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FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED 600 MM WATERMAIN RELOCATION
HIGHWAY 401 LESLIE STREET INTERCHANGE
TORONTO, ONTARIO
G.W.P. 2061-13-00

GEOCRES No. 30M14-460

Report

to

WSP / MMM Group

Date: March 1, 2017
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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) along the proposed alignment of the relocation of a 600 mm watermain that will cross under Highway 401 at the Leslie Street Interchange in the City of Toronto, Ontario. Thurber carried out the investigation as a sub-consultant to WSP / MMM Group under MTO Agreement Number 2013-E-0032.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan and soil strata drawing with stratigraphic profile, records of boreholes, laboratory test results and written descriptions of the subsurface conditions. A model of the subsurface conditions was developed for the site based on the data obtained from the present investigation.

2. SITE DESCRIPTION

The site is located at the southwest and northwest quadrants of the Highway 401 and Leslie Street interchange in the City of Toronto, Ontario. It is understood that the existing 600 mm diameter watermain is to be relocated prior to commencing the proposed interchange reconstruction works. The proposed watermain alignment is over 400 m in length and comprises open cut and trenchless sections, including a crossing under the Highway 401 mainlines and other crossings under existing interchange ramps. It is noted that the Highway 401 mainlines at this location are elevated by a series of bridges supported on deep foundations, and that the ground surface above the watermain is actually the top of pavement of the existing Oriole GO parking lot.

The site lies within an area of industrial and commercial lands. In general, the terrain is slightly

undulating and decreases in elevation in a southerly direction toward Lake Ontario.

According to Physiography of Southern Ontario by L.J Chapman and D.F. Putnam, 1984, the project site is located within the physiographic region known as the South Slope. The South Slope is a smooth and drumlinized till plain that has formed as a result of glacial action and deposition of till materials just south of the Oak Ridges Moraine. The South Slope contains a variety of soils that have developed over till. The depth of the overburden in the general area can be expected to be more than 50 m. Within and adjacent to the Don River valley, the site area is underlain by glacio-lacustrine sands, silts, silty clay and glacial till deposits.

3. INVESTIGATION PROCEDURES

The field investigation for this project was carried out between October 19 and November 13, 2016. A total of eleven (11) boreholes, denoted as Boreholes WM16-01 to WM16-11, were drilled along the proposed watermain alignment. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings provided in Appendix C.

A track-mounted Diedrich D50T drill rig supplied and operated by DBW Drilling Limited of Toronto, Ontario, and a track-mounted Diedrich D50T drill rig supplied and operated by Walker Drilling Ltd. out of Utopia, Ontario, were used. The boreholes were advanced using hollow stem and solid stem augers to depths of between 12.8 m and 18.9 m below existing ground surface elevation (Elev. 122.6 m to Elev. 132.6 m). In all boreholes, soil samples were obtained at selected intervals with a 50 mm outside diameter split spoon sampler driven in conjunction with the Standard Penetration Test (SPT).

The field investigation was supervised on a full time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, arranged for the clearance of subsurface utilities, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. Monitoring wells were installed in six of the boreholes (Boreholes WM16-01, WM16-04, WM16-06, WM16-07, WM16-10, and WM16-11) to permit monitoring of the groundwater levels at the site. Each monitoring well consisted of a 50 mm diameter PVC pipe, with a slotted screen sealed at selected depths within the boreholes. The boreholes, in which no monitoring wells were installed, were backfilled in general accordance with Ontario Regulation 903.

Details of the monitoring well installations and borehole completion are summarized as follows:

Borehole Number	Monitoring Well Installations			Completion Details
	Sand Screen Depth (m)	Sand Screen Elevation (m)	Filter Strata	
WM16-01	4.0 - 7.6	137.4 – 133.8	Sand, Sand and Silt	Backfilled with bentonite holeplug to 7.6 m then filter sand from 7.6 m to 4.0 m, then bentonite holeplug from 4.0 m to 0.2 m, then cement to surface.
WM16-02	None Installed			Bentonite holeplug and cuttings to 0.2 m, then asphalt to surface.
WM16-03	None Installed			Bentonite holeplug and cuttings to surface.
WM16-04	5.5 – 9.1	135.4 – 131.8	Sand and Silt to Silty Sand	Backfilled with bentonite holeplug to 9.1 m, then filter sand to 5.5 m, then bentonite holeplug to surface.
WM16-05	None Installed			Bentonite holeplug and cuttings to 0.1 m, then asphalt to surface.
WM16-06	5.5 – 12.2	135.4 – 128.7	Silt Silty Clay	Backfilled with filter sand from 12.2 to 5.5 m, bentonite holeplug from 5.5 to 4.5 m, then bentonite holeplug and cuttings to 0.3 m, then cement to surface.
WM16-07	4.6 – 9.1	136.9 – 132.4	Sand	Backfilled with bentonite holeplug and cuttings to 9.1 m, then filter sand to 4.6 m, then bentonite holeplug to 4.0 m, then bentonite holeplug and cuttings to 0.3 m, then filter sand from 0.3 m to surface
WM16-08	None Installed			Bentonite holeplug and cuttings to surface
WM16-09	None Installed			Bentonite holeplug and cuttings to surface
WM16-10	7.5 – 12.2	130.7 – 126.0	Silty Clay, Silt	Backfilled with filter sand to 7.5 m, then bentonite holeplug to 6.7 m, then bentonite holeplug and cuttings to 0.3 m, then filter sand to surface
WM16-11	7.6 – 12.2	130.5 – 125.9	Silty Clay	Backfilled with filter sand to 7.6 m, then bentonite holeplug to 0.3 m then cement to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. Laboratory testing results are summarized on the Record of Borehole sheets included in Appendix A and are presented on the figures included in Appendix B.

Selected soil samples were submitted to AGAT Laboratories and SGS Canada, both CALA accredited analytical laboratories in Ontario, for analytical testing of Petroleum Hydrocarbons (PHCs), Volatile Organic Compounds (VOCs) including BTEX, Metals and Inorganics (M&I), TCLP (leachate) metals, and corrosivity parameters. The results are included in Appendix C and discussions on the results are contained in Sections 13 and 14.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the subsurface conditions encountered in the boreholes beneath the pavement structure and topsoil generally consisted of varying thicknesses of embankment fills consisting of sands and silts, underlain by native sand and silt deposits, which were in turn underlain by native silty clay. Descriptions of the individual strata are presented below.

5.1 Pavement Structure

An asphalt pavement structure was encountered in boreholes WM16-01 to WM16-03, WM16-05, WM16-06, and WM16-11. The pavement structure at the existing parking lots consisted of approximately 90 mm to 150 mm overlying approximately 0.6 to 1.4 m of granular base. The existing pavement structure encountered in boreholes on the existing Hwy 401 ramps consisted of approximately 200 mm to 300 mm of asphalt over approximately 0.5 to 1.2 m of granular base. A 150 mm thick buried layer of asphalt was noted at 1.4 m depth in Borehole 16-01.

The road and pavement granular base materials generally consisted of gravelly sand to sand and gravel, trace silt, and was brown in colour. SPT ‘N’ values ranged from 22 to 46 blows for 0.3 m penetration of the sampler indicating the base material is generally compact to dense. Measured

moisture contents in the gravelly sand to sand and gravel fill varied between 2 percent and 4 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and gravel to gravelly sand are presented on the Record of Borehole sheets included in Appendix A and on Figures B1 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	28 to 46
Sand	49 to 58
Silt and Clay	5 to 14

5.2 Topsoil/Soil Mixed with Organics

Topsoil and surficial soil mixed with organics were encountered in Boreholes WM16-04, WM16-07, WM16-09, and WM16-10 and ranged in thickness from 75 mm to 400 mm. The thickness of topsoil and soil mixed with organics may vary between and beyond borehole locations.

5.3 Fill

Embankment fill was encountered in all boreholes with the exception of WM16-01 and WM16-11. The fill generally consisted of sand and silt to sand, some clay, trace gravel, and was brown in colour. The fill extended to depths of approximately 1.5 m to 4.5 m below existing ground surface (Elev. 136.7 to Elev. 141.7 m)

SPT ‘N’ values within the sand and silt to sand fill ranged from 2 to 60 blows per 0.3 m penetration of the sampler, though typical values were between 12 and 35 indicating a compact to dense condition. Measure moisture contents within the sand and silt to sand fill varied between 2 percent and 20 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and silt to silty sand fill are presented on the Record of Borehole sheets included in Appendix A and on Figure B2 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 12
Sand	37 to 71
Silt	21 to 41
Clay	8 to 16

5.4 Sand and Silt to Sandy Silt

Native sand and silt to sandy silt was encountered in Boreholes WM16-01 to WM16-04, and WM16-11 beneath the fill deposits. These deposits generally contained some clay, trace gravel and was brown in colour. These layers were approximately 2.9 m to 4.6 m thick and extended to depths ranging from 3.7 m to 8.1 m below existing ground surface elevation (Elev. 133.7 to Elev. 137.3 m).

SPT 'N' values within the sand and silt to sandy silt ranged from 1 to 32 blows for 0.3 m penetration of the sampler. Typical values fell between 7 to 27 blows indicating the material was loose to compact. Measured moisture values in the deposit varied between 7 percent and 19 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and silt to sandy silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	30 to 46
Silt	35 to 50
Clay	15 to 23

5.5 Silty Sand to Sand

Silty sand to sand deposits were encountered in all boreholes. In Boreholes WM16-01 to WM16-04, and WM16-11, the silty sand and sand was encountered beneath the sand and silt to sandy silt deposits, and in Boreholes WM16-05 to WM16-10, the silty sand to sand was encountered beneath the fill deposits. These deposits generally contained some silt, trace gravel, trace clay, and trace organics in some boreholes. The soils were generally brown to grey in colour. Where

fully penetrated the deposit was approximately 1.1 m to 7.3 m thick (base Elev. 130.3 to 136.8m). Borehole WM16-02 was terminated in the sand at 12.8 m depth (Elev. 132.6 m).

SPT 'N' values in the silty sand to sand ranged from 0 to 43 blows per 0.3 m penetration, indicating the material is very loose to dense. Measured moisture content in the deposit varied between 3 percent and 27 percent. A higher moisture content value of 37 percent was measured in Borehole WM16-02 and was likely the result of organic content in the sample.

The results of grain size distribution analyses carried out on selected samples of the silty sand to sand are presented on the Record of Borehole sheets included in Appendix A and on Figures B4 and B5 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 2
Sand	61 to 85
Silt	11 to 35
Clay	2 to 9

5.6 Silt

Silt was encountered in Boreholes WM16-05, WM16-06, and WM16-08 to WM16-10 beneath the sand and silty sand deposits. The silt generally contained trace to some sand, trace clay and was brown to grey in colour. The silt deposits ranged in thickness from approximately 2.3 m to 5.0 m and extended to depths of approximately 7.8 m to 9.5 m below existing ground surface elevation (Elev. 133.4 to 130.4 m).

SPT 'N' values in the silt ranged from 4 to 9 blows for 0.3 m penetration indicating that the material was loose. Measure moisture contents in the silt varied between 27 percent and 33 percent.

The results of grain size distribution analyses carried out on selected samples of the silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B6 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	6 to 13
Silt	76 to 84
Clay	5 to 11

5.7 Silty Clay

Silty clay was encountered in every borehole with the exception of borehole WM16-02. The silty clay was encountered beneath the sand and silt deposits and extended to the maximum depth drilled of 18.9 m below existing ground surface elevation (Elev. 122.6 m). The silty clay generally contains trace to some sand, trace gravel, and was grey in colour.

SPT 'N' values in the silty clay ranged from 0 to 6 blows for 0.3 m penetration of the sampler. Field vane shear tests (VST) conducted in the silty clay measured in-situ undrained shear strengths ranging from 20 kPa to 78 kPa. Based on the SPT and VST data, the consistency of the silty clay ranged between soft and stiff. Measured moisture contents in the silty clay varied between 14 percent and 44 percent.

The results of grain size distribution analyses and Atterberg Limit tests conducted on selected samples of the silty clay, are presented on the Record of Borehole sheets included in Appendix A and on Figures B7 and B8 of Appendix B. The results of the grain size distribution and Atterberg Limits are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 4
Sand	9 to 35
Silt	31 to 47
Clay	32 to 44
Soil Property	**Percentage (%)**
Liquid Limit	24 to 31
Plasticity Index	12 to 17

The results of the Atterberg Limits testing indicate the silty clay is of low plasticity with group symbol CL.

5.8 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. Monitoring wells were installed in Boreholes WM16-01, WM16-04, WM16-06, WM16-07, WM16-10, and WM16-11 to monitor the groundwater level at the site. The groundwater levels measured in the open boreholes and in the monitoring wells are summarized below.

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
WM16-01	November 9, 2016	1.0	140.4	Open borehole
	December 21, 2016 January 4, 2017	3.7 2.8	137.7 138.6	Monitoring Well
WM16-02	October 27, 2016	8.8	136.6	Open borehole
WM16-03	October 28, 2016	5.5	135.6	Open borehole
WM16-04	November 9, 2016	2.9	138.0	Open borehole
	December 21, 2016 January 4, 2017	4.2 3.5	136.7 137.4	Monitoring Well
WM16-05	November 2, 2015	4.5	137.0	Open borehole
WM16-06	November 9, 2016	1.1	139.8	Open borehole
	December 21, 2016 January 4, 2017	2.8 3.1	138.1 137.8	Monitoring Well
WM16-07	November 9, 2016	3.0	138.5	Open borehole
	December 21, 2016 January 4, 2017	4.5 2.1	137.0 139.4	Monitoring Well
WM16-08	October 26, 2016	4.9	135.6	Open borehole
WM16-09	October 26, 2016	5.0	135.6	Open borehole
WM16-10	November 9, 2016	1.4	136.8	Open borehole
	December 21, 2016 January 4, 2017	3.8 1.9	134.4 136.3	Monitoring Well
WM16-11	November 13, 2016 January 23, 2017	10.7 1.7	127.4 136.4	Monitoring Well

The above readings indicate that the groundwater level along the watermain alignment is at approximately 1 to 4 m depth below existing ground surface.

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

6. MISCELLANEOUS

Thurber marked the borehole locations in the field and obtained subsurface utility clearances prior to drilling.

DBW Drilling Limited of Toronto, Ontario, and Walker Drilling Ltd. of Utopia, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis either Mr. Cory Zanatta, EIT or Ms. Eckie Siu of Thurber. Overall supervision of the field program was provided by Dr. Sydney Pang, P.Eng. of Thurber.

The coordinates and ground surface elevations at the borehole locations were provided by MMM Group Limited.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Interpretation of the field data and preparation of this report was carried out by Mr. Cory Zanatta, EIT. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report presents foundation recommendations for the design and construction of the proposed watermain crossing under Highway 401, based on design information provided by WSP / MMM to Thurber and on the factual data obtained during the course of this investigation.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction contractor. The contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

It is noted that the Highway 401 mainlines at this location are elevated by a series of bridges supported on deep foundations, and that the ground surface above the watermain is actually the top of pavement of the existing Oriole GO parking lot. Reference is also made to selected borehole data from a previous investigation carried out by Thurber. For the purpose of this report, Highway 401 is considered to run in an east-west orientation, and the watermain alignment in a north-south orientation.

Information provided by WSP / MMM indicates that the proposed watermain may be a Concrete Cylinder Pipe (CCP) or a ductile iron pipe of 600 mm in diameter. Where trenchless methods are to be used to install the pipe, a steel or concrete microtunnel jacking pipe of 1,200 mm in diameter will be used as a sleeve. For the purpose of reporting, foundation recommendations for the watermain alignment are provided in three sections (north, central and south). Further details of each section are as follows:

- North Section (Boreholes WM16-01 to WM16-04)

  This section has a total length of approximately 115 m with three segments in a generally northwesterly to southeasterly orientation; from its northerly limit, the alignment runs adjacent to the City of Toronto yard parking lot, under the Highway 401 future and existing westbound on-ramps and then under the GO parking lot driveway. Soil cover above the crown of the pipe varies from 1.5 to 4.0 m. Existing information from WSP / MMM indicates that an approximately 45 m long segment under the existing westbound on-ramp (Stations 253+91 to 254+36) is to be constructed using trenchless methods. It is understood that the remainder of this section is proposed to be constructed in open cut.

- Central Section (Boreholes WM16-04, C15-03, WM16-05, WM16-06, C15-04, WM16-07)

  This straight section has a total length of approximately 127 m running in a north-south orientation; the alignment predominantly runs under the existing Oriole GO Station parking lot and between adjacent rows of augered caissons and driven piles which support the Highway 401 mainline bridges above the parking lot. The two rows of deep foundation elements are approximately 16 m apart centre-to-centre. Soil cover (from parking lot grade) above the crown of the pipe varies from 2.5 to 4.5 m. Existing information from WSP / MMM indicates that construction is proposed to be carried out using microtunnelling (trenchless) techniques.

- South Section (Boreholes WM16-08 to WM16-11)

  This section has a total length of approximately 205 m in a generally north-south orientation; the alignment runs under the Highway 401 future and existing eastbound on-ramps, and under the existing eastbound off-ramp. Soil cover above the crown of the pipe varies from 2.0 to 3.5m. Existing information from WSP / MMM indicates that the three pipe segments under the ramps are proposed to be installed in steel sleeves. The entire south section is proposed to be constructed in open cut.

Boreholes WM16-05 and WM16-06 have been drilled at an offset of approximately 16 m to 18 m from the proposed tunnelling alignment in the Central Section. The offset is primarily due to physical constraints inside the parking lot such as low headroom and parked vehicles. An interpolation between the two new boreholes and two other boreholes C15-03 and C15-04 drilled previously has therefore been made to arrive at a subsurface model for the tunnel alignment.

The watermain invert slopes southerly from an approximate Elevation 138.0 m at the north limit to approximate Elevation 135.2 m at the south limit. Within the trenchless section under Highway

401, the invert of the steel casing slopes downwards from approximate Elevation 137.5m at the north limit to approximate Elevation 136.2 m at the south limit.

The subsurface stratigraphy along the watermain alignment generally consists of a surficial 1 to 5 m thick layer of typically loose to dense sand and silt fill overlying native deposits of sands and silts ranging between 2 and 9 m in combined thickness. The cohesionless soils generally consist of varying proportions of sands and silts, and are typically in a compact to dense state with some loose zones. The site is underlain by a deposit of soft to stiff silty clay. Groundwater levels measured to date in monitoring wells installed in selected boreholes are generally 1 to 4 m below the existing ground surface. These levels are typically at or just below the proposed pipe invert, except in the vicinity of the southern portion of the Highway 401 tunnel crossing where the groundwater is in the order of 1 to 2 m above the pipe invert. The above information is summarized on the Borehole Locations and Soil Strata Drawing in Appendix C.

8. TEMPORARY LAUNCHING AND RECEIVING SHAFTS

A launching shaft and a receiving shaft will be located near the northerly and southerly limits, respectively, of the tunnel crossing under Highway 401. The tunnelling segment under the existing 401 on-ramp on the north side of the mainlines will also require shafts at each end of the crossing. Temporary shaft excavations will extend through the existing fill into the native sands and silts. Given the subsurface conditions, the temporary support system for these excavations may consist of steel interlocking sheetpiles installed into the underlying silty clay to provide a partial groundwater cutoff. A braced soldier piles and wood lagging system may also be considered as roadway protection (temporary shoring), but it must be used in conjunction with more elaborate dewatering systems.

Basal heave is not anticipated at the shafts if sheetpile enclosures installed into the underlying silty clay is used. For permeable systems such as soldier piles and lagging, depressurization/dewatering of the underlying sands and silts, using systems such as vacuum well points and/or eductors, is required to minimize the potential of basal heave due to upward hydrostatic pressure. Sump pumping will be required, regardless of the form of roadway protection, to maintain reasonably dry excavations throughout construction.

Design of the temporary shoring (roadway protection) systems is the responsibility of the Contractor. The temporary shoring should be designed by a licensed Professional Engineer experienced in such designs, with consideration of adjacent traffic loads and any sloping retained surfaces. Protection systems should be provided as per OPSS.PROV 539 which should be

included in the contract documents. Performance Level 2 corresponding to not more than 25mm ground movement should be specified.

For design of a roadway protection system at the shafts, the lateral pressure distribution as shown on Figure D1 should be used in conjunction with the following parameters.

H	=	ground surface to base of shaft (variable)
h_W	=	water height above base of shaft (assume g.w.l. at Elev. 140 m)
	=	0 (permeable soldier pile and lagging wall)
K_A	=	0.33 (fill, sands and silts)
	=	0.35 (silty clay)
K_P	=	3.0 (fill, sands and silts)
	=	2.8 (silty clay)
γ	=	20 kN/m^3 (fill, sands and silts)
	=	19 kN/m^3 (silty clay)

All temporary excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and local regulations. Under OHSA, the soils above the water level are generally classified as Type 3 soils, and the soils below the water level are Type 4 soils. Slopes of any temporarily unsupported cuts, where space permits, should conform with the requirements of OHSA.

Provision should be made for handling and removal of possible cobbles and boulders in the glacially derived soils and oversize debris in the fill during excavation.

9. TRENCHLESS METHODS

Some of the commonly used methods that may be considered for the trenchless portions of this project include the following:

- Micro-tunnelling (MTBM)
- Jack and Bore
- Pipe Ramming
- Tunnelling (TBM or Hand mining)

Selection of an appropriate trenchless method should be the responsibility of the Contractor. The experience of the Contractor is of primary importance for trenchless installation. The Contractor must submit a detailed work plan including the proposed trenchless methodology, means of

maintenance of alignment and groundwater control. Appendix F presents two NSSPs on trenchless methods, one titled “Pile Installation by Trenchless Method” and the other titled “Microtunnelling for Watermain 1200 MM”.

Based on the design information provided by MMM and available borehole information, the tunnel crossing under Highway 401 will be constructed through typically compact sands and silts with occasional loose zones. The groundwater levels recorded in the boreholes indicate that the hydrostatic pressure head present at the tunnel face is typically 1 m or less, except between approximate Stations 252+80 and 252+10 where the head could be in the order of 1.5 to 2 m above the tunnel invert.

Effective means of groundwater control will be required during tunnelling, unless microtunnelling methods are used in which case dewatering is only required at the shafts. The design of groundwater control systems is the responsibility of the Contractor, who must retain a specialist in this field to undertake the design. The systems must remain operational until pipe construction is completed.

Microtunnelling is considered suitable for use at this site. The equipment should be capable of maintaining a balancing face pressure. Control of the pipe alignment should also be maintained while excavating and advancing through locations, such as in the vicinity of Station 253+00 (Borehole WM16-05), where the existing fill could daylight on the tunnel face and where the presence of cobbles and boulders are possible.

Due to the relatively small diameter of the casing, tunnelling in the form of conventional hand-mining using mechanical tools is not considered feasible at this site. This method requires personnel access and the small diameter poses severe restrictions and risks.

There are risks associated with the jack and bore technique at this site due to the installation length, the wet sands and silts at some locations, groundwater level above the tunnel crown along some sections, and the possible presence of cobbles and boulders at the excavation face.

Pipe ramming is an alternate method for installing steel casings. At this site, the trenchless section under the GO parking lot is well over 100 m in length. Moreover, personnel access to the tunnel face is risky due to the small diameter should oversized obstructions be encountered. Therefore, the feasibility of pipe ramming for this section must be carefully evaluated.

Horizontal Directional Drilling (HDD) is another available trenchless method. For the section under the Highway 401 mainlines, it is important to maintain a precise pipe alignment since it will pass between two rows of caissons and piles that are supporting the existing overpass structures. As such, the feasibility of HDD for this section must be carefully evaluated.

It is recommended that the Contractor be alerted to the following points which should be included in the contract documents:

- It is anticipated that the majority of the pipe installation will be carried out through predominantly compact water-bearing sands and silts. It is noted that there are locations where the groundwater level is higher than the crown level of the casing or where loose soils are present. The Contractor's methodology must include means of handling potential sloughing of these soils and water seepage at the excavation face.
- The embankment fill that may daylight at the tunnel face during casing installation could contain cobbles and boulders. The Contractor should be equipped to dislodge, remove and otherwise handle such obstructions at the tunnel face should it be required.
- The proposed watermain alignment runs between two adjacent rows of deep foundations that are about 16 m apart. As long as the alignment stays near the middle of this opening, the risk of adverse effects on the caissons and piles due to watermain construction is low.

The risk of adverse impact resulting from the proposed pipe installation on the performance of the highway and the existing Oriole GO Station parking lot is anticipated to be low. Despite such low risk, a pre-construction condition survey should be carried out to document the existing conditions of the highway and GO parking lot pavement, columns in the parking lot adjacent to the watermain alignment which provide support to the highway bridge, and any other buried utilities adjacent to the watermain alignment.

From a foundations technical, constructability and risk aversion perspective, it is considered that microtunnelling is the preferred method of pipe installation under the Highway 401 mainlines. For the trenchless section under the Highway 401 westbound on-ramp, various methods such as microtunnelling, pipe ramming and HDD may be considered. Should microtunnelling be selected for the highway mainline crossing, microtunnelling may also become the preferred method for the on-ramp crossing from a cost effectiveness perspective.

10. OPEN CUTTING

It is understood that open cutting is proposed to be used for watermain installation beyond the two tunnelling segments discussed above (under Highway 401 mainlines and under existing WB on ramp). Based on the borehole information and site conditions, staged open cutting is technically feasible and carries lesser risk than the trenchless methods in terms of causing ground

settlement. However, open cut construction could result in disruption to traffic flow amongst other logistics issues. Protection systems (temporary shoring) and groundwater control will be required. Where the work area encroaches onto the MTO Highway 401 ramps, City of Toronto yard or the Metrolinx GO parking lot, approvals from the respective owners of these facilities will be required.

Information provided by WSP / MMM indicate that the watermain under the EB on-ramp will be constructed by open cut. It is understood that a temporary ramp closure will be implemented to facilitate watermain construction.

