



## **Geotechnical Investigation Report**

### **Part 1: Factual Information**

*Bell Canada Conduit; Highway 401*

*Westbrook Road (GEOCRES No. 31C-244)*

**Prepared for:**

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**June, 2016 - Revised**

**CP-15-0412**

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## **Geotechnical Investigation Report for Bell Canada Conduit Across Highway 401**

### **Part 1: Factual Information**

#### **1.0 INTRODUCTION**

This report presents the factual findings obtained from a geotechnical investigation performed at the crossing of proposed utility tunnel and Highway 401, west of Westbrook Bridge in Westbrook, Kingston.

The purpose of the investigation was to explore the subsurface conditions at this site and to provide subsurface information required for trenchless installation of 356 mm diameter steel casing for carrying Bell Canada communication cables across Highway 401. The proposed length of the casing is approximately 100 m long. This report provides anticipated geotechnical conditions influencing the design and construction of the proposed installation.

McIntosh Perry Consulting Engineers (McIntosh Perry) was retained by Planview Utility Services Ltd. (Planview) to carry out this work.

Location of the site for the proposed utility tunnel is shown on Figure 1, Key Plan, included in Appendix B.

#### **2.0 SITE DESCRIPTION**

The proposed utility tunnel will be advanced under the Highway 401, approximately 23.5 m west of the Westbrook Road underpass. The land to the north and south of the highway along the Westbrook Road is sloped down from the bridge approach embankments. The land from the toe of the embankments on both sides of the highway is relatively flat. The gore areas are lightly vegetated with grass and some trees. The area to the south of Highway 401 borders on private residential property. Approximately 148.5 m long guiderail along the eastbound shoulder of Highway 401 prevents immediate access from highway to south side of the proposed tunnel or drive pit. The drive pit or south end of tunnel will have to be accessed by driving behind the guiderail. The ground behind the guiderail is relatively flat and accessible by motor vehicle from the Highway 401 eastbound lanes. Access to the north end of the tunnel is not inhibited by guiderail. The profile of the westbound shoulder of Highway 401 is sloped down to a shallow drainage ditch before sloping upward to the vegetated area. Refer to Figure 2 in Appendix B for profile near borehole locations and tunnel alignment.

#### **3.0 FIELD PROCEDURE**

Staff of McIntosh Perry initially visited the site on February 2, 2016 to evaluate the access to the site and plan for execution of field work. Borehole locations were identified on preliminary drawings and staked on site by survey crew of McIntosh Perry. Encroachment permits were obtained from Ministry of Transportation Ontario (MTO). All field work was coordinated with the MTO Switch Board for traffic management

coordination. Public and private utility authorities were informed and all utility clearance documents were obtained before the commencement of drilling work. Utility clearance was carried out through ON1Call and MTO utility coordinators.

Two geotechnical boreholes were advanced as part of this investigation. Borehole locations were selected based on the proposed alignment included in preliminary drawings prepared by Planview. BH16-1-W was advanced close to the receiving pit, approximately 1.2 m east of the proposed alignment of the tunnel. Second borehole, BH16-2-W was advanced in the close proximity of the entry pit at about 1.3 m west of the alignment. MTO guidelines require that the 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 BH16-1-W and BH16-2-W were located 43.5 m apart, which meet the spacing requirements of MTO Guidelines. The field work for this investigation program was carried out during the winter season with noticeable amount of snow accumulated on the road shoulders and on both sides of the median ditch. A third borehole midway on the proposed alignment could not be advanced due to the difficulty to mobilize during the winter weather conditions and the posted speed limit on Highway 401.

The equipment used for drilling was owned and operated by GET Drilling of Napanee, Ontario. Boreholes were advanced using hollow stem augers aided by a truck-mounted L-45 drilling rig. Rock coring was carried out by the use of double core barrel with diamond drill bit and the cores were retrieved by wireline tool. Boreholes were advanced to a maximum depth of 4.8 m (El. 115.6) below the ground level. Bulk soil samples from the thin mantle of overburden were collected. Borehole locations are shown on Figure 2, included in Appendix B. Standpipe piezometers were installed in both boreholes for monitoring of groundwater level, after purging to remove the water that was used for rock coring. Construction of standpipe piezometer is illustrated in the borehole records included in Appendix C.

Rock cores retrieved and soil samples were brought to McIntosh Perry laboratory for detailed examination, measurements, classification and identification of bedrock geology.

A traffic control plan was prepared according to Ontario Traffic Manual Book 7 and implemented on site by a professional traffic control subcontractor Donald H. Wills Construction Co. Ltd. of Portland, Ontario.

One standpipe piezometer was installed in each borehole for further monitoring of the groundwater elevation. Standpipe piezometers were sealed below ground surface by bentonite as per the Ministry of Environment and Climate Change (MOECC) Regulation 903.

Upon completion of site investigation, borehole locations were surveyed by McIntosh Perry surveying crew. Location of boreholes are shown on Figure 2 included in Appendix B. Borehole information is summarized in Table 3-1 below:



**Table 3-1: Summary of Borehole Data**

Borehole	UTM NAD 83 Zone 18		Ground Surface El. (m)	Borehole Depth (m)	Bedrock Elevation
	Northing	Easting			
BH16-1-W	4905268.161	294470.506	120.5	4.4	120.4
BH16-2-W	4905224.845	294469.940	120.4	4.8	119.7

## **4.0 LABORATORY TESTING**

All overburden and rock core samples were returned to McIntosh Perry office for further examination and classification. All rock cores were closely examined by McIntosh Perry geologist to perform rock quality index measurements, identify rock minerology and geologic formation of bedrock.

Compressive strength test in accordance with ASTM-D7012 Method C was performed on selected segments of the rock core samples. Stantec laboratories in Ottawa, Ontario performed the compressive strength test, on behalf of McIntosh Perry. Test results provided by Stantec laboratory are included in Appendix E.

Detailed information obtained from the rock cores and soil samples are presented in Borehole Records included in Appendix D. Rock core samples recovered will be stored in McIntosh Perry storage facility for a period of one month after submission of the final report. Samples will be disposed after this period of time unless otherwise requested in writing by Planview. Rock core samples can be delivered to Planview or its subcontractors upon request.

## **5.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS**

### **5.1 Site Geology**

Physiographically the site is located in the region known as the “Napanee Plain”. It is a flat to undulating plain of limestone. The glacier stripped most of the overburden from the limestone bedrock of the Gull River and Bobcaygeon Formation. The soil is only a few centimeters deep over much of this physiographic region. Shallow soil on limestone with a typical cover of cedar and spruce trees near the Town of Napanee is further evidence of thin mantle of soil overlying the bedrock.

The Physiography of Southern Ontario by Putnam and Chapman suggest that deeper glacial till occurs in the stream valleys and toward the north where Napanee Plain borders on the Dummer Moraines. Further, this publication suggest that in the South of Napanee Plain, particularly, the depressions often have shallow deposits of stratified clay. Published Surficial Geology maps of the region indicate that the area falls within Paleozoic bedrock.

## **5.2 Subsurface Conditions**

In general the site stratigraphy as observed in the exploratory boreholes consisted of approximately 100 mm to 700 mm of sandy gravel fill overlying the bedrock. For classification purposes, the subsoil conditions encountered at this site can be divided into two different zones:

- a) Sandy Gravel, Some Silt (Fill)
- b) Limestone Bedrock

The subsoil conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix D of this report. In addition, rock core description and photo of rock cores are included in Appendix D. One Stratigraphical profile section along the proposed alignment of the tunnel is shown on Figure 2 in Appendix B. Description of the strata encountered are given below.

### **5.2.1 *Sandy Gravel, Some Silt (Fill)***

The thickness of the sandy gravel fill layer was found to be 100 mm and 700 mm in boreholes BH16-1-W and BH16-2-W, respectively. This fill layer predominantly consisted of gravel and sand similar to the constituents of base and subbase materials.

Thickness of this layer was too small to conduct any field test to determine the denseness of the material.

### **5.2.2 *Bedrock***

Presence of bedrock was proved by coring at both borehole locations and obtaining rock cores ranging in length from 4.1 m to 4.3 m. The termination depth of boreholes vary from minimum of 4.4 m (El. 116.1) at BH16-1-W to maximum of 4.8 m (El. 115.6) at BH16-2-W. The bedrock at this site was identified as limestone of the Gull River Formation. The outcrops of this bedrock formation can be found at several locations in the vicinity of project area. This bedrock formation is typically light grey to brown in colour and inter-bedded with thin layers of shale. However, the bedrock at this site was medium to dark brown-grey microcrystalline to fine crystalline limestone, weathers mottled brown-grey to light grey. Further, it is mottled and laminar appearance from bioturbation and argillaceous content with sparse sparry-calcite filled fossils. For complete description of the bedrock, refer to rock core description logs provided in Appendix D.

The RQD measured from the rock cores retrieved down to about El. 118.2 to El. 117.9 range between 48% and 51%. Based on the RQD values, the bedrock down to El. 117.9 may be classified as poor to fair quality. The rock core recovery measured in this section vary from 97% to 100%. This section of the bedrock is highly to moderately weathered and intensely fractured. The compressive strength of the selected samples from this section ranges from 117.3 MPa to 158.8 MPa.

The bedrock below about El. 118.2 to the depth of termination is slightly weathered and moderately fractured. The recovery of the rock cores retrieved below El. 118.2 range from 98% to 100%. The RQD measured from the rock cores retrieved below El. 118.2 to the depth of termination range between 50% and 80%, and the bedrock in this section may be classified as fair to good quality. The compressive strength of the selected samples from the rock cores below El. 118.2 range from 121.1 MPa to 140.7 MPa.

Results of unconfined compression tests provided by Stantec laboratory are summarized in Table 5-2 below;

**Table 5-1: Compression Strength Test Results**

Borehole No.	Sample No.	Sample Depth	Compressive Strength (MPa)
BH16-1-W	HQ -2	0.78	128.9
BH16-1-W	HQ-3	1.823	117.3
BH16-1-W	HQ-4	3.706	121.1
BH16-2-W	HQ -2	1.096	158.8
BH16-2-W	HQ-3	2.606	131.0
BH16-2-W	HQ-4	3.562	140.7

### **5.3 Groundwater**

Standpipe piezometers were installed in both boreholes upon completion of the drilling. The groundwater level measurements were taken 16 days after the installation of standpipe piezometers. The measurement of groundwater level was delayed to allow time for dissipation of water that was used for rock coring. Groundwater elevations are shown on the borehole logs included in Appendix D and are summarized in Table 5-3 below:

**Table 5-2: Groundwater Elevations**

Borehole	Ground Surface El. (m)	Groundwater Below Surface (m)	Groundwater Table El. (m)
BH16-1-W	120.5	1.16	119.34
BH16-2-W	120.4	0.20	120.21

## **6.0 PAVEMENT CONDITION**

Observations were made to assess the conditions of existing pavements on both, eastbound and westbound lanes across a 10 m wide section along the proposed tunnel alignment. Refer to pavement condition evaluation forms provided in Appendix C for observations and assessments. Frequent and slight centerline cracking and multiple moderate transverses cracking were observed on the westbound driving lanes. The cracking on the eastbound lanes observed were also similar to that of westbound lanes, with the exception of transverse cracking.

## **7.0 CLOSURE**

Field work for this investigation was supervised by Corey O'Neill, C.E.T. The laboratory tests were conducted by Stantec laboratory in Ottawa, which is registered in RAQS for the specialty of Soil and Rock Including Testing for Foundation Engineering – Medium Complexity.

This report was prepared by N'eem Tavakkoli, M.Eng., P.Eng., Cara Stapley, P.Eng., and Mary-Ellen Gleeson, M.Eng., EIT. Peer Review was done by Mark Vasavithasan, P.Eng. and Carlos Nascimento, P.Eng., who is the designated principal MTO contact at Peto MacCallum Ltd for Medium and High Complexity Foundation Engineering and Tunneling specialties.

The "Limitations of Report" presented in Appendix A are an integral part of this report.

McIntosh Perry Consulting Engineers Ltd.

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Geotechnical Engineering Intern



Cara Stapley, P.Eng.  
Geotechnical Engineer



N'eem Tavakkoli, M.Eng., P.Eng.  
Senior Geotechnical Engineer

## **REFERENCES**

- ASTM 4.08. Standard D1586-99: Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.
- ASTM 4.08. Standard D2487-00: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
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- MTO LS-702. Standard D422-63: Standard Test Method for Particle-Size Analysis of Soils.
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- Canadian Geotechnical Society, "Canadian Foundation Engineering Manual", 4th Edition, 2006.
- Ontario Ministry of Natural Resources (OMNR), Ontario Geological Survey, Special Volume 2, "The Physiography of Southern Ontario", 3rd Edition, 1984.
- Google Earth, Google, 2015.
- Government of Canada, National Building Code of Canada (NBCC), "Seismic Hazard Calculation" (online), 2010.
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- Government of Ontario, "Ontario Building Code (OBC)," (online), 2012

## **Appendix A**

### **Limitations of Report**



## LIMITATIONS OF REPORT

---

McIntosh Perry Consulting Engineers Ltd. (MPCE) carried out the field work and prepared the report. This document is an integral part of the Foundation Investigation and Design report presented.

The conclusions and recommendations provided in this report are based on the information obtained at the borehole locations where the tests were conducted. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the specific locations where tests were conducted and conditions may become apparent during construction, which were not detected and could not be anticipated at the time of the site investigation. The benchmark level used and borehole elevations presented in this report are primarily to establish relative differences in elevations between the borehole locations and should not be used for other purposes such as to establish elevations for grading, depth of excavations or for planning construction.

The recommendations presented in this report for design are applicable only to the intended structure and the project described in the scope of the work, and if constructed in accordance with the details outlined in the report. Unless otherwise noted, the information contained in this report does not reflect on any environmental aspects of either the site or the subsurface conditions.

The comments or recommendation provided in this report on potential construction problems and possible construction methods are intended only to guide the designer. The number of boreholes advanced at this site may not be sufficient or adequate to reveal all the subsurface information or factors that may affect the method and cost of construction. The contractors who are undertaking the construction shall make their own interpretation of the factual data presented in this report and make their conclusions, as to how the subsurface conditions of the site may affect their construction work.

The boundaries between soil strata presented in the report are based on information obtained at the borehole locations. The boundaries of the soil strata between borehole locations are assumed from geological evidences. If differing site conditions are encountered, or if the Client becomes aware of any additional information that differs from or is relevant to the MPCE findings, the Client agrees to immediately advise MPCE so that the conclusions presented in this report may be re-evaluated.

