PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

for

SIGN SUPPORT STRUCTURES
HIGHWAY 401 – STATION 16+587 TO STATION 17+596 TILBURY NORTH
STATION 10+000 TO STATION 15+887 TILBURY EAST
TOWNSHIP OF TILBURY, CHATHAM-KENT, ONTARIO
G.W.P. 3034-19-00
ASSIGNMENT NO. 3017-E-0006/0007
WORK ITEM NO. 07

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PML Ref.: 19KF030A
Index No.: 034FIR and 035FDR
GEOCRES No.: 40J8-76
December 17, 2019

PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT

for

SIGN SUPPORT STRUCTURES
HIGHWAY 401 – STATION 16+587 TO STATION 17+596 TILBURY NORTH
STATION 10+000 TO STATION 15+887 TILBURY EAST
TOWNSHIP OF TILBURY, CHATHAM-KENT, ONTARIO
G.W.P. 3034-19-00
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PML Ref.: 19KF030A
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TABLE OF CONTENTS

PART A - FOUNDATION INVESTIGATION REPORT

Peto MacCallum Ltd.
CONSULTING ENGINEERS

PART A – PRELIMINARY FOUNDATION INVESTIGATION REPORT
For
Sign Support Structures
Highway 401 – Station 16+587 to Station 17+596 Tilbury North
Highway 401 – Station 10+000 to Station 15+887 Tilbury East
Township of Tilbury, Chatham-Kent, Ontario
G.W.P. 3034-19-00, Assignment No. 3017-E-0006/0007, Work Item No. 07

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1. INTRODUCTION

The Ministry of Transportation Ontario (MTO) has retained WSP Global Inc. (WSP) as the Prime Consultant, to provide support for the Detail Design services for the Widening of four (4) structures on Highway 401. WSP retained Peto MacCallum Ltd. (PML) on behalf of MTO to provide foundation engineering services. The Terms of Reference and Scope of Work for the Foundation Engineering services are outlined in MTO Assignment No. 3017-E-0006/0007, Work Item No. 07, dated May 2016. The foundation engineering services under this assignment include the following:

- Tilbury Creek Bridges (06X-0050/B1&B2) – Eastbound Lanes (EBL) and Westbound Lanes (WBL)
- Little Baptiste Creek Bridges (13X-0187/B1&B2) – EBL and WBL
- Baptiste Creek Bridges (13X-0188/B1&B2) – EBL and WBL
- Five (5) Overhead Signs (OHS) and Sign Support Structures

The foundation investigation work reported herein includes the five (5) OHS and sign support structures. The Tilbury Creek Bridges, Little Baptiste Creek bridges, and Baptiste Creek bridges, are issued under separate covers.

Pavement investigations were also carried out in conjunction with the foundation investigation. The pavement investigation report is issued under a separate cover.

This report summarizes the results of the foundation investigation carried out for the proposed five (5) overhead signs from approximate Station 16+587 to Station 17+596 in Tilbury North, and from approximate Station 10+000 to Station 15+887 in Tilbury East along Highway 401 in the Township of Tilbury, Chatham-Kent, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the proposed locations of the overhead signs.

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2. SITE DESCRIPTION

The existing Highway 401 roadway is slightly elevated from the natural topography, and accommodates two (2) lanes of vehicular traffic. The site is generally a flat area, with the exception of the highway embankments. The study area is surrounded by a mixture of commercial, agricultural and residential develpments.

3. FIELD INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between October 23 to 29, 2019. A total of 10 boreholes were advanced to depths of 8.2 m and 10.7 m. The Record of Borehole sheets are provided in Appendix A. The borehole location plans are presented on Drawings SS-1 to SS-4.

Refer to Table 3.0 for a summary of the proposed location of overhead signs, location and depth of boreholes.

Table 3.0 – Borehole Information

SIGN No.	EXISTING STATION[1]	BOREHOLE ID	DRILLED DEPTH (m)	COORDINATES (MTM ON-11)	
				NORTHING	EASTING
1	16+587 (Tilbury North)	OHS-1	8.2	4 680 979.9	309 469.5
		OHS-2	10.7	4 680 968.1	309 472.3
2	13+724 (Tilbury East)	OHS-3	8.2	4 682 042.4	314 081.6
		OHS-4	8.2	4 682 025.0	314 085.2
3	14+724 (Tilbury East)	OHS-5	8.2	4 682 202.1	315 064.2
		OHS-6	8.2	4 682 183.9	315 060.1
4	14+887 (Tilbury East)	OHS-7	8.2	4 682 214.0	315 227.7
		OHS-8	8.2	4 682 195.2	315 227.0
5	15+887 (Tilbury East)	OHS-9	8.2	4 682 371.5	316 192.6
		OHS-10	8.2	4 682 360.4	316 197.8

Note 1. OHS locations and stations are in accordance with AutoCAD drawing "*GWP 3034-19-00 Plan_.dwg*" provided to PML by WSP via e-mail dated October 1, 2019.

PML staff visited the site on October 8, 2019 to mark out the borehole locations. The respective utility companies cleared the underground services at the borehole locations. Public and private utility authorities were informed and all of the utility clearance documents were obtained prior to the commencement of the drilling work.

PML staff used a portable GPS device to establish the location of boreholes in the field. Subsequently, PML carried out the survey of the borehole locations as drilled and elevations using

a Sokkia SHC5000 Differential GPS system, equipped with a GCX3 (Network RTK rover) GNSS Receiver. The vertical and horizontal accuracy of this equipment are within 0.1 m and 0.5 m, respectively. All elevations (EL.) reported in this report are referred to in MTM NAD 83 Northing and Easting (MTM Zone – ON11) Geodetic datum and expressed in meters.

The equipment used for drilling was owned and operated by London Soil Test Inc. (London Soil), of London, Ontario. London Soil is a specialist drilling contractor and worked under the full time supervision of a PML field supervisor. Boreholes OHS-1 to OHS-10 were drilled between October 23 and 29, 2019. The boreholes were advanced using a Turbo D50 track-mounted drilling rig equipped with 200 mm diameter hollow stem augers.

Refer to Drawing SS-1 to SS-4 in Appendix A for borehole location details.

Representative soil samples were recovered from the boreholes at 0.75 m intervals to a depth of 6.0 m and at 1.5 m to the depth of termination, using a conventional 51 mm OD split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The groundwater conditions at the borehole locations were observed during the drilling by visual examination of the soil samples, sampler and drill rods as the samples were retrieved. In addition, water level measurements were taken in the open boreholes upon completion of drilling. Water levels were measured using a Solinst flat tape water level reader.

Upon completion of drilling, the boreholes were backfilled in accordance with the MTO guidelines and Ontario Regulation 903, amended by Ontario Regulation 372.

The recovered soil samples were returned to the PML laboratory to carry out detailed visual examination, and soil index testing.

4. LABORATORY TEST PROCEDURES

Laboratory tests were conducted on representative SPT soil samples recovered during the fieldwork investigation work. Testing was conducted at PML's laboratory facility located in Toronto, Ontario. The laboratory testing program included the following:

- Natural moisture content determinations (99)
- Grain size distribution analysis (30)
- Atterberg limit tests (30)

All laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow the American Society for Testing Materials (ASTM) standards, with the exception of hydrometer tests (LS-702). The results of the grain size distribution analyses are presented in Figures GS-OHS-1A/1B and GS-OHS-2A/2B. The results of the Atterberg Limit tests are presented in Figures PC-OHS-1A/1B and PC-OHS-2A/2B. All of the test results are summarized in the attached Record of Borehole Logs provided in Appendix A.

5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

In general, the project area is located within the St. Clair Clay Plains physiographic region. The Quaternary Geology map published by the Ontario Ministry of Northern Development and Mines (MNDM), indicates that the surface conditions in the area of the culvert site consist of lacustrine deposits; predominantly silt and clay. Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the project area consists of Middle Devonian limestone, dolostone and shale of the Hamilton Group rock formation.

5.2 Subsurface Conditions

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations are shown on Drawings SS-1 to SS-4.

The extent of the site area covers approximately 6.9 km in length and it is not practical to give detail description for the individual strata. For classification purposes, the soil encountered at this site can be divided into two (2) distinct zones:

1) Gravelly Sand, some silt (Pavement Fill)
2) Clayey Silt to Silty Clay, some sand, trace gravel (Till)

Refer to Table 5.2 for details of subsurface conditions such as type of soil, depth and elevation of soil strata encountered at each borehole location.

Table 5.2 – Summary of Subsurface Conditions at Borehole Locations

BOREHOLE	SOIL BOUNDARY DEPTH (m)	SOIL BOUNDARY ELEVATION (m)	SOIL TYPE
OHS-1	0.0 to 0.7	178.6 to 177.9	Very dense gravelly Sand (Pavement Fill)
	0.7 to 8.2	177.9 to 170.4	Stiff Clayey Silt to Silty Clay (Till)
OHS-2	0.0 to 0.7	178.4 to 177.7	Very dense gravelly Sand (Pavement Fill)
	0.7 to 10.7	177.7 to 167.7	Stiff to very stiff Clayey Silt to Silty Clay (Till)
OHS-3	0.0 to 8.2	177.1 to 168.9	Stiff to very stiff Clayey Silt to Silty Clay (Till)
OHS 4	0.0 to 0.7	178.6 to 177.9	Very dense gravelly Sand (Pavement Fill)
	0.7 to 8.2	177.9 to 170.4	Stiff Clayey Silt to Silty Clay (Till)
OHS-5	0.0 to 8.2	175.7 to 167.5	Hard to Stiff Clayey Silt to Silty Clay (Till)
OHS-6	0.0 to 0.7	176.8 to 176.1	Very dense gravelly Sand (Pavement Fill)
	0.7 to 8.2	176.1 to 168.6	Stiff to very stiff Clayey Silt to Silty Clay (Till)
OHS-7	0.0 to 0.7	175.7 to 175.0	Compact gravelly Sand (Pavement Fill)
	0.7 to 8.2	175.0 to 167.5	Stiff to very stiff Clayey Silt to Silty Clay (Till)
OHS-8	0.0 to 8.2	176.2 to 168.0	Stiff to very stiff Clayey Silt to Silty Clay (Till)
OHS-9	0.0 to 0.7	179.4 to 178.7	Dense gravelly Sand (Pavement Fill)
	0.7 to 8.2	178.7 to 171.2	Stiff to very stiff Clayey Silt (Till)
OHS-10	0.0 to 0.7	179.9 to 179.2	Dense gravelly Sand (Pavement Fill)
	0.7 to 8.2	179.2 to 171.7	Stiff to very stiff Clayey Silt to Silty Clay (Till)

5.2.1 Groundwater

Groundwater was encountered during drilling in boreholes OHS-4 and OHS-10 at 3.1 m (EL. 175.5) and 0.9 m (EL. 179.0), respectively, below ground surface. Upon completion of drilling, groundwater was encountered in borehole OHS-4 at 1.8 m (EL. 176.8) below ground surface. In the remaining boreholes groundwater was not encountered during and upon completion of drilling.