In general, the proposed watermain invert is some 3 to 5 m below the existing ground surface. Excavations not deeper than 3 m may be carried out within roadway protection systems (temporary shoring) or steel trench boxes where suitable. For deeper excavations, or where water seepage is a concern, or where adjacent ground movement is to be minimized, temporary shoring such as interlocking sheetpiles may be considered. Soldier pile and lagging may be considered in situations where water seepage is not an issue. Sloped open cuts to certain depths may be possible if there is sufficient available space adjacent to the trench. Groundwater control in the form of dewatering (e.g. localized groundwater lowering using vacuum well points or eductors) will be required in conjunction with various forms of earth support and excavation outlined above. Pumping from filtered sumps within the trenches is always required regardless of the type of shoring system used.

Along the proposed open cut sections, existing readings in the monitoring wells indicate that the groundwater level between December 2016 and January 2017 is generally at or below the proposed watermain invert. However, it is possible that the groundwater level can rise above the invert level at some locations during the wet seasons. As such, provisions must be included in the contract for providing effective groundwater control during watermain installation. Depending on the water pressure head above the excavation base, vacuum well points and/or eductors will be required to dewater/depressurize the sands and silts such that the groundwater may be lowered to and maintained at about 0.5 m depth below the excavation base during construction. The design of dewatering systems is the responsibility of the Contractor, who must retain a specialist in this field to undertake the design. The systems must remain operational until pipe construction is completed.

Where the localized groundwater level is lowered by, say 3 m, it is estimated that ground settlement due to groundwater lowering would be in the order of 10 to 15 mm close to the edge of the excavation and that the settlement influence zone would be within 10 to 15 m of either edge of the excavation. It is also recommended that groundwater lowering at any given time where

required should be limited to, say a 20 m long section along the watermain alignment, in order to limit the potential effects to the adjacent ground.

It is noted that a trench box is primarily used to enhance the safety of workers inside trenches and is not effective in minimizing water seepage or limiting adjacent ground movements.

In deeper excavations through sands and silts, sheetpiles and/or localized dewatering (e.g. well points or eductors) may be required. Surface runoff should be diverted away from excavations at all times.

Prior to placement of the pipe bedding, the base of the trench excavation must be properly dewatered and dry, and free of disturbed or loose soil. Any identified disturbed/wet soils should be sub-excavated. In order to maintain uniformity along the alignment, the exposed subgrade should be compacted to at least 95% of its Standard Proctor Maximum Dry Density (SPMDD) prior to placement of the bedding material. Within localized areas where surficial ponding water prohibits adequate compaction of new fill or where compaction is not practical due to saturated conditions, it is recommended that materials that do not require compaction, such as OPSS 1004 clear crushed stone, be used as backfill to the sub-excavation until the top of backfill is above the water level. Unshrinkable fill conforming to City of Toronto TS 13.10 standard should be used for backfilling within the trenches where compaction is difficult due to confined space and wet conditions. It is critical that the pipe be supported on well compacted bedding overlying a competent and uniform subgrade in order to minimize the potential for differential settlement.

The pipe bedding should consist of City of Toronto Granular A material according to TS 1010, and compacted to 100% SPMDD according to TS 501. It is recommended that watermain pipe installation, trenching, backfilling and compaction be carried out in accordance with TS 401 and TS 501. Other aspects of the works should be carried out in accordance with applicable City of Toronto standards. Reference should also be made to OPSS 407, OPSS 410, OPSS 538 and OPSD 802.030, OPSD 802.031, OPSD 802.032 as appropriate. Care must be exercised when compacting the fill immediately above the crown of the pipe in order not to damage the pipe.

11. MONITORING PROGRAM AND CONSTRUCTION INSPECTION

Monitoring of the GO parking lot surface and ground surface along the watermain alignment should be carried out during construction. A settlement monitoring program and condition survey for tunnelling under the Hwy 401 right-of-way has been prepared following MTO's Guidelines for Foundation Engineering - Tunnelling Specialty for Corridor Encroachment Permit Application. A recommended instrumentation and monitoring program is provided in Appendix G.

It is also recommended that settlement monitoring of the parking lot columns adjacent to the watermain alignment be carried out during construction.

12. SETTLEMENT SENSITIVE STRUCTURES AND UTILITIES

The selection of the trenchless technique for installing the casing should take into account the

potential impact on the existing parking lot columns which support the existing highway bridges on deep foundations. Settlement monitoring of these columns should be carried out during and after casing and watermain installation.

Information provided by WSP / MMM indicates that the future EB on-ramp and the future WB on-ramp will be constructed after the watermain is installed. At the proposed future EB on-ramp where it merges with the EB mainlines, up to 4 m of new fill is to be placed. It is estimated that post construction ground settlement could be up to the order of 30 to 35 mm. At the proposed future WB on-ramp, up to 4.5 m of new fill is to be placed. It is estimated that post construction ground settlement could be up to the order of 35 to 40 mm. Information from MMM indicated that consideration is being given to using flexible joints for the casing connections and compressible grout inside the casing in order to mitigate potential adverse impacts on the pipe. It is recommended that the pipe design should be able to accommodate the magnitudes of settlement quoted above.

Moreover, the designer should check if any protective measures are required for crossing below any existing utilities including gas lines, hydro lines, watermains and other buried utilities that may exist in the vicinity of the work areas. This may require discussions with relevant owners of these facilities and design of temporary protection and support systems for particular utilities. These procedures should cover the entire watermain alignment.

13. CORROSIVITY

Corrosivity testing was carried out on five (5) selected soil samples from the boreholes. Detailed laboratory test results are included in Appendix C and a summary of the results is tabulated below.

Soil Type	Borehole	Sample	pH	Sulphate Content (ppm)	Chloride Content (ppm)	Resistivity (Ohm-cm)
Sand and Silt	WM16-01	SS 4	8.74	35 (0.035%)	35	7,520

Sand and Silt	WM16-04	SS 5	7.51	25 (0.025%)	810	1,020
Silty Sand	WM16-05	SS 6	8.15	38 (0.038%)	1,100	709
Silty Sand	WM16-06	SS 5	8.53	32 (0.032%)	770	1,130
Silt	WM16-08	SS 6	9.09	17 (0.017%)	430	1,580

Based on the pH values ranging from about 7.5 to 9.1 and sulphate concentration ranging from 17 to 38 ppm, there appears to be low potential for sulphate attack on concrete.

In Borehole 16-01, the relatively high soil resistivity and low chloride values appear to indicate low corrosion potential for metals. In Boreholes 16-04, 16-05, 16-06 and 16-08, however, soil resistivity values ranging from about 700 to 1600 Ohm.cm and chloride values ranging from about 430 to 1100 ppm appear to suggest high corrosion potential for metals.

14. SOIL MANAGEMENT AND DISPOSAL STRATEGY

The strategies developed herein for soil management and disposal are based on field observations and analytical testing carried out at the locations of the boreholes advanced by Thurber during this investigation. Due to the inherent variability of subsurface conditions, inspection will be required during construction in order to confirm that the quality of the excess excavated soil is consistent with the assumptions made in establishing these management procedures. Additional analytical testing of soil may be required during construction to meet the requirements of re-use on site and receivers of excess fill off site.

Observations made during drilling and in the laboratory did not indicate the presence of unusual staining or odour in the soil samples that would be indicative of environmental impact. In order to evaluate the requirements for management and/or disposal of excess excavated soil generated during construction, selected fill and native soil samples from the field investigation were subjected to analytical laboratory testing.

Detailed analytical results are attached in Appendix C. These results were compared with the Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition guidelines of O.Reg. 153 for both Residential/Parkland/Institutional and industrial/Commercial/ Community property uses to assess whether the material can be reused on site or at other sites. The parameters that exceeded the Table 3 guidelines are summarized below:

Table 14.1: Summary of Parameter Exceedances

Sample Identification	Parameters Exceeding Table 3 Residential / Parkland / Commercial Guidelines	Parameters Exceeding Table 3 Industrial / Commercial / Community Guidelines
Borehole WM16-01 SS4	Electrical Conductivity	Electrical Conductivity
Borehole WM16-04 SS5	Electrical Conductivity	Electrical Conductivity
Borehole WM16-05 SS6	Electrical Conductivity	Electrical Conductivity
Borehole WM16-06 SS4	Sodium Adsorption Ratio	Sodium Adsorption Ratio
Borehole WM16-06 SS5	Electrical Conductivity	Electrical Conductivity
Borehole WM16-08 SS6	Electrical Conductivity	Electrical Conductivity

The above table indicates that the Electrical Conductivity of selected samples of sands and silts, within which the new watermain is to be located, exceeded the O.Reg. 153 Table 3 guidelines. The SAR guideline limit is also exceeded in one silty sand sample. These exceedances are likely a result of road salting operations.

Based on the available subsurface information and results of the analytical testing conducted on selected soil samples, the following comments are presented regarding reuse or disposal of excess materials:

- There are elevated concentrations of Electrical Conductivity in several samples of the sands and silts that exceed the O.Reg. 153 Table 3 guidelines. Contractors must confirm the requirements of their proposed receiving sites at the tendering stage.

- Acceptance criteria stipulated by individual fill receivers may vary, and some receivers may require that all test results meet the stringent Table 1 standards or other specified criteria. Contractors must confirm the requirements of their proposed receiving sites at the tendering stage.

- Since the test results on samples of the sands and silts meet the O.Reg. 558/00 Leachate Quality criteria, excavated sands and silts from this site may be classified as “non-subject waste” for landfill disposal purposes.

15. CONSTRUCTION CONCERNS

Potential construction concerns that have been identified for this project include the following:

15.1 Dewatering/Depressurization

Dewatering/depressurization must be carried out within the underlying sands and silts below the

launching and receiving shafts during their operation. Groundwater control will be required along the open cut sections and some trenchless sections.

15.2 Loss of ground

Given the proposed use of micro-tunnelling techniques and in view of the approximately three (3) diameter of crown cover which consists predominantly of compact sands and silts, it is anticipated that the risk of loss of ground at the tunnel face is low. Pipe horizontal alignment control is particularly important to confirm that the watermain casing stays well clear from the adjacent, existing caissons and piles supporting the highway bridges. The Contractor's methodology must recognize the inherent risks of groundwater pressure at the tunnel face and prepare contingency plans to manage any adverse impacts that may arise as a result of improper alignment control.

Each of the other trenchless methods discussed in Section 9 above carries varying degree of relatively higher risks of loss of ground. The Contractor is required to select a suitable method for watermain installation such that the ground settlement review and alert levels of 10 mm and 15 mm, respectively, stipulated in the instrumentation and monitoring program (Appendix G) can be satisfied.

For open cut sections, groundwater seepage may result in loss of ground adjacent to the trenches. Adequate groundwater control measures should therefore be implemented prior to excavating below the groundwater level. Surface runoff should also be diverted away from all excavations.

15.3 Obstructions

There is a low risk of the casing encountering obstructions such as cobbles and boulders. However, the Contractor's equipment and methodology must be selected to handle such obstructions as discussed above should it be required. The micro-tunnelling equipment should be capable of mitigating potential pipe mis-alignments (horizontal and vertical) due to such obstructions.

15.4 Buried Utilities

The Contractor must accurately establish the exact locations of the caissons and piles adjacent to the proposed watermain alignment, and any buried utilities crossing or close to the alignment.

16. CLOSURE

Engineering assessment and preparation of this report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. Paulo J. Branco, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations and Tunnelling Projects.

THURBER

60 YEARS

Thurber Engineering Ltd.

Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer

P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT[(1)] 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

1) Laboratory Triaxial Testing
2) Field Insitu Vane Testing
3) Laboratory Vane Testing
4) SPT value
5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS

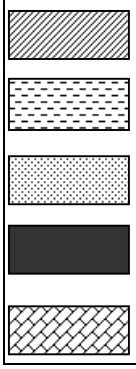
ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.

DISCONTINUITY SPACING

Bedding	**Bedding Plane Spacing**
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

BEDROCK

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**	**(psi)**	**Field Estimation of Hardness***
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length
Solid Core Recovery:(SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run
Rock Quality Designation:(RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a % of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index:(FI)	Frequency of natural fractures per 0.3m of core run.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C15-03 1 OF 1 METRIC

W.P. 2061-13-00 LOCATION N 4 847 404.7 E 315 778.3 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2015.12.21 - 2015.12.21 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.4	GROUND SURFACE										
0.0	**ASPHALT:** (50mm)										
0.0	**SAND**, trace gravel Dense Brown Moist (FILL)		1	GS			141		○		
			1	SS	30				○		
			2	SS	36		140		○		
	Compact		3	SS	11		139		○		
138.4											
3.0	Sandy **SILT**, trace clay, occasional cobbles Compact to Loose Brown Moist		4	SS	17		138		○		
			5	SS	8		137		○		
			6	SS	8		136		○		
135.7											
5.7	Silty **CLAY**, trace to some sand, trace gravel Stiff Brown Moist		7	SS	9		135		○		
134.7											
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN CEMENT TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No C15-04 1 OF 1 METRIC

W.P. 2061-13-00 LOCATION N 4 847 345.1 E 315 812.3 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2015.12.21 - 2015.12.21 CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.4	GROUND SURFACE										
0.0 / 0.1	**ASPHALT:** (100mm)										
	SAND, some gravel Brown Damp		1	GS			140				
139.6 / 0.8	(FILL)										
	Silty **CLAY**, some sand, trace gravel, topsoil stained Very Stiff Brown to Dark Brown Moist		1	SS	18		139				
138.8 / 1.6	(FILL)										
	SAND, trace gravel, trace silt Compact Brown		2	SS	22						
138.1 / 2.3	Moist (FILL)						138				
	Silty **SAND**, trace clay Compact Brown Moist		3	SS	15						
			4	SS	24		137				
			5	SS	22	▽					
			6	SS	14		136				
							135				
133.7			7	SS	12		134				
6.7	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN AND WATER LEVEL AT 4.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN CONCRETE TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \div 5}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-01 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 476.4 E 315 673.6 ORIGINATED BY CZ

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.4	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	**SAND** and **GRAVEL**, trace silt Compact Brown Moist (FILL)		1	SS	24		141				46 49 5 (SI+CL)
139.8	150mm ashpalt layer at 1.4m depth						140				
1.6	**SAND** and **SILT**, some clay, trace gravel Dense to Compact Brown Moist		2	SS	32						
			3	SS	20		139				
	Becoming Grey		4	SS	10	▼	138				0 46 35 19
137.7											
3.7	Loose to Very Loose		5	SS	8		137				
			6	SS	1		136				
135.3											
6.1	**SAND**, some silt, trace clay, trace gravel Very Loose Grey Wet		7	SS	3		135				
			8	SS	2		134				0 74 20 6
132.9	300mm organic layer at 8.2m depth						133				
8.5	Silty **CLAY**, some sand Soft to Firm Grey Wet		9	SS	1		132				0 17 39 44

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-01 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 476.4 E 315 673.6 ORIGINATED BY CZ

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.20 - 2016.10.20 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand Firm to Stiff Grey Wet						131	3.0			
			10	SS	1		130	1.5	○		
			11	SS	3		129		○		
128.6											
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE CAVED TO 7.0m UPON COMPLETION OF DRILLING. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.11.09 1.0 140.4 2016.12.21 3.7 137.7										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-02 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 449.6 E 315 703.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.27 - 2016.10.27 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
145.4	GROUND SURFACE										
0.0	**ASPHALT:** (200mm)										
0.2	Gravelly **SAND**, trace silt Dense Brown Moist (FILL)		1	GS			145				
			1	SS	46						28 58 14 (SI+CL)
144.0							144				
1.4	**SAND** and **SILT**, some clay, some gravel Compact to Very Dense Brown Moist (FILL)		2	SS	16						
			3	SS	35		143				12 37 40 11
			4	SS	58		142				
141.7											
3.7	**SAND** and **SILT**, some clay Compact Brown Moist		5	SS	21						0 44 40 16
			6	SS	27		141				
							140				
			7	SS	14		139				
							138				
137.3			8	SS	26						
8.1	**SAND**, some silt, trace gravel Compact Grey Moist to Wet					▽	137				
			9	SS	29		136				

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-02 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 449.6 E 315 703.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.27 - 2016.10.27 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	SAND, some silt, trace gravel Loose to Compact Grey Wet						135				
	Occasional wood fibres		10	SS	5				○		
							134				
132.6			11	SS	17		133		○		
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 8.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-03 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 450.2 E 315 727.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.28 - 2016.10.28 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.1	GROUND SURFACE						141				
0.0	**ASPHALT:** (150mm)										
0.2	**SAND**, trace gravel Brown Moist		1	GS					○		
140.3	(FILL)						140				
0.8	**SAND** and **SILT**, some clay Compact to Loose Brown Moist (FILL)		1	SS	13				○		
			2	SS	8		139		○		
			3	SS	8				○		
138.1							138				
3.0	**SAND** and **SILT** Compact Brown Moist		4	SS	15				○		0 41 44 15
137.1							137				
4.0	Sandy **SILT**, some clay, trace organics, trace rootlets Compact Grey Moist		5	SS	20				○		
			6	SS	17	▽			○		0 30 50 20
135.0							136				
6.1	**SAND**, fine grained, some silt, trace gravel Very Loose Grey Moist		7	SS	0		135		○		
			8	SS	2		134		○		
							133				
	Trace organics		9	SS	0		132		○		

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-03 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 450.2 E 315 727.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.28 - 2016.10.28 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						131			
130.3										
10.8	Silty **CLAY**, trace sand, trace gravel Soft to Firm Grey Moist		10	SS	0		130		○	
								+ 1.7		
							129			
128.3			11	SS	4				○	
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 5.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.									

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-04 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 428.6 E 315 759.2 ORIGINATED BY CZ

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.19 - 2016.10.19 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.9	GROUND SURFACE								
0.0	**TOPSOIL:** (100mm)								
0.1	**SAND** and **SILT**, some clay Compact to Dense Brown Moist (FILL)		1	SS	10		140		
			2	SS	35		139		0 48 37 15
138.3			3	SS	13		138		
2.6	**SAND** and **SILT**, some clay, trace gravel Dense to Compact Brown Moist		4	SS	31		137		
			5	SS	18	▼	136		0 39 41 20
			6	SS	16		135		
135.3									
5.6	Loose		7	SS	7		134		
133.7									
7.2	Silty **SAND**, trace clay, trace gravel Very Loose to Compact Grey Moist		8	SS	0		133		2 62 31 5
			9	SS	22		132		
							131		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-04 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 428.6 E 315 759.2 ORIGINATED BY CZ

HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.19 - 2016.10.19 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.8	Continued From Previous Page										
10.1	Silty **CLAY**, with sand, trace gravel Soft to Firm Grey Wet										
			10	SS	1		130				
							129				
128.1			11	SS	2						2 35 31 32
12.8	END OF BOREHOLE AT 12.8m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2016.11.09	2.9	138.0
2016.12.21	4.2	136.7

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-05 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 397.0 E 315 793.6 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.01 - 2016.11.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.5	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND**, trace gravel Brown Moist (FILL)		1	GS			141		○		
140.5			1	SS	22				○		
1.0	**SAND** and **SILT**, some clay, trace gravel Compact Brown Moist (FILL)		2	SS	19		140		○		
			3	SS	17		139		○		2 42 41 15
	75mm organic layer at 1.9m		4	SS	20		138		○		
137.0			5	SS	13	▽			○		
4.5	Silty **SAND**, trace clay Compact Brown Wet		6	SS	23		137		○		0 61 35 4
135.9							136				
5.6	**SILT**, trace sand, trace to some clay Loose Grey Saturated		7	SS	8		135		○		Augering with drilling mud (quick gel) 0 6 84 10
133.4			8	SS	4		134		○ ○		
8.1	Silty **CLAY**, some sand Firm Grey Wet						133				
	Trace gravel		9	SS	6		132		○		

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-05 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 397.0 E 315 793.6 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.01 - 2016.11.02 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Silty **CLAY**, some sand Firm Grey Wet						131	2.5	○		
			10	SS	4						
							130	2.8			
128.7			11	SS	5		129		○		
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 4.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-06 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 358.5 E 315 818.9 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.02 - 2016.11.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.9	GROUND SURFACE										
0.0	**ASPHALT:** (90mm)										
0.1	**SAND**, trace gravel Brown Moist		1	GS					○		
140.1	(FILL)						140				
0.8	**SAND** and **SILT**, some clay, trace gravel Very Dense Brown Moist		1	SS	60				○		
139.2	(FILL)						139				
1.7	**SAND**, fine grained, trace gravel, mixed with organics Dense Dark Brown to Brown Moist		2	SS	41				○		
138.7	(FILL)						138				
2.2	Silty **SAND**, fine grained, trace clay Dense to Compact Brown Moist to Wet		3	SS	43	▽			○		
			4	SS	29				○		
			5	SS	17		137		○		0 66 30 4
			6	SS	17		136		○		
135.3											
5.6	**SILT**, some sand, some clay Loose Grey Wet		7	SS	8		135		○		0 13 76 11
133.0			8	SS	4		134		○		
7.9	Silty **CLAY**, trace sand, trace gravel Firm Grey Wet						133				
							132	+ 2.8			
			9	SS	6		131		e		0 9 47 44

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-06 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 358.5 E 315 818.9 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.02 - 2016.11.02 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, trace sand, trace gravel Firm to Soft Grey Wet							2.8			
			10	SS	0		130		○		
								2.8			
128.1			11	SS	1		129		○		
12.8	END OF BOREHOLE AT 12.8m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.11.09 1.1 139.8 2016.12.21 2.8 138.1										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \div 10}$ 5 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-07 1 OF 3 METRIC

W.P. 2061-13-00 LOCATION N 4 847 321.4 E 315 822.2 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.25 - 2016.10.25 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
141.5	GROUND SURFACE										
0.0 / 141.1	**TOPSOIL**, some clay, trace gravel, roots and rootlets Compact Dark Brown Moist		1	SS	16		141				
0.4	Silty **SAND**, some clay, trace gravel Compact to Dense Brown Moist (FILL)		2	SS	30						6 50 28 16
	Occasional organic seams		3	SS	45		140				
139.2											
2.3	**SAND**, fine grained, some silt to silty, trace gravel Compact Brown Moist to Wet		4	SS	14		139				
			5	SS	26		138				0 80 18 2
			6	SS	21	▼					0 84 14 2
			7	SS	14		137				
			8	SS	13		136				
135.5											
6.0	Loose to Very Loose		9	SS	5		135				
	Saturated		10	SS	2		134				
							133				
131.9			11	SS	4		132				
9.6	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey										

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-07 2 OF 3 METRIC

W.P. 2061-13-00 LOCATION N 4 847 321.4 E 315 822.2 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.25 - 2016.10.25 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet						131	3.5			
			12	SS	2						4 21 41 34
							130	2.8			
			13	SS	1		129				
								2.5			
			14	SS	3		128				
							127	2.5			
	Trace gravel		15	SS	2		126				
								2.3			
			16	SS	3		125				
							124	2.0			
122.6			17	SS	0		123				
18.9	END OF BOREHOLE AT 18.9m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$\frac{20}{15 \cdot 10 \cdot 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-07 3 OF 3 METRIC

W.P. 2061-13-00 LOCATION N 4 847 321.4 E 315 822.2 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.25 - 2016.10.25 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2016.11.09 3.0 138.5 2016.12.21 4.5 137.0										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-08 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 279.3 E 315 827.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.26 - 2016.10.26 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.5	GROUND SURFACE										
0.0	Silty **SAND**, some clay, trace gravel, trace organics Dense to Compact Brown Moist (FILL)		1	SS	36		140		○		3 57 24 16
139.0			2	SS	16		139		○		
1.5	**SAND**, fine grained, trace silt Compact Brown Moist		3	SS	22		138		○		
			4	SS	21		137		○		
136.8			5	SS	12				○		
3.7	**SILT**, trace sand, trace clay Loose Brown Wet		6	SS	9		136		○		Split spoon sampler wet 0 10 83 7
			7	SS	6	▽	135		○		
			8	SS	5		134		○		
			9	SS	9		133		○		
131.8							132				
8.7	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet		10	SS	0		131		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-08 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 279.3 E 315 827.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.26 - 2016.10.26 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet						130	2.5			
			11	SS	2				○		
							129	3.5			
127.7			12	SS	2		128		○		
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 4.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
$\frac{10}{}$

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-09 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 227.2 E 315 832.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.26 - 2016.10.26 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.6	GROUND SURFACE										
0.0	Clayey **SILT**, some sand, trace gravel, mixed with organics Stiff Dark Brown Moist (FILL)		1	SS	47		140				
0.2	Silty **SAND**, trace clay, trace gravel, trace organics Compact to Very Loose Brown Moist (FILL)		2	SS	19						
			3	SS	3		139				0 71 21 8
			4	SS	2		138				
137.6											
3.0	**SAND**, fine grained, some silt Compact Brown Moist to Wet		5	SS	19		137				
			6	SS	17						
			7	SS	14	▽	136				0 85 11 4
135.0											
5.6	**SILT**, trace clay, trace sand Loose Brown Saturated		8	SS	9		135				
			9	SS	5		134				
			10	SS	2		133				
131.1							132				
9.5	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey						131				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-09 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 227.2 E 315 832.5 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.26 - 2016.10.26 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet							3.0			
			11	SS	2		130		○		
							129	2.7			
127.8			12	SS	2		128		○		
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 5.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-10 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 174.1 E 315 837.6 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.27 - 2016.10.27 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.2	GROUND SURFACE								
0.0	**TOPSOIL:** (75mm)								
0.1	**SAND**, trace to some silt, trace clay, trace gravel Compact Brown Moist (FILL)		1	SS	12		138		
			2	SS	12		137		
136.7									
1.5	**SAND**, fine grained, some silt, trace clay Compact Brown Moist to Wet		3	SS	25				
			4	SS	11		136		0 80 18 2
134.7			5	SS	13		135		
3.5	**SILT**, trace to some sand, trace clay Loose Brown Wet		6	SS	6		134		0 10 83 7
			7	SS	5				0 12 83 5
			8	SS	6		133 132		
130.4							131		
7.8	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet		9	SS	1		130		
			10	SS	0		129		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa 20 40 60 80 100
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

