



**FOUNDATION INVESTIGATION REPORT
for
DORCHESTER ROAD OVERHEAD SIGNS
HIGHWAY 401
STATION 12+385 TO STATION 15+153
LONDON, ONTARIO
ASSIGNMENT NO. 3016-E-0009
WORK ORDER NO. 19**

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

Distribution:

3 Hard Copies: WSP Canada Group Limited for distribution to
MTO, Project Manager

Electronic Copy: WSP Canada Group Limited for distribution to
MTO, Pavements and Foundations Section

Electronic Copy: WSP Canada Group Limited

1 cc: PML Toronto

1 cc: PML Kitchener

PML Ref.: 19KF028A

Index No.: 012FIR

GEOCRES No.: 40I14-191

January 22, 2020



TABLE OF CONTENTS

FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION	1
2. SITE DESCRIPTION	1
3. FIELD INVESTIGATION PROCEDURES	2
3.1 Previous Field Investigation	2
3.2 Current Field Investigation	3
4. LABORATORY TEST PROCEDURES	5
4.1 Soil Testing	5
5. SITE GEOLOGY AND SUBSURFACE CONDITIONS	5
5.1 Site Geology	5
5.2 Subsurface Conditions	6
5.3 Groundwater	7
6. CLOSURE	8
Appendix A – Previous Investigation – MTO GEOCRES No. 40I14-182	
Record of Borehole BH-410	
Results of Grain Size Distribution Analyses – Figure A-10	
Results of Atterberg Limit Tests – Figure A-13	
Appendix B – Borehole Location Plan – Drawing DRS-1	
Explanation of Terms Used in Report	
Record of Borehole Sheets – Boreholes 14W, 25E, and 26E	
Results of Grain Size Distribution Analyses – Figures GS-OHS-1 and GS-OHS-2	
Results of Atterberg Limit Tests – Figure PC-OHS-1	

FOUNDATION INVESTIGATION REPORT
for
Dorchester Road Overhead Signs, Highway 401
Station 12+385 to Station 15+153
London, Ontario
Assignment No. 3016-E-0009, Work Order No. 19

1. INTRODUCTION

WSP Canada Group Ltd. (WSP) has retained Peto MacCallum Ltd. (PML) on behalf of the Ministry of Transportation Ontario (MTO) to conduct the geotechnical investigation in support of the Design Build Ready Report for Agreement No. 3016-E-0009, Work Order No. 19. The Design Build Ready package under Agreement No. 3016-E-0009-019 includes foundation investigation reports for the proposed four (4) overhead signs along Highway 401 at the intersection of Dorchester Road (formerly Highway 32) and replacement of the underpass located at the interchange of Highway 401 and Dorchester Road.

A foundation investigation report for the replacement of the underpass and ramps, located at the interchange of Highway 401 and Dorchester Bourne, will be completed by PML under a separate cover.

This report summarizes the results of the foundation investigation carried out for the proposed four (4) overhead signs, located off-highway from approximate Station 12+385 to Station 15+153 along Highway 401 in London, Ontario.

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

2. SITE DESCRIPTION

The existing Highway 401 roadway is slightly depressed from the natural topography, and accommodates a total of six (6) lanes of vehicular traffic; three (3) westbound lanes and three (3) eastbound lanes. The existing Dorchester Road accommodates one (1) northbound and one (1) southbound lanes of vehicular traffic and oriented almost perpendicular to Highway 401. The site is generally a flat area, with the exception of the highway and approach embankments. The site is surrounded by tall grass and coniferous forestation with mature trees and shrubs.



The surrounding area is mainly used for farming. A Petro Canada fuel station is located in the southwest quadrant of the Highway 401 and Dorchester Bourne Interchange. Dorchester, Ontario is the residential and commercial core of the Municipality of Thames Centre and is located approximately 5.0 km north of the site.

3. FIELD INVESTIGATION PROCEDURES

3.1 Previous Field Investigation

Golder Associates (Golder) carried out a preliminary foundation investigation and submitted a design report for the improvements of Dorchester Road (Middlesex Road 32) E-N/S and N/S-W ramps as part of GWP 3053-11-00. The field work for the investigation was carried out between May 29 and June 6, 2017 and between December 15 and December 19, 2017. A total of 27 boreholes (BH-405 to BH-431) were drilled. The results of the Golder investigation are provided in the following report:

“Preliminary Foundation Investigation and Design Report, Middlesex Road 32 (Dorchester Road) E-N/S and N/S-W Ramps, Highway 401 Interchange Improvements/Structural Replacements, GWP 3053-11-00, Assignment No. 2 (3011-E-0047)”, dated November 2018 (GEOCRE5 40114-182).

Based on the information provided by WSP and MTO, Borehole BH-410 was advanced in close proximity (within 8.0 m) of the proposed location of overhead sign 16W, and considered relevant for the design of this overhead sign. As a result, the current investigation program was revised to only three (3) overhead sign locations. Information from Borehole BH-410 is also included in the subsoil information provided under Section 5.2, Subsurface Conditions. Refer to Table 3.1 for a summary of the proposed location of overhead sign 16W, and the location and depth of Borehole BH-410.



Table 3.1 – Borehole Information¹

SIGN NO.	EXISTING STATION	BOREHOLE ID	DRILLED DEPTH (m)	COORDINATES (MTM ON-11)	
				NORTHING	EASTING
16W	14+153	BH-410	4.42	4 758 745	422 582

Note: 1. Based on Geocres No. 40I14-182.