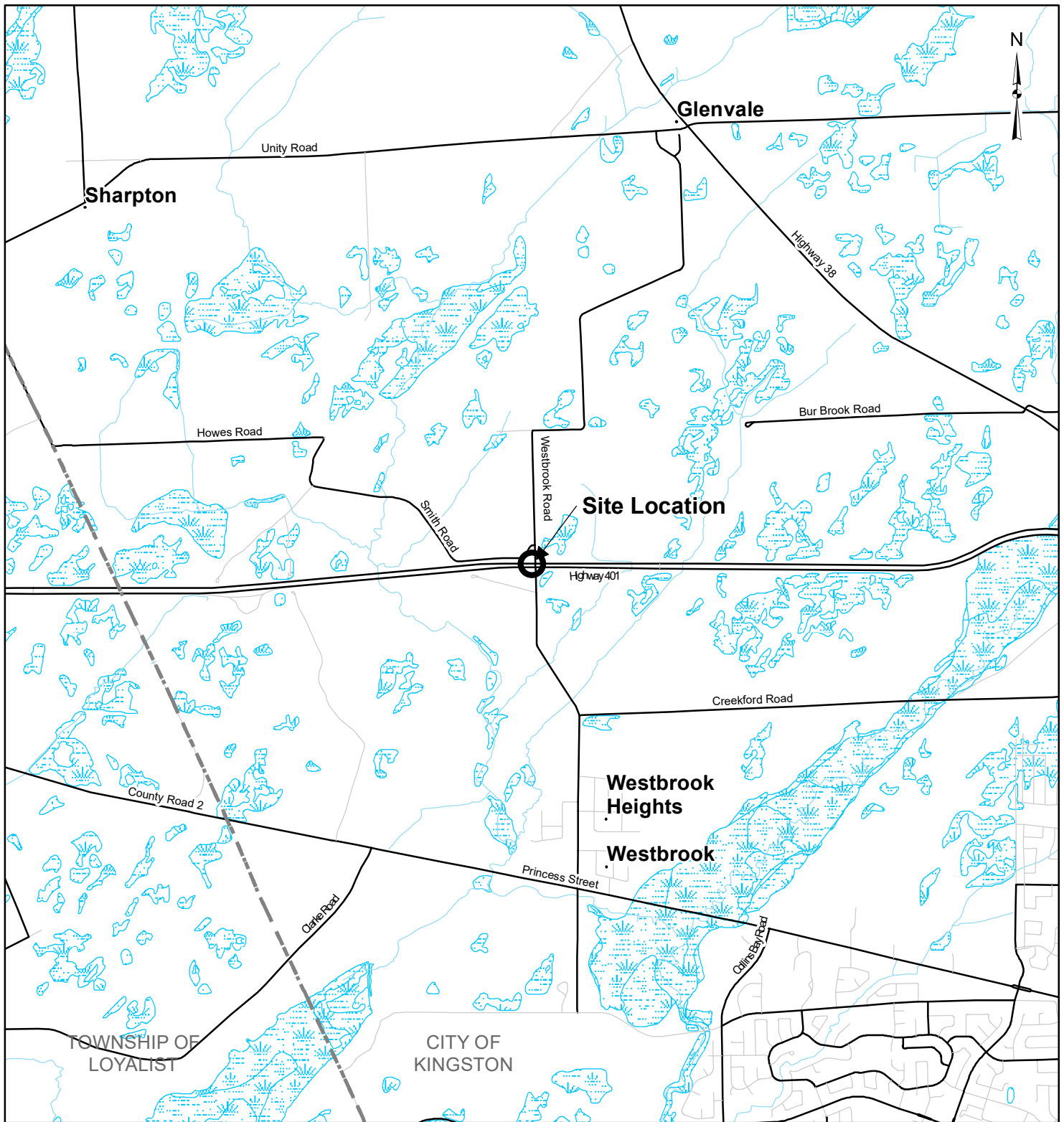
Under no circumstances shall the liability of MPCE for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify MPCE. Such errors and omissions policies are available for inspection by the Client at all times upon request, and if the Client desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, MPCE will co-operate with the Client to obtain such insurance.

MPCE prepared this report for the exclusive use of the Client. Any use which a third party makes of this report, or any reliance on or decision to be made based on it, are the responsibility of such third parties. MPCE accepts no responsibility and will not be liable for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.




## **Appendix B**

### **Figures**

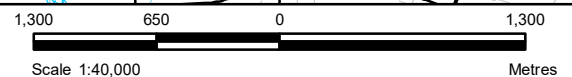


#### LEGEND

-  Site Location
-  Local Road
-  Major Road
-  Watercourse
-  Wetland

#### REFERENCE

Basedata provided by the Ontario Ministry of Natural Resources, 2015.



CLIENT:  
**PLANVIEW UTILITY SERVICES LTD.**

PROJECT:  
**WESTBROOK RD. AND HWY 401**

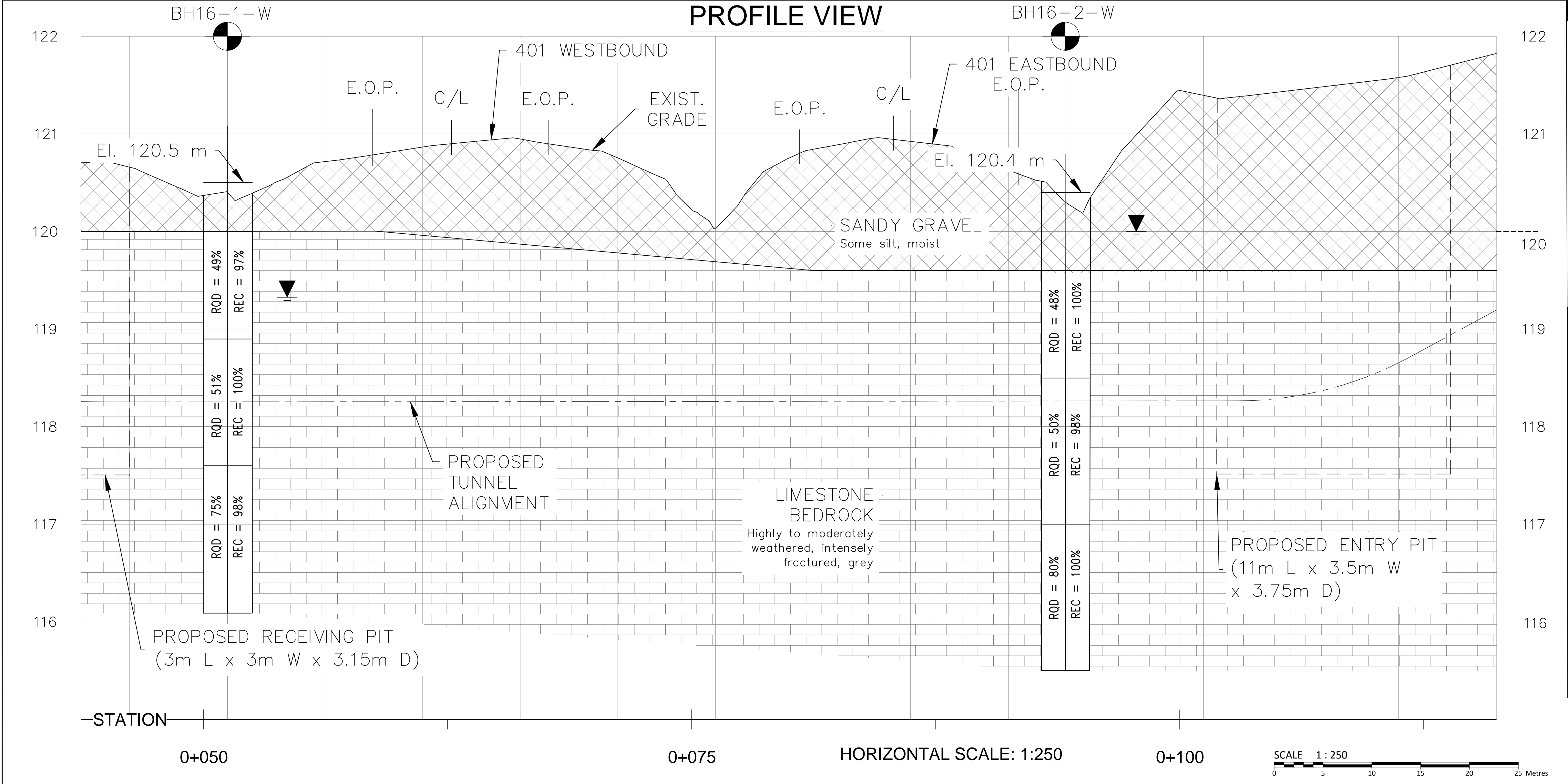
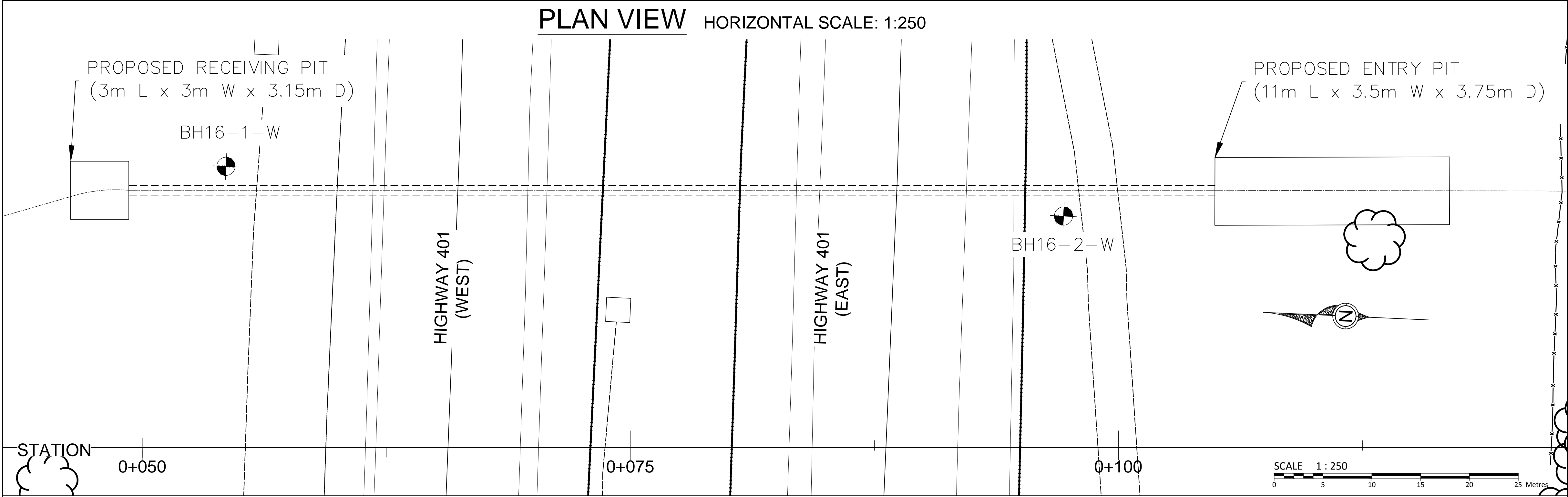
TITLE:  
**KEY PLAN**



115 Walgreen Rd., RR#3, Carp, ON K0A1L0  
Tel: 613-836-2184 Fax: 613-836-3742

PROJECT NO: CP-15-0412	FIGURE:
Date Mar. 29, 2016	1
GIS JD	
Checked By MG	





METRIC

PLATE No PLATE

MTO GEOCRES NO.  
31C-244

BORE HOLE LOCATIONS  
AND SOIL STRATA  
HWY 401 AND WESTBROOK ROAD

Survey SURVEYED Revised REVISED

**McINTOSH PERRY** **MP**

115 Walgreen Road R.R. #3, Carp, ON K0A 1L0  
Tel: 613-836-2184 Fax: 613-836-3742

Figure 2

LICENSED PROFESSIONAL ENGINEER  
M. AZIZI TAVAKOLI  
100150911  
June 3/16  
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER  
C. L. STAPLEY  
100128923  
03/06/2016  
PROVINCE OF ONTARIO

**KEY MAP (N.T.S.)**

SMITH RD.

GENGE RD.

WESTBROOK RD.

HIGHWAY 401

**LEGEND**

BOREHOLE

GROUND WATER LEVEL

**BORE HOLE COORDINATES**

BORE HOLE	ELEVATION (m)	NORTHING	EASTING
BH16-1-W	120.5	4905268.161	294470.506
BH16-2-W	120.4	4905224.845	294469.940

NOTE:  
The boundaries between soil strata have been established only at bore hole locations. Between bore holes the boundaries are assumed from geological evidence.

## **Appendix C Pavement Reports**

# FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location: Highway 401

From: 35 meters west of westbrook bridge Centerline

To: 25 meters west of westbrook Rd Bridge Centerline

LHRS

BEGINS  
[ ][ ][ ][ ]

OFFSET  
[ ][ ] • [ ][ ] km

Section

Length  
[ ][ ] • [ ][ ] 0 km

Traffic  
Direction

Survey Date

YEAR MONTH  
[1][6] [3]

PCR

[9][5]

RCR

[9][7]

Contract No.

Ride  
Condition  
Rating  
(at 80 km/h)

10 EXCELLENT  
Smooth and pleasant  
8 GOOD  
Comfortable  
6 FAIR  
Uncomfortable  
4 POOR  
Very rough and bumpy  
2 VERY POOR  
Dangerous at 80 km/h  
0

WP No.

[ ][ ][ ][ ] - [ ][ ][ ] - [ ][ ][ ][ ]

Facility

E

B: BOTH DIRECTIONS  
N: NORTH BOUND  
S: SOUTH BOUND  
E: EAST BOUND  
W: WEST BOUND

District

[ ][ ]

Highway

[4][0][1]

A: ALL LANES  
C: COLLECTOR  
E: EXPRESS  
O: OTHERS  
(Additional Lanes)

A

Class

F: FREEWAY  
A: ARTERIAL  
C: COLLECTOR  
L: LOCAL  
S: SECONDARY

F

Pavement		Distress Type		We	Ve	Sl	Mo	Se	Ve						DMI count
			(wi)	0.5	1	2	3	4	<10	10-20	20-50	50-80	80-100		
Surface Defects		Ravelling & C. Agg. Loss	1	3.0										0.00	
		Flushing	2	1.5										0.00	
Surface Deformations		Rippling and Shoving	3	1.0										0.00	
		Wheel Track Rutting	4	3.0										0.00	
		Distortion	5	3.0										0.00	
Cracking	Longitudinal Wheel Track	Single and Multiple	6	1.5										0.00	
		Alligator	7	3.0										0.00	
	Centre Line	Single and Multiple	8	0.5										1.50	
		Alligator	9	2.0										0.00	
	Pavement Edge	Single and Multiple	10	0.5										0.00	
		Alligator	11	1.5										0.00	
	Transverse	Half, Full and Multiple	12	1.0										4.00	
		Alligator	13	3.0										0.00	
	Long Meander and Midlane		14	1.0										0.00	
	Random		15	0.5										0.00	
Ride Condition Rating (RCR) from 0-10:				9.5										DMI	9.7

PCI Value: 96

Distress comments (Items not covered above)

Centerline Crack most likely from cold joint during paving

Moderate multiple transverse crack accross highway

Shoulders			Severity of Distress				Density of Distress (Extent of Occurrence, %)			
Dominant Type	one ft	Distress	Right		Left		Right		Left	
			Mod	Severe	Mod	Severe	10-30	>30	10-30	>30
Paved Full		Cracking								
		Pavement Edge/Curb Separation								
Paved Partial		Distortion								
Surface Treated		Breakup/Separation								
		Edge Break								
Primed		Breakup								
Gravel										

Maintenance Treatment		Extent of Occurrence, %				
		<10	10-20	20-50	50-80	>80
Pavement	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
Shoulders	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Other Comments (e.g. subsections, additional contracts)

Evaluated by



# FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location: Highway 401

From: 35 meters west of westbrook bridge Centerline

To: 25 meters west of westbrook Rd Bridge Centerline

LHRS       km  
BEGINS OFFSET

Section     0 km  
Length LENGTH

Traffic Direction

Survey Date  1  6  3  
YEAR MONTH

PCR  9  5 RCR  9  7

Contract No.

