



FOUNDATION INVESTIGATION AND DESIGN REPORT

for

**CULVERT ACROSS LASALLE LINE FOR
IMPROVEMENTS OF DRAINAGE ALONG HIGHWAY 40
SARNIA, ONTARIO**

AGREEMENT NO. 3016-E-0009-08

WORK ORDER # 8

GWP 3054-17-00

LATITUDE AND LONGITUDE: 42.912181, -82.412825

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:

- 2 cc: WSP Canada Group Limited for distribution
to MTO Project Manager + 2 digital copy (pdf)
- 2 cc: WSP Canada Group Limited for distribution
to MTO Foundations Section + 2 digital copy (pdf)
- 1 cc: WSP Canada Group Limited + 1 digital copy (pdf)
- 1 cc: PML Toronto
- 1 cc: PML Kitchener

PML Ref.: 19TF005
Index No.: 020FIR and 021FDR
GEOCRES No.: 40J16-89
November 15, 2019



PART A - FOUNDATION INVESTIGATION REPORT

for

**CULVERT ACROSS LASALLE LINE FOR
IMPROVEMENTS OF DRAINAGE ALONG HIGHWAY 40
SARNIA, ONTARIO
AGREEMENT NO. 3016-E-0009-08
WORK ORDER # 8
GWP 3054-17-00
LATITUDE AND LONGITUDE: 42.912181, -82.412825**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:

2 cc: WSP Canada Group Limited for distribution
to MTO Project Manager + 2 digital copy (pdf)
2 cc: WSP Canada Group Limited for distribution
to MTO Foundations Section + 2 digital copy (pdf)
1 cc: WSP Canada Group Limited + 1 digital copy (pdf)
1 cc: PML Toronto
1 cc: PML Kitchener

PML Ref.: 19TF005
Index No.: 020FIR
GEOCRES No.: 40J16-89
November 15, 2019



TABLE OF CONTENTS

PART A - FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION	1
2. SITE DESCRIPTION	1
3. FIELD INVESTIGATION PROCEDURES	2
4. LABORATORY TEST PROCEDURES	3
5. SITE GEOLOGY AND SUBSURFACE CONDITIONS	4
5.1 Site Geology	4
5.2 Subsurface Conditions.....	4
5.2.1 Pavement Structure	5
5.2.2 Clayey Silt (Fill)	5
5.2.3 Clayey Silt, Some Sand, Trace Gravel	5
5.2.4 Groundwater	6
6. CHEMICAL ANALYSIS	6
7. CLOSURE	8
Appendix A – Borehole Locations Plan and Soil Strata Drawing C-1	
Explanation of Terms Used in Report	
Record of Borehole Sheets	
Results of Grain Size Distribution Analyses – Figure SS-GS-1	
Results of Atterberg Limit Tests – Figure SS-PC-1	
Appendix B – Results of Chemical Tests Provided by SGS Canada Inc.	

PART A - FOUNDATION INVESTIGATION REPORT

Culvert Across LaSalle Line for Improvement of Drainage along Highway 40
Sarnia, Ontario.

Agreement No. 3016-E-0009-08
GWP 3054-17-00

1. INTRODUCTION

The Ministry of Transportation Ontario (MTO) has retained WSP Canada Group Limited (WSP) as the Prime Consultant, to provide Owner's Engineer services for the detail design to improve the drainage along Highway 40 at the crossing of LaSalle Line. WSP has retained Peto MacCallum Ltd. (PML) on behalf of MTO to provide geotechnical engineering services for the assignment.

The geotechnical investigation work reported herein is part of Agreement No. 3016-E-0009-08, Work Order No. 08 (WO No. 08). This assignment includes the following:

- Installation of a culvert across LaSalle Line, consisting of three (3) 750 mm diameter pipes; and
- Installation of a 825 mm diameter mainline sewer across Highway 40

This report summarizes the results of the foundation investigation carried out to support the installation of a new culvert east of Highway 40 and LaSalle Line intersection. The proposed culvert, are located approximately 35 m east of the intersection of Highway 40 and LaSalle Line in Sarnia, Ontario. A foundation investigation and design report will be submitted for the proposed mainline sewer under a separate cover.

2. SITE DESCRIPTION

The location of the proposed culvert is approximately 35.0 m east of Highway 40 and LaSalle Line intersection. Highway 40 and LaSalle Line are slightly elevated from the natural topography, of the area and accommodate four (4) and two (2) lanes of vehicular traffic, respectively. The site is generally a flat area, with the exception of the roadway embankments. Talfourd creek flows from east to west, almost perpendicular to Highway 40, and crosses the highway at approximately 200 m south of the LaSalle Line intersection. LaSalle Line is running in the east to west direction, while Highway 40 is running in the north to south direction. The proposed culvert site is located within the rural setting, covering residential, farm lands and wooded area in the vicinity of Highway 40.



3. FIELD INVESTIGATION PROCEDURES

The fieldwork for the foundation investigation consisted of advancing two (2) boreholes to a maximum depth of 11.3 m below the existing ground surface (El. 176.5 to El. 176.6), and were terminated below the 9.0 m depth that was proposed. The locations, ground elevations and depths of drilling are summarized in Table 3.

Table 3 – Borehole Locations and Termination Depths						
Borehole No.	LOCATION				Depth (m)	Ground Elevation (m)
	Northing	Easting	Latitude	Longitude		
SS-1	4 752 483.7	311 917.5	42.912096	-82.412828	11.3	187.9
SS-2	4 752 491.3	311 917.5	42.912181	-82.412825	11.3	187.8

The number and location of the boreholes were selected based on discussion with MTO and WSP considering the site conditions and underground utilities including oil pipelines and watermain. The staff of PML visited the site on August 06, 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 before the commencement of drilling work.

PML staff used a portable GPS device to establish the borehole locations 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 reported in this report are referred to in MTM NAD 83 Northing and Easting (MTM Zone – ON10) Geodetic datum and expressed in meters.

The equipment used for drilling was owned and operated by Determination Drilling Inc. (Determination), of Hamilton, Ontario. Determination is a specialist drilling contractor and worked under the full-time supervision of a PML field supervisor. Boreholes SS-1 and SS-2 were drilled between September 7 and 22, 2019, using a CME 55 track-mounted drilling rig equipped with 200 mm diameter hollow stem augers.



