



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION REPORT
CHESTNUT STREET NBL OVERPASS REPLACEMENT
SITE NO. 18-175/1
ON-RAMP SPEED CHANGE LANE EXTENSION AND
NOISE BARRIER WALL REPLACEMENT
HIGHWAY 406
ST. CATHARINES, ONTARIO
G.W.P. 2259-15-00**

GEOCRES NO. 30M3-295

Report

to

WSP

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Appendix E	Selected photographs of the site

Each of Appendices A to C includes:

- Record of Borehole Sheets
- Laboratory Test Results
- Drawings titled "Borehole Locations and Soil Strata"

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the existing northbound lane (NBL) overpass bridge located on Highway 406 at Chestnut Street, on-ramp speed change lane (SCL) extension at Highway 406/Glendale Avenue (W/E-N Ramp), and replacement of the Highway 406 NBL noise barrier wall in St. Catharines, Ontario. Roadway protection required during the overpass bridge replacement will be addressed.

The purpose of this investigation was to explore the subsurface conditions at the specific location of each of the proposed project components and, based on the data obtained, to provide borehole location plans and soil strata drawings with stratigraphic profiles and cross-sections, records of boreholes, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed for the site based on the data obtained from the present investigation.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the MTO Assignment Number 2014-E-0030.

During the preparation of this report and in addition to the boreholes drilled, general reference has been made to information on subsurface conditions contained in previous foundation reports in the area. The titles of these reports are listed as follows:

- D.H.O. Foundation Investigation Report, Overpass Structure for Highway #58, Line 'B' at Chestnut Street West, District #4, W.J. 60-F-89, W.P. 44-61, dated May 7, 1961, (Reference 1).
- Foundation Investigation Report for N-EW Ramp, Chestnut St. Widening, Geocres No. 30M3-178, W.P. 90-74-03, Site 18-175, Hwy #406, District #4, Hamilton. (Reference 2).

2 SITE DESCRIPTION

The site is located at the Highway 406 crossing at Chestnut Street in St. Catharines, Ontario. The existing structures are concrete single-span twin bridges carrying the Highway 406 northbound lanes (NBL) and southbound lanes (SBL) over Chestnut Street. Existing concrete retaining walls extend between and beyond the footprint of the twin bridges along both sides of Chestnut Street.

The terrain adjacent to the structure is generally flat. Residential dwellings are located on the east and northwest quadrants of the site. The Pen Centre mall is located on the southwest quadrant of the site. Existing noise barrier walls are located adjacent to the Highway 406 NBL and SBL travel lanes. Treed areas are generally located behind the noise barrier walls. Selected photographs of the immediate surroundings of the site are presented in Appendix E.

The site is situated within the physiographic region known as the Haldimand Clay Plain, which is characterized by glacio-lacustrine deposits laid down in glacial Lake Warren during the Wisconsinian Age. These deposits consist of silts and clays and are generally underlain by a glacial till, which in turn overlies bedrock.

3 PROJECT DESCRIPTION

The entire project at this site involves reconstruction of the existing NBL crossing of Highway 406 at Chestnut Street in St. Catharines, Ontario. The project components are:

- Replacement of the existing Highway 406 Chestnut Street NBL overpass bridge. The Highway NBL superstructure will be completely removed (deck, abutments), as well as the existing footings. The new structure will be a rigid frame structure to accommodate the new Highway 406 NBL alignment, which will be shifted to the east by 4.09 m, and the extended speed change lane. The approaches to the bridge and the median retaining walls will also be reconstructed.

- Extension of the on-ramp (SCL) at Highway 406/Glendale Avenue (W/E-N Ramp). The SCL extension will be from approximate Stations 26+430 to 26+936. The existing Highway 406 NBL platform will also be widened to the east. The maximum widening will be 8.3 m. The maximum height of the new embankment will be approximately 6.0 m with sideslope of 2H : 1V.
- Replacement of the existing noise barrier wall along the Highway 406 NBL extension. As result of highway platform extension and widening, the existing noise barrier wall will be relocated to the east and replaced.
- Roadway protection. Roadway protection (temporary shoring) systems will be required for bridge replacement and roadway widening.

4 INVESTIGATION PROCEDURES

The site investigation and field testing for this project were carried out from November 3, 2106 to December 19, 2016, and on May 7, 2016. Details of the site investigation and field testing for each project component are presented in Table 4.1.

Table 4.1 – Borehole Designations and Details

Design component	Borehole	Sampled borehole termination depth (m)	Sampled borehole termination elevation (m)	Appendix
Highway 406 Chestnut Street NBL Overpass Bridge, approaches and retaining walls	CS16-01 to CS16-04	15.5 to 17.0	98.3 to 100.7	A
	CH16-01 CH16-02	8.2	109.3 and 109.8	
On-ramp SCL extension and noise barrier wall	SC16-01 to SC16-08	8.2 to 12.8	103.4 to 113.1	B
Roadway protection	RP16-01 to RP16-04	8.2	112.6 to 113.6	C

The approximate locations of the boreholes drilled during the present investigation are shown on the attached Borehole Locations and Soil Strata Drawings in Appendices A to C. The coordinates and elevations of the boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendices A to C. Boreholes drilled during previous investigations in the 1990's, 1980's and 1950's near this site are included in Appendix D.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by WSP.

Truck-mounted D25 and D50 drill rigs were used to drill and sample the boreholes. Hollow stem augers were used to advance the boreholes until the target depth was reached. In general, soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT). The in situ shear strength of the cohesive soils was also assessed using an MTO 'N' size shear vane, where applicable.

The drilling, sampling and in-situ testing operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing. Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendices A to C.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Seven standpipe piezometers were installed in selected boreholes (CS16-02, CS16-04, SC16-01, SC16-03, SC6-08, CH16-01 and CH16-02). Each piezometer consisted of a 25 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen enclosed in a column of filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. Upon completion of the drilling operations, the boreholes without piezometers were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). The details of standpipe piezometer installation and borehole completion are summarized in Table 4.2. The piezometer installations have been decommissioned as per O.Reg. 903 after the last set of water level readings were obtained.

Table 4.2 – Borehole Completion Details

Project Element	Borehole No.	Borehole Depth / Base Elevation (m)	Piezometer Depth / Tip Elevation (m)	Completion Details
Highway 406 Chestnut Street NBL Overpass Bridge, approaches and retaining walls	CS16-01	15.5/100.7	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	CS16-02	17.0/99.2	16.7/99.5	Backfilled with filter sand from 17.0 m to 13.3 m, bentonite holeplug from 13.3m to 12.7 m, bentonite holeplug and auger cuttings from 12.7 m to 0.15 m, then asphalt to surface.
	CS16-03	17.0/98.3	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	CS16-04	16.9/98.3	16.7/98.5	Backfilled with filter sand from 16.9 m to 13.2 m, bentonite holeplug from 13.2m to 12.6 m, bentonite holeplug and auger cuttings from 12.6 m to 0.15 m, then concrete to surface.
	CH16-01	8.2/109.3	7.6/109.9	Backfilled with filter sand from 8.2 m to 5.5 m, bentonite holeplug and auger cuttings from 5.5 m to surface.
	CH16-02	8.2/109.8	7.6/110.4	Backfilled with filter sand from 8.2 m to 5.5 m, bentonite holeplug and auger cuttings from 5.5 m to surface.
On-ramp SCL extension and noise barrier wall	SC16-01	8.2/105.7	7.6/106.3	Backfilled with filter sand from 8.2 m to 5.5 m, bentonite holeplug and auger cuttings from 5.5 m to surface.
	SC16-02	9.8/103.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, concrete from 0.5 m to 0.2 m, then asphalt to surface.
	SC16-03	8.2/106.7	7.6/107.3	Backfilled with filter sand from 8.2 m to 5.5 m, bentonite holeplug and auger cuttings from 5.5 m to surface.
	SC16-04	11.3/104.9	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.6 m, concrete from 0.6 m to 0.2 m, then asphalt to surface.
	SC16-05	8.2/107.6	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.

Project Element	Borehole No.	Borehole Depth / Base Elevation (m)	Piezometer Depth / Tip Elevation (m)	Completion Details
	SC16-06	12.8/106.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	SC16-07	8.2/111.1	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
	SC16-08	8.2/113.1	7.6/113.7	Backfilled with filter sand from 8.2 m to 5.5 m, bentonite holeplug and auger cuttings from 5.5 m to surface.
Roadway protection	RP16-01	8.2/112.7	None installed	Borehole backfilled with auger cuttings to surface.
	RP16-02	8.2/112.6	None installed	Borehole backfilled with auger cuttings to surface.
	RP16-03	8.2/113.4	None installed	Borehole backfilled with auger cuttings to surface.
	RP16-04	8.2/113.6	None installed	Borehole backfilled with auger cuttings to surface.

5 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. Results of the laboratory testing of the present investigation, are summarized on the Record of Borehole sheets, and presented on the figures included in Appendices A to C. Laboratory test results of the previous investigations (References 1 and 2), are presented in Appendix D.

6 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices A to C for details of the encountered soil stratigraphy. Soil profiles and cross sections (where applicable) of the project elements (overpass bridge, retaining walls, SCL extension, noise barrier wall, roadway protection), are presented on the "Borehole Locations and Soil Strata" drawings in Appendices A to C. Overall descriptions of the stratigraphy are given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site

conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations. More detailed descriptions of the individual strata are presented below.

6.1 Highway 406 Chestnut Street NBL Overpass Bridge

A total of four boreholes, numbered CS16-01 to CS16-04, were drilled in the vicinity of the Highway 406 Chestnut Street NBL overpass bridge. The boreholes were drilled on the Chestnut Street grade, near the proposed north and south abutments. Two boreholes, numbered CH16-01 and CH16-02, were drilled along the proposed bridge approaches.

Records of boreholes, laboratory testing results, borehole location plan, stratigraphic profile and cross section drawings are contained in Appendix A.

In general, the subsurface stratigraphy encountered at this location, consists of pavement structure (asphalt and granular base) overlying cohesive embankment fill, and underlain by an extensive deposit of native silty clay overlying glacial till. The above soils are underlain by shale bedrock. More detailed descriptions of the individual strata are presented below.

6.1.1 Topsoil

Topsoil was encountered at ground surface in the Boreholes CH16-01 and CH16-02, with a thickness of 75 mm.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data presented in this report should not be used for quantity estimation purposes.

6.1.2 Pavement Structure

Boreholes CS16-01 to CS16-04 encountered surficial asphalt over granular base. The thickness of the asphalt pavement was 100 mm.

The granular base consisted of gravelly sand to sand fill containing some silt and trace clay. The thickness of the granular base was 600 mm. Moisture contents of the granular fill ranged from 2 percent to 8 percent.

Three samples of the granular fill were subjected to laboratory gradation analysis. The results of these tests are summarized in the table below as well as on the Record of Borehole sheets included in Appendix A. Figures A1 and A2 in Appendix A, present the grain size distribution curves for these samples.

Soil Particles	Gravelly Sand Fill Percentage	Sand Fill Percentage
Gravel	31	17 to 18
Sand	45	57
Silt	-	19
Clay	-	7
Silt and Clay	24	25

6.1.3 Silty Clay Fill

Brown silty clay fill containing trace sand and trace gravel was contacted below the granular base in Boreholes CS16-03 and CS16-04. In Boreholes CH16-01 and CH16-02, the silty clay fill was contacted below the topsoil. The thickness of the silty clay fill was 0.7 m to 0.8 m in Boreholes CS16-03 and CS16-04, and 1.4 m and 1.3 m in Boreholes CH16-01 and CH16-02

The depth to the base of the silty clay fill was 1.4 m and 1.5 m (Elevations 113.9 and 113.7), in Boreholes CS16-03 and CS16-04, and 1.5 m and 1.4 m (Elevations 116.0 and 116.6) in Boreholes CH16-01 and CH16-02, respectively.

SPT 'N' values obtained in the silty clay fill ranged from 7 to 17 blows for 0.3 m penetration, indicating a firm to very stiff consistency. An SPT 'N' value of 38 blows per 0.3 m of penetration was measured in Borehole CH16-01, indicating a hard consistency. Natural moisture contents of the silty clay fill ranged from 12 percent to 28 percent.

6.1.4 Silty Clay

An extensive deposit of native brown to grey silty clay containing trace sand and trace gravel was encountered below the fill in all the boreholes. The silty clay was contacted at 0.7 m depth in Boreholes CS16-01 and CS16-02, and at 1.4 m and 1.5 m depths in Boreholes CS16-03 and CS16-04, respectively. The silty clay was contacted at 1.5 m and 1.4 m depths (Elevations 116.0 and 116.6) in Boreholes CH16-01 and CH16-02, drilled near the proposed approaches to the widening. The thickness of the silty clay ranged from 12.0 m to 12.6 m. The depth to the base of the silty clay varied from 13.3 m to 14.0 m (Elevations 101.2 to 102.9). Boreholes CH16-01 and CH16-02 were terminated within the silty clay at 8.2 m depth (Elevations 109.3 and 109.8).

Based on higher 'N' values, soil colour and texture, and an estimation of the over-consolidation ratio, a weathered crust between about 1 m to 3 m thick was encountered within the upper portion of the silty clay. Below the Chestnut Street grade, the base of the crust is at approximate

Elevations 112 to 113 m. At the widened south approach, the base of the crust is at approximate Elevation 114 m. The crust appears to be thicker than 3 m at the widened north approach. Within this crust, SPT 'N' values typically ranged from 12 to 26 blows for 0.3 m of penetration indicating a stiff to very stiff consistency.

Below the crust, the silty clay was found to be firm to stiff. In situ vane testing indicated that the undrained shear strength ranges from 63 to 98 kPa which corresponds to a typical stiff consistency. An SPT 'N' value of 30 blows per 0.3 m of penetration, indicating a hard consistency, was measured in Borehole CH16-02 at approximately 1.5 m depth. The SPT 'N' values ranged from 6 to 12 blows per 0.3 m penetration which indicate firm to stiff consistency. An SPT 'N' value of 2 blows per 0.3 m of penetration, indicating a soft consistency, was measured below Elevation 103.0 in Borehole CS16-03. Natural moisture contents of the silty clay ranged from 12 percent to 41 percent.

The results of grain size analyses conducted on silty clay samples are presented on the Record of Borehole sheets in Appendix A, and are illustrated in Figures A3 to A5 of Appendix A. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	29 to 51
Clay	49 to 71

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure A7 of Appendix A. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	41 to 54
Plasticity Index	23 to 27

The results of the Atterberg Limits testing indicate the deposit is of medium to high plasticity with group symbols CI and CH.

6.1.5 Silt to Sand and Silt Till

A deposit of brown to greyish brown silt to sand and silt till, some clay, trace gravel with clayey silt seams was contacted below the silty clay at depths ranging from 13.3 m to 14.0 m. The till

was fully penetrated in Borehole CS16-03, and at this location its thickness was 1.7 m. The depth to the base of the silt till was 15.1 m (Elevation 100.2) in Borehole CS16-03. Boreholes CS16-01, CS16-02 and CS16-04 were terminated within the silt till at depths ranging from 15.5 m to 17.0 m (Elevations 98.3 to 100.7).

SPT 'N' values recorded in the till were typically greater than 100 blows for less than 0.3 m of penetration, indicating a very dense state. An SPT 'N' value of 14 blows per 0.3 m of penetration, indicating a compact state was measured in Borehole CS16-01 near Elevation 102.2. Natural moisture contents of the till ranged from 8 percent to 29 percent.

The results of grain size analyses conducted on samples of the till are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure A6 of Appendix A. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	19 to 51
Silt	39 to 62
Clay	10 to 19

It is noted that glacial till inherently contains cobbles and boulders.

6.1.6 Shale Bedrock

The soils described above are underlain by shale bedrock. Reddish brown shale bedrock was contacted at 15.1 m depth in Borehole CS16-03. Borehole CS16-03 was terminated within the shale bedrock at 17.0 m depth (Elevation 98.3).

SPT 'N' values measured in the shale bedrock were 100 blows for less than 0.3 m of penetration.

6.1.7 Groundwater Conditions

The water levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. All boreholes were open to the depths investigated and dry upon completion of drilling. Standpipe piezometers were installed in Boreholes CS16-02, CS16-04, CH16-01 and CH16-02 to permit longer term monitoring of the groundwater level. Groundwater levels measured in the piezometers are presented in Table 6.1.

Table 6-1. Measured Groundwater Levels

Borehole Number	Date	Groundwater Level		Comment
		Depth (m)	Elevation (m)	
CS16-02	January 11, 2017	Frozen	-	Piezometer
	March 16, 2017	2.0	114.2	
	August 30, 2017	1.4	114.8	
CS16-04	January 11, 2017	2.0	113.2	Piezometer
	March 16, 2017	1.5	113.7	
CH16-01	January 4, 2017	4.1	113.4	Piezometer
	January 13, 2017	3.9	113.6	
	March 16, 2017	3.2	114.3	
	August 30, 2017	2.3	115.2	
CH16-02	January 4, 2017	4.1	113.9	Piezometer
	January 13, 2017	6.1	111.9	
	March 16, 2017	3.2	114.8	
	August 30, 2017	2.8	115.2	

The values shown in Table 6-1 are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6.2 On-ramp Speed Change Lane (SCL) Extension and Noise Barrier Wall

A total of eight boreholes, numbered SC16-01 to SC16-08, were drilled along Highway 406 NBL from Stations 26+550 to 27+000. The boreholes were located along the alignment of the proposed on-ramp SCL extension. The replacement noise barrier wall has an alignment along the shoulder of the widened NBL.

