

**FOUNDATION INVESTIGATION AND
DESIGN REPORTS – NOISE BARRIER
WEST OF COUNTY RD 45 INTERCHANGE
HIGHWAY 401, COBOURG, ONTARIO,
W.P. NO. 205-00-01, GEOCRETS 30M16- 47**

AECOM

TRANETOB10434AA-AI
November 23, 2011

November 23, 2011

AECOM
5080 Commerce Boulevard
Mississauga, ON L4W 4P2

Attention: Ms. Peggy Baleka

Dear Ms. Baleka:

RE: Foundation Investigation and Design Reports, Noise Barrier West of County Road 45 Interchange, Highway 401, Cobourg, Ontario G.W.P. No. 205-00-01

Coffey Geotechnics Inc (Coffey) is pleased to present the Foundation Investigation and Design Reports for the proposed noise barrier to be located west of County Road 45 interchange, south of Highway 401, Cobourg, Ontario.

Please call us on 416 213 1255 should you require further clarification on any aspects of the reports.

For and on behalf of Coffey Geotechnics Inc.


Ramon Miranda, P.Eng.

Principal

Distribution: Original held by Coffey Geotechnics Inc.
1 hard copy to AECOM
1 hard copy to MTO Project Manager
1 hard copy to MTO Pavements and Foundation Section

**FOUNDATION INVESTIGATION REPORT
NOISE BARRIER WEST OF COUNTY RD 45
INTERCHANGE, HIGHWAY 401
COBOURG, ONTARIO
W.P. NO. 205-00-01, GEOCREC 30M16- 47**

AECOM

TRANETOB10434AA-AI
November 23, 2011

CONTENTS

1	INTRODUCTION	1
2	SITE DESCRIPTION AND PHYSIOGRAPHY	1
2.1	Site Description	1
2.2	Physiography	1
3	METHOD OF INVESTIGATION	2
3.1	Fieldwork	2
3.2	Laboratory Testing	3
4	SUBSURFACE CONDITIONS	3
4.1	Topsoil	4
4.2	Fill	4
4.3	Clayey Silt Interbedded with Sand to Silty Sand and Sandy Silt	4
4.4	Silty Sand Till	5
4.5	Groundwater Conditions	5

Tables

Table 1: Borehole Details

Table 2: Groundwater Level Observations

CONTENTS

Drawing

Drawing 1: Borehole Location Plan and Soil Strata

Appendices

Appendix A: Record of Borehole Sheets

Appendix B: Laboratory Test Results

Figure B1: Grain Size Distribution – Clayey Silt

Figure B2: Plasticity Chart – Clayey Silt

Figure B3: Grain Size Distribution – Sand

Appendix C: Site Photographs

Appendix D: Explanation of Terms Used in Report

**FOUNDATION INVESTIGATION REPORT
NOISE BARRIER – WEST OF COUNTY ROAD 45 INTERCHANGE
HIGHWAY 401, COBOURG, ONTARIO
W.P. 205-00-01**

1 INTRODUCTION

At the request of AECOM, Coffey Geotechnics Inc. (Coffey) has prepared this foundation investigation report for a proposed noise barrier wall to be located west of County Road 45 interchange, south of Highway 401, Cobourg, Ontario. The work was carried out as part of the Highway 401 Expansion (6-Laning) from Burnham Street to approximately 2.0 km east of Nagle Road, within the Town of Cobourg and Township of Hamilton, Ontario. There are two noise barrier walls proposed for the project, namely, to the east and west of County Road 45. This report deals with the walls to be constructed west of County Road 45, while those to the east are reported under a separate cover. The foundation investigation was generally carried out in accordance with Coffey proposal (Reference PO 9236, dated May 25, 2009) and the requirements of the RFP.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes, and to assess the engineering characteristics of the subsurface soils by means of field and laboratory tests.

This report provides factual information concerning subsurface conditions, in situ test and laboratory test results, based on the foundation investigation undertaken.

2 SITE DESCRIPTION AND PHYSIOGRAPHY

2.1 Site Description

The site is located between Stations 17+980 and 18+260, about 43 m south of Highway 401 centreline, east of County Road 45 Interchange in Cobourg, Ontario. The noise barrier will be located generally on top of a slope, adjacent to the south fence of the highway.

At the time of our investigation, vegetation such as grass and trees occupied the site. Beyond the fence line, residential houses are located. The ground elevation at the noise barrier location is generally higher (maximum 3 m) than the existing highway grade but gradually drops to about 3 m lower on the east end.

Cobourg Creek is located to the west of the site.

Photographs of the site are presented in Appendix C.

2.2 Physiography

According to "The Physiography of Southern Ontario" by L.J. Chapman and D.F. Putnam, 1984, the proposed noise barrier is located within the physiographic region known as the Iroquois Plain. The Iroquois Plain was previously inundated by a body of water known as Lake Iroquois, the fore-runner of the present Lake Ontario. Iroquois Plain at Cobourg is about five kilometers in width and has a peculiar belted pattern. The land within the project area is covered by glaciolacustrine deposits overlying sandy glacial till deposits.

The bedrock underlying the project area is known to belong to the Trenton and Black River Groups (Simcoe Group), which are approximately 480 million years old, and consist of primarily limestone, with some dolostone, shale, arkose and sandstone (Bedrock Geology of Ontario, Southern Sheet, Map 2544 and Geological Highway Map Southern Ontario, Map 2441).

3 METHOD OF INVESTIGATION

3.1 Fieldwork

The fieldwork for the investigation was carried out in July 2010 and comprised of drilling five boreholes (W1 to W5) at the locations shown on the Borehole Location Plan, Drawing 1. Table 1 below presents a summary of the borehole details.

Table 1: Borehole Details

Borehole No.	Station	Offset from Hwy 401 C/L	Existing Ground Elevation (m)	Drilled Depth (m)
W1	17+981	39 m Right of C/L	94.1	12.7
W2	18+052	45 m Right of C/L	100.1	6.6
W3	18+101	39 m Right of C/L	98.2	6.6
W4	18+171	37 m Right of C/L	98.2	6.6
W5	18+236	38 m Right of C/L	100.0	12.7

The borehole drilling was carried out by Strong Soil Search, using a track mounted (Bombardier) drill rig. Each borehole was advanced using solid flight augers or hollow stem augers to depths of about 6.6 to 12.7 m below the ground surface. Standard Penetration Tests (SPTs) were carried out at selected depth intervals, to assess the soil strength and obtain samples for logging and testing purposes. SPTs were carried out in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm outside diameter (OD) split-barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils).

The soil samples were described in the field, placed in appropriate containers, labelled and transported to our Etobicoke geotechnical laboratory where the samples underwent further detailed visual examination and samples were selected for geotechnical laboratory testing.

