

**FOUNDATION INVESTIGATION AND DESIGN REPORT
NOISE BARRIER WALLS
HIGHWAY 400
TOWNSHIP OF KING, ONTARIO
G.W.P. 2085-15-00**

GEOCRES NO. 31D-672

Report

to

WSP / MMM Group

Date: May 12, 2017
File: 12187

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	project and SITE DESCRIPTION	1
3.	INVESTIGATION PROCEDURES	2
4.	LABORATORY TESTING	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Topsoil.....	4
5.2	Silt Fill.....	4
5.3	Sandy Silt	5
5.4	Clayey Silt Till.....	5
5.5	Clayey Silt	6
5.6	Sand and Silty Sand	7
5.7	Groundwater Conditions	8
6.	MISCELLANEOUS	9

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.	GENERAL.....	11
8.	foundation design parameters.....	12
8.1	Caisson Installation.....	13
8.2	Construction Concerns	13
8.3	Construction Inspection and Testing	14
9.	closure	14

TABLE

Table 1	Geotechnical Design Parameters for Noise Barrier Walls
---------	--

APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Borehole Location and Soil Strata Drawing
Appendix D	Selected Photographs of the site
Appendix E	List of OPS Specifications

**FOUNDATION INVESTIGATION AND DESIGN REPORT
NOISE BARRIER WALLS
HIGHWAY 400
TOWNSHIP OF KING, ONTARIO
G.W.P. 2085-15-00**

GEOCRES NO. 31D-672

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the detailed design of two sections of noise barrier wall adjacent to the Highway 400 Southbound Lane. The south limit of the wall is at approximately 530 m north of the Highway 400 and Lloydtown-Aurora Road interchange in the Township of King, Ontario.

The purpose of this investigation was to explore the subsurface conditions near the alignment of the noise barrier wall and, based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by WSP / MMM Group (WSP/MMM) to carry out this foundation investigation under the MTO Assignment Number 2015-E008.

2. PROJECT AND SITE DESCRIPTION

The proposed sections of noise barrier wall will be located north of the Highway 400 and Lloydtown-Aurora Road interchange, in the Township of King, Ontario. These walls will be built adjacent to the Highway 400 Southbound Lanes (SBL). The alignment of one section of wall will be along the property line from Stations 22+050 to 22+330. The alignment of the other section of wall will be located along the edge of the highway shoulder, from Stations 21+730 to 22+102. The total length of the two walls is approximately 652 m.

The area adjacent to the west side of the proposed noise barrier walls is treed and vegetated. Residential dwellings are located behind the treed zone. The lands to the east are used for agricultural purposes.

The terrain in the general vicinity of the site gently slopes downwards from south to north. Selected photographs of the immediate surroundings are presented in Appendix D.

The project area is located within the transition zone between physiographic regions known as the South Slope and the Oak Ridges Moraine. The South Slope is comprised predominantly of the Halton Till which is an interbedded complex of clayey silt to silt till and sand. This till comprises a slightly hummocky till plain, into which the surface watercourses have eroded 10 to 15 m deep gullies. The Oak Ridges Moraine is comprised of till overlying sands and gravels, sometimes with artesian conditions, in this area.

3. INVESTIGATION PROCEDURES

The site investigation and field testing for this project were carried out from November 2 to 8, 2016 and consisted of drilling and sampling nine boreholes (numbered 16-01 to 16-09) near the wall alignments on the west side of the Highway 400 SBL. Boreholes 16-01 to 16-05, were drilled near the property line and Boreholes 16-06 to 16-09 were drilled near the current highway right-of-way (ROW). All the boreholes were terminated at depths ranging from 7.7 m to 8.2 m (Elevations 276.3 to 288.4).

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 MMM. The approximate locations of the boreholes are shown on Borehole Locations and Soil Strata drawings included in Appendix C. The coordinates and elevations of these boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendix A.

A track-mounted D50 drill rig was used to drill and sample the boreholes. Solid and 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 Standard Penetration Testing (SPT).

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil 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 and B.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Five standpipe piezometers were installed in selected boreholes (Boreholes 16-01, 16-03, 16-05,

16-07 and 16-09). Each piezometer consisted of a 19 mm Schedule 40 PVC pipe with a 1.5 m long slotted screen enclosed in 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 piezometers will be decommissioned as per O.Reg. 903 after the final set of water level readings are taken. The details of standpipe piezometer installation and borehole completion are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Station	Borehole No.	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
22+318	16-01	8.2/276.3	7.6/276.9	Borehole backfilled with sand filter from 8.2 m to 5.5 m, bentonite holeplug from 5.5 m to 4.9 m, then bentonite holeplug and auger cuttings from 4.9 m to surface.
22+255	16-02	8.2/279.3	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
22+172	16-03	7.7/282.5	7.6/282.6	Borehole backfilled with sand filter from 7.7 m to 3.0 m, bentonite holeplug from 3.0 m to 2.4 m, then bentonite holeplug and auger cuttings from 2.4 m to surface.
22+118	16-04	7.8/283.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
22+055	16-05	7.8/284.3	7.6/284.5	Borehole backfilled with sand filter from 7.8 m to 5.4 m, bentonite holeplug from 5.4 m to 4.9 m, then bentonite holeplug and auger cuttings from 4.9 m to surface.
21+995	16-06	7.8/285.5	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
21+888	16-07	8.2/287.7	7.6/288.3	Borehole backfilled with sand filter from 8.2 m to 5.4 m, bentonite holeplug from 5.4 m to 4.9 m, then bentonite holeplug and auger cuttings from 4.9 m to surface.
21+810	16-08	8.1/287.2	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface.
21+775	16-09	8.2/288.4	7.6/288.9	Borehole backfilled with sand filter from 8.2 m to 5.1 m, bentonite holeplug from 5.1 m to 4.6 m, then bentonite holeplug and auger cuttings from 4.6 m to surface.

4. 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 to MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and are presented on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A soil profile along the proposed noise barrier wall site is presented on the “Borehole Locations and Soil Strata” drawings in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations. More detailed descriptions of the individual strata are presented below.

In general, the subsurface conditions encountered in the boreholes drilled along the west side of the Highway 400 SBL consist of surficial topsoil and at some locations fill, overlying a deposit of native clayey silt till with sand on the north side which transitions to sand and silty sand on the south side. Groundwater was observed at between 1 m and 7 m depths. More detailed descriptions of the individual stratum are presented below.

5.1 Topsoil

A layer of topsoil between 50 and 150 mm in thickness was encountered at ground surface in Boreholes 16-03 to 16-09. In Boreholes 16-01 and 16-02, the thickness of the surficial topsoil was 700 mm.

The topsoil thickness may vary between and beyond the borehole locations, and the limited data is not suitable for estimating topsoil quantities.

5.2 Silt Fill

A 700-mm thick layer of brown silt fill containing some sand, trace clay, trace gravel and occasional roots and rootlets was contacted below the topsoil in Borehole 16-01. The depth to the base of the silt fill was at 1.4 m (Elevation 283.1).

A SPT 'N' value recorded in the silt fill was 28 blows per 0.3 m of penetration, indicating a compact state. Moisture content of the silt fill was 8 percent.

5.3 Sandy Silt

In Boreholes 16-07 and 16-09, a layer of native brown to grey sandy silt containing trace to some clay, trace gravel, occasional roots and rootlets and clay pockets, was encountered below the topsoil. The thickness of the sandy silt was 1.5 m and 0.65 m in Boreholes 16-07 and 16-09, respectively. The depths to the base of the sandy silt were at 1.7 m and 0.7 m (Elevations 294.2 and 295.9), in Boreholes 16-07 and 16-09, respectively.

SPT 'N' values recorded in the sandy silt were 4, 7 and 14 blows per 0.3 m of penetration, indicating a loose to compact state. Moisture content of the sandy silt ranged from 10 percent to 12 percent.

5.4 Clayey Silt Till

Brown to grey clayey silt till with sand and trace gravel was contacted below the topsoil and below the fill in Boreholes 16-01 to 16-06. Inferred cobbles and resistance to augering were noted in Borehole 16-01. It is noted that glacial till inherently contains cobbles and boulders, and such obstructions may be encountered at other locations. The thickness of the clayey silt till was 5.6 m in Borehole 16-01. The depth to the base of the clayey silt till was at 7.0 m (Elevation 277.5) in Borehole 16-01.

Boreholes 16-02 to 16-06 were terminated within the clayey silt till at depths ranging from 7.7 m to 8.2 m (Elevations 279.3 to 285.5).

SPT 'N' values obtained in the clayey silt till ranged from 12 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration, indicating a stiff to hard consistency. Moisture contents of the clayey silt till ranged from 6 percent to 20 percent.

The results of grain size analyses conducted on clayey silt till samples are presented on the Record of Borehole sheets in Appendix A, 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 to 2
Sand	40 to 49
Silt	40 to 51
Clay	9 to 18

The results of Atterberg Limits tests conducted on two samples of the clayey silt till are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B7 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	15
Plasticity Index	5 to 6

The results of the Atterberg Limits testing indicate this till deposit to be of slight to low plasticity with a group symbol CL-ML.

5.5 Clayey Silt

Grey clayey silt containing some sand was contacted below the clayey silt till at 7.0 m depth (Elevation 277.5) in Borehole 16-01, and below the sand at 7.2 m depth (Elevation 288.7) in Borehole 16-07.

Boreholes 16-01 and 16-07 were terminated within the clayey silt at 8.2 m depth (Elevations 276.3 and 287.7) in Boreholes 16-01 and 16-07.

