

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
PROPOSED SEWER PIPE CROSSINGS  
HWY 400 WIDENING  
MAJOR MACKENZIE DRIVE TO KING ROAD  
YORK REGION, ONTARIO  
G.W.P. 192-00-00 AND 2539-04-00  
ASSIGNMENT NOS. 2005-E-0036 AND -0037**

**Geocres Number: 30M13-196**

**Report to**

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May 11, 2012

File: 19-92-68

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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation carried out at the locations of the proposed sewer crossings under the Highway 400 right-of-way between Major MacKenzie Drive and King Road. This investigation is part of an on-going project which involves widening of the highway to accommodate additional lanes of traffic. It is understood that the Ministry of Transportation Ontario (MTO) requires the design to accommodate the ultimate 10-lane configuration including one HOV lane in each direction, within the current MTO right-of-way.

The purpose of this investigation was to determine the subsurface conditions near the locations of the sewer crossings in order to provide borehole locations plans and soil strata drawings, records of boreholes, laboratory test results, and a generalized description of the subsurface conditions. A model of the subsurface conditions was developed for each crossing location based on data obtained from this and previous investigations.

Thurber Engineering Ltd. (Thurber) carried out this investigation as a sub-consultant to SNC-Lavalin Inc. (SNC-Lavalin) under MTO Assignment Nos. 2005-E-0036 and 0037.

**2 PROJECT AND SITE DESCRIPTION**

The alignment covered in this report extends along Highway 400 from north of Major Mackenzie Drive northerly to south of the King Road Underpass. The general location of each of the relevant sewer crossings is shown on the key plans on the Borehole Locations and Soil Strata drawings in Appendix C.

The project area is located within the physiographic region known as the South Slope of the Oak Ridges Moraine, which comprised predominantly of the Halton till. The Halton till is an interbedded complex of clayey silt to silt till and sand. This till comprises a slightly hummocky till plain, into which the surface watercourses have eroded 10 to 15 m deep gullies. Relatively recent fluvial sediments have been deposited in the gullies. The Halton till overlies bedrock at depths in the order of 100 m in the vicinity of the project area.



Drainage in the vicinities of the project areas is largely controlled by the Humber River and its tributaries. Localized drainage is facilitated by the creeks flowing within the gullies.

The land use adjacent to this section of Highway 400 is largely rural and agricultural, although there is increasing residential and commercial development in recent years.

### **3 SITE INVESTIGATION AND FIELD TESTING**

Site investigation and field testing for the proposed sewer crossings consisted of drilling and sampling sixteen (16) boreholes, designated as 11T-01, 11T-02, 11T-05, 11T-06, 11T-07, 11T-08 to 11T-18 to depths ranging from 9.6 to 17.4 m below the ground surface. At each of the sewer crossing locations, one borehole was drilled near each end of the proposed pipe as specified in the terms of reference. All boreholes were drilled within the period of October 18, 2011 to December 1, 2011.

All boreholes were drilled during approved lane closure times in the right of way and on the outside shoulders of the northbound and southbound lanes of Highway 400. Lane closures and traffic control were carefully planned for drilling each borehole. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawings in Appendix C. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A. The borehole coordinates were surveyed using a Trimble Pathfinder ProXRT differential GPS, and the approximate ground surface elevations were determined using topographic drawings provided by SNC-Lavalin. It is understood that all as-drilled borehole locations will be surveyed by professional surveyors to be arranged by SNC-Lavalin.

Solid stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT).

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Nine standpipe piezometers were installed at selected locations to permit monitoring of groundwater levels. The piezometers consisted of 19 mm PVC pipes with slotted screens. The locations and completion details of the piezometers are shown in Table A-1 in Appendix A. The borehole completion details are also shown in Table A-1.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered soil samples, and transported them to Thurber's laboratory for further examination and testing.

### **4 LABORATORY TESTING**

Visual identification and natural moisture content determination was undertaken on all recovered soil samples returned to the laboratory. At least 25% of the recovered soil samples were subjected to grain size distribution analysis. Selected cohesive soil samples underwent Atterberg Limits tests.

The results of this testing program are shown on the Records of Borehole sheets in Appendix A and on the accompanying figures in Appendix B.

## **5 DESCRIPTION OF SUBSURFACE CONDITIONS**

This section presents a generalized summary of the subsurface conditions encountered at the borehole locations drilled for the proposed sewer crossings. Reference is made to the Record of Borehole sheets in Appendix A. Stratigraphic profiles for each crossing are also presented on the Borehole Locations and Soil Strata Drawings in Appendix C. An overall description of the stratigraphy encountered in the boreholes is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.

In general terms, the soil stratigraphy encountered along this stretch of the highway consists of pavement structure and embankment fill overlying native clayey silt to silty clay till deposits which is underlain by silt and sand till. Occasional sand deposits were also encountered in the boreholes. More detailed descriptions of the individual stratum are presented below.

### **5.1 Pavement Structure**

Pavement structure consisting of asphalt overlying granular fill materials was encountered in Boreholes 11T-02, 11T-06, 11T-08, 11T-09, 11T-11, 11T-14, and 11T-16. Asphalt was present at ground surface in boreholes drilled on the median shoulder of the travelled portion of the highway. The asphalt thickness ranged from 150 mm to 225 mm. The listed boreholes were drilled on the median shoulder, therefore the asphalt thicknesses do not necessarily represent the conditions under the travelled lanes of the highway.

The granular fill consisted of sand and gravel and was found to range between 1.0 m and 1.5 m in thickness, with base elevations varying between 229.7 and 271.2 m. These soils were in a compact state as indicated by SPT 'N' values ranging from 11 to 29 blows per 0.3m of penetration. The moisture contents ranged from 2% to 12%.

The thickness of the pavement structure may vary between and beyond the borehole locations.

### **5.2 Topsoil**

Dark brown to black topsoil was present at most of the boreholes drilled in the highway right of way. Topsoil was encountered in Boreholes 11T-05, 11T-07, 11T-10, 11T-12, 11T-13, 11T-15 and 11T-17. The topsoil thickness ranged from 50 mm to 225 mm. The thickness of the topsoil may vary between and beyond the borehole locations.

### **5.3 Fill**

Fill was encountered in Borehole 11T-01 from the surface, 11T-02, 11T-09 and 11T-16 below the pavement structure and 11T-07 below the topsoil. The fill consisted of clayey silt

to occasional silty clay with varying proportions of sand, trace gravel, trace roots and was brown in colour. The thickness of the fill ranged from 0.6 m to 4.4 m, with base elevations between 227.8 and 248.2 m.

Recorded SPT N-values in the cohesive fill ranged from 7 to 13 blows per 0.3 m penetration indicating a firm to stiff consistency.

The natural moisture contents of the fill samples obtained generally ranged from approximately 10% to 27%.

Grain size distribution curves for fill samples tested are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. Atterberg Limit test results are presented on Figure B13 of Appendix B.

The results of the laboratory gradation and Atterberg Limits tests are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0 to 2
Sand	20 to 25
Silt	50 to 56
Clay	19 to 27

<b>Index Property</b>	<b>(%)</b>
Liquid Limit	26 to 27
Plasticity Index	11 to 12

The above results show that the clayey silt fill is of low plasticity with group symbol of CL.

#### **5.4 Clayey Silt to Silty Clay Till**

Clayey silt to silty clay till was encountered in all of the boreholes except for 11T-05, 11T-13, 11T-14, 11T-15 and 11T-16. The cohesive till consisted of brown clayey silt to silty clay with some sand and trace gravel and was encountered below the pavement, surficial soils and fill in most of the boreholes. The till deposits were encountered at depths ranging from 0.1 m to 5.6 m, and were observed to be 3.6 m to 9.0 m thick where fully penetrated with base elevations varying between 219.4 and 245.2 m. Boreholes 11T-08, 11T-09, 11T-11 and 11T-12 were terminated within the till and a minimum thickness range from 5.7 to 11.1 m was observed.

Based on SPT N-values ranging from 8 blows for 0.3 m of penetration to greater than 100 blows for less than 0.3 m penetration, the clayey silt to silty clay till is described as stiff to hard, but typically very stiff to hard.

The natural moisture contents of the samples recovered from cohesive till deposits ranged from 5% to 32%, but typically ranged between 10% and 20%.

Grain size distribution results for the cohesive till samples tested are presented on the Record of Borehole sheets and on Figures B2 to B7 of Appendix B. Atterberg Limit test results are presented on Figures B14 to B16 of Appendix B.

The results of laboratory gradation and Atterberg Limits tests are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0 to 2
Sand	3 to 35
Silt	33 to 72
Clay	14 to 57

<b>Index Property</b>	<b>(%)</b>
Liquid Limit	19 to 33
Plasticity Index	8 to 19

The above results show that the clayey silt/silty clay till has low plasticity with a group symbol of CL. A sample at a depth of 2.6 m in Borehole 11T-02 consists of a silty clay till of very high plasticity and group symbol of CH.

Occasional cobbles were encountered in the glacial till in the boreholes. Glacial tills inherently contain cobbles and boulders.

### **5.5 Sand and Silt to Sandy Silt Till**

Sand and silt to sandy silt till was encountered below and within the clayey silt to silty clay till deposits in all boreholes except for 11T-01, 11T-08, 11T-09, 11T-11, 11T-12, 11T-14, and 11T-15. The cohesionless till consisted of brown sand and silt to sandy silt, trace to some clay, and trace gravel with occasional sand seams. The cohesionless till deposits were encountered at depths ranging from 3.7 to 10.4 m, and were observed to be 3.5 m to 4.6 m thick where fully penetrated with base elevations varying between 231.3 and 241.7 m. Boreholes 11T-02, 11T-05, 11T-07, 11T-10, 11T-13, 11T-16, 11T-17 and 11T-18 were terminated within the till and a minimum thickness range from 0.7 to 5.2 m was observed.

The sandy silt till is described as compact to very dense, based on SPT N-values ranging from 16 blows per 0.3 m penetration to greater than 100 blows per 0.3 m penetration. In general, this till deposit is in a dense to very dense state.

The natural moisture contents of the samples recovered from the sand and silt till deposits ranged from 5% to 22%.

Grain size distribution curves for the till samples tested are presented on the Record of Borehole sheets and on Figures B8 to B9 of Appendix B.

The results of laboratory gradation and Atterberg Limits tests are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0 to 1
Sand	12 to 61
Silt	28 to 82
Clay	3 to 14

Occasional cobbles were encountered in the cohesionless till in the boreholes. Cohesionless tills inherently contain cobbles and boulders.

### **5.6 Silty Sand to Sandy Silt**

In Boreholes 11T-01, 11T-05, 11T-13, 11T-14 and 11T-15, cohesionless deposits ranging in composition from sand with some silt to silt, some sand were encountered within or above the glacial till layers. These deposits were encountered at depths from 0.1 m to 10.7 m below the ground surface and extended to depths ranging from 6.1 m up to the full depth of the boreholes at 15.8 m. The base of these deposits were at elevations 216.1 to 258.4 m.

The SPT N-values recorded in the cohesionless deposits ranged from 5 to greater than 100 blows for 0.3 m of penetration, indicating that the deposits are loose to very dense; with a typically compact condition.

These deposits were observed to be moist to wet, with natural moisture contents of recovered samples ranging from 4% to 23% and typically greater than 15%.

Grain size distribution curves for samples tested from the sand deposits are presented on the Record of Borehole sheets and on Figure B10 of Appendix B.

The results of the laboratory gradation tests are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0
Sand	11 to 76
Silt	21 to 85
Clay	2 to 22

### **5.7 Silty Clay and Clayey Silt**

Silty clay and clayey silt were encountered in the Boreholes 11T-05, 11T-13, 11T-14, 11T-15, 11T-16, 11T-17 and 11T-18. The silty clay and clayey silt deposits were encountered at depths ranging from ground surface to 7.2 m, and were observed to be 0.4 m to 6.0 m thick. The base elevation of the deposit ranged from 223.3 m to 261.3 m.

Based on SPT N-values ranging from 6 blows for 0.3 m of penetration to 24 blows per 0.3 m penetration, the silty clay and clayey silt is described as firm to very stiff.

The natural moisture contents of the samples recovered from the silty clay and clayey silt deposits ranged from 12% to 33%.

Grain size distribution curves for the silt and clay samples tested are presented on the Record of Borehole sheets and on Figures B11 to B12 of Appendix B. Atterberg Limit test results are presented on Figure B18 of Appendix B.

The results of laboratory gradation and Atterberg Limits tests are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0 to 4
Sand	1 to 28
Silt	23 to 80
Clay	17 to 45

<b>Index Property</b>	<b>(%)</b>
Liquid Limit	19 to 31
Plasticity Index	6 to 15

The above results show that the silty clay to clayey silt is of low plasticity with a group symbol of CL.

## 5.8 Water Levels

The groundwater level was observed in the boreholes during and upon completion of drilling. Nine standpipe piezometers were installed to monitor water levels after completion of drilling. The water levels measured in the piezometers and open boreholes upon completion of drilling are summarized in Table 5.1.

**Table 5.1 – Measured Groundwater Levels**

<b>Station</b>	<b>Borehole</b>	<b>Date</b>	<b>Water Level (m)</b>	
			<b>Depth</b>	<b>Elevation</b>
18+438	11T-01	December 9, 2011	10.5	219.6
	11T-02	November 7, 2011	5.8	225.6
20+885	11T-05	December 9, 2011	6.2	231.0
21+286	11T-07	December 9, 2011	-	-
21+825	11T-09	November 9, 2011	6.9	244.9
	11T-10	December 9, 2011	5.8	243.1
23+775	11T-12	December 9, 2011	3.2	271.1
10+999	11T-13	December 9, 2011	7.8	257.6
20+688	11T-15	December 9, 2011	4.5	227.5
10+079 (ramp)	11T-17	December 9, 2011	10.4	236.9
	11T-18	December 9, 2011	10.9	234.4

The above table indicates that the groundwater levels along this stretch of Highway 400 range from Elevations 219.6 m to 271.1 m corresponding to depths between 3.2 and 10.9 m.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

## **6 MISCELLANEOUS**

The drilling and sampling equipment was supplied and operated by DBW Drilling of Ajax, Ontario, Kodiak Environmental Ltd, of Oakville, Ontario and Walker Drilling Ltd. of Utopia, Ontario. Traffic control was provided by Barricade Traffic Services of Concord, Ontario. The field work was supervised on a full time basis by Mr. Ryan Kromer, Mr. Adam Schneider, Mr. Jason Mei, Mr. Stephane Loranger and Mr. Mubashar Tahir of Thurber Engineering Ltd. Laboratory testing was carried out at Thurber's Laboratory in Oakville, Ontario.

Supervision of the field program was conducted by Mr. Lukasz Gilarski, E.I.T. Interpretation of the field data and preparation of the investigation report was conducted by Mr. Lukasz Gilarski, E.I.T. and Dr. Sydney Pang, P.Eng.

Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.

THURBER ENGINEERING LTD.

Lukasz Gilarski, E.I.T.  
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P.K. Chatterji, P.Eng.  
Review Principal, Designated MTO Contact



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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**7 GENERAL**

This section of the report presents foundation recommendations for the design and installation of the proposed eight (8) sewer pipe crossings of Highway 400 by trenchless methods. The proposed sewer pipe diameters vary from 375 to 825 mm and their invert depths range from approximately 3.4 m to 4.1 m under the highway grade.

The subsurface stratigraphy revealed in the boreholes drilled within the highway embankment footprint at the proposed pipe crossings generally consists of a pavement structure (asphalt, granular base/subbase) overlying embankment fill (clayey silt/silty clay) which is underlain by native stiff to hard silty clay/clayey silt glacial till, underlain by or interlayered with sand and silt/sandy silt till. Beyond the highway embankment, the subsurface typically consists of topsoil overlying similar native soils. The existing ground surface at the borehole locations on the highway ranges from Elevations 231.4 to 272.5 m.

Groundwater levels measured in nine (9) piezometers installed at the proposed pipe crossing locations ranged from 3.2 m to 10.9 m below the ground surface, or at Elevations 219.6 to 271.1 m.

Preliminary information on the general layout of the proposed pipe crossing locations and their proposed depths of installation were provided to Thurber by SNC-Lavalin prior to the commencement of the field work. Updated design information was provided to Thurber after completion of the field work. Available details of the pipe crossings are included in Table 7.1, including the soil type through which each pipe is expected to be installed. The locations and depths of the proposed pipes are shown on the Borehole Locations and Soil Strata Drawings in Appendix C.

The discussion and recommendations presented in this report are based on information provided by SNC-Lavalin to Thurber, and on the factual data obtained during the course of this investigation.

**Table 7.1 – Sewer Pipe Crossing Details**

Borehole	Station	Pipe Invert Elevation (m)		Approx. Trenchless Length (m)	Diameter (mm)	Soil Type* Around Pipe	Pipe Cover Below Top of Pavement (m)
		Inlet	Outlet				
11T-01 11T-02	18+438	228.00	227.70	35	375	Clayey Silt / Silty Clay Till / Fill	3.0
11T-15 11T-16	20+688	233.55	233.13	30	750	Clayey Silt Fill	3.4
11T-05 11T-06	20+885	238.00	236.84	28	450	Clayey Silt Till / Possible Fill	3.0
11T-07 11T-08	21+286	244.85	244.50	31	675	Clayey Silt to Silty Clay Till	3.0
11T-17 11T-18	10+079 (ramp)	244.00	243.00	37	825	Silty Clay to Silty Clay Till	3.0
11T-09 11T-10	21+825	247.62	247.38	38	675	Clayey Silt Fill / Till	3.0
11T-11 11T-12	23+775	268.60	268.52	30	750	Clayey Silt to Silty Clay Till	3.1
11T-13 11T-14	10+999	264.05	263.70	25	600	Silty Clay	3.0

\* Reference must be made to the records of boreholes for detailed descriptions of soil type around the pipe.

## **8 TRENCHLESS METHODS RECOMMENDATIONS**

All work must be carried out in accordance with the requirements of the Non-Standard Special Provision (NSSP) “Pipe Installation by Trenchless Methods”. A copy of this NSSP is attached in Appendix D.

Trenchless installation methods that are typically used to install pipes under highways include:

- Tunnelling - hand-mining or tunnel boring machine (TBM)
- Horizontal directional drilling
- Pipe ramming
- Jack and bore

Selection of an appropriate trenchless method should be the responsibility of the Contractor and will depend upon the relative costs and risks associated with each method. The experience of the Contractor is of primary importance for trenchless installation. The Contractor must submit a detailed

work plan, including the proposed methodology, maintenance of alignment, and disposal of cuttings, all in accordance with the NSSP.

Based on the design information shown in Table 7.1, all of the pipe crossings under Highway 400 will be installed in cohesive silty clay or clayey silt till or fill.

Tunnelling (hand-mining or TBM) is not considered practical for these crossings due to the relatively small crown cover (approximately 3.0 to 3.4 m) and due to the relatively short pipe lengths (30 to 38 m) that require trenchless procedures.

Horizontal directional drilling procedures are not suitable for these crossings since the method will not be able to provide temporary support of the open cavities under the highway.

Pipe ramming is considered a viable option for installing these crossings at locations where a crown cover of at least 3 m below the top of pavement can be maintained throughout the alignment. Should obstructions be encountered during installation, however, the potential of pipe mis-alignment would increase.

The jack and bore technique is considered feasible for installing these crossings, but the equipment must be capable of excavating and advancing through cobbles and boulders and any other obstructions that may be present in the fill and glacial till materials. It is recommended that preference be given to using equipment with alignment adjustment capabilities.

In general, both the jack and bore technique and the pipe ramming method are technically feasible for installing these sewer crossings. The relative cost effectiveness of these methods should be assessed. It is also noted that there is only a very limited number of local contractors that are qualified to carry out the pipe ramming operation.

In addition to the NSSP referenced above, it is strongly recommended that the Contractor be alerted to the following points, either by a further NSSP or otherwise by inclusion in the Contract Documents in an appropriate manner:

- The fill material and glacial till deposits may contain cobbles and boulders.
- The majority of the pipe installation will be carried out through cohesive fill and glacial till. The Contractor's equipment must be able to advance the pipes through these cohesive deposits. For the jack and bore technique, this should be accomplished without choking up the augers.
- For the jack and bore technique, a maximum distance of 600 mm should be maintained between the boring face and the pipe during installation to minimize the potential for sloughing or caving of any embedded cohesionless or otherwise loose soils. Pipe installation should be continuous and no gaps should be left between the boring face and the pipe during work stoppages, e.g. overnight and weekends.

- At locations where the pipe crossings are to be installed through highway embankment fill, loss of ground due to sloughing or caving may occur in the borings. In these areas, installation method selection should be based on minimizing the risks of caving and loss of ground. If jack and bore is used, the pipe should be advanced closely behind the boring face.

A NSSP for the above is included in Appendix D.

A minimum vertical distance of 3.0 m between the top of the pavement and the crown of the pipe is recommended to reduce the potential for disturbance of the highway pavement structure.

Based on groundwater observations and measurements in the boreholes, groundwater seepage during installation of the pipe crossings is expected to be minimal. It is anticipated that sumps and pumps should be adequate to handle groundwater and surface runoff entering the launching pit excavations. The Contractor is responsible for maintaining dry excavations during the course of the installation.

## **9 INSTRUMENTATION AND MONITORING PROGRAM**

The impact of the proposed installation on existing nearby structures and underground utilities should be assessed. A pre-construction condition survey should be carried out to document the existing condition of the highway pavement and assess the potential for damage to all facilities and underground services along the alignments of the trenchless crossings. Monitoring of the roadway surface, underground utilities, and any nearby structures should be carried out during construction.

A monitoring program and condition survey of the Hwy 400 pavement in the proximity of the pipe crossings has been prepared following MTO's Guidelines for Foundation Engineering - Tunnelling Specialty for Corridor Encroachment Permit Application.

Detailed specifications and drawings for the implementation of the monitoring program are presented in Appendix E.

## **10 TEMPORARY PITS AND ROADWAY PROTECTION**

Temporary pit excavations at the pipe crossing locations will extend through the cohesive fill, native cohesive glacial tills, and native interbedded cohesionless deposits.