+2.7

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 1/6/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-10 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 174.1 E 315 837.6 ORIGINATED BY ES

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.10.27 - 2016.10.27 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	γ kN/m³	GR SA SI CL
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet						128	2.4			
			11	SS	1		127	2.8			
125.4			12	SS	1		126				
12.8	END OF BOREHOLE AT 12.8m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2016.11.09	1.4	136.8
2016.12.21	3.8	134.4

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-11 1 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 132.2 E 315 834.8 ORIGINATED BY TM

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.13 - 2016.11.13 CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.1	GROUND SURFACE				
0.0 / 137.8	**ASPHALT:** (300mm)	1	SS	38	
0.3 / 137.3	Gravelly **SAND**, trace silt Dense Brown				
0.8 / 135.9	Moist (FILL) **SAND** and **SILT**, some clay, trace gravel Compact Brown Moist	2	SS	25	
		3	SS	15	0 37 40 23
2.2 / 135.1	Loose	4	SS	8	
3.0 / 134.4	Compact	5	SS	10	
3.7 / 132.5	**SAND**, some silt, trace clay Loose Brown Moist	6	SS	7	Split spoon sampler wet 0 74 17 9
		7	SS	7	
5.6	Silty **CLAY**, some sand, trace gravel Very Soft to Firm Grey Wet	8	SS	2	
		9	SS	1	
		10	SS	0	

ELEVATION SCALE: 138, 137, 136, 135, 134, 133, 132, 131, 130, 129

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

1.8

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 2/1/17

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No WM 16-11 2 OF 2 METRIC

W.P. 2061-13-00 LOCATION N 4 847 132.2 E 315 834.8 ORIGINATED BY TM

HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.13 - 2016.11.13 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Silty **CLAY**, some sand, trace gravel Soft to Firm Grey Wet						128	2.7			
			11	SS	2		127	1.7			
125.3			12	SS	1		126				
12.8	END OF BOREHOLE AT 12.8m. BOREHOLE OPEN UPON COMPLETION OF DRILLING. WATER LEVEL AT 10.7m UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.01.23 1.7 136.4										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}$ 5 $\frac{}{10}$ (%) STRAIN AT FAILURE

ONTMT4S MTO-12371.GPJ 2015TEMPLATE(MTO).GDT 2/1/17

THURBER

60 YEARS

Appendix B

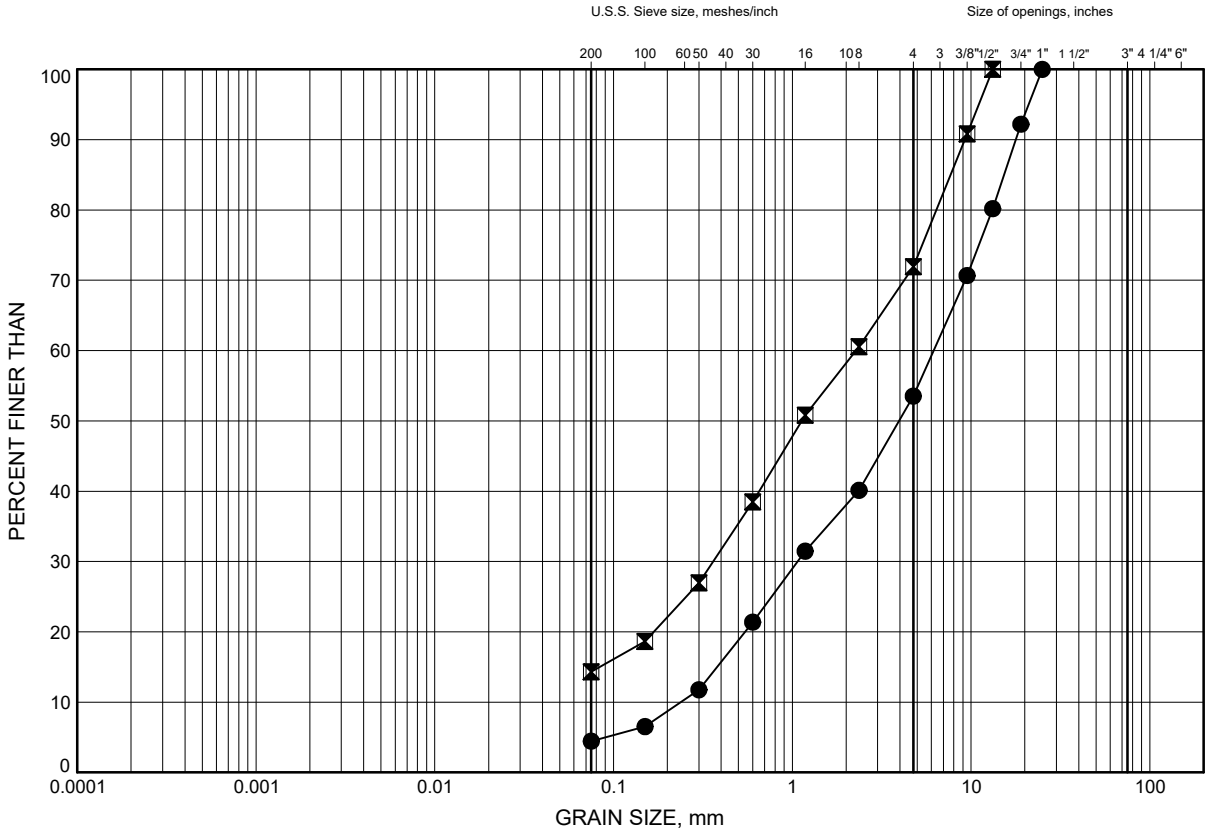
Geotechnical Laboratory Test Results

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND and GRAVEL / Gravelly SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-01	1.07	140.33
⊠	WM 16-02	1.07	144.33

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

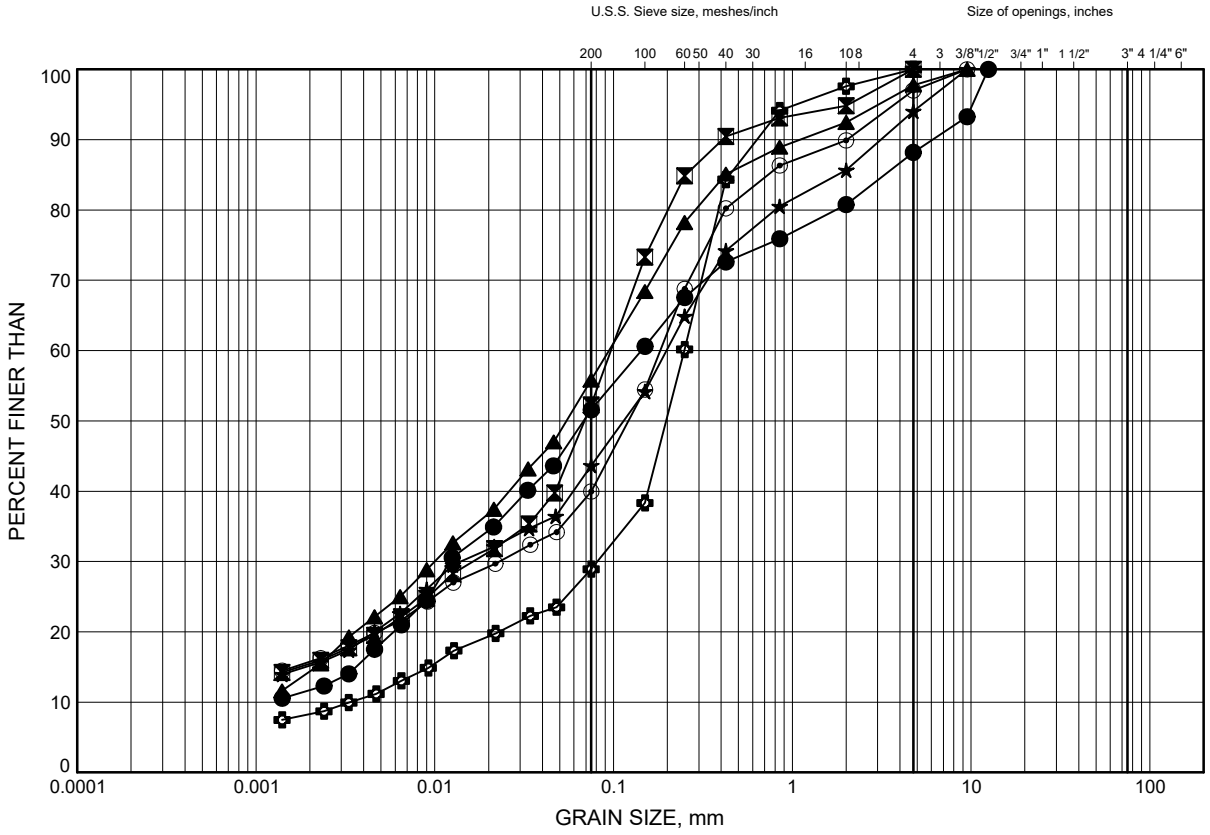
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/21/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND and SILT / Silty SAND FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-02	2.59	142.81
⊠	WM 16-04	1.83	139.07
▲	WM 16-05	2.59	138.91
★	WM 16-07	1.07	140.43
⊙	WM 16-08	0.30	140.20
✿	WM 16-09	1.83	138.77

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

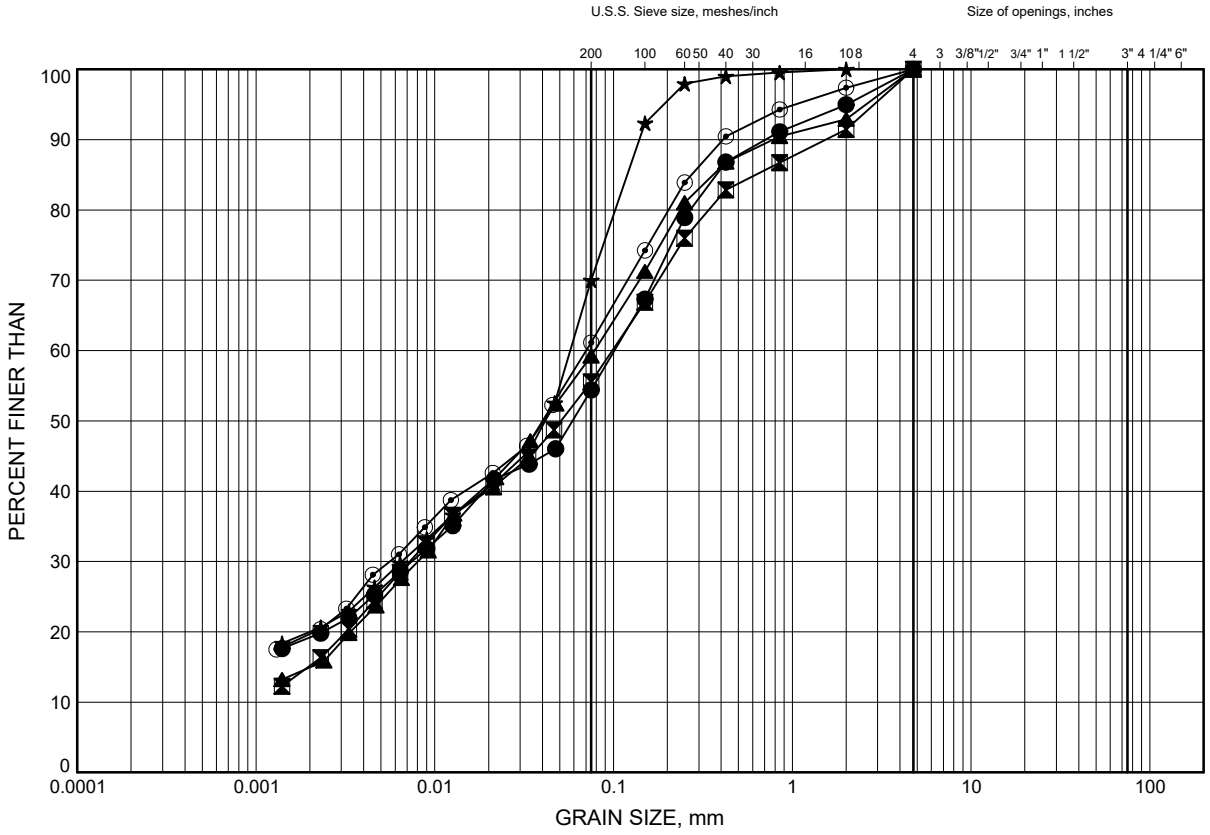
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/21/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND and SILT / Sandy SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-01	3.35	138.05
⊠	WM 16-02	4.11	141.29
▲	WM 16-03	3.35	137.75
★	WM 16-03	4.88	136.22
⊙	WM 16-04	4.11	136.79

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

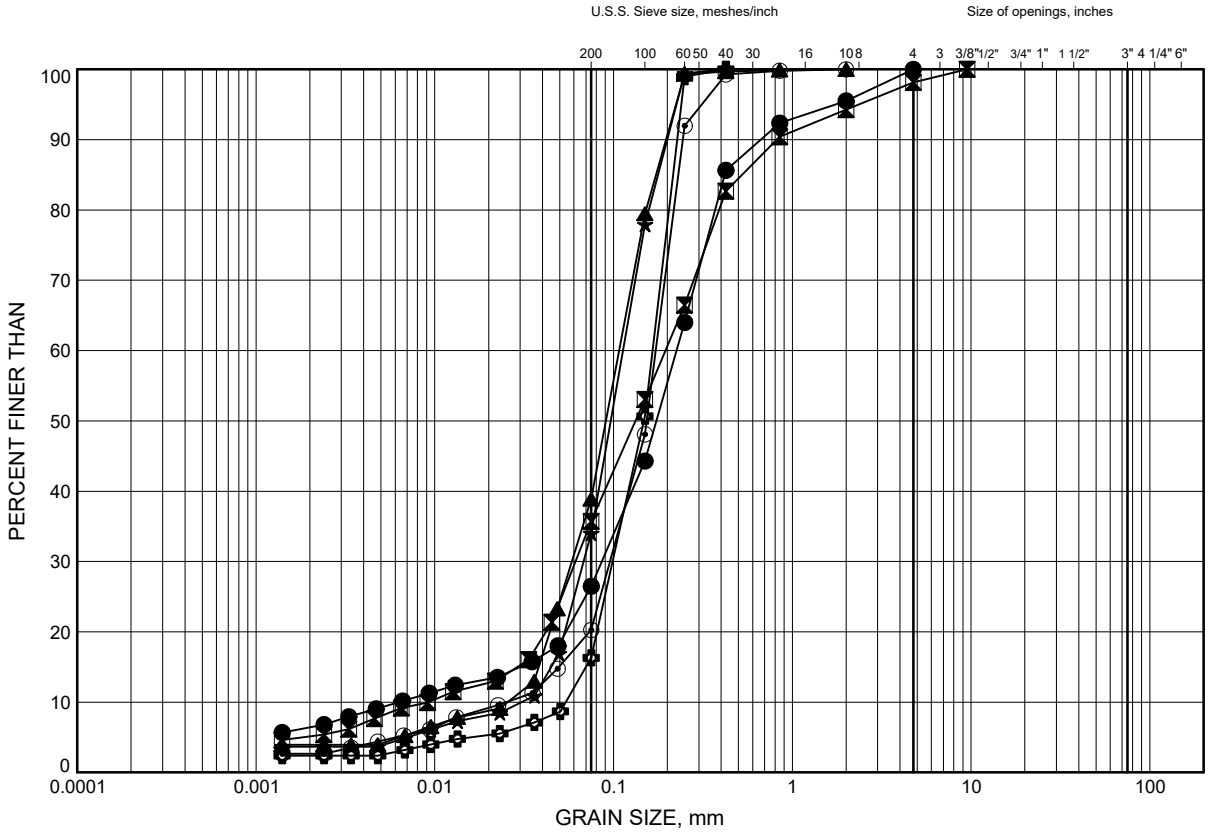
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/22/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND / Silty SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-01	7.92	133.48
⊠	WM 16-04	7.92	132.98
▲	WM 16-05	4.88	136.62
★	WM 16-06	4.11	136.79
⊙	WM 16-07	3.35	138.15
✿	WM 16-07	4.11	137.39

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

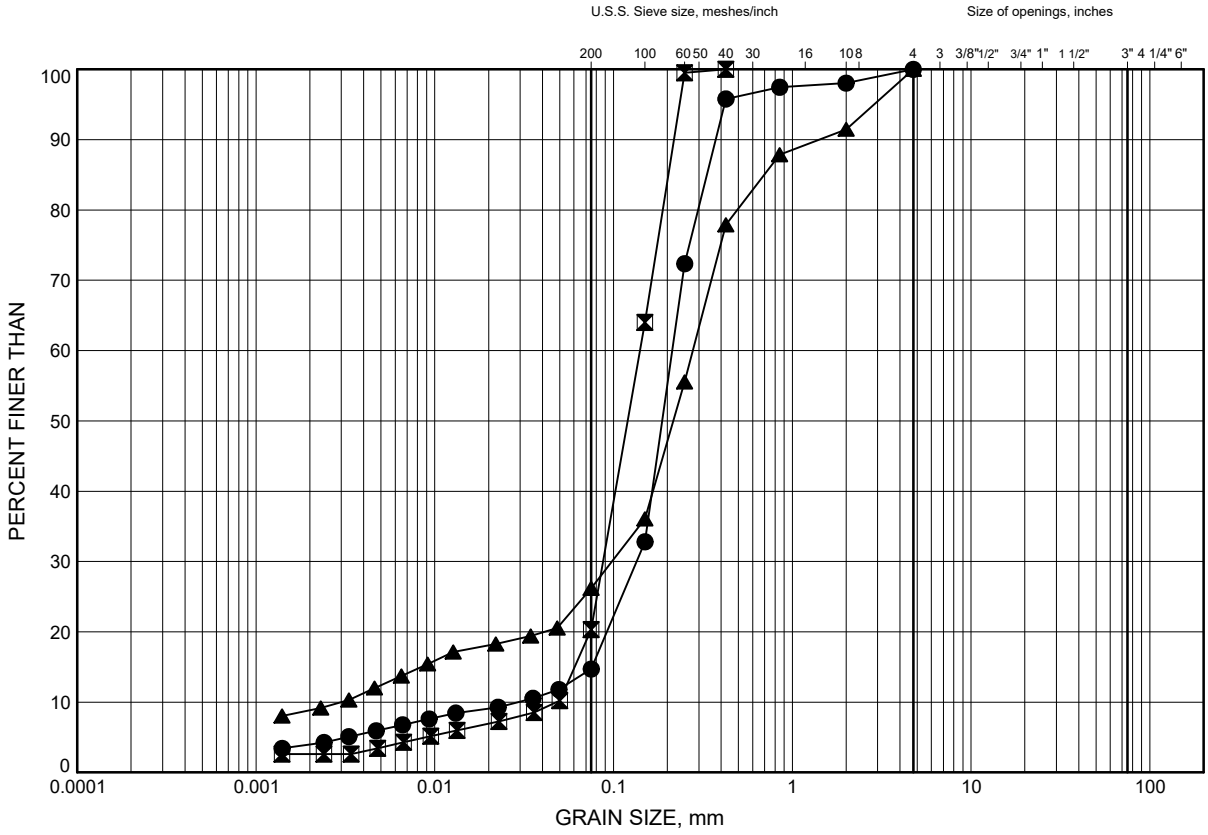
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/22/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B5

SAND / Silty SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-09	4.88	135.72
⊠	WM 16-10	2.59	135.61
▲	WM 16-11	4.11	133.99

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

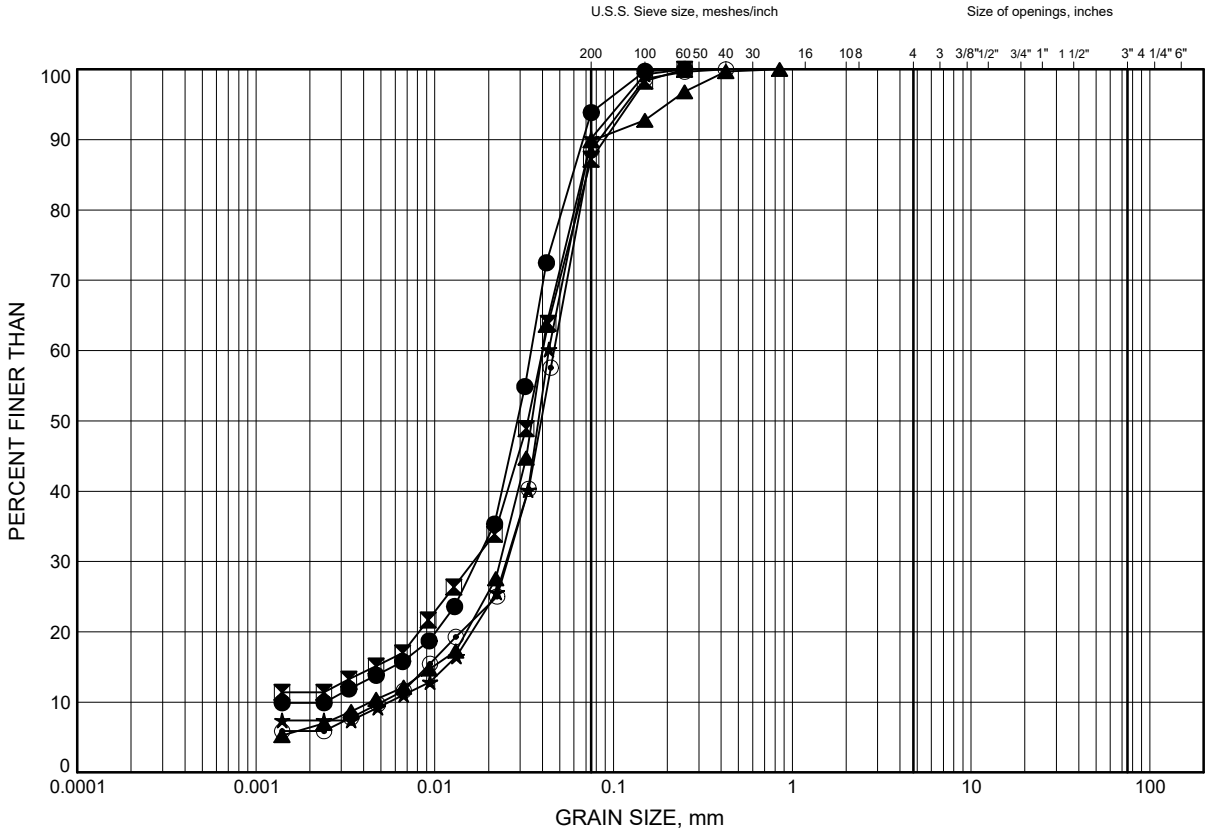
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/22/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-05	6.40	135.10
⊠	WM 16-06	6.40	134.50
▲	WM 16-08	4.11	136.39
★	WM 16-10	4.11	134.09
⊙	WM 16-10	4.88	133.32

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

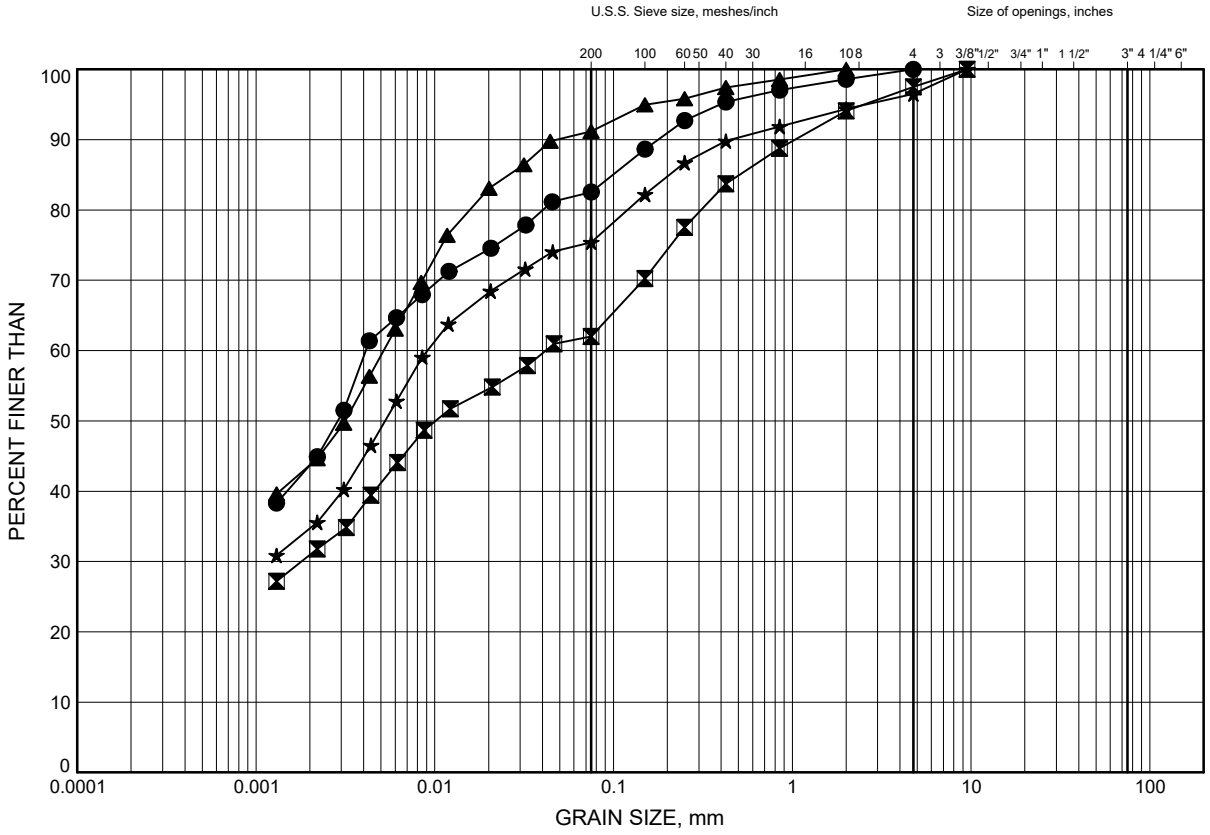
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/21/16

