Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION INVESTIGATION AND DESIGN REPORT

for

RETAINING WALLS
HIGHWAY 7A
TOWNSHIP OF PORT PERRY, ONTARIO
AGREEMENT NO. 2013-E-0039
TASK NO. 2013-E-0039-008

PREPARED FOR MINISTRY OF TRANSPORTATION OF ONTARIO

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PML Ref.: 15TF002
Index No.: 011FIR and 012FDR
GEOCRES No.: 31D-628
October 15, 2015

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FOUNDATION INVESTIGATION REPORT
for
Retaining Walls
Highway 7A
Township of Port Perry, Ontario
Task No. 2013-E-0039-008

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1. INTRODUCTION

This report summarizes the results of the foundation investigation carried out for the detail design and construction for the replacement of four (4) retaining walls along Highway 7A in Port Perry, Ontario. The study was carried out by Peto MacCallum Ltd. (PML) for the Ministry of Transportation of Ontario (MTO).

A Site and Photograph Location Plan, Drawing RW-1 is attached within this report which indicates the location of each retaining wall and location and direction of each photograph that was taken with respect to each retaining wall. Site photographs indicated on the Site and Photograph Location plan are attached in Appendix FIR-A of this report. Borehole Locations and Soil Strata are shown on attached Drawings, PS-1, SS-1 and OS-1.

An internal MTO technical memorandum concerning the same retaining walls dated November 1, 1994, was reviewed and is attached in Appendix FIR-B of this report.

All elevations in this report are expressed in metres.

2. SITE DESCRIPTION AND RECONNAISSANCE SURVEY

Four retaining walls are to be replaced on Highway 7A between Ottawa Street and Perry Street in Port Perry, Ontario.

The details of each retaining wall identified for replacement can be found in the following table (Table 2).

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Table 2: Details of Existing Retaining Walls

RETAINING WALLS	WALL #	MTO SITE ID	LENGTH (m)	MAX HEIGHT (m)
Perry Street	Wall # 1 and 2	22-579/W, 22-580/W	32 and 11	1.25 and 0.75
Simcoe Street	Wall # 3	N/A	32	0.96
Ottawa Street	Wall # 4	22-578/W	78	1.35

Two of the retaining walls, which are the farthest east along Highway 7A are near each other and are designated as the Perry Street retaining walls. The retaining wall adjacent to Regional Road 2 (Simcoe Street) is designated as the Simcoe Street retaining wall. Lastly, the retaining wall which is the farthest west along Highway 7A is designated as the Ottawa Street retaining wall. The Ottawa Street and Perry Street retaining walls are on the north side of Highway 7A while the Simcoe Street retaining wall is on the south side of Highway 7A. These retaining walls are highlighted in green on the attached Site and Photograph Location Plan.

The site reconnaissance survey was carried out on April 16, 2015. Refer to Appendix FIR-A for the site photographs obtained on April 16 and subsequently on May 12 and 13, 2015 during the borehole drilling of each retaining wall. The site photos provide illustration of the existing slopes and drainage behind the existing walls.

Refer to the attached Borehole Locations and Soil Strata Drawing for illustration of existing above ground utilities, trees and fences in close proximity to the existing walls.

The existing retaining walls are of the modular precast concrete type, such as the Pisa Stone retaining walls. The typical precast concrete element (stone) is approximately 75 mm thick, 300 mm wide and 600 mm long. The walls retain the front and side yards of the respective lots to provide room for a concrete or asphalt sidewalk immediately in front of the retaining walls.

It is noted that the Ottawa Street retaining wall and sections of the Perry Street retaining wall were observed to have a forward lean while the other sections of the Perry Street and the Simcoe Street retaining walls were measured to stand nearly vertical.

According to the technical memorandum attached in Appendix FIR-B, the retaining walls were to be constructed at 1H:8V. Assuming that the walls were constructed as designed, it is concluded that the retaining walls have experienced some movement mostly within the upper portion of the walls.

The photographs attached in Appendix FIR-A illustrate the deterioration of the retaining walls and / or the layers of stones that comprise the walls.

The Ottawa Street retaining wall (photographs 1 to 4) experienced forward movement / sliding or possible overturning in the top four to five lifts of stone near the far west end of the wall, as these layers of stones have been removed (see photograph 1). Forward movement, spacing between stones and outward / forward leaning within the upper portion of the wall was observed throughout the reconnaissance and borehole investigation of the Ottawa Street retaining wall (see photographs 2, 3 and 4). The upper portion of the Ottawa Street retaining wall was measured to be leaning forward / outward at an approximate slope of 1H:10V. Based on photographs 2 and 3, this wall may have been raised by up to 6 rows of stones (450 mm) in the past. No visible weeping holes for drainage of water infiltration that may exist behind the retaining wall were observed, indicating that drainage is being made through the retaining wall stone spaces. The retaining wall also shows signs of missing and / or cracked stones and spacing between blocks near the east end of the walls.

The Simcoe Street retaining wall (photographs 5 to 8) was measured to be near vertical and shows evidence of deteriorated / cracked stones, loose stones that may have been removed and replaced (see photographs 6 to 8). Visible weeping holes were observed and noted at approximate 3 m intervals along the Simcoe Street retaining wall during the site reconnaissance.

The Perry Street retaining walls (photographs 9 to 12) were also measured to be near vertical with a section of the upper portion of the wall leaning forward at an approximate slope of 1H:15V. The stones illustrate deterioration as some stones have been removed while others show vertical cracking and spacing between the stones through which vegetation has grown (see photographs 9 to 11). No visible weeping holes for drainage of water that may exist behind the retaining walls were observed during the investigation and reconnaissance of the Perry Street retaining walls.

3. SITE PHYSIOGRAPHY

The project site lies within the Port Perry urban area which overlies the Schomberg Clay Plain. The primary physiographic units represented in and around the Port Perry area are; the Oak Ridges Moraine located to the south and the Peterborough Drumlin Field located north of the Moraine, west of Port Perry, and to the east of Lake Scugog toward Peterborough. The soils are well drained Schomberg silty clay loam, imperfectly drained Smithfield silty clay loam, and poorly drained Simcoe silty clay and silt loams (Chapman and Putnam, 1984). These soil types are typical of glacial till plains.

4. INVESTIGATION PROCEDURES

The subsurface investigation for the retaining walls was carried out on May 12 and 13, 2015. A total of six boreholes were advanced behind the four retaining walls along Highway 7A. Refer to the following table (Table 4) for information pertaining to the boreholes advanced for each retaining wall.

Table 4: Details of Borehole Investigation

RETAINING WALL	LENGTH (m)	BOREHOLES	BOREHOLE DEPTH (m)
Perry Street	32 and 11	PS-1 and PS-2	2.9
Simcoe Street	32	SS-1 and SS-2	3.7 to 4.1
Ottawa Street	78	OS-1 and OS-2	3.7

All 6 boreholes were advanced behind the respective retaining walls to obtain information regarding the existing backfill material, groundwater conditions and the founding soil for each retaining wall. Refer to Drawings PS-1, SS-1 and OS-1 for the borehole locations and soil strata.

PML laid out the proposed borehole locations on site in order to organize and carry out the clearances of various underground services and utilities in the vicinity of the proposed borehole locations. Several of the boreholes needed relocation due to interference from underground and overhead services. All the required permission to enter and construct forms were completed and obtained from the private property owners whose properties fall adjacent to the investigated retaining walls.

The Ottawa Street retaining wall had both boreholes relocated 2 to 3 m behind the retaining wall due to an untraceable asbestos cement watermain that exists approximately 1 m behind the retaining wall, according to The Regional Municipality of Durham Water Locate Department. In addition to the untraceable watermain, overhead utilities including existing hydro poles within 1 m behind the Ottawa Street retaining wall also caused the relocation of boreholes OS-1 and OS-2.

Similarly, borehole PS-2 required relocation due to a 1.2 m wide underground Bell conduit containing multiple ducts located within 1 m behind the retaining walls. Borehole PS-1 was drilled at the proposed location, directly behind the retaining wall, because there was sufficient clearance between the Bell conduit and the back of the retaining wall.

Boreholes SS-1 and SS-2 were relocated from directly behind the wall to 0.8 m behind the retaining wall due to the requirement to maintain the required minimum separation from the overhead utilities including the presence of hydro poles located approximately 1 m in front of the retaining wall.

After completion of the investigation Coe Fisher Cameron Surveyors, a wholly owned subsidiary of J.D. Barnes Limited, determined the coordinates and ground surface elevations of the borehole locations. All elevations in this report are expressed in metres and are referred to the geodetic datum.

Boreholes OS-1, OS-2, PS-1 and PS-2 were advanced using a manual hammer while boreholes SS-1 and SS-2 were advanced using continuous flight solid stem augers, powered by a track mounted 7822DT Geoprobe, supplied and operated by a specialist drilling subcontractor, working under the full-time supervision of a member of the PML engineering staff.

Representative samples of the soils were recovered in the boreholes at depth intervals of 0.75 m. The soil samples were obtained using a split spoon sampler in conjunction with standard penetration tests. A single in situ vane shear testing was also performed in borehole SS-2 to assess the shear strength of a layer of the cohesive soils.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as the samples were retrieved and upon completion of drilling. The water level observations are noted on the attached record of boreholes and in subsequent sections of this report.

All boreholes were backfilled in accordance with the MTO guidelines and MOE Reg. 903 for borehole abandonment procedures.

Soils were identified in the field in accordance with the MTO Soil Classification procedures. Recovered soil samples were returned to the PML laboratory in Toronto for detailed visual examination, moisture content determination and soil classification. Laboratory testing including grain size distribution analyses, hydrometer analyses, Atterberg limits testing and specific gravity determination was conducted at the MTO laboratory at the Downsview complex. The laboratory testing program comprised the following tests:

- Natural moisture content determinations (28)
- Grain size distribution analyses (9)
- Hydrometer analyses (8)
- Atterberg limits (8)

The results of the laboratory natural moisture content determinations, grain size distribution analyses and Atterberg limits are shown on the Record of Borehole sheets. The grain size distribution charts for the respective soil types are presented in Figures RW-GS-1 to RW-GS-4 and the Atterberg limits results for the respective soil types are presented in Figures RW-PC-1 to RW-PC-3. The results of Atterberg limits testing, moisture content determinations and frost susceptibility of the soils are listed in Table A.

5. SUMMARIZED SUBSURFACE CONDITIONS

5.1 General

Refer to the Record of Borehole sheets for the details of the subsurface conditions including soil classifications, inferred stratigraphy, soil boundary levels and groundwater observations.

The location of the Perry Street, Simcoe Street and Ottawa Street retaining wall structures are presented on the attached Drawing RW-1.

5.2 Perry Street Retaining Walls

Boreholes PS-1 and PS-2 were advanced behind the 32 and 11 m long retaining walls located within the vicinity of Perry Street. The soil stratigraphy revealed in the boreholes comprised topsoil and / or granular fill overlying cohesive deposits of clayey silt glacial till.

5.2.1 Topsoil

A 0.2 to 0.3 m thick surficial topsoil layer was encountered in boreholes PS-1 and PS-2. The topsoil layer extended to elevations 263.2 and 262.0 in boreholes PS-1 and PS-2 respectively.

5.2.2 Granular Fill

Underlying the topsoil at a depth of 0.3 m in borehole PS-1 was granular fill. The non-cohesive fill layer comprised sandy gravel with 17% silt and organics inclusions. The sandy gravel fill was loose to compact in relative density (SPT-'N' values of 5 to 21) and was penetrated at a depth of 1.8 m (elevation 261.7). The moisture content of the granular fill was determined to range between 2 and 21%. The higher moisture content is attributed to the organic inclusions contained within the fill deposit.

The results of the grain size distribution analysis performed on one sample of the sandy gravel fill in borehole PS-1 is presented in Figure RW-GS-1. The grain size distribution was plotted against the Granular A gradation requirement envelope for comparative purposes for acceptable backfill material. The granular fill encountered in borehole PS-1 does not meet the requirements for acceptable backfill material due to higher than specified fines content of 17%, while the allowed range is between 5 and 8%.

5.2.3 Clayey Silt Till

Clayey silt glacial till was revealed below the granular fill in borehole PS-1 and below the topsoil in borehole PS-2. The clayey silt till was encountered at depths of 1.8 and 0.2 m (elevation 261.7 and 262.0) in boreholes PS-1 and PS-2 respectively. This stratum was stiff to hard in consistency (SPT-'N' values of 11 to 63) and had a moisture content ranging from 10 to 16%. With a measured thickness of 1.1 and 2.7 m, the clayey silt glacial till was not penetrated upon termination of the boreholes at a depth of 2.9 m (elevation 260.6 and 259.3) in boreholes PS-1 and PS-2 respectively.

The results of Atterberg limits testing and grain size distribution analyses conducted on two samples of clayey silt till from boreholes PS-1 and PS-2 are presented in respective Figures RW-GS-3 and RW-PC-2. The liquid and plastic limits of the clayey silt till in boreholes PS-1 and PS-2 ranged from 25 to 30 and from 15 to 16 respectively, with the plasticity index of 10 to 14.

The clayey silt glacial till in boreholes PS-1 and PS-2 was found to have a medium to high susceptibility to frost heave (MSFH-HSFH) based on the percentage of particles between the 75 and 5 µm sieves. The percentage of particles between the 75 and 5 µm sieves was found to be 43 and 57% based on the 2 samples tested. This medium to high susceptibility to frost heave could impact the performance of the retaining walls if this native soil exists behind the retaining structure at any location above the founding elevation. Refer to Table A for the material properties of the soil.

5.2.4 Groundwater

No groundwater was observed in any of the boreholes during or upon completion of drilling. However, it is noted that the groundwater levels are subjected to seasonal fluctuations and rainfall patterns.

5.3 Simcoe Street Retaining Wall

Boreholes SS-1 and SS-2 were advanced behind the 32 m long retaining wall located within the vicinity of Simcoe Street. The soil stratigraphy revealed in the boreholes comprised topsoil over sandy clayey silt fill overlying cohesive deposits of clayey silt glacial till.

5.3.1 Topsoil

A 0.2 to 0.3 m thick surficial topsoil layer was encountered in boreholes SS-1 and SS-2. The topsoil layer extended to elevations 263.5 and 263.2 in boreholes SS-1 and SS-2 respectively.

5.3.2 Fill

Underlying the topsoil at a depth of 0.2 and 0.3 m in boreholes SS-1 and SS-2 was sandy clayey silt to clayey silt with sand fill. The cohesive fill layer in boreholes SS-1 and SS-2 was soft to stiff in relative density (SPT-‘N’ values of 2 to 14) and was penetrated at a depth of 1.3 and 1.4 m (elevation 262.4 and 262.1) in boreholes SS-1 and SS-2 respectively. The moisture content of the cohesive fill was determined to range between 12 and 17%.