The relevant Record of Borehole and summary of the laboratory tests results from the Golder report are provided in Appendix A. The location of Borehole BH-410 is also presented on Drawing DRS-1 in Appendix B.

3.2 Current Field Investigation

The fieldwork for the current investigation was carried out on October 7, 2019. A total of three (3) boreholes were advanced to a maximum depth of 9.8 m below the existing ground surface. The Record of Borehole Sheets are provided in Appendix B. The borehole location plan is presented on Drawing DRS-1 in Appendix B.

Refer to Table 3.2 for a summary of the overhead signs stations, and the drilled depths and coordinates of the boreholes.

Table 3.2 – Borehole Information

SIGN NO.	EXISTING STATION	BOREHOLE ID	DRILLED DEPTH (m)	COORDINATES			
				(MTM ON-11)		GEOGRAPHIC	
				NORTHING	EASTING	LATITUDE	LONGITUDE
14W	15+153	14W	9.8	4 758 971.5	423 574.4	42.961284	-81.044157
25E	12+385	25E	9.8	4 758 303.3	420 888.6	42.955684	-81.077206
26E	13+385	26E	9.8	4 758 526.7	421 863.3	42.957546	-81.065217

The proposed locations of the signs were provided in the Work Item Order Form, Agreement No. 3016-E-0009, Work Order No. 19. The boreholes were laid out by PML engineering staff, in conformance with the locations and coordinates approved by WSP and MTO.



Boreholes 25E and 26E were relocated during the field investigation due to the presence of underground utilities and difficulty to access the planned locations by drill rig.

PML staff used a portable GPS device to establish the location of boreholes in the field. Subsequently, PML carried out the survey of the as-drilled borehole locations 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, as required by MTO Guidelines. All elevations (EL.) reported in this report are referred to in MTM NAD 83 Northing and Easting (MTM Zone–ON11) Geodetic datum and expressed in meters. Refer to Drawing DRS-1 in Appendix B for the details of borehole locations.

Traffic control services where required were provided by Almon Equipment Ltd. of Toronto, Ontario, in accordance with Ontario Traffic Manual, Book 7-Temporary Conditions (2014).

PML engineering staff arranged for the clearance of underground services and appropriate permit applications. 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. Fieldwork was supervised on a full-time basis by PML staff operating under the direction of an engineer.

The boreholes were advanced using continuous flight hollow stem augers powered by a truck mounted CME-75 drill rig. The drilling equipment was supplied and operated by London Soil Test Inc. (London Soil), of London, Ontario. London Soil is a specialist drilling contractor and the drilling crews worked under the full-time supervision of a member of the PML engineering staff.

Representative soil samples were recovered starting from the ground surface and continued at 0.75 m intervals to a depth of 6.0 m using a conventional 51 mm outer diameter split spoon sampler. Below 6.0 m depth, the samples were recovered at 1.5 m intervals to the termination depth of boreholes. The sampler was driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The soil samples were identified in the field in accordance with the MTO Soil Classification procedures and transported to the Toronto PML laboratory for further visual classification and



testing. Index tests (water content determination, grain size distribution and Atterberg limits) were carried out on selected representative samples.

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.

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

4. LABORATORY TEST PROCEDURES

4.1 Soil Testing

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

- Natural moisture content determinations (33)
- Grain size distribution analysis (9)
- Atterberg limits tests (6)

All the laboratory tests to determine the soil 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 GS-OHS-1 and GS-OHS-2. The results of the Atterberg limits tests are represented on Figure PC-OHS-1. All test results are summarized on the attached Record of Borehole sheets provided in Appendix B.

5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

In general, the project area is located within the Mount Elgin Ridges physiographic region, which consists of a series of ridges and vales, as outlined in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984). The ridges are composed mainly of pale brown calcareous clay or



silty clay deposits, and it is common to find alluvium of gravel, sand or silt in the vales. The ridges are well drained, while poor drainage prevails in the hollows.

Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the Ontario Ministry of Northern Development and Mines (MNDM), the project site lies within the Dundee rock formation. The project area consists mainly of middle Devonian limestone, dolostone, and shale. The Bedrock Surface map (Map 3.3, 2004) published by Conservation Ontario based on the Middlesex-Elgin Groundwater Study, suggests that the bedrock surface is expected to be encountered at about EL. 230.0 to EL. 220.1.

The Quaternary Geology map published by the MNDM, indicates that the sub-surface conditions near signs 25E and 26E, located west of Dorchester Road, consist of Port Stanley Till; comprised of strongly calcareous, moderate to low clast silt to sandy silt; and Catfish Creek Till; consisting of strongly calcareous sandy silt to silt

Subsurface conditions near Sign 14W, located east of Dorchester Road is expected to consist of Port Stanley Till, and Glaciofluvial ice deposits; including gravel and sand, and minor till.