All temporary excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and local regulations. The fill, native clayey silts/silty clays, sands and silts are classified as Type 3 soils under OHSA, and the native clayey silt to silty clay glacial tills are classified as Type 2 soils.

Where excavation for the pipe installations is located in close proximity to live traffic lanes or existing buried utilities, shoring in the form of trench boxes, continuous timber sheathings and bracing, or other temporary systems should be provided.

Roadway protection systems should be designed by a licensed Professional Engineer experienced in design of shoring, with consideration of adjacent traffic loads and any sloping retained surfaces. If roadway protection is required, it should be provided as per OPSS 539, which should be included in the contract documents. Performance Level 2 is recommended for protection system design.

Use of a hydraulic excavator should be suitable for temporary pit excavation. Provision should be made for handling and removal of possible cobbles, boulders, and other obstructions in the fill and glacial tills during excavation.

## **11 CONSTRUCTION CONCERNS**

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

### **11.1 Loss of ground**

Trenchless installations at relatively shallow depth below a highway inherently include some risk of loss of ground into the bore. If it is significant, this loss of ground can create settlement of the pavement surface and create safety hazards. The Contractor's methodology selection must recognize and take into consideration this inherent risk. Contingency plans should be in place to manage any adverse impacts on the highway.

### **11.2 Obstructions**

Glacial till soils typically contain cobbles and boulders, and fill placed for the highway construction may contain similar and other obstructions. The Contractor's equipment and methodology must be selected to handle such obstructions and successfully remove them without jeopardizing the highway. The impact of such obstructions on the pipe alignment should be assessed.

### **11.3 Buried Utilities**

The Contractor must accurately establish, in three dimensions, the locations of all buried utilities crossing or closely paralleling the path of the bores. Any discrepancy from the Contract Drawings must be reported to the Contract Administrator.

## **12 CLOSURE**

Engineering analysis and preparation of the foundation design report was conducted by Dr. Sydney Pang, P.Eng. Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects reviewed the report.

THURBER ENGINEERING LTD.



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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 <sup>(1)</sup> '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  
 Shear Strength Determination by Pocket Penetrometer


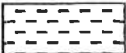
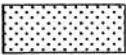


- (1) SPT 'N' Value      Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT              Dynamic Cone Penetration Test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



# 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			

## EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
<b>Fresh (FR)</b>	No visible signs of weathering.		
<b>Fresh Jointed (FJ)</b>	Weathering limited to the surface of major discontinuities.		CLAYSTONE
<b>Slightly Weathered (SW)</b>	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
<b>Moderately Weathered (MW)</b>	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
<b>Highly Weathered (HW)</b>	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
<b>Completely Weathered (CW)</b>	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
<u>TERMS</u>		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage 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.				

RECORD OF BOREHOLE No 11T-01

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 856 427.7 E 300 851.1 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ <sub>t</sub> kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
231.0												
0.0	Clayey SILT, some sand, trace gravel, trace roots Stiff Brown Moist (FILL)		1	AS			231					
			1	SS	12		230					
229.6												
1.4	Clayey SILT, with sand Stiff Brown Moist (FILL)		2	SS	12		229					0 23 50 27
228.7												
2.3	Clayey SILT, with sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		3	SS	20		228					0 29 49 21
			4	SS	39							
			5	SS	100/ 0.275		227					
			6	SS	100		226					
							225					1 24 54 21
			7	SS	71		224					
							223					
222.4												
8.6	Silty CLAY, some sand, trace gravel Hard Brown Moist (TILL)		8	SS	52		222					1 13 59 28

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

ONTMT4S 9268.GPJ 5/10/12

RECORD OF BOREHOLE No 11T-01

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 856 427.7 E 300 851.1 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
	Continued From Previous Page						221							
220.3														
10.7														
220.0	SAND, trace silt Very Dense Brown Moist		9	SS	65/									
11.0					0.150									
	END OF BOREHOLE AT 11.0m. BOREHOLE OPEN TO 11.0m AND DRY. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 10.5 220.5													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-02

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 856 430.7 E 300 875.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.07 - 2011.11.07 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
						WATER CONTENT (%)								
						20 40 60 80 100			20 40 60					
231.3														
0.0	ASPHALT: (150mm)													
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS			231							
			1	SS	17									
229.6							230							
1.7	Silty CLAY, occasional sand, occasional gravel Firm		2	SS	8									
229.0	Grey Moist (FILL)						229							
2.3	Silty CLAY, some sand, trace gravel Firm to Stiff Brown Moist (TILL)		3	SS	9								0 10 33 58	
			4	SS	8		228							
227.2	Clayey SILT, with sand, trace gravel Stiff Brown Moist (TILL)						227							
			5	SS	11									
							226							
225.7	Becoming hard													
5.6							225						1 26 53 20	
			6	SS	53									
							224							
222.9	Silty CLAY, some sand, trace gravel Hard Brown Moist (TILL)						223							
8.4			7	SS	100/ 0.225									
							222						0 15 54 31	
			8	SS	73									

Continued Next Page

+ 3, × 3 Numbers refer to  
Sensitivity 20  
15 10 5  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-02

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 856 430.7 E 300 875.7 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.07 - 2011.11.07 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
221.1														
10.2	SAND and SILT, trace clay Very Dense Brown Moist (TILL)		9	SS	50/		221							
220.4														
10.9	END OF BOREHOLE AT 10.9m AND WATER LEVEL AT 5.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG FROM 10.9m TO 1.5m, CUTTINGS FROM 1.5m TO 0.15m THEN ASPHALT TO SURFACE.				0.075									

ONTMT4S 9268.GPJ 5/10/12

# RECORD OF BOREHOLE No 11T-05

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 839.4 E 300 428.7 ORIGINATED BY RK  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.19 - 2011.10.19 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)
235.4 0.0	TOPSOIL, some sand, some rootlets: (50mm) Dark Brown Moist		1	SS	9									
	Sandy SILT, some clay, trace rootlets Loose to Compact Brown Wet		2	SS	10									
			3	SS	8									
			4	SS	28									
232.5 3.0	Some gravel Clayey SILT		5	SS	23									
231.7 3.7			6	SS	29									
	Becoming grey Wet		7	SS	5									
229.3 6.1	SAND and SILT, trace clay Dense Grey Wet (TILL)		8	SS	34									
228.2 7.2	Sandy SILT, trace gravel, trace clay, occasional sand seam Very Dense Grey Wet (TILL)		9	SS	100									
			10	SS	114									

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-05

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 839.4 E 300 428.7 ORIGINATED BY RK  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.19 - 2011.10.19 CHECKED BY LPG

SOIL PROFILE			SAMPLES				ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS		20 40 60 80 100	20 40 60 80 100					
	Continued From Previous Page													
224.2			11	SS	45		225							0 26 65 9
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 6.2 229.2													

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No 11T-06

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 845.2 E 300 463.2 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.08 - 2011.11.08 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
241.5													
0.0	ASPHALT: (200mm)												
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS			241						
			1	SS	16								
240.2													
1.3	Clayey SILT, some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		2	SS	17		240						0 20 55 24
			3	SS	25		239						
			4	SS	48		238						
			5	SS	64		237						1 14 63 22
235.9							236						
5.6	SILT, some sand, trace gravel, trace clay Dense to Very Dense Brown Moist (TILL)		6	SS	48		235						
	Becoming wet		7	SS	61		234						0 12 82 6
			8	SS	47		233						
							232						

Continued Next Page

+ 3, x 3: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-06

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 845.2 E 300 463.2 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.08 - 2011.11.08 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
231.3														
10.2	Clayey SILT, with sand, trace gravel Hard Grey Moist (TILL)		9	SS	71		231							2 21 53 24
230.2														
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.2m THEN ASPHALT TO SURFACE.													

# RECORD OF BOREHOLE No 11T-07

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 240.4 E 300 365.1 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT  NATURAL MOISTURE CONTENT  LIQUID LIMIT	UNIT WEIGHT  UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						WATER CONTENT (%) w <sub>p</sub> w w <sub>L</sub>
249.4 0.0 0.1	TOPSOIL: (75mm)							20 40 60 80 100						
	Clayey SILT, trace sand Brown Moist (FILL)		1	AS			249				○			
248.6 0.8	Silty CLAY, some sand, trace gravel Hard Brown to Grey Moist (TILL)		1	SS	55		248				○			2 14 50 34
			2	SS	74						○			
			3	SS	100/ 0.275		247				○			
			4	SS	102/ 0.300		246				○			0 18 54 28
							245							
			5	SS	57		244				○			
							243							
	With sand		6	SS	42		243				○			1 29 46 23
242.2 7.2	Sandy SILT, trace clay, trace gravel Very Dense Grey/Brown Moist (TILL)		7	SS	100/ 0.250		242				○			
							241							
			8	SS	100/ 0.250		240				○			0 21 72 8

Continued Next Page

+<sup>3</sup> ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-07

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 240.4 E 300 365.1 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.10 - 2011.11.10 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
	Continued From Previous Page																
238.1			9	SS	54												
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND DRY. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m)																

+<sup>3</sup>, ×<sup>3</sup> Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-08

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 246.8 E 300 394.7 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.09 - 2011.11.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
248.5 0.0	ASPHALT: (225mm)												
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS			248						
			1	SS	29								
247.0							247						
1.4	Clayey SILT, some sand, trace gravel Hard Grey Moist (TILL)		2	SS	32								2 18 55 25
			3	SS	45		246						
			4	SS	55		245						
							244						0 12 66 22
			5	SS	77		243						
							242						1 30 45 23
			6	SS	43		241						
			7	SS	100/ 0.225		240						
			8	SS	90		239						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
5  
0  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-08

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 246.8 E 300 394.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.09 - 2011.11.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
237.2	Becoming grey		9	SS	51		238							0 35 45 20
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.2m THEN ASPHALT TO SURFACE.													

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-09

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 767.2 E 300 305.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.09 - 2011.11.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
251.2														
0.0	ASPHALT: (225mm)													
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS			251							
250.0			1	SS	16									
1.2	Clayey SILT, with sand, trace gravel Firm to Stiff Brown Moist (FILL)		2	SS	7		250							
			3	SS	13		249							0 25 50 25
			4	SS	10		248							
			5	SS	11		247							1 22 57 21
245.6							246							
5.6	Silty CLAY, with sand, trace gravel, occasional roots Very Stiff to Hard Grey/Brown Moist (TILL)		6	SS	20		245							
			7	SS	35		244							1 24 45 29
	Becoming grey		8	SS	34		243							
							242							

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-09

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 767.2 E 300 305.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.09 - 2011.11.09 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
239.9			9	SS	42		241							1 24 44 31
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND WATER LEVEL AT 6.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.2m THEN ASPHALT TO SURFACE.						240							

ONTMT4S 9268.GPJ 5/10/12



# RECORD OF BOREHOLE No 11T-10

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 775.6 E 300 336.5 ORIGINATED BY RK  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.18 - 2011.10.18 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED	+ FIELD VANE									
								● QUICK TRIAXIAL	x LAB VANE									
249.0						20	40	60	80	100	PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>					
0.0	TOPSOIL, clayey, some rootlets: (100mm) Black Moist  Clayey SILT, with sand, trace gravel, occasional cobbles Very Stiff to Hard Brown to Greyish Brown Moist (TILL)		1	AS														
0.1			2	SS	17													
			3	SS	54													
			4	SS	46													
			5	SS	65													
			6	SS	74													
245.3																		
3.7	Sandy SILT, trace clay, trace gravel Very Dense Brown Moist (TILL)  Becoming wet		7	SS	73													
			8	SS	65													
			9	SS	53													
241.8																		
7.2	Clayey SILT, with sand, trace gravel Hard Brown Moist (TILL)		10	SS	32													
			11	SS	37													

Continued Next Page

+<sup>3</sup> × 3<sup>3</sup> Numbers refer to  
Sensitivity

20  
15 10 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-10

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 775.6 E 300 336.5 ORIGINATED BY RK  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.18 - 2011.10.18 CHECKED BY LPG

SOIL PROFILE			SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)						
	Continued From Previous Page														
238.8							239								
10.2	Sandy SILT, some sand, trace gravel Dense Grey Moist (TILL)		12	SS	39		238								1 16 72 11
237.7															
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 5.8 243.2														

# RECORD OF BOREHOLE No 11T-11

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 861 694.3 E 299 971.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.07 - 2011.11.07 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
272.4	ASPHALT: (225mm)											
0.0												
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS			272					
			1	SS	11							
271.1												
1.3	Clayey SILT, with sand, trace gravel Firm Brown Moist (TILL)		2	SS	5		271					1 22 63 14
			3	SS	5		270					
							269					
268.3												
4.1	Silty CLAY, some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		4	SS	25		268					2 20 47 31
							267					
	Becoming grey		5	SS	29		266					
							265					
			6	SS	32							1 13 46 40
							264					
			7	SS	33		263					

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup> Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-11

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 861 694.3 E 299 971.7 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.07 - 2011.11.07 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
261.1	Very Stiff		8	SS	16		262							0 35 40 25
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.2m THEN ASPHALT TO SURFACE.													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-12

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 861 698.4 E 300 004.5 ORIGINATED BY MAT  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED		+ FIELD VANE					
								● QUICK TRIAXIAL		× LAB VANE					
274.1						20	40	60	80	100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>		
0.0	TOPSOIL: (150mm)										WATER CONTENT (%)				
0.2	Silty <b>CLAY</b> , trace to some sand Very Stiff to Hard Brown Moist (TILL)		1	SS	6										
			2	SS	36										
			3	SS	31										
			4	SS	55										
			5	SS	24										
			6	SS	21										
			7	SS	17										
			8	SS	23										
			9	SS	24										
			10	SS	32										

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-12

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 861 698.4 E 300 004.5 ORIGINATED BY MAT  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
262.9			11	SS	46		264							
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 3.2 270.9						263							

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-13

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 861 461.0 E 299 636.6 ORIGINATED BY SLL  
 HWY 400 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.12.01 - 2011.12.02 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w <sub>P</sub>	w	w <sub>L</sub>							
								○ UNCONFINED	+ FIELD VANE											
								● QUICK TRIAXIAL	x LAB VANE											
263.3							20	40	60	80	100	20	40	60						
0.0	<b>TOPSOIL</b> , with roots and rootlets Black Moist (225mm)  Silty <b>CLAY</b> , with sand, trace gravel, with roots and rootlets Stiff to Very Stiff Brown Moist to Wet																			
0.2																				
			1	SS	14															
			2	SS	16												4	28	23	45
			3	SS	11															
			4	SS	13															
259.2																				
4.1	<b>SAND</b> , some silt, trace gravel Dense to Very Dense Brown Moist																			
			5	SS	34															
			6	SS	59															
256.3																				
7.0	Silty <b>SAND</b> , some clay Dense to Very Dense Brown Moist (TILL)																			
			7	SS	44															
			8	SS	20													0	61	28
			9	SS	51															
253.7																				
9.6	END OF BOREHOLE AT 9.6m. Piezometer installation consists of																			

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Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-13

2 OF 2

**METRIC**

W.P. 2539-04-00 LOCATION N 4 861 461.0 E 299 636.6 ORIGINATED BY SLL  
 HWY 400 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2011.12.01 - 2011.12.02 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT Y kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)			
	Continued From Previous Page											
	19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.											
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 7.8 255.3											

ONTMT4S 9268.GPJ 5/10/12





# RECORD OF BOREHOLE No 11T-14

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 863 471.4 E 299 667.6 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.07 - 2011.11.07 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
256.4			9	SS	28		257							
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE OPEN TO 11.3m AND DRY. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.15m THEN ASPHALT TO SURFACE.													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-15

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 655.7 E 300 456.6 ORIGINATED BY RK  
 HWY 400 BOREHOLE TYPE Solid Stem Augers/Coring COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.19 - 2011.10.19 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W <sub>P</sub>	W			W <sub>L</sub>
232.6								20	40	60	80	100		
0.0	TOPSOIL, clayey Black Moist (50mm)		1	SS	8									
	Clayey SILT, some sand seams, trace gravel Firm Dark Brown Moist		2	SS	8									
231.2														
1.4	SAND and SILT, trace clay Compact Light Brown Moist		3	SS	16									
			4	SS	17									
229.7														
2.9	SILT, trace to some sand, trace clay Compact to Dense Light Brown to Brown Moist to Wet		5	SS	25									
			6	SS	41									
			7	SS	45									
226.5	Becoming grey		8	SS	30									
225.4	Silty CLAY, trace sand Very Stiff Grey Moist		9	SS	23									
223.9	SILT, trace to some sand, trace clay Loose Grey Wet		10	SS	2									
8.7														

Continued Next Page

+ 3 X 3 Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-15

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 655.7 E 300 456.6 ORIGINATED BY RK  
HWY 400 BOREHOLE TYPE Solid Stem Augers/Coring COMPILED BY AN  
DATUM Geodetic DATE 2011.10.19 - 2011.10.19 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
Continued From Previous Page														
222.4	SAND, fine, some silt to silty Compact Grey Wet						222							
10.2			11	SS	11		221							
							220							
			12	SS	10		219							
							218							
			13	SS	17		217							
216.7			14	SS	11		216							
15.8	END OF SAMPLING AT 15.8m AND START DCPT													
215.2	END OF BOREHOLE AT 17.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
17.4	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 4.5 228.1													

ONTMT4S 9268.GPJ 5/10/12

# RECORD OF BOREHOLE No 11T-16

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 664.3 E 300 494.2 ORIGINATED BY JM  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.08 - 2011.11.08 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								WATER CONTENT (%)					
237.9													
0.0	ASPHALT: (200mm)												
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	AS									
			1	SS	29		237						
236.5													
1.4	Clayey SILT, with sand, trace gravel Stiff Brown Moist (FILL)		2	SS	13		236						2 25 53 19
			3	S	12								
234.9							235						
3.0	Silty CLAY Firm		4	SS	7								0 20 53 27
233.8							234						
4.1													
			5	SS	12		233						
232.3													
5.6	Clayey SILT, trace sand Very Stiff Brown Moist		6	SS	23		232						0 3 80 17
							231						
230.7													
7.2	SILT and SAND, some clay Compact to Very Dense Brown Moist (TILL)		7	SS	16		230						
			8	SS	45		229						0 31 55 14
							228						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-16

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 858 664.3 E 300 494.2 ORIGINATED BY JM  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.11.08 - 2011.11.08 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
226.6			9	SS	85		227							
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS FROM 11.3m TO 1.5m, CUTTINGS FROM 1.5m TO 0.2m THEN ASPHALT TO SURFACE.													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 11T-17

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 197.8 E 300 375.5 ORIGINATED BY MAT  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT		UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL      × LAB VANE	20 40 60 80 100	20 40 60				GR SA SI CL
247.4													
0.0	TOPSOIL, with grass												
0.2	(200mm)												
246.8	Silty CLAY, trace roots		1	SS	11								
0.6	Stiff												
	Brown												
	Moist												
	Silty CLAY, trace to some sand		2	SS	42								0 20 53 27
	Hard												
	Brown												
	Moist												
	(TILL)												
			3	SS	64								
			4	SS	68								
			5	SS	80								
			6	SS	38								0 7 65 28
			7	SS	67								
			8	SS	64								2 27 52 20
240.2													
7.2	Sandy SILT, some clay, trace gravel												
	Very Dense												
	Grey												
	Moist												
	(TILL)		9	SS	100/ 0.225								
			10	SS	48								0 23 63 14

Continued Next Page

+ 3 x 3 Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11T-17

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 197.8 E 300 375.5 ORIGINATED BY MAT  
HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
DATUM Geodetic DATE 2011.10.21 - 2011.10.21 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
236.1	Grey		11	SS	80									
11.3	END OF BOREHOLE AT 11.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 10.4 237.0													

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE





# RECORD OF BOREHOLE No 11T-18

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION N 4 859 159.2 E 300 357.0 ORIGINATED BY ACS  
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2011.11.15 - 2011.11.15 CHECKED BY LPG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)	
Continued From Previous Page																		
237.1 10.4	SAND and SILT, trace clay Dense Brown Moist to Wet (TILL)		11	SS	46		237								0	49	46	4
234.7 12.8	END OF BOREHOLE AT 12.8m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Dec09/11 10.9 236.6						235											

+ 3, × 3, Numbers refer to 20  
Sensitivity 15 5  
10 (%) STRAIN AT FAILURE

**Table A-1 – Borehole Completion Details**

<b>Location</b>	<b>Details</b>	
	<b>Piezometer Tip Depth / Elevation (m)</b>	<b>Completion Details</b>
11T-01	11.0 /	Piezometer with 1.5 m slotted screen installed with sand filter to 8.8 m, bentonite seal from 8.8 m to 1.4 m, and cuttings to surface.
11T-02	None Installed	Backfilled with bentonite holeplug to 1.5 m, cuttings to 0.15 m, then asphalt to ground surface.
11T-05	11.0 /	Piezometer with 1.5 m slotted screen installed with sand filter to 6.5 m, then bentonite seal from 6.5 m to ground surface.
11T-06	None Installed	Backfilled with bentonite holeplug to 1.5 m, cuttings to 0.2 m, then asphalt to ground surface.
11T-07	11.3 /	Piezometer with 1.5 m slotted screen installed with sand filter to 9.1 m, bentonite seal from 9.1 m to 1.5 m, and cuttings from 1.5 m to ground surface.
11T-08	None Installed	Backfilled with bentonite holeplug and cuttings to 1.5 m, cuttings to 0.2 m, then asphalt to ground surface.
11T-09	None Installed	Backfilled with bentonite holeplug and cuttings to 1.5 m, cuttings to 0.2 m, then asphalt to ground surface.
11T-10	11.3 /	Piezometer with 1.5 m slotted screen installed with sand filter to 7.3 m, bentonite seal from 7.3 m to ground surface.
11T-11	None Installed	Backfilled with bentonite holeplug and cuttings to 1.5 m, cuttings to 0.2 m, then asphalt to ground surface.
11T-12	11.3 /	Piezometer with 1.5 m slotted screen installed with sand filter to 9.1 m, bentonite seal from 9.1 m to 6.4 m, cuttings from 6.4 m to 3.7 m, bentonite holeplug from 3.7 m to 0.6 m, then cuttings to ground surface.
11T-13	9.6 /	Piezometer with 1.5 m slotted screen installed with sand filter to 7.0 m then bentonite seal from 7.0 m to ground surface.
11T-14	None Installed	Backfilled with bentonite holeplug and cuttings to 1.5 m, cuttings to 0.15 m, then asphalt to ground surface.
11T-15	8.4 /	Piezometer with 1.5 m slotted screen installed with sand filter to 3.0 m, then bentonite seal to ground surface.
11T-16	None Installed	Backfilled with bentonite holeplug and cuttings to 1.5 m, cuttings to 0.2 m, then asphalt to ground surface.
11T-17	11.3 /	Piezometer with 1.5 m slotted screen installed with sand filter to 8.8 m, bentonite seal from 8.8 m to 3.7 m, then cuttings to ground surface.
11T-18	12.2 /	Piezometer with 1.5 m slotted screen installed with sand filter to 6.7 m, then bentonite seal to ground surface.