SPT 'N' values recorded in the clayey silt were 53 blows for 0.3 m of penetration and 50 blows for less than 0.3 m of penetration indicating a hard consistency. Natural moisture contents of the clayey silt were 15 percent and 16 percent.

The results of grain size analyses conducted on a sample of the clayey silt are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	14
Silt	71
Clay	15

The results of Atterberg Limits tests conducted on a sample of the clayey silt are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B8 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	18
Plasticity Index	6

5.6 Sand and Silty Sand

A deposit of reddish brown to brown sand was contacted below the sandy silt in Boreholes 16-07 and 16-09 at depths of 1.7 m and 0.7 m (Elevations 294.2 and 295.9). A layer of silty sand was encountered below the topsoil in Borehole 16-08. The sand and silty sand deposits contain trace clay and trace gravel. The thickness of the sand deposit was 5.5 m in Borehole 16-07. The depth to the base of the sand was at 7.2 m (Elevation 288.7) in Borehole 16-07. Boreholes 16-08 and 16-09 were terminated within the silty sand and sand layers at 8.1 m and 8.2 m depth (Elevations 287.2 and 288.4), respectively.

SPT 'N' values obtained in the sand and silty sand generally ranged from 13 to 76 blows per 0.3 m of penetration, indicating a compact to very dense state. SPT 'N' values of 7 and 5 blows per 0.3 m of penetration, indicating a loose state, were measured in the upper 1.5 m of the sand/silty sand in Boreholes 16-08 and 16-09. An SPT 'N' value of 100 blows for less than 0.3 m of penetration, indicating a very dense state, was measured in Borehole 16-08 near the borehole termination depth.

The results of grain size analyses conducted on sand and silty sand samples are presented on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B5 and B6 of Appendix B. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%) Sand	Percentage (%) Silty Sand
Gravel	0	0
Sand	82 to 97	55 to 68
Silt	13	30 to 40
Clay	5	2 to 5
Silt and Clay	3	-

5.7 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. All boreholes were dry upon completion of drilling. Standpipe piezometers were installed in Boreholes 16-01, 16-03, 16-05, 16-07 and 16-09 to permit longer term monitoring. Water levels measured in the five installed standpipes are presented below.

Table 5-1. Measured Groundwater Levels

Borehole Number	Date	Groundwater Level		Comment
		Depth (m)	Elevation (m)	
16-01	November 3, 2016	5.9	278.6	Piezometer (clayey silt till)
	November 4, 2016	5.9	278.6	
	November 7, 2016	5.9	278.6	
	November 8, 2016	5.9	278.6	
	January 18, 2017	3.8	280.7	
16-03	November 7, 2016	6.8	283.4	Piezometer (clayey silt till)
	November 8, 2016	6.8	283.4	
	January 18, 2017	4.9	285.3	
16-05	November 7, 2016	3.6	288.5	Piezometer (clayey silt till)
	November 8, 2016	3.6	288.5	
	January 18, 2017	2.1	290.0	
16-07	November 8, 2016	1.0	294.9	Piezometer (sand)
	January 18, 2017	0.9	295.0	
16-09	January 18, 2017	2.7	293.9	Piezometer (sand)

The values shown in Table 5-1 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. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. MMM provided the northing and easting coordinates and ground surface elevations.

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

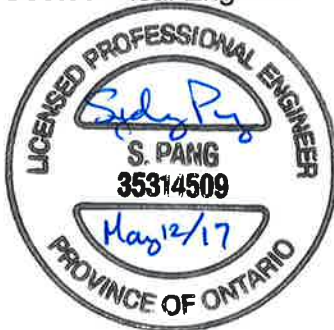
The drilling and sampling operations in the field were supervised on a full time basis by Ms. Cecile Ritchie of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

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.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



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



**FOUNDATION INVESTIGATION AND DESIGN REPORT
NOISE BARRIER WALLS
HIGHWAY 400
TOWNSHIP OF KING, ONTARIO
G.W.P. 2085-15-00**

GEOCRES NO. 31D-672

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical parameters for design of foundations for two proposed sections of noise barrier wall along Highway 400 SBL, north of the Highway 400 and Lloydtown-Aurora Road interchange, in the Township of King, Ontario. Comments regarding foundation installation and potential construction concerns are also provided.

It is understood that one section of the wall will be constructed adjacent to the proposed property line from Stations 22+050 to 22+330, and the second section will be located near the edge of the proposed shoulder, from Stations 21+730 to 22+102. The height of the walls will not exceed 8.0 m.

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

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

Client: MMM Group Ltd.

File No.: 12187

E file: H:\12000-12999\12187 Highway 400 16th SR & Lloydtown-Aurora\Reports & Memos\Noise Barrier Wall\FINAL\12187

Noise Barrier Wall Hwy 400 FIDR may 17.docx

Date: May 12, 2017

Page: 11 of 15

8. FOUNDATION DESIGN PARAMETERS

The use of a proprietary post-and-panel noise barrier wall supported by small diameter drilled shafts (caissons) is considered feasible at the wall locations. Installation of the foundations is expected to be carried out primarily within the existing hard clayey silt till with sand on the north side, and compact to very dense sand and silty sand on the south side.

For design of the noise barrier wall foundations, reference may be made to the following document:

- Canadian Highway Bridge Design Code and Commentary (2010). CAN/CSA-S6-00 and S6.1-00 (Reference 1).
- Ministry of Transportation, Ontario (2004) "Guidelines for the Design of High Mast Pole Foundation", Fourth Edition, BRO-009, Engineering Standards Branch, Bridge Office (Reference 2).

It is anticipated that the proposed noise barrier walls will be supported on conventional augered caissons (i.e. drilled shafts) with typical diameters ranging from 0.45 to 0.9 m. Table 1 immediately following the text of this report presents the recommended geotechnical design parameters for the augered caisson foundations.

In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance of a caisson within the upper 1.4 m below final grade should be neglected in the foundation design. It is recommended that all surficial weak soils, including topsoil and organics, be neglected in determining lateral resistance. Sloping highway embankments in front of a caisson will result in reduced lateral passive resistance that must be taken into account during design.

Where downward sloping fill or native soil exists in front of a caisson, reduction of lateral passive resistance should be taken into account during design. For design of the caissons, it should be assumed that full lateral resistance can only be mobilized where the width of the soil in front of or behind the caisson is equal to or greater than approximately four (4) times the diameter of the caissons. For sloping ground in front of a caisson, the magnitude of the mobilized passive resistance can be estimated by interpolating between zero passive resistance at the level where the slope face intersects the pile, and full passive resistance at the level where the slope face is at a horizontal distance equal to or greater than four (4) times the diameter of the caisson.

Where an undrained shear strength, C_u , is provided for a cohesive soil (silty clay, silty clay till, clayey silt), the ultimate lateral passive resistance should be calculated in conjunction with the

total soil unit weight. When designing for portions of the caissons below the groundwater level in cohesionless soils (sands and silts) and fills, the submerged soil unit weight, γ' , should be used. The required depth of the drilled shaft will be governed by lateral loads, including wind loads, acting on the wall. The length of the caisson should also be sufficient to counteract frost jacking (upward) forces.

An equivalent caisson width equal to two (2) times the caisson diameter may be assumed for lateral resistance calculations. Appropriate load and resistance factors should be applied for caisson design.

Noise barrier wall construction and installation should generally be carried out in accordance with OPSS 760 and SP 760F01.

8.1 Caisson Installation

Caisson installation should generally be carried out in accordance with OPSS 903.

At the noise barrier wall sites, cobbles and boulders are anticipated within the clayey silt till. The resistance to augering noted at the location of Borehole 16-01, during the investigation, may be attributed to the presence of such cobbles and possible boulders.

Caisson installation equipment must be able to dislodge, handle and remove cobbles, boulders, and to penetrate other obstructions within the fill and within the native till, where encountered.

Groundwater levels are at variable depths below existing ground surface. Soil sloughing and water seepage may occur in unsupported holes especially at depths below the groundwater level. Temporary liners must be available to support the caisson sidewalls and provide seepage cut-off where required. Any accumulated water may have to be pumped out from the hole prior to placing concrete. Should it be considered impractical to remove the accumulated water inside the hole, it is recommended that the concrete be placed by the tremie method. Suggested wordings for an NSSP to cover the above aspects are provided in Appendix E.

8.2 Construction Concerns

Concerns during caisson construction mainly involve the handling and removal of cobbles or boulders in the existing till, soil sloughing and water seepage from caisson sidewalls.

Recommendations on how to address these issues have been outlined in the previous section.

8.3 Construction Inspection and Testing

Caisson construction should be monitored by qualified geotechnical personnel as per OPSS 903 and OPSS 760 to verify the soil conditions and to confirm that those conditions are consistent with the design assumptions in this report.

9. CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Ms. Rocío Palomeque Reyna, P.Eng and Dr. Sydney Pang, P.Eng.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

Thurber Engineering Ltd.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng
Associate, Senior Foundation Engineer



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

TABLE 1
GEOTECHNICAL DESIGN PARAMETERS
NOISE BARRIER WALLS
HIGHWAY 400
TOWNSHIP OF KING, ONTARIO

Approximate Location along Wall Alignment	Borehole Number	Reference Simplified Subsurface Stratigraphy for Design	Depth Below Existing Highway Grade (m)	Geotechnical Design Parameters						Groundwater Depth (m)
				C_u (kPa)	ϕ' (deg.)	γ (kN/m ³)	γ' (kN/m ³)	n_h (kN/m ³)	K_p	
Northerly limit to Station 22+275	16-01	Silt fill	0.7 – 1.5	-	30	20	-	2,500	3.0	3 (below ground surface)
		Clayey silt till with sand (very stiff to hard)	1.5 – 4.5	100	-	20	-	-	-	
		Clayey silt till with sand (hard)	4.5 – 7.0	200	-	20	-	-	-	
		Clayey silt (hard)	7.0 – 8.0	200	-	20	-	-	-	
Stations 22+275 to 21+975	16-02 16-03 16-04 16-05 16-06	Clayey silt till with sand (very stiff to hard)	0.2 – 4.0	125	-	20	-	-	-	4 (below ground surface)
		Clayey silt till with sand (hard)	4.0 – 8.0	200	-	20	-	-	-	

Approximate Location along Wall Alignment	Borehole Number	Reference Simplified Subsurface Stratigraphy for Design	Depth Below Existing Highway Grade (m)	Geotechnical Design Parameters						
				C_u (kPa)	ϕ' (deg.)	γ (kN/m ³)	γ' (kN/m ³)	n_h (kN/m ³)	K_p	Groundwater Depth (m)
Stations 21+975 to 21+850	16-07	Sandy silty (compact)	0.0 – 1.5	-	30	20	-	3,000	3.0	1 (below ground surface)
		Sand (compact to dense)	1.5 – 7.0	-	32	21	-	4,000	3.2	
		Clayey silt (hard)	7.0 – 8.0	150	-	21	-	-	-	
Station 21+850 to southerly limit	16-08 16-09	Sand to Silty Sand (loose to compact)	0.0 – 2.0	-	30	20	-	3,000	3.0	1 (below ground surface)
		Sand to Silty sand (compact to very dense)	2.0 – 8.0	-	33	21	-	5,000	3.4	

Legend:

C_u	=	undrained shear strength = unconfined compressive strength, $q_u / 2$
ϕ'	=	angle of internal friction
γ	=	bulk unit weight
γ'	=	submerged unit weight
n_h	=	coefficient related to soil density
K_p	=	coefficient of passive earth pressure

Notes:

- This table must be read in conjunction with the report. In order to take into account frost action and surficial disturbance, the ultimate lateral passive resistance in front of the caisson within the upper 1.4 m below final grade should be neglected in the foundation design.
- All groundwater levels are reported as the depth below the ground surface in metres at the time of the borehole investigation.



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

EXPLANATION OF ROCK LOGGING TERMS


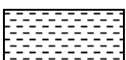

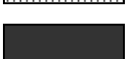

ROCK WEATHERING CLASSIFICATION

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

DISCONTINUITY SPACING

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

SYMBOLS

	CLAYSTONE
	SILTSTONE
	SANDSTONE
	COAL
	BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
	(MPa)	(psi)	
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No 16-01

1 OF 2

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+318, N 4 874 610.9 E 297 595.4 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.02 - 2016.11.02 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
284.5	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL , some silt, trace clay, occasional roots and rootlets Compact Brown Moist (700mm)		1	SS	10		284							○			
283.8																	
0.7	SILT , some sand, trace clay, trace gravel, occasional roots and rootlets Compact Brown Moist (FILL)		2	SS	28		283							○			
283.1																	
1.4	Clayey SILT , with sand Very Stiff to Hard Brown Moist (TILL)		3	SS	26		282							○			0 48 40 12
	Occasional cobbles at 2.6m Brown to Grey		4	SS	51		281							○			
			5	SS	50		280							○			
	Resistance to augering		6	SS	60/ 0.100		279							○			0 42 46 12
	Wet		7	SS	50/ 0.100		278							○			
277.5																	
7.0	Clayey SILT , trace sand Hard Grey Wet		8	SS	50/ 0.125		277							○			
276.3																	
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.11.03 5.9 278.6 2016.11.04 5.9 278.6																

Continued Next Page

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

RECORD OF BOREHOLE No 16-01

2 OF 2

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+318, N 4 874 610.9 E 297 595.4 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.02 - 2016.11.02 CHECKED BY RPR

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																
	2016.11.07 5.9 278.6																
	2016.11.08 5.9 278.6																
	2017.01.18 3.8 280.7																

RECORD OF BOREHOLE No 16-02

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+255, N 4 874 541.5 E 297 616.1 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.03 - 2016.11.03 CHECKED BY RPR

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									
								20	40	60	80	100					
287.5	GROUND SURFACE																
0.0	TOPSOIL, some silt, trace sand, trace gravel, occasional roots and rootlets Compact Brown Moist (700mm)		1	SS	18												
286.8																	
0.7	Clayey SILT, with sand, trace gravel Hard Brown Moist (TILL)		2	SS	73												
			3	SS	49												
285.3																	
2.2	Very Stiff		4	SS	17												
284.5																	
3.0			5	SS	35												
			6	SS	162/ 0.250												
	Brown to Grey																
			7	SS	110												
	Grey																
			8	SS	40												
279.3																	
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG MIXED WITH AUGER CUTTINGS TO SURFACE.																

ONTMT4S MTO-12187.GPJ 2015TEMPLATE(MTO).GDT 5/12/17

RECORD OF BOREHOLE No 16-03

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+172, N 4 874 459.2 E 297 632.6 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.03 - 2016.11.03 CHECKED BY RPR

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								
290.2	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL: (75mm)							20	40	60	80	100				
0.1	Clayey SILT , with sand, trace gravel, occasional roots and rootlets Hard Brown Moist (TILL)		1	SS	43		290							○		
			2	SS	97		289							○		0 42 41 17
			3	SS	57		288							○		
			4	SS	33		287							○		
			5	SS	60		286							○		
			6	SS	95		285							○		0 43 42 15
			7	SS	100/ 0.250		284							○		
	Brown to Grey						283							○		
282.5	END OF BOREHOLE AT 7.7m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													○		
7.7					0.125											
WATER LEVEL READINGS																
DATE DEPTH(m) ELEV.(m)																
2016.11.07 6.8 283.4																
2016.11.08 6.8 283.4																
2017.01.18 4.9 285.3																

ONTMT4S MTO-12187.GPJ 2015TEMPLATE(MTO).GDT 5/12/17

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

RECORD OF BOREHOLE No 16-04

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+118, N 4 874 402.9 E 297 646.6 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.03 - 2016.11.03 CHECKED BY RPR

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
291.2	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (100mm)							20	40	60	80	100							
0.1	Clayey SILT , with sand, trace gravel, occasional roots and rootlets Very Stiff to Hard Brown Moist (TILL)		1	SS	23		291							○					
			2	SS	53		290							○					
			3	SS	33		289							○				0	43 41 16
			4	SS	37		288							○					
			5	SS	100/ 0.100		287							○					
			6	SS	80		286							○					
			7	SS	100/ 0.125		285							○				0	40 51 9
	Brown to Grey		8	SS	100/ 0.075		284							○					
283.4	END OF BOREHOLE AT 7.8m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG MIXED WITH AUGER CUTTINGS TO SURFACE.																		
7.8																			

ONTMT4S MTO-12187.GPJ 2015TEMPLATE(MTO).GDT 5/12/17

RECORD OF BOREHOLE No 16-05

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 22+055, N 4 874 343.5 E 297 664.5 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.04 - 2016.11.04 CHECKED BY RPR

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									
292.1	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (100mm)							20	40	60	80	100					
0.1	Clayey SILT , with sand, trace gravel, occasional roots and rootlets Stiff to Hard Brown Moist (TILL)		1	SS	13		292										
			2	SS	65		291										
			3	SS	64		290										
	Sand seam at 1.9m		4	SS	41		289										
			5	SS	98		288										
			6	SS	100/ 0.225		287										
			7	SS	100/ 0.275		286										
	Grey Wet		8	SS	100/ 0.138		285										
284.3	END OF BOREHOLE AT 7.8m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
7.8																	
	WATER LEVEL READINGS																
	DATE DEPTH(m) ELEV.(m)																
	2016.11.07 3.6 288.5																
	2016.11.08 3.6 288.5																
	2017.01.18 2.1 290.0																

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

RECORD OF BOREHOLE No 16-06

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 21+995, N 4 874 288.8 E 297 705.6 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.04 - 2016.11.04 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							WATER CONTENT (%) w _P w w _L			
293.3	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (100mm)							20	40	60	80	100						
0.1	Clayey SILT , with sand, trace gravel, occasional roots and rootlets Stiff to Hard Brown Moist (TILL)		1	SS	12		293								○			
			2	SS	27		292								○			
			3	SS	35		291								○		0 41 46 13	
			4	SS	20		290								○			
290.3	Hard Wet		5	SS	35		289								○			
			6	SS	86		288								○		0 49 40 11	
	Brown to Grey		7	SS	67		287								○			
			8	SS	100/		286								○		0 40 42 18	
285.5	END OF BOREHOLE AT 7.8m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG MIXED WITH AUGER CUTTINGS TO SURFACE.				0.175													
7.8																		

