

**DRAFT
FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED RETAINING WALL, BRIDGE RECONSTRUCTION
663 VICTORIA STREET
KITCHENER, ONTARIO
W.P. 1614093-001**

**Prepared For:
MMM Group
100 Commerce Valley Drive West
Thornhill, Ontario, L3T 0A1**

**SPL Project No.: 10001862- DRAFT
October 6, 2015**

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1. INTRODUCTION

SPL Consultants Limited (SPL) was retained by MMM Group to undertake a foundation investigation for the proposed retaining wall for the bridge reconstruction located at 663 Victoria Street at the interchange of Hwy 85 and Victoria Street in the Town of Kitchener, Ontario.

It is understood the Ministry of Transportation (MTO) intends to reconstruct the twin span bridge at the interchange of Victoria Street and Highway 85 in the Town of Kitchener, Ontario. We understand that the reconstruction of the bridge involves the construction of a retaining wall at the southwest corner of the interchange.

It is also understood as per the information provided to us that proposed retaining wall will be supported by caissons or driven piles. The pile cut off elevations will be 322m on the north side and 319m on the south side.

The purpose of the geotechnical investigation was to obtain subsurface information at the location of the retaining wall by means of exploratory boreholes and to assess the engineering characteristics of the subsurface soils by means of field and laboratory tests.

This report presents the findings of the foundation investigation carried out at the site and provides factual information concerning subsurface conditions, in-situ and laboratory test results carried out as part of the investigation.

This report is provided on the basis of the terms of reference presented above and on the assumption that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The foundation investigation follows generally accepted practice for geotechnical consultants in Ontario and in compliance with Canadian Highway Bridge Design Code (2004). The format and contents are guided by client specific needs and economics. Field and laboratory testing for most part follows ASTM, LS or CSA Standards or modifications of these standards that have become standard practice.

The limitations conditions presented in this report form an integral part of the report and they must be considered in conjunction with this report.

2. SITE AND REGIONAL GEOLOGY

The project site is located at southwest corner of the interchange of Hwy 85 and Victoria Street North in the Town of Kitchener.

The regional geology of the Victoria Street and Highway 85 area in Kitchener, Ontario is a result of the interaction of several glacial lobes. The area is part of the physiographic region known as the Waterloo Sand Hills or Waterloo Moraine (Chapman & Putnam, 1984). The oldest deposits (mapped in the area to the northeast and another to the west of the intersection of Victoria Street and Highway 85) is a sandy silt till to silty sand textured till. This till was reworked and overlain by ice contact stratified sand and gravel, with minor silt, clay and till that were deposited as the ice lobes receded and re-advanced. There are also glaciofluvial major river and delta deposits of sand located to the south of the Victoria Street and Highway 85 intersection, which were laid down as the glacial ice melted and retreated.

3. FIELD AND LABORATORY WORK

Three boreholes (BH15-RW1 through BH15-RW3, see **Drawing 1** for borehole locations) were drilled at the locations of the proposed retaining wall to depths varying from 26.5 to 34.1m. Borehole logs are attached in **Appendix A** of the report. The soil profiles at borehole locations are shown in **Drawing 2**.

The location and number of boreholes were decided by MMM Group. The ground surface geodetic elevations at the location of all boreholes are shown on the borehole logs which were surveyed by SPL using differential GPS, based on Benchmark No. 00819648096 located on south side of Highway 7 (Victoria St. North), 61m east of Edna Street (Elevation: 329.13m).

The field investigation work (borehole drilling) was undertaken between August 25 and 27, 2015 by At Cost Drilling Inc. under subcontract to SPL. Borehole logging services were provided by the engineering staff of SPL. The boreholes were advanced with power auger drilling machines equipped with solid and hollow stem augers. The soil stratigraphy was recorded by observing the quality and changes of augered materials which were retrieved from the boreholes, and by sampling the soils at regular intervals of depth using a 50mm O.D. split spoon sampler, in accordance with the Standard Penetration Test (ASTM D 1586) method. This sampling method recovers samples from the soil strata, and the number of blows (SPT 'N'-values) required to drive the sampler 0.3m depth into the undisturbed soil gives an indication of the compactness condition or consistency of the sampled soil material. The SPT 'N' values are indicated on the borehole log sheets (Refer to Appendix A). Soil samples were visually classified in the field and later re-evaluated in our laboratory.

Water level observations were made during drilling and in the open boreholes upon completion of the drilling operations. For the purpose of longer term groundwater monitoring, two (2) boreholes BH15-RW1 and BH15-RW3 were equipped with 50 mm diameter monitoring wells. The groundwater levels in the monitoring wells were measured on September 16, 2015 and the data are shown in the borehole logs at the end of each log sheet.

As well as visual examination in the laboratory, all soil samples were tested for moisture contents. Grain size analyses of eleven (11) selected soil samples were conducted and the results are presented on Figures

1 and 2 in **Appendix B** of this report. Atterberg Limits Tests were conducted on seven (7) soil samples and results are presented on individual log sheets.

4. SUBSURFACE CONDITIONS

The subsurface conditions at the site are discussed in the following sections. Detailed descriptions of the soil and groundwater conditions encountered at each of the borehole locations are included in the individual borehole logs in **Appendix A**. General notes on sample description and explanation of terms used in the record of borehole are also presented in Appendix A.

4.1 Pavements

All boreholes were drilled on the parking lot in MTO right of way and encountered 30 to 40mm of asphalt overlying 500 to 550mm of granular base and sub-base.

4.2 Fill

Underlying the pavement, fill material consisted of cohesionless silty sand and sand were found in the boreholes, extending to depths ranging from 1.5 to 4.6m below existing grade. The fill was found to be in a loose to dense state, with measured SPT 'N' values ranging from 4 to 21 blows/0.3m. Moisture contents in the tested samples from the fill material ranged from 5 to 13%.