## **Appendix B**

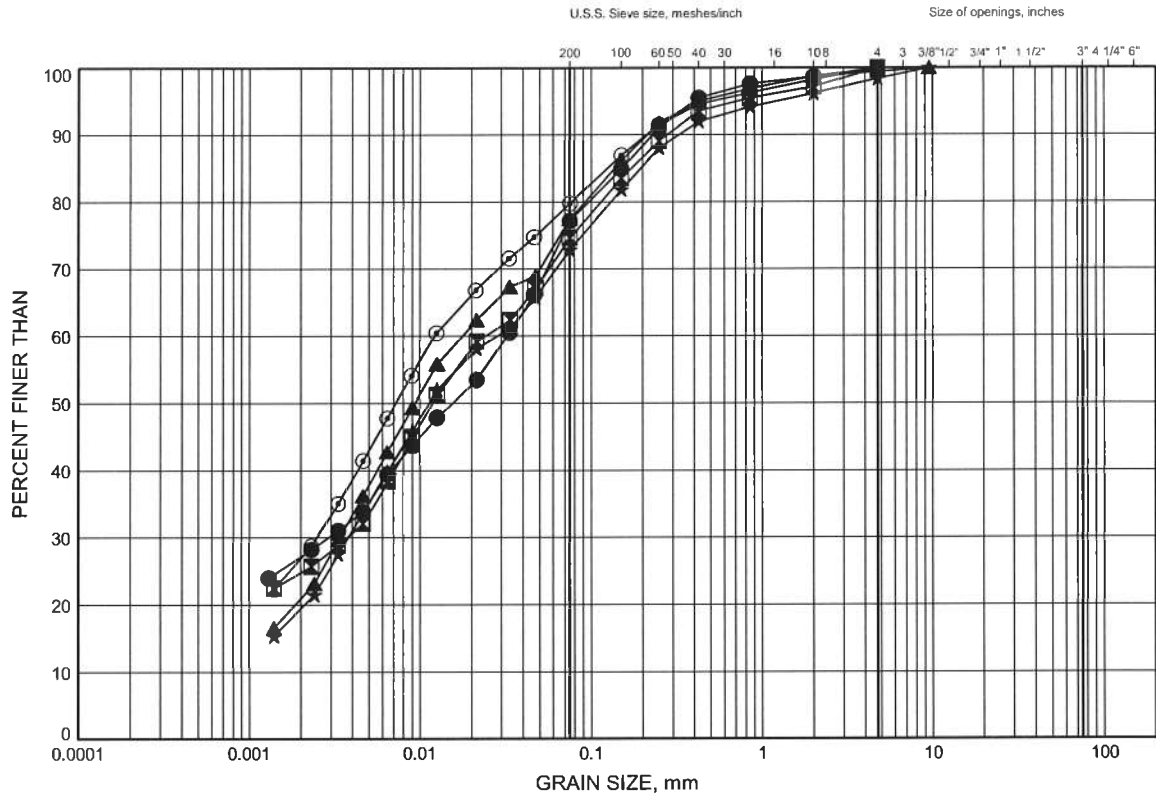
### **Laboratory Test Results**

Widening of Hwy 400, Major Mackenzie to King Road

## GRAIN SIZE DISTRIBUTION

FIGURE B1

### CLAYEY SILT FILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-01	1.83	229.18
⊠	11T-09	2.59	248.61
▲	11T-09	4.88	246.32
★	11T-16	1.83	236.08
⊙	11T-16	3.35	234.56

Date May 2012

W.P.# 2539-04-00

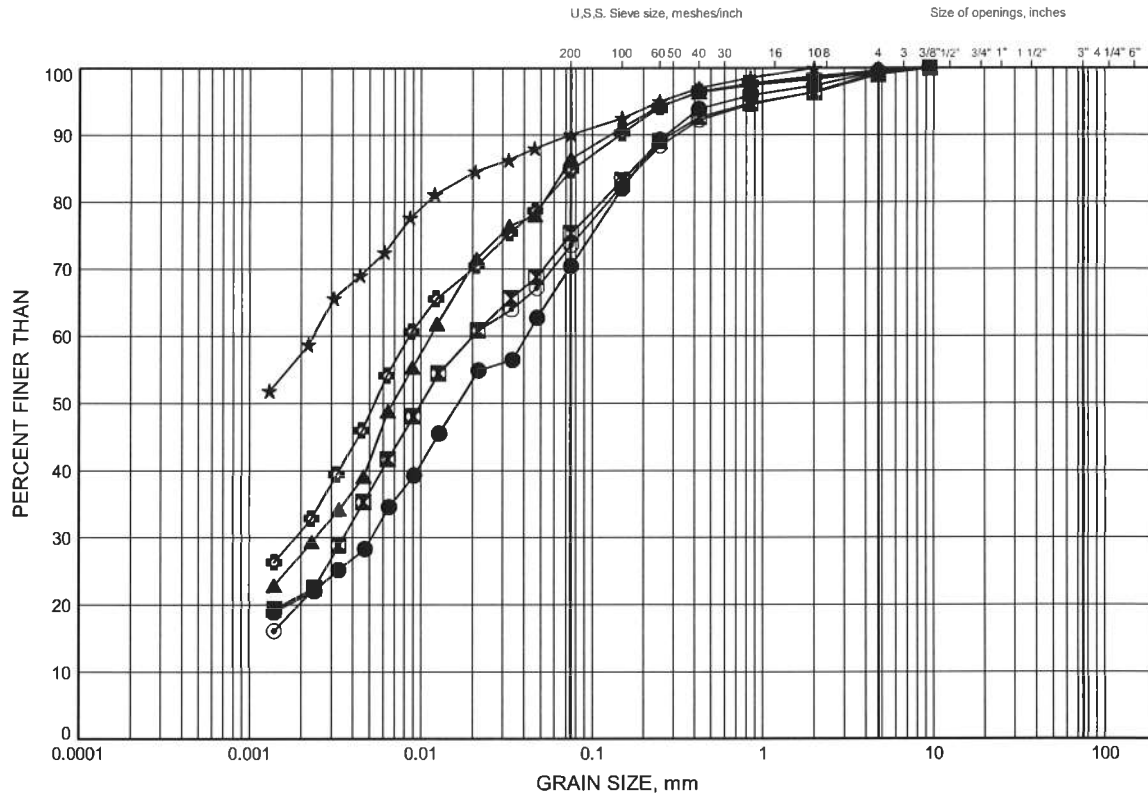


Prep'd MFA

Chkd. SKP

## GRAIN SIZE DISTRIBUTION

## CLAYEY SILT/SILTY CLAY TILL



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

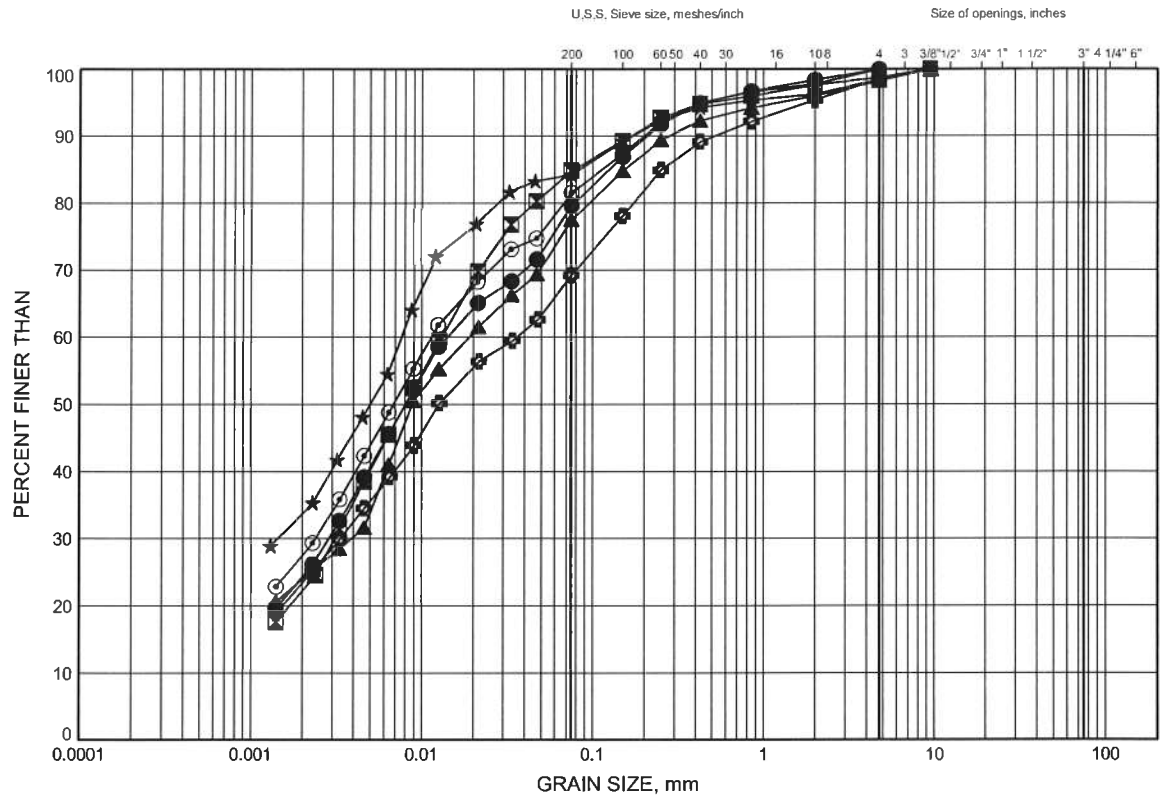
## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-01	3.35	227.66
⊠	11T-01	6.32	224.69
▲	11T-01	9.45	221.56
★	11T-02	2.59	228.73
⊙	11T-02	6.40	224.92
⊕	11T-02	9.42	221.90

Widening of Hwy 400, Major Mackenzie to King Road  
**GRAIN SIZE DISTRIBUTION**

**FIGURE B3**

**CLAYEY SILT/SILTY CLAY TILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-06	1.83	239.68
■	11T-06	4.88	236.63
▲	11T-06	10.97	230.54
★	11T-07	1.78	247.62
⊙	11T-07	3.28	246.12
⊕	11T-07	6.40	243.00

Date May 2012  
W.P.# 2539-04-00

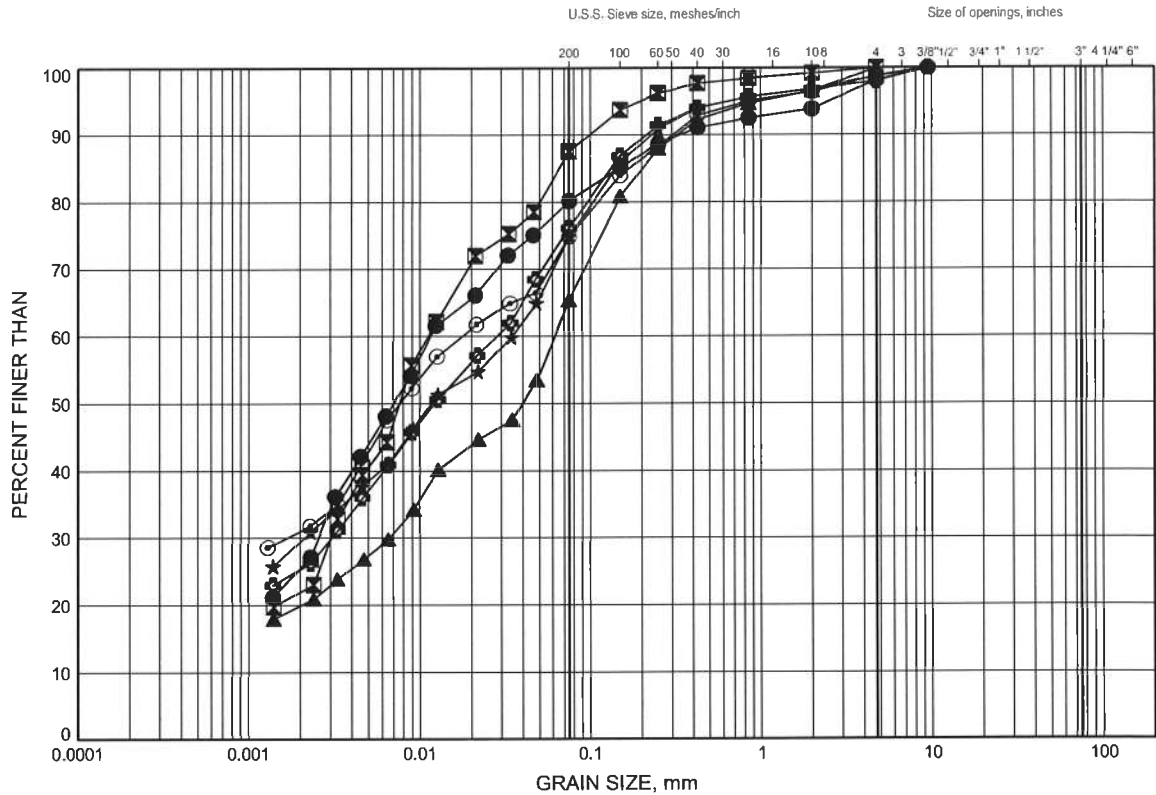


Prep'd MFA  
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**GRAIN SIZE DISTRIBUTION**

**FIGURE B4**

**CLAYEY SILT/SILTY CLAY TILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-08	1.83	246.67
⊠	11T-08	4.88	243.62
▲	11T-08	10.97	237.52
★	11T-09	7.92	243.27
⊙	11T-09	10.97	240.22
⊕	11T-10	2.74	246.25

Date May 2012

W.P.# 2539-04-00



Prep'd MFA

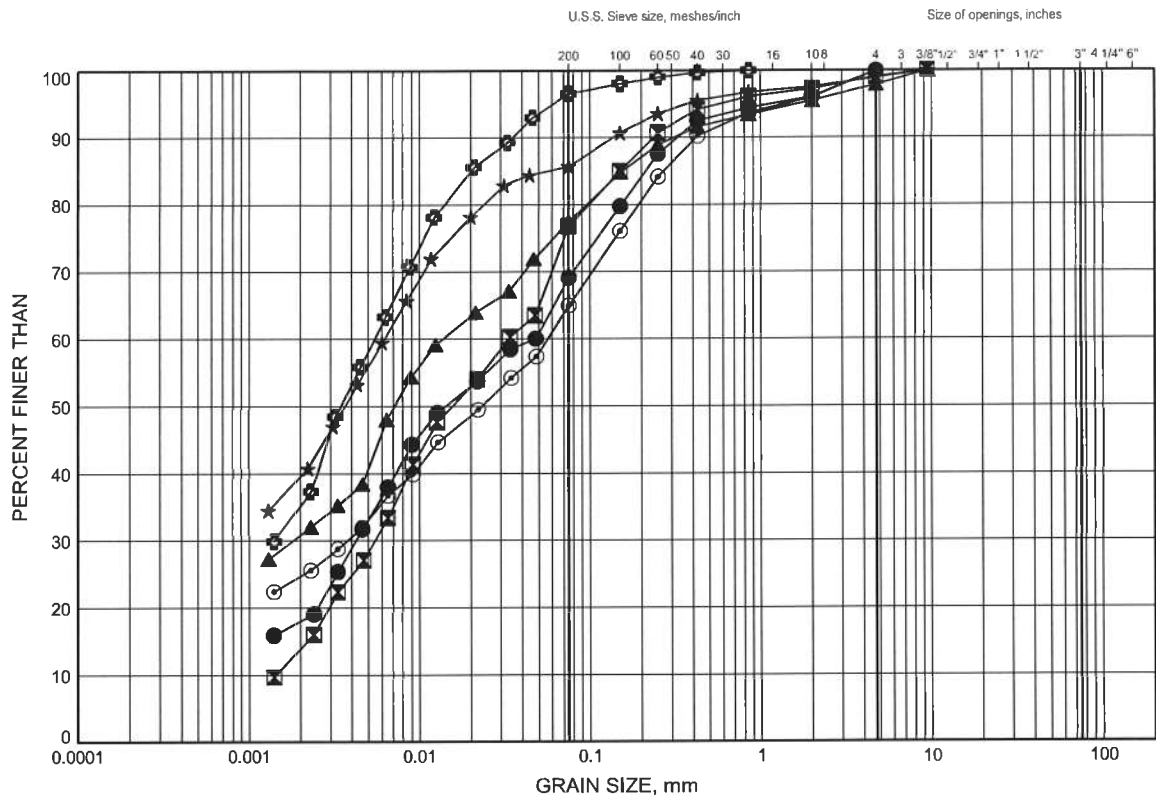
Chkd. SKP



Widening of Hwy 400, Major Mackenzie to King Road  
**GRAIN SIZE DISTRIBUTION**

FIGURE B5

**CLAYEY SILT/SILTY CLAY TILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-10	7.92	241.07
⊠	11T-11	1.83	270.57
▲	11T-11	4.88	267.52
★	11T-11	7.92	264.47
⊙	11T-11	10.97	261.42
⊕	11T-12	1.07	273.06

Date May 2012

W.P.# 2539-04-00



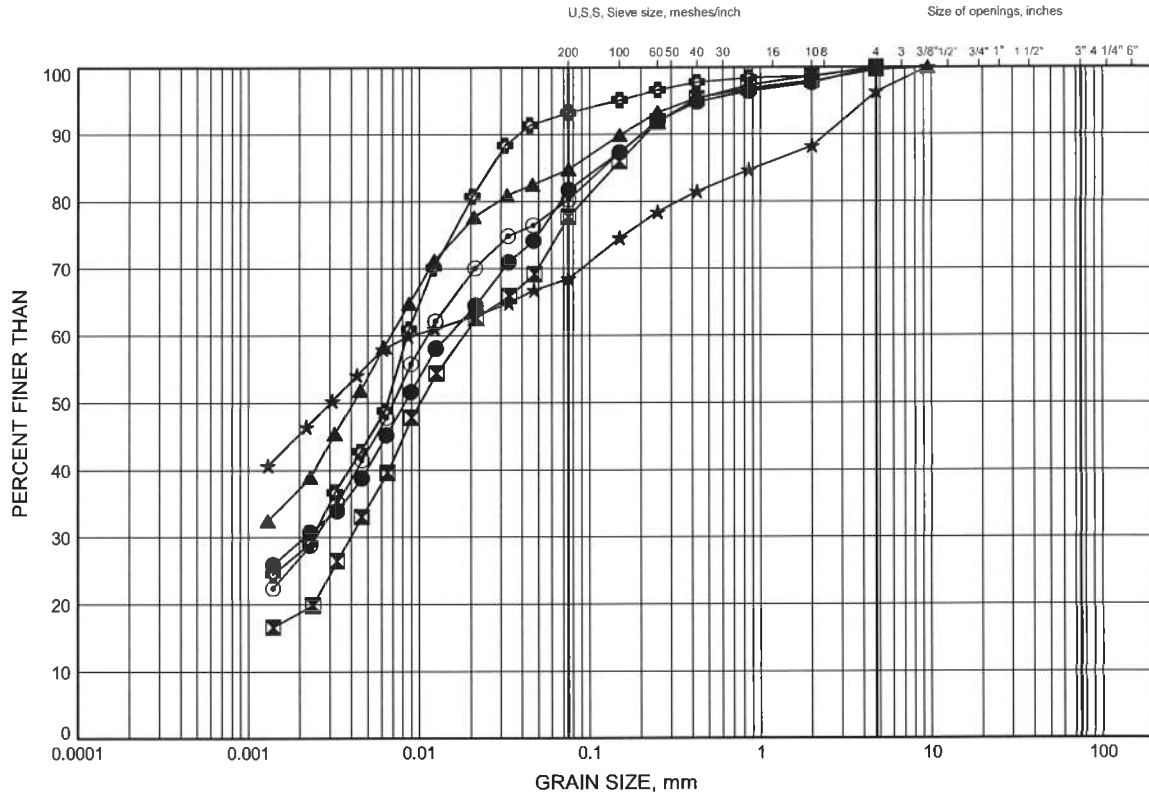
Prep'd MFA

Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**GRAIN SIZE DISTRIBUTION**

FIGURE B6

**CLAYEY SILT/SILTY CLAY TILL**



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

**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-12	3.35	270.78
⊠	11T-12	6.40	267.73
▲	11T-12	9.45	264.68
★	11T-13	1.75	261.57
⊙	11T-17	1.07	246.34
⊕	11T-17	4.11	243.30