Ride Condition Rating (at 80 km/h)

10 EXCELLENT  
Smooth and pleasant  
8 GOOD  
Comfortable  
6 FAIR  
Uncomfortable  
4 POOR  
Very rough and bumpy  
2 VERY POOR  
Dangerous at 80 km/h  
0

WP No.     -   -

Facility

W  
B: BOTH DIRECTIONS  
N: NORTH BOUND  
S: SOUTH BOUND  
E: EAST BOUND  
W: WEST BOUND

District

Highway  4  0  1

A  
A: ALL LANES  
C: COLLECTOR  
E: EXPRESS  
O: OTHERS  
(Additional Lanes)

Class  F  
F: FREEWAY  
A: ARTERIAL  
C: COLLECTOR  
L: LOCAL  
S: SECONDARY

Pavement	Distress Type	Weight (wi)	Severity of Distress					Density of Distress (Extent of Occurrence, %)					DMI count
			Very Slight	Slight	Moderate	Severe	Very Severe	Few	Intermittent	Frequent	Extensive	Throughout	
Surface Defects	Ravelling & C. Agg. Loss	1	3.0										0.00
	Flushing	2	1.5										0.00
Surface Deformations	Rippling and Shoving	3	1.0										0.00
	Wheel Track Rutting	4	3.0										0.00
	Distortion	5	3.0										0.00
Cracking	Longitudinal Single and Multiple	6	1.5										0.00
	Alligator	7	3.0										0.00
	Centre Line Single and Multiple	8	0.5										1.50
	Alligator	9	2.0										0.00
	Pavement Edge Single and Multiple	10	0.5										0.00
	Alligator	11	1.5										0.00
	Transverse Half, Full and Multiple	12	1.0										2.00
	Alligator	13	3.0										0.00
	Long Meander and Midlane	14	1.0										0.00
	Random	15	0.5										0.00
Ride Condition Rating (RCR) from 0-10:			9.5					DMI 9.8					

PCI Value: 97

Distress comments (Items not covered above)

Centerline Crack most likely from cold joint during paving

Partial slight transverse crack in left lane

Shoulders			Severity of Distress				Density of Distress (Extent of Occurrence, %)			
Dominant Type	one ft	Distress	Right		Left		Right		Left	
			Mod	Severe	Mod	Severe	10-30	>30	10-30	>30
Paved Full		Cracking								
		Pavement Edge/Curb Separation								
Paved Partial		Distortion								
Surface Treated		Breakup/Separation								
		Edge Break								
Primed		Breakup								
Gravel										

Maintenance Treatment		Extent of Occurrence, %				
		<10	10-20	20-50	50-80	>80
Pavement	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
Shoulders	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Other Comments (e.g. subsections, additional contracts)

Evaluated by

## **Appendix D Borehole Logs**

## RECORD OF BOREHOLE No BH16-1-W

1 OF 1

METRIC

DATE 23/02/2016

ID 0CP-15-0412

LOCATION Co-ord: UTM Zone 18: 294470.506m E, 4905268.161 m N

ORIGINATED BY CO

CLIENT Planview

CONTRACTOR GET Drilling Ltd

COMPILED BY MG

ELEVATION 120.5

DATUM Geodetic

CHECKED BY NT

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)			SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE						
120.5							20	40	60	80	100						
120.0 0.1	SANDY GRAVEL, some silt, moist (FILL)	XXXX					20	40	60	80	100						
	LIMESTONE BEDROCK, highly weathered, very intensely factured, poor quality, grey																
119.8 0.7			1	RC HQ	REC 97%											RQD = 49% 128.9 MPa	
	LIMESTONE BEDROCK, moderately weathered, intensely factured, poor to fair quality, grey															117.3 MPa	
			2	RC HQ	REC 100%											RQD = 51%	
117.8 2.7																	
	LIMESTONE BEDROCK, slightly weathered, moderately factured, fair quality, grey															RQD = 75% 121.1 MPa	
			3	RC HQ	REC 98%												
116.1 4.4	END OF BOREHOLE																

**RECORD OF BOREHOLE No BH16-2-W**

1 OF 1

**METRIC**

DATE 23/02/2016

ID 0CP-15-0412

LOCATION Co-ord: UTM Zone 18: 294469.94m E, 4905224.845 m N

ORIGINATED BY CO

CLIENT Planview




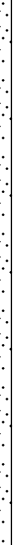
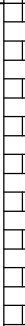
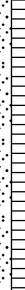


CONTRACTOR GET Drilling Ltd

COMPILED BY MG

ELEVATION 120.4

DATUM Geodetic

CHECKED BY NT

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)			SHEAR STRENGTH kPa							
								20 40 60 80 100							
120.4 0.0	SANDY GRAVEL, some silt, moist (FILL)						20	40	60	80	100	PLASTIC LIMIT w <sub>P</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
119.7 0.7															
	LIMESTONE BEDROCK, weathered, intensely to moderately factured, poor quality, grey		1	RC HQ	REC 100%		20	40	60	80	100	25	50	75	158.8 MPa RQD = 48%
118.2 2.2	LIMESTONE BEDROCK, slightly weathered, moderately factured, fair to good quality, grey		2	RC HQ	REC 98%		20	40	60	80	100	25	50	75	RQD = 50%  131.0 MPa
	LIMESTONE BEDROCK, slightly weathered, moderately factured, fair to good quality, grey		3	RC HQ	REC 100%		20	40	60	80	100	25	50	75	140.7 MPa  RQD = 80%
115.6 4.8	END OF BOREHOLE														

## ROCK CORE DESCRIPTION

Project Name, Reference: Westbrook Road North, OCP-15-0412

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	Sample No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
16-1-W	1	0.05 – 1.55	97	49	0.05 – 4.45	<b>LIMESTONE (GULL RIVER FORMATION):</b> medium to dark brown- grey microcrystalline to fine crystalline limestone weathers mottled brown-grey to light grey. Mottled and laminar appearance from bioturbation and argillaceous content. Sparse sparry-calcite filled fossils.
	2	1.55 – 2.92	100	51		<ul style="list-style-type: none"> <li>- highly weathered and very intensely fractured from 0.05 to 0.66m</li> <li>- moderately weathered and intensely fractured from 0.66 to 2.67m</li> </ul> <p>Very thin irregular and discontinuous wavy shaly laminae and blebs within the limestone beds from 0.05 to 2.92m</p> <ul style="list-style-type: none"> <li>-intraclastic, bioturbated zone with mudstone intraclasts up to 4cm between 1.93m and 2.49.</li> </ul>
	3	2.92 – 4.45	98	75		<ul style="list-style-type: none"> <li>- stylolite at 1.98m</li> <li>- vertical fractures between 2.46-2.57 and 2.57 and 2.67m.</li> <li>- slightly weathered and moderately fractured from 2.67 to 4.45m</li> </ul> <p>Increase in laminated and irregular shaly zones; some with pronounced bioturbation and intraclasts between 2.92 and 4.45m.</p>

**CR\*** - Core Recovery

Logged by: Angela L. Gulley, P.Geo.

**RQD\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%

# ROCK CORE DESCRIPTION

Project Name, Reference: Westbrook Road South, OCP-15-0412

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	Sample No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
16-2-W	1	0.69– 1.68	100	48	0.69 – 4.83	<p><b>LIMESTONE (GULL RIVER FORMATION):</b> medium to dark brown- grey microcrystalline to fine crystalline limestone weathers mottled brown-grey to light grey. Mottled and laminar appearance from bioturbation and argillaceous content. Sparse sparry-calcite filled fossils.</p> <p>- weathered and intensely to moderately fractured from 0.69 to 2.24m.</p>
	2	1.68 – 3.30	98	50		<p>Very thin irregular and discontinuous wavy shaly laminae and blebs with associated bioturbation within the limestone beds from 0.69 to 3.40m</p> <p>- stylolites at 1.07m and 1.58m - stylolites at 2.37m and 2.54m</p>
	3	3.30 – 4.83	100	80		<p>-slightly weathered and moderately fractured from 2.24 to 4.83m</p> <p>Greater occurrence of irregular shaly zones with more pronounced bioturbation within the limestone beds from 3.40 to 4.83m.</p>

**CR\*** - Core Recovery

Logged by: Angela L. Gulley, P.Geo.

**RQD\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%





0CP-15-0456  
Westbrook Road - North Side

BH16-1-W  
HQ 1: 0.05 m to 1.55 m  
HQ 2: 1.55 m to 2.92 m  
HQ 3: 2.92 m to 4.45 m





OCP-15-0456  
Westbrook Road - South Side

BH16-2-W  
HQ 1: 0.69 m to 1.68 m  
HQ 2: 1.68 m to 3.30 m





OCP-15-0456  
Westbrook Road - South Side

BH16-2-W  
HQ 4: 3.30 m to 4.83 m

## **Appendix E**

### **Laboratory Test Results**



**Stantec**

**Stantec Consulting Ltd**  
2781 Lancaster Rd, Suite 100B  
Ottawa, ON K1B 1A7  
Tel: (613) 738-6075  
Fax: (613) 722-2799

March 24, 2016  
File: 122410330

**Attention:** Mary-Ellen Gleeson, McIntosh Perry  
**Reference:** ASTM D7012, Unconfined Compressive Strength of Intact Rock Core, Method C

The table below summarizes twelve Rock Core compressive strength results.

Location	Sample Depth (m)	Compressive Strength (MPa)	Description of Break
BH16-1 HQ-2	0.78	128.9	Well-formed cone on one end, vertical cracks through other
BH16-1 HQ-3	1.823	117.3	Two well-formed cones on either end
BH16-1 HQ-4	3.706	121.1	Two well-formed cones on either end
BH16-2 HQ-2	1.096	158.8	Two well-formed cones on either end
BH16-2 HQ-3	2.606	131.0	Well-formed cone on one end, vertical cracks through other
BH16-2 HQ-4	3.562	140.7	No well-formed cones, vertical cracks through other
BH16-3 HQ-3 (1)	2.766	132.8	One cone, vertical cracks through other
BH16-3 HQ-3 (2)	3.056	116.2	Diagonal crack through the centre of the core
BH16-3 HQ-4 (1)	3.421	133.2	One well-formed cone, vertical cracks through other
BH16-3 HQ-4 (2)	3.971	144.3	Two well-formed cones on either end
BH16-4 HQ-2	1.569	137.1	Two well-formed cones on either end
BH16-4 HQ-4	3.832	139.8	No well-formed cones, vertical cracks through both ends

**Stantec**

March 24, 2016

122410330

Page 2 of 2

Sincerely,

**Stantec Consulting Ltd**



Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)



April 6, 2016

**Re: Stantec Consulting Ltd; Rock Core Compressive Strength Results**

Due to a change in the naming convention of the borehole and rock core runs please refer to the table below which shows the results with respect to the appropriately naming convention.

Location (Stantec)	Location (corrected)	Sample Depth (m)	Compressive Strength (MPa)	Description of Break
BH16-1 HQ-2	BH16-1-W HQ-1	0.78	128.9	Well-formed cone on one end, vertical cracks through other
BH16-1 HQ-3	BH16-1-W HQ-2	1.823	117.3	Two well-formed cones on either end
BH16-1 HQ-4	BH16-1-W HQ-3	3.706	121.1	Two well-formed cones on either end
BH16-2 HQ-2	BH16-2-W HQ-1	1.906	158.8	Two well-formed cones on either end
BH16-2 HQ-3	BH16-2-W HQ-2	2.606	131.0	Well-formed cone on one end, vertical cracks through other
BH16-2 HQ-4	BH16-2-W HQ-3	3.562	140.7	No well-formed cones, vertical cracks through other
BH16-3 HQ-3 (1)	BH16-1-O HQ-2 (1)	2.766	132.8	One cone, vertical crack through the centre of the core
BH16-3 HQ-3 (2)	BH16-1-O HQ-2 (2)	3.056	116.2	Diagonal crack through the centre of the core
BH16-3 HQ-4 (1)	BH16-1-O HQ-3 (1)	3.421	133.2	One well-formed cone, vertical cracks through other
BH16-3 HQ-4 (2)	BH16-1-O HQ-3 (2)	3.971	144.3	Two well-formed cones on either side
BH16-4 HQ-2	BH16-2-O HQ-1	1.5969	137.1	Two well-formed cones on either side
BH16-4 HQ-4	BH16-2-O HQ-3	3.832	139.8	No well-formed cones, vertical cracks through both ends

## **Appendix F**

### **Explanation of Terms Used in Report**

## EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS  $\bar{N}$ .

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$C_u$ (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

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

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINT AND BEDDING:**

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	GS	GRAB SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$c_c$	1	COMPRESSION INDEX
$c_s$	1	SWELLING INDEX
$c_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\Phi$	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\Phi_u$	°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

$P_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1.0%	VOID RATIO	$e_{\min}$	1.0%	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1.0%	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1.0%	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$s_r$	%	DEGREE OF SATURATION	$D_n$	mm	N PERCENT – DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_P$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_P$	%	PLASTICITY INDEX = $(W_L - W_P)$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(W - W_P) / I_P$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $(W_L - W) / I_P$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1.0%	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						



## **Geotechnical Investigation Report**

### **Part 2: Engineering Discussion and Recommendations**

*Bell Canada Conduit; Highway 401*  
*Westbrook Road (GEOCRES No. 31C-244)*

**Prepared for:**

Richard Robert  
Planview Utility Services Ltd.  
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L3R 4B9

**Prepared by:**

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115 Walgreen Road  
Carp, ON  
K0A 1L0

**June, 2016 - Revised**  
**CP-15-0412**

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Appendix H – Non-Standard Specification

Appendix I – Proposed Instrumentation and Monitoring Guidelines

# **Geotechnical Investigation and Design Report for Bell Canada Conduit Across Highway 401 Part 2 – Engineering Discussions and Recommendations**

## **8.0 DISCUSSION AND RECOMMENDATIONS**

### **8.1 General**

This section of the report provides recommendations for the design of the proposed installation of casing by trenchless methods to carry Bell cable across Highway 401, 23.5 m west of Westbrook Bridge located in Westbrook, Kingston, Ontario. The recommendations are based on interpretation of the factual information obtained from the boreholes advanced during this subsurface investigation. The discussions and recommendations presented are intended to provide sufficient information to the designer of the casing installation by trenchless methods.

The comments made on the construction are intended to highlight those aspects that could have impact or affect the detail design of the installation, for which special provisions may be required in the Contract Documents. Those who require information on construction aspects should make their own interpretation of the factual data presented under a separate volume. Interpretation of the data presented may affect equipment selection, proposed construction methods, and scheduling of construction activities.

### **8.2 Proposed Installation**

Bell Canada is proposing to carry communication cables across Highway 401 from the south side of eastbound lanes to north side of westbound lanes. The cables are proposed to be placed in multiple carrier pipes, encased in 356 mm diameter steel casing. Gauge of the steel casing shall be designed by the specialty contractor. The total length of the casing and carrier pipe across the highway will be approximately 100 m. Based on the method of installation opted, the overcut or over break between the external wall of the casing and excavated bore will be grouted to minimize the post-construction settlement. The preliminary drawings provided by Planview indicate that the invert of the casing will be located at about El. 118.1 and the entry and receiving pits will have adequate setback from the highway corridor on both sides of the road. The elevations at key locations along the proposed alignment are provided in Table 8-1 below to verify whether the depth of cover meets the requirements of MTO Corridor Management policy for encroachments and utilities.

The utility clearances carried out by MTO and ON1Call, prior to the site investigation did not identify any underground utilities such as gas line, storm sewer lines, electrical or telecommunication cables within the proximity of the proposed alignment of tunnel. It appears that the storm sewer in this area is carried by the



drainage ditches located on both sides of the highway and the median, and no existing utilities are expected to impose any potential conflict with the proposed alignment of the tunnel.

The scope of geotechnical investigation work carried out by McIntosh Perry does not cover or include accessing beyond location of boreholes and easement requirements. However, the specialty contractor and owner of the utility shall confirm the existence of any utility or obstructions that may impose potential conflict with the proposed alignment and advised to obtain necessary permits, prior to the commencement of construction.

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

**Table 8-1: Key Elevations in Alignment Profile**

<b>Location Along Casing Alignment</b>	<b>Approximate Elevation (m)</b>	<b>Depth of Cover (m)</b>
Eastbound Ditch Line	120.1	1.64
Eastbound Lanes C/L	120.9	2.44
Median Ditch Line	119.9	1.44
Westbound Lanes C/L	120.8	2.34
Westbound Ditch Line	120.2	1.74
Proposed Invert of Casing	118.1	-

### **8.3 MTO Requirements and Policy for Encroachments and Utilities**

MTO does not permit open cut or trenching for installation of pipe or conduit across 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 or drive and receiving pits are required to be located at the bottom of the ditch-line and back-slope of the ditch. In a fill area, pits should be located beyond the toe of the slope or embankment. Open cut or trenching and entry or receiving pit are prohibited within 3.0 m of the travelled portion of the highway or within the shoulder area of the highway.