4.3 Fine Sand and Silty Sand

These cohesionless sandy deposits consisting of sand and silty sand were encountered at different depths below the fill material in the boreholes. Cohesive soils are embedded within the cohesionless deposits. Boreholes BH15-1 and BH15-3 were terminated in these deposits. SPT 'N' values in these cohesionless deposits were in the range of 16 to 101 blows per 0.3m penetration, corresponding to a compact to very dense state. These cohesionless sandy deposits were also found to be saturated below the depths of 6.1 to 7.6m. Moisture contents in the tested samples from the sand to silty sand deposit ranged from 4 to 24%.

Grain size analysis of four (4) samples from fine sand (BH15-RW1/SS6, BH15-RW1/SS18, BH15-RW2/SS11 and BH15-RW3/SS29) were conducted and the gradation curves are presented in Appendix B (Figure 1), with the following fractions:

Clay: 3 to 5%
Silt: 9 to 17%
Sand: 78 to 87%
Gravel: 0 to 1%

4.4 Silt

This cohesionless silt deposit was locally encountered as an interbedded layer in BH15-RW1. SPT 'N' value of 54 blows per 0.3m penetration was recorded in this deposit corresponding to a very dense state. This deposits was found to be saturated.

4.5 Silty Clay and Clayey Silt

The cohesive deposit of silty clay and clayey silt was encountered in all boreholes at various depths or as interbedded layers in cohesionless deposits. Boreholes BH15-2 was terminated in this deposit. Saturated interbedded sand and silt seams were observed in this deposit at few locations. The consistency of this deposit was found to be generally very stiff to hard with occasional firm and stiff layers, corresponding to SPT 'N' values in the range of 7 to more than 50 blows per 0.3m penetration. Water contents in the tested samples from the silty clay deposit ranged from 11 to 35%.

Grain size analysis of seven (7) samples from silty clay (BH15-RW1/SS10, BH15-RW1/SS15, BH15-RW2/SS15, BH15-RW2/SS19, BH15-RW3/SS13, BH15-RW3/SS16 and BH15-RW3/SS20) were conducted and the gradation curves are presented in Appendix B (Figure 2), with the following fractions:

Clay: 47 to 64%
Silt: 34 to 51%
Sand: 1 to 4%
Gravel: Nil

The silty clay till and clayey silt till deposits were encountered at various depths as an interbedded layers in between silty clay and cohesionless deposits. Water contents in the tested samples from the till deposit ranged from 11 to 18 percent.

4.6 Groundwater Conditions

Two (2) monitoring wells were installed with screens set at different materials at different depths for the longer-term monitoring of groundwater levels.

The groundwater levels measured from the monitoring wells installed ranged from 7.4 to 10.4m below existing grade (Elev. 314.1 to 317.9). Over the long term, seasonal fluctuations in the groundwater level are expected.

Groundwater measurements in the monitoring wells are shown on the attached borehole logs and are also summarized on Table 4.6.

Table 4.6 - Measured Water Levels in Monitoring Wells

BH No.	Ground Surface Elev. (m)	Soil Type at Screen Location (Depth, m)	Depth / Water Level Elevation (m)
			Sept. 16/2015
BH15-RW1	324.5	Silty Clay/Silt/Sand (21.3 – 24.3)	10.4/314.1
BH15-RW2	325.3	Silty Sand (9.1 – 12.1)	7.4/317.9

SPL CONSULTANTS LIMITED

Naeem Ehsan, M.Eng., P.Eng.

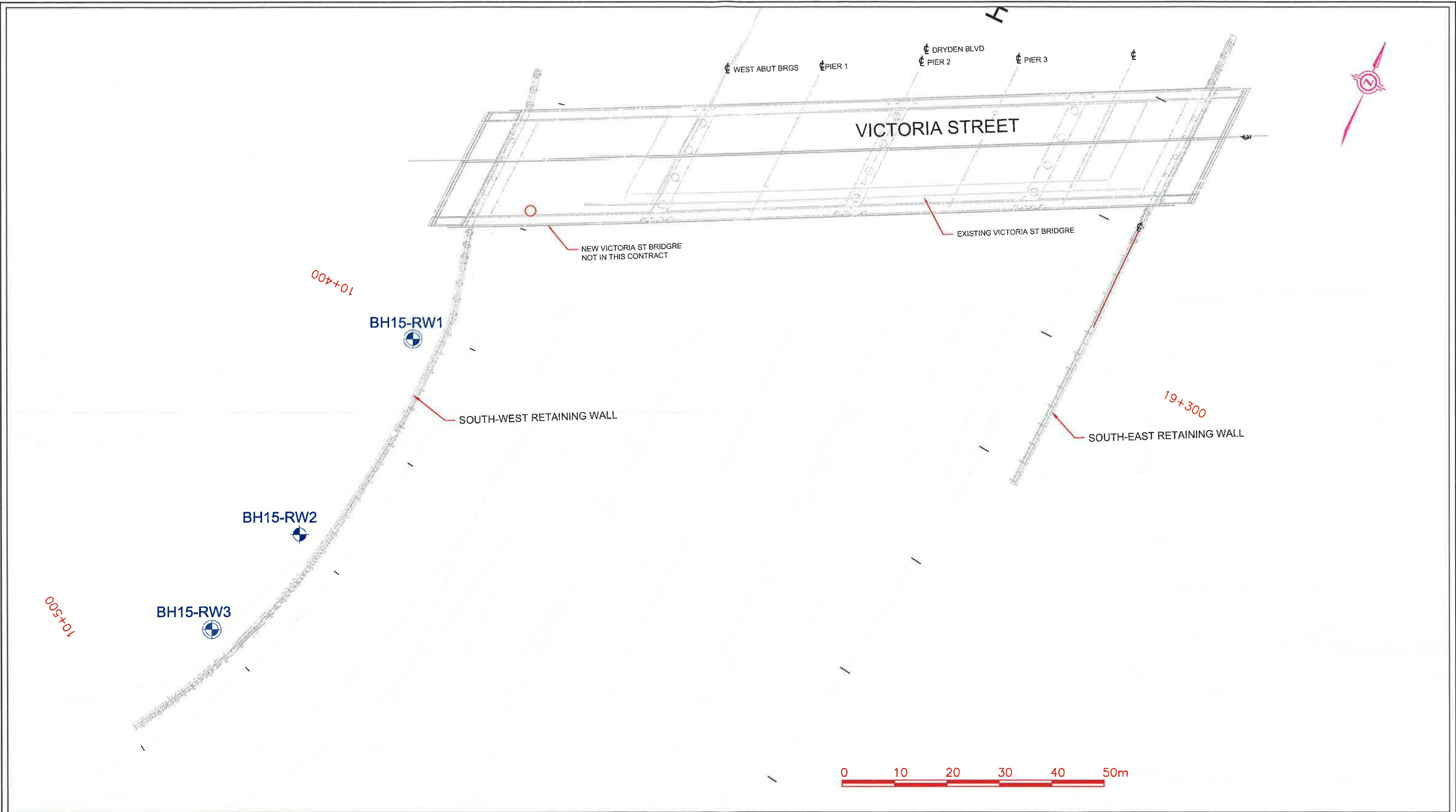
Laifa Cao, Ph.D., P.Eng.