The results of Atterberg limits testing and grain size distribution analyses conducted on two samples of cohesive fill from boreholes SS-1 and SS-2 are presented in respective Figures RW-GS-2 and RW-PC-1. The liquid limits of the cohesive fill ranged from 18 to 21, while the plastic limit was 13 for both samples. The corresponding plasticity index was found to range from 5 to 8 for the cohesive fill.

The clayey silt fill in boreholes SS-1 and SS-2 was found to have very similar material properties to the native clayey silt till encountered in the boreholes. The remolded cohesive fill has a low to medium susceptibility to frost heave (LSFH-MSFH) based on the percentage of particles between the 75 and 5 µm sieves. The percentage of particles between the 75 and 5 µm sieves was found to be 40 and 38% based on the 2 samples tested. This low to medium susceptibility to frost heave will impact the performance of the retaining wall as this soil was encountered behind the retaining wall. Refer to Table A for the material properties of the soil.

For illustration purposes, the grain size distribution analyses for the cohesive fill in Figure RW-GS-2 was plotted against the Granular A gradation requirements envelope for acceptable backfill material. The cohesive material is not acceptable backfill material for the retaining wall.

5.3.3 Clayey Silt Till

Clayey silt glacial till was revealed below the cohesive fill in boreholes SS-1 and SS-2. The clayey silt till was encountered at depths of 1.3 and 1.4 m (elevation 262.4 and 262.1) in boreholes SS-1 and SS-2 respectively. This stratum was firm to very stiff in consistency (SPT-'N' values of 5 to 28) and had a moisture content ranging from 10 to 18%.

The results of Atterberg limits testing and grain size distribution analyses conducted on two samples of the clayey silt till from boreholes SS-1 and SS-2 are presented in respective Figures RW-GS-3 and RW-PC-2. The liquid and plastic limits of the clayey silt till in boreholes SS-1 and SS-2 ranged from 18 to 24 and from 13 to 14 respectively, with the plasticity index of 5 to 10. With a measured thickness of 2.4 and 2.7 m, the clayey silt glacial till was not penetrated upon termination of the boreholes at depths of 3.7 and 4.1 m (elevation 260.0 and 259.4) in boreholes SS-1 and SS-2 respectively.

The clayey silt glacial till in boreholes SS-1 and SS-2 was found to have a low susceptibility to frost heave (LSFH) based on the percentage of particles between the 75 and 5 µm sieves. The percentage of particles between the 75 and 5 µm sieves was found to be 29 and 37% based on the 2 samples tested. It should be noted that 40 percent of particles between 75 and 5 µm sieves is the limit between low and medium susceptibility to frost heave and this material can result in frost heaving action. The clayey silt glacial till could impact the performance of the retaining wall if this native soil exists behind the retaining structure at any location above the founding elevation. Refer to Table A for the material properties of the soil.

5.3.4 Groundwater

No groundwater was observed in any of the boreholes during or upon completion of drilling. However, it is noted that the groundwater levels are subjected to seasonal fluctuations and rainfall patterns.

5.4 Ottawa Street Retaining Wall

Boreholes OS-1 and OS-2 were advanced behind the 78 m long Ottawa Street retaining wall. The soil stratigraphy revealed in boreholes OS-1 and OS-2 comprised topsoil overlying non-cohesive deposits of sand and silt to sandy silt glacial till.

5.4.1 Topsoil

A 0.3 m thick surficial topsoil layer was encountered in boreholes OS-1 and OS-2. The topsoil layer extended to elevations 271.7 and 269.6 in boreholes OS-1 and OS-2 respectively.

5.4.2 Sand and Silt Till / Sandy Silt Till

Sand and silt to sandy silt glacial till was revealed below the topsoil at a depth of 0.3 m (elevation 271.7 and 269.6) in boreholes OS-1 and OS-2 respectively. This stratum was typically compact to dense in relative density (SPT-‘N’ values of 13 to 44) and had a moisture content ranging from 8 to 15%. With a measured thickness of 3.4 m, the sand and silt to sandy silt glacial till was not penetrated upon termination of the boreholes at a depth of 3.7 m (elevation 268.3 and 266.2) in boreholes OS-1 and OS-2 respectively.

The results of Atterberg limits testing and grain size distribution analysis performed on one sample of sand and silt till and one sample of sandy silt till from boreholes OS-1 and OS-2 are presented in respective Figures RW-PC-3 and RW-GS-4. The liquid and plastic limits of the sand and silt to sandy silt till was 15 and 12 respectively, with the plasticity index of 3 for both samples.

The sand and silt to sandy silt glacial till was found to have a low to medium susceptibility to frost heave based on the percentage of particles between the 75 and 5 µm sieves. The percentage of particles between the 75 and 5 µm sieves was found to be 36 and 42% based on the 2 samples tested. This low to medium susceptibility to frost heave could impact the performance of the retaining wall. Refer to Table A for the material properties of the soil.

5.4.3 Groundwater

Perched water was detected in the process of augering at a depth of 2.4 m (elevation 267.5) in borehole OS-2. The perched water dissipated as the borehole advanced to termination. Groundwater was not observed in any of the boreholes during and upon completion of drilling in May 2015. However, it is noted that the groundwater levels are subjected to seasonal fluctuations and rainfall patterns.

6. CLOSURE

The site reconnaissance survey was carried out by Mr. K. R. Daly, B.Eng., EIT and by Mr. R. MacLaughlan, EIT of the MTO Foundations Office. The drilling of the boreholes was carried out under the supervision of Mr. K. R. Daly, B.Eng., EIT, and direction of Mr. C. M. P. Nascimento, P.Eng., Project Manager. The drilling equipment was supplied and operated by Tri-Phase Group. The laboratory testing was carried out by the MTO laboratories in Downsview.

This report was prepared by Mr. K. R. Daly, B.Eng., EIT, Project Supervisor, and reviewed by Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineer. Mr. C.M.P. Nascimento, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

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TABLE A

LIST OF ATTERBERG LIMITS, MOISTURE CONTENT RESULTS AND FROST SUSCEPTIBILITY

SOIL TYPE	BOREHOLE NO.	SAMPLE NO.	SAMPLE DEPTH (m)	LIQUID LIMIT (W_L)	PLASTIC LIMIT (W_P)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)	% PARTICLES BETWEEN 5 µm & 75 µm	FROST SUSCEPTIBILITY
Clayey Silt Fill	SS-1	2	0.8 - 1.4	21	13	8	14	40	LSFH-MSFH
	SS-2	2	0.8 - 1.4	18	13	5	12	38	LSFH
Clayey Silt Till	PS-1	4	2.3 – 2.9	30	16	14	15	57	HSFH
	PS-2	3	1.5 – 2.1	25	15	10	13	43	MSFH
	SS-1	4	2.3 – 2.9	24	14	10	17	29	LSFH
	SS-2	3	1.5 – 2.1	18	13	5	12	37	LSFH
Sand and Silt to Sandy Silt Till	OS-1	3	1.5 – 2.1	15	12	3	9	36	LSFH
	OS-2	2	0.8 - 1.4	15	12	3	11	42	MSFH

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 475 J 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.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0 – 10	10 – 20	20 – 30	30 – 40	> 40
	TRACE	*SOME*	*WITH*	*ADJECTIVE (SILTY)*	*AND (AND SILT)*

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/0.3 m)	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 (R Q D), FOR MODIFIED RECOVERY, IS:

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

JOINTING 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

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE
F V	FIELD VANE		

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
τ_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
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL
e	1,%	VOID RATIO

n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
DTPL		DRIER THAN PLASTIC LIMIT
APL		ABOUT PLASTIC LIMIT
WTPL		WETTER THAN PLASTIC LIMIT

e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PS-1

METRIC

G.W.P. 2013-E-0039-008 LOCATION Coords: 4 884 656.2 N; 349 453.8 E ORIGINATED BY K.D.

DIST Central **HWY** 7A BOREHOLE TYPE Manual Hammer COMPILED BY K.D.

DATUM Geodetic DATE May 13, 2015 CHECKED BY G.D.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
263.5	Ground Surface				*						
0.0 263.2	Topsoil	1	SS	5		263					
0.3	Sandy gravel, some silt organic inclusions. Loose to compact Brown Moist (FILL)	2	SS	11		262		46	37	17	0
261.7 1.8	Clayey silt, some sand. Very stiff to hard Brown Moist (TILL)	3	SS	21							
		4	SS	44		261		0	14	62	24
260.6 2.9	End of borehole										

* Borehole dry

Legend: 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; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ON MTO_VER3 NEW LOGO 15TF002.GPJ ON_MOT.GDT 16/09/2015 10:56:01 AM

+7, ×5 : Numbers refer to Sensitivity

20 / 15—○—5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No PS-2

METRIC

G.W.P. 2013-E-0039-008 LOCATION Coords: 4 884 664.8 N; 349 472.5 E ORIGINATED BY K.D.

DIST Central **HWY** 7A BOREHOLE TYPE Manual Hammer COMPILED BY K.D.

DATUM Geodetic DATE May 13, 2015 CHECKED BY G.D.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
262.2	Ground Surface										
262.0	Topsoil				262						
0.2	Clayey silt, some sand; Stiff to hard; Brown; Moist (TILL)	1	SS	11		○					
		2	SS	40	261	○					
		3	SS	63	260	○ (with plastic/liquid limit range)		0	19	56	25
259.3		4	SS	48		○					
2.9	End of borehole										

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); 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; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

* Borehole dry

+[7], ×[5]: Numbers refer to Sensitivity

20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No SS-1

METRIC

G.W.P. 2013-E-0039-008 LOCATION Coords: 4 884 553.6 N; 349 161.7 E ORIGINATED BY K.D.

DIST Central **HWY** 7A BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY K.D.

DATUM Geodetic DATE May 12, 2015 CHECKED BY G.D.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
263.7	Ground Surface						
263.5 / 0.2	Topsoil / Clayey silt, with sand, Firm to stiff, Brown, Moist (FILL)	1	SS	4		263	
262.4		2	SS	10			0 23 53 24
1.3	Clayey silt, some sand, Firm to stiff, Brown, Moist (TILL)	3	SS	10		262	
		4	SS	7		261	0 17 49 34
260.0		5	SS	13		260	
3.7	End of borehole						

* Borehole dry

Plot legend: 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; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+7, ×5 : Numbers refer to Sensitivity; 20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No SS-2

METRIC

G.W.P. 2013-E-0039-008 LOCATION Coords: 4 884 551.4 N; 349 154.2 E ORIGINATED BY K.D.

DIST Central **HWY** 7A BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY K.D.

DATUM Geodetic DATE May 12, 2015 CHECKED BY G.D.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	GR SA SI CL
263.5	Ground Surface							
263.2 / 0.0–0.3	Topsoil	1	SS	2	263			
0.3	Sandy clayey silt. Soft to stiff, Brown, Moist (FILL)	2	SS	14				0 30 50 20
262.1 / 1.4	Sandy clayey silt. Very stiff to stiff, Brown, Moist (TILL)	3	SS	28	262			0 30 48 22
		4	SS	18	261			
		5	SS	5	260			
			FV			+ (field vane), sensitivity 2		
259.4 / 4.1	End of borehole							

* Borehole dry

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS *; 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; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+7, ×5 : Numbers refer to Sensitivity   20 / 15 –○– 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

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RECORD OF BOREHOLE No OS-1

METRIC

G.W.P. 2013-E-0039-008 | LOCATION Coords: 4 884 464.6 N; 348 784.3 E | ORIGINATED BY K.D.

DIST Central | HWY 7A | BOREHOLE TYPE Manual Hammer | COMPILED BY K.D.

DATUM Geodetic | DATE May 13, 2015 | CHECKED BY G.D.

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS *	ELEVATION SCALE	NATURAL MOISTURE CONTENT W (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.0	Ground Surface								
0.0 / 271.7	Topsoil								
0.3	Sand and silt, some clay; Loose to dense; Brown; Moist; (TILL)		1	SS	6				
			2	SS	15		271		
			3	SS	24		270		0 42 41 17
			4	SS	33		269		
268.3			5	SS	37				
3.7	End of borehole								

* Borehole dry

Plot headings: 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; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+7, ×5 : Numbers refer to Sensitivity

20 / 15 —○— 5 / 10 (%) STRAIN AT FAILURE

Ontario

Peto MacCallum Ltd. CONSULTING ENGINEERS

Foundation Design

RECORD OF BOREHOLE No OS-2

METRIC

G.W.P. 2013-E-0039-008 LOCATION Coords: 4 884 472.1 N; 348 813.4 E ORIGINATED BY K.D.

DIST Central **HWY** 7A BOREHOLE TYPE Manual Hammer COMPILED BY K.D.

DATUM Geodetic DATE May 12, 2015 CHECKED BY G.D.