The standard depth of cover for buried utility pipes under the travelled portion of the highway should not be less than 1.2 m. In Southern Ontario, the depth of cover for buried pipes should not be less than 0.75 m below the bottom of a highway ditch. The proposed depth of cover along the alignment provided in Table 8-1 exceeds the MTO policy requirements for encroachments and utilities.

### **8.4 Site Description and Subsoil Conditions**

#### **8.4.1 Site Description**

Based on the available site plans and as indicated during our site visits, there is adequate space available to set up entry and receiving pits on site. McIntosh Perry does not possess any information on the land

ownership within areas adjoining the MTO Corridor. The Owner and/or its agents are responsible to enquire necessary encroachment permits and work permits from public and private stake holders.

#### **8.4.2 Subsoil Conditions**

In general, a relatively thin layer of base and subbase fill material is underlain by limestone of Gull River and Bobcaygeon Formation. It is inter-bedded with thin layers of shale. The bedrock encountered to the proposed invert elevation of casing (El. 118.1) is highly to moderately weathered and intensely fractured. The quality of the bedrock to El. 117.9 may be classified as poor to fair quality. However, the bedrock below the proposed invert elevation of El. 118.1 is slightly weathered and moderately fractured and the bedrock to the depth of termination may be classified as fair to good quality.

The highest groundwater level measured in the standpipes was at about El. 120.2 or approximately 0.20 m below the surface of the borehole locations.

### **8.5 Seismic Zone and Site Response**

The National Building Code of Canada (NBCC, 2005) presents the seismic hazard for Canada in terms of a probabilistic based uniform hazard spectrum. The central part of Canada is identified as the low-seismicity region and is defined as the “Stable Canada”.

The bedrock below the proposed invert elevation (El. 118.1) of casing is slightly weathered and moderately fractured to the depth of termination of boreholes. Overall, the bedrock below the invert elevation may be classified as fair to good quality. The compressive strength of the selected samples from the rock cores below El. 118.2 range from 121.1 MPa to 140.7 MPa.

Based on the quality of the bedrock, the site may be classified as a Site Class “B” for the purposes of site-specific seismic response to earthquakes based on Table 4.1.8.4.A of Ontario Building Code (OBC) 2012 as well as Table 4.1 of Canadian Highway Bridge Design Code (CHBDC, 2014), if the invert of the casing is located below El. 118.1.

## **9.0 INSTALLATION USING TRENCHLESS TECHNOLOGY**

### **9.1 Selection of Installation Method**

The installation of casing at this site requires boring through highly to moderately weathered and intensely fractured limestone bedrock. There are number of trenchless technologies employed in the industry depending on the site conditions and the size of the casing to be installed. The bedrock encountered immediately below the thin mantle of sandy gravel fill and the size of the proposed utility casing limit the number of trenchless technology options that can be employed at this site. Open cut or trenching to install the casing to carry the Bell cables does not comply with the MTO policy for encroachments and utilities,

especially across four hundred series highway. Pipe jacking method is generally unsuitable to install utility pipe or casing through bedrock and the minimum diameter of the boring should be 1.07 m to employ this method. Pipe ramming method is inexpensive and the technology is available for installing casing with diameter as low as 305 mm. However, this method is not suitable to install casing through bedrock. Once the method of installation of Bell casing by trenchless method is selected, the general requirements for the installation may be addressed with a Non Standard Special Provision (NSSP).

As recommended by the MTO guidelines all practical installation methods were considered and evaluated. The discussions and recommendations below are limited only to the trenchless technologies that are employable at this site. A comparison of the technical advantages and disadvantages of the trenchless technology or option for the installation of casing are presented in Appendix G.

#### **9.1.1 Option 1 - Horizontal Directional Drilling (HDD)**

The use of HDD method to install the pipe through the highly to moderately weathered, intensely fractured, and poor to fair quality bedrock at this site is possible but difficulties may occur while advancing the borehole. The difficulty could be alleviated by allowing installation at a deeper depth through the slightly weathered to unweathered and fair to good quality bedrock without changing the entry and receiving locations. Adequate space is available at the site to accommodate a desired entry and exit angle. HDD drilling method has the fastest boring rate among all the trenchless methods. In the past, it was generally used in full face bedrock with compressive strength less than about 103 MPa (15 Kips/in<sup>2</sup>). Currently, equipment and technology are available in Ontario to drill through bedrock with compressive strength as high as 140 MPa (20 Kips/in<sup>2</sup>). The compressive strength of the selected rock cores from this site range from 121 MPa to 140 MPa. Therefore, the contractor shall be pre-qualified and selected based on their ability to install the pipe through the bedrock encountered at this site. This may have to be taken into consideration when planning the installation by HDD method.

This trenchless application is widely used for installing pressure lines, water lines, gas lines and cables. The proposed 356 mm diameter casing to carry Bell cables falls under Midi-HDD Class used to construct medium diameter pipes. Pipes used in this class are made of high density Polyethylene (HDPE), ductile iron or steel. This method can be used to install utility pipes with diameter as low as 50 mm, which is significantly smaller than the diameter of the proposed casing of 356 mm, and is capable of boring up to a length of 1850 m.

HDD method of installation involves a three phase process and uses a steerable arc drilling rig. In the first phase, a drill bit tool creates a pilot-hole approximately 25 mm to 125 mm in diameter, from the entry to the receiving locations at an angle of 5 to 30 degrees from the ground surface. The second phase of the process is reaming to enlarge the boring by approximately 50% and prepares it for placement of casing. In this phase, a reamer tool replaces the drill bit and is pulled back or pushed forward by the HDD machinery to expand the pilot-hole. Care should be taken to prevent rock crushing at higher elevations close to entry and exit locations and it may lead to loss of ground. Third phase is the pullback of the pipe into place by attaching the

pipe to the reamer and pulling through the HDD borehole. Drilling fluid is used to suspend and remove cuttings, reduce friction, cool and lubricate the drill bit.

There are no known utilities or obstacles at this site that conflict with the proposed alignment. However, the bore path in this method can be monitored and adjusted according to the location of the proposed utility or obstacles that are encountered. It is a surface launched and no entry or receiving pits are required, other than work space at both ends for storage and equipment. This method of installation results in a safer environment for construction workers. Accuracy of HDD methods is dependent on the skill of the Operator. However, the recent advancements in technologies allow more precise control of the bore path.

The borehole for HDD method required to be oversized to facilitate the installation of casing. However, OPSS 450 limits the final staged ream to no more than 1.5 times the largest outside diameter of the casing and requires that the drilling mud in the annular space shall not be removed after installation, and permitted to solidify to provide support for the pipe and the surrounding soil or rock. The potential for hydraulic fracturing under the highway is expected to be low if the pipe is installed at the proposed depth. Pressure loss of drilling fluid may occur, considering the highly to moderately weathered and poor to fair quality bedrock above the proposed alignment. For these reasons, the grout mix should be designed by the contractor and the requirements of the grout mix shall be addressed with a Non Standard Special Provision (NSSP).

#### **9.1.2      *Option 2 - Jack and Bore***

Jack and bore method is generally used in weathered to unweathered rock and is preferable for the quality of bedrock encountered at this site. This method is applicable for all types of crossings to install utility pipes to a maximum length of 150 m, which is longer than the length of the proposed Bell casing of 100 m. The diameter of the proposed casing is expected to be 356 mm, which is larger than the minimum diameter of 203 mm required to employ this method. The pipe for employing this method must resist abrasion caused by the rotation of augers and steel is the typical material used, although concrete pipe may also be used. The bedrock encountered at this site may warrant steel pipe. Jack and bore method is generally used in full face bedrock with compressive strength less than about 83 MPa (15 Kips/in<sup>2</sup>). The compressive strength of the rock core samples tested range from 121 MPa to 140 MPa, which may reduce the rate of advancing the boring or limit the feasibility of using this method at this site unless, a drill bit that is capable of advancing through bedrock with compressive strength higher than 83 MPa is used.

Jack and bore is a process of simultaneously jacking casing while removing the spoil material by means of an auger. A rotating cutting head is attached to the leading edge of the auger string. The spoil is transported back by the rotation of auger flights within the steel pipe casing being placed. Surface subsidence and heave during construction may pose major problems. Heave occurs when excessive force is applied to the face of excavation and surface subsidence occurs when over excavation is permitted. Lubrication system is optional for this method and the lubricants are typically bentonite and polymer mix. The workers are not required to

enter the shaft during construction, however, working space for entry and receiving 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 most critical part of using this method is positioning the track system on the same line and grade as the bore. The drive shaft should have a stable foundation and an adequate thrust block to transmit the horizontal jacking force. The bedrock encountered at this site is capable of providing adequate thrust for transmitting the horizontal jacking force. The track system will require at least 2.5 m deep rock excavation and a dewatering scheme to maintain the shaft in drained condition. In addition, a secure fence around the perimeter of the access shaft area with gates and truck entrances are required as specified in OPSS 416. The fence should be removed and shaft should be back filled and restored to original conditions upon completion of the work.

Jack and bore technique has limited steering ability, which can affect the line and grade accuracy. It is typically unguided once it is launched and any subsurface obstructions can cause large deflection. Recent improvements in the technology allow significantly greater accuracy and an accuracy of one percent of the length of drive can be achieved in vertical grade with the steering head and water-level grade monitoring system. However, horizontal alignment is generally not controlled.

#### **9.1.3      *Option 3 - Microtunnelling***

The use of microtunnelling is possible at this site, however, difficulties may occur while advancing through intensely fractured bedrock. This method is widely used for installation of sewer lines and the techniques can be used successfully for installation of casing with a minimum diameter of 250 mm to a maximum length of 300 m. However, large obstructions can pose significant problems and it may result in excavation of rescue shaft if the obstruction cannot be removed. The type of pipe material used are steel, reinforced concrete, and glass-fiber reinforced plastic. Microtunnelling method can be used in full face bedrock with compressive strength as high as approximately 207 MPa (30 Kips/in<sup>2</sup>), which is substantially higher than the compressive strength of the rock cores tested.

Microtunnelling is a remotely controlled and guided pipe jacking technique that provides continuous support to the excavation face and does not require personnel entry into the tunnel or drive shaft. Microtunnelling can be used in wide variety of subsurface conditions with a precise automated guidance while maintaining very close tolerances to line and grade. Two types of microtunnelling, namely the slurry type and auger type are used in the industry. The slurry type is the more commonly used method to remove spoils. This method requires significant excavation of bedrock to construct drive and receiving shafts. The drive and receiving shafts will require a length ranging from 15 m to 30 m and width ranging from 6 m to 12 m.

This method of installation is extremely accurate and a positional accuracy of 25 mm can be achieved along the entire pipe run. The rotating cutting head typically overcuts by about 13 mm to reduce friction on the advancing casing. Contact grouting with cement and bentonite mix may require at the end of advancing the casing to fill the overcut to minimise post construction settlement.

The cost effectiveness of this method will depend on the availability of a contractor with previously used tunnel boring machine (TBM) meeting the size required at this site. The cost associated with microtunnelling may be substantial and uneconomical unless a contractor with previously used TBM can be found.

#### **9.1.4      *Recommended Method***

Considering the quality of the bedrock encountered at this site and to minimize the disturbance or impact on the MTO corridor and interruption of traffic, HDD method is recommended for the installation of casing to carry the Bell cables across the highway. This method meets with the requirements of MTO policy for encroachments and utilities and provided the fastest boring rate.

Microtunnelling method discussed above is technically feasible to execute but this method requires significant excavation of bedrock to launch the rigs at the entry and receiving pits. Considering the compressive strength of the bedrock at this site, jack and bore method may not be technically feasible. For these reasons, neither of these two methods are recommended.

#### **9.1.5      *Location of Entry and Receiving Pits***

The locations for entry and exit pits are shown on Figure 2 included in the Appendix B. The size of the pits shall be designed to accommodate for pressure relief of drilling fluid. The depth of excavation for entry and receiving pits may vary depending on the method of installation. Considering the quality of bedrock to the depth of excavation, the excavation to the required depth may require a designed protection system.

As required by the MTO guidelines, Contractor shall be responsible for restoration and a warranty provision shall be included in the contract documents by addressing with a Non-Standard Special Provision (NNSP). Both pits shall be restored in accordance with the requirements of OPSS 492, upon completion of the drilling and installation of casing. The ground shall be restored to the original elevation and the site shall be revisited by the general contractor and remediated in case of any ground subsidence. Excavation protection system shall be designed and stamped drawings must be provided to the Construction Contract Administrator prior to the commencement of work.

## **10.0      DEWATERING SYSTEM**

Both boreholes were located at the lowest location (bottom of ditch) of the site. Groundwater was observed in BH16-W-1 at a depth of 1.16 m (El. 119.3) and at and at a depth of 0.2 m (El 120.2) below the existing ground surface at the borehole locations, respectively. High water level observed in the boreholes may have resulted from percolation or seeping of surface run-off from the higher elevations. The depth of water level may be expected vary depending on the season.

The excavation for the entry and receiving pits is expected to extend below El. 118.1 and the pits should be maintained in dry condition. If any groundwater or surface run-off encountered during the excavation, a

commonly used sump and pump method should be adequate to control the water. Sump should be located away and isolated from the pits to control the flow of water into the pits.

## **11.0 CONSTRUCTION CONSIDERATIONS**

### **11.1 Installation of Casing**

The drilling and reaming to expand the pilot-hole in the HDD method will originate from the surface of the bedrock at the entry and receiving pits where only a thin overburden is available. Lack of overburden may result in crushing of rock while reaming near the surface. The crushing of rock may lead to subsidence of the surface and care should be taken to prevent such occurrence.

In the jack and bore method, surface subsidence and heave during drilling may pose major problems, especially with a limited depth of cover at this site. Surface subsidence occurs when over excavation is permitted while advancing the boring and heave occurs when excessive force is applied to the face of excavation. This can cause damage to the road and result in major traffic interruption.

In the microtunnelling method, large obstructions can pose significant problems and it may result in excavation of rescue shaft if the obstruction cannot be overcome. Sometimes the proposed alignment may have to be abandoned, especially under the highway to prevent any interruption of traffic.

### **11.2 Rock Excavation for Entry and Drive Pits**

Significant excavation through limestone bedrock will be required to launch the drill rigs at the entry and receiving pits for jack and bore and microtunnelling methods. The depth of excavation will be at least 2.5 m to the grade of the invert of casing (El. 118.1). Rock excavation may be conducted through line drilling in conjunction with hoe-ramming, considering the quality of the bedrock to the invert level. Controlled blasting is not recommended at this due to close proximity to the Westbrook underpass and residential properties to the area of excavation.

In case any blasting is employed for rock excavation, the peak particle velocity during blasting shall be limited to 50 mm per second to avoid any damage to the adjoining bridge and it should be limited to 10 mm per second to prevent any discomfort to residents near the site.

The excavations for the entry and receiving pits would be advanced through highly to moderately weathered and intensely fractured limestone bedrock. The excavation should be completed in accordance with Ontario Regulation (O.Reg.) 213/91 under the Occupational Health and Safety Act (OHSA) with specific reference to acceptable stabilization requirements. The general stratigraphy outlined OHSA are applicable only to soils. Considering the quality of bedrock and the depth of excavation, a properly designed protection system will be required to protect the machinery and workers. Entry and receiving pits shall be of a size commensurate with safe working practices.

### **11.3 Settlement Monitoring**

As required by the MTO guidelines, the contractor shall have a monitoring plan to monitor the existing structures and the utilities along the alignment of the Bell cable crossing during construction. Contractor shall be responsible for condition survey, reading data, data collection and transfer of data. The requirements for monitoring during construction shall be addressed with a NSSP.

