



FOUNDATION INVESTIGATION AND DESIGN REPORT

for

SEWER AND WATERMAIN INSTALLATIONS – HIGHWAY 7/8

STRATFORD, ONTARIO

EC-2024-31L-00000070

LATITUDE: 43.370696°; LONGITUDE: -80. 941592

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Distribution:
Electronic Copy: Cachet Developments (Stratford) Inc.
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PML Ref.: 24LF001
Geocres No: 40P07-070
Report: 1
July 26, 2024



PART A - FOUNDATION INVESTIGATION REPORT

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PART A - FOUNDATION INVESTIGATION REPORT

For

Sewer and Watermain Installations – Highway 7/8
Stratford, Ontario
EC-2024-311-00000070
Latitude: 43.370696°; Longitude: -80. 941592

1. INTRODUCTION

Cachet Developments (Stratford) Inc. (Cachet) retained Peto MacCallum Ltd. (PML) to conduct a foundation investigation for the planned storm sewer and watermain installation along Highway 7/8, from about 80 m west of the current City of Stratford connecting link to about 130 m west of Road 111, in the County of Perth, Ontario.

One trenchless watermain crossing of Highway 7/8 is proposed, along with approximately 360 m of storm sewer, and 250 m of watermain along the flanks of the roadway. The proposed watermain crossing will comprise a 600 mm diameter smooth wall steel casing, approximately 35 m long with invert at elevation 358.3 to 359.9 (approximately 4.4 to 2.8 m below the highway); inclined down towards the south, as shown on the appended Drawing 1.

In addition to the watermain crossing, a new 300 mm diameter watermain is to be installed parallel to the highway along the north ditch, and will have 1.8 m of cover. A new 900 mm diameter storm sewer will replace a portion of the exiting 450 mm diameter storm sewer under the outside eastbound lane within the Stratford city limits. The storm sewer routing will also extend easterly (beyond the current municipal boundary), with a new 750 mm diameter storm sewer pipe to be located south of the highway with an invert at about 3.5 m depth below the travelled lanes.

The purpose of the foundation investigation was to identify the subsurface conditions at the site and based on the findings, provide geotechnical engineering recommendations for the selection of a trenchless method for installation of the watermain crossing, as well as provide recommendations for the storm sewer and watermain installations using conventional open cut methods.

It is understood that the Highway 7/8 asphalt pavement was recently rehabilitated and a previous geotechnical investigation report was completed by AMEC Foster Wheeler (MTO West Region Retainer 3014-E-12-00, Stratford East Limit to Shakespeare, dated February 26, 2016).



It is also understood that a geotechnical investigation was conducted for the Cachet lands to the south of Highway 7/8 by Soil-Mat Engineers & Consultants Ltd., (Report SM301888-G, dated July 18, 2024). It is understood that the Soil-Mat report did not include investigation of the highway corridor and would not meet the MTO requirements. Accordingly, PML's scope of work includes preparation of a Foundation Investigation and Design Report (FIDR) in accordance with MTO requirements.

2. SITE DESCRIPTION

The topography of the site is generally flat with a slight downhill gradient along the highway to the west. The land on the south side of the highway is currently agricultural cropland scheduled for future residential development. The lands to the north, east and west generally comprise commercial properties, with localized residential infill to the east of Road 111.

Surface ditching has been provided on north and south sides of the highway for drainage. The grades of the highway corridor in the proximity of the site are about 0.5 to 1.0 m higher than the ditching on the north and south sides of the road.

The Highway 7/8 right-of-way at the proposed drainage crossing is approximately 34 m in width. Highway 7/8 accommodates five lanes of vehicular traffic in the vicinity of the crossing locations (two eastbound, two westbound and one centre turn lane), with fully paved shoulders on both sides. Based on MTO Provincial Highway Traffic volumes published for 2016 the average annual daily traffic (AADT) was 9,800 vehicles per day.

3. FIELD INVESTIGATION PROCEDURES

The field work for the proposed crossing was carried out between April 8 and 18, 2024 and comprised a total of 14 boreholes. Boreholes 1 to 14 were advanced at the crossing, and along the storm sewer and watermain routes to maximum depths of 6.7 m below the existing grades as shown on the appended Drawings 1 and 2.

In general, the depths of the boreholes drilled within MTO's corridor permit control area were established based on the minimum requirements of the "MTO Guidelines for Foundation Engineering – Tunnelling Speciality for Corridor Encroachment Permit Applicants" dated February 2021.



The borehole locations were established in the field by PML in advance of drilling. The survey and tie in of the boreholes were completed by PML, using a Sokkia GCX3 GNSS Receiver. The vertical and horizontal accuracies of this unit are 0.1 and 0.5 m, respectively. All elevations in this report are geodetic and expressed in metres. Both UTM and MTM coordinates along with Latitude and Longitude are provided for the boreholes in the table 1 below:

Table 1: Borehole Coordinates

BOREHOLE NUMBER	UTM (ZONE 17T)		MTM (ZONE 10)		LATITUDE	LONGITUDE
	NORTHING	EASTING	NORTHING	EASTING	N	W
1	4801985	504495	4804438	187734	43.370717	-80.944516
2	4801984	504543	4804437	187782	43.370709	-80.943926
3	4801983	504596	4804435	187836	43.3707	-80.943266
4	4801978	504633	4804429	187872	43.370656	-80.94281
5	4801975	504704	4804424	187943	43.370621	-80.941943
6	4801974	504736	4804423	187975	43.370615	-80.941547
7	4801963	504785	4804411	188024	43.370518	-80.940941
8	4801963	504837	4804410	188076	43.370514	-80.94029
9	4801994	504867	4804440	188106	43.370792	-80.939929
10	4801995	504817	4804442	188056	43.370803	-80.940544
11	4801996	504768	4804444	188007	43.370813	-80.941154
12	4801997	504731	4804445	187971	43.370818	-80.941602
13	4801997	504678	4804447	187917	43.37082	-80.942262
14	4801996	504632	4804447	187872	43.370818	-80.942825

Borehole Log Sheets and Borehole Location and Soil Strata drawings appended to the report are referenced to the MTM coordinates.

The fieldwork was supervised throughout by a PML engineering staff member, who directed the drilling and sampling operations, prepared the stratigraphic logs, monitored ground water conditions and processed the recovered samples.



Boreholes 1 to 6 and 9 to 14 were advanced using a CME-75 truck mounted drill rig equipped with continuous flight solid stem augers, and automatic hammer. Boreholes 7 and 8 were advanced using a Geoprobe drill rig equipped with continuous flight solid stem augers, and automatic hammer. The drilling equipment was owned and operated by a specialist drilling contractor working under subcontract to PML. Traffic control and protection was provided by PML in accordance with the MTO road occupancy permit and Ontario Traffic Manual - Temporary Conditions Manual, Book 7.

Representative soil samples were recovered at 0.75 m and 1.5 m intervals throughout the depths explored. Standard penetration testing (SPT) was conducted simultaneously with split spoon sampling operations to assess the strength of the subsurface strata.

The ground water conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as samples were retrieved and when appropriate, by measurement of the water level in the borehole. The drilling and decommissioning of the boreholes were carried out in accordance with O.Reg. 903.

Soils were identified and documented in the field according to the MTO soil classification system. The recovered soil samples were delivered to PML's laboratory located in Kitchener, (Ontario) for detailed visual examination and index tests.

4. LABORATORY TEST PROCEDURES

Visual examination and moisture content determination were conducted on all the recovered soil samples. In addition, 25 particle size tests and 11 Atterberg Limit Tests were carried out on 25% of soil samples to determine the index properties of the main soil type encountered. In addition, four samples from fill material were tested for organic content. Results of the particle size distribution analyses are presented in Figures GS1 to GS6, and Atterberg Limits Tests are presented in Figure PC-1; as well as the Record of Borehole sheets.

One sample was also submitted for corrosivity analysis by SGS Canada, and Miller box resistivity analysis at PML's Toronto laboratory. The results are appended.



5. SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

The site lies within the eastern part of the physiographic region known as the Stratford Till Plain. Soil within the Stratford Till plain generally comprises silty clay with shallow surface deposits of silt. Drainage in the area is through the Avon River located approximately 600 m north of the site. The river meanders to the west and connects to the Thames River. According to the Ontario Ministry of Natural Resources Map 2441, bedrock is known to be limestone and dolostone of the Detroit River Group formation. According to the Department of Mines Bedrock Topographic Map P168, the underlying bedrock may be more than 55 m below the existing grades of the highway.

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 1. The boundaries between soil strata have been 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 subsurface soil conditions encountered below the traveled lanes and shoulders consisted of pavement structure followed by fill and buried topsoil, which is underlain by clayey silt followed by a deeper silt deposit. For classification purposes, the soils encountered at this site can be divided into four distinct zones:

- a) Pavement Structure
- b) Fill / Topsoil
- c) Clayey Silt Till
- d) Silt



5.2.1 Pavement Structure

Pavement structure was encountered in Boreholes 1 to 6 and Boreholes 9 to 14, extending to depths ranging from 0.45 to 0.76 m. The pavement structure comprised of 80 to 220 mm asphaltic concrete over 140 to 200 mm of granular base over 200 to 410 mm granular subbase. The granular base and subbase were found to be moist. Reference is given to Figures GS1 and GS2 for the result of particles size distribution analyses conducted on samples of the granular base and subbase respectively. The test results revealed that the granular base samples consisted of 38 to 42% gravel, 45 to 45% sand, and 12 to 16% silt and clay sized particles. The test results revealed that the granular subbase samples consisted of 41 to 45% gravel, 41 to 44% sand, and 12 to 16% silt and clay sized particles. In general, the granular base and subbase did not meet Ontario Provincial Standard Specification (OPSS) gradation requirements for Granular A or B due to elevated silt fractions, but meet OPSS gradation requirements for select subgrade material (SSM).

5.2.2 Fill and Topsoil

A fill layer 0.2 to 2.0 m thick was encountered in Boreholes 1 to 6 and Boreholes 9 to 14, below the surficial pavement structure, and extended to between 0.7 and 2.5 m depth. In Boreholes 6 and 12 at the watermain crossing the fill extended to 1.4 and 2.1 m depth, respectively. The fill generally comprised clayey silt, sandy silt, and silt. The SPT N values of the fill ranged between 4 and 13 blows per 0.3 m penetration of the split spoon sampler, indicating loose to compact or soft to stiff state of compaction or consistency. The fill was moist or about plastic limit (APL), with moisture contents ranging from 3 to 24%. The results of the grain size distribution analyses conducted on representative samples of the fill are presented in Figure GS3. The test results revealed that the fill samples consisted of 0 to 4% gravel, 14 to 33% sand, 39 to 55% silt and 22 to 43% clay sized particles. Organic contents of the fill samples tested ranged from 1.4 to 3.5%

Surficial clayey silt topsoil was encountered in Boreholes 7 and 8 on the Cachet land south of the highway and extended to 0.3 and 0.2 m depth, respectively. A buried topsoil layer, 0.3 m thick, was also encountered below the fill in Borehole 3; the layer extended to depth of 1.7 m.



5.2.3 Clayey Silt Till

A 2.1 to 4.8 m thick clayey silt till layer was encountered below the pavement structure, fill and topsoil in all of the boreholes, and extended to between 3.7 and 6.2 m depth. The clayey silt till contained trace to some sand, trace to some gravel, and occasional cobbles. Cobbles and boulders should be expected in the till deposit. Reference is made to the appended Figures GS4 and GS5 for the results of particle size distribution analyses conducted on samples of the clayey silt. The test results revealed that the clayey silt till samples consisted of 1 to 13% gravel, 10 to 30% sand, 40 to 58% silt and 22 to 29% clay sized particles. It is noted that the particle size distribution analyses exclude materials larger than 38 mm in diameter due to the limitation of the split spoon sampling equipment.

The clayey silt till was very soft to hard with SPT N values ranging from 3 to greater than 50 blows, with an average of 28 blow per 0.3 m penetration of the split spoon sampler (typically very stiff to hard).

The clayey silt till was of low plasticity with plastic limit ranging from 13 to 17, liquid limit ranging from 21 to 32, and corresponding plasticity index of 6 to 15. The clayey silt till was in drier than plastic limit (DTPL) to about plastic limit (APL) condition, with moisture contents between 8 and 28%. Reference is made to Figure PC1 for the results of Atterberg Limits testing on samples of the clayey silt till.

5.2.4 Silt

A silt layer was encountered below the clayey silt till in all the boreholes; this layer extended to the borehole termination depths of 6.7 m. The native silt was compact to very dense with SPT N values ranging from 23 to greater than 50 blows per 0.3 m penetration of the split spoon sampler.

The results of the grain size distribution analyses conducted on representative samples of the silt are presented in Figure GS6. The test results revealed that the silt deposit consists of 1 to 3% gravel, 2 to 3% sand, 82 to 83% silt and 12 to 15% clay sized particles. Atterberg limits tests on the silt found the silt to be non-plastic.



5.3 Ground Water

Free water was observed during drilling in all the boreholes at depths of 0.8 and 3.5 m. The free water seepage was generally observed in the near surface fill soils at about the level of the road-side ditches. Upon completion of auguring, free water was observed in Boreholes 2, and 4 to 14 at depths between 0.9 and 5.8 m. The water levels in the boreholes reflect the perched near surface ground water level at the site.

The ground water levels at the site are subject to seasonal fluctuations and precipitation patterns. It should be noted that the relatively impermeable nature of the clayey silt till may contribute to the development of perched water conditions following short term and seasonal precipitation events.

5.4 Chemical Testing

A sample of the clayey silt till was taken at the proposed watermain crossing, and was tested to determine soil corrosivity. Details of the chemical test results are presented on the certificate of analysis presented in Appendix B, and summarized in the following table 2 below:

Table 2: Summary Of Corrosivity Test Results

Borehole	Sample	Depth (m)	Soil Type	Sulphate (µg/g)	Chloride (µg/g)	pH	Resistivity (0hm-cm)
6	4	2.3 to 2.9	Clayey Silt	15	52	8.64	3050



6. CLOSURE

The field work was carried out under the supervision of Mr. W. Loghrin, P.Eng. The drilling equipment was supplied and operated by a specialist drilling contractor working under subcontract to PML. The laboratory work was carried out in the PML Kitchener laboratory.

This report was prepared by Mr. W. Loghrin, P.Eng. Independent review of the report was carried out by Mr. Geoffrey Uwimana, MEng, P.Eng., MTO Designated Principal Contact.

We trust this report has been completed within the terms of reference and is sufficient for your current needs. Should you have further questions, do not hesitate to contact our office.

Sincerely

Peto MacCallum Ltd.



William Loghrin, P.Eng.
Manager, Engineering Services



Geoffrey Uwimana, MEng, P.Eng.
MTO Designated Principal Contact

WL/GU: nk

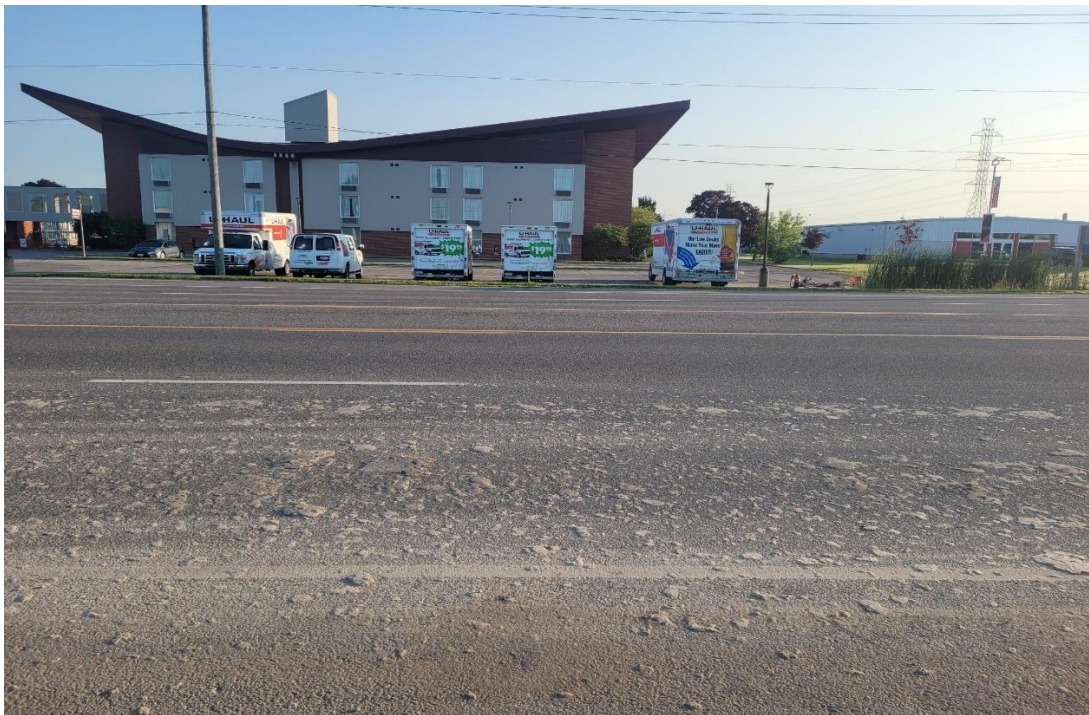


APPENDIX A

Site Photographs



Photograph 1: Facing South at Watermain Crossing.



Photograph 2: Facing North at Watermain Crossing.



APPENDIX B

Drawing 1 – Borehole Location Plan

Drawing 2 – Borehole Location Plan and Soil Strata

Explanation of Terms Used in Report

Log of Borehole Sheets

Figures GS1 to GS6 – Particle Size Distribution Charts

Figure PC1 – Plasticity Index Chart

Figure UP1 – General Recommendations Regarding Underpinning of
Foundation/Utilities Located Close to Excavation

Figure BC1 – Multi-Braced Cuts in Cohesionless Soils

Figure BC2 Singly-Braced Cuts in Cohesionless Soils

EC-2024-31L-00000070



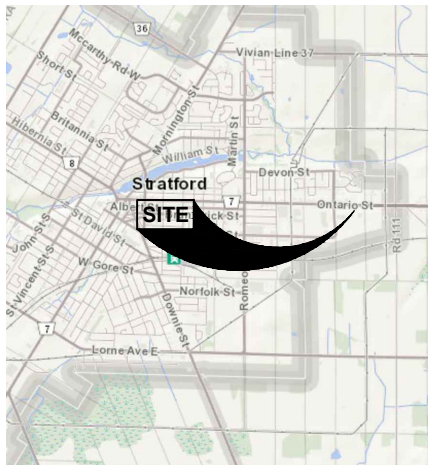
SEWER AND WATERMAIN INSTALLATIONS
HIGHWAY 7/8
BOREHOLE LOCATIONS

SHEET



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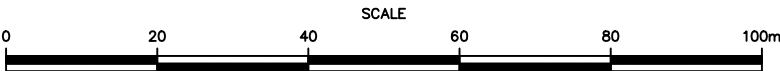
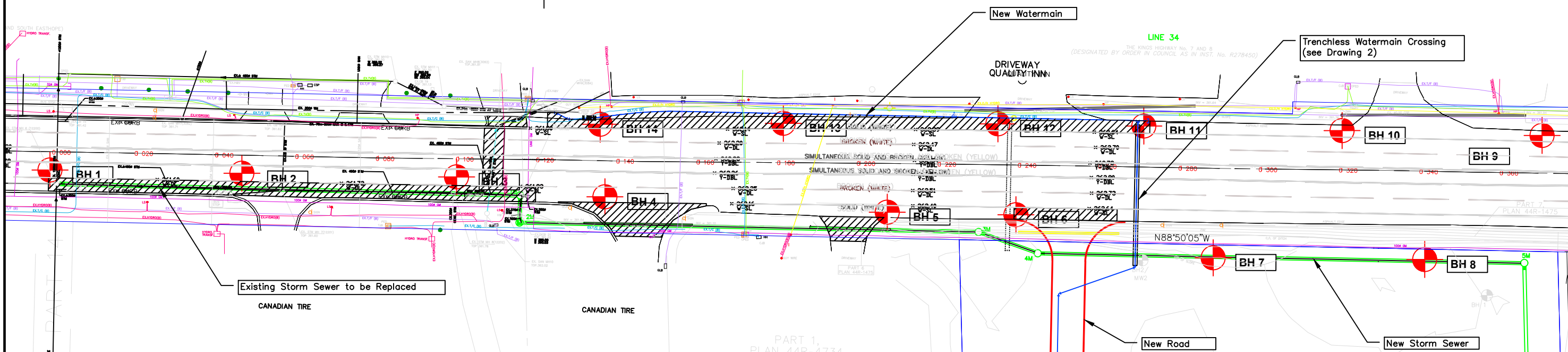
- PML Borehole
- Soil-Mat Borehole
- Proposed Asphalt Cut



KEY PLAN
N.T.S.

ONTARIO STREET – CITY OF STRATFORD

KINGS HIGHWAY No. 7 and 8 (LINE 34) – COUNTY OF PERTH



BH No	ELEVATION	COORDINATES (UTM 17T)	
		NORTHINGS	EASTINGS
1	361.6	4801985.1	504495.1
2	361.8	4801984.3	504542.9
3	361.9	4801983.3	504596.4
4	362.1	4801978.4	504633.3
5	363.3	4801974.6	504703.6
6	362.5	4801973.9	504735.7
7	362.4	4801963.2	504784.8
8	362.2	4801962.8	504837.5
9	363.2	4801993.7	504866.7
10	362.9	4801994.9	504816.9
11	362.7	4801996.0	504767.5
12	362.5	4801996.5	504731.2
13	362.3	4801996.7	504677.8
14	361.9	4801996.5	504632.1

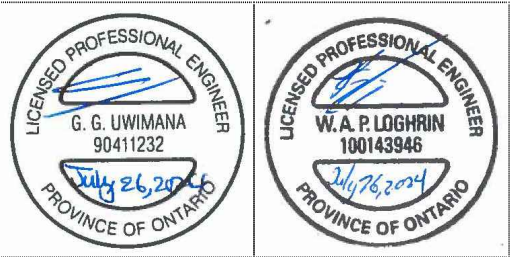
– NOTE –
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS		
DATE	BY	DESCRIPTION