Drawings

Borehole Location Plan (Drawing No.1)

Geological Section (Drawing No.2)

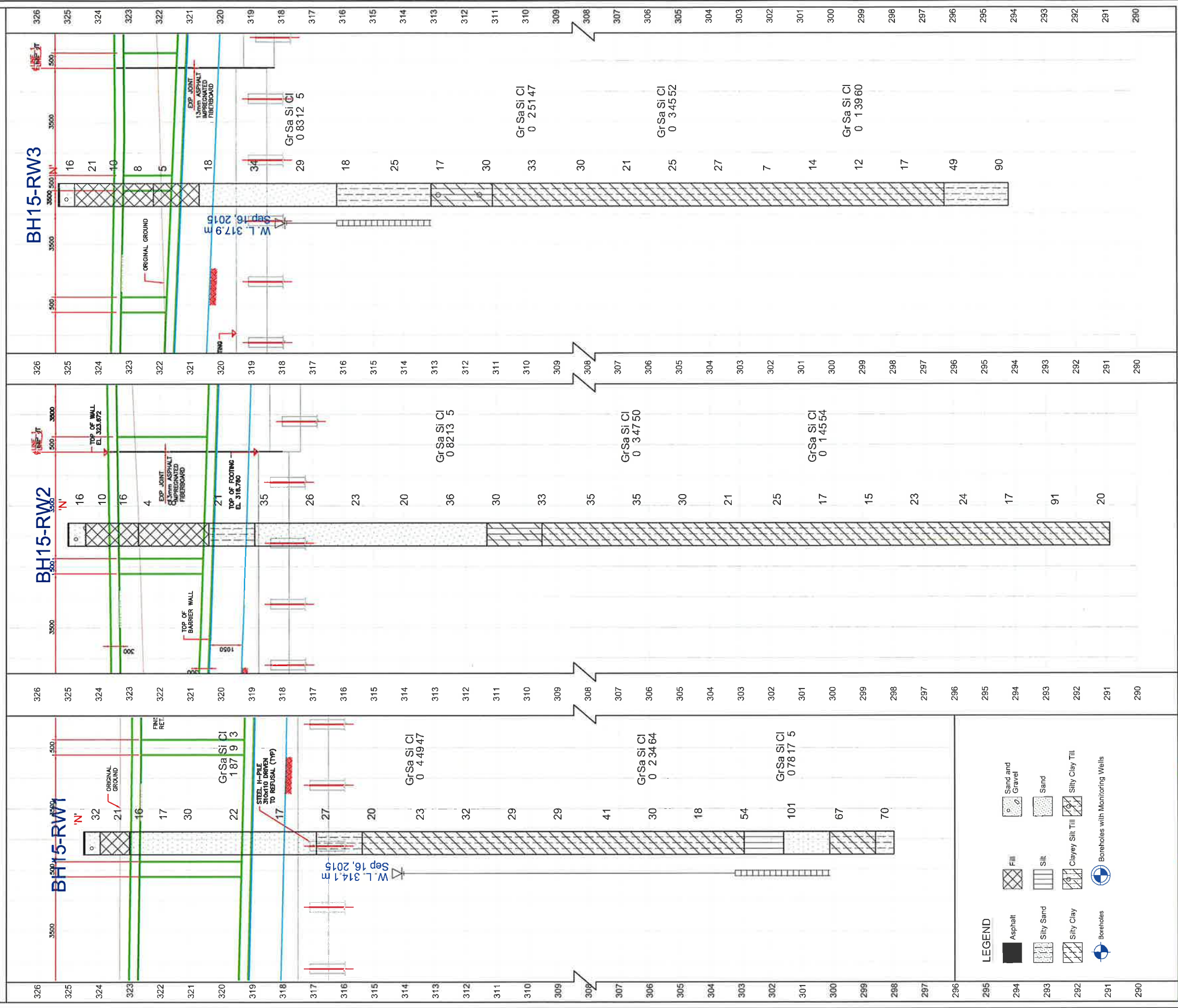
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LEGEND

- Borehole Location
- Borehole with Monitoring Well Location

Client: MMM GROUP		Project No.: 10001862	Drawing No.: 1
Drawn: ZMO	Approved: LC	Title: Borehole Location Plan	
Date: Sept 22, 2015	Scale: As Shown	Project: Geotechnical Investigation - Proposed Retaining Wall 663 Victoria Street, Kitchener, ON	
Original Size: Tabloid	Rev: N/A	 SPL Consultants Limited Geotechnical • Environmental • Materials • Hydrogeology	