Date May 2012  
W.P.# 2539-04-00

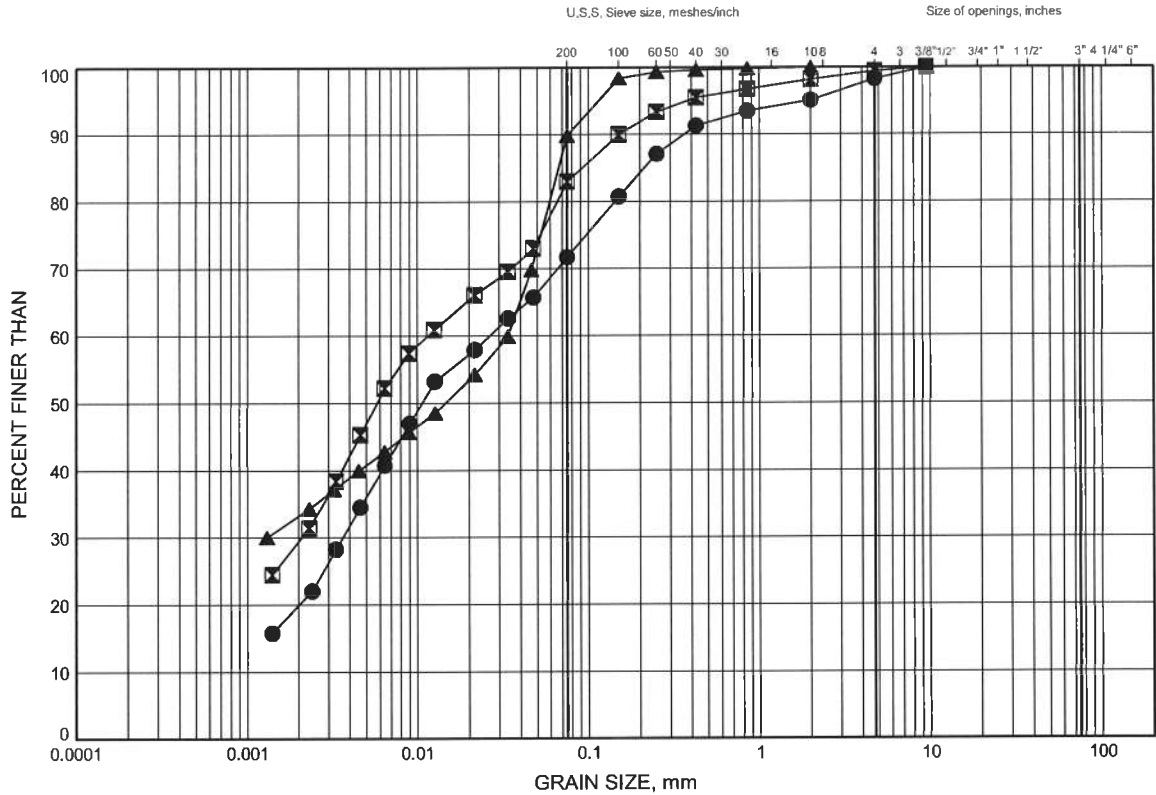


Prep'd MFA  
Chkd. SKP

# GRAIN SIZE DISTRIBUTION

**FIGURE B7**

## CLAYEY SILT/SILTY CLAY TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-17	6.40	241.01
⊠	11T-18	4.88	242.62
▲	11T-18	7.92	239.57

Date May 2012

W.P.# 2539-04-00

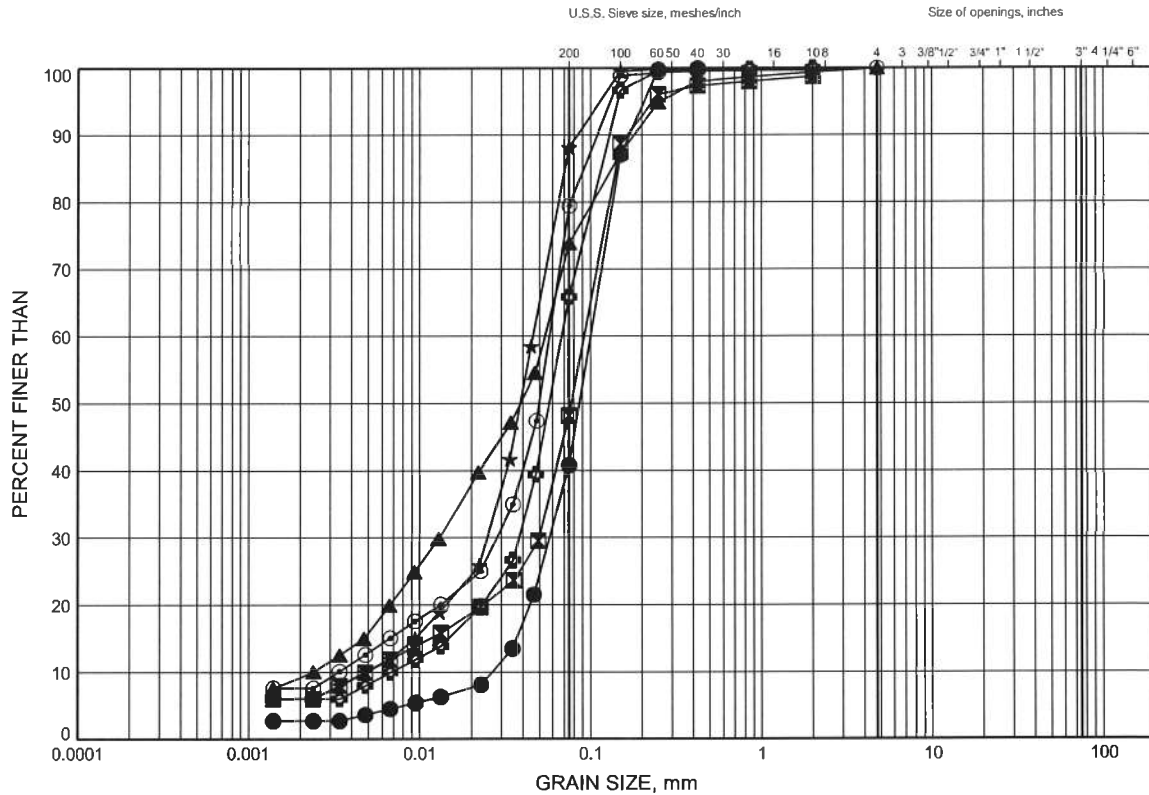
Prep'd MFA

Chkd. SKP

# GRAIN SIZE DISTRIBUTION

FIGURE B8

## SAND & SILT to SANDY SILT TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-02	10.78	220.54
⊠	11T-05	6.40	229.04
▲	11T-05	10.97	224.47
★	11T-06	7.92	233.59
⊙	11T-07	9.35	240.05
⊕	11T-10	4.88	244.12

Date May 2012

W.P.# 2539-04-00



Prep'd MFA

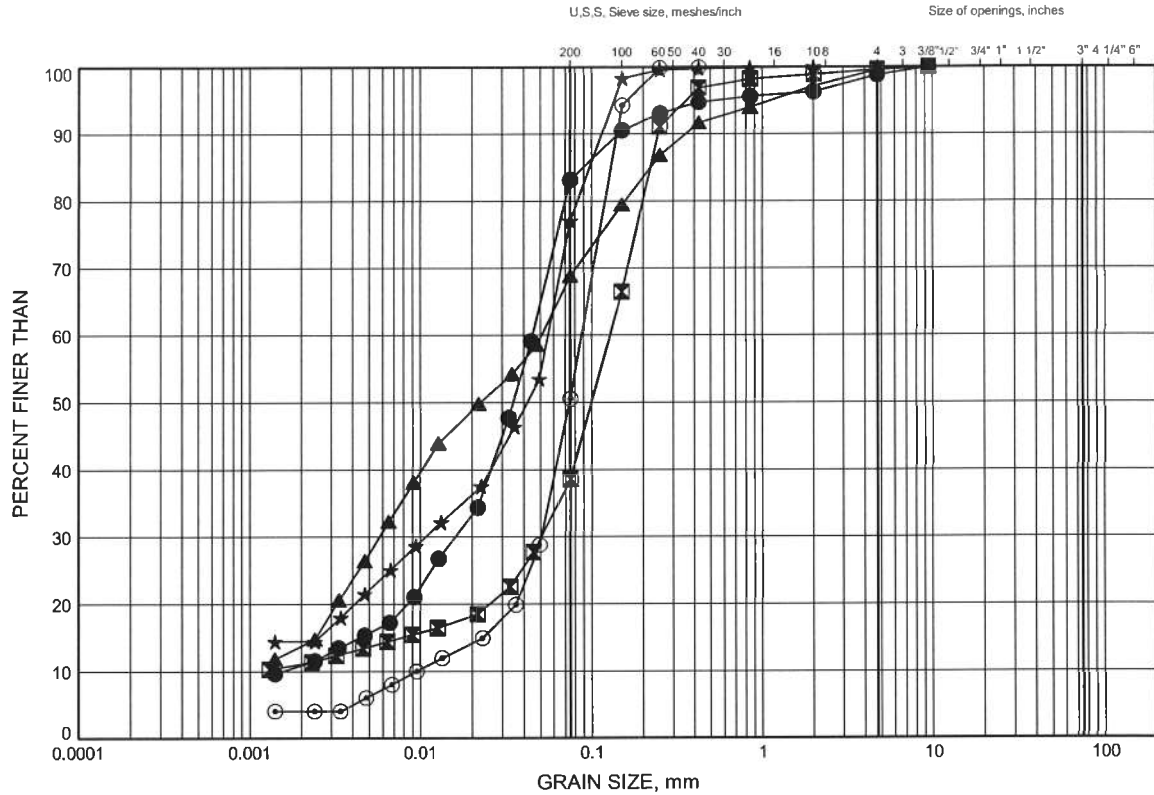
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road

## GRAIN SIZE DISTRIBUTION

FIGURE B9

### SAND & SILT to SANDY SILT TILL



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-10	10.97	238.02
⊠	11T-13	8.15	255.17
▲	11T-16	9.45	228.46
★	11T-17	9.45	237.96
⊙	11T-18	10.97	236.52

Date May 2012  
W.P.# 2539-04-00

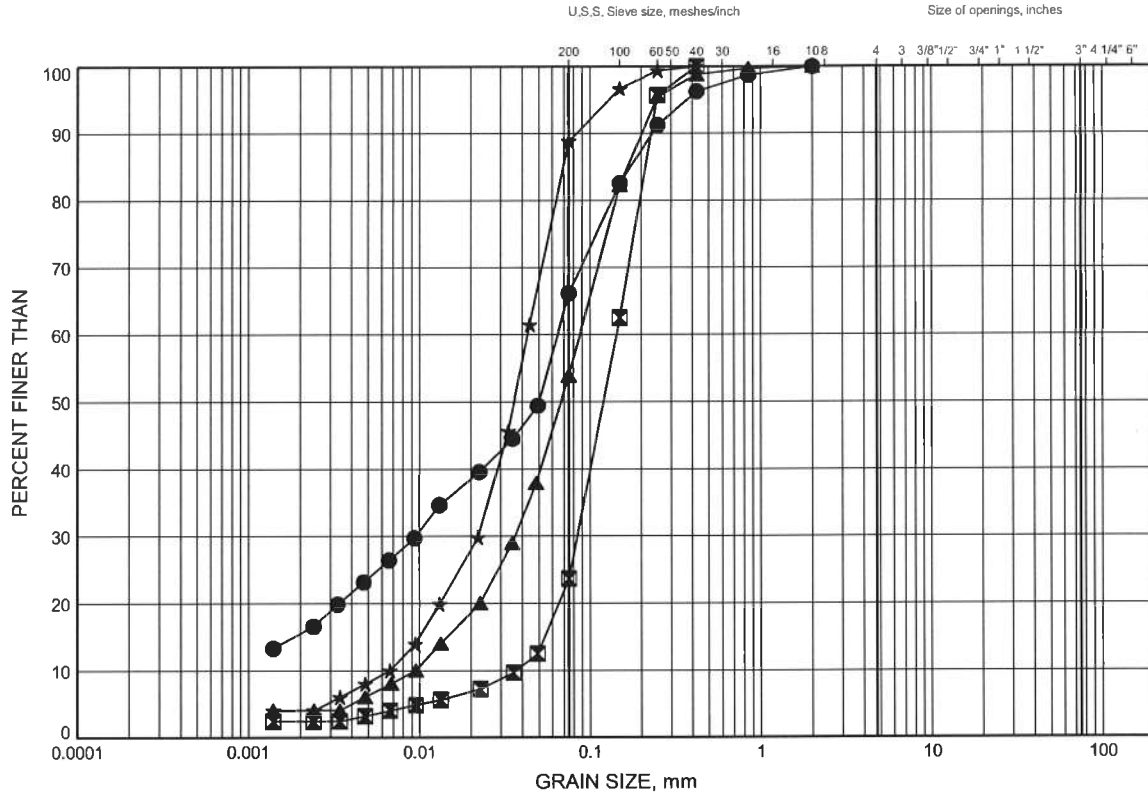


Prep'd MFA  
Chkd. SKP

# GRAIN SIZE DISTRIBUTION

FIGURE B10

## SANDY SILT to SAND & SILT



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-05	1.83	233.61
⊠	11T-14	9.45	258.25
▲	11T-15	2.59	230.01
★	11T-15	4.88	227.72

Date May 2012  
W.P.# 2539-04-00



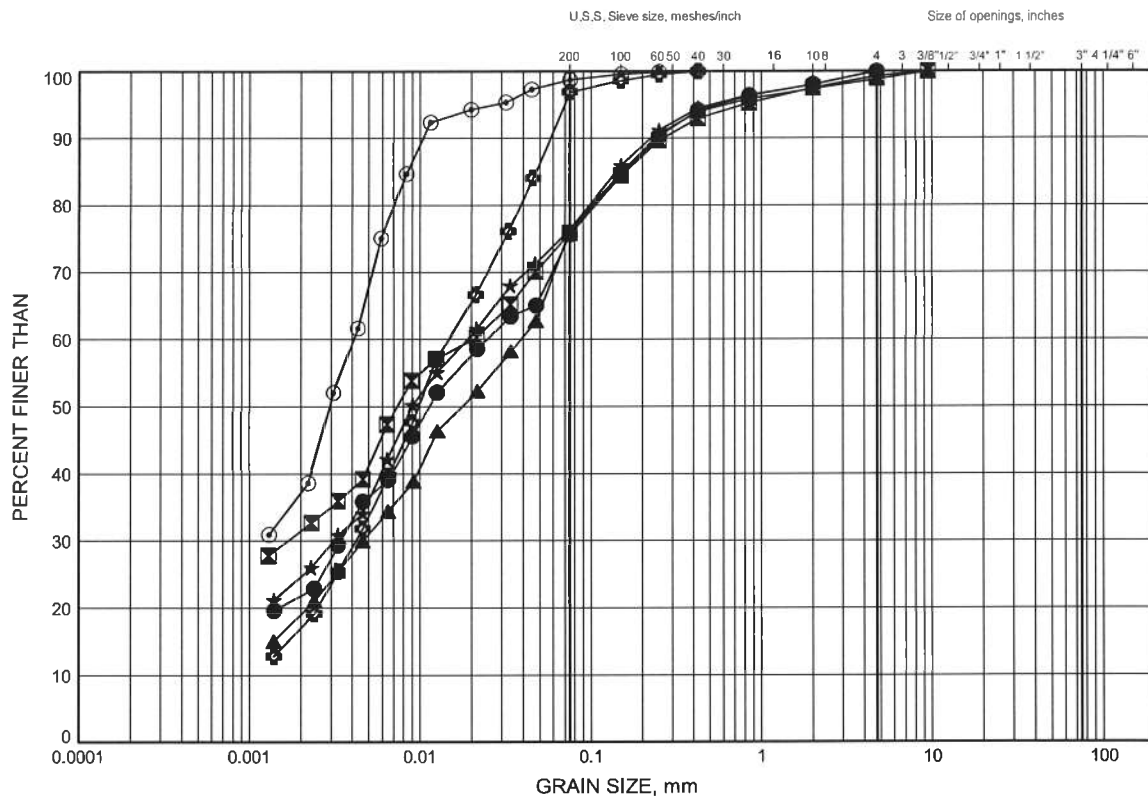
Prep'd MFA  
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road

## GRAIN SIZE DISTRIBUTION

FIGURE B11

### SILTY CLAY to CLAYEY SILT



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-05	3.43	232.01
⊠	11T-14	1.83	265.87
▲	11T-14	3.35	264.34
★	11T-14	6.40	261.30
⊙	11T-15	7.92	224.67
⊕	11T-16	6.40	231.51

Date May 2012  
W.P.# 2539-04-00



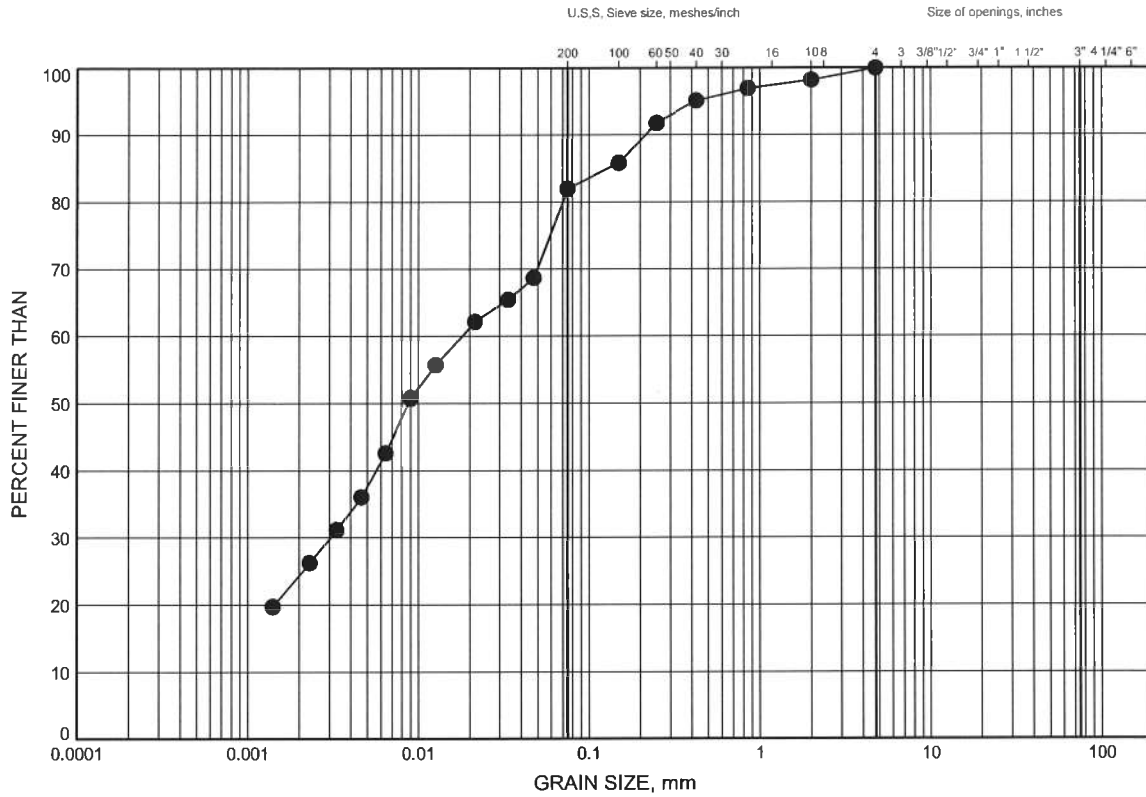
Prep'd MFA  
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road