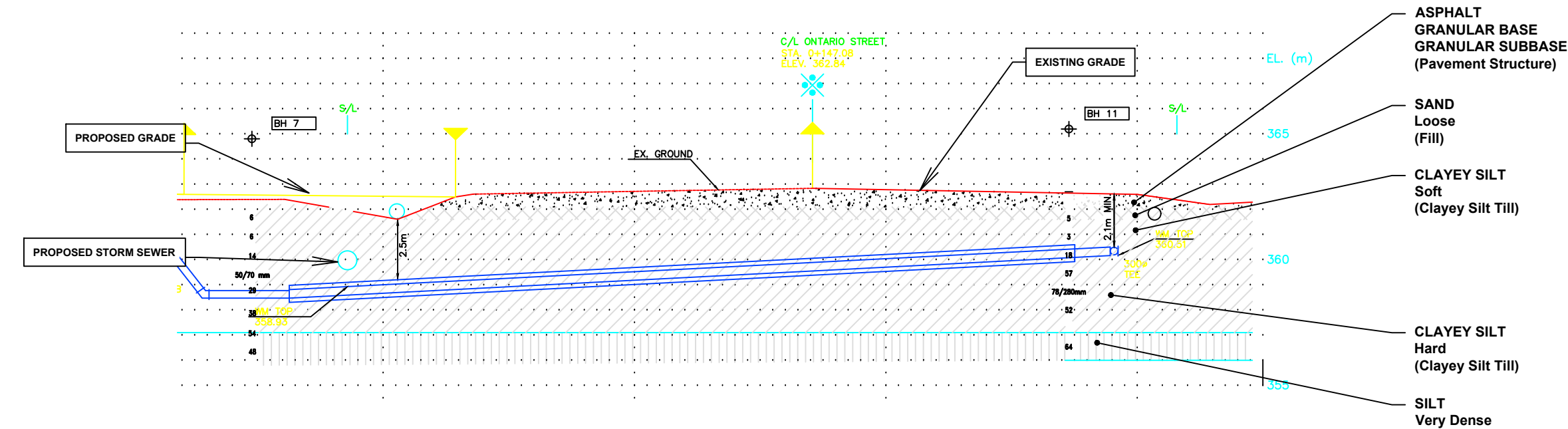
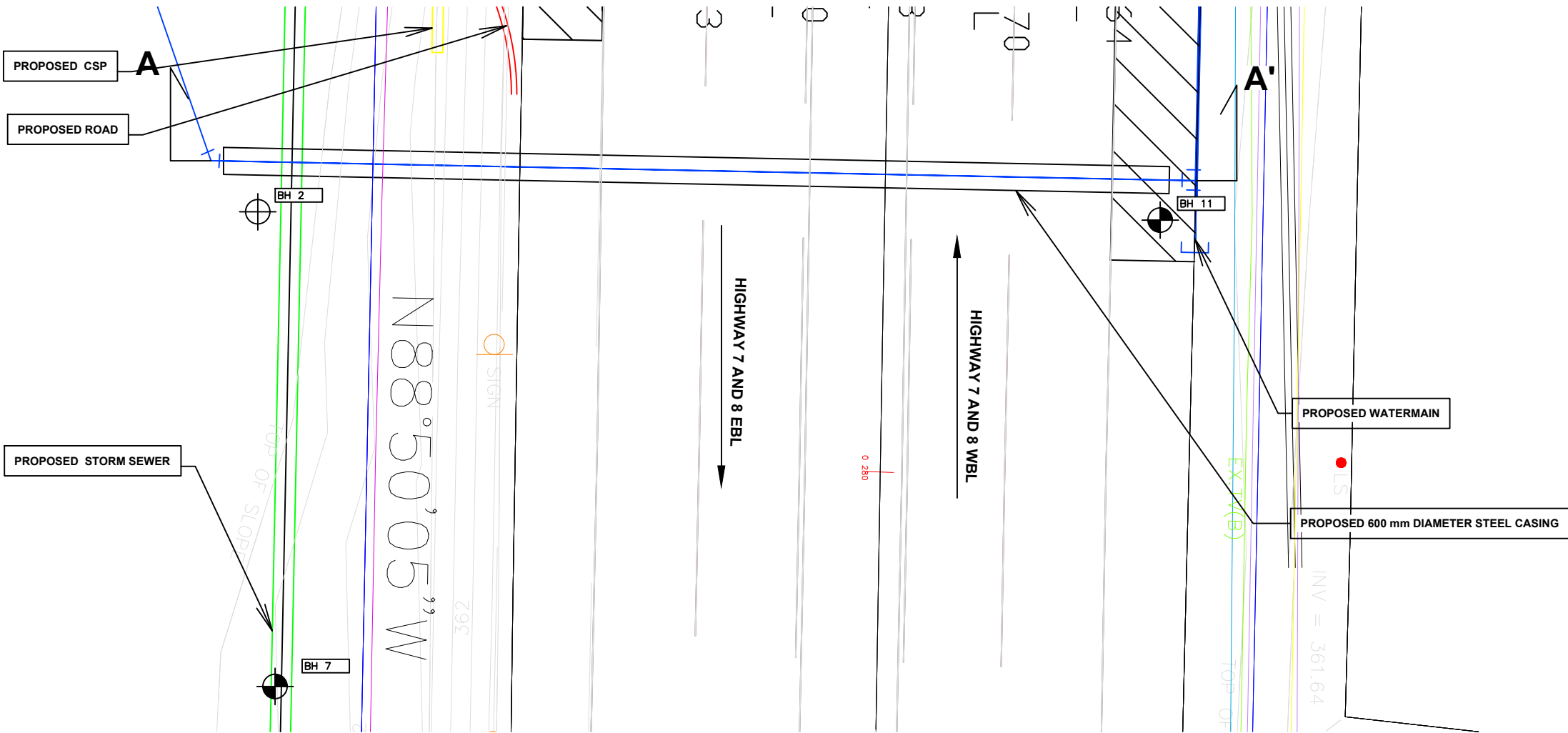
Geocres No. 40P07-070			
HWY No	WL	CHECKED WL	DATE July 2024
SUBMD	NG	CHECKED WL	APPROVED WL
DRAWN	NG	CHECKED WL	APPROVED WL
DIST PERTH			DWG 1

NOTES:

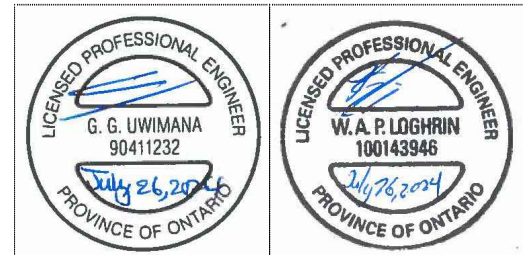
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RECORD OF BOREHOLES AND REPORT
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.



Reference
CACHET.STRATFORD-ONTARIO.ST-WM.CROSSING-JUNE03_24.dwg



- NOTES:
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Reference
CACHET.STRAFORD-ONTARIO.ST-WM.CROSSING-JUNE03_24.dwg



LEGEND:			
	PML Borehole		
	Soil-Mat Borehole		
	Proposed Asphalt Cut		
BH No	ELEVATION	COORDINATES	
		NORTHINGS	EASTINGS
7	362.4	4801963.2	504784.8
11	362.7	4801996.0	504767.5

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

REVISIONS	DATE	BY	DESCRIPTION

Geocres No. 40P07-070				DIST	PERTH
HWY No	WL	CHECKED	WL	DATE	July 2024
SUBMTD	NG	CHECKED	WL	APPROVED	WL
DRAWN	NG	CHECKED	WL	APPROVED	WL
DWG				2	

EXPLANATION OF TERMS USED IN REPORT

SPT N VALUE: THE STANDARD PENETRATOIN TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT-BARREL SAMPLER TO PENETRATE 0.3 m. AFTER AN INITIAL PENETRATIO OF 150 mm, INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76 m FOR PENETRATIONS. A SPT N VALUE IS INDICATED AS THE NUMBER OF BLOWS REQUIRED TO DRIVE THE SPLIT-BARREL SAMPLER A DISTANCE OF 300 MM. AN AVERAGE SPT N VALUE IS DENOTED AS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm O.D., 60° CONE ANGLE) DRIVEN BY 475 JOULES IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION, CONSISTENCY OR COMPACTNESS.

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

PERCENTAGE BY MASS	0 - 10	10 - 20	20 - 35	>35	>35 and main fraction
	'trace'	'some'	Adjective (silty, sandy, clayey etc.)	'and'	Noun (gravel, sand, silt, clay)

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

COMPACTNESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF COMPACTNESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3 m PENETRATION)	0 - 4	4 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

TOTAL CORE RECOVERY (REC): CORE RECOVERED AS A PERCENTAGE OF TOTAL CORE RUN LENGTH.

ROCK QUALITY DESIGNATION (RQD): TOTAL LENGTH OF SOUND ROCK RECEIVED IN PIECES 10 cm OR LARGER AS A PERCENTAGE OF TOTAL CORE RUN LENGTH. CLASSIFICATION OF ROCK WITH RESPECT TO RQD VALUE AS FOLLOWS:

RQD VALUE (%)	<25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

UNIAXIAL COMPRESSIVE STRENGTH (UCS): MAXIMUM AXIAL COMPRESSIVE STRESS THAT A ROCK CORE SPECIMEN CAN WITHSTAND BEFORE FAILING.

POINT LOAD STRENGTH INDEX: AN INDEX TEST TO DETERMINE POINT LOAD STRENGTH INDEX OF ROCK.

CLASSIFICATION OF ROCK WITH RESPECT TO STRENGTH IS AS FOLLOWS:

GRADE*	R0	R1	R2	R3	R4	R5	R6
UCS (MPa)	0.25 - 1	1 - 5	5 - 25	25 - 50	50 - 100	100 - 250	>250
POINT LOAD INDEX (MPa)	**	**	**	1 - 2	2 - 4	4 - 10	>10
TERM	EXTREMELY WEAK	VERY WEAK	WEAK	MEDIUM STRONG	STRONG	VERY STRONG	EXTREMELY STRONG

* - GRADE ACCORDING TO THE INTERNATIONAL SOCIETY OF ROCK MECHANICS (ISRM), 1981.

** - ROCKS WITH UNIAXIAL COMPRESSIVE STRENGTH BELOW 25 MPa ARE LIKELY TO YIELD HIGHLY AMBIGUOUS RESULTS UNDER POINT LOAD TESTING.

DISCONTINUITY SPACING: DISTANCE BETWEEN A PAIR OF DISCONTINUITIES MEASURED ALONG A LINE OF SPECIFIED LOCATION AND ORIENTATION. CLASSIFICATION OF ROCK WITH RESPECT TO DISCONTINUITY SPACING IS AS FOLLOWS (ISRM, 1981):

SPACING WIDTH (m)	<0.02	0.02 - 0.06	0.06 - 0.20	0.20 - 0.6	0.6 - 2.0	2.0 - 6.0	>6.0
SPACING CLASSIFICATION	EXTREMELY CLOSE	VERY CLOSE	CLOSE	MODERATELY CLOSE	WIDE	VERY WIDE	EXTREMELY WIDE

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS - SPLIT SPOON
WS - WASH SAMPLE
AS - AUGER SAMPLE
FV - FIELD VANE
CS - CHUNK SAMPLE
TW - THINWALL SHELBY TUBE SAMPLE
PH - TW ADVANCED HYDRAULICALLY
PM - TW ADVANCED MANUALLY

TP - THINWALL PISTON SAMPLE
OS - OSTERBERG SAMPLE
RC - ROCK CORE
BS - BLOCK SAMPLE
FS - FOIL SAMPLE

STRESS AND STRAIN

u_p	PORE WATER PRESSURE (kPa)
r_p	PORE PRESSURE RATIO
σ	TOTAL NORMAL STRESS (kPa)
σ'	EFFECTIVE NORMAL STRESS (kPa)
τ	SHEAR STRESS (kPa)
$\sigma_1, \sigma_2, \sigma_3$	PRINCIPAL STRESSES (kPa)
ϵ	LINEAR STRAIN (%)
$\epsilon_1, \epsilon_2, \epsilon_3$	PRINCIPAL STRAINS (%)
E	MODULUS OF LINEAR DEFORMATION (MPa)
G	MODULUS OF SHEAR DEFORMATION (MPa)
μ	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

C_c	COMPRESSION INDEX
C_{cr}	RECOMPRESSION INDEX
C_s	SWELL INDEX
e_c	COEFFICIENT OF CONSOLIDATION - VERTICAL (cm^3/s)
e_h	COEFFICIENT OF CONSOLIDATION - HORIZONTAL (cm^3/s)
C_α	COEFFICIENT OF SECONDARY CONSOLIDATION
m_v	COEFFICIENT OF VOLUME CHANGE (kPa^{-1})
σ'_p	PRECONSOLIDATION PRESSURE (kPa)
σ'_{v1}	EFFECTIVE OVERBURDEN PRESSURE (kPa)
H	DRAINAGE PATH (m)
U	DEGREE OF CONSOLIDATION
T_v	TIME FACTOR; VERTICAL DRAINAGE
T_h	TIME FACTOR; HORIZONTAL DRAINAGE
S_u, c_u	UNDRAINED SHEAR STRENGTH (kPa)
S_R	RESIDUAL SHEAR STRENGTH (kPa)
S_r	REMOULDED SHEAR STRENGTH (kPa)
α	UNIAXIAL COMPRESSIVE STRENGTH (kPa)
c'	EFFECTIVE COHESION INTERCEPT (kPa)
c	APPARENT COHESION INTERCEPT (kPa)
ϕ'	EFFECTIVE ANGLE OF INTERNAL FRICTION (Degrees)
S_i	SENSITIVITY ($= c_u / S_r$)
I_p	POINT LOAD STRENGTH INDEX

PHYSICAL PROPERTIES

W_p - PLASTIC LIMIT (%)	W_L - LIQUID LIMIT (%)	W - MOISTURE CONTENT (%)
W_s - SHRINKAGE LIMIT (%)	I_p - PLASTICITY INDEX (%)	Y_w - UNIT WEIGHT OF WATER (kg/m^3)
γ - UNIT WEIGHT OF SOIL (kg/m^3)	γ_{sat} - UNIT WEIGHT OF SATURATED SOIL (kg/m^3)	γ_d - UNIT WEIGHT OF DRY SOIL (kg/m^3)
ρ_w - DENSITY OF WATER (kN/m^3)	ρ - DENSITY OF SOIL (kN/m^3)	ρ_{sat} - DENSITY OF SATURATED SOIL (kN/m^3)
ρ_d - DENSITY OF DRY SOIL (kN/m^3)	S_r - DEGREE OF SATURATION (%)	D_r, SG - RELATIVE DENSITY (FORMERLY SPECIFIC GRAVITY)
C_u - UNIFORMITY COEFFICIENT	C_c - CURVATURE COEFFICIENT	

RECORD OF BOREHOLE No 1										1 OF 1		METRIC			
G.W.P. EC-2024-31L-00000070			LOCATION Coordinates: UTM 17T 4801985.1N, 504495.1E			ORIGINATED BY NG									
DIST Southwest HWY 7/8			BOREHOLE TYPE Solid Stem Augers			COMPILED BY WL									
DATUM Geodetic			DATE 2024.04.09			LATITUDE 43.370717		LONGITUDE -80.944516		CHECKED BY WL					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	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		ELEVATION SCALE	SHEAR STRENGTH kPa							
361.6	GROUND SURFACE														
360.4	PAVEMENT: 180 mm asphalt, over 160 mm granular base, over 250 mm granular subbase, moist		1A	GS	-										40 45 (16)
361.0			1B	GS	-										45 41 (14)
0.6	CLAYEY SILT, some gravel, trace to some sand		2	SS	7										
360.2	Firm, Brown to dark brown, APL (FILL)														
1.4	CLAYEY SILT, some sand to sandy, trace to some gravel, occasional sand layers, occasional cobbles, occasional boulder		3	SS	18										
	Very stiff to hard, Brown to grey, DTPL to APL, occasional wet layers		4	SS	20										
			5	SS	21										
			6	SS	28										
	(CLAYEY SILT TILL)		7	SS	44										
356.6	SILT, some sand, trace gravel, trace clay, occasional cobbles														
5.0	Dense, Grey, Wet to moist														
	(SILT)		8	SS	44										
354.9	End of borehole														
6.7	NOTES: 1. First water strike noted at 3.1 m during drilling. 2. No free water or cave was noted upon completion of drilling.														

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801984.3N, 504542.9E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.09 LATITUDE 43.370709 LONGITUDE -80.943926 CHECKED BY WL

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 (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE											
361.8	GROUND SURFACE							20	40	60	80	100							
361.8 0.2	PAVEMENT: 200 mm asphalt, over 150 mm granular base, over 410 mm granular subbase, moist		1A	GS	-														
361.0 0.8			1B	GS	-														
360.7 1.1	GRAVELLY SAND, trace silt Loose, Brown, Moist (FILL)		2	SS	8								○	○			4 22 52 22		
360.4 1.4	CLAYEY SANDY SILT, trace gravel Firm, Dark Brown, APL (FILL)		3	SS	14								○	○			4 17 54 25		
	CLAYEY SILT, trace to some sand, trace to some gravel, occasional cobbles, occasional boulder		4	SS	17								○						
	Stiff to very stiff, Brown to grey, DTPL to APL, occasional wet seams		5	SS	18								○						
			6	SS	21								○	○					
			7	SS	22									○					
	(CLAYEY SILT TILL)																		
355.6 6.2	SILT, some sand, trace clay		8	SS	30									○					
355.1 6.7	Compact, Grey, Wet (SILT)																		
	End of borehole NOTES: 1. First water strike noted at 3.5 m during drilling. 2. Water at 5.2 m upon completion of augering.																		

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801983.3N, 504596.4E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.09 LATITUDE 43.3707 LONGITUDE -80.943266 CHECKED BY WL

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 (%)		
								○ UNCONFINED		+ FIELD VANE										
								● QUICK TRIAXIAL		× LAB VANE										
361.9	GROUND SURFACE						20	40	60	80	100									
361.8	PAVEMENT: 220 mm asphalt, over		1A	GS	-															
0.2	170 mm granular base, over		1B	GS	-															
361.2	310 mm granular subbase, moist																			
0.7	SAND, some gravel, trace silt		2	SS	13															
360.5	Compact, Brown, Moist (FILL)																			
1.4	CLAYEY SILT, trace gravel, trace organics		3	SS	6															
360.2	Firm, Black, APL (TOPSOIL)																			
1.7	CLAYEY SILT, some sand to sandy, trace gravel, occasional cobbles, occasional boulder		4	SS	12															
	Firm to very stiff, Brown to grey, DTPL to APL, occasional wet seams		5	SS	21															
	(CLAYEY SILT TILL)		6	SS	25															
357.4	SILT, trace sand to some sand, trace clay		7	SS	23															
4.5	Compact to dense, Grey, Wet to moist																			
	(SILT)		8	SS	40															
355.2	End of borehole																			
6.7	NOTES: 1. First water strike noted at 2.4 m during drilling. 2. No free water noted upon completion of augering.																			

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801978.4N, 504633.3E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.09 LATITUDE 43.370656 LONGITUDE -80.94281 CHECKED BY WL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
362.1	GROUND SURFACE														
361.8	PAVEMENT: 220 mm asphalt, over		1A	GS	-										
0.2	170 mm granular base, over		1B	GS	-										
361.4	300 mm granular subbase, moist														
0.7	SAND, some gravel, trace silt		2	SS	15										
361.0	Compact, Brown, Moist to wet (FILL)														
1.1	CLAYEY SILT, trace sand to sandy, trace to some gravel, occasional cobbles, occasional boulder		3	SS	3										2 30 40 28
	Soft to hard, Brown to grey, DTPL to APL, occasional wet seams		4	SS	14										
			5	SS	18										
			6	SS	43										
			7	SS	36										
	(CLAYEY SILT TILL)														
356.5	SILT, trace sand														
5.6	Very dense, Grey, Moist to wet		8	SS	56										
	(SILT)														
355.4	End of borehole														
6.7	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 3.1 m upon completion of augering.														

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801974.6N, 504703.6E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.08 LATITUDE 43.370621 LONGITUDE -80.941943 CHECKED BY WL

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									
								20	40	60	80	100					
								○ UNCONFINED	+	FIELD VANE							
								● QUICK TRIAXIAL	×	LAB VANE							
								20	40	60	80	100					
362.3	GROUND SURFACE																
360.9	PAVEMENT: 90 mm asphalt, over 180 mm granular base, over 250 mm granular subbase, moist		1A	GS	-		362										
361.8	SAND, some gravel, trace silt		1B	GS	-												
361.3	Loose, Brown, Wet (FILL)		2	SS	6												
360.9	SANDY SILT, trace gravel, trace clay						361										
	Loose, Brown, Moist (FILL)		3	SS	17												
	CLAYEY SILT, some sand, trace to some gravel, occasional cobbles, occasional boulder						360										
	Very stiff to hard, Brown to grey, DTPL to APL		4	SS	46												
			5	SS	44		359										
	(CLAYEY SILT TILL)		6	SS	53		358										
357.8	SILT, trace gravel, trace sand		7	SS	100/250mm		357										
	Very dense, Grey, Moist																
	(SILT)		8	SS	70		356										
355.6	End of borehole																
	NOTES: 1. First water strike noted at 0.8 m during drilling. 2. Water at 4.9 m upon completion of augering.																

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801973.9N, 504735.7E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.08 LATITUDE 43.370615 LONGITUDE -80.941547 CHECKED BY WL

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											
362.5	GROUND SURFACE						20	40	60	80	100								
360.9	PAVEMENT: 80 mm asphalt, over 150 mm granular base, over 250 mm granular subbase, moist		1A	GS	-														
362.0			1B	GS	-														
361.8	SAND, some gravel, trace silt, occasional cobbles																		
361.1	Loose, Brown, Moist to wet (FILL)		2	SS	4														
361.1	CLAYEY SILT, some sand, trace gravel Soft, Brown, APL (FILL)		3	SS	14														
	CLAYEY SILT, some sand to sandy, trace to some gravel, occasional cobbles, occasional boulder		4	SS	28														
	Stiff to hard, Brown to grey, DTPL to APL, occasional wet seams		5	SS	41														
	(CLAYEY SILT TILL)		6	SS	43														
358.0	SILT, some clay, trace sand, trace gravel, occasional cobbles		7	SS	77														
	Very dense, Grey, Moist		8	SS	70														
	(SILT)		9	SS	56														
355.8	End of borehole																		
	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 2.9 m upon completion of augering.																		

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801963.2N, 504784.8E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.18 LATITUDE 43.370518 LONGITUDE -80.940941 CHECKED BY WL

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									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)					
							20	40	60	80	100		20	40	60		
362.4	GROUND SURFACE																
0.0 362.1 0.3	CLAYEY SILT, some organics, trace gravel, APL Loose, Black, APL (TOPSOIL) CLAYEY SILT, some sand, trace to some organics, trace gravel, occasional sand and gravel layers, occasional cobbles, occasional boulder Firm to hard, Brown to grey, DTPL to APL, occasional wet layers		1	SS	6								○				
			2	SS	6								○				
			3	SS	14								○	○			
			4	SS	50/70mm								○				
			5	SS	29								○				
	(CLAYEY SILT TILL)		6	SS	38								○				
357.9 4.5	SILT, trace gravel, trace sand, trace clay, occasional cobbles Very dense to dense, Grey, Moist		7	SS	54								○				
	(SILT)		8	SS	48								○				
355.7 6.7	End of borehole																
	NOTES: 1. First water strike noted at 1.5 m during drilling. 2. Water at 1.7 m upon completion of augering.																

RECORD OF BOREHOLE No 8										1 OF 1		METRIC		
G.W.P. EC-2024-31L-00000070			LOCATION Coordinates: UTM 17T 4801962.8N, 504837.5E			ORIGINATED BY NG								
DIST Southwest HWY 7/8			BOREHOLE TYPE Solid Stem Augers			COMPILED BY WL								
DATUM Geodetic			DATE 2024.04.18			LATITUDE 43.370514		LONGITUDE -80.94029		CHECKED BY WL				
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			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						
362.2	GROUND SURFACE							20 40 60 80 100						
362.0	CLAYEY SILT, trace organics, trace gravel		1	SS	5		362							
0.2	Loose, Dark brown, APL (TOPSOIL)													
	CLAYEY SILT, trace to some sand, trace to some gravel, occasional sandy layers, occasional cobbles, occasional boulder		2	SS	7									
	Firm to hard, Brown to grey, DTPL to APL, occasional wet layers		3	SS	37									
			4	SS	32		360							
			5	SS	59									
	(CLAYEY SILT TILL)													
358.5	SILT, some sand, trace gravel, trace clay		6	SS	58									
3.7	Dense to very dense, Grey, Moist		7	SS	46		358							
							357							
			8	SS	75		356							
355.5	(SILT)													
6.7	End of borehole													
	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 3.2 m upon completion of augering.													

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801993.7N, 504866.7E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.08 LATITUDE 43.370792 LONGITUDE -80.939929 CHECKED BY WL

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 (%)			GR
363.2	GROUND SURFACE					▽		20	40	60	80	100								
363.0	PAVEMENT: 170 mm asphalt, over 200 mm granular base, over 250 mm granular subbase, moist		1A	GS	-		363												42 46 (12)	
0.2			1B	GS	-														43 44 (12)	
362.6	SAND, some gravel, trace silt, occasional cobbles		2	SS	5															
0.6	Loose, Brown, Moist to wet (FILL)						362													
362.2	CLAYEY SILT, some sand, trace to some gravel, occasional sandy layers, occasional cobbles, occasional boulder		3	SS	3															
1.0	Soft to hard, Brown to grey, DTPL to APL		4	SS	23		361													
			5	SS	42		360													
	(CLAYEY SILT TILL)		6	SS	43	359														
358.7	SILT, trace sand, trace gravel, occasional cobbles		7	SS	67	▼														
4.5	Very dense, Grey, Wet						358													
	(SILT)		8	SS	56	357														
356.5	End of borehole																			
6.7	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 5.3 m upon completion of augering.																			

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801994.9N, 504816.9E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.08 LATITUDE 43.370803 LONGITUDE -80.940544 CHECKED BY WL

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									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
362.9	GROUND SURFACE						20	40	60	80	100						
362.9	PAVEMENT: 180 mm asphalt, over		1A	GS	-												
0.2	170 mm granular base, over		1B	GS	-												
362.3	250 mm granular subbase, moist																
362.3	SAND, some gravel, trace silt, occasional cobbles		2	SS	7												
0.8	Loose, Brown, Moist to wet (FILL)																
	CLAYEY SILT, some sand, trace to some gravel, occasional cobbles, occasional boulders		3	SS	4												
	Firm to hard, Brown, DTPL to APL		4	SS	31												
			5	SS	23												
			6	SS	24												
			7	SS	33												
	(CLAYEY SILT TILL)																
357.3	SILT, some clay, trace sand, trace gravel																
5.6	Dense, Grey, Moist to wet		8	SS	42												
	(SILT)																
356.2	End of borehole																
6.7	NOTES: 1. First water strike noted at 0.8 m during drilling. 2. Water at 2.0 m upon completion of augering.																

RECORD OF BOREHOLE No 11

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801996.0N, 504767.5E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.08 LATITUDE 43.370813 LONGITUDE -80.941154 CHECKED BY WL

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												
362.7	GROUND SURFACE							20	40	60	80	100								
362.6	PAVEMENT: 200 mm asphalt, over		1A	GS	-															
0.2	160 mm granular base, over		1B	GS	-															
362.0	250 mm granular subbase, moist																			
0.6	SAND, some gravel, trace silt																			
361.6	Loose, Brown, Moist to wet (FILL)		2	SS	5															
1.1	CLAYEY SILT, trace to some sand, trace to some gravel, occasional cobbles, occasional boulder																			
	Soft to hard, Brown to grey, DTPL to APL, occasional wet seams		3	SS	3															
			4	SS	18															
			5	SS	57															
			6	SS	78/280mm															
			7	SS	52															
	(CLAYEY SILT TILL)																			
357.1	SILT, some sand																			
5.6	Very dense, Grey, Moist to wet																			
	(SILT)		8	SS	64															
356.0	End of borehole																			
6.7	NOTES: 1. First water strike noted at 0.8 m during drilling. 2. Water at 0.9 m upon completion of augering.																			