5.2 Subsurface Conditions

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

The extent of the site area covers approximately 2.8 km in length and it is not practical to give detail description for the individual strata. For classification purposes, the soil encountered at this site can be divided into four (4) distinct zones:

- 1) Gravelly Sand, trace silt, trace gravel (Pavement Structure/Fill)
- 2) Clayey Silt, some sand, trace gravel (Fill)
- 3) Clayey Silt, some sand, trace/some gravel
- 4) Sand, trace/some gravel, trace silt, trace clay

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



Table 5.2 – Summary of Subsurface Conditions at Borehole Locations

BOREHOLE	SOIL BOUNDARY DEPTH (m)	SOIL BOUNDARY ELEVATION (m)	SOIL TYPE
14W	0.0 to 0.8	262.7 to 261.9	300 mm Asphalt over Compact Sand and Gravel (Pavement Structure)
	0.8 to 3.0	261.9 to 258.9	Compact to Loose Sand
	3.0 to 9.8	258.9 to 252.9	Compact Sand
BH-410 ¹	0.0 to 1.37	267.25 to 265.88	240 mm Asphalt over Very Dense Sand and Gravel (Fill)
	1.37 to 4.42	265.88 to 262.83	Hard to Very Stiff Clayey Silt (Till)
25E	0.0 to 1.2	281.8 to 280.6	Dense Gravelly Sand (Pavement Fill)
	1.2 to 5.3	280.6 to 276.5	Stiff to Very Stiff Clayey Silt
	5.3 to 9.8	276.5 to 282.0	Very Stiff Clayey Silt
26E	0.0 to 0.8	284.9 to 284.1	Compact Gravelly Sand (Pavement Fill)
	0.8 to 3.4	284.1 to 281.5	Stiff Clayey Silt (Fill)
	3.4 to 9.8	281.5 to 275.1	Stiff Clayey Silt

Note: 1. Subsurface conditions are based on descriptions provided in the Record of Borehole Sheet from previous investigation by Golder (GEOCRES No. 40I14-182)

5.3 Groundwater

Groundwater was encountered during drilling in Borehole 26E at 5.3 m (EL. 279.6), below ground surface. Upon completion of drilling, groundwater was not encountered in Borehole 26E. Borehole 14W was charged with water during drilling, and thus groundwater could not be established upon completion of drilling. Groundwater was not encountered in Borehole 25E during and upon completion of drilling. From the previous investigation, Borehole BH-410 was recorded as 'dry' during drilling on May 29, 2017.

Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes. The groundwater measurements were taken prior to backfilling the boreholes. Groundwater levels are shown on the Borehole Logs provided in Appendix A and Appendix B.



6. CLOSURE

Mr. M. Mohamed carried out the field investigations under the supervision of Mr. N. Rahman, P.Eng., Senior Engineer. London Soil Test Inc. of London, Ontario supplied the drilling equipment for the subsurface exploration. Traffic control services were provided by Almon Equipment Ltd. of Toronto, Ontario. Surveying of borehole locations were carried out by PML. The laboratory testing of the selected samples was carried out at the PML laboratory in Toronto.

This report was prepared by Ms. N. Leong-Sem, B.Eng., EIT, Geotechnical Services and reviewed by Mr. N. Rahman, P.Eng., and Mr. G. Uwimana, MEng., P.Eng. Senior Engineers, 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.

Natasha Leong-Sem, B.Eng., EIT
Geotechnical Services



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



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



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



APPENDIX A

PREVIOUS INVESTIGATION - MTO GEOCRES No. 40114-182

Record of Borehole BH-410

Results of Grain Size Distribution Analyses – Figure A-10

Results of Atterberg Limit Tests – Figure A-13

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_{α}	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$\tau = c' + \sigma' \tan \phi'$
shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness	N
Condition	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS



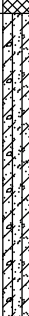
Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