Groundwater levels may fluctuate due to the influence of precipitation and seasonal change. The groundwater measurements were observed and measured prior to backfilling the boreholes. Groundwater levels are shown in the Record of Borehole Logs in Appendix A.

5.2.2 Soil Corrosivity

Five (5) representative soil samples were sent to SGS Canada Inc.'s (SGS) laboratory located in Toronto, Ontario, which is accredited by Canadian Analytical Laboratory Association (CALA). The corrosivity test results provided by SGS are presented in Appendix A. A summary of the test results is presented in the Table 5.2.2.

Table 5.2.2: Summary of Corrosivity Test Results

Borehole ID	Sample No. (Depth, m)	Corrosivity Index	Sulphate (µg/g)	Chloride (µg/g)	Resistivity (Ohm-cm)	pH
OHS-1	6 (3.8 to 4.4)	4.5	67	27	5020	8.13
OHS-3	8 (5.3 to 5.9)	14.5	1500	76	785	7.94
OHS-5	8 (5.3 to 5.9)	9.5	360	36	1910	8.02
OHS-7	6 (3.8 to 4.4)	9.5	410	80	1850	8.05
OHS-9	9 (6.1 to 6.7)	4.5	230	18	3210	8.12

6. CLOSURE

Mr. M. Mohamed and Mr. J. Suk-O carried out the field investigations under the supervision of Mr. N. Rahman, P.Eng., Project Engineer, and Ms. N. Leong-Sem, EIT. London Soil Test Ltd. of London, Ontario supplied the drilling equipment for the subsurface exploration. The laboratory testing of the selected samples was carried out in the PML laboratory in Toronto.

This report was prepared by Ms. N. Leong-Sem, B.Eng., EIT, Geotechnical Services and reviewed by Mr. N. Rahman, P.Eng., Project Engineer, Geotechnical Services. Mr. R. Ng, MBA, PhD, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

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EIT
Geotechnical Services

Nazibur Rahman, P.Eng.
Project Engineer
Geotechnical Services

Geoffrey Uwimana, MEng., P.Eng.
Discipline Head
Senior Engineer, Geotechnical Services

Robert Ng, MBA, PhD, P.Eng.
MTO Designated Principal Contact

NL/KA/RN:nl-nk

APPENDIX A

Borehole Locations Plan Drawings SS-1 to SS-4

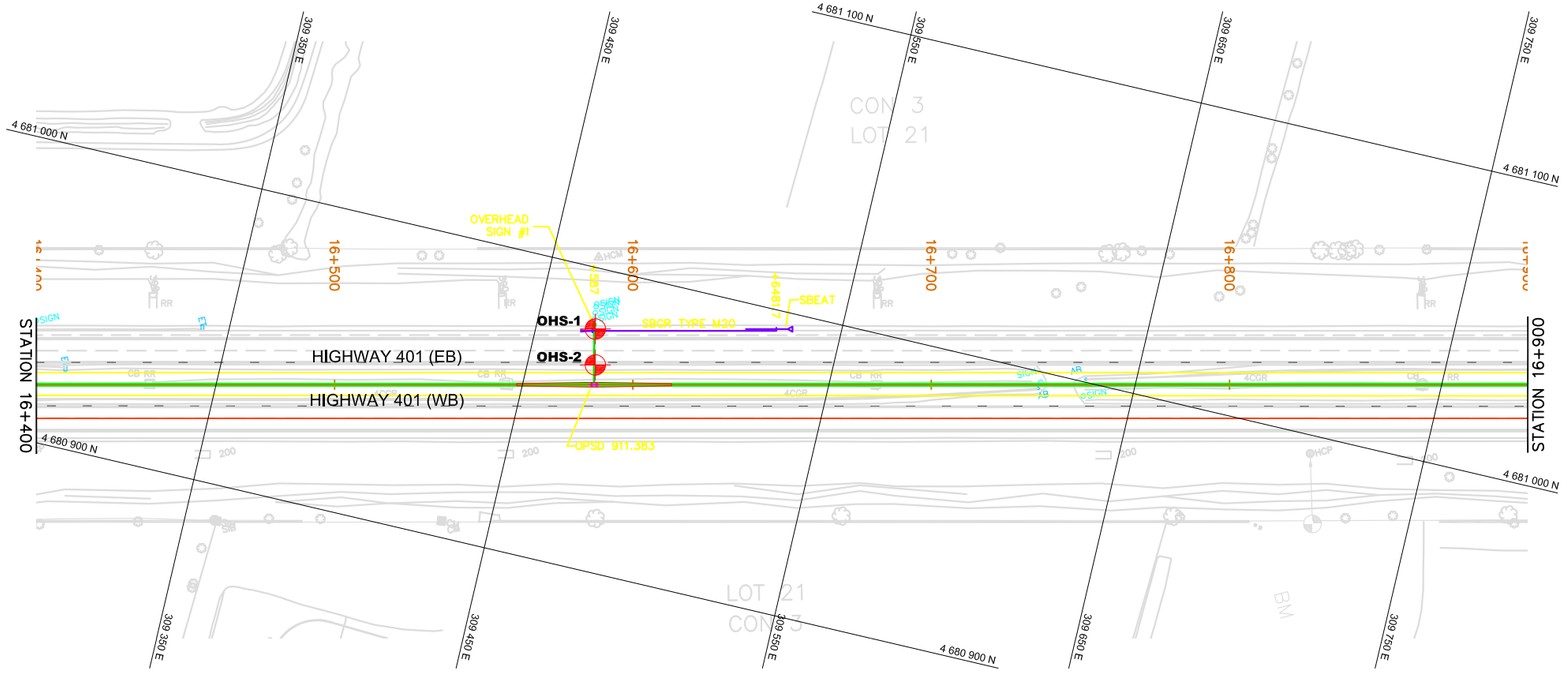
Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures GS-OHS-1A/1B and GS-OHS-2A/2B

Results of Atterberg Limit Tests – Figures PC-OHS-1A/1B and PC-OHS-2A/2B

Results of Chemical Tests provided by SGS Canada Inc.



PLAN

SCALE

20 0 20 40m

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.

Work Item No. 7
GWP No 3034-19-00

SIGN SUPPORT STRUCTURES
HIGHWAY 401 – SIGN NO. 1
BOREHOLE LOCATION PLAN

SHEET

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LEGEND

OHS-2
Borehole Location

BH No	ELEVATION	NORTHINGS	EASTINGS
OHS-1	178.6	4 680 979.9	309 469.5
OHS-2	178.4	4 680 968.1	309 472.3

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Reference WSP Ltd. Drawing: GWP 3034-19-00 Base.dwg, provided December 14, 2019.

REVISIONS			
	DATE	BY	DESCRIPTION

Geocres No. 40J8-76

HWY No	401			DIST	LONDON
SUBM'D	NL	CHECKED	NR	DATE DEC. 16, 2019	SITE
DRAWN	NL	CHECKED		APPROVED CN	DWG SS-1

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GWP No 3034-19-00

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BOREHOLE LOCATION PLAN

SHEET

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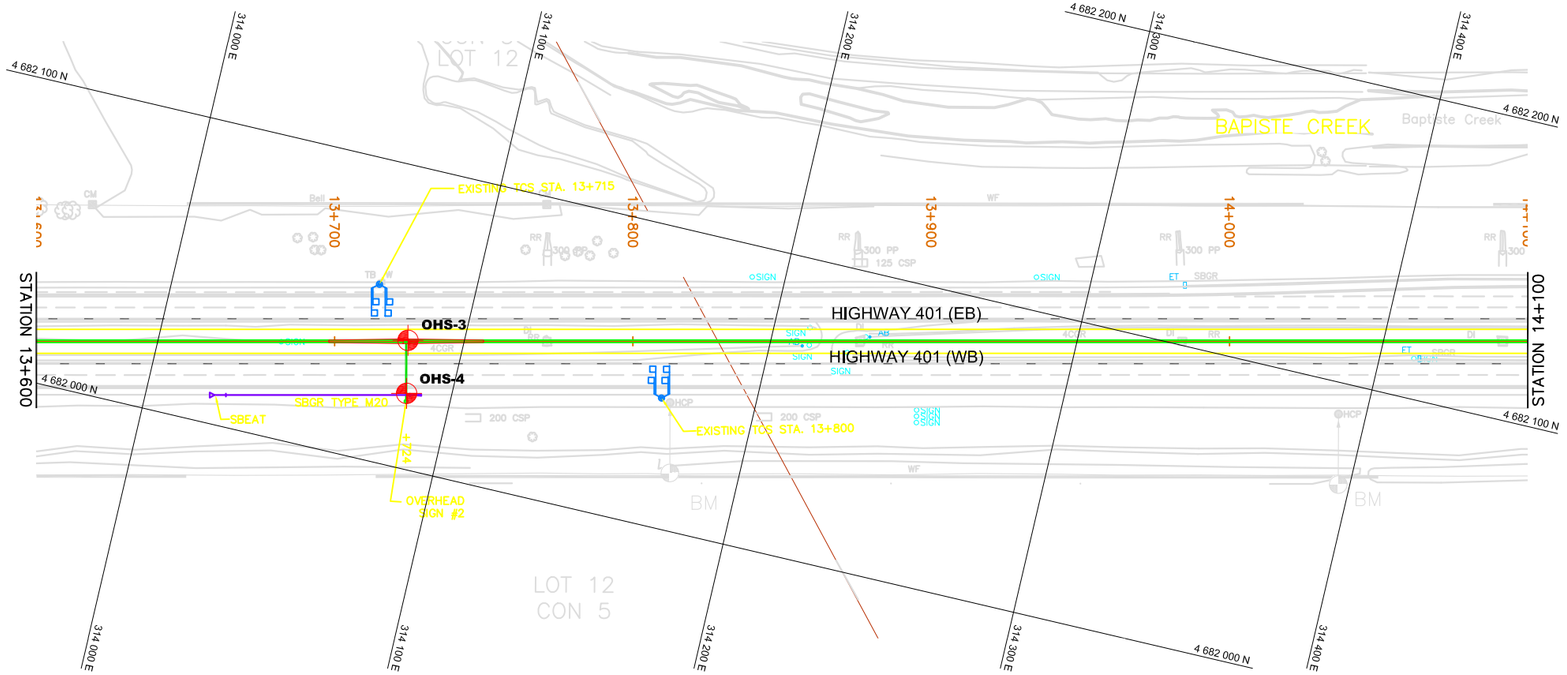