RECORD OF BOREHOLE No 12

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801996.5N, 504731.2E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.10 LATITUDE 43.370818 LONGITUDE -80.941602 CHECKED BY WL

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												
362.5	GROUND SURFACE							20	40	60	80	100								
360.8	PAVEMENT: 160 mm asphalt, over 150 mm granular base, over 250 mm granular subbase, moist		1A	GS	-															
361.9	SAND, some gravel, trace silt		1B	GS	-															
361.5	Loose, Brown, Moist to wet (FILL)		2	SS	9															
360.4	SILTY CLAY, some sand																			
360.4	Stiff to firm, Brown to grey, APL to DTPL (FILL)		3	SS	4															
360.4	CLAYEY SILT, some sand to sandy, trace to some gravel, occasional cobbles, occasional boulder		4	SS	37															
358.0	Hard, Brown to grey, DTPL with wet seams		5	SS	43															
358.0	(CLAYEY SILT TILL)		6	SS	29															
358.0	SILT, some clay, trace sand, trace gravel		7	SS	61															
358.0	Very dense, Grey, Moist with wet seams		8	SS	60															
355.8	(SILT)		9	SS	63															
355.8	End of borehole																			
	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 4.4 m upon completion of augering.																			

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801996.7N, 504677.8E ORIGINATED BY NG
 DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
 DATUM Geodetic DATE 2024.04.10 LATITUDE 43.37082 LONGITUDE -80.942262 CHECKED BY WL

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/m³	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									
							20 40 60 80 100					20 40 60					
362.3	GROUND SURFACE																
361.8	PAVEMENT: 100 mm asphalt, over 150 mm granular base, over 200 mm granular subbase, moist		1A	GS	-		362									38 46 (16)	
0.5	SAND, some gravel, trace silt		1B	GS	-											41 44 (16)	
361.4	Loose, Brown, Moist to wet (FILL)		2	SS	5											2 32 40 26	
0.9	CLAYEY SILT, with sand, trace gravel, organic and sand pockets						361										
360.5	Firm to stiff, Dark brown to black, APL (FILL)		3	SS	14												
1.8	GRAVELLY SAND, trace silt						360										
359.8	Compact, Brown, Wet (FILL)		4	SS	13												
2.5	CLAYEY SILT, trace to some sand, trace gravel, occasional cobbles, occasional boulder						359										
	Stiff to hard, Grey, DTPL to APL		5	SS	32												
	(CLAYEY SILT TILL)		6	SS	33		358										
357.8	SILT, trace to some sand, trace gravel, occasional cobbles		7	SS	42												
4.5	Dense to very dense, Grey, Moist						357										
	(SILT)		8	SS	58		356										
355.6	End of borehole																
6.7	NOTES: 1. First water strike noted at 0.8 m during drilling. 2. Water at 3.5 m upon completion of augering.																

RECORD OF BOREHOLE No 14

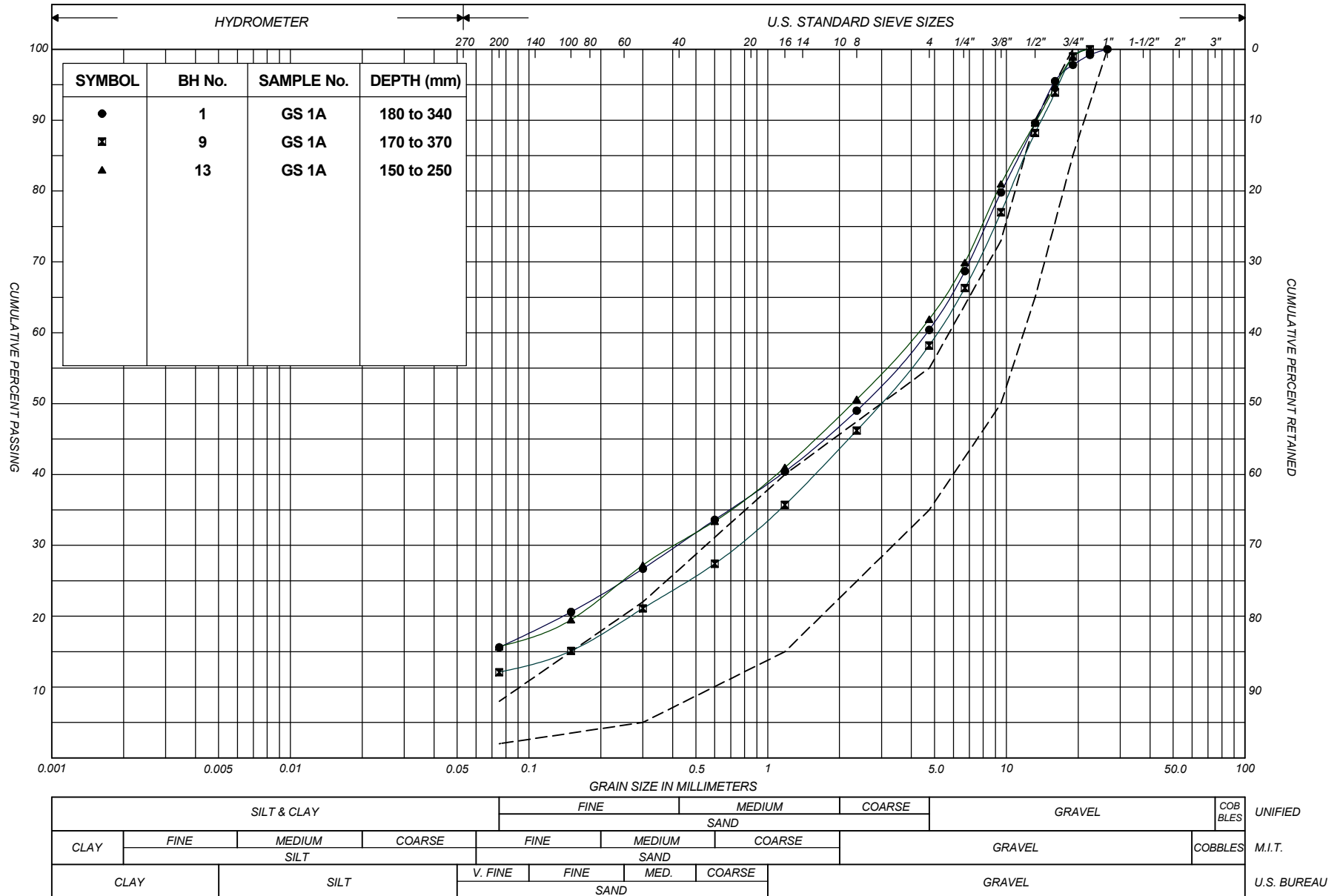
1 OF 1

METRIC

G.W.P. EC-2024-31L-00000070 LOCATION Coordinates: UTM 17T 4801996.5N, 504632.1E ORIGINATED BY NG
DIST Southwest HWY 7/8 BOREHOLE TYPE Solid Stem Augers COMPILED BY WL
DATUM Geodetic DATE 2024.04.10 LATITUDE 43.370818 LONGITUDE -80.942825 CHECKED BY WL

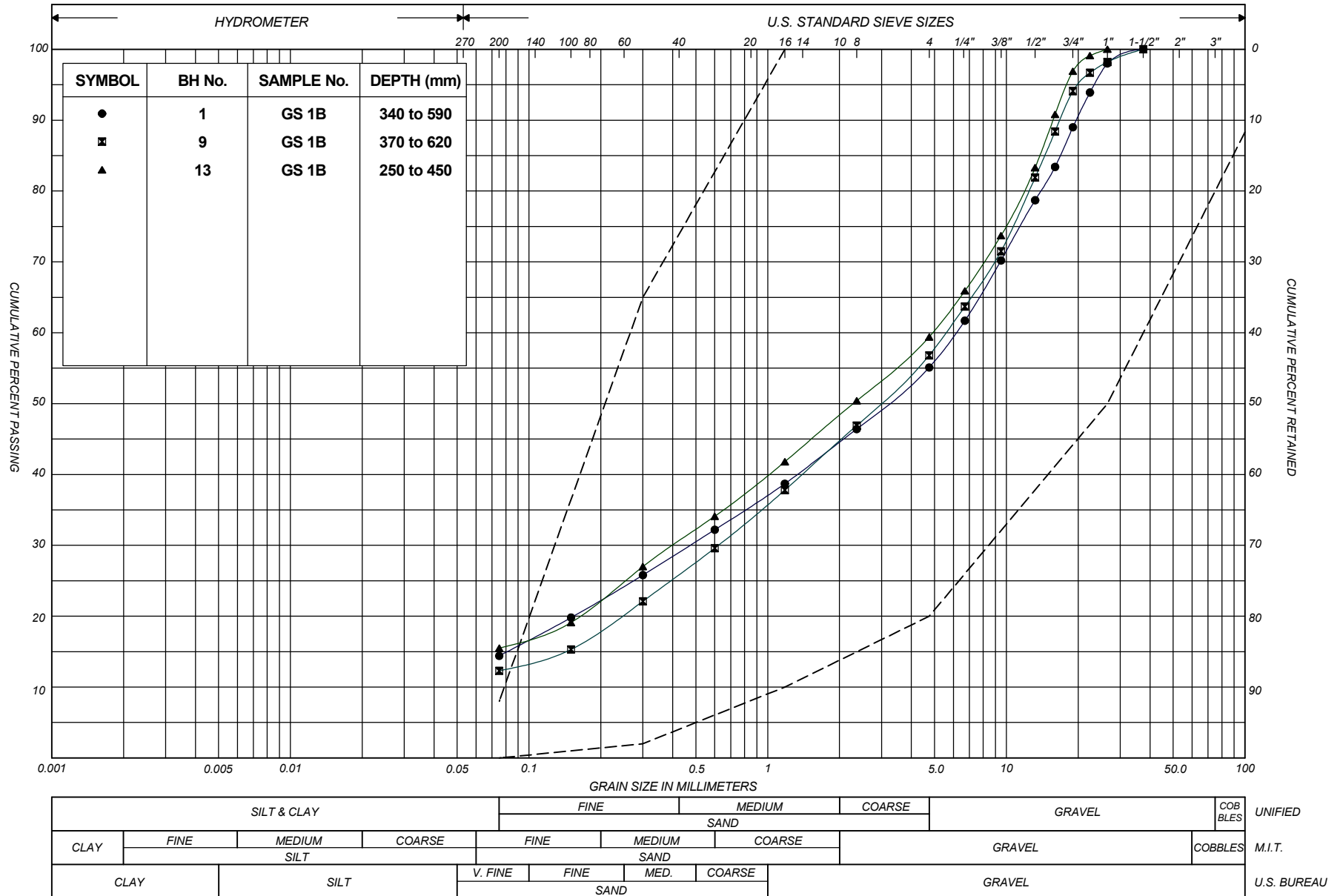
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							× LAB VANE
361.9	GROUND SURFACE					20	40	60	80	100	20	40	60				
360.9	PAVEMENT: 130 mm asphalt, over		1A	GS	-												
361.4	140 mm granular base, over		1B	GS	-												
361.4	230 mm granular subbase, moist																
0.5	SAND, some gravel, trace silt																
360.9	Loose, Brown, Moist to wet (FILL)		2	SS	5	▽	361										
1.0	CLAYEY SILT, some sand to sandy, trace to some gravel, occasional cobbles, occasional boulder		3	SS	13		360								4 26 47 23		
	Firm to hard, Brown to grey, DTPL to APL, occasional wet layers		4	SS	12		359										
			5	SS	27		358										
			6	SS	20		357										
			7	SS	39												
	(CLAYEY SILT TILL)																
356.3	SILT, trace sand							▼	356								
5.6	Very dense, Grey, Moist																
	(SILT)		8	SS	63												
355.2	End of borehole																
6.7	NOTES: 1. First water strike noted at 0.9 m during drilling. 2. Water at 5.8 m upon completion of augering.																

PARTICLE SIZE DISTRIBUTION CHART



REMARKS: Granular Base
COMPARED TO OPSS GRANULAR A SPECIFICATONS

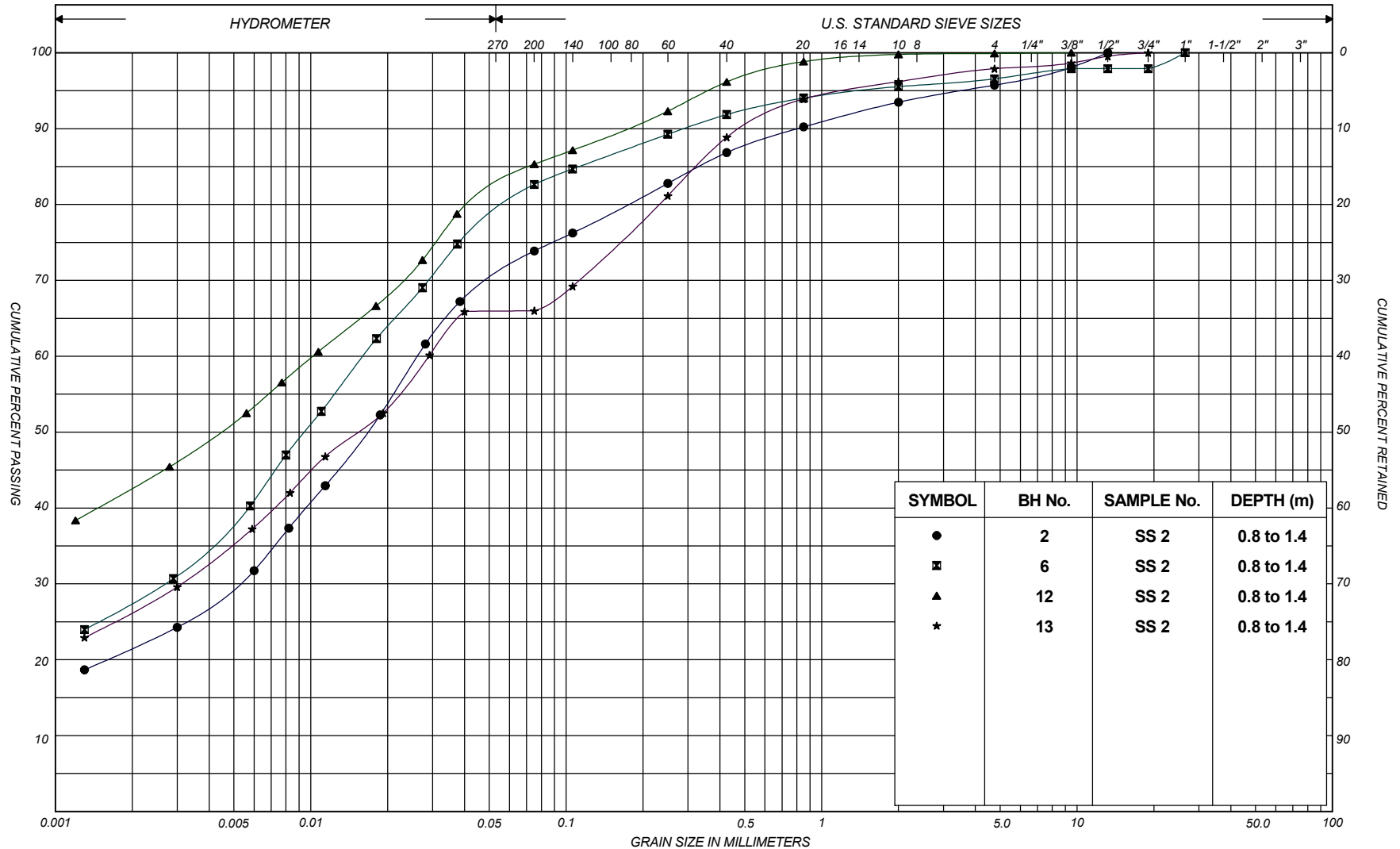
PARTICLE SIZE DISTRIBUTION CHART



REMARKS: Granular Subbase
COMPARED TO OPSS GRANULAR B TYPE 1 SPECIFICATONS

PARTICLE SIZE DISTRIBUTION CHART

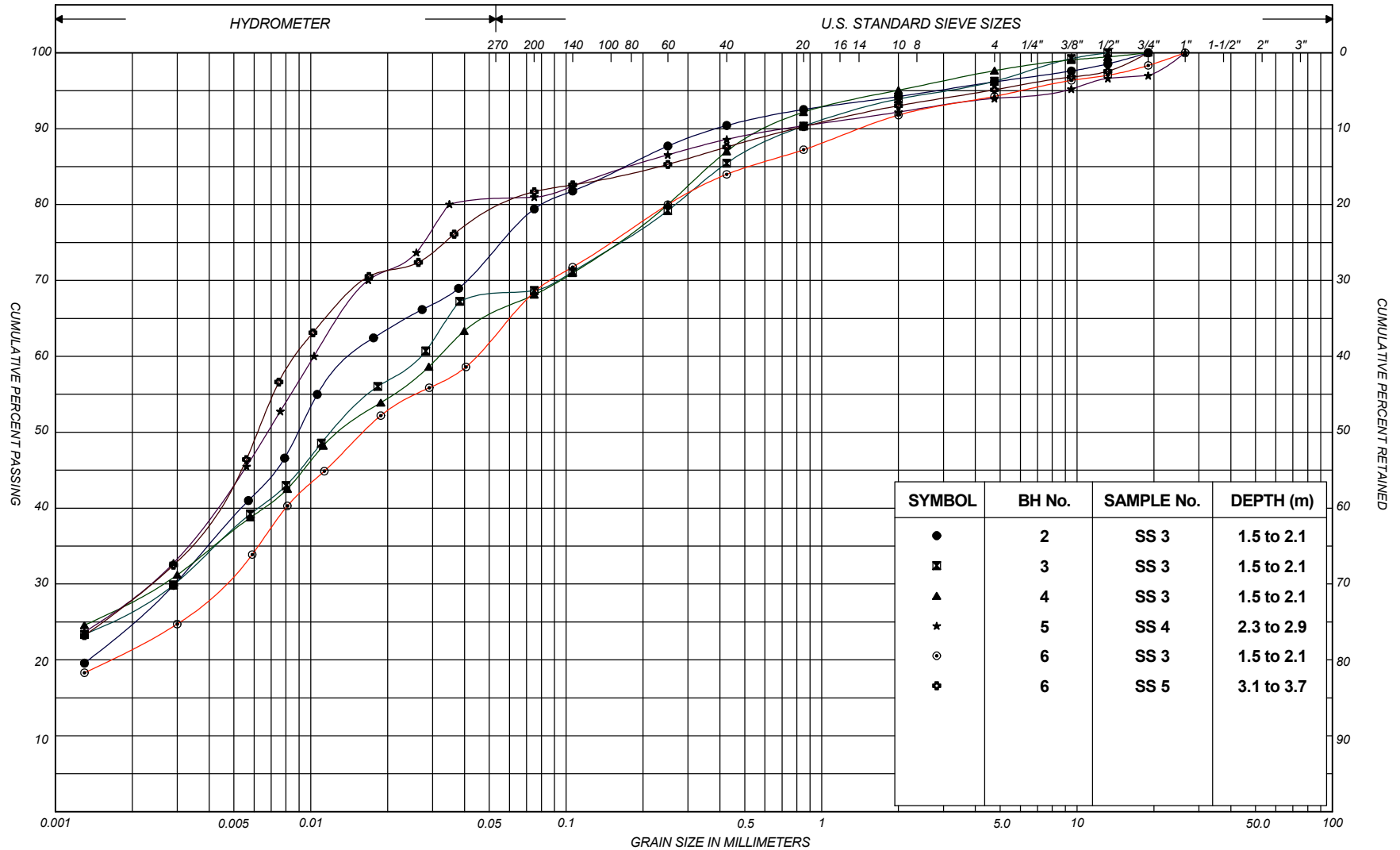
PROJECT NO.
FIGURE NO. GS3



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COBBLES	UNIFIED		
					SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT							SAND									
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL					U.S. BUREAU	
					SAND												

REMARKS: FILL

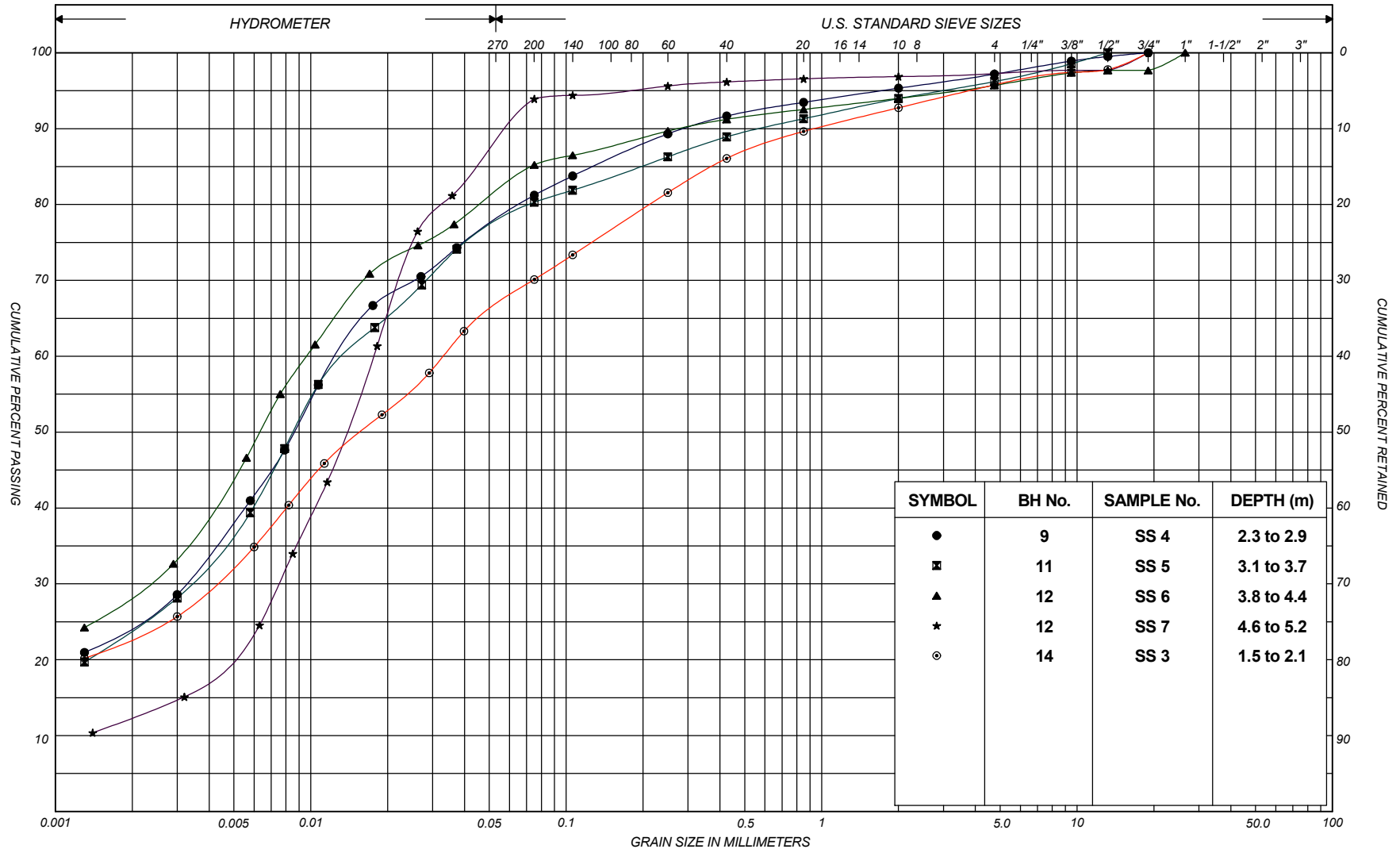
PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	SAND		GRAVEL		GRAVEL		COBBLES	M.I.T.
CLAY	SILT			V. FINE	FINE	MED.	COARSE	SAND		GRAVEL		GRAVEL		U.S. BUREAU