Traffic control services were provided by Construction Support Services (CSS) of Mississauga, Ontario, in accordance with Ontario Traffic Manual, Book 7-Temporary Conditions (2014). In addition, paid-duty police officer from Sarnia Police Department was engaged during the drilling of both boreholes because the drilling operation was carried out within 30 m from the traffic signal.

Representative soil samples were recovered from the boreholes at 0.75 m intervals using a conventional 51 mm OD split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure (ASTM D 1586). 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. A monitoring well, consisting of 50 mm outside diameter rigid PVC pipe, was installed in one of the boreholes to measure subsequent groundwater levels. Refer to Record of Borehole Sheet in Appendix A for details of monitoring well installation. Water levels were measured using a Solinst flat tape water level reader.

The water level in the Talfourd Creek was observed at approximate elevation of El. 183.1 during the fieldwork.

Upon completion of drilling, the boreholes were backfilled with bentonite or cement grout in accordance with the MTO guidelines and Ministry of the Environment, Conservation and Parks (MECP) Regulation 903, amended by Ontario Regulation 372. The monitoring well was decommissioned on October 4, 2019 in accordance with the regulation. The pavement was reinstated for the two boreholes.

The recovered soil samples were returned to the PML laboratory for detailed visual examination and index tests.

4. LABORATORY TEST PROCEDURES

Laboratory tests on representative SPT samples recovered during the fieldwork were conducted by the laboratory owned by PML, located in Toronto. The laboratory testing program included the following:



- Natural moisture content determinations (24)
- Grain size distribution analysis (6)
- Atterberg limit tests (6)

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 on Figure SS-GS-1. The results of the Atterberg Limit tests are presented on Figure SS-PC-1. All of the test results are summarized on the attached Record of Borehole Logs provided in Appendix A.

One (1) selected sample was sent to SGS Canada Inc. (SGS) in Toronto, Ontario, which is accredited by Canadian Analytical Laboratory Association (CALA) for corrosivity analyses.

5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

In general, the project area is located within the physiographic region of St. Clair Clay Plains, which is dominated by a mixture of clay, and silt deposits of lacustrine origin. It is an essentially till plain smoothed by shallow deposits of lacustrine clay. The land pattern in this region is generally flat and consists of a deeper covering of stratified clay and silt. The region is underlain largely by black shale bedrock and which is an important component of clays but limestone flour is also abundantly available, as outlined in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984).

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 St. Joseph Till deposits; predominantly silt to silty clay matrix. Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the culvert sites lie within the Upper Devonian shale bedrock of the Kettle Point formations.

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 and stratigraphic profile sections are shown on Drawing C-1. The boundaries



between soil strata were established at the borehole locations only. The boundaries of soil strata between and beyond the boreholes are assumed and may vary from location to location.

It should be noted that the soil stratigraphy are interpolated between the drilled boreholes. Since, buried pipe lines exist within LaSalle line, fill associated with installation and backfill of the pipes will likely exist.

In general, the subsoil conditions consist of 0.6 m to 0.8 m pavement structure immediately below the ground surface, underlain very stiff to hard clayey silt fill (reworked). The fill is immediately followed by stiff to very stiff clayey silt deposit. The clayey silt layer encountered extends to the maximum termination depth of 11.3 m (El. 176.6 to 176.5) below the existing ground surface. For classification purposes, the soils encountered at this site can be divided into three (3) distinct zones.

- a) Pavement Structure
- b) Clayey Silt (Fill)
- c) Clayey Silt, some Sand, Trace Gravel

5.2.1 Pavement Structure

Pavement structure comprised of 200 mm and 255 mm thick asphalt overlying 405 mm and 500 mm granular fill was encountered immediately below the existing ground surface. The granular fill extends to depths 0.6 m (El. 187.3) and 0.8 m (El. 187.0) below the existing ground surface.

The SPT “N”-values recorded within the granular fill layer were 44 and 61 blows, indicating dense to very dense state of compaction of the granular fill. The moisture contents of the two samples tested from granular fill were 3.1% and 7.4%.

5.2.2 Clayey Silt (Fill)

The pavement structure is immediately underlain by 0.6 m to 0.7 m thick clayey silt fill layer in the two boreholes. This layer extends to depths 1.2 m (El. 186.7) and 1.5 m (El. 186.3). The SPT “N”-values recorded within the fill layer were 17 and 33 blows, indicating very stiff to hard consistency. The moisture contents of two samples tested from the clayey silt fill were 8.8% and 15.6%.

5.2.3 Clayey Silt, Some Sand, Trace Gravel

This layer was encountered immediately below the clayey silt fill layer. This layer extends to the termination depth of 11.3 m (El. 176.5). The SPT “N”-values recorded to about El. 184.1 ranged from 16



to 28, indicating very stiff of consistency. Below this elevation, the SPT “N”-values recorded ranged from 9 to 15, indicating stiff to very stiff consistency. The moisture content of samples tested from the clayey silt deposit varies from 15.3% to 23.3%, with an average value of 19.3%.

The grain size distribution results of six (6) representative samples from the clayey silt are presented on Figure SS-GS-1. A total of six (6) Atterberg limits test results are presented on Figure SS-PC-1. These samples contained none to 4% gravel, 4% to 14% sand, 43% to 55% silt, and 38% to 43% clay. The liquid limits of the samples tested were between 33 and 36 and the plastic limits were between 16 and 18. The values of plasticity index computed range between 16 and 19. Based on the results of Atterberg limit tests, the soil may be classified as clayey of low plasticity (CL) in the Unified Soil Classification System and in the MTO Classification System, it may be classified as clayey silt.

5.2.4 Groundwater

The groundwater level was not encountered in both boreholes during or upon completion of drilling.

A monitoring well consisting of 50 mm diameter PVC pipe was installed in borehole SS-2. Water level readings from the monitoring well are summarized in Table 5.2.4.

Table 5.2.4: Water Level Readings in Monitoring Well

GROUND SURFACE ELEVATION (m)	MID SCREEN DEPTH (m) (ELEVATION)	WATER LEVEL MEASURED IN MONITORING WELL		DATE OF READING
		DEPTH (m)	ELEVATION (m)	
187.8	9.9 (177.9)	1.5	186.1	Sept. 13, 2019
		1.2	186.4	Sept. 25, 2019
		1.3	186.5	Oct. 4, 2019

The water level in the creek was observed at approximately elevation of El. 183.1 during the fieldwork.