PLAN

SCALE
20 0 20 40m

LEGEND

OHS-4
Borehole Location

BH No	ELEVATION	NORTHINGS	EASTINGS
OHS-3	177.1	4 682 042.4	314 081.6
OHS-4	178.6	4 682 025.0	314 085.2

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DATE	BY	DESCRIPTION	

Geocres No. 40J8-76

HWY No	401			DIST	LONDON
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DRAWN	NL	CHECKED		APPROVED CN	DWG SS-2

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GWP No 3034-19-00

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BOREHOLE LOCATION PLAN

SHEET

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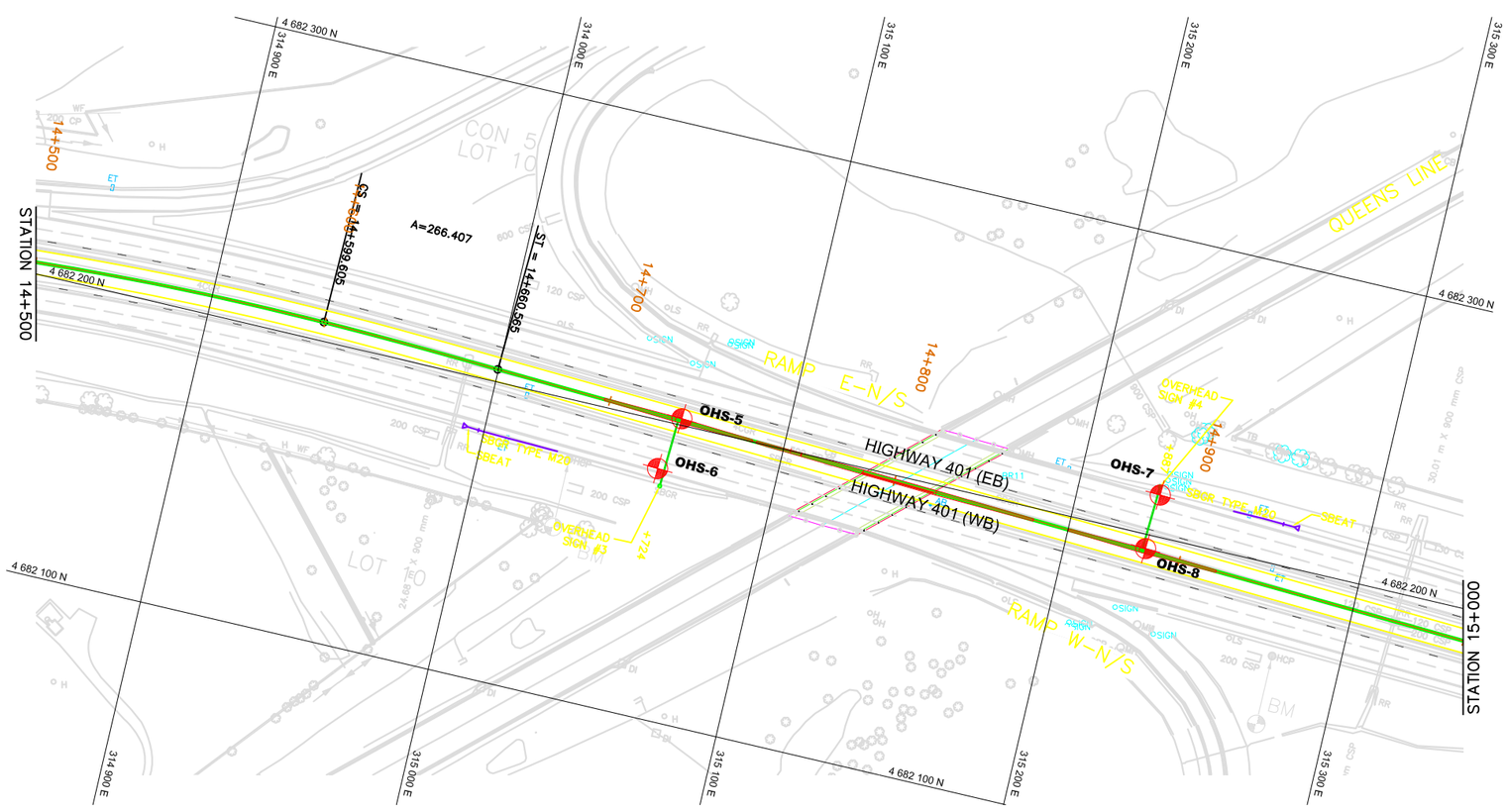

PLAN

SCALE
20 0 20 40m

LEGEND

OHS-8
Borehole Location

BH No	ELEVATION	NORTHINGS	EASTINGS
OHS-5	175.7	4 682 202.1	315 064.2
OHS-6	176.8	4 682 183.9	315 060.1
OHS-7	175.7	4 682 214.0	315 227.7
OHS-8	176.2	4 682 195.2	315 227.0

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Work Item No. 7
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BOREHOLE LOCATION PLAN

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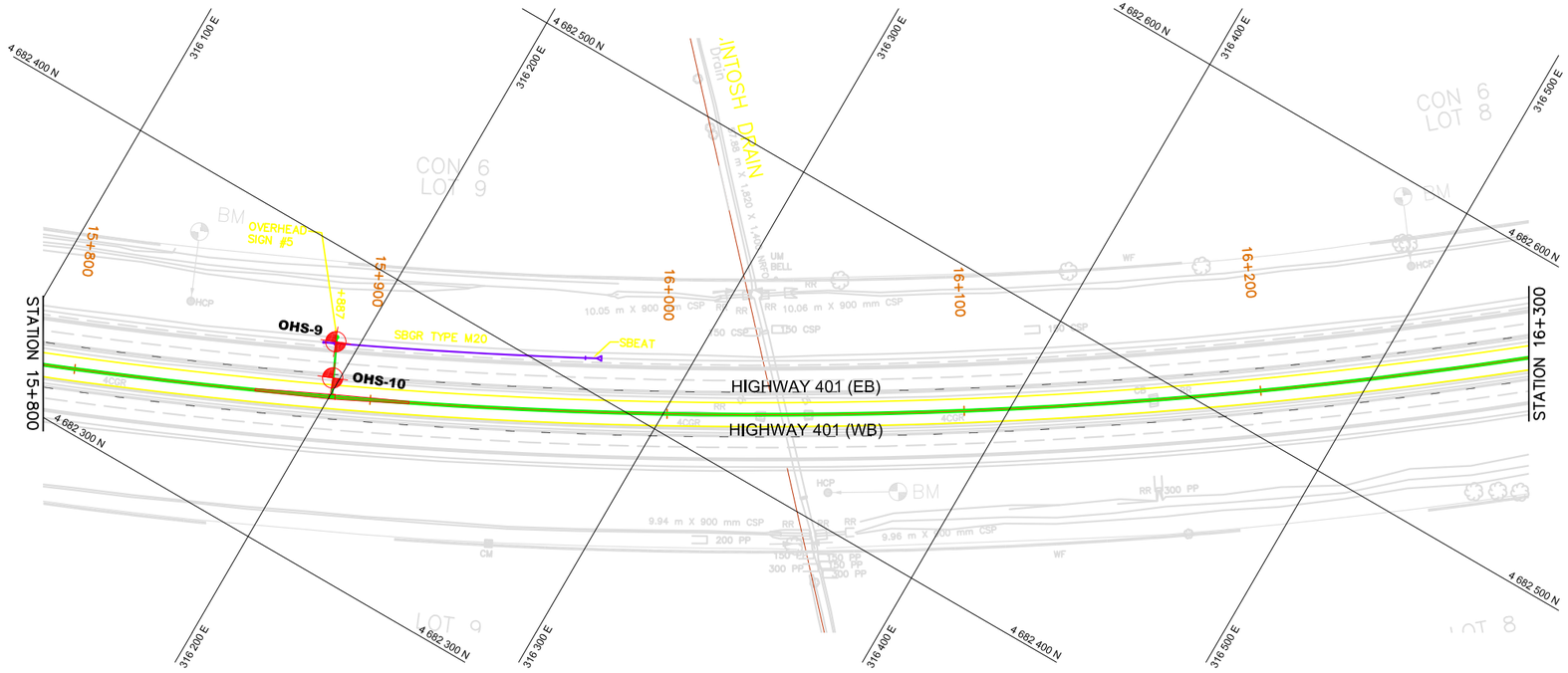

PLAN

SCALE
20 0 20 40m

LEGEND

OHS-10
Borehole Location

BH No	ELEVATION	NORTHINGS	EASTINGS
OHS-9	179.4	4 682 371.5	316 192.6
OHS-10	179.9	4 682 360.4	316 197.8

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SUBM'D	NL	CHECKED	NR	DATE DEC. 16, 2019	SITE
DRAWN	NL	CHECKED		APPROVED CN	DWG SS-4

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/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

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

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

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

RECORD OF BOREHOLE No OHS-1

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 680 979.9 N; 309 469.5 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A./M.M

DATUM Geodetic DATE 2019.10.29 LATITUDE 42.268372 LONGITUDE -82.443395 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
178.6	Ground										
0.0 / 177.9	gravelly SAND, some silt Very Dense, Grey, Moist (PAVEMENT FILL)		1	SS	67		178	○	○		
0.7	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff, Grey, Moist (TILL)		2	SS	13						
			3	SS	13		177		○		
			4	SS	13		176		○		
			5	SS	7				○		1 22 42 35
			6	SS	15		175		○		
			7	SS	13		174		○		
			8	SS	5		173		○		
			9	SS	9				○		2 16 43 39
							172				
170.4			10	SS	9		171		○		4 16 41 39
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-2

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 680 968.1 N; 309 472.3 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A./M.M

DATUM Geodetic DATE 2019.10.29 LATITUDE 42.268266 LONGITUDE -82.443362 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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
178.4	Ground										
0.0	gravelly SAND, some silt Very Dense, Grey, Moist (PAVEMENT FILL)		1	SS	51		178	○	○		
177.7											
0.7	SILTY CLAY to CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Grey, Moist (TILL)		2	SS	13		177	○	○		
			3	SS	12			○	○		
			4	SS	9		176	○	○		
			5	SS	9		175	○	○		
			6	SS	10			○	○		
			7	SS	14		174	⊢●	⊢●		2 17 38 43
			8	SS	10		173	○	○		
			9	SS	9		172	⊢○	⊢○		2 17 39 42
			10	SS	9		171	○	○		
			11	SS	8		170	⊢●	⊢●		2 17 39 42
				VANE			169	>>			
167.7							168				
10.7	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 19KF030A - WO7.GPJ ONTARIO MTO.GDT 12/13/19

RECORD OF BOREHOLE No OHS-3

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 042.4 N; 314 081.6 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A./M.M