Groundwater levels and inflows, observed in the open boreholes during drilling, were recorded. No long term groundwater level monitoring was carried out for the site. Upon drilling completion, the boreholes were grouted using a cement/bentonite mixture, as per MTO procedures.

The borehole locations were located on site using existing site features. The borehole location coordinates and ground elevations were subsequently measured by the client's surveyors and were provided to Coffey.

A Coffey representative was present during the drilling operations to direct sampling and testing, record test results and log materials encountered.

Appendix A presents the Record of Borehole Sheets.

3.2 Laboratory Testing

Soil samples obtained during the investigation were taken to our Etobicoke laboratory. The following tests were performed on selected soil samples:

- Natural moisture content tests;
- Grain size analyses (sieve and hydrometer tests); and
- Atterberg Limits tests.

Appendix B presents laboratory test results sheets for all the tests carried out except the natural moisture content results as they are presented on the Record of Borehole Sheets in Appendix A.

4 SUBSURFACE CONDITIONS

Detailed descriptions of the materials encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A. Explanation of Terms Used in Report is presented in Appendix D.

Drawing 1 presents the borehole location plan and the generalized subsurface profile along the proposed noise barrier.

In general, below a veneer of topsoil and some fill (encountered in Borehole W1 only), the site is underlain by native soils consisting of clayey silt (interbedded with sand to silty sand and sandy silt layers) and silty sand till (encountered in Borehole W1 only). The fill encountered in Borehole W1 was found to extend 0.8 m below the ground surface. All boreholes except Borehole W1 were terminated within the clayey silt deposit (interbedded with sand to silty sand and sandy silt) at Elevations 93.5 to 87.3 m, indicating that this deposit has a thickness of 10.5 m in Borehole W1 and greater than 6.6 to 12.7 m in the remaining boreholes. The silty sand till was encountered at 11.3 m below the ground surface or at Elevation 82.8 m in Borehole W1. Borehole W1 was terminated within the till deposit at 12.7 m below the ground surface or at Elevation 81.4 m.

The Record of Borehole Sheets and the profile provided indicate the subsurface conditions only at the borehole locations. Note that the material boundaries indicated on the logs are approximate and based on visual observations. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions may vary across this Site.

The following summarizes the surface conditions encountered in the boreholes.

4.1 Topsoil

Topsoil, about 0.10 to 0.18 m thick, was encountered at the ground surface.

Note that in our experience, the thickness of organic rich soils frequently varies in between and beyond borehole locations.

4.2 Fill

Fill was encountered in Borehole W1 only. It was contacted below the topsoil and extended to 0.8 m below the ground surface or to Elevation 93.3 m. The fill was described as silty sand to sandy silt with traces of gravel and some clay.

Standard Penetration Test yielded an SPT N-value of 6 blows/0.3 m within the fill layer, indicating a loose condition.

4.3 Clayey Silt Interbedded with Sand to Silty Sand and Sandy Silt

Below the topsoil and fill (Borehole W1 only), in all the five boreholes, a clayey silt to silty clay deposit, interbedded with sand to silty sand and sandy silt layers, was encountered. This deposit was found to have a thickness of 10.5 m in Borehole W1 and greater than 6.6 to 12.7 m in the remaining boreholes (i.e. Boreholes W2 to W5 were terminated within this deposit at Elevations 93.5 to 87.3 m). There are two distinct zones of sand to silty sand and sandy silt within this clayey silt deposit, one located on top of this deposit and the second one at about 2.6 to 5.9 m below the ground surface or at Elevations 95.6 to 88.2 m. These layers have thicknesses ranging from 0.8 to 1.9 m.

The clayey silt is a cohesive (i.e. non-granular) material while the sand to silty sand and sandy silt layers are non-cohesive (i.e. granular) in nature.

The following are the grain size distributions of the selected five samples taken from the clayey silt, as presented in Figure B1, in Appendix B.

Gravel:	0 %
Sand:	1 – 14 %
Silt:	63 – 78 %
Clay:	11 – 35 %

Atterberg Limits tests conducted on two samples retrieved from this deposit indicated the following results (also shown in Figure B2, in Appendix B).

Liquid Limit:	22 – 27 %
Plastic Limit:	14 – 17 %
Plasticity Index:	8 – 10 %

The Atterberg Limits test results indicate a clayey soil of low plasticity (i.e. a CL material).

Grain size analyses carried out on a sample retrieved from the sand to silty sand and sandy silt zones indicated the following grain size distribution, as also presented in Figure B3, in Appendix B.

Gravel:	15 %
Sand:	78 %
Silt and Clay:	7 %

Standard Penetration Tests yielded SPT N-values of 7 to 30 blows/0.3 m within the clayey silt component of this deposit and SPT N-values of 7 to 29 blows/0.3 m within the sand to silty sand and sandy silt layers. Field vane testing in the clayey silt recorded undrained in-situ shear strength values of 50 to 90 kPa. Based on these test results, this deposit is considered to have a stiff to very stiff consistency and the granular layers are considered to be in a loose to compact condition. The loose condition recorded for the granular layers was generally encountered on the layer near the surface (i.e. granular layer on top of the clayey silt).

4.4 Silty Sand Till

In Borehole W1, a glacial till deposit was encountered at 11.3 m below the ground surface or at Elevation 82.8 m. This till deposit was described as a heterogeneous mixture of silty sand with traces of gravel and clay. Borehole W1 was terminated within this deposit at 12.7 m depth or Elevation 81.4 m.

This is a basically granular (i.e. non-cohesive) soil type. This deposit appeared to be wet and water bearing.

Due to their mode of deposition, cobbles and boulders should always be anticipated within the till deposit.

Standard Penetration Tests yielded an SPT N-value of 40 blows/0.3 m within the till deposit indicating dense condition.

4.5 Groundwater Conditions

Groundwater levels were observed in the open boreholes while drilling and upon completion of each borehole. The groundwater levels observed during the investigation are presented on the Record of Borehole Sheets in Appendix A and are summarized in the following table.

Table 2: Groundwater Level Observations

Borehole No.	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
W1	Jul 16 2010	1.5 / 92.6*	measured upon borehole completion
W2	Jul 19 2010	5.0 / 95.1*	measured upon borehole completion
W3	Jul 19 2010	3.4 / 94.8*	measured upon borehole completion
W4	Jul 19 2010	2.7 / 95.5*	measured upon borehole completion
W5	Jul 20 2010	4.0 / 96.0*	measured upon borehole completion

Note: * Groundwater level measured not stabilized.

These short term groundwater observations may not represent the stabilized groundwater conditions at the site.

Based on the moisture condition of the soil samples and our observations, the site groundwater level at the time of our investigations was at about Elevation 96 to 95 m, dipping down to Elevation 93 m towards the western end towards the Cobourg Creek.