Records of boreholes, laboratory testing results, borehole location plan and stratigraphic profile drawing are contained in Appendix B.

In general, the subsurface stratigraphy encountered in these boreholes consists of topsoil or pavement structure overlying silty clay fill which is underlain by native silty clay. More detailed descriptions of the individual strata are presented below.

6.2.1 Topsoil

Topsoil was encountered at ground surface in Boreholes SC16-01, SC16-03, SC16-05, SC16-07 and SC16-08. The thickness varies from 50 mm to 75 mm.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data presented in this report should not be used for quantity estimation purposes.

6.2.2 Pavement Structure

In Boreholes SC16-02, SC16-04 and SC16-06 drilled from the Highway 406 grade, a pavement structure consisting of 75 mm to 100 mm of asphalt overlying 0.6 m to 1.0 m of brown to grey gravelly sand was encountered. The base of the pavement structure ranged from 0.7 m to 1.1 m depths (Elevations 112.1 to 118.5). Moisture contents of the gravelly sand were measured at about 3 percent to 5 percent.

6.2.3 Silty Clay Fill

Brown to grey silty clay fill containing trace sand and trace gravel, occasional roots, rootlets and topsoil, was contacted below the topsoil in Boreholes SC16-01, SC16-03, SC16-05, SC16-07 and SC16-08, and below the gravelly sand fill at 0.7 m depth (Elevation 115.5) in Borehole SC16-04. Silty clay fill was not encountered in Borehole SC16-02. The thickness of the silty clay fill varied from 0.6 m to 1.3 m, and locally at 2.2 m in Borehole SC16-01.

The depth to the base of the silty clay fill varied from 0.7 m to 1.5 m (Elevations 113.5 to 119.9), and locally at 2.3 m (Elevation 111.6) in Borehole SC16-01.

SPT 'N' values obtained in the silty clay fill ranged from 7 to 27 blows for 0.3 m penetration indicating a firm to very stiff consistency, except in Borehole SC16-04 where an 'N' value of 32 blows per 0.3 m penetration was recorded indicating a hard consistency. Moisture contents of the silty clay fill were 17 percent to 36 percent.

6.2.4 Silty Clay

An extensive deposit of brown to grey silty clay containing trace sand and trace gravel was encountered below the fill in all the boreholes. The silty clay was contacted at depths typically ranging from 0.7 m to 1.5 m (Elevations 112.1 to 119.9) and at 2.3 m depth (Elevation 111.6) in Borehole SC16-01. The eight boreholes were terminated within the silty clay at 8.2 m to 12.8 m depths (Elevations ranging from 103.4 to 113.1).

The majority of SPT 'N' values obtained in the silty clay layer ranged from 8 to 29 blows for 0.3 m penetration indicating a stiff to very stiff consistency. Occasional 'N' values of 6 to 7 blows indicated the firm zones within this deposit. In Boreholes SC16-04 and SC 16-06, 'N' values greater than 30 blows per 0.3 m penetration were recorded which indicate a hard consistency.

In general, the silty clay above approximate Elevations 112 to 113 m may be considered as the weathered crust. Natural moisture contents of the silty clay ranged from 15 percent to 34 percent.

The results of grain size analyses conducted on silty clay samples are presented on the Record of Borehole sheets in Appendix B, and are illustrated in Figures B1 to B3 of Appendix B. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	30 to 54
Clay	46 to 70

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix A and illustrated in Figures B4 and B5 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	47 to 54
Plasticity Index	26 to 30

The results of the Atterberg Limits testing indicate the silty clay deposit to be of medium to high plasticity with group symbols CI and CH.

6.2.5 Groundwater Conditions

The water levels in the boreholes were observed during the drilling operations and upon completion of drilling. All boreholes were open to the depths investigated and dry upon completion of drilling. Three standpipe piezometers were installed in Boreholes SC16-01, SC16-03 and SC16-08 to permit longer term monitoring of the groundwater level. Groundwater levels measured in the piezometers are presented in Table 6.2.

Table 6-2. Measured Groundwater Levels

Borehole Number	Date	Groundwater Level		Comment
		Depth (m)	Elevation (m)	
SC16-01	January 13, 2017	7.2	106.7	Piezometer
	March 16, 2017	6.3	107.6	
	August 30, 2017	6.1	107.8	
SC16-03	January 13, 2017	5.8	109.1	Piezometer
	March 16, 2017	4.9	110.0	
	August 30, 2017	4.7	110.2	
SC16-08	January 13, 2017	3.0	118.3	Piezometer
	March 16, 2017	1.5	119.8	
	August 30, 2017	1.6	119.7	

The values shown in Table 6-2 are short term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6.3 Roadway Protection

A total of four boreholes, numbered RP16-01 to RP16-04, were drilled in the vicinity of the existing abutments where roadway protection will likely be required during the replacement of the existing Highway 406 NBL overpass bridge at Chestnut Street.

Records of boreholes, laboratory testing results, borehole location plan and stratigraphic profile drawing are contained in Appendix C.

In general, the subsurface stratigraphy encountered at these locations consists of pavement structure overlying granular (abutment) fill and silty clay embankment fill, which are underlain by native silty clay. More detailed descriptions of the individual strata are presented below.

6.3.1 Asphalt and Concrete

The four boreholes were drilled on Highway 406 NBL roadway and encountered surficial asphalt over concrete. The thickness of the asphalt pavement was 75 mm where encountered, and asphalt was not encountered in Borehole RP16-03. The thickness of the concrete underlying the asphalt varies from 150 mm to 375 mm.

6.3.2 Granular Fill

Granular fill consisting of gravelly sand overlying sand was encountered in Boreholes RP16-01, RP16-02 and RP16-04. The grey gravelly sand fill was contacted immediately below the concrete in Boreholes RP16-02 and RP16-04. The thickness of the upper gravelly sand fill was 0.4 m and 0.9 m. The sand fill containing trace gravel, some silt and trace to some clay was contacted immediately below the concrete in Borehole RP16-01, and below the gravelly sand fill in Boreholes RP16-02 and RP16-04. The thickness of the sand fill varied between 4.5 m and 6.1m, with the depth to the base of the granular fill ranging from 5.0 m to 7.5 m (Elevations 114.3 to 115.9).

An SPT 'N' value of 24 blows per 0.3 m of penetration, measured in the gravelly sand fill, indicated a compact state. SPT 'N' values measured in the sand fill varied from 11 to 46 blows per 0.3 m of penetration indicating a compact to dense condition. An SPT 'N' value of 80 blows for less than 0.3 m of penetration, indicating a very dense state, was measured in Borehole RP16-02 near Elevation 118.5. Measured moisture contents in the granular fill ranged from 4 percent to 8 percent.

Selected samples of the granular fill were subjected to laboratory gradation analysis. The results of these tests are summarized in the table below as well as on the Record of Borehole sheets included in Appendix C. Figure C1 in Appendix C, present the grain size distribution curves for these samples.

Soil Particles	Sand Fill Percentage
Gravel	1 to 19
Sand	58 to 81
Silt	12 to 19
Clay	4 to 6
Silt and Clay	17 to 23

6.3.3 Silty Clay Embankment Fill

Grey silty clay embankment fill containing some sand and some gravel, was contacted below the concrete in Borehole RP16-03. The thickness of the silty clay fill was 3.8 m with a depth to the base of the silty clay fill of 4.0 m (Elevation 117.6).

SPT 'N' values obtained in the silty clay fill ranged from 8 to 13 blows for 0.3 m penetration

indicating a stiff consistency. Moisture contents of the silty clay fill ranged from 19 percent to 27 percent.

The results of grain size analyses conducted on a silty clay fill sample are presented on the Record of Borehole sheets in Appendix C, and are illustrated in Figure C2 of Appendix C. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	36
Clay	64

6.3.4 Silty Clay

A deposit of brown silty clay containing trace sand and trace gravel was encountered below the fill in Boreholes RP16-01 to RP16-04. The silty clay was contacted at depths ranging from 4.0 m to 7.5 m. All four boreholes were terminated within the silty clay at 8.2 m depth (Elevations 112.6 to 113.6).

SPT 'N' values ranged from 21 to 51 blows per 0.3 m of penetration indicating a very stiff to hard consistency. Natural moisture contents of the silty clay ranged from 20 percent to 27 percent.

The results of grain size analyses conducted on silty clay samples are presented on the Record of Borehole sheets in Appendix C, and are illustrated in Figure C3 of Appendix C. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	0 to 8
Silt	32 to 40
Clay	60 to 67

The results of Atterberg Limits tests conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix C and illustrated in Figure C4 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	46 to 54
Plasticity Index	26 to 33

The results of the Atterberg Limits testing indicate the silty clay to be of medium to high plasticity with group symbols CI and CH.

6.3.5 Groundwater Conditions

The water levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. These four boreholes were open to the depths investigated and dry upon completion of drilling.

Seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

7 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the coordinates of the boreholes using a GPS device. WSP provided the ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated truck-mounted D25 and D50 drill rigs to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Omar Ali of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. R. Palomeque Reyna, P. Eng. and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



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Review Principal, Designated MTO Contact



Appendix A

Hwy 406 Chestnut Street NBL Overpass Bridge and Approaches

Boreholes CS16-01 to CS16-04

Boreholes CH16-01 to CH16-02





- Record of Borehole Sheets
- Laboratory Test Results
- Drawings titled "Borehole Locations and Soil Strata"

RECORD OF BOREHOLE No CH16-01

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Widening Approaches N 4 777 726.6 E 327 533.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.25 - 2016.11.25 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
117.5	GROUND SURFACE							20	40	60	80	100	PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L			
0.0	TOPSOIL: (75mm) Silty CLAY , trace sand, trace gravel Firm to Hard Greyish Brown Moist (FILL)		1	SS	7													
0.1																		
			2	SS	38													
116.0																		
1.5	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		3	SS	26													
			4	SS	22													
			5	SS	22													
			6	SS	21													
			7	SS	22													
			8	SS	21													
109.3																		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.04 4.1 113.4 2017.01.13 3.9 113.6 2017.03.16 3.2 114.3 2017.08.30 2.3 115.2																	

ONTMT4S MTO-11336.GPJ 2017TEMPLATE(MTO).GDT 9/12/17

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

RECORD OF BOREHOLE No CH16-02

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Widening Approaches N 4 777 677.5 E 327 531.9 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.03 - 2016.11.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
118.0	GROUND SURFACE							20	40	60	80	100						
0.0 0.1	TOPSOIL: (75mm)							20	40	60	80	100						
	Silty CLAY , trace sand, trace gravel, occasional organics Stiff to Very Stiff Brown Moist (FILL)		1	SS	12									o				
			2	SS	17									o				
116.6																		
1.4	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		3	SS	30									o			0 0 50 50	
			4	SS	21									o				
			5	SS	17									o				
113.9																		
4.1	Stiff		6	SS	13									o				
112.4																		
5.6			7	SS	15									o				
			8	SS	24									o				
109.8																		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.04 4.1 113.9 2017.01.13 6.1 111.9 2017.03.16 3.2 114.8 2017.08.30 2.8 115.2																	

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

RECORD OF BOREHOLE No CS16-01

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Overpass N 4 777 704.1 E 327 524.8 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.28 - 2016.11.28 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
116.2	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (100mm)																			
0.1	Gravelly SAND, some silt, some clay		1	GS			116												31 45 24 (SI+CL)	
115.5	Brown																			
	Moist																			
0.7	(FILL)																			
	Silty CLAY, trace sand, trace gravel		2	SS	16		115													
	Very Stiff to Stiff																			
	Brown																			
	Moist																			
			3	SS	16		114													
			4	SS	14														0 0 34 66	
			5	SS	12		113													
							112													
			6	SS	10		111													
							110													
	Becoming grey		7	SS	16															
							109													
			8	SS	11		108												0 0 39 61	
							107													
			9	SS	11															

Continued Next Page

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

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CS16-02

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Overpass N 4 777 695.7 E 327 525.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.29 - 2016.11.29 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				W _P W W _L WATER CONTENT (%)				GR	SA	SI	CL		
116.2	GROUND SURFACE							20	40	60	80	100									
0.0	ASPHALT:(100mm)							20	40	60	80	100									
0.1	Gravelly SAND , some silt, trace clay Brown Moist (FILL)		1	GS			116							○							
115.5																					
0.7	Silty CLAY , trace sand, trace gravel Very Stiff to Stiff Brown Moist		1	SS	18		115							○							
			2	SS	19		114							○				0	0	51	49
			3	SS	13		113							○							
			4	SS	13		112														
			5	SS	8		111							○	—			0	0	36	64
110.6	Becoming grey Firm						110														
5.6			6	SS	6		109							○							
109.0							108														
7.2			7	SS	10		107							○							
			8	SS	7									○				0	0	36	64

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

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RECORD OF BOREHOLE No CS16-03

2 OF 2

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Overpass N 4 777 694.8 E 327 500.0 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.29 - 2016.11.30 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL		
								20 40 60 80 100				w _p w w _L									
Continued From Previous Page																					
	Silty CLAY , trace sand, trace gravel Stiff Grey Moist		9	SS	8		105														
								104													
	Soft		10	SS	2		103														
								102													
101.9																					
13.4	SILT , some sand, some clay Very Dense Grey Moist (TILL)		11	SS	100/ 0.250		101											0	19	62	19
100.2																					
15.1	SHALE BEDROCK weathered Reddish Brown		12	SS	100/ 0.150		100														
							99														
98.3			13	SS	100/ 0.200																
17.0	END OF BOREHOLE AT 17.0m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																				

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

RECORD OF BOREHOLE No CS16-04

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION Chestnut St Overpass N 4 777 703.3 E 327 500.1 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.30 - 2016.12.01 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
115.2	GROUND SURFACE												
0.0	ASPHALT: (100mm)												
0.1	SAND, some gravel, some silt, trace clay Brown Moist (FILL)		1	GS			115						17 57 19 7
114.5													
0.7	Silty CLAY, trace sand, trace gravel Stiff Brown Moist (FILL)		1	SS	11		114						
113.7													
1.5	Silty CLAY, trace sand, trace gravel Very Stiff to Stiff Brown Moist		2	SS	17		113						
			3	SS	12		112						0 0 36 64
			4	SS	11		111						
			5	SS	8		110						
			6	SS	9		109						
							108						
	Firm		7	SS	7		107						
			8	SS	8		106						

Continued Next Page

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

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80			100	W _P	W	W _L
								SHEAR STRENGTH kPa		WATER CONTENT (%)							
	Continued From Previous Page																
	Silty CLAY , trace sand, trace gravel Stiff Brown Moist		9	SS	11												
			10	SS	8												
101.2			11	SS	100/ 0.200												
14.0	SILT , some sand, some clay, trace gravel Very Dense Greyish Brown Moist (TILL)		12	SS	100/ 0.150												
			13	SS	100/ 0.150												
98.3	END OF BOREHOLE AT 16.9m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.																
16.9																	
WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.11 2.0 113.2 2017.03.16 1.5 113.7 2017.08.30 1.3 113.9																	