Appendix A

Explanation of Terms Used in the Record of Boreholes Borehole Logs (BH15-RW1 to BH15-RW3)

Explanation of Terms Used in the Record of Boreholes

Sample Type

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Dimension type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Spoon sample
SH	Shelby tube Sample
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

Penetration Resistance

Standard Penetration Resistance (SPT), N:

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

WH – Samples sinks under “weight of hammer”

Dynamic Cone Penetration Resistance, N_d :

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

Textural Classification of Soils

Classification	Particle Size
Boulders	> 200 mm
Cobbles	75 mm - 200 mm
Gravel	4.75 mm - 75 mm
Sand	0.075 mm – 4.75 mm
Silt	0.002 mm-0.075 mm
Clay	<0.002 mm

Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion
Trace	0-10%
Some	10-20%
Adjective (e.g. silty or sandy)	20-35%
And (e.g. sand and gravel)	> 35%

Soil Description

a) Cohesive Soils(*)

Consistency	Undrained Shear Strength (kPa)	SPT “N” Value
Very soft	<12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very stiff	100-200	15-30
Hard	>200	>30

(*) Hierarchy of Shear Strength prediction

1. Lab triaxial test
2. Field vane shear test
3. Lab. vane shear test
4. SPT “N” value
5. Pocket penetrometer

b) Cohesionless Soils

Density Index (Relative Density)	SPT “N” Value
Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Soil Tests

w	Water content
w _p	Plastic limit
w _l	Liquid limit
C	Consolidation (oedometer) test
CID	Consolidated isotropically drained triaxial test
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement
D _R	Relative density (specific gravity, G _s)
DS	Direct shear test
ENV	Environmental/ chemical analysis
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified proctor compaction test
SPC	Standard proctor compaction test
OC	Organic content test
U	Unconsolidated Undrained Triaxial Test
V	Field vane (LV-laboratory vane test)
γ	Unit weight

RECORD OF BOREHOLE No BH15-RW1

METRIC 1 OF 3

W.P.	1614093-001	LOCATION	See Drawing 1, E 542714, N 4812192	ORIGINATED BY	JZ
DIST	HWY 85 Kitchener	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	MB
DATUM	Geodetic	DATE	Aug/25/2015	CHECKED BY	NE

[illegible]

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015.GPJ ON MOT.GDT 10/6/15

Continued Next Page





 $+ 3 \times 3$

Numbers refer to
Sensitivity

○ $\epsilon=3\%$ Strain at Failure

10001862

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

RECORD OF BOREHOLE No BH15-RW1

METRIC 2 OF 3

W.P. 1614093-001 LOCATION See Drawing 1, E 542714, N 4812192 ORIGINATED BY JZ
DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug/25/2015 CHECKED BY NE

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	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40						
	SILTY CLAY: trace sand, occasional gravel, contains sand seams/pockets, grey, moist, very stiff to hard (continued)														
11			10	SS	23		313								0 4 49 47
12			11	SS	32		312								
13							311								
14			12	SS	29		310								
15							309								
16			13	SS	29		308								
17			14	SS	41		307								
18							306								0 2 34 64
19			15	SS	30		305								

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015 GPJ ON MOT GDT 10/6/15



Continued Next Page

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

+ 3, x 3. Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001862





METRIC 3 OF 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT 	POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES							
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 10 20 30	γ		GR SA SI CL

Depth (m)	Description	Soil Type	SS (%)	Sand (%)	Gravel (%)	Notes
302.9 - 301.6	SILT: trace sand, trace clay, grey, saturated, very dense	17	SS	54		contains sand pockets
301.6 - 300.1	FINE SAND: some silt, trace clay, embedded silt and calyey silt till layers, grey, saturated, very dense	18	SS	101		
300.1 - 298.6	SILTY CLAY: trace sand, occasional gravel, contains sand/silt partings/pockets, grey, moist, hard	19	SS	67		
298.6 - 298.0	SILTY SAND: trace clay, interbedded silt and calyey silt layers, grey, saturated, very dense	20	SS	70		
298.0 - 26.5	END OF BOREHOLE Notes: 1) 50mm diameter monitoring well installed on completion of drilling. Water level readings: Date W.L. (bgl)(m) September 16, 2015 10.4					

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015 GPJ ON MOT GDT 10/6/15

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

+3, ×3: Numbers refer to Sensitivity ○ $\epsilon=3\%$ Strain at Failure

10001852

RECORD OF BOREHOLE No BH15-RW2

METRIC 1 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542709, N 4812149 ORIGINATED BY JZ
 DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
 DATUM Geodetic DATE Aug/27/2015 CHECKED BY NE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W _p	W	W _L																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015.GPJ ON MOT.GDT 10/6/15

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GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001862

METRIC 2 OF 4

Continued Next Page

10001862

	1st	2nd	3rd	4th
Measurement				

RECORD OF BOREHOLE No BH15-RW2

METRIC 3 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542709, N 4812149 ORIGINATED BY JZ
DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug/27/2015 CHECKED BY NE

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	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
	SILTY CLAY: trace sand, occasional gravel, contains sand seams/pockets, grey, moist, very stiff to hard (continued)		16	SS	30		304													
21																				
			17	SS	21		303													
22																				
23							302													
			18	SS	25															
24							301													
25							300													
			19	SS	17															
26							299													
	saturated sand/silt seams, sand pockets below 25.9m		20	SS	15															
27							298													
28							297													
			21	SS	23															
29							296													
30			22	SS	24															

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015 GPJ ON MOT GDT 10/6/15

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3

Numbers refer to
Sensitivity

○ ε=3% Strain at Failure

10001852

RECORD OF BOREHOLE No BH15-RW2

METRIC 4 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542709, N 4812149 ORIGINATED BY JZ
DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug27/2015 CHECKED BY NE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
31	SILTY CLAY: trace sand, occasional gravel, contains sand seams/pockets, grey, moist, very stiff to hard (continued) 300mm thick saturated silt/sandy silt layer at 32m		23	SS	17		294							
32							293							
33							292							
34			25	SS	20		291							
290.9 34.1	END OF BOREHOLE Notes: 1) Groundwater was at 7.6m during drilling.													