DATUM Geodetic DATE 2019.10.25 LATITUDE 42.277897 LONGITUDE -82.387470 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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
177.1	Ground										
0.0	organics CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff to very stiff, Brown to grey, Moist		1	SS	6		177				
			2	SS	9		176				
			3	SS	11		175				
			4	SS	21		174				
			5	SS	19						7 18 37 38
			6	SS	13		173				
			7	SS	13		172				7 17 38 38
			8	SS	10						
			9	SS	10		171				4 18 38 40
							170				
168.9			10	SS	10		169				
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-4

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 025.0 N; 314 085.2 E ORIGINATED BY J.O.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY K.A./M.M

DATUM Geodetic DATE 2019.10.23 LATITUDE 42.277740 LONGITUDE -82.387427 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
178.6	Ground										
0.0 / 177.9	gravelly SAND, some silt Very Dense, Grey, Moist (PAVEMENT FILL)		1	SS	50		178	○	○		
0.7	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff, Grey, Moist (TILL)		2	SS	10				○		
			3	SS	3	▼	177		○		
			4	SS	2		176		○		
			5	SS	20	▽	175		○		
			6	SS	14				⊖		3 18 43 36
			7	SS	14		174		○		
			8	SS	11		173		⊖		2 42 19 37
			9	SS	10				○		
							172				
			10	SS	12		171		⊖		4 18 38 40
170.4											
8.2	End of borehole										

▽ Groundwater level observed during drilling

▼ Groundwater level measured upon completion of drilling

NOTE: No cave-in was noted upon extraction of hollow stem augers

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-5

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 202.1 N; 315 064.2 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.24 LATITUDE 42.279323 LONGITUDE -82.375554 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
175.7	Ground										
0.0	organics										
	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Hard to stiff, Brown, Moist (TILL)		1	SS	5		175				
			2	SS	10						
			3	SS	23		174				
			4	SS	33		173				
			5	SS	31		172				6 18 39 37
			6	SS	22						
			7	SS	16		171				2 18 43 37
			8	SS	18		170				
			9	SS	12		169				3 19 40 38
167.5			10	SS	17		168				
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-6

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 183.9 N; 315 060.1 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.24 LATITUDE 42.279158 LONGITUDE -82.375605 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
176.8	Ground										
176.7 / 0.1	100 mm ASPHALT over gravelly SAND, some silt Very Dense, Grey, Moist (PAVEMENT FILL)		1	SS	54				○		
176.1 / 0.7	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff to very stiff, Grey, Moist		2	SS	6		176		○		
			3	SS	15		175		○		
			4	SS	24		174		○ —		1 19 40 40
			5	SS	20				○		
			6	SS	14		173		○		
			7	SS	13		172		○ —		6 17 42 35
			8	SS	16				○		
			9	SS	11		171		○ —		4 18 39 39
							170				
168.6			10	SS	13		169		○		
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO 19KF030A - WO7.GPJ ONTARIO MTO.GDT 12/13/19

RECORD OF BOREHOLE No OHS-7

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 214.0 N; 315 227.7 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.25 LATITUDE 42.279427 LONGITUDE -82.373572 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
175.7	Ground										
0.0	gravelly SAND, some silt Compact, Grey, Dry (PAVEMENT FILL)		1	SS	24				○		
175.0							175				
0.7	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff to very stiff, Grey, Moist (TILL)		2	SS	7				○		
			3	SS	11		174		○		
			4	SS	8		173		○		1 17 42 40
			5	SS	23				○		
			6	SS	19		172		○		
			7	SS	28		171		○		2 20 39 39
			8	SS	11				○		
			9	SS	18		170		○		3 20 47 30
							169				
167.5			10	SS	15		168		○		
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-8

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 195.2 N; 315 227.0 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.24 LATITUDE 42.279258 LONGITUDE -82.373580 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
176.2	Ground										
0.0	organics						176				
	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff to very stiff, Grey, Moist (TILL)		1	SS	6						
			2	SS	9		175				
			3	SS	27		174				
			4	SS	15						2 22 38 38
			5	SS	20		173				
			6	SS	15		172				4 20 38 38
			7	SS	11						
			8	SS	10		171				
			9	SS	6		170				2 20 46 32
				VANE			169	>>			
168.0			10	SS	9		168				
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-9

1 OF 1

METRIC

G.W.P. 3034-19-00 LOCATION Coords: 4 682 371.5 N; 316 192.6 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.28 LATITUDE 42.280832 LONGITUDE -82.361870 CHECKED BY M.V.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
179.4	Ground										
0.0	gravelly SAND, some silt Dense, Grey, Moist (PAVEMENT FILL)		1	SS	36		179	○	○		
178.7											
0.7	CLAYEY SILT, with/some sand, trace gravel Stiff to very stiff, moist, grey (TILL)		2	SS	13				○		
			3	SS	11		178		○		
			4	SS	14		177		○		
			5	SS	17		176		○		
			6	SS	21				⊢●		8 34 41 17
			7	SS	19		175		○		
			8	SS	19		174		○⊣		4 18 43 35
			9	SS	13		173		○		
							172				
171.2			10	SS	12				⊢●		3 19 41 37
8.2	End of borehole										

NOTES:
1. Groundwater level was not encountered during or upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No OHS-10

1 OF 1 **METRIC**

G.W.P. 3034-19-00 LOCATION Coords: 4 682 360.4 N; 316 197.8 E ORIGINATED BY M.M.

DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY M.M

DATUM Geodetic DATE 2019.10.24 LATITUDE 42.280732 LONGITUDE -82.361807 CHECKED BY M.V.

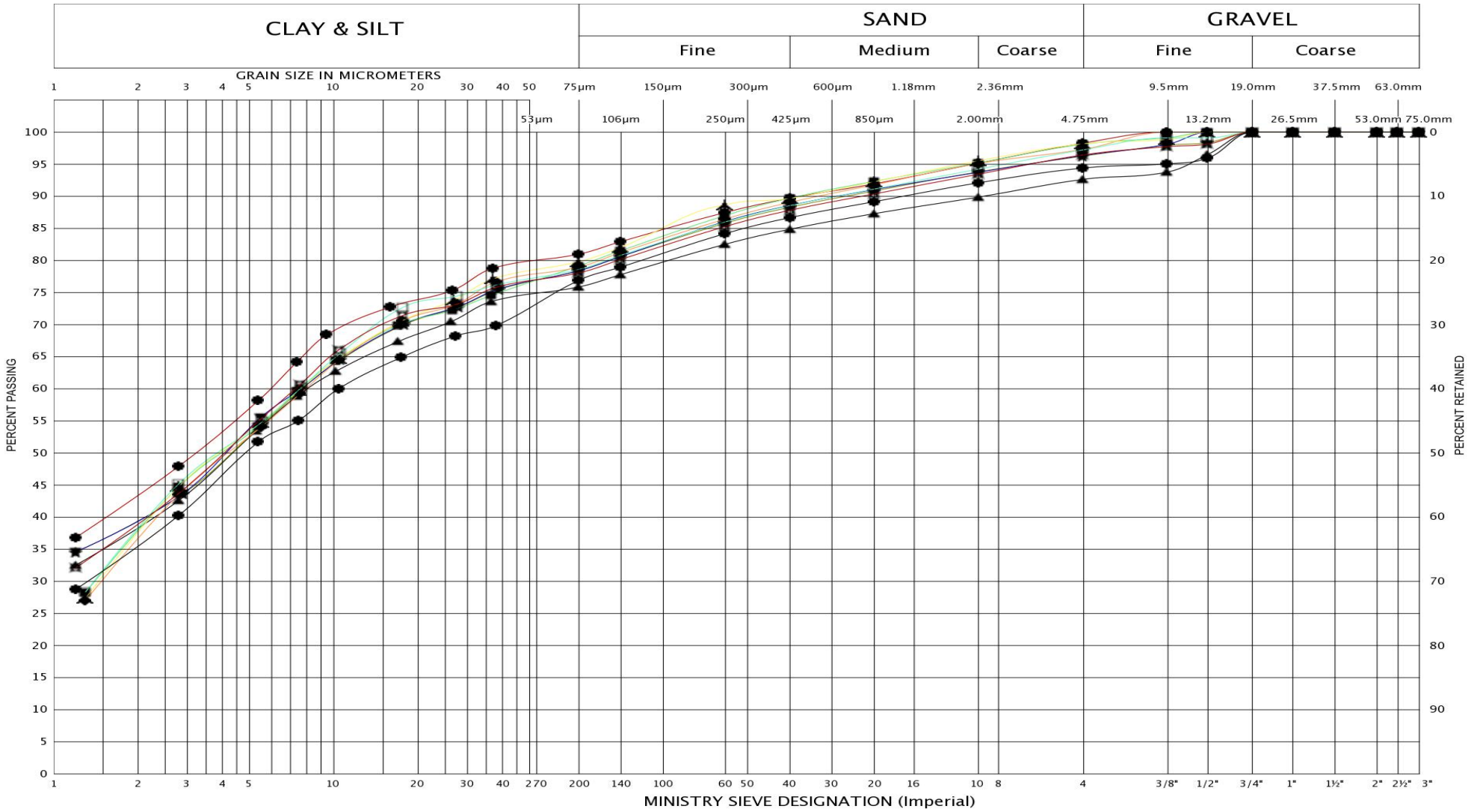
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.9	Ground										
0.0	gravelly SAND, some silt Dense, Grey, Moist (PAVEMENT FILL)		1	SS	39				○		
179.2											
0.7	CLAYEY SILT to SILTY CLAY, some sand, trace gravel Stiff to very stiff, Grey, Moist (TILL)		2	SS	11	▽	179		○		
			3	SS	9		178		○		
			4	SS	6		177		○		
			5	SS	11				○⊢		3 43 38 16
			6	SS	17		176		○		
			7	SS	9		175		⊢○		5 20 40 35
			8	SS	11		174		○		
			9	SS	13				⊢○		5 20 39 36
							173				
171.7			10	SS	10		172		○		
8.2	End of borehole										

▽ Groundwater level observed during drilling

NOTES:
1. Groundwater level was not encountered upon completion of drilling.
2. No cave-in was noted upon extraction of hollow stem augers.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	OHS-2	OHS-3	OHS-3	OHS-4	OHS-4	OHS-4	OHS-5	OHS-5	OHS-6	OHS-6
	SAMPLE	9	7	9	6	8	10	7	9	7	9
	SYMBOL	●	▲	★	◆	■	▼	⅄	□	●	⊠