REMARKS: CLAYEY SILT TILL

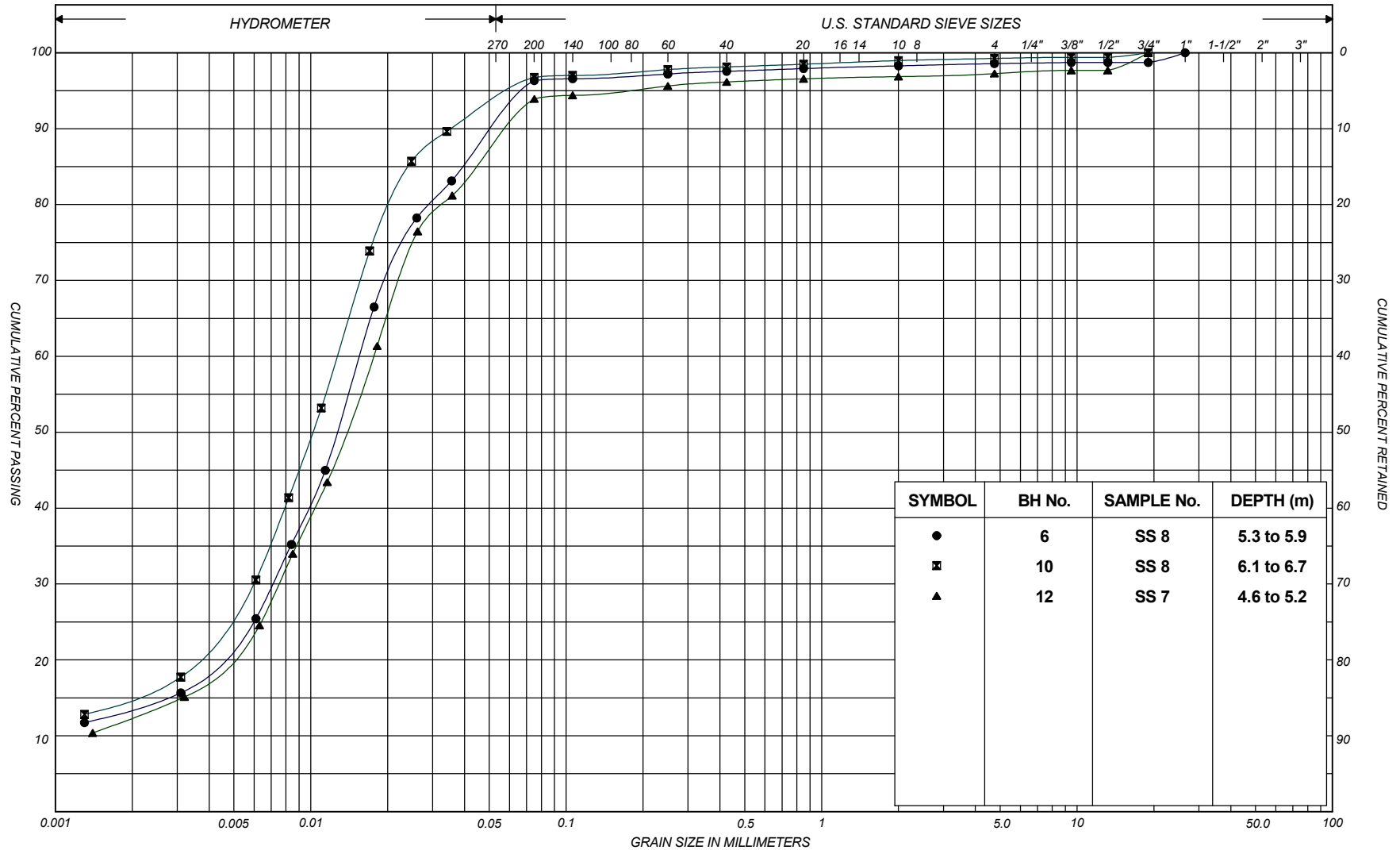
PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	SAND		GRAVEL		GRAVEL		COBBLES	M.I.T.
CLAY	SILT			V. FINE	FINE	MED.	COARSE	SAND		GRAVEL		GRAVEL		U.S. BUREAU

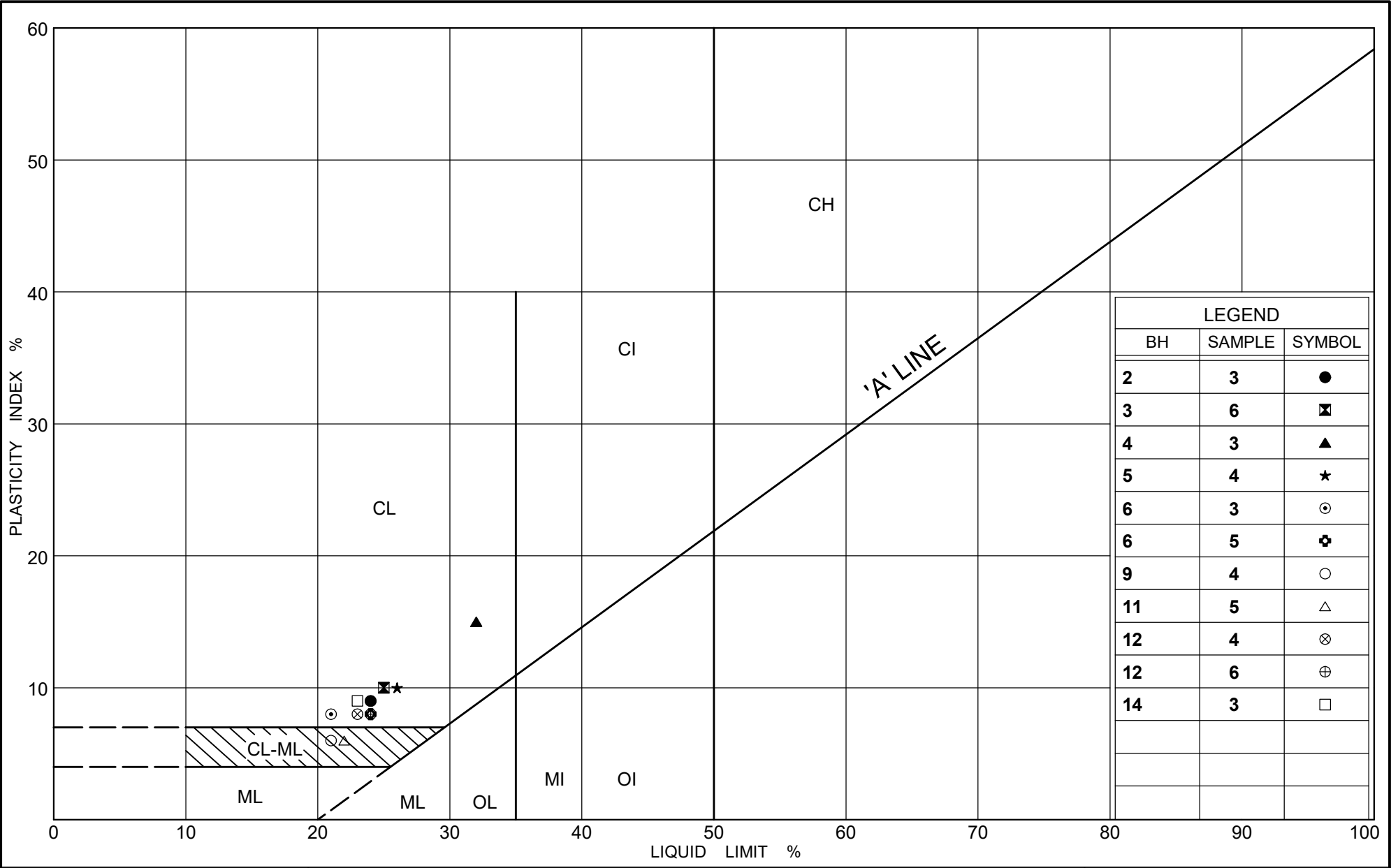
REMARKS: CLAYEY SILT TILL

PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COBBLES	UNIFIED
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	SAND		GRAVEL		GRAVEL		COBBLES	M.I.T.
CLAY	SILT			V. FINE	FINE	MED.	COARSE	SAND		GRAVEL		GRAVEL		U.S. BUREAU

REMARKS: SILT



<div>Peto MacCallum Ltd. CONSULTING ENGINEERS</div>	PLASTICITY CHART Clayey Silt Till	Figure No. PC1
		Project No. EC-2024-31L-00000070
		Highway 7/8 Stratford

NOTES

1. The need to underpin existing footings/utilities is dependent upon soil type, proximity of the existing facility to the face of the excavation, loads imposed on the foundation and permissible movements.

ZONE A:

Foundations of relatively heavy and/or settlement sensitive structures/utilities located in Zone A generally require underpinning.

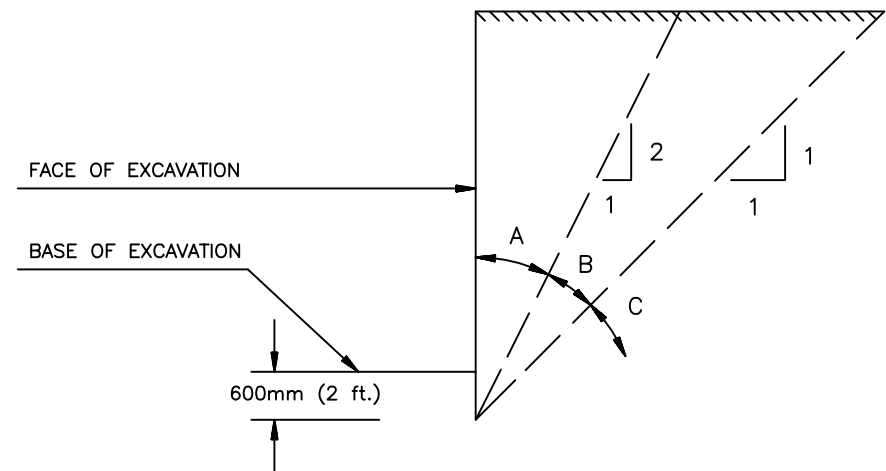
ZONE B:

Foundations of structures located within Zone B generally do not require underpinning. Consideration should be given to underpinning of settlement sensitive utilities or heavy foundation units located in this zone.

ZONE C:

Utilities and foundations located within Zone C do not normally require underpinning.

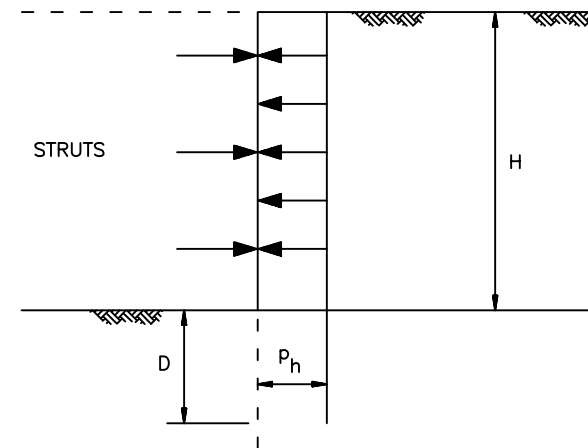
Underpinning of foundations located in Zones A and B should extend at least into Zone C.



2. As an alternative to underpinning, it may be possible to control movement of existing utilities and foundations by supporting the face of the excavation with bracing/tiebacks or a rigid (caisson) wall. Horizontal and vertical earth pressures imposed on the excavation wall by non-underpinned foundations must be considered in the design of the support system.
3. A condition survey should be conducted prior to construction and appropriate monitoring (surface and insitu) carried out during construction to monitor any movement which may occur.
4. All work should be carried out in accordance with the Occupational Health and Safety Act and local regulations. Good quality workmanship and construction practices are to be employed.
5. This sheet is to be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.

NOTES

1. The actual magnitude and distribution of the horizontal earth pressures which will act on the bracing system are dependent upon the permissible lateral/vertical movements adjacent to the excavation, the soil type, groundwater conditions, drainage provisions, temporary/permanent surcharge loads, the type of bracing system adopted, weather conditions, quality of workmanship and length of time the excavation will be supported. Hence, the recommended pressure diagram and design parameters should be reviewed when construction details, schedule and type of support system are established.
2. Stability of base of excavation must be confirmed when bracing system design, excavation geometry and surcharge loads are established. If groundwater table is well above base of excavation and/or artesian conditions exist, local lowering of the groundwater level will be necessary to prevent bottom heave/piping of the base of the excavation.
3. Earth pressure diagram is applicable to maximum depth of cut of 12m (40 ft.).
4. Structural components of bracing system should be confirmed adequate for each level of excavation.
5. If sheeting will not permit drainage, bracing system must be designed to resist water pressure.
6. Surcharge loads such as street/construction traffic, supported utilities, adjacent foundations, temporary stockpiles and other loads carried by bracing system are not included in earth pressure diagram.
7. Temporary surcharge loading should not be closer to the face of the excavation than half the depth of excavation unless accounted for in bracing design.
8. If settlement sensitive structures are located near the excavation, special measures should be undertaken to control settlements. A condition survey should be conducted prior to construction and appropriate monitoring (surface and insitu) carried out during construction.
9. Earth pressure diagram is applicable for relatively short construction periods. If excavation is to be open for long periods, monitoring of deformation is essential, earth pressure diagram must be reviewed, and remedial works may be required.
10. Earth pressure diagram does not account for extended periods of exposure of the excavation to freezing temperatures.
11. Bracing system should be regularly examined for signs of distress.
12. All work should be carried out in accordance with the Occupational Health and Safety Act and local regulations. Good quality workmanship and construction practices are to be employed.
13. This sheet should be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.

EARTH PRESSURE DIAGRAM

$$p_h = \text{design lateral earth pressure} \\ = 0.65 \ K \gamma H$$

$$K = \text{lateral earth pressure coefficient}$$

$$\gamma = \text{unit weight of soil}$$

$$H = \text{depth of excavation}$$

$$D = \text{depth of embedment of soldier piles (if used).}$$

RECOMMENDED DESIGN PARAMETERS

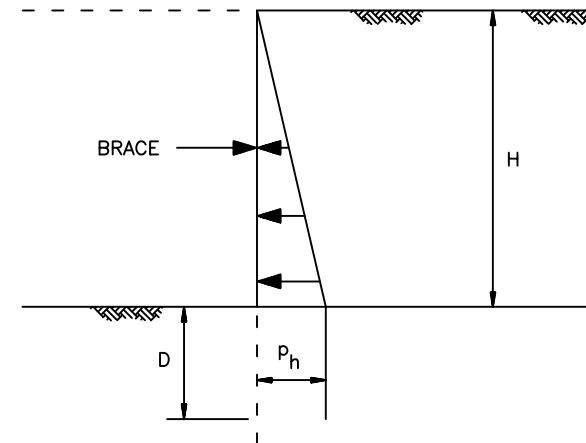
$$\gamma = 20.0 \text{ kN/m}^3$$

$$K = 0.30 \text{ (movement of retained soil acceptable)}$$

$$0.50 \text{ (movement of adjacent structures/facilities unacceptable)}$$

NOTES

1. The actual magnitude and distribution of the horizontal earth pressures which will act on the bracing system are dependent upon the permissible lateral/vertical movements adjacent to the excavation, the soil type, groundwater conditions, drainage provisions, temporary/permanent surcharge loads, the type of bracing system adopted, weather conditions, quality of workmanship and length of time the excavation will be supported. Hence, the recommended pressure diagram and design parameters should be reviewed when construction details, schedule and type of support system are established.
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13. This sheet should be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.

EARTH PRESSURE DIAGRAM

$$p_h = \text{design lateral earth pressure} \\ = K\gamma H$$

K = lateral earth pressure coefficient

γ = unit weight of soil

H = depth of excavation

D = depth of embedment of soldier piles (if used).

RECOMMENDED DESIGN PARAMETERS

$$\gamma = 20.0 \text{ kN/m}^3$$

$K = 0.30$ (movement of retained soil acceptable)

0.50 (movement of adjacent structures/facilities unacceptable)



APPENDIX C

Results of Chemical Tests by SGS Resistivity Test Results



FINAL REPORT

CA40052-MAY24 R1

24LF1

Prepared for

Peto MacCallum Ltd

First Page

CLIENT DETAILS

Client Peto MacCallum Ltd

Address 16 Franklin St S
Kitchener, ON
N2C 1R4, Canada

Contact William Loghrin

Telephone 519-893-7500

Facsimile 519-893-0654

Email bloghrin@petomacallum.com

Project 24LF1

Order Number

Samples Soil (1)

LABORATORY DETAILS

Project Specialist Jill Campbell, B.Sc.,GISAS

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 2165

Facsimile 705-652-6365

Email jill.campbell@sgs.com

SGS Reference CA40052-MAY24

Received 05/06/2024

Approved 05/14/2024

Report Number CA40052-MAY24 R1

Date Reported 05/14/2024

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: no

Custody Seal Present: yes

Chain of Custody Number: 037889

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

Jill Campbell, B.Sc.,GISAS





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FINAL REPORT

CA40052-MAY24 R1

Client: Peto MacCallum Ltd

Project: 24LF1

Project Manager: William Loghrin

Samplers: William Loghin

MATRIX: SOIL

Sample Number 5
Sample Name BH6 SS4
Sample Matrix Soil

Parameter	Units	RL	Result
Corrosivity Index			
Corrosivity Index	none	1	4
Soil Redox Potential	mV	no	319
Sulphide (Na2CO3)	%	0.01	< 0.01
pH	pH Units	0.05	8.64
Resistivity (calculated)	ohms.cm	-9999	5620
General Chemistry			
Conductivity	uS/cm	2	178
Metals and Inorganics			
Moisture Content	%	0.1	13.2
Sulphate	µg/g	0.4	15
Other (ORP)			
Chloride	µg/g	0.4	52



FINAL REPORT

CA40052-MAY24 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	DIO0269-MAY24	µg/g	0.4	<0.4	7	35	101	80	120	94	75	125
Sulphate	DIO0269-MAY24	µg/g	0.4	<0.4	7	35	96	80	120	90	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 (Na2CO3)	ECS0039-MAY24	%	0.01	< 0.01								

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	EWL0145-MAY24	uS/cm	2	< 2	0	20	99	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-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	EWL0145-MAY24	pH Units	0.05	NA	1		101			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

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. 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 and Excess Soil Quality" 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.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

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This report supersedes all previous versions.

-- End of Analytical Report --



RESISTIVITY OF SOIL

CLIENT : Cachet Developments (Stratford) Inc.

PROJECT : Sewer and Watermain Installations – Highway 7/8

LOCATION : Stratford, Ontario

PML Ref : 24LF001

REPORT No. :

ENCLOSURE :

TESTED BY : L. Gowry

DATE TESTED : 07 May 2024

LAB NO.	LOCATION	RESISTIVITY(Ohm-cm)		MOISTURE CONTENT						
		NATIVE CONDITION	SATURATED CONDITION	TARE No.	WET SOIL + TARE (g)	DRY SOIL + TARE (g)	TARE (g)	WATER (g)	DRY SOIL (g)	MOISTURE %
2401484-A	BH-6 SN-4 (7.5 - 9.5 ft)	3050		23087	68.83	62.54	16.76	6.29	45.78	13.7
			3300	F2	139.05	112.37	20.02	26.68	92.35	28.9

REMARKS :

REVIEWED BY: L. Gowry

REVIEWED DATE: May 8, 2024



PART B - FOUNDATION DESIGN REPORT

for

SEWER AND WATERMAIN INSTALLATIONS – HIGHWAY 7/8

STRATFORD, ONTARIO

EC-2024-31L-00000070

LATITUDE: 43.370696°; LONGITUDE: -80. 941592

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PART B - FOUNDATION DESIGN REPORT

For

Sewer and Watermain Installations – Highway 7/8

Stratford, Ontario

EC-2024-311-00000070

Latitude: 43.370696°; Longitude: -80. 941592

1. INTRODUCTION

This Foundation Design Report, with the interpretations and recommendations, is intended for use by Cachet Developments (Stratford) Inc. (Cachet), and shall not be used or relied upon for any other purposes or by any other parties. Where comments are made on construction, they are provided only to highlight aspects, which could affect the design of the structure. Contractors must make their own interpretation of the factual data provided in the Foundation Investigation Report (Part A), as it may affect equipment selection, proposed construction methods and scheduling.

It is understood that a previous geotechnical investigation was conducted for Cachet's planned residential development south of Highway 7/8 site by Soil-Mat Engineers & Consultants Ltd, (Report SM 301888-G, dated January 18, 2024). It is also understood that the report prepared by Soil-Mat Engineers & Consultants Ltd. did not include sufficient information to meet MTO's requirements for the section of project located within MTO's corridor permit control area. Accordingly, the purpose of this investigation was to further explore the subsurface soil and ground water conditions at the site, and based on the findings, prepare a Foundation Investigation and Design report in accordance with MTO requirements. This foundation Design Report (Part B), provides discussion and recommendations pertaining to the planned works within Highway 7/8 right-of-way.

2. DISCUSSION AND RECOMMENDATIONS

2.1 General

This section of the report provides recommendations for the design of the proposed installation of watermain carrier pipe by trenchless method across Highway 7/8, and open cut trenching works for new storm sewer and watermain extending from about 80 m west of the City of Stratford connecting link to about 120 m west of Road 111, in the County of Perth, Ontario. The recommendations presented herein were based on interpretation of the factual information obtained from the boreholes drilled during the site investigation. The discussions and recommendations presented are intended to provide information required to facilitate design of the watermain crossing

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installation by trenchless method and storm sewer and watermain trenching installations along the highway ditches.

The profile and detail drawings provided by Cachet and utility locates carried out prior to the field work identified underground utilities located within the Highway 7/8 right-of-way, which cross the proposed alignments of the watermain and trenching works. The storm water runoff in this area appears to be carried to the west by the drainage ditches located on both sides of the highway, which connect to storm sewers within the City of Stratford. Existing underground telecommunications cables, watermain, sewer pipes, gas lines and the culverts may impose potential conflict with the proposed alignment of the planned works; precautionary measures to prevent damage must be arranged with the respective utility owners.

The scope of foundation investigation work carried out by PML does not cover or include geotechnical assessment beyond the location of boreholes and easement requirements. Therefore, the specialty contractor and development proponent (Cachet) should confirm the existence of any utility or obstructions that may impose potential conflict with the proposed pipe alignment and are advised to obtain necessary permits, prior to the commencement of construction.

Based on our assessment and observations of the site during the field work, there appears to be adequate space or setback from the bottom of ditches located on both sides of the highway (EBL and WBL) to set up small entry and exit pits for trenchless method of construction.

2.2 Proposed Installation

Based on information provided by Cachet, the planned work will include a trenchless watermain crossing of Highway 7/8, along with approximately 360 m of storm sewer, and 250 m of watermain along the flanks of the roadway.

Reference is given to the Access Road Block 118 Drawings, dated March 2024 (Revision 3) provided by Urbtech Engineering Inc., outlining the proposed crossing and trenching works. A copy of which has been included in Appendix C.

2.2.1 Watermain Crossing

The proposed watermain crossing will comprise a 600 mm diameter smooth wall steel casing, approximately 35 m long, with invert at Elevation 358.3 to 359.9 (approximately 4.4 to 2.8 m below the highway) inclined down towards the south, as shown on the appended Drawing 1. The location



of the proposed trenchless watermain crossing on Highway 7/8 is about 300 m west of Road 111 (east of the Stratford connecting link marker), near Boreholes 6 and 12. The gauge or thickness of the steel casing will be designed by the specialty contractor, once the method of installation is finalized, but a typical casing about 12 mm thick is envisaged.

Depending on the trenchless method of installation opted, the overbreak between the external wall of the casing and excavated bore may have to be grouted to minimise the post construction settlement of the road. Generally, the depth of cover meets the requirements of MTO Corridor Management policy for encroachment and utilities. The minimum cover requirement of 1.8 m below the travelled lanes will generally be met, given the design grade requirements for the watermain design.

2.2.2 Storm Sewer and Watermain Trenching

An extension of the watermain is planned. A new 300 mm diameter watermain is to be installed parallel to the highway along the north ditch, and will have 1.8 m of cover. In addition, a new 900 mm diameter storm sewer will replace a portion of the exiting 450 mm diameter storm sewer under the outside eastbound lane within the Stratford city limits, and a new 750 mm diameter storm sewer pipe is to be located south of the highway with invert at depth of about 3.5 m. It is understood that conventional cut and cover trenching methods will be employed for the watermain and storm sewer pipe installations.

2.3 MTO Requirements and Policy For Encroachments and Utilities

As the project involves the crossing of Highway 7/8, the investigation must comply with the Ministry of Transportation (MTO) "Guidelines for Foundation Engineering - Tunnelling Specialty for Corridor Encroachment Permit Application" dated February 2021, a copy of which is provided in Appendix D. This Foundation Design Report was prepared as per the project requirements and the above noted MTO Guidelines.

Reference is also made to the Transportation Association of Canada (TAC) Guidelines for Underground Utility Installations Crossing Highway Rights-of-Way, dated March 2013.

As per the TAC guidelines, plastic watermain pipes used for highway crossings should generally be encased. MTO does not typically permit open cut or trenching for installation of utility pipe or casing across the highway corridor, except where in the opinion of the Field Service Engineer other



methods are not possible because of the size of the pipe or the nature of the subsoil conditions. Entry and receiving pits are required to be located beyond the shoulder, or on the adjacent lands. Open cut and entry or exit pit are prohibited within 3.0 m of the travelled portion of the highway or within the shoulder area of the highway.