It should be noted that groundwater levels are subject to variations due to the influence of rainfall, temperature, local drainage, seasons and other factors. There is also a potential for development of perched groundwater tables in the relatively more pervious granular layers underlain by the practically impervious clayey silt to silty clay material.

For and on behalf of Coffey Geotechnics Inc.


Delfa Sarabia, M.Eng.

Senior Geotechnical Engineer


Ramon Miranda, P.Eng.

Principal




Zuhtu Ozden, P.Eng.

Senior Principal

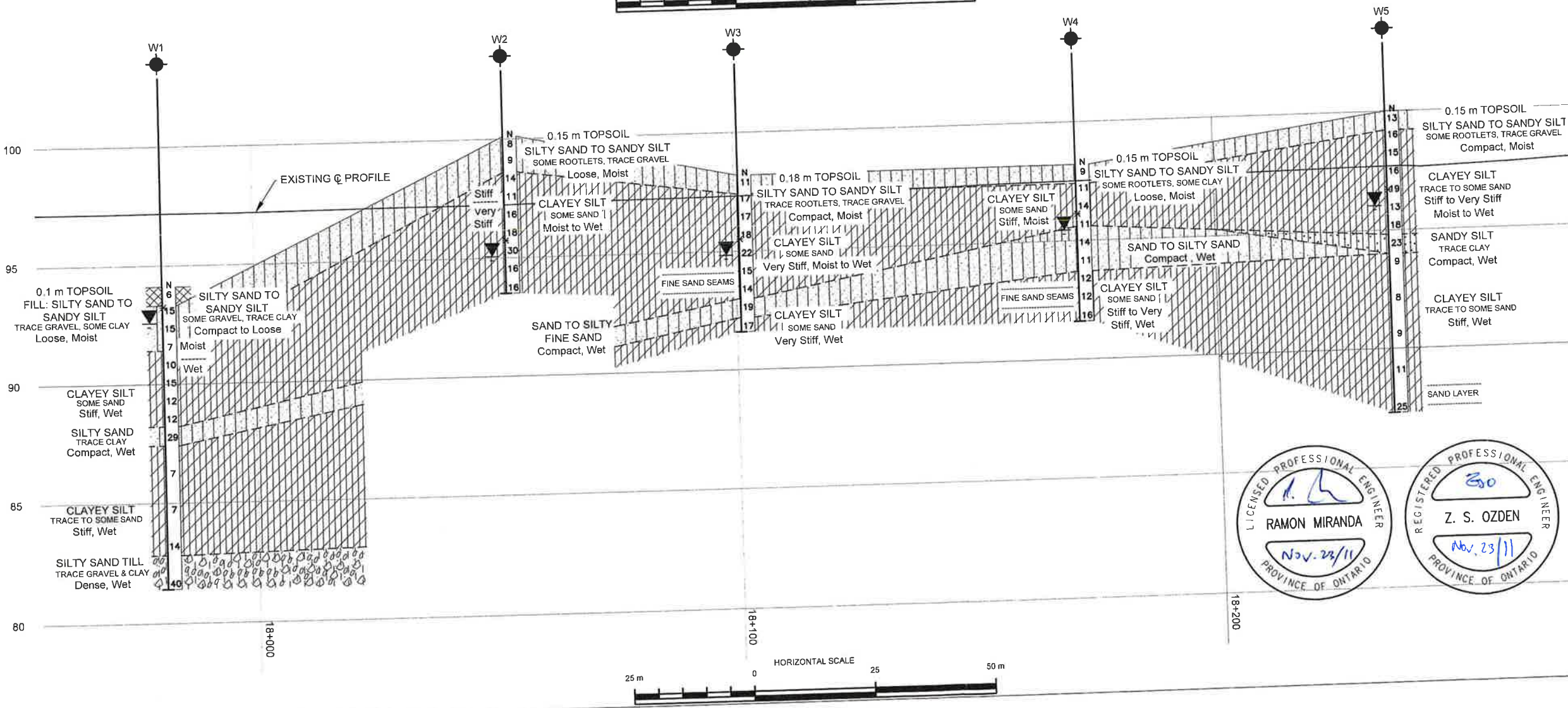
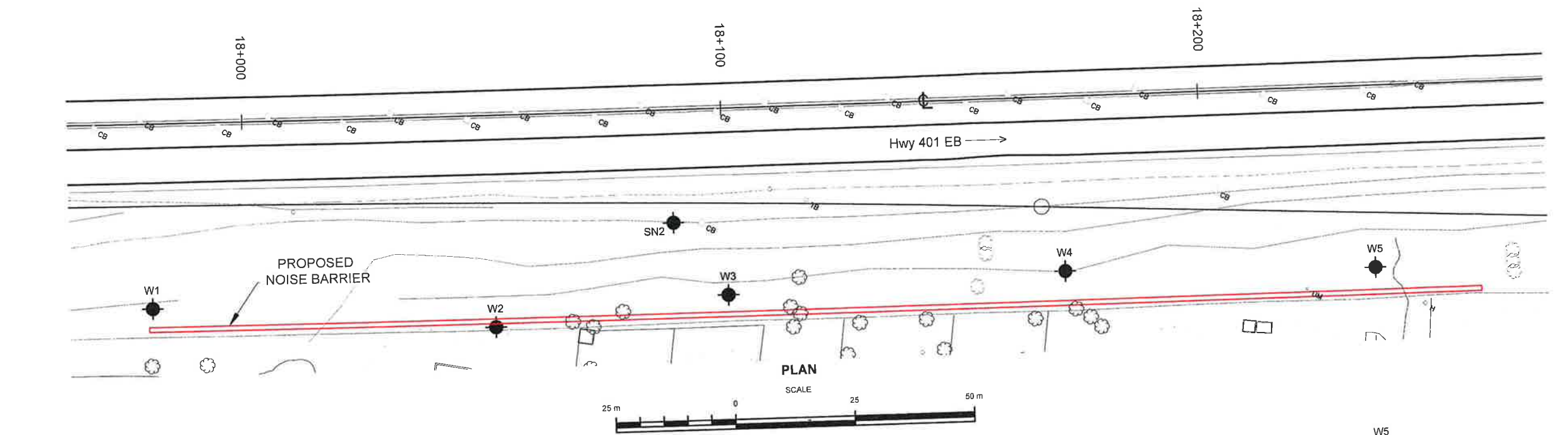


Drawing

NOTES:
FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

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

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



LEGEND

Borehole

Borehole & Cone

N

Blows/0.3m (Std. Pen. Test, 475 J/blow)

Water Level at Time of Investigation
(W. L. NOT STABILIZED)

Water Level in Piezometer

Piezometer

No.	ELEVATION	EASTING	NORTHING
W1	94.1	410722.3	4872364.7
W2	100.1	410789.0	4872390.4
W3	98.2	410830.5	4872416.2
W4	98.2	410893.0	4872449.1
W5	100.0	410952.0	4872475.7