The existing conditions of the highway pavements along the close proximity of the proposed alignment are provided in Section 6.0, Pavement Conditions, in the factual part of the report. Monitoring pins at the toe of the embankments on both sides of the eastbound and westbound lanes as required by MTO have been installed and anchored below frost penetration depth. In addition, the monitoring points on paved area at 5 m intervals on both sides of the proposed alignment are already marked. Monitoring requirements as outlined in the MTO guidelines as well as proposed monitoring plans are included in Appendix I.

The non-standard specifications published by MTO and titled Pipe Installation by Trenchless Method is provided in Appendix H. The attached NSSP shall be included in the tender package.



## **12.0 CLOSURE**

The field work was carried out under the supervision of Corey O'Neil and direction of N'eem Tavakkoli. The equipment used was owned and operated by CCC Geotechnical & Environmental Drilling Ltd. of Ottawa, Ontario

This Geotechnical Investigation Report was prepared by N'eem Tavakkoli, P.Eng., Senior Geotechnical Engineer, Cara Stapley, P.Eng., and Mary-Ellen Gleeson, EIT, Geotechnical Engineering Intern. Peer Review was done by Mark Vasavithasan, P.Eng., and Carlos Nascimento, P.Eng., who is the designated principal MTO contact at Peto MacCallum Ltd for Medium and High Complexity Foundation Engineering and Tunneling specialties.

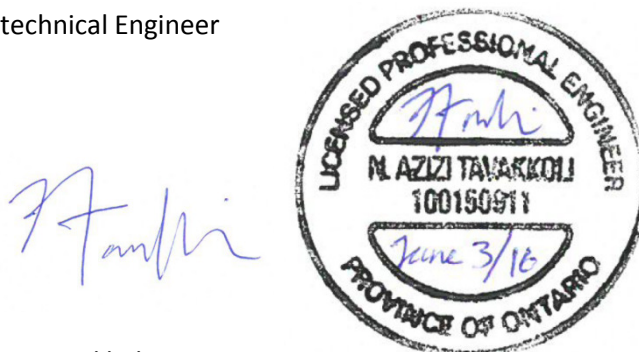
The "Limitations of Report" presented in Appendix A are an integral part of this report.

McIntosh Perry Consulting Engineers Ltd.

Mary-Ellen Gleeson, M.Eng., EIT.  
Geotechnical Engineering Intern



Cara Stapley, P.Eng.  
Geotechnical Engineer



N'eem Tavakkoli, M.Eng., P.Eng.  
Senior Geotechnical Engineer

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## **Appendix A**

### **Limitations of Report**

## LIMITATIONS OF REPORT

---

McIntosh Perry Consulting Engineers Ltd. (MPCE) carried out the field work and prepared the report. This document is an integral part of the Foundation Investigation and Design report presented.

The conclusions and recommendations provided in this report are based on the information obtained at the borehole locations where the tests were conducted. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the specific locations where tests were conducted and conditions may become apparent during construction, which were not detected and could not be anticipated at the time of the site investigation. The benchmark level used and borehole elevations presented in this report are primarily to establish relative differences in elevations between the borehole locations and should not be used for other purposes such as to establish elevations for grading, depth of excavations or for planning construction.

The recommendations presented in this report for design are applicable only to the intended structure and the project described in the scope of the work, and if constructed in accordance with the details outlined in the report. Unless otherwise noted, the information contained in this report does not reflect on any environmental aspects of either the site or the subsurface conditions.

The comments or recommendation provided in this report on potential construction problems and possible construction methods are intended only to guide the designer. The number of boreholes advanced at this site may not be sufficient or adequate to reveal all the subsurface information or factors that may affect the method and cost of construction. The contractors who are undertaking the construction shall make their own interpretation of the factual data presented in this report and make their conclusions, as to how the subsurface conditions of the site may affect their construction work.

The boundaries between soil strata presented in the report are based on information obtained at the borehole locations. The boundaries of the soil strata between borehole locations are assumed from geological evidences. If differing site conditions are encountered, or if the Client becomes aware of any additional information that differs from or is relevant to the MPCE findings, the Client agrees to immediately advise MPCE so that the conclusions presented in this report may be re-evaluated.

Under no circumstances shall the liability of MPCE for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify MPCE. Such errors and omissions policies are available for inspection by the Client at all times upon request, and if the Client desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, MPCE will co-operate with the Client to obtain such insurance.

MPCE prepared this report for the exclusive use of the Client. Any use which a third party makes of this report, or any reliance on or decision to be made based on it, are the responsibility of such third parties. MPCE accepts no responsibility and will not be liable for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

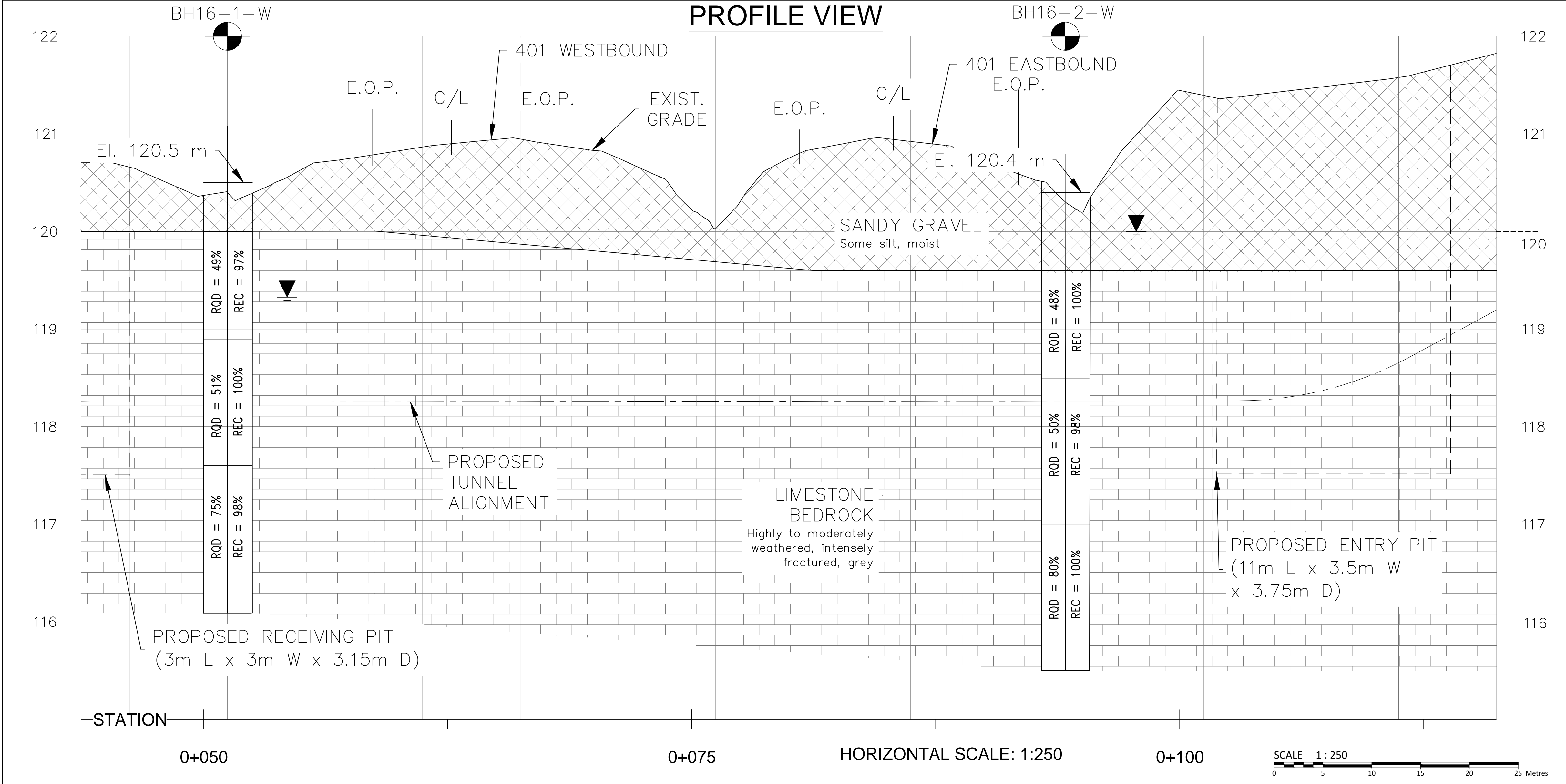
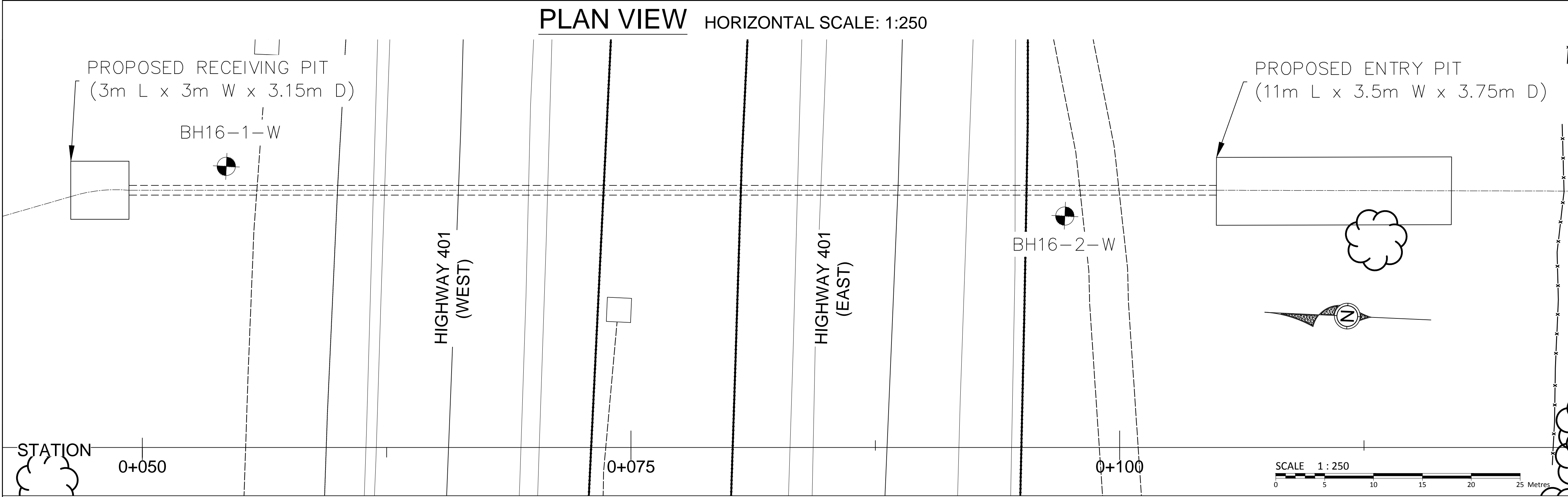


## **Appendix B**

### **Figures**







METRIC

PLATE No PLATE

MTO GEOCRES NO.  
31C-244

BORE HOLE LOCATIONS  
AND SOIL STRATA  
HWY 401 AND WESTBROOK ROAD

Survey SURVEYED Revised REVISED

**McINTOSH PERRY** **MP**

115 Walgreen Road R.R. #3, Carp, ON K0A 1L0  
Tel: 613-836-2184 Fax: 613-836-3742

Figure 2

LICENSED PROFESSIONAL ENGINEER  
M. AZIZI TAVAKOLI  
100150911  
June 3/16  
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER  
C. L. STAPLEY  
100128923  
03/06/2016  
PROVINCE OF ONTARIO

**KEY MAP (N.T.S.)**

SMITH RD.

GENGE RD.

HIGHWAY 401

WESTBROOK RD.

**LEGEND**

BOREHOLE

GROUND WATER LEVEL

**BORE HOLE COORDINATES**

BORE HOLE	ELEVATION (m)	NORTHING	EASTING
BH16-1-W	120.5	4905268.161	294470.506
BH16-2-W	120.4	4905224.845	294469.940

NOTE:  
The boundaries between soil strata have been established only at bore hole locations. Between bore holes the boundaries are assumed from geological evidence.

## **Appendix C Pavement Reports**

# FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location: Highway 401

From: 35 meters west of westbrook bridge Centerline

To: 25 meters west of westbrook Rd Bridge Centerline

LHRS

BEGINS  
[ ][ ][ ][ ]

OFFSET  
[ ][ ] • [ ][ ] km

Section

Length  
[ ][ ] • [ ][ ] 0 km  
LENGTH

Traffic  
Direction

Survey Date

YEAR MONTH  
[1][6] [3]

PCR

[9][5]

RCR

[9][7]

Contract No.

Ride  
Condition  
Rating  
(at 80 km/h)

10 EXCELLENT  
Smooth and pleasant  
8 GOOD  
Comfortable  
6 FAIR  
Uncomfortable  
4 POOR  
Very rough and bumpy  
2 VERY POOR  
Dangerous at 80 km/h  
0

WP No.

[ ][ ][ ][ ] - [ ][ ][ ] - [ ][ ][ ][ ]

Facility

E

B: BOTH DIRECTIONS  
N: NORTH BOUND  
S: SOUTH BOUND  
E: EAST BOUND  
W: WEST BOUND

District

[ ][ ]

Highway

[4][0][1]

A

A: ALL LANES  
C: COLLECTOR  
E: EXPRESS  
O: OTHERS  
(Additional Lanes)

Class

F: FREEWAY  
A: ARTERIAL  
C: COLLECTOR  
L: LOCAL  
S: SECONDARY

Pavement		Distress Type		We	Ve	Sl	Mo	Se	Ve						DMI count
				(wi)	0.5	1	2	3	4	<10	10-20	20-50	50-80	80-100	
Surface Defects		Ravelling & C. Agg. Loss	1	3.0											0.00
		Flushing	2	1.5											0.00
Surface Deformations		Rippling and Shoving	3	1.0											0.00
		Wheel Track Rutting	4	3.0											0.00
		Distortion	5	3.0											0.00
Cracking	Longitudinal Wheel Track	Single and Multiple	6	1.5											0.00
		Alligator	7	3.0											0.00
	Centre Line	Single and Multiple	8	0.5											1.50
		Alligator	9	2.0											0.00
	Pavement Edge	Single and Multiple	10	0.5											0.00
		Alligator	11	1.5											0.00
	Transverse	Half, Full and Multiple	12	1.0											4.00
		Alligator	13	3.0											0.00
	Long Meander and Midlane		14	1.0											0.00
	Random		15	0.5											0.00
Ride Condition Rating (RCR) from 0-10:				9.5										DMI	9.7

PCI Value: 96

Distress comments (Items not covered above)

Centerline Crack most likely from cold joint during paving

Moderate multiple transverse crack accross highway

Shoulders			Severity of Distress				Density of Distress (Extent of Occurrence, %)			
Dominant Type	one ft	Distress	Right		Left		Right		Left	
			Mod	Severe	Mod	Severe	10-30	>30	10-30	>30
Paved Full		Cracking								
Paved Partial		Pavement Edge/Curb Separation								
		Distortion								
Surface Treated		Breakup/Separation								
		Edge Break								
Primed		Breakup								
Gravel										

Maintenance Treatment		Extent of Occurrence, %				
		<10	10-20	20-50	50-80	>80
Pavement	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
Shoulders	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Other Comments (e.g. subsections, additional contracts)

Evaluated by

# FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location: Highway 401

From: 35 meters west of westbrook bridge Centerline

To: 25 meters west of westbrook Rd Bridge Centerline

LHRS       km  
BEGINS OFFSET

Section     0 km  
Length LENGTH

Traffic Direction

Survey Date  1  6  3  
YEAR MONTH

PCR  9  5 RCR  9  7

Contract No.