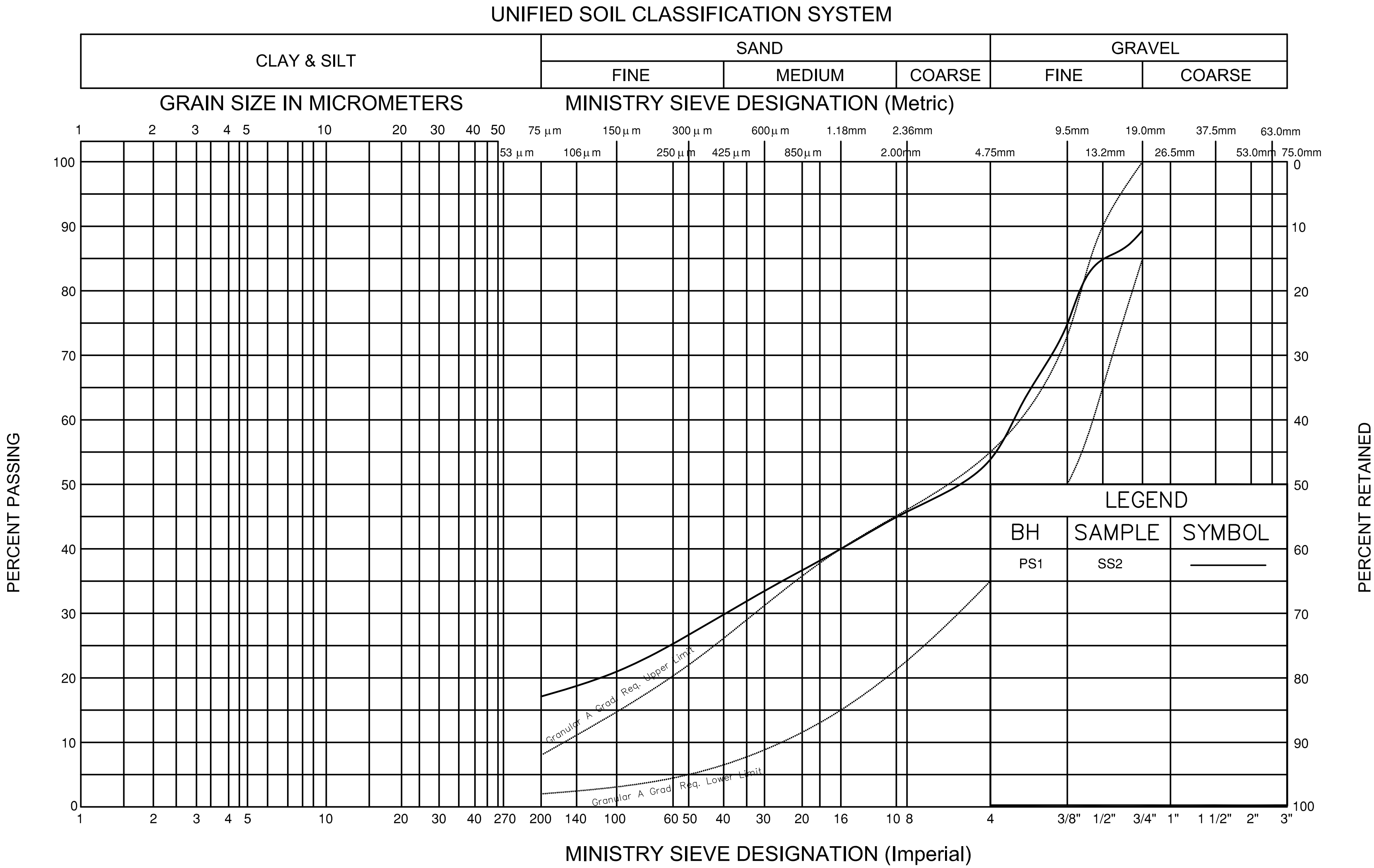
ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
269.9	Ground Surface									
269.6 / 0.0	Topsoil									
0.3	Sandy silt, some clay; Loose to dense, Brown/grey, Moist to wet (TILL)	1	SS	3						
		2	SS	13			0	37	49	14
		3	SS	33						
					▽*					
		4	SS	44						
266.2		5	SS	36						
3.7	End of borehole									

* 2015 05 12

▽ Water level observed during drilling

Chart legend: 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); ELEVATION SCALE: 269, 268, 267; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+7, ×5 : Numbers refer to Sensitivity; 20 / 15 ○ 5 / 10 (%) STRAIN AT FAILURE

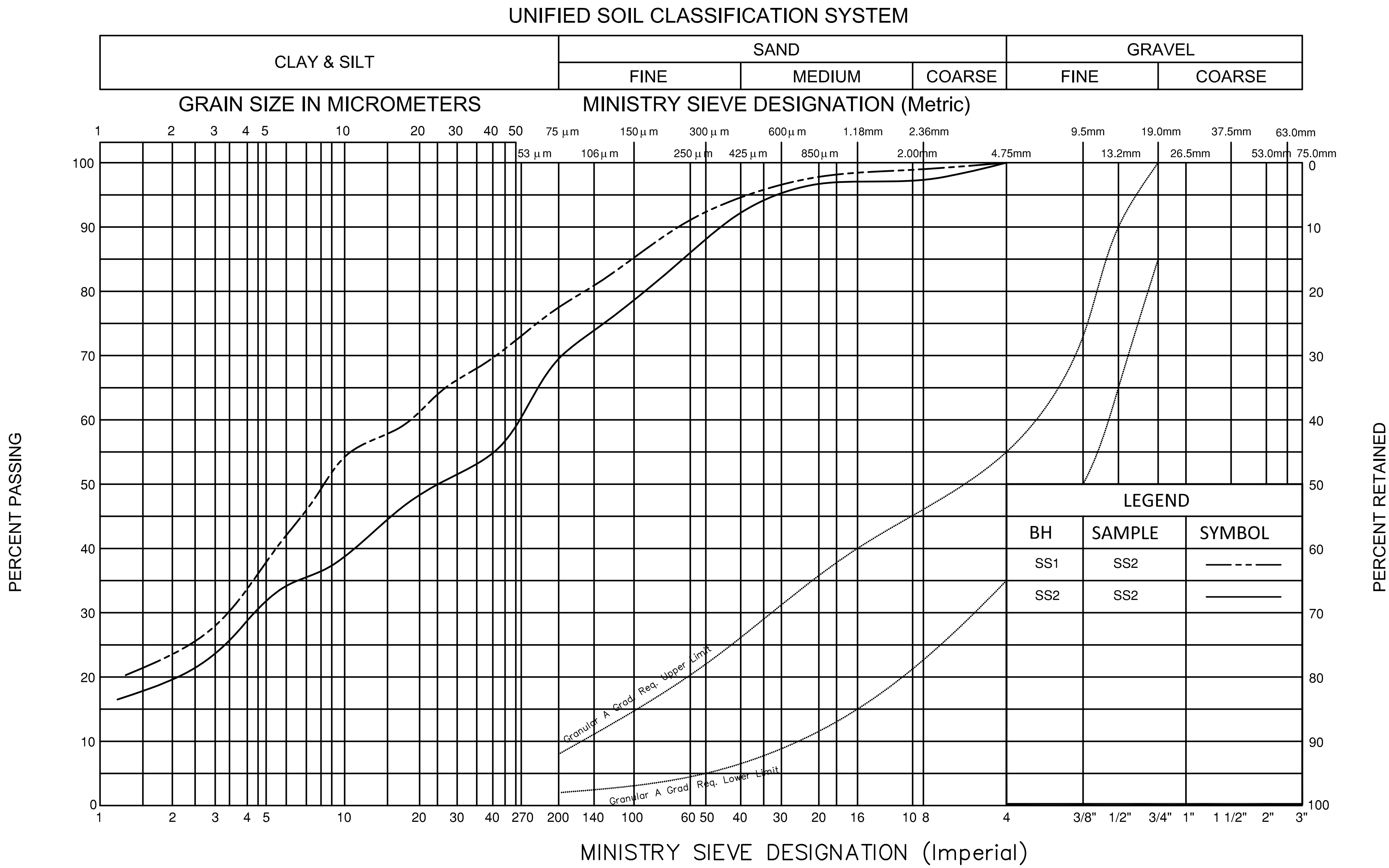


Ontario

GRAIN SIZE DISTRIBUTION

SANDY GRAVEL, some silt
(FILL)

FIG. No	RW-GS-1
HWY 7A Retaining Wall	
TASK No. 2013-E-0039-008	



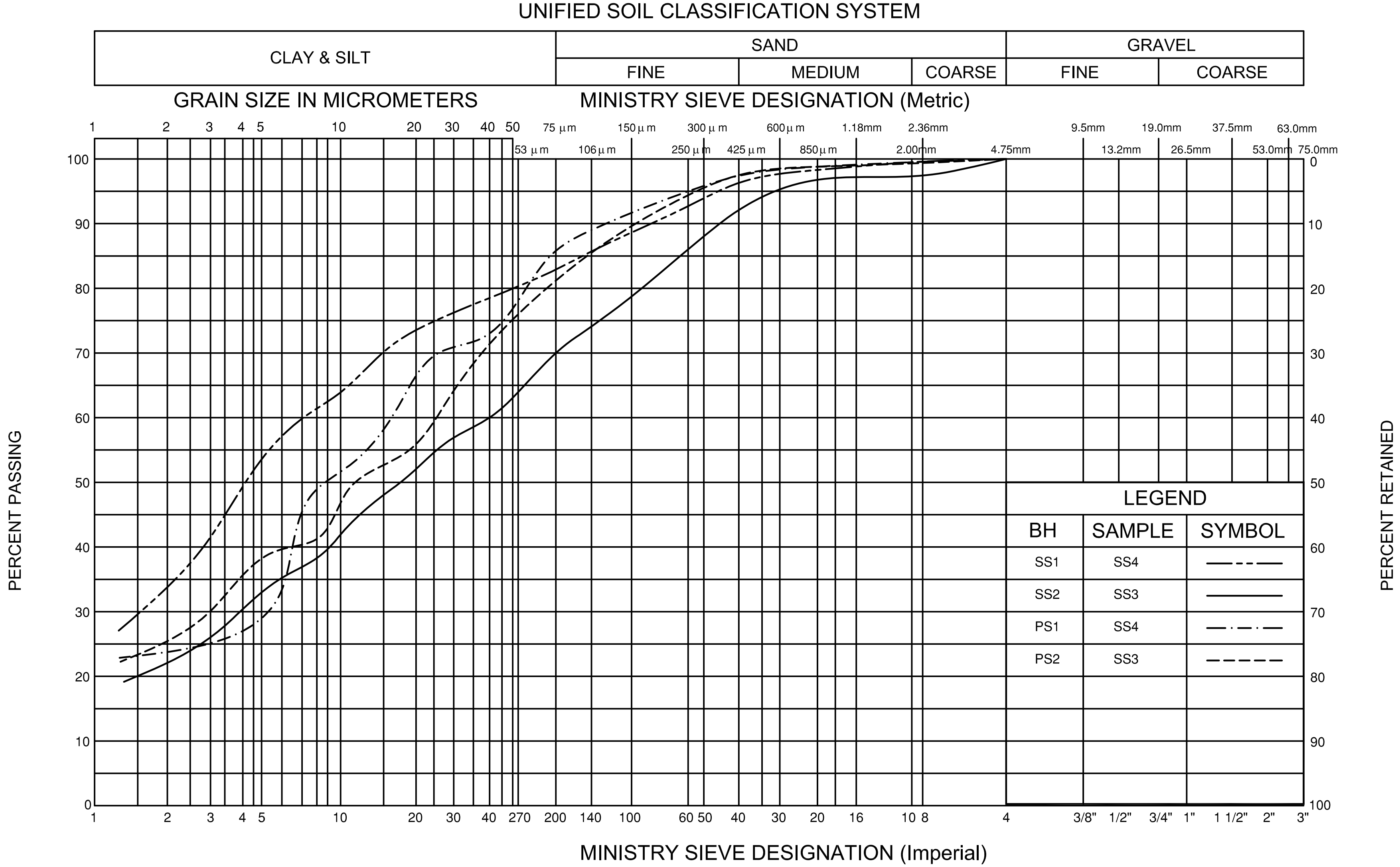
GRAIN SIZE DISTRIBUTION

CLAYEY SILT, with sand to sandy (CL)

(FILL)

Ontario

FIG. No RW-GS-2
HWY 7A Retaining Wall
TASK No. 2013-E-0039-008

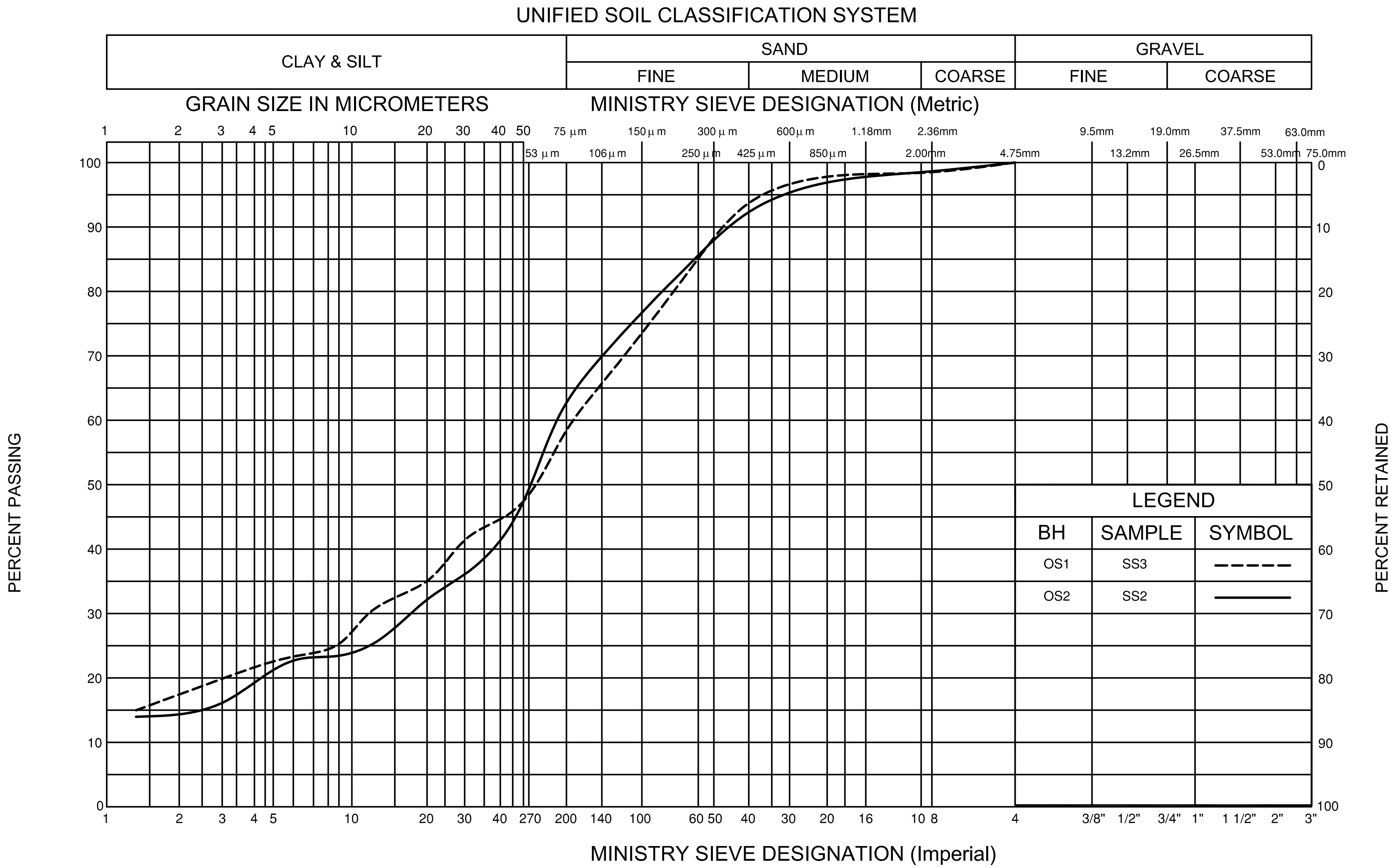


Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT, some sand to sandy (CL)
(TILL)