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS			DATE	BY	DESCRIPTION

Geocres No. 30M16-47					DIST
TRANET0B10434AA					SITE
SUBMD	CHECKED	DATE	Nov 23, 2011	APPROVED	DWG
DRAWN	SH	CHECKED	RM	20	1

RAMON MIRANDA
Nov. 23/11
PROVINCE OF ONTARIO

Z. S. OZDEN
Nov. 23/11
PROVINCE OF ONTARIO

Appendix A

Record of Borehole Sheets

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No W1

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 17+981, 39 m Rt of C/L (E 410722.3, N 4872364.7) ORIGINATED BY RK
DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
DATUM Geodetic DATE 7/16/2010 7/19/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
94.1	GROUND SURFACE						94					
0.0	0.1 m TOPSOIL		1	SS	6							
93.3	FILL: Silty Sand to Sandy Silt											
0.8	tr. gravel, some clay		2	SS	15		93					15 78 (7)
	SILTY SAND TO SANDY SILT											spoon wet below
	some gravel, tr. clay		3	SS	15							1.5 m
	grey, compact to loose						92					
			4	SS	7							
91.4							91					
2.7			5	SS	10							0 14 75 11
	CLAYEY SILT											
	some sand		6	SS	15		90					
	grey, stiff, wet											
			7	SS	12							
			8	SS	12		89					
88.2												
5.9	SILTY SAND		9	SS	29		88					
	trace clay											
87.4	grey, compact, wet						87					
6.7												
	CLAYEY SILT		10	SS	7		86					
	trace to some sand											
	grey, stiff, wet						85					
			11	SS	7							
							84					
			12	SS	14		83					
82.8												
11.3							82					
	SILTY SAND TILL		13	SS	40							
	trace gravel and clay											
	grey, dense, wet											
81.4												
12.7	End of Borehole.											
	Water level @ 1.5 m (not stabilized)* upon											
	completion.											
	Borehole caved-in @ 8.2 m upon completion.											

TRANETOB10434AA: Highway 401

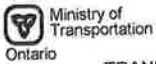
RECORD OF BOREHOLE No W2

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+052, 45 m Rt of C/L (E 410789.0, N 4872390.4) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/19/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. X LAB VANE	WATER CONTENT (%)					
100.1 0.0	GROUND SURFACE													
	0.15 m TOPSOIL		1	SS	8									
	SILTY SAND TO SANDY SILT some rootlets, tr. gravel dk. brown, loose, moist		2	SS	9									
98.6 1.5			3	SS	14									
	CLAYEY SILT some sand moist to wet		4	SS	11									
		stiff	5	SS	16									
		v. stiff	6	SS	18									
			7	SS	30									
			8	SS	16									
		brown												
		grey	9	SS	16									
93.5 6.6	End of Borehole. Water level @ 5.0 m (not stabilized)* upon completion. Borehole caved-in @ 5.5 m upon completion.													



TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No W3

1 OF 1

METRIC

GWP G W P 205-00-01 LOCATION Station 18+101, 39 m Rt of C/L (E 410830.5, N 4872416.2) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/19/2010 CHECKED BY ZO

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			20 40 60 80 100	20 40 60 80 100					
98.2	GROUND SURFACE					98							
0.0	0.18 m TOPSOIL SILTY SAND TO SANDY SILT tr. rootlets, tr. gravel dk. brown, compact, moist		1	SS	11								
97.4													
0.8	CLAYEY SILT some sand v. stiff, moist to wet		2	SS	17	97							0 1 78 21
			3	SS	17								
			4	SS	18	96							
	fine sand seams		5	SS	22	95							spoon wet below 3.1 m
			6	SS	15	94							
	brown		7	SS	14	93							0 2 63 35
	grey, stiff		8	SS	19	92							
93.0	SAND TO SILTY FINE SAND grey, compact, wet												
5.2													
92.2	CLAYEY SILT some sand, grey, v. stiff, wet		9	SS	17								
6.0													
91.6	End of Borehole. Water level @ 3.4 m (not stabilized)* upon completion. Borehole caved-in @ 4.3 m upon completion.												
6.6													

TRANETO10434AA: Highway 401

RECORD OF BOREHOLE No W4

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+171, 37 m Rt of C/L (E 410893.0, N 4872449.1) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/19/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L		
98.2	GROUND SURFACE						98							
0.0	0.15 m TOPSOIL SILTY SAND TO SANDY SILT some rootlets, some clay dk. brown, loose, moist		1	SS	9		98							
97.4														
0.8	CLAYEY SILT some sand brown, stiff, moist		2	SS	11		97							
			3	SS	14									
95.6			4	SS	11		96							
2.5	SAND TO SILTY SAND grey, compact, wet		5	SS	14		95							
			6	SS	11		94							
93.7			7	SS	12		93							
4.5	CLAYEY SILT some sand grey, stiff to v. stiff, wet		8	SS	12		92							
			9	SS	16									
91.6	End of Borehole. Water level @ 2.7 m (not stabilized)* upon completion. Borehole caved-in @ 4.3 m upon completion.													
6.8														

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No W5

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+236, 38 m Rt. of C/L (E 410952.0, N 4872475.7) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/20/2010 CHECKED BY ZO

