0.001	1175.533	0.001
0.000	27.791	0.000	29.104	0.000	29.760	0.000	29.760	0.002	1835.181	0.002	1978.756	0.002	2122.331	0.002	2265.906	0.002	2409.481
0.000	41.686	0.000	43.655	0.000	44.640	0.000	44.640	0.003	2598.976	0.003	2802.307	0.003	3005.637	0.003	3208.968	0.003	3412.298
0.001	55.581	0.001	58.207	0.001	59.520	0.001	59.520	0.004	3290.632	0.004	3472.597	0.004	3724.563	0.004	3976.528	0.004	4228.494
0.003	69.476	0.003	72.759	0.003	74.400	0.003	74.400	0.005	3702.047	0.005	3991.676	0.005	4281.305	0.005	4570.935	0.005	4860.564
0.006	83.372	0.006	87.311	0.006	89.280	0.006	89.280	0.006	4060.697	0.006	4378.385	0.006	4696.073	0.006	5013.760	0.006	5331.448
0.011	97.267	0.011	101.862	0.011	104.160	0.011	104.160	0.007	4320.250	0.007	4658.244	0.007	4996.238	0.007	5334.232	0.007	5672.226
0.018	111.162	0.018	116.414	0.018	119.040	0.018	119.040	0.008	4504.172	0.008	4856.555	0.008	5208.938	0.008	5561.321	0.008	5913.704
0.029	125.058	0.029	130.966	0.029	133.920	0.029	133.920	0.009	4632.563	0.009	4994.991	0.009	5357.419	0.009	5719.847	0.009	6082.272
0.045	138.953	0.045	145.518	0.045	148.800	0.045	148.800	0.009	4721.256	0.010	5090.623	0.010	5459.989	0.010	5829.356	0.010	6198.723
0.066	152.848	0.066	160.069	0.066	163.680	0.066	163.680	0.010	4782.083	0.011	5156.208	0.011	5530.333	0.011	5904.459	0.012	6278.584
0.093	166.744	0.093	174.621	0.093	178.560	0.093	178.560	0.011	4823.591	0.012	5200.964	0.012	5578.337	0.012	5955.709	0.013	6333.082
0.128	180.639	0.128	189.173	0.128	193.440	0.128	193.440	0.012	4851.820	0.013	5231.402	0.013	5610.983	0.013	5990.564	0.014	6370.146
0.173	194.534	0.173	203.725	0.173	208.320	0.173	208.320	0.013	4870.975	0.014	5252.054	0.014	5633.134	0.014	6014.214	0.015	6395.294
0.227	208.429	0.227	218.276	0.227	223.200	0.227	223.200	0.014	4883.951	0.015	5266.046	0.015	5648.141	0.015	6030.236	0.016	6412.331
0.284	208.429	0.284	218.276	0.284	223.200	0.284	223.200	0.015	4892.732	0.016	5275.514	0.016	5658.296	0.016	6041.078	0.017	6423.860

**NOTES:** \* Depth (z) is measured to be positive below the existing ground surface. It is assumed that existing fill will be excavated and replaced with embankment fill. A surcharge load equal to half of the proposed embankment height is assumed. Underside of abutment wall at Elev. 74.3 m. Please note the following assumptions:





SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - WBL EAST PIER

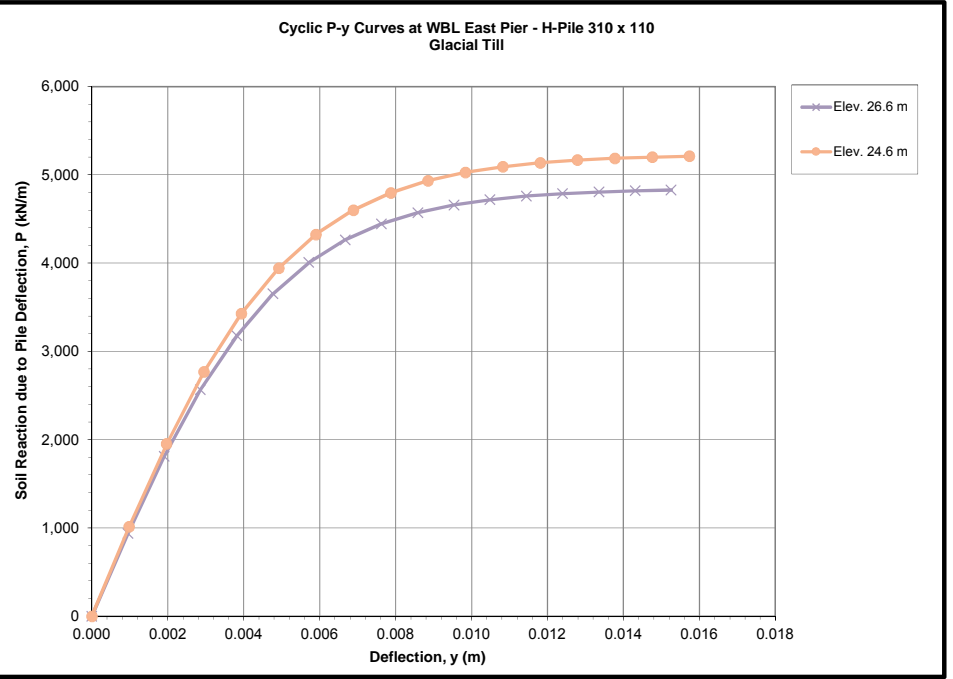
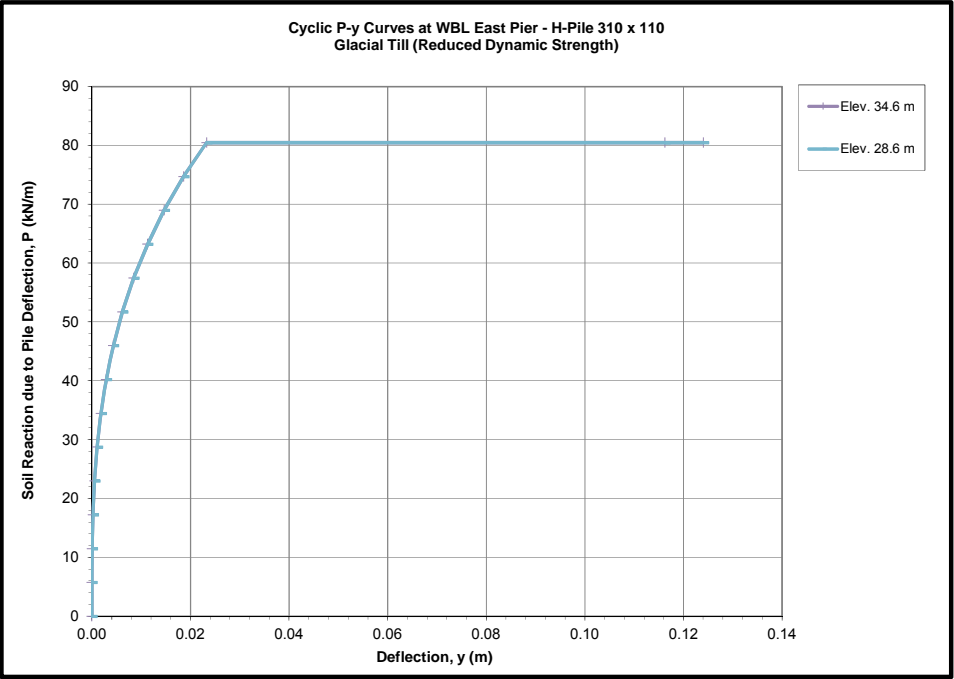
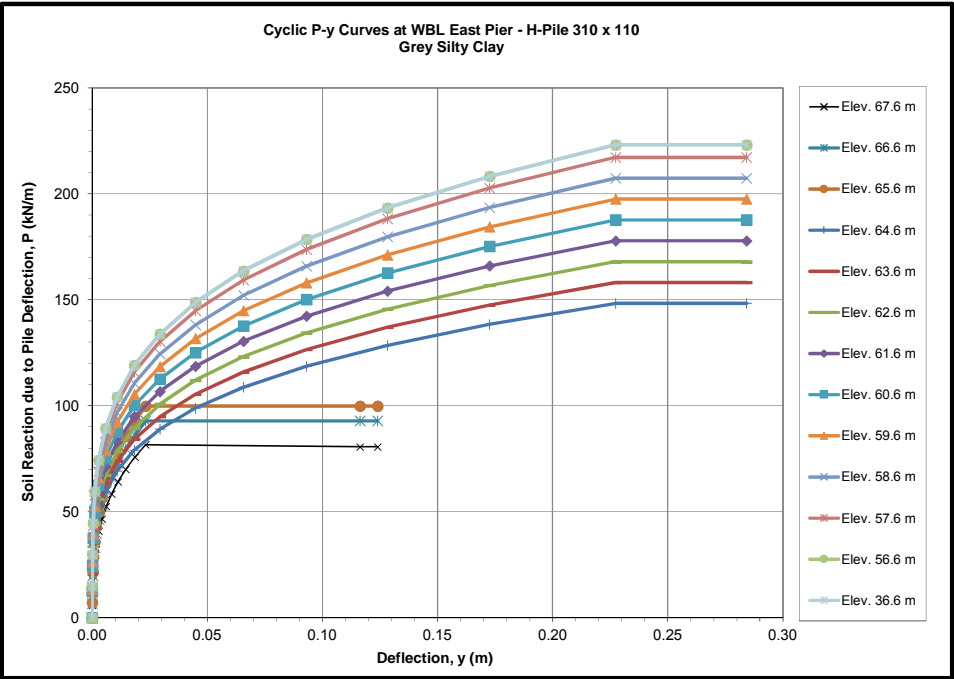
Description Depth (z) * Elevation P-y Curves	Grey Silty Clay																									
	z= 2.0 m		z= 3.0 m		z= 4.0 m		z= 5.0 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 33.0 m	
	Elev. 67.6 m		Elev. 66.6 m		Elev. 65.6 m		Elev. 64.6 m		Elev. 63.6 m		Elev. 62.6 m		Elev. 61.6 m		Elev. 60.6 m		Elev. 59.6 m		Elev. 58.6 m		Elev. 57.6 m		Elev. 56.6 m		Elev. 36.6 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	5.830	0.000	6.636	0.000	7.136	0.000	9.891	0.000	10.547	0.000	11.204	0.000	11.860	0.000	12.517	0.000	13.173	0.000	13.830	0.000	14.486	0.000	14.880	0.000	14.880
	0.000	11.660	0.000	13.271	0.000	14.271	0.000	19.782	0.000	21.095	0.000	22.408	0.000	23.720	0.000	25.033	0.000	26.346	0.000	27.659	0.000	28.972	0.000	29.760	0.000	29.760
	0.000	17.491	0.000	19.907	0.000	21.407	0.000	29.672	0.000	31.642	0.000	33.611	0.000	35.581	0.000	37.550	0.000	39.520	0.000	41.489	0.000	43.458	0.000	44.640	0.000	44.640
	0.001	23.321	0.001	26.543	0.001	28.542	0.001	39.563	0.001	42.189	0.001	44.815	0.001	47.441	0.001	50.067	0.001	52.693	0.001	55.319	0.001	57.944	0.001	59.520	0.001	59.520
	0.001	29.151	0.001	33.178	0.001	35.678	0.003	49.454	0.003	52.736	0.003	56.019	0.003	59.301	0.003	62.584	0.003	65.866	0.003	69.148	0.003	72.431	0.003	74.400	0.003	74.400
	0.002	34.981	0.002	39.814	0.002	42.813	0.006	59.345	0.006	63.284	0.006	67.223	0.006	71.161	0.006	75.100	0.006	79.039	0.006	82.978	0.006	86.917	0.006	89.280	0.006	89.280
	0.003	40.812	0.003	46.450	0.003	49.949	0.011	69.236	0.011	73.831	0.011	78.426	0.011	83.022	0.011	87.617	0.011	92.212	0.011	96.808	0.011	101.403	0.011	104.160	0.011	104.160
	0.004	46.642	0.004	53.085	0.004	57.084	0.018	79.127	0.018	84.378	0.018	89.630	0.018	94.882	0.018	100.134	0.018	105.385	0.018	110.637	0.018	115.889	0.018	119.040	0.018	119.040
	0.006	52.472	0.006	59.721	0.006	64.220	0.029	89.017	0.029	94.926	0.029	100.834	0.029	106.742	0.029	112.650	0.029	118.559	0.029	124.467	0.029	130.375	0.029	133.920	0.029	133.920
	0.008	58.302	0.008	66.356	0.008	71.355	0.045	98.908	0.045	105.473	0.045	112.038	0.045	118.602	0.045	125.167	0.045	131.732	0.045	138.296	0.045	144.861	0.045	148.800	0.045	148.800
	0.011	64.133	0.011	72.992	0.011	78.491	0.066	108.799	0.066	116.020	0.066	123.241	0.066	130.463	0.066	137.684	0.066	144.905	0.066	152.126	0.066	159.347	0.066	163.680	0.066	163.680
	0.015	69.963	0.015	79.628	0.015	85.626	0.093	118.690	0.093	126.568	0.093	134.445	0.093	142.323	0.093	150.200	0.093	158.078	0.093	165.956	0.093	173.833	0.093	178.560	0.093	178.560
	0.019	75.793	0.019	86.263	0.019	92.762	0.128	128.581	0.128	137.115	0.128	145.649	0.128	154.183	0.128	162.717	0.128	171.251	0.128	179.785	0.128	188.320	0.128	193.440	0.128	193.440
	0.023	81.623	0.023	92.899	0.023	99.897	0.173	138.472	0.173	147.662	0.173	156.853	0.173	166.043	0.173	175.234	0.173	184.424	0.173	193.615	0.173	202.806	0.173	208.320	0.173	208.320
	0.116	80.625	0.116	92.899	0.116	99.897	0.227	148.362	0.227	158.209	0.227	168.056	0.227	177.904	0.227	187.751	0.227	197.598	0.227	207.445	0.227	217.292	0.227	223.200	0.227	223.200
	0.124	80.625	0.124	92.899	0.124	99.897	0.284	148.362	0.284	158.209	0.284	168.056	0.284	177.904	0.284	187.751	0.284	197.598	0.284	207.445	0.284	217.292	0.284	223.200	0.284	223.200

Description Depth (z) * Elevation P-y Curves	Glacial Till												Zone of reduced dynamic strength from elevation 30.3 m to 28.3 m.											
	z= 35.0 m		z= 37.0 m		z= 39.0 m		z= 41.0 m		z= 43.0 m		z= 45.0 m													
	Elev. 34.6 m		Elev. 32.6 m		Elev. 30.6 m		Elev. 28.6 m		Elev. 26.6 m		Elev. 24.6 m													
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)												
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000												
	0.000	5.748	0.000	5.748	0.000	5.748	0.000	5.748	0.001	939.682	0.001	1014.167												
	0.000	11.497	0.000	11.497	0.000	11.497	0.000	11.497	0.002	1811.289	0.002	1954.864												
	0.000	17.245	0.000	17.245	0.000	17.245	0.000	17.245	0.003	2565.141	0.003	2768.471												
	0.001	22.994	0.001	22.994	0.001	22.994	0.001	22.994	0.004	3178.703	0.004	3430.668												
	0.001	28.742	0.001	28.742	0.001	28.742	0.001	28.742	0.005	3653.851	0.005	3943.480												
	0.002	34.490	0.002	34.490	0.002	34.490	0.002	34.490	0.006	4007.831	0.006	4325.519												
	0.003	40.239	0.003	40.239	0.003	40.239	0.003	40.239	0.007	4264.006	0.007	4602.000												
	0.004	45.987	0.004	45.987	0.004	45.987	0.004	45.987	0.008	4445.533	0.008	4797.916												
	0.006	51.736	0.006	51.736	0.006	51.736	0.006	51.736	0.009	4572.253	0.009	4934.681												
	0.008	57.484	0.008	57.484	0.008	57.484	0.008	57.484	0.010	4659.791	0.010	5029.158												
	0.011	63.232	0.011	63.232	0.011	63.232	0.011	63.232	0.010	4719.826	0.011	5093.951												
	0.015	68.981	0.015	68.981	0.015	68.981	0.015	68.981	0.011	4760.794	0.012	5138.167												
	0.019	74.729	0.019	74.729	0.019	74.729	0.019	74.729	0.012	4788.656	0.013	5168.237												
	0.023	80.478	0.023	80.478	0.023	80.478	0.023	80.478	0.013	4807.560	0.014	5188.640												
	0.116	80.478	0.116	80.478	0.116	80.478	0.116	80.478	0.014	4820.368	0.015	5202.463												
	0.124	80.478	0.124	80.478	0.124	80.478	0.124	80.478	0.015	4829.035	0.016	5211.817												

NOTES: \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations. Underside of pile cap at Elev. 67.6 m.