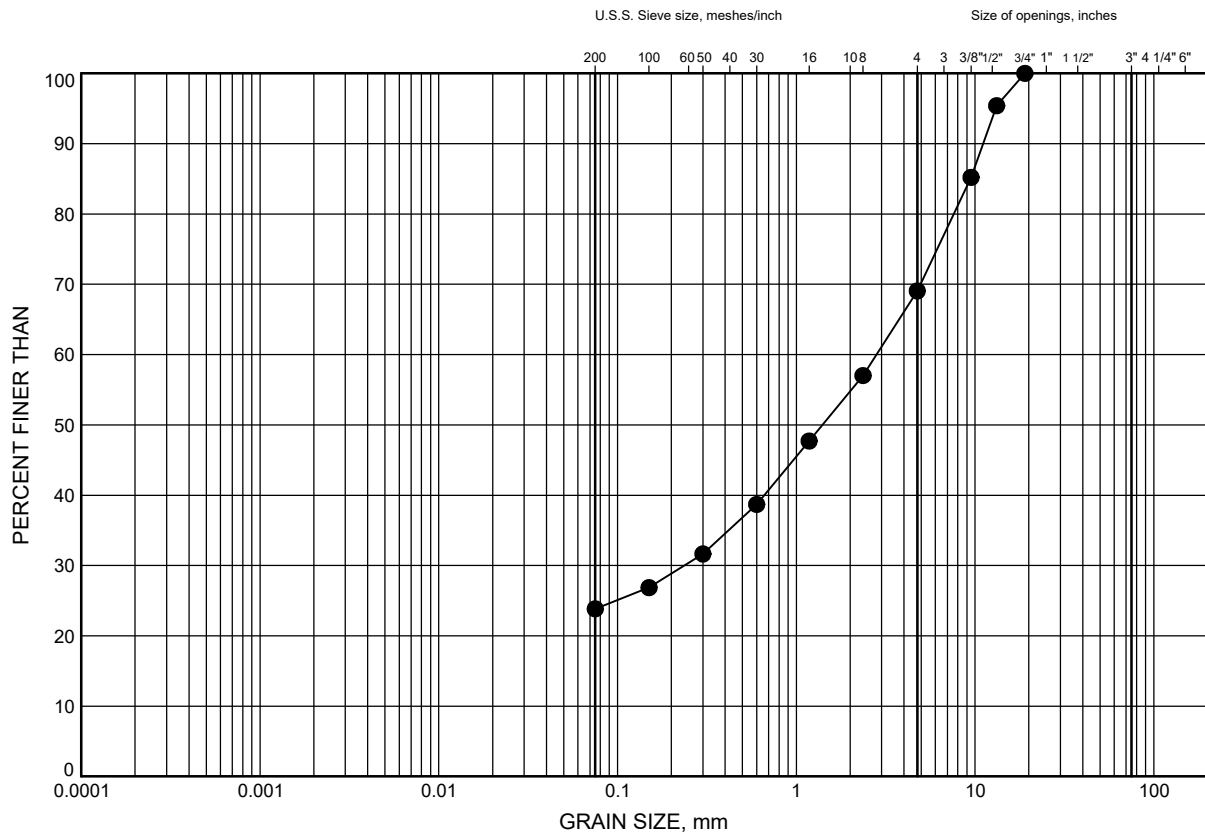
+³, ×³: Numbers refer to Sensitivity

Chestnut St Overpass

GRAIN SIZE DISTRIBUTION

FIGURE A1

Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CS16-01	0.3	115.9

Date September 2017
GWP# 2259-15-00

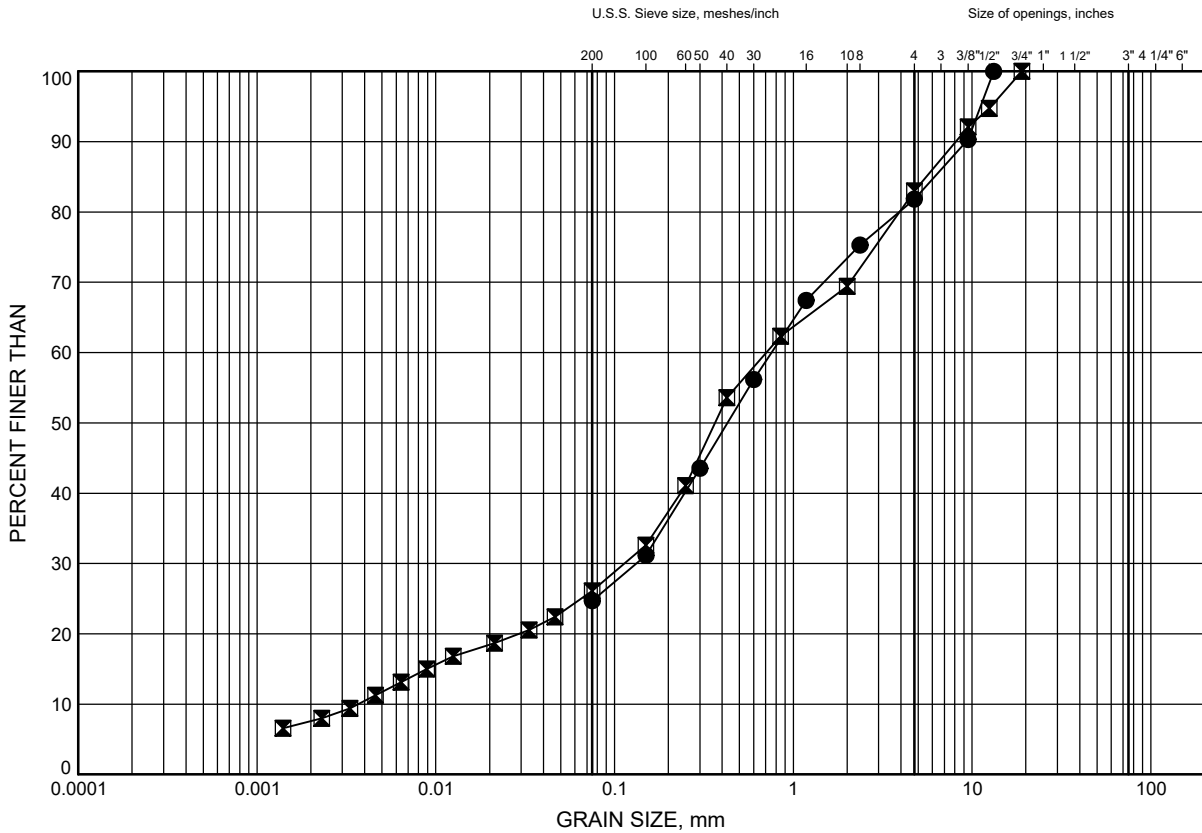


Prep'd AN
Chkd. RPR

Chestnut St Overpass GRAIN SIZE DISTRIBUTION

FIGURE A2

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CS16-03	0.3	115.0
⊠	CS16-04	0.3	114.9

Date September 2017

GWP# 2259-15-00



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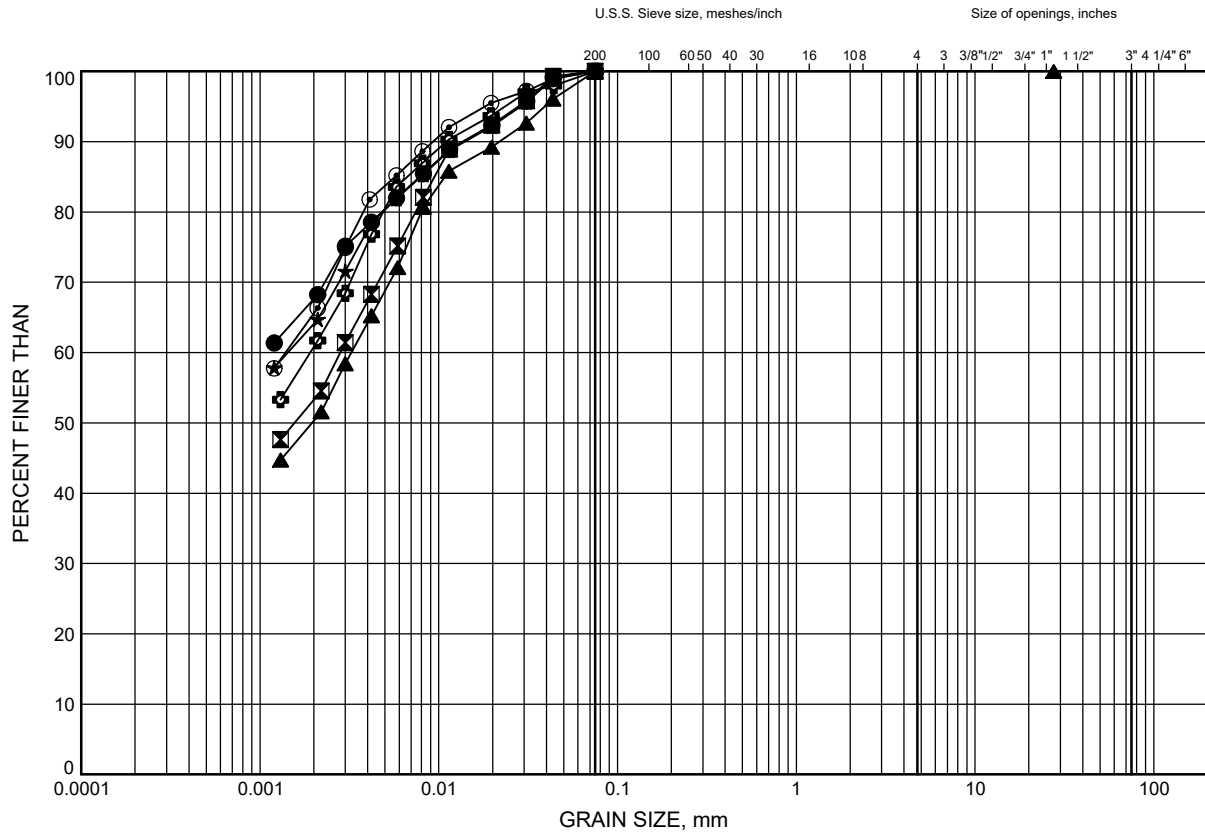
Chkd. RPR

Chestnut St Overpass

GRAIN SIZE DISTRIBUTION

FIGURE A3

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CH16-01	3.4	114.1
⊠	CH16-01	6.4	111.1
▲	CH16-02	1.8	116.2
★	CH16-02	4.9	113.1
⊙	CS16-01	2.6	113.6
⊕	CS16-01	7.9	108.3

Date September 2017

GWP# 2259-15-00



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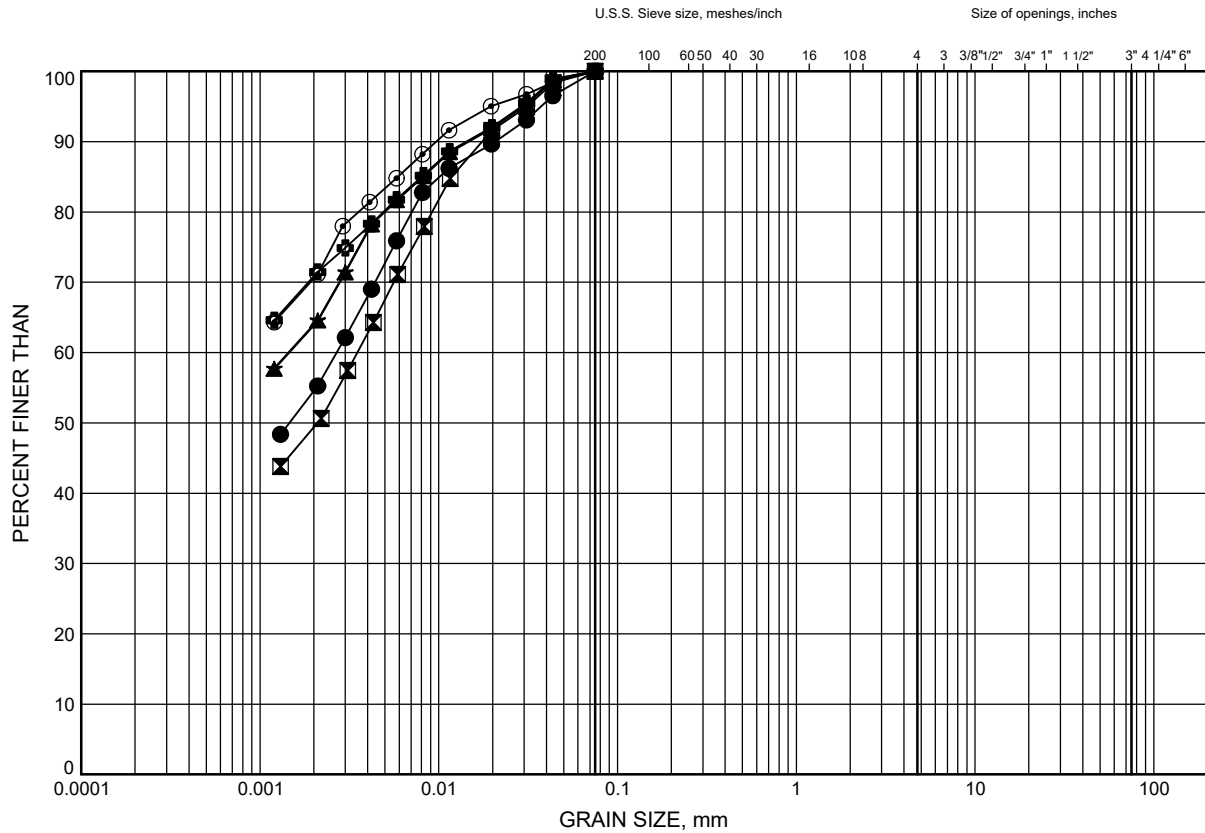
Chkd. RPR

Chestnut St Overpass

GRAIN SIZE DISTRIBUTION

FIGURE A4

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CS16-01	12.5	103.7
⊠	CS16-02	1.8	114.4
▲	CS16-02	4.9	111.3
★	CS16-02	9.4	106.8
⊙	CS16-03	3.4	111.9
⊕	CS16-03	9.4	105.9

Date September 2017

GWP# 2259-15-00



Prep'd AN

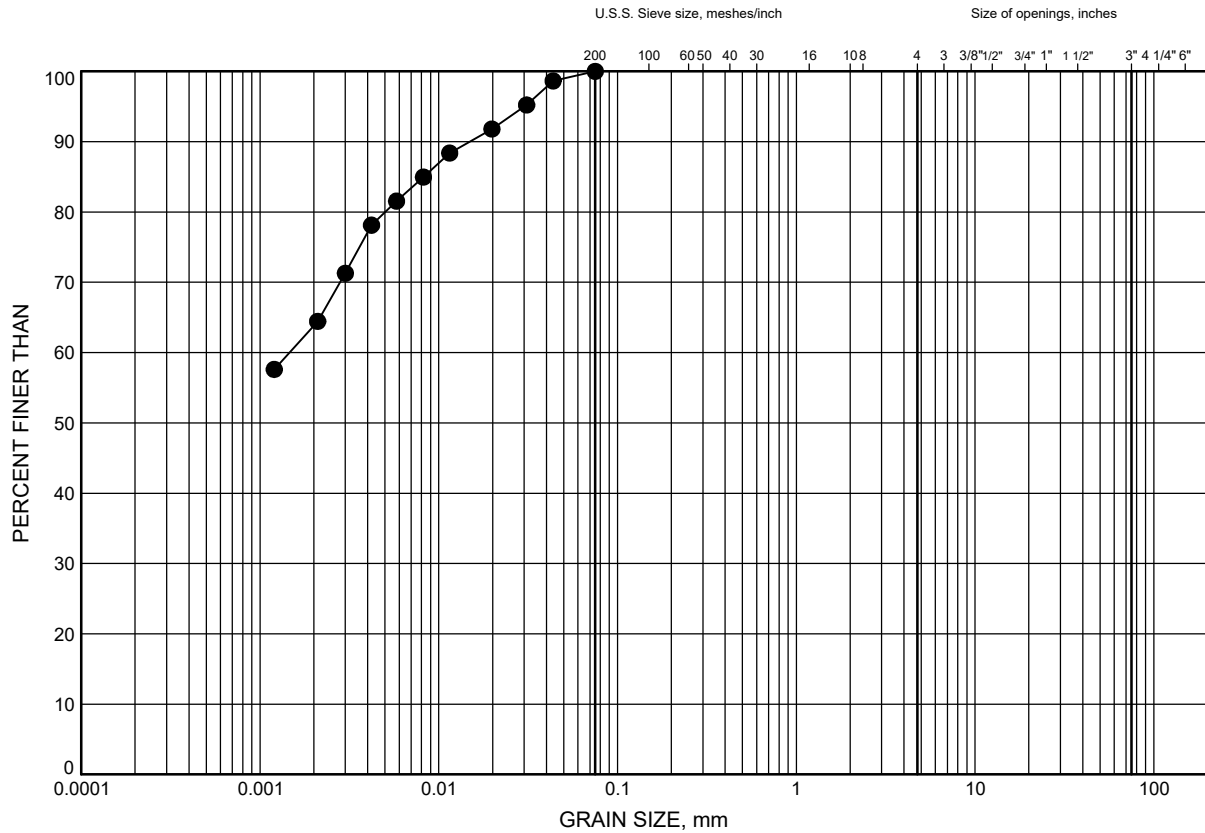
Chkd. RPR

Chestnut St Overpass

GRAIN SIZE DISTRIBUTION

FIGURE A5

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CS16-04	3.4	111.8

Date September 2017

GWP# 2259-15-00



Prep'd AN

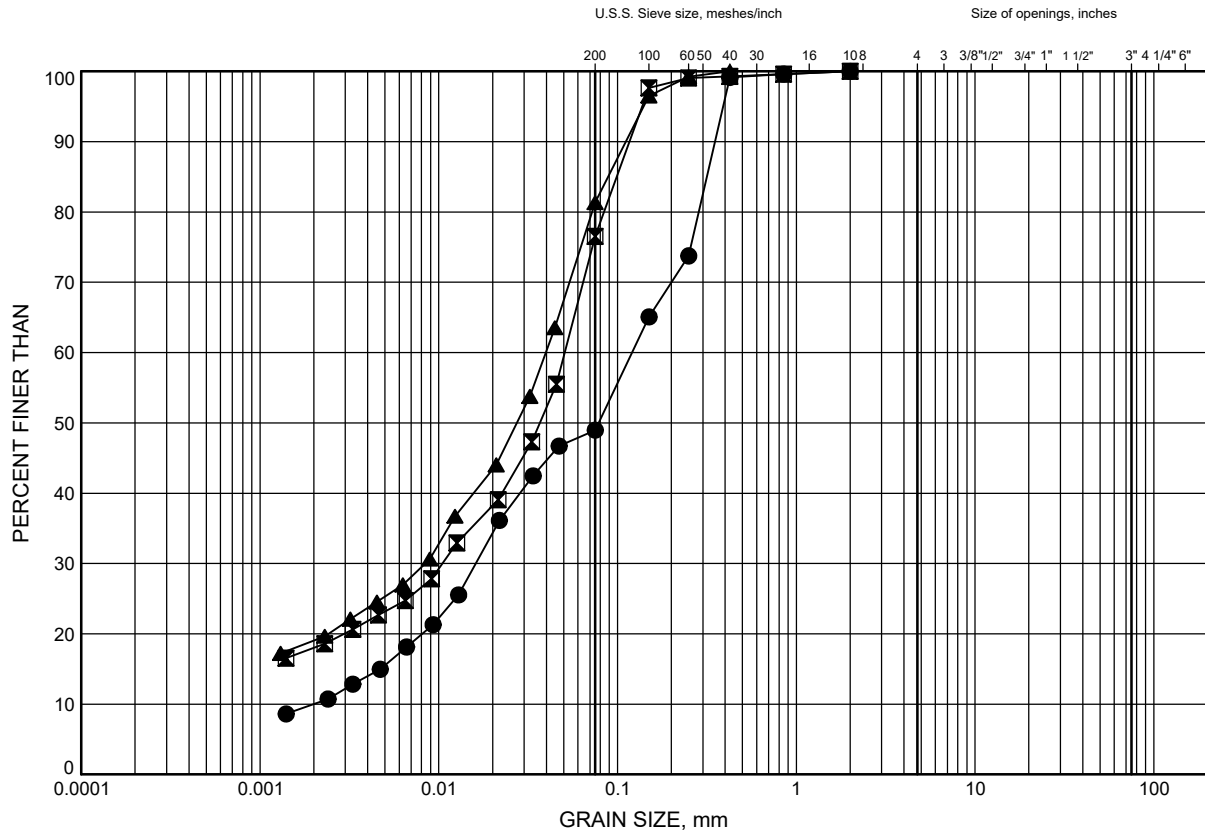
Chkd. RPR

Chestnut St Overpass

GRAIN SIZE DISTRIBUTION

FIGURE A6

SILT to SAND and SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CS16-01	15.4	100.8
⊠	CS16-02	15.4	100.8
▲	CS16-03	14.0	101.3