Under the TAC guidelines, the depth of cover for buried watermain and sewer pipes should not be less than 1.8 m below the lanes, and 1.2 m below the bottom of highway ditch. The proposed depth of cover along the alignment of the proposed watermain casing, is greater than 1.8 m, and meets the MTO requirements for encroachments and utilities below the travelled lanes.

2.4 Subsoil Conditions

In general, at the watermain crossing the subsurface stratigraphy encountered under the roadway typically comprised of pavement structure, fill and localized topsoil, clayey silt till, and silt deposits. Free water seepage was observed during drilling in all the boreholes at between depths of 0.8 and 3.5 m, from perched ground water trapped above the relatively impermeable clayey silt till. The tunnel invert of the watermain will be at about Elevation 358.3 to 359.9 under the highway, which will be in clayey silt till soils about three to four tunnel diameters below the transition from the bottom of the fill.

Based on the investigation findings, the top of the casing pipe will be very close to the level of the soft clayey silt at the north end. In this case, it is understood that the watermain depths will be established based on municipal servicing standards, and that the City of Stratford has established that the desired depth of cover for the watermain shall be between 1.8 to 2.1m. From a geotechnical engineering perspective, it is recommended that the proposed boring route be lowered overall or the profile flattened with greater depth of cover provided at the north end; in order to provide at least one diameter (0.6 m) of embedment into the very stiff clayey silt till. A shallower depth of cover or embedment in the till will not prevent a trenchless installation but will increase the potential risk for alignment problems and settlement during installation.

In general, the stability of a tunnel face in cohesive soil is determined by the undrained shear strength of clayey silt till. The overload factor (OF) is defined as the ratio of overburden pressure to the undrained shear strength of clayey soil. For tunnels with relatively small diameters with respect to their depth of cover, the OF may be computed by dividing the overburden pressure by the shear strength. For the design of tunnels, it is desirable to maintain a OF value of 4 or less.



It is recommended that the watermain casing pipe be installed at least one tunnel diameter below the interface of fill and into very stiff to hard clayey silt with a relatively low OF value (less than 1). Provided the watermain crossing grades can be lowered (as noted above), there is a relatively low risk for collapse and loss of ground during construction, provided that an appropriate method of installation and good workmanship is employed.

The proposed pipe is expected to be installed below the perched ground water levels encountered. It is envisaged that localized sump pumping from the excavations and diversion of surface water will be employed to provide an adequately dry work area during construction.

2.5 Frost Penetration Depth

In accordance with OPSD 3090.101, the frost penetration depth for design purposes in the area where the site is located is 1.4 m.

3. INSTALLATION USING TRENCHLESS TECHNOLOGY

3.1 Selection of Installation Method

Trenchless utility installations for highway crossings are generally warranted to minimize disturbance to highway users, avoid discontinuities from pavement patches on the roadway, and in some cases minimize or eliminate the costs associated with excavation and reinstatement of the roadway and underlying soils. For the project, installation of conventional pipe with bedding and cover by open-cut method with staging may be a feasible and practical option for completion of the watermain crossing, however, open-cut installation would not align with MTO's policy with respect to encroachments and utilities located within MTO's right-of-way. Consequently, the proposed watermain is to be installed below the travelled lanes using trenchless methods, with open cut tie-ins to new utility trenches that will extend along the shoulder and current highway ditches.

As recommended by MTO Guidelines, various installation methods are considered and evaluated for this project. Once the method of installation of proposed watermain is selected, the general requirements for the installation may be addressed with a Non-Standard Special Provision (NSSP).

Watermain pipes can often be installed directly into position using Horizontal Directional Drilling (HDD) methods. However, in this case the relatively large 300 mm diameter watermain pipe will require a very long staging area to layout and align the pipe before it can be pulled into the HDD tunnel. For larger diameter and less flexible pipes the layout area should be in line with the bore



and only have gradual directional / grade changes when pulled into the tunnel. A long gently sloping slot trench will likely have to be excavated to provide the grade needed, and a pipe layout and assembly area will also be needed beyond the slot trench. Given the proposed 34 m length of crossing under the highway along with proposed steep inclination proposed and the routing constraints from utilities and properties adjacent to the crossing, HDD installation for the proposed watermain is not recommended.

The crossing can be completed by installing a casing by trenchless methods, with the watermain pipe subsequently inserted through the casing. Oversize steel casings are frequently installed, as the steel is intrinsic to many common trenchless installation methods. Typically, the casing remains in place to act as a carrier pipe during construction and remains as a permanent housing around the watermain. The oversized casing also allows for correction of potential deviations in the alignment and grade, which could occur during a trenchless installation. There are a number of trenchless technologies employed in the industry for installation of steel casing. At this site, based on the design drawings, the appropriate method will advance through stiff to hard cohesive clayey silt till deposits which contain occasional cobbles along with occasional boulders.

Based on the details of the planned crossing, Jack and Bore, Pipe Ramming, and Micro-tunnelling, may be employed to install the casing. Discussions and recommendations below are limited only to these three trenchless methods, considered feasible at this site. A comparison of the technical advantages of the trenchless technology for the installation of proposed casing are presented in the COMPARISON OF ALTERNATE TRENCHLESS METHODS table below.

It should be noted that the following discussions and recommendations are presented in relation to the crossing design details provided by Cachet. Alternative configurations and installation methods may also be considered, if the installation methodologies meet the requirements of the project's proponent and MTO's policy for encroachment. Further, the recommendations presented are based on the boreholes drilled along the currently proposed alignment. Additional subsurface investigation will be required if the alignment of the crossing is altered or shifted.

Regardless of the installation method used, it is recommended that the Contractor prepare a plan in advance of construction outlining the details of the installation and the measures taken to ensure compliance with MTO permit requirements. The plan should also be reviewed by the project's proponent prior to construction. Upon request, PML can assist in reviewing the plan to check that the assumptions regarding soil and ground water conditions are appropriate.



The presence of buried utilities must be verified, and measures should be implemented to prevent damage. The impact of the proposed pipe installation method on adjacent structures shall be assessed and mitigation measures shall be put in place to address potential issues.

3.1.1 Jack and Bore

Jack and bore (cased auger boring) typically involve the simultaneous advancement of a continuous flight auger and conduit pipe. The auger is used to excavate soil in advance of the casing and transport cuttings back to the entry or jacking pit where they are removed. Rotary power to auger and pushing force is provided by a drill rig located within a jacking pit.

In this method, surface subsidence and heave during installation may pose major problems. Heave occurs when excessive force is applied to the face of boring and surface subsidence occurs when over excavation is permitted. Conversely, if the rate of advance is too slow in loose or wet deposits then the risk of over cut and loss due to raveling at the cutting face increases. The workers are not required to enter the shaft to remove the spoil, however, working space for entry (jacking) and receiving (exit) pits ranging in length from 7.5 m to 10.5 m and width ranging from 3.0 m to 3.5 m will be required.

The Jack and bore method is feasible for the firm to very stiff cohesive clayey silt till soils encountered at this site, provided appropriate measures are taken to remove cobbles and/or boulders when encountered and adequate ground water control is employed. Special cutters and tooling may be required to breakup and dislodge cobbles and boulders which cannot be handled by the typical earth cutting head and augers. If soil within the pipe cannot be augured, use of a pipe shovel will be necessary. A pipe shovel is essentially a special scoop made from a pipe which fits inside the liner. Excavation via pipe shovel involves advancing the shovel into the soil plug using impact hammer (mole), then pulling the shovel and its contents out with a chain or cable. This process is repeated as required.

The jack and bore installation method can be used to install sewer or utility carrier pipes up to a maximum length of 150 m, which is longer than the length of the proposed casing of the proposed 34 m watermain crossing. The diameter of the proposed casing is expected to be 600 mm, which is larger than the minimum diameter of 203 mm commonly required to employ this method. The pipe for employing this method should resist abrasion caused by the rotation of augers and steel is



the typical material used, although concrete pipe may also be used in a corrosive environment for buried metallic pipes.

A critical part of this method is positioning the track system on the same line and grade as the bore of the casing. The jacking forces should be estimated to select the appropriate jacking system. Suitable jacking head and bracing between jacks and jacking head should be used to assure that pressure will be applied to the pipe uniformly around the ring of the pipe. The drive shaft should have a stable foundation and an adequate thrust block designed to transmit the horizontal jacking force. The firm to very stiff native soil is capable of providing adequate thrust or bearing for transmitting the jacking force. The track system will require an effective dewatering system to maintain the drive shaft in dry condition.

Utilizing an effective lubrication system may minimize potential pipe friction during advance. A suitable face pressure or soil plug should be maintained to minimize loss of ground during advance. If necessary, the jack and bore casing may be fitted with grout injection pipes for lubrication, or grouting to fill possible voids. Any over-cut during auguring and pipe advance, which may potentially create soil disturbance, space or void outside the pipe should be grouted or filled to avoid potential ground movements.

Jack and bore methods have limited steering ability, which can affect the line and accuracy of grade. It is typically unguided once it is launched and any subsurface obstructions can cause large deflection.

Jack and bore installation(s) should be conducted in accordance with OPSS.MUNI 416, Construction Specifications for Pipeline and Utility Installation by Jacking and Boring.

3.1.2 Pipe Ramming

Pipe ramming installation is analogous to driving an open-ended tube pile horizontally. Impact forces from a percussive hammer are used to advance a conduit pipe from an entry pit to a receiving pit. During the advance, most of the soil being penetrated fills the conduit rather than being excavated. The rammed conduit is terminated in a receiving pit at which point the soil contained in the pipe is removed. When the driving has been completed, soil within the pipe can be removed via auguring or by using a pipe shovel. Auguring is expected to be the preferred method given the typical clayey silt till soils found at the site. If soil within the pipe cannot be augured, use of a pipe shovel will be necessary. A pipe shovel is essentially a special scoop made from a pipe which fits



inside the liner. Excavation via pipe shovel involves advancing the shovel into the soil plug using impact hammer (mole), then pulling the shovel and its contents out with a chain or cable. This process is repeated as required.

In general, pipe ramming is able to accommodate cobbles and boulders more easily than jack and bore, provided that the boulders are small enough to fit inside the casing. However, significantly thicker steel casing is generally required due to the intrinsic driving forces needed to advance the casing using pipe ramming. A commonly specified 12.7 mm or greater steel thickness is generally envisaged for pipe ramming for the proposed highway crossing, however, the thickness might have to be further increased subject to the size and energy output of the impact hammer employed.

In general, compared to jack and bore, less extensive ground water control measures should be needed along the installation path because the soil within the pipe is typically not removed until after the crossing has been completed. The retained soil will tend to act as a plug, reducing the potential for ground water seepage and soil flowing through the pipe. The risk of ravelling and loss of gravel due to over cut is reduced compared to jack and bore.

The initial set-up is the critical factor in the success of any pipe ramming project. The drive shaft must be located on very stable ground or a concrete slab must be placed below the casing. In this method, the pipe is unguided, therefore the floor of the drive shaft must be engineered to be on the same line and grade as the pipe to provide the accuracy needed. Reference is made to the Entry and Receiving Pits section of this report for recommendations pertaining to the construction of entry and receiving pits.

In addition, subsidence of the fill under the road may occur due to the compaction resulting from the vibratory action of the hammer.

The specific design grade for the proposed waterman crossing is expected to be relatively steep to avoid conflict with the proposed storm sewer, it will be more difficult to install the proposed conduits where tolerances are tight because of the limited ability to adjust grades during pipe ramming. Pipe ramming does not allow for alignment corrections during installation.

Pipe ramming is considered feasible for the proposed installation of casing in view of the subsoil conditions and the proposed depths and grades of installation.



3.1.3 Micro-tunnelling

Micro-tunnelling involves the advancement of a tunnel boring machine from the jacking pit to the receiving pit. The micro-tunnel boring machine (MTBM) and the tunnel segments are pushed from the jacking pit while line and grade are controlled by the tunnel boring machine as it advances. These machines typically utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. The excavated soil slurry is withdrawn in a controlled manner to prevent loss of ground during tunnel advance. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. Given the machines ability to control soil and water pressures at the face, dewatering prior to advancing the tunnel would not be necessary with this tunnelling method. However, dewatering of the staging and receiving pit will still be required and reference is made to the Staging Excavation section. The size of drive and receiving pits required may vary in length ranging from 15 to 30 m and width ranging from 6 to 12 m depending on specifics of the equipment to be used.

Cognizant of the grade requirements and subsurface conditions, micro-tunnelling is a potential tunnelling method. However, micro tunnelling may not be practical from a cost perspective. The substantial mobilization / set up cost associated with micro-tunnelling may be prohibitive for such a small project. Utilization of micro-tunnelling is therefore not recommended.



Table 3: Comparison of Alternate Trenchless Methods

TUNNELLING METHOD	ADVANTAGES	DISADVANTAGES
Jack and Bore	<ul style="list-style-type: none"> • Spoils are removed by auger through casing being placed • Lubricant or drilling fluid is optional • Relatively inexpensive • Contractors may be readily available • Well suited for shorter tunnel lengths 	<ul style="list-style-type: none"> • Entry pit needs to be designed and constructed properly including dewatering system • Require excavation of 7.5 to 10.5 m by 3 to 3.5 m and 2 m deep entry and exit pits • It is typically unguided and vertical and horizontal alignment not controlled • Subsurface obstructions can cause large deflection from the intended alignment • Elevated potential for ravelling and over cut in loose or wet soils • Requires operators with relatively high skills • Not suitable for installations through numerous cobbles and / or boulders
Pipe Ramming	<ul style="list-style-type: none"> • Minimal ground water control required along the installation route • Faster installation than Jack and Bore • Can advance through soil with cobbles and small boulders • Less risk of ravelling and over cut in loose and wet soils 	<ul style="list-style-type: none"> • Entry pit needs to be designed and constructed properly including dewatering system • Ground water control is required for the entry and exit pits • Poor grade control • Effects of vibrations may have to be assessed and possibly monitored for potential subsidence • Requires thicker steel casing to withstand driving compared to jack and bore
Micro-tunnelling	<ul style="list-style-type: none"> • It is remotely controlled and positional accuracy is extremely accurate • Better accuracy on line and grade compared to other methods • Some obstruction can be overcome by reverse rotation • Capable of balancing hydrostatic pressure and groundwater control may not be required 	<ul style="list-style-type: none"> • Relatively expensive, especially if a Contractor with used MTBM is not available • Requires significant excavation (15 to 30 m by 6 to 12 m) for entry and exit pits • Require slurry separation unit to remove spoil • Large obstructions can pose significant problems • Ground water control is required for the entry and exit pits • Requires dewatering scheme for entry and exit pits



3.1.4 Recommended Method

Cognizant of the site conditions and grade requirements for the watermain crossing, it is recommended that jack and bore be used for the installation of the casing.

The pipe ramming method discussed above is technically feasible but may not be warranted given the relative cost and potentially adverse effects of vibrations to the highway and adjacent/buried utilities/structures. A micro-tunnelling method is also technically feasible but it requires substantial excavation and is relatively very expensive.

As noted previously, the presence of nearby buried utilities must be verified, and measures should be implemented to prevent damage.

3.1.5 Entry and Receiving Pits

It is anticipated that open cut excavations will be used for staging areas and tie points to the tunnelling segment. Further reference is given to the Trenching section for discussion of excavations and backfilling of the entry and receiving pits.

3.2 Seismic Zone and Site Response

The Spectral and Peak Ground Accelerations ($S_a(0.2)$ and PGA) for the project site, for the 2% in 50 year probability of Exceedance, are 0.227 and 0.129, respectively (National Building Code of Canada, 2020). The Reference Peak Ground Acceleration (PGA_{ref}) based on these $S_a(0.2)$ and PGA values is 0.024.

Based on the type of soil, the site for seismic design purposes may be classified as Site Class D in accordance with the Canadian Highway Bridge Design Code, 2019.



3.3 Soil Corrosivity

A representative sample of the clayey silt recovered within the proposed depth of watermain installation was tested to determine the potential for soil corrosivity, and potential exposure of concrete to sulphate attack. A summary of the chemical test results is provided in Section 5.4 in Part A of this Report.

As shown by the analysis, the sulphate concentration in the clayey silt sample was 15 µg/g. According to clause 4.1.1.6 of the Canadian Standard Association (CSA) standard A23.1-14, soluble sulphate concentrations less than 1000 µg/g generally indicate a low potential for sulphate attack on concrete when in contact with soil or ground water.

In general, for non-corrosive environment the chloride concentration should be below 250 ppm and the resistivity should be greater than 2000 ohm-cm. The measured chloride concentration and resistivity of the sample tested was 52 ppm and 3050 ohm-cm, respectively. The chemical analysis indicates that the steel casing for the watermain crossing would not be subject to a severely corrosive environment. In general, no significant potential for sulphate attack or corrosion is expected for concrete or steel founded in the clayey silt till. Further reference is given to the Canadian Highway Bridge Design Code and Commentary, for further details on corrosion protection of buried metal structures.

4. TRENCHING

In addition to the trenchless watermain crossing, a new 300 mm diameter watermain is to be installed parallel to the highway along the north ditch. A new 900 mm diameter storm sewer will replace a portion of the existing 450 mm diameter storm sewer under the outside eastbound lane within the Stratford city limits. The storm sewer routing will also extend easterly (beyond the current municipal boundary), with new 750 mm diameter storm sewer pipe to be located south of the highway right-of-way.

4.1 Excavation and Ground Water Control

It is anticipated that excavations for the proposed watermain and storm sewer installations will extend to a maximum 5 m depth. The excavations will be advanced through the existing pavement structure and fill into the underlying native clayey silt till and silt subgrade.



Provided adequate ground water control has been achieved, the excavation side slopes may be assumed to be within a Type 3 soil, for which side slopes can be no steeper than one horizontal to one vertical (1H:1V). Workers should not enter an unprotected excavation if there is evidence of ongoing ground water seepage in the banks. All construction work should be carried out in accordance with the Occupational Health and Safety Act (OHSA).

Excavations for some of the proposed waste are anticipated to extend several metres below the perched ground water level, and dewatering will be required to maintain a safe and sufficiently dry excavation and the use of surface water diversion, keg wells and high-capacity sump pumps is envisaged.

Regardless of the dewatering method chosen, the hydraulic head and ground water inflow must be properly controlled to ensure stable and safe excavation and to facilitate construction. The design of the dewatering system should be left to the contractor's discretion, and the system should meet a performance specification to maintain and control ground water at least 0.3 m below the excavation base level, in order to provide a stable excavation base throughout construction.

It should be noted that, under the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment, Conservation and Parks (MECP) is required if the dewatering discharge is greater than 50,000 L/day. In accordance with the above noted regulatory requirements and in compliance with the MECP's PTTW Manual (April 2005), and application should be filed to the MECP for the subject property construction dewatering PTTW, if the dewatering discharge is greater than 400,000 L/day, or about 4.6 L/S. If the dewatering discharge is between 50,000 L/day (or about 0.6 L/S) and 400,000 L/day (or about 4.6 L/S) dewatering activities need to be registered on the Environmental Activity and Sector Registry (EASR). PML would be pleased to assist with this process, if required.

Installation of new sewers or watermain to a maximum 5 m invert depths would also require dewatering in localized areas. However, the dewatering rate is expected to be less than 50,000 litres per day, and therefore, an EASR or PTTW may not be required.

It is recommended that test pits be carried out during the tendering stage of the project in order that prospective contractors may familiarize themselves with soil and ground water conditions. Also, the dewatering requirements should be established by the contractor in the context of a performance specification.



In general, where adequate space is available it will be possible to use open cut excavations in conjunction with sump pumping to control ground water flow. If space is not available for enlarged open cut excavations, then consideration should be given to using an engineered system to support the excavation walls. The soil parameters presented in the following table may be used for the design. The parameters are based on the Rankin method of analysis which ignores wall friction.

Table 4: Earth Pressure Parameters

SOIL TYPE	FILL	NATIVE DEPOSITS	
		CLAYEY SILT TILL	SILT
Coefficient of Active Earth Pressure K_a	0.39	0.33	0.31
Coefficient of Passive Earth Pressure K_p	2.56	3.00	3.25
Angle of Internal Friction ϕ	26	30	32
Cohesive Strength c_u	--	100	--
Unit Weight γ (kN/m ³)	19	20	20

It will also be important to ensure that the excavation(s) do not undermine existing in-ground structures, roads and or other services in their proximity. The need for underpinning or braced excavation can be established according to criteria illustrated on the appended Figure UP1. It should be noted that a trench liner box may not be relied on for bracing of settlement sensitive structures.

For the soil stratigraphy encountered, the bracing system may be designed as a multi-braced system using a rectangular stress distribution in accordance with methods outlined in the latest Canadian Foundation Engineering Manual (CFEM) and summarized on the appended Figure BC1, or as a singly-braced system using a triangular stress distribution and summarized on the appended Figure BC2. The system design should also consider load effects from ground water, the adjacent embankments, structures and construction equipment.

The ground surface adjacent to a braced excavation is expected to experience some inward movement and vertical settlement. The magnitude of movements adjacent to a braced cut can be limited by proper selection of the lateral earth pressure coefficient provided good quality workmanship and construction practice is employed.



All temporary protection systems in the MTO right-of-way must be design and constructed in accordance with OPSS.PROV 539, and a performance level 2 would generally apply to the proposed works. For design of temporary protection systems at this site the ground water level should be expected to rise to the level of the current roadway ditching.

4.2 Buried Pipes and Backfill

Provided adequate ground water control is achieved, no bearing problems are anticipated for sewer or watermain pipes founded in the native mineral soils encountered along the proposed alignment. Conventional bedding and cover materials such as OPSS Granular A per OPSS 1010 will be suitable. Localized areas of very soft or very loose fill and otherwise deleterious soils should be anticipated under existing roadways and in proximity to existing utilities, and in these areas, it will be necessary to subexcavate the deleterious soils and place additional bedding material below the pipe.

Material containing stones larger than 50 mm size should not be used in the bedding or cover layers. The bedding should be constructed in accordance with applicable municipal and Ontario Provincial Standard Drawings (OPSD). The bedding and cover material should be placed in 150 mm lifts and compacted to a minimum 95% Standard Proctor Maximum Dry Density (SPMDD).

The backfill materials beneath roads, walkways and other settlement sensitive areas should be placed in 300 mm maximum lifts and compacted to a minimum of 95% SPMDD. The use of wet material should be specifically avoided within the top 1.2 m below pavement subgrade level. For landscaped and parkland areas where pavement support or post construction settlement are not a concern, the trench / excavation backfill should be compacted to at least 90% SPMDD.

The majority of the onsite mineral soils are expected to be reusable for backfill provided they are not exposed to the elements for prolonged time periods, allowed to become wet or frozen, or mixed with other deleterious materials.

Topsoil and organic materials may be reused for landscaping purposes only, or disposed of off-site.

The in-situ clayey silt till soils will tend to retain a voided structure when placed as backfill. Sufficient compaction must be applied to breakdown all lumps / clods within the fill matrix to achieve a non-voided condition. Significant post construction settlement could otherwise result.



All trenching operations should be carried out in such a manner as to minimize the length of trench left open, while still efficiently accommodating pipe laying and compaction procedures.

4.3 Pavement Reinstatement

Excavations for the entry and receiving pits for the trenchless crossing as well as the watermain installation along the north ditch might extend through the fully paved shoulder and entrance driveways along Highway 7/8. In addition, within the City of Stratford limits excavation to replace the current 450 mm diameter storm sewer with a new 900 mm diameter storm sewer will involve excavation into the travelled lanes of the roadway within the City of Stratford limits. Consequently, full depth pavement reconstruction will be required to reinstate the asphalt pavements.

A detailed investigation and analysis of the Highway 7/8 pavements was not within PML's terms of reference for this assignment, and current roadway traffic data for Highway 7/8 has not been provided. However as noted previously, the MTO has published traffic data for Highway 7/8 which identifies a 2016 AADT of 9,800 vehicles per day, but commercial vehicle data and growth rates are not available. It is generally understood that the current roadway pavements have had satisfactory performance, and the pavement has recently been rehabilitated for both the MTO and City of Stratford sections.

Therefore, where excavations encroach into the paved areas it is recommended that the pavements be reinstated to match the current pavement thicknesses. In the case of the trenchless installation and trenching works, in the MTO area east of the connecting link, reconstruction of only the shoulders is envisaged, and the pavement of the travelled lanes will not be affected. Within the City of Stratford limits excavations will extend into the travelled lanes west of the connecting link, near Boreholes 1 to 4. Extensive reconstruction of the pavement structure along storm sewer trench in the City of Stratford section will be required. Based on the borehole findings reinstatement with the following pavement components are recommended.



Table 5: Pavement Reinstatement Recommendations for Highway 7/8		
PAVEMENT COMPONENT	Travelled Lanes*	Shoulders
	Thickness (mm)	
Asphalt	220	100
Granular A	150	250
Granular B	450	450
Total Thickness	800	800

Note: * Within the City of Stratford Limits only

The 220 mm asphalt recommended below the travelled lanes will consist of 40 mm Superpave 12.5FC2 surface course over three layers of 60 mm Superpave 19.0 binder courses. The recommended shoulder pavement will consist of 40 mm Superpave 12.5FC2 surface course over 60 mm Superpave 19.0 binder course.