FIG. No RW-GS-3
HWY 7A Retaining Wall
TASK No. 2013-E-0039-008

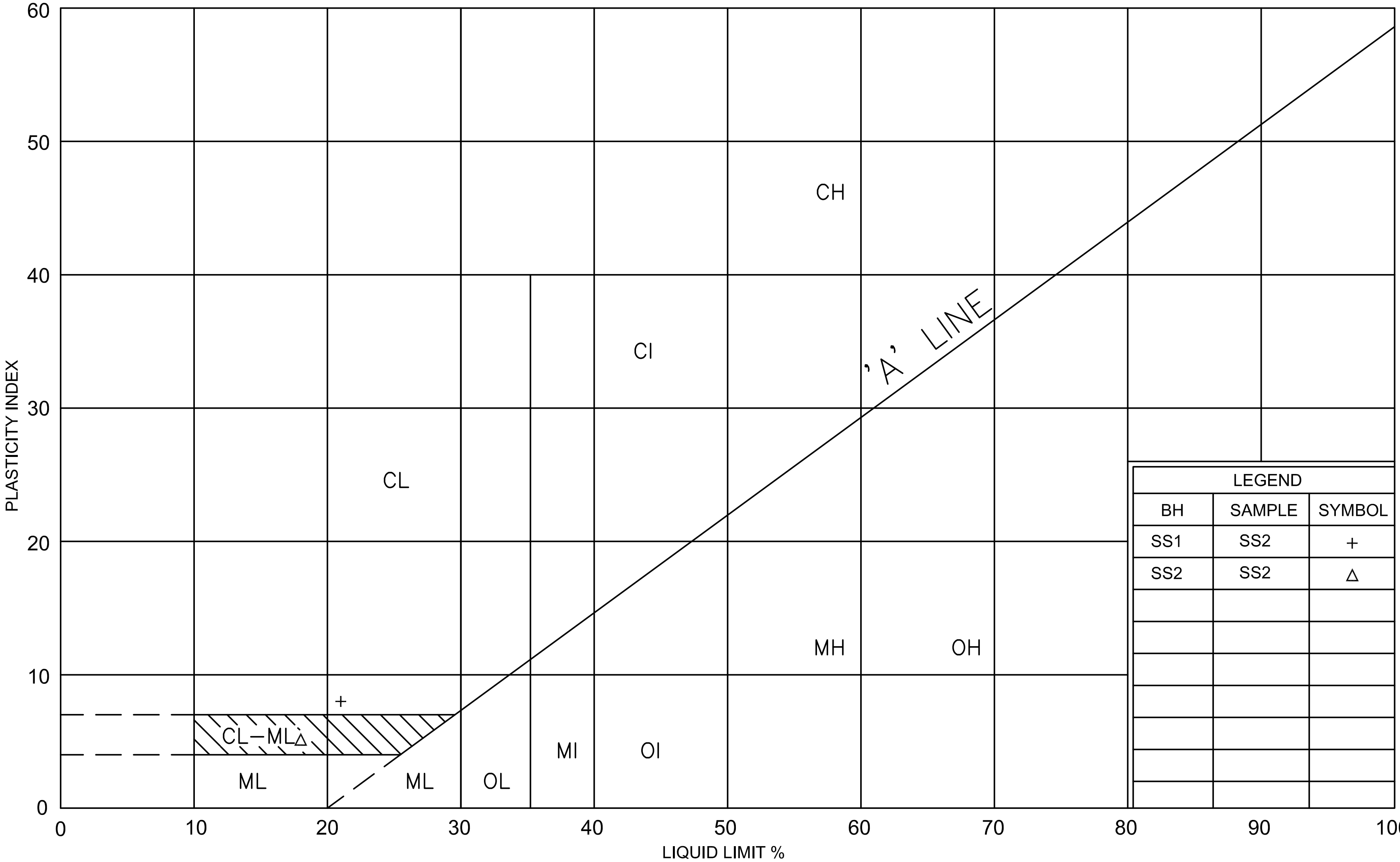


GRAIN SIZE DISTRIBUTION

SAND AND SILT to SANDY SILT, some clay (ML)
(TILL)

Ontario

FIG. No RW-GS-4	
HWY 7A Retaining Wall	
TASK No. 2013-E-0039-008	



LEGEND		
BH	SAMPLE	SYMBOL
SS1	SS2	+
SS2	SS2	△

PLASTICITY CHART

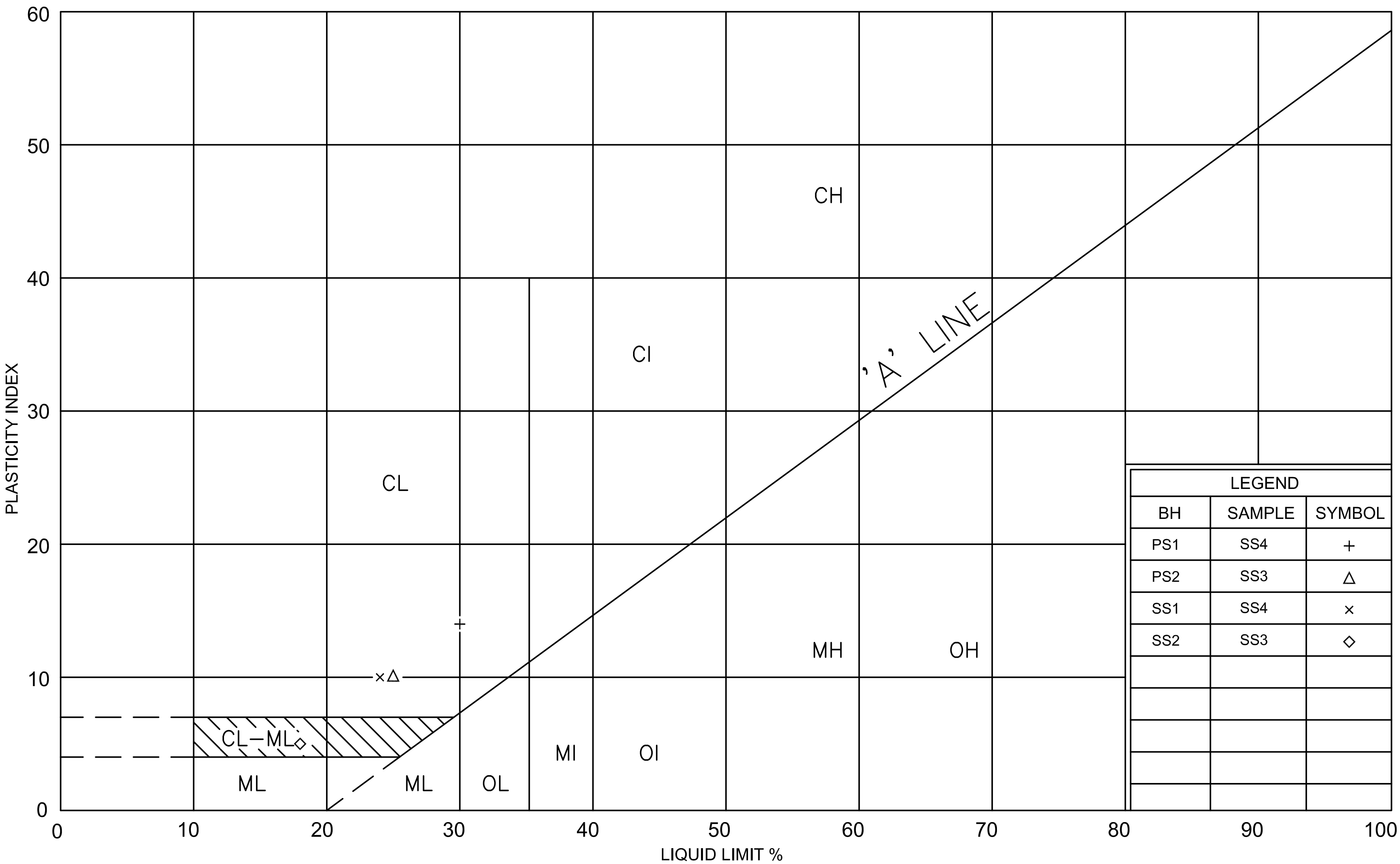
CLAYEY SILT, with sand to sandy (CL-ML / CL)

(FILL)

FIG. No RW-PC-1

HWY 7A Retaining Wall

TASK No. 2013-E-0039-008



LEGEND		
BH	SAMPLE	SYMBOL
PS1	SS4	+
PS2	SS3	△
SS1	SS4	×
SS2	SS3	◇

Ontario

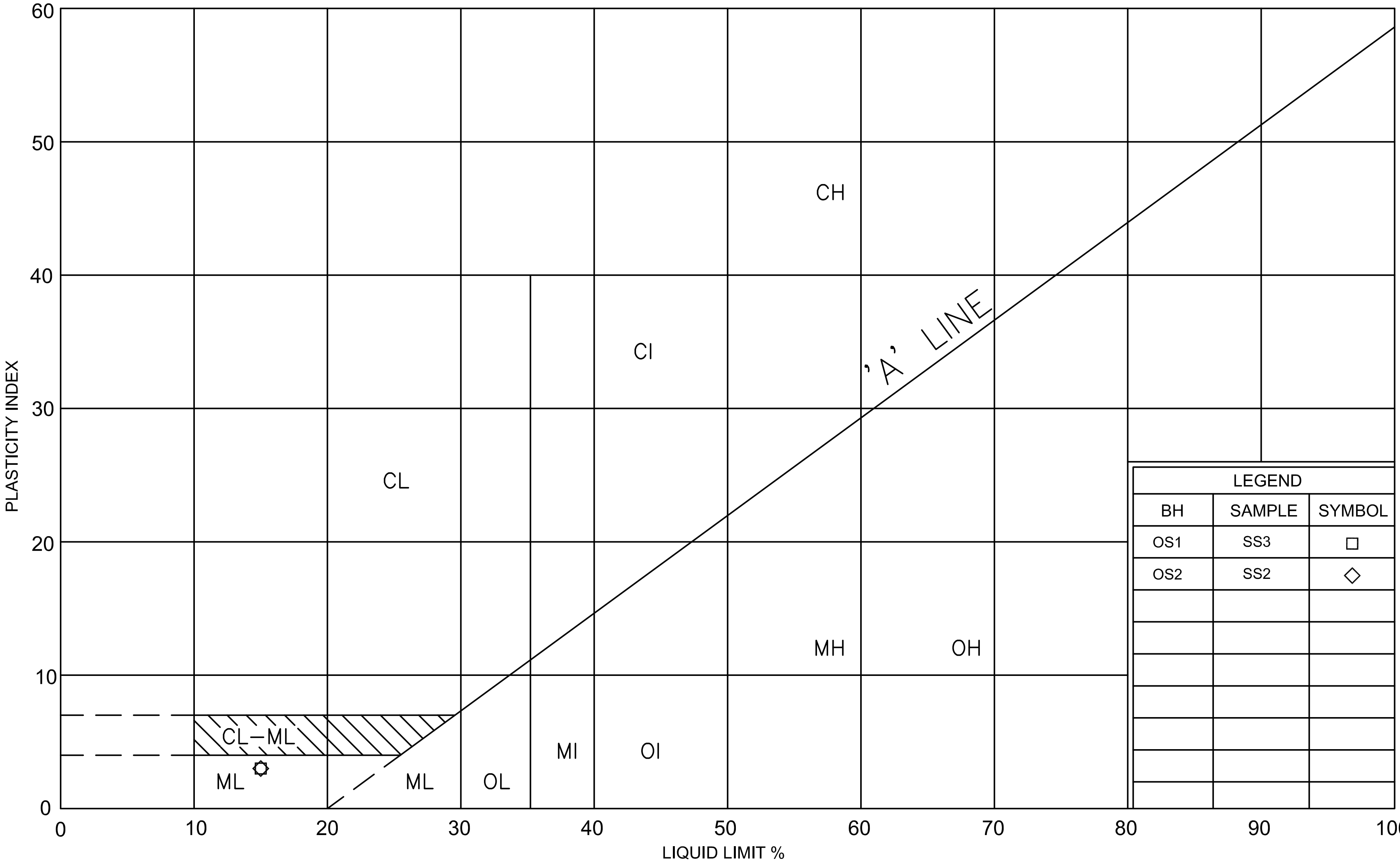
PLASTICITY CHART

CLAYEY SILT, with sand to sandy (CL-ML / CL)
(TILL)

FIG. No RW-PC-2

HWY 7A Retaining Wall

TASK No. 2013-E-0039-008



Ontario

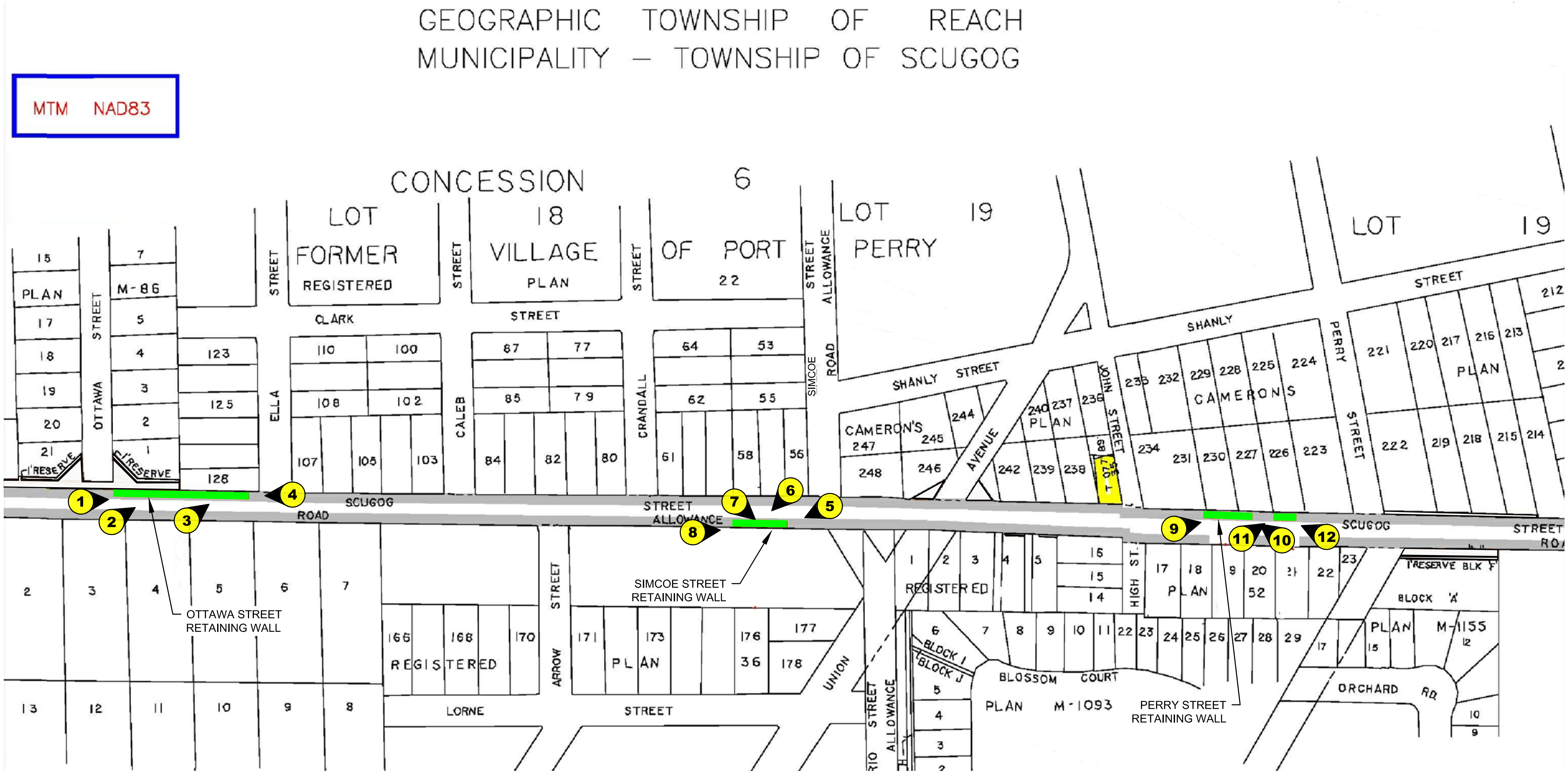
PLASTICITY CHART

SAND AND SILT TO SANDY SILT, some clay (ML)
(TILL)

FIG. No RW-PC-3

HWY 7A Retaining Wall

TASK No. 2013-E-0039-008



SITE AND PHOTOGRAPH LOCATION PLAN

LEGEND:

12 Location and direction of photograph

Approximate location of retaining wall

REFERENCE: THIS DRAWING WAS PREPARED FROM ***'PROPERTY OWNERSHIP PLATES PAGE 1'*** PLATE No. 034-7A/TRS, DRAWING No. 03407AOS DATED MAY 2010 PROVIDED BY THE MINISTRY OF TRANSPORTATION - ONTARIO.