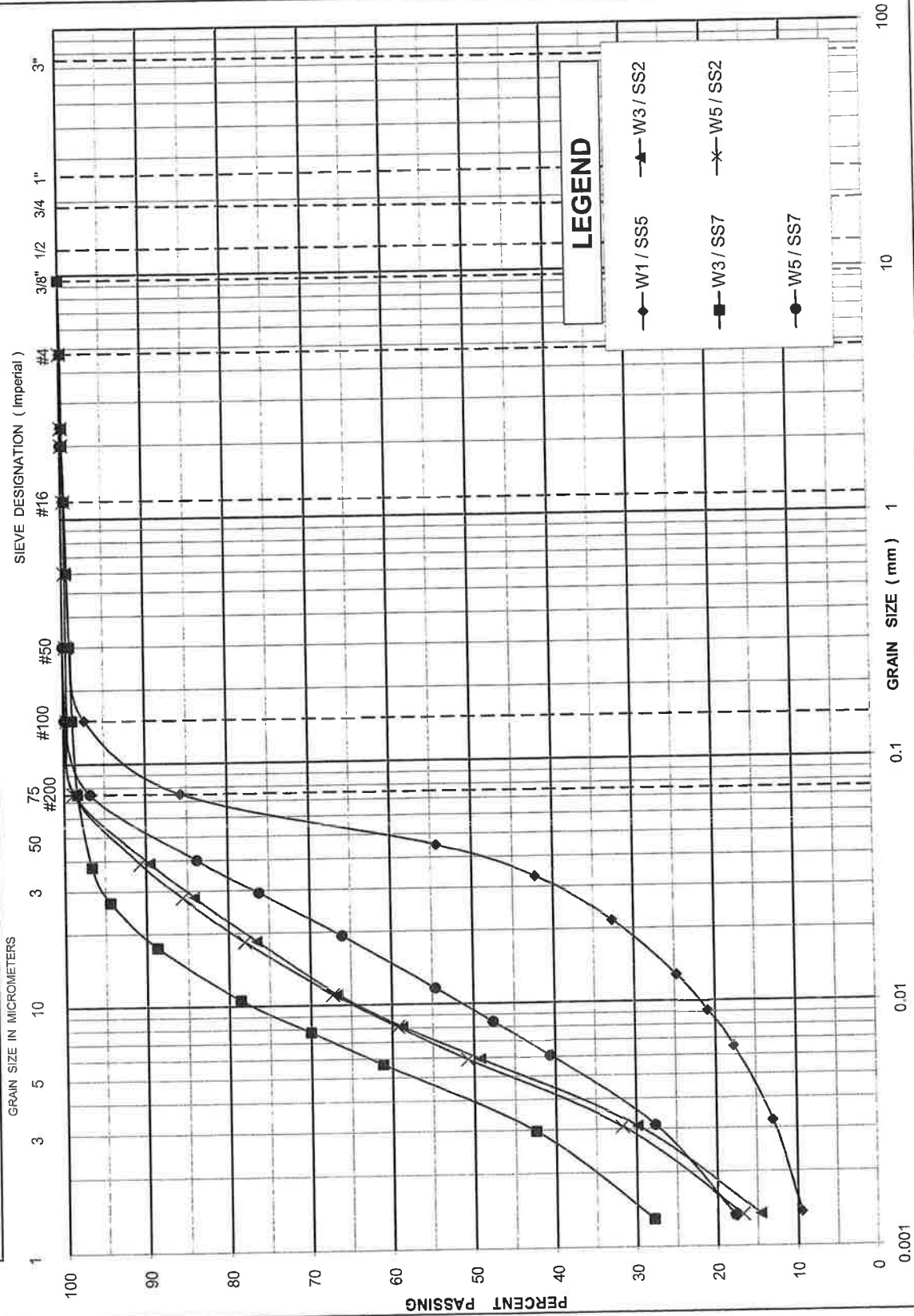
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
100.0	GROUND SURFACE						100						
0.0	0.15 m TOPSOIL SANDY SILT TO SILTY SAND some rootlets, tr. gravel dk. brown, compact, moist		1	SS	13								
99.2							99						0 1 76 23
0.8	CLAYEY SILT tr. to some sand brown, stiff to v. stiff moist to wet		2	SS	16								
			3	SS	15		98						
			4	SS	16								spoon wet below 2.3 m
			5	SS	19		97						
			6	SS	13		96						
			7	SS	18		95						0 3 75 22
94.8	SANDY SILT tr. clay grey, compact, wet		8	SS	23		94						
5.2			9	SS	9		93	2.4					
94.0	CLAYEY SILT trace to some sand grey, stiff, wet		10	SS	8		92						
6.0			11	SS	9		91						
			12	SS	11		90	2.5					
			13	SS	25		89						
87.3	0.12 m thick sand layer						88						
12.7	End of Borehole. Water level @ 4.0 m (not stabilized)* upon completion. Borehole caved-in @ 6.1 m upon completion.												