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

RECORD OF BOREHOLE No 16-07

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 21+888, N 4 874 179.3 E 297 730.6 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.07 - 2016.11.07 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)						
295.9	GROUND SURFACE							20	40	60	80	100		W _P	W	W _L	kN/m ³	GR SA SI CL	
0.0	TOPSOIL: (150mm)							20	40	60	80	100							
0.2	Sandy SILT , trace to some clay, trace gravel, occasional roots and rootlets, clay pockets Loose to Compact Brown to Grey Moist		1	SS	7		295							○					
			2	SS	14									○					
294.2														○					
1.7	SAND , some silt, trace gravel, trace clay Compact to Dense Brown Wet		3	SS	35		294							○					
			4	SS	23									○				0 82 13 5	
			5	SS	39		293							○					
							292							○				Switch to Hollow Stem Augers at 3.6m	
			6	SS	37		291							○					
							290							○					
			7	SS	33		289												
288.7																			
7.2	Clayey SILT , some sand Hard Grey Wet		8	SS	53		288							○				0 14 71 15	
287.7																			
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.11.08 1.0 294.9 2017.01.18 0.9 295.0																		

ONTMT4S MTO-12187.GPJ 2015TEMPLATE(MTO).GDT 5/12/17

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

RECORD OF BOREHOLE No 16-08

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 21+810, N 4 874 105.2 E 297 732.2 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Solid Stem Augers & Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 1108/2016 - 2016.11.08 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
								20 40 60 80 100	W P W W L											
295.3	GROUND SURFACE																			
0.0	TOPSOIL: (100mm)																			
0.1		Silty SAND , trace clay, occasional roots and rootlets Loose to Compact Brown Moist																		
			1	SS	7		295													
			2	SS	20															
							294													
	Grey Wet		3	SS	13															
293.1							293													
2.2			4	SS	35															
			5	SS	33		292													
							291													
			6	SS	70		290													
			7	SS	76		289													
							288													
			8	SS	100/ 0.275															
287.2																				
8.1	END OF BOREHOLE AT 8.1m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG MIXED WITH AUGER CUTTINGS TO SURFACE.																			

ONTMT4S MTO-12187.GPJ 2015TEMPLATE(MTO).GDT 5/12/17

RECORD OF BOREHOLE No 16-09

1 OF 1

METRIC

GWP# 2085-15-00 LOCATION Sta. 21+775, N 4 874 037.0 E 297 746.0 ORIGINATED BY CAR
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2016.11.08 - 2016.11.08 CHECKED BY RPR

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										
296.6	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (50mm)																	
	Sandy SILT , trace gravel, occasional roots and rootlets		1	SS	4													
295.9	Loose						296											
0.7	Moist																	
	SAND , trace silt, trace clay																	
	Loose to Compact		2	SS	5													
	Reddish Brown																	
	Moist																	
	Brown																	
	Wet		4	SS	25		294											
			5	SS	29													
							293											
292.5																		
4.1																		
	Dense		6	SS	31		292											
291.0							291											
5.6																		
			7	SS	21													
							290											
							289											
	Dense																	
288.4	Some silt		8	SS	35													
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE DRY UPON COMPLETION OF DRILLING. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																	
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.18 2.7 293.9																	

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



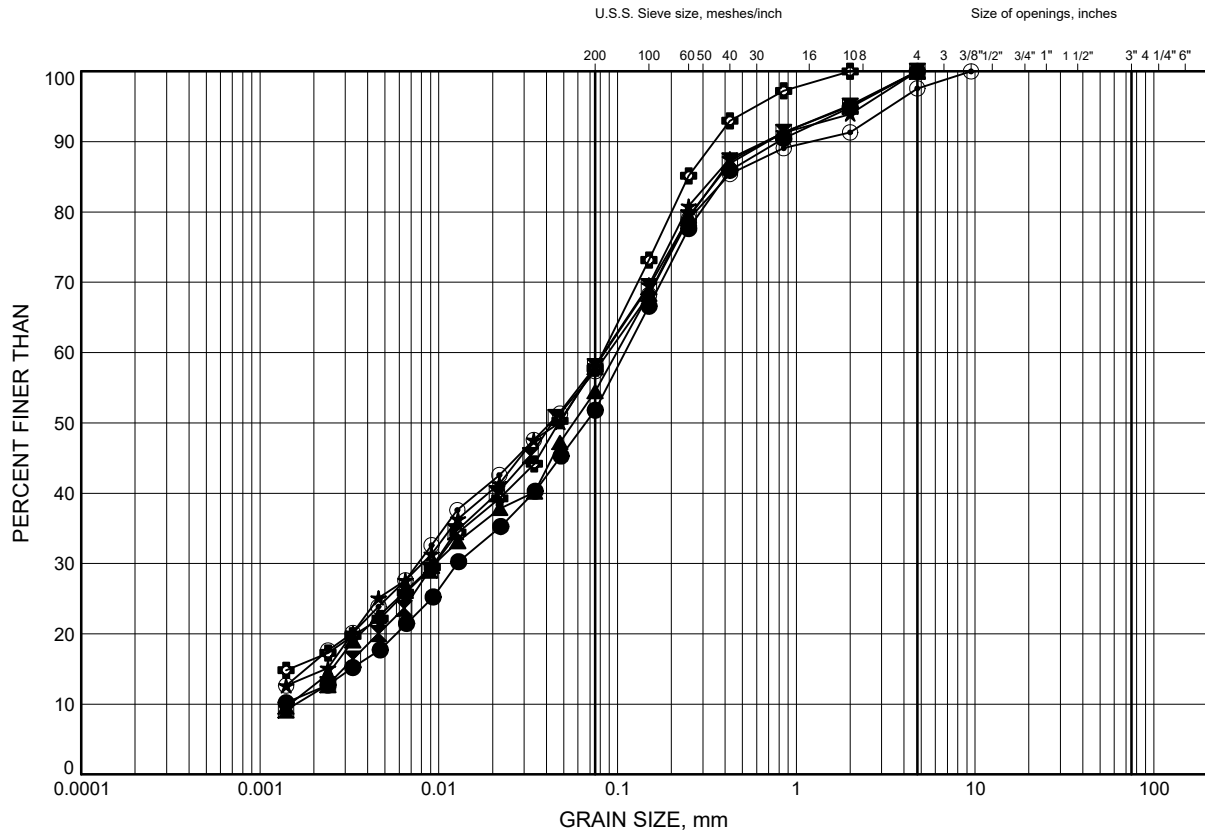
Appendix B

Laboratory Test Results

HWY 400 Noise Barrier GRAIN SIZE DISTRIBUTION

FIGURE B1

Clayey SILT TILL, with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	1.83	282.67
⊠	16-01	4.88	279.62
▲	16-02	2.59	284.91
★	16-02	6.40	281.10
⊙	16-02	7.92	279.58
⊕	16-03	1.07	289.13

Date May 2017

GWP# 2085-15-00



Prep'd AN

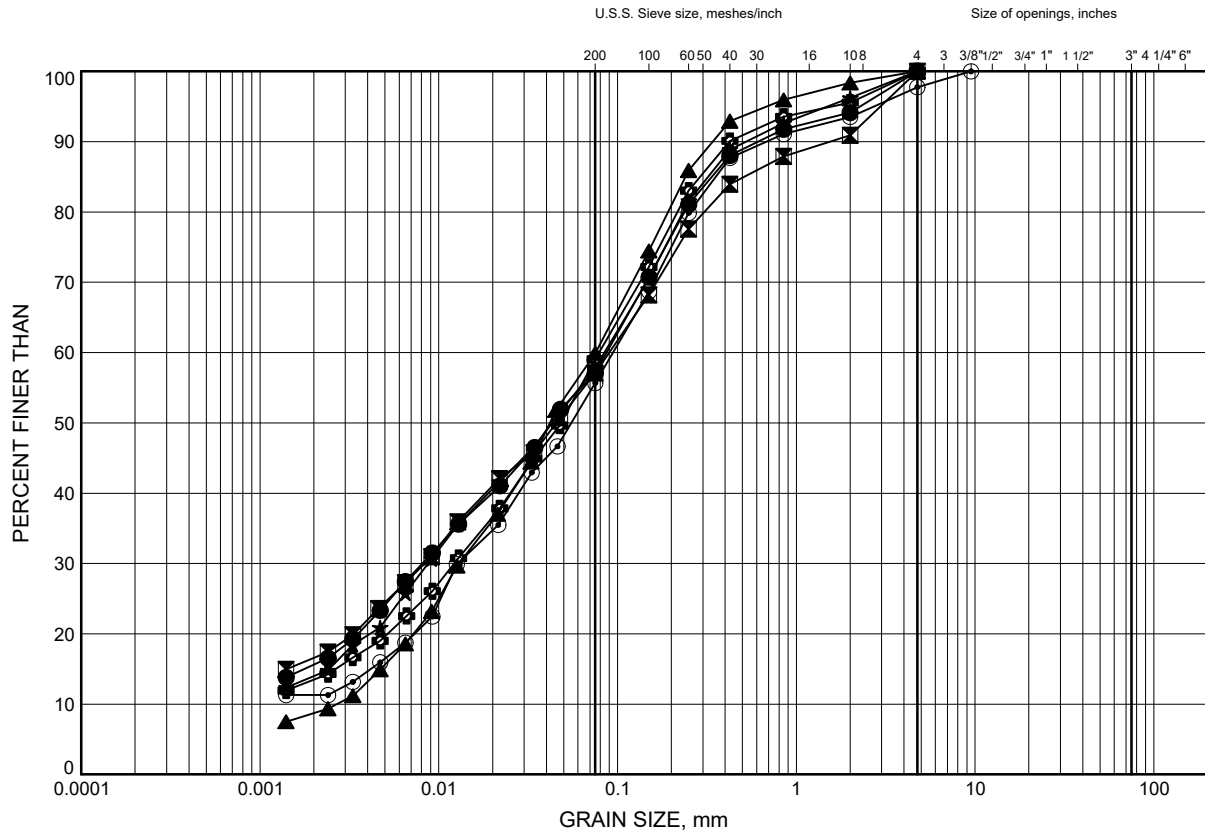
Chkd. RPR

HWY 400 Noise Barrier

GRAIN SIZE DISTRIBUTION

FIGURE B2

Clayey SILT TILL, with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	4.88	285.32
⊠	16-04	1.83	289.37
▲	16-04	6.40	284.80
★	16-05	2.59	289.51
⊙	16-05	7.69	284.41
⊕	16-06	1.83	291.47