Groundwater levels may fluctuate due to the influence of precipitation and seasonal change. The groundwater observations were made prior to backfilling the boreholes. Groundwater levels are shown on the Borehole Logs in Appendix A.

6. CHEMICAL ANALYSIS

A summary of the chemical test results provided by SGS are presented in Table 6.1. The details of the test results provided by SGS are also presented in Appendix B.



Table 6.1: Soil Chemical Analysis Results

BOREHOLE	SAMPLE	DEPTH (M)	CORROSIVITY INDEX	CHLORIDE (%)	SOIL REDOX POTENTIAL (mV)	SULPHATE (%)	pH	RESISTIVITY (ohms.cm)
SS-1	3	1.5 - 2.1	2	0.015	263	0.0042	8.35	2610



7. CLOSURE

Mr. M. Mohamed carried out the field investigations under the supervision of Mr. N. Rahman, P.Eng., Project Engineer, and Ms. N. Leong-Sem, EIT. Determination Drilling Ltd. of Hamilton, 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 Mr. Keshav K. Amatya, MEng., P. Eng., Project Engineer, Geotechnical Services and reviewed by Mr. N. Rahman, 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.



Keshav K. Amatya, MEng., P.Eng.
Project Engineer, Geotechnical Services



Nazibur Rahman, P.Eng.
Senior Engineer, Geotechnical Services



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

KA/NR/RN:ka-nr-nk



APPENDIX A

Borehole Locations Plan and Soil Strata Drawing C-1

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figure SS-GS-1

Results of Atterberg Limit Tests – Figure SS-PC-1



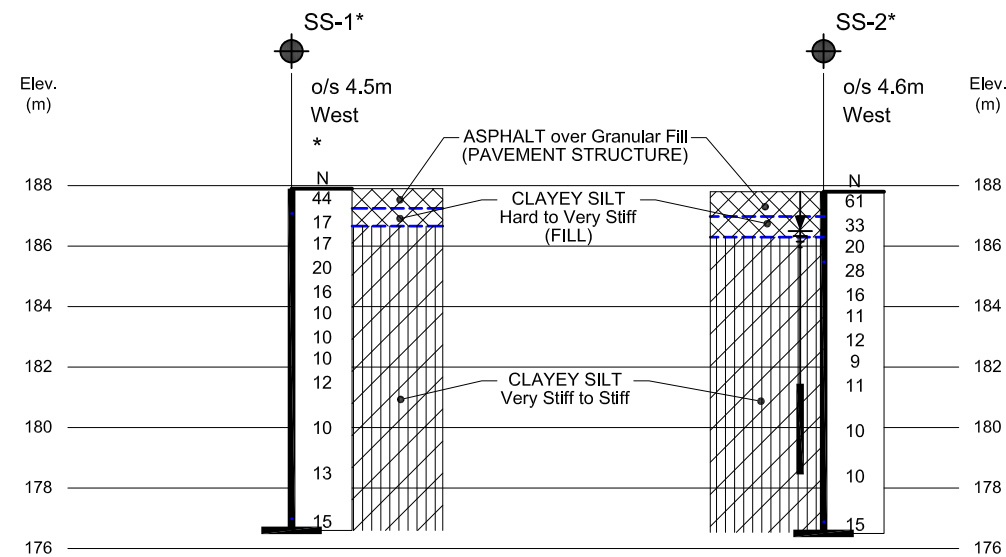
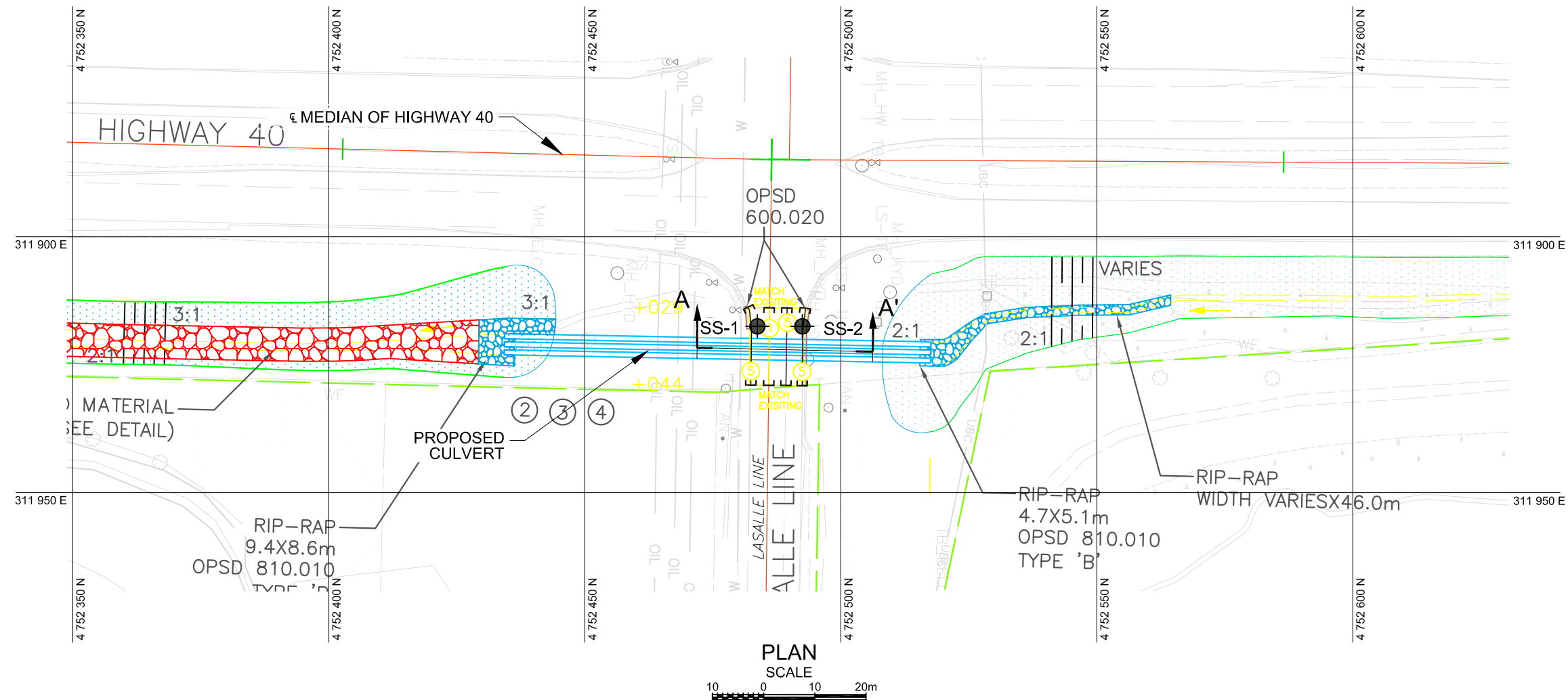
LEGEND			
	Borehole		
	Blows/0.3m (Std. Pen Test, 475 J/blow)		
	Groundwater level measured in Monitoring Well October 2019		
	Groundwater not encountered during drilling		
	50 mm diameter Monitoring Well		