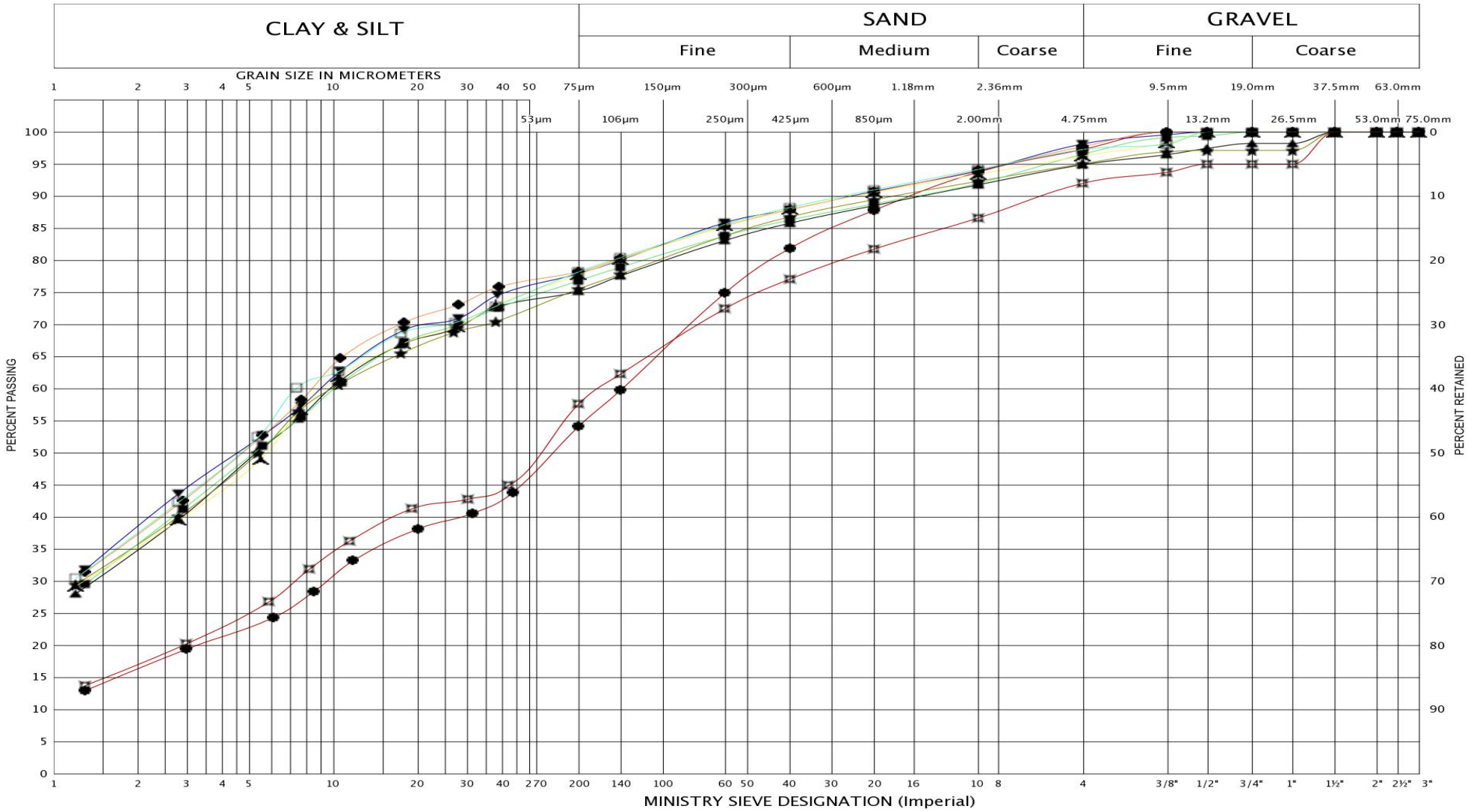
Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL, some/with sand, trace gravel

FIG No.:	GS-OHS-1A
HWY :	401
GWP	3094-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	OHS-7	OHS-7	OHS-8	OHS-9	OHS-9	OHS-9	OHS-10	OHS-10	OHS-10
	SAMPLE	7	10	9	6	8	10	5	7	9
	SYMBOL	▼	■	◆	✖	✳	□	●	▲	★

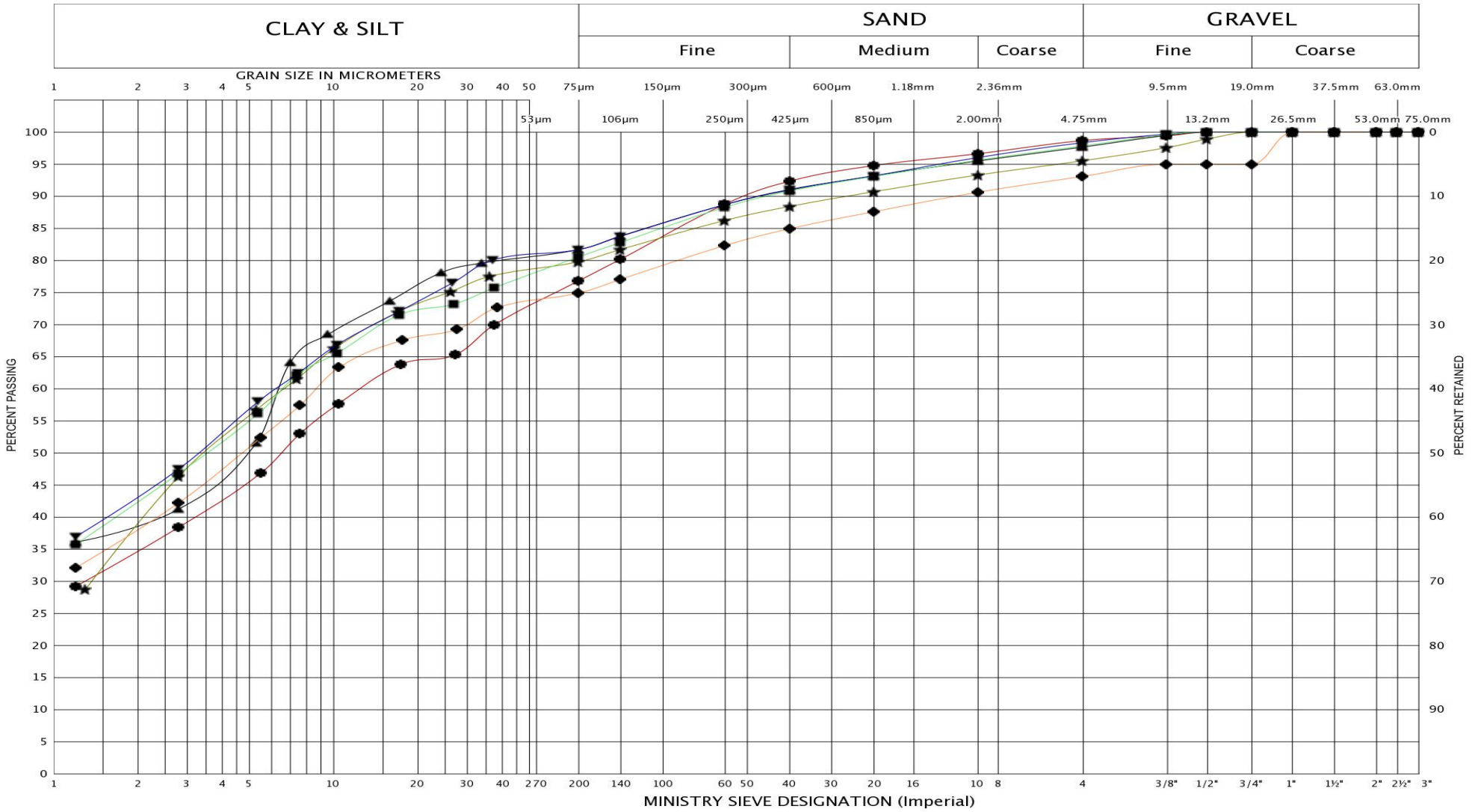
Ontario

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL, some/with sand, trace gravel

FIG No.:	GS-OHS-1B
HWY :	401
GWP	3094-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



	BH	OHS-1	OHS-1	OHS-1	OHS-2	OHS-2	OHS-3
LEGEND	SAMPLE	5	9	10	7	11	5
	SYMBOL	●	▲	✱	▼	■	◆

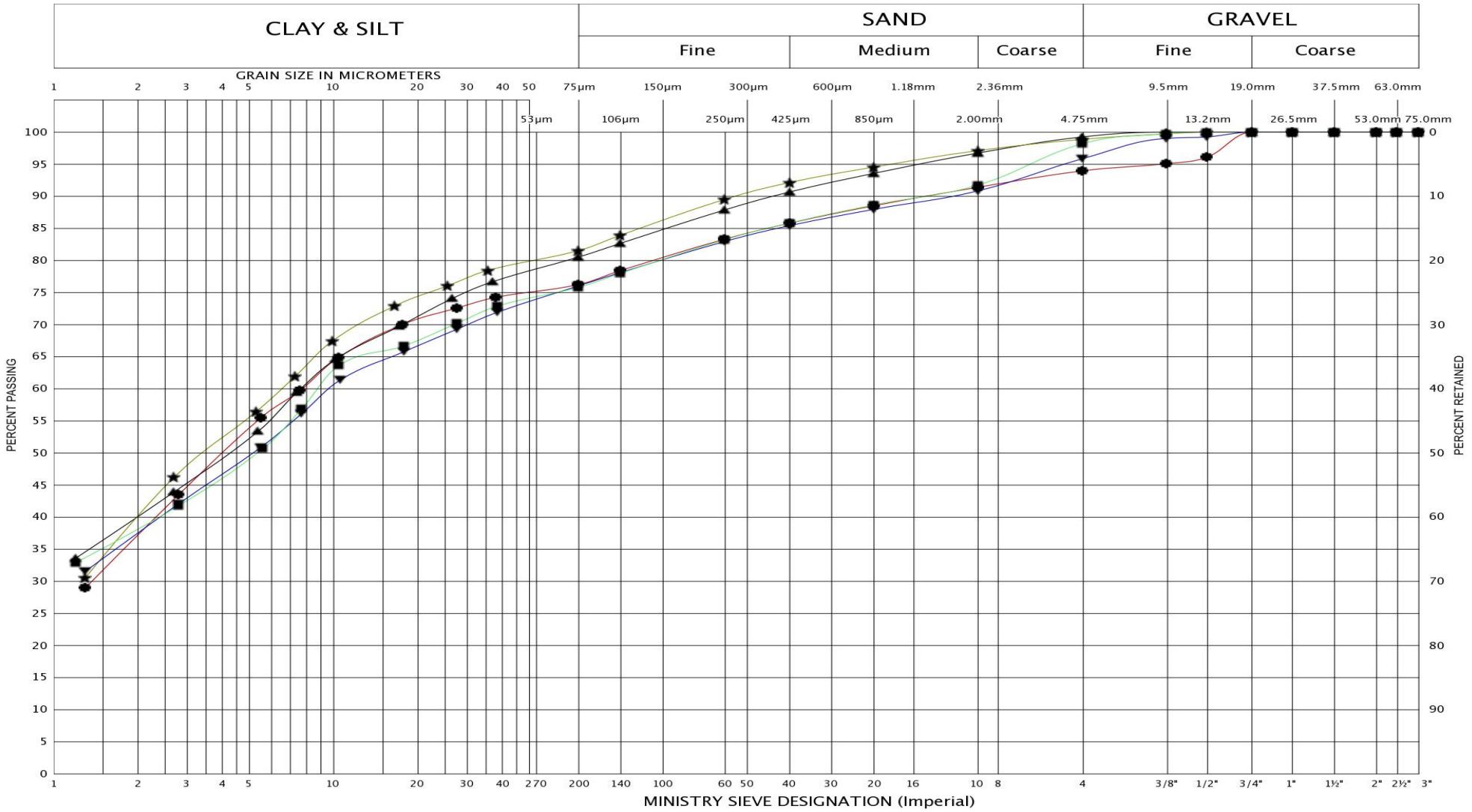
Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL, some/with sand, trace gravel