Date May 2017

GWP# 2085-15-00



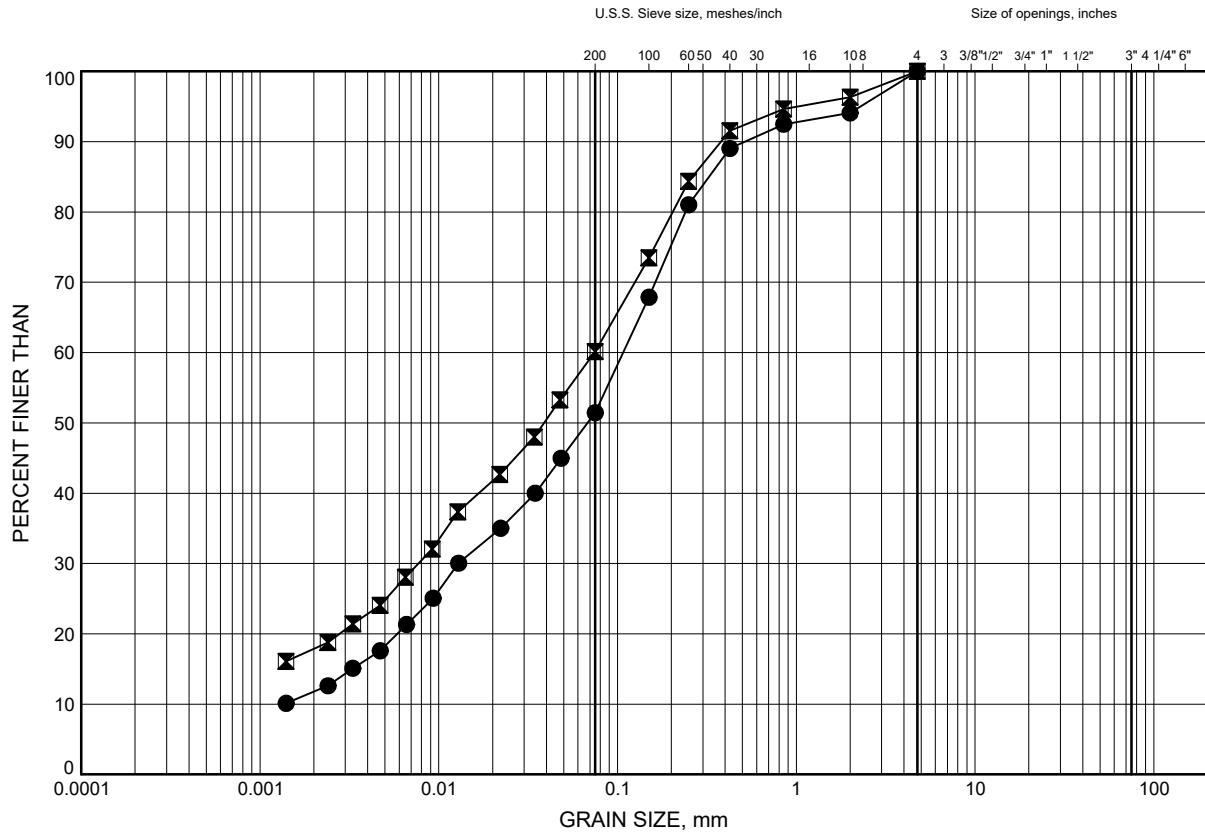
Prep'd AN

Chkd. RPR

HWY 400 Noise Barrier GRAIN SIZE DISTRIBUTION

FIGURE B3

Clayey SILT TILL, with Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-06	4.88	288.42
⊠	16-06	7.71	285.59