It is expected that pavement construction will be carried out during the drier time of the year and that the subgrade is stable, as determined by proofrolling and inspection by PML personnel. Preparation of the subgrade should involve removal of any existing topsoil, organic fills or other obvious deleterious materials, followed by proofrolling of the subgrade with a heavy roller to ensure adequate support. If the subgrade is wet and unstable, subexcavation and placement of additional granular subbase or select subgrade material (SSM) material will be required. Where necessary, any backfill beneath the pavement should be placed in maximum 300 mm lifts and be compacted to 95% SPMDD.

The pavement materials should conform to current OPSS and municipal specifications. The Granular A base and Granular B subbase courses should be placed in thin lifts and compacted to a minimum of 100% SPMDD. Asphalt should comprise Superpave 12.5FC 2 over Superpave 19.0 and should use an asphalt cement with a PGAC of 70-28 for surface courses and a PGAC of 64-28 for binder courses. Traffic Category D would generally be applicable for the majority of this project. Asphalt should be placed to a minimum of 92% of the material's maximum relative density (MRD). Reference is made to OPSS.MUNI 310.



In general, the existing granular base and subbase materials are expected to be marginally too silty to meet the OPSS Granular A or B specification. Consequently, any excavated existing granular base and subbase are would only be suitable for reuse as SSM below the new pavement structure. Imported new Granular A and Granular B will be required within the new pavements.

During construction, testing should be conducted to confirm the gradation and compatibility characteristics of the granular base materials and the mix design properties of the asphalt.

Proofrolling procedures and the placement and compaction of all the granular materials and asphalt for the pavement construction should be inspected on a continuous basis by PML personnel.

In areas where reconstruction is chosen, and an urban cross section is to be constructed, longitudinal subdrains should be provided to prevent water accumulation on the pavement subgrade surface. The pavement structure subgrade should be graded so that water is directed to longitudinal drains at the pavement edge. The subdrains should be discharged in to the catch basins. The subdrains may consist of 100 mm diameter perforated filter wrapped plastic pipes, bedded in concrete sand (as per OPSS.MUNI 1002 Table 1 Gradation Requirements for Fine Aggregate), and set within the subbase layer at the level of the subgrade surface. It is noted that water was not typically observed within the in-situ pavement granular; as such, the existing pavement drainage appears to be performing adequately.

5. CONSTRUCTION CONSIDERATIONS

Reference is also given to OPSS.MUNI 415, Construction Specifications for Pipeline and Utility Installation by Tunnelling.

It is the responsibility of the contractor to ensure that potential loss of ground is minimized and any excessive movements and settlements resulting from the tunnelling operations are to be dealt with immediately at no additional cost to the owner.

5.1 Pipe Protection

The proposed installation will have more than 2.5 m of cover under the travelled lanes of Highway 7/8, and in general meets the recommended depth of cover for the MTO guidelines for encroachment and utilities.



5.2 Settlement Monitoring

The ground surface over the tunnel route may become distorted and distressed by tunnelling. The most common type of distress is settlement caused by loss of ground around the tunnel. Heave of the ground surface and or inadvertent drilling fluid returns are also possible depending on the type of installation. Mitigation of the distress or distortion on the travelled lanes of Highway 7/8 would be a major inconvenience to highway users and possibly a safety issue.

Distress at the ground surface is generally prevented or minimized by good construction practices and proper planning. In this regard, preparation of an installation plan as noted above is recommended.

It is also recommended that the project's proponent implement a monitoring program to check the condition of the ground over the tunnel before, during and upon completion of construction. The monitoring program should be carried out by a qualified geotechnical consulting firm that is MTO RAQS approved and should conform to the MTO Settlement Monitoring Guidelines for Tunnelling which are presented in Appendix D. As noted in the Appendix, monitoring points should be installed over the proposed tunnelling route at a maximum interval of 5 m. Monitoring period should begin prior to tunnelling, extend throughout the duration and continue at least 2 weeks after completion of tunnelling. Measurement of the monitoring points should be done at least 3 times a day for everyday in the monitoring period. The monitoring program will include two sets of readings on these points prior to construction to establish a base line, followed by 3 sets of readings, per day during construction. The monitoring will continue for two weeks following construction. The frequency following construction is recommended by MTO to be three times per day, however, considering that this installation is relatively low risk for loss of ground, we would suggest once per day following construction is satisfactory. If movements exceed anticipated limits, program modifications would be required.

A pavement condition survey should also be carried out prior to commencement of construction and following completion of construction.

Reference is made to the drawings in Appendix E which presents our recommended monitoring point positions for the crossing.



Monitoring points should be marked using a method approved by MTO. Monitoring points should also be functional throughout the monitoring period and should not deteriorate because of highway traffic, maintenance activities, and weather conditions.

If distress is observed during construction, the contractor should be informed and corrective action should be undertaken immediately. Specific corrective action will be dependent on the nature of the distress and type of installation. Regardless, the process should be outlined in the monitoring program and be part of the contingency actions in the contractor's installation plan.

Settlement or heave of the roadway from a jack and bore installation carried out in accordance with the recommendations noted in this report should be less than 10 mm (Review Level). If settlement or heave of the ground surface exceeds 10 mm, the construction process should be reviewed and adjusted to mitigate further disturbances for the remainder of the tunnelling work.

If total settlement or heave exceeds 15 mm (Alarm Level), tunnelling operations should be terminated, the site secured against further deterioration and mitigative action should be undertaken immediately to reinstate the roadway, ditches and/or the existing storm sewer.

All actions to prevent, secure, or mitigate destruction or damage to the highway and associated features should be done in accordance with and approved by MTO.



6. CLOSURE

The field work was carried out under the supervision of Mr. N. Garland working under the direction of Mr. W. Loghrin, P.Eng. The drilling equipment was supplied and operated by Direct Environmental Drilling Inc. The laboratory work was carried out in the PML Kitchener laboratory.

This Foundation Design Report was prepared by Mr. W. Loghrin, P.Eng. Independent review of the report was carried out by Mr. Geoffrey Uwimana, MEng, P.Eng., MTO Designated Principal Contact.

Sincerely

Peto MacCallum Ltd.



William Loghrin, P.Eng.
Manager, Engineering Services



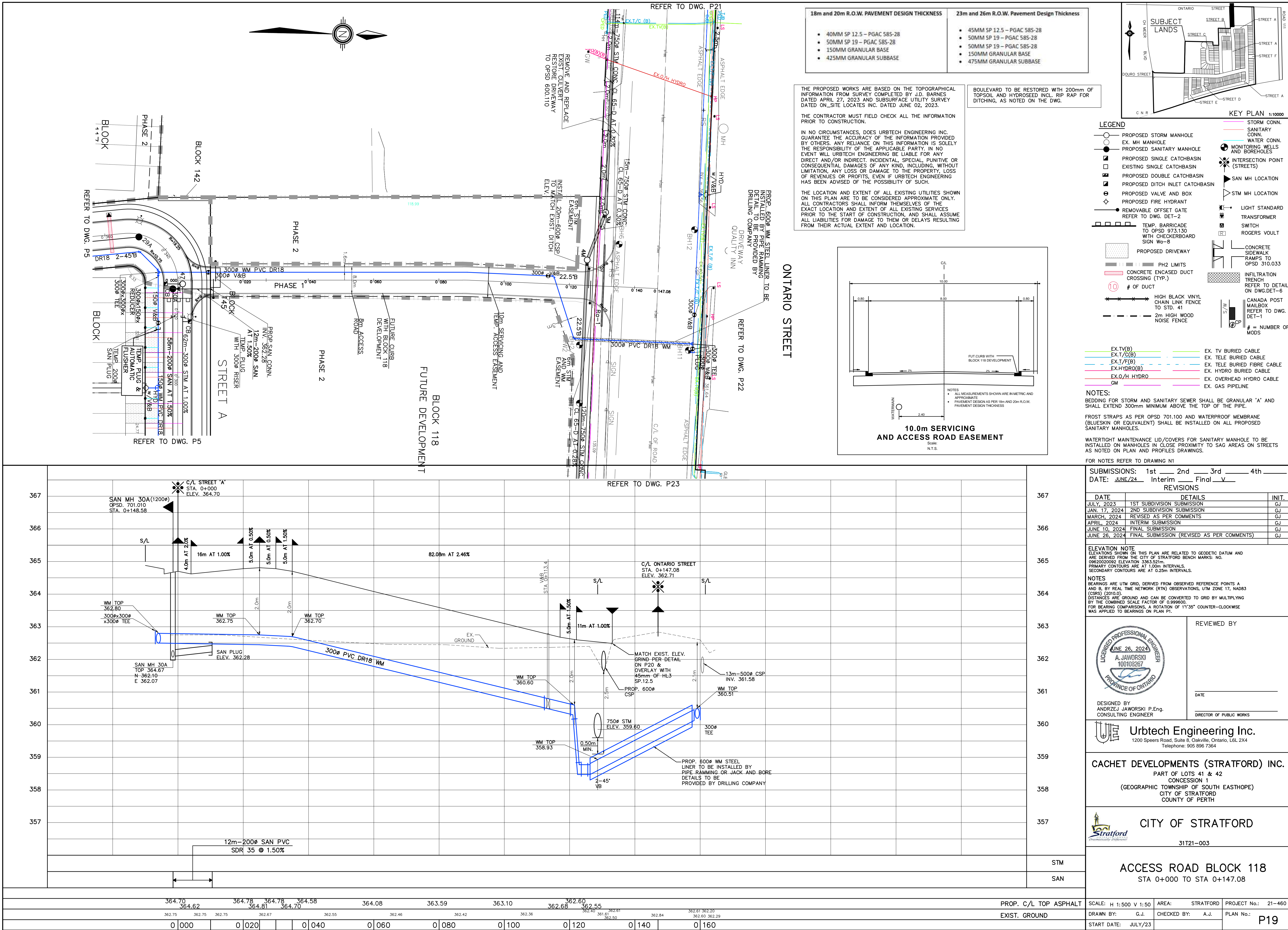
Geoffrey Uwimana, MEng, P.Eng.
MTO Designated Principal Contact

WL/GU. nk

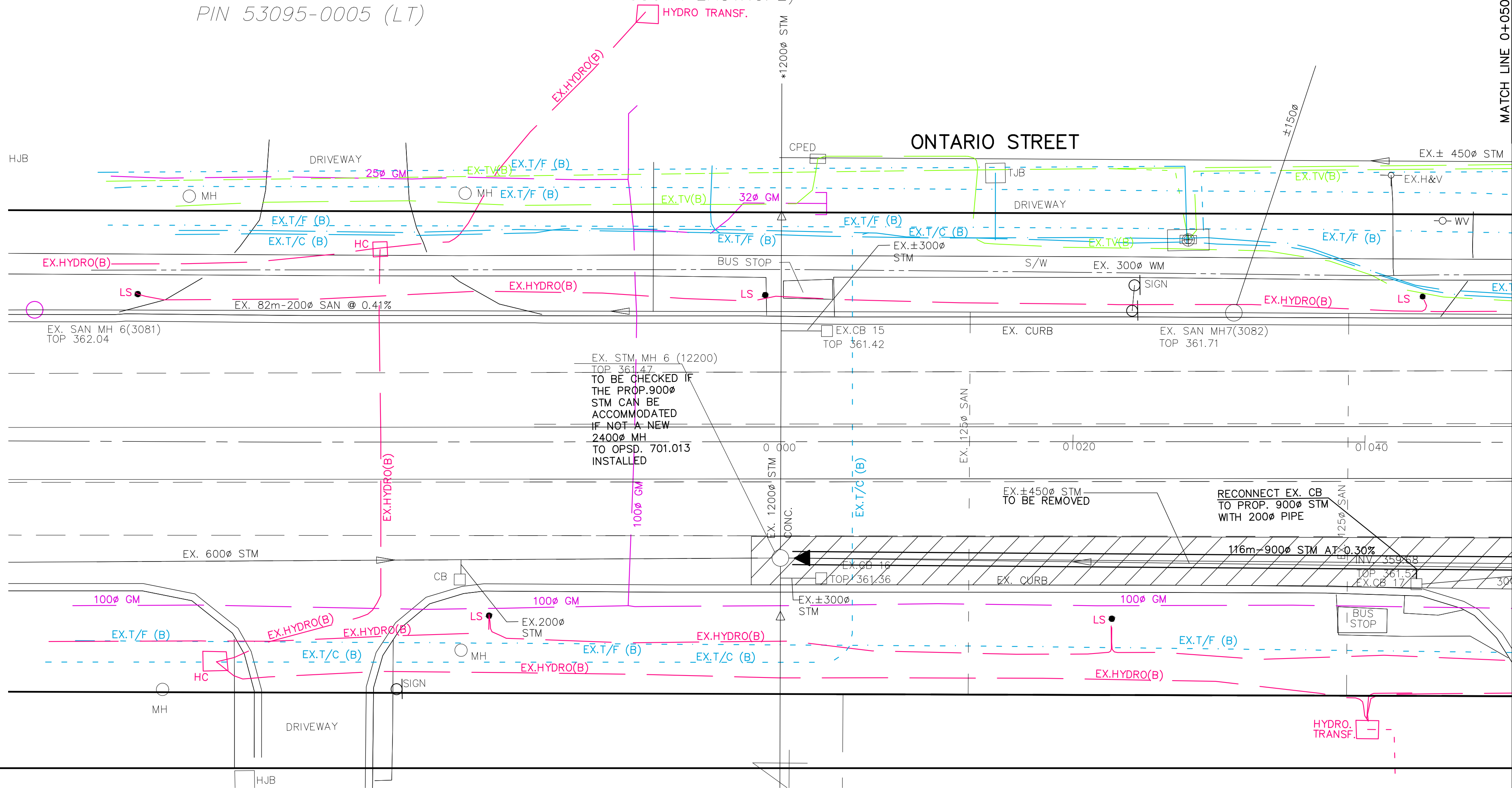


APPENDIX D

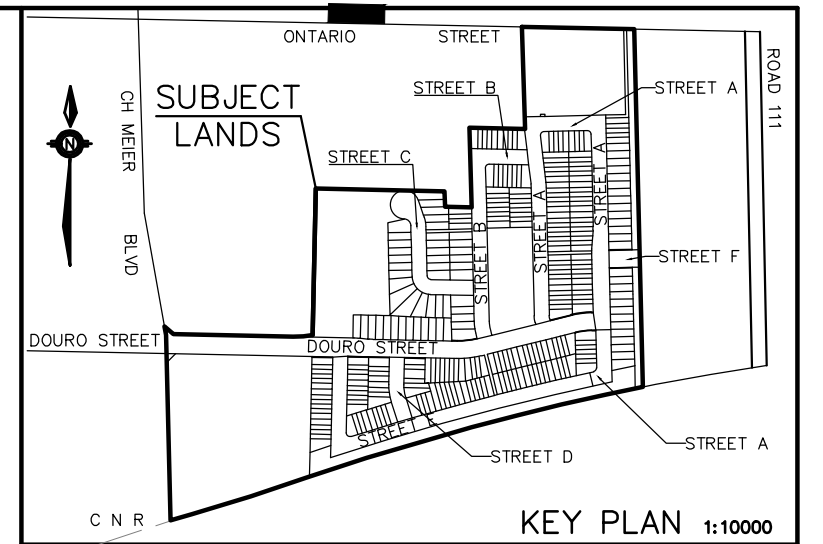
Copy of Plan and Profile Drawings by Urbtech Engineering Inc.



BETWEEN THE GEOGRAPHIC TOWNSHIPS OF NORTH EASTHOPE AND SOUTH EASTHOPE)
PIN 53095-0005 (LT)



MATCH LINE 0+050
REFER TO DWG. P21



- LEGEND**
- PROPOSED STORM MANHOLE
 - EX. MH MANHOLE
 - PROPOSED SANITARY MANHOLE
 - PROPOSED SINGLE CATCHBASIN
 - EXISTING SINGLE CATCHBASIN
 - PROPOSED DOUBLE CATCHBASIN
 - PROPOSED DITCH INLET CATCHBASIN
 - PROPOSED VALVE AND BOX
 - PROPOSED FIRE HYDRANT
 - REMOVABLE OFFSET GATE
 - REFER TO DWG. DET-2
 - TEMP. BARRICADE TO OPSD 973.130 WITH CHECKERBOARD SIGN W-6
 - PROPOSED DRIVEWAY
 - PH2 LIMITS
 - CONCRETE ENCASED DUCT CROSSING (TYP.)
 - # OF DUCT
 - HIGH BLACK VINYL CHAIN LINK FENCE TO STD. 41
 - 2m HIGH WOOD NOISE FENCE
 - STORM CONN.
 - SANITARY CONN.
 - WATER CONN.
 - MONITORING WELLS AND BOREHOLES
 - INTERSECTION POINT (STREETS)
 - SAN MH LOCATION
 - STM MH LOCATION
 - LIGHT STANDARD
 - TRANSFORMER
 - SWITCH
 - ROGERS VOULT
 - CONCRETE SIDEWALK RAMP TO OPSD 310.033
 - INFILTRATION TRENCH REFER TO DETAIL ON DWG. DET-5
 - CANADA POST MAILBOX REFER TO DWG. DET-1
 - # = NUMBER OF MODS

- EX.TV(B)
- EX.T/C(B)
- EX.T/F(B)
- EX.HYDRO(B)
- EX.O/H HYDRO
- GM
- EX. TV BURIED CABLE
- EX. TELE BURIED CABLE
- EX. TELE BURIED FIBRE CABLE
- EX. HYDRO BURIED CABLE
- EX. OVERHEAD HYDRO CABLE
- EX. GAS PIPELINE

NOTES:
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FOR NOTES REFER TO DRAWING N1

SUBMISSIONS: 1st 2nd 3rd 4th		
DATE: JUNE/24 Interim Final V		
REVISIONS		
DATE	DETAILS	INIT.
JULY, 2023	1ST SUBDIVISION SUBMISSION	GJ
JAN. 17, 2024	2ND SUBDIVISION SUBMISSION	GJ
MARCH, 2024	REVISED AS PER COMMENTS	GJ
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JUNE 26, 2024	FINAL SUBMISSION (REVISED AS PER COMMENTS)	GJ

ELEVATION NOTE
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SECONDARY CONTOURS ARE AT 0.25m INTERVALS.

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FOR BEARING COMPARISONS, A ROTATION OF 11°35" COUNTER-CLOCKWISE WAS APPLIED TO BEARINGS ON PLAN P1.



DESIGNED BY
ANDRZEJ JAWORSKI P.Eng.
CONSULTING ENGINEER



1200 Speers Road, Suite 8, Oakville, Ontario, L6L 2X4
Telephone: 905 896 7364

CACHET DEVELOPMENTS (STRATFORD) INC.
PART OF LOTS 41 & 42
CONCESSION 1
(GEOGRAPHIC TOWNSHIP OF SOUTH EASTHOPE)
CITY OF STRATFORD
COUNTY OF PERTH

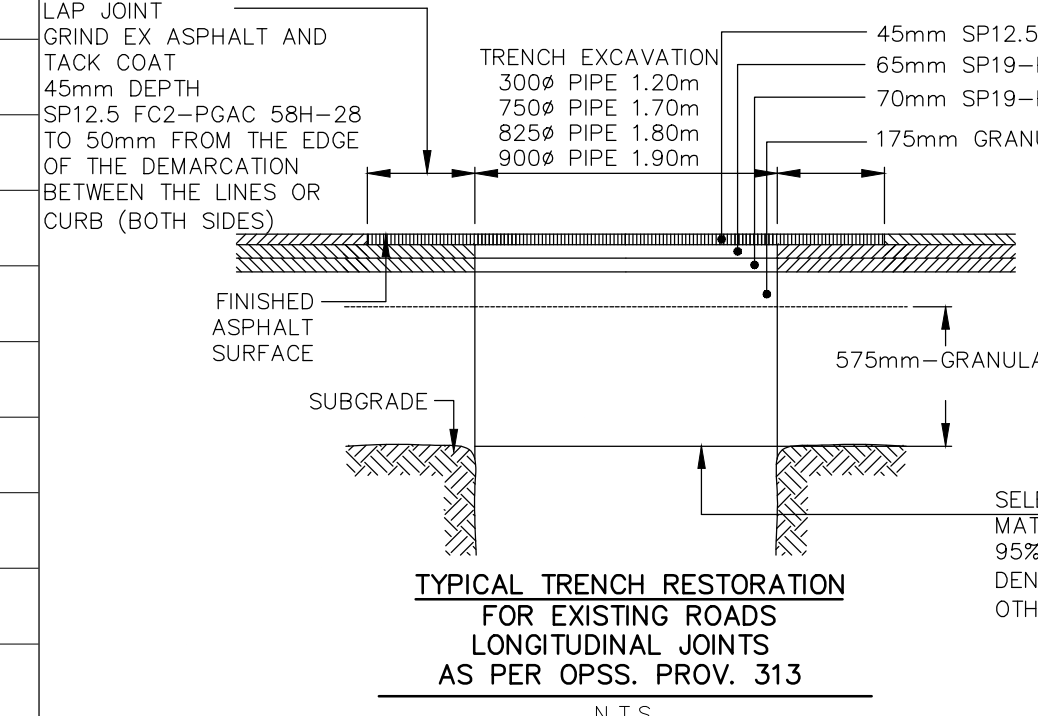


CITY OF STRATFORD

31T21-003

ONTARIO STREET
STA 0+000 TO STA 0+050

SCALE: H 1:200 V 1:50	AREA: STRATFORD	PROJECT No.: 21-460
DRAWN BY: G.J.	CHECKED BY: A.J.	PLAN No.: P20
START DATE: JULY/23		



THE PROPOSED WORKS ARE BASED ON THE TOPOGRAPHICAL INFORMATION FROM SURVEY COMPLETED BY J.D. BARNES DATED APRIL 27, 2023 AND SUBSURFACE UTILITY SURVEY DATED ON SITE LOCATES INC. DATED JUNE 02, 2023.

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EXISTING ASPHALT OVERLAY NOT TO EXTEND INTO LIVE LANE

BOULEVARD TO BE RESTORED WITH 200mm OF TOPSOIL AND HYDROSED INCL. RIP RAP FOR DITCHING, AS NOTED ON THE DWS.