FIG No.:	GS-OHS-2A
HWY :	401
GWP	3094-19-00

UNIFIED SOIL CLASSIFICATION SYSTEM



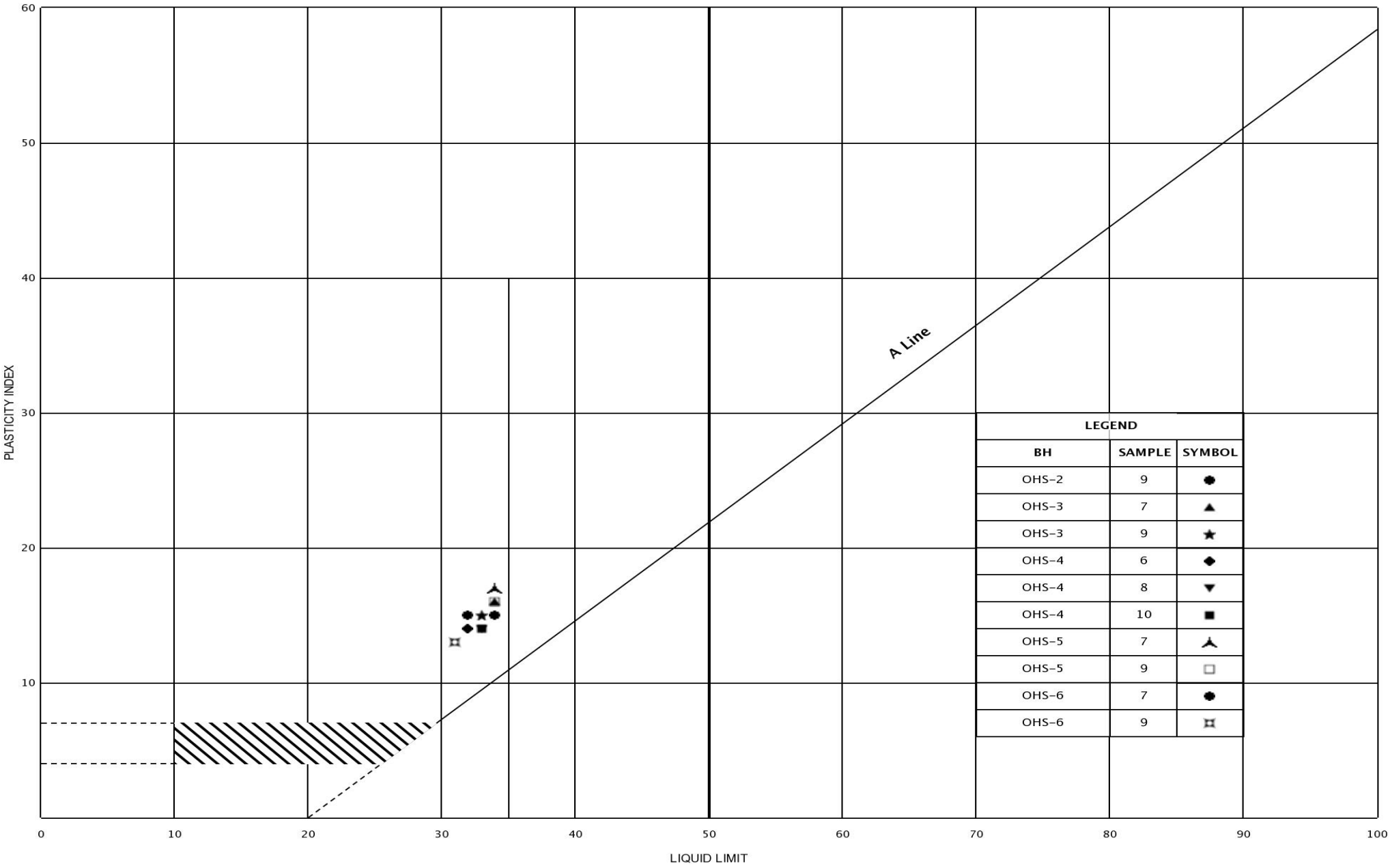
	BH	OHS-5	OHS-6	OHS-7	OHS-8	OHS-8
LEGEND	SAMPLE	5	4	5	4	6
	SYMBOL	●	▲	★	■	▼

Ontario

GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL, some/with sand, trace gravel

FIG No.:	GS-OHS-2B
HWY :	401
GWP	3094-19-00



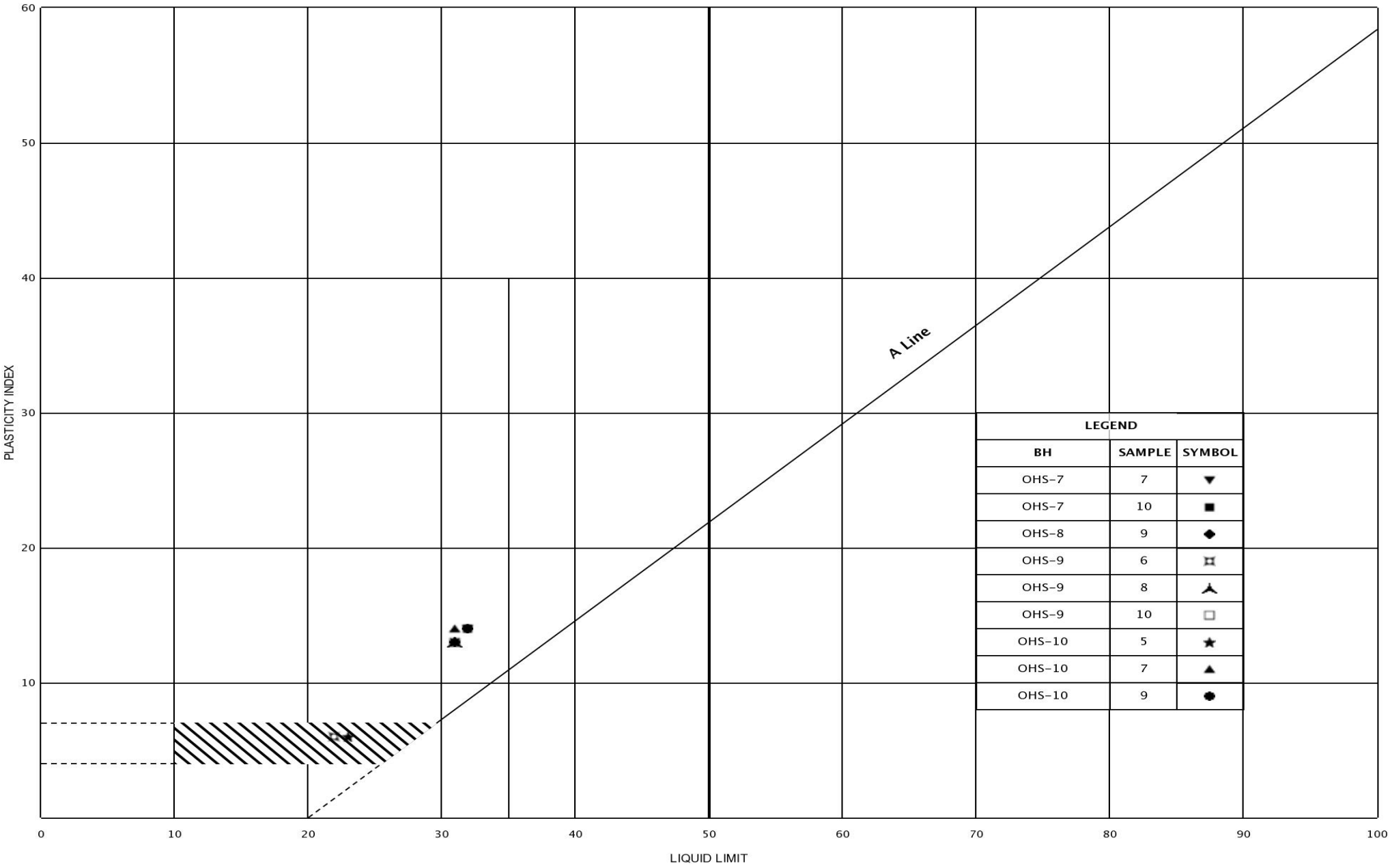
LEGEND		
BH	SAMPLE	SYMBOL
OHS-2	9	
OHS-3	7	
OHS-3	9	
OHS-4	6	
OHS-4	8	
OHS-4	10	
OHS-5	7	
OHS-5	9	
OHS-6	7	
OHS-6	9	