Please note the following assumptions:

1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Cyclic loading condition is considered and 500 cycles of loading are assumed. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.



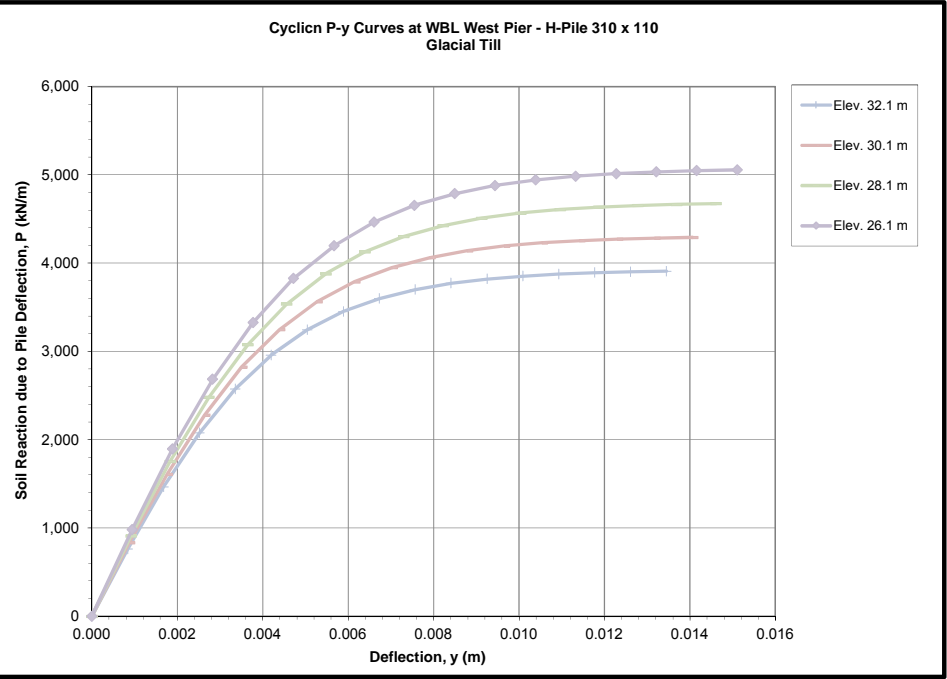
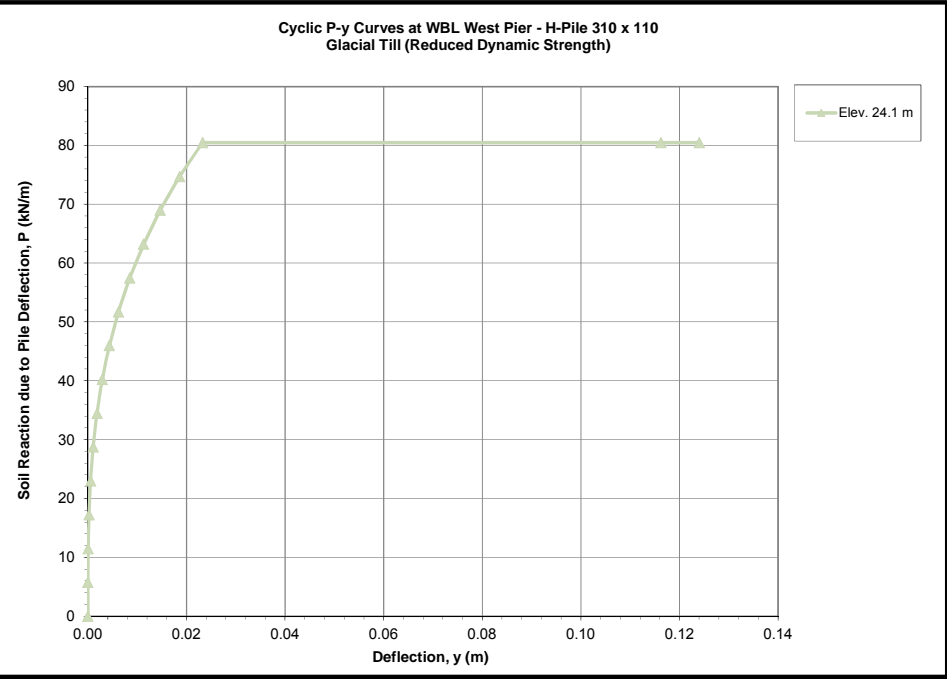
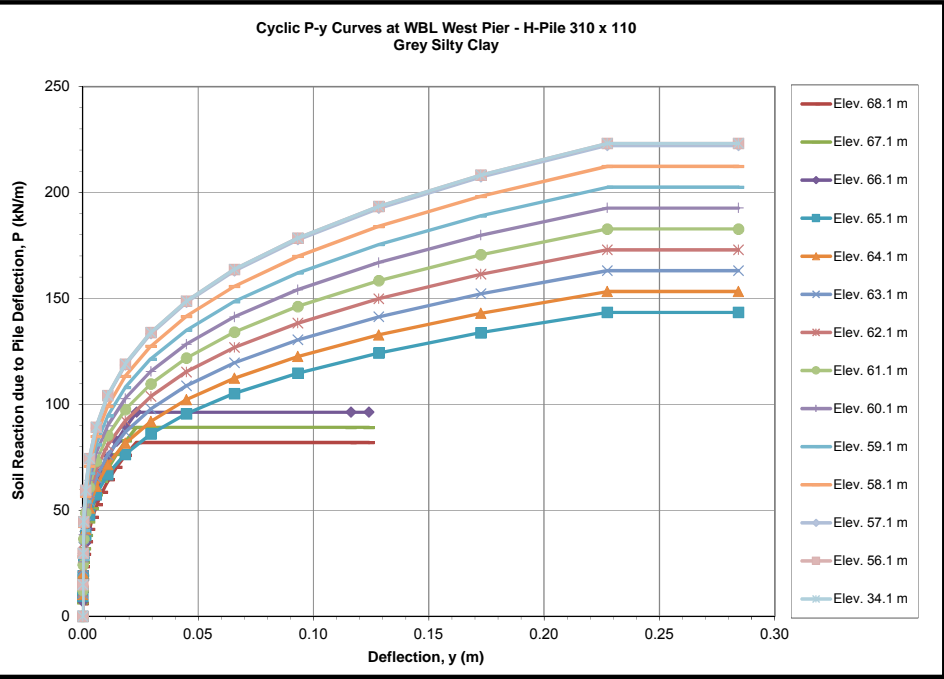


SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - WBL WEST PIER

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay																															
	z= 3.0 m		z= 3.5 m		z= 4.5 m		z= 5.5 m		z= 6.5 m		z= 7.5 m		z= 8.5 m		z= 9.5 m		z= 10.5 m		z= 11.5 m		z= 12.5 m		z= 13.5 m		z= 14.5 m		z= 15.5 m		z= 37.5 m			
	Elev. 68.6 m		Elev. 68.1 m		Elev. 67.1 m		Elev. 66.1 m		Elev. 65.1 m		Elev. 64.1 m		Elev. 63.1 m		Elev. 62.1 m		Elev. 61.1 m		Elev. 60.1 m		Elev. 59.1 m		Elev. 58.1 m		Elev. 57.1 m		Elev. 56.1 m		Elev. 34.1 m			
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)		
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
	0.000	8.310	0.000	5.860	0.000	6.370	0.000	6.880	0.000	9.563	0.000	10.219	0.000	10.876	0.000	11.532	0.000	12.188	0.000	12.845	0.000	13.501	0.000	14.158	0.000	14.814	0.000	14.880	0.000	14.880		
	0.000	16.619	0.000	11.719	0.000	12.739	0.000	13.759	0.000	19.125	0.000	20.438	0.000	21.751	0.000	23.064	0.000	24.377	0.000	25.690	0.000	27.003	0.000	28.316	0.000	29.629	0.000	29.760	0.000	29.760		
	0.000	24.929	0.000	17.579	0.000	19.109	0.000	20.639	0.000	28.688	0.000	30.657	0.000	32.627	0.000	34.596	0.000	36.565	0.000	38.535	0.000	40.504	0.000	42.474	0.000	44.443	0.000	44.640	0.000	44.640		
	0.000	33.239	0.001	23.439	0.001	25.478	0.001	27.518	0.001	38.250	0.001	40.876	0.001	43.502	0.001	46.128	0.001	48.754	0.001	51.380	0.001	54.006	0.001	56.632	0.001	59.257	0.001	59.520	0.001	59.520		
	0.001	41.548	0.001	29.298	0.001	31.848	0.001	34.398	0.003	47.813	0.003	51.095	0.003	54.378	0.003	57.660	0.003	60.942	0.003	64.225	0.003	67.507	0.003	70.789	0.003	74.072	0.003	74.400	0.003	74.400		
	0.002	49.858	0.002	35.158	0.002	38.218	0.002	41.277	0.006	57.376	0.006	61.314	0.006	65.253	0.006	69.192	0.006	73.131	0.006	77.070	0.006	81.008	0.006	84.947	0.006	88.886	0.006	89.280	0.006	89.280		
	0.002	58.168	0.003	41.018	0.003	44.587	0.003	48.157	0.011	66.938	0.011	71.533	0.011	76.129	0.011	80.724	0.011	85.319	0.011	89.915	0.011	94.510	0.011	99.105	0.011	103.700	0.011	104.160	0.011	104.160		
	0.004	66.477	0.004	46.877	0.004	50.957	0.004	55.036	0.018	76.501	0.018	81.752	0.018	87.004	0.018	92.256	0.018	97.508	0.018	102.760	0.018	108.011	0.018	113.263	0.018	118.515	0.018	119.040	0.018	119.040		
	0.005	74.787	0.006	52.737	0.006	57.326	0.006	61.916	0.029	86.063	0.029	91.972	0.029	97.880	0.029	103.788	0.029	109.696	0.029	115.604	0.029	121.513	0.029	127.421	0.029	133.329	0.029	133.920	0.029	133.920		
	0.007	83.097	0.008	58.597	0.008	63.696	0.008	68.795	0.045	95.626	0.045	102.191	0.045	108.755	0.045	115.320	0.045	121.885	0.045	128.449	0.045	135.014	0.045	141.579	0.045	148.144	0.045	148.800	0.045	148.800		
	0.010	91.406	0.011	64.456	0.011	70.066	0.011	75.675	0.066	105.188	0.066	112.410	0.066	119.631	0.066	126.852	0.066	134.073	0.066	141.294	0.066	148.516	0.066	155.737	0.066	162.958	0.066	163.680	0.066	163.680		
	0.012	99.716	0.015	70.316	0.015	76.435	0.015	82.554	0.093	114.751	0.093	122.629	0.093	130.506	0.093	138.384	0.093	146.262	0.093	154.139	0.093	162.017	0.093	169.895	0.093	177.772	0.093	178.560	0.093	178.560		
	0.016	108.026	0.019	76.176	0.019	82.805	0.019	89.434	0.128	124.314	0.128	132.848	0.128	141.382	0.128	149.916	0.128	158.450	0.128	166.984	0.128	175.518	0.128	184.052	0.128	192.587	0.128	193.440	0.128	193.440		
	0.020	116.335	0.023	82.035	0.023	89.174	0.023	96.313	0.173	133.876	0.173	143.067	0.173	152.257	0.173	161.448	0.173	170.639	0.173	179.829	0.173	189.020	0.173	198.210	0.173	207.401	0.173	208.320	0.173	208.320		
	0.099	111.416	0.116	82.035	0.116	89.174	0.116	96.313	0.227	143.439	0.227	153.286	0.227	163.133	0.227	172.980	0.227	182.827	0.227	192.674	0.227	202.521	0.227	212.368	0.227	222.215	0.227	223.200	0.227	223.200		
	0.105	111.416	0.124	82.035	0.124	89.174	0.124	96.313	0.284	143.439	0.284	153.286	0.284	163.133	0.284	172.980	0.284	182.827	0.284	192.674	0.284	202.521	0.284	212.368	0.284	222.215	0.284	223.200	0.284	223.200		

Description Depth (z) * Elevation P-y Curves	Glacial Till								Zone of reduced dynamic strength from elevation 24.6 m to 23.7 m.	
	z= 39.5 m		z= 41.5 m		z= 43.5 m		z= 47.5 m			
	Elev. 32.1 m		Elev. 30.1 m		Elev. 28.1 m		Elev. 26.1 m			
P-y Curves	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.001	760.742	0.001	835.227	0.001	909.713	0.001	984.198	0.000	5.748
	0.002	1466.372	0.002	1609.947	0.002	1753.522	0.002	1897.097	0.000	11.497
	0.003	2076.671	0.003	2280.002	0.003	2483.332	0.003	2686.663	0.000	17.245
	0.003	2573.395	0.004	2825.361	0.004	3077.326	0.004	3329.292	0.001	22.994
	0.004	2958.063	0.004	3247.692	0.005	3537.321	0.005	3826.950	0.001	28.742
	0.005	3244.636	0.005	3562.324	0.005	3880.012	0.006	4197.700	0.002	34.490
	0.006	3452.028	0.006	3790.022	0.006	4128.016	0.007	4466.010	0.003	40.239
	0.007	3598.988	0.007	3951.371	0.007	4303.754	0.008	4656.137	0.004	45.987
	0.008	3701.577	0.008	4064.005	0.008	4426.432	0.009	4788.860	0.006	51.736
	0.008	3772.445	0.009	4141.812	0.009	4511.179	0.009	4880.545	0.008	57.484
	0.009	3821.048	0.010	4195.173	0.010	4569.299	0.010	4943.424	0.011	63.232
	0.010	3854.215	0.011	4231.587	0.011	4608.960	0.011	4986.333	0.015	68.981
	0.011	3876.771	0.011	4256.352	0.012	4635.933	0.012	5015.515	0.019	74.729
	0.012	3892.076	0.012	4273.156	0.013	4654.235	0.013	5035.315	0.023	80.478
	0.013	3902.444	0.013	4284.539	0.014	4666.634	0.014	5048.729	0.116	80.478
	0.013	3909.461	0.014	4292.243	0.015	4675.025	0.015	5057.807	0.124	80.478

NOTES: \* Depth (z) is measured to be positive below the existing ground surface. No changes from the existing grade are anticipated at the pier locations.  
Please note the following assumptions:  
1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.  
2. Cyclic loading condition is considered and 500 cycles of loading are assumed. Lateral loading is considered normal to the strong axis.  
3. There are no pile group effects (i.e., analysis is based on a single pile).  
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