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015 GPJ ON_MOT GDT 10/6/15

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001862

RECORD OF BOREHOLE No BH15-RW3

METRIC 1 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542701, N 4812126 ORIGINATED BY JZ
DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug/26/2015 CHECKED BY NE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
325.3	ASPHALT: 40mm						concrete							
324.8	GRANULAR: 530mm (sand and gravel)		1	SS	16		sand							
324.8	FILL: silty sand, trace clay, trace organics, brown, moist to wet, loose to compact		2	SS	21									
322.2	FILL: sand, some silt, trace clay, trace gravel, interbeds of silty clay and clay silt, brown, wet, loose		3	SS	10									
322.2			4	SS	8									
320.7	SAND: some silt, trace clay, occasional gravel, greyish brown, moist, compact to dense		5	SS	5									
320.7			6	SS	18									
319.9			7	SS	34									
317.9			8	SS	29									
316.2	SILTY SAND: trace clay, brownish grey, saturated, compact		9	SS	18									

W. L. 317.9 m
Sep 16, 2015

0 83 12 5

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015.GPJ ON MOT.GDT 10/6/15

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, × 3, Numbers refer to Sensitivity ○ ε=3% Strain at Failure

10001862

RECORD OF BOREHOLE No BH15-RW3

METRIC 2 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542701, N 4812126 ORIGINATED BY JZ
DIST HWY 85 Kilchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug/26/2015 CHECKED BY NE

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³) γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
313.1	SILTY SAND: trace clay, brownish grey, saturated, compact (continued)		10	SS	25		315							
314							314							
313.1	CLAYEY SILT: some sand, trace gravel, contains sand pockets, grey, moist, very stiff 100mm wet saturated silt layer embedded at 12.4m		11	SS	17		313							
312							312							
311.1			12	SS	30		311							
311.1	SILTY CLAY: trace sand, occasional gravel, contains sand/silt seams/pockets, grey, moist, stiff to hard						311							
310			13	SS	33		310							0 2 51 47
309							309							
308			14	SS	30		308							
307							307							
306			15	SS	21		306							

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015.GPJ ON MOT.GDT 10/6/15

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

+ 3, X 3

Numbers refer to
Sensitivity

○ ε=3% Strain at Failure

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METRIC 3 OF 4

Continued Next Page

○ $\epsilon = 3\%$ Strain at Failure

1st 2nd 3rd 4th

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RECORD OF BOREHOLE No BH15-RW3

METRIC 4 OF 4

W.P. 1614093-001 LOCATION See Drawing 1, E 542701, N 4812126 ORIGINATED BY JZ
DIST HWY 85 Kitchener BOREHOLE TYPE Hollow Stem Auger COMPILED BY MB
DATUM Geodetic DATE Aug/26/2015 CHECKED BY NE

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	POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (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	20 40 60 80 100	20 40 60 80 100	10 20 30					
	SILTY SAND: trace clay, occasional gravel, interbedded with silt and clayey silt layers, grey, saturated, dense to very dense (continued) interbeds of sandy silt at 30.5m		23	SS	90		295								
31 294.2 31.1	END OF BOREHOLE Notes: 1) 50mm diameter monitoring well installed on completion of drilling. Water level readings: Date W.L. (bgl)(m) September 16, 2015 7.4														