Ontario

PLASTICITY CHART

CLAYEY SILT TILL, some/with sand, trace gravel

FIG No.:	PC-OHS-1A
HWY.:	401
GWP	3034-19-00

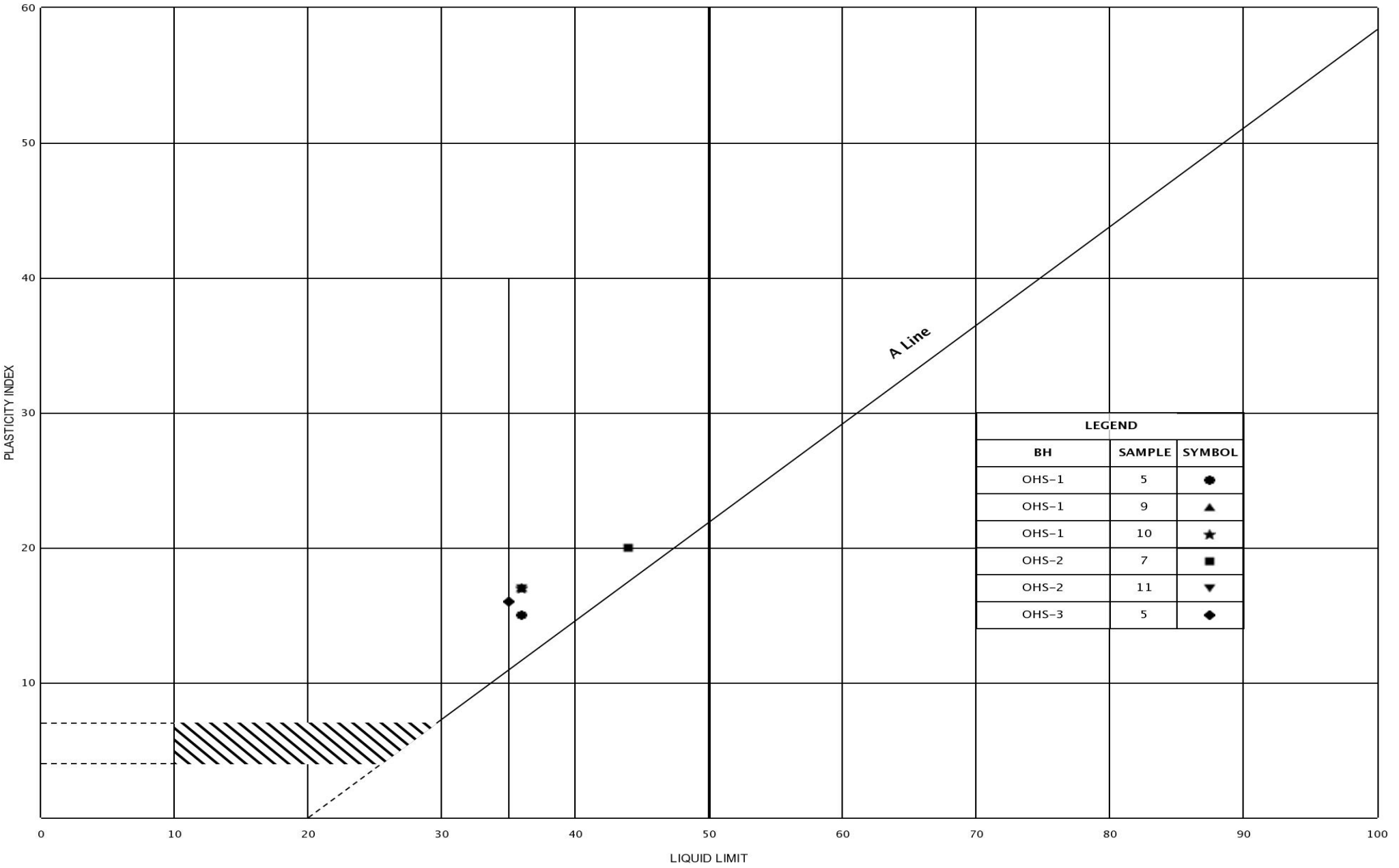


Ontario

PLASTICITY CHART

CLAYEY SILT TILL, some/with sand, trace gravel

FIG No.:	PC-OHS-1B
HWY.:	401
GWP	3034-19-00

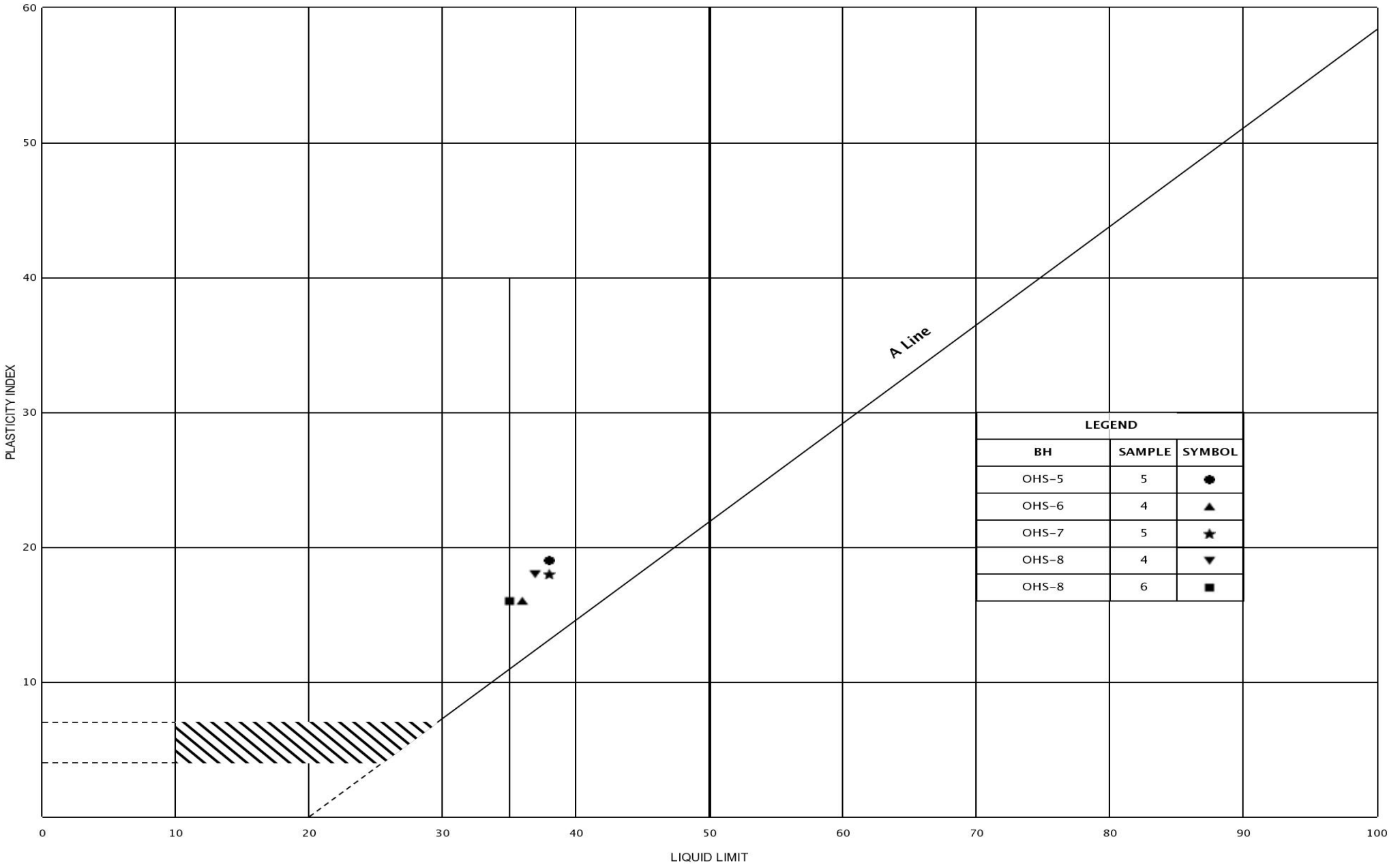


Ontario

PLASTICITY CHART

SILTY CLAY TILL, some/with sand, trace gravel

FIG No.:	PC-OHS-2A
HWY.:	401
GWP	3034-19-00



Ontario

PLASTICITY CHART

SILTY CLAY TILL, some/with sand, trace gravel

FIG No.:	PC-OHS-2B
HWY.:	401
GWP	3034-19-00

FINAL REPORT

CA14483-NOV19 R1

19KF030A

Prepared for

Peto MacCallum Ltd

FINAL REPORT

First Page

CLIENT DETAILS

Client	Peto MacCallum Ltd
Address	165 Cartwright Ave Toronto, ON M6A 1V5. Canada
Contact	Nazibur Rahman
Telephone	416-785-5110
Facsimile	416-785-5120
Email	nrahman@petomaccallum.com
Project	19KF030A
Order Number	
Samples	Soil (5)

LABORATORY DETAILS

Project Specialist	Brad Moore Hon. B.Sc
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	705-652-2143
Facsimile	705-652-6365
Email	brad.moore@sgs.com
SGS Reference	CA14483-NOV19
Received	11/14/2019
Approved	11/19/2019
Report Number	CA14483-NOV19 R1
Date Reported	11/19/2019

COMMENTS

Temperature of Sample upon Receipt: 11 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:00242

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

Client: Peto MacCallum Ltd
Project: 19KF030A
Project Manager: Nazibur Rahman
Samplers: Jinsuko

PACKAGE: **- Corrosivity Index** (SOIL)

Sample Number			5	6	7	8	9
Sample Name			BH# OHS-1, SS6 (12.5-14.5')	BH# OHS-3, SS8 (17.5-19.5')	BH# OHS-5, SS8 (17.5-19.5')	BH# OHS-7, SS6 (12.5-14.5')	BH# OHS-9, SS9 (20-22')
Sample Matrix			Soil	Soil	Soil	Soil	Soil
Sample Date			14/11/2019	14/11/2019	14/11/2019	14/11/2019	14/11/2019
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index							
Corrosivity Index	none	1	4.5	14.5	9.5	9.5	4.5
Soil Redox Potential	mV	-	235	247	152	164	184
Sulphide	%	0.02	0.02	0.05	0.46	0.43	0.46
pH	pH Units	0.05	8.13	7.94	8.02	8.05	8.12
Resistivity (calculated)	ohms.cm	-9999	5020	785	1910	1850	3210

PACKAGE: **- General Chemistry** (SOIL)

Sample Number			5	6	7	8	9
Sample Name			BH# OHS-1, SS6 (12.5-14.5')	BH# OHS-3, SS8 (17.5-19.5')	BH# OHS-5, SS8 (17.5-19.5')	BH# OHS-7, SS6 (12.5-14.5')	BH# OHS-9, SS9 (20-22')
Sample Matrix			Soil	Soil	Soil	Soil	Soil
Sample Date			14/11/2019	14/11/2019	14/11/2019	14/11/2019	14/11/2019
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry							
Conductivity	uS/cm	2	199	1270	524	541	312

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number			5	6	7	8	9
Sample Name			BH# OHS-1, SS6 (12.5-14.5')	BH# OHS-3, SS8 (17.5-19.5')	BH# OHS-5, SS8 (17.5-19.5')	BH# OHS-7, SS6 (12.5-14.5')	BH# OHS-9, SS9 (20-22')
Sample Matrix			Soil	Soil	Soil	Soil	Soil
Sample Date			14/11/2019	14/11/2019	14/11/2019	14/11/2019	14/11/2019
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics							
Moisture Content	%	0.1	13.7	18.0	15.4	14.8	15.6

Client: Peto MacCallum Ltd
Project: 19KF030A
Project Manager: Nazibur Rahman
Samplers: Jinsuko

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number			5	6	7	8	9
Sample Name			BH# OHS-1, SS6 (12.5-14.5')	BH# OHS-3, SS8 (17.5-19.5')	BH# OHS-5, SS8 (17.5-19.5')	BH# OHS-7, SS6 (12.5-14.5')	BH# OHS-9, SS9 (20-22')
Sample Matrix			Soil	Soil	Soil	Soil	Soil
Sample Date			14/11/2019	14/11/2019	14/11/2019	14/11/2019	14/11/2019
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics (continued)							
Sulphate	µg/g	0.4	67	1500	360	410	230