BH No	ELEVATION	NORTHINGS	EASTINGS
SS-1	187.9	4 752 483.7	311 917.5
SS-2	187.8	4 752 491.3	311 917.5

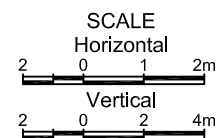
NOTE -
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

DATE	BY	DESCRIPTION

Geocres No. 40J16-89			
HWY No	40	DIST	West Region
SUBM'D	NL	CHECKED	KA
DATE	NOV. 15, 2019	SITE	
DRAWN	NL	CHECKED	NR
APPROVED	RN	DWG	C-1



PROFILE A-A' ALONG C/L OF PROPOSED CULVERT



NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF REPORT AND RECORD OF BOREHOLE LOGS.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.
- FILL IS ANTICIPATED BETWEEN BOREHOLE LOCATIONS ASSOCIATED WITH EXISTING UTILITIES.



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'_{v0}	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_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL




ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ³	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No SS-1

1 OF 1

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 483.7 N; 311 917.5 E ORIGINATED BY M.M.
DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE 2019.09.12 LATITUDE 42.91209596 LONGITUDE -82.41282791 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)								
187.9 0.0	Ground 200 mm ASPHALT over 405 mm granular fill (PAVEMENT STRUCTURE)		1	SS	44	187											1 12 44 43									
187.3 0.6	CLAYEY SILT, some sand, trace gravel Very stiff, Brown, Moist (FILL)		2	SS	17																					
186.7 1.2	CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Brown to grey, Moist to wet		3	SS	17		186																			
			4	SS	20			185																		
			5	SS	16				184																	
			6	SS	10					183																
			7	SS	10						182															
			8	SS	10							181														
			9	SS	12								180													
			10	SS	10									179												
			11	SS	13										178											
			12	SS	15											177										
176.6 11.3	End of borehole																									
NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. Borehole caved-in at a depth of 10.5 m (El. xxx) below the existing ground surface, upon extraction of augers.																										

ONTARIO MTO 19TF005.GPJ ONTARIO MTO.GDT 10/24/19

RECORD OF BOREHOLE No SS-2

1 OF 2

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 491.3 N; 311 917.5 E ORIGINATED BY M.M.
DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.
DATUM Geodetic DATE 2019.09.12 LATITUDE 42.91218148 LONGITUDE -82.41282496 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
								WATER CONTENT (%)								
187.8	Ground						20	40	60	80	100	20	40	60		
0.0	255 mm ASPHALT over 500 mm granular fill		1	SS	61							○				
	(PAVEMENT STRUCTURE)															
187.0	CLAYEY SILT, some sand, trace gravel Hard, Brown, Moist (FILL)		2	SS	33							○				
0.8																
186.3	CLAYEY SILT, some sand, trace gravel		3	SS	20							○				
1.5	Very stiff to stiff, Brown to grey, Moist to wet															
			4	SS	28							○				
			5	SS	16							⊞	⊞			2 14 46 38
			6	SS	11							○				
			7	SS	12							○				
			8	SS	9							○				
			9	SS	11							⊞	⊞			1 14 44 41
			10	SS	10							○				
	trace sand		11	SS	10							⊞	⊞			0 4 55 41
			12	SS	15							○				
176.5	End of borehole															
11.3	Groundwater level measured in monitoring well															
NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. Borehole caved-in at a depth of 10.5 m (El. 177.3) below the existing ground surface, upon extractinon of augers. Monitoring Well Readings: Date Depth Elev. (m) Sept.13/19 1.5 186.1 Sept.25/19 1.2 186.4 Oct.4/19 1.3 186.5																

