



**FOUNDATION INVESTIGATION AND DESIGN REPORT**

**for**

**MAINLINE SEWER CROSSING AT HIGHWAY 40 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: 42.915480, -82.412901**

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PML Ref.: 19TF005  
Index No.: 023FIR and 024FDR  
GEOCRES No.: 40J16-88  
November 15, 2019



**PART A - FOUNDATION INVESTIGATION REPORT**

**for**

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**PART A - FOUNDATION INVESTIGATION REPORT**

Mainline Sewer Crossing at Highway 40 for Improvements of Drainage along Highway 40  
Township of St. Clair, Sarnia, Ontario.  
Agreement No. 3016-E-0009-08

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**1. INTRODUCTION**

The Ministry of Transportation Ontario (MTO) has retained WSP Canada Limited. (WSP) as the Prime Consultant, to provide Owner's Engineer services for the detail design for drainage improvements along Highway 40 at 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 825 mm diameter mainline sewer across Highway 40; and
- Installation of a culvert across LaSalle Line, consisting of three (3) 750 mm diameter pipes;

This report summarizes the results of the foundation investigation carried out to support the installation of the proposed 825 mm diameter mainline sewer across Highway 40. A foundation investigation report will be submitted for the installation of the culvert across LaSalle Line under a separate cover.

**2. SITE DESCRIPTION**

The location of the proposed mainline sewer is approximately 375 m north of Highway 40 and LaSalle Line intersection. Highway 40 is slightly elevated from the natural topography of the surrounding area and accommodate four (4) lanes of vehicular traffic. The site is generally a flat area, with the exception of the roadway embankments. Talfourd creek flows from west to east, almost perpendicular to Highway 40, and crosses the highway at approximately 200 m south of the LaSalle Line intersection. The proposed mainline sewer 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 four (4) boreholes to a maximum depth of 11.3 m below the existing ground surface (El. 177.0 to El. 178.1), 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		
C-1	4 752 866.5	311 867.2	42.915481	-82.412902	9.8	187.9
C-2	4 752 860.9	311 881.6	42.915581	-82.413145	11.3	188.4
C-3	4 752 868.9	311 893.0	42.915478	-82.413275	11.3	188.3
C-4	4 752 860.4	311 911.4	42.915557	-82.413454	9.6	187.3

The number and location of the boreholes were selected based on discussion with MTO and WSP. 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 C-1 to C-4 were drilled on September 10 and 11, 2019, using a CME 55 track-mounted drilling rig equipped with 200 mm diameter hollow stem augers. Boreholes C-2 and C-3 were advanced at the median shoulder of Highway 40.

Traffic control services were provided by Construction Support Services (CSS) of Mississauga, Ontario, in accordance with Ontario Traffic Manual, Book 7-Temporary Conditions (2014).



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 near the inlet and outlet of the proposed mainline sewer. 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, about 550 m south from the sewer site, 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 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 (44)
- Grain size distribution analysis (12)
- Atterberg limit tests (12)

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 Figures C-GS-1A and C-GS-1B. The results of the Atterberg Limit tests are presented on Figures C-PC-1A and C-PC-1B. 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 MS-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.

In general, the subsoil conditions consist of 100 to 200 mm thick topsoil immediately below the ground surface in the two boreholes investigated at the east and west ditch lines. A 300 mm thick pavement granular fill was encountered immediately below the ground surface in the two



boreholes investigated at the median shoulders. The granular fill is immediately followed by 0.7 m thick clayey silt fill (reworked). The topsoil and fill is immediately followed by stiff to very stiff silty clay to clayey silt deposit. The cohesive layer encountered extends to the maximum termination depth of 11.3 m (El. 177.0 to El. 178.1) below the existing ground surface. For classification purposes, the soils encountered at this site can be divided into three (3) distinct zones:

- a) Topsoil
- b) Granular Fill
- c) Clayey Silt (Fill)
- d) Silty Sand (Fill)
- e) Silty Clay to Clayey Silt, Some Sand, Trace Gravel

#### 5.2.1 Topsoil

A layer of topsoil, approximately 100 mm to 200 mm in thickness, was encountered immediately below the existing ground surface in boreholes C-1 and C-4, located at the west and east ditch lines of Highway 40 SBL and NBL, respectively, and extends to a maximum depth of El. 187.2.

#### 5.2.2 Granular Fill

A layer of granular fill, approximately 300 mm in thickness, was encountered immediately below the existing ground surface in boreholes C-2 and C-3, located at the median SBL and NBL shoulders, respectively. The granular fill extends to a maximum depth of El. 188.0. The moisture contents of the two samples tested from granular fill were 5.2% and 10.6%.

#### 5.2.3 Clayey Silt (Fill)

The granular base is immediately underlain by 0.7 m thick clayey silt fill layer. This layer extends to 1.0 m (El. 187.4 to El. 187.3). The moisture contents of two samples tested from the clayey silt fill were 15.9% and 21.3%.

#### 5.2.4 Silty Sand (Fill)

Topsoil encountered in borehole C-4 is immediately underlain by 0.8 m thick silty sand deposit and extends to 0.9 (El. 186.5). The SPT "N"-value recorded within the fill layer was none (penetration due to weight and hammer), indicating very loose state of compaction.





#### 5.2.5 Silty Clay to Clayey Silt, Some Sand, Trace Gravel

This layer was encountered immediately below the fill layer in boreholes C-2 to C-4 and below topsoil in borehole C-1. This layer extends to the termination depth of 9.6 m to 11.3 m (El. 177.0 to El. 178.1). The SPT “N”-values recorded ranged from 9 to 24, indicating stiff to very stiff of consistency, with the exception of one SPT “N”-value of none (penetration due to weight of hammer and rods) in borehole C-4 in the upper cohesive deposit below fill. In general, the consistency of the cohesive deposit increases with depth. The moisture content of samples tested from the deposit varies from 15.8% to 29.1%, with an average value of 19.4%.

The grain size distribution results of twelve (12) representative samples from the silty clay to clayey silt are presented on Figures C-GS-1A and C-GS-1B. A total of twelve (12) Atterberg limits test results are presented on Figures C-PC-1A and C-PC-1B. These samples contained none to 6% gravel, 1% to 14% sand, 42% to 66% silt, and 33% to 44% clay. The liquid limits of the samples tested were between 31 and 37 and the plastic limits were between 15 and 17. The values of plasticity index computed range between 14 and 20. 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.

#### 5.2.6 Groundwater Conditions

The groundwater encountered at 0.8 m (El. 186.5) in borehole C-4 during drilling is considered to be perched water. Upon completion of drilling, the groundwater was measured at 5.2 m (El. 182.1) below ground surface.