Ride Condition Rating (at 80 km/h)

10 EXCELLENT  
Smooth and pleasant  
8 GOOD  
Comfortable  
6 FAIR  
Uncomfortable  
4 POOR  
Very rough and bumpy  
2 VERY POOR  
Dangerous at 80 km/h  
0

WP No.     -   -

Facility

W  
B: BOTH DIRECTIONS  
N: NORTH BOUND  
S: SOUTH BOUND  
E: EAST BOUND  
W: WEST BOUND

District

Highway  4  0  1

A  
A: ALL LANES  
C: COLLECTOR  
E: EXPRESS  
O: OTHERS  
(Additional Lanes)

Class  F  
F: FREEWAY  
A: ARTERIAL  
C: COLLECTOR  
L: LOCAL  
S: SECONDARY

Pavement	Distress Type	Weight (wi)	Severity of Distress					Density of Distress (Extent of Occurrence, %)					DMI count
			Very Slight	Slight	Moderate	Severe	Very Severe	Few	Intermittent	Frequent	Extensive	Throughout	
Surface Defects	Ravelling & C. Agg. Loss	1	3.0										0.00
	Flushing	2	1.5										0.00
Surface Deformations	Rippling and Shoving	3	1.0										0.00
	Wheel Track Rutting	4	3.0										0.00
	Distortion	5	3.0										0.00
Cracking	Longitudinal Single and Multiple	6	1.5										0.00
	Alligator	7	3.0										0.00
	Centre Line Single and Multiple	8	0.5										1.50
	Alligator	9	2.0										0.00
	Pavement Edge Single and Multiple	10	0.5										0.00
	Alligator	11	1.5										0.00
	Transverse Half, Full and Multiple	12	1.0										2.00
	Alligator	13	3.0										0.00
	Long Meander and Midlane	14	1.0										0.00
	Random	15	0.5										0.00
Ride Condition Rating (RCR) from 0-10:			9.5					DMI 9.8					

PCI Value: 97

Distress comments (Items not covered above)

Centerline Crack most likely from cold joint during paving

Partial slight transverse crack in left lane

Shoulders			Severity of Distress				Density of Distress (Extent of Occurrence, %)			
Dominant Type	one ft	Distress	Right		Left		Right		Left	
			Mod	Severe	Mod	Severe	10-30	>30	10-30	>30
Paved Full		Cracking								
		Pavement Edge/Curb Separation								
Paved Partial		Distortion								
Surface Treated		Breakup/Separation								
		Edge Break								
Primed		Breakup								
Gravel										

Maintenance Treatment		Extent of Occurrence, %				
		<10	10-20	20-50	50-80	>80
Pavement	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
Shoulders	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Other Comments (e.g. subsections, additional contracts)

Evaluated by

## **Appendix D Borehole Logs**

## RECORD OF BOREHOLE No BH16-1-W

1 OF 1

METRIC

DATE 23/02/2016

ID 0CP-15-0412

LOCATION Co-ord: UTM Zone 18: 294470.506m E, 4905268.161 m N

ORIGINATED BY CO

CLIENT Planview

CONTRACTOR GET Drilling Ltd

COMPILED BY MG

ELEVATION 120.5

DATUM Geodetic

CHECKED BY NT

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
120.5								20	40	60	80	100					
120.0	SANDY GRAVEL, some silt, moist (FILL)	XXXX															
0.1																	
	LIMESTONE BEDROCK, highly weathered, very intensely factured, poor quality, grey																
119.8			1	RC HQ	REC 97%		120										RQD = 49% 128.9 MPa
0.7																	
	LIMESTONE BEDROCK, moderately weathered, intensely factured, poor to fair quality, grey		2	RC HQ	REC 100%		119										117.3 MPa
																	RQD = 51%
117.8							118										
2.7																	
	LIMESTONE BEDROCK, slightly weathered, moderately factured, fair quality, grey		3	RC HQ	REC 98%		117										RQD = 75% 121.1 MPa
116.1																	
4.4	END OF BOREHOLE																



**RECORD OF BOREHOLE No BH16-2-W**

1 OF 1

**METRIC**

DATE 23/02/2016

ID 0CP-15-0412

LOCATION Co-ord: UTM Zone 18: 294469.94m E, 4905224.845 m N

ORIGINATED BY CO

CLIENT Planview

CONTRACTOR GET Drilling Ltd

COMPILED BY MG

ELEVATION 120.4

DATUM Geodetic

CHECKED BY NT

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES (REC)			20	40	60	80	100		
120.4 0.0	<b>SANDY GRAVEL</b> , some silt, moist (FILL)						120							
119.7 0.7	<b>LIMESTONE BEDROCK</b> , weathered, intensely to moderately factured, poor quality, grey		1	RC HQ	REC 100%		119							158.8 MPa RQD = 48%
118.2 2.2			2	RC HQ	REC 98%		118							RQD = 50%  131.0 MPa
	<b>LIMESTONE BEDROCK</b> , slightly weathered, moderately factured, fair to good quality, grey		3	RC HQ	REC 100%		117							140.7 MPa
							116							RQD = 80%
115.6 4.8	<b>END OF BOREHOLE</b>													

## ROCK CORE DESCRIPTION

Project Name, Reference: Westbrook Road North, OCP-15-0412

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	Sample No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
16-1-W	1	0.05 – 1.55	97	49	0.05 – 4.45	<b>LIMESTONE (GULL RIVER FORMATION):</b> medium to dark brown- grey microcrystalline to fine crystalline limestone weathers mottled brown-grey to light grey. Mottled and laminar appearance from bioturbation and argillaceous content. Sparse sparry-calcite filled fossils.
	2	1.55 – 2.92	100	51		<ul style="list-style-type: none"> <li>- highly weathered and very intensely fractured from 0.05 to 0.66m</li> <li>- moderately weathered and intensely fractured from 0.66 to 2.67m</li> </ul> <p>Very thin irregular and discontinuous wavy shaly laminae and blebs within the limestone beds from 0.05 to 2.92m</p> <ul style="list-style-type: none"> <li>-intraclastic, bioturbated zone with mudstone intraclasts up to 4cm between 1.93m and 2.49.</li> </ul>
	3	2.92 – 4.45	98	75		<ul style="list-style-type: none"> <li>- stylolite at 1.98m</li> <li>- vertical fractures between 2.46-2.57 and 2.57 and 2.67m.</li> <li>- slightly weathered and moderately fractured from 2.67 to 4.45m</li> </ul> <p>Increase in laminated and irregular shaly zones; some with pronounced bioturbation and intraclasts between 2.92 and 4.45m.</p>

**CR\*** - Core Recovery

Logged by: Angela L. Gulley, P.Geo.

**RQD\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%

# ROCK CORE DESCRIPTION

Project Name, Reference: Westbrook Road South, OCP-15-0412

BH No.	CORE RECOVERY				CORE DESCRIPTION	
	Sample No.	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
16-2-W	1	0.69– 1.68	100	48	0.69 – 4.83	<p><b>LIMESTONE (GULL RIVER FORMATION):</b> medium to dark brown- grey microcrystalline to fine crystalline limestone weathers mottled brown-grey to light grey. Mottled and laminar appearance from bioturbation and argillaceous content. Sparse sparry-calcite filled fossils.</p> <p>- weathered and intensely to moderately fractured from 0.69 to 2.24m.</p>
	2	1.68 – 3.30	98	50		<p>Very thin irregular and discontinuous wavy shaly laminae and blebs with associated bioturbation within the limestone beds from 0.69 to 3.40m</p> <p>- stylolites at 1.07m and 1.58m - stylolites at 2.37m and 2.54m</p>
	3	3.30 – 4.83	100	80		<p>-slightly weathered and moderately fractured from 2.24 to 4.83m</p> <p>Greater occurrence of irregular shaly zones with more pronounced bioturbation within the limestone beds from 3.40 to 4.83m.</p>

**CR\*** - Core Recovery

Logged by: Angela L. Gulley, P.Geo.

**RQD\*** - Rock Quality Designation

**Note:** Depths are approximated where core recovery is less than 100%



0CP-15-0456  
Westbrook Road - North Side

BH16-1-W  
HQ 1: 0.05 m to 1.55 m  
HQ 2: 1.55 m to 2.92 m  
HQ 3: 2.92 m to 4.45 m





OCP-15-0456  
Westbrook Road - South Side

BH16-2-W  
HQ 1: 0.69 m to 1.68 m  
HQ 2: 1.68 m to 3.30 m





OCP-15-0456  
Westbrook Road - South Side

BH16-2-W  
HQ 4: 3.30 m to 4.83 m



## **Appendix E**

### **Laboratory Test Results**



**Stantec**

**Stantec Consulting Ltd**  
2781 Lancaster Rd, Suite 100B  
Ottawa, ON K1B 1A7  
Tel: (613) 738-6075  
Fax: (613) 722-2799

March 24, 2016  
File: 122410330

**Attention:** Mary-Ellen Gleeson, McIntosh Perry  
**Reference:** ASTM D7012, Unconfined Compressive Strength of Intact Rock Core, Method C

The table below summarizes twelve Rock Core compressive strength results.

Location	Sample Depth (m)	Compressive Strength (MPa)	Description of Break
BH16-1 HQ-2	0.78	128.9	Well-formed cone on one end, vertical cracks through other
BH16-1 HQ-3	1.823	117.3	Two well-formed cones on either end
BH16-1 HQ-4	3.706	121.1	Two well-formed cones on either end
BH16-2 HQ-2	1.096	158.8	Two well-formed cones on either end
BH16-2 HQ-3	2.606	131.0	Well-formed cone on one end, vertical cracks through other
BH16-2 HQ-4	3.562	140.7	No well-formed cones, vertical cracks through other
BH16-3 HQ-3 (1)	2.766	132.8	One cone, vertical cracks through other
BH16-3 HQ-3 (2)	3.056	116.2	Diagonal crack through the centre of the core
BH16-3 HQ-4 (1)	3.421	133.2	One well-formed cone, vertical cracks through other
BH16-3 HQ-4 (2)	3.971	144.3	Two well-formed cones on either end
BH16-4 HQ-2	1.569	137.1	Two well-formed cones on either end
BH16-4 HQ-4	3.832	139.8	No well-formed cones, vertical cracks through both ends

**Stantec**

March 24, 2016

122410330

Page 2 of 2

Sincerely,

**Stantec Consulting Ltd**



Brian Prevost  
Laboratory Supervisor  
Tel: 613-738-6075  
[brian.prevost@stantec.com](mailto:brian.prevost@stantec.com)

April 6, 2016

**Re: Stantec Consulting Ltd; Rock Core Compressive Strength Results**

Due to a change in the naming convention of the borehole and rock core runs please refer to the table below which shows the results with respect to the appropriately naming convention.

Location (Stantec)	Location (corrected)	Sample Depth (m)	Compressive Strength (MPa)	Description of Break
BH16-1 HQ-2	BH16-1-W HQ-1	0.78	128.9	Well-formed cone on one end, vertical cracks through other
BH16-1 HQ-3	BH16-1-W HQ-2	1.823	117.3	Two well-formed cones on either end
BH16-1 HQ-4	BH16-1-W HQ-3	3.706	121.1	Two well-formed cones on either end
BH16-2 HQ-2	BH16-2-W HQ-1	1.906	158.8	Two well-formed cones on either end
BH16-2 HQ-3	BH16-2-W HQ-2	2.606	131.0	Well-formed cone on one end, vertical cracks through other
BH16-2 HQ-4	BH16-2-W HQ-3	3.562	140.7	No well-formed cones, vertical cracks through other
BH16-3 HQ-3 (1)	BH16-1-O HQ-2 (1)	2.766	132.8	One cone, vertical crack through the centre of the core
BH16-3 HQ-3 (2)	BH16-1-O HQ-2 (2)	3.056	116.2	Diagonal crack through the centre of the core
BH16-3 HQ-4 (1)	BH16-1-O HQ-3 (1)	3.421	133.2	One well-formed cone, vertical cracks through other
BH16-3 HQ-4 (2)	BH16-1-O HQ-3 (2)	3.971	144.3	Two well-formed cones on either side
BH16-4 HQ-2	BH16-2-O HQ-1	1.5969	137.1	Two well-formed cones on either side
BH16-4 HQ-4	BH16-2-O HQ-3	3.832	139.8	No well-formed cones, vertical cracks through both ends

## **Appendix F**

### **Explanation of Terms Used in Report**

## EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS  $\bar{N}$ .

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$C_u$ (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

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

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINT AND BEDDING:**

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	GS	GRAB SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$c_c$	1	COMPRESSION INDEX
$c_s$	1	SWELLING INDEX
$c_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\Phi$	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\Phi_u$	°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

$P_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1.0%	VOID RATIO	$e_{\min}$	1.0%	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1.0%	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1.0%	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$s_r$	%	DEGREE OF SATURATION	$D_n$	mm	N PERCENT – DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_P$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_P$	%	PLASTICITY INDEX = $(W_L - W_P)$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(W - W_P) / I_P$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $(W_L - W) / I_P$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho^*$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1.0%	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^3$	SEEPAGE FORCE
$\gamma^*$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						



## **Appendix G**

### **Comparison of Tunnelling Options**

### Comparison of Alternate Trenchless Technology Options

Option 1: Horizontal Directional Drilling (HDD)	Option 2: Jack and Bore	Option 3: Microtunneling
<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. Applicable to variety of pipe diameters</li> <li>2. Surface launched and no entry or receiving pits are required</li> <li>3. Has the ability to control movement of the reamer and redirect</li> <li>4. HDD has the fastest boring rate among all the methods</li> <li>5. Bore path can be monitored and adjusted if obstacles are encountered</li> <li>6. Depth of installation can be adjusted independent of entry and receiving pits</li> </ol>	<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. Spoils are removed by auger through casing being placed</li> <li>2. Lubricant or drilling fluid is optional</li> <li>3. Relatively inexpensive</li> <li>4. Contractors may readily available</li> <li>5. Well suited for shorter tunnel lengths</li> </ol>	<b>Advantages:</b> <ol style="list-style-type: none"> <li>1. It is remotely controlled and positional accuracy is extremely accurate</li> <li>2. Better accuracy on line and grade compared to other methods</li> <li>3. Some obstruction can be overcome by reverse rotation</li> <li>4. Capable of balancing hydrostatic pressure and groundwater control may not be required</li> </ol>
<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Difficulties may occur in weathered and fractured bedrock</li> <li>2. Accuracy of placement varies widely and depends on skills of Operator</li> <li>3. Precise grade control may not be feasible</li> <li>4. Depending on the type of casing, longer staging area may be required for placing pipes</li> </ol>	<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Not feasible through bedrock with strength higher than 85 MPa</li> <li>2. Entry shaft need to be designed and constructed properly including dewatering scheme</li> <li>3. Require excavation in bedrock for entry and receiving pits</li> <li>4. It is typically unguided and horizontal alignment not controlled</li> <li>5. Subsurface obstructions can cause large deflection</li> <li>6. Requires operators with relatively high skills</li> </ol>	<b>Disadvantages:</b> <ol style="list-style-type: none"> <li>1. Relatively very expensive, especially if a Contractor with used TBM is not available</li> <li>2. Require significant excavation in bedrock for entry and receiving pits</li> <li>3. Require slurry separation unit to remove the spoil</li> <li>4. Large obstruction can pose significant problems</li> <li>5. Requires dewatering scheme for entry and exit pits</li> </ol>
<b>Cost of Installation:</b> \$/m or total cost: \$1200/m	<b>Cost of Installation:</b> \$/m or total cost: \$850/m	<b>Cost of Installation:</b> \$/m or total cost: \$2200/m
<b>Recommended</b>	<b>Not Feasible</b>	<b>Feasible But Not Recommended</b>

## **Appendix H**

### **Non-Standard Specification**

## **1.0 SCOPE**

This specification covers the general requirements for the trenchless installation of a 360 mm diameter steel casing for carrying Bell Canada communication cables across Highway 401.

The Contractor is to determine the most appropriate method of installation. Specifications for Jack and Bore, Horizontal Directional Drilling, and Microtunnelling are provided herein, and are to be applied to the installation method recommended by the Contractor.

The following specifications is to be used at the designers' discretion to do the work for the above tender item: OPSS 415 (Construction Specification for Pipeline and Utility Installation by Tunnelling), OPSS 416 (Construction Specification for Pipeline and Utility Installation by Jacking and Boring), and OPSS 450 (Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling). Some portions of the above mentioned specifications are applicable to municipal work only.