Date September 2017

GWP# 2259-15-00



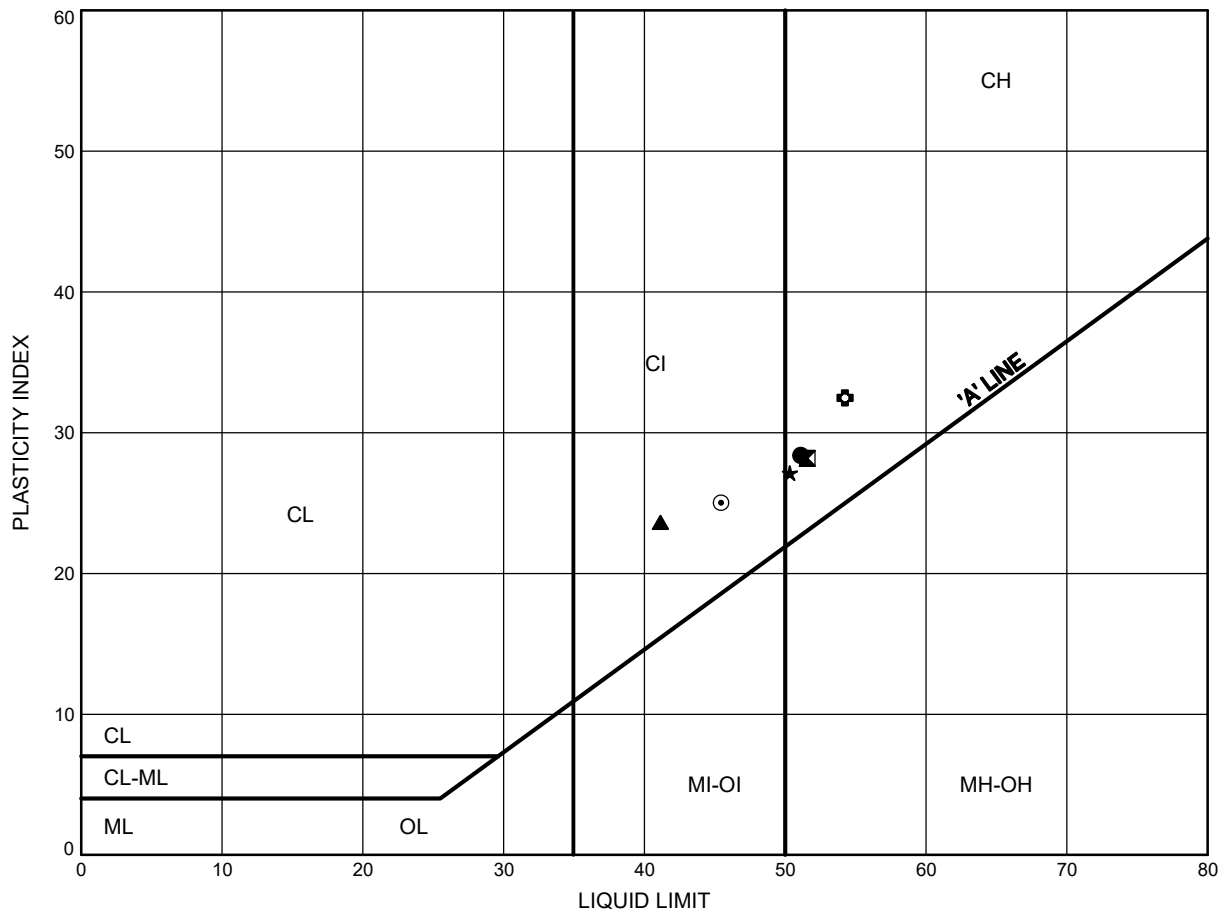
Prep'd AN

Chkd. RPR

Chestnut St Overpass
ATTERBERG LIMITS TEST RESULTS

FIGURE A7

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CH16-01	3.4	114.1
⊠	CH16-02	4.9	113.1
▲	CS16-01	7.9	108.3
★	CS16-02	4.9	111.3
⊙	CS16-03	9.4	105.9
⊕	CS16-04	3.4	111.8

Date September 2017

GWP# 2259-15-00



Prep'd AN

Chkd. RPR

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

CONT No
GWP No 2259-15-00



HIGHWAY 406
CHESTNUT ST NBL OVERPASS
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
1	117.2	4 777 720.5	327 521.3
2	116.5	4 777 719.5	327 491.3
3	118.1	4 777 679.6	327 492.4
4	118.0	4 777 680.5	327 520.8
CH16-01	117.5	4 777 726.6	327 533.2
CH16-02	118.0	4 777 677.5	327 531.9
CS16-01	116.2	4 777 704.1	327 524.8
CS16-02	116.2	4 777 695.7	327 525.2
CS16-03	115.3	4 777 694.8	327 500.0
CS16-04	115.2	4 777 703.3	327 500.1
RP16-01	120.9	4 777 716.4	327 515.2
RP16-02	120.8	4 777 711.6	327 507.9
RP16-03	121.6	4 777 683.5	327 507.8
RP16-04	121.8	4 777 682.4	327 516.7

-NOTES-

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

GEOCREs No. 30M3-295

DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP
DRAWN	AN	CHK RPR
		CODE
		LOAD
		DATE
		SEP 2017
		STRUCT
		DWG 1

FILENAME: H:\Working\11000\11336\11336-11336-PLR-CSU.dwg
PLOTDATE: 9/12/2017 11:06 AM

↔ HWY 406 SBL
↔ TO ST. CATHARINES

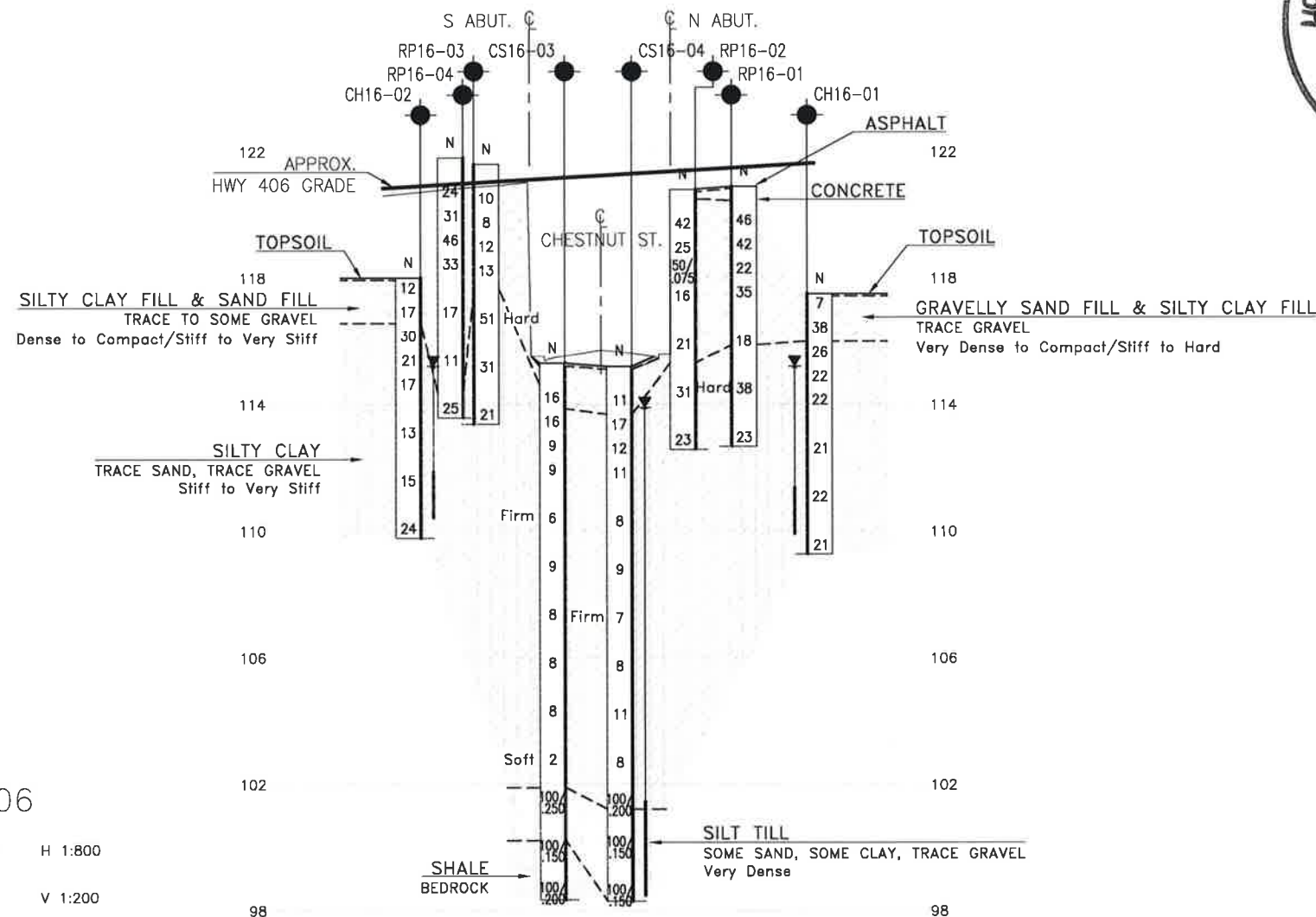
E 327 500

E 327 550



PLAN

SCALE 1:800



PROFILE ALONG C HWY 406



H 1:800

V 1:200

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

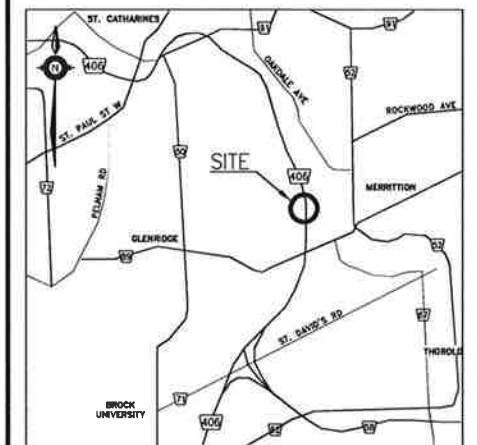
CONT No
GWP No 2259-15-00

HIGHWAY 406
CHESTNUT ST NBL OVERPASS
BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
1	117.2	4 777 720.5	327 521.3
2	116.5	4 777 719.5	327 491.3
3	118.1	4 777 679.6	327 492.4
4	118.0	4 777 680.5	327 520.8
CH16-01	117.5	4 777 726.6	327 533.2
CH16-02	118.0	4 777 677.5	327 531.9
CS16-01	116.2	4 777 704.1	327 524.8
CS16-02	116.2	4 777 695.7	327 525.2
CS16-03	115.3	4 777 694.8	327 500.0
CS16-04	115.2	4 777 703.3	327 500.1
RP16-01	120.9	4 777 716.4	327 515.2
RP16-02	120.8	4 777 711.6	327 507.9
RP16-03	121.6	4 777 683.5	327 507.8
RP16-04	121.8	4 777 682.4	327 516.7