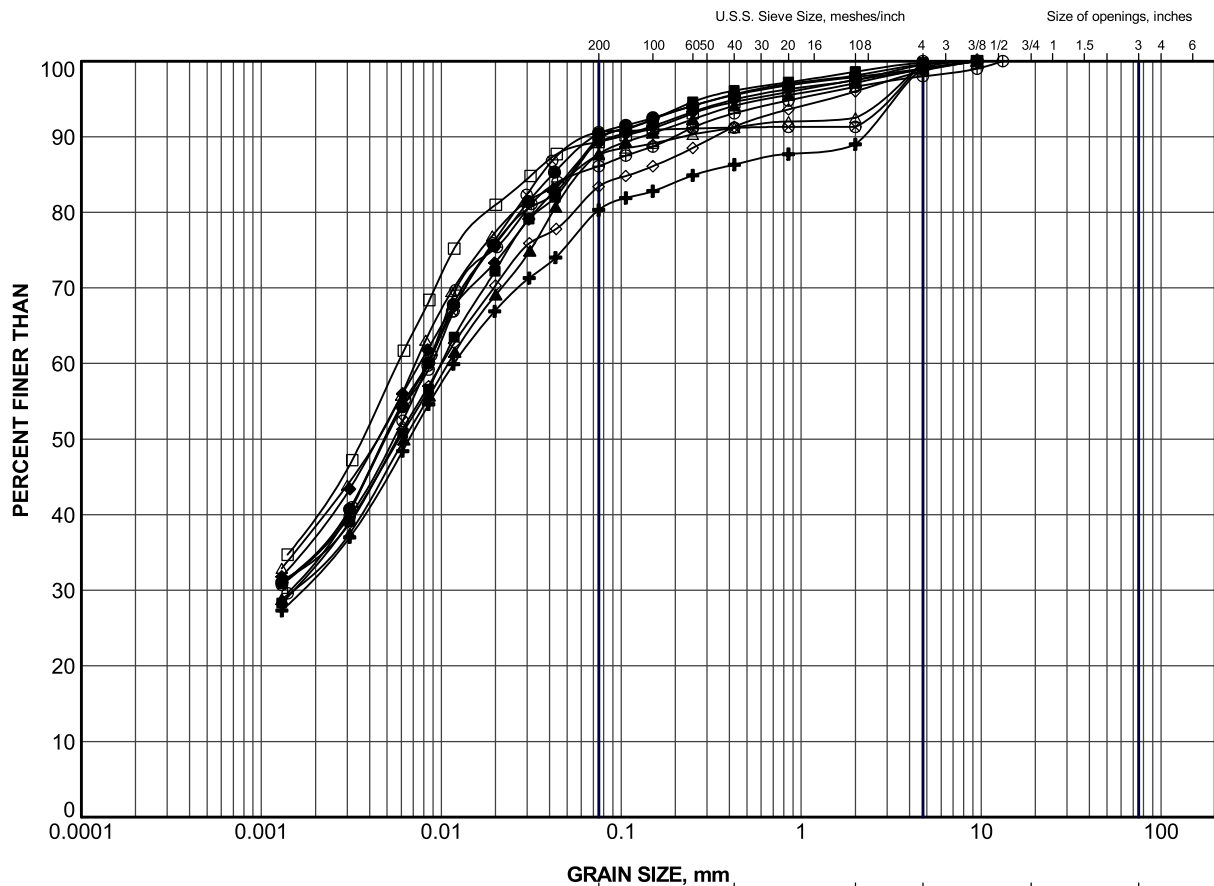
RECORD OF BOREHOLE No BH-410

1 OF 1

METRIC

PROJECT 12-1132-0076-2001A
W.P. 3053-11-00 LOCATION N 4758745.0 , E 422581.8 ORIGINATED BY MR
DIST HWY 401 BOREHOLE TYPE POWER AUGER, HOLLOW STEM COMPILED BY ZJB/LMK
DATUM GEODETIC DATE May 29, 2017 CHECKED BY *UK*


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			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) w _p w w _L				
267.25 0.00	GROUND SURFACE ASPHALT							20	40	60	80	100					
0.24	FILL, sand and gravel, trace silt Very dense Brown		1	SS	57		267							○			
265.88							266								○		
1.37	CLAYEY SILT TILL, some sand, trace gravel Hard to very stiff Brown turning grey at about elev. 263.6m		2	SS	45		265										
			3	SS	51		264										
			4	SS	36												
			5	SS	24		263								┌───┐		0 11 53 36
262.83 4.42	END OF BOREHOLE Borehole dry during drilling on May 29, 2017																



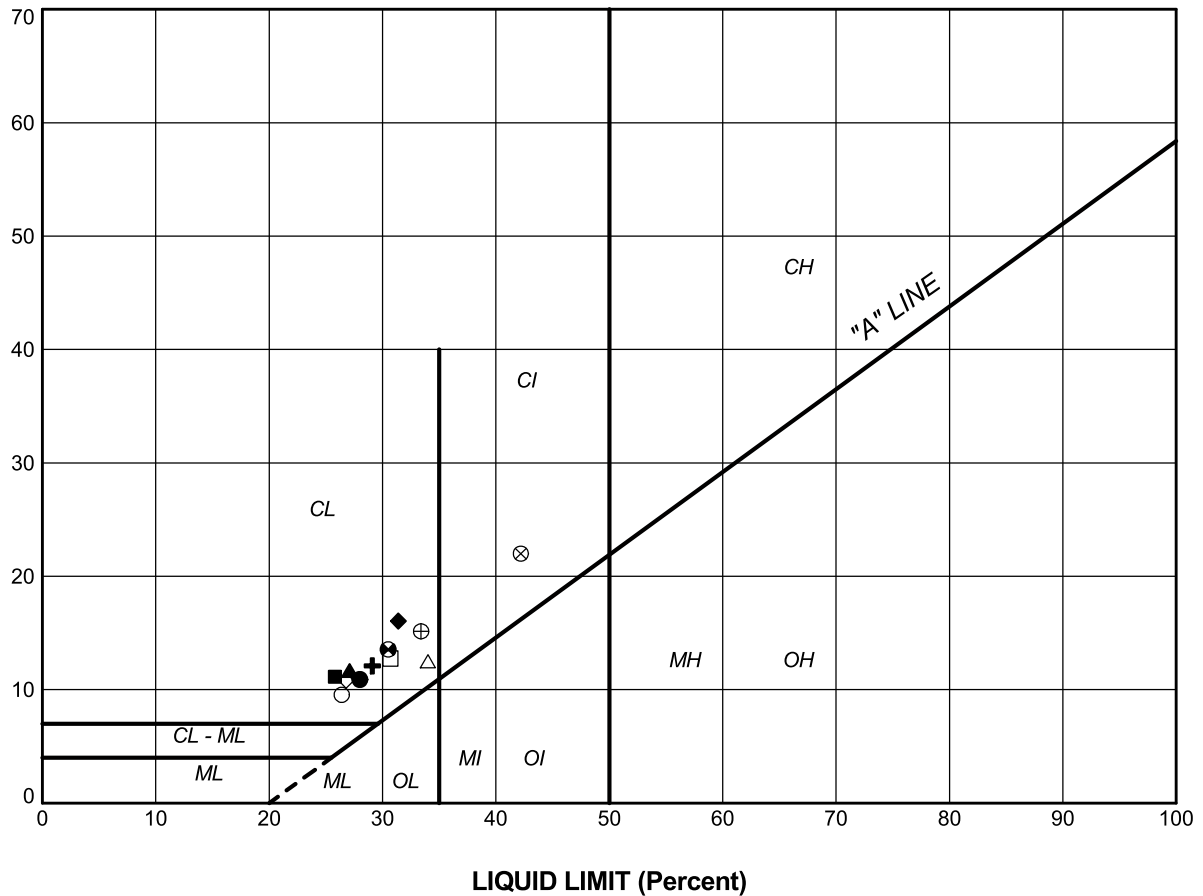
GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	BH-405	6	272.8
■	BH-405	10	269.7
▲	BH-406	4	271.1
+	BH-407	3	272.3
◆	BH-408	4	267.4
◇	BH-409	6	262.7
○	BH-410	5	263.1
△	BH-411	1	264.4
⊗	BH-412	5	260.4
⊕	BH-421	3	263.4
□	BH-422	8	257.4