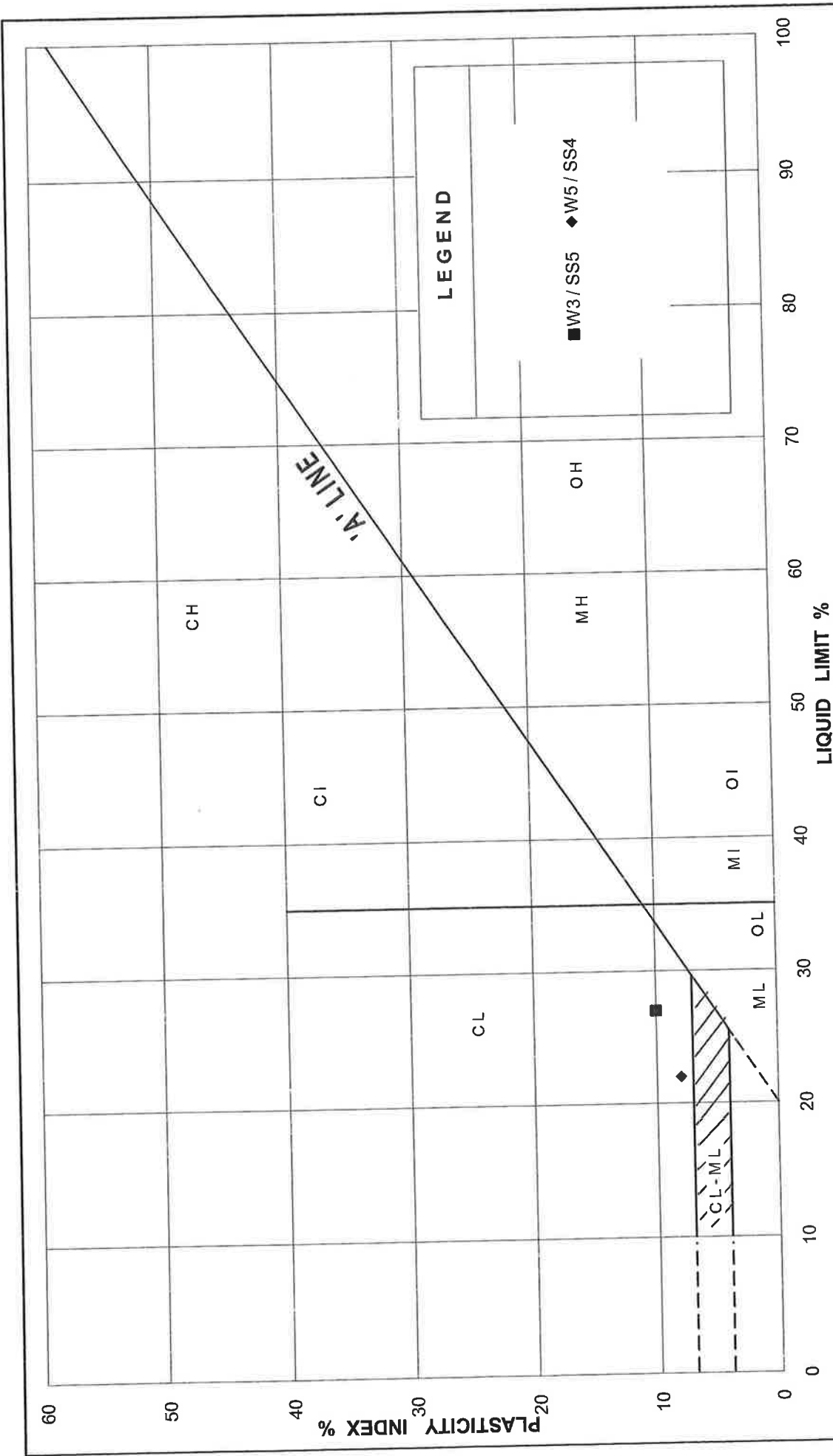
Appendix B


Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

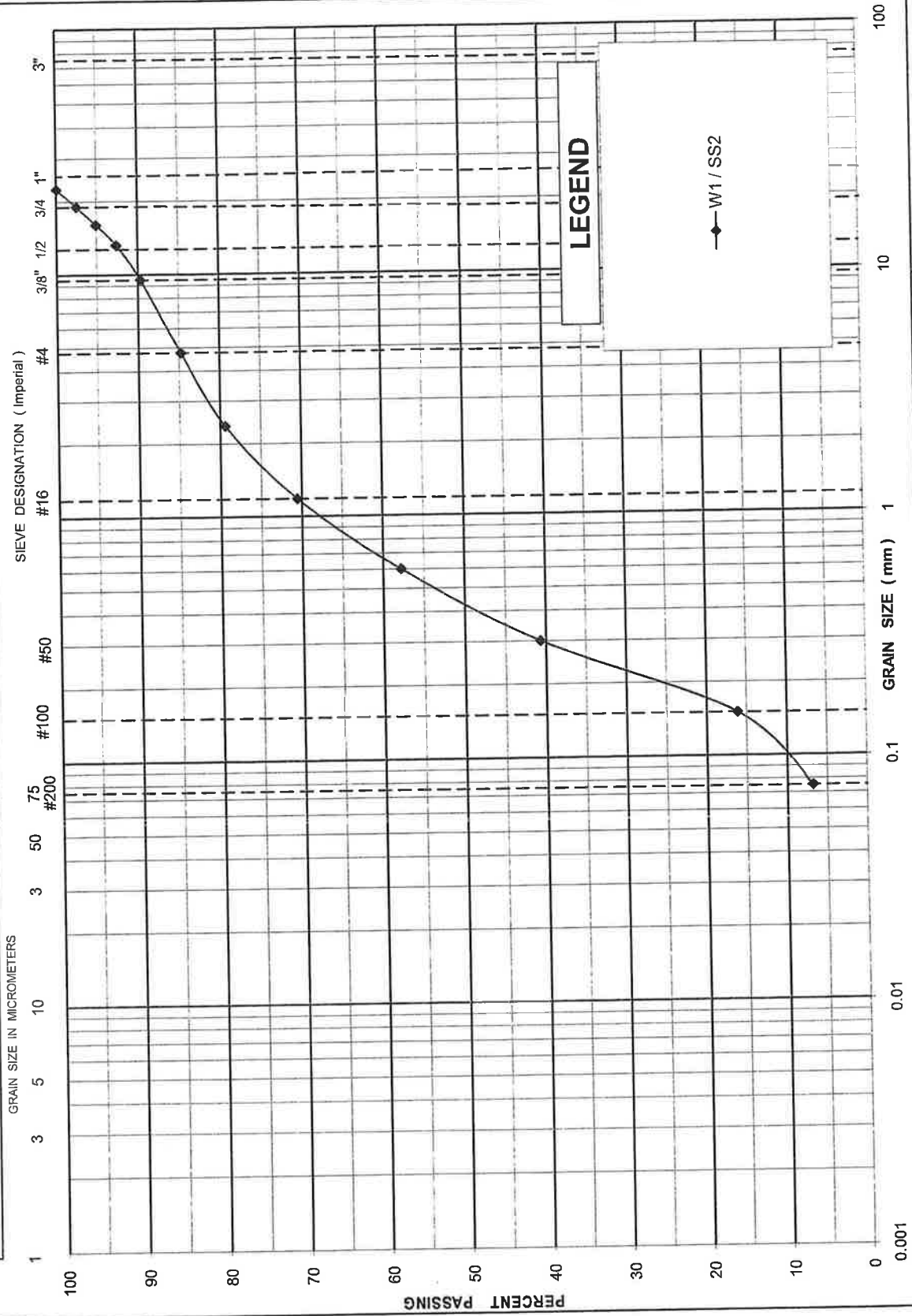




	PLASTICITY CHART CLAYEY SILT		FIGURE No. B2
			REF. No. TRANETOB10434AA
			DATE JAN. 10, 2011

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	



Appendix C

Site Photographs



Photograph 1. Station 18+050 EB (looking east)



Photograph 2. Station 18+050 EB near the south fence line (looking east)



Photograph 3. Station 18+100 EB near the south fence line (looking east)



Photograph 4. Station 18+200 EB near the south fence line (looking east)

Appendix D

Explanation of Terms Used in Report

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa		PORE WATER PRESSURE
r_u	1		PORE PRESSURE RATIO
σ	kPa		TOTAL NORMAL STRESS
σ'	kPa		EFFECTIVE NORMAL STRESS
τ	kPa		SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa		PRINCIPAL STRESSES
ϵ	%		LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%		PRINCIPAL STRAINS
E	kPa		MODULUS OF LINEAR DEFORMATION
G	kPa		MODULUS OF SHEAR DEFORMATION
μ	1		COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}		COEFFICIENT OF VOLUME CHANGE
c_c	1		COMPRESSION INDEX
c_s	1		SWELLING INDEX
c_α	1		RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s		COEFFICIENT OF CONSOLIDATION
H	m		DRAINAGE PATH
T_v	1		TIME FACTOR
U	%		DEGREE OF CONSOLIDATION
σ'_{vo}	kPa		EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa		PRECONSOLIDATION PRESSURE
t_f	kPa		SHEAR STRENGTH
c'	kPa		EFFECTIVE COHESION INTERCEPT
ϕ'	°		EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa		APPARENT COHESION INTERCEPT
ϕ_u	°		APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa		RESIDUAL SHEAR STRENGTH
s_t	kPa		REMOULDED SHEAR STRENGTH
S_1	1		SENSITIVITY = c_u / τ_c

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
P_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	W_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	W_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	W_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(W_L - W_p)$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(W_L - W) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

**FOUNDATION DESIGN REPORT
NOISE BARRIER WEST OF COUNTY RD 45
INTERCHANGE, HIGHWAY 401
COBOURG, ONTARIO
W.P. NO. 205-00-01, GEOCRETS 30M16- 47**

AECOM

TRANETOB10434AA-AI
November 23, 2011

CONTENTS

5	DISCUSSIONS AND RECOMMENDATIONS	8
5.1	General	8
5.2	Design Considerations	9
5.3	Construction Considerations	11
6	CLOSURE	13

Tables

Table 3: Recommended Design Parameters

Appendices

Appendix E: NSSP

Appendix F: Limitations of Report

**FOUNDATION DESIGN REPORT
NOISE BARRIER – WEST OF COUNTY ROAD 45 INTERCHANGE
HIGHWAY 401, COBOURG, ONTARIO
W.P. 205-00-01**

5 DISCUSSIONS AND RECOMMENDATIONS

5.1 General

As part of the Highway 401 Expansion (6-Laning) from Burnham Street to approximately 2.0 km east of Nagle Road, within the Town of Cobourg and Township of Hamilton, Ontario, noise barriers will be constructed for the project. There are two noise barrier locations proposed for the project and they are reported separately.