ON-MTO-2015 RETAINING WALL SEPTEMBER 14, 2015 GPJ ON_MOT.GDT 10/6/15

GROUNDWATER ELEVATIONS

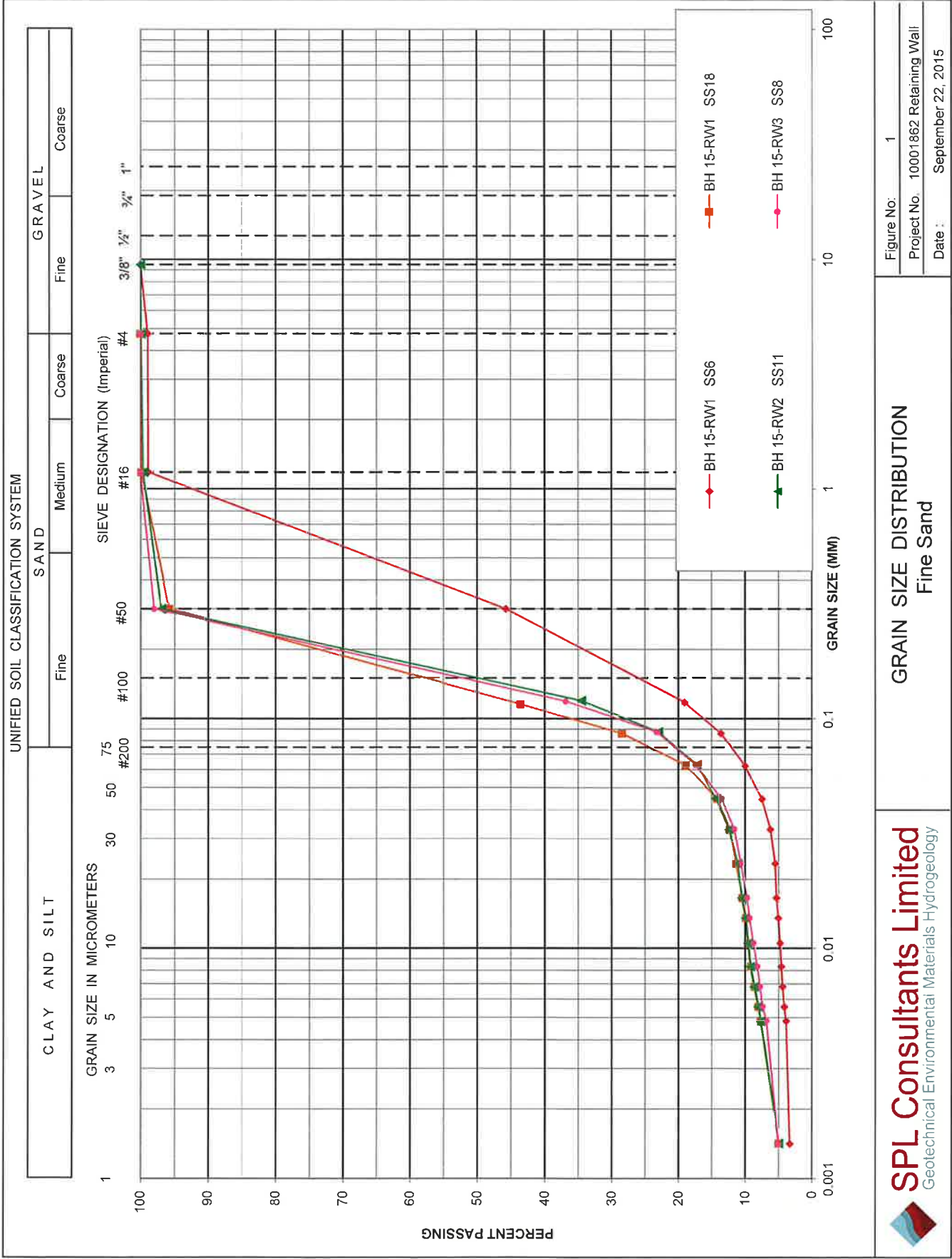
Measurement 1st 2nd 3rd 4th

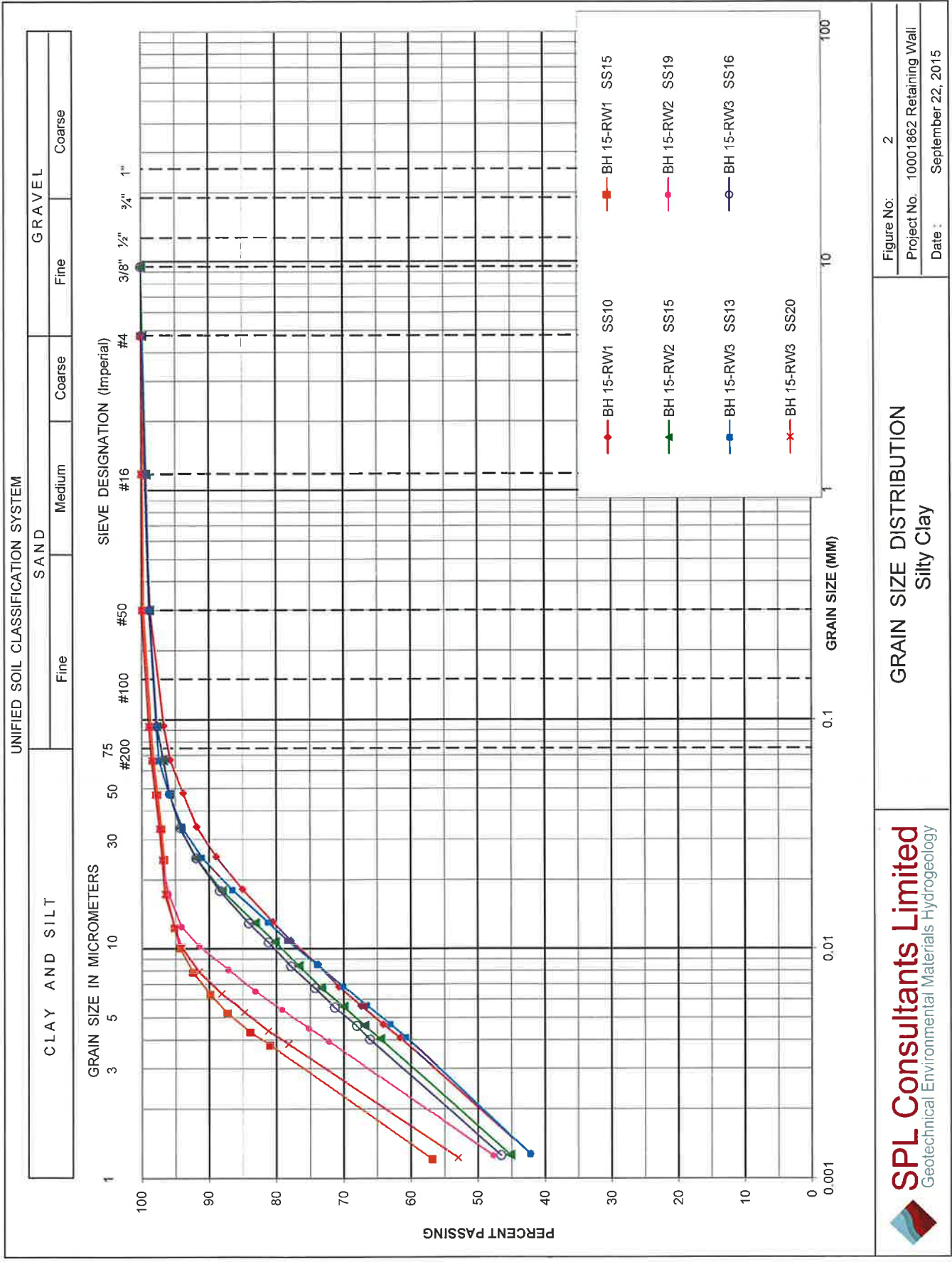
+³, ×³: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