## GRAIN SIZE DISTRIBUTION

FIGURE B12

### SILTY CLAY to CLAYEY SILT



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-18	1.07	246.43

Date May 2012  
W.P.# 2539-04-00



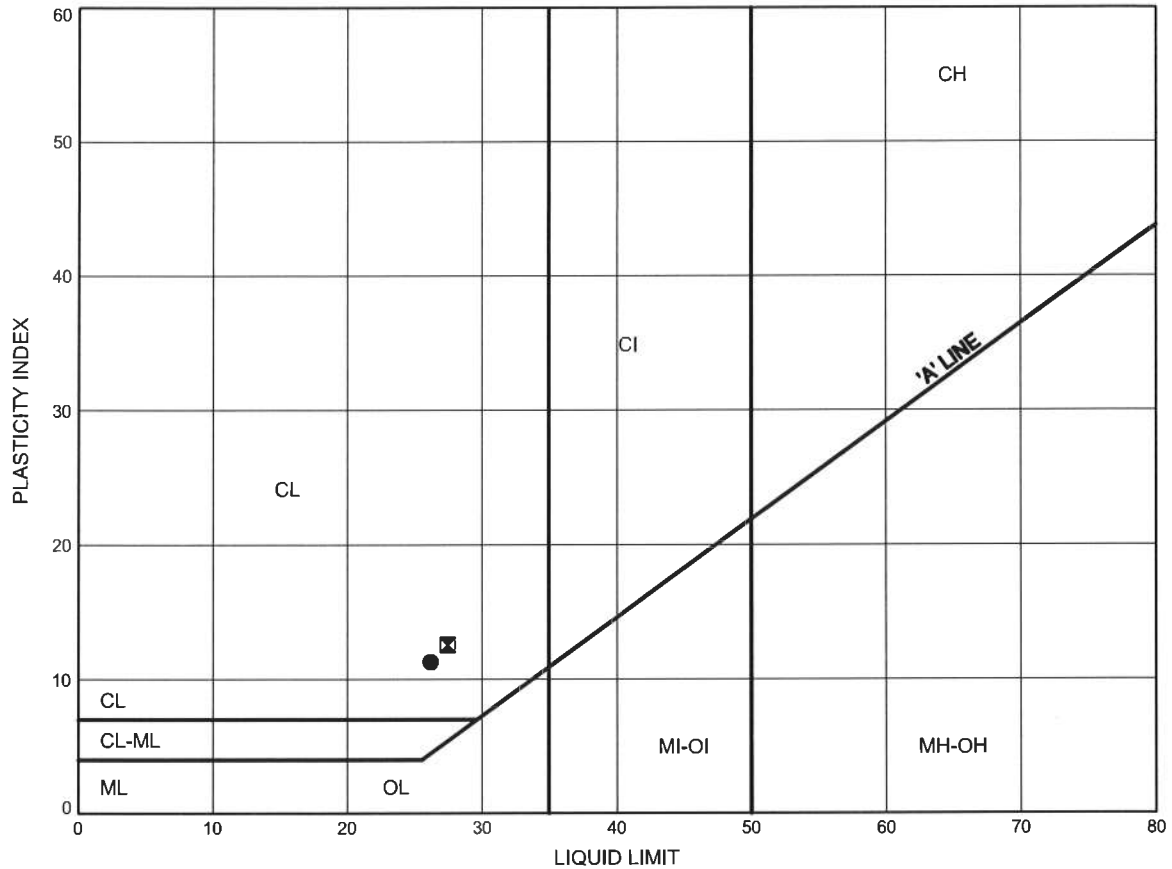
Prep'd MFA  
Chkd. SKP



Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B13

**CLAYEY SILT FILL**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-09	4.88	246.32
⊠	11T-16	3.35	234.56

THURBALT 9268.GPJ 5/10/12

Date May 2012  
W.P.# 2539-04-00

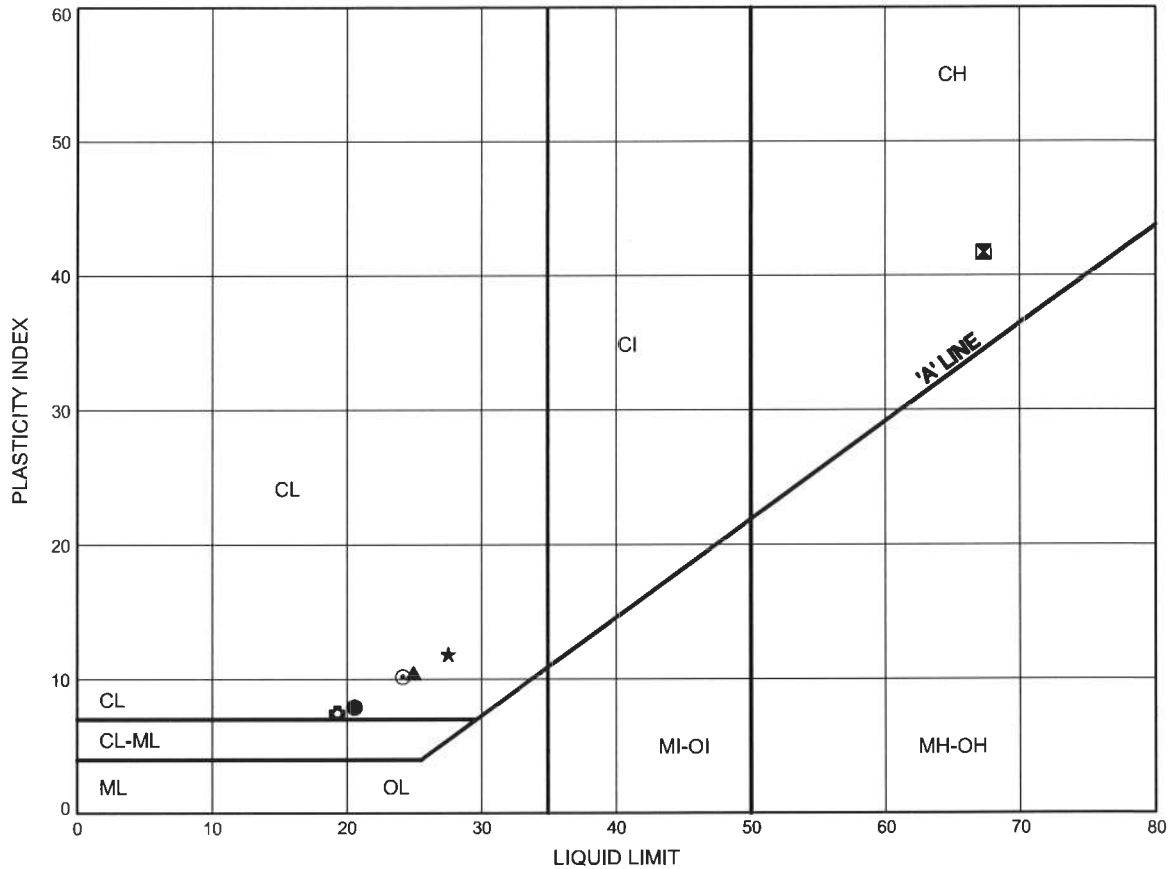


Prep'd MFA  
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B14

**CLAYEY SILT/SILTY CLAY TILL**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-01	3.35	227.66
⊠	11T-02	2.59	228.73
▲	11T-02	6.40	224.92
★	11T-06	1.83	239.68
⊙	11T-07	6.40	243.00
⊕	11T-09	10.97	240.22

Date May 2012  
W.P.# 2539-04-00

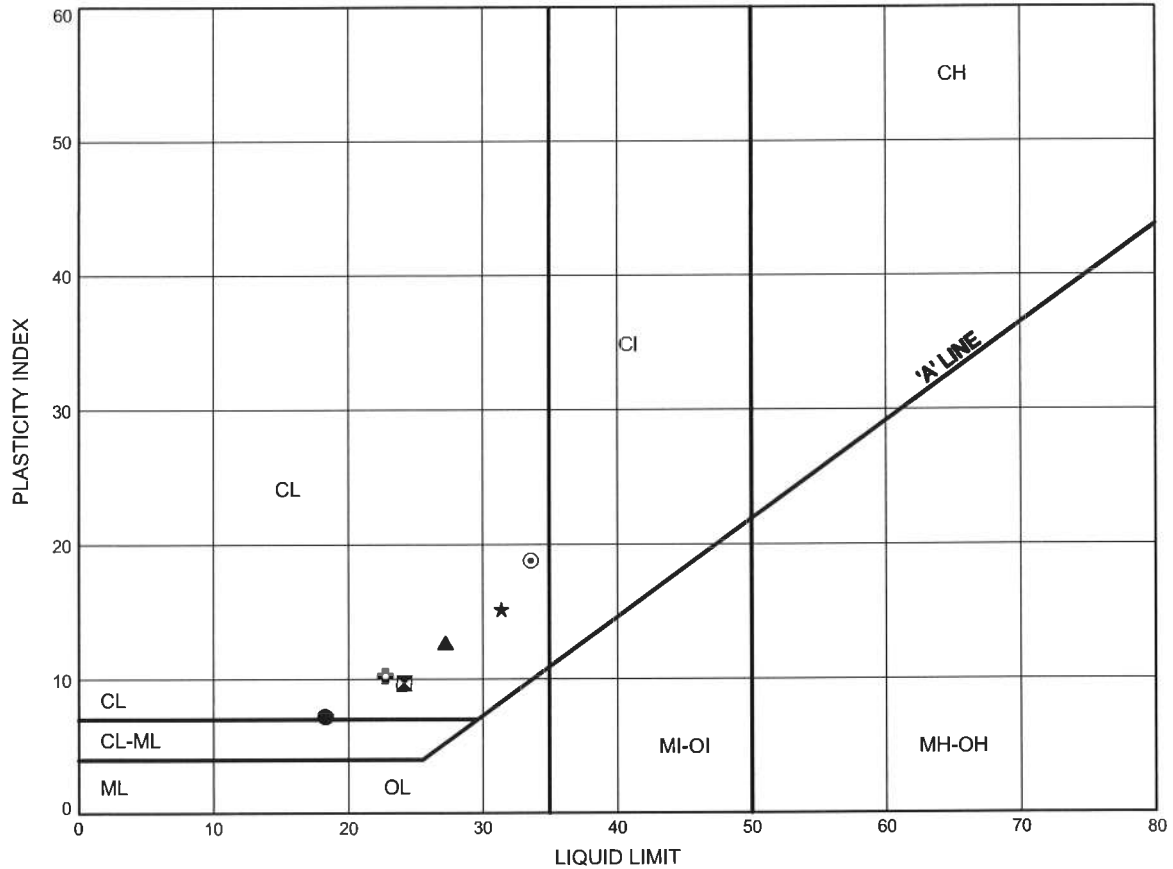


Prep'd MFA  
Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B15

**CLAYEY SILT/SILTY CLAY TILL**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-10	7.92	241.07
⊠	11T-11	1.83	270.57
▲	11T-11	4.88	267.52
★	11T-11	7.92	264.47
⊙	11T-11	10.97	261.42
⊕	11T-12	3.35	270.78

Date May 2012

W.P.# 2539-04-00



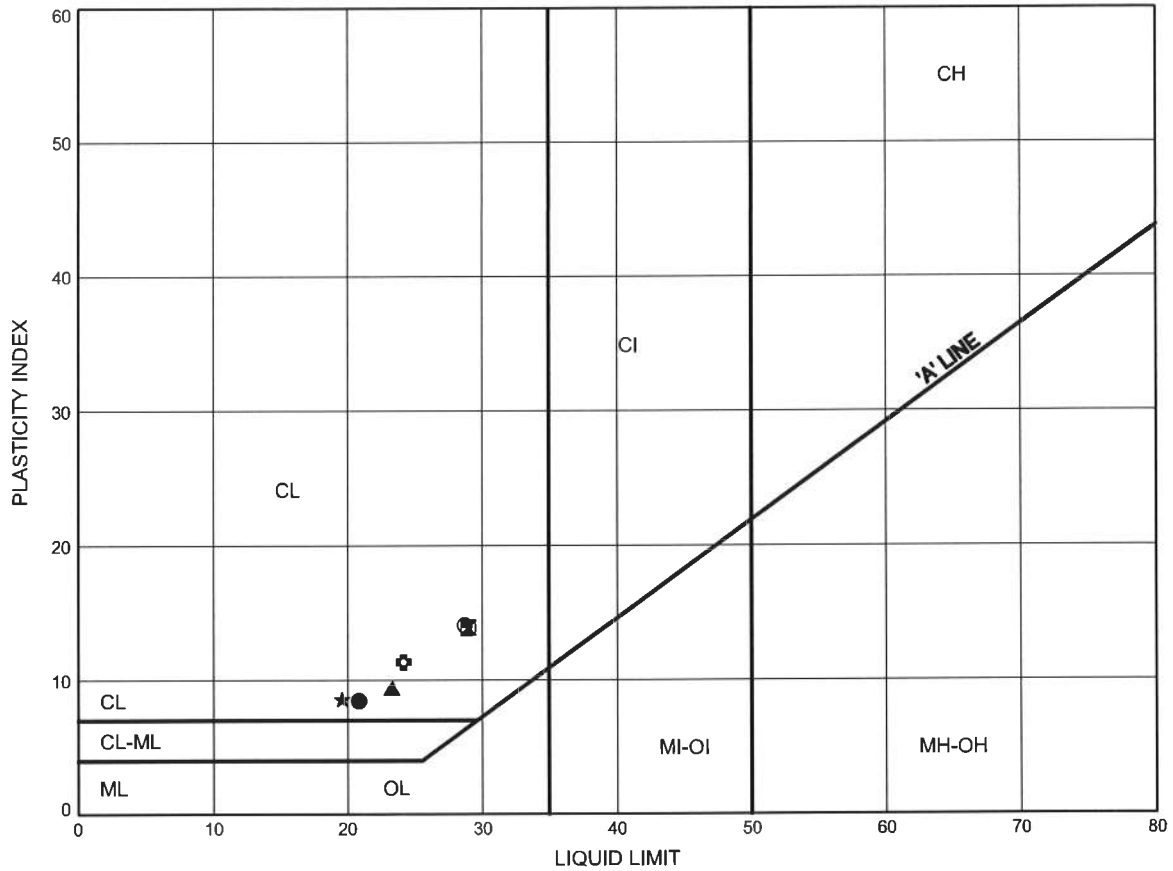
Prep'd MFA

Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B16

**CLAYEY SILT/SILTY CLAY TILL**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-12	6.40	267.73
⊠	11T-12	9.45	264.68
▲	11T-17	4.11	243.30
★	11T-17	6.40	241.01
⊙	11T-18	4.88	242.62
⊕	11T-18	7.92	239.57

Date May 2012

W.P.# 2539-04-00



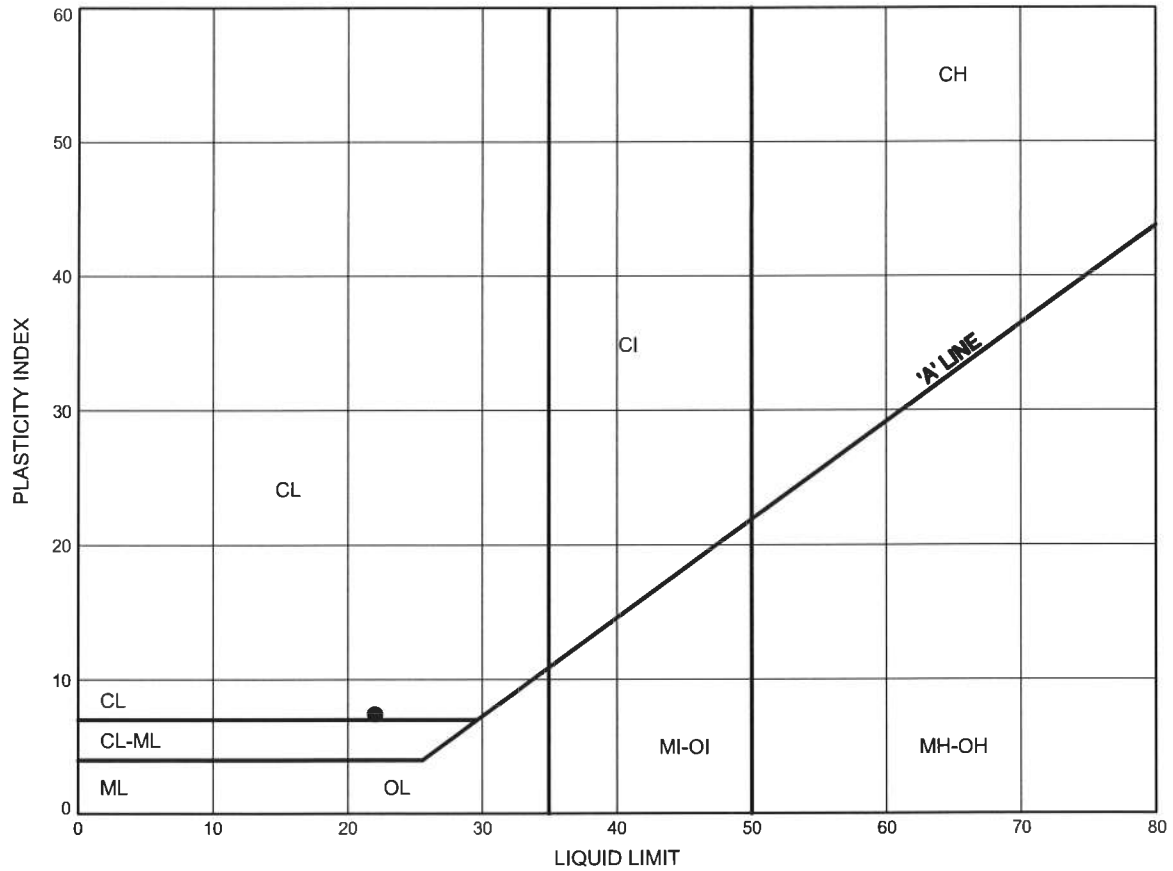
Prep'd MFA

Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B17

**SANDY SILT, Some Clay**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-05	1.83	233.61

Date May 2012

W.P.# 2539-04-00



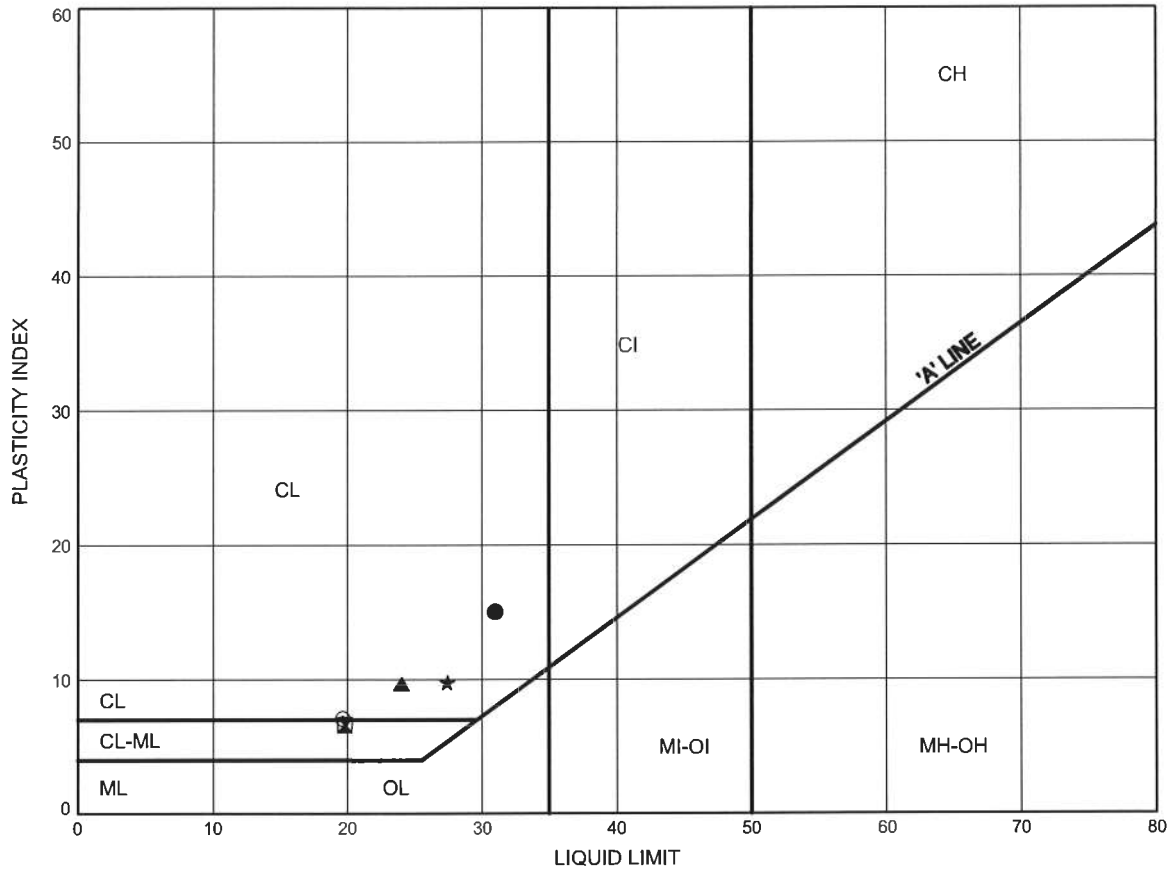
Prep'd MFA

Chkd. SKP

Widening of Hwy 400, Major Mackenzie to King Road  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B18

**SILTY CLAY to CLAYEY SILT**



**LEGEND**

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	11T-13	1.75	261.57
⊠	11T-14	3.35	264.34
▲	11T-14	6.40	261.30
★	11T-15	7.92	224.67
⊙	11T-16	6.40	231.51

Date May 2012

W.P.# 2539-04-00

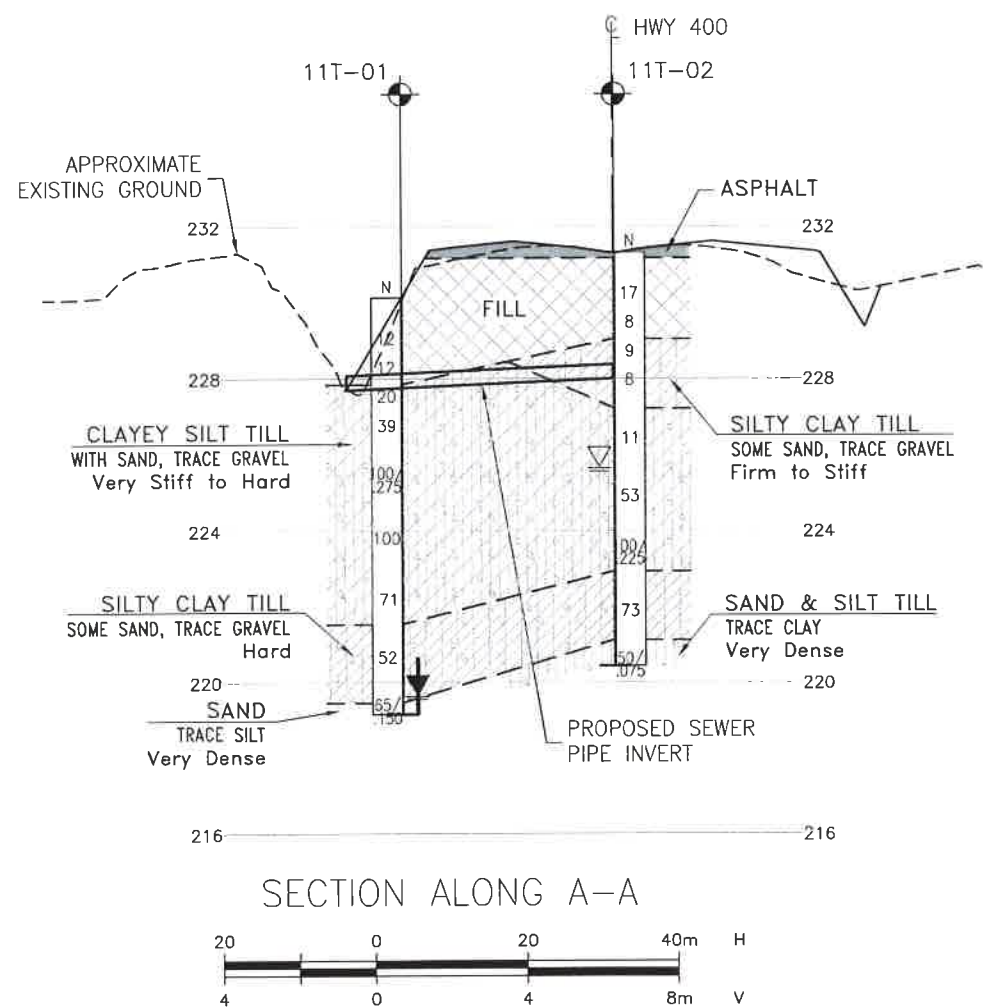
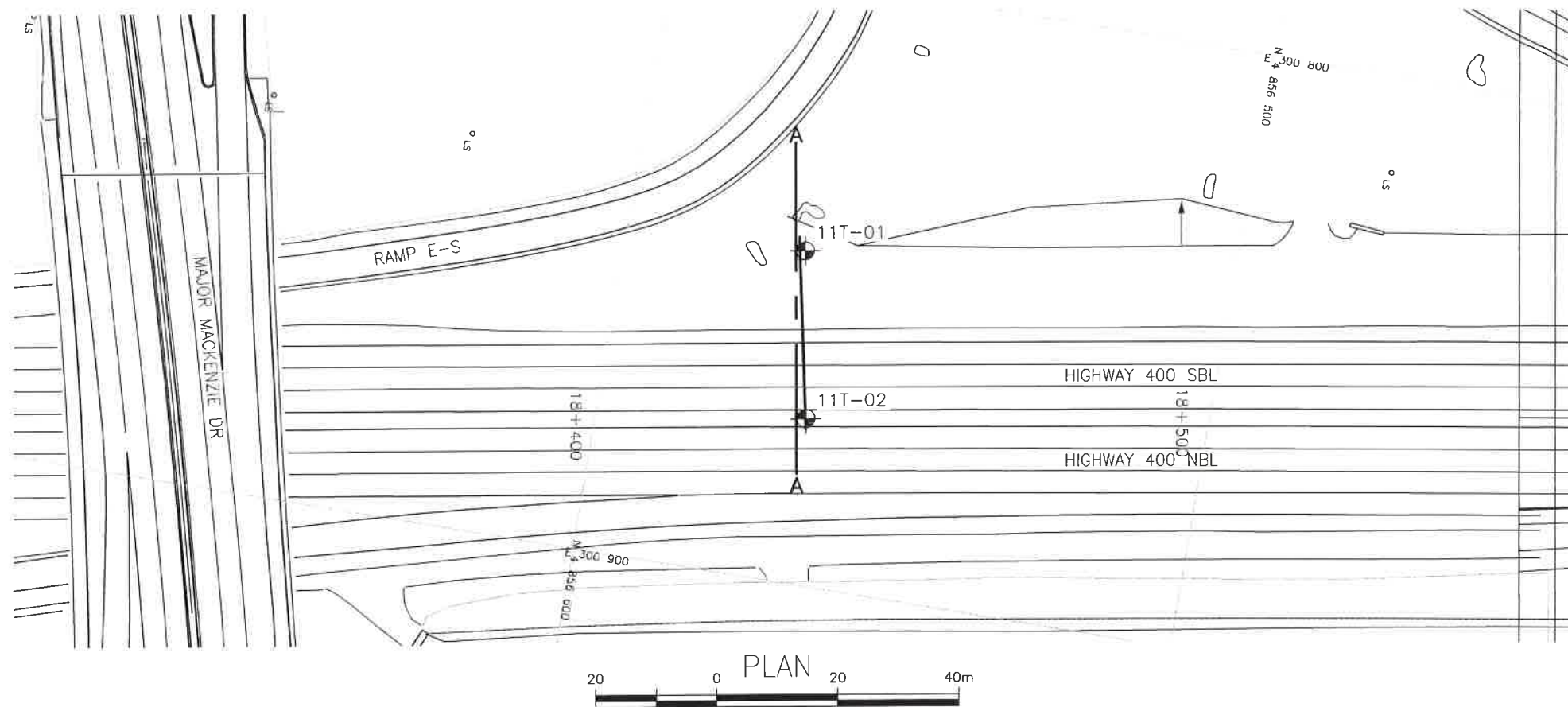