PACKAGE: **- Other (ORP)** (SOIL)

Sample Number			5	6	7	8	9
Sample Name			BH# OHS-1, SS6 (12.5-14.5')	BH# OHS-3, SS8 (17.5-19.5')	BH# OHS-5, SS8 (17.5-19.5')	BH# OHS-7, SS6 (12.5-14.5')	BH# OHS-9, SS9 (20-22')
Sample Matrix			Soil	Soil	Soil	Soil	Soil
Sample Date			14/11/2019	14/11/2019	14/11/2019	14/11/2019	14/11/2019
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)							
Chloride	µg/g	0.4	27	76	36	80	18

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0313-NOV19	µg/g	0.4	<0.4	3	20	99	80	120	112	75	125
Sulphate	DIO0313-NOV19	µg/g	0.4	<0.4	15	20	95	80	120	95	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0027-NOV19	%	0.02	<0.02	1	20	105	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0283-NOV19	uS/cm	2	< 0.002	2	10	98	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0283-NOV19	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.
RL Reporting Limit.
↑ Reporting limit raised.
↓ Reporting limit lowered.
NA The sample was not analysed for this analyte
ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

-- End of Analytical Report --

Peto MacCallum Ltd.
CONSULTING ENGINEERS

PART B – PRELIMINARY FOUNDATION DESIGN REPORT

for

SIGN SUPPORT STRUCTURES
HIGHWAY 401 – STATION 16+587 TO STATION 17+596 TILBURY NORTH
STATION 10+000 TO STATION 15+887 TILBURY EAST
TOWNSHIP OF TILBURY, CHATHAM-KENT, ONTARIO
G.W.P. 3034-19-00
ASSIGNMENT NO. 3017-E-0006/0007
WORK ITEM NO. 07

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
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Distribution:
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PML Ref.: 19KF030A
Index No.: 035FDR
GEOCRES No.: 40J8-76
December 17, 2019

TABLE OF CONTENTS

PART B - FOUNDATION DESIGN REPORT

PART B – PRELIMINARY FOUNDATION DESIGN REPORT
For
Sign Support Structures
Highway 401 – Station 16+587 to Station 17+596 Tilbury North
Highway 401 – Station 10+000 to Station 15+887 Tilbury East
Township of Tilbury, Chatham-Kent, Ontario
G.W.P. 3034-19-00, Assignment No. 3017-E-0006/0007, Work Item No. 07

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7. INTRODUCTION

This preliminary foundation investigation and design report with the interpretation and recommendations are intended for the use of WSP on behalf of MTO. Any other parties including the Project CO Team or design-build contractor may use the information presented in this report at their own risks. Where comments are made on construction, they are provided only to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the factual information provided in Part A of the report, as it may affect equipment selection, proposed construction methods and scheduling.

8. PROJECT DESCRIPTION

8.1 General

This report provides foundation design recommendations based on interpretation of the geotechnical data presented in the factual report (Part A). This section of the report provides foundation recommendations for the design of proposed Overhead Sign (OHS) structures along Highway 401 in the Township of Tilbury, Ontario.

The discussions and recommendations presented in this report are based on the information provided by WSP and the factual data obtained during the geotechnical investigation carried out by PML.

8.2 Design of Overhead Sign Foundations

The design of OHS structure foundations should be in accordance with the MTO *Sign Support Manual*, dated February 2019.

The standard design for OHS foundation presented in the *Sign Support Manual (February 2019)* have been developed based on the following minimum cohesive soil strength parameters:

Cohesive soils: "Soft" clay with an undrained shear strength, s_u, of 25 kPa in the upper two-thirds of the caisson foundation below the frost depth, and "firm" clay with an undrained shear strength, s_u, of 50 kPa in the lower third of the caisson foundation below the frost depth.

Table 8.2 presents preliminary design parameters based on the subsoil conditions encountered.

Table 8.2
Location of Proposed Structures and Geotechnical Design Parameters for Overhead Signs

SIGN No.	EXISTING STATION	BOREHOLE ID	ELEVATION (m)		SOIL TYPE	DESIGN PARAMETERS		
			FROM	TO		BULK UNIT WEIGHT (KN/m^3)	SHEAR STRENGTH (Cu, KPa)	INTERNAL FRICTION ANGLE (degrees)
1	16+587 (Tilbury North)	OHS-1	177.6	170.4	Stiff Clayey Silt to Silty Clay (Till)	19	50	0
		OHS-2	177.4	167.7	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0
2	13+724 (Tilbury East)	OHS-3	176.1	168.9	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0
		OHS-4	177.6	170.4	Stiff Clayey Silt to Silty Clay (Till)	19	50	0
3	14+724 (Tilbury East)	OHS-5	174.7	167.5	Hard to stiff Clayey Silt to Silty Clay (Till)	19	75	0
		OHS-6	175.8	168.6	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0
4	14+887 (Tilbury East)	OHS-7	174.7	167.5	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0
		OHS-8	175.2	168.0	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0
5	15+887 (Tilbury East)	OHS-9	178.4	171.2	Stiff to very stiff Clayey Silt (Till)	19	50	0
		OHS-10	178.9	171.7	Stiff to very stiff Clayey Silt to Silty Clay (Till)	19	50	0

Based on OPSD 3090.101, the anticipated frost depth is 1.0 m. Passive resistance within the frost depth are neglected and soil parameters within the upper 1.0 m are not provided in Table 8.2.

Based on the existing subsurface information, the soil conditions at the locations of OHS-1 to OHS-10 are expected to have equal to or higher undrained shear strength/ internal friction angles values than that of the parameters assumed for the design provided in the manuals. Therefore, the standard caisson foundation design is applicable.

The standard caisson design is applicable for installations in relatively level ground. If the OHS poles are to be placed in the proximity of a slope, a detail design may be necessary, resulting in extended embedment length and/or increased pole diameter. The lateral resistance within the embankment fill will be reduced based on the proximity to the crest of the slope, and the inclination of the slope. In these cases, the reduction to the lateral resistance may be referenced to Mezazigh and Levacher[1].

If the sign post foundation is located on shallow slope that is part of a drainage ditch, the top of the "standard" foundation may be located at or below the bottom of the drainage ditch.

8.3 Construction Considerations

Construction of the caisson foundations for the OHS should be in accordance with *Ontario Provincial Standard Specification*, OPSS.PROV 915 (Sign Support System), amended by SP 109S26 and OPSS.PROV 903 (Deep Foundations), amended by SP 109F57.

Appropriate equipment and procedures should be employed to minimize ground loss during drilling and concrete placement. This may include the use of temporary or permanent liners, and/or the use of drilling mud.

Cobbles and/or boulders were not encountered in the ten (10) boreholes drilled along Highway 401. Nevertheless, appropriate equipment and procedures may be required to penetrate these obstructions, if encountered, for the installation of caisson. The nature of glacial till deposit is such that it may contain cobbles and boulders, which may be encountered in the areas where not investigated. In view of this, a Notice to Contractor (NTC) of potential risks of cobbles and/or boulders is suggested to be included during the detail design.

1. *Mezazigh, S and Levacher, D. 1988. CGJ Vol 35.*

8.4 Soil Corrosivity

A total of five (5) samples from the clayey silt to silty clay till deposit were tested for soil corrosivity and potential exposure of concrete to sulphate attack. A summary of the results of chemical analyses are provided in section 5.2.2 of Part A of this report. The sulphate concentration varied from 67 µg/g to 410 µg/g (0.0067% to 0.041%) in four samples. Compared to the values suggested in Canadian Standard A23.1-14, the effect of soil on buried concrete is considered negligible. However, the suphate concentration was 1500 µg/g (0.15%) in borehole OHS-3, sample 8 (5.3 m to 5.9 m), indicating the effect of soil on buried concrete is considered severe at this site location.

The chloride contents of the samples ranged from as low as 27 µg/g to 80 µg/g (0.0027% to 0.0080%). Generally, the concentration value in excess of 250 ppm (0.025%) leads to corrosive environment for buried metals or reinforcing steel. The potential for corrosive environment based on chloride content is assessed to be low.

Electrical resistivity less than 2000 ohm-cm generally leads to highly corrosive environment for steel elements in contact with soil. The resistivity values of two samples from boreholes OHS-1 (sample 6, 3.8 m to 4.4 m) and OHS-9 (sample 9, 6.1m to 6.7 m) were 5020 ohm-cm and 3210 ohm-cm, respectively. The test results suggest that a low to very low corrosive environment exist at these sites for steel elements. Further, the resistivity values of two samples from boreholes OHS-5 (sample 8, depth 5.3 m to 5.9 m) and OHS-9 (sample 6, 3.8 m to 4.4 m) were 1910 ohm-cm and 1850 ohm-cm, respectively. The test results suggest that a low to moderate corrosive environment exists at these sites for steel elements. In addition, the resistivity value of 785 ohm-cm from borehole OHS-3 (sample 8, 5.3 m to 5.9m) suggest that a corrosive environment exists at this site for steel elements.

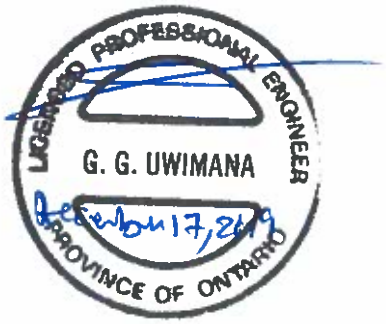
9. CLOSURE

This Foundation Design Report was prepared by Mr. N. Rahman, P.Eng., Project Engineer, and reviewed by Mr. G. Uwimana, MEng, P.Eng., Senior Engineer. Geotechnical Services. Mr. R. Ng, MBA, PhD, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

Yours very truly,

Peto MacCallum Ltd.

Nazibur Rahman, P.Eng.
Project Engineer
Geotechnical Services



Geoffrey Uwimana, MEng., P.Eng.
Discipline Head
Senior Engineer, Geotechnical Services

Robert Ng, MBA, PhD, P.Eng.
MTO Designated Principal Contact

NR/GU/RN:nr-nk

APPENDIX B

List of Standard Specifications Relevant to Report

Notice to Contractor (NTC)

LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS.PROV 903	Construction Specification For Deep Foundations
OPSS.PROV 915	Construction Specification For Sign Support Structures
SP 109F57	Amendment to OPSS 903, April 2016
SP 109S26	Amendment to OPSS 915, November 2014
OPSD 3090.101	Foundation Frost Penetration Depths for Southern Ontario

NOTICE TO CONTRACTOR (NTC)

NTC 1 – Obstructions During Caisson Construction

The Contractor shall be advised that cobbles and boulders could be present within the glacial till soils. The Contractor shall be responsible for selecting construction methods and equipment that will enable operations to advance through the fill and native glacial till soils including zones where cobbles and boulders could be encountered.