Relocated Watermain Crossing Hwy 401 at Leslie

GRAIN SIZE DISTRIBUTION

FIGURE B7

Silty CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-01	9.45	131.95
⊠	WM 16-04	12.50	128.40
▲	WM 16-06	9.45	131.45
★	WM 16-07	10.97	130.53

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

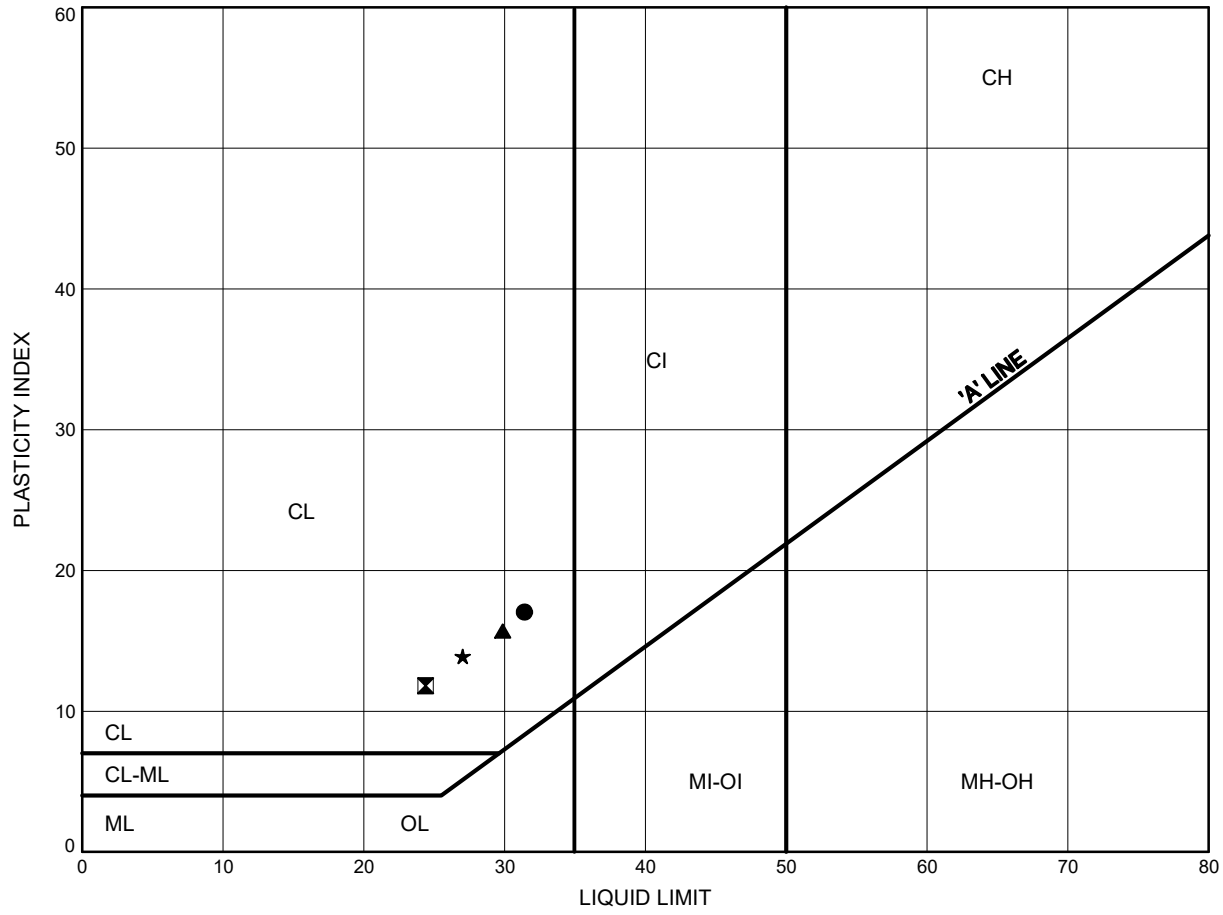
GRAIN SIZE DISTRIBUTION - THURBER MTO-12371.GPJ 12/21/16

Relocated Watermain Crossing Hwy 401 at Leslie

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Silty CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	WM 16-01	9.45	131.95
⊠	WM 16-04	12.50	128.40
▲	WM 16-06	9.45	131.45
★	WM 16-07	10.97	130.53

Date December 2016

W.P. 2061-13-00

THURBER

Prep'd AN

Chkd. SKP

THURBALT MTO-12371.GPJ 12/21/16

Appendix C

Environmental Laboratory Test Results

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD
SUITE 103, 2010 WINSTON PARK DRIVE
OAKVILLE, ON L6H5R7
(905) 829-8666

ATTENTION TO: Cory Zanatta

PROJECT: 12371

AGAT WORK ORDER: 16T151944

TRACE ORGANICS REVIEWED BY: Inga Kuzmina, Trace Organics Lab Manager

DATE REPORTED: Oct 31, 2016

PAGES (INCLUDING COVER): 10

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16T151944

PROJECT: 12371

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - PHCs F1 - F4 (-BTEX) (Soil)

DATE RECEIVED: 2016-10-21

DATE REPORTED: 2016-10-31

					SAMPLE DESCRIPTION:	16-01 SS1	16-04 SS2
					SAMPLE TYPE:	Soil	Soil
					DATE SAMPLED:	2016-10-20	2016-10-19
Parameter	Unit	G / S: A	G / S: B	RDL		7951431	7951434
F1 (C6 to C10)	µg/g	25	55	5		<5[<A]	<5[<A]
F1 (C6 to C10) minus BTEX	µg/g	25	55	5		<5[<A]	<5[<A]
F2 (C10 to C16)	µg/g	10	230	10		<10[<A]	<10[<A]
F3 (C16 to C34)	µg/g	240	1700	50		150[<A]	<50[<A]
F4 (C34 to C50)	µg/g	120	3300	50		360[A-B]	<50[<A]
Gravimetric Heavy Hydrocarbons	µg/g	120	3300	50		NA[<A]	NA[<A]
Moisture Content	%			0.1		7.1	6.9
Surrogate	**Unit**	**Acceptable Limits**					
Terphenyl	%	60-140				130	138

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use, B Refers to Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition - Soil - Industrial/Commercial/Community Property Use - Coarse Textured Soils

7951431-7951434 Results are based on sample dry weight.
The C6-C10 fraction is calculated using toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
The chromatogram has returned to baseline by the retention time of nC50.
Total C6 - C50 results are corrected for BTEX contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified without the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.

Certified By:

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Certificate of Analysis

AGAT WORK ORDER: 16T151944

PROJECT: 12371

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - VOCs (Soil)

DATE RECEIVED: 2016-10-21

DATE REPORTED: 2016-10-31

			SAMPLE DESCRIPTION:		16-01 SS1	16-04 SS2
			SAMPLE TYPE:		Soil	Soil
			DATE SAMPLED:		2016-10-20	2016-10-19
Parameter	Unit	G / S: A	G / S: B	RDL	7951431	7951434
Dichlorodifluoromethane	µg/g	0.05	16	0.05	<0.05[<A]	<0.05[<A]
Vinyl Chloride	ug/g	0.02	0.032	0.02	<0.02[<A]	<0.02[<A]
Bromomethane	ug/g	0.05	0.05	0.05	<0.05[<A]	<0.05[<A]
Trichlorofluoromethane	ug/g	0.25	4	0.05	<0.05[<A]	<0.05[<A]
Acetone	ug/g	0.5	16	0.50	<0.50[<A]	<0.50[<A]
1,1-Dichloroethylene	ug/g	0.05	0.064	0.05	<0.05[<A]	<0.05[<A]
Methylene Chloride	ug/g	0.05	1.6	0.05	<0.05[<A]	<0.05[<A]
Trans- 1,2-Dichloroethylene	ug/g	0.05	1.3	0.05	<0.05[<A]	<0.05[<A]
Methyl tert-butyl Ether	ug/g	0.05	1.6	0.05	<0.05[<A]	<0.05[<A]
1,1-Dichloroethane	ug/g	0.05	0.47	0.02	<0.02[<A]	<0.02[<A]
Methyl Ethyl Ketone	ug/g	0.5	70	0.50	<0.50[<A]	<0.50[<A]
Cis- 1,2-Dichloroethylene	ug/g	0.05	1.9	0.02	<0.02[<A]	<0.02[<A]
Chloroform	ug/g	0.05	0.47	0.04	<0.04[<A]	<0.04[<A]
1,2-Dichloroethane	ug/g	0.05	0.05	0.03	<0.03[<A]	<0.03[<A]
1,1,1-Trichloroethane	ug/g	0.05	6.1	0.05	<0.05[<A]	<0.05[<A]
Carbon Tetrachloride	ug/g	0.05	0.21	0.05	<0.05[<A]	<0.05[<A]
Benzene	ug/g	0.02	0.32	0.02	<0.02[<A]	<0.02[<A]
1,2-Dichloropropane	ug/g	0.05	0.16	0.03	<0.03[<A]	<0.03[<A]
Trichloroethylene	ug/g	0.05	0.55	0.03	<0.03[<A]	<0.03[<A]
Bromodichloromethane	ug/g	0.05	1.5	0.05	<0.05[<A]	<0.05[<A]
Methyl Isobutyl Ketone	ug/g	0.5	31	0.50	<0.50[<A]	<0.50[<A]
1,1,2-Trichloroethane	ug/g	0.05	0.05	0.04	<0.04[<A]	<0.04[<A]
Toluene	ug/g	0.2	6.4	0.05	<0.05[<A]	<0.05[<A]
Dibromochloromethane	ug/g	0.05	2.3	0.05	<0.05[<A]	<0.05[<A]
Ethylene Dibromide	ug/g	0.05	0.05	0.04	<0.04[<A]	<0.04[<A]
Tetrachloroethylene	ug/g	0.05	1.9	0.05	<0.05[<A]	<0.05[<A]
1,1,1,2-Tetrachloroethane	ug/g	0.05	0.087	0.04	<0.04[<A]	<0.04[<A]
Chlorobenzene	ug/g	0.05	2.4	0.05	<0.05[<A]	<0.05[<A]
Ethylbenzene	ug/g	0.05	1.1	0.05	<0.05[<A]	<0.05[<A]
m & p-Xylene	ug/g			0.05	<0.05	<0.05

Certified By:

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Certificate of Analysis

AGAT WORK ORDER: 16T151944

PROJECT: 12371

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

O. Reg. 153(511) - VOCs (Soil)

DATE RECEIVED: 2016-10-21

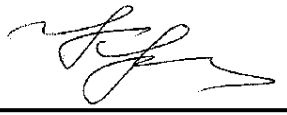
DATE REPORTED: 2016-10-31

			SAMPLE DESCRIPTION:		16-01 SS1	16-04 SS2
			SAMPLE TYPE:		Soil	Soil
			DATE SAMPLED:		2016-10-20	2016-10-19
Parameter	**Unit**	**G / S: A**	**G / S: B**	**RDL**	**7951431**	**7951434**
Bromoform	ug/g	0.05	0.61	0.05	<0.05[<A]	<0.05[<A]
Styrene	ug/g	0.05	34	0.05	<0.05[<A]	<0.05[<A]
1,1,2,2-Tetrachloroethane	ug/g	0.05	0.05	0.05	<0.05[<A]	<0.05[<A]
o-Xylene	ug/g			0.05	<0.05	<0.05
1,3-Dichlorobenzene	ug/g	0.05	9.6	0.05	<0.05[<A]	<0.05[<A]
1,4-Dichlorobenzene	ug/g	0.05	0.2	0.05	<0.05[<A]	<0.05[<A]
1,2-Dichlorobenzene	ug/g	0.05	1.2	0.05	<0.05[<A]	<0.05[<A]
Xylene Mixture	ug/g	0.05	26	0.05	<0.05[<A]	<0.05[<A]
1,3-Dichloropropene	µg/g	0.05	0.059	0.04	<0.04[<A]	<0.04[<A]
n-Hexane	µg/g	0.05	46	0.05	<0.05[<A]	<0.05[<A]
Surrogate	**Unit**		**Acceptable Limits**			
Toluene-d8	% Recovery		50-140		112	94
4-Bromofluorobenzene	% Recovery		50-140		98	92

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to Table 1: Full Depth Background Site Condition Standards - Soil - Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use, B Refers to Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition - Soil - Industrial/Commercial/Community Property Use - Coarse Textured Soils

7951431-7951434 The sample was analysed using the high level technique. The sample was extracted using methanol, a small amount of the methanol extract was diluted in water and the purge & trap GC/MS analysis was performed. Results are based on the dry weight of the soil.

Certified By:



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Guideline Violation

AGAT WORK ORDER: 16T151944

PROJECT: 12371

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: Cory Zanatta

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
7951431	16-01 SS1	ON T1 S RPI/ICC	O. Reg. 153(511) - PHCs F1 - F4 (-BTEX) (Soil)	F4 (C34 to C50)	120	360

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Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T151944

PROJECT: 12371

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

Trace Organics Analysis

RPT Date: Oct 31, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - VOCs (Soil)															
Dichlorodifluoromethane	7939569		< 0.05	< 0.05	NA	< 0.05	97%	50%	140%	106%	50%	140%	96%	50%	140%
Vinyl Chloride	7939569		< 0.02	< 0.02	NA	< 0.02	106%	50%	140%	110%	50%	140%	91%	50%	140%
Bromomethane	7939569		< 0.05	< 0.05	NA	< 0.05	108%	50%	140%	104%	50%	140%	108%	50%	140%
Trichlorofluoromethane	7939569		< 0.05	< 0.05	NA	< 0.05	103%	50%	140%	107%	50%	140%	110%	50%	140%
Acetone	7939569		< 0.50	< 0.50	NA	< 0.50	98%	50%	140%	104%	50%	140%	101%	50%	140%
1,1-Dichloroethylene	7939569		< 0.05	< 0.05	NA	< 0.05	102%	50%	140%	117%	60%	130%	78%	50%	140%
Methylene Chloride	7939569		< 0.05	< 0.05	NA	< 0.05	115%	50%	140%	118%	60%	130%	87%	50%	140%
Trans- 1,2-Dichloroethylene	7939569		< 0.05	< 0.05	NA	< 0.05	103%	50%	140%	99%	60%	130%	83%	50%	140%
Methyl tert-butyl Ether	7939569		< 0.05	< 0.05	NA	< 0.05	82%	50%	140%	104%	60%	130%	80%	50%	140%
1,1-Dichloroethane	7939569		< 0.02	< 0.02	NA	< 0.02	92%	50%	140%	117%	60%	130%	84%	50%	140%
Methyl Ethyl Ketone	7939569		< 0.50	< 0.50	NA	< 0.50	97%	50%	140%	102%	50%	140%	96%	50%	140%
Cis- 1,2-Dichloroethylene	7939569		< 0.02	< 0.02	NA	< 0.02	105%	50%	140%	96%	60%	130%	90%	50%	140%
Chloroform	7939569		< 0.04	< 0.04	NA	< 0.04	118%	50%	140%	114%	60%	130%	81%	50%	140%
1,2-Dichloroethane	7939569		< 0.03	< 0.03	NA	< 0.03	85%	50%	140%	110%	60%	130%	85%	50%	140%
1,1,1-Trichloroethane	7939569		< 0.05	< 0.05	NA	< 0.05	86%	50%	140%	106%	60%	130%	92%	50%	140%
Carbon Tetrachloride	7939569		< 0.05	< 0.05	NA	< 0.05	78%	50%	140%	107%	60%	130%	85%	50%	140%
Benzene	7939569		< 0.02	< 0.02	NA	< 0.02	100%	50%	140%	112%	60%	130%	116%	50%	140%
1,2-Dichloropropane	7939569		< 0.03	< 0.03	NA	< 0.03	112%	50%	140%	112%	60%	130%	112%	50%	140%
Trichloroethylene	7939569		< 0.03	< 0.03	NA	< 0.03	84%	50%	140%	114%	60%	130%	104%	50%	140%
Bromodichloromethane	7939569		< 0.04	< 0.04	NA	< 0.05	91%	50%	140%	116%	60%	130%	101%	50%	140%
Methyl Isobutyl Ketone	7939569		< 0.50	< 0.50	NA	< 0.50	97%	50%	140%	105%	50%	140%	98%	50%	140%
1,1,2-Trichloroethane	7939569		< 0.04	< 0.04	NA	< 0.04	114%	50%	140%	115%	60%	130%	86%	50%	140%
Toluene	7939569		< 0.05	< 0.05	NA	< 0.05	113%	50%	140%	116%	60%	130%	111%	50%	140%
Dibromochloromethane	7939569		< 0.03	< 0.03	NA	< 0.05	111%	50%	140%	107%	60%	130%	82%	50%	140%
Ethylene Dibromide	7939569		< 0.04	< 0.04	NA	< 0.04	103%	50%	140%	113%	60%	130%	104%	50%	140%
Tetrachloroethylene	7939569		< 0.05	< 0.05	NA	< 0.05	112%	50%	140%	110%	60%	130%	117%	50%	140%
1,1,1,2-Tetrachloroethane	7939569		< 0.04	< 0.04	NA	< 0.04	112%	50%	140%	102%	60%	130%	116%	50%	140%
Chlorobenzene	7939569		< 0.05	< 0.05	NA	< 0.05	117%	50%	140%	97%	60%	130%	108%	50%	140%
Ethylbenzene	7939569		< 0.05	< 0.05	NA	< 0.05	107%	50%	140%	118%	60%	130%	109%	50%	140%
m & p-Xylene	7939569		< 0.05	< 0.05	NA	< 0.05	117%	50%	140%	101%	60%	130%	102%	50%	140%
Bromoform	7939569		< 0.03	< 0.03	NA	< 0.05	100%	50%	140%	108%	60%	130%	105%	50%	140%
Styrene	7939569		< 0.05	< 0.05	NA	< 0.05	81%	50%	140%	114%	60%	130%	87%	50%	140%
1,1,2,2-Tetrachloroethane	7939569		< 0.05	< 0.05	NA	< 0.05	115%	50%	140%	113%	60%	130%	101%	50%	140%
o-Xylene	7939569		< 0.05	< 0.05	NA	< 0.05	115%	50%	140%	99%	60%	130%	109%	50%	140%
1,3-Dichlorobenzene	7939569		< 0.05	< 0.05	NA	< 0.05	85%	50%	140%	111%	60%	130%	93%	50%	140%
1,4-Dichlorobenzene	7939569		< 0.05	< 0.05	NA	< 0.05	84%	50%	140%	111%	60%	130%	93%	50%	140%
1,2-Dichlorobenzene	7939569		< 0.05	< 0.05	NA	< 0.05	81%	50%	140%	113%	60%	130%	104%	50%	140%
1,3-Dichloropropene	7939569		< 0.04	< 0.04	NA	< 0.04	95%	50%	140%	95%	60%	130%	96%	50%	140%
n-Hexane	7939569		< 0.05	< 0.05	NA	< 0.05	101%	50%	140%	95%	60%	130%	85%	50%	140%

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Quality Assurance

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T151944

PROJECT: 12371

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

Trace Organics Analysis (Continued)

RPT Date: Oct 31, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - PHCs F1 - F4 (-BTEX) (Soil)															
F1 (C6 to C10)	7949223		< 5	< 5	NA	< 5	74%	60%	130%	87%	85%	115%	83%	70%	130%
F2 (C10 to C16)	7951395		< 10	< 10	NA	< 10	93%	60%	130%	96%	80%	120%	73%	70%	130%
F3 (C16 to C34)	7951395		< 50	< 50	NA	< 50	98%	60%	130%	99%	80%	120%	81%	70%	130%
F4 (C34 to C50)	7951395		< 50	< 50	NA	< 50	94%	60%	130%	99%	80%	120%	97%	70%	130%

Comments: When the average of the sample and duplicate results is less than 5x the RDL, the Relative Percent Difference (RPD) will be indicated as Not Applicable (NA).

Certified By:

AGAT Laboratories

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Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T151944

PROJECT: 12371

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Trace Organics Analysis			
F1 (C6 to C10)	VOL-91-5009	CCME Tier 1 Method, SW846 5035	P &T GC / FID
F1 (C6 to C10) minus BTEX	VOL-91-5009	CCME Tier 1 Method, SW846 5035	P & T GC / FID
F2 (C10 to C16)	VOL-91-5009	CCME Tier 1 Method	GC / FID
F3 (C16 to C34)	VOL-91-5009	CCME Tier 1 Method	GC / FID
F4 (C34 to C50)	VOL-91-5009	CCME Tier 1 Method	GC / FID
Gravimetric Heavy Hydrocarbons	VOL-91-5009	CCME Tier 1 Method	GRAVIMETRIC ANALYSIS
Moisture Content	VOL-91-5009	CCME Tier 1 Method, SW846 5035,8015	BALANCE
Terphenyl	VOL-91-5009		GC/FID
Dichlorodifluoromethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Vinyl Chloride	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Bromomethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Trichlorofluoromethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Acetone	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1-Dichloroethylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Methylene Chloride	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Trans- 1,2-Dichloroethylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Methyl tert-butyl Ether	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1-Dichloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Methyl Ethyl Ketone	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Cis- 1,2-Dichloroethylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Chloroform	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,2-Dichloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1,1-Trichloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Carbon Tetrachloride	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Benzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,2-Dichloropropane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Trichloroethylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Bromodichloromethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Methyl Isobutyl Ketone	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1,2-Trichloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Toluene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Dibromochloromethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Ethylene Dibromide	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Tetrachloroethylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1,1,2-Tetrachloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Chlorobenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Ethylbenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
m & p-Xylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Bromoform	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Styrene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,1,2,2-Tetrachloroethane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
o-Xylene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,3-Dichlorobenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,4-Dichlorobenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,2-Dichlorobenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
Xylene Mixture	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
1,3-Dichloropropene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
n-Hexane	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: THURBER ENGINEERING LTD

AGAT WORK ORDER: 16T151944

PROJECT: 12371

ATTENTION TO: Cory Zanatta

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Toluene-d8	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS
4-Bromofluorobenzene	VOL-91-5002	EPA SW-846 5035 & 8260	(P&T)GC/MS

SGS Canada Inc.
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Project : 12371 401 & Leslie

17-January-2017

Thurber Engineering Ltd
Attn : Cory Zanatta

2010 Winston Park Dr
Oakville, ON
L6H 5R7,

Phone: 905-829-8666 x 240
Fax:

Date Rec. : 10 January 2017
LR Report: **CA14160-JAN17**
Reference: 12371 Cory Zanatta

Copy: #1

CERTIFICATE OF ANALYSIS
Final Report

Analysis	1: Date Extracted / Digested	2: Date Analyzed	3: Analysis Approval Date	4: Analysis Approval Time	5: Table 3 Residential / Parkland / Institutional Property Use	6: Table 3 Industrial/Commercial/Community Property Use	7: Schedule 4 Limits	8: RL	9: 16-01 SS1	10: 16-01 SS4	11: 16-01 SS6	12: 16-02 SS4
Sample Date & Time									01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16
Corrosivity Index [none]	16-Jan-17	16-Jan-17	16-Jan-17	15:21					---	4	---	---
pH [no unit]	12-Jan-17	12-Jan-17	13-Jan-17	09:04					---	8.74	---	---
Soil Redox Potential [mV]	12-Jan-17	12-Jan-17	13-Jan-17	10:08					---	297	---	---
Sulphide [%]	13-Jan-17	13-Jan-17	13-Jan-17	14:01					---	< 0.02	---	---
Moisture Content [%]	13-Jan-17	16-Jan-17	16-Jan-17	09:11	---	---	---	---	---	---	16.9	6.1
Sulphate [µg/g]	12-Jan-17	12-Jan-17	13-Jan-17	15:00					---	35	---	---
Conductivity [uS/cm]	16-Jan-17	16-Jan-17	16-Jan-17	15:33					---	133*	---	---
Resistivity (calculated) [Ohms.cm]	16-Jan-17	16-Jan-17							---	7520	---	---
Sample weight [g]	12-Jan-17	13-Jan-17	13-Jan-17	11:14	---	---	---	---	100	---	---	---
Ext Fluid [#1 or #2]	12-Jan-17	13-Jan-17	13-Jan-17	11:14	---	---	---	---	2	---	---	---
Ext Volume [mL]	12-Jan-17	13-Jan-17	13-Jan-17	11:14	---	---	---	---	2000	---	---	---
Final pH	12-Jan-17	13-Jan-17	13-Jan-17	11:14	---	---	---	---	5.72	---	---	---
Mercury [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	09:42	---	---	2.5*	0.00001	< 0.00001	---	---	---
Arsenic [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	5*	0.01	< 0.01	---	---	---
Silver [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	100*	0.08	< 0.08	---	---	---
Barium [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	500*	0.0009	0.498	---	---	---

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Project : 12371 401 & Leslie