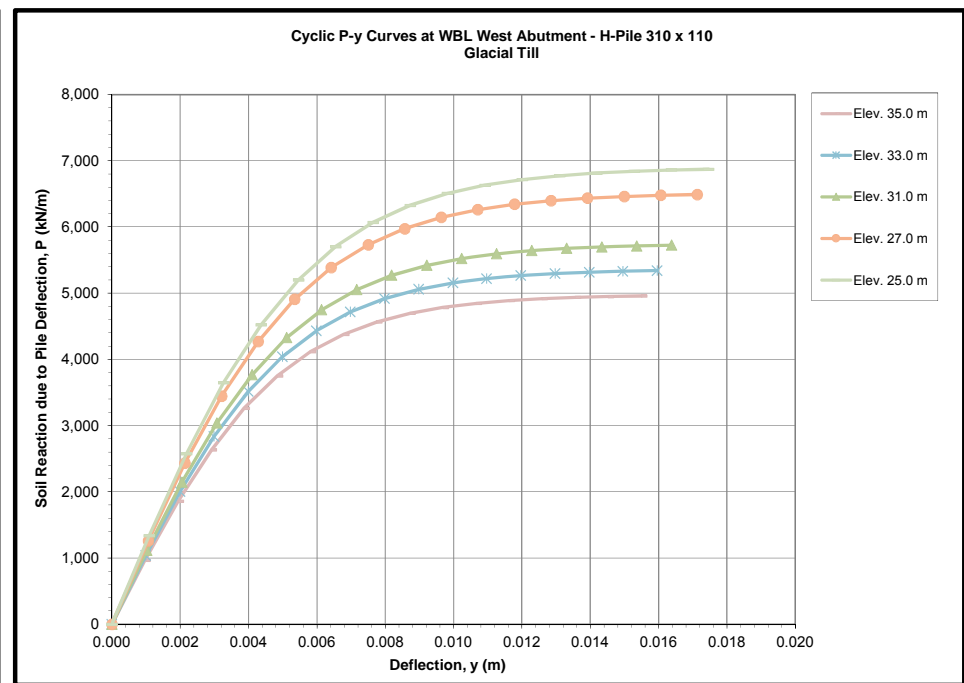
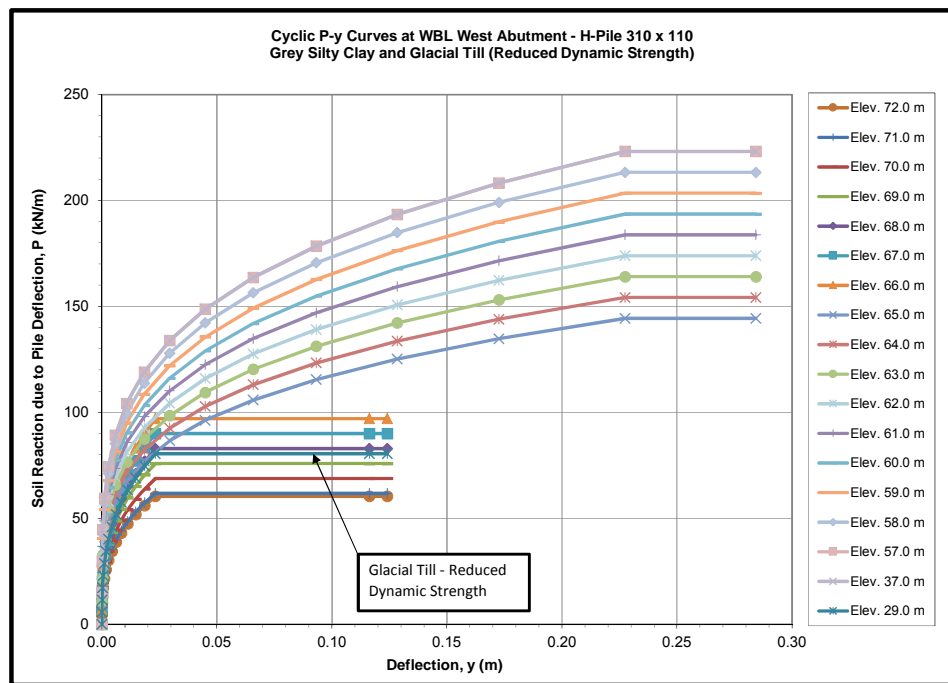
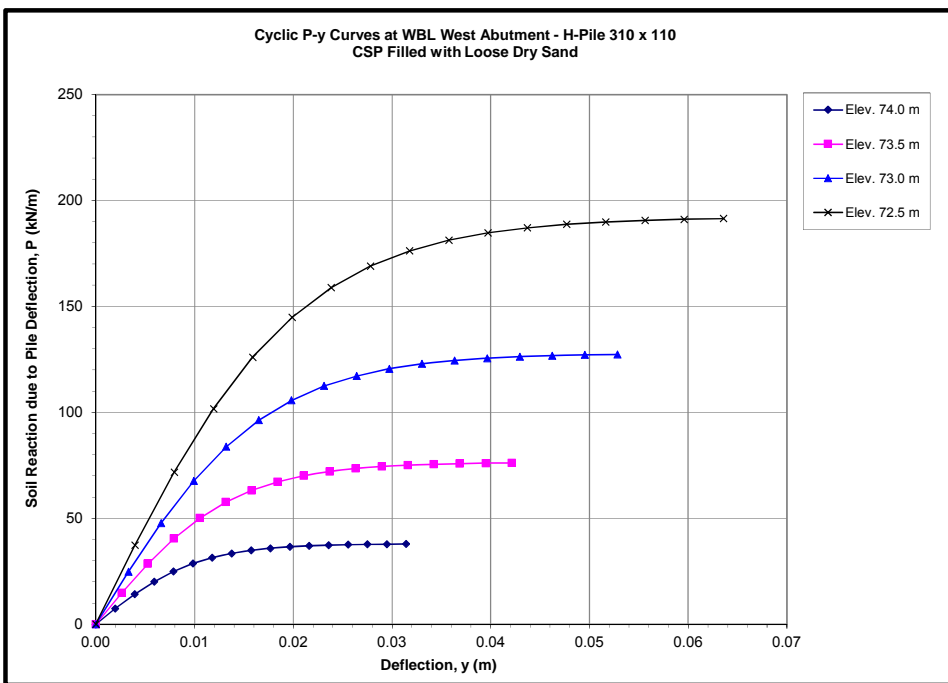
**SUMMARY OF CYCLIC P-Y CURVES FOR H-PILE 310x110 - WBL WEST ABUTMENT**