Continued Next Page









+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No SS-2

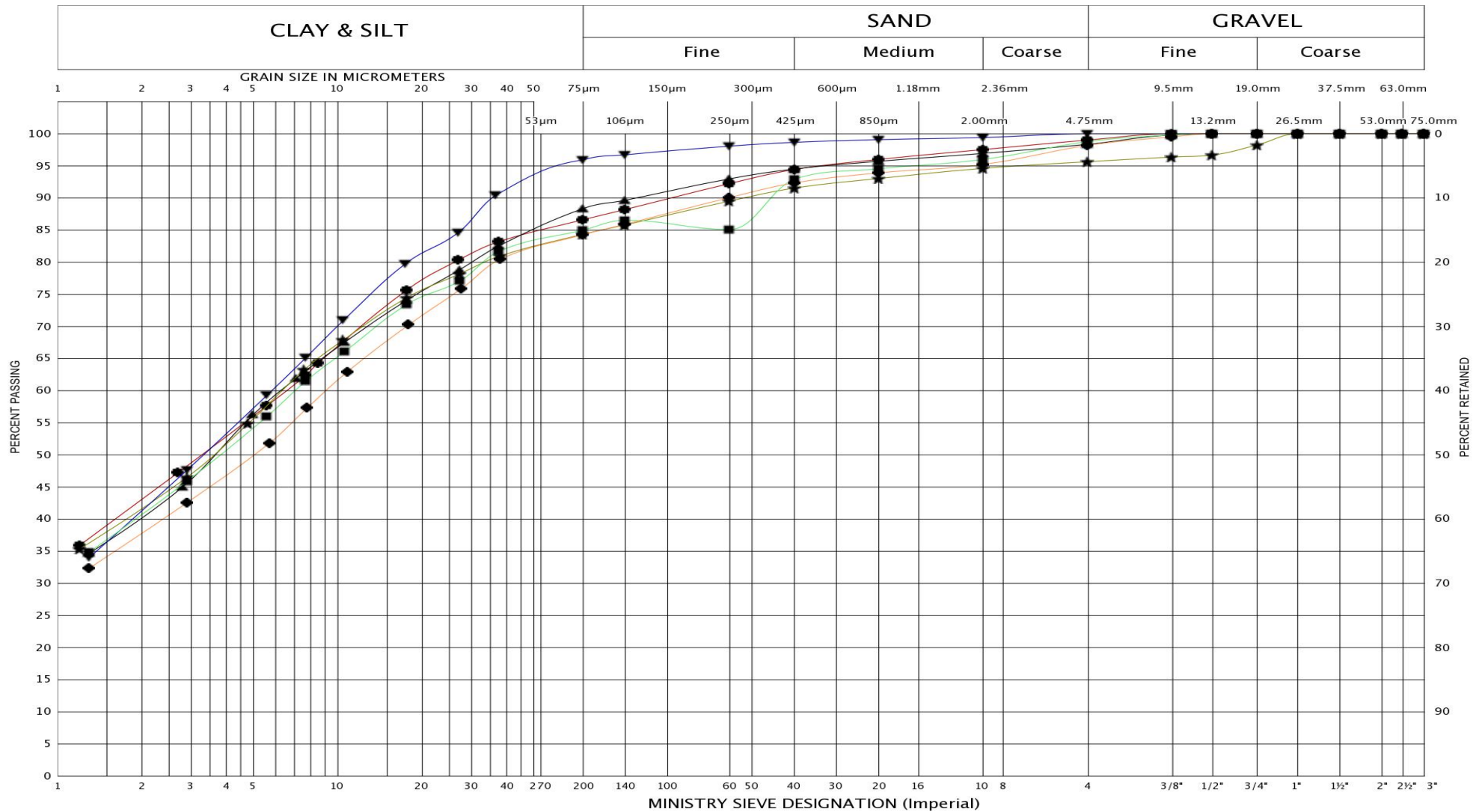
2 OF 2

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 491.3 N; 311 917.5 E ORIGINATED BY M.M.
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.
 DATUM Geodetic DATE 2019.09.12 LATITUDE 42.91218148 LONGITUDE -82.41282496 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
172.8	<p><u>Monitoring Well Legend:</u></p> <p>  Flush Mount  Cement Sand  Bentonite  Filter Sand  19 mm PVC Screen  Filter Bottom  Bentonite Bottom  Cave-in </p>																

UNIFIED SOIL CLASSIFICATION SYSTEM

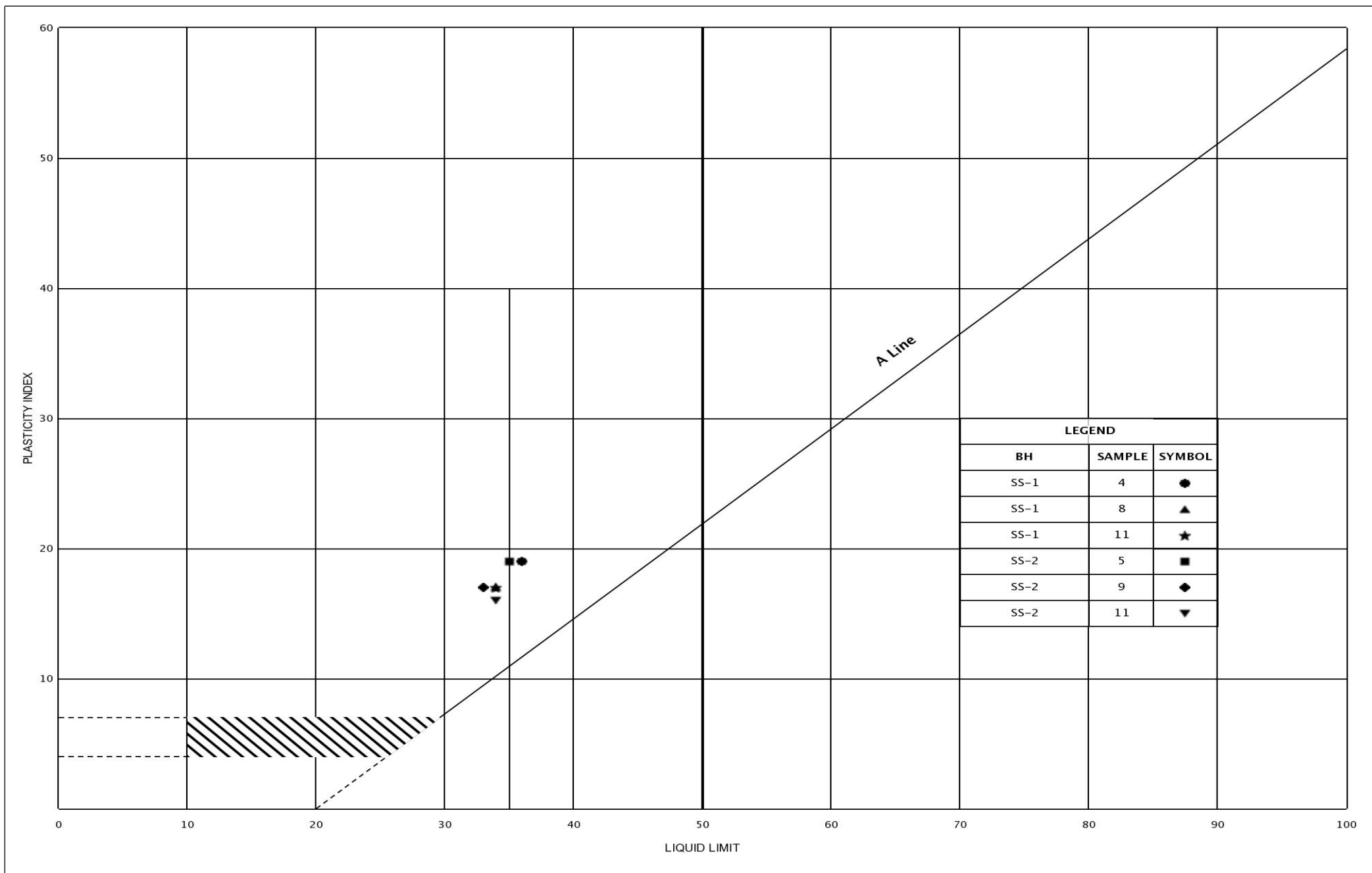


LEGEND	BH	SS-1	SS-1	SS-1	SS-2	SS-2	SS-2
	SAMPLE	4	8	11	5	9	11
	SYMBOL	●	▲	◆	■	▼	▼



GRAIN SIZE DISTRIBUTION
CLAYEY SILT, trace/some sand, trace gravel

FIG No.: SS-GS-1
HWY : 40
WO 3016-E-0009-8





APPENDIX B

Results of Chemical Tests Provided by SGS Canada Inc.