Prep'd MFA

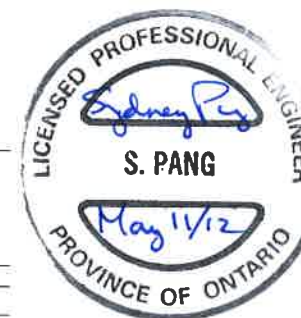
Chkd. SKP

## **Appendix C**

### **Borehole Locations and Soil Strata Drawings**



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

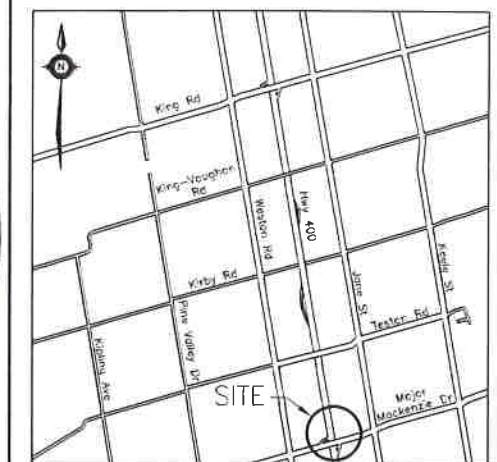


GWP No 192-00-00  
& 2539-04-00

SEWER PIPE  
CROSSINGS  
BOREHOLE LOCATIONS AND SOIL STRATA

**SNC-LAVALIN**

**THURBER ENGINEERING LTD.**



**KEYPLAN**

**LEGEND**

◆	Borehole (Previous Investigation)
◆	Borehole (Current 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
11T-01	230.1	4 856 429.7	300 844.9
11T-02	231.3	4 856 434.4	300 872.5

**NOTES-**

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

**GEOCREs No. 30M13-196**

DATE	BY	DESCRIPTION
DESIGN	LPG	CHK LPG
DRAWN	AN	CHK SKP
		SITE
		STRUCT
		DWG
		LOAD
		DATE
		MAY 2012



**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

A circular professional engineer seal for the Province of Ontario. The outer ring contains the text "LICENSED PROFESSIONAL ENGINEER" at the top and "PROVINCE OF ONTARIO" at the bottom. In the center, the name "P. K. CHATTERJI" is printed. Handwritten in blue ink over the seal are the signature "P. K. Chatterji" and the date "May 11/12".

GWP No 192-00-00  
& 2539-04-00

# SEWER PIPE CROSSINGS

## BOREHOLE LOCATIONS AND SOIL STRATA







**SNC-LAVALIN**



**THURBER** ENGINEERING LTD.



	Borehole (Previous Investigation)
	Borehole (Current 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

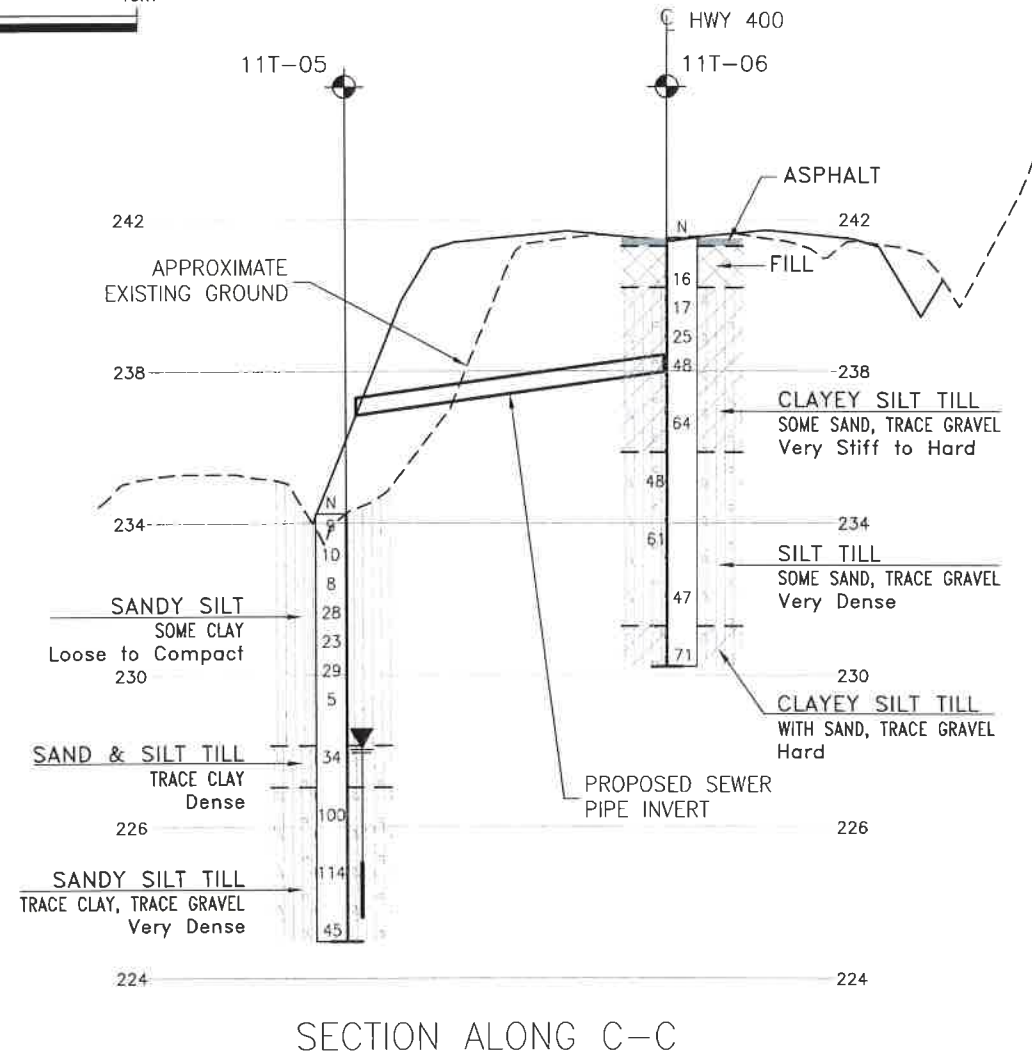
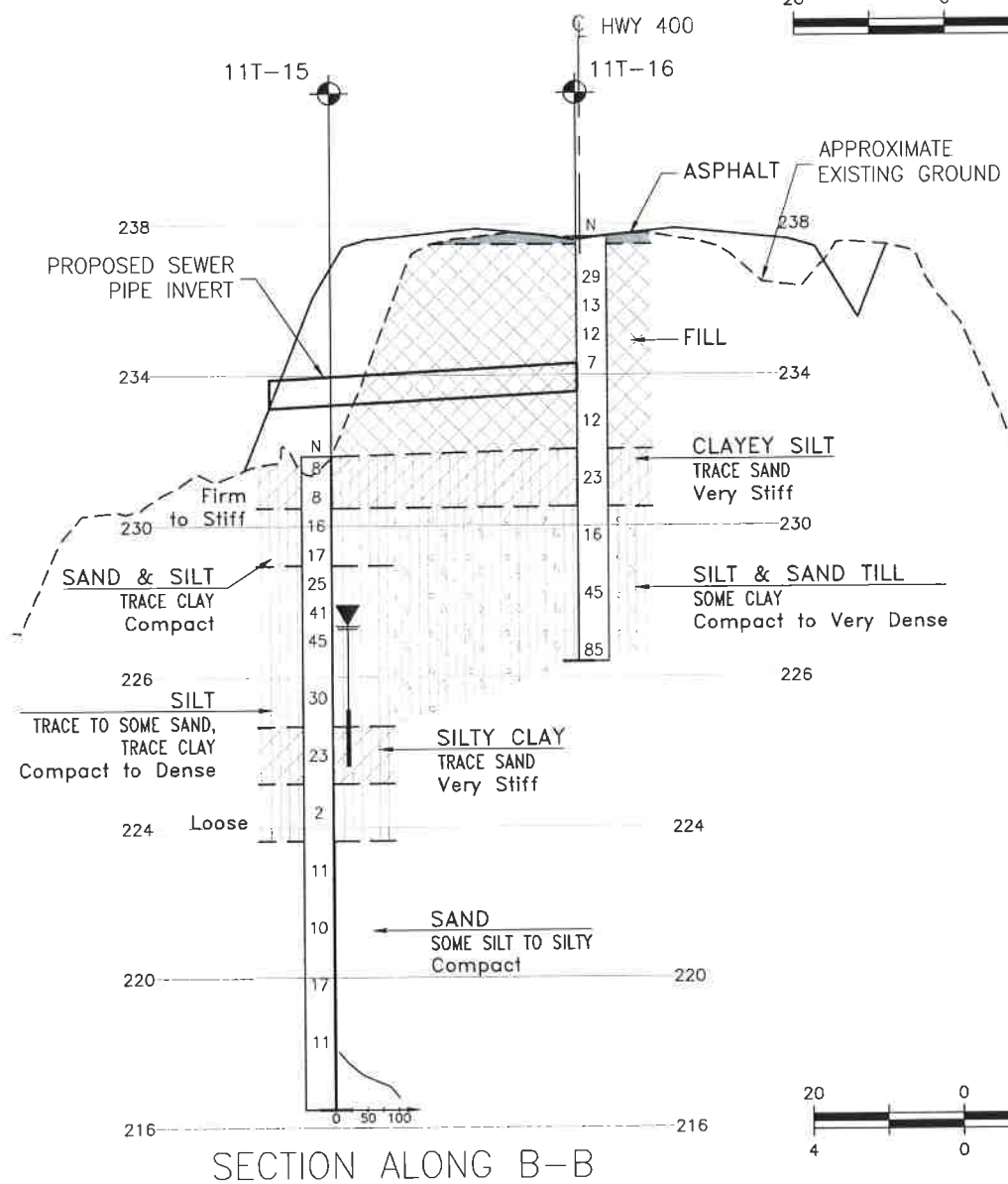
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11T-05	234.2	4 858 839.3	300 418.3
11T-06	241.5	4 858 846.4	300 460.0
11T-15	231.8	4 858 654.4	300 459.2
11T-16	237.7	4 858 659.8	300 491.4

**-NOTES-**

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
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GEOCRES No. 30M13-196

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	LPG	CHK	LPG	CODE	LOAD	DATE	MAY 2012		
DRAWN	AN	CHK	SKP	SITE	STRUCT	DWG			





METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

GWP No 192-00-00  
& 2539-04-00

## SEWER PIPE CROSSINGS

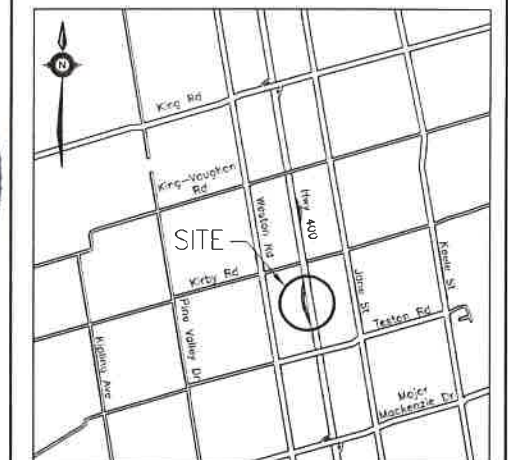
### BOREHOLE LOCATIONS AND SOIL STRATA








**SNC-LAVALIN**



**THURBER** ENGINEERING LTD.



KEYPLAN  
LEGEND

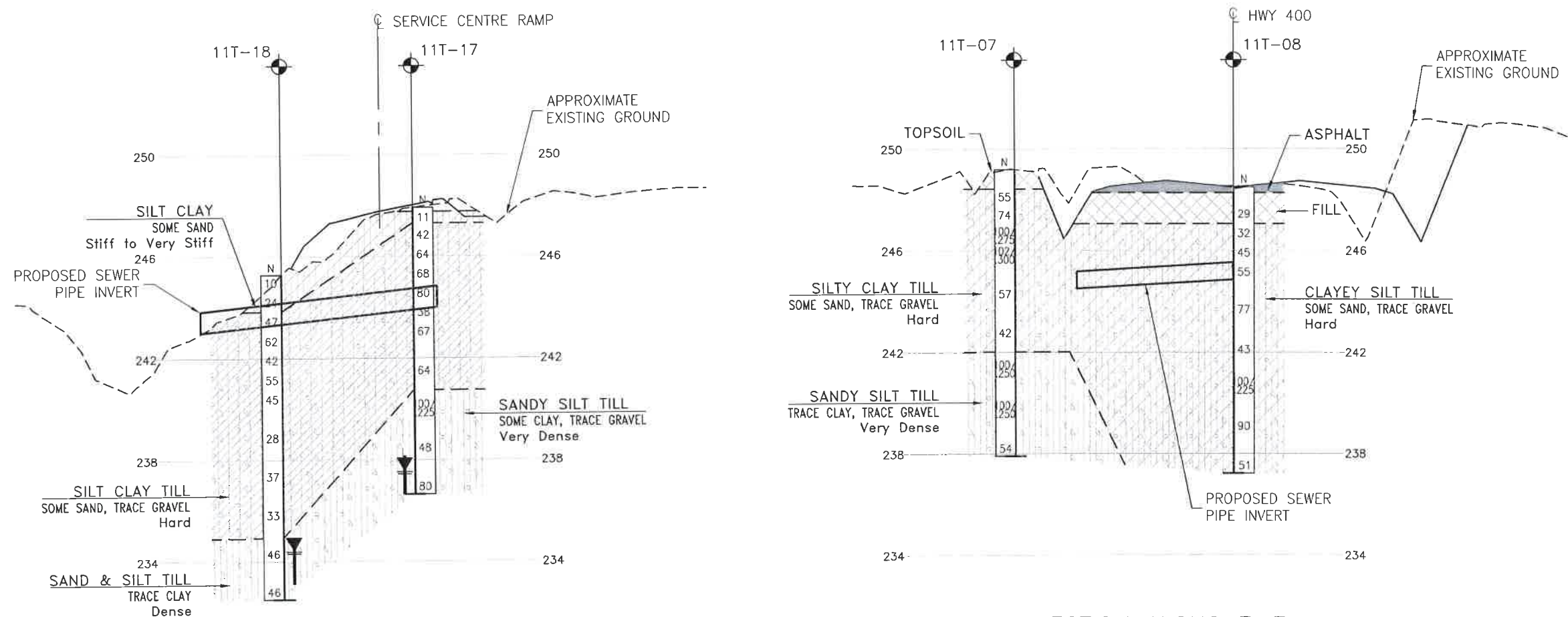
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|---|---------------------------------------|
|  | Borehole (Previous Investigation)     |
|  | Borehole (Current Investigation)      |
| N   | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)     |
| PH  | Pressure,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

NO	ELEVATION	NORTHING	EASTING
11T-07	249.2	4 859 234.4	300 350.0
11T-08	248.5	4 859 241.7	300 392.5
11T-17	247.9	4 859 197.4	300 376.1
11T-18	245.3	4 859 154.9	300 364.1

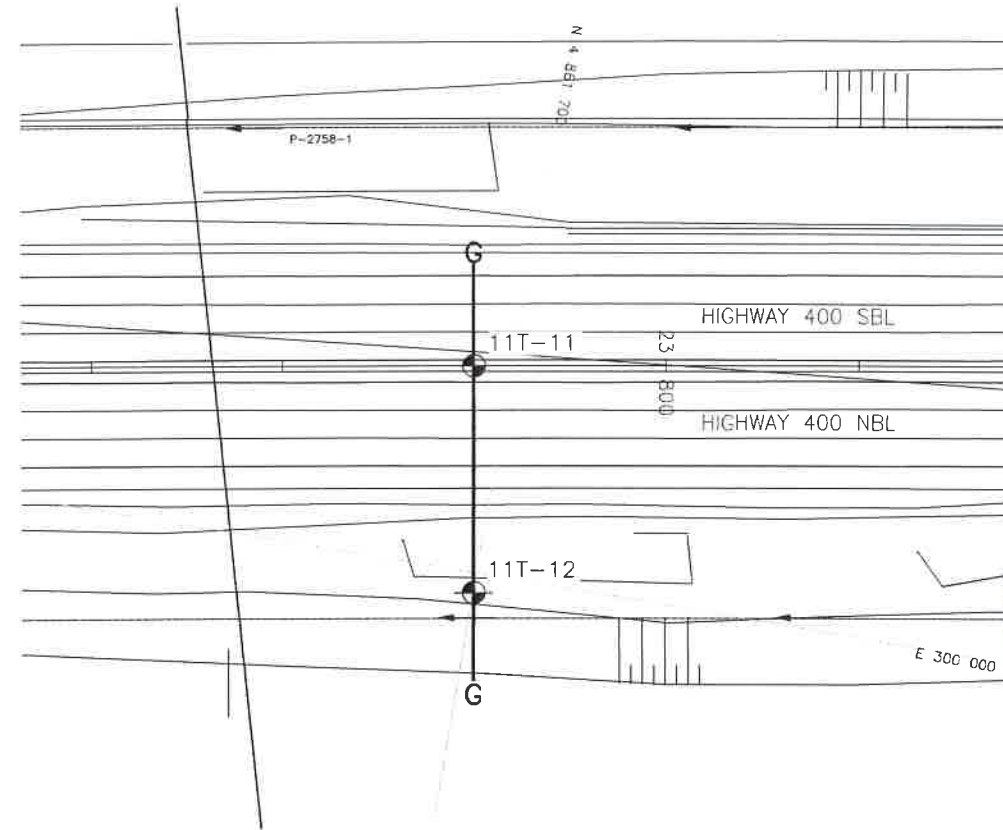
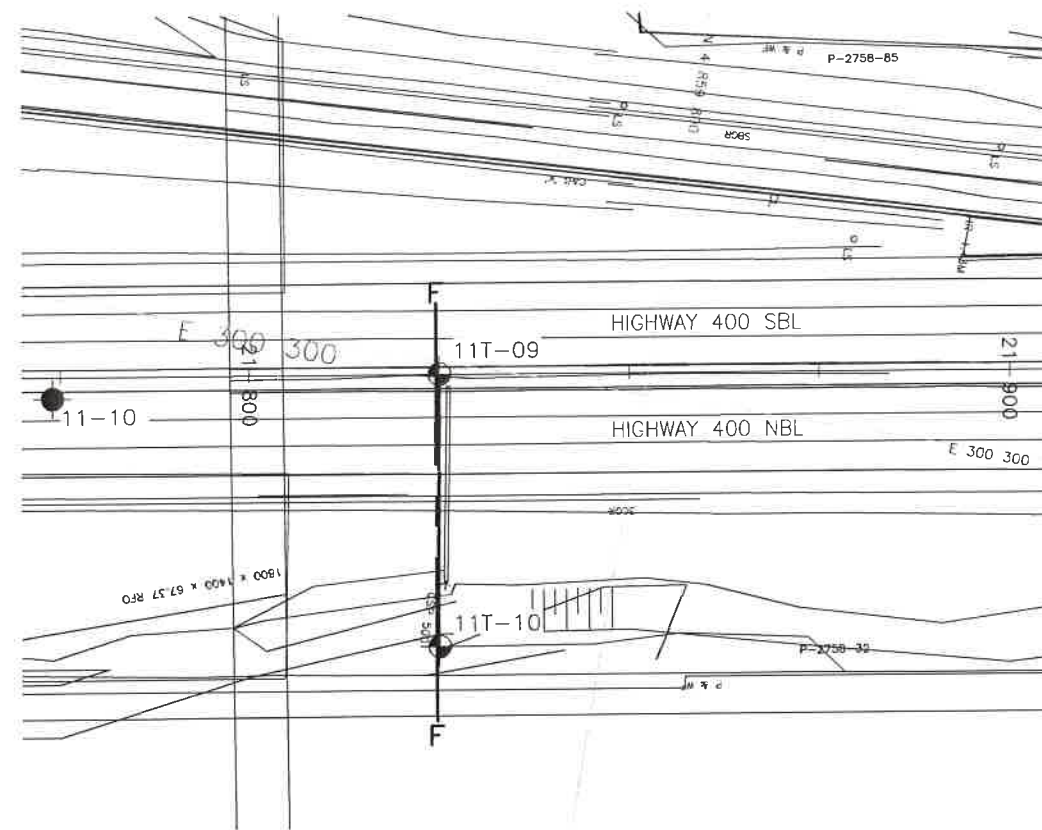
**-NOTES-**