Groundwater was not encountered in boreholes C-1 to C-3 during and upon completion of the drilling.

A monitoring well consisting of 50 mm diameter PVC pipe was installed in boreholes C-1 and C-4. Water level readings from the monitoring wells are summarized in Table 5.2.6.



**Table 5.2.6: Water Level Readings in Monitoring Wells**

BOREHOLE ID.	GROUND SURFACE ELEVATION (m)	Water Level measured in Monitoring Well		DATE OF READING
		DEPTH (m)	ELEVATION (m)	
C-1	187.9	No water encountered	-	Sept. 11, 2019
		1.6	186.3	Sept. 13, 2019
		1.5	186.4	Sept. 25, 2019
		1.5	186.4	Oct. 4, 2019
C-4	187.3	8.8	178.5	Sept. 13, 2019
		8.8	178.5	Sept. 25, 2019
		8.7	178.6	Oct. 4, 2019

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)
C-1	3	1.5 - 2.1	11	0.068	278	0.0043	7.77	698



## 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.



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Project Manager and  
MTO Designated Principal Contact

KA/NR/RN:ka-nr-nk



## **APPENDIX A**

Borehole Locations Plan and Soil Strata Drawing MS-1

Explanation of Terms Used in Report

Record of Borehole Sheets

Results of Grain Size Distribution Analyses – Figures C-GS-1A and C-GS-1B

Results of Atterberg Limit Tests – Figures C-PC-1A and C-PC-1B



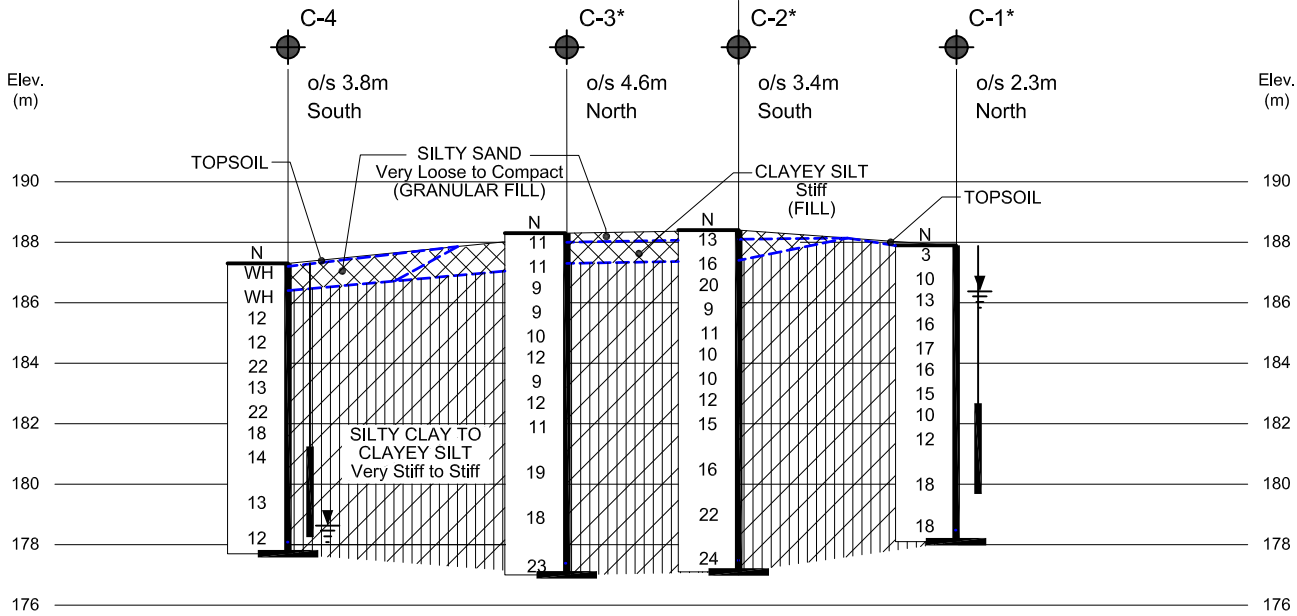
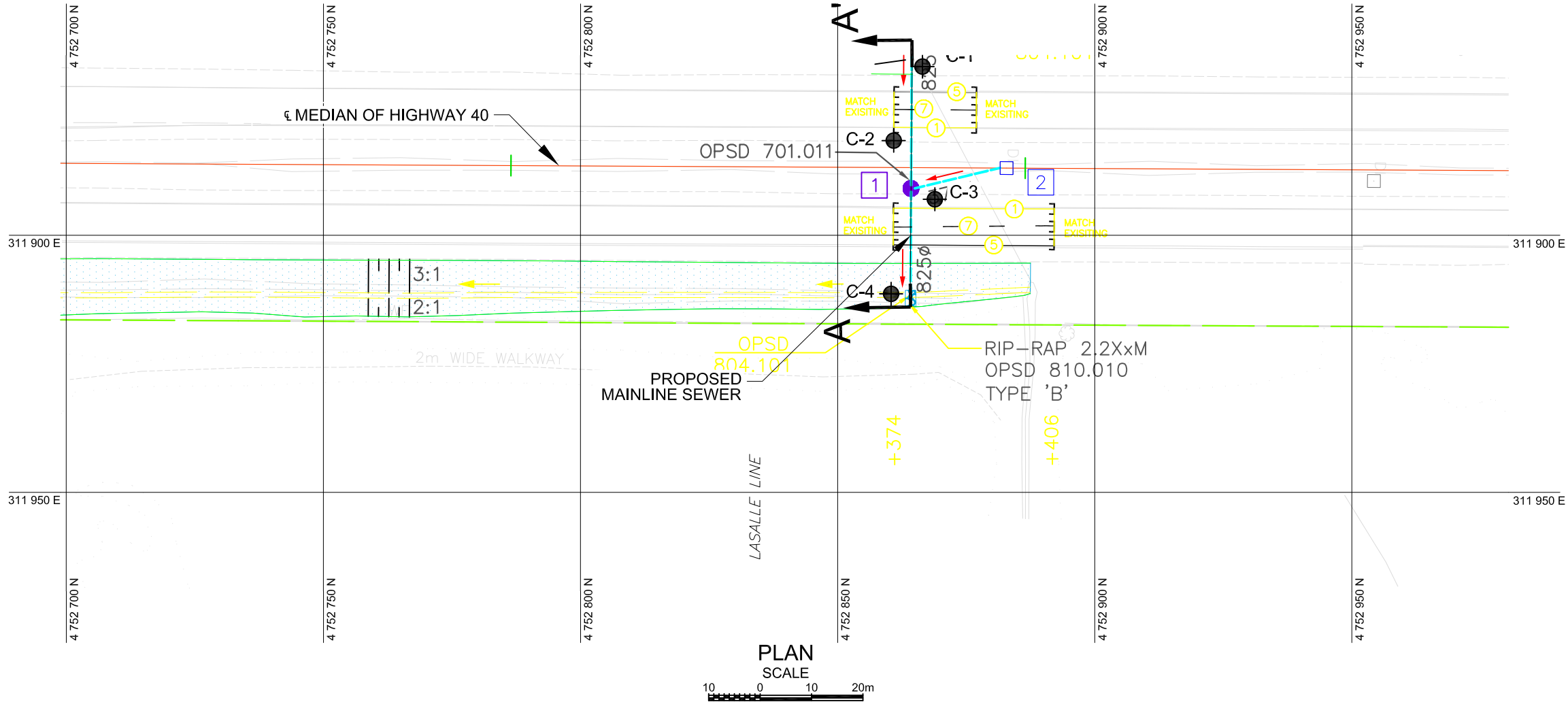
LEGEND			
	Borehole		
N	Blows/0.3m (Std. Pen Test, 475 J/blow)		
WH	Penetration due to weight of hammer and rods		
	Groundwater level measured in Monitoring Well October, 2019		
*	Groundwater not encountered during drilling		
	50 mm diameter Monitoring Well		