HIGHWAY 7A RETAINING WALLS

PORT PERRY, ONTARIO

METRIC

Ontario

SCALE 50 0 25 50

Peto MacCallum Ltd. CONSULTING ENGINEERS

SITE AND PHOTOGRAPH LOCATION PLAN

TASK No. 2013-E-0039-008

DRAWING # RW-1

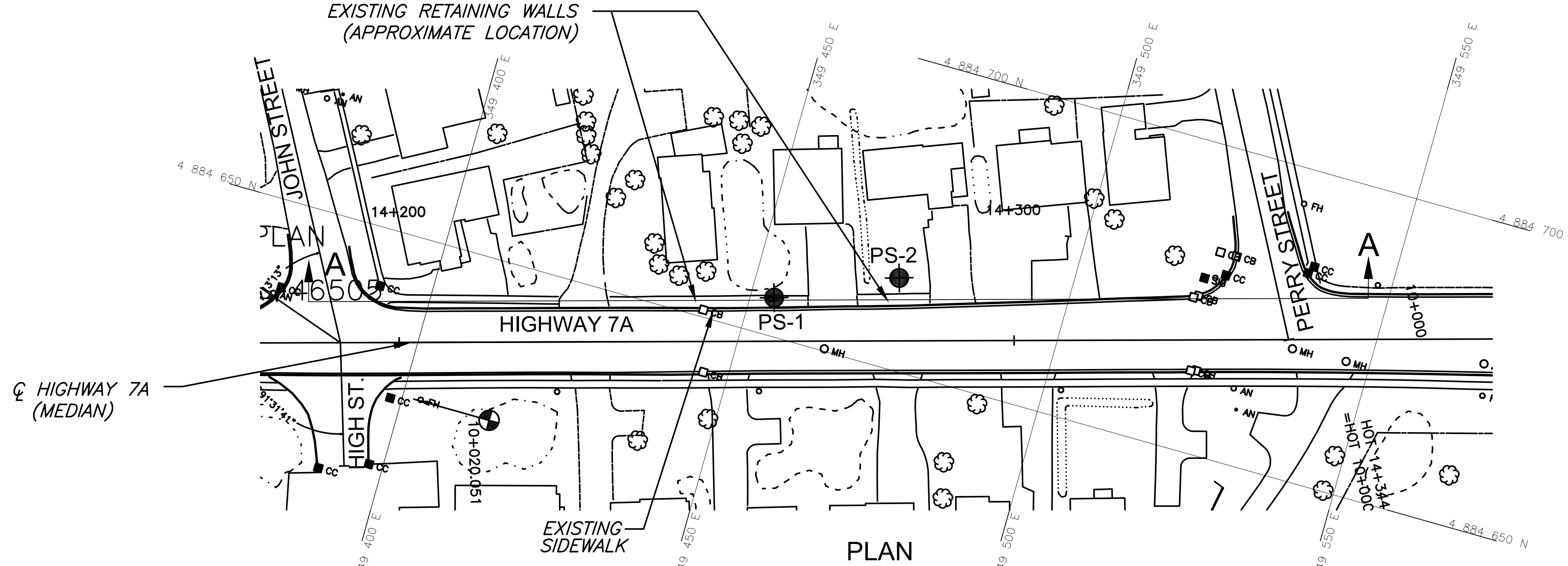
CONT No

TASK No 2013-E-0039-008

PERRY STREET RETAINING WALL
HIGHWAY 7A
BOREHOLE LOCATIONS AND SOIL STRATA

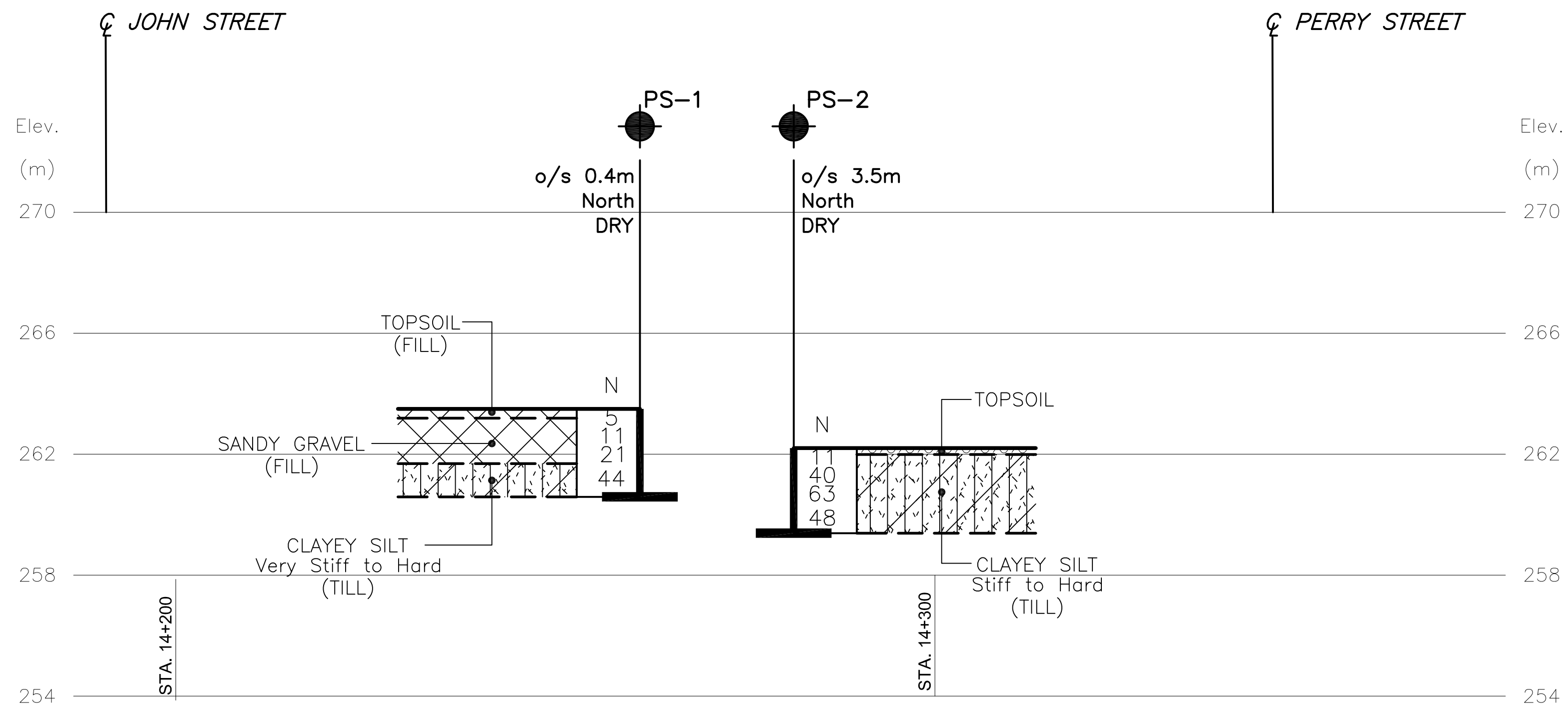
SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN

SCALE



PROFILE A-A

SCALE
HORIZONTAL

VERTICAL

KEY PLAN
SCALE: 1 : 25,000

LEGEND

Borehole

Borehole and Cone

Auger probe (AP)

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

CONE Blows/0.3m (60 Cone, 475 J/blow)

WL at time of investigation May 2015

WH Penetration due to weight of hammer

* Water level not established

Head

ARTESIAN WATER

Encountered

PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
PS–1	263.5	4 884 656.2	349 453.8
PS–2	262.2	4 884 664.8	349 472.5

– NOTE –

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Reference MTO Drawings:
b-34-7a-46504.dwg, b-34-7a-46505.dwg, and b-34-7a-46506.dwg, undated

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31D-628

HWY No 7A			DIST Central
SUBM'D NA	CHECKED KD	DATE OCT. 15, 2015	SITE 22-579/W & 22-580/W
DRAWN NL	CHECKED GD	APPROVED CN	DWG PS-1

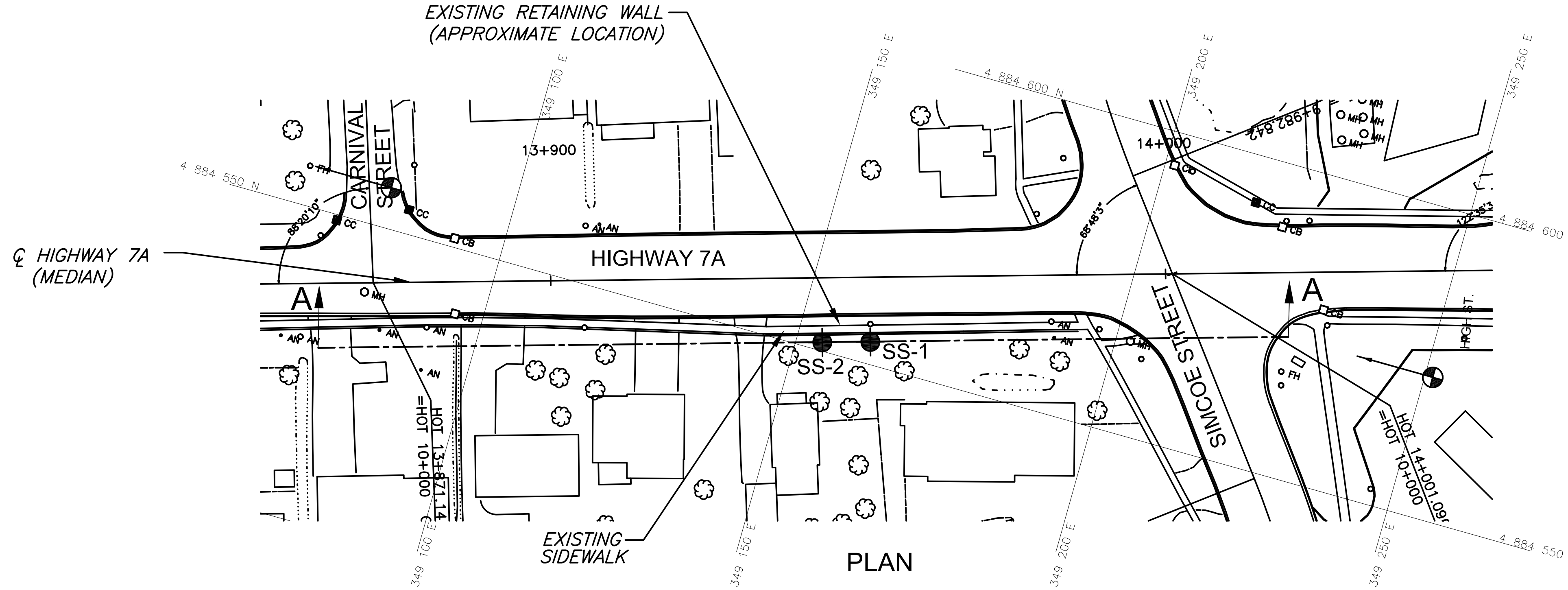
CONT No

TASK No 2013-E-0039-008

SIMCOE STREET RETAINING WALL
HIGHWAY 7A
BOREHOLE LOCATIONS AND SOIL STRATA

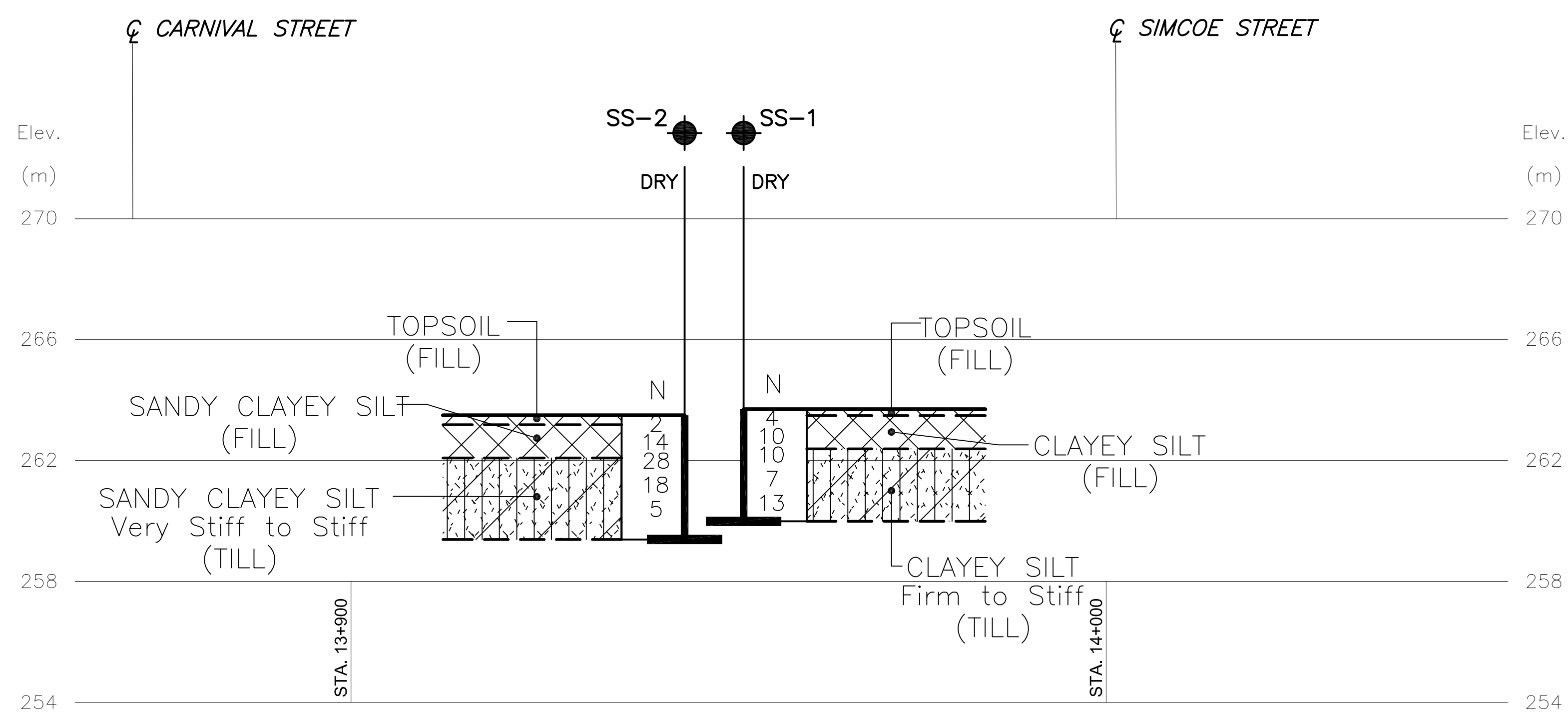
SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN

SCALE



PROFILE A-A

SCALE
HORIZONTAL

VERTICAL

KEY PLAN
SCALE: 1 : 25,000

LEGEND

Borehole

Borehole and Cone

Auger probe (AP)

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

CONE Blows/0.3m (60 Cone, 475 J/blow)

WL at time of investigation May 2015

WH Penetration due to weight of hammer

* Water level not established

Head
ARTESIAN WATER
Encountered

PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
SS–1	263.7	4 884 553.6	349 161.7
SS–2	263.5	4 884 551.4	349 154.2

– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Reference MTO Drawings:
b-34-7a-46504.dwg, b-34-7a-46505.dwg, and b-34-7a-46506.dwg, undated

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31D-628

HWY No 7A			DIST Central
SUBM'D NA	CHECKED KD	DATE OCT. 15, 2015	SITE
DRAWN NL	CHECKED GD	APPROVED CN	DWG SS-1

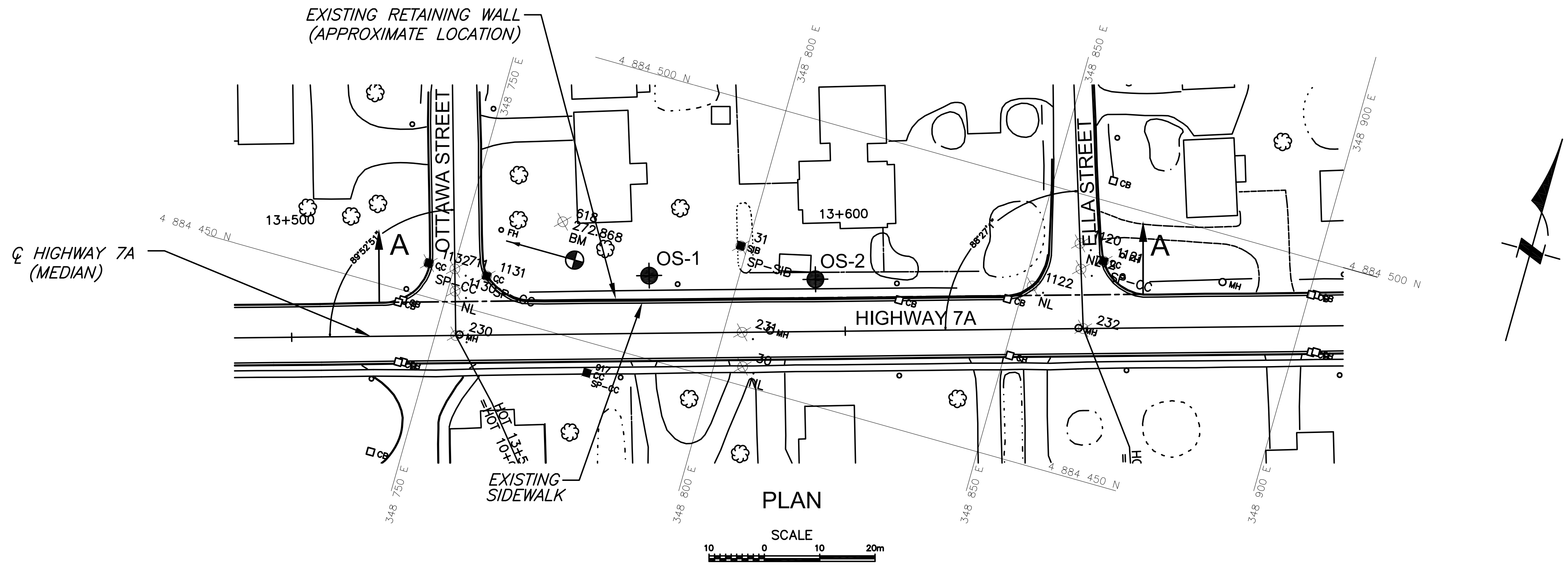
CONT No

TASK No 2013-E-0039-008

SHEET

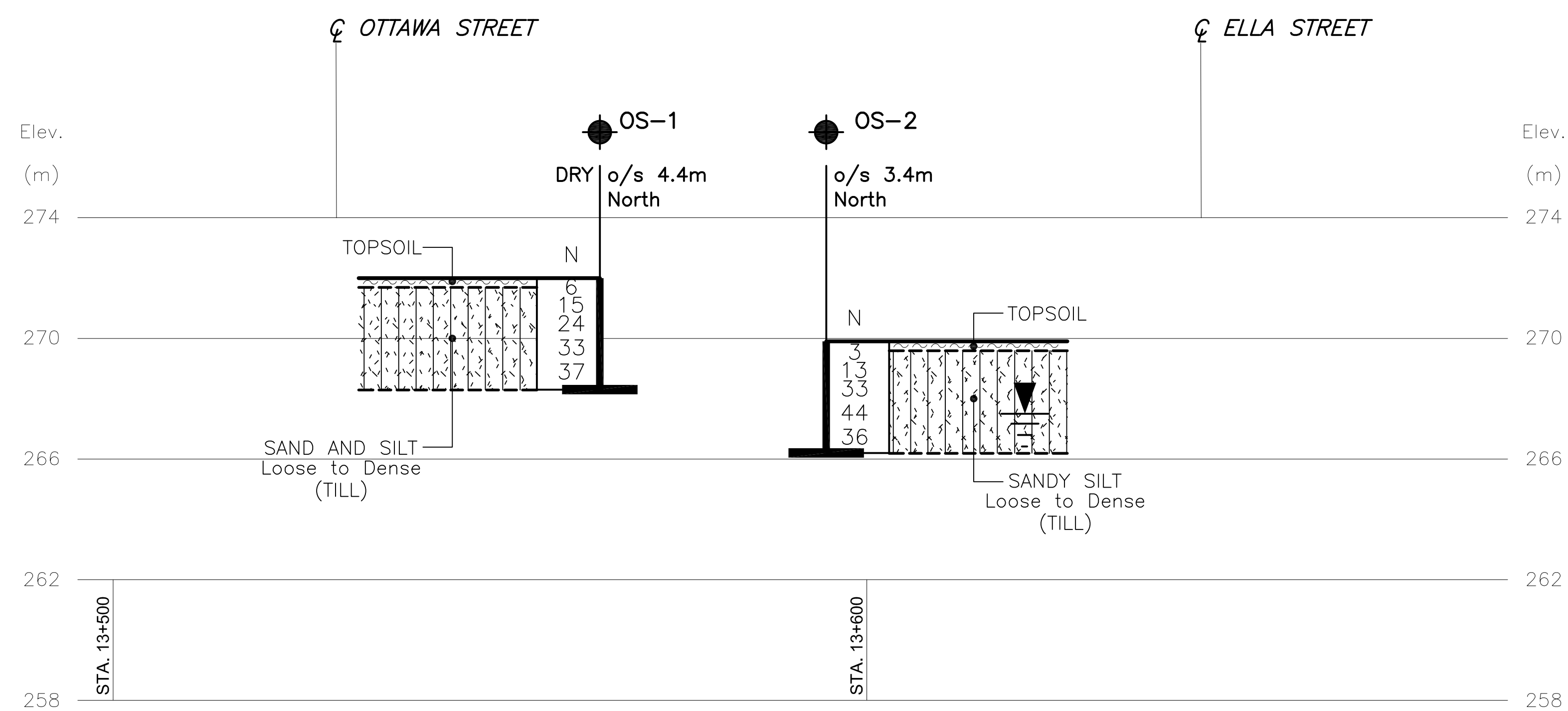
OTTAWA STREET RETAINING WALL
HIGHWAY 7A
BOREHOLE LOCATIONS AND SOIL STRATA

Peto MacCallum Ltd.
CONSULTING ENGINEERS



PLAN

SCALE



PROFILE A-A

SCALE
HORIZONTAL
VERTICAL

LEGEND

- Borehole
- Borehole and Cone
- Auger probe (AP)
- N Blows/0.3m (Std. Pen Test, 475 J/blow)
- CONE Blows/0.3m (60 Cone, 475 J/blow)
- WL at time of investigation May 2015
- WH Penetration due to weight of hammer
- * Water level not established
- Head
- ARTESIAN WATER
- Encountered
- PIEZOMETER

BH No	ELEVATION	NORTHINGS	EASTINGS
OS–1	272.0	4 884 464.6	348 784.3
OS–2	269.9	4 884 472.1	348 813.4

– NOTE –

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

NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

Reference MTO Drawings:
b-34-7a-46504.dwg, b-34-7a-46505.dwg, and b-34-7a-46506.dwg, undated

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 31D-628

HWY No	7A			DIST	Central
SUBM'D	NA	CHECKED KD	DATE OCT. 15, 2015	SITE	22-578/W
DRAWN	NL	CHECKED GD	APPROVED CN	DWG	OS-1

APPENDIX FIR-A

Site Photographs

Photograph 1: Taken at the west end of the Ottawa Street retaining wall, facing east. (April 16, 2015)

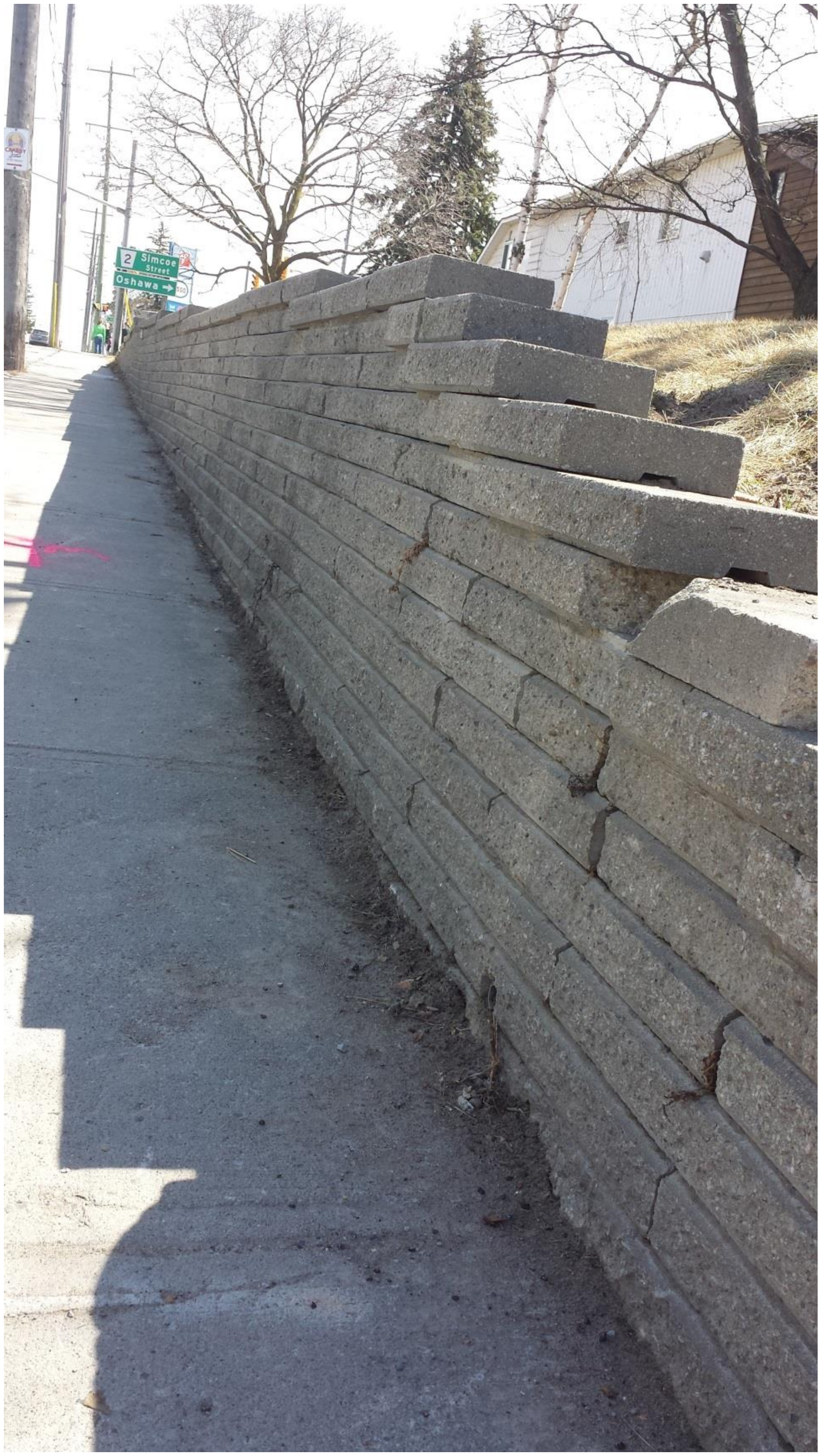
Photograph 2: Taken at the Ottawa Street retaining wall, facing northeast. (May 13, 2015)

Photograph 3: Taken near the east end of the Ottawa Street retaining wall, facing northeast. (May 13, 2015)

Photograph 4: Taken at the east end of the Ottawa Street retaining wall, facing west. (May 13, 2015)

Photograph 5: Taken at the east end of the Simcoe Street retaining wall, facing west. (April 16, 2015)

Photograph 6: Taken at the Simcoe Street retaining wall, facing southwest. (April 16, 2015)



Photograph 7: Taken at the Simcoe Street retaining wall, facing southeast. (April 16, 2015)

Photograph 8: Taken at the west end of the Simcoe Street retaining wall, facing east. (April 16, 2015)

Photograph 9: Taken at the Perry Street retaining wall, facing east. (April 16, 2015)

Photograph 10: Taken at the Perry Street retaining wall, facing west. (April 16, 2015)

Photograph 11: Taken at the Perry Street retaining wall, facing northeast. (April 16, 2015)

Photograph 12: Taken at the Perry Street retaining wall, facing west. (April 16, 2015)

APPENDIX FIR-B

Memorandum dated November 1, 1994

memorandum

Ontario

(416) 235-3731

1994 11 01

To: Karen Smith
Assistant Maintenance Engineer
Central Region
1st Floor, Atrium Tower

From: Pavement and Foundation Design Section
Room 315, Central Building
Downsview, Ontario

Re: Pisa Stone Retaining Wall
Hwy 7A, Near Regional Road 2 in Port Perry
W.O. 94-11013
District 6, Toronto

At your request, we visited the above mentioned site to investigate the cause of distress to a retaining wall. It is understood that the retaining wall was constructed in 1983. Recently some movement took place in the wall which caused a gap between the wall and the retained soil.