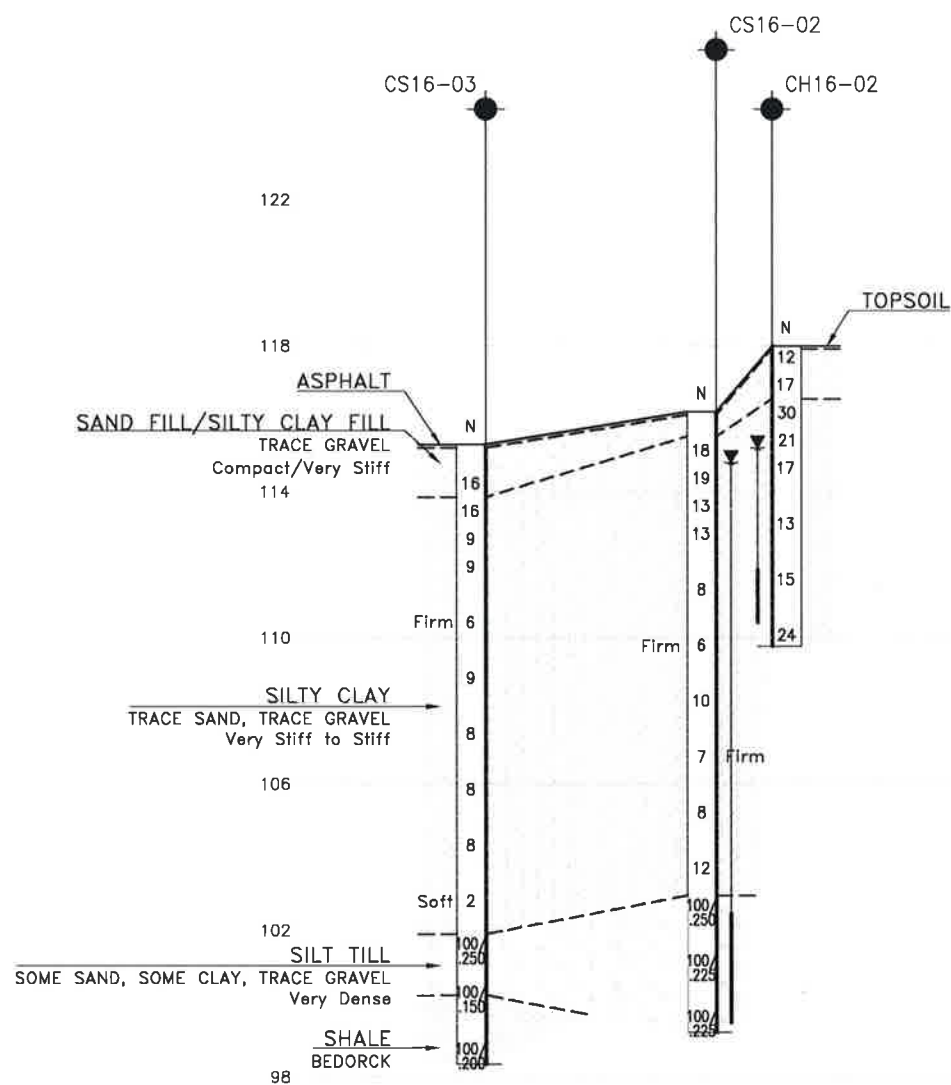
-NOTES-

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

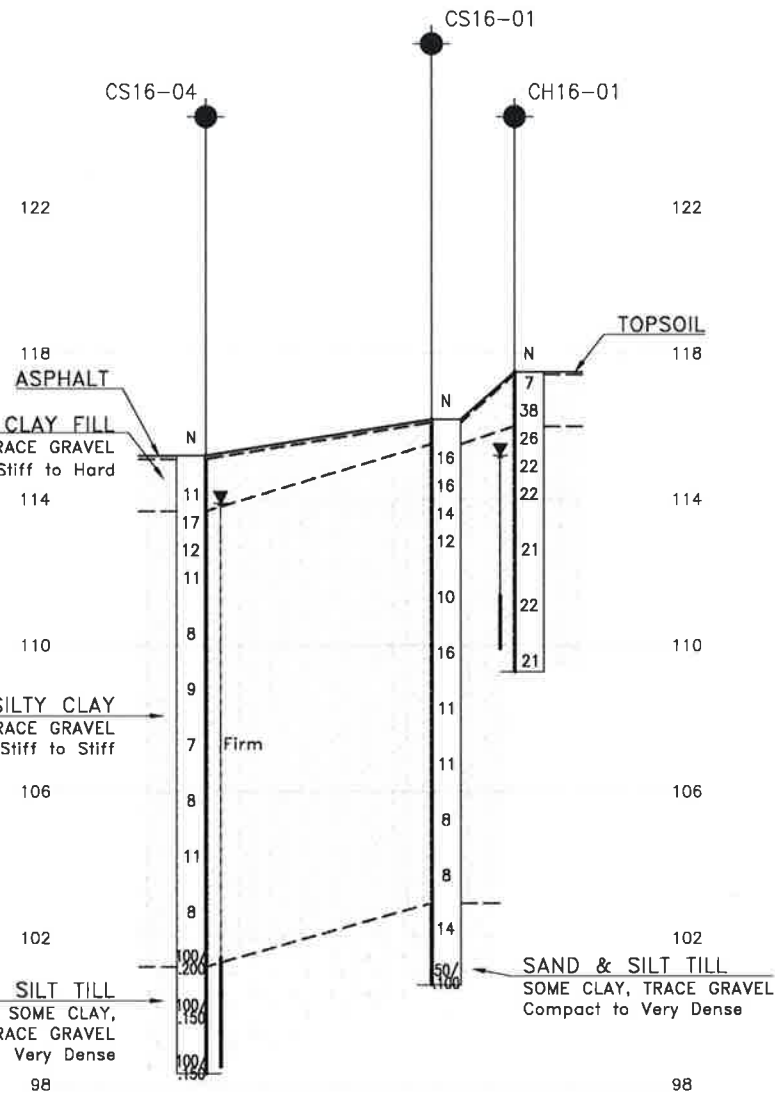
GEOCRES No. 30M3-295

REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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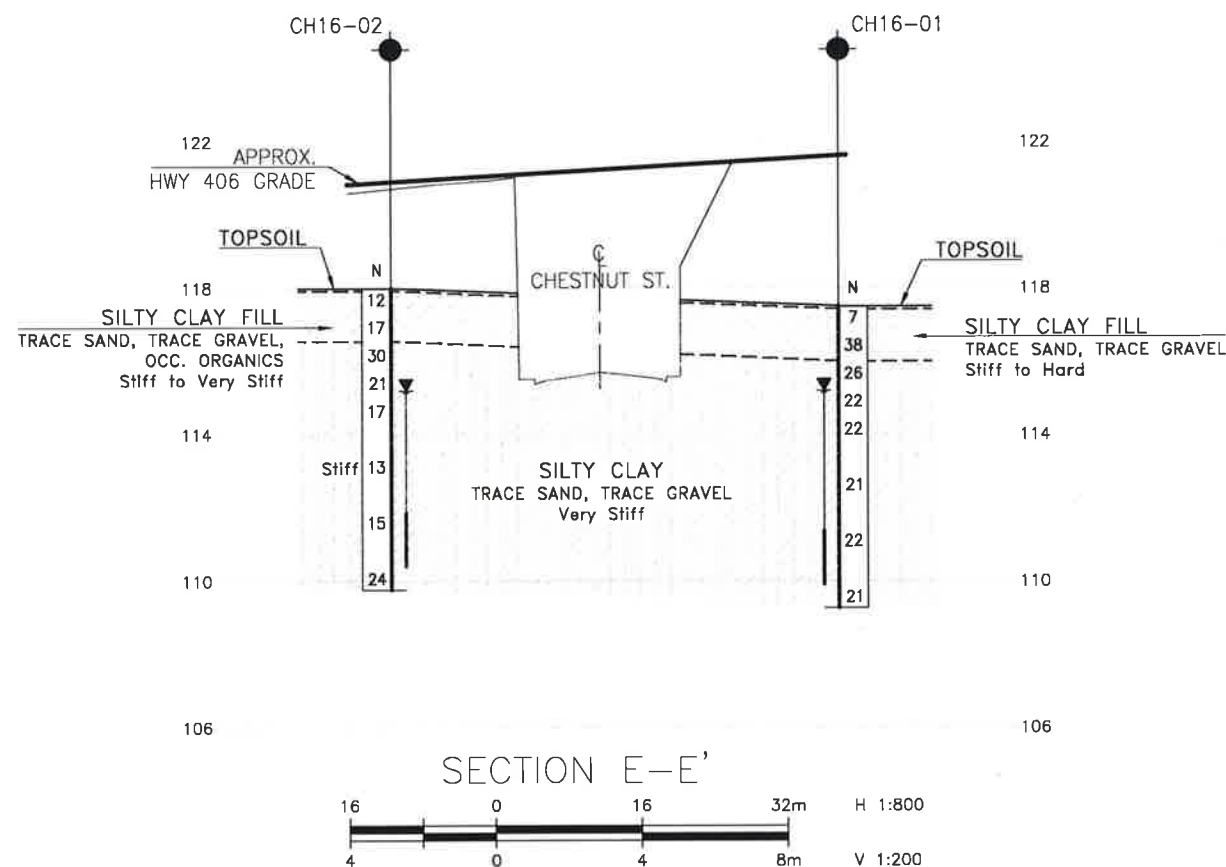
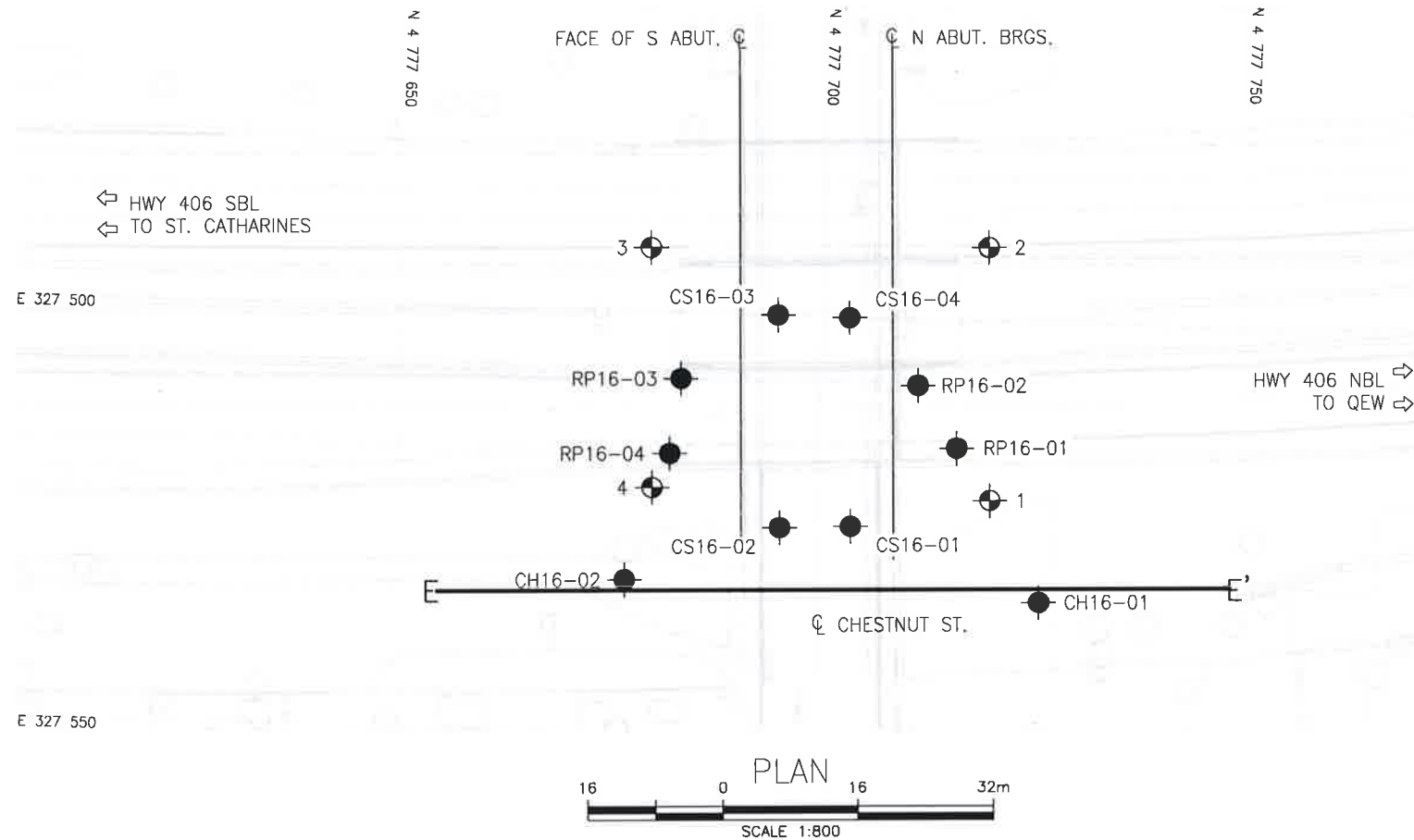


SECTION A-A



SECTION B-B





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

CONT No
GWP No 2259-15-00

HIGHWAY 406
CHESTNUT STREET OVERPASS
WIDENING APPROACHES
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊙	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
↑	Head Artesian Water
—	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
1	117.2	4 777 720.5	327 521.3
2	116.5	4 777 719.5	327 491.3
3	118.1	4 777 679.6	327 492.4
4	118.0	4 777 680.5	327 520.8
CH16-01	117.5	4 777 726.6	327 533.2
CH16-02	118.0	4 777 677.5	327 531.9
CS16-01	116.2	4 777 704.1	327 524.8
CS16-02	116.2	4 777 695.7	327 525.2
CS16-03	115.3	4 777 694.8	327 500.0
CS16-04	115.2	4 777 703.3	327 500.1
RP16-01	120.9	4 777 716.4	327 515.2
RP16-02	120.8	4 777 711.6	327 507.9
RP16-03	121.6	4 777 683.5	327 507.8
RP16-04	121.8	4 777 682.4	327 516.7

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M3-295



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	SKP
DRAWN	AN	CHK	RPR
LOAD	DATE	SEP 2017	
STRUCT	DWG	4	

Appendix B

On- Ramp Speed Change Lane (SCL) Extension and Noise Barrier Wall Replacement Boreholes SC16-01 to SC16-08

- Record of Borehole Sheets
- Laboratory Test Results
- Drawings titled “Borehole Locations and Soil Strata”

RECORD OF BOREHOLE No SC16-01

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 778 024.4 E 327 470.8 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.24 - 2016.11.24 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
113.9	GROUND SURFACE							20	40	60	80	100		
0.0 0.1	TOPSOIL , with roots and rootlets: (75mm) Silty CLAY , trace gravel, occasional roots and rootlets and organic inclusions Firm to Very Stiff Dark Grey Moist (FILL)		1	SS	7		113							
			2	SS	19									
			3	SS	17		112							
111.6														
2.3	Silty CLAY , trace sand, trace gravel Very Stiff Greyish Brown Moist		4	SS	19		111							0 0 32 68
			5	SS	17									
							110							
			6	SS	16		109							
							108							
			7	SS	20		107							0 0 39 61
105.7			8	SS	29		106							
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.13 7.2 106.7 2017.03.16 6.3 107.6 2017.08.30 6.1 107.8													

+³, ×³: Numbers refer to
Sensitivity

20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SC16-02

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 971.4 E 327 466.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.19 - 2016.12.19 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						PLASTIC LIMIT w _P NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L WATER CONTENT (%)				
113.2	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (100mm)							20	40	60	80	100						
0.1	Gravelly SAND Brown Moist (FILL)		1	GS			113							○				
112.1	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		1	SS	23		112							○				0 0 54 46
1.1	Becoming stiff		2	SS	14		110							○				
			3	SS	10		109							○				
			4	SS	8		107							○				0 0 35 65
			5	SS	9		106							○				
			6	SS	10		104							○				
103.4	END OF BOREHOLE AT 9.8m.																	
9.8																		

Continued Next Page

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

RECORD OF BOREHOLE No SC16-02

2 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 971.4 E 327 466.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.19 - 2016.12.19 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	WATER LEVEL AT 8.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.5m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.																

ONTMT4S MTO-11336.GPJ 2017TEMPLATE(MTO).GDT 9/12/17

RECORD OF BOREHOLE No SC16-03

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 927.7 E 327 495.5 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.24 - 2016.11.24 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
114.9	GROUND SURFACE													
0.0 0.1	TOPSOIL: (75mm)													
	Silty CLAY , trace sand, trace gravel, occasional organic inclusions Stiff to Very Stiff Brown Moist (FILL)		1	SS	12									
			2	SS	27									
113.5														
1.4	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		3	SS	20									
			4	SS	15									0 0 49 51
			5	SS	16									
	Becoming stiff													
			6	SS	10									
			7	SS	7									
														Vane pusehd to 7.3m depth, did not turn
			8	SS	11									0 0 30 70
106.7														
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 125mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS													
	DATE DEPTH(m) ELEV.(m)													
	2017.01.13 5.8 109.1													
	2017.03.16 4.9 110.0													
	2017.08.30 4.7 110.2													

ONTMT4S MTO-11336.GPJ 2017TEMPLATE(MTO).GDT 9/12/17

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SC16-04

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 874.5 E 327 489.3 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.13 - 2016.12.19 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
116.2	GROUND SURFACE							20 40 60 80 100		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
0.0	ASPHALT: (75mm)							20 40 60 80 100		WATER CONTENT (%)			
0.1	Gravelly SAND Brown to Grey Moist		1	GS			116						
115.5	(FILL)												
0.7	Silty CLAY , trace sand, trace gravel Hard Grey Moist (FILL)		1	SS	32		115						
114.7	(FILL)												
1.5	Silty CLAY , trace sand, trace gravel Hard to Very Stiff Brown Moist		2	SS	52		114						
			3	SS	27		113						0 0 38 62
			4	SS	15		112						
			5	SS	15		111						
			6	SS	12		110						
	Becoming stiff						109						
	Grey		7	SS	14		108						0 0 48 52
							107						
			8	SS	13								

Continued Next Page

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

RECORD OF BOREHOLE No SC16-04

2 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 874.5 E 327 489.3 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.13 - 2016.12.19 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
104.9	Continued From Previous Page Silty CLAY , trace sand, trace gravel Stiff Grey Moist		9	SS	14		106										
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN AND WATER LEVEL AT 10.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.						105										

RECORD OF BOREHOLE No SC16-05

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 828.6 E 327 516.6 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.25 - 2016.11.25 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
115.8	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (75mm) Silty CLAY , trace sand, trace gravel, organic inclusions Stiff Greyish Brown Moist (FILL) Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		1	SS	8													
0.1																		
115.1																		
0.7				2	SS	25												
				3	SS	27												0 0 32 68
				4	SS	21												
			5	SS	19													
			6	SS	17													
110.2																		
5.6																		
	Stiff		7	SS	11												0 0 36 64	
108.6																		
7.2																		
			8	SS	27													
107.6																		
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																	

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RECORD OF BOREHOLE No SC16-06

1 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 776.1 E 327 503.9 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.12 - 2016.12.13 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
119.2	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT: (75mm)																	
0.1	Gravelly SAND Grey Moist (FILL)		1	GS			119											
118.5																		
0.7	Silty CLAY , trace sand, trace gravel Very Stiff to Hard Grey Moist		1	SS	20		118											
			2	SS	17		117											
			3	SS	36		116											
			4	SS	43		115											
			5	SS	43		114											
			6	SS	29		113											
			7	SS	22		112											
			8	SS	18		111											
							110											

Continued Next Page


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

RECORD OF BOREHOLE No SC16-06

2 OF 2

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 776.1 E 327 503.9 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.12 - 2016.12.13 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR
	Continued From Previous Page							20	40	60	80	100								
	Silty CLAY , trace sand, trace gravel Very Stiff Grey Moist						109													
			9	SS	21		108													
106.4			10	SS	13		107													
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																			

RECORD OF BOREHOLE No SC16-07

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 627.5 E 327 534.0 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.23 - 2016.11.23 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _P w w _L				GR	SA	SI	CL		
119.3	GROUND SURFACE																				
0.0 0.1	TOPSOIL , trace roots and rootlets: (75mm) Silty CLAY , some sand, trace gravel Firm to Very Stiff Brown Moist (FILL)		1	SS	7		119														
			2	SS	26		118														
117.9			3	SS	27		117														
1.4	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		4	SS	17		116										0	0	40	60	
			5	SS	16		115														
			6	SS	20		114														
			7	SS	18		113											0	0	37	63
			8	SS	17		112														
111.1																					
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																				

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RECORD OF BOREHOLE No SC16-08

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION On Ramp SCL Extension N 4 777 576.6 E 327 531.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.24 - 2016.11.24 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L				GR	SA	SI	CL	
121.3	GROUND SURFACE							20	40	60	80	100								
0.0	TOPSOIL: (50mm) Silty CLAY , trace sand, trace roots, topsoil inclusions Stiff to Very Stiff Brown Moist (FILL)		1	SS	8		121													
			2	SS	20		120													
119.9																				
1.4	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		3	SS	20		119											0	0	
			4	SS	19		118											44	56	
			5	SS	17		117													
			6	SS	22		116													
							115													
			7	SS	15		114													
			8	SS	16													0	0	
113.1																		39	61	
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.13 3.0 118.3 2017.03.16 1.5 119.8 2017.08.30 1.6 119.7																			