Date May 2017
GWP# 2085-15-00



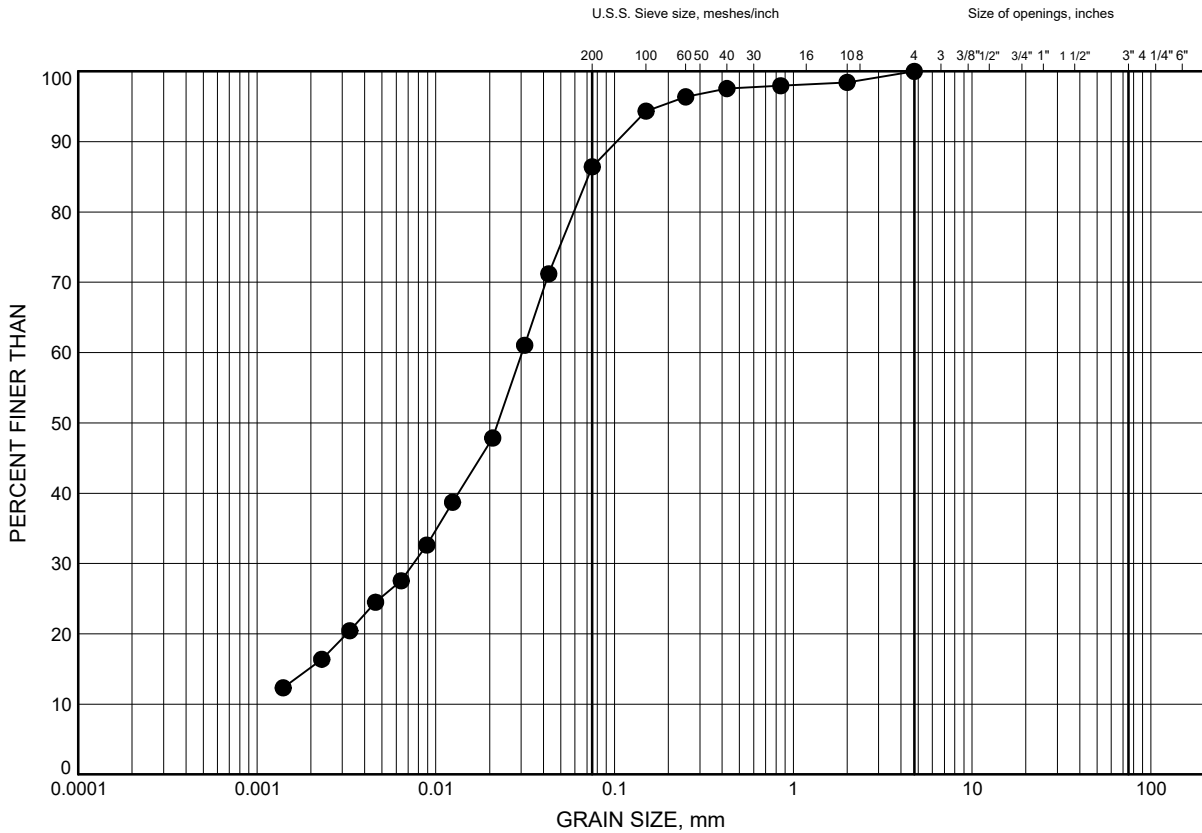
Prep'd AN
Chkd. RPR

HWY 400 Noise Barrier

GRAIN SIZE DISTRIBUTION

FIGURE B4

Clayey SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	7.92	287.98

Date May 2017
GWP# 2085-15-00

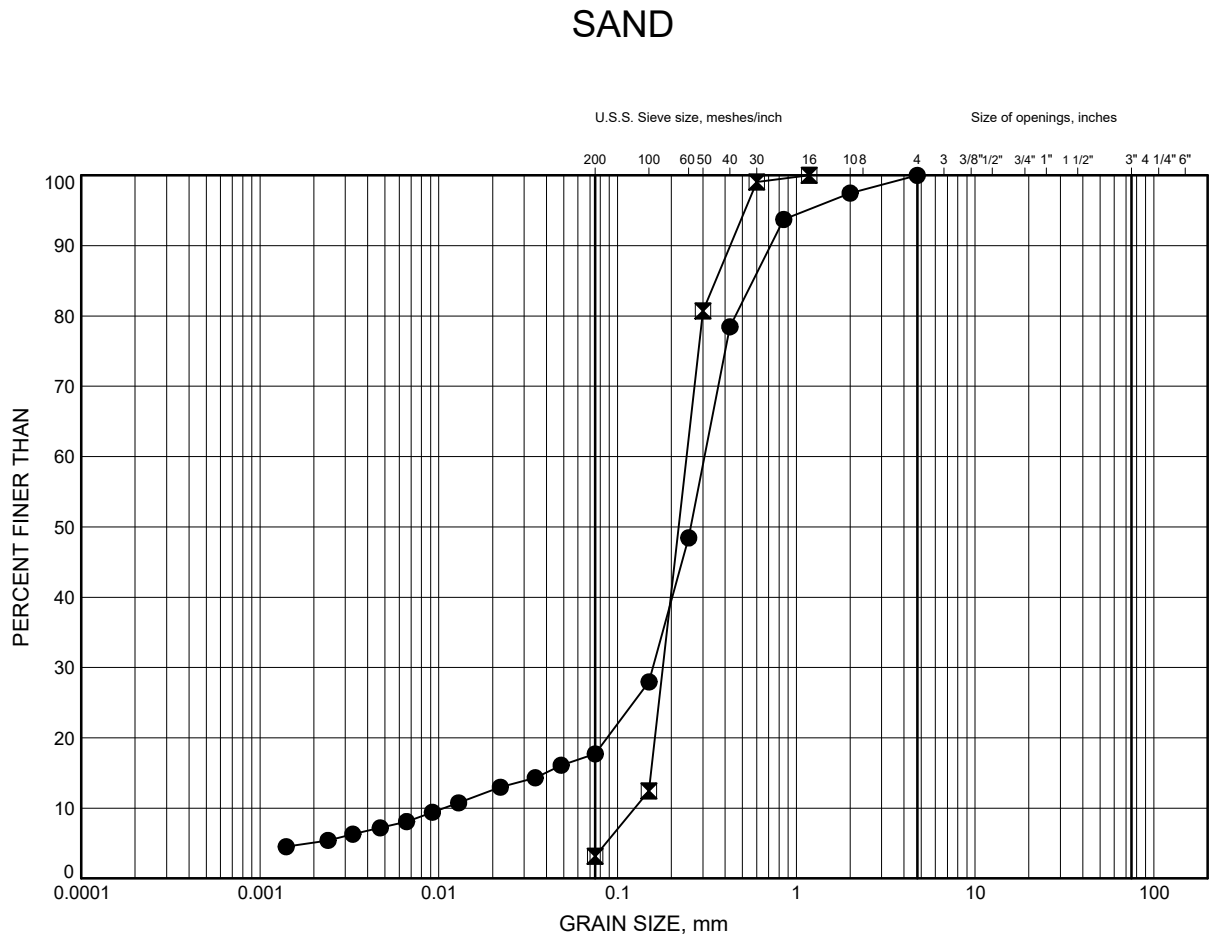


Prep'd AN
Chkd. RPR

HWY 400 Noise Barrier

GRAIN SIZE DISTRIBUTION

FIGURE B5



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	2.59	293.31
⊠	16-09	4.88	291.72

Date May 2017
GWP# 2085-15-00



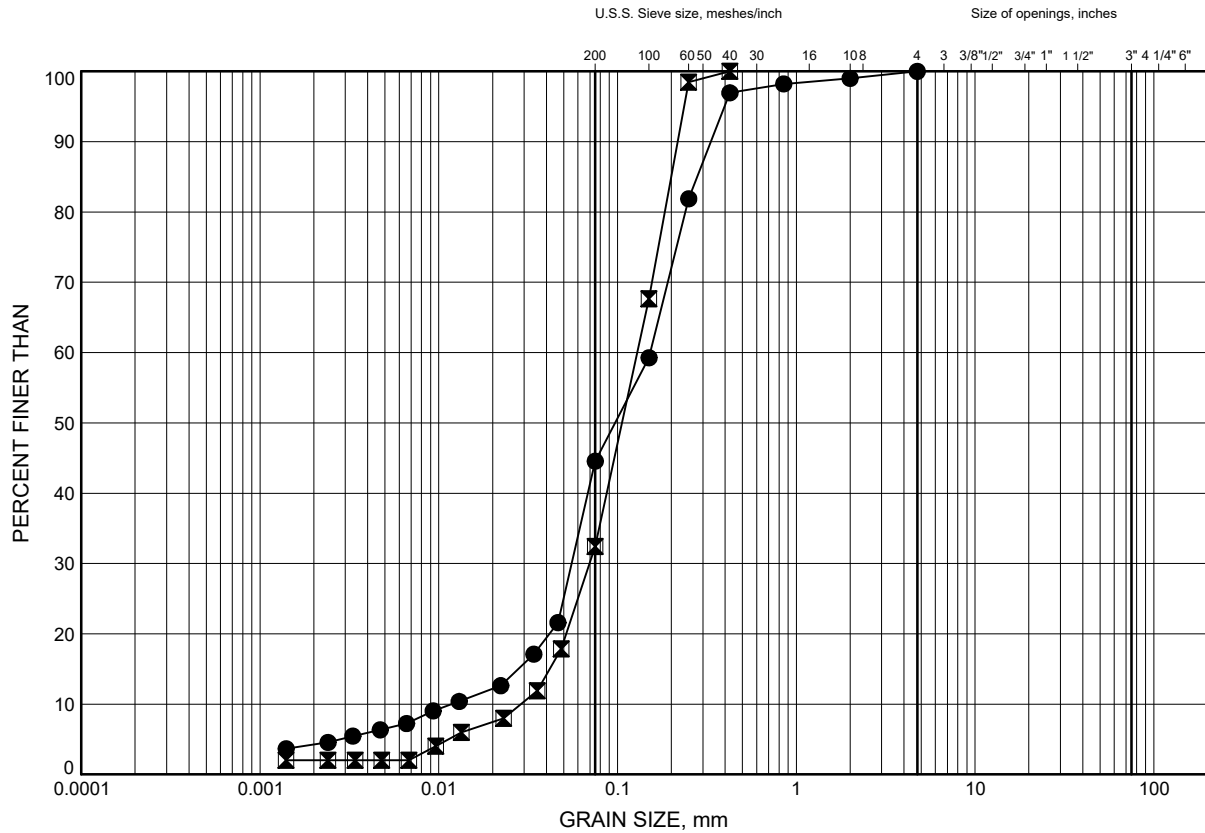
Prep'd AN
Chkd. RPR

HWY 400 Noise Barrier

GRAIN SIZE DISTRIBUTION

FIGURE B6

Silty SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-08	1.07	294.23
⊠	16-08	6.40	288.90

Date May 2017
GWP# 2085-15-00

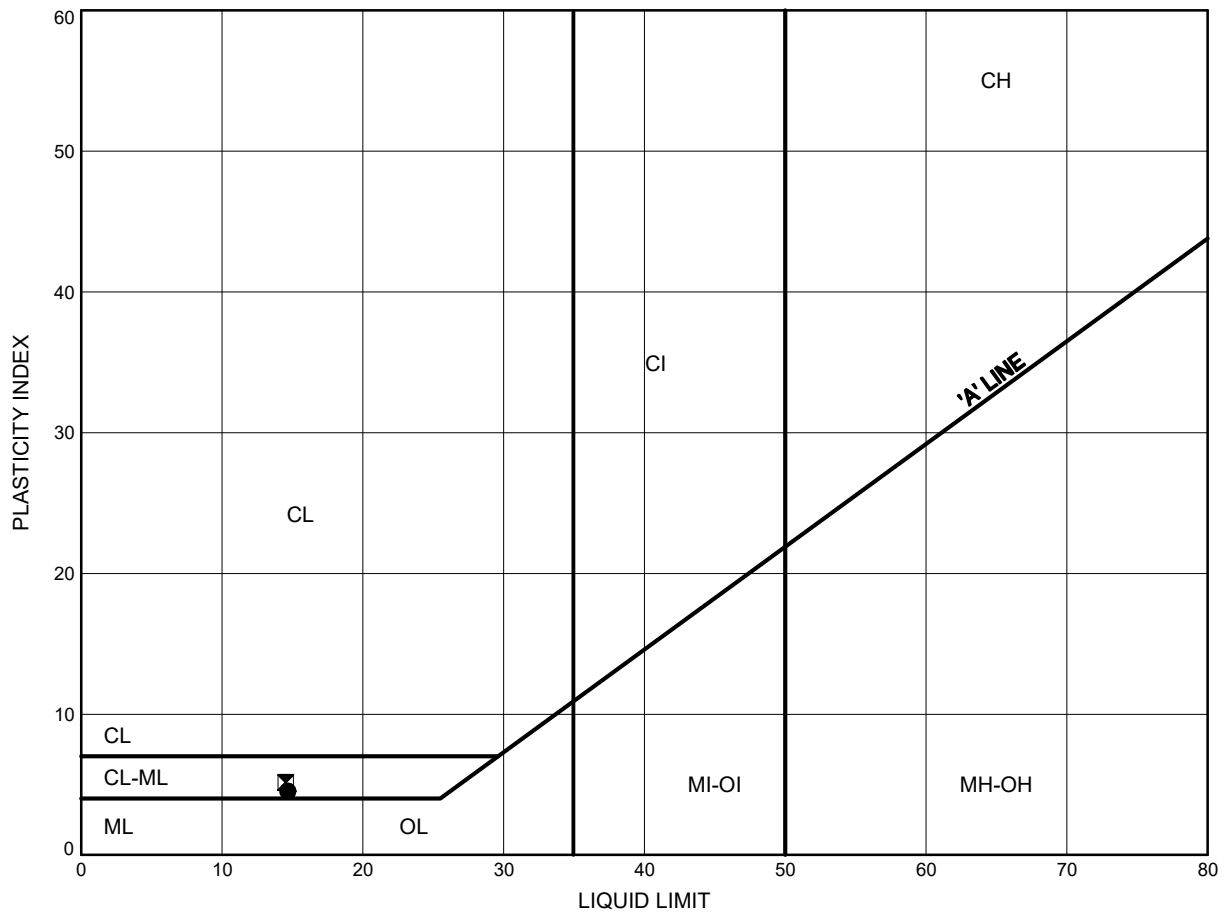


Prep'd AN
Chkd. RPR

HWY 400 Noise Barrier ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Clayey SILT TILL, with Sand



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	2.59	284.91
⊠	16-02	7.92	279.58