This report presents the proposed noise barrier to be located between Stations 17+980 and 18+260, south of Highway 401, west of County Road 45 Interchange in Cobourg, Ontario. The proposed noise barrier at this location will be 5 m high and approximately 300 m long and the alignment is parallel to the south fence of the highway. Drawing 1 presents the location of the proposed noise barrier.

The five boreholes drilled at the site indicate that the site is generally underlain by topsoil, fill (at one borehole location only) and native soils consisting of clayey silt (interbedded with sand to silty sand and sandy silt layers) and silty sand till. The fill, encountered near the western end of the site only, was found to extend 0.8 m below the ground surface or to Elevation 93.3 m and was described as loose silty sand to sandy silt fill. Below the topsoil and fill, a clayey silt to silty clay deposit, interbedded with sand to silty sand and sandy silt layers, was encountered with thicknesses ranging from 10.5 m in Borehole W1 to greater than 6.6 to 12.7 m in the remaining boreholes. A silty sand till deposit was encountered Borehole W1, underlying the clayey silt to silty clay deposit. Boreholes W2 to W5 were terminated within the clayey silt deposit at Elevations 93.5 to 87.3 m (i.e. before possibly encountering the till deposit). The sand to silty sand and sandy silt interbeds, 0.8 to 1.9 m thick, are generally located on top of this deposit as well as further below at about 2.6 to 5.9 m below the ground surface or at Elevations 95.6 to 88.2 m. The surface of underlying dense silty sand till (penetrated in the western end only) was encountered at 11.3 m below the ground surface or at Elevation 82.8 m.

Based on the change of colour of the soil, it is our opinion that the site groundwater level at the time of our investigation was at about Elevation 96 to 95 m, dipping down to Elevation 93 m towards the western end in the direction of Cobourg Creek. It is however believed that a perched water table exists in the basically granular sand to silty sand and sandy silt layers and interbeds. The groundwater level but would be subject to seasonal variations and variations in response to major weather events, as well as variations in the level of water in the adjacent watercourse, Cobourg Creek.

Design and construction of the foundations for the noise barrier wall shall be conducted in accordance with SP 599F01

5.2 Design Considerations

The noise barrier will typically extend about 5 m above the ground surface. It is likely that the noise barrier will be supported on augered caissons (i.e. drilled and poured-in-place concrete foundations). Typical caisson diameters range from 0.6 m to 0.9 m. As per MTO practice, the design is generally carried out in accordance with the method described by Broms, as detailed in the following papers.

- BROMS, B.B.: Lateral Resistance of Piles in Cohesive Soils, Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 90, No. SM2, Paper No. 3825, 1964.
- BROMS, B.B.: Lateral Resistance of Piles in Cohesionless Soils, Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 90, No. SM3, Paper No. 3909, 1964.
- BROMS, B.B.: Design of Laterally Loaded Piles, Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 91, No. SM3, 1965.

The resistance to lateral loading in front of a vertical caisson can be estimated using subgrade reaction theory where the coefficient of horizontal subgrade reaction (k_s in kN/m^3) is determined based on the equations given below (CHBDC S6-06 C6.8.7.1):

In cohesionless soils, the coefficient of horizontal subgrade reaction can be estimated from:

$$k_s = n_h z / d$$

Where k_s = coefficient of horizontal subgrade reaction

n_h = coefficient related to soil density as given in Table 3

z = depth

d = pile width.

Where the soil is primarily cohesive, the coefficient of horizontal subgrade reaction can be estimated from:

$$k_s = 67c_u / d$$

Where k_s = coefficient of horizontal subgrade reaction

c_u = undrained shear strength as given in Table 3

d = pile width.

The recommended soil parameters for the design of augered caisson foundation at each borehole location are given in the following table.

Table 3: Recommended Design Parameters

Station / Borehole Number	Elevation (m)		Type of Soil	Consistency or Compactness Condition	Undrained Shear Strength, c_u (kPa)	Internal Friction Angle, ϕ (degrees)	Bulk Unit Weight, γ (kN/m ³)	Horizontal Subgrade Reaction Coefficient, n_h (kN/m ³)	Water Level depth / Elevation (m)
	From	To							
17+981 / W1	94.0	93.3	Fill	loose	-	28	17	2,200	1.5 / 92.6 ♦
	93.3	92.0	cohesionless	compact	-	30	19	4,400	
	92.0	91.4	cohesionless	loose	-	28	17	1,300	
	91.4	88.2	cohesive	stiff	75	-	18	-	
	88.2	87.4	cohesionless	compact	-	32	19	4,400	
	87.4	82.8	cohesive	stiff	60	-	18	-	
	82.8	81.4	cohesionless	dense	-	35	21.2	11,000	
18+052 / W2	100.0	98.6	cohesionless	loose	-	28	17	2,200	5.0 / 95.1 ♦
	98.6	97.0	cohesive	stiff	100	-	18.5	-	
	97.0	93.5	cohesive	v. stiff	120	-	18.5	-	
18+101 / W3	98.0	97.4	cohesionless	compact	-	30	19	6,600	3.4 / 94.8 ♦
	97.4	93.0	cohesive	v. stiff	120	-	18.5	-	
	93.0	92.2	cohesionless	compact	-	32	19	4,400	
	92.2	91.6	cohesive	v. stiff	120	-	18.5	-	
18+171 / W4	98.0	97.4	cohesionless	loose	-	28	17	2,200	2.3 / 95.9 ♦
	97.4	95.6	cohesive	stiff	100	-	18.5	-	
	95.6	93.7	cohesionless	compact	-	30	19	4,400	
	93.7	91.6	cohesive	stiff to v. stiff	120	-	18.5	-	
18+236 / W5	99.8	99.2	cohesionless	compact	-	30	19	6,600	4.0 / 96.0 ♦
	99.2	94.8	cohesive	stiff to v. stiff	100	-	18.5	-	
	94.8	94.0	cohesionless	compact	-	32	19	4,400	
	94.0	87.3	cohesive	stiff	70	-	18	-	

Notes:

♦ = estimated

The contribution to lateral resistance of the soil within the frost depth (i.e. 1.5 m below the final grade) should not be included in the calculations, except of course, for the weight of the soil. Research shows, however, that restraint provided at the ground surface level plays a significant role in the performance of

laterally loaded structures and, therefore, the placement of well compacted, competent material at and near the ground surface immediately around the augered caisson is recommended.