BH No	ELEVATION	NORTHINGS	EASTINGS
C-1	187.9	4 752 866.5	311 867.2
C-2	188.4	4 752 860.9	311 881.6
C-3	188.3	4 752 868.9	311 893.0
C-4	187.3	4 752 860.4	311 911.4

— 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. 40J16-88			
HWY No	40	DIST	West Region
SUBM'D	NL	CHECKED	KA
DATE	NOV. 15, 2019	SITE	
DRAWN	NL	CHECKED	NR
APPROVED	RN	DWG	MS-1



PROFILE A-A' ALONG C/L OF PROPOSED MAINLINE SEWER

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.



## 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:

R Q D (%)	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_i$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

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

# RECORD OF BOREHOLE No C-1

1 OF 2

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 866.5 N; 311 867.2 E ORIGINATED BY M.M.  
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.  
 DATUM Geodetic DATE 2019.09.10 LATITUDE 42.91548051 LONGITUDE -82.41290152 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	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 (%)
187.9	Ground						20	40	60	80	100	20	40	60			
187.7	TOPSOIL						20	40	60	80	100	20	40	60			
0.2	Soft, Brown to grey, Moist		1	SS	3							○					
	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel		2	SS	10							○					
	Stiff to very stiff, Grey, Moist		3	SS	13							○					
			4	SS	16							○					
			5	SS	17							○					
			6	SS	16							○					
			7	SS	15							○					
			8	SS	10							○					
			9	SS	12							○					
			10	SS	18							○					
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






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

# RECORD OF BOREHOLE No C-1

2 OF 2

**METRIC**

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 866.5 N; 311 867.2 E ORIGINATED BY M.M.  
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.  
 DATUM Geodetic DATE 2019.09.10 LATITUDE 42.91548051 LONGITUDE -82.41290152 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 $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
172.9	<p><u>Monitoring Well Legend:</u></p> <p>  Flush Mount   Cement Sand   Bentonite   Filter Sand   19 mm PVC Screen   Filter Bottom   Bentonite Bottom                             </p>																



# RECORD OF BOREHOLE No C-2

1 OF 1

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 860.9 N; 311 881.6 E ORIGINATED BY M.M.  
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.  
 DATUM Geodetic DATE 2019.09.10 LATITUDE 42.91558071 LONGITUDE -82.41314475 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
188.4	Ground													
0.0	SILTY SAND, some gravel													
188.1	Compact, Brown, Moist													
0.3	(GRANULAR FILL)		1	SS	13		188							
187.4	CLAYEY SILT, some sand, trace gravel													
1.0	(FILL)		2	SS	16									
	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel						187							
	Stiff to very stiff, Brown to grey, Moist		3	SS	20									
			4	SS	9		186							
			5	SS	11		185							4 13 46 37
			6	SS	10		184							
			7	SS	10		183							1 12 46 41
			8	SS	12		182							
			9	SS	15		181							
			10	SS	16		180							1 12 47 40
			11	SS	22		179							
			12	SS	24		178							
177.1	End of borehole													
11.3														
NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. No cave-in was noted upon extraction of augers.														

# RECORD OF BOREHOLE No C-3

1 OF 1

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 868.9 N; 311 893.0 E ORIGINATED BY M.M.  
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.  
 DATUM Geodetic DATE 2019.09.11 LATITUDE 42.91547837 LONGITUDE -82.41327498 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
188.3	Ground							20	40	60	80	100					
0.0	SILTY SAND, some gravel		1	SS	11		188										
188.0	Compact, Brown, Moist																
0.3	(GRANULAR FILL)																
187.3	CLAYEY SILT, some sand, some gravel																
1.0	Stiff, Grey, Moist		2	SS	11		187										
	(FILL)																
	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel																
	Stiff to very stiff, Brown to grey, Moist		3	SS	9		186										
			4	SS	9		185										
			5	SS	10		184										
			6	SS	12		183										
			7	SS	9		182										
			8	SS	12		181										
			9	SS	11		180										
			10	SS	19		179										
			11	SS	18		178										
			12	SS	23		177										
177.0	End of borehole																
11.3																	
NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. Borehole caved-in at a depth of 10.5 m (El. 177.8) below the existing ground surface, upon extraction of augers.																	

# RECORD OF BOREHOLE No C-4

1 OF 2

METRIC

G.W.P. 3016-E-0009-8 LOCATION Coords: 4 752 860.4 N; 311 911.4 E ORIGINATED BY M.M.  
 DIST West Region HWY 40 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY N.R.  
 DATUM Geodetic DATE 2019.09.11 LATITUDE 42.91555733 LONGITUDE -82.41345398 CHECKED BY M.V.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
187.3	Ground													
187.2	TOPSOIL													
0.1	SILTY SAND Very loose, Brown, Moist		1	SS	WH		187							
186.4	Very soft, Wet		2	SS	WH		186							
0.9	SILTY CLAY TO CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Brown to grey, Moist to wet		3	SS	12		185							
			4	SS	12		184							1 14 46 39
			5	SS	22		183							
			6	SS	13		182							2 14 46 38
			7	SS	22		181							
			8	SS	18		180							
			9	SS	14		179							2 12 46 40
			10	SS	13		178							
177.7	End of borehole		11	SS	12									
9.6	WH Penetration due to weight of hammer and rods ▽ Groundwater level observed during drilling (Perched) ▼ Groundwater level measured upon completion of drilling ▽ Groundwater level measured in monitoring well NOTE: Borehole caved-in at a depth of 9.5 m (El. 177.8) below the existing ground surface, upon extraction of augers.  Monitoring Well Readings: Date Depth Elev. (m) Sept.13/19 8.8 178.5 Sept.25/19 8.8 178.5 Oct.4/19 8.7 178.6													