FINAL REPORT

CA14819-SEP19 R1

19TF005 Hwy 40 and Lasalle Line, Sarnia ON

Prepared for

Peto MacCallum Ltd

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@petomacallum.com

Project 19TF005 Hwy 40 and Lasalle Line, Sarnia ON

Order Number

Samples Soil (2)

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 CA14819-SEP19

Received 09/23/2019

Approved 09/26/2019

Report Number CA14819-SEP19 R1

Date Reported 09/26/2019

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: Yes

Custody Seal Present: No

Chain of Custody Number: 006621

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

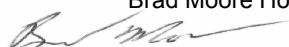




TABLE OF CONTENTS

First Page..... 1

Index..... 2

Results..... 3-4

QC Summary..... 5-6

Legend..... 7

Annexes..... 8



FINAL REPORT

CA14819-SEP19 R1

Client: Peto MacCallum Ltd

Project: 19TF005 Hwy 40 and Lasalle Line, Sarnia ON

Project Manager: Nazibur Rahman

Samplers: K Amatya

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6
Sample Name	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
Sample Matrix	Soil	Soil
Sample Date	19/09/2019	19/09/2019

Parameter	Units	RL		Result	Result
Corrosivity Index					
Corrosivity Index	none	1		11	2
Soil Redox Potential	mV	-		278	263
Sulphide	%	0.02		< 0.02	< 0.02
pH	pH Units	0.05		7.77	8.35
Resistivity (calculated)	ohms.cm	-9999		698	2610

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6
Sample Name	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
Sample Matrix	Soil	Soil
Sample Date	19/09/2019	19/09/2019

Parameter	Units	RL		Result	Result
General Chemistry					
Conductivity	uS/cm	2		1430	383

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6
Sample Name	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
Sample Matrix	Soil	Soil
Sample Date	19/09/2019	19/09/2019

Parameter	Units	RL		Result	Result
Metals and Inorganics					
Moisture Content	%	0.1		13.8	14.1
Sulphate	µg/g	0.4		43	42



FINAL REPORT

CA14819-SEP19 R1

Client: Peto MacCallum Ltd

Project: 19TF005 Hwy 40 and Lasalle Line, Sarnia ON

Project Manager: Nazibur Rahman

Samplers: K Amatya

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
Sample Matrix	Soil	Soil
Sample Date	19/09/2019	19/09/2019

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		680	150



FINAL REPORT

CA14819-SEP19 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-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	DIO0370-SEP19	µg/g	0.4	<0.4	2	20	94	80	120	110	75	125
Sulphate	DIO0370-SEP19	µg/g	0.4	<0.4	2	20	96	80	120	97	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-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	ECS0038-SEP19	%	0.02	<0.02	ND	20	116	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-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	EWL0393-SEP19	uS/cm	2	< 0.002	1	10	97	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0393-SEP19	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.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



PART B - FOUNDATION DESIGN REPORT

for

**CULVERT ACROSS LASALLE LINE FOR
IMPROVEMENTS OF DRAINAGE ALONG HIGHWAY 40
ST. CLAIR TOWNSHIP, SARNIA, ONTARIO
AGREEMENT NO. 3016-E-0009-08
WORK ORDER # 8
GWP 3054-17-00
LATITUDE AND LONGITUDE: 42.912181, -82.412825**

PETO MacCALLUM LTD.
165 CARTWRIGHT AVENUE
TORONTO, ONTARIO
M6A 1V5
Phone: (416) 785-5110
Fax: (416) 785-5120
Email:toronto@petomaccallum.com

Distribution:

2 cc: WSP Canada Group Limited for distribution
to MTO Project Manager + 2 digital copy (pdf)
2 cc: WSP Canada Group Limited for distribution
to MTO Foundations Section + 2 digital copy (pdf)
1 cc: WSP Canada Group Limited + 1 digital copy (pdf)
1 cc: PML Toronto
1 cc: PML Kitchener

PML Ref.: 19TF005
Index No.: 021FDR
GEOCRES No.: 40J16-89
November 15, 2019



TABLE OF CONTENTS

PART B - FOUNDATION DESIGN REPORT

8. INTRODUCTION	8
9. PROJECT DESCRIPTION	8
9.1 General	8
9.2 Existing Utilities.....	8
9.3 Proposed Culvert	9
9.4 Installation of Pipe Culvert.....	10
10. REINSTATEMENT OF EMBANKMENT.....	11
11. FOUNDATION FROST DEPTH	11
12. SEISMIC CONSIDERATIONS	11
13. EXCAVATION.....	12
14. GROUNDWATER CONTROL.....	13
15. SOIL CORROSIVITY.....	14
16. CLOSURE	15

Appendix C – List of Standard Specifications Relevant to Report
Non-Standard Special Provisions (NSSP)

PART B - FOUNDATION DESIGN REPORT

Culvert Across LaSalle Line for Improvement of Drainage along Highway 40
Township of St. Clair, Sarnia, Ontario.
Agreement No. 3016-E-0009-08
GWP 3054-17-00

8. INTRODUCTION

This foundation investigation and design report with the interpretation and recommendations are intended for the use of WSP on behalf of MTO, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. 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.

9. PROJECT DESCRIPTION

9.1 General

This report provides recommendations for design and installation of the culvert based on interpretation of the geotechnical data presented in the factual report (Part A), to assist the designer of the proposed culvert consisting of three (3) 750 mm diameter pipes to be installed across LaSalle Line, adjoining Highway 40 in Sarnia, 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.

9.2 Existing Utilities

Highway 40 in the vicinity of the existing culvert is slightly elevated from the natural topography of the surrounding area and the height of embankment range from 0.6 m to 0.7 m. The existing embankment on both sides of the LaSalle Line appear in stable condition.

Based on the Drainage Improvements Ditch Profile Drawing (modified) dated July 24, 2019 and Construction Drawing (modified) dated September 24, 2019 provided by WSP, three Enbridge oil pipes are located at about 1.5 m to 2.8 m below the pavement of LaSalle Line. In addition, a 900 mm diameter watermain owned and operated by Lambton Area Water Supply System (LAWSS) is located approximately 4.0 m below the pavement. These utilities are running in the



east-west direction along Lasalle Line on the south side of the intersection of Highway 40 and LaSalle Line.