EX. STM MH 6
TOP 361.47
N 358.11-12000
E 358.17 ±4500
W 358.22 ±6000
S 358.12-12000
PROP. E 358.55
TO BE CHECKED IF
THE PROP. 9000
CAN BE ACCOMMODATED
IF NOT A NEW 24000 MH
TO OPSD 701.013
INSTALLED

EX. SAN MH 7
TOP 361.71
NE 358.05 1500
E 357.65 2000
W 357.63-2000

EX. 59.8m-600mm STM
@ 0.54%

EX. 450mm STM @ 0.71%
TO BE REMOVED

EX. 82m-200mm SAN. @ 0.41%

EX. 78m-200mm SAN.
@ 0.47%

PROP. C/L TOP ASPHALT

EXIST. C/L ROAD

361.81

361.73

361.81

361.88

0 000

0 020

0 040

0 050

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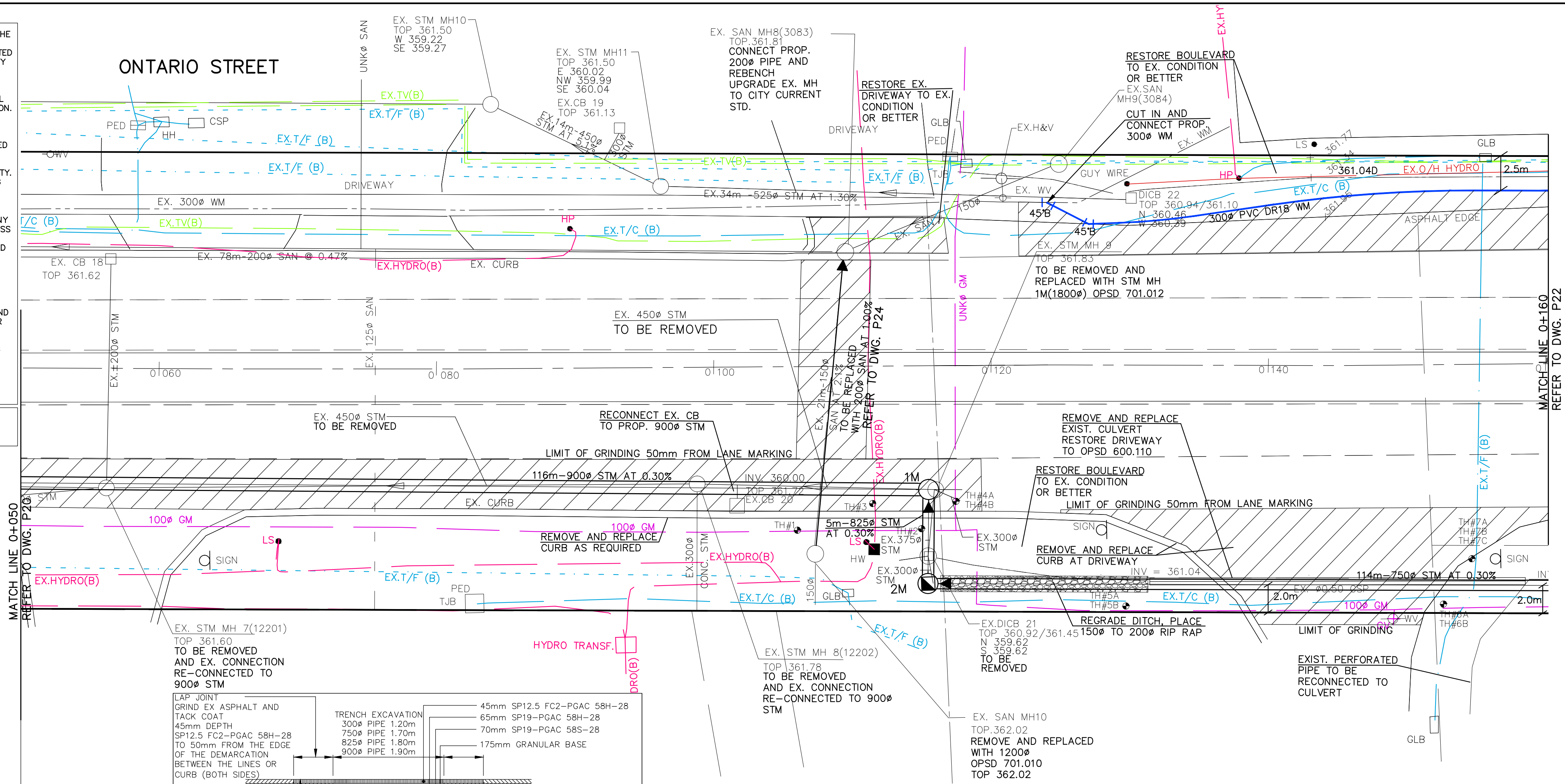
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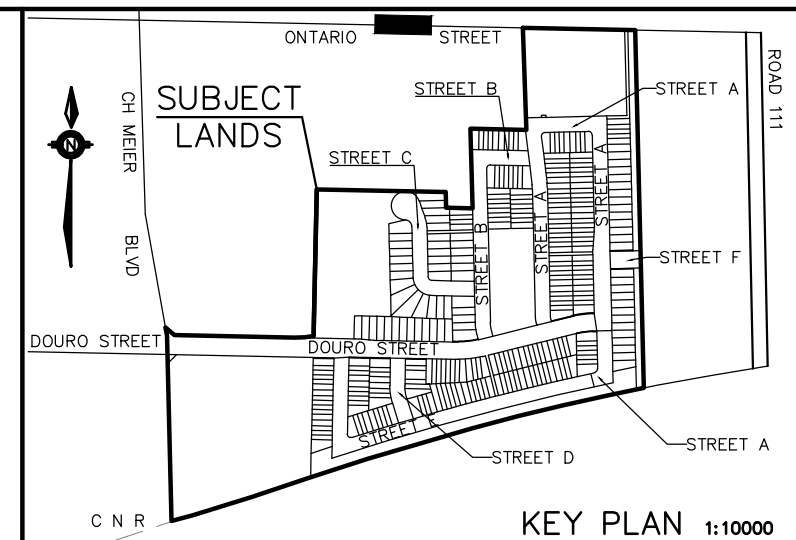
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ONTARIO STREET



MATCH LINE 0+050
REFER TO DWG. P20

MATCH LINE 0+160
REFER TO DWG. P22



- LEGEND**
- PROPOSED STORM MANHOLE
 - EX. MH MANHOLE
 - PROPOSED SANITARY MANHOLE
 - PROPOSED SINGLE CATCHBASIN
 - EXISTING SINGLE CATCHBASIN
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 - TEMP. BARRICADE
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CROSSING (TYP.)
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 - HIGH BLACK VINYL
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 - 2m HIGH WOOD
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000.000
 - TH TEST HOLES BY
ONSITE LOCATES INC.
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 - EX. TV/F(B)
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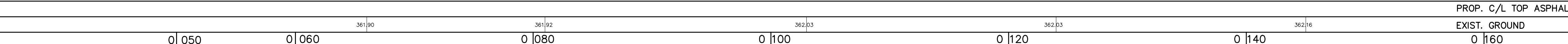
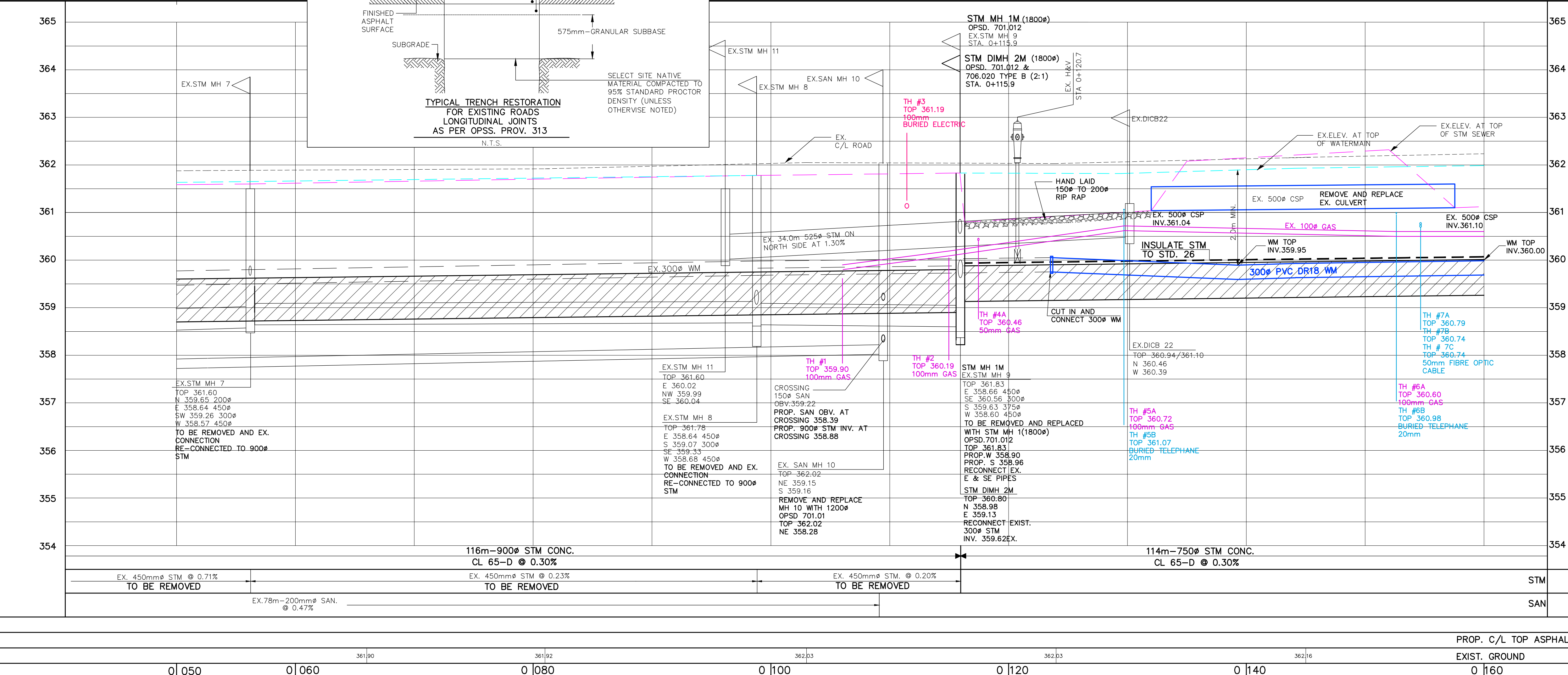
REVIEWED BY
DATE
DESIGNED BY
ANDRZEJ JAWORSKI P.Eng.
CONSULTING ENGINEER
DIRECTOR OF PUBLIC WORKS

Urbtech Engineering Inc.
1200 Speers Road, Suite 8, Oakville, Ontario, L6L 2X4
Telephone: 905 896 7364

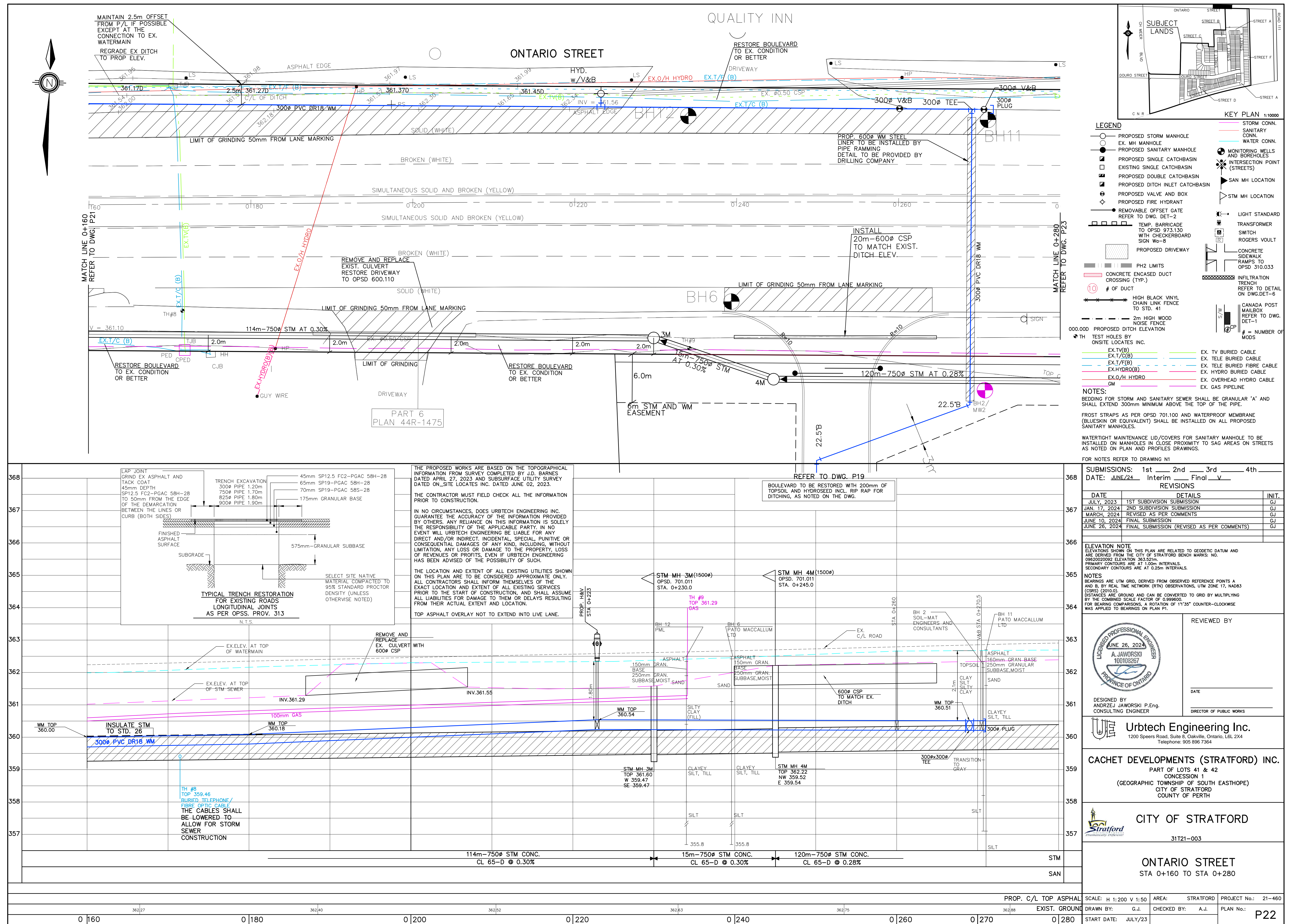
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PART OF LOTS 41 & 42
CONCESSION 1
(GEOGRAPHIC TOWNSHIP OF SOUTH EASTHOPE)
CITY OF STRATFORD
COUNTY OF PERTH

CITY OF STRATFORD
31T21-003

ONTARIO STREET
STA 0+050 TO STA 0+160



SCALE: H 1:200 V 1:50	AREA: STRATFORD	PROJECT No.: 21-460
DRAWN BY: G.J.	CHECKED BY: A.J.	PLAN No.: P21
START DATE: JULY/23		



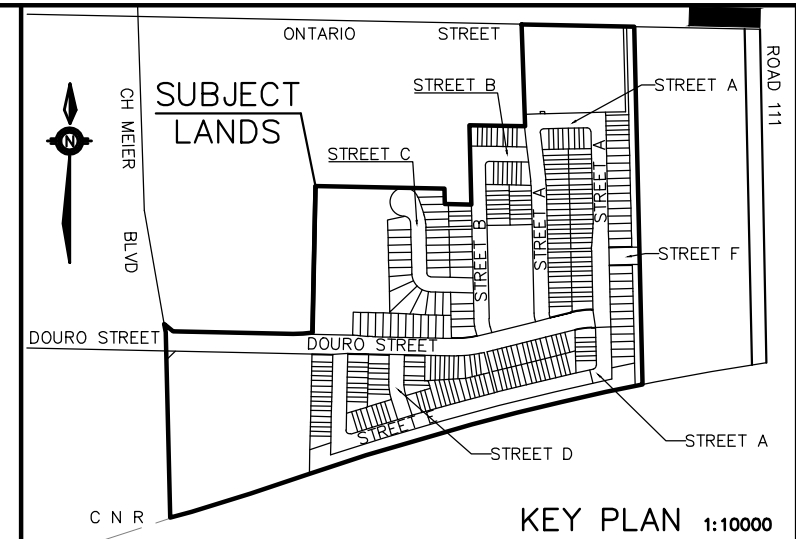
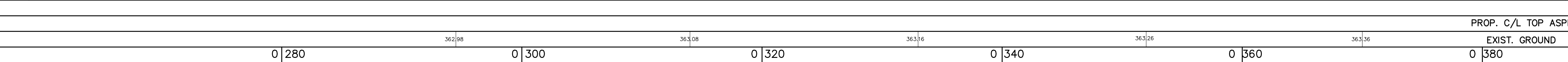
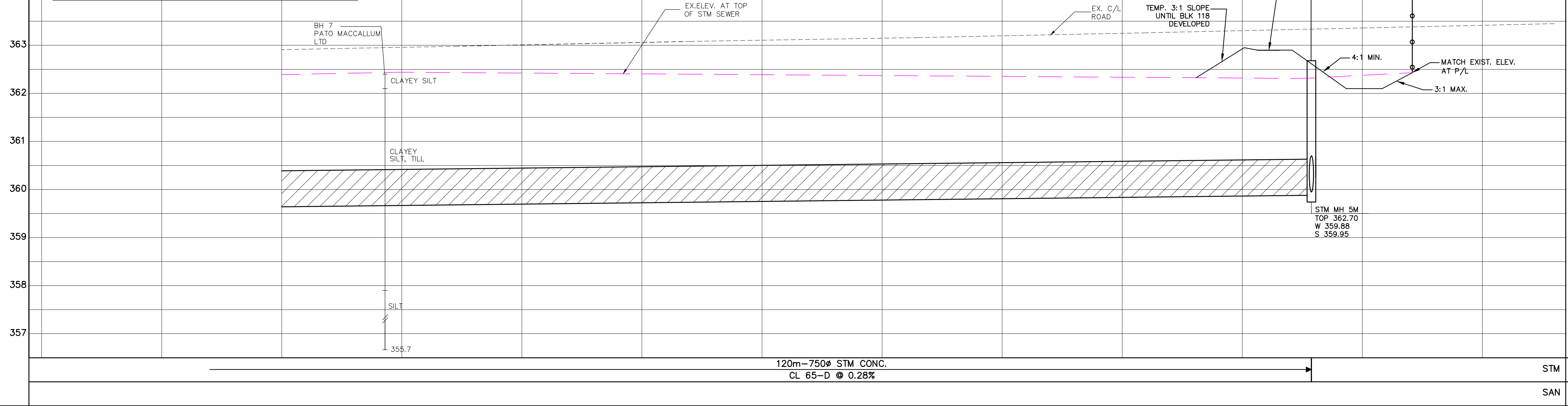
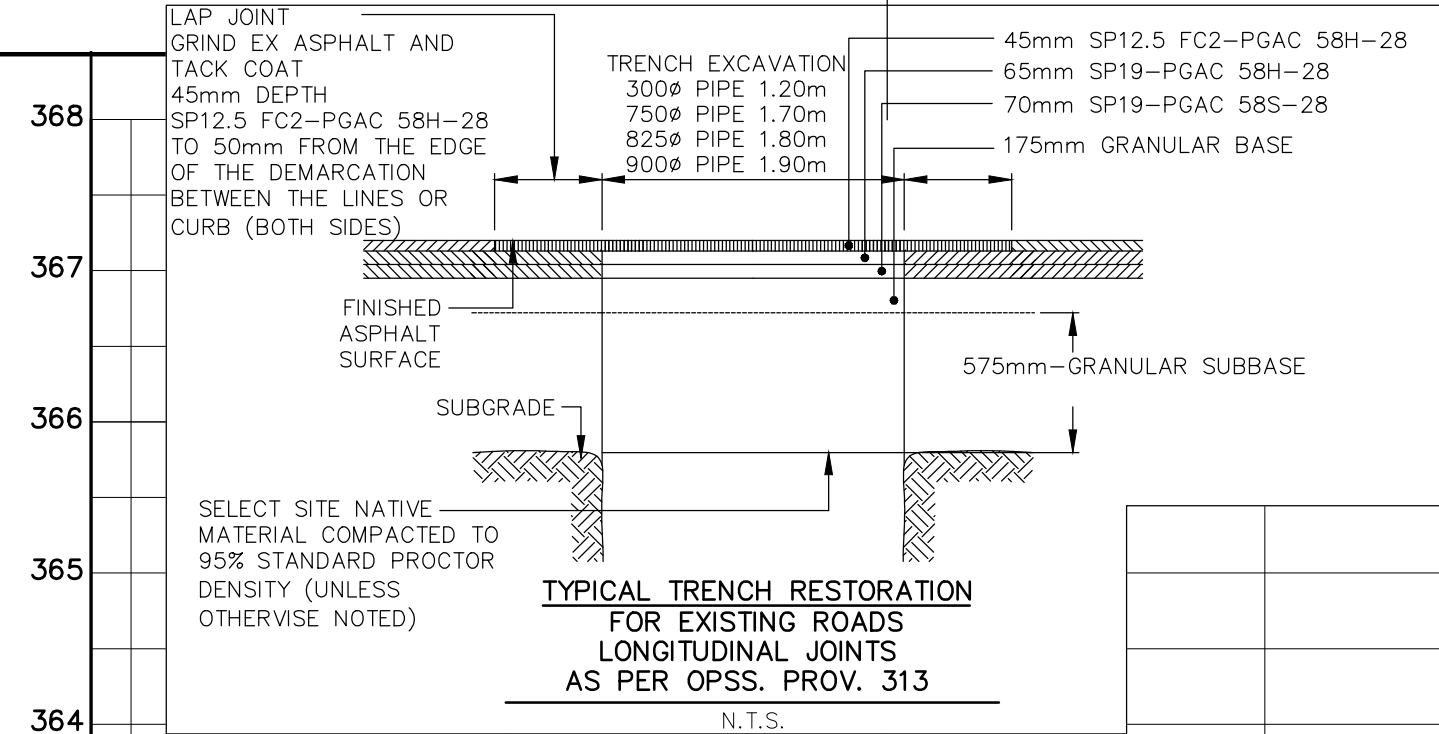
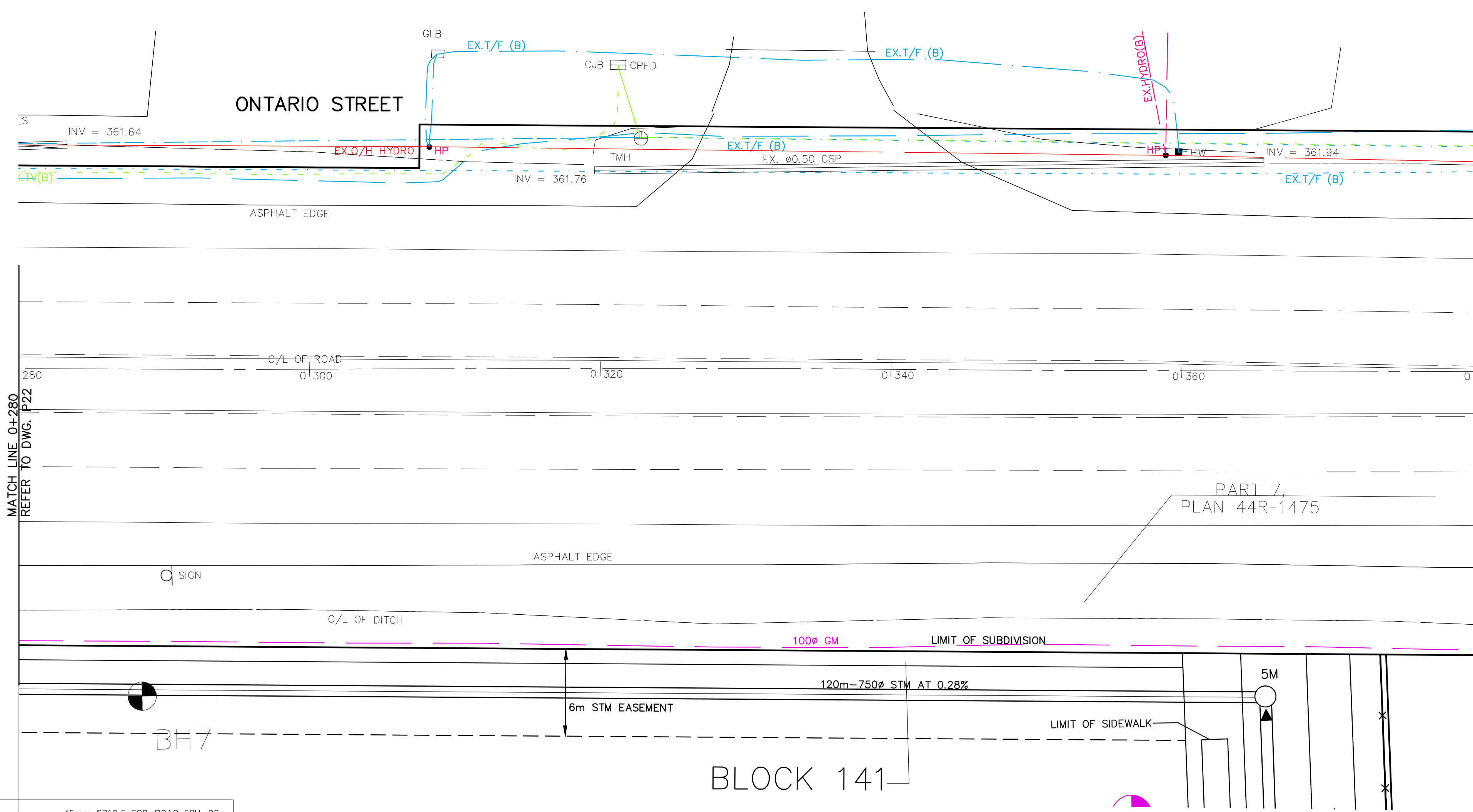
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 - EX. MH MANHOLE
 - PROPOSED SANITARY MANHOLE
 - PROPOSED SINGLE CATCHBASIN
 - EXISTING SINGLE CATCHBASIN
 - PROPOSED DOUBLE CATCHBASIN
 - PROPOSED DITCH INLET CATCHBASIN
 - PROPOSED VALVE AND BOX
 - PROPOSED FIRE HYDRANT
 - REMOVABLE OFFSET GATE REFER TO DWG. DET-2
 - TEMP. BARRICADE TO OPSD 973.130 WITH CHECKERBOARD SIGN Wg-8
 - PROPOSED DRIVEWAY
 - PH2 LIMITS
 - CONCRETE ENCASED DUCT CROSSING (TYP.)
 - # OF DUCT
 - HIGH BLACK VINYL CHAIN LINK FENCE TO STD. 41
 - 2m HIGH WOOD NOISE FENCE
 - TH TEST HOLES BY ONSITE LOCATES INC.
 - STORM CONN.
 - SANITARY CONN.
 - WATER CONN.
 - MONITORING WELLS AND BOREHOLES
 - INTERSECTION POINT (STREETS)
 - SAN MH LOCATION
 - STM MH LOCATION
 - LIGHT STANDARD REFER TO DWG. DET-2
 - TRANSFORMER SWITCH ROGERS VOULT
 - CONCRETE SIDEWALK RAMP TO OPSD 310.033
 - INFILTRATION TRENCH REFER TO DETAIL ON DWG. DET-6
 - CANADA POST MAILBOX REFER TO DWG. DET-1
 - # = NUMBER OF MODS

- EX. TV(B)
- EX. T/G(B)
- EX. T/F(B)
- EX. HYDRO(B)
- EX. Q/H HYDRO
- GM
- EX. TV BURIED CABLE
- EX. TELE BURIED CABLE
- EX. TELE BURIED FIBRE CABLE
- EX. HYDRO BURIED CABLE
- EX. OVERHEAD HYDRO CABLE
- EX. GAS PIPELINE

NOTES:

BEDDING FOR STORM AND SANITARY SEWER SHALL BE GRANULAR 'A' AND SHALL EXTEND 300mm MINIMUM ABOVE THE TOP OF THE PIPE.