While the geotechnical design of noise barrier wall foundation is governed by the horizontal (lateral) resistance, the following comments are included for axial resistances for the sake of completeness. The following approximate axial resistances would be available for a 0.6 m diameter caisson (pile) extending to a depth of at least 5.0 m below the ground surface:

Factored Resistance at ULS = 250 kN/pile

Bearing Resistance at SLS = 170 kN/pile*

**SLS for 25 mm total settlement*

These values can be increased to 375 kN/pile and 250 kN/pile, respectively for a 0.9 m diameter caisson, again assuming that the caisson extends at least 5.0 m below the ground surface. When recommending these values it is assumed that the bearing subgrade will not be unduly disturbed. As well, these values depend, among other factors, on the method of installation and as such they should be further discussed with us.

5.3 Construction Considerations

The construction of the proposed noise barrier should be carried out in accordance with SP 599F01.

Based on the borehole information, the installation of caissons is anticipated to be generally within the clayey silt deposit interbedded with silty sand to sandy silt and possibly till, depending on the depth of caissons. Groundwater is also anticipated to be encountered during the installation of the caissons.

As the bulk of the excavation will be within the clayey soils and the relatively fine grained sandy interbeds, it may be possible to construct the caissons by pouring the concrete immediately upon the completion of the excavation of the caisson hole. However, it is also possible the sandy interbeds may cause cave-ins or excessive groundwater seepage in unlined caisson holes. If this is the case, the use of temporary steel casing is required to support the granular soils below the groundwater and to reduce the risk of caving in. This will also enable the bases to be properly cleaned of any disturbed soils and to enable the inspection and approval of the base by the engineer. The casing would then be carefully withdrawn as the concrete is poured, with a sufficient head of concrete in the casing to prevent 'necking'. Alternatively, tremie concrete method can be used for concreting of caissons installed below the groundwater.

In summary, the clayey silt deposit can be expected to be self-supporting and should not yield significant amount of water in the short term, in caisson holes, even below the groundwater table. However, the concrete should be poured expeditiously on completion of the caisson hole, without undue delay. As well, when extending the caisson holes through the more pervious water bearing soils, (e.g. sand to silty sand and sandy silt layers), problems may occur during the installation of the caissons, as discussed before. Where the bottom of the caisson is within the water bearing sand to silty sand and sandy silt layers, it would be prudent to extend the caisson a little deeper into the underlying clayey silt deposit.

Water bearing layers may cause instability problems during the installation of the caissons. Where these layers are rather thin and the soil is relatively fine grained, it may be possible to effect construction by pouring the concrete rapidly upon the completion of the excavation of the caisson hole. In other cases,

however, the sand layers may cause cave-ins or excessive groundwater seepage in unlined caisson holes and will necessitate special precautions.

The use of dewatering techniques to lower the groundwater table during construction is unlikely to be economically viable due to the limited construction effort required and space limitations on Highway 401.

Within the coarse textured till and/or the sand to silty sand and sandy silt layers below the water table, the soil is susceptible to disturbance due to the unbalanced hydrostatic head and seepage and will likely become unstable, especially with increased depth of excavation below the water table. The contractor should maintain the stability of the soil at the sides and bases of the holes for the concrete footings, at all times from the commencement of excavation to the completion of the pouring of the concrete.

In view of these, we recommend that the following special provisions be included in the contract documents:

- The contractor shall install concrete foundations in earth for noise barrier wall foundations. At the various foundation locations, strata may consist of fill, clayey silt, sand to silty sand and sandy silt, and silty sand till deposits. Groundwater is likely to be encountered above the base of the excavations at most locations.
- At the various foundation locations, soil deposits may consist of basically granular (i.e. non-cohesive) soils such as sand to silty sand and sandy silt, and silty sand till. In such cases where the soil is susceptible to conditions of unbalanced hydrostatic head and seepage forces, "boiling" or a quick condition may occur and the soil may become unstable.
- The contractor shall maintain the stability of the soil along the side and at the base of the holes for the concrete caissons at all times, from the commencement of their construction to the placing of the concrete.
- Dewatering may be required to maintain a sufficiently dry condition for proper installation of the caisson hole and the placement of concrete.

Where the caissons extend to the glacial till deposit, random cobbles and boulders can be expected within the till deposit. The contractor should be made aware that the presence of cobbles and boulders can be expected which can cause problems during the installation of caissons, such as increasing the time required for drilling, the employment of special equipment, etc. An NSSP should be issued to alert the Contractor of these aspects, as well as possible dewatering requirements, as presented in Appendix E.

6 CLOSURE

The "Limitations of Report" as presented in Appendix F are integral part of the report.

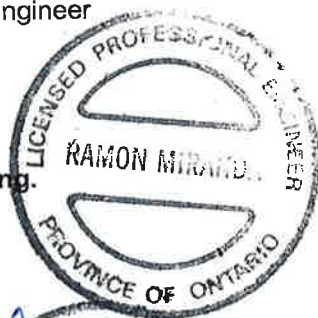
For and on behalf of Coffey Geotechnics Inc.


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Principal




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Appendix E

NSSP

CAISSON PILES

Special Provision

The requirements of OPSS 903, November 2009 shall govern this specification with the following amendments:

903.07.03 Caisson Piles

903.07.03.01 General

Subsection 903.07.03.01 is amended by the addition of the following paragraphs:

The Contractor is alerted that there is a possibility of the presence of cobbles and boulders in the till where caisson piles are to be installed. If cobbles and boulders are encountered, the Contractor shall employ the necessary measures to comply with the requirements of OPSS 903.

The Contractor is alerted that dewatering may be required to facilitate the installation of the caisson units due to the presence of granular soil layers below the groundwater table. The Contractor shall be prepared to employ adequate dewatering procedure if the flow into the hole becomes a problem. Temporary steel liner will be required during the construction of the caisson holes to prevent caving. The liner shall be withdrawn as the concrete is poured, ensuring a sufficient head of concrete in the liner to prevent 'necking'. Concrete must be poured expeditiously after the preparation and approval of the base of the caisson to prevent its disturbance due to hydrostatic uplift.

903.10 BASIS FOR PAYMENT

903.10.02 Caisson Piles - Item

Subsection 903.10.02 is amended by the addition of the following paragraphs:

If cobbles and boulders are encountered and/or dewatering is required for the installation of the caisson piles, there will be no additional cost to the Contractor.

Appendix F

Limitations of Report

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Coffey Geotechnics Inc. (Coffey) at the time of preparation. Unless otherwise agreed in writing by Coffey, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

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