PROJECT				DORCHESTER ROAD RAMPS HIGHWAY 401 INTERCHANGE IMPROVEMENTS GWP 3053-11-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL			
PROJECT No.		12-1132-0076		FILE No.		1211320076-2001A-F010A10	
DRAWN		LMK		SCALE		N/A	
CHECK		Mar 08/18		REV.			
				FIGURE A-10			

PLASTICITY INDEX (Percent)




SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	BH-405	6	28.0	17.1	10.9
■	BH-405	10	25.8	14.7	11.2
▲	BH-406	4	27.1	15.4	11.7
+	BH-407	3	29.1	17.0	12.1
◆	BH-408	4	31.4	15.4	16.1
◇	BH-409	6	26.8	16.0	10.8
○	BH-410	5	26.4	16.9	9.6
△	BH-411	4	34.0	21.5	12.5
⊗	BH-412	3	42.2	20.2	22.0
⊕	BH-412	5	33.4	18.3	15.2
□	BH-421	3	30.7	18.0	12.8
⊙	BH-422	8	30.5	17.0	13.6

PROJECT		DORCHESTER ROAD RAMPS HIGHWAY 401 INTERCHANGE IMPROVEMENTS GWP 3053-11-00	
TITLE		PLASTICITY CHART (GLACIAL TILL)	
PROJECT No. 12-1132-0076		FILE No. 12-1132-0076-2001A-F010A13	
DRAWN	ZJR	Mar 08/18	SCALE N/A
CHECK	UK		REV.
			FIGURE A-13



APPENDIX B

Borehole Location Plan – Drawing DRS-1

Explanation of Terms Used in Report

Record of Borehole Sheets – Boreholes 14W, 25E, and 26E

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

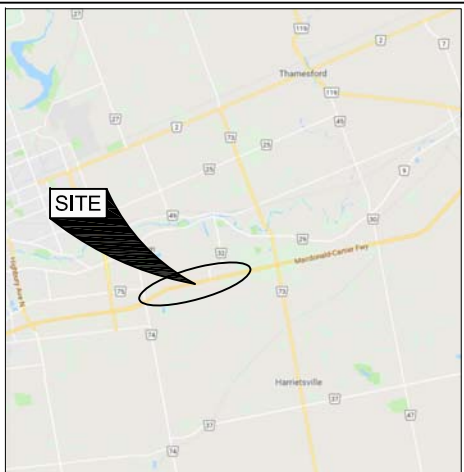
Results of Atterberg Limit Tests – Figure PC-OHS-1

AGR. No.: 3053-11-00-19



OVERHEAD SIGN REPLACEMENTS
HIGHWAY 401 AT DORCHESTER ROAD
BOREHOLE LOCATION PLAN

SHEET



LEGEND

- 26E**
Borehole Location (Current Investigation)
- BH-410**
Previous Borehole Location (GEOCRES No.40114-182)