## **2.0 REFERENCES**

This specification refers to the following standards, specifications, or publications:

### **Geotechnical Investigation Report for Bell Canada Conduit across Highway 401**

#### **Part 1: Factual Information**

Highway 401 and Westbrook Road Crossing  
Bell Canada Conduit Crossing  
Kingston, ON  
McIntosh Perry Project No. OCP-15-0412

### **Geotechnical Investigation and Design Report for Bell Canada Conduit across Highway 401**

#### **Part 2: Engineering Discussions and Recommendations**

Highway 401 and Westbrook Road Crossing  
Bell Canada Conduit Crossing  
Kingston, ON  
McIntosh Perry Project No. OCP-15-0412

#### **Ontario Provincial Standard Specifications, General**

OPSS 180            Management and Disposal of Excess Material

#### **Ontario Provincial Standard Specifications, Construction**

OPSS 504            Preservation, Protection, and Reconstruction of Existing Facilities

OPSS 507            Site Restoration Following Installation of Pipelines, Utilities and Associated Structures in

	Open Cut
OPSS 514	Trenching, Backfilling, and Compaction
OPSS 517	Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 538	Support Systems
OPSS 539	Protection Schemes

#### **Ontario Provincial Standard Specifications, Material**

OPSS 1004	Aggregates - Miscellaneous
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe

#### **MTO Specifications**

OPSS 1820	Material Specification for Circular Concrete Pipe
OPSS 1840	Material Specification for Non-Pressure Polyethylene Plastic Pipe Products

#### **American Society for Testing and Materials (ASTM) International Standards**

ASTM A252-93	Welding and Seamless Steel Pipe Piles
ASTM D2657-03	Standard Practice for Heat Fusion Joining of Polyelofin Pipe and Fittings
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F894	Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

#### **Canadian Standards Association Standards:**

CSA B182.6	Profile Polyethylene Sewer Pipe and Fittings.
CAN/CSA A5-93	Portland Cement
CSA W59	Welded Steel Construction (Metal Arc Welding)

## **3.0 DEFINITIONS**

For the purpose of this specification, the following definitions apply:

**Drilling Fluid Fracture or Frac-Out:** a condition where the drilling fluid's pressure in the bore is sufficient to overcome the in situ confining stress, thereby fracturing the soil and/or rock materials and allowing the drilling fluids to migrate to the surface at an unplanned location.

**Engineer:** a Professional Engineer licensed by the Professional Engineers of Ontario to practice in the Province of Ontario.

**Excavation:** includes all materials encountered regardless of type and extent. Excavation is to include removal of natural soil, large boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

**Environmentally Sensitive Area (ESA):** areas adjacent to construction that are off limits to the Contractor as specified elsewhere in the Contract.

**Fill:** man-made mixture of previously placed/handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

**Grouting:** injection of grout into voids.

**Guidance System:** an electronic system capable of locating the position, depth and orientation of the drill head during the directional drilling process.

**HDPE:** high density polyethylene.

**Horizontal Directional Drilling (HDD):** directional boring or guided boring.

**Inadvertent Returns:** the flow of unexpected fluids, saturated materials (or running soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

**Jack and Bore:** a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead and rotating a cutter head, followed by removal of material from inside the bore.

**Loss of Circulation:** the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

**Pilot Bore:** the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

**Pipe Jacking:** a method for installing steel casing or concrete pipe in the subsurface utilizing hydraulically operated jacks of adequate number and capacity to ensure smooth and uniform advancement without overstressing the liner/pipe.

**Primary Liner (Support):** system installed prior to or concurrent with excavation, to maintain stability of an excavation and to support earth or rock and any structure utilities or other facilities in or on the supported earth or rock mass, until the excavation is completed.

**Product:** conduit pipes, pipe culverts, pipe sewers, watermain pipe and sanitary pipe.

**Pullback:** that part of the DD method in which the drill string is pulled back through the bore path to the entry point.



**Quality Verification Engineer (QVE):** an Engineer who has a minimum of five (5) years of experience in the field of pipe installation using trenchless methods or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Quality Verification Engineer is to be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

**Reaming:** a process for pulling a tool attached to the end of the drill string through the bore path to enlarge the bore and mix the cuttings with the drilling fluid. This typically includes multiple passes.

**Rock:** natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a size equivalent to 0.3 m in diameter or greater.

**Secondary Liner:** concrete pipe, HDPE pipe or un-reinforced cast-in-place concrete, installed subsequent to tunnel excavation.

**Shaft:** vertically sided excavation used as entry and/or exit points from which the trenchless method is initiated or directed for the installation of product.

**Strike Alert:** a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

**Slurry:** a mixture of soil and/or rock cuttings, and drilling fluid.

**Soil:** all materials except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials; includes rock fragments having an equivalent size less than 0.3 m in diameter.

**Tunnelling:** an underground method of constructing a passage open at both ends that involves installing a pipe.

## 4.0 DESIGN AND SUBMISSION REQUIREMENTS

### 4.1 General

The Contractor's documentation, submission requirements, and installation methods must specifically consider and address the subsurface conditions at each crossing as identified in Part 2: Engineering Discussion and Recommendations.

### 4.2 Working Drawings

Three copies of stamped working drawings for portal or shaft construction, primary liner, excavation, secondary lining, dewatering and groundwater control, and grouting is to be submitted to the Contract

Administrator (CA) at least one (1) week prior to the commencement of the work for reference purposes. All submissions are to bear the seal and signature of the Design Engineer and Design Checking Engineer. The Contractor is to have a copy of the stamped working drawings at the site during construction.

As a minimum, working drawings/details pertaining to the tunnel design and construction are to include the following (as appropriate):

a) Plans, Elevations, and Details:

- A work plan outlining the materials, procedures, methods, and schedule to be used to execute the work;
- A list of personnel, including backup personnel, and their qualifications and experience;
- A safety plan, including the company safety manual and emergency procedures;
- The work area layout;
- An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail;
- A drilling fluid management plan, if applicable, that addresses control of frac-out pressures and any potential environmental impacts, and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails;
- Lighting, ventilation, and fire safety details as may be required by applicable occupational health and safety regulations; and
- Excavated materials disposal plan

b) Design Criteria

- Primary liner design details, if applicable;
- Design assumption and material data when materials other than those specified are proposed for use; and
- Drill path design, details of alignment and alignment control, maximum curvature, and reaming stages;

c) Materials:

- Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer's product specification and that the materials supplied are suitable for the application; and
- Material mixture for filling voids and installation procedures.

d) Upstream/Downstream Portal Installation Procedure:

- The access shaft or entry/exit pit details designed and stamped/signed by the Design Engineer, as applicable; and

- Face support and other temporary support details, if applicable.
- e) Primary Liner/Secondary Liner Installation and Grouting Procedure:
  - Excavation and pipe jacking procedures, including methodology to handle obstructions and preventing soil cave-in; and
  - Details of tunnelling equipment/methods to be used for the works
- f) Excavation and Dewatering:
  - Ground control/dewatering details, as applicable, describing the proposed method for control, handling, treatment, and disposal of water.
- g) Alignment Monitoring Method:
  - The methods to be employed to monitor and maintain the alignment of the installation;

### **4.3 Site Survey**

Prior to commencing the work, the Contractor is to lay out the alignment and confirm locations of entry and exit pits. McIntosh Perry will only lay out the alignment of settlement monitoring points at road crossings within the road right-of-way.

### **4.4 Certificate of Conformance**

The Contractor is to submit details of the sequence and method of construction to the Quality Verification Engineer for review, which has already been prepared and stamped by the Design Engineer. The Contractor is to submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate is to state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor is to submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation for each pipe installation:

Site surveying

Excavation for pits including dewatering of excavation

Jacking/Ramming/Directional Drilling of Casing/Liner

Excavation and Dewatering

Installation of the Product

Grouting Operations

Each Certificate of Conformance is to state that the work has been carried out in general conformance with the contract documents, specifications, and/or stamped working drawings.

In addition, upon completion of the installation of the pipe at each location, the Contractor is to submit to the Contract Administrator a **final** Certificate of Conformance sealed and signed by the Quality Verification Engineer. The Certificate is to state that the pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, stamped working drawings, and contract documents.

The Design Engineer is not permitted to carry out the work of the Quality Verification Engineer.

## **5.0 MATERIALS**

### **5.1 Product**

The product is to be a steel casing as specified.

### **5.2 Steel**

Steel pipe is to be according to OPSS 1802 Material Specification for Smooth Walled Steel Pipe.

### **5.3 Concrete**

Concrete is to be according to OPSS 1350. The concrete strength is to be as specified in the Contractor's design submission.

### **5.4 Concrete Reinforcement**

Steel reinforcing for concrete work is to be according to OPSS 1440.

### **5.5 Timber**

Timber is to be sound, straight, and free from cracks, shakes, and large or loose knots.

### **5.6 Grout**

The Contractor is to submit the proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces. Purging grout is to consist of a mixture of one part Portland cement conforming to the requirements of CAN/CSA A5-93 and two parts mortar sand conforming to OPSS 1004, wetted with only sufficient water to make the mixture plastic.

### **5.7 Horizontal Directional Drilling Materials**

#### **5.7.1 Drilling Fluids**

The drilling fluids are to be mixed according to the manufacturer's recommendations and be appropriate for the anticipated subsurface conditions.

### **5.7.2**     *Pipe Materials*

The following is a list of material requirements for directional drilling piping:

- Steel Pipe shall satisfy requirements of OPSS 1802. The Contractor is to determine the required dimensional ratio (DR) of the steel pipe to support all subsurface conditions and hydrostatic pressures, and to withstand the grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.
- The Contractor's submission is to demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate the in-ground pressure without damage once subject to the heat of hydration generated by grout curing.
- Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.
- Jointing of steel piping is to be completed by welding in accordance with manufacturer's recommended procedures. All manufacturer's recommendations and procedures is to be followed during the jointing process.
- Jointing of steel piping to other piping materials or appurtenances is to be completed using flanged connections.

## **5.8**     **Jack and Bore Materials**

### **5.8.1**     *Pipe Materials*

Steel pipe is to conform to ASTM A252-95 welded joints suitable for jacking operations. The Contractor is to select pipe class for pipe jacking.

Concrete pipe must conform with OPSS 1820.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

## **5.9**     **Microtunnelling Materials**

### **5.9.1**     *Primary Liner*

Tunnelling methods will require installation of a primary liner to provide support and stability to the excavation.

### **5.9.2**     *Secondary Liner*

Concrete or High Density Polyethylene Pipe is to be used according to the following requirements.

### **5.9.3**     *Concrete Pipe*

Concrete pipe as per OPSS 1820 is to be used. The Contractor is to select the pipe class to withstand grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

#### **5.9.4     *High Density Polyethylene (HDPE)***

High Density Polyethylene (HDPE) pipe as per OPSS 1840 is to be used in accordance with ASTM D3350.

The requirements for fittings are to be according to CAN/CSA-B182.6 or ASTM F894.

The Contractor is to determine the required dimensional ratio (DR) to withstand the grouting pressure and installation forces. The Contractor is to identify these forces in his submission requirements.

Fittings are to be suitable for and compatible with the class and type of pipe with which they will be used.

Joining of HDPE piping is to be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures is to be followed during the joining process.

Joining of HDPE piping to other piping materials is to be completed using flanged connections.

#### **5.9.5     *Steel Pipe***

Steel pipe material as specified in Section 5.7.2.

## **6.0     EQUIPMENT**

### **6.1     Horizontal Directional Drilling Equipment**

#### **6.1.1     *General***

The directional drilling equipment is to consist of a directional drilling rig and a drilling fluid mixing and delivery system of sufficient capacity to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

#### **6.1.2     *Drilling Rig***

The directional drilling rig is to:

- consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head;
- contain a guidance system to accurately guide boring operations;

- be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation; and
- be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

#### **6.1.3**     *Drill Head*

The drill head is to be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions.

#### **6.1.4**     *Guidance System*

The guidance system is to be setup, installed, and operated by trained and experienced personnel. The operator is to be aware of any magnetic or electromagnetic anomalies and is to consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

#### **6.1.5**     *Drilling Fluid Mixing System*

The drilling fluid mixing system is to be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

#### **6.1.6**     *Drilling Fluid Delivery System*

The delivery system is to have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe is to be leak-free.

### **6.2**        **Jack and Bore Equipment**

The selection of jack and bore equipment is to be determined by the Contractor and is to be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner is to be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

### **6.3**        **Microtunnelling Equipment**

Microtunnelling equipment is to be determined by the Contractor and is to be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the tunnel face is to be submitted to the Contract Administrator information purposes. Use of explosives or rock fracturing



chemicals is to only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.

## **7.0 CONSTRUCTION**

### **7.1 General**

The Contractor is to notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation is to be subject to the limitations presented in the following subsections.

#### **7.1.1 *Layout, Alignment and Depth Control***

The location of the installation is to be established from the lines, elevations and tolerances specified in the Contract Documents. The pipe installation is to be to the horizontal and vertical alignments specified in the Contract Drawings. Deviations from location, alignment, grades and/or invert levels are to be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the pipe installation and appurtenances is to be laid out.

The Contractor is to calibrate tracking and locating equipment at the beginning of each work day, and is to monitor and record the alignment and depth readings provided by the tracking system at every 5 m in normal conditions and every 2 m where precise alignment control is necessary;

The Contract Administrator is to be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

All excavations are to be carried out in accordance with the Occupational Health and Safety Act (OHSA) of Ontario.

For directional drilling, the contractor is to ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” is to be 2.5 degrees per 9m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location is to be within 0.5m of the target location.

#### **7.1.2 *Shafts***

Shafts are to be specified in the Contractor's submission. The boundaries and protection of these is to be as required to contain all disturbances to areas outside of the ESA limits.

Shafts are to be maintained in a drained condition.

A minimum 2.4 m high secure fencing is to be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence is to be removed on completion of the work.

#### **7.1.3      *Protection Systems***

The construction of all protection systems is to be according to OPSS 539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA's may be impaired due to the method of operation, protection is to be provided. Protection systems include primary liner and portal excavation support systems. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

#### **7.1.4      *Settlement or Heave***

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation is to be immediately corrected by the Contractor, at no additional cost.

#### **7.1.5      *Stability of Excavation***

The construction methods, plant, procedures, and precautions employed is to ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, and materials employed is to prevent the migration of soil and/or rock material into the excavation from adjacent ground.

#### **7.1.6      *Preservation and Protection of Existing Facilities***

Preservation and protection of existing facilities is to be according to OPSS 504.

Subsurface Utility Mapping (SUM) should be reviewed as a part of contractors' responsibility to locate existing buried infrastructure. Existing underground facilities is to be exposed to verify its horizontal and vertical locations when the outlet pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities is to be exposed by non-destructive methods.

#### **7.1.7      *Transporting, Unloading, Storing and Handling Materials***

Manufacturer's handling and storage recommendations is to be followed.

#### **7.1.8      *Trenching, Backfilling and Compacting***

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path is to be according to OPSS 514.

#### **7.1.9      *Dewatering***

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor is to review the Geotechnical Investigation Report Part 1: Factual Report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor is to control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor is to maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor is to take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering is to be performed according to OPSS 517.

#### **7.1.10    *Removal of Boulders***

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor is to address the removal of cobbles and boulders in the proposed method of construction. The Contractor immediately informs the Contract Administrator of any obstruction encountered.

#### **7.1.11    *Record Keeping***

Verification record requirements of the alignment and depth of the installation is to be as specified in the Contract Documents. A copy of the verification records is to be given to the Contract Administrator at the completion of the installation.

#### **7.1.12    *Testing***

Testing of the product installation is to consist of verifying the specified grade between the two ends of the pipe and passing of water from the median end of the pipe to the outlet end to confirm gravity flow conditions.