The site is located in the southwest corner of Hwy 7A and Regional Road 2 in Port Perry. A 30.5m long and 1m high 'Pisa stone' retaining wall is constructed on the south side of Hwy 7A oriented in the east-west direction. The wall retains the front yard of a house to provide room for a sidewalk on the immediately north side of the wall. The house is situated on the south side of the wall at a distance of about 12m from the wall on a higher ground. The wall is 0.96m high and is constructed with 12 layers of block, each 75mm thick and 600mm long.

The wall appeared to be almost vertical. However, according to the contract drawings (Cont. No 83-84, WP No 138-75-03) the wall was supposed to be constructed at 1H:8V. If the wall was constructed as per drawing, then it means the top of the wall had moved up to 12 cm. According to the drawing, weeping holes were to be provided every 3m (i.e. at least 10 weeping holes in the entire length of the wall), but there were no weeping holes in the retaining wall. We observed two longitudinal cracks in the ground, one adjacent to the wall and the other at a distance of 760mm from the wall. The cracks were 50mm to 75mm wide and of similar depth in a conical shape. The cracks were covered with grass. There were few vertical cracks in the wall as well.

Assuming the Pisa Stone retaining wall was designed to withstand the earth pressures imposed by the geometry, in our opinion, the distress in the wall is due to lack of provision to allow drainage of water behind the retaining wall, e.g. no weeping holes as shown in the drawing and/or inadequate free draining material behind the retaining wall.

Provided that you have no concern for the safety of the residents with respect to the cracks behind the wall, in our opinion, there is no immediate danger to the integrity of the wall. The movement in the wall has been taking place for a long period of time. However, we suggest that if any further movement in the wall is observed, then the wall should be repaired. In order to provide free draining material behind the wall, perhaps the entire wall will have to be replaced. Alternatively, the wall could be replaced with reinforced earth type wall.

If you have any questions please call our office.

K.S.Q. Ahmad, P. Eng.
Foundation Engineer

For

D. Dundas, P. Eng.
Senior Foundation Engineer

Peto MacCallum Ltd.
CONSULTING ENGINEERS

FOUNDATION DESIGN REPORT

for

RETAINING WALLS
HIGHWAY 7A
TOWNSHIP OF PORT PERRY, ONTARIO
AGREEMENT NO. 2013-E-0039
TASK NO. 2013-E-0039-008

PREPARED FOR MINISTRY OF TRANSPORTATION OF ONTARIO

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GEOCRES No.: 31D-628
October 15, 2015

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FOUNDATION DESIGN REPORT
for
Retaining Walls
Highway 7A
Township of Port Perry, Ontario
Task No. 2013-E-0039-008

7. INTRODUCTION

7.1 General

This report provides recommendations for foundation design and comments for construction of the replacement retaining wall structures along Highway 7A in Port Perry, Ontario.

The project calls for the replacement of four earth retaining walls that are located on the north or south sides of Highway 7A. The Site and Photograph Location Plan, Drawing RW-1 in the Foundation Investigation Report, illustrates the locations of the four retaining walls. Drawings PS-1, SS-1 and OS-1 depict the borehole locations and soil strata at the respective retaining wall sites.

The existing retaining walls are of the modular precast concrete type, such as Pisa Stone retaining walls. The typical precast concrete element (stone) is approximately 75 mm thick, 300 mm wide and 600 mm long. The walls retain the front and side yards of the respective lots to provide room for a concrete or asphalt sidewalk immediately in front of the structures. The details of each retaining wall identified for replacement can be found in the following table (Table 7.1).

Table 7.1: Details of Existing Retaining Walls

RETAINING WALLS	WALL #	MTO SITE ID	LENGTH (m)	MAX HEIGHT (m)
Perry Street	Wall # 1 and 2	22-579/W, 22-580/W	32 and 11	1.25 and 0.75
Simcoe Street	Wall # 3	N/A	32	0.96
Ottawa Street	Wall # 4	22-578/W	78	1.35

The deterioration of the existing retaining walls is attributed to lack of drainage behind the walls, frost susceptibility of the backfill and native soils present at the site and deterioration of the adhesive or cementing material over time.

All elevations in this report are expressed in metres.

7.2 Perry Street Retaining Walls – Wall #'s 1 and 2

In summary, the soil stratigraphy revealed in the reference boreholes PS-1 and PS-2 for the Perry Street retaining walls generally comprised topsoil and / or granular fill overlying a deep and continuous deposit of clayey silt till. The retaining walls are founded in a desiccated zone of the glacial till, which was not penetrated by the reference boreholes and extends to levels below elevations 259.3 to 260.6. The cohesive till typically exhibited very stiff to hard consistency.

No groundwater was observed in either borehole during or upon completion of drilling.

7.3 Simcoe Street Retaining Wall – Wall # 3

In summary, the soil stratigraphy revealed in the reference boreholes SS-1 and SS-2 for the Simcoe Street retaining wall generally comprised topsoil overlying fill material, underlain by an extensive deposit of clayey silt till. The retaining wall is founded in a desiccated zone of the glacial till, which was not penetrated by the reference boreholes and extends to levels below elevations 259.4 to 260.0. The cohesive till typically exhibited stiff to very stiff consistency.

No groundwater was observed in either borehole during or upon completion of drilling.

7.4 Ottawa Street Retaining Wall – Wall # 4

In summary, the soil stratigraphy revealed in the reference boreholes OS-1 and OS-2 for the Ottawa Street retaining wall generally comprised topsoil overlying an extensive deposit of sand and silt to sandy silt till. The retaining wall is founded in the glacial till, which was not penetrated by the reference boreholes extending to levels below elevations 266.2 to 268.3. The non-cohesive till typically exhibited compact to dense relative density.

Perched groundwater was observed during drilling at 2.4 m depth (elevation 267.5) in borehole OS-2. No water was observed in borehole OS-2 upon completion of drilling. However, it should be noted that groundwater levels are subject to seasonal fluctuations and rainfall patterns.

8. EVALUATION OF RETAINING WALL ALTERNATIVES

8.1 General

Refer to Table 8.1 for the comparison of retaining wall alternatives proposed for the replacement of the 4 structures. A retained soil system (RSS) gravity type, RSS mechanically stabilized earth (MSE) type and conventional cast-in-place concrete walls bearing on spread footings were considered as feasible alternatives.

Table 8.1: Comparison of Retaining Wall Alternatives

WALL ALTERNATIVE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST
Cast-in-Place Concrete on Spread Footings	Longer service life than RSS walls.	Requires site specific design. Requires deeper frost protection and hence deeper excavations to construct footings.	Increased risk of destabilization of retained ground due to deeper excavation requirements for foundations. Increases risk of dewatering issues due to deeper excavation requirements for foundations. May require protection or relocation of utilities.	More expensive than RSS walls.
Cast-in-Place Concrete on Deep Foundations	Longer service life RSS Walls.	Requires site specific design. Requires more complex construction including pile installation equipment.	Increased risk of destabilization of retained ground due to deeper excavation requirements for foundations. Increases risk of dewatering issues due to deeper excavation requirements for foundations. May require protection or relocation of utilities.	More expensive than RSS walls and CIP spread footing walls.

WALL ALTERNATIVE	ADVANTAGES	DISADVANTAGES	RISKS / CONSEQUENCES	RELATIVE COST
RSS Gravity Type	Superior appearance. Fast and efficient design and construction. Less depth of excavation required for frost protection of footings.		Contracting protocol for RSS would permit any type of RSS wall that meets the performance and appearance requirements and some types or walls may be inappropriate due to their backfill requirements.	Less expensive than cast-in-place or RSS MSE or Deep Foundations walls.
RSS Mechanically Stabilized Earth (MSE) Type	Superior appearance.	Requires more excavation for MSE zone behind walls that could impact existing utilities and vegetation.	Contracting protocol for RSS would permit any type of RSS wall that meets the performance and appearance requirements and some types or walls may be inappropriate due to their backfill requirements.	More expensive than RSS Gravity walls.
RSS Deep Foundations Type	Superior appearance.	Requires more excavation and pile installation equipment. The installation of piles could impact existing utilities and vegetation.	Contracting protocol for RSS would permit any type of RSS wall that meets the performance and appearance requirements and some types or walls may be inappropriate due to their backfill requirements.	More expensive than RSS Gravity walls.

8.2 Preferred Alternative

In consideration of the low height of the walls, the space and property constraints and the relative costs, a proprietary gravity block wall comprising modular precast concrete elements is the preferred alternative for the replacement of the 4 retaining walls. The net increase in pressure from the new wall backfill will be relatively small given that the proposed height of the structures will be similar to that of the existing structures at a maximum of about 1.5 m.

Consideration should be given to explicitly specifying a gravity type RSS wall with medium performance and high appearance in order to avoid the possibility of other types of RSS walls that might not be appropriate for this application and that could impose unnecessary property damage due to the extent of their backfill zones.

9. FOUNDATION RECOMMENDATIONS

9.1 Retained Soil System (RSS)

The following comments pertain to both RSS gravity type and RSS MSE type retaining walls.

A medium performance, high appearance rated RSS wall should be employed. The design, supply and construction of the RSS wall should conform to SP 599S22 and SP 599S23.

RSS walls can be founded at the same locations as the existing structures on the native glacial till soils. Refer to Sections 9.1.1, 9.1.2 and 9.1.3 of this report for further details pertaining to each specific retaining wall site. It is envisioned that the RSS earth retaining walls will be constructed utilizing a series of steps in the founding level to match the elevation variations with respect to the site grading.

The RSS supplier should be responsible for specifying the type of backfill material to be employed and the drainage requirements behind the RSS walls for the replacement of the retaining walls.

The designer of the RSS should be responsible for the detail design of the structures and provide drawings to show pertinent information such as location, length, height, elevations, performance level, appearance, etc.

9.1.1 Perry Street Retaining Walls – Walls # 1 and 2

The existing Perry Street retaining walls are 32 and 11 m in length and range from approximately 0.2 to 1.25 m in height above the adjacent paved asphalt sidewalk. The adjacent asphalt sidewalk gradually slopes downward from west to east.

The factored geotechnical resistance at ultimate limit state (ULS) and the geotechnical resistances at serviceability limit states (SLS) at the recommended founding level for RSS gravity type, RSS MSE type and cast-in-place alternatives for the Perry Street retaining walls are summarized in the following table (Table 9.1.1).

Table 9.1.1: Perry Street Retaining Walls Founding Parameters

RETAINING WALL	RETAINING WALL TYPE	FOUNDING ELEVATION (m)	REFERENCE BOREHOLE	FOUNDING SOIL	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Perry Street West Wall # 1	RSS	261.7	PS-1	Very Stiff to Hard Clayey Silt Till	225	150
	Cast-in-Place	260.9			225	150
Perry Street East Wall # 2	RSS	260.7	PS-2	Stiff to Hard Clayey Silt Till	225	150
	Cast-in-Place	259.9			225	150

The recommended geotechnical resistance at SLS allows for a maximum 25 mm compression of the founding medium.

9.1.2 Simcoe Street Retaining Wall – Wall # 3

The existing Simcoe Street retaining wall is 32 m in length and ranges from approximately 0.3 to 0.96 m in height above the adjacent sidewalk. The adjacent sidewalk gradually slopes downward from east to west.

The factored geotechnical resistance at ultimate limit state (ULS) and the geotechnical resistances at serviceability limit states (SLS) at the recommended founding level for RSS gravity type, RSS MSE type and cast-in-place alternatives for the Simcoe Street retaining wall is summarized in the following table (Table 9.1.2).

Table 9.1.2: Simcoe Street Retaining Wall Founding Parameters

RETAINING WALL	RETAINING WALL TYPE	FOUNDING ELEVATION (m)	REFERENCE BOREHOLE	FOUNDING SOIL	FACTORED GEOTECHNICAL RESISTANCE AT ULS (kPa)	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Simcoe Street	RSS	261.9	SS-1	Firm to Stiff Clayey Silt Till	150	100
	Cast-in-Place	261.1			150	100
	RSS	261.9	SS-2	Stiff to Very Stiff Clayey Silt Till	150	100
	Cast-in-Place	261.1			150	100

The recommended geotechnical resistance at SLS allows for a maximum 25 mm compression of the founding medium.

9.1.3 Ottawa Street Retaining Wall – Wall # 4

The existing Ottawa Street retaining wall is 78 m in length and ranges from approximately 0.3 to 1.35 m in height above the adjacent paved boulevard. The adjacent asphalt sidewalk slopes downward from the west end to the east end of the retaining wall.

The factored geotechnical resistance at ultimate limit state (ULS) and the geotechnical resistances at serviceability limit states (SLS) at the recommended founding level for RSS gravity type, RSS MSE type and cast-in-place alternatives for the Ottawa Street retaining wall is summarized in the following table (Table 9.1.3).

Table 9.1.3: Ottawa Street Retaining Wall Founding Parameters

RETAINING WALL	RETAINING WALL TYPE	FOUNDING ELEVATION (m)	REFERENCE BOREHOLE	FOUNDING SOIL	FACTORED GEOTECHNICAL RESISTANCE	GEOTECHNICAL RESISTANCE AT SLS (kPa)
Ottawa Street	RSS	270.5	OS-1	Dense Sand and Silt Till	225	150
	Cast-in-Place	269.7			225	150
	RSS	267.9	OS-2	Dense Sandy Silt Till	225	150
	Cast-in-Place	267.1			225	150

The recommended geotechnical resistance at SLS allows for a maximum 25 mm compression of the founding medium.