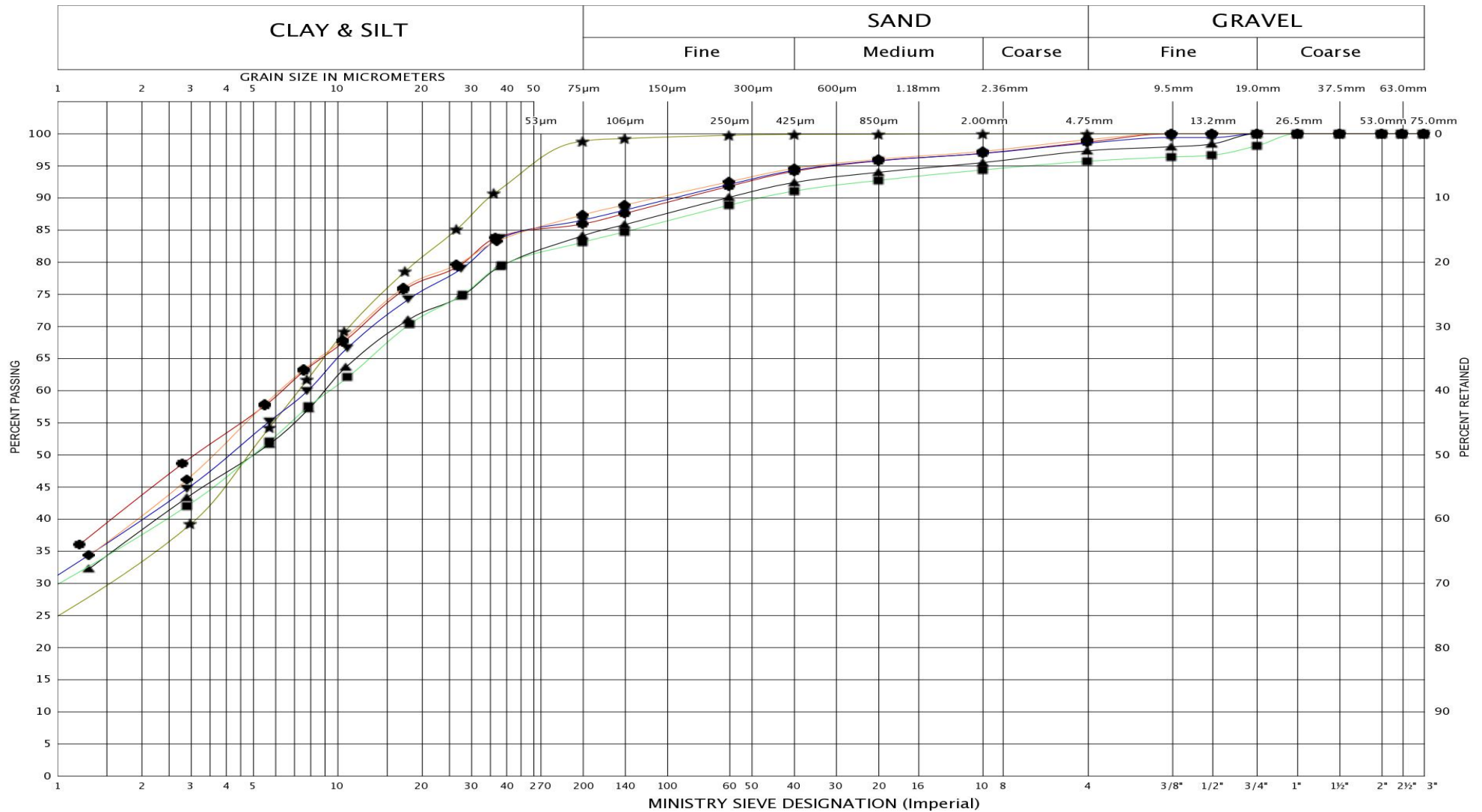
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity ○ 3% STRAIN AT FAILURE

## METRIC

[illegible]

# UNIFIED SOIL CLASSIFICATION SYSTEM



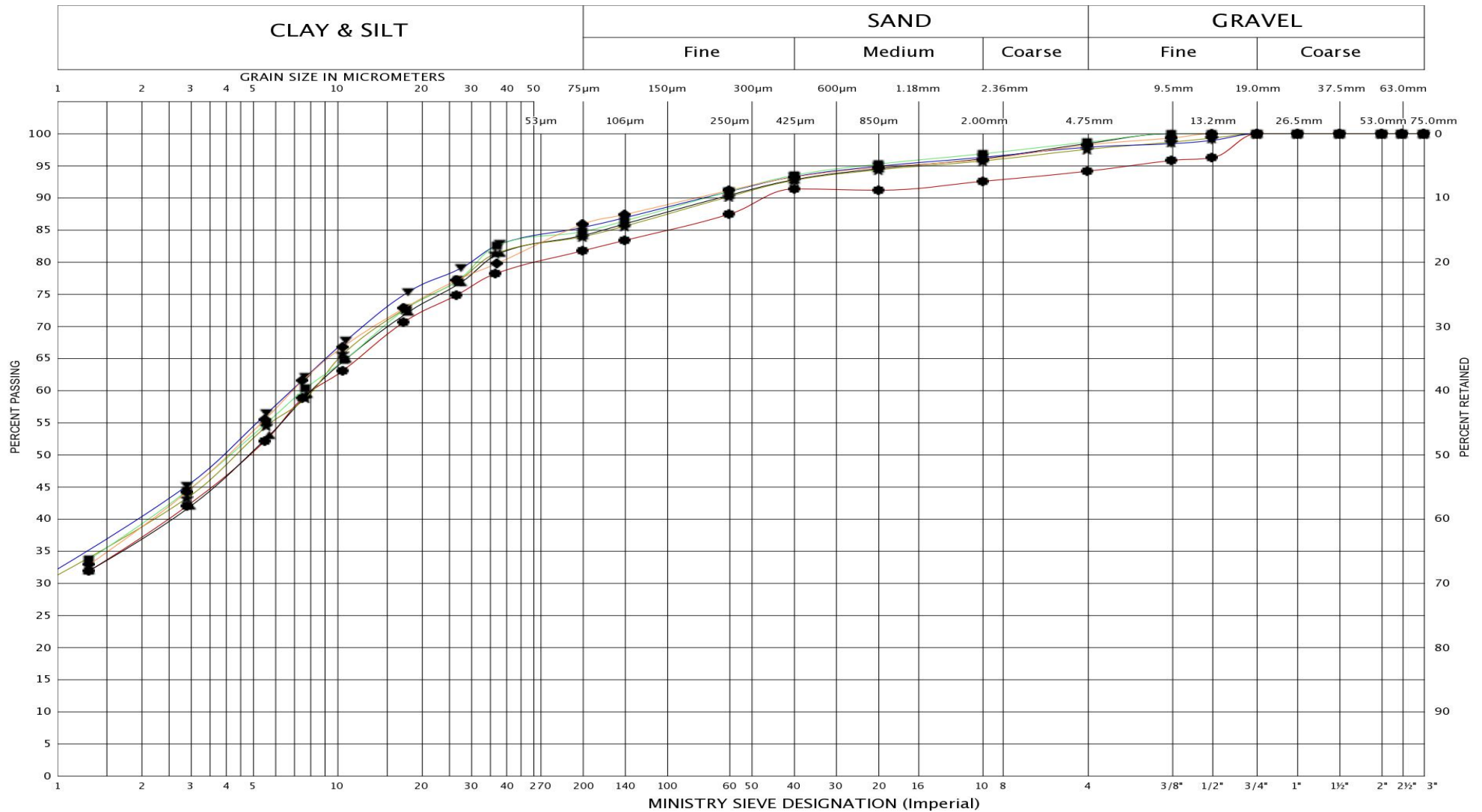
LEGEND	BH	C-1	C-1	C-1	C-2	C-2	C-2
	SAMPLE	4	8	11	5	7	10
	SYMBOL	▲	●	★	■	▼	◆