#### **7.1.13    *Management and Disposal of Excess Material***

Management and disposal of excess material is to be according to OPSS 180. Satisfactory re-usable excavated material required for backfill is to be separated from unsuitable excavated material.

#### **7.1.14    *Site Restoration***

Site restoration is to be according to OPSS 507.

#### **7.1.15**     *Supervision*

A qualified individual, who is experienced in the pipe installation by trenchless methods, is to supervise the work at all times.

## **7.2        Horizontal Directional Drilling Installation**

### **7.2.1**     *General*

When strike alerts are provided on a drilling rig, they are to be activated during drilling and maintained at all times. This is the responsibility of the Contractor to maintain the strike alert system and stop the process upon any strike incident.

### **7.2.2**     *Site Preparation*

The work site is to be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for HDD operations are to be made. All activities are to be confined to designated work areas.

### **7.2.3**     *Pilot Bore*

The pilot bore is to be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor's submitted drilling plan to ensure that the product is installed to the line and grade shown on the Contract Drawings. The Contractor's methods must take into consideration the conditions at each crossing within the pipe alignment, and are to be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contractor is to notify the Contract Administrator. The Contract Administrator may require the Contractor to pullback and re-drill from the location along the bore path before the deviation.

In the event that a drilling fluid fracture, inadvertent returns, or loss of circulation occurs during pilot bore drilling operations, the Contract Administrator is to be advised of the event and action is to be taken in accordance with the Contractor's submitted contingency plan.

At the entry and exit points, there is potential for ravelling of the existing soil, fill and or weathered rock areas along the alignment. This is conventionally addressed by the use of drilling fluid. However, casing may be required. The Contractor's methods must take into consideration the potential need to install sections of casing to manage ravelling at or near ground surface.

If a drill hole beneath the highway must be abandoned, the hole is to be backfilled with grout or bentonite to prevent future subsidence.

The Contractor is to maintain drilling fluid pressure and circulation throughout the HDD process, including during the initial pilot bore and during the reaming process.

The Contractor is to at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

McIntosh Perry will install and monitor settlement points at traversed road crossings within the road right of way. If in any case the settlement reaches the alert level, the Contract Administrator will be advised of the event and action is to be taken in accordance with the Contractor's submitted contingency plan.

#### **7.2.4      *Drilling Fluid Fracture (Frac-Out)***

In order to reduce the potential for hydraulic fracturing of the hole during directional drilling, a minimum depth of cover of 5m is normally maintained between the pipe and the ground surface when drilling is conducted through overburden. In case of horizontal drilling in rock the depth of alignment shall be determined based rock mechanical parameters. Sections of the pipe close to the exit pit with less than 5m cover is to be cased. The Contractor is to ensure that drilling fluid pressures are properly set and controlled to prevent frac-out, for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Since fluid loss normally occurs in fault zones, fracture zones, or seams of coarse material, fluid migration does not always gravitate to the surface, thus making detection difficult. Once a fluid loss is detected, the Contractor is to halt operations immediately and conduct a detailed examination of the drill path and implement measures to mitigate fluid loss. If no surface migration is evident, resume operation while paying particular attention to fluid monitoring.

In the event of a fluid migration to the surface occurring, the Contractor is to halt all operations immediately, isolate the migration site, and recover fluids. Once the fracture is controlled, continue drilling operations with the operator paying particular attention to the fracture points.

#### **7.2.5      *Reaming***

The bore is to be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

#### **7.2.6      *Product Installation***

##### **7.2.6.1    *General***

The product is to be jointed according to manufacturer's recommendations. The length of the product to be pulled is to be jointed as one length before commencement of the continuous pulling operation.

The product is to be protected from damage during the pullback operation.

The minimum allowable bending radius for the product must not be exceeded.

Product must be allowed to recover before connections to new or existing facility are made. Product recovery time is to be according to the manufacturer's recommendations.

#### **7.2.6.2 Pullback and Grouting**

After successfully reaming the bore to the required diameter, the product is to be pulled through the bore path. Once the pullback operation has commenced, it is to continue without interruption until the product is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel is to be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. When specified in the Contract Documents, a weak link or breakaway connector is to be used to prevent excess pulling force from damaging the product.

The product is to be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted is to be rectified to the satisfaction of the Contract Administrator.

The pull back and reaming operations cannot exceed the fluid circulation rate capabilities. Reaming and back pulling operations is to be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the excavation walls is to be filled with grout.

### **7.3 Jack and Bore Installation**

#### **7.3.1 Method of Installation Procedure**

The installation procedure to be used is to be subject to the following limitations:

- Hydraulically operated jacks of adequate number and capacity are to be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- A suitably padded jacking head or collar is to be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- The jacking pipe is to be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment is to take into consideration the conditions at each pipe crossing.



### **7.3.2**     *Pipe Installation*

Concrete pipe joints are to be water tight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavation is to be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavation is to be filled with grout.

The annular space between the liner and the product is to be fully grouted with a water tight, expandable and stable grout.

## **7.4**       **Mircotunnelling Installation**

### **7.4.1**     *General*

The method of tunnelling is to be selected by the Contractor and submitted to the Contract Administrator prior to commencement of the work for information purposes.

Excavation of native soil and fill is to be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel are to be capable of fully supporting the face and must accommodate the removal of boulders and other oversize objects from the face. Continuous ground support is to be maintained during excavation.

As the excavation progresses, the Contractor is to continuously monitor (every 2m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor is to advance the ventilation system as a regular part of the normal excavation cycle.

The Contractor is to provide lighting in accordance with OHS requirements for the entire length of the tunnel.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor is to maintain clean working conditions at all times in tunnels.

In the event that excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor is to cease excavation. The Contractor must then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor is to maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

#### **7.4.2     *Tunnelling Method***

The tunnelling method is to be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil conditions at each pipe crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

#### **7.4.3     *Primary Liner (Support System)***

Primary support systems are to prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system is to be designed and installed to achieve the intended performance requirements.

The primary liner support system must maintain the safety of personnel, minimize ground movement into the excavation, ensure stability, and maintain strength of ground surrounding the excavation.

The primary liner is to be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and is to ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner is to be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems are to be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the surface of the excavation are to be filled with cement grout. If an unexpanded liner is used, the space outside the liner plates is to be grouted at least daily.

#### **7.4.4     *Secondary Liner***

##### **7.4.4.1     *Placing of Grout***

The void outside the finished secondary liner is to be filled with cement grout according to the Contractor's submission.

Grout is to not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting is to be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property.

### **7.5     *Instrumentation and Monitoring***

McIntosh Perry will install instrumentation and provide ground surface monitoring services at road crossings along the pipeline alignment during the HDD operation. The scope of this service will be as outlined in McIntosh Perry document "Instrumentation and Monitoring Plan for Horizontal Directional Drilling, Highway 401 and Westbrook Road Crossing Bell Canada Conduit Crossing, Kingston, ON"

## **7.6 Condition survey**

Prior to commencement of the construction McIntosh Perry will perform and document a road condition survey based on MTO Manual for Condition Rating, Distress Manifestation, SP-024 for the purpose of requirement of restoration. During the condition survey all visible defects such as cracks, distortions and deviations, heaves and depressions will be documented. McIntosh Perry will repeat the condition survey two weeks after the construction is completed or until such time at which all parties agree that further movement has stopped.

The Contractor should provide McIntosh Perry with Traffic Control services during the initial and final Road Condition Survey. Contractor will be held liable for any occurred damages to the pavement. All suffered damages should be remediated by the Contractor in conformance to applicable MTO Standards.

## **7.7 Criteria for Assessment of Roadway Subsidence/Heave**

For monitoring of ground movement the following represents trigger levels that define magnitude of movement and corresponding action:

- Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor is to review or modify the method, rate of sequence of construction, or ground stabilization measures to mitigate further ground displacement.
- If the Review Level is exceeded, McIntosh Perry is to immediately notify the CA and the contractor to review and discuss response actions. The Contractor is to submit a plan of action to prevent Alert Levels from being reached. All construction work is to be continued such that the Alert Level is not reached.
- Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor is to cease construction operations upon McIntosh Perry notification, informs the Contract Administrator, and execute pre-planned measures to secure the site, to mitigate further movements, and to assure safety of public and maintain traffic.
- No construction is to take place until all the following conditions are satisfied:
  - The cause of the settlement has been identified.
  - The Contractor submits a corrective/preventive plan.
  - Any corrective and/or preventive measure deemed necessary by the Contractor is implemented.
  - The Contract Administrator deems it is safe to proceed.

The Contractor is to avoid damaging instrumentation during construction. Instrumentation that is damaged as a result of the Contractor's operation is to be repaired or replaced by the Contractor within one business day. The costs for replacement/repair are to be borne by the Contractor.

At the completion of the job, the Contractor is to abandon all instrumentations installed during the course of the Work.

## **8.0 MEASUREMENT FOR PAYMENT**

Measurement is to be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of pipe installed by trenchless methods.

## **9.0 BASIS OF PAYMENT**

Payment at the contract price is to be full compensation for providing all labour, equipment, and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of pipe liners, site restoration, and for all other work necessary to complete the installation as specified.

Payment for the rigid or flexible pipe conduits installed inside the pipe liners are to be paid separately under the appropriate tender items.

Where a protection system is made necessary because of the Contractor's operations (e.g. choice of trenchless installation method), the cost is to be included in this item and is to be full compensation for all labour, equipment, and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for removal of boulders/obstructions greater than an equivalent 0.3 m in diameter is to be on a time and materials basis. The Contractor is to inform the Contract Administrator when boulders/obstructions are encountered and prior to removal to allow for proper and accurate tracking of time and material charges.

## **Appendix I**

# **Proposed Instrumentation and Monitoring Guideline**

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

These guidelines specify MTO's minimum 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 do not cover all the design requirements.

The complexity ratings of Foundations Engineering services are defined in Table 1.

**Table 1: Complexity ratings for tunnelling specialty services**

Highway Classification	Tunnel Excavation Diameter (ϕ)					
	≤ 1 m		>1 m & ≤ 2 m		>2 m	
	Minimum Overburden Cover * (m)					
	≥ 3 ϕ (or 1.5 m whichever is greater)	< 3 ϕ (or 1.5 m whichever is greater)	≥ 3 ϕ	< 3 ϕ (or 1.5 m whichever is greater)	≥ 3 ϕ	< 3 ϕ (or 1.5 m whichever is greater)
Kings Highway	Low	Medium	Medium	High	High	High
400 Series Freeway	Medium	High	High	High	High	High

\*Minimum overburden cover is the vertical distance measured from the lowest ground elevation to the crown of the tunnel.

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.

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.

Consultant services shall be provided 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.



Services include, but are not restricted to, conducting a site investigation that 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 requirements for Subsurface Investigation and Recommendations**

A minimum of one borehole shall be advanced at each end of tunnel crossing. The boreholes shall be located outside but within 2 m 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 the 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 shall be carried out in accordance with the Occupational Health and Safety Act.

Traffic protection in accordance with MTO requirements 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.

### **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 Limit 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.

### **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.

### **Minimum 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.

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 consultant shall analyse field data and test results and make comprehensive and practical recommendations pertaining to temporary, interim and permanent conditions at the Project.

The consultant 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 (if economically feasible), utility tunnelling using TBM (two pass system), Horizontal Directional Drilling (HDD) and cut and cover methods.

The consultant shall identify and present overview assessments of the advantages, disadvantages, 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 Consultant 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 consultant 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 consultant 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 consultant shall develop a detailed instrumentation and monitoring program that meets the requirements of these guidelines. (see Appendix for typical settlement monitoring guidelines).

The consultant is responsible for preparing Traffic Control 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 consultant shall ensure that the foundations engineering component of the project is adequately reflected in the design drawings, specifications and related contract documents.

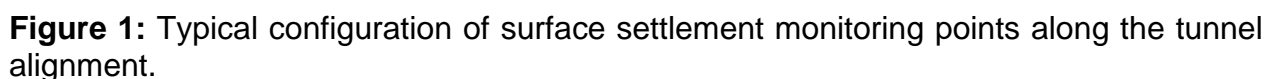
Written confirmation is required from the Proponent and the tunnelling consultant that the design package submitted to MTO have been reviewed by the tunnelling consultant and that all recommendations have been satisfactorily incorporated in the contract package.

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.

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

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).

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



## **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/consultant 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 Consultant 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 consultant 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 qualified Geotechnical Consultant to supervise the installation of surface settlement points on site and to provide direction, technical input and field inspection on this project.

METRIC

PLATE No  
MT0 GEOCRES NO.  
31C-244

PLATE  
SETTLEMENT PIN LOCATIONS  
HWY 401 AND WESTBROOK ROAD  
Survey   SURVEYED   Revised   REVISED

McINTOSH  
PERRY

MP

115 Walgreen Road R.R. #3, Carp, ON K0A 1L0  
Tel: 613-836-2184 Fax: 613-836-3742

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Figure  
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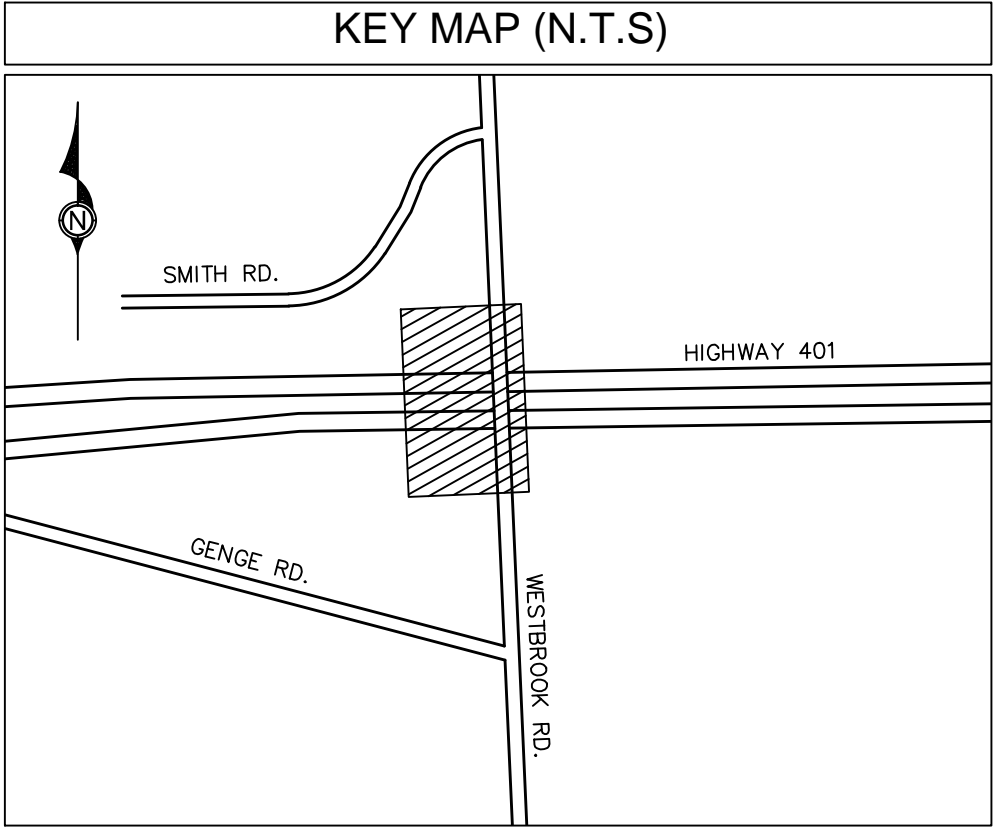
PLAN VIEW

HORIZONTAL SCALE: 1:250



LICENSED PROFESSIONAL ENGINEER  
M. AZIZI TAVAKOLI  
100180911  
June 3/16  
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER  
C. L. STAPLEY  
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LEGEND

- SETTLEMENT PIN
- ▼ SETTLEMENT ROD