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Appendix B

Gradation Distribution Curves (Figures 1 and 2)





**DRAFT
FOUNDATION DESIGN REPORT
PROPOSED RETAINING WALL, BRIDGE RECONSTRUCTION
663 VICTORIA STREET
KITCHENER, ONTARIO
W.P. 1614093-001**

**Prepared For:
MMM Group
100 Commerce Valley Drive West
Thornhill, Ontario, L3T 0A1**

**SPL Project No.: 10001862- DRAFT
October 6, 2015**

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APPENDIX C:

Limitations of Report

DRAFT
FOUNDATION DESIGN REPORT
PROPOSED RETAINING WALL, BRIDGE RECONSTRUCTION
663 VICTORIA STREET
KITCHENER, ONTARIO
W.P. 1614093-001

5.0 DISCUSSION AND RECOMMENDATIONS

SPL Consultants Limited (SPL) was retained by MMM Group to undertake a foundation investigation for the proposed retaining wall for the bridge reconstruction located at 663 Victoria Street at the interchange of Hwy 85 and Victoria Street in the Town of Kitchener, Ontario.

It is understood the Ministry of Transportation (MTO) intends to reconstruct the twin span bridge at the interchange of Victoria Street and Highway 85 in the Town of Kitchener, Ontario. We understand that the reconstruction of the bridge involves the construction of a retaining wall at the southwest corner of the interchange.

It is also understood as per the information provided to us that proposed retaining wall will be supported by caissons or driven piles. The pile cut off elevations will be 322m on the north side and 319m on the south side.

Three boreholes (BH15-RW1 through BH15-RW3) were drilled at the site (see **Drawing 1** for borehole locations), indicating that the site at the borehole locations is underlain by a pavement structure and fill to depths of 1.5 to 4.6m which is generally underlain by compact to very dense sand and silty sand and stiff to hard silty clay and silty clay till.

Groundwater observed in the monitoring wells installed in Boreholes BH15-1 and BH15-3 was in the range of 7.4 to 10.4m. The frost depth applicable to the subject site is 1.2m.

Based on the boreholes information, foundation comments and recommendations for the proposed retaining wall are presented as follows.

5.1 Foundation Design Considerations

The subsurface conditions encountered at the site are considered suitable for the construction of the cast in place retaining wall using the conventional deep foundation techniques.

Based on the borehole information, the proposed retaining wall can be supported by caisson foundation (drilled, cast in place concrete piles) or on driving piles.

5.1.1 Drilled Caissons

The caissons must be founded on hard silty clay about 17m below ground surface. The caisson vertical resistances are recommended in Table 5.1.1a below.

Table 5.1.1 a – Caisson's Vertical Resistance

BH No.	Caisson Founding Depth/Elevation (m)	Caisson Diameter (mm)	SLS Vertical Resistance (kN)	Factored ULS Vertical Resistance (kN)
BH15-RW1	17.0/307.5	900	700	1000
BH15-RW2	17.0/308.0	900	700	1000
BH15-RW3	17.0/308.3	900	700	1000

For caisson spacing is not less than 4.5 times the caisson diameter, the group efficiency can be taken as 1 for vertical resistance.

The displacements required to mobilize the ultimate shaft friction in a properly constructed caisson are typically small, and therefore settlement at SLS may not govern the design of caissons. Settlement under the SLS resistance provided is expected to be less than 15mm.

The caisson's lateral resistance assessed using Brom's method is provided in Table 5.1.1 b.

Table 5.1.1 b - Caisson Lateral Resistance

Caisson Dia. (mm)	SLS Lateral Resistance (kN)	Factored ULS Lateral Resistance (kN)	SLS Lateral Resistance (kN)	Factored ULS Lateral Resistance (kN)
	1% of Steel Reinforcement		2% of Steel Reinforcement	
900	110	170	160	240

Additional lateral resistance can be obtained using battered caissons. At this instance, we recommend that the batter be limited to not more than 4:1. For centre-to-centre caissons spacing is not less than 3 times caisson diameter, the group efficiency can be taken as 1 for lateral resistance.

For the estimation of lateral deflections, the soil/caisson interaction can be modelled using the following spring constant, k_s :

$$k_s = n_h z \Delta z$$

where $n_h = 0.3 \text{ MN/m}^3$ for existing fill

$$n_h = 1.3 \text{ MN/m}^3 \text{ for native soils with SPT N-value} \leq 10$$

$$n_h = 4.4 \text{ MN/m}^3 \text{ for native soils with SPT N-value} > 10$$

z = depth below grade

Δz = length of pile served by spring

Construction Considerations

The caissons piles will be drilled through existing fill, sand, silty sand, silty clay to clayey silt till and silty clay. Temporary steel casing will be required to prevent collapse of the sidewalls during construction.

Groundwater was found to be at 7.4 to 10.4m depth at borehole location. Caissons will therefore be below the water table. Groundwater flows in the saturated sand to silty sand are high and contractors have to deal with higher inflows (by extending casing to silty clay and by pumping water out at a faster rate) during construction.

All deep foundation construction should be inspected on a full-time basis by qualified geotechnical engineering staff.

5.1.2 Driven Piles

Based on the borehole information, the proposed retaining wall can also be supported by driven piles founded in the hard silty clay to a depth of 17m below ground surface. The piles can consist of steel H-piles, such as HP310x110. For design purpose, the ultimate bearing capacity of the piles driven in the hard silty clay deposit can be taken as

HP 310x110 piles:

Vertical Factored geotechnical resistance at ULS	= 950 kN/pile
Horizontal Factored geotechnical resistance at ULS	= 85 kN/pile
Vertical Factored geotechnical resistance at SLS	= 650 kN/pile
Horizontal Factored geotechnical resistance at SLS	= 55 kN/pile

Additional lateral resistance can be obtained using battered piles. At this instance, we recommend that the batter be limited to not more than 4:1. The pile group efficiency can be taken as 1 for the centre-to-centre spacing is not less than 3 pile diameter.