Existing underground utilities, especially the watermain and oil pipelines may impose potential conflict with the proposed alignment of the culverts and precautionary measures to prevent damage must be arranged with the respective utility owners. The scope of foundation investigation work carried out by PML does not cover or include accessing beyond the location of borehole requirements. Therefore, the specialty contractor and owner of the proposed culverts should confirm the existence of any utility or obstructions that may impose potential conflict with the proposed alignment and is advised to obtain necessary permits, prior to the commencement of construction.

It is anticipated that the vertical and horizontal clearances for excavation and shoring during the installation may largely influence the recommendation of the proposed culvert with respect to location. PML understands that properly designed temporary utility support systems will be required during the installation of the proposed culvert.

9.3 Proposed Culvert

The Construction Drawing (modified) dated September 24, 2019 provided by WSP, indicates that the proposed pipe culvert will be about 80 m long across LaSalle Line. This drawing indicates that the invert of the culvert at the inlet will be set at El. 183.05 and at the outlet, it will be set at El. 182.96. It is anticipated that concrete pipes will be specified based on WSP October 17, 2019 email.

Based on the drawing, the alignment of proposed culvert across LaSalle Line will be almost parallel to the existing alignment of Highway 40. The drawing also indicates that the ditch line on both sides of the proposed culvert will be protected with rip-rap in accordance with OPSD 810.010. Further, it indicates that the rip-rap at the inlet will cover about 4.7 m x 5.1 m of the ditch and the width of the rip-rap will vary to a distance of 46.0 m. The rip-rap at the outlet will cover approximately 9.5 m x 8.6 m of the ditch, and the ditch line following the rip-rap to a distance of approximately 110 m towards Talfourd Creek will be covered by streambed material.

The existing grade of LaSalle Line along the centerline varies from El. 188.2 to El. 187.8. The grade of LaSalle Line is expected to be maintained at the existing elevation and the height of fill above the top of the pipes is not expected to exceed 4.2 m.



PML understands that LaSalle Line will be closed during the installation of the culvert and the traffic will be diverted through detour route along Kimball Road and Petrolia Line. PML also learned from the minutes of the meeting, dated September 24, 2019, that the existing crossing utilities limit the option of using trenchless methods, and an open-cut or trenching method will be opted to install the proposed culvert.

9.4 Installation of Pipe Culvert

In summary, the subsoil conditions consist of 0.6 m to 0.8 m of pavement structure immediately below the ground surface, underlain by clayey silt fill to about El. 186.7 to El. 186.3. Below the fill layer, the subsoil consists of stiff to very stiff clayey silt, which extends to the termination depth of 11.3 m (El. 176.5), below the existing ground surface. The groundwater was not encountered in both boreholes upon completion of drilling. It should be noted that fill associated with installation and backfill of the existing pipes will likely exist.

The inverts of the culvert at the inlet and outlet will be set approximately at El. 183.05 and EL. 182.96, respectively. It is expected that the pipes will be embedded about 3.2 m to 3.7 m into the stiff to very stiff clayey silt.

The installation of the culvert consisting of three (3) 750 mm diameter pipes shall be in accordance with OPSS.PROV 421. For rigid pipes, the bedding material, cover and backfill shall be in accordance with OPSD 802.031 (Type 3 Soil). The bedding material may be Granular A meeting the requirements of OPSS.PROV 1010.

The moisture content of the clayey silt deposit encountered at this site range from 15.3 % to 23.3 %, with an average value of 19.3%. This material does not meet the requirements of OPSD 802.031 and OPSS 401 to use as bedding or cover material. However, it may meet the requirements of Section 401.05.05 of OPSS 401 to use as backfill material, as defined in Section 401.03 of OPSS 401. In case, the native clayey silt is used as backfill material, it may require processing to reduce the natural moisture content to place at or near the optimum moisture content, as well as, environmental assessment of the excavated material may be required.

Trenching, backfilling and compacting shall be in accordance with OPSS.PROV 401. The backfill material may be Granular B Type II meeting the requirements of OPSS.PROV 1010.



The clayey silt layer at the bedding level may be susceptible to disturbance due to construction activity and any ponded water. In order to limit the degradation, it is recommended that the granular bedding be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade.

Sufficient horizontal and vertical clearance should be maintained as practically as possible in order to mitigate the conflict with existing crossing utilities.

10. REINSTATEMENT OF EMBANKMENT

The proposed grade of LaSalle Line along the centerline varies from El.± 188.2 to El.± 187.8. Based on the Construction drawing, the height of embankment fill required above the culvert to the existing grade of LaSalle Line, approximately at Station 26+584 is not expected to exceed 4.5 m, including the pavement structure. Considering the subsoil conditions at this site, no major instability problems are anticipated for the embankments constructed with 2H:1V side slope or flatter. Any spongy or soft area observed within the base of the embankment should be removed before placing the fill.

As indicated on the Construction Drawing, rip-rap should be provided on both the upstream and downstream sides of the channel to protect the toe of the embankments and to prevent erosion of the channel bed in the proximity of the culvert. Rip-rap material shall be in accordance with OPSS.PROV 511 and should be provided to a minimum height of 1.0 m above the highest flood level expected in the channel. It is recommended to place a geotextile layer over the founding soil prior to placing rip-rap. Geotextile material shall be in accordance with OPSS.PROV 1860. Construction of the rip-rap shall be in accordance with OPSS.PROV 511 and OPSD 810.010.

11. FOUNDATION FROST DEPTH

In accordance with OPSD 3090.101, a minimum of 1.2 m earth cover is required to protect against the frost penetration in the area where the site is located.

12. SEISMIC CONSIDERATIONS

The Spectral ($S_a(T)$, where T is in seconds) and Peak Ground Acceleration (PGA) for the project site is 0.088 ($S_a(0.2)$) and 0.051 (2%/50 years), respectively, based on the longitude and latitude coordinates of the proposed structure (National Building Code of Canada, 2015). The soil below the founding level at this site for seismic design purposes is classified as Site Class D in accordance with Clause 4.4.3.2, CHBDC 2014.



13. EXCAVATION

Based on the Construction drawing, it is estimated that the maximum depth of excavation will be about 5.2 m (El. 182.6). The excavation for the construction of the new culvert will be advanced through existing fill material underlain by very stiff to stiff clayey silt deposit. Any spongy or soft area observed within the base of the excavation should be removed and replaced with suitable fill material and compacted in accordance with OPSS.PROV 401.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

Surface water should be diverted away from open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and MTO Regulations for Construction Projects.