LR Report : **CA14160-JAN17**

Analysis	1: Date Extracted / Digested	2: Date Analyzed	3: Analysis Approval Date	4: Analysis Approval Time	5: Table 3 Residential / Parkland / Institutional Property Use	6: Table 3 Industrial/Commercial/Community Property Use	7: Schedule 4 Limits	8: RL	9: 16-01 SS1	10: 16-01 SS4	11: 16-01 SS6	12: 16-02 SS4
Boron [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	0.5	0.005	0.084	---	---	---
Cadmium [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	5*	0.001	0.002	---	---	---
Chromium [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	5	0.001	0.012	---	---	---
Lead [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	1	0.007	0.011	---	---	---
Selenium [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---	10*	0.01	< 0.01	---	---	---
Uranium [mg/L]	16-Jan-17	16-Jan-17	16-Jan-17	15:36	---	---		0.1	< 0.1	---	---	---
INORGANIC PARAMETERS	***	***	***	***	***	***	***	***	***	***	***	***
METALS	***	***	***	***	***	***	***	***	***	***	***	***
Barium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	390*	670*	---	0.01	---	---	39	17
Beryllium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	(5) 4	(10) 8	---	0.02	---	---	0.23	0.09
Boron [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	120	120	---	1	---	---	2	2
Cadmium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	1.2*	1.9*	---	0.02	---	---	0.07	0.03
Chromium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	160*	160*	---	0.5	---	---	13*	6.8*
Cobalt [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	22	(100) 80	---	0.01	---	---	5.0	3.3
Copper [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	(180) 140	(300) 230	---	0.1	---	---	9.8	7.1
Lead [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	120*	120*	---	0.1	---	---	5.6*	1.9
Molybdenum [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	6.9	40	---	0.1	---	---	0.2	0.2
Nickel [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	(130) 100	(340) 270	---	0.1	---	---	11	6.7
Silver [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	(25) 20	(50) 40	---	0.01	---	---	0.02	0.01
Thallium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	1	3.3	---	0.02	---	---	0.08	0.04
Uranium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	23*	33*	---	0.002	---	---	0.36	0.23
Vanadium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	86	86	---	3	---	---	19	14
Zinc [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	340	340	---	0.7	---	---	25	10
HYDRIDES	***	***	***	***	***	***	***	***	***	***	***	***
Antimony [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	7.5	(50) 40	---	0.8	---	---	< 0.8	< 0.8
Arsenic [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	18*	18*	---	0.5	---	---	1.8	1.2
Selenium [µg/g]	13-Jan-17	13-Jan-17	16-Jan-17	15:36	2.4*	5.5*	---	0.7	---	---	< 0.7	< 0.7
ORPs	***	***	***	***	***	***	***	***	***	***	***	***
Mercury [µg/g]	12-Jan-17	13-Jan-17	13-Jan-17	13:29	(1.8) 0.27	(20) 3.9	---	0.05	---	---	< 0.05	< 0.05
Water Soluble Boron [µg/g]	12-Jan-17	13-Jan-17	13-Jan-17	13:29	1.5	2	---	0.5	---	---	< 0.5	< 0.5
Sodium Adsorption Ratio [---]	13-Jan-17	13-Jan-17	13-Jan-17	15:34	5	12	---	0.2	---	---	3.4	9.1
SAR Calcium [mg/L]	13-Jan-17	13-Jan-17	13-Jan-17	15:34	---	---	---	0.09	---	---	26	29
SAR Magnesium [mg/L]	13-Jan-17	13-Jan-17	13-Jan-17	15:34	---	---	---	0.02	---	---	1.7	4.1

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Project : 12371 401 & Leslie

LR Report : **CA14160-JAN17**

Analysis	1: Date Extracted / Digested	2: Date Analyzed	3: Analysis Approval Date	4: Analysis Approval Time	5: Table 3 Residential / Parkland / Institutional Property Use	6: Table 3 Industrial/Commercial/Community Property Use	7: Schedule 4 Limits	8: RL	9: 16-01 SS1	10: 16-01 SS4	11: 16-01 SS6	12: 16-02 SS4
SAR Sodium [mg/L]	13-Jan-17	13-Jan-17	13-Jan-17	15:34	---	---	---	0.15	---	---	65	199
Conductivity [mS/cm]	13-Jan-17	13-Jan-17	16-Jan-17	11:09	0.7	1.4	---	0.002	---	---	0.66	1.4
pH [no unit]	13-Jan-17	13-Jan-17	13-Jan-17	13:40	---	---	---	0.05	---	---	7.43	8.00
Chloride [µg/g]	12-Jan-17	12-Jan-17	13-Jan-17	15:00	NA	NA	---	0.4	---	35	---	---
Chromium VI [µg/g]	12-Jan-17	13-Jan-17	17-Jan-17	14:12	(10) 8	(10) 8	---	0.2	---	---	< 0.2	< 0.2
Free Cyanide [µg/g]	11-Jan-17	12-Jan-17	16-Jan-17	10:44	0.051	0.051	---	0.05	---	---	< 0.05	< 0.05

Analysis	13: 16-02 SS5	14: 16-03 SS1	15: 16-04 SS1	16: 16-04 SS5	17: 16-05 SS4	18: 16-05 SS6	19: 16-06 SS4	20: 16-06 SS5	21: 16-07 SS5	22: 16-07 SS7	24: 16-08 SS6	25: 16-08 SS7
Sample Date & Time	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16	01-Nov-16
Corrosivity Index [none]	---	---	---	11	---	11	---	14	---	---	12	---
pH [no unit]	---	---	---	7.51	---	8.15	---	8.53	---	---	9.09	---
Soil Redox Potential [mV]	---	---	---	294	---	271	---	268	---	---	246	---
Sulphide [%]	---	---	---	< 0.02	---	< 0.02	---	< 0.02	---	---	< 0.02	---
Moisture Content [%]	---	9.0	---	---	9.3	---	13.7	---	4.0	---	---	---
Sulphate [µg/g]	---	---	---	25	---	38	---	32	---	---	17	---
Conductivity [uS/cm]	---	---	---	977*	---	1410*	---	889*	---	---	633*	---
Resistivity (calculated) [Ohms.cm]	---	---	---	1020	---	709	---	1130	---	---	1580	---
Sample weight [g]	100	---	100	---	---	---	---	---	---	100	---	100
Ext Fluid [#1 or #2]	2	---	2	---	---	---	---	---	---	2	---	2
Ext Volume [mL]	2000	---	2000	---	---	---	---	---	---	2000	---	2000
Final pH	5.68	---	5.71	---	---	---	---	---	---	5.63	---	5.67
Mercury [mg/L]	< 0.00001	---	< 0.00001	---	---	---	---	---	---	< 0.00001	---	< 0.00001
Arsenic [mg/L]	< 0.01	---	0.01	---	---	---	---	---	---	< 0.01	---	< 0.01
Silver [mg/L]	< 0.08	---	< 0.08	---	---	---	---	---	---	< 0.08	---	< 0.08
Barium [mg/L]	0.447	---	0.306	---	---	---	---	---	---	0.0941	---	0.294
Boron [mg/L]	0.075	---	0.490	---	---	---	---	---	---	0.121	---	0.146
Cadmium [mg/L]	0.001	---	0.001	---	---	---	---	---	---	< 0.001	---	< 0.001

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Project : 12371 401 & Leslie

LR Report : **CA14160-JAN17**

Analysis	13: 16-02 SS5	14: 16-03 SS1	15: 16-04 SS1	16: 16-04 SS5	17: 16-05 SS4	18: 16-05 SS6	19: 16-06 SS4	20: 16-06 SS5	21: 16-07 SS5	22: 16-07 SS7	24: 16-08 SS6	25: 16-08 SS7
Chromium [mg/L]	< 0.001	---	0.002	---	---	---	---	---	---	0.002	---	0.001
Lead [mg/L]	< 0.007	---	< 0.007	---	---	---	---	---	---	0.052	---	< 0.007
Selenium [mg/L]	< 0.01	---	< 0.01	---	---	---	---	---	---	< 0.01	---	< 0.01
Uranium [mg/L]	< 0.1	---	< 0.1	---	---	---	---	---	---	< 0.1	---	< 0.1
INORGANIC PARAMETERS	***	***	***	***	***	***	***	***	***	***	***	***
METALS	***	***	***	***	***	***	***	***	***	***	***	***
Barium [µg/g]	---	33	---	---	52	---	17	---	8.5	---	---	---
Beryllium [µg/g]	---	0.22	---	---	0.32	---	0.15	---	0.09	---	---	---
Boron [µg/g]	---	3	---	---	5	---	3	---	2	---	---	---
Cadmium [µg/g]	---	0.03	---	---	0.07	---	0.03	---	0.03	---	---	---
Chromium [µg/g]	---	10*	---	---	11*	---	6.0*	---	7.8*	---	---	---
Cobalt [µg/g]	---	4.4	---	---	4.9	---	2.6	---	1.6	---	---	---
Copper [µg/g]	---	8.5	---	---	9.6	---	6.3	---	4.4	---	---	---
Lead [µg/g]	---	3.8	---	---	5.0	---	2.7	---	1.9	---	---	---
Molybdenum [µg/g]	---	0.3	---	---	0.2	---	0.2	---	0.9	---	---	---
Nickel [µg/g]	---	9.1	---	---	10	---	5.7	---	4.3	---	---	---
Silver [µg/g]	---	0.02	---	---	0.02	---	0.02	---	< 0.01	---	---	---
Thallium [µg/g]	---	0.08	---	---	0.11	---	0.04	---	0.03	---	---	---
Uranium [µg/g]	---	0.40	---	---	0.52	---	0.30	---	0.28	---	---	---
Vanadium [µg/g]	---	17	---	---	18	---	11	---	8	---	---	---
Zinc [µg/g]	---	18	---	---	21	---	13	---	8.4	---	---	---
HYDRIDES	***	***	***	***	***	***	***	***	***	***	***	***
Antimony [µg/g]	---	< 0.8	---	---	< 0.8	---	< 0.8	---	< 0.8	---	---	---
Arsenic [µg/g]	---	1.7	---	---	1.7	---	1.4	---	1.1	---	---	---
Selenium [µg/g]	---	< 0.7	---	---	< 0.7	---	< 0.7	---	< 0.7	---	---	---
ORPs	***	***	***	***	***	***	***	***	***	***	***	***
Mercury [µg/g]	---	< 0.05	---	---	< 0.05	---	< 0.05	---	< 0.05	---	---	---
Water Soluble Boron [µg/g]	---	< 0.5	---	---	< 0.5	---	< 0.5	---	< 0.5	---	---	---
Sodium Adsorption Ratio [---]	---	6.2	---	---	4.9	---	13*	---	1.0	---	---	---
SAR Calcium [mg/L]	---	24	---	---	67	---	12	---	12	---	---	---
SAR Magnesium [mg/L]	---	5.1	---	---	8.1	---	1.1	---	0.98	---	---	---
SAR Sodium [mg/L]	---	128	---	---	160	---	175	---	14	---	---	---
Conductivity [mS/cm]	---	0.81	---	---	1.4	---	1.1	---	0.15	---	---	---

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Project : 12371 401 & Leslie
LR Report : **CA14160-JAN17**

Analysis	13: 16-02 SS5	14: 16-03 SS1	15: 16-04 SS1	16: 16-04 SS5	17: 16-05 SS4	18: 16-05 SS6	19: 16-06 SS4	20: 16-06 SS5	21: 16-07 SS5	22: 16-07 SS7	24: 16-08 SS6	25: 16-08 SS7
pH [no unit]	---	8.14	---	---	7.92	---	8.05	---	8.15	---	---	---
Chloride [µg/g]	---	---	---	810	---	1100	---	770	---	---	430	---
Chromium VI [µg/g]	---	< 0.2	---	---	< 0.2	---	< 0.2	---	< 0.2	---	---	---
Free Cyanide [µg/g]	---	< 0.05	---	---	< 0.05	---	< 0.05	---	< 0.05	---	---	---

Deanna Edwards, B.Sc, C.Chem
Project Specialist
Environmental Services, Analytical

OnLine LIMS

000087674

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CCME Method Compliance: Analyses were conducted using analytical procedures that comply with the Reference Method for the CWS for Petroleum Hydrocarbons in Soil and have been validated for use at the SGS laboratory, Lakefield, ON site.

Quality Compliance: Instrument performance / calibration quality criteria were met and extraction and analysis limits for holding times were met.
nC6 and nC10 response factors within 30% of response factor for toluene: YES
nC10, nC16 and nC34 response factors within 10% of the average response for the three compounds: YES
C50 response factors within 70% of nC10 + nC16 + nC34 average: YES
Linearity is within 15%: YES

F4G - gravimetric heavy hydrocarbons cannot be added to the C6 to C50 hydrocarbons.
The results for F4 and F4G are both reported and the greater of the two values is to be used in application to the CWS PHC.

Hydrocarbon results are expressed on a dry weight basis.

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

Temperature of Sample upon Receipt 19 degrees C
Cooling Agent Not Present
Custody Seal Not Present

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LR Report : **CA14160-JAN17**

Method Descriptions

Parameter	SGS Method Code	Reference Method Code
Anions by IC	ME-CA-[ENV]IC-LAK-AN-001	EPA300/MA300-Ions1.3
Carbon/Sulphur	ME-CA-[ENV]ARD-LAK-AN-020	ASTM E1915-07A
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	EPA 6010/SM 2510
Conductivity	ME-CA-[ENV]EWL-LAK-AN-006	SM 2510
Cyanide by SFA	ME-CA-[ENV]SFA-LAK-AN-005	SM 4500
Hexavalent Chromium by IC	ME-CA-[ENV]IC-LAK-AN-008	EPA218.6/EPA3060A
Mercury by CVAAS	ME-CA-[ENV]SPE-LAK-AN-004	EPA 7471A/EPA 245
Mercury by CVAAS	ME-CA-[ENV]SPE-LAK-AN-004	EPA 7471A/SM 3112B
Metals in aqueous samples - ICP-OES	ME-CA-[ENV]SPE-LAK-AN-003	MOE 4696e01/EPA 6010
Metals in aqueous samples - ICP-OES	ME-CA-[ENV]SPE-LAK-AN-003	SM 3030/EPA 200.7
Metals in Soil - Aqua-regia/ICP-MS	ME-CA-[ENV]SPE-LAK-AN-005	EPA 3050/EPA 200.8
Moisture	ME-CA-[ENV]GC-LAK-AN-010	CCME Tier 1
pH	ME-CA-[ENV]EWL-LAK-AN-001	SM 4500
Sodium adsorption ratio (SAR)	ME-CA-[ENV]ARD-LAK-AN-021	MOE 4696e01/EPA 6010
Water Soluble Boron	ME-CA-[ENV] SPE-LAK-AN-003	O.Reg. 153/04

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LR Report : **CA14160-JAN17**

Quality Control Report

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Anions by IC - QCBatchID: DIO0138-JAN17												
Chloride	0.4	µg/g	<0.4		5	20	95	80	120	99	75	125
Sulphate	0.4	µg/g	<0.4		1	20	97	80	120	91	75	125
Carbon/Sulphur - QCBatchID: ECS0029-JAN17												
Sulphide	0.02	%	<0.02		ND	20	110	80	120			
Conductivity - QCBatchID: EWL0172-JAN17												
Conductivity	0.002	mS/cm	<0.002		0	10	99	90	110	NA		
Cyanide by SFA - QCBatchID: SKA5019-JAN17												
Free Cyanide	0.05	µg/g	<0.05		ND	20	101	80	120	104	75	125
Hexavalent Chromium by IC - QCBatchID: DIO0112-JAN17												
Chromium VI	0.2	µg/g	<0.2		ND	20	94	80	120	98	75	125
Mercury by CVAAS - QCBatchID: EHG0012-JAN17												
Mercury	0.05	µg/g	<0.05		ND	20	100	80	120	108	70	130
Metals in aqueous samples - ICP-OES - QCBatchID: ESG0041-JAN17												
SAR Calcium	0.09	mg/L	<0.09		3	20	99	80	120	94	70	130
SAR Magnesium	0.02	mg/L	<0.02		1	20	97	80	120	98	70	130
SAR Sodium	0.15	mg/L	<0.15		5	20	97	80	120	83	70	130
Metals in aqueous samples - ICP-OES - QCBatchID: ESG0042-JAN17												
Arsenic	0.01	mg/L	< 0.01		ND	20	101	90	110	100	70	130
Barium	0.0009	mg/L	< 0.0009		7	20	102	90	110	NV	70	130
Boron	0.005	mg/L	< 0.005		6	20	103	90	110	97	70	130
Cadmium	0.001	mg/L	< 0.001		6	20	102	90	110	99	70	130
Chromium	0.001	mg/L	< 0.002		ND	20	103	90	110	86	70	130
Lead	0.007	mg/L	< 0.007		ND	20	103	90	110	106	70	130
Selenium	0.01	mg/L	< 0.01		ND	20	101	90	110	117	70	130
Silver	0.08	mg/L	< 0.08		ND	20	100	90	110	106	70	130
Uranium	0.1	mg/L	< 0.1		ND	20	101	90	110	NV	70	130
Metals in Soil - Aqua-regia/ICP-MS - QCBatchID: EMS0038-JAN17												
Antimony	0.8	µg/g	<0.8		ND	20	100	70	130	106	70	130
Arsenic	0.5	µg/g	<0.5		14	20	100	70	130	95	70	130
Barium	0.01	µg/g	<0.01		11	20	96	70	130	92	70	130
Beryllium	0.02	µg/g	<0.02		ND	20	106	70	130	114	70	130
Boron	1	µg/g	<1		ND	20	90	70	130	109	70	130
Cadmium	0.02	µg/g	<0.02		15	20	103	70	130	101	70	130
Chromium	0.5	µg/g	<0.5		2	20	101	70	130	98	70	130
Cobalt	0.01	µg/g	<0.01		2	20	102	70	130	99	70	130
Copper	0.1	µg/g	<0.1		4	20	100	70	130	92	70	130

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

Project : 12371 401 & Leslie
LR Report : **CA14160-JAN17**

Inorganic Analysis												
Parameter	Reporting Limit	Unit	Method Blank		RPD	Acceptance Criteria	LCS / Spike Blank			Matrix Spike / Reference Material		
							Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
						%		Low	High		Low	High
Lead	0.1	µg/g	<0.1		10	20	98	70	130	101	70	130
Molybdenum	0.1	µg/g	<0.1		ND	20	101	70	130	107	70	130
Nickel	0.1	µg/g	<0.1		5	20	105	70	130	98	70	130
Selenium	0.7	µg/g	<0.7		ND	20	100	70	130	90	70	130
Silver	0.01	µg/g	<0.01		ND	20	102	70	130	97	70	130
Thallium	0.02	µg/g	<0.02		ND	20	98	70	130	105	70	130
Uranium	0.002	µg/g	<0.002		9	20	96	70	130	NV	70	130
Vanadium	3	µg/g	<3		4	20	102	70	130	99	70	130
Zinc	0.7	µg/g	<0.7		16	20	105	70	130	90	70	130
pH - QCBatchID: ARD0034-JAN17												
pH	0.05	no unit			0	20	100	80	120			
Water Soluble Boron - QCBatchID: ESG0031-JAN17												
Water Soluble Boron	0.5	µg/g	<0.5		ND	20	97	80	120	NV	70	130

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Project : 12371 401 & Leslie
LR Report : **CA14160-JAN17**

Regulation Exceedances

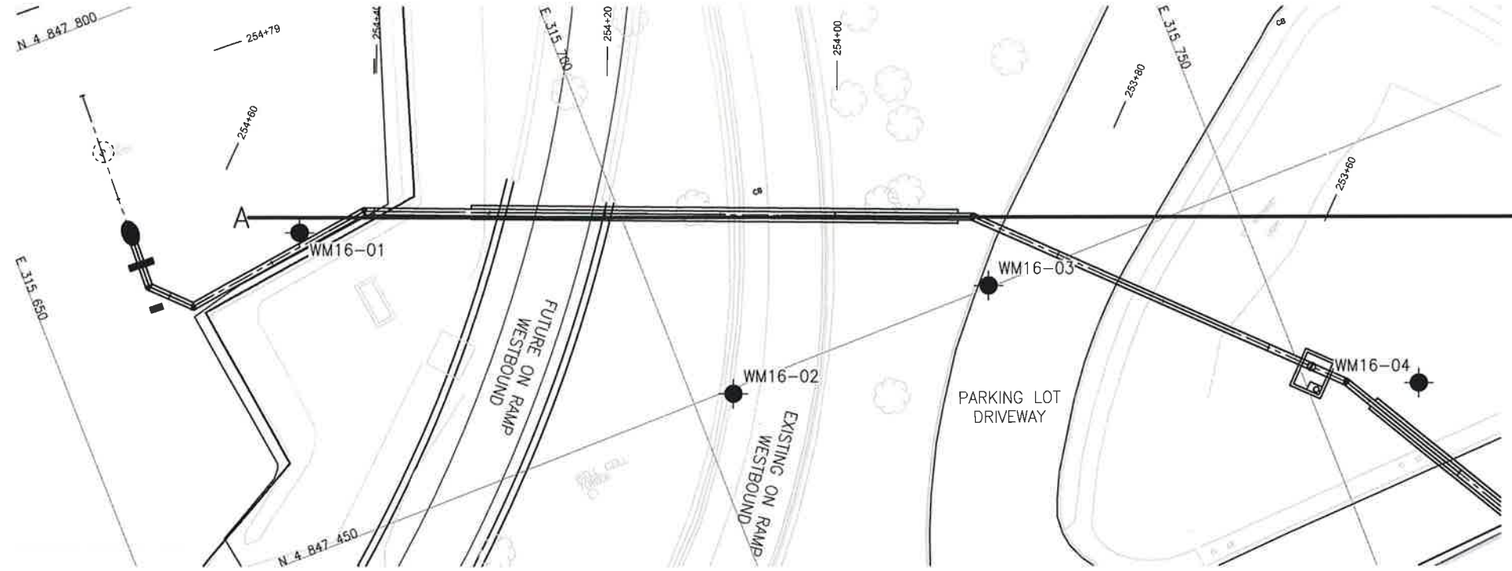
SAMPLEID PARAMETER	REG153 / SOIL / FINE TABLE 3 INDUSTRIAL/COMMERCIAL UNDEFINED
16-01 SS4 : Conductivity [uS/cm]	133 [limit: 1.4]
16-04 SS5 : Conductivity [uS/cm]	977 [limit: 1.4]
16-05 SS6 : Conductivity [uS/cm]	1410 [limit: 1.4]
16-06 SS4 : Sodium Adsorption Ratio [---]	13 [limit: 12]
16-06 SS5 : Conductivity [uS/cm]	889 [limit: 1.4]
16-08 SS6 : Conductivity [uS/cm]	633 [limit: 1.4]

OnLine LIMS

000087674

Appendix D

Borehole Locations and Soil Strata Drawing



PLAN

10 0 10 20m

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

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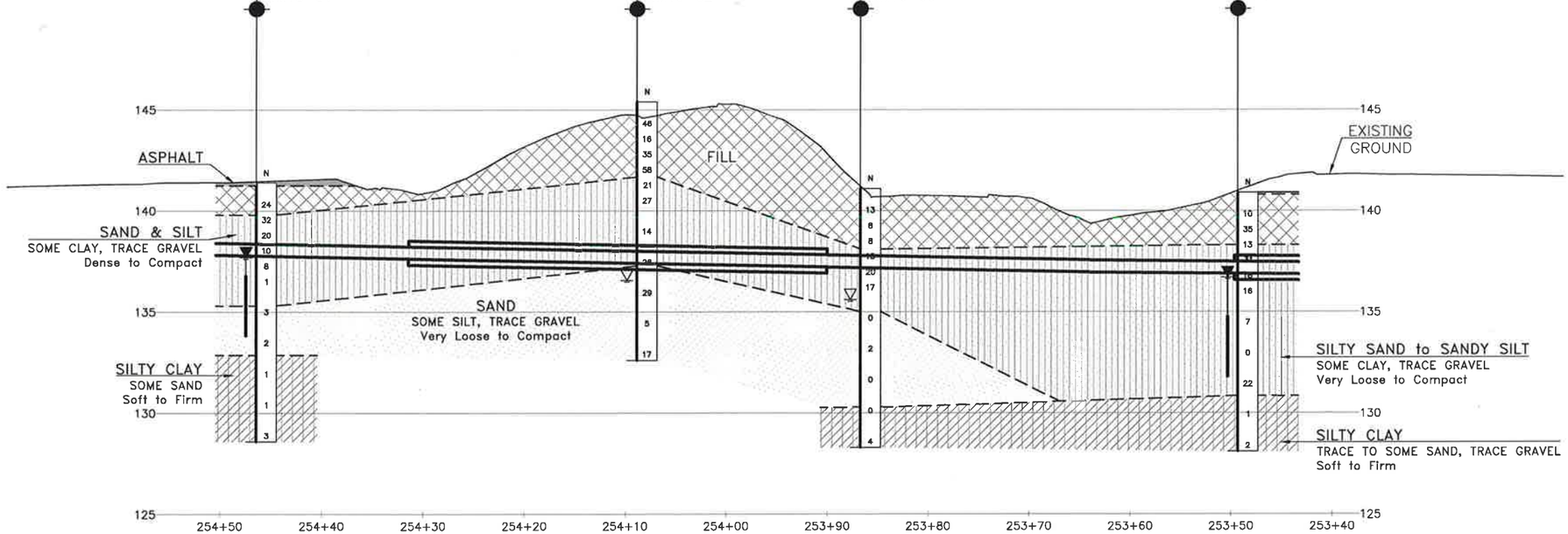
P. K. CHATTERJI
Mar 1/17
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
S. PANG
Mar 1/2017
PROVINCE OF ONTARIO



PROFILE ALONG A–A'

10 0 10 20m H

5 0 5 10m V

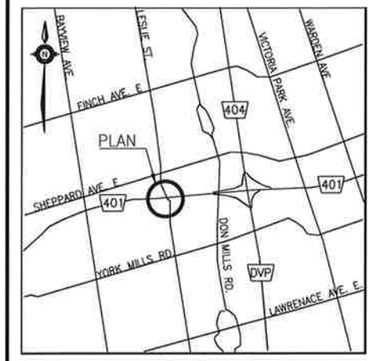
CONT No 2016–2048
WP No 2061–13–00

HIGHWAY 401 & LESLIE STREET
RELOCATED WATERMAIN CROSSING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 89

MMM GROUP

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
WM16–01	141.4	4 847 476.4	315 673.6
WM16–02	145.4	4 847 449.6	315 703.5
WM16–03	141.1	4 847 450.2	315 727.5
WM16–04	140.9	4 847 428.6	315 759.2
WM16–05	141.5	4 847 397.0	315 793.6
WM16–06	140.9	4 847 358.5	315 818.9
WM16–07	141.5	4 847 321.4	315 822.2
WM16–08	140.5	4 847 279.3	315 827.5
WM16–09	140.6	4 847 227.2	315 832.5
WM16–10	138.2	4 847 174.1	315 837.6
WM16–11	138.1	4 847 132.2	315 834.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M14-460