9.2 Cast-in-Place Concrete Walls

9.2.1 Geotechnical Bearing Resistances

Cast-in-place concrete walls bearing on spread footings are also considered to be feasible at the project sites. The geotechnical resistances and founding elevations recommended in Sections 9.1.1, 9.1.2 and 9.1.3 apply for cast-in-place structures founded on native soils.

9.2.2 Lateral Earth Pressure

The retaining walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure, p (kPa) may be computed using the following equation.

$$p = K(\gamma h + q) + Cp + Cs$$

Where:

	K	=	coefficient of lateral earth pressure (dimensionless)
	γ	=	unit weight of free-draining granular material, kN/m^3
	h	=	depth below final grade, m
	q	=	surcharge load, kPa, if present
	Cp	=	compaction pressure, kPa
	Cs	=	earth pressure induced by seismic events, kPa

Free-draining granular material should be used as backfill behind the wall. Refer to Table 9.2.2 for parameters recommended for design:

Table 9.2.2: Parameters for Backfill Material

PARAMETERS	GRANULAR A OR GRANULAR B TYPE II
Internal Friction Angle, Ø (degrees)	35
Unit weight, γ (kN/m^3)	22.8
Coefficient of Active Earth Pressure, K_a	0.27
Coefficient of Earth Pressure At Rest, K_o	0.43
Coefficient of Passive Earth Pressure, K_p	3.69

The coefficient of earth pressure at rest should be used for the design of unyielding walls. The active earth pressure coefficient should be used for unrestrained structures. Alternatively, the material above the top of the wall could be treated as a surcharge load (q in the preceding equation).

The magnitude of the passive resistance is dependent on the actual lateral movement of the structure toward the retained soil. Refer to Figure C6.16 of the CHBDC for this computation.

9.2.3 Sliding Resistance

The horizontal resistance / sliding resistance of the foundations should be calculated in accordance with Section 6.7.5 of the CHBDC (2006). The coefficient of friction, tan δ, between the retaining walls and the native glacial till soils may be taken as 0.45.

9.2.4 Backfill

The backfill behind the retaining walls should consist of suitable free draining granular materials such as Granular A or Granular B Type II and the backfill geometry should be according to OPSD 3121.150 and OPSD 3120.100. Backfilling adjacent to retaining structures should be carried out in conformance with OPSS.PROV 501. In view of the urban location of the retaining walls that will be subjected to frequent watering resulting in possible contamination of the backfill with silt particles, protection using geotextile fabric should be considered. The geotextile should be placed between the soil and the granular backfill and should consist of the same material specified for the sub drain system in Section 10.6 of the report.

9.3 Global Stability Analysis

The global stability of the Perry Street and Ottawa Street retaining walls were analysed using the limit equilibrium method (Morgenstern-Price) and employing the commercially available program SLOPE/W version 7.23 developed by Geo-Slope International Ltd.

Based on the results of the Perry Street subsurface investigation, the retaining walls are founded on native clayey silt till. The global stability analysis, using effective stress parameters, indicates that the critical cross-section of the retaining walls will have a Factor of Safety (FoS) greater than 1.5 against deep seated, global failure surface as shown on Figure 1 in Appendix FDR-B.

Based on the results of the Ottawa Street subsurface investigation, the retaining wall is founded on native sandy silt till with perched water encountered at about elevation 267.5. The global stability analysis, using effective stress parameters, indicates that the critical cross-section of the retaining wall will have a Factor of Safety (FoS) greater than 1.5 against deep seated, global failure surface as shown on Figure 2 in Appendix FDR-B.

The results of the Ottawa and Perry Street global stability analyses are considered to be representative of all 4 retaining walls identified for replacement.

9.4 Foundation Frost Depth

The foundation frost depth for structure foundations at this site is 1.4 m, according to OPSD 3090.101. The native soils will allow for a minimum of 0.6 and 1.4 m partial and full foundation frost protection for RSS type and cast-in-place type retaining walls, respectively.

9.5 Seismic Site Coefficient

The seismic site coefficient for the stratigraphic conditions at this site is 1.0 [soil profile Type I, Canadian Highway Bridge Design Code (CHBDC)]. No seismic considerations are required for foundation design of these retaining walls.

10. CONSTRUCTION CONSIDERATIONS

10.1 Specifications

Refer to Table 1 in Appendix FDR-A for a list of specifications relevant to the project.

10.2 Existing Utilities

Protection of existing utilities (underground and above ground) is required during the excavation adjacent to the existing retaining walls.

A single light pole supporting a street light was observed within 0.3 m in front of a section of the Perry Street retaining wall #1. An underground Bell conduit carrying multiple ducts exists within 1.0 to 1.5 m behind both Perry Street retaining walls #1 and #2.

A single hydro pole supporting multiple hydro lines and a street light exists approximately 1.0 m in front of the Simcoe Street retaining wall.

Existing hydro poles supporting multiple hydro lines and street lights are present approximately 1.0 m behind the Ottawa Street retaining wall. In addition, an underground untraceable asbestos cement watermain also exists within 1.0 m of the Ottawa Street retaining wall according to The Regional Municipality of Durham Water Locate Department.

10.3 Excavation

Excavations at the retaining wall locations should be carried out in accordance with the Occupational Health and Safety Act (OHSA), local and MTO regulations. For this purpose, the encountered fill soils and compact to dense sand and silt to sandy silt till soil are considered Type 3 soils. The stiff to hard clayey silt till is considered Type 2 soils. Temporary open-cut excavations should be made with side slopes no steeper than 1H:1V provided that proper groundwater control / dewatering is in place.

10.4 Staging

Staging and lane closures should be considered by the planning and construction engineers. A lane closure is probably required to carry out the work.

10.5 Groundwater Control

No groundwater was observed during the course of the field work at the borehole locations. It is considered that seepage from perched water deposits, soil fissures or surface water run-off that enters the excavation could be handled by conventional sump pumping techniques and no permit to take water will be required. It is noted that groundwater levels are subject to fluctuations due to seasonal and rainfall patterns.

10.6 Drainage and Erosion Control

A sub drain system (SP 405F03) and weep holes (OPSD 3190.100) should be installed to minimize the build-up of hydrostatic pressure behind the retaining walls. The subdrain tiles should be surrounded by a properly designed granular filter or non-woven Class II geotextile (with an FOS of 75 – 100 μm according to OPSS 1860) to prevent migration of fines into the system. The drainage pipes should be installed on a positive grade and lead to frost-free outlets.

Earth fill slopes constructed for this project should be protected against surface erosion by sodding and suitable vegetation. Refer to OPSS 803 and OPSS.PROV 804 for time constraints and the type of seed and mulch required. The upper 300 mm of backfill against the retaining walls should consist of relatively impermeable local clayey material shaped into a swale to mitigate storm water infiltration.

11. CLOSURE

This Foundation Design Report was prepared Mr. K. R. Daly, B.Eng., EIT, Project Supervisor, and reviewed by Mr. D. Dundas, P.Eng and Mr. G.O. Degil, PhD, P.Eng., Senior Foundation Engineers. Mr. C.M.P. Nascimento, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

LICENSED PROFESSIONAL ENGINEER
G. DEGIL
100056241
Oct. 15/15
PROVINCE OF ONTARIO

Kyle R. Daly, B.Eng., EIT
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C. M. P. Nascimento
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Carlos M.P. Nascimento, P.Eng.
MTO Designated Principal Contact

KD/CN/GD/DD:kd/jk

APPENDIX FDR-A

List of Standard Specifications Relevant to the Project

TABLE 1

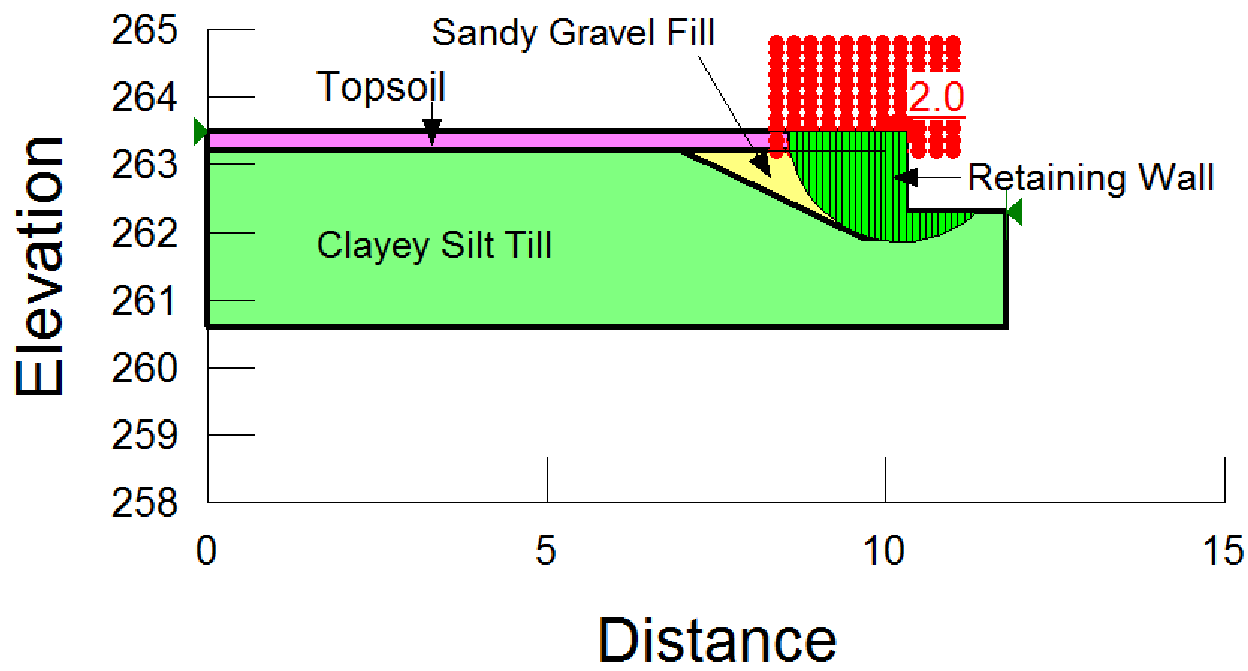
LIST OF STANDARD SPECIFICATIONS RELEVANT TO THE PROJECT

DOCUMENT	TITLE
OPSS.PROV 501	Construction Specification for Compacting
OPSS 803	Construction Specification for Sodding
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS 1860	Material Specification for Geotextiles
SP 405F03	Construction Specification for Pipe Subdrains
SP 599S22	Requirements for The Design, Supply and Construction of Retaining Soil Systems (RSS)
SP 599S23	Requirements for Materials, Quality Control and Quality Assurance Testing and Acceptance Criteria for Precast Concrete Facing Elements Including Panels
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario
OPSD 3120.100	Concrete Toe Wall – Retaining Walls
OPSD 3121.150	Minimum Granular Backfill Requirements – Retaining Walls
OPSD 3190.100	Retaining Wall and Abutment Wall Drain Detail

APPENDIX FDR-B

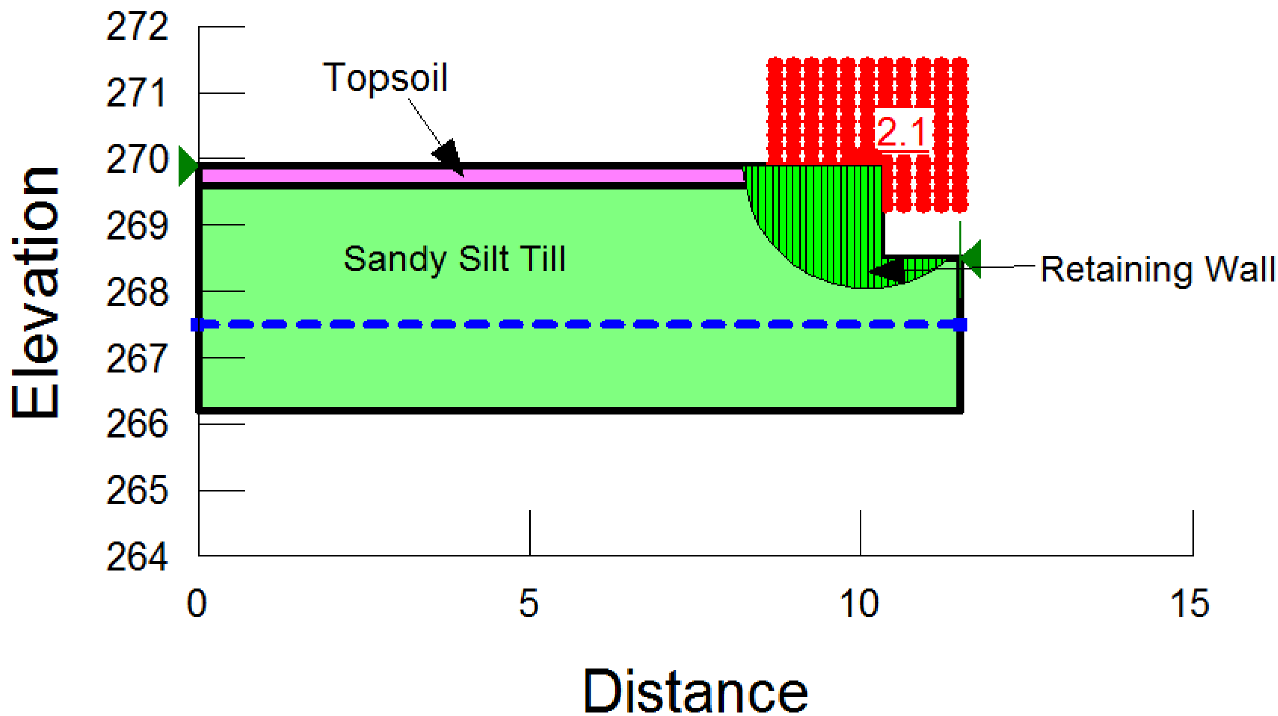
Slope Stability Analysis Results

Figure 1: Perry Street Retaining Wall Stability Analysis



Name: Topsoil Unit Weight: 18 kN/m³ Cohesion: 0 kPa Phi: 26 °
Name: Sandy Gravel Fill Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Clayey Silt Till Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Retaining Wall Unit Weight: 24 kN/m³ Cohesion: 150 kPa Phi: 35 °

Figure 2: Ottawa Street Retaining Wall Stability Analysis



Name: Topsoil	Unit Weight: 18 kN/m³	Cohesion: 0 kPa	Phi: 26 °
Name: Sandy Silt Till	Unit Weight: 21 kN/m³	Cohesion: 0 kPa	Phi: 30 °
Name: Retaining Wall	Unit Weight: 24 kN/m³	Cohesion: 150 kPa	Phi: 35 °