According to OHSA criteria, the existing clayey silt fill layer, clayey silt deposit and any existing fill can be classified as Type 3 soil. Soils below groundwater table and soils showing persistent seepages are considered having the characteristics of a Type 4 soil. Open cut excavations are governed by soils with the highest soil type number. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Temporary shoring systems may be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided.

Excavated material shall not be stockpiled in the areas immediately adjacent to the top of the excavation slopes. All excavated surfaces should be kept free of frost and water during the period of construction. Runoff shall be directed away from open excavations and should not be allowed to flow into the excavation.

Prior to excavation, the locations and depths of existing underground utilities should be verified. All underground utilities that might be exposed and become unsupported as a result of the excavation should be properly supported to avoid potential damage.

If excavations steeper than approximately 1H:1V are required and open excavation is restricted such that a road protection system is required, it should be designed to meet the appropriate Performance Level 2 as specified in OPSS.PROV 539 and SP 105S09. It should be noted that the use of shoring



may conflict with existing utilities in some locations. The Contractor is responsible for the selection, design, construction, and performance of the temporary protection systems.

All temporary shoring if installed within MTO ROW should be removed after construction, and restored and repaired to initial conditions without damage to any existing utilities, structures and pavement.

Geotechnical parameters based on boreholes SS-1 and SS-2 are provided in Table 13.1 may be used for temporary protection systems.

Table 13.1: Soil Parameters

ELEVATION (m)		SOIL TYPE	SOIL PARAMETERS		
FROM	TO		FRICTION ANGLE (ϕ°)	UNIT WEIGHT (γ) kN/m ³	C _u , (kPa)
187.3	186.3	Very Stiff to hard Clayey Silt (fill)	-	19	100
186.3	184.1	Very Stiff Clayey Silt	-	19	125
184.1	176.5	Very Stiff to Stiff Clayey Silt	-	18	75

Note: Submerged unit weight should be used below the water level.

14. GROUNDWATER CONTROL

A temporary dewatering system may be required to place the bedding material in the dry condition. The groundwater level should be lowered to a minimum of 0.5 m below the proposed founding level of the culvert, in order to allow for construction in the dry.

Surface water flow or seepage from perched water should be directed away from the excavation areas to mitigate disturbance and weakening of the founding soil.

No major groundwater problems are anticipated at the proposed culvert location. Conventional sump pumping techniques are considered to be adequate to mitigate any surface runoff and seepage from localized soil fissures at the excavation depth.

If infiltration is anticipated, a more positive dewatering scheme is required to lower the water level a minimum of 0.5 m below the base of excavation. Such a dewatering scheme may require the construction of an appropriately designed cofferdam.



The contractor should be responsible for the selection, performance and detailed design of the dewatering system, including the cofferdam. The dewatering system should be designed to conform to the requirements of OPSS.PROV 517 and SP 517F01.

In accordance with SP 517F01, the dewatering system should be designed by a designer with a minimum 5 years of experience in the field. A preconstruction survey is not required due to the relatively shallow depth of dewatering and the relatively large distances to critical private properties. It is understood that the existing three oil pipe lines and the watermain at the site location will be temporarily supported during the installation of the proposed culvert.

15. SOIL CORROSIVITY

One soil sample was tested for soil corrosivity and potential exposure of concrete to sulphate attack. The sulphate content of the clayey silt samples is 42 µg/g or 0.0042%. Compared to the values suggested in Canadian Standard A23.1-14, the effect of clayey silt at the site on buried concrete structure is considered negligible. In general, no sulphate attack is expected for concrete founded in the clayey silt.

The chloride content for the sample is 150 µg/g or 0.015%. Generally the concentration value in excess of 250 ppm (0.025%) leads to corrosive environment for buried metals or reinforcing steel. Electrical resistivity less than 2000 ohms-cm generally leads to highly corrosive environment for steel elements in contact with soil. The resistivity value of the clayey silt samples is 2610 ohms.cm. The chemical analyses indicates a low corrosive environment for buried steel or metal.



16. CLOSURE

This Foundation Investigation and Design Report was prepared by Mr. Keshav K. Amatya, MEng., P.Eng., Project Engineer, Geotechnical Services, and reviewed by Mr. N. Rahman, 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.



Keshav K. Amatya, MEng., P.Eng.
Project Engineer, Geotechnical Services



Nazibur Rahman, P.Eng.
Senior Engineer, Geotechnical Services



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

KA/NR/RN:ka-nr-nk



APPENDIX C

List of Standard Specifications Relevant to Report
Non-Standard Special Provisions (NSSP)



LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS.PROV 401	Construction Specification for Trenching, Backfilling and Compacting
OPSS.PROV 421	Construction Specification for Pipe Culvert installation in Open Cut
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection and Granular Sheeting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Temporary Protection Systems
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSS.PROV 1010	Material Specification For Aggregates - Base, Subbase, Select Subgrade, And Backfill Material
OPSS.PROV 1860	Material Specification for geotextiles
SP 105S09	Amendment to OPSS 539, November 2014
SP 517F01	Amendment to OPSS 517, November 2016
OPSD 802.031	Rigid Pipe Bedding, Cover and Backfill, Type 3 Soil – Earth Excavation
OPSD 810.010	General Rip-Rap Layout Sewer and Culvert Outlets
OPSD 3090.101	Foundation, Frost Penetration depths for Southern Ontario



NON-STANDARD SPECIAL PROVISIONS (NSSP)

NSSP 1 – Surface Water Control and Dewatering (Addition to OPSS 517)

The Contractor shall take necessary measures for diversion of surface water and drainage, and to lower the prevailing groundwater level to a minimum of 0.5 m below the base of the excavations to allow for construction work within the overburden.

The Contractor shall be responsible for designing and implementing measures for surface water control and dewatering. The dewatering design and the implementation shall prevent unsafe conditions, such as sloughing, base heave, or boiling under unbalanced hydrostatic conditions.

NSSP 2 – Obstructions during Excavation (Addition to OPSS.PROV 421)

The Contractor shall take necessary measures to expose existing oil pipelines, watermain and other underground utilities during construction or installation of temporary or permanent services without any damages and in safe manner.

The Contractor shall be responsible for designing and implementing temporary support systems for the existing underground utilities such that no damages are incurred during construction or installation of temporary or permanent services.