Date May 2017
GWP# 2085-15-00

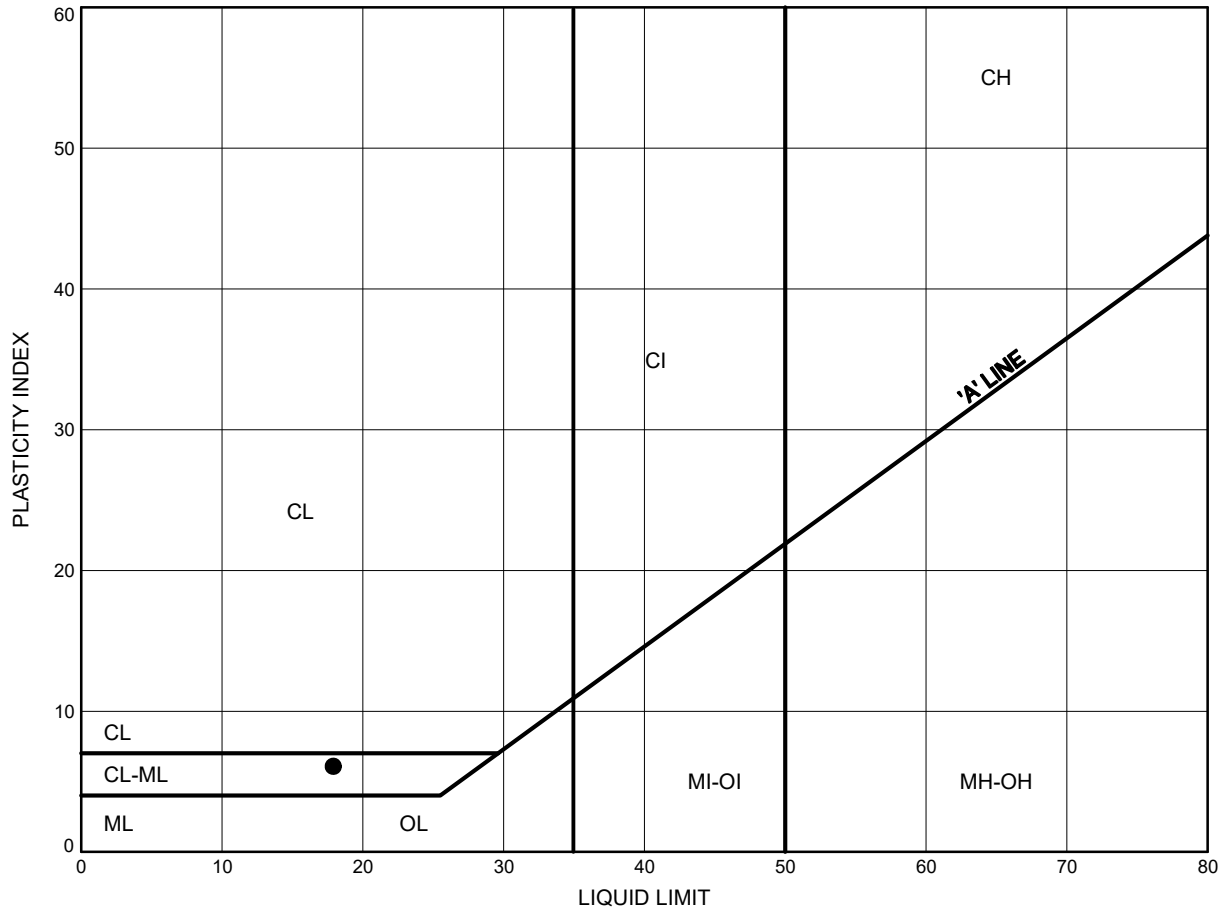


Prep'd AN
Chkd. RPR

HWY 400 Noise Barrier ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Clayey SILT



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-07	7.92	287.98

Date May 2017
GWP# 2085-15-00

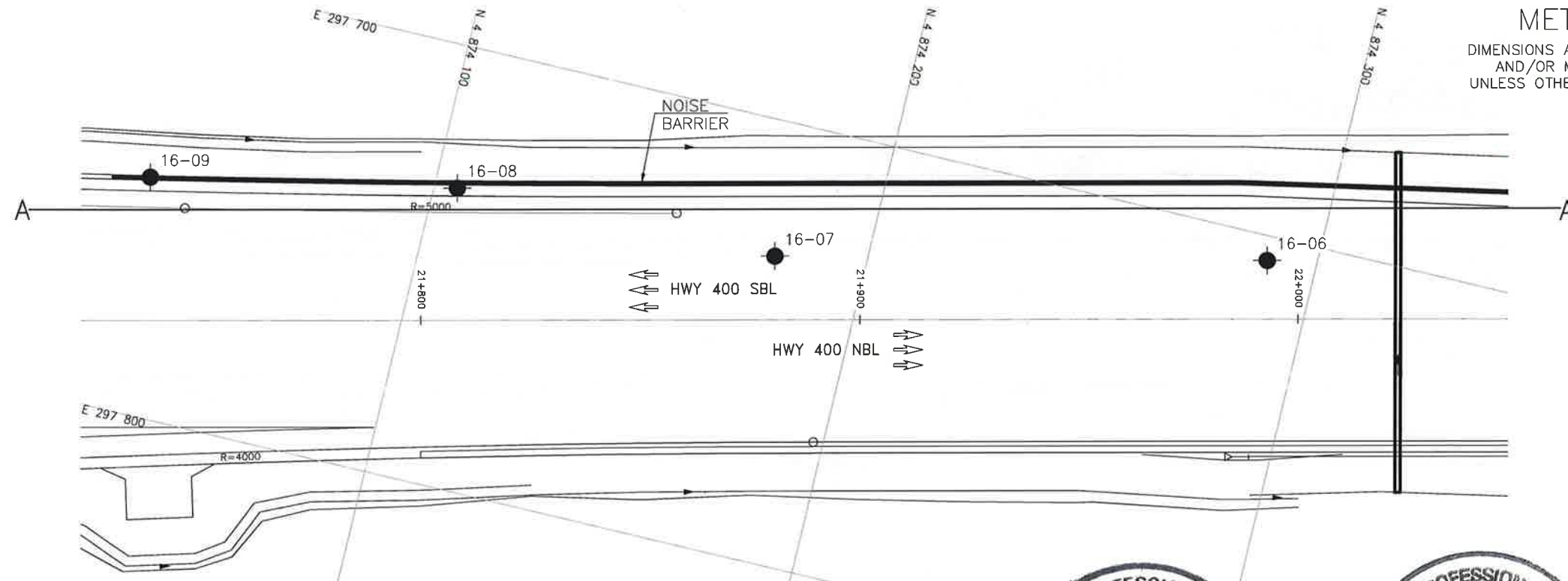


Prep'd AN
Chkd. RPR

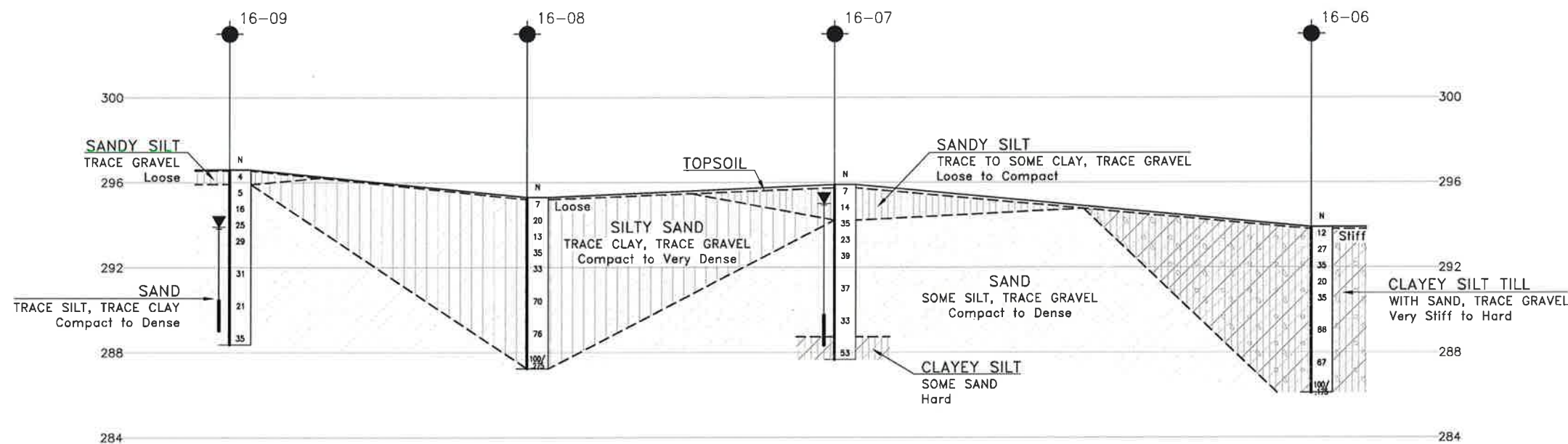


Appendix C

Borehole Locations and Soil Strata Drawing



PLAN
SCALE 1:1250

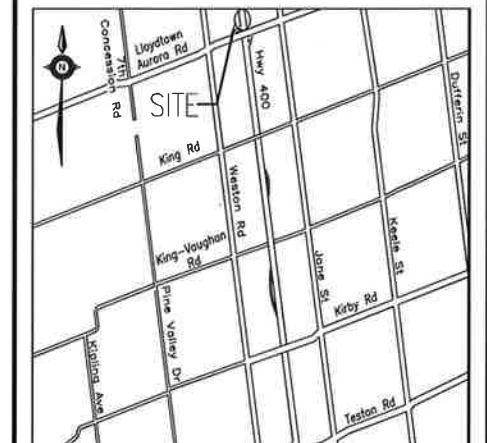


PROFILE ALONG A-A'
H 1:1250
V 1:250

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

CONT No
WP No 2085-15-00

HIGHWAY 400 SBL
NOISE BARRIER WALL
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN
LEGEND