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

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

# UNIFIED SOIL CLASSIFICATION SYSTEM

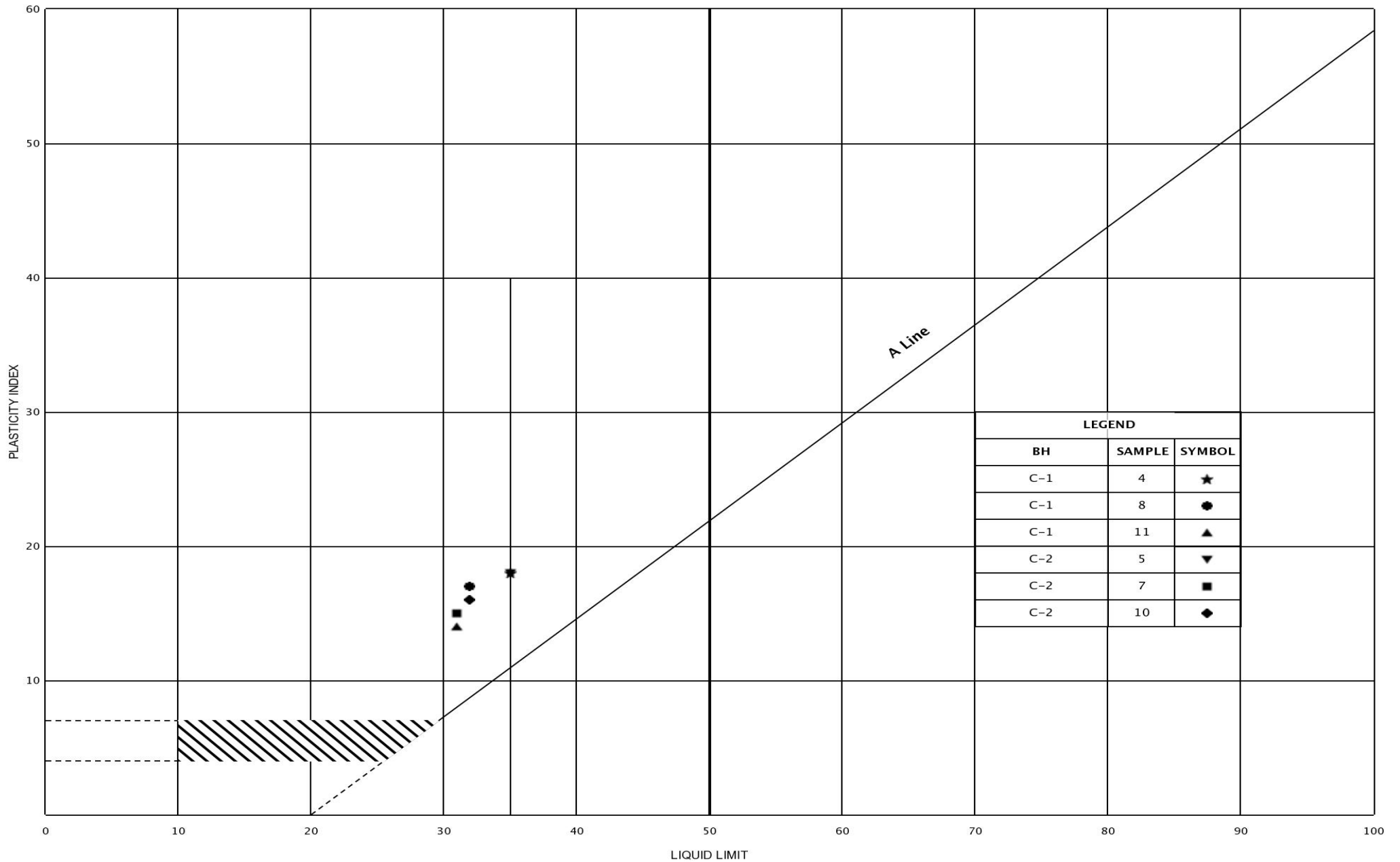


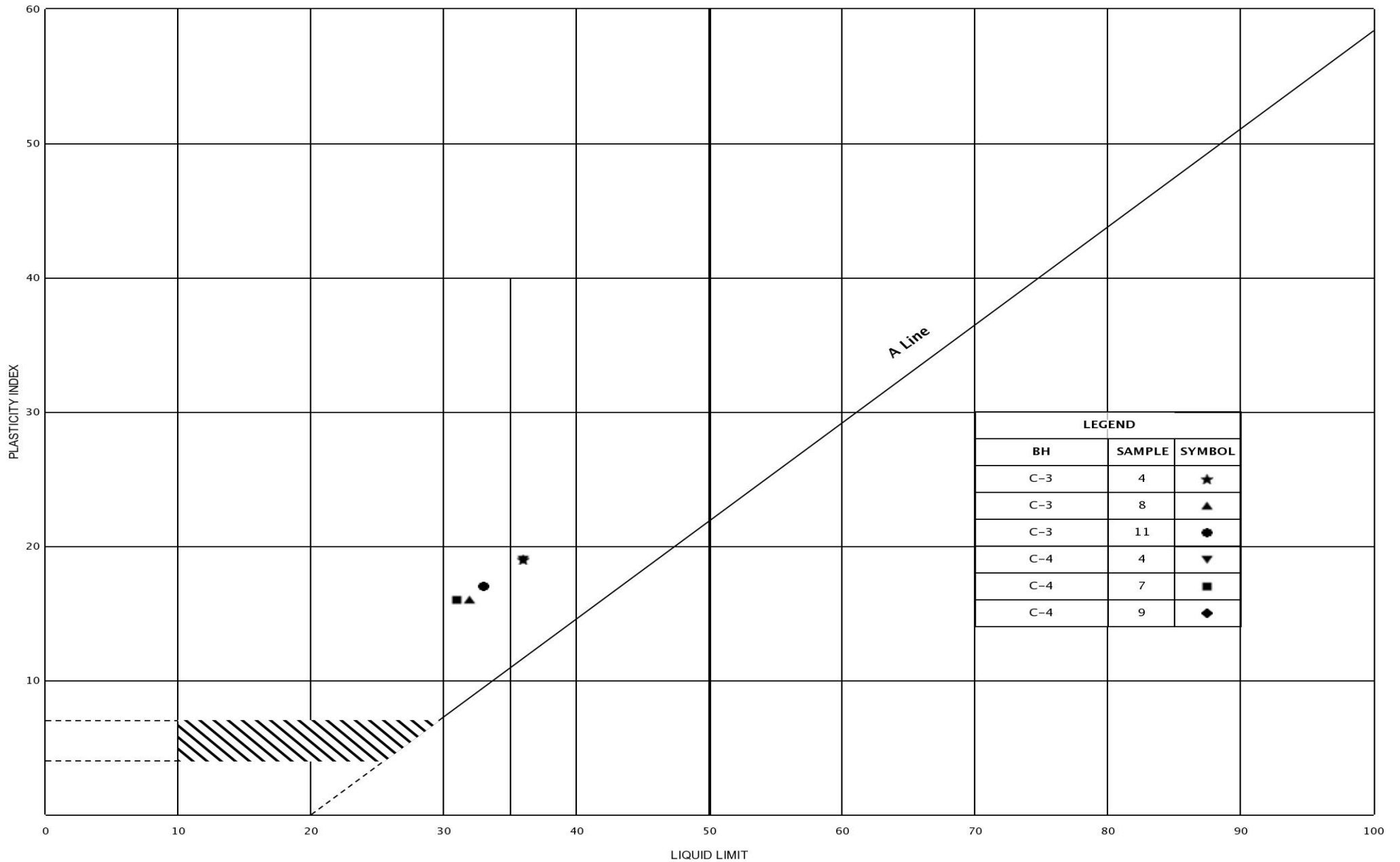
LEGEND	BH	C-3	C-3	C-3	C-4	C-4	C-4
	SAMPLE	4	8	11	4	7	9
	SYMBOL	▲	●	◆	■	★	▼



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

FIG No.: C-GS-1B  
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

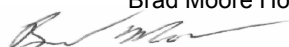




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# FINAL REPORT

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)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	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)

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

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

## PACKAGE: - Metals and Inorganics (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	C-1, SS#3 (5'-7')	SS-1, SS#3 (5'-7')
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	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		



# FINAL REPORT

CA14819-SEP19 R1

## 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](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.

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-- End of Analytical Report --



**PART B - FOUNDATION DESIGN REPORT**

**for**

**MAINLINE SEWER CROSSING AT HIGHWAY 40 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: 42.915480, -82.412901**

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**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.: 024FDR  
GEOCRES No.: 40J16-88  
November 15, 2019



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

Appendix D – Stage 1 and Stage 2 Drawings

**PART B - FOUNDATION DESIGN REPORT**

Mainline Sewer Crossing at Highway 40 for Improvements of Drainage along Highway 40  
Township of St. Clair, Sarnia, Ontario.  
Agreement No. 3016-E-0009-08

---

**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 825 mm diameter mainline sewer based on interpretation of the geotechnical data presented in the factual report (Part A), to assist the designer of the proposed mainline sewer to be installed across 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 Culvert**

The existing 1000 mm diameter CSP culvert under Highway 40 NBL and SBL is at a skew approximately from Station 10+377 to Station 10+401. The invert levels of the culvert approximately ranges from El. 186.7 at the inlet to El.186.3 at the outlet. Approximate overburden cover depth ranges up to 1.0 m under Highway 40 Northbound Lanes (NBL) and Southbound Lanes (SBL). The culvert will be replaced with the proposed 825 mm diameter mainline sewer.