Description Depth (z) * Elevation P-y Curves	CSP Filled with Loose Dry Sand																Grey Silty Clay																	
	z= 3.0 m		z= 3.5 m		z= 4.0 m		z= 4.5 m		z= 5.0 m		z= 6.0 m		z= 7.0 m		z= 8.0 m		z= 9.0 m		z= 10.0 m		z= 11.0 m		z= 12.0 m		z= 13.0 m		z= 14.0 m		z= 15.0 m		z= 16.0 m		z= 17.0 m	
	Elev. 74.0 m		Elev. 73.5 m		Elev. 73.0 m		Elev. 72.5 m		Elev. 72.0 m		Elev. 71.0 m		Elev. 70.0 m		Elev. 69.0 m		Elev. 68.0 m		Elev. 67.0 m		Elev. 66.0 m		Elev. 65.0 m		Elev. 64.0 m		Elev. 63.0 m		Elev. 62.0 m		Elev. 61.0 m		Elev. 60.0 m	
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.002	7.368	0.003	14.820	0.003	24.784	0.004	37.259	0.000	4.311	0.000	4.412	0.000	4.916	0.000	5.421	0.000	5.925	0.000	6.429	0.000	6.933	0.000	7.437	0.000	7.941	0.000	8.445	0.000	8.949	0.000	9.453	0.000	9.957	0.000
0.004	14.203	0.005	28.567	0.007	47.772	0.008	71.818	0.000	8.623	0.000	8.824	0.000	9.833	0.000	10.841	0.000	11.850	0.000	12.858	0.000	13.867	0.000	14.875	0.000	15.883	0.000	16.891	0.000	17.899	0.000	18.907	0.000	19.915	0.000
0.006	20.114	0.008	40.456	0.010	67.854	0.012	101.708	0.000	12.934	0.000	13.236	0.000	14.749	0.000	16.262	0.000	17.775	0.000	19.287	0.000	20.800	0.000	22.313	0.000	23.825	0.000	25.338	0.000	26.850	0.000	28.363	0.000	29.875	0.000
0.008	24.926	0.011	50.133	0.013	83.836	0.016	126.036	0.001	17.245	0.001	17.649	0.001	19.666	0.001	21.683	0.001	23.700	0.001	25.717	0.001	27.733	0.001	29.750	0.001	31.767	0.001	33.784	0.001	35.801	0.001	37.818	0.001	39.835	0.001
0.010	28.651	0.013	57.627	0.017	96.368	0.020	144.876	0.001	21.556	0.001	22.061	0.001	24.582	0.001	27.103	0.001	29.624	0.001	32.146	0.001	34.667	0.003	37.188	0.003	39.709	0.003	42.230	0.003	44.751	0.003	47.272	0.003	49.793	0.003
0.012	31.427	0.016	63.209	0.020	105.704	0.024	158.911	0.002	25.868	0.002	26.473	0.002	29.498	0.002	32.524	0.002	35.549	0.002	38.575	0.002	41.600	0.006	44.625	0.006	47.650	0.006	50.675	0.006	53.700	0.006	56.725	0.006	59.750	0.006
0.014	33.436	0.018	67.250	0.023	112.460	0.028	169.068	0.003	30.179	0.003	30.885	0.003	34.415	0.003	37.944	0.003	41.474	0.003	45.004	0.003	48.534	0.011	52.064	0.011	55.594	0.011	59.124	0.011	62.654	0.011	66.184	0.011	69.714	0.011
0.016	34.859	0.021	70.113	0.026	117.248	0.032	176.266	0.004	34.490	0.004	35.297	0.004	39.331	0.004	43.365	0.004	47.399	0.004	51.433	0.004	55.467	0.018	59.501	0.018	63.535	0.018	67.569	0.018	71.603	0.018	75.637	0.018	79.671	0.018
0.018	35.853	0.024	72.111	0.030	120.590	0.036	181.290	0.006	38.802	0.006	39.709	0.006	44.248	0.006	48.786	0.006	53.324	0.006	57.862	0.006	62.400	0.029	66.938	0.029	71.476	0.029	76.014	0.029	80.552	0.029	85.089	0.029	89.627	0.029
0.020	36.540	0.026	73.492	0.033	122.899	0.040	184.761	0.008	43.113	0.008	44.121	0.008	49.164	0.008	54.206	0.008	59.249	0.008	64.291	0.008	69.334	0.045	74.376	0.045	79.418	0.045	84.460	0.045	89.502	0.045	94.544	0.045	99.586	0.045
0.022	37.010	0.029	74.439	0.036	124.882	0.044	187.142	0.011	47.424	0.011	48.534	0.011	54.080	0.011	59.627	0.011	65.174	0.011	70.720	0.011	76.267	0.066	81.814	0.066	87.360	0.066	92.906	0.066	98.452	0.066	103.998	0.066	109.544	0.066
0.024	37.332	0.032	75.085	0.040	125.563	0.048	188.766	0.015	51.736	0.015	52.946	0.015	58.997	0.015	65.048	0.015	71.099	0.015	77.150	0.015	83.200	0.093	89.251	0.093	95.302	0.093	101.353	0.093	107.404	0.093	113.455	0.093	119.506	0.093
0.026	37.550	0.034	75.524	0.043	126.298	0.052	189.871	0.019	56.047	0.019	57.358	0.019	63.913	0.019	70.468	0.019	77.023	0.019	83.579	0.019	90.134	0.128	96.689	0.128	103.244	0.128	109.799	0.128	116.354	0.128	122.909	0.128	129.464	0.128
0.027	37.698	0.037	75.822	0.046	126.796	0.056	190.620	0.023	60.358	0.023	61.770	0.023	68.829	0.023	75.889	0.023	82.948	0.023	90.008	0.023	97.067	0.173	104.126	0.173	111.185	0.173	118.244	0.173	125.303	0.173	132.362	0.173	139.421	0.173
0.029	37.799	0.040	76.024	0.050	127.134	0.060	191.128	0.116	60.358	0.116	61.770	0.116	68.829	0.116	75.889	0.116	82.948	0.116	90.008	0.116	97.067	0.227	104.126	0.227	111.185	0.227	118.244	0.227	125.303	0.227	132.362	0.227	139.421	0.227
0.031	37.867	0.042	76.161	0.053	127.363	0.064	191.472	0.124	60.358	0.124	61.770	0.124	68.829	0.124	75.889	0.124	82.948	0.124	90.008	0.124	97.067	0.284	104.126	0.284	111.185	0.284	118.244	0.284	125.303	0.284	132.362	0.284	139.421	0.284

Description Depth (z) * Elevation P-y Curves	Grey Silty Clay (continued)																Glacial Till										Zone of reduced dynamic strength from elevation 30.3 m to 28.3 m.
	z= 18.0 m		z= 19.0 m		z= 20.0 m		z= 40.0 m		z= 42.0 m		z= 44.0 m		z= 46.0 m		z= 50.0 m		z= 52.0 m										
	Elev. 58.0 m		Elev. 59.0 m		Elev. 57.0 m		Elev. 37.0 m		Elev. 35.0 m		Elev. 33.0 m		Elev. 31.0 m		Elev. 27.0 m		Elev. 25.0 m										
	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)									
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000										
0.000	13.567	0.000	14.224	0.000	14.880	0.000	14.880	0.001	965.228	0.001	1039.714	0.001	1114.199	0.000	5.748	0.001	1263.170	0.001	1337.656								
0.000	27.134	0.000	28.447	0.000	29.760	0.000	29.760	0.002	1860.531	0.002	2004.106	0.002	2147.681	0.000	11.497	0.002	2434.831	0.002	2578.406								
0.000	40.701	0.000	42.671	0.000	44.640	0.000	44.640	0.003	2634.877	0.003	2838.207	0.003	3041.538	0.000	17.245	0.003	3448.199	0.003	3651.529								
0.001	54.268	0.001	56.894	0.001	59.520	0.001	59.520	0.004	3265.119	0.004	3517.085	0.004	3769.050	0.001	22.994	0.004	4272.981	0.004	4524.947								
0.003	67.835	0.003	71.118	0.003	74.400	0.003	74.400	0.005	3753.185	0.005	4042.814	0.005	4332.443	0.001	28.742	0.005	4911.701	0.005	5201.330								
0.006	81.402	0.006	85.341	0.006	89.280	0.006	89.280	0.006	4116.789	0.006	4434.476	0.006	4752.164	0.002	34.490	0.006	5387.540	0.007	5705.228								
0.011	94.969	0.011	99.565	0.011	104.160	0.011	104.160	0.007	4379.927	0.007	4717.921	0.007	5055.915	0.003	40.239	0.008	5731.903	0.008	6069.897								
0.018	108.536	0.018	113.788	0.018	119.040	0.018	119.040	0.008	4566.389	0.008	4918.773	0.008	5271.156	0.004	45.987	0.009	5975.922	0.009	6328.305								
0.029	122.104	0.029	128.012	0.029	133.920	0.029	133.920	0.009	4696.554	0.009	5058.982	0.009	5421.410	0.006	51.736	0.010	6146.265	0.010	6508.693								
0.045	135.671	0.045	142.235	0.045	148.800	0.045	148.800	0.010	4786.472	0.010	5155.839	0.010	5525.206	0.008	57.484	0.011	6263.939	0.011	6633.306								
0.066	149.238	0.066	156.459	0.066	163.680	0.066	163.680	0.011	4848.139	0.011	5222.265	0.011	5596.390	0.011	63.232	0.012	6344.641	0.012	6718.766								
0.093	162.805	0.093	170.682	0.093	178.560	0.093	178.560	0.012	4890.221	0.012	5267.594	0.012	5644.966	0.015	68.981	0.013	6399.712	0.013	6777.085								
0.128	176.372	0.128	184.906	0.128	193.440	0.128	193.440	0.013	4918.840	0.013	5298.422	0.013	5678.003	0.019	74.729	0.014	6437.165	0.014	6816.747								
0.173	189.939	0.173	199.129	0.173	208.320	0.173	208.320	0.014	4938.259	0.014	5319.339	0.014	5700.419	0.023	80.478	0.015	6462.578	0.015	6843.658								
0.227	203.506	0.227	213.353	0.227	223.200	0.227	223.200	0.015	4951.414	0.015	5333.509	0.015	5715.604	0.116	80.478	0.016	6479.794	0.016	6861.889								
0.284	203.506	0.284	213.353	0.284	223.200	0.284	223.200	0.016	4960.317	0.016	5343.099	0.016	5725.881	0.124	80.478	0.017	6491.445	0.017	6874.227								

**NOTES:** \* Depth (z) is measured to be positive below the existing ground surface. It is assumed that existing fill will be excavated and replaced with embankment fill. A surcharge load equal to half of the proposed embankment height is assumed. Underside of abutment wall at Elev. 74.5 m.  
Please note the following assumptions:

1. Cyclic p-y curves have been generated for vertical piles (i.e. no inclination) with a ground slope angle of zero.
2. Cyclic loading condition is considered and 500 cycles of loading are assumed. Lateral loading is considered normal to the strong axis.
3. There are no pile group effects (i.e., analysis is based on a single pile).
4. The effects of construction disturbance are not considered. The effects of possible artesian conditions are not considered.