FROST STRAPS AS PER OPSD 701.100 AND WATERPROOF MEMBRANE (BLUESKIN OR EQUIVALENT) SHALL BE INSTALLED ON ALL PROPOSED SANITARY MANHOLES.

WATERTIGHT MAINTENANCE LID/COVERS FOR SANITARY MANHOLE TO BE INSTALLED ON MANHOLES IN CLOSE PROXIMITY TO SAG AREAS ON STREETS AS NOTED ON PLAN AND PROFILES DRAWINGS.

FOR NOTES REFER TO DRAWING N1

SUBMISSIONS:	1st	2nd	3rd	4th
DATE:	JUNE/24	Interim	Final	V
REVISONS				
DATE	DETAILS			INIT.
JULY, 2023	1ST SUBDIVISION SUBMISSION			GJ
JAN. 17, 2024	2ND SUBDIVISION SUBMISSION			GJ
MARCH, 2024	REVISED AS PER COMMENTS			GJ
JUNE 10, 2024	FINAL SUBMISSION			GJ
JUNE 26, 2024	FINAL SUBMISSION (REVISED AS PER COMMENTS)			GJ

ELEVATION NOTE

ELEVATIONS SHOWN ON THIS PLAN ARE RELATED TO GEODETIC DATUM AND ARE DERIVED FROM THE CITY OF STRATFORD BENCH MARKS: NO. 0962020092 ELEVATION 363.521m. (CSRS) (2010.0).

DISTANCES ARE GROUND AND CAN BE CONVERTED TO GRID BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 0.999600.

FOR BEARING COMPARISONS, A ROTATION OF 1°1'35" COUNTER-CLOCKWISE WAS APPLIED TO BEARINGS ON PLAN P1.

NOTES

BEARINGS ARE UTM GRID, DERIVED FROM OBSERVED REFERENCE POINTS A AND B, BY REAL TIME NETWORK (RTN) OBSERVATIONS, UTM ZONE 17, NAD83 (CSRS) (2010.0).

DISTANCES ARE GROUND AND CAN BE CONVERTED TO GRID BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 0.999600.

FOR BEARING COMPARISONS, A ROTATION OF 1°1'35" COUNTER-CLOCKWISE WAS APPLIED TO BEARINGS ON PLAN P1.

REVIEWED BY

DATE

DESIGNED BY
ANDRZEJ JAWORSKI P.Eng.
CONSULTING ENGINEER

DIRECTOR OF PUBLIC WORKS

Urbtech Engineering Inc.
1200 Speers Road, Suite 8, Oakville, Ontario, L6L 2X4
Telephone: 905 896 7364

CACHET DEVELOPMENTS (STRATFORD) INC.
PART OF LOTS 41 & 42
CONCESSION 1
(GEOGRAPHIC TOWNSHIP OF SOUTH EASTHOPE)
CITY OF STRATFORD
COUNTY OF PERTH

CITY OF STRATFORD
31T21-003

ONTARIO STREET
STA 0+280 TO STA 0+385

SCALE: H 1:200 V 1:50	AREA: STRATFORD	PROJECT No.: 21-460
DRAWN BY: G.J.	CHECKED BY: A.J.	PLAN No.: P23
START DATE: JULY/23		



APPENDIX E

Ministry of Transportation's
"Guidelines for Foundation Engineering – Tunnelling Specialty for Corridor
Encroachment Permit Application"

Guidelines for Foundation Engineering – Tunnelling Specialty For Corridor Encroachment Permit Application

General

These guidelines specify MTO requirements for the Foundation Engineering – Tunnelling Specialty component of submissions from proponents of development within the Ministry of Transportation's (MTO) corridor permit control area. The Foundation Engineering – Tunnelling Specialty component of submissions is a requirement for the permit application only and does not cover all the design requirements.

All applications containing tunnelling proposals shall be forwarded to the regional Geotechnical Section for review. Applications containing Low Complexity tunnelling proposals will typically be reviewed by the regional Geotechnical Section. The Geotechnical Section will forward applications involving Medium and High Complexity tunnelling proposals to the Foundation Section of the Structures Office for review.

Foundations Engineering consultants that are registered in the MTO consultant acquisition system (RAQS) at complexity ratings identified in Table 1 are eligible to provide Foundations Engineering services for this project. Alternatively, the proponents may propose a Foundations Engineering consultant that is not registered in RAQS, in which case, the proponent must submit sufficient documentation to demonstrate that the consultant's qualifications meet or exceed the RAQS complexity requirements. The submission for RAQS exemption shall demonstrate that the proponent has successfully completed tunnelling/trenchless projects on projects of similar scope and complexity. The proponent shall submit a minimum of three (3) Foundation Investigation and Design Reports on projects of similar scope and complexity produced in the last five (5) years. The proponent shall submit any supplementary engineering and construction experience to demonstrate their qualifications.

For Engineering Materials Testing and Evaluation, the consultant shall be qualified for Soil and Rock testing of complexity level at least equal to that identified for this project.

Please refer to Table 1 on Page 2 for the Foundation Engineering Complexity of Work guideline.

Table 1: Complexity ratings for tunnelling specialty services

Excavation Diameter (Ø)	≤ 300 mm		1 m ≥ Ø > 300 mm		2 m ≥ Ø > 1 m		Ø > 2 m
Design Cover* (m)	≥ 1.5 m	< 1.5 m	≥ 3 Ø and > 1.5 m	< 3 Ø or < 1.5 m	≥ 3 Ø	< 3 Ø	N/A
King's Highway	Low	Medium	Low	Medium	Medium	High	High
400 Series Freeway	Low	High	Medium	High	High	High	High

* Design cover is the proposed vertical distance measured from the lowest ground elevation to the crown of the tunnel

Site Investigation, Field Testing and Monitoring

General

This section describes requirements for site investigation, field/laboratory testing and monitoring programs for a proposed tunnelling projects. For low complexity projects, some or all of these requirements may not be necessary. Foundation field investigation, laboratory analyses and monitoring for low complexity projects with an excavation diameter of 300 mm or less will generally only be required on an exception basis. The applicant's Foundation Engineering service can contact MTO Geotechnical staff for clarification regarding appropriate levels of investigation, testing and monitoring.

Field Testing

A minimum of one borehole is required at each end of tunnel crossing. The boreholes shall be located outside but within two metres of the tunnel's excavated footprint.

Spacing between the boreholes shall not exceed 50 m. In case of larger spacing between the boreholes, additional boreholes shall be advanced except where significant traffic disruptions might occur and where consistent conditions are evident.

Boreholes shall be advanced to 3 tunnel diameters (excavated diameters) below invert. If bedrock is encountered earlier, the borehole shall advance to at least 3 m below the invert of tunnel into the bedrock.

The investigations, if required, shall be supplemented with additional and deeper boreholes to verify consistent conditions and existence of boulders within critical foundation zones.

Sampling and testing, consisting of Standard Penetration Test, thin wall tube sample, rock cores, and MTO Field Vane Test where appropriate, shall be conducted to develop a comprehensive subsurface model. Semi-continuous sampling at 0.75m (2.5ft) intervals is required within overburden; whereas, sampling interval of 1.5m (5.0ft) is required below the tunnel invert.

Where encountered, the bedrock-soil interface shall be determined by geological definition and not by the material properties.

All aspects of implementation of means of subsurface investigations including, but not limited to, planning, licensing, construction, maintenance, abandonment, and reporting, shall be in accordance with Ministry of the Environment Regulation 903 and its amendments (the water well regulation under the OWRA).

Boreholes and piezometer tubes shall be backfilled with a suitable bentonite/cement mixture. Test pits shall be backfilled with suitable material and either re-vegetated or otherwise protected from erosion. Temporary open holes shall be adequately covered. Holes in roads shall be backfilled as required to prevent future settlement and acceptably patched where pavement surfaces have been damaged. Backfilling requirements shall be described in the Foundation Investigation and Design Report.

Where encountered, artesian groundwater conditions shall be sealed. Details of the artesian condition and the sealing operation shall be included in the Foundation Investigation Report.

Fieldwork, including any Traffic Protection Plans required, shall be carried out in accordance with the Occupational Health and Safety Act.

Traffic Control in accordance with Ontario Traffic Manual Book 7 shall be provided during the course of any field investigations. However, where significant traffic disruptions might occur, boreholes may be relocated or numbers reduced with MTO's approval.

The locations and ground surface elevations of all boreholes, test pits and soundings shall be surveyed and referred to fixed reference points and data. Locations are to be identified by co-ordinates (Northing and Easting). The vertical accuracy of survey readings shall be within 0.1m; whereas, horizontal accuracy shall be within 0.5m.

The site investigation shall be of sufficient scope to verify design assumptions and to provide the contractor with adequate subsurface information for design and construction planning.

Sufficient subsurface (factual) information is required to determine the vertical and horizontal extent of subsurface materials (including both soil and rock) and their pertinent engineering properties and groundwater conditions.

Subsurface information is usually acquired by advancing boreholes, laboratory testing of soil samples and rock core samples, performing in-situ tests such as standard penetration tests, dynamic cone tests, and piezocone tests (CPTU) and test pits.

Minimum Laboratory Testing Requirements

Laboratory testing shall consist of routine testing of 25% of samples. One routine lab test is defined as natural water content plus Atterberg Limits plus grain size distribution tests. Complex laboratory testing is defined by all other tests including compressive strength, shear strength, consolidation, permeability and triaxial testing. Laboratory testing requirements shall be supplemented with additional routine and complex tests if required to verify strata boundaries and properties and behaviour of critical subsurface zones.

A minimum of one (1) soil chemical test shall be conducted at maximum of 100 m spacing. A soil chemical test includes pH, water soluble sulphate, sulphide, chloride, resistivity and electrical conductivity analyses.

Borehole Log Preparation and Foundation Drawing

Borehole log sheets, figures and drawings shall be prepared in accordance with MTO standards. The Foundation Drawing shall consist of a plan showing the locations of all borings, test pits and soundings and various stratigraphical longitudinal profiles and stratigraphical cross-sections at each tunnel structure foundation element and groundwater levels.

Requirements for the Foundation Investigation and Design Report

A Foundation Investigation and Design Report shall consist of the factual subsurface information (including the field and laboratory test information) and the recommendations required for foundation design.

Service Provider services shall be in accordance with the most recent editions of the Canadian Highway Bridge Design Code (CHBDC), and the 'Guideline for Professional Engineers Providing Geotechnical Engineering Services' published by the Professional Engineers of Ontario.

The designated principal contact identified for Foundations Engineering services by MTO shall sign, and where required, seal, all submissions and correspondence that are submitted to MTO.

The report shall be signed and sealed by two professional engineers, registered with the Professional Engineers of Ontario, representing the consulting firm; one of them shall be the firm's designated principal contact for MTO's Foundations Engineering projects.

The Foundation Investigation component of the report shall contain:

- Site Description - including topography, vegetation, drainage, existing land use, and structures.
- Investigation Procedures - including site investigation and lab testing procedures.
- Description of Subsurface Conditions - including soil, boulders, rock and groundwater conditions.
- Miscellaneous Section - that identifies the name of the drilling company, the laboratory where testing was performed, the persons who carried out the field supervision, and those who wrote and reviewed the report.

The Foundation Design component of the report shall present discussion and recommendations for design. The Service Provider shall analyse field data and test results and make comprehensive and practical recommendations pertaining to temporary, interim and permanent conditions at the Project.

The Service Provider shall identify and evaluate all reasonable and appropriate alternatives for the proposed tunnel crossing. Alternatives may include, but not limited to, jack & bore, pipe jacking using TBM, pipe ramming, micro-tunnelling, utility tunnelling using TBM (two pass system), Horizontal Directional Drilling (HDD) and cut and cover methods.

The Service Provider shall identify and present overview assessments of the advantages, disadvantages, relative costs and risks/consequences of alternative tunnelling methods in a table. The report should conclude a preferred alternative from foundation engineering and cost effectiveness perspective.

In the development and design of the preferred alternative, the Service Provider shall, as applicable, address:

- impacts on the land use and property, traffic and transportation, and environment,
- length and diameter constraints
- control of face stability
- capability of boulder excavation
- evaluation of temporary and permanent support
- alignment control
- estimated settlements and heave and management of these deformations

- special access and egress requirements for TBM's and other similar equipment such as those used for the Jack & Bore method including recommendations for vertical shafts and jacking pits;
- shored and un-shored alternatives for open-cut excavation;
- groundwater control & dewatering;
- the long-term stability of the tunnel;
- relative costs; and
- traffic management and contractor access for each alternative.

If borehole logs available from previous projects are included to meet the requirements of field investigations then the accuracy of subsurface information from these boreholes remains the responsibility of Service Provider except in situations where MTO specify the use of previous boreholes. Borehole logs from previous studies that are appended to the report shall be reformatted to meet the MTO's requirements.

The final foundation recommendations shall detail the geometric, material and strength properties of the new tunnel crossing plus the liner, bedding and backfill requirements, and slope and embankment restoration requirements. The invert elevation should be assessed in view of the subsurface conditions and the anticipated open face stability control.

The Service Provider is responsible for developing contract documents sufficient to implement the design. This typically includes:

- Contract specifications for materials and specialized construction activities, and
- Recommendations for methods of overcoming anticipated construction problems, in particular, those relating to dewatering, boulder excavation, alignment control and the stability of excavations and embankments.

The Service Provider shall develop a detailed instrumentation and monitoring program that meets the requirements of these guidelines. (see Appendix for typical settlement monitoring guidelines).

The Service Provider is responsible for preparing Traffic Control Plans, Traffic Protection Plans and to obtain approvals and an Encroachment Permit from the Ministry, which are required for lane closures necessary to install the settlement monitoring points.

The tunnelling Service Provider shall ensure that the foundations engineering component of the project is adequately reflected in the design drawings, specifications and related contract documents.

Written confirmation is required from the Proponent and the tunnelling Service Provider that the design package submitted to MTO have been reviewed by the tunnelling Service Provider and that all recommendations have been satisfactorily incorporated in the contract package.

APPENDIX: SETTLEMENT MONITORING GUIDELINES - TUNNELLING

The purpose of settlement monitoring is to prevent damage to existing utilities and highway structures along the tunnel alignment. Ground settlement include settlement due to lost ground and dewatering/drainage.

Daily visual monitoring of the road surface and shoulders shall be carried out for any evidence of movements (e.g. cracks, bulges, heaves, depressions, ponding, etc.)

Instrumentation Arrays

All measurement points shall be installed and surveyed before the start of excavation to establish benchmarks/baseline.

Surface Monitoring Points

Surface monitoring points will be installed to cover the whole length of the tunnel with in the right of way under the jurisdiction of MTO (Figure 1).

Surface monitoring points will be located at not greater than 5m intervals along the tunnel alignment. The surface monitoring will be identified using paint marks on the pavement. Surface monitoring points installed on the unpaved right of way shall be founded below frost penetration depths. The interval and/or marking of the points should be changed with MTO's approval where traffic disruptions might occur.

The final instrumentation plan should be finalised when Contractor's proposed construction method is available.

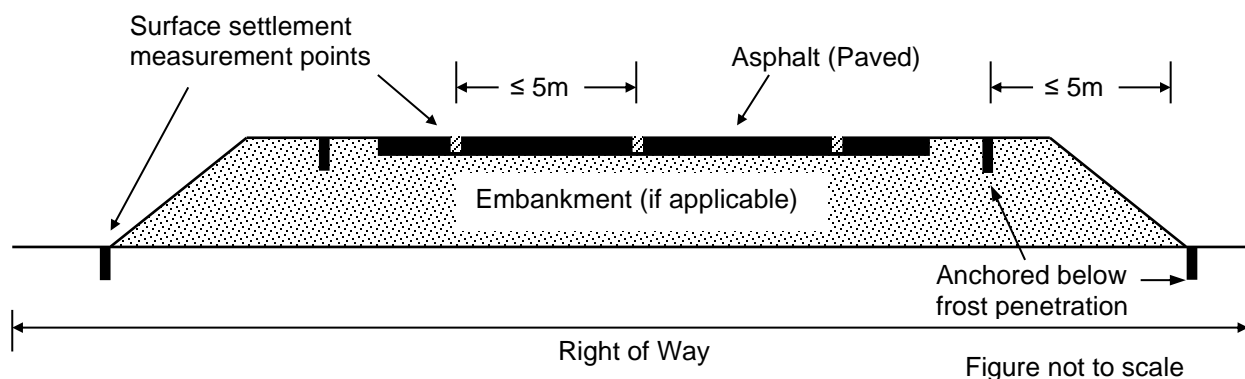


Figure 1: Typical configuration of surface settlement monitoring points along the tunnel alignment.

Condition Survey

A condition survey for the pavement will be carried out prior to commencement of construction and documented for the purpose of requirement of restoration. The condition survey shall document visible flaws such as cracks, distortions and deviations, heaves, and depressions. This surface survey will be completed during the installation of the monitors and again once the tunnel has been completed.

Reading Frequency

An average of at least two readings shall be taken to establish the initial conditions.

The reading and collection of data from the surface monitoring points shall be read and recorded by the Contractor during the construction period and after construction for period of at least 2 weeks provided that further settlement has stopped.

A minimum of three (3) sets of reading be taken daily, provided that movements are within anticipated limits. Otherwise, the frequencies should increase according to a pre-planned interval.

Monitoring of movements is required during work stoppages, such as during non-operation period (off-shifts) or weekends. A minimum of three (3) sets of readings should be taken daily.

Measurements of the monitoring points shall be reported promptly to MTO for review.

Data Collection and Data Transfer

A procedure is required to be established in consultation with MTO so that the monitoring data and the interpreted data will reach all parties as soon as necessary. The contract administrator/Service Provider and the Contractor should interpret monitoring data as needed for the purpose of on-going construction. The Foundation Engineer should be contacted for technical support to the prime Service Provider in the interpretation of ground movements and review of the Contractor's response when Review and Alert Levels are reached.

Criteria for Assessment

The acceptable surface settlement (or heave) will be according to criteria as specified below.

Baseline Reading – A baseline reading of the instrumentation shall be taken prior to commencement of the work. An average of at least two initial readings shall be recorded as baseline reading.

Review Level – A maximum value of 10 mm relative to the baseline readings is suggested for this project. If this level is reached, the method, rate or sequence of construction, or ground stabilization measures should be reviewed or modified to mitigate further ground displacements.

Alert Level – A maximum value of 15mm relative to the baseline readings is suggested for this project. If this level is reached, the Contractor shall cease construction operations and to execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.

Review of Contractor's Proposed Method

MTO, the Proponent's prime Service Provider and Foundation Engineer should review the Contractor's proposed method of construction. The proposed method should include a description of the potential loss of ground, and calculation of the maximum settlement in relation to the Contractor's procedure and equipment, alternative/remedial measures when review level of measurement is reached; and contingency/remedial measures when alert level of measurement is reached.

Contractor's Responsibility for Restoration and Warranty Provision

In addition to the monitoring program to assess the adequacy of the construction method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving) should movements or other surface distress occur, and provide a reasonable warranty period acceptable to MTO. Remedial measures shall be approved by MTO; however, MTO maintains the right to perform the maintenance at the proponent's expense.

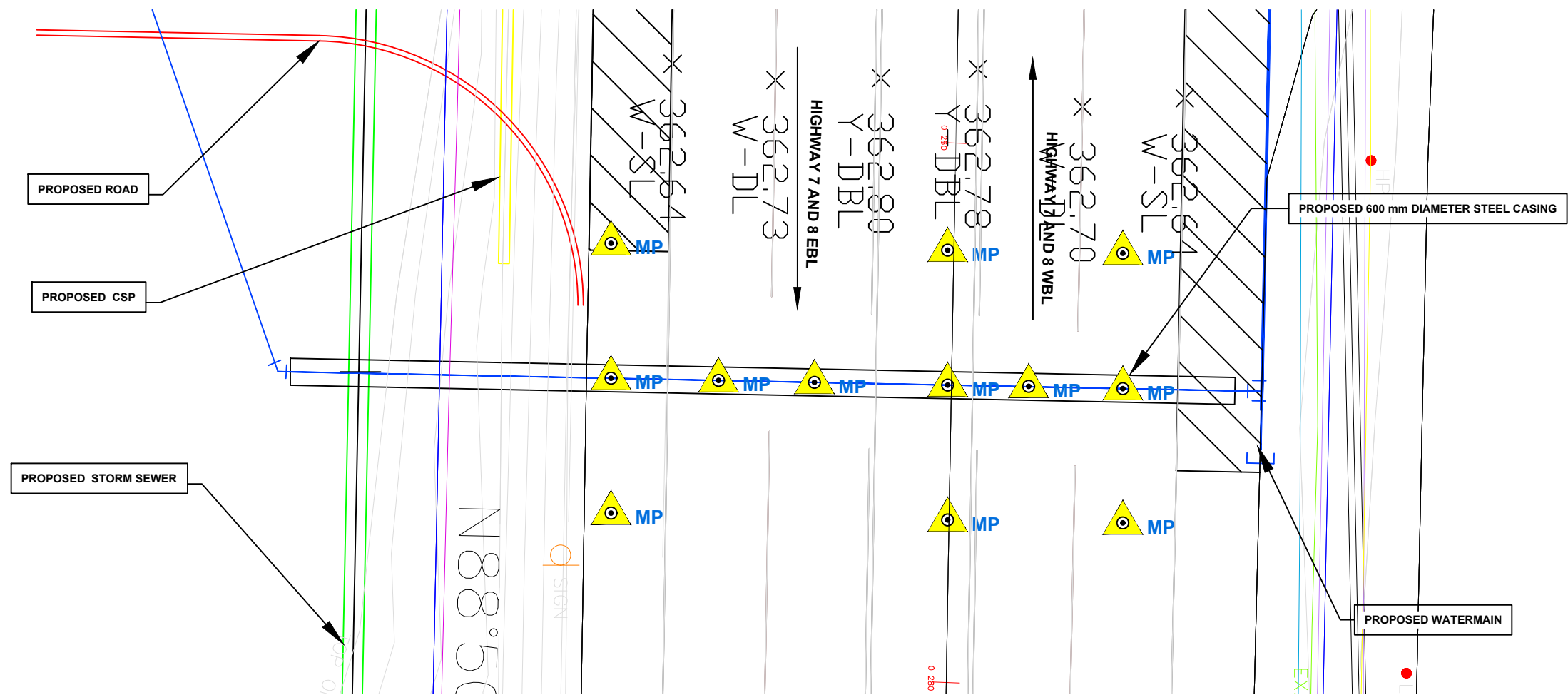
Construction Monitoring

The Proponent shall retain a RAQS qualified Geotechnical Service Provider – Medium Complexity to supervise the installation of surface settlement points on site and to provide direction, technical input and field inspection on this project.




APPENDIX F

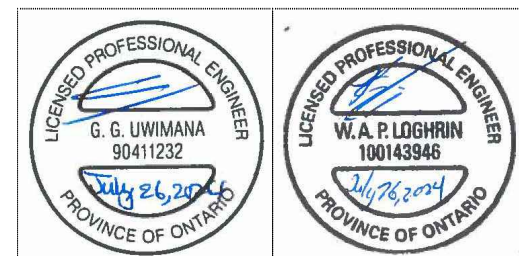
Settlement Monitoring Plan Drawing M1



LEGEND:

 MONITORING POINT

- NOTES:
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RECORD OF BOREHOLES AND REPORT
 - 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.
 - MAXIMUM SPACING ALLOWED BETWEEN MONITORING POINTS IS 5 m



— NOTE —

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

REVISIONS		
DATE	BY	DESCRIPTION

Reference
CACHET.STRATFORD-ONTARIO.ST-WM.CROSSING-JUNE03_24.dwg

Geocres No. 40P07-070						
HWY No					DIST PERTH	
SUBM'D	WL	CHECKED	WL	DATE July 2024		
DRAWN	NG	CHECKED	WL	APPROVED WL	DWG M1	



APPENDIX G

List of Standard Specifications Relevant to Report



LIST OF STANDARD SPECIFICATION RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS.MUNI 415	Construction Specifications for Pipeline and Utility Installation by Tunnelling
OPSS.MUNI 416	Construction Specifications for Pipeline and Utility Installation by Jacking and Boring
OPSS.MUNI 1002	Material Specification for Aggregate - Concrete
OPSS.PROV 539	Temporary Protection Systems
OPSS.MUNI 310	Hot Mix Asphalt
OPSS.MUNI 1010	Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
OPSD 3090.101	Frost Penetration Depth for Southern Ontario