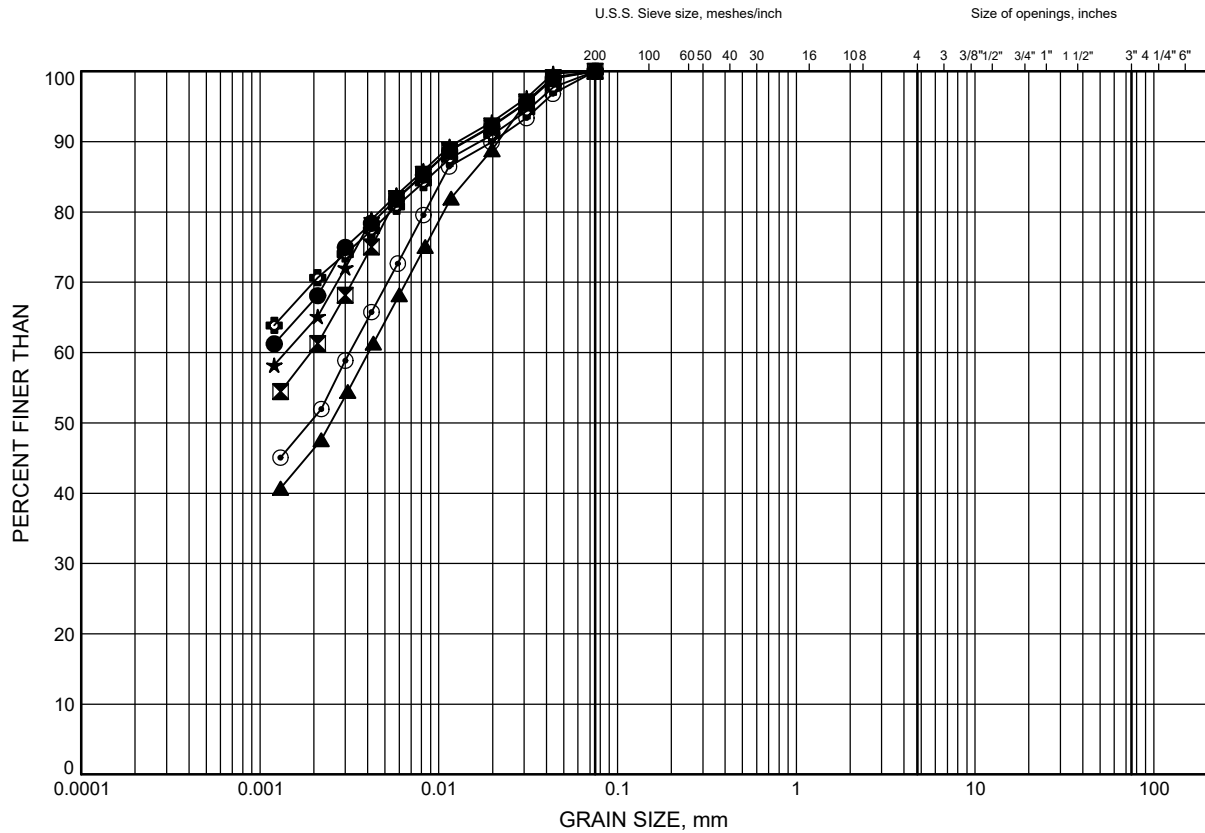
ONTMT4S MTO-11336.GPJ 2017TEMPLATE(MTO).GDT 9/12/17

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

On Ramp SCL Extension GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC16-01	2.6	111.3
⊠	SC16-01	6.4	107.5
▲	SC16-02	1.8	111.4
★	SC16-02	6.4	106.8
⊙	SC16-03	2.6	112.3
⊕	SC16-03	7.9	107.0

Date September 2017

GWP# 2259-15-00



Prep'd AN

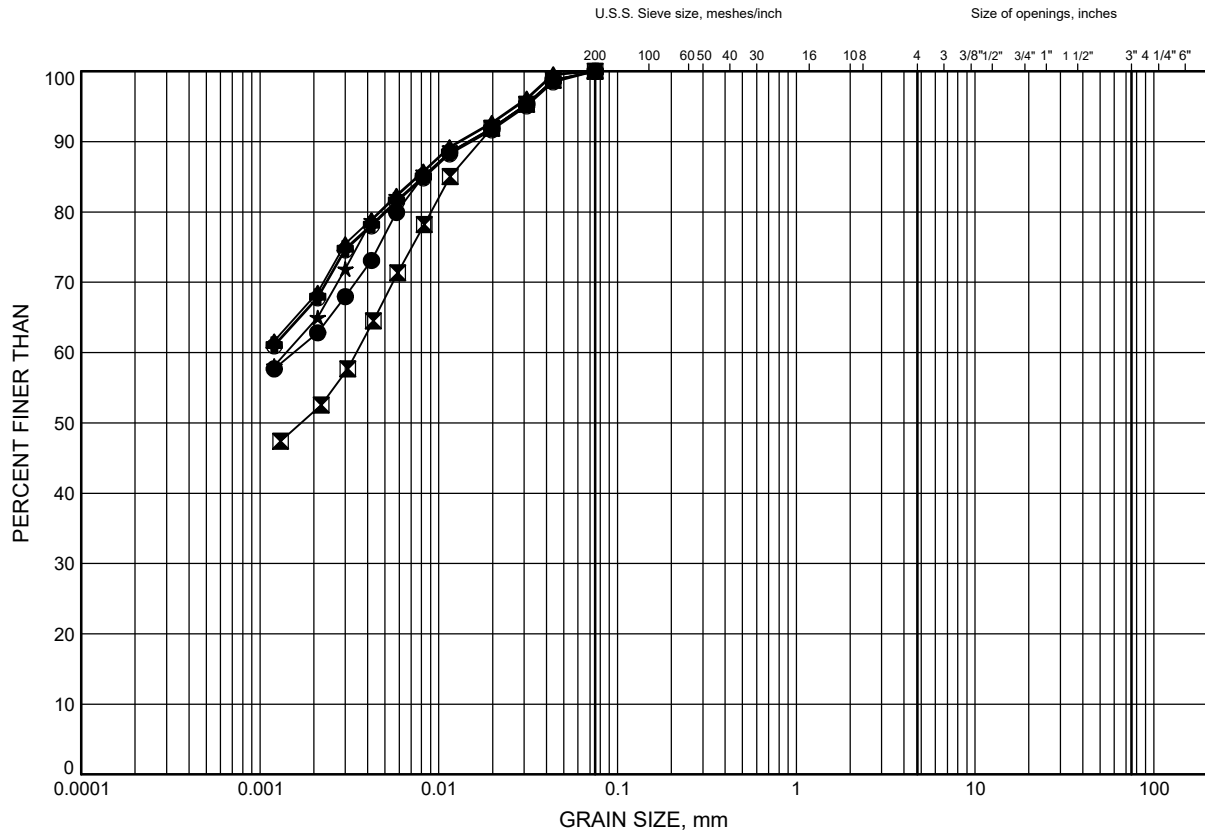
Chkd. RPR

On Ramp SCL Extension

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC16-04	2.6	113.6
⊠	SC16-04	7.9	108.3
▲	SC16-05	1.8	114.0
★	SC16-05	6.4	109.4
⊙	SC16-06	3.4	115.8
⊕	SC16-06	7.9	111.3

Date September 2017

GWP# 2259-15-00



Prep'd AN

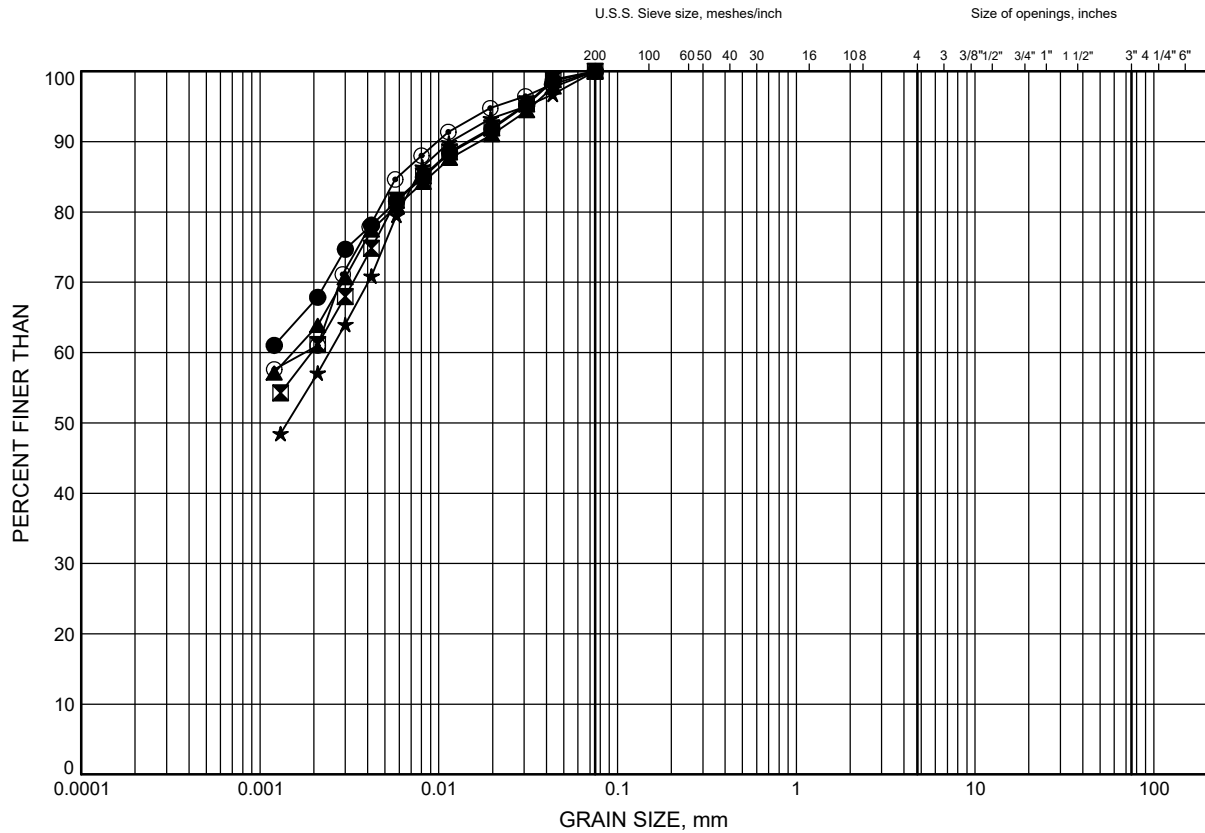
Chkd. RPR

On Ramp SCL Extension

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC16-06	11.0	108.2
⊠	SC16-07	2.6	116.7
▲	SC16-07	6.4	112.9
★	SC16-08	1.8	119.5
⊙	SC16-08	7.9	113.4

Date September 2017

GWP# 2259-15-00



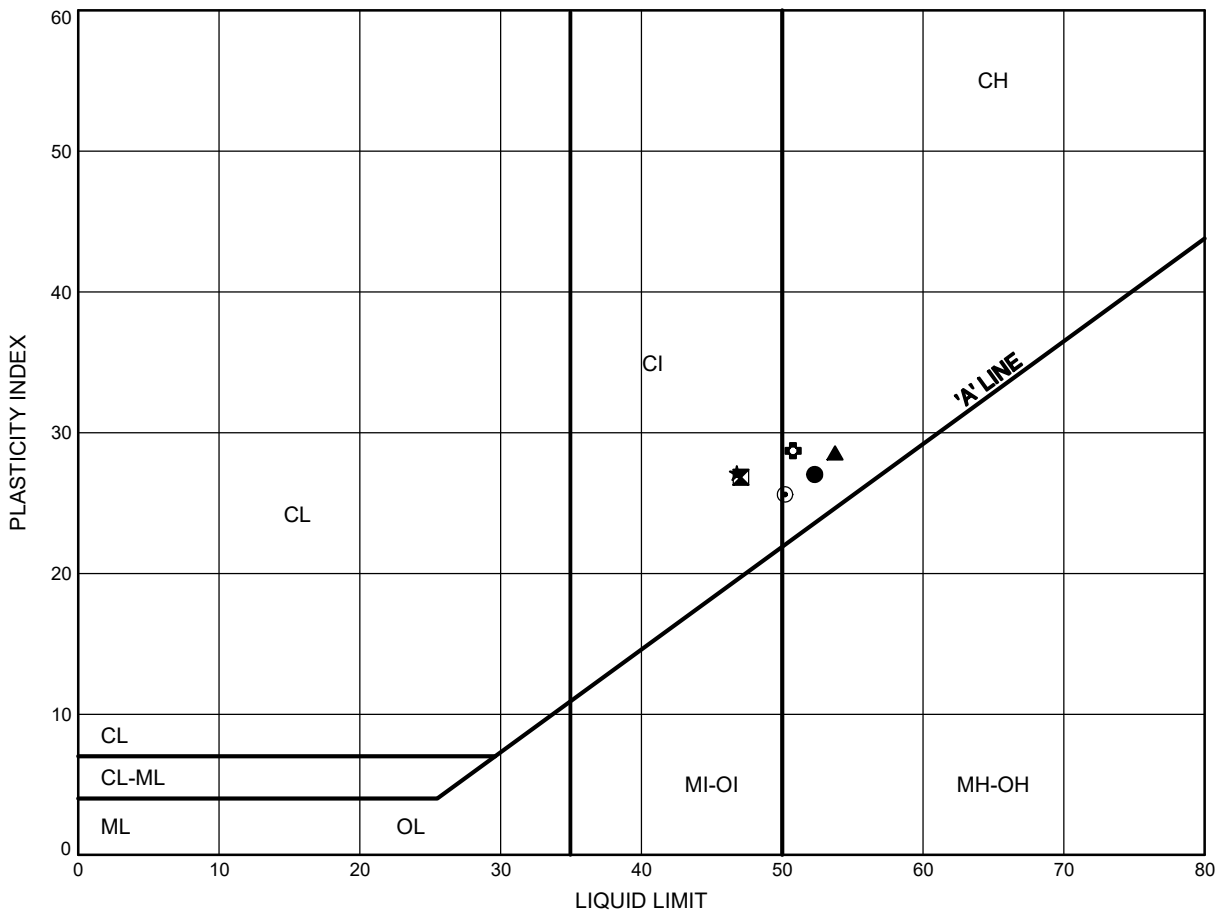
Prep'd AN

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On Ramp SCL Extension
ATTERBERG LIMITS TEST RESULTS

FIGURE B4

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC16-01	6.4	107.5
⊠	SC16-02	6.4	106.8
▲	SC16-03	7.9	107.0
★	SC16-04	7.9	108.3
⊙	SC16-05	6.4	109.4
⊕	SC16-06	7.9	111.3

Date September 2017
 GWP# 2259-15-00



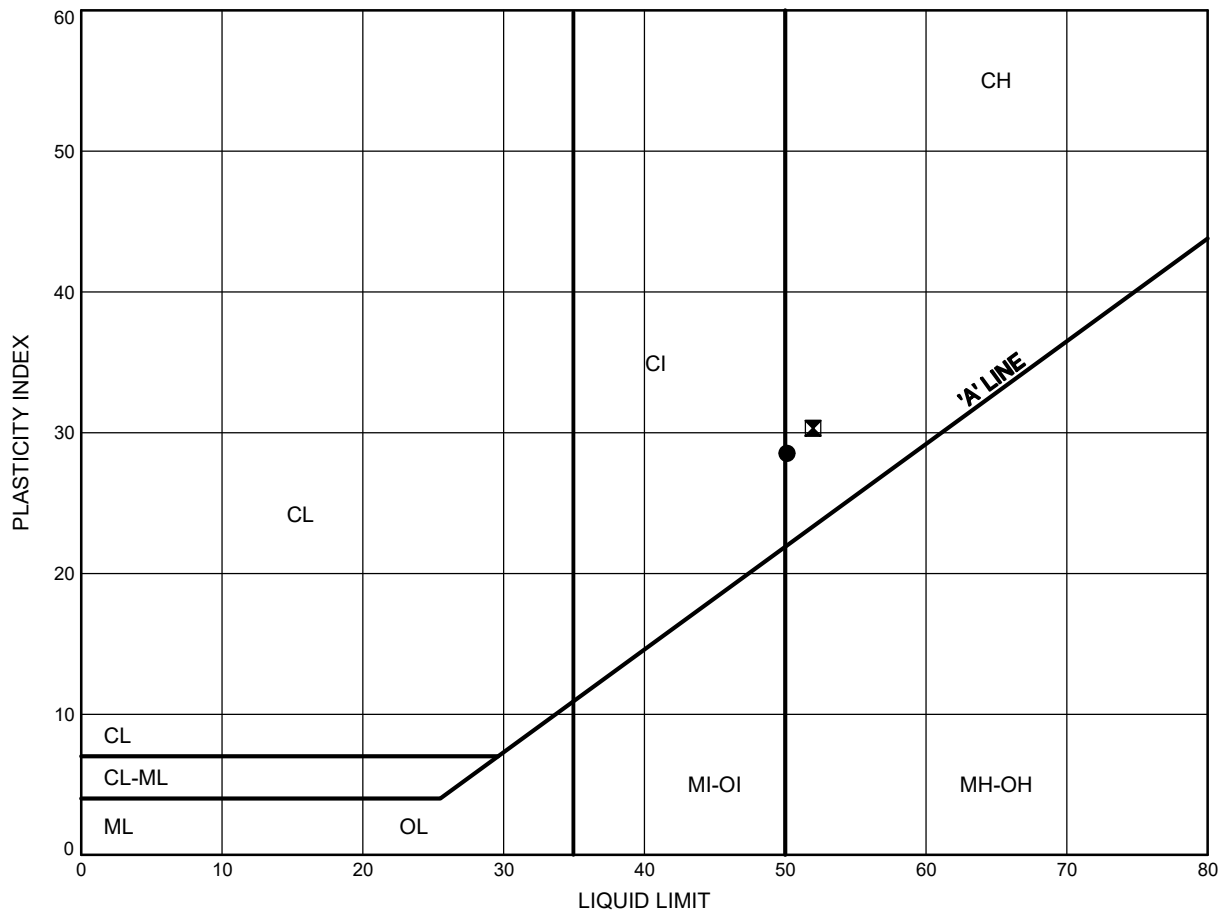
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On Ramp SCL Extension

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	SC16-07	6.4	112.9
⊠	SC16-08	7.9	113.4