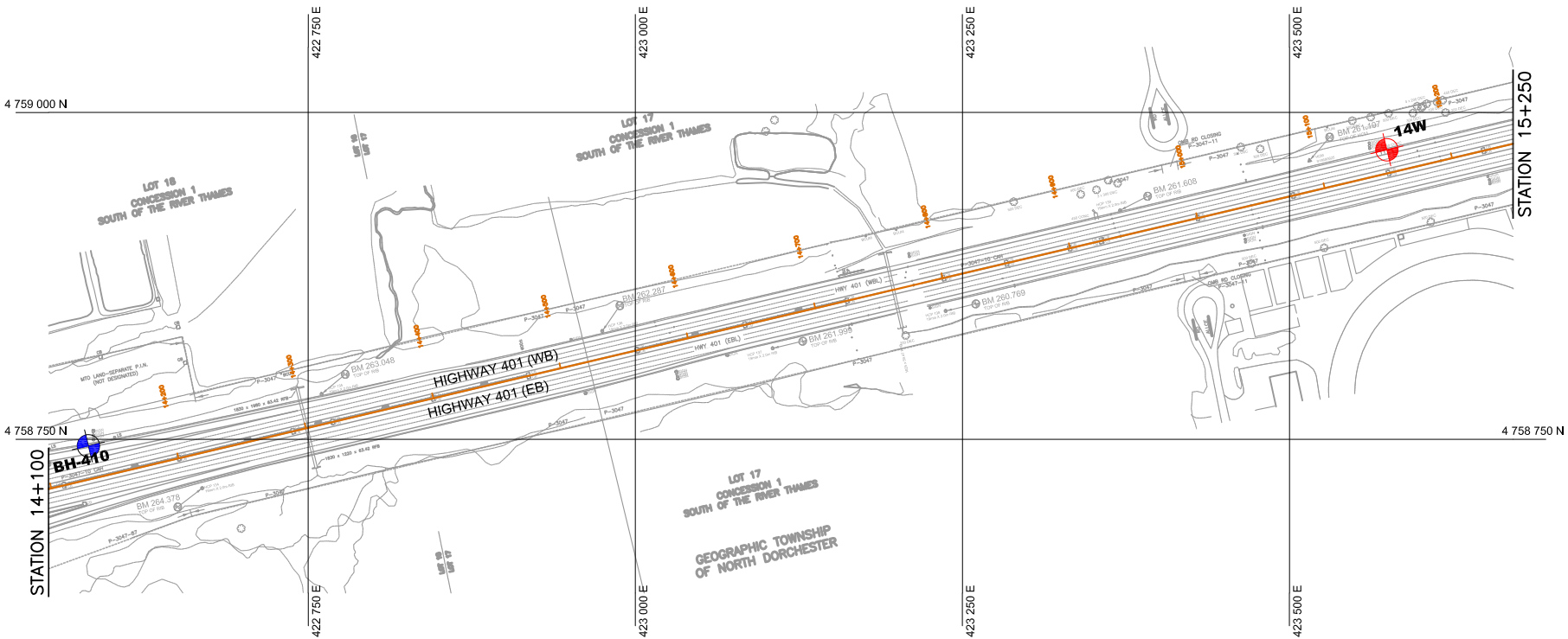
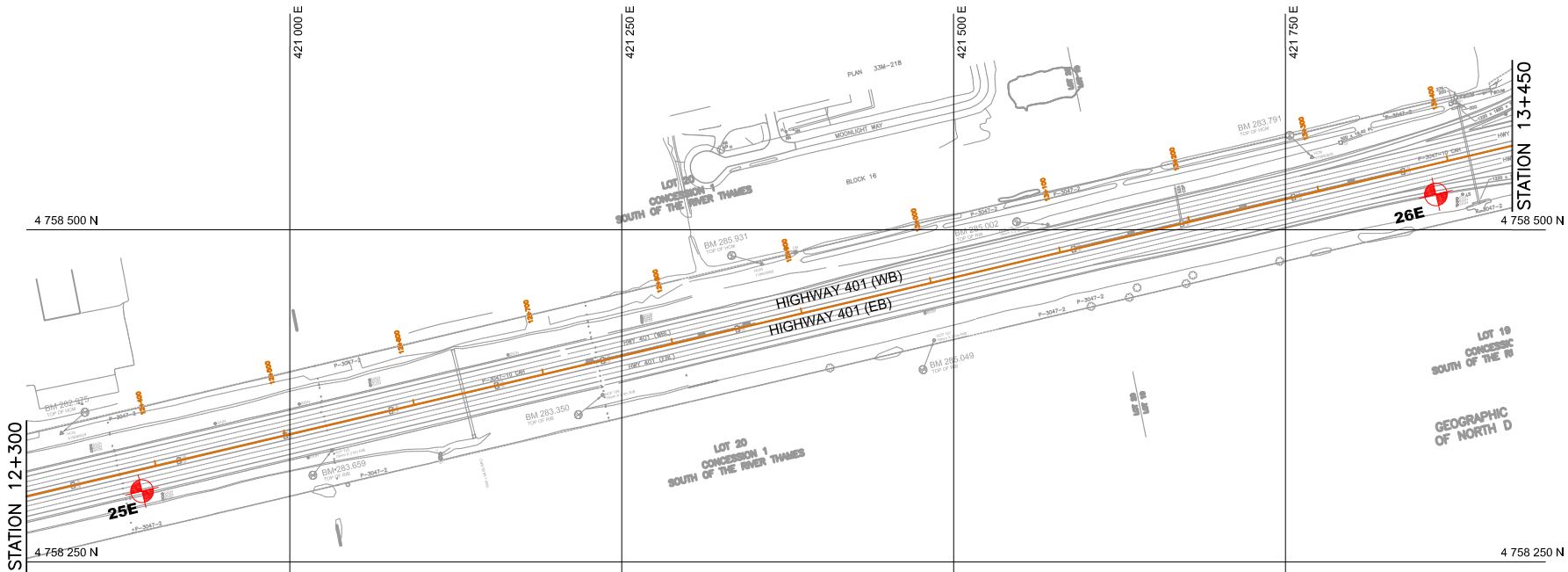
BH No	ELEVATION	NORTHINGS	EASTINGS
CURRENT INVESTIGATION			
14W	262.7	4 758 971.5	423 574.4
25E	281.8	4 758 303.3	420 888.6
26E	284.9	4 758 526.7	421 863.3
PREVIOUS INVESTIGATION (GEOCRES 40114-182)			
BH-410	267.3	4 758 745	422 582

REVISIONS		

DATE	BY	DESCRIPTION

Geocres No. 40114-191

HWY No	401	DIST	LONDON
SUBM'D	NL	CHECKED	NR
DATE	JAN. 21, 2020	SITE	
DRAWN	NL	CHECKED	MV
APPROVED	RN	DWG	DRS-1



PLAN



NOTES:

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



Reference WSP Ltd. Drawing: 17M-00802-13_XB01, Undated.

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
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 14W

1 OF 1

METRIC

G.W.P. 3016-E-0009 LOCATION Coords: 4 758 971.5 N; 423 574.4 E ORIGINATED BY M.M.
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2019.10.07 LATITUDE 42.961284 LONGITUDE -81.044157 CHECKED BY N.R.