REVISIONS			
DATE	BY	DESCRIPTION	

DESIGN SKP	CHK	CODE	LOAD	DATE	JAN 2017
DRAWN AN	CHK SKP	SITE	STRUCT	DWG 1	

FILENAME: H:\Drafting\12000\12371\TED12371-PLPR.dwg
PLOTDATE: 1/31/2017 3:50 PM

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
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CONT No 2016-2048
WP No 2061-13-00

HIGHWAY 401 &
LESLIE STREET
RELOCATED WATERMAIN CROSSING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 90

MMM GROUP

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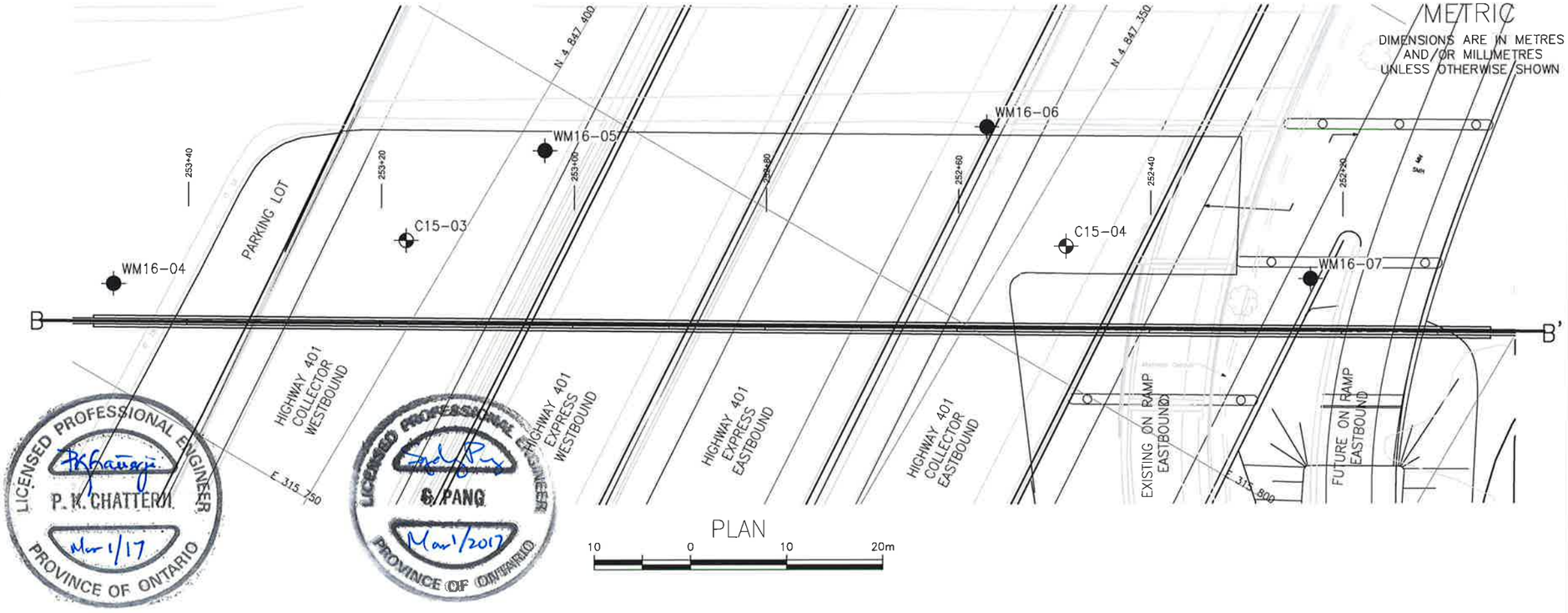

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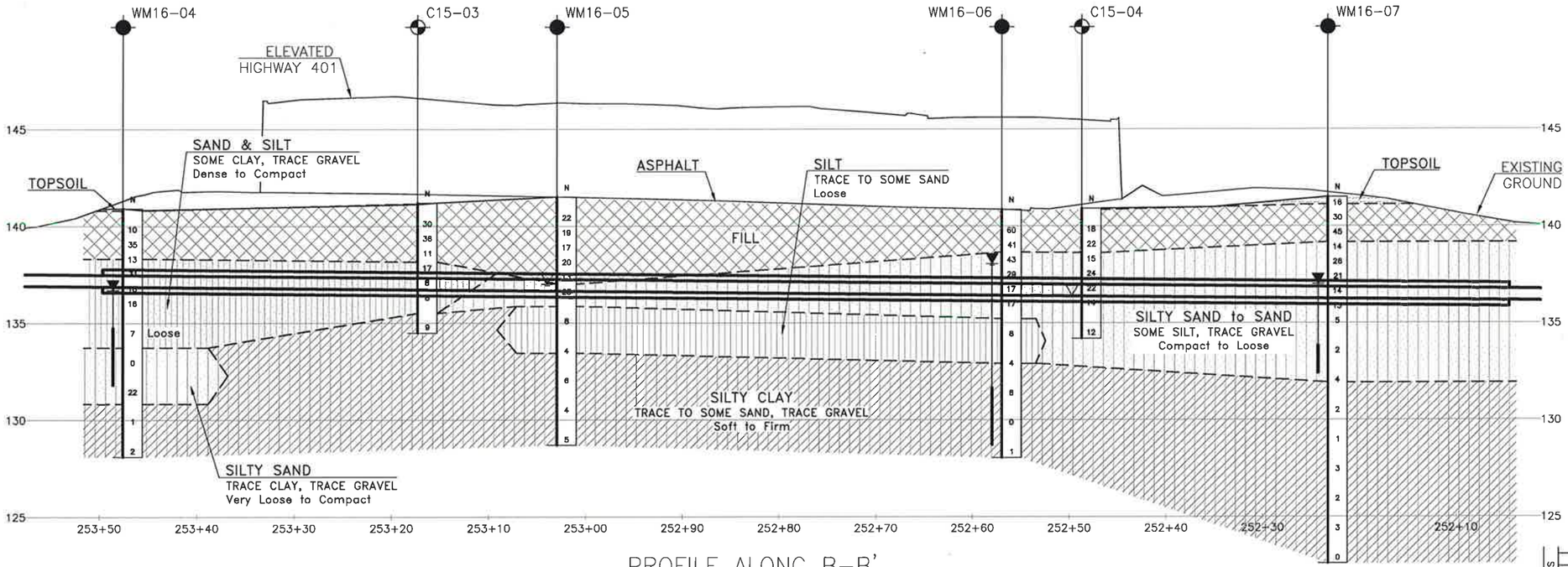
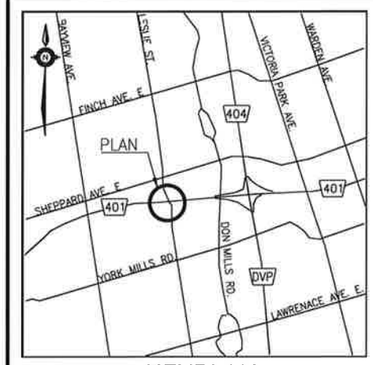
Mar 1/2017



PROFILE ALONG B-B'
10 0 10 20m H
5 0 5 10m V



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
C15-03	141.4	4 847 404.7	315 778.3
C15-04	140.4	4 847 345.1	315 812.3
WM16-01	141.4	4 847 476.4	315 673.6
WM16-02	145.4	4 847 449.6	315 703.5
WM16-03	141.1	4 847 450.2	315 727.5
WM16-04	140.9	4 847 428.6	315 759.2
WM16-05	141.5	4 847 397.0	315 793.6
WM16-06	140.9	4 847 358.5	315 818.9
WM16-07	141.5	4 847 321.4	315 822.2
WM16-08	140.5	4 847 279.3	315 827.5
WM16-09	140.6	4 847 227.2	315 832.5
WM16-10	138.2	4 847 174.1	315 837.6
WM16-11	138.1	4 847 132.2	315 834.8

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GEOCRES No. 30M14-460

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	SKP	CHK	CODE	LOAD	DATE JAN 2017
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METRIC

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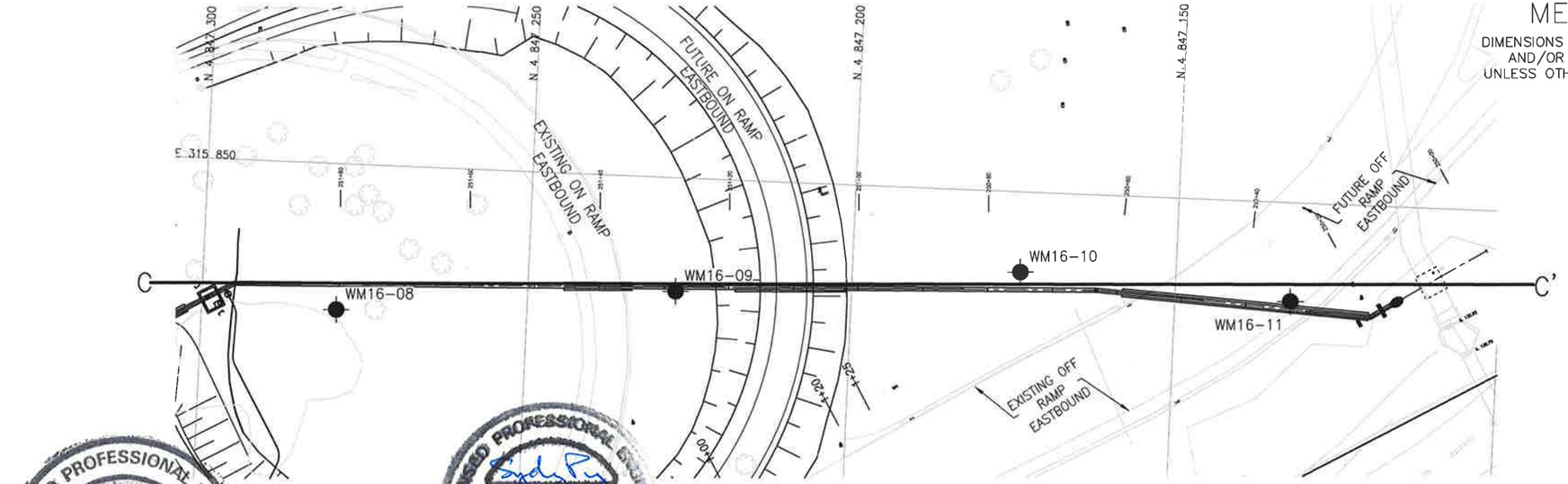
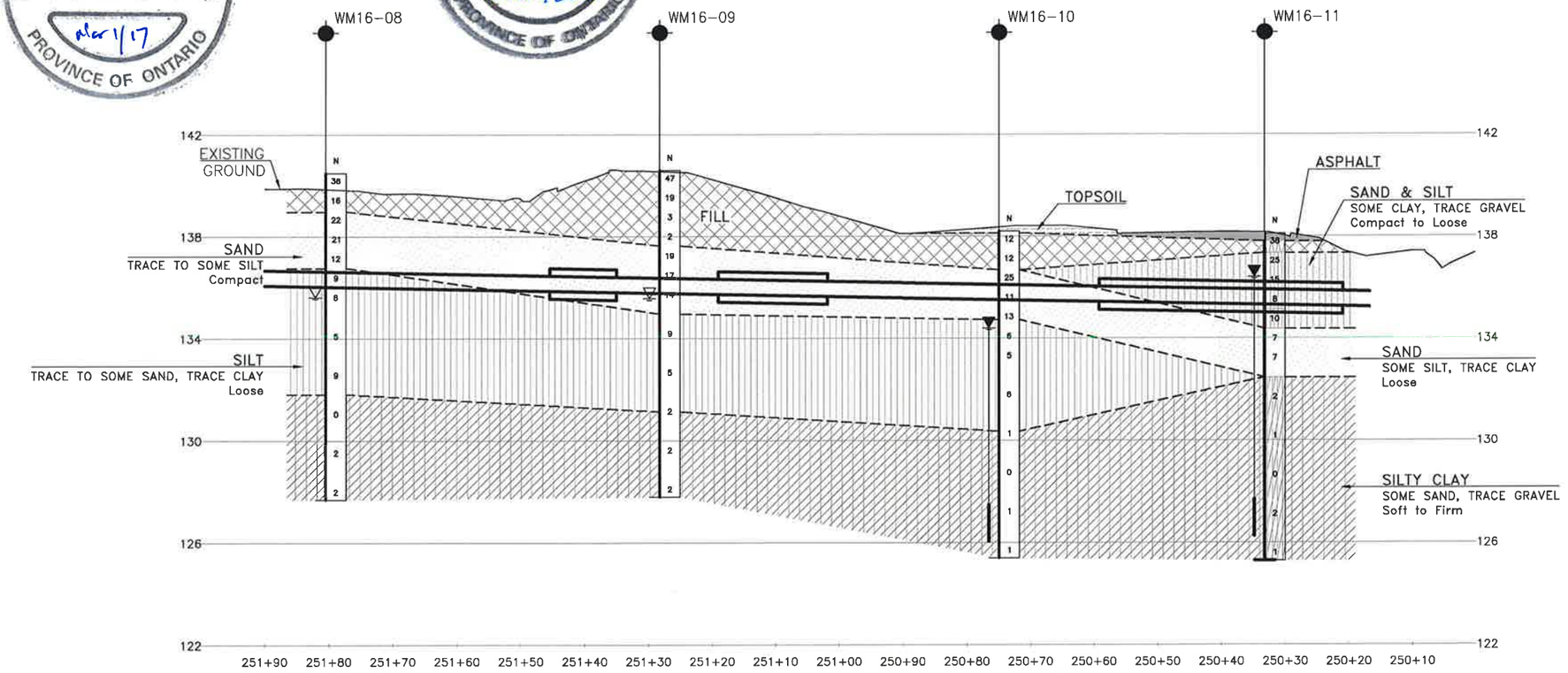


PLAN

16 0 16 32m



PROFILE ALONG C–C'

16 0 16 32m H

4 0 4 16m V

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G. PANG
Mar 1/2017
PROVINCE OF ONTARIO

CONT No 2016-2048
WP No 2061-13-00

HIGHWAY 401 & LESLIE STREET
RELOCATED WATERMAIN CROSSING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 91

MMM GROUP

THURBER ENGINEERING LTD.

KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
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▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
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WM16-03	141.1	4 847 450.2	315 727.5
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WM16-05	141.5	4 847 397.0	315 793.6
WM16-06	140.9	4 847 358.5	315 818.9
WM16-07	141.5	4 847 321.4	315 822.2
WM16-08	140.5	4 847 279.3	315 827.5
WM16-09	140.6	4 847 227.2	315 832.5
WM16-10	138.2	4 847 174.1	315 837.6
WM16-11	138.1	4 847 132.2	315 834.8

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GEOCRES No. 30M14-460

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	SKP	CHK		CODE		LOAD	DATE JAN 2017
DRAWN	AN	CHK	SKP	SITE		STRUCT	DWG 3

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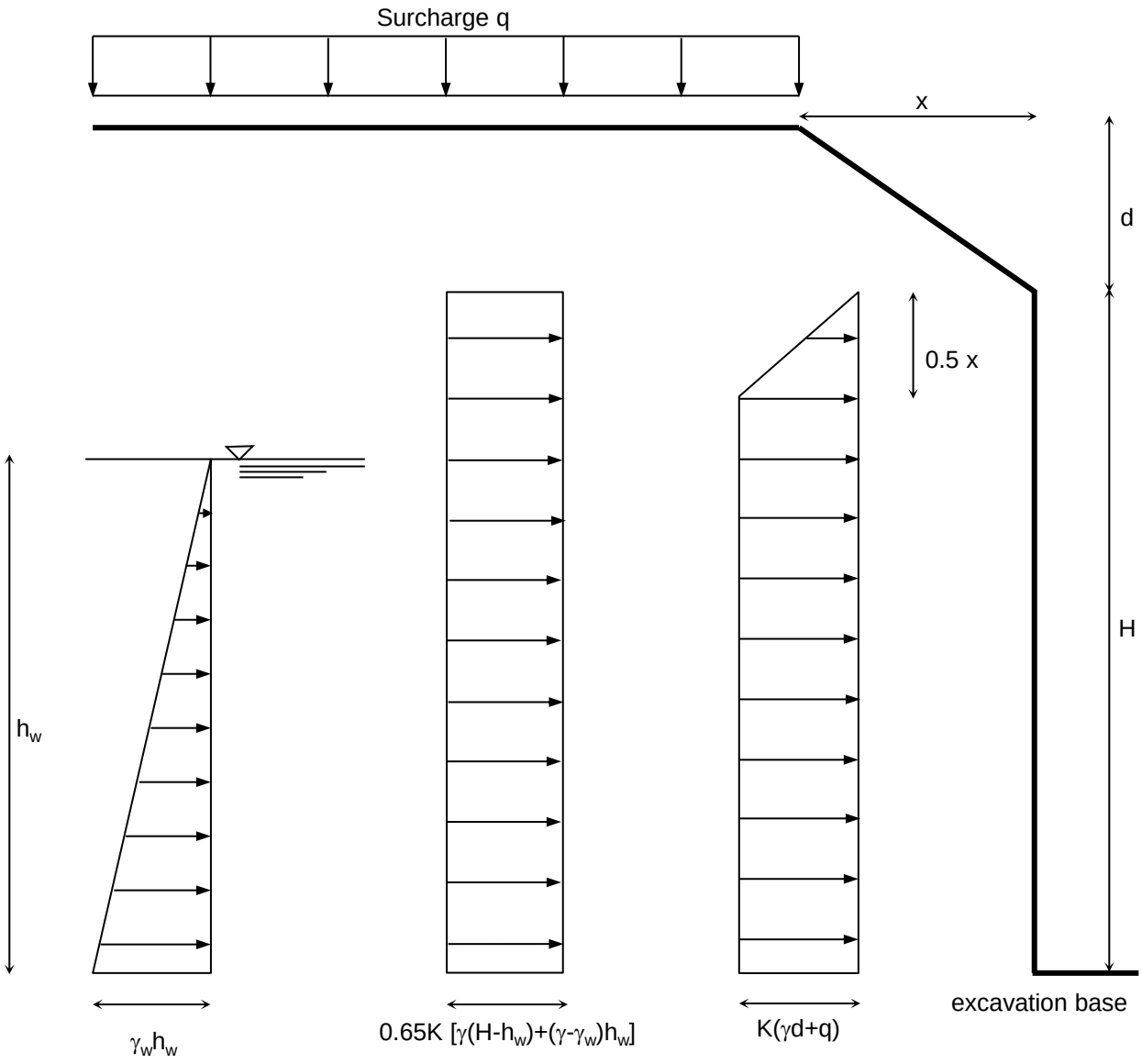
THURBER

60 YEARS

Appendix E

Lateral Pressure Distribution for Roadway Protection Design



H = shoring wall height above base of excavation

h_w = see foundation report for groundwater conditions

γ = unit weight of soil

γ_w = unit weight of water

K = earth pressure coefficient

LATERAL PRESSURE DISTRIBUTION
Roadway Protection (Temporary Shoring)
Design in Sands

FIGURE E1

THURBER

60 YEARS

Appendix F

Suggested Wordings for NSSP on Trenchless Methods

MICROTUNNELING FOR WATERMAIN 1200 MM - ITEM NO.

Special Provision

1. SCOPE

This specification covers the requirements for the installation of pipes, conduits and culverts by microtunnelling. This construction method involves jacking a pipe behind a micro-tunnel boring machine (MTBM).

2. DEFINITIONS

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

Casing: A pipe to support a bore. Usually not a product pipe.

Cased Bore: A bore in which a pipe, usually a steel sleeve, is inserted simultaneously with the boring operation.

Conditioning Agents: Bentonite, polymers, surfactants, foam and soda ash, or other additives used as an aid in performing the microtunnelling excavation.

Contact Grouting: Grouting of the overcut.

Contractor's Engineer: The engineer retained by the Contractor who produces the Contractor's design and Working Drawings. The contractor's engineer shall be a professional engineer licensed to practice in the Province of Ontario.

Contract Administrator: The Agency's Project Manager or its authorized representatives.

Earth Pressure Balance Shield: A shield on a microtunnel boring machine that uses the excavated soil to provide continuous face support that counteracts the soil and groundwater pressure at the tunnel face.

Excavation: Excavation shall include removal of natural soil, boulders, cobbles and fill regardless of means/methods necessary including break up of materials into a manageable size for removal.

Geotechnical Report: The Geotechnical Report provides information on the anticipated geotechnical subsurface conditions. May be a geotechnical data report or a geotechnical interpretive report. May or may not be a contract document.

Grouting: The process of filling voids or modifying/improving ground conditions. Grouting materials may be cementitious, chemical, or other mixtures. In microtunnelling, grouting may be used to fill voids around the pipe or shaft, or to improve ground conditions.

Intermediate Jacking Station: A fabricated steel cylinder fitted with hydraulic jacks that is incorporated into a pipeline between two pipe segments. Its function is to distribute the jacking load over the pipe string on long drives.

Jacking Pipes: Pipes designed to be installed using pipe jacking techniques. May be casing and/or product pipe.

Launch/Exit Seal: A mechanical seal, usually composed of a rubber flange that is mounted to the wall of the drive shaft. The flange seal is distended by the MTBM as it passes through, creating a seal to prevent water or lubrication inflow into the shaft during tunnelling operations.

Lubricant: a mixture of water and additives designed to reduce friction in the bore.

Microtunnelling: A trenchless construction method for installing pipelines that includes the following features: (1) Remote Controlled, (2) Guided, (3) Pipe Jacked, (4) Continuously Supported.

Microtunnel Boring Machine (MTBM): Mechanized excavating component of the microtunnelling system including cutter head, machine can, and any trailing cans.

Microtunnelling Methodology: A written description, together with supporting documentation that defines the Contractor's plans and procedures for microtunnelling operations.

Obstruction: Any object or feature that lies completely or partially within the cross-section of the microtunnel and prevents continued forward progress.

OHSA: Occupational Health and Safety Act of Ontario.

Overcut: The annular space between the excavated hole and the outside diameter of the jacking pipe.

Pipe Jacking: A system of directly installing pipes behind a shield machine by hydraulic jacking from a drive shaft such that the pipes form a continuous string in the ground.

Product Pipe: Pipe used for conveyance of water, gas, sewage, and other products and services.

Portal: Entrance (start) and exit (end) of the microtunnel drive. Also referred to as the tunnel eye.

Shaft: vertically sided excavation from which the microtunnelling operation is initiated or directed.

Slurry: A fluid, normally water, used in a closed loop system for the removal of spoil and for the balance of groundwater pressure during microtunnelling.

Slurry Separation: A process in which excavated material is separated from the circulation slurry.

Spoil: Earth, rock and other materials removed during installation.

Work: The total construction and related services required by the Contract Documents.

3. DESIGN AND SUBMISSION REQUIREMENTS

a. General

The Contractor's documentation, submission requirements and installation methods shall address the subsurface conditions as identified in the Geotechnical Report and/or Geotechnical Baseline Report.

b. DESIGN AND SUBMISSION REQUIREMENTS

When any of the following information is not specified in the Contract Documents, it shall be submitted to the Contract Administrator for review a minimum of 14 calendar days prior to the commencement of tunnelling operations. Submittals must provide sufficient detail to allow the Contract Administrator to

determine whether the proposed equipment, materials, and procedures will meet the Contract requirements.

i. PROJECT SPECIFIC SHOP DRAWINGS

1) A Scaled Site and Equipment Layout Plan.
2) Project Utility/Site Servicing Details.
3) Traffic Management Plan, Including Emergency Access/Egress.
4) Environmental Erosion and Sediment Control Plan.

ii. CONSTRUCTION SHAFTS

1) Shop Drawings & Calculations for Work Shafts sealed by the Contractor's Engineer.
2) Shaft Construction Details including Access/Egress, Launch/Reception Seals and Thrust Wall.

iii. METHODOLOGY

1) Microtunnelling Method Statement, including Pre-Launch and MTBM Reception Procedures and a Site Specific Construction Program.
2) Estimated Jacking Force Calculations, including identifying the need for any intermediate jacking stations, sealed by the Contractor's Engineer.
3) Casing Pipe Details, including any intermediate jacking stations and pipe specials, sealed by the Contractor's Engineer. Casing Pipe Design must demonstrate that the pipe is capable of sustaining all anticipated loads including loads imposed during jacking. Also to include potential larger jacking forces required to advance the pipeline following stoppages.
4) Contingency Plans as specified in the contract documents.
5) Microtunnelling Guidance System Details.
6) Spoil Disposal Plan.
7) Casing Contact Grouting Plan.

iv. EQUIPMENT

1) MTBM and Jacking Frame Details.
2) Slurry Management and Separation System Details.
3) Lubrication System Details.
4) Ventilation System Details.
5) Atmosphere Monitoring Systems and Alert Protocols.
6) Communication System Plan.

v. HEALTH AND SAFETY PLAN

1) Response Plan to Hazardous Atmosphere Detection.
2) Confined Space Entry Plan.
3) Emergency Microtunnel and Shaft Evacuation and Rescue Plans, to Encompass Injury, Fire, Flooding, and Security Breach.

vi. ENVIRONMENTAL CONTINGENCY PLANS

1) Environmental Spill Response Plan.
2) Adverse Weather Plan, if required.

vii. QUALITY CONTROL AND AS-BUILT RECORDS

1) Survey Control: Verification of Jacking Frame Alignment and Elevation

2) Monitoring data (settlement, vibration, noise, building, groundwater, etc.) as specified in the Contract Documents.
3) Calibration and Certification Records as Specified in the Contract Documents.
4) Details of MTBM Data Logging and Daily Record Sheets.
5) Vertical and horizontal alignment survey of jacked pipe and/or final product pipe.