Date September 2017
GWP# 2259-15-00



Prep'd AN
Chkd. RPR

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

CONT No
GWP No 2259-15-00



HIGHWAY 406
ON RAMP SPEED CHANGE
LANE EXTENSION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

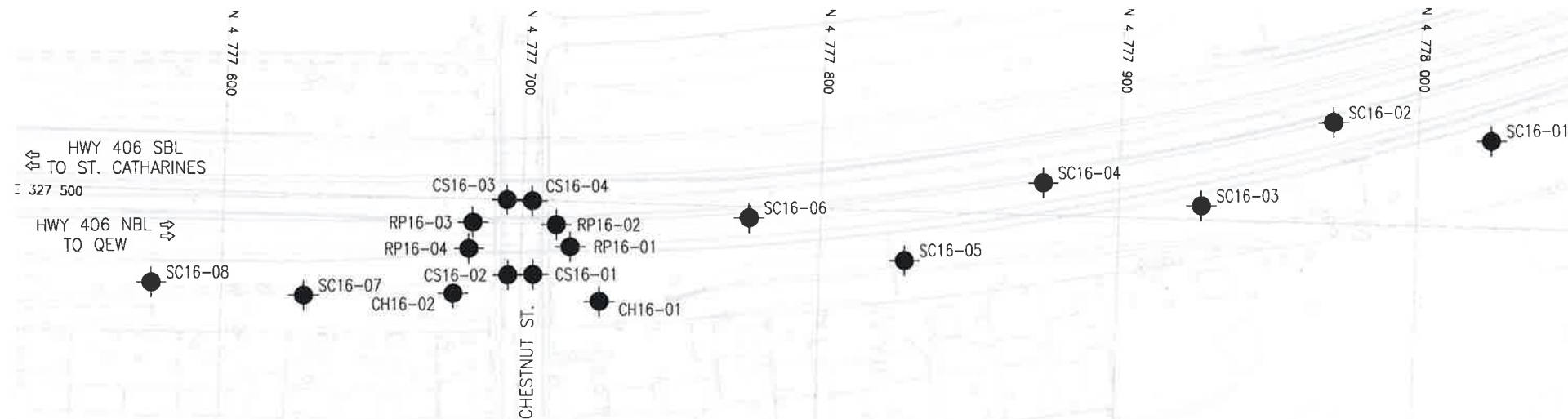
NO	ELEVATION	NORTHING	EASTING
CH16-01	117.5	4 777 726.6	327 533.2
CH16-02	118.0	4 777 677.5	327 531.9
CS16-01	116.2	4 777 704.1	327 524.8
CS16-02	116.2	4 777 695.7	327 525.2
CS16-03	115.3	4 777 694.8	327 500.0
CS16-04	115.2	4 777 703.3	327 500.1
RP16-01	120.9	4 777 716.4	327 515.2
RP16-02	120.8	4 777 711.6	327 507.9
RP16-03	121.6	4 777 683.5	327 507.8
RP16-04	121.8	4 777 682.4	327 516.7
SC16-01	113.9	4 778 024.4	327 470.8
SC16-02	113.2	4 777 971.4	327 466.2
SC16-03	114.9	4 777 927.7	327 495.5
SC16-04	116.2	4 777 874.5	327 489.3

NOTES

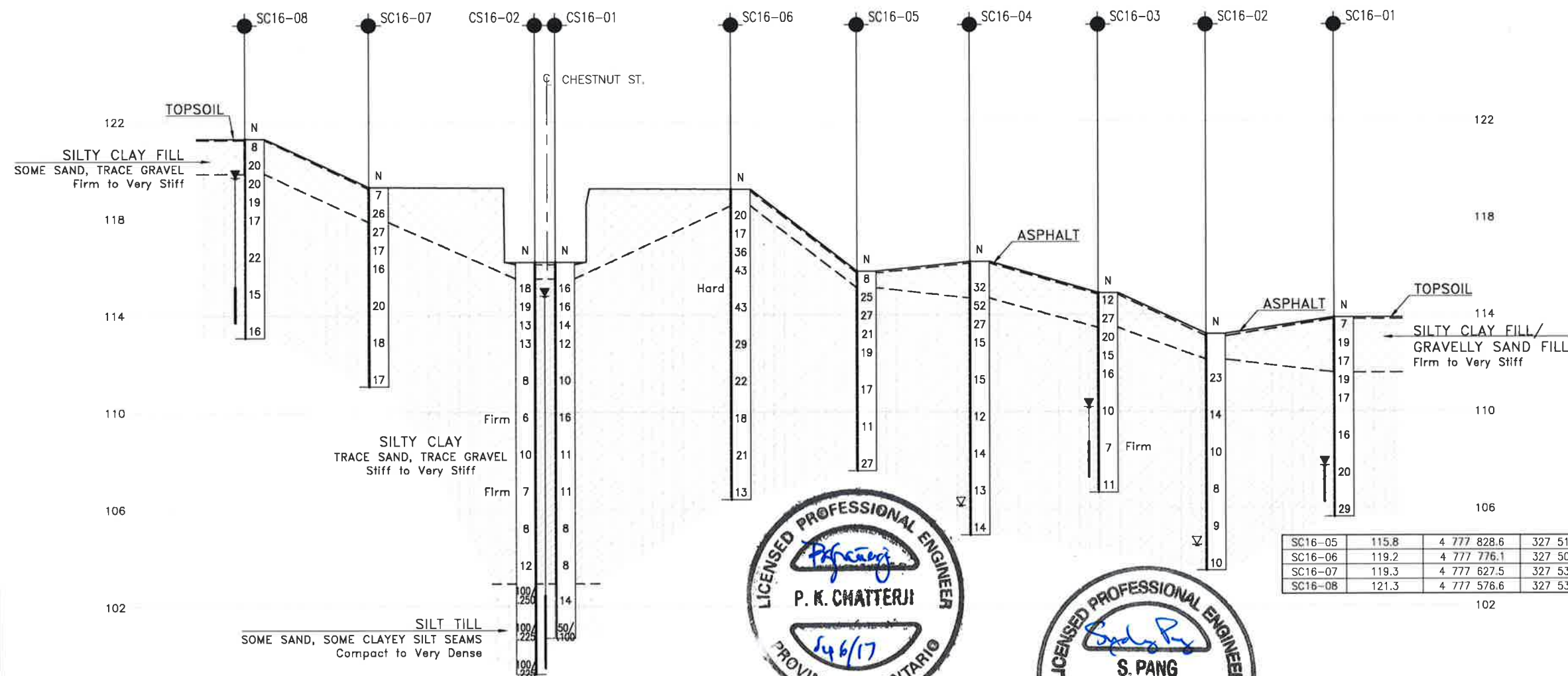
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M3-295

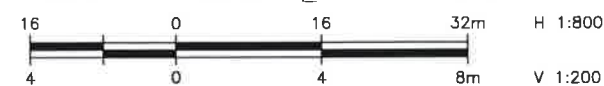
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PLAN
SCALE 1:2000



PROFILE ALONG C HWY 406





Appendix C

Roadway Protection Boreholes RP16-01 to RP16-04




- Record of Borehole Sheets
- Laboratory Test Results
- Drawings titled "Borehole Locations and Soil Strata"

RECORD OF BOREHOLE No RP16-01

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION Roadway Protection N 4 777 716.4 E 327 515.2 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.12 - 2016.12.12 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
120.9	GROUND SURFACE														
0.0	ASPHALT: (75mm)														
0.1	CONCRETE: (375mm)		1	GS											
120.4															
0.5	SAND , trace to some gravel, some silt, trace clay Dense to Compact Brown Moist (FILL)														
				1	SS	46		120							
				2	SS	42		119							10 72 12 6
				3	SS	22		118							
			4	SS	35		117							19 58 19 4	
			5	SS	18		116								
115.9															
5.0	Silty CLAY , trace sand, trace gravel Hard to Very Stiff Brown Moist														
				6	SS	38		115							0 8 32 60
							114								
			7	SS	23		113								
112.7															
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.														

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

RECORD OF BOREHOLE No RP16-02

1 OF 1


METRIC

GWP# 2259-15-00 LOCATION Roadway Protection N 4 777 711.6 E 327 507.9 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.12.05 - 2016.12.05 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE				WATER CONTENT (%) w _p w w _L					GR	SA	SI	CL
120.8	GROUND SURFACE																			
0.0	ASPHALT: (75mm)																			
120.5	CONCRETE: (300mm)																			
0.3	Gravelly SAND		1	GS																
120.1	Grey Moist (FILL)		1	SS	42															
0.7	SAND, trace to some clay, some silt, trace gravel Dense to Compact Grey Moist		2	SS	25															
118.6	Very Dense		3	SS	80/ 0.225															
117.9	Compact	4	SS	16																

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

METRIC

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

[illegible]

ONTMT4S MTO-11336.GPJ 2017TEMPLATE(MTO).GDT 9/12/17

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No RP16-04

1 OF 1

METRIC

GWP# 2259-15-00 LOCATION Roadway Protection N 4 777 682.4 E 327 516.7 ORIGINATED BY OA
 HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.05.07 - 2016.05.07 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
121.8	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (75mm)							20	40	60	80	100								
0.1	CONCRETE: (375mm)							20	40	60	80	100								
121.3								20	40	60	80	100								
0.5	Gravelly SAND Compact Grey Moist (FILL)		1	GS			121													
			1	SS	24															
120.4																				
1.4	SAND , trace gravel, some silt, trace to some clay Dense to Compact Brown Moist (FILL)		2	SS	31		120													
			3	SS	46		119													
			4	SS	33															
							118													
			5	SS	17		117													
							116													
			6	SS	11		115													
114.3							114													
7.5	Silty CLAY , trace sand, trace gravel Very Stiff Brown Moist		7	SS	25															
113.6																				
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH AUGER CUTTINGS TO SURFACE.																			

+³, ×³: Numbers refer to
Sensitivity

20
15
10

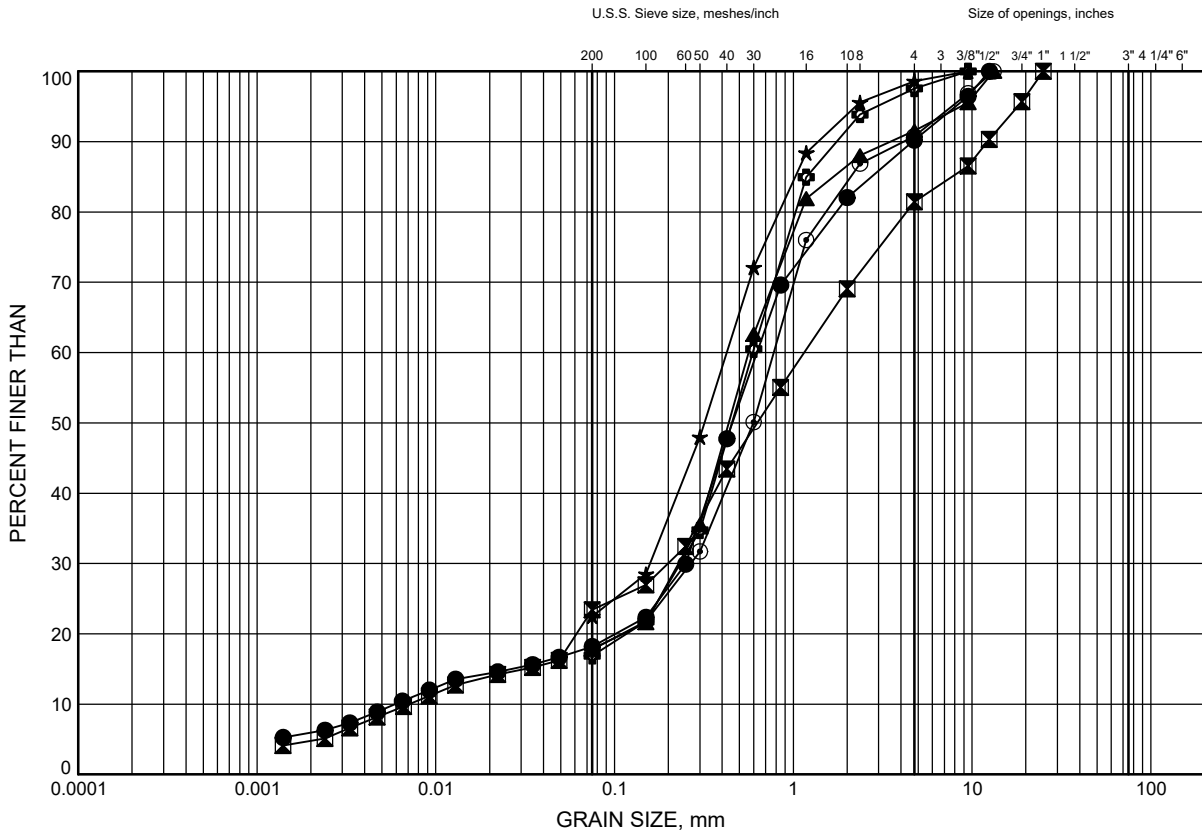
(%) STRAIN AT FAILURE

Roadway Protection

GRAIN SIZE DISTRIBUTION

FIGURE C1

SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RP16-01	1.8	119.1
⊠	RP16-01	3.4	117.5
▲	RP16-02	1.8	119.0
★	RP16-02	4.9	115.9
⊙	RP16-04	2.6	119.2
⊕	RP16-04	6.4	115.4

Date September 2017

GWP# 2259-15-00



Prep'd AN

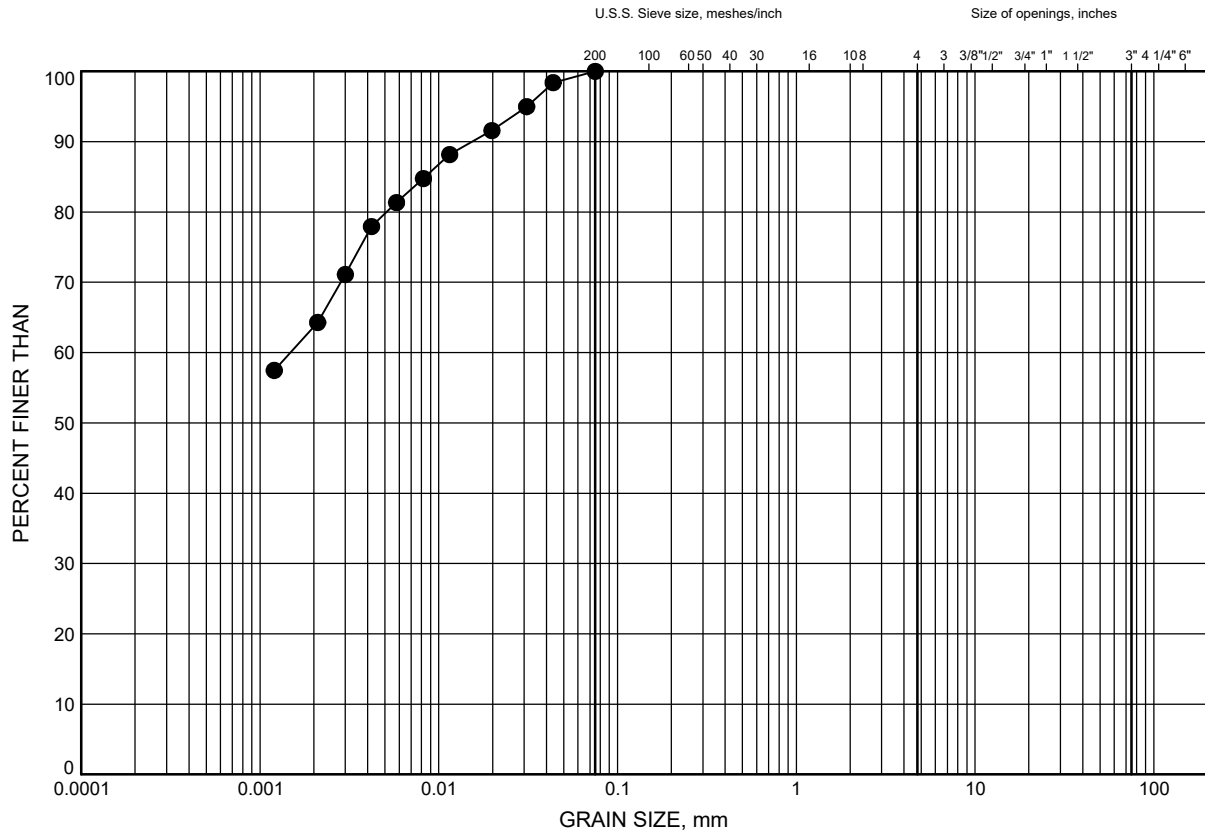
Chkd. RPR

Roadway Protection

GRAIN SIZE DISTRIBUTION

FIGURE C2

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RP16-03	3.4	118.2

Date September 2017
GWP# 2259-15-00



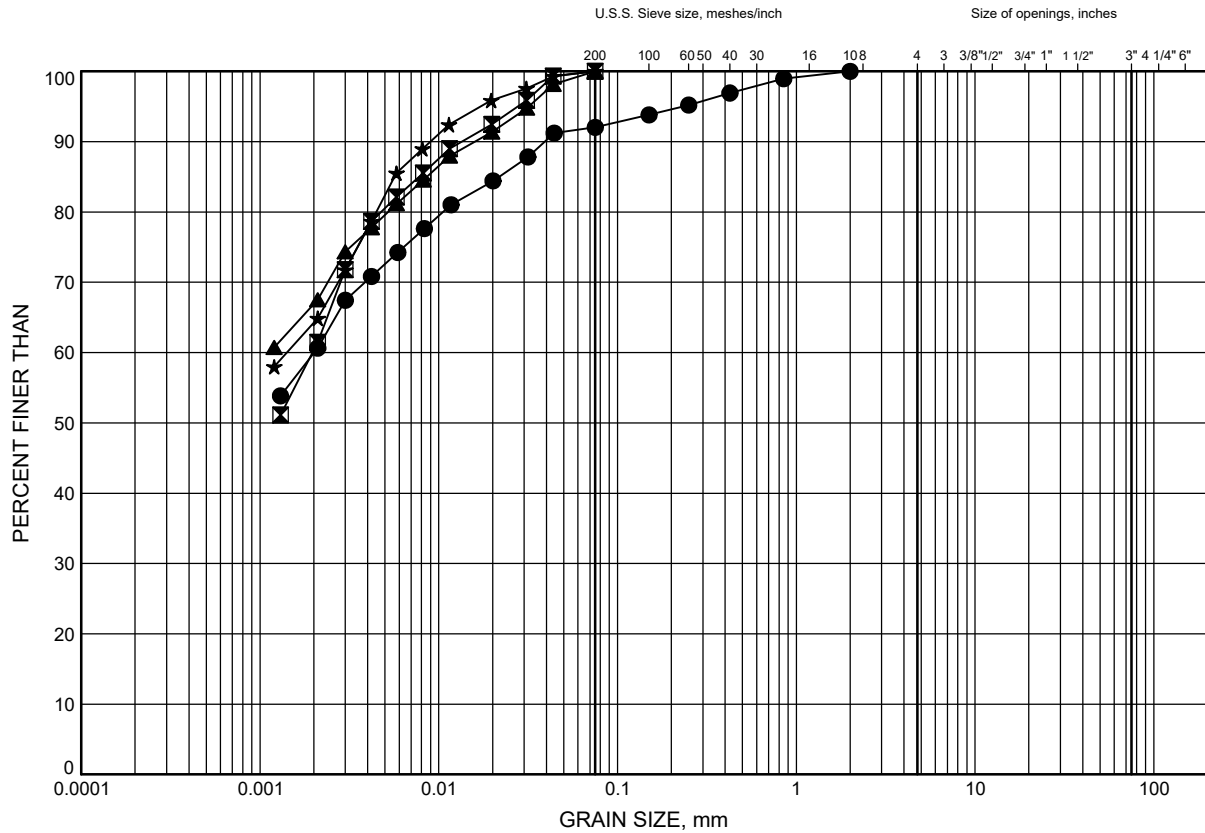
Prep'd AN
Chkd. RPR

Roadway Protection

GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RP16-01	6.4	114.5
◻	RP16-02	6.4	114.4
▲	RP16-03	7.9	113.7
★	RP16-04	7.9	113.9