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**GEOCRES No. 30M13-196**

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AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

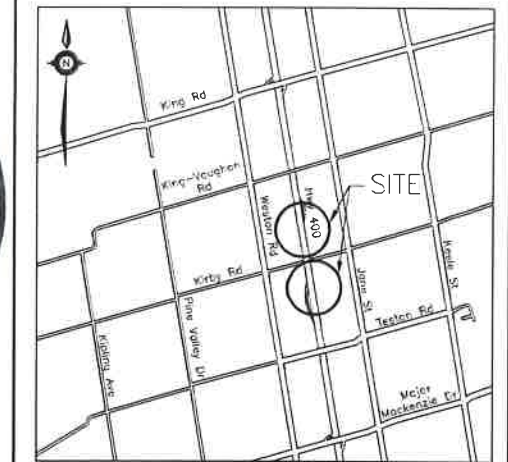


GWP No 192-00-00  
& 2539-04-00

SEWER PIPE  
CROSSINGS  
BOREHOLE LOCATIONS AND SOIL STRATA

**SNC-LAVALIN**

**THURBER ENGINEERING LTD.**



**KEYPLAN**

**LEGEND**

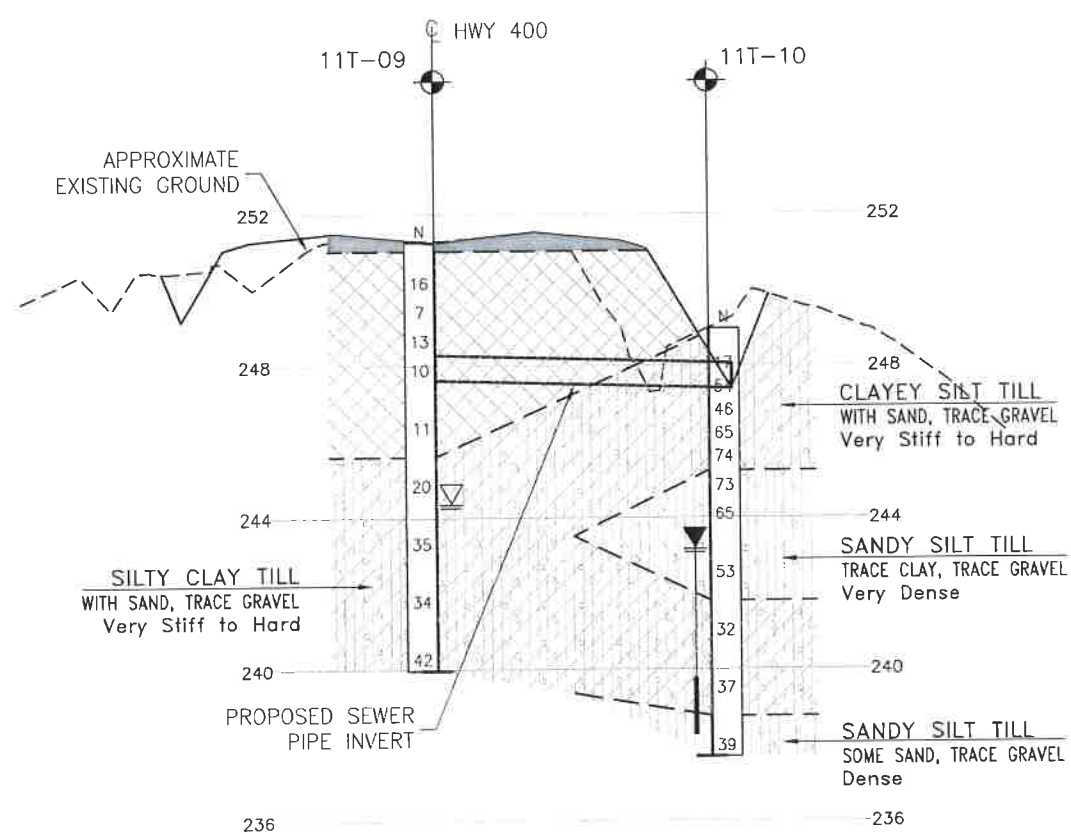
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●	Borehole (Current Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
↑	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
11T-09	251.3	4 859 773.0	300 301.6
11T-10	248.9	4 859 779.0	300 337.1
11T-11	272.5	4 861 695.1	299 973.0
11T-12	274.1	4 861 700.1	300 002.6

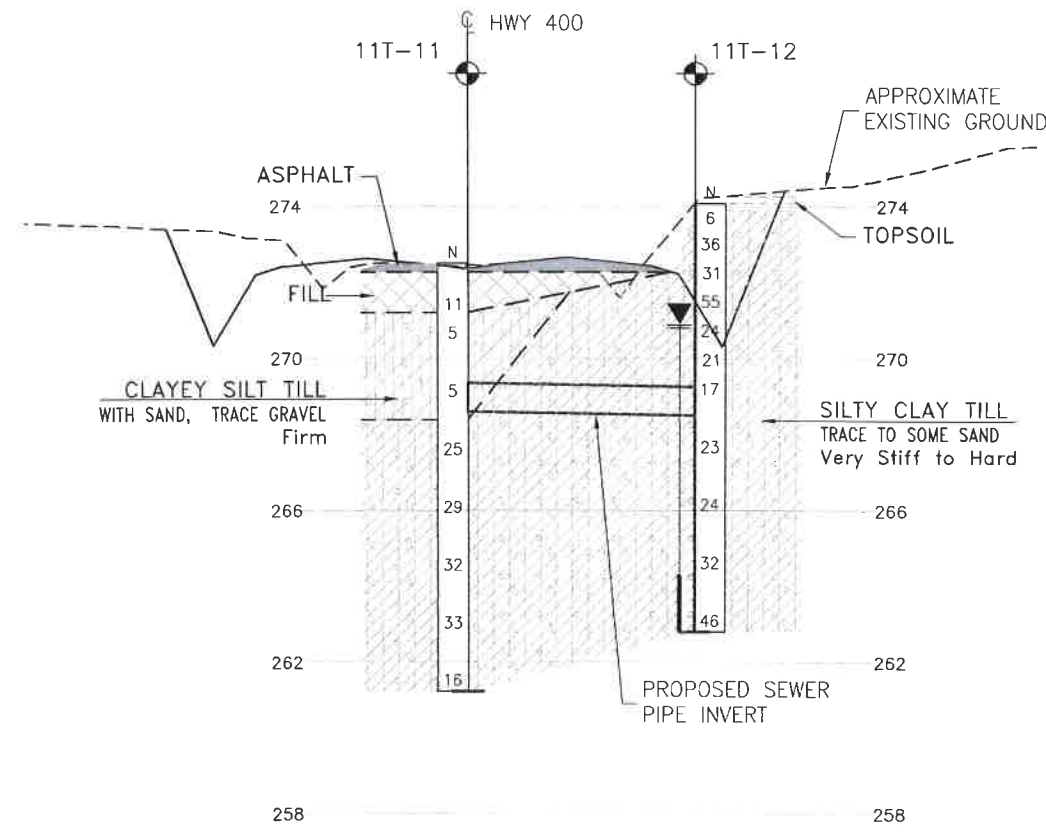
**-NOTES-**

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**GEOCREs No. 30M13-196**



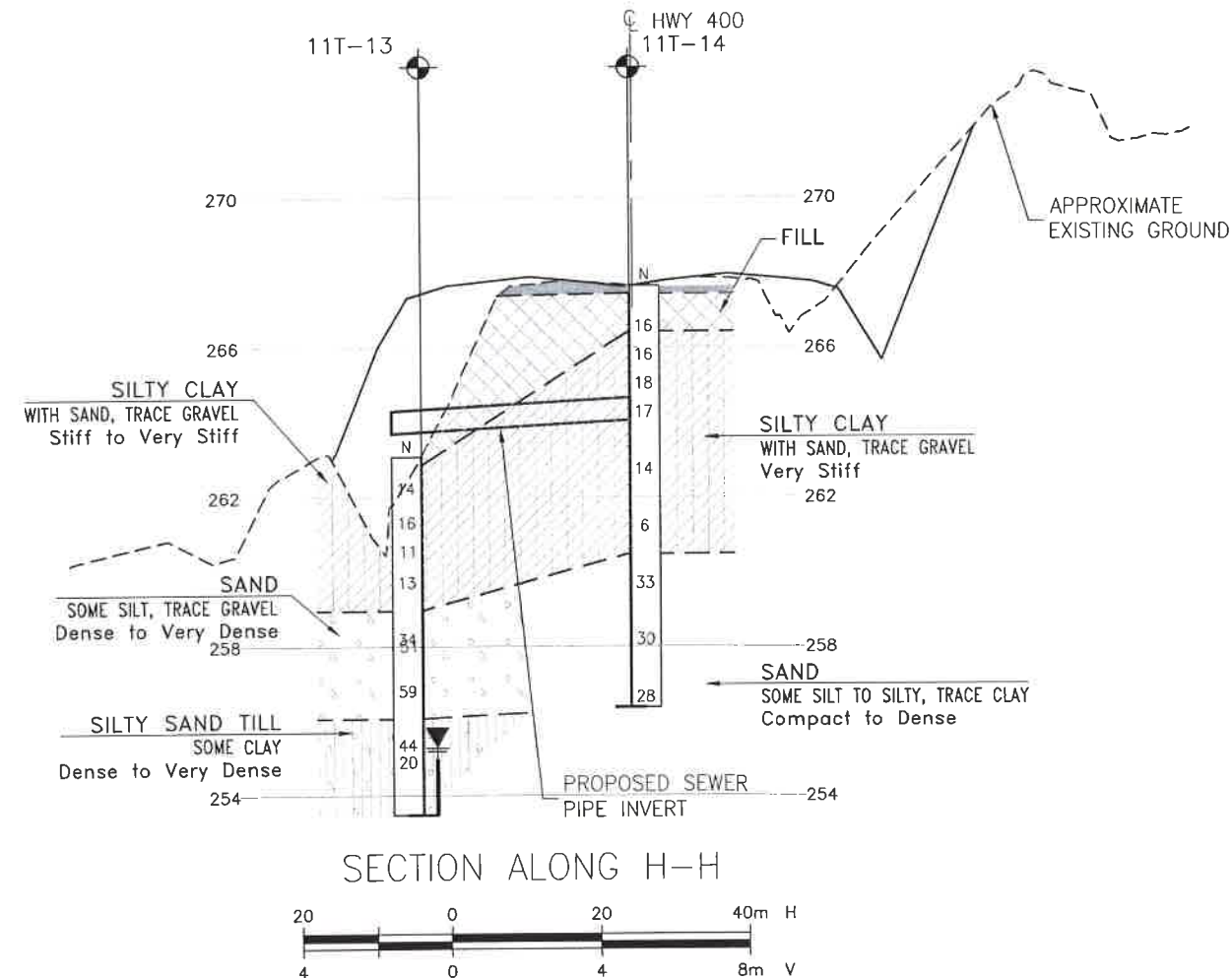
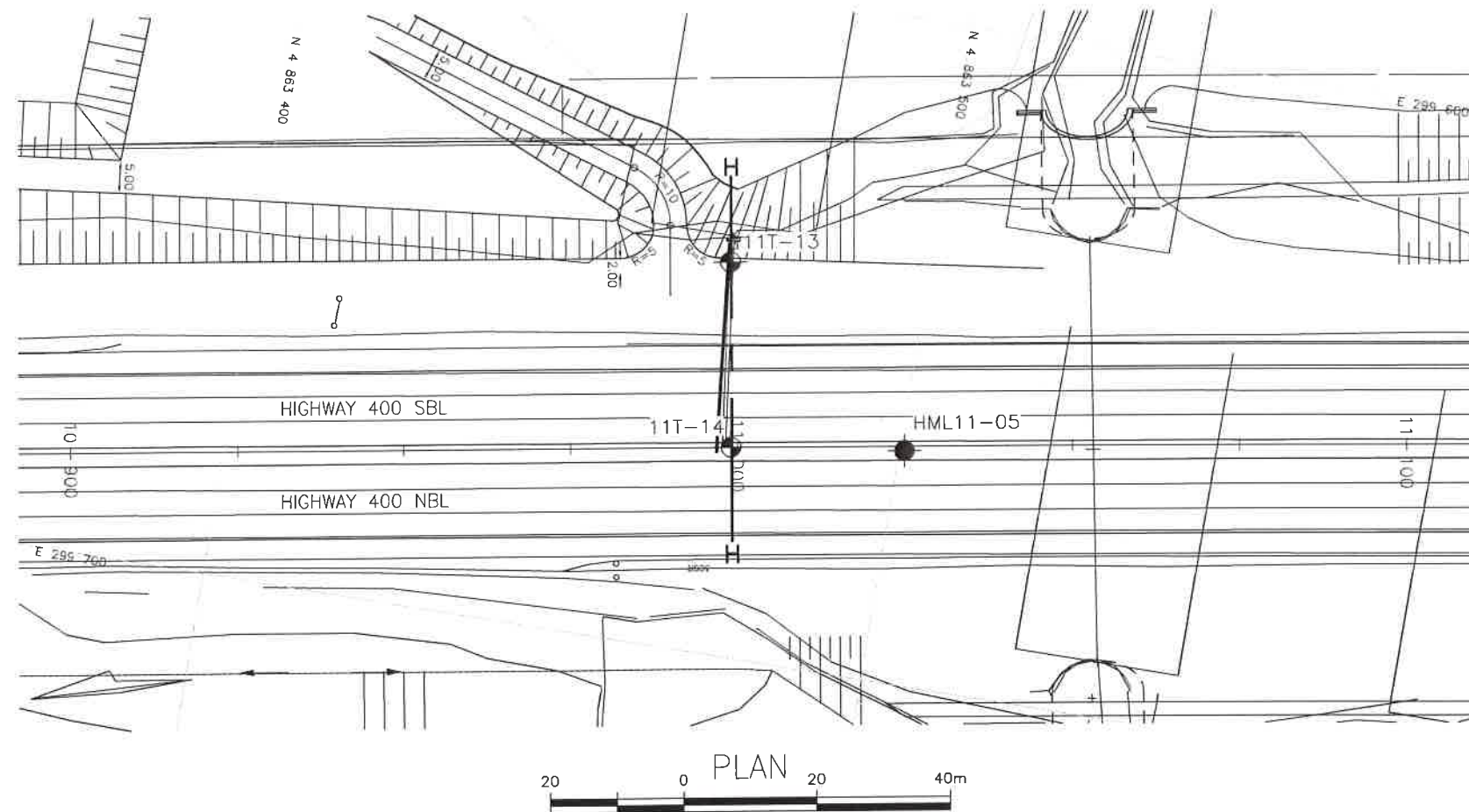
SECTION ALONG F-F



SECTION ALONG G-G



DATE	BY	DESCRIPTION
DESIGN	LPG	CHK LPG
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		SITE
		STRUCT
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DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



GWP No 192-00-00 & 2539-04-00
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# SEWER PIPE CROSSINGS

## BOREHOLE LOCATIONS AND SOIL STRATA



**SNC-LAVALIN**








**THURBER** ENGINEERING LTD.



## KEYPLAN

### LEGEND

	Borehole (Previous Investigation)
	Borehole (Current 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
11T-13	263.1	4 863 470.4	299 641.0
11T-14	267.6	4 863 475.1	299 668.6

-NOTES-

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**GEOCRES No. 30M13-196**

REVISIONS									
	DATE	BY	DESCRIPTION						
DESIGN	LPG	CHK	LPG	CODE	LOAD	DATE MAY 2012			
DRAWN	AN	CHK	SKP	SITE	STRUCT	DWG			

**Appendix D**  
**List of Special Provisions**  
**and**  
**Suggested Text for NSSP**



## **1. List of Special Provisions Referenced in this Report**

- OPSS 539

## **2. Suggested Text for NSSP on Trenchless Installation.**

The Contractor's attention is drawn to the following:

- The fill materials and glacial till deposits may contain cobbles and boulders.
- The majority of the pipe installation will be carried out through cohesive fill and glacial till. The Contractor's equipment must be able to advance the pipes through these cohesive deposits. For the jack and bore technique, this should be accomplished without choking up the augers.
- For the jack and bore technique, a maximum distance of 600 mm should be maintained between the boring face and the pipe during installation to minimize the potential for sloughing or caving of any embedded cohesionless or otherwise loose soils. Pipe installation should be continuous and no gaps should be left between the boring face and the pipe during work stoppages, e.g. overnight and weekends.
- At locations where the pipe crossings are to be installed through highway embankment fill, loss of ground due to sloughing or caving may occur in the borings. In these areas, installation method selection should be based on minimizing the risks of caving and loss of ground. If jack and bore is used, the pipe should be advanced closely behind the boring face.

## PIPE INSTALLATION BY TRENCHLESS METHOD – Item No.

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Non Standard Special Provision

January 2012

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### 1. SCOPE

This specification covers the general requirements for the installation of pipes by trenchless methods.

The Contractor shall determine the most appropriate method of installation. Specifications for Jack and Bore, Pipe Ramming, Directional Drilling, and Tunnelling are provided herein, and shall be applied to the installation method considered feasible by the Contractor.

OPSS 415 (Construction Specification for Pipeline and Utility Installation by Tunnelling), OPSS 416 (Construction Specification for Pipeline and Utility Installation by Jacking and Boring) and OPSS 450 (Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling) shall not be used to do the work for the above tender item.

### 2. REFERENCES

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

Foundation Investigation Report, Proposed Sewer Pipe Crossings, Highway 400 Widening, Major MacKenzie Drive to King Road, York Region, Ontario, G.W.P. 192-00-00 and 2539-04-00, by Thurber Engineering Ltd., Reference No. 19-92-68.

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

OPSS 180 Management and Disposal of Excess Material

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

OPSS 504 Preservation, Protection, and Reconstruction of Existing Facilities  
OPSS 507 Site Restoration Following Installation of Pipelines, Utilities and Associated Structures in Open Cut  
OPSS 514 Trenching, Backfilling, and Compaction  
OPSS 517 Dewatering of Pipeline, Utility, and Associated Structure Excavation  
OPSS 538 Support Systems  
OPSS 539 Protection Schemes

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

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

#### **MTO Specifications**

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

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

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

**Canadian Standards Association Standards:**

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

**3. DEFINITIONS**

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

**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.

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

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

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

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

**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.

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

## **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.

### **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 (1) 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; and
- Design assumption and material data when materials other than those specified are proposed for use.
- Drill path design, details of alignment and alignment control, maximum curvature and reaming stages;

c) Materials:

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

d) Upstream/Downstream Portal Installation Procedure:

- The access shaft or entry/exit pit details designed and stamped/signed by the Design Engineer, as applicable; and
- Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

- Excavation and pipe jacking procedures, including methodology to handle obstructions and preventing soil cave-in; and
- Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

- Ground control/dewatering details, as applicable, describing the proposed method for control, handling, treatment, and disposal of water.

g) 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, layout 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 excavation  
Jacking/Ramming/Directional Drilling of Casing/Liner  
Excavation and Dewatering  
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 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 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 1004 wetted with only sufficient water to make the mixture plastic.

### **5.06 Jack and Bore Materials**

#### **5.06.01 Pipe Materials**

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

Concrete pipe as per OPSS 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. A minimum wall thickness of 50 mm and minimum yield strength of 240 MPa is required.

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.

Joining 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 joining process.

Joining 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 to provide support and stability to the excavation.

### **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 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.

Joining 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 joining process.

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

## **6. EQUIPMENT**

### **6.01 Jack & Bore Equipment**

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 explosives or rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.

## **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 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 Shafts**

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 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 systems include primary liner and portal excavation support systems. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works

#### **7.01.04 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 504.

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.

#### **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 514.

#### **7.01.09 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.

#### **7.01.10 Removal of Boulders**

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor 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.

#### **7.01.11 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.

#### **7.01.12 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 median end of the pipe to the outlet end to confirm gravity flow conditions.

#### **7.01.13 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.

#### **7.01.14 Site Restoration**

Site restoration shall be according to OPSS 507.

#### **7.01.15 Supervision**

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

### **7.02 Jack and 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 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**

##### **7.04.06.01 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 2m) 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 OSHA 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  $\pm 1$  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 as shown on the Contract Drawings.

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 Subsection 4.02, 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 of sequence of construction or ground stabilization measures to mitigate further ground displacement.

If the 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 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 providing all labour, equipment and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of pipe liners, settlement monitoring and instrumentations site restoration and for all other work necessary to complete the installation as specified.

Payment for the rigid or flexible pipe conduits installed inside the pipe liners 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.

*Notes to Designer:*

*Under Section 7.01.06, minimum horizontal and vertical clearances to existing facilities shall be identified in the Contract Documents. 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. The number of exposures required to monitor work progress shall be specified in the Contract Documents.*

## **Appendix E**

### **Instrumentation and Monitoring Program**

**INSTRUMENTATION AND MONITORING PROGRAM**  
**PROPOSED SEWER CROSSINGS OF HIGHWAY 400**  
**MAJOR MACKENZIE DRIVE TO KING ROAD**

- Item No.

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Special Provision

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**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)

The instruments shall be installed along the centreline of the sewer alignments and in arrays. Each array consists of a group of instruments installed approximately perpendicular to the sewer alignments.

**1.2 Purpose**

The purpose of these instruments is to monitor settlements during installation of eight (8) proposed lateral storm water sewer pipes with diameters ranging from 300 mm to 825 mm.