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

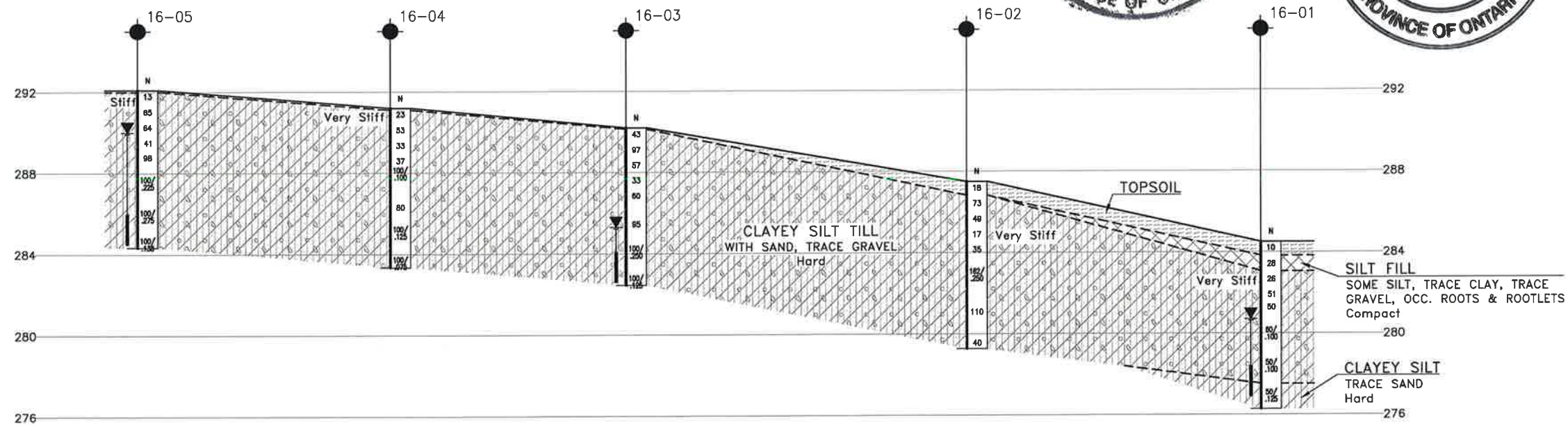
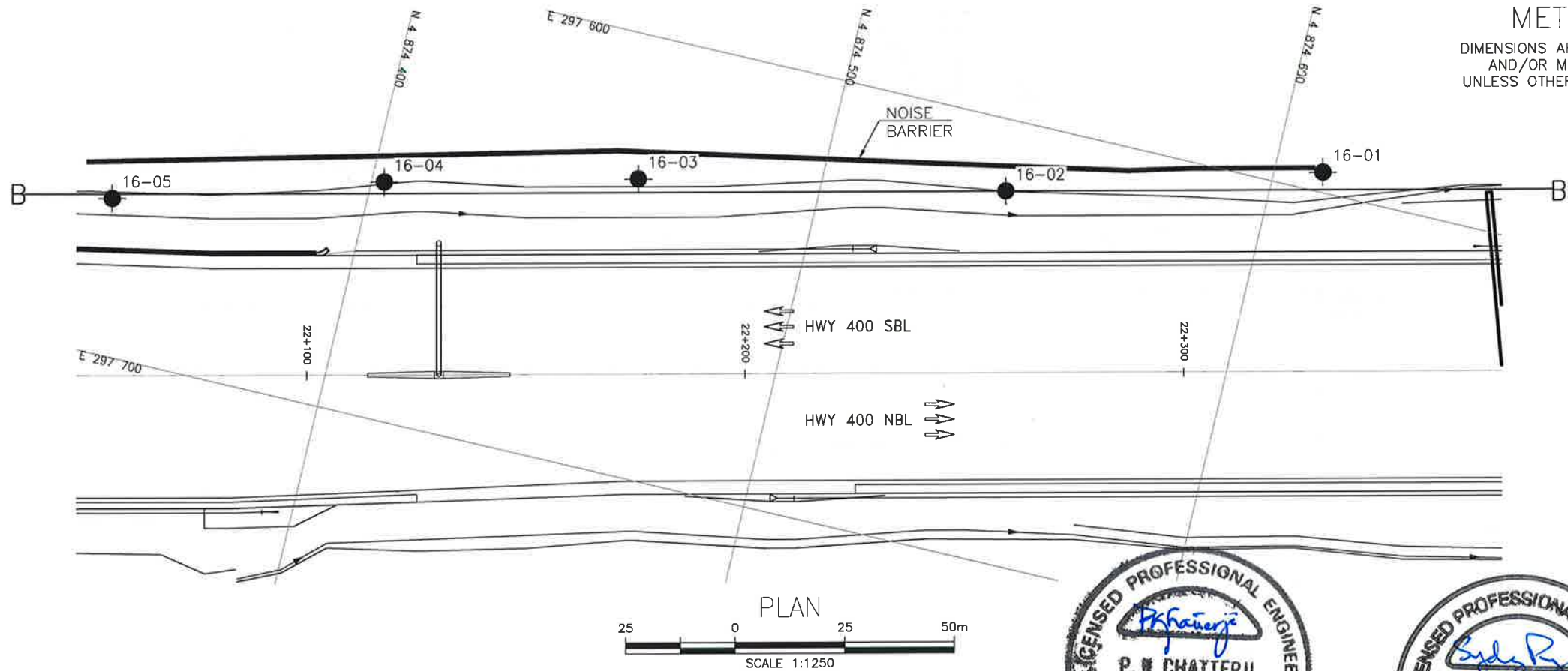
NO	ELEVATION	NORTHING	EASTING
16-01	284.5	4 874 610.9	297 595.4
16-02	287.5	4 874 541.5	297 616.1
16-03	290.2	4 874 459.2	297 632.6
16-04	291.2	4 874 402.9	297 646.6
16-05	292.1	4 874 343.5	297 664.5
16-06	293.3	4 874 288.8	297 705.6
16-07	295.9	4 874 179.3	297 730.6
16-08	295.3	4 874 105.2	297 732.2
16-09	296.6	4 874 037.0	297 746.0

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. 31D-672

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE
LOAD	DATE	MAY 2017	
STRUCT	DWG	1	



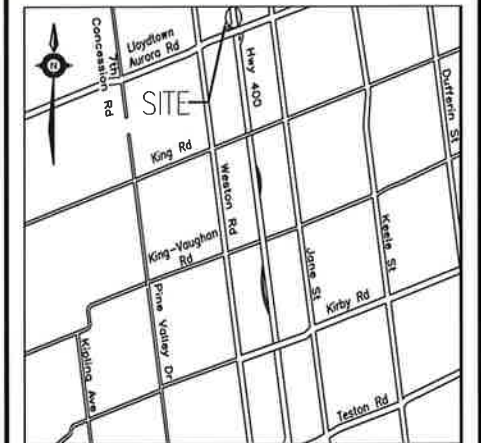
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 2085-15-00



HIGHWAY 400 SBL
NOISE BARRIER WALL
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
16-01	284.5	4 874 610.9	297 595.4
16-02	287.5	4 874 541.5	297 616.1
16-03	290.2	4 874 459.2	297 632.6
16-04	291.2	4 874 402.9	297 646.6
16-05	292.1	4 874 343.5	297 664.5
16-06	293.3	4 874 288.8	297 705.6
16-07	295.9	4 874 179.3	297 730.6
16-08	295.3	4 874 105.2	297 732.2
16-09	296.6	4 874 037.0	297 746.0

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. 31D-672

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE
			LOAD
			DATE MAY 2017
			STRUCT
			OWG 2



Appendix D

Selected Site Photographs



Photo 1. – West side of Hwy 400 SBL



Photo 2.- East side of Hwy 400 NBL



Appendix E

List of OPS Specifications

List of OPSS Documents Referenced in this Report

- OPSS 903
- OPSS 760
- SP 760F01

Suggested Text for NSSP on:

“Augered Caisson Construction for Noise Barrier Wall Foundations”

The Contractor is advised that variable types of subsurface materials may be encountered at the locations of the noise barrier wall foundations. Cobbles and boulder amongst other obstructions is potentially present within the underlying glacial tills. For additional information regarding subsurface conditions, the Contractor is referred to the Foundation Investigation Report.

For bidding purposes, the Contractor shall assume the following:

1. The subsurface conditions at an augered caisson location are the same as those encountered in the borehole closest to the subject caisson location.
2. Cobbles and boulders may be encountered within the glacial till deposits. Obstructions including cobbles and boulders may also be present within the fills. The soil matrix is anticipated to become harder or denser with depth. Caisson installation equipment must be able to dislodge, handle, remove or otherwise penetrate these obstructions and hard layers.
3. Water seepage and/or soil sloughing into the caisson hole will occur from existing fill and cohesionless soils. The cohesionless soils would be susceptible to disturbance under conditions of unbalanced hydrostatic head. Temporary liners shall be available on site, or be made available on very short notice, to support the caisson sidewalls and provide seepage cut-off where required. All concrete shall be placed in the dry. Should it be impractical to remove the water in the caisson hole, consideration could be giving to using the tremie method for placing concrete.

The Contractor is responsible for constructing the noise barrier wall foundations without disturbing the material at the sides or bases of the foundations.