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 1.0 m to 1.9 m. The existing embankment on both sides of the highway appear in stable condition.



### 9.3 Proposed Mainline Sewer

The Construction Drawing (modified) dated September 24, 2019 provided by WSP, indicates that the proposed 825 mm diameter mainline sewer will cross Highway 40 approximately at Station 10+375. This drawing indicates that the invert of the sewer at the inlet will be set approximately at El. 186.57 and at the outlet, it will be approximately at El. 186.41.

Based on the drawing, the alignment of proposed mainline sewer crossing Highway 40 will be almost perpendicular to the existing alignment of Highway 40. The ditch line before and after the proposed sewer will be protected with rip-rap in accordance with OPSD 810.010.

The existing ground surface in the vicinity of the mainline sewer alignments varies from approximately Elevations 187.3 m to 188.4 m. The grade of Highway 40 NBL and SBL is expected to be maintained at about the same existing elevations. Table 9.3 tabulates the approximate overburden cover depth available above the proposed mainline sewer obvert along the proposed alignment based on the borehole ground surface elevations.

**Table 9.3: Cover Depth for Proposed Mainline Sewer**

LOCATION	BOREHOLE ID	GROUND SURFACE ELEVATION	APPROXIMATE OBVERT ELEVATION	APPROXIMATE OVERBURDEN COVER DEPTH (m)
West Ditch	C-1	187.9	187.4	0.5
Highway 40 SBL Median Shoulder	C-2	188.4	187.3	1.1
Highway 40 NBL Median Shoulder	C-3	188.3	187.3	1.0
East Ditch	C-4	187.3	187.2	0.1

### 9.4 Installation of Mainline Sewer

In summary, the subsoil conditions consist of topsoil immediately below the ground surface in the two boreholes investigated at the east and west ditch lines to a maximum depth of El. 187.2. Granular fill was encountered immediately below the ground surface in the two boreholes investigated at the median shoulders to a maximum depth of El. 188.0. The granular fill is immediately followed by 0.7 m thick clayey silt fill to a maximum depth of El. 187.3. The topsoil



and fill is immediately followed by stiff to very stiff silty clay to clayey silt deposit, which extends to the maximum termination depth of El. 177.0 below the existing ground surface. Groundwater encountered during drilling in borehole C-4 is considered to be perched. The groundwater was measured at El. 182.1 below ground surface upon completion of drilling in the borehole. Groundwater was not encountered in the remaining boreholes.