4. MATERIALS

a. Casing

Casing shall be as specified in the Contract Documents.

b. Lubricant

Lubricants shall be appropriately mixed for the anticipated in situ ground conditions. Only bentonite or additives shall be used as annular lubricants. All additives shall be chemically inert, biodegradable, and non-toxic. No petroleum-based or detergent additives shall be permitted.

c. Grout

Grout shall be as specified in the contract documents.

5. EQUIPMENT

a. Microtunnelling Equipment

The Contractor shall be responsible for selecting microtunnelling equipment which, based on past experience, has proven to be satisfactory for excavation of the soils that will be encountered.

The Contractor shall employ microtunnelling equipment that will be capable of handling the various anticipated ground conditions indicated in the Geotechnical Report. The MTBM shall also be capable of controlling loss of soil ahead of and around the machine and shall provide continuous pressurized support of the excavated face.

i. Remote Control System

Provide a MTBM that includes a remote control system with the following features:
1) Allows for operation of the system without the need for personnel to enter the microtunnel. Has a display available to the operator, at a remote operation console, showing the position of the shield in relation to a design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force cutter head torque, rate of advance and installed length.
2) Integrates the system of excavation and removal of spoil and its simultaneous replacement by Product Pipe. As each pipe section is jacked forward, the control system shall synchronize all of the operational functions of the system.
3) The system shall be capable of adjusting the face pressure to maintain face stability for the particular soil condition encountered.
4) The system shall monitor and continuously balance the soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow.
5) The pressure at the excavation face shall be managed by controlling the volume of spoil removal with respect to the advance rate.
6) The system shall include a separation process designed to provide adequate separation of the spoil from the slurry so that slurry with a sediment content within the limits required for successful

microtunnelling, can be returned to the cutting face for reuse. Appropriately contain spoil at the site prior to disposal.

7) The type of separation process shall be suited to the size of microtunnel being constructed, the soil type being excavated, and the work space available at each work area.
8) The system shall allow the composition of the slurry to be monitored to maintain the slurry weight and viscosity limits required.

ii. b) Active Direction Control

Provide an MTBM that includes an active direction control system with the following features:

1) Controls line and grade by a guidance system that relates the actual position of the MTBM to a design reference Provides active steering information that shall be monitored and transmitted to the operating console and recorded.
2) Provides positioning and operation information to the operator on the control console.

b. Pipe Jacking Equipment

Provide a pipe jacking system with the following features:

1) Has the main jacks mounted in a jacking frame located in the launch shaft.
2) Has a jacking frame that successively pushes towards a receiving shaft, a string of Product Pipe that follows the microtunnelling excavation equipment.
3) Has sufficient jacking capacity to push the microtunnelling excavation equipment and the string of pipe through the ground.
4) The main jack station may be complemented with the use of intermediate jacking stations as required.
5) Has a capacity at least 20 percent greater than the calculated maximum jacking load.
6) Develops a uniform distribution of jacking forces on the end of the casing pipe.
7) Provides and maintains a pipe lubrication system at all times to lower the friction developed on the surface of the pipe during jacking.
8) Jack Thrust Blocking shall adequately support the jacking pressure developed by the main jacking system.
9) Special care shall be taken when setting the pipe guide rails in the jacking shaft to ensure correctness of the alignment, grade, and stability.

c. Spoil Separation System

The Contractor shall determine the type of spoil separation equipment needed for each drive based on the geotechnical information available and other project constraints.

d. Electrical Equipment, Fixtures and Systems

Electrical equipment shall be suitably insulated for noise reduction. Noise produced by electrical equipment must comply with local municipal noise by-laws. Electrical systems shall conform to requirements of the Canadian Electrical Code – CSA C22.1.

e. Air Quality

Provide equipment to maintain proper air quality in shafts and in any manned microtunnel intervention during construction in accordance with OSHA requirements.

6. CONSTRUCTION

a. General

The Contractor shall notify the Contract Administrator and any other authorities identified in the contract documents at least 72 hours in advance of starting work.

Construction shall be subject to the requirements presented in the following subsections.

i. Layout, Alignment and Grade Control

The layout, alignment and grade of the microtunnel shall be established from the lines, elevations and tolerances specified in the Contract Documents. Deviations from location, alignment, grades and/or invert levels shall be corrected by the Contractor at no additional cost.

The following tolerances shall be as specified in the Contract Documents:
1) Maximum Departure from Established Grade.
2) Maximum Departure from Established Line.
3) Return to line and grade (i.e.: maximum steering correction).
4) Overcut diameter.

All reference points necessary to construct the pipe installation and appurtenances shall be confirmed and/or established by the contractor.

When required, the Contract Administrator shall be provided with access necessary to check the layout of the pipe installation and associated appurtenances.

All excavations shall be carried out in accordance with the OHSA.

ii. Shafts

Construction Shafts shall be provided at locations and constructed as specified in the Contract Documents or according to the Contractor's submission.

Shafts shall be maintained in a drained condition.

A secure fence as stipulated in the OHSA shall be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence shall be removed on completion of the Work.

iii. Protection Systems

The construction and monitoring of all protection systems shall be according to OPSS 539.

iv. Settlement or Heave

Any settlement or heave at the ground surface as a result of the pipe installation, that exceeds the limits specified in the contract documents, shall be immediately corrected by the Contractor at no additional cost.

v. Stability of Excavation

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

The construction methods, plant, and materials employed shall prevent the migration of any material into the excavation from adjacent ground.

vi. Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

vii. Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

viii. Backfilling and Compacting

Backfilling and compacting for shafts or other locations along the pipe path shall be according to OPSS 401, OPSS 402, OPSS 403 or the contract documents as appropriate.

ix. Dewatering

Dewatering shall be according to OPSS 517.

x. Obstructions

The Contractor shall address the removal of obstructions in the proposed method of construction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered.

xi. Record Keeping

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

The Contractor shall maintain shift logs of construction events and observations. The Contract Administrator shall have access to the Contractor's logs with regard to the following information:

1) Location of MTBM by station and progress of microtunnel drive during shift.
2) Hours worked per shift on microtunnelling operations.
3) Completed field forms for checking line and grade of the microtunnelling operation, showing achieved tolerance relative to design alignment. Steering control logs will generally be acceptable.
4) Maximum pipe jacking forces per drive.
5) Location, elevation and brief soil descriptions of soil strata.
6) Groundwater control operations and groundwater levels.
7) Observation of any lost ground or other ground movement.
8) Any unusual conditions or events.
9) Reasons for operational shutdown in the event a drive is halted.
10) Pressure at the face of the tunnel.

xii. Management and Disposal of Excess Material

Management and disposal of excess material shall be according to OPSS 180.

xiii. Site Restoration

Site restoration shall be according to OPSS 492.

xiv. Personnel

Documentation summarizing the qualifications of the project superintendent and machine operators shall be requested by the Contract Administrator and provided by the Contractor.

b. Microtunnelling

i. General

Excavation of soil, rock and fill shall be done in a manner to control and prevent groundwater inflow to the tunnel.

The MTBM shall be capable of fully supporting the face and shall accommodate the removal of boulders and other obstructions from the face. Continuous ground support shall be maintained during excavation.

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

The Contractor shall maintain clean working conditions at all times.

In the event that excavation threatens to endanger personnel, the Work, adjacent property, roadways, railways, waterways, or the public in any way , the Contractor shall cease excavation. The Contractor shall then evaluate the methods of construction and revise as necessary to ensure the safe continuation of the Work.

The Contractor shall maintain the tunnel excavation line and grade to provide for construction of the culvert within the specified tolerances.

ii. Method of Installation

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

1) The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
2) Selection of the excavation method and jacking equipment shall take into consideration the subsurface conditions within the tunnel alignment.
3) Perform microtunnelling operations in a manner that will minimize the movement of the ground in front of and surrounding the tunnel in conformance with the limits listed in the Contract Documents.
4) Prevent damage to structures and utilities above and in the vicinity of the microtunnelling operations.
5) Excavated diameter should be the minimum size required to permit pipe installation by jacking.
6) Whenever there is a condition encountered which could endanger the microtunnel excavation or adjacent structures if tunnelling operations cease, continue to operate without intermission including 24-hour working days, weekends and holidays, until the condition no longer exists.
7) Maintain an envelope of lubricant around the exterior of the pipe during the jacking and excavation operation to reduce the exterior soil/pipe friction and possibility of the pipe seizing in place.
8) In the event a section of pipe is damaged during the jacking operation or a joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, the Contractor shall submit for approval his methods for repair or replacement of the pipe.

iii. Casing Installation

Casing must withstand the jacking forces determined by the Contractor.

The space between the Casing and the wall of the excavation shall be kept filled with lubricant during the pipe jacking operation. Upon completion of pipe jacking, the space between the Casing and the wall of the excavation shall be filled with grout that is compatible with the Casing.

The Casing shall act as a support system to maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the Casing.

The Casing shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting.

iv. Instrumentation Monitoring

The Work specified in this Section includes the supply and installation of all instruments for monitoring settlement and ground stability.

Ground stability and settlement shall be monitored by in-ground and surface monitoring points at the locations shown on the Contract Drawings. The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within ± 1 mm of the actual elevation.

Settlement monitoring points shall be installed as shown on the Settlement Monitoring Drawings.

The Contractor shall install all surface settlement instruments and monitoring points a minimum of two (2) weeks prior to the start of work and complete baseline readings as specified in the Contract Documents.

The surface settlement instruments and monitoring points shall be clearly labelled for easy identification and protected during construction.

The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points that includes coordinates (Northings and Eastings) and elevations recorded at the time intervals specified in the Contract Documents.

All readings shall be submitted daily in spreadsheet format to the Contract Administrator for information purposes and a report including the settlement readings in spreadsheet format shall be submitted to the Contract Administrator on a weekly basis. Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the Work.

v. Criteria for Assessment of Settlement/Heave

The following represents trigger levels that define magnitude of movement and corresponding action:

1) Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor shall review or modify the method, rate or sequence of construction or ground stabilization measures to mitigate against further ground movement. If the Review Level is exceeded, the Contractor shall immediately notify the Contract Administrator and present response actions for discussion and implementation. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.

2) Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public while maintaining traffic flow.

No construction shall take place until all the following conditions are satisfied:

1) The cause of the settlement/heave has been identified.
2) The Contractor submits a corrective/preventive plan.
3) Any corrective and/or preventive measures deemed necessary by the Contractor are implemented.

4) The Contract Administrator deems it is safe to proceed.

The Contractor shall avoid damaging instrumentation during construction. Instrumentation that is damaged as a result of the Contractor's operation shall be repaired or replaced by the Contractor within one business day.

The costs for replacement/repair shall be borne by the Contractor.

At the completion of the job, the Contractor shall abandon all instruments installed during the course of the Work and restore the site in accordance with OPSS 492.

7. MEASUREMENT FOR PAYMENT

Measurement of tunnel shall be by length in metres along the centreline of the tunnel to the ends of the tunnel as constructed.

8. BASIS OF PAYMENT

Payment at the Contract price for the above tender items shall be full compensation for all labour, equipment, and material to do the Work.

PIPE INSTALLATION BY TRENCHLESS METHOD – Item No.

Special Provision

1. SCOPE

This specification covers the general requirements for the installation of pipes by trenchless methods, including Jack & Bore, Pipe Ramming, Directional Drilling, and Tunnelling. The Contractor shall determine the most appropriate method of installation for each of the crossing locations.

This specification shall supersede OPSS 415 (Construction Specification for Pipeline Installation by Tunneling), 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).

2. REFERENCES

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

Ontario Provincial Standard Specifications, General

OPSS 180	Management and Disposal of Excess Materials

Ontario Provincial Standard Specifications, Construction

OPSS 401	Trenching, Backfilling, and Compacting
OPSS 404	Support Systems
OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 492	Site Restoration Following Installation of Pipelines, Utilities and Associated Structures
OPSS 517	Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS.PROV 539	Temporary Protection Systems

Ontario Provincial Standard Specifications, Material

OPSS.PROV 1004	Aggregates - Miscellaneous
OPSS.PROV 1350	Concrete - Materials and Production
OPSS.PROV 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe
OPSS.PROV 1820	Circular and Elliptical Concrete Pipe
OPSS 1840	Non-Pressure Polyethylene (PE) 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. DEFINITIONS

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

Auger Jack & 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 by using an auger.

Backreamer: a cutting head suitably designed for the subsurface conditions that is attached to the end of a drill string to enlarge the pilot bore during a pullback operation.

Bore Path: a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings. The design engineer shall be licensed to practice in the Province of Ontario.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings. The design checking engineer shall be licensed to practice in the Province of Ontario.

Digger Shield/Hand Mining: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead while tunnelling advances using hand–mining (man-entry operation or "Jack and Mine) or a "digger" type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Drilling Fluids: a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

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 shall 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.

Directional Drilling (DD): directional boring or guided boring.

HDPE: high density polyethylene.

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.

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.

Pipe Ramming: a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

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: 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 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 shall 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.

Trenchless Installation: an underground method of constructing a passage open at both ends that involves installing a pipe. For the purpose of this specification, the pipe may be installed by any of the various methods defined herein such as Auger Jack & Boring, Pipe Jacking, Pipe Ramming, Directional Drilling, or using a tunnelling machine or hand mining methods.

Tunnelling: An underground method of constructing a passage using a tunnel boring machine (TBM), a microtunnel boring machine (MTBM) or hand mining using a shield to support the opening.

4. DESIGN AND SUBMISSION REQUIREMENTS

4.01 General

The Contractor's documentation, submission requirements and installation methods shall specifically consider and address the subsurface conditions at each pipe crossing as identified in the Foundation Investigation Report or elsewhere in the Contract Documents.

4.02 Working Drawings

Three copies of stamped working drawings for portal or shaft construction, primary liner, excavation, secondary lining, dewatering and groundwater control and grouting shall be submitted to the Contract Administrator (CA) at least one week prior to the commencement of the work for information purposes. All submissions shall bear the seal and signature of the Design Engineer and Design Checking Engineer. The Contractor shall 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 shall 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, 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 installation procedures, including methods to handle obstructions and prevent 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) Monitoring Method:
- The methods to be employed to monitor and maintain the alignment of the installation.

4.03 Site Survey

Prior to commencing the work, the Contractor shall, at each pipe location, lay-out the alignment and install settlement monitoring points.

4.04 Certificate of Conformance

The Contractor shall submit details of the sequence and method of construction to the Quality Verification Engineer for review, prepared and stamped by the Design Engineer. The Contractor shall 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 shall state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor shall 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 (as noted in Section 4.02)
Excavation for pits including dewatering of excavations
Jacking/Ramming/Directional Drilling of Casing/Liner
Installation of the Product
Grouting Operations

Each Certificate of Conformance shall 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 shall submit to the Contract Administrator a final Certificate of Conformance sealed and signed by the Quality Verification Engineer. The Certificate shall 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 will not be permitted to carry out the work of the Quality Verification Engineer.

5. MATERIALS

5.01 Product

The product shall be concrete pipe or high density polyethylene pipe as specified.

5.02 Concrete

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

5.03 Concrete Reinforcement

Steel reinforcing for concrete work shall be according to OPSS.PROV 1440.

5.04 Timber

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

5.05 Grout

The Contractor shall 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 shall 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.PROV 1004 wetted with only sufficient water to make the mixture plastic.

5.06 Auger Jack & Bore Materials

5.06.01 Pipe Materials

Steel pipe shall conform with ASTM A252-93 welded joints suitable for jacking operations. The Contractor shall select pipe class for pipe jacking.

Concrete pipe as per OPSS.PROV 1820.

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

5.07 Pipe Ramming Materials

5.07.01 Pipe Materials

Steel pipe shall conform with ASTM A 252-93 welded joints.

New steel casing when specified shall be smooth wall carbon steel pipe according to ASTM A252-93 Grade 2.

Used steel casing can be used provided that the steel casing can resist the applicable static and dynamic loadings.

Pipe wall thickness shall be determined by the Contractor based on static and dynamic loads from traffic loading and anticipated ramming forces for selected pipe and driven pipe lengths. The wall thickness shall be increased as required to ensure the casing is not damaged during handling and installation. The pipe minimum wall thickness shall be as per Table 1 of OPSS 1802.

Pipe segments shall be determined by the Contractor.

Steel pipe joints shall be pressure fit type or welded.

All steel casing pipe shall be square cut.

Steel casing pipe shall have roundness such that the difference between the major and minor outside diameters shall not exceed 1% of the specified nominal outside diameter or 6 mm, whichever is less.

Steel casing pipe shall have a minimum allowable straightness of 1.5 mm maximum per metre of length.

5.07.02 Mill Certificates

For permanent casing, the Contractor shall submit to the Contract Administrator at the time of delivery one copy of the mill certificate, indicating that the steel meets the requirements for the appropriate standards for casings.

Where mill test certificates originate from a mill outside Canada or the United States of America the Contractor shall have the information on the mill certificate verified by testing by a Canadian laboratory. The laboratory shall be accredited by a Canadian National Accreditation Body to comply with the requirements of ISO/IEC Guide 25 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date and the signature of an authorized officer of the Canadian testing laboratory.

5.08 Directional Drilling Materials

5.08.01 Drilling Fluids

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

5.08.02 Pipe Materials

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

The requirements for fittings shall be suitable for and compatible with the class and type of pipe with which they will be used and in according to CAN/CSA-B182.6 or ASTM F894.

The Contractor shall determine the required dimensional ratio (DR) of the HDPE pipe to support all subsurface conditions and hydrostatic pressures, and to withstand the grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

The Contractor's submission shall demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate without damage the heat of hydration generated by grout curing.

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

Jointing of HDPE piping shall 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 shall be followed during the jointing process.

Jointing of HDPE piping to other piping materials or appurtenances shall be completed using flanged connections.

5.09 Tunnelling Materials

5.09.01 Primary Liner

Tunnelling methods will require installation of a primary liner. The primary liner shall be designed by the Contractor and the design/drawings shall be stamped/signed by the Design Engineer. The design shall be submitted to the Contract Administrator as specified herein.

5.09.02 Secondary Liner

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

5.09.02.01 Concrete Pipe

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

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

5.09.02.02 High Density Polyethylene (HDPE)

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

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

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

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

Jointing of HDPE piping shall 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 shall be followed during the jointing process.

Jointing of HDPE piping to other piping materials shall be completed using flanged connections.

6. EQUIPMENT

6.01 Auger Jack & Bore Equipment

Pipe auger jack & bore equipment shall be determined by the Contractor and shall 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 shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.02 Pipe Ramming Equipment

Pipe ramming equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

The pipe ramming hammer(s) shall be capable of driving the pipe casing from the drive pit through the existing subsurface conditions at the site.

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 pipe shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.03 Directional Drilling Equipment

6.03.01 General

The directional drilling equipment shall 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.

6.03.02 Drilling Rig

The directional drilling rig shall:

- 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.

6.03.03 Drill Head

The drill head shall 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,

6.03.04 Guidance System

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

6.03.05 Drilling Fluid Mixing System

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

6.03.06 Drilling Fluid Delivery System

The delivery system shall 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 shall be leak-free.

6.04 Tunnelling Equipment

Tunnelling equipment shall be determined by the Contractor and shall 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 shall be submitted to the Contract Administrator information purposes. Use of rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.
Use of explosives is prohibited.

7. CONSTRUCTION

7.01 General

The Contractor shall notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation to be used by the Contractor shall be submitted to the Contract

Administrator for information purposes prior to commencing the work and shall be subject to the limitations presented in the following subsections.

7.01.01 Layout, Alignment and Depth Control

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

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

The Contractor shall calibrate tracking and locating equipment at the beginning of each work day, and shall 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 shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

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

For directional drilling, the contractor shall ensure that during pilot hole drilling the maximum degree of deviation or "dog-leg" shall 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 shall be within 0.5m of the target location.

7.01.02 Construction Shafts

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

Shafts shall be maintained in a drained condition.

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

7.01.03 Protection Systems

The construction of all protection systems shall be according to OPSS.PROV 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 shall be provided. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

7.01.04 Settlement or Heave

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

7.01.05 Stability of Excavation

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

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

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

Minimum horizontal and vertical clearances to existing facilities as specified in the Contract Documents shall be maintained. Clearances shall be measured from the nearest edge of the largest cut diameter required to the nearest edge of the facility being paralleled or crossed.

Existing underground facilities shall 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 shall be exposed by non-destructive methods. The number of exposures required to monitor work progress shall be as specified in the Contract Documents.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path shall be according to OPSS 401.

7.01.09 Support Systems

Support systems shall be according to OPSS 404.

If any open excavation will encroach into the highway embankment the protection system shall satisfy the requirements for Performance Level 2 as specified in OPSS.PROV 539.

7.01.10 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor shall review the foundation investigation report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor shall 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 shall 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 shall 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 shall be according to OPSS 517.

7.01.11 Removal of Boulders

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

7.01.12 Record Keeping

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

7.01.13 Testing

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

7.01.14 Management and Disposal of Excess Material

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

7.01.15 Site Restoration

Site restoration shall be according to OPSS 492.

7.01.16 Supervision

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

7.02 Auger Jack & Bore Installation

7.02.01 Method of Installation Procedure

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

- Hydraulically operated jacks of adequate number and capacity shall be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- A suitably padded jacking head or collar shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.

- Selection of the excavation method and jacking equipment shall take into consideration the conditions at each pipe crossing.

7.02.02 Pipe Installation

Concrete pipe joints shall be water tight and according to OPSS.PROV 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 shall be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavation shall be filled with grout.

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

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe shall be used. But welding of pipe joints shall conform to CAS W59.

Ramming equipment of adequate capacity shall be provided to ensure smooth and uniform advancement without overstressing of the pipe. Delays shall be avoided between ramming operations.

A ramming head shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills shall be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe shall be installed to the line and grade specified.

Following installation of the liner pipe, all material shall be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall shall be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product shall be fully grouted with a water tight, expandable and stable grout.

7.04 Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they shall be activated during drilling and maintained at all times.

7.04.02 Site Preparation

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

7.04.03 Pilot Bore

The pilot bore shall 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 shall take into consideration the conditions at each crossing within the pipe alignment and shall 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 Contract Administrator shall be notified. 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 shall be advised of the event and action shall 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 shall 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 shall be backfilled with grout or bentonite to prevent future subsidence.

The Contractor shall maintain drilling fluid pressure and circulation throughout the DD process, including during the initial pilot bore and during the reaming process.

The Contractor shall 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.

7.04.04 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. Sections of the pipe close to the exit pit with less than 5m cover shall be cased. The Contractor shall 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 shall 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 shall 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

7.04.05 Reaming

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

7.04.06 Product Installation

7.04.06.0 General

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

The product shall be protected from damage during the pullback operation.

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

Product shall be allowed to recover before connections to new or existing facility are made. Product recovery time shall be according to manufacturers recommendations.

7.04.06.02 Pullback and Grouting

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

A swivel shall 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 shall be used to prevent excess pulling force from damaging the product.

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

The pull back and reaming operations shall not exceed the fluid circulation rate capabilities. Reaming and back pulling operations shall 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 shall be filled with grout.

7. 05 Tunnelling Installation

7.05.01 General

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

Excavation of native soil and fill shall 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 shall be capable of fully supporting the face and shall accommodate the removal of boulders and other oversize objects from the face. Continuous ground support shall be maintained during excavation.

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

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

The Contractor shall provide lighting in accordance with OHSA 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 shall 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 shall cease excavation. The Contractor shall then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

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

7.05.01 Tunnelling Method

The tunnelling method shall 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.

7.05.02 Primary Liner (Support System)

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

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

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

The primary liner shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and shall 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 shall 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 shall 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 shall be filled with cement grout. If an unexpanded liner is used, the space outside the liner plates shall be grouted at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

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

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

7.06 Instrumentation Monitoring

The work specified in this Section includes furnishing and installing instruments for monitoring of settlement and ground stability.

Surface settlement markers for monitoring ground stability shall be installed at the pavement/ground surface level on the shoulder, side slope and pavement at not greater than 5 m intervals along the tunnel alignment and as an array of three in-ground (1.5 m depth) measurement points on the shoulder of the highway perpendicular to the alignment. The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within ± 1 mm of the actual elevation.

Surface settlement markers shall be hardened steel markers treated or coated to resist corrosion, with an exposed convex head having a minimum diameter of 12 mm and similar to surveyor's PK nails. Markers shall be rigidly affixed so as not to move relative to the surface to which it is attached. Traffic shall be managed by the contractor using short-term lane closures in accordance with the Ontario Traffic Manual (OTM).

In general, settlement monitoring points shall be 12-18 mm rebar encased in a 50-70 mm, SCH40 PVC pipe, set to a depth of 1.5 m below ground surface. The assembly shall be placed in a drill hole and backfilled with uniform sand.

The Contractor shall install all surface settlement instruments a minimum of one week prior to the start of works.

The surface settlement instruments shall be clearly labelled for easy identification.

The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points including station, offset and elevation recorded at the following time intervals:

- Three consecutive readings at least one week prior to commencement of the work (Baseline Reading);
- Once per shift during tunnelling operations period; and
- Weekly after completion of the work for one month, or until such time at which all parties agree that further movement has stopped.

All readings shall be submitted to the Contract Administrative for information purposes on a weekly basis. Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

7.07 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsections 4.02 and 7.06, 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 shall review or modify the method, rate or sequence of construction or ground stabilization measures to mitigate further ground displacement. If this Review Level is exceeded, the Contractor shall immediately notify the CA and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall 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 shall cease construction operations, inform 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 shall take place until all of 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 CA deems it is safe to proceed.

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

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

9. MEASUREMENT FOR PAYMENT

Measurement shall 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.

10. BASIS OF PAYMENT

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

Payment for the rigid or flexible pipe conduits installed inside the pipe liners shall 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 shall be included in this item and shall 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 connecting intercepted drains and service connections shall be made on the following basis:

(a) Where such drains and service connections are shown on the contract drawings the cost of connections shall be included in the contract price for pipe installation.