## **APPENDIX G**

# **Non Standard Special Provisions**

Vibration Monitoring During Piling

Driving Piles Adjacent to Existing Piles

Placement of Working Slab – Structures

Obstructions During Piling

Settlement Monitoring During Grading

Excavating Through Obstructions - Structures



## **Deep Foundations - Item No.**

---

Special Provision

---

### ***Amendment to OPSS 903, April 2016***

#### ***Vibration Monitoring During Piling***

This special provision describes requirements for vibration monitoring during pile installation works.

#### ***Definitions***

Foundation Engineering Specialist (FES): An Engineer with a minimum of five (5) years experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the piling work at a minimum of two (2) projects of similar scope to the contract. The FES shall be retained by the Contract Administrator to ensure general conformance with the contract documents and shall issue certificate(s) of conformance.

#### ***Submission Requirements***

The Contractor shall submit details of the vibration monitoring plan to the FES for review. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- Qualifications of vibrations monitoring specialist;
- Proposed instrumentation;
- Proposed location of instruments;
- Proposed frequency of readings; and,
- Proposed methods for adjusting piling methods if readings show vibrations exceeding tolerable levels.

The submittals shall satisfy the specifications and at a minimum contain the above information as provided to the FES.

#### ***Monitoring***

The FES shall take readings during driving of each pile. The readings should be taken and recorded during the entire length of driving and during seating of the pile on the bedrock (if applicable). As a minimum, one vibration monitoring point shall be installed on the nearest existing abutment wall to the pile driving activities.

The pile(s) furthest from the monitored structure or utility should be driven first to assess the vibration level at the existing structures. If necessary, the contractor must alter the pile driving procedures for the remaining piles. The revised procedure shall be submitted to the Contract Administrator for approval prior to driving the remaining piles.

The measured vibrations shall not exceed 100 mm/s (peak particle velocity).



If it is not practical to drive the piles furthest from the existing structure first due to space constraints, the piles nearest the existing structure may be driven first but the measured vibrations in that case shall not exceed 50 mm/s.

The results shall be submitted to the Contract Administrator after each pile has been driven and prior to continuing with the subsequent piles. As a minimum, the pile number, location, set criteria and driving log must be submitted with vibration monitoring results.

If the vibration monitoring results are acceptable, the Contractor may continue with the next piles with readings taken during driving of each pile. The results of subsequent piles should be submitted to the Contract Administrator after each pile has been driven.

If the readings are not within the limits stated above, the Contractor must alter the driving procedures until the vibrations are within acceptable levels. The above process must be repeated for each pile.

### **Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



**Deep Foundations - Item No.**

---

Special Provision

---

***Amendment to OPSS 903, April 2016***

***Driving Piles Adjacent to Existing Piles***

This special provision describes requirements for pile installation adjacent to existing piles.

***Definitions***

Foundation Engineering Specialist (FES): An Engineer with a minimum of five (5) years experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the piling work at a minimum of two (2) projects of similar scope to the contract. The FES shall be retained by the Contract Administrator to ensure general conformance with the contract documents and shall issue certificate(s) of conformance.

***Pile Driving Adjacent to Existing Piles***

For new piles driven within the potential zone of interference with existing piles the driving operations shall be continuously monitored by the FES. The potential zone of interference is defined as a distance around the existing pile tip, reflected all the way up to ground surface, equal to 10% of the existing pile length where the new or existing pile is vertical and 20% of the existing pile length where the new or existing pile is battered.

The contractor shall cease driving of the pile if the FES indicates that the driven pile may have come in contact with an existing pile.

If contact between the new and existing piles is believed to exist the contractor shall take remedial action as directed by the Contract Administrator, which may include extracting the pile and re-driving or replacing the pile.

***Basis of Payment***

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



**Earth Excavation for Structures – Item No.**

---

Special Provision

---

***Amendment to OPSS 902, November 2010***

***Placement of Working Slab – Structures***

**902.05 MATERIALS**

Section 902.05 of OPSS 902 shall be amended by the addition of the following:

Concrete for working slabs shall have a minimum 28-day strength of 20 MPa. The concrete curing requirements of OPSS.PROV 904 shall not apply.

**902.07 CONSTRUCTION**

Section 902.07.05.02 of OPSS 902 shall be amended by the addition of the following:

Within four hours following inspection and approval of the prepared subgrade, a working slab with a minimum thickness of 100 mm shall be placed on the foundation subgrade as specified in the Contract Documents.

**Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



## **Deep Foundations - Item No.**

---

Special Provision

---

### ***Amendment to OPSS 903, April 2016***

#### ***Obstructions During Piling***

This special provision describes requirements for pile installation through obstructions and natural cobbles and boulders.

#### ***Definitions***

Foundation Engineering Specialist (FES): An Engineer with a minimum of five (5) years experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the piling work at a minimum of two (2) projects of similar scope to the contract. The FES shall be retained by the Contract Administrator to ensure general conformance with the contract documents and shall issue certificate(s) of conformance.

#### ***Submission Requirements***

The Contractor shall submit details for advancing the piles through obstructions, cobbles and boulders. The submittals shall satisfy the specifications and at a minimum contain specific information on their approach to advancing the piles in the event such conditions are encountered.

#### ***Pile Driving Through Obstacles, Cobbles, Boulders***

The soils at the site are glacially-derived and are known to contain cobbles and boulders within the till deposits. The embankment fills at the site may also contain some obstructions. The Contractor is advised that appropriate equipment and construction procedures will be required to penetrate or remove obstructions, such as cobbles and boulders, to permit installation of deep foundations.

#### ***Basis of Payment***

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



**Grading - Item No.**

---

Special Provision

---

***Amendment to OPSS 206, November 2014***

***Settlement Monitoring During Grading***

**206.01 SCOPE**

Section 206.01 of OPSS 206 shall be amended by the addition of the following:

Shall also include the supply and installation of settlement plates and data collection during construction. The purpose of the settlement plates is to directly monitor settlement of the soils in areas of the new approach embankments. Settlement is to be measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

**206.03 DEFINITIONS**

Section 206.03 of OPSS 206 shall be amended by the addition of the following:

Foundation Engineering Specialist (FES): An Engineer with a minimum of five (5) years experience in the field of installation of piling and vibration monitoring or alternatively has demonstrated expertise by providing satisfactory quality verification services for the piling work at a minimum of two (2) projects of similar scope to the contract. The FES shall be retained by the Contract Administrator to ensure general conformance with the contract documents and shall issue certificate(s) of conformance.

**206.07.05.01 EARTH EMBANKMENTS**

Section 206.07.05.01 of OPSS 206 shall be amended by the addition of the following:

**General Procedure Settlement Plates**

Settlement rods shall be attached to plates installed within the native subgrade at the underside of the embankment fill. As embankment construction proceeds, the rods shall be extended above the new ground level. The settlement plates shall be installed before any new embankment fill placement. As the embankment construction proceeds, the rods shall be extended above the new ground level.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod as the embankment settles. As embankment construction proceeds, the sleeves shall also be extended above the new ground level.

A protective surround shall be extended with the rods and sleeves as embankment construction proceeds above the existing embankment grade.

The holes and protective surround shall be backfilled with uniform sand around the rods and sleeves. NO sand is to be placed within the sleeves.

Once the embankment preload has been constructed to its final grade, the rods and sleeves shall be cut down to just below subgrade level and covered with a flush mount casing.



## **MATERIALS**

### **Rod**

The Contractor shall supply a steel rod with an outside diameter of at least 19 mm.

The top of the rod shall be capped in such a way that a single survey point can be clearly identified and returned to.

### **Friction Reducing Sleeve**

The Contractor shall supply a PVC pipe, friction reducing sleeve with an internal diameter of at least 25 mm and at least 25 per cent larger than the rod outside diameter.

### **Sand**

The Contractor shall supply uniform medium-grained sand to backfill the hole once the rod and friction reducing sleeve are in place as well as within the protective surround as the rod and sleeve are extended as embankment construction proceeds above the existing embankment grade.

### **Protective Surround**

The Contractor shall supply a protective surround for the portion of the rod and sleeve above the existing embankment grade. The surround shall consist of a 300 mm diameter corrugated metal pipe (CMP).