The bearing capacity and the required depth of the piles must be determined by field pile driving analyzer (PDA) tests. During the driving of the piles, the cohesionless deposits will be disturbed and excess pore pressure will be generated in the cohesionless deposits around the piles. Therefore, the bearing capacity of the piles at the end of initial driving (EIOD) and shortly after the pile installation is expected to be lower than the design values. However, the bearing capacity of the piles will increase with time due to setup effect and due to the excess pore pressure dissipation in the cohesionless deposits. A minimum waiting period of 2 to 3 weeks after the pile installation will be required to the piles to achieve the design bearing values. Therefore, retapping with PDA testing should be conducted at least 2 to 3 weeks after the pile installation.

The piling contractor should ensure that the pile-driving hammer is adequate to achieve the required bearing capacity and depth of the piles, but will not cause damage of the piles during the pile driving.

Pile tip protection using flange plates is recommended. Care must be taken to avoid overdriving and damaging the pile tip, i.e. the structural capacity of the piles should not be exceeded. The possibility of the piles encountering potential obstructions in fill and native soil should be anticipated. Stiffening of the tops of the piles may also be required.

The pile driving should be observed, on a full time basis, by an experienced soil technician, who will record penetration resistance, pile tip elevation etc. The technician must be supervised by a professional engineer experienced in this type of work.

During the driving process, piles that have already been driven will need to be monitored to determine if heaving occurred due to the effect of driving of the adjacent piles. If this phenomenon occurs, the affected piles will need to be re-driven. Re-tapping to check that relaxation has not occurred will be necessary. Furthermore, it may be necessary to stagger the driving of the piles. The piles should be provided with reinforced tips.

The horizontal spacing of the piles should be at least 3 times the pile size/diameter.

It should be noted that occasional cobbles/boulders may exist within the soil deposits. Possible large obstructions such as buried concrete pieces and existing foundations are also anticipated in the fill material. Therefore, boulders or obstructions may be encountered during the installation of the piles.

It should also be noted that the recommended foundation type and bearing capacities based on the borehole information are for design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by SPL Consultants Limited to validate the information for use during the construction stage.

5.2 Earth Pressures

Backfilling behind retaining walls should consist of granular materials in accordance with the applicable Standards. Free draining backfill materials, weepholes, etc. should be provided in order to prevent hydrostatic pressure build-up.

Computation of earth pressures acting against the retaining walls should be in accordance with the Canadian Highway Bridge Design Code, (CHBDC) S6-06. For design purposes, the following properties can be assumed for backfill.

Compacted Granular 'A' or Granular 'B' Type II

Angle of Internal Friction $\phi = 35^\circ$ (unfactored)

Unit weight = 22 kN/m³

Coefficient of Lateral Earth Pressure:

Level Backfill	Backfill Sloping at 3H:1V	Backfill Sloping at 2H:1V
$K_a=0.27$	$K_a=0.34$	$K_a=0.40$
$K_b=0.35$	$K_b=0.44$	$K_b=0.50$
$K_o=0.43$	$K_o=0.56$	$K_o=0.62$
$K^*=0.45$	$K^*=0.60$	$K^*=0.66$

Compacted Granular 'B' Type I

Angle of Internal Friction $\phi=32^\circ$ (unfactored)

Unit Weight = 21 kN/m³

Coefficient of Lateral Earth Pressure:

Level Backfill	Backfill Sloping at 3H:1V	Backfill Sloping at 2H:1V
$K_a=0.31$	$K_a=0.39$	$K_a=0.47$
$K_b=0.39$	$K_b=0.49$	$K_b=0.57$
$K_o=0.47$	$K_o=0.62$	$K_o=0.69$
$K^*=0.54$	$K^*=0.68$	$K^*=0.78$

Note: K_a is the coefficient of active earth pressure

K_b is the backfill earth pressure coefficient for an unrestrained structure including compaction efforts

K_o is the coefficient of earth pressure at rest

K^* is the earth pressure coefficient for a soil loading a fully restrained structure and includes compaction effects

These values are based on the assumption that the backfill behind the retaining structures is free-draining granular material and adequate drainage is provided.

The earth pressure coefficient to be adopted will depend on whether the retaining structure is restrained or some movement can occur such that the active state of earth pressure can develop. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients. The use of vibratory compaction equipment behind the abutments and the retaining walls should be restricted in size.

As an alternative to conventional retaining walls, consideration could be given to Retained Soil System in which case the designer will have to include the geometric, performance and appearance requirements. The Retained Soil System must be designed and constructed by a specialized contractor.

5.3 Frost Protection

All pile caps exposed to seasonal freezing conditions must have at least 1.2m of soil cover or its thermal equivalent for frost protection.

5.4 Seismic Site Classification

Based on the borehole information and according to Table 4.1.8.4.A of OBC 2012, the subject site for the proposed structure can be classified as 'Class D' for seismic site response.

6. CLOSURE

We recommend that once the details of the project are finalized, our recommendations be reviewed for their specific applicability.

The Limitations of Report, as quoted in Appendix C, are an integral part of this report.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

SPL CONSULTANTS LIMITED

Naeem Ehsan, M.Eng., P.Eng.

Laifa Cao, Ph.D., P.Eng.

Appendix C

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 SPL Consultants Limited at the time of preparation. Unless otherwise agreed in writing by SPL Consultants Limited, 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 test hole 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 test holes may differ from those encountered at the test hole 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 test hole 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 test holes 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. SPL Consultants Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.