Date September 2017

GWP# 2259-15-00



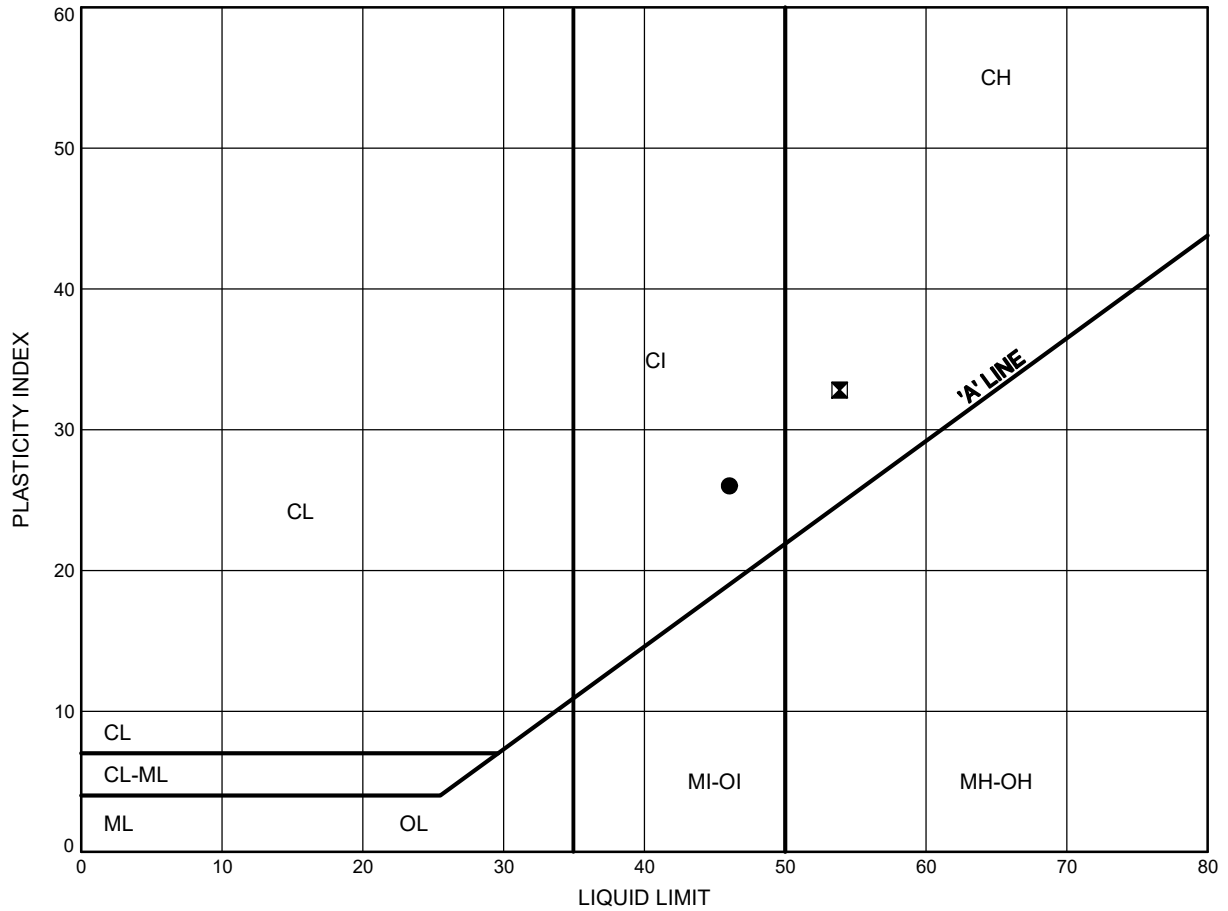
Prep'd AN

Chkd. RPR

Roadway Protection ATTERBERG LIMITS TEST RESULTS

FIGURE C4

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	RP16-02	6.4	114.4
⊠	RP16-03	7.9	113.7

Date September 2017
GWP# 2259-15-00



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Chkd. RPR

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

CONT No
CWP No 2259-15-00

HIGHWAY 406
ROADWAY PROTECTION
NBL BRIDGE REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
1	117.2	4 777 720.5	327 521.3
2	116.5	4 777 719.5	327 491.3
3	118.1	4 777 679.6	327 492.4
4	118.0	4 777 680.5	327 520.8
CH16-01	117.5	4 777 726.6	327 533.2
CH16-02	118.0	4 777 677.5	327 531.9
CS16-01	116.2	4 777 704.1	327 524.8
CS16-02	116.2	4 777 695.7	327 525.2
CS16-03	115.3	4 777 694.8	327 500.0
CS16-04	115.2	4 777 703.3	327 500.1
RP16-01	120.9	4 777 716.4	327 515.2
RP16-02	120.8	4 777 711.6	327 507.9
RP16-03	121.6	4 777 683.5	327 507.8
RP16-04	121.8	4 777 682.4	327 516.7

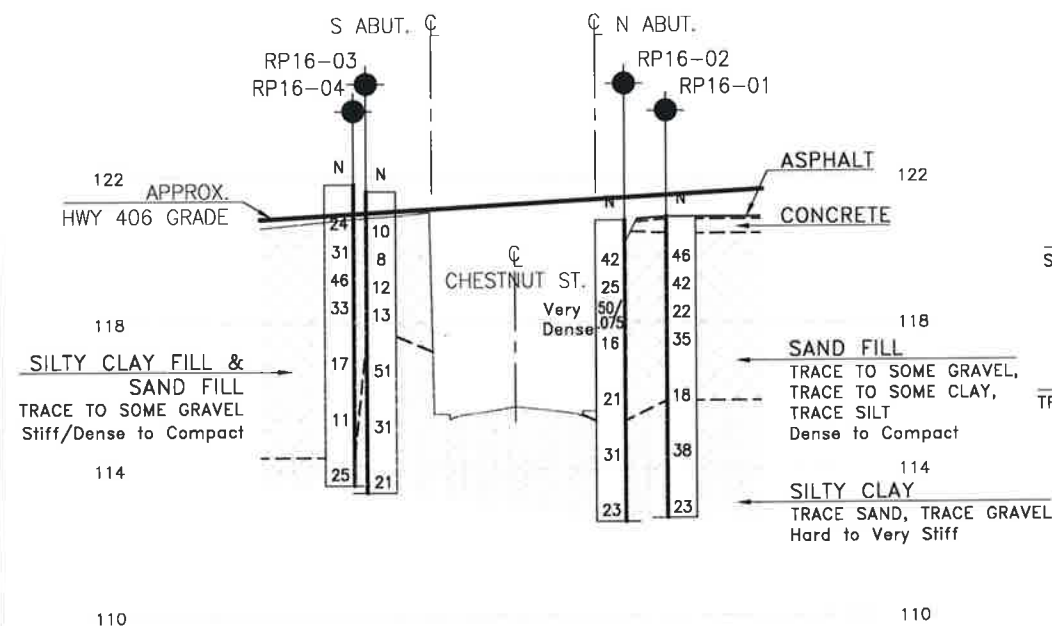
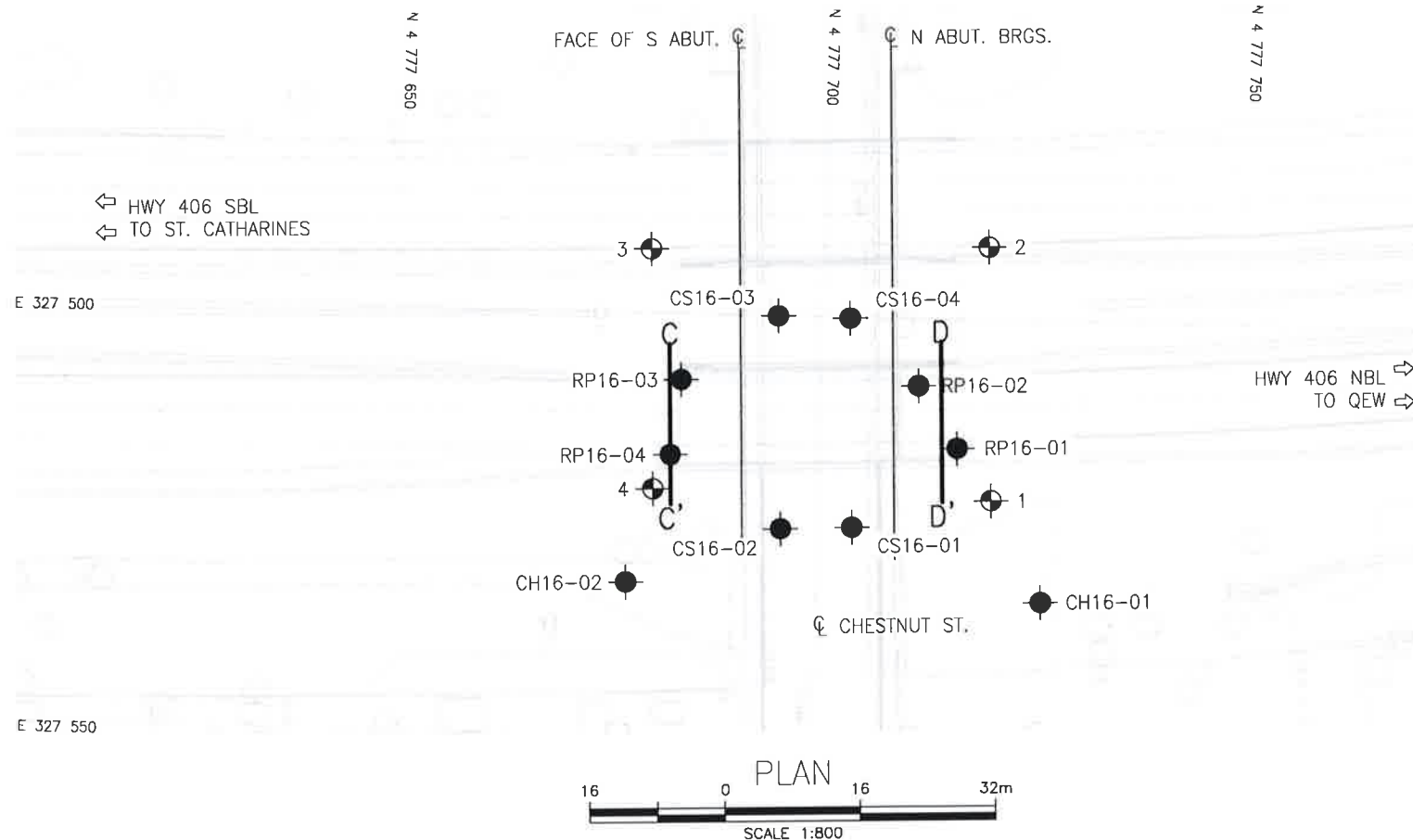
NOTES

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

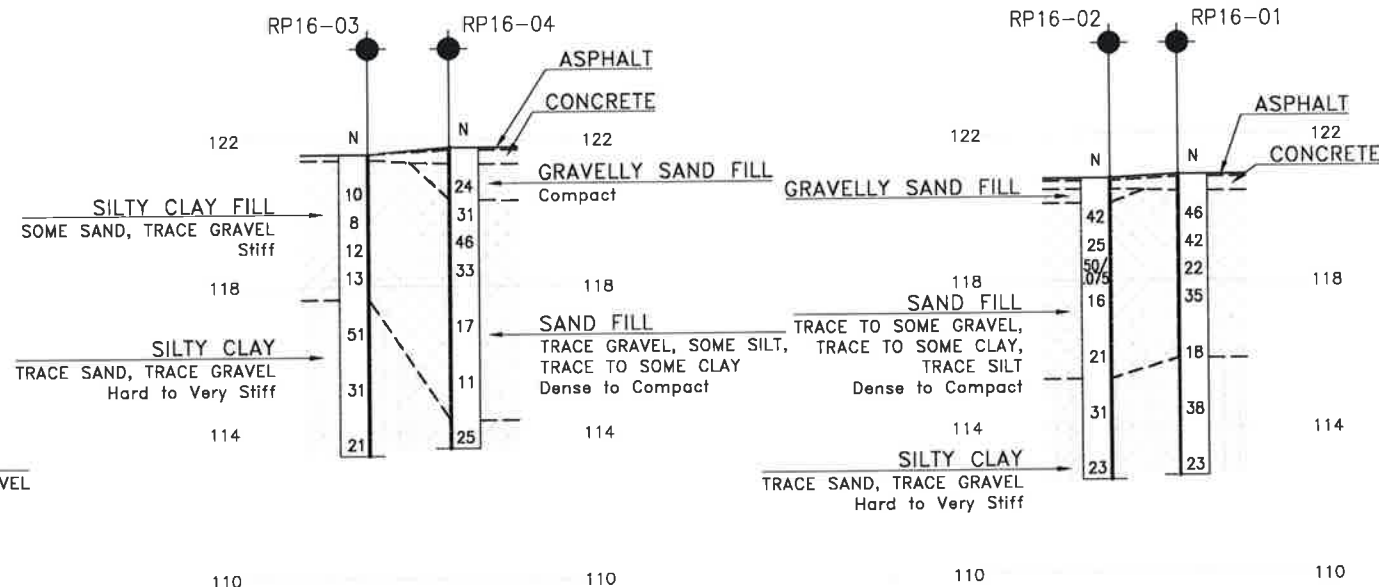
GEOCRES No. 30M3-295

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DESIGN	RPR	CHK SKP	CODE
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			LOAD
			STRUCT
			DWG 3
			DATE SEP 2017

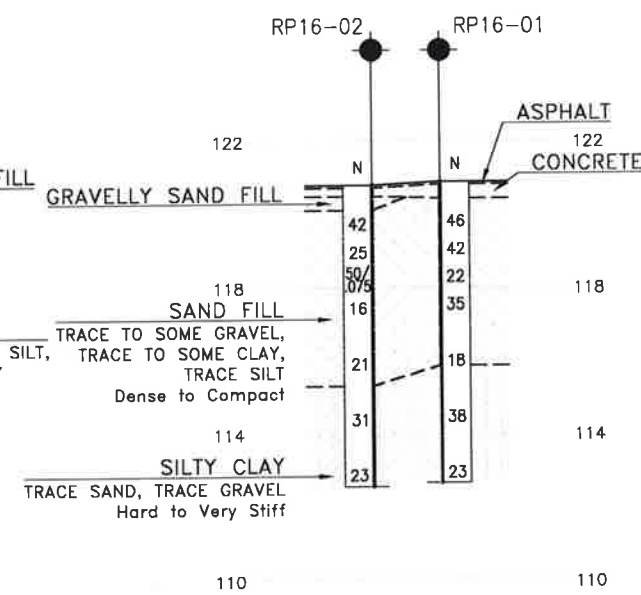
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PROFILE ALONG \varnothing HWY 406



SECTION C-C'



SECTION D-D'



Appendix D

Record of Borehole of previous investigations



Appendix E

Selected photographs of the site



Photo 1. - Highway 406 NBL at Chestnut Street



Photo 2.- East side of Highway 406 NBL, from Chestnut Street



Photo 3.- West side of Highway 406 NBL, from Chestnut Street



Photo 4. – West side of north abutment of Highway 406 NBL, from Chestnut Street



Photo 5. – West side of south abutment of Highway 406 NBL, from Chestnut Street