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 (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								20	40	60	80						100	20	40
262.7	Ground																		
0.0	300 mm Asphalt over SAND and GRAVEL, some silt Compact, Brown, Moist (PAVEMENT STRUCTURE)		1	SS	22														
261.9																			
0.8	SAND, trace silt, trace gravel Loose to compact, moist, brown		2	SS	16														
			3	SS	8														
			4	SS	9														
			5	SS	15														
			6	SS	40														
			7	SS	17														
			8	SS	11														
			9	SS	20														
			10	SS	19														
	</																		

ONTARIO MTO 19KF028A-DORCHESTER ROAD.GPJ ONTARIO MTO.GDT 1/8/20

RECORD OF BOREHOLE No 25E

1 OF 1

METRIC

G.W.P. 3016-E-0009 LOCATION Coords: 4 758 303.3 N; 420 888.6 E ORIGINATED BY M.M.
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2019.10.07 LATITUDE 42.955684 LONGITUDE -81.077206 CHECKED BY N.R.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
281.8 0.0	Ground gravelly SAND, trace silt, trace clay Dense, Grey, Moist (PAVEMENT FILL)		1	SS	41		281							
280.6 1.2	CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Brown to grey, Moist		2	SS	30		280							10 12 47 31
			3	SS	13		279							
			4	SS	19		278							2 15 55 28
			5	SS	17		277							
			6	SS	14		276							
			7	SS	14		275							
			8	SS	16		274							2 13 54 31
			9	SS	17		273							
			10	SS	18		272							
272.0 9.8	End of borehole		11	SS	22									
NOTES: 1. Groundwater was not encountered during or upon completion of drilling. 2. No cave-in was noted upon extraction of hollow stem augers.														

ONTARIO MTO 19KF028A-DORCHESTER ROAD.GPJ ONTARIO MTO.GDT 1/8/20

RECORD OF BOREHOLE No 26E

1 OF 1

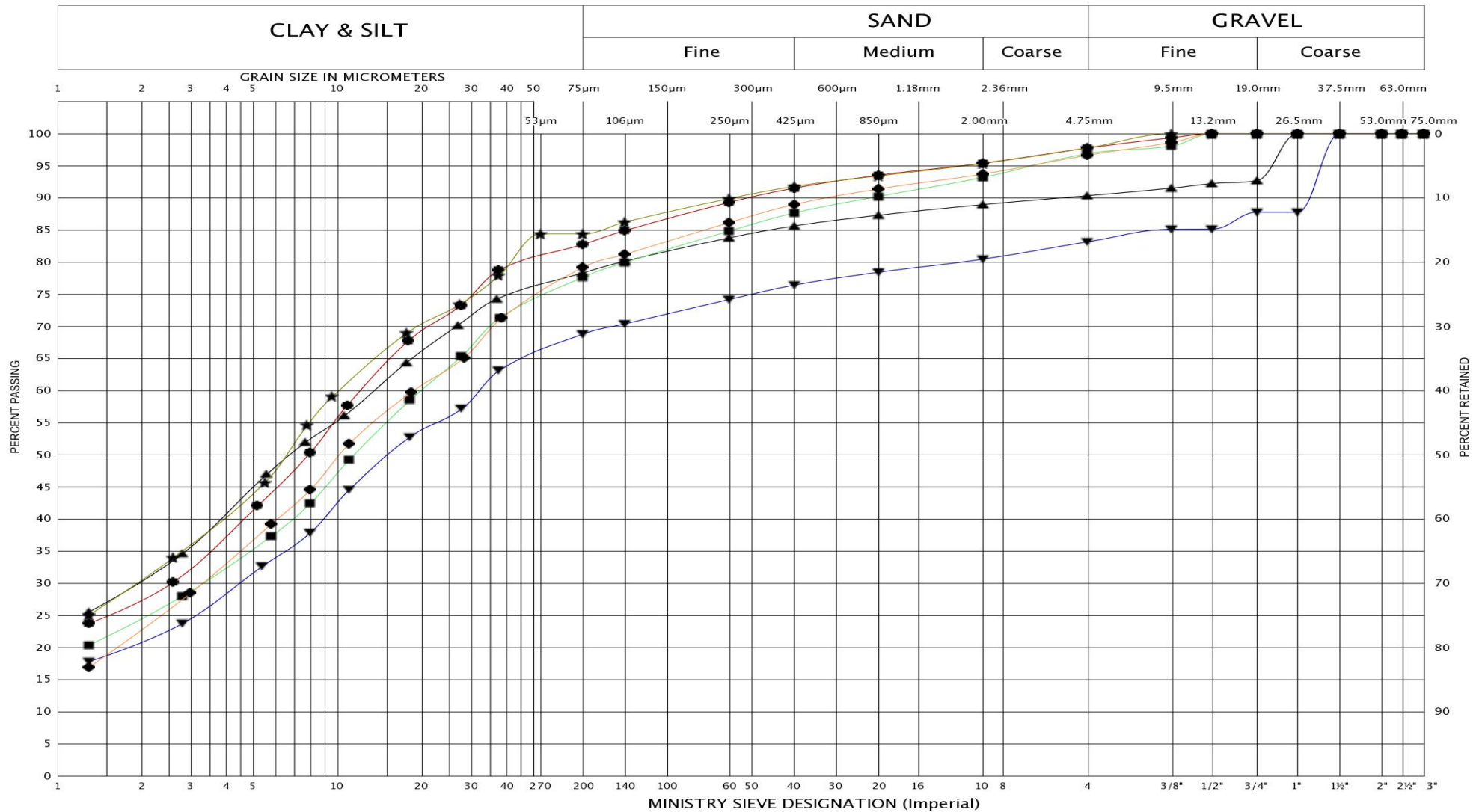
METRIC

G.W.P. 3016-E-0009 LOCATION Coords: 4 758 526.7 N; 421 863.3 E ORIGINATED BY M.M.
 DIST West Region HWY 401 BOREHOLE TYPE Continuous Flight Hollow Stem Augers COMPILED BY N.L.
 DATUM Geodetic DATE 2019.10.07 LATITUDE 42.957546 LONGITUDE -81.065217 CHECKED BY N.R.