### **Monitoring Equipment**

An experienced registered surveyor, retained by the Contractor to provide the datum readings, shall survey the elevation of the top of the settlement points. The surveyor shall provide suitable equipment capable of surveying settlement point elevations to an accuracy of +/- 2 mm or better.

## **LOCATION**

The Contractor shall install a total of 16 settlement rods at the locations shown on the Contract Drawings, as follows:

Instrument Number	Structure	Location	Approximate Offset from Centreline
SP1	EBL	5 m from W abutment	See drawing detail
SP2	EBL	15 m from W abutment	See drawing detail
SP3	EBL	30 m from W abutment	See drawing detail
SP4	EBL	50 m from W abutment	See drawing detail
SP5	EBL	5 m from E abutment	See drawing detail
SP6	EBL	15 m from E abutment	See drawing detail
SP7	EBL	30 m from E abutment	See drawing detail
SP8	EBL	50 m from E abutment	See drawing detail
SP9	WBL	5 m from W abutment	See drawing detail



SP10	WBL	15 m from W abutment	See drawing detail
SP11	WBL	30 m from W abutment	See drawing detail
SP12	WBL	50 m from W abutment	See drawing detail
SP13	WBL	5 m from E abutment	See drawing detail
SP14	WBL	15 m from E abutment	See drawing detail
Sp15	WBL	30 m from E abutment	See drawing detail
Sp16	WBL	50 m from E abutment	See drawing detail

## REPORTING

### Installation Records

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Settlement rod location, easting, northing;
- Elevation of top of rod;
- Distance between bottom of hole and top of rod;
- Dates of installation and datum readings;
- Installation notes / sketches;
- Description of settlement rod and backfill.

### Monitoring Records

The party responsible for monitoring the settlement points shall record and report the readings to the Contract Administrator within 24 hours of completion of the survey. Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

## INSTALLATION

### Plates

The settlement plate may be installed after stripping of topsoil or existing fill, and shall be placed prior to placement of any new embankment/preload fill.

### Friction Reducing Sleeve

The friction reducing sleeve shall extend over the entire length of the rod, with a 25 to 50 mm gap between the bottom of the sleeve and the top of the concrete.

The settlement rod shall be in the centre of the sleeve.



**Protective Surround**

The sand or CMP protective surround shall be extended in 1.5 m increments with the rods.

**Backfill**

The annulus between the ground or CMP and the friction reducing sleeve shall be filled with sand to a level no higher than the top of the sleeve.

**Installation Details**

The elevation, easting and northing of the top of the rod shall be surveyed by the Contractor.

The total distance from the base of the plate to the top of the rod shall be measured and recorded to an accuracy of +/- 2 mm or better.

The contractor is responsible for preventing damage to the settlement plates during the embankment construction. If the plate assembly is damaged or the location/inclination of the point is altered during the filling or other construction activities, the rods and protective casing shall be replaced and surveyed before resuming the filling.

**MONITORING**

The settlement plates shall be monitored by a licensed surveyor, under the direction of the Contract Administrator. The Contractor shall meet with the Contract Administrator and staff responsible for the on-going monitoring immediately after installation of the instruments and before completing the embankment widening. This meeting is referred to as the "hand-over" meeting.

At the meeting, the Contractor shall hand over to the Contract Administrator all records pertaining to the installation of the instruments and all equipment to be supplied by the Contractor.

Monitoring by others for the baseline readings shall commence within two working days after the "hand over" meeting and prior to placing embankment widening fill. The monitoring shall continue on a schedule described herein throughout the completion of the embankment construction, and for approximately up to 12 months following the completion of construction or as dictated by the instrumentation readings.

**Baseline Readings**

Monitoring of the settlement point shall commence within seven (7) working days after the "hand over" meeting as described elsewhere in the Contract Documents.

Prior to the start of the embankment construction, a minimum of three baseline readings must be obtained. Anomalous readings which cannot be repeated are to be discarded and the average of the remaining readings used as a baseline datum.



### Monitoring Frequency

Each settlement point shall be monitored at the following minimum frequencies:

PERIOD	MINIMUM FREQUENCY
During construction of the embankment widening	Daily
First month following end of filling	Twice per week
Up to 11 months after completion of embankment widening and grade raise	Every second week

Anomalous readings should be flagged, checked and discarded, if necessary. The reason for the anomalous reading should be identified and corrected, if possible. Damaged settlement rods shall be reported to the Contract Administrator.

The monitoring data should be reviewed and analysed monthly in order to assess the progression of settlement, and to determine if adjustment of the monitoring schedule or construction methodology or schedule is necessary.

### Removal

After completion of the settlement monitoring period, the settlement points shall be removed. Removal shall extend to at least 0.3 m below the subgrade by excavating and cutting of the rods, sleeves, protective surround and surface casings. The voids resulting from the removal of the settlement rods should be backfilled with compacted granular.

### MEASUREMENT FOR PAYMENT

Measurement is by Plan Quantity, as may be revised by Adjusted Plan Quantity, of the number of settlement plates placed. The unit of measurement is each.

### BASIS OF PAYMENT

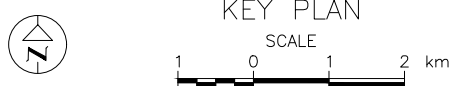
Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material to do the work.

END OF SECTION





SHEET



● Settlement Plate (SP)



Base plans provided in digital format by WSP, drawing file nos. XA1-NAD 83.dwg and XB1-NAD 83 (CSRS).dwg, received APR. 19, 2017 and RAMSAY-CREEK\_GA\_WBL.dwg received SEPT. 19, 2017.

-	-	-	-
NO.	DATE	BY	REVISION
Geocres No..			
HWY. 417		PROJECT NO. 1662565	DIST. EASTERN
SUBM'D SAT	CHKD. WAM	DATE: 3/27/2018	SITE: 3-265/2
DRAWN: ABD	CHKD. SAT	APPD. FUJ	DWG. 1



**Earth Excavation for Structures – Item No.**

---

Special Provision

---

***Amendment to OPSS 902, November 2010***

***Excavating Through Obstructions – Structures***

**902.07 CONSTRUCTION**

Section 902.07 of OPSS 902 shall be amended by the addition of the following:

The Contactor is alerted to the potential presence of cobbles and boulders within the fill. Consideration of the presence of these obstructions shall be made in the selection of appropriate equipment and procedures for excavations and temporary protection systems.

**Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION



**APPENDIX H**

# Site Photographs





**Photograph 1:** West of Site 3-265/1 (EBL), looking north (October 10, 2016).



**Photograph 2:** South of north abutment of Site 3-265/2 (WBL), looking north west (October 10, 2016).

CLIENT  
WSP CANADA GROUP LIMITED

CONSULTANT



YYYY-MM-DD 2018/02/07

PREPARED WAM

DESIGN --

REVIEW MSS

APPROVED FJH

PROJECT  
RAMSAYVILLE ROAD UNDERPASS REPLACEMENT  
SITE NO. 3-265/1 (EBL) AND 3-265/2 (WBL)  
HIGHWAY 417, OTTAWA, ONTARIO

TITLE  
**SELECTED SITE PHOTOGRAPHS**

PROJECT No.  
**1662565**

Phase  
**1130**

Rev.  
**1**

Figure  
**H1**





**Photograph 3:** North of south abutment of Site 3-265/2 (WBL), looking south (October 10, 2016).



**Photograph 4:** North of south abutment of Site 3-265/1 (EBL), looking south east (October 10, 2016).

CLIENT  
WSP CANADA GROUP LIMITED

CONSULTANT



YYYY-MM-DD 2018/02/07

PREPARED WAM

DESIGN --

REVIEW MSS

APPROVED FJH

PROJECT  
RAMSAYVILLE ROAD UNDERPASS REPLACEMENT  
SITE NO. 3-265/1 (EBL) AND 3-265/2 (WBL)  
HIGHWAY 417, OTTAWA, ONTARIO

TITLE  
**SELECTED SITE PHOTOGRAPHS**

PROJECT No.  
**1662565**

Phase  
**1130**

Rev.  
**1**

Figure  
**H2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI/A

1 in





**[golder.com](http://golder.com)**