It is anticipated that the mainline sewer will be installed under Highway 40 NBL and SBL utilizing an open-cut or trenching method. It is also anticipated that the new by-pass ditch on the east side will be constructed prior to diverting the flow away from the existing culvert and then remove the existing culvert and place the new mainline sewer under Highway 40.

The installation of the 825 mm diameter mainline sewer shall be in accordance with OPSS.PROV 410. 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.

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

The silty clay to 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.

It is understood that the removal of the existing culvert and installation of the proposed 825 mm diameter mainline sewer will be carried out in two stages based on the drawings provided by WSP via email dated October 18, 2019. The staging drawings prepared by WSP are provided in Appendix D.

## **10. REINSTATEMENT OF EMBANKMENT**

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 mainline sewer. 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 high 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 record of boreholes and the drawing provided by WSP, the excavations for the construction of new mainline sewer will be advanced through existing fill material underlain by native cohesive deposit. It is assumed that the depth of excavation will be up to 1.9 m in height. 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 and clayey silt deposit 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.

If excavations steeper than approximately 1H:1V are required, the protection systems should be designed to meet the appropriate Performance Level 2 as specified in OPSS 539 and SP 105S09. The Contractor is responsible for the selection, design, construction, and performance of the temporary protection systems.

Geotechnical parameters provided in Table 13.1 may be used for the temporary protection systems.

<b>Table 13.1: Soil Parameters</b>					
<b>ELEVATION (m)</b>		<b>SOIL TYPE</b>	<b>SOIL PARAMETERS</b>		
<b>FROM</b>	<b>TO</b>		<b>FRICTION ANGLE (<math>\phi^\circ</math>)</b>	<b>UNIT WEIGHT (<math>\gamma</math>) kN/m<sup>3</sup></b>	<b>C<sub>u</sub>, (kPa)</b>
188.1	187.3	Stiff Clayey Silt (fill)	-	18	50
187.3	177.0	Very Stiff to Stiff Clayey Silt	-	18	100

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

#### **14. GROUNDWATER CONTROL**

A temporary dewatering system may be required to construct the foundation for the culvert 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 and to place the culvert foundation.





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

No major groundwater problems are anticipated at the proposed mainline sewer 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.

## **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 43 µg/g or 0.0043%. 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 680 µg/g or 0.068%. 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 698 ohms.cm. The chemical analyses indicates a severe corrosive environment for buried steel or metal. Corrosion protection measures should be provided for the proposed sewer constructed of steel pipe, if selected.



## 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.



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Project Manager and  
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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 410	Construction Specification for Pipe Sewer 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 802.032	Rigid Pipe Bedding, Cover and Backfill, Type 4 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.



## **APPENDIX D**

### Stage 1 and Stage 2 Drawings

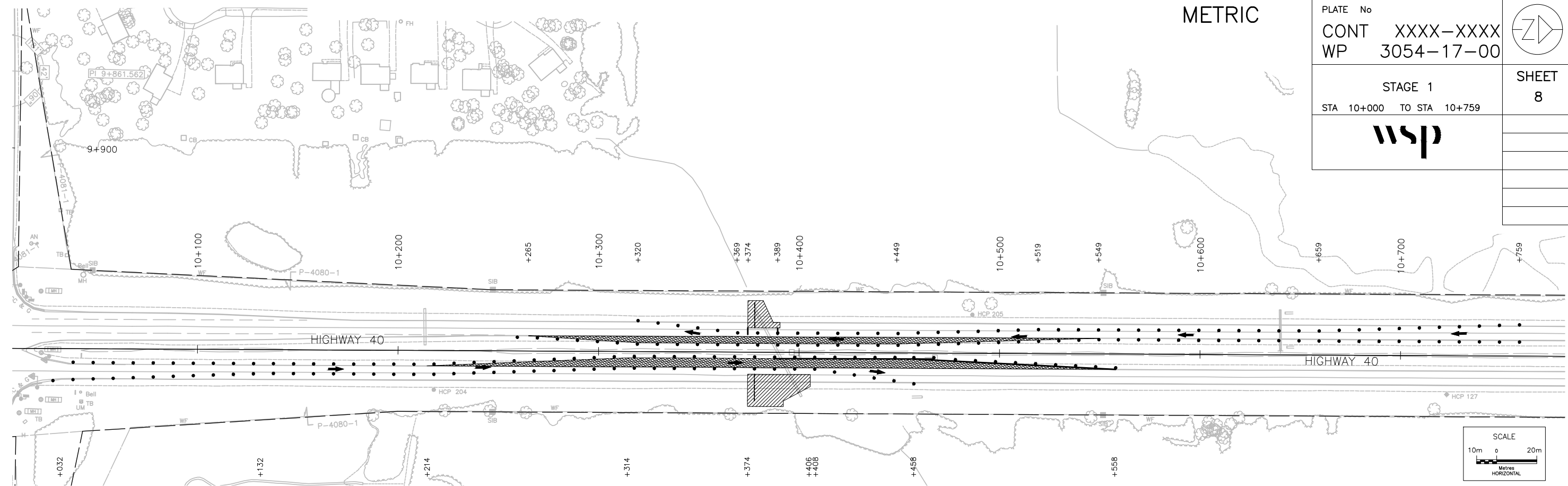
METRIC

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WP	3054-17-00

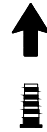
STAGE 1	
STA 10+000	TO STA 10+759

wsp

SHEET  
8



LEGEND:

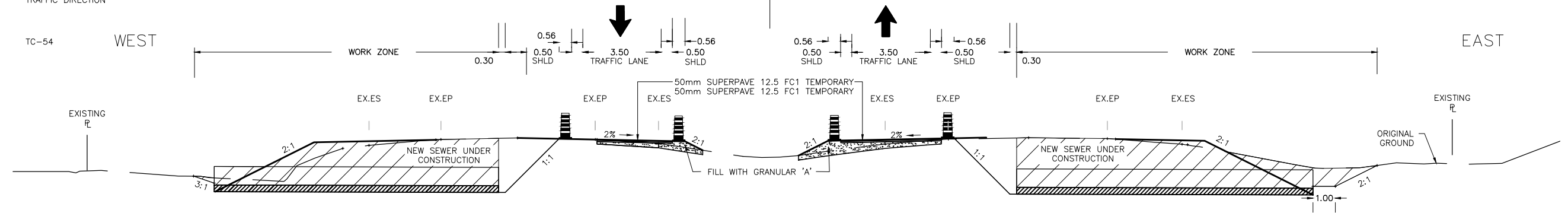


TRAFFIC DIRECTION

TC-54

WEST

EAST



STAGE 1

N.T.S

## STAGE 1

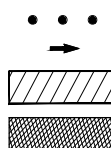
TRAFFIC

- TRAFFIC CONTROL AND LANE CLOSURE SHALL BE IN ACCORDANCE WITH ONTARIO TRAFFIC MANUAL BOOK 7.
- CLOSE SINGLE NBL AND SBL ON HIGHWAY 40

CONSTRUCTION ACTIVITIES:

1. TEMPORARY PAVEMENT WIDENING FOR STAGING TO BE COMPLETED IN ADVANCE.
2. CONSTRUCT OUTER SECTIONS OF SEWERS.

LEGEND:



TC-54

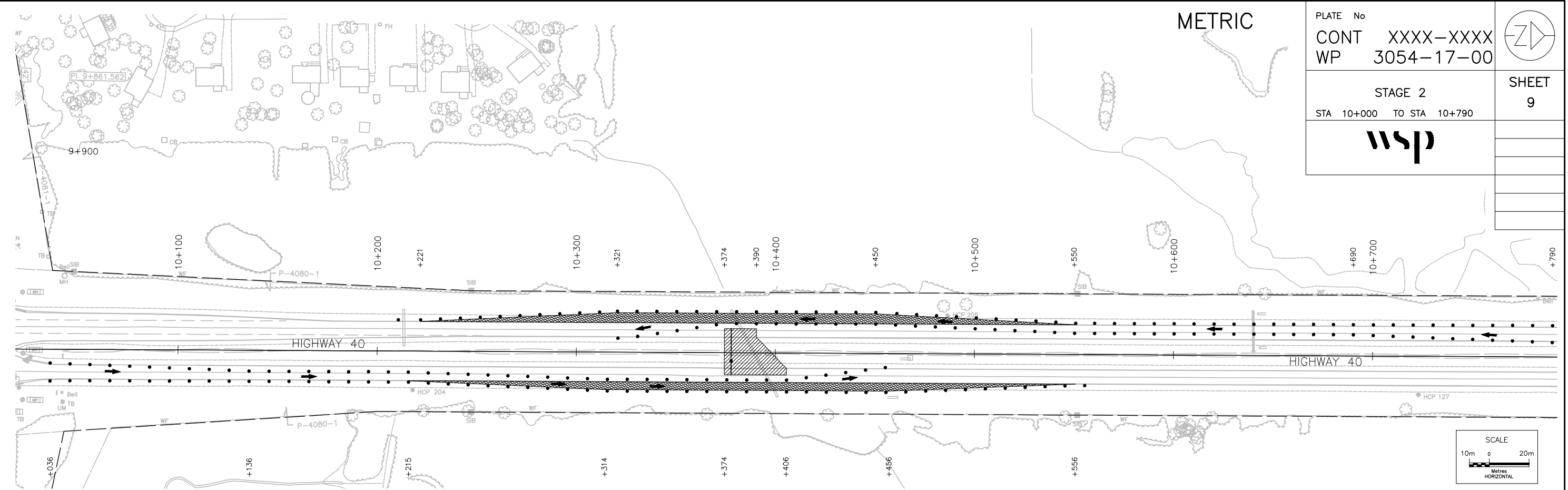
TRAFFIC FLOW

WORK AREA

### TEMPORARY WIDENING

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MODIFIED: 10/11/2019 5:32:28 PM BY: ETINGENW  
DATE PLOTTED: 10/15/2019 2:53:00 PM

PR-D-707 88-05  
MINISTRY OF TRANSPORTATION, ONTARIO



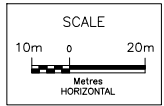
METRIC

PLATE No  
CONT XXXX-XXXX  
WP 3054-17-00

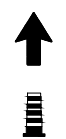
SHEET  
9

STAGE 2  
STA 10+000 TO STA 10+790

wsp

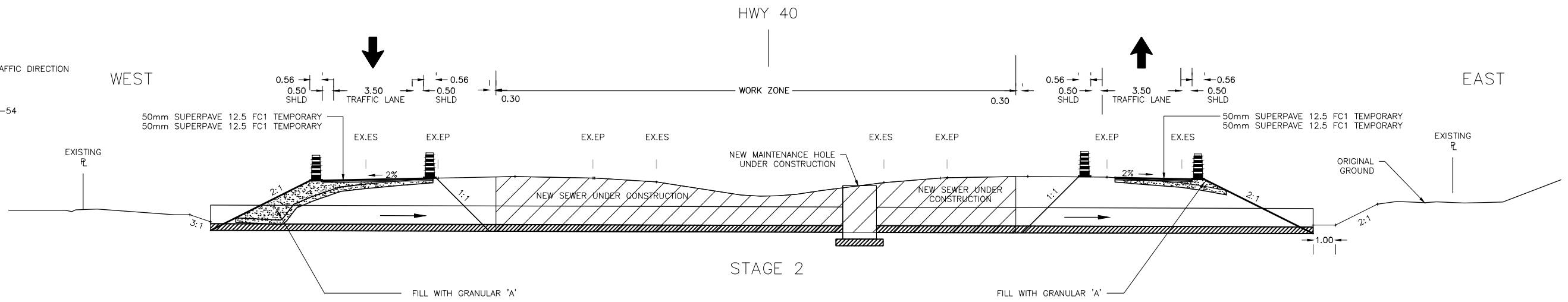


LEGEND:



TRAFFIC DIRECTION  
TC-54

WEST



EAST

STAGE 2

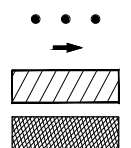
TRAFFIC

- TRAFFIC CONTROL AND LANE CLOSURE SHALL BE IN ACCORDANCE WITH ONTARIO TRAFFIC MANUAL BOOK 7.
- CLOSE SINGLE NBL AND SBL ON HIGHWAY 40

CONSTRUCTION ACTIVITIES:

- TEMPORARY PAVEMENT WIDENING FOR STAGING TO BE COMPLETED IN ADVANCE.
- CONSTRUCT INNER SECTIONS OF SEWERS AND MANHOLE.

LEGEND:



TC-54  
TRAFFIC FLOW  
WORK AREA  
TEMPORARY WIDENING

N.T.S