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)								
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE																		
284.9 0.0	Ground gravelly SAND, trace silt, trace clay Compact, Brown, Moist (PAVEMENT FILL)		1	SS	14		284										3 17 57 23									
284.1 0.8	CLAYEY SILT, some sand, trace gravel Stiff, Grey, Moist (FILL)		2	SS	8			283																		
			3	SS	11				282																	
			4	SS	8					281																
281.5 3.4	CLAYEY SILT, some sand, trace gravel Stiff, Grey, Moist		5	SS	9						280															
			6	SS	10							279														
			7	SS	10								278													
			8	SS	10									277												
			9	SS	13										276											
			10	SS	16																					
			11	SS	15																					
275.1 9.8	End of borehole Groundwater observed during drilling NOTES: 1. Groundwater was not encountered upon completion of drilling. 2. No cave-in was noted upon extraction of hollow stem augers.																									

ONTARIO MTO 19KF028A-DORCHESTER ROAD.GPJ ONTARIO MTO.GDT 1/8/20

UNIFIED SOIL CLASSIFICATION SYSTEM



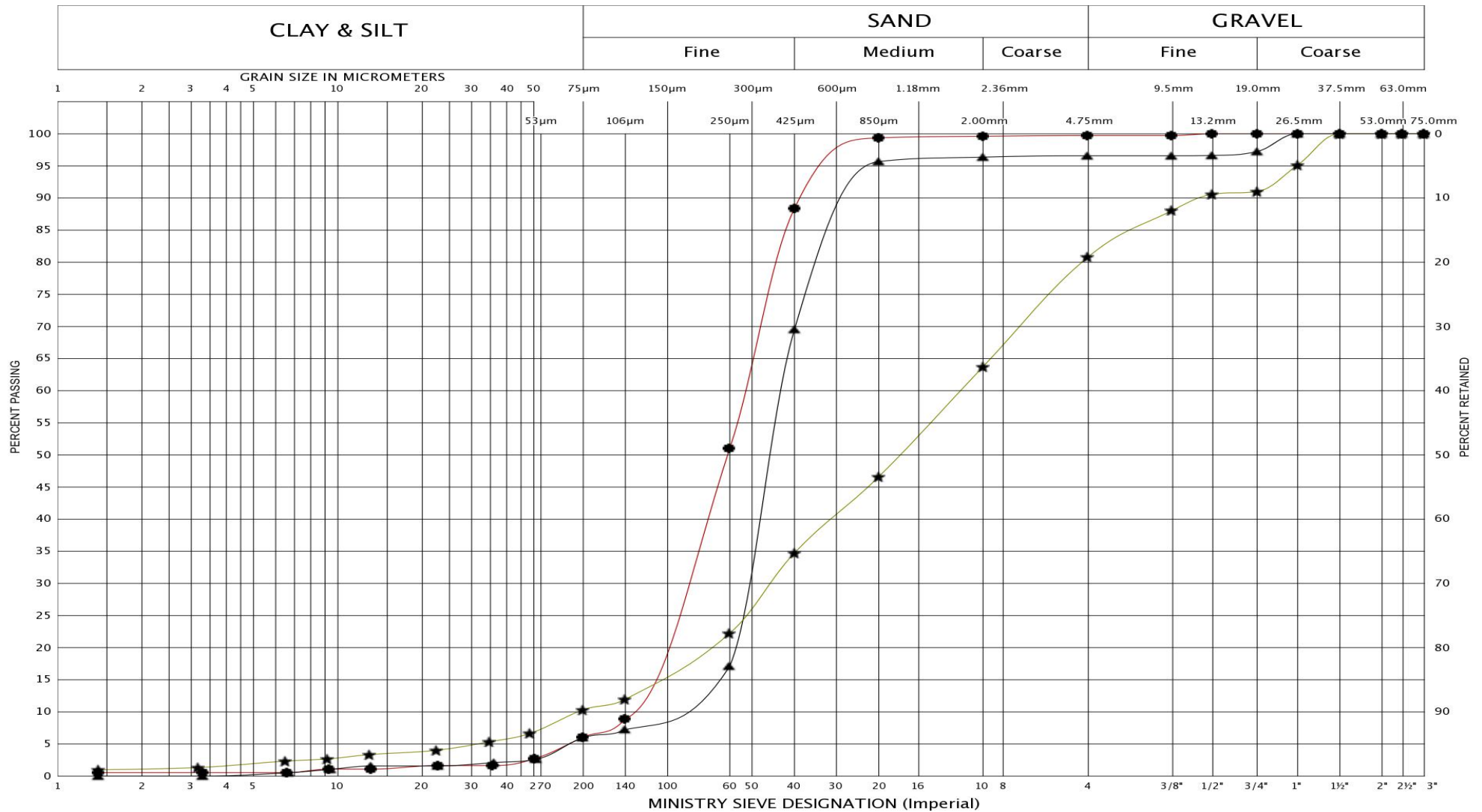
LEGEND	BH	25E	25E	25E	26E	26E	26E
	SAMPLE	3	6	10	5	8	11
	SYMBOL	▲	●	★	◆	■	▼



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

FIG No.: GS-OHS-1
HWY : 401
GWP 3016-E-2009

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	14W	14W	14W
	SAMPLE	4	8	11
	SYMBOL	▲	●	★



GRAIN SIZE DISTRIBUTION
SAND, trace silt, trace/some gravel

FIG No.: GS-OHS-2
HWY : 401
GWP 3016-E-2009