The methodologies and rate of installation may need to be adjusted as a result of the instrumentation readings.

**1.3 Contractor's Scope of Work**

The Contractor shall be fully responsible to procure, install, protect, monitor, 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 the Contractor's qualified surveyors.

**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 Owner, the Ontario Ministry of Transportation (MTO), the Contract Administrator (CA), and CA's Geotechnical Consultant, 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 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 19-92-68-1 to 19-92-68-4 for instrument locations.

1.8 Subsurface Conditions

The subsurface conditions at the site are described in Thurber's Report titled "Foundation Investigation Report, Proposed Sewer Pipe Crossings, Highway 400 Widening, Major MacKenzie Drive to King Road, York Region, Ontario, G.W.P. 192-00-00 and 2539-04-00, by Thurber Engineering Ltd., Reference No. 19-92-68, dated May 2012.

**2 INSTALLATION**

2.1 General

There are eighty (**80**) surface monitoring points (SMP) and ten (**10**) settlement rods (SR) to be installed at this site as shown on Drawings 19-92-68-1 to 19-92-68-4.

SMPs will be installed along the centreline of traffic lanes and / or paved shoulders in arrays of either three (3) instruments or one (1) single instrument. SRs will be installed on the side slopes or at the toes of highway embankments along the proposed sewer centrelines.

The number of monitoring points that will be installed at each sewer crossing are shown in the table below:

Station No. (Outlet No.)	Diameter (mm)	Trenchless Length (m)	Depth of Pipe Crown Below Top of Pavement (m)	Number of Monitoring Points	
				SMP	SR
18+438 (#205)	375	35	3.0	10	1
20+688 (#39)	750	30	3.4	13	1
20+885 (#43)	450	30	3.0	13	1
21+286 (#50-51)	675	31	3.0	10	2
10+079 (ramp) (#52)	825	37	3.0	4	2
21+825 (#63)	675	38	3.0	10	1
23+775 (#91-92)	750	30	3.1	10	1
10+999 (#118-119)	600	32	3.0	10	1
			Total	80	10

Each of the arrays with three instruments will consist of the following:

- One (1) instrument installed at the proposed sewer centreline
- One (1) instrument installed at 1.5 m north of the proposed sewer centreline
- One (1) instrument installed at 1.5 m south of the proposed sewer centreline

## 2.2 Instrument Location

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

## 2.3 Survey Benchmarks

The Contractor's surveyors shall identify or establish non-yielding survey benchmarks (BM) at the site in order to carry out elevation surveying and achieve the accuracy specified below.

## 2.4 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of  $\pm 2$  millimetres or better.



**2.5     Materials and Equipment**

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

**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 trenchless installation operations.

**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 surface. The ground movement readings shall assist in assessing the sewer performance and any need to modify the installation methodology as required. Settlement is measured by level surveying the SMPs 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 19-92-68-1 to 19-92-68-4.

**3.2     Materials**

**3.2.1   General**

The Contractor shall supply all materials and equipment required for the installation of the 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 measurements with total-station 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 and highway embankments along the proposed sewer alignments. The settlement readings shall assist in assessing the sewer performance and any need to modify the installation methodology as required. Settlement is measured by level surveying the top of the rod 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 E1.

4.1.3 Location

The locations of SRs are shown on Drawings 19-92-68-1 to 19-92-68-4.

**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 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 E1 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 CA and CA's Geotechnical Consultant.

## 6 **MONITORING PROGRAM**

### 6.1 General

The instrumentation monitoring services specified herein apply to all the SMPs and SPs for this site. The requirements include data collection, reporting, data reduction and data transmission.

The Contractor shall carry out the monitoring program for this project. The required tasks include the following:

- Supply materials and equipment required for monitoring;
- Level survey the instruments with no interference with the traffic on Hwy 400 and its ramps;
- Compile and reduce the survey data as described in Section 6.4.2;
- Transmit the settlement data and associated pipe installation /construction activities to CA, CA's Geotechnical Consultant and MTO;
- Notify CA, CA's Geotechnical Consultant and MTO of any required modifications to the construction procedures;
- Notify CA, CA's Geotechnical Consultant and MTO of any modifications of the original site conditions related to pipe installation or otherwise, including appearance

- of cracks on the pavement and shoulder, concrete barriers etc;  
Notify immediately CA, CA's Geotechnical Consultant 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 surfaces and embankments at selected locations during the trenchless installation of the storm water sewers.

The rate and / or methodology of trenchless 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 location of the advancing 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 CA and CA's Geotechnical Consultant.

The minimum monitoring frequencies along with the anticipated number of readings are given in Table 5.1 below. The monitoring frequency is the same for each individual instrument. Instruments shall be read more frequently as required by CA and CA's Geotechnical Consultant.

**Table 5.1 - Minimum Monitoring Frequency**

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER INSTRUMENT (**)
Baseline Readings (*)	3 readings on 2 consecutive days	3
Just prior to start of sewer installation	Once	1
During sewer installation	A minimum of three (3) sets of readings be taken daily for all instruments located above a sewer being installed, 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 sewer installation	After the end of installation of each sewer, all instruments located above the sewer shall be read weekly for the first month.	4

(\*) Baseline Readings: Instrument elevation readings taken prior to sewer installation to provide a baseline against which all subsequent readings are compared to assess settlements of the ground.

(\*\*) Number of readings may vary.

## **6.4 Specific Requirements**

### **6.4.1 Surveying**

The elevations of the instruments shall be surveyed to an accuracy of plus/minus two ( $\pm 2$ ) millimetres or better, and shall be reported to the nearest millimetre. Shoulder and lane closures 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 face (i.e. distance from launching point) at the time of data recording
- Construction activities (e.g. sewer installation underway; weekend – no construction; boulder encountered at the advancing face of installation, 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 sewer alignment between the advancing face of installation 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 installation for each instrument
- Settlement profile for different dates along each of the sewer alignments
- 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 CA, CA's Geotechnical Consultant 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:

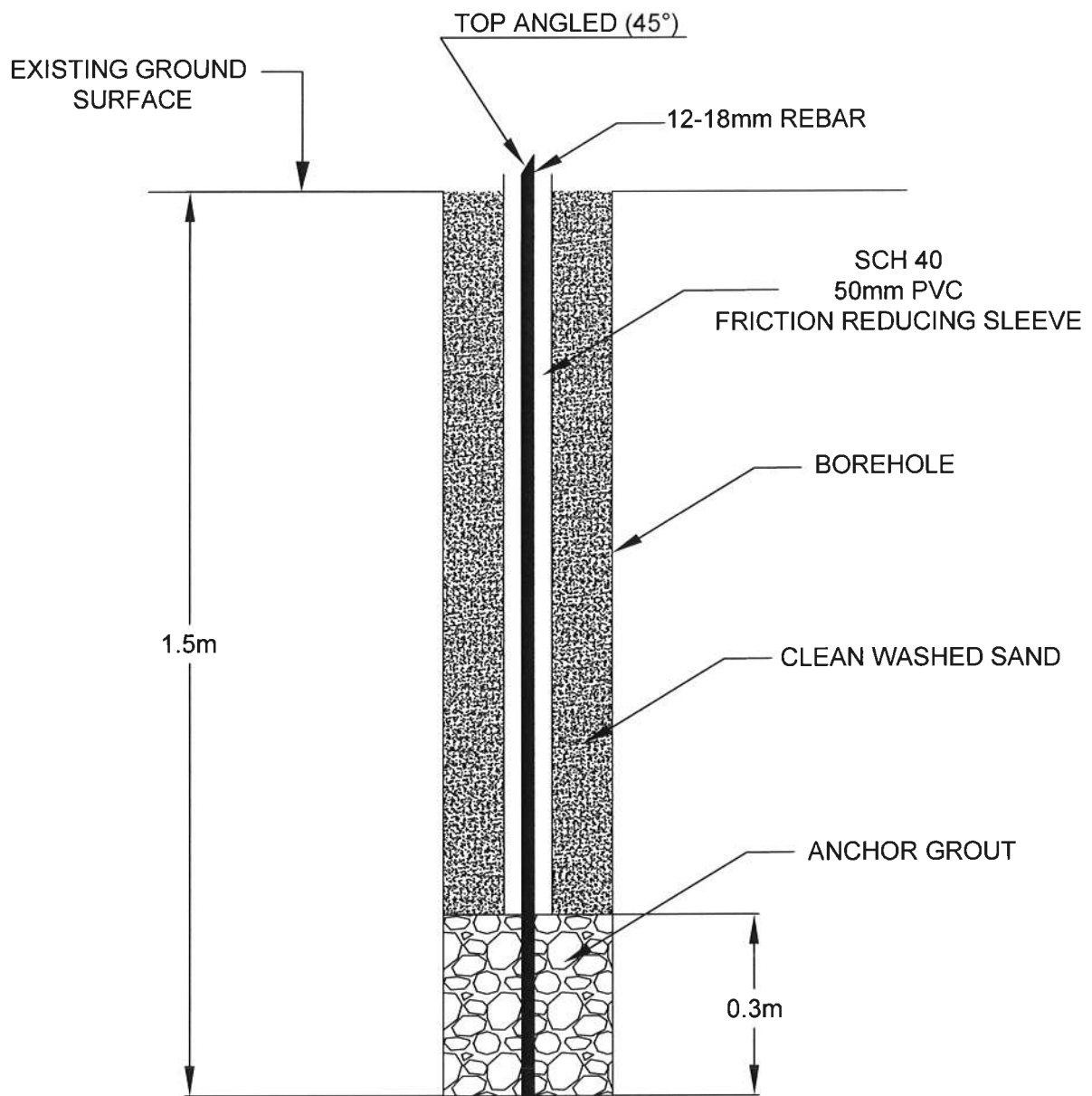
Review Level – A maximum value of 10 mm relative to the baseline or zero readings. If the Review Level is exceeded, the Contractor shall immediately notify CA, CA's Geotechnical Consultant and MTO, and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert 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 or the highway pavement, as indicated by monitoring instruments or direct observation, the Contractor shall cease installation operation immediately and inform CA, CA's Geotechnical Consultant 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 and / or preventive measure deemed necessary by the Contractor is implemented;
- CA, CA's Geotechnical Consultant and MTO deem it is safe to proceed.

## 7 CONTRACTOR'S RESPONSIBILITY FOR RESTORATION

Notwithstanding the monitoring program to assess the adequacy of the sewer installation method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving and fill placement) should movements or other surface distress occurs.

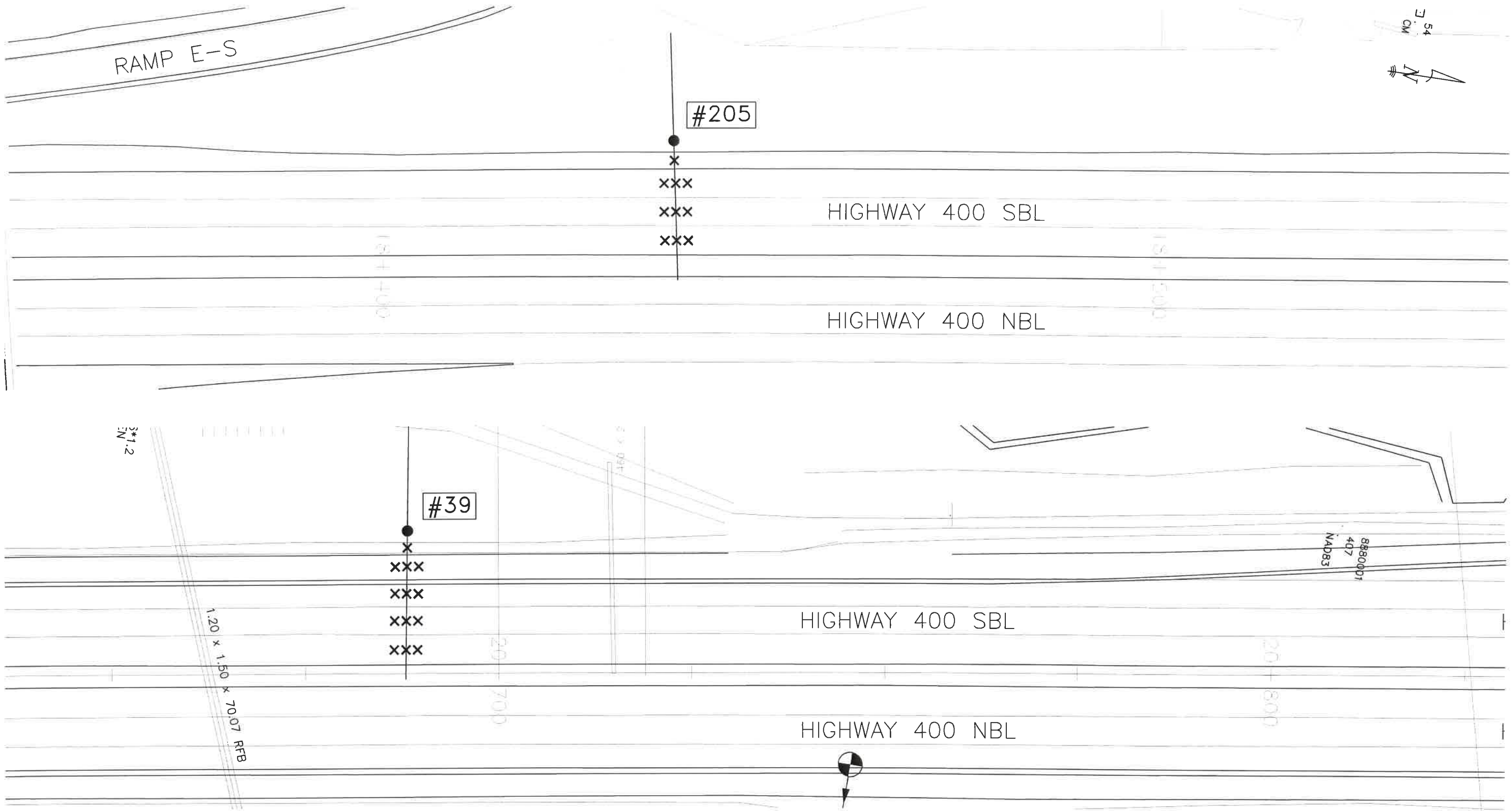


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## SETTLEMENT ROD DETAILS

FIGURE E1





- PROPOSED SEWER CROSSINGS
- X SURFACE MONITORING POINT (SMP)
- SETTLEMENT PIN (SP)



BASE PLAN PROVIDED BY SNC-LAVALIN

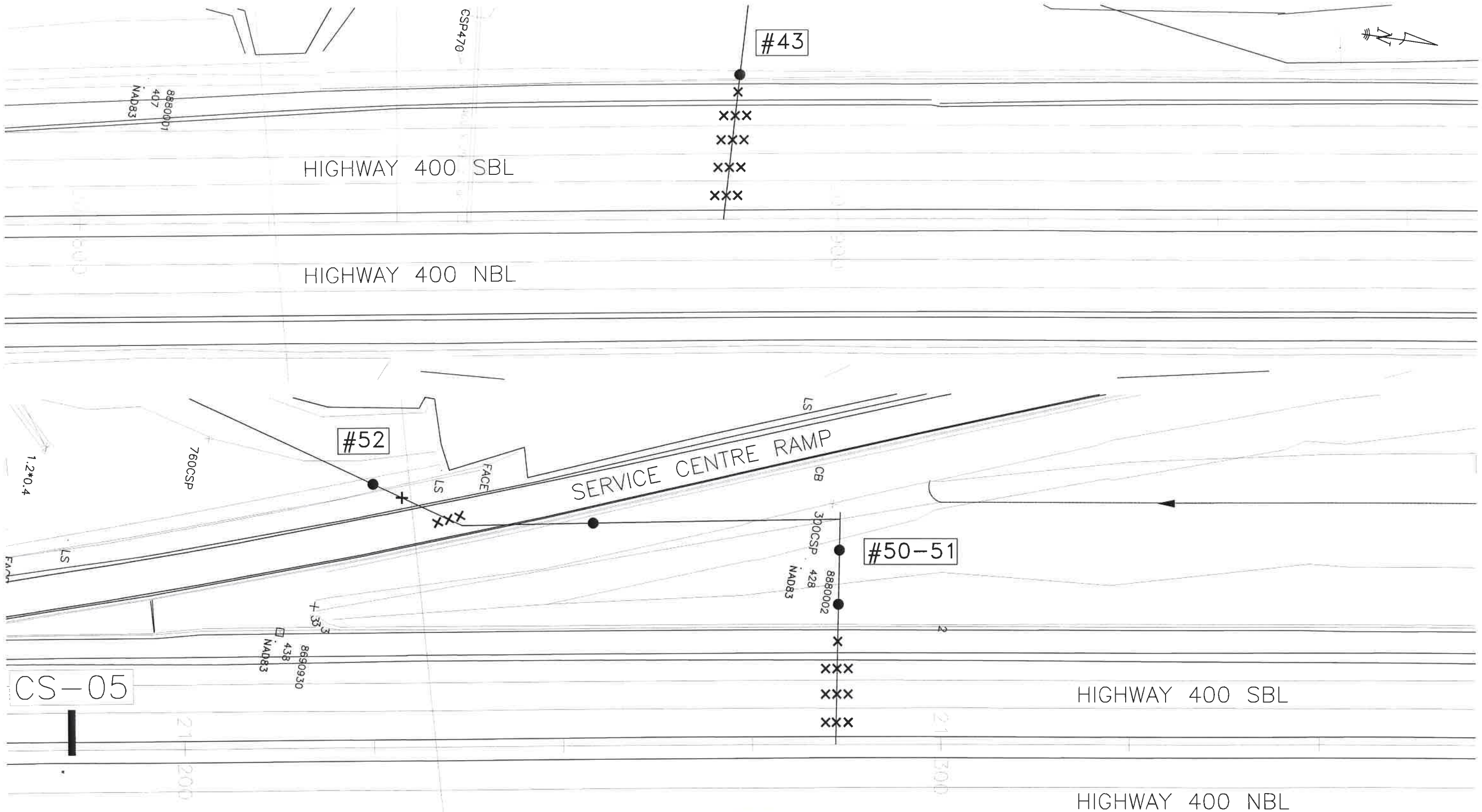
SNC-LAVALIN INC.

HIGHWAY 400 WIDENING  
FROM FASKEN DR. TO STEELES AVE.  
G.W.P. 192-00-00 & 2539-04-00  
PROPOSED SEWER PIPE CROSSINGS  
INSTRUMENTATION & MONITORING PROGRAM

19-92-68

**THURBER ENGINEERING LTD.**

ENGINEER: SKP	DRAWN: AN	APPROVED: PKC
DATE: MAY 2012	SCALE: 1:500	DRAWING NO: 19-92-68-1



- PROPOSED SEWER CROSSINGS
- × SURFACE MONITORING POINT (SMP)
- SETTLEMENT PIN (SP)



BASE PLAN PROVIDED BY SNC-LAVALIN

SNC-LAVALIN INC.

HIGHWAY 400 WIDENING  
FROM FASKEN DR. TO STEELES AVE.  
G.W.P. 192-00-00 & 2539-04-00  
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19-92-68

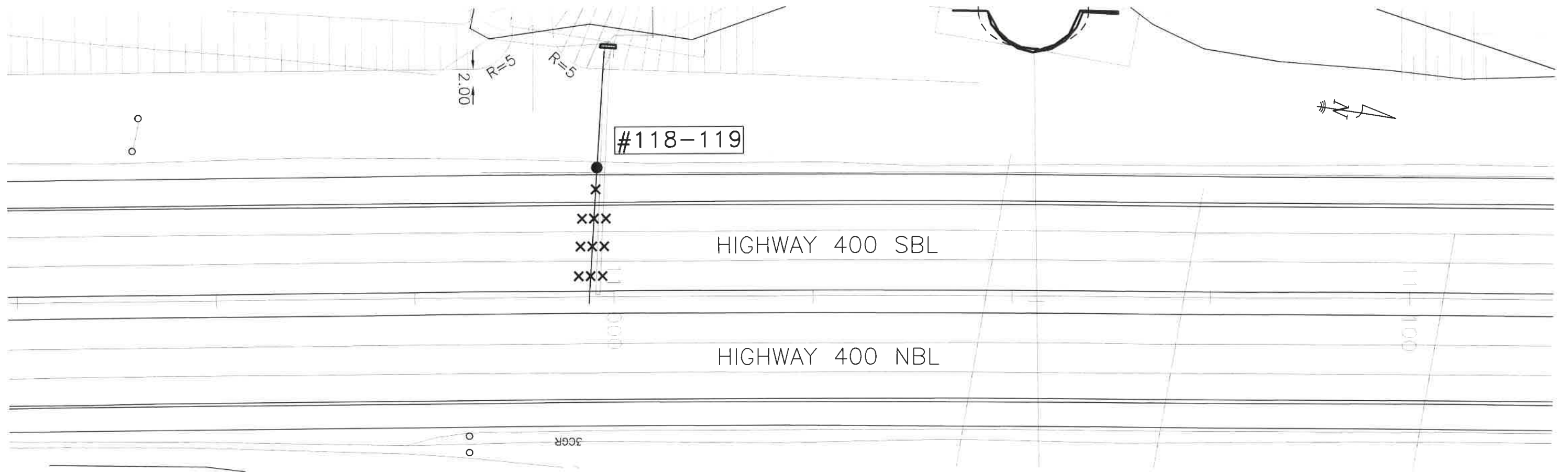


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SKP	AN	PKC
DATE:	SCALE:	DRAWING No.
MAY 2012	1:500	19-92-68-2








- PROPOSED SEWER CROSSINGS
- × SURFACE MONITORING POINT (SMP)
- SETTLEMENT PIN (SP)



BASE PLAN PROVIDED BY SNC-LAVALIN

SNC-LAVALIN INC.
HIGHWAY 400 WIDENING FROM FASKEN DR. TO STEELES AVE. G.W.P. 192-00-00 & 2539-04-00 PROPOSED SEWER PIPE CROSSINGS INSTRUMENTATION & MONITORING PROGRAM
19-92-68

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DATE: MAY 2012	SCALE: 1:500	DRAWING No: 19-92-68-4