(b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders/obstructions greater than an equivalent 0.3 m in diameter shall be on a time and materials basis. The Contractor shall 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 G

Instrumentation and Monitoring Program

INSTRUMENTATION AND MONITORING PROGRAM - Item No.
PROPOSED 600 MM WATERMAIN RELOCATION
HIGHWAY 401 LESLIE STREET INTERCHANGE

Special Provision

1 GENERAL

1.1 Scope

This special provision contains the requirements for the supply, installation and monitoring of the following instruments:

- Surface Monitoring Point (SMP)
- Settlement Rod (SR)

Within trenchless sections, the instruments shall be installed along the centreline of the relocated watermain alignment and in arrays. The arrays shall be located at every other instrument along the centreline. Each array consists of a group of three (3) instruments installed approximately perpendicular to the watermain alignment.

Within open cut sections with roadway protection (temporary shoring) where necessary, the instruments shall be installed at a short distance away from the edge of trench/excavation.

1.2 Purpose

The purpose of these instruments along the trenchless sections is to monitor potential settlement of the GO parking lot, the Highway 401 WB on-ramp and adjacent ground during and following installation of the proposed casing until the completion of watermain installation. The methodology and rate of tunnelling as well as the installation of the casing may need to be adjusted as a result of the instrumentation readings.

The purpose of these instruments along the open cut sections is to monitor potential settlement of the ground adjacent to the trench during and following installation of the proposed watermain.

1.3 Contractor's Scope of Work

The Contractor shall be fully responsible to procure, install, protect, monitor, compile/reduce and transmit data for all monitoring instruments and to decommission the instruments as described herein.

The required survey of all the instruments shall be carried out by a qualified surveyor retained by the Contractor.

1.4 Or equal

The term, or equal, shall be understood to indicate that the equal product is the same or

better than the specified product in function, performance, reliability, quality and general configuration.

1.5 Notification

The Ontario Ministry of Transportation (MTO), GO Transit (GO) and the Contract Administrator (CA) shall be notified five days in advance of commencing the installation of instruments. All instruments shall be installed and their baseline readings (see Section 6.3) established to the satisfaction of all parties listed above not less than five days in advance of the watermain installation operations.

1.6 Instrument Installation and Monitoring Requirements

The Contractor shall be prepared to install and monitor all instruments.

1.7 Drawings

Reference shall be made to Drawings 12371-1 to 12371-2 for instrument locations.

The instrument layout along the trenchless sections is in general accordance with the MTO "Guidelines for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application".

1.8 Subsurface Conditions

The subsurface conditions at the site are described in Thurber's Report titled "Foundation Investigation Report, Proposed 600 mm Watermain Relocation, Highway 401 Leslie Street Interchange, Toronto, Ontario", prepared for WSP / MMM Group, File: 12371, dated February 1, 2017.

2 INSTALLATION

2.1 General

There are sixty seven (67) surface monitoring points (SMP) and twenty one (21) settlement rods (SR) to be installed at this site as shown on Drawings 12371-1 to 12371-2. SMPs will be installed on paved surfaces such as in parking lots, on roadways and highway ramps. SRs will be installed on the side slopes and toes of roadway embankments or other unpaved open areas. For instrument layout purposes, the watermain alignment is assumed to have a north-south orientation.

Each of the arrays with three instruments along the trenchless sections will consist of the following:

- One (1) instrument installed at the proposed watermain centreline
- One (1) instrument installed at 3 m west of the proposed watermain centreline
- One (1) instrument installed at 3 m east of the proposed watermain centreline.

The exact number of instruments may be slightly more or less than that indicated above

depending on the watermain installation methodology and site conditions at the time of construction. The Contractor shall determine the actual number of instruments and locations where installation and monitoring are to be carried out. Such information shall be provided to MTO, GO and the CA prior to commencement of instrument installation.

2.2 Instrument Location

The Contractor's surveyor shall accurately survey the location of each instrument to obtain coordinates and elevations.

2.3 Survey Benchmarks

The Contractor's surveyor shall identify or establish non-yielding survey benchmarks (BM) at the site in order to carry out level survey with total station and/or precise levelling equipment, and achieve the accuracy specified below.

2.4 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 millimetres or better.

2.5 Materials and Equipment

The Contractor shall supply all materials and equipment required for installation of the instruments.

2.6 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged directly or indirectly by the Contractor's work shall be immediately replaced by the Contractor at the Contractor's expense.

Instruments installed in the travelled portion of the roadway (lanes and shoulders) shall be protected to avoid puncturing of vehicle tires.

2.7 Installation Program

Instrument installation and baseline readings shall be completed before any construction operations which include roadway protection and dewatering systems where required.

3 SURFACE MONITORING POINT (SMP) - SUPPLY & INSTALLATION

3.1 General

3.1.1 Scope

This Section contains the requirements for the supply and installation of SMPs.

The purpose of SMP is to monitor settlement of asphalt paved surfaces. The ground

movement readings shall assist in assessing the trenchless, open cutting and watermain installation performance, and any need to modify the installation methodology as required. Settlement is measured by surveying the SMPs using suitable survey equipment stipulated elsewhere with reference to stable, non-settling benchmarks.

3.1.2 General Procedure

SMPs shall be rigidly affixed so as not to move relative to the asphalt pavement surface to which they are attached.

3.1.3 Location

The locations of SMPs are shown on Drawings 12371-1 to 12371-2.

3.2 Materials

3.2.1 General

The Contractor shall supply all materials and equipment required for the installation of SMPs.

3.2.2 Steel Markers

The Contractor shall supply hardened steel markers with an exposed convex head, similar to surveyor's PK nails, treated or coated to resist corrosion. The steel markers shall have a minimum diameter of 12 mm and have sufficient length for anchoring in the pavement and to withstand the weather conditions and effects of traffic.

The exposed nail head shall be equipped with reflective paint or reflective tape to allow for repeated measurements by total station and/or precise levelling equipment.

3.3 Installation

3.3.1 General

Traffic shall be managed by the Contractor using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

3.4 Documentation

Relevant installation details shall be recorded and documented. These include, but are not limited to:

- SMP easting, northing and elevation;
- Dates of installation;
- Installation notes / sketches.

4 SETTLEMENT ROD (SR) - SUPPLY & INSTALLATION

4.1 General

4.1.1 Scope

This Section contains the requirements for the supply and installation of SRs.

The purpose of SR is to monitor the settlement of the ground, highway embankment and other unpaved surfaces along the proposed watermain alignment. The settlement readings shall assist in assessing the trenchless, open cutting and watermain installation performance, and any need to modify the installation methodology as required. Settlement is measured by surveying the top of the rod using suitable survey equipment stipulated elsewhere with reference to stable, non-settling benchmarks.

4.1.2 General Procedure

The SR shall consist of a 12 to 18 mm diameter rebar encased in a PVC pipe used as a friction reducing sleeve.

The assembly shall be placed in a drilled hole and backfilled with anchor grout and clean washed sand as shown on the attached Figure 1.

4.1.3 Location

The locations of SRs are shown on Drawings 12371-1 to 12371-2.

4.2 Materials

4.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the SRs.

4.2.2 Rod

The Contractor shall supply 12 to 18 mm diameter steel rebars in the required lengths in order to complete this installation.

The top end of each rod shall be equipped with reflective paint or reflective tape to allow for measurements with total station and/or precise levelling equipment.

4.2.3 Anchor

The Contractor shall supply concrete for anchoring the lower end of the steel rebar. The concrete shall be prepared in accordance with OPSS 1350 with a minimum compressive strength of 10 MPa.

4.2.4 Sand

The Contractor shall supply clean washed sand. The sand will be Sakcrete washed general purpose sand, or equal.

4.2.5 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40, 50 mm O.D. PVC pipe cut perpendicular to the axis of the pipe.

4.2.6 Protective Casing

The Contractor shall supply protective steel casings installed flush with the ground surface where the SRs are installed in shoulders that can be travelled by vehicles.

4.3 Installation

4.3.1 General

The Contractor shall install SRs as per Figure 1 in addition to what is stated or emphasized below. Traffic control for instrument installation shall be managed by the Contractor, as required, using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

4.3.2 Rod

The rod shall be centred in the borehole.

4.3.3 Friction Reducing Sleeve

The friction reducing sleeve shall extend for the length of the rod above the anchor grout.

4.4 Documentation

Relevant installation details shall be recorded and documented. These include, but are not limited to:

- SR location, easting and northing;
- Elevation of top of rod;
- Dates of installation;
- Installation notes / sketches.

5 DECOMMISSIONING OF INSTRUMENTS

5.1 General

The Contractor shall decommission all SMPs and SRs after the completion of the monitoring program as directed by the CA.

6 MONITORING PROGRAM

6.1 General

The instrumentation monitoring services specified herein apply to all the SMPs and SRs installed at this site. The requirements include data collection, reporting, data compilation/reduction and data transmission.

The Contractor shall carry out the monitoring program. The required tasks include, but are not necessarily limited to, the following:

- Supply materials and equipment required for monitoring;
- Level survey the instruments using total station and/or precise levelling equipment with no interference with the highway traffic;
- Compile and reduce the survey data as described in Section 6.4.2;
- Transmit the settlement data and associated construction activities to the CA, GO and MTO;
- Notify the CA, GO and MTO of any required modifications to the watermain installation procedures;
- Notify the CA, GO and MTO of any modifications of the original site conditions related to trenchless installation, open cutting or otherwise, including appearance of cracks on the paved surfaces, roadway shoulders, concrete barriers etc;
- Notify immediately the CA, GO and MTO if Review or Alert Levels have been reached or exceeded and follow the procedures outlined in Section 6.5.

6.2 Purpose

The purpose of this program is to monitor settlement of the paved and unpaved surfaces at selected locations during installation of the watermain.

The rate and/or methodology of watermain installation may need to be adjusted based on the instrumentation readings.

6.3 Reading Schedule and Frequency

The Contractor shall keep a complete record in electronic and hard copy formats of all instrumentation survey and associated data, including the locations of the tunnel face and open cut face at the time of each survey.

Monitoring shall commence after the installation of an instrument. Monitoring is to continue as specified in this document and as required by the CA.

The minimum monitoring frequencies along with the anticipated number of readings are given in Table 6.1 below. The monitoring frequency is the same for each individual instrument. Instruments shall be read more frequently as required by the CA.

Table 6.1 - Minimum Monitoring Frequency

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER INSTRUMENT (**)
Baseline Readings (*)	3 readings on 3 consecutive days	3
Just prior to start of trenchless and open cut installations	Once	1
During trenchless installations	A minimum of three (3) sets of readings be taken daily for all instruments located within a distance of 20 m of the advancing tunnel face, provided that movements are within anticipated limits. Monitoring of movements is also required during work stoppages, such as during non-operation periods (off-shifts) or weekends.	Variable
During open cut installations	A minimum of one (1) set of readings be taken daily for all instruments located within a distance of 20 m of the advancing trench/excavation face, provided that movements are within anticipated limits.	Variable
From completion of trenchless/open cut installation to completion of watermain installation	A minimum of one (1) set of readings be taken weekly for all instruments during the first month, and every two (2) weeks thereafter provided that movements are within anticipated limits. Monitoring of movements is also required during work stoppages, such as during non-operation periods (off-shifts) or weekends.	Variable
After completion of watermain installation	After the end of installation, all instruments shall be read weekly for the first month.	4

(*) Baseline Readings: Instrument elevation readings taken prior to trenchless and open cut installations to provide a baseline against which all subsequent readings are compared to assess settlements of the ground and embankments.

(**) Number of readings may vary.

6.4 Specific Requirements

6.4.1 Surveying

Elevations of the instruments shall be surveyed using total station and/or precise levelling

equipment to an accuracy of plus/minus two (±2) millimetres or better, and shall be reported to the nearest millimetre. Shoulder and lane closures on highway ramps for instrument readings are not permitted.

6.4.2 Data Recording and Data Reduction

For every instrument elevation reading, the following information shall be recorded electronically in an Excel spreadsheet containing the following information:

- Date and time of the day
- Location of the advancing tunnel or trench/excavation face (i.e. distance from launching point) at the time of reading
- Construction activities (e.g. tunnelling underway, trenching, weekend – no construction, etc.)
- Pavement visual survey (e.g.: No visual pavement distress; 1 mm wide, 3 m long pavement crack parallel to west shoulder and close to instruments No. A, B and C, sketches and photos, etc.)
- Instrument Number
- Settlement Array Number
- Horizontal distance measured along the alignment between the advancing tunnel or trench/excavation face, and the instrument or array of instruments that contains the instrument being monitored
- Instrument elevation
- Instrument settlement

The settlement data shall be presented in X-Y charts as follows:

- Settlement versus Time for each instrument
- Settlement versus Distance from the advancing face of tunnel or trench/excavation for each instrument
- Settlement profile for different dates along the watermain alignment
- Settlement profile for different dates along each of the settlement arrays

Reported information should be supplemented by sketches, diagrams and plots as necessary.

6.4.3 Data Transmission

All settlement data obtained on a particular day shall be reported in electronic format to the CA, GO and MTO not later than mid-day on the next calendar day. Any unusual movements deduced from the field data must be reported immediately before leaving the site.

6.5 Criteria for Assessment

The following settlement levels are to be observed:

Review Level – A maximum value of 10 mm relative to the baseline or zero readings. If the Review Level is reached or exceeded, the Contractor shall immediately notify the CA, GO

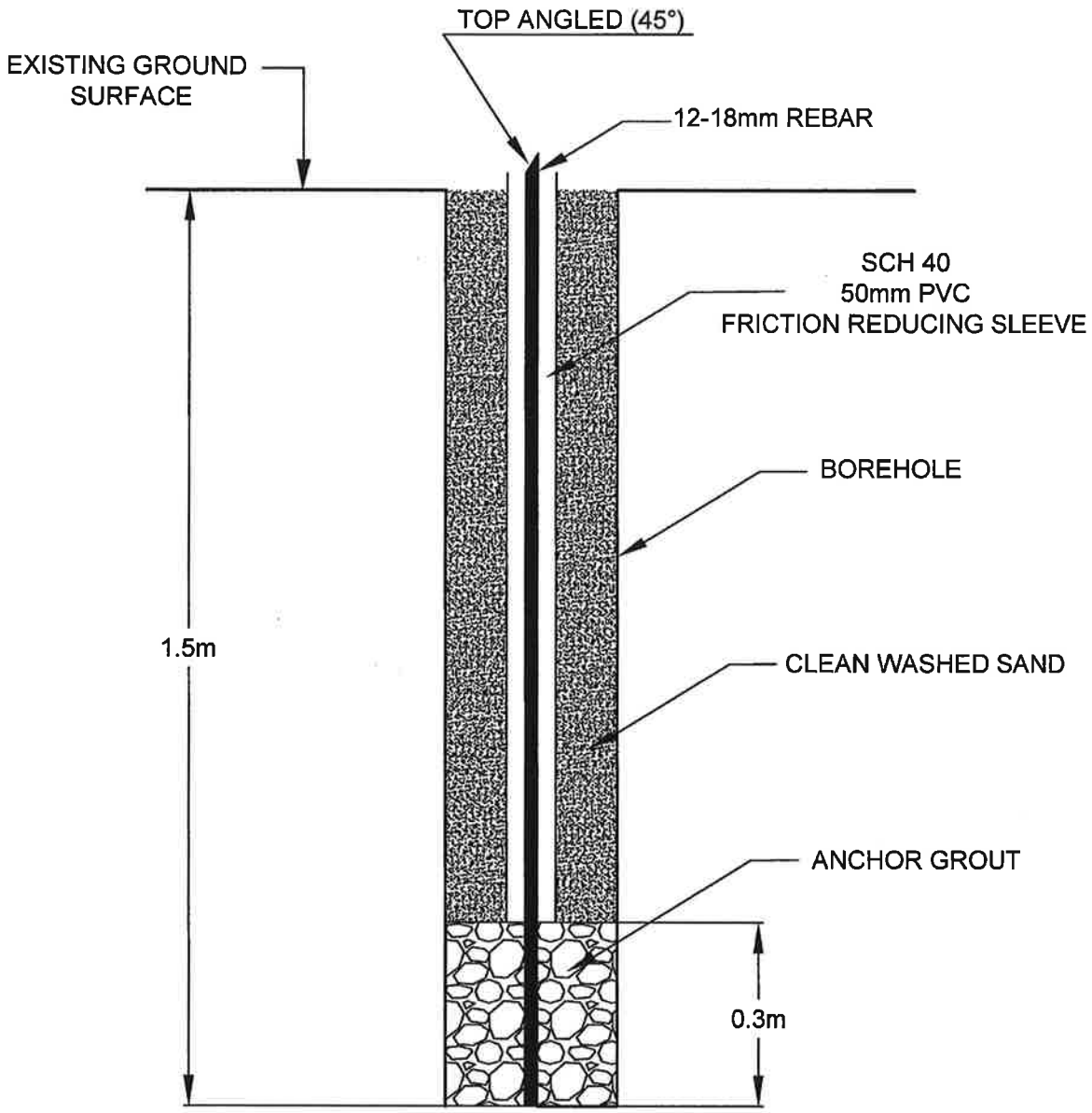
and MTO, and review and discuss response actions. The Contractor shall submit a plan of action to prevent the Alert Level from being reached. All construction work shall be continued such that Alert Level is not reached.

Alert Level – A maximum value of 15 mm relative to the baseline or zero readings. If the Alert Level is reached or exceeded, or lesser ground settlements cause or threaten to cause damage to utilities, roadway and highway ramp pavement, as indicated by monitoring instruments or direct observation, the Contractor shall cease any construction activities immediately and inform the CA, GO and MTO. No construction shall 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/preventive measure deemed necessary by the Contractor is implemented;
- The CA, GO and MTO deem it is safe to proceed.

7 CONTRACTOR'S RESPONSIBILITY FOR RESTORATION

Notwithstanding the monitoring program to assess the adequacy of the tunnelling, open cutting and sewer installation methods to control potential ground movements, the Contractor is responsible for reinstatement (such as surface paving and fill placement) should ground movements or other surface distresses occur.



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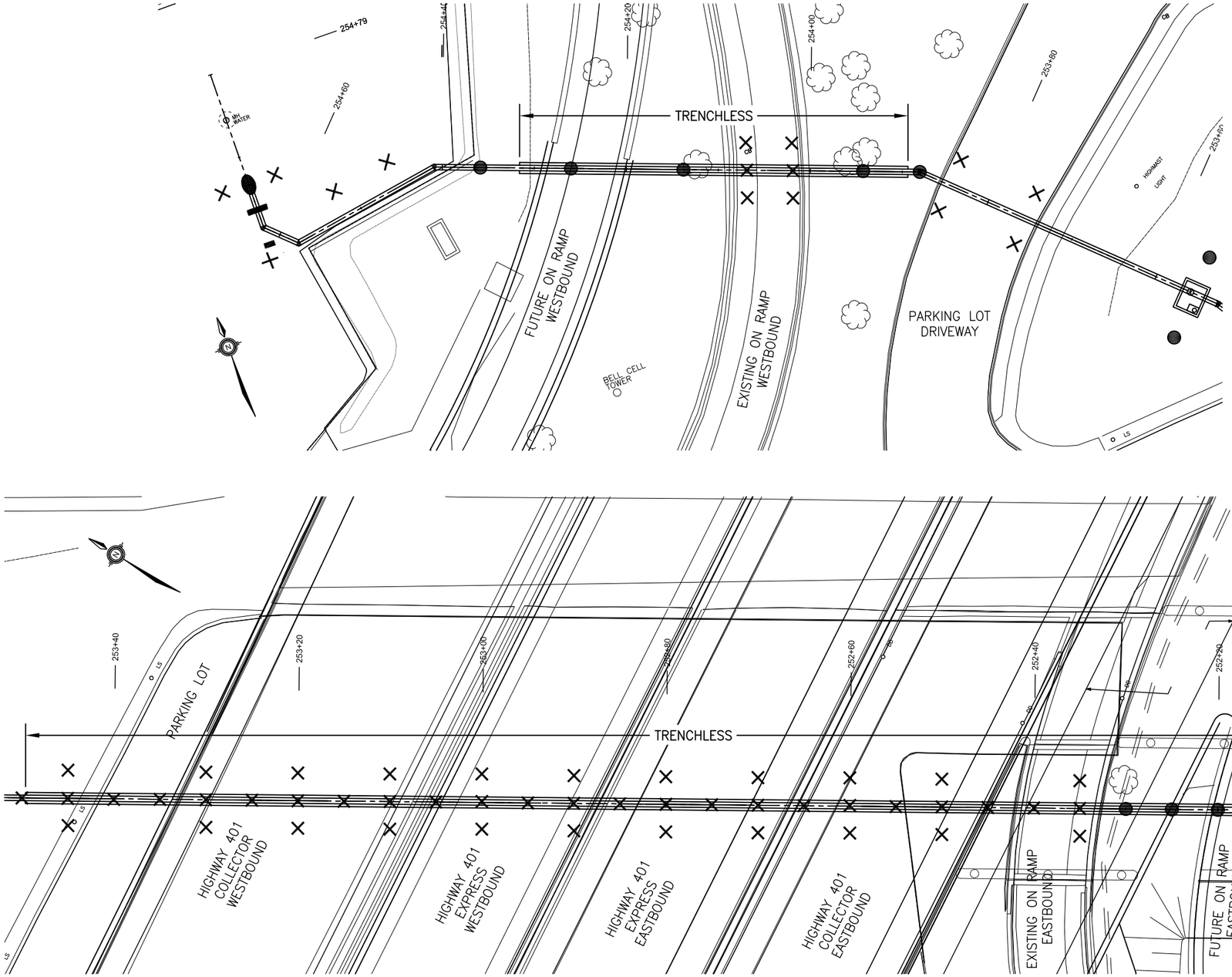
SETTLEMENT ROD DETAILS

FIGURE 1



LEGEND:

- ✕ SURFACE MONITORING POINT (SMP)
- ● SETTLEMENT ROD (SR)

NOTES:

1. THE SURFACE MONITORING POINTS UNDER THE HIGHWAY 401 (COLLECTORS AND EXPRESS) ARE TO BE INSTALLED AT THE GO PARKING LOT GRADE.
2. SMP's ARE TO BE INSTALLED ON PAVED SURFACES AND SR's ARE TO BE INSTALLED ON UNPAVED SURFACES. MINOR ADJUSTMENT OF INSTRUMENT TYPES AND LOCATIONS MAY BE REQUIRED TO SUIT THE SITE CONDITIONS.
3. ALL SECTIONS NOT LABELED AS TRENCHLESS ARE PROPOSED TO BE CONSTRUCTED AS OPEN CUTS.

BASE PLAN PROVIDED BY

WSP/MMM GROUP

HIGHWAY 401 & LESLIE STREET
RELOCATED WATERMAIN CROSSING
TORONTO, ON
INSTRUMENTATION AND MONITORING PROGRAM

JOB# 12371

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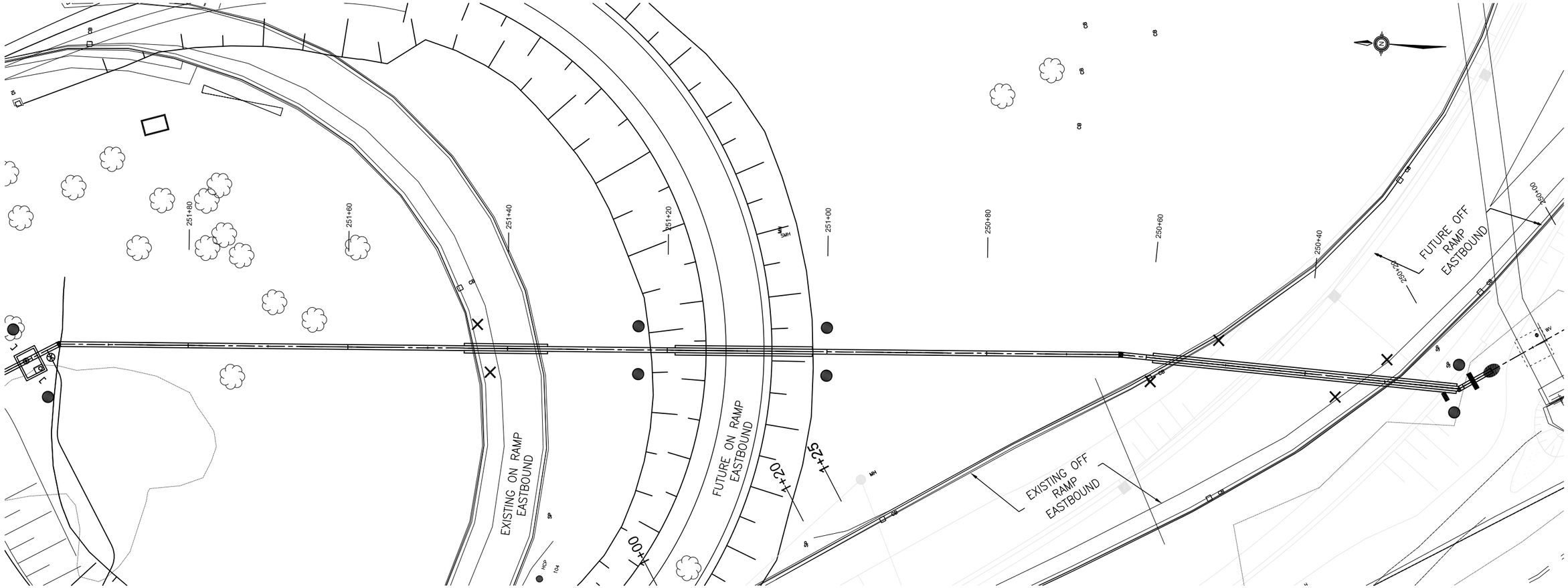

LEGEND:

- ✕ SURFACE MONITORING POINT (SMP)
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BASE PLAN PROVIDED BY

WSP/MMM GROUP

HIGHWAY 401 & LESLIE STREET RELOCATED WATERMAIN CROSSING TORONTO, ON

INSTRUMENTATION AND MONITORING PROGRAM

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