

**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORMWATER MANAGEMENT POND #2
HIGHWAY 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: 30M13-191

Report to

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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 location of the proposed Stormwater Management Pond #2 (SWMP2) on the west side of Highway 400 and just south of the Humber Arch Culvert. This pond is part of a Ministry of Transportation Ontario (MTO) Highway 400 widening project that includes accommodation of the ultimate 10-lane configuration including one HOV lane in each direction, while the current MTO right-of-way is to be maintained.

The purpose of this investigation was to determine the subsurface conditions in the vicinity of the pond and the surrounding slopes, provide borehole location 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 the pond area 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. (SLI) under MTO Assignment Nos. 2005-E-0036 and 0037.

2 SITE DESCRIPTION

The highway alignment east of the pond construction extends along Highway 400 from north of Major Mackenzie Drive northerly to just north of the King Road Underpass. The general location of SWMP2 covered in this report is shown on the key plans on the Borehole Locations and Soil Strata drawings in Appendix C.

The pond is to be located within a patch of gently sloping land some 150 m to the south of the Humber Arch Culvert on the west side of Highway 400. At the time of the field work, the site had a thin cover of grass and occasional shrubs. Beyond the crest of the Humber River valley slopes, there is modest vegetation of small trees and shrubs.

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 vicinity of the project area 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

The site investigation and field testing for SWM2 was carried out during the period of February 1 to 4, 2010 inclusive. The current program consisted of drilling and sampling four (4) boreholes.

Information obtained from other reports of this Highway 400 widening project and previous investigations along the alignment have been utilized where appropriate. These reports are listed as follows:

- Thurber report titled “Foundation Investigation Report, High Embankments, Teston Road to King Road, Highway 400 Widening, Vaughan, Ontario, G.W.P. 2539-04-00, Assignment 2005-E-0036”, GEOCRE No. 30M13-178, File:19-92-68, dated April 6, 2010 (Reference 1).
- Thurber report titled “Draft Foundation Investigation Report, Proposed Culvert Extensions and New Culvert, Highway 400 Widening, Major MacKenzie Drive to King Road, York Region, Ontario”, File: 19-92-68, dated October 22, 2010 (Reference 2).
- AMEC report titled “Final Foundation Investigation Report, Proposed Humber River Arch Culvert Extension, Highway 400 Interim Widening, Vaughan, Ontario”, W.P. 192-00-00, Central Region, File: TT22852B, dated September, 2003 (Reference 3).

The boreholes for the SWMP2 investigation program were initially marked and/or staked in the field by Thurber, and their locations temporarily established using Thurber’s in-house GPS survey unit. Prior to commencement of drilling, utility clearances were obtained for all borehole locations. The as-drilled borehole locations and elevations have subsequently been tied in by J.D. Barnes Ltd. and the survey data provided to Thurber. Approximate borehole locations are shown on the Borehole Locations and Soil Strata drawings in Appendix C.

A track mounted drill rig was used to undertake the drilling, sampling and in-situ testing operations.

The depths of the boreholes ranged from approximately 15.8 m to 20.4 m below existing ground surface. Hollow and solid stem augers were used to advance the boreholes. Soil samples were obtained at selected intervals using a 50 mm outside diameter split spoon sampler in conjunction with Standard Penetration Tests (SPT).

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers of 19 mm in diameter were installed in selected boreholes for monitoring of groundwater levels. The installation details are presented on the Record of Boreholes in Appendix A. Details of borehole grouting and piezometer sealing for this investigation are presented in Table 1 immediately following the text. All boreholes were backfilled in general accordance with the terms of reference of this project.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the soil samples in labelled and sealed containers, which were then transported 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 delivered to the laboratory. Selected soil samples were subjected to grain size distribution analysis. Selected cohesive soil samples underwent Atterberg Limits testing. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the accompanying figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on Record of Borehole sheets, and on the "Borehole Locations and Soil Strata" drawings in Appendices A and C, respectively. A general description of the stratigraphy established at Boreholes 10-01 to 10-04 is presented in the following paragraphs. It should be noted that the subsurface conditions vary between and beyond the borehole locations.

Results of grain size distribution analyses conducted on selected samples of various types of soils from this investigation are presented in Figures B1 to B5 in Appendix B. Results of Atterberg Limits tests carried out on selected cohesive soil samples are shown on the plasticity charts on Figure B6 in Appendix B. The Borehole Locations and Soil Strata Drawings in Appendix C present the inferred subsurface conditions in the pond area.

5.1 Topsoil

Topsoil of thicknesses ranging from 100 mm to 180 mm was encountered in Boreholes 10-01 to 10-04. Topsoil thickness may vary between and beyond the borehole locations.

5.2 Fill

A surficial layer of gravel fill was encountered beneath the topsoil in Borehole 10-03. The thickness and base elevation of the fill are 0.3 m and 266.6 m, respectively.

5.3 Clayey Silt

A surficial layer of clayey silt containing some sand and trace gravel was encountered in Boreholes 10-01 and 10-02. The thickness and base elevation of these deposits are summarized in Table 5.3.1 below:

Table 5.3.1 Clayey Silt Thickness and Base Elevation

Borehole Number	Clayey Silt	
	Thickness (m)	Base Elevation (m)
10-01	1.2	262.1
10-02	3.0	261.3

This soil is brown in colour and has a stiff to very stiff consistency as indicated by SPT 'N' values ranging from 9 to 22 blows per 0.3 m penetration. Measured moisture contents ranged between 12% and 22%.

Figure B1 presents the grain size distribution curve of a clayey silt sample. The test results are summarized in the tables below.

Soil Particles	%
Gravel	1
Sand	17
Silt	62
Clay	20

5.4 Silts and Sands

Deposits of cohesionless soils with varying proportions of silts and sands with trace of clay were encountered in Boreholes 10-01 to 10-04. The thickness and base elevation of these soils in the boreholes are summarized in Table 5.4.1:

Table 5.4.1 Silt and Sand Thickness and Base Elevation

Borehole Number	Silts and Sands Thickness (m)	Base Elevation (m)
10-01	5.9 (upper)	256.2
	1.4 (lower)	248.7
10-02	3.6	256.6
10-03	4.6	253.7
10-04	2.1	256.2

These soils are typically grey in colour with occasional brown zones at shallow depths, non-plastic, and in a typically compact state as indicated by SPT 'N' values ranging between 12

and 29 blows per 0.3 m penetration. Measured moisture contents were typically between 15% and 22%, with a lower value of 8% measured in Borehole 10-01.

Figures B2 and B3 present the grain size distribution curves of selected samples of silt, sandy silt and silty sand. The test results are summarized in the tables below.

Silt

Soil Particles	%
Gravel	0
Sand	5 – 13
Silt	82 – 85
Clay	5 – 10

Sandy Silt to Silty Sand

Soil Particles	%
Gravel	0 – 1
Sand	35 – 71
Silt and Clay	28 – 65

5.5 Clayey Silt Till

Clayey silt till containing some sand and trace gravel was encountered in Boreholes 10-01, 10-02, 10-03 and 10-04. An occasional zone of silty clay till was contacted in Boreholes 10-03. None of the boreholes fully penetrated the clayey silt till deposit. The thickness and base elevation of this till deposit are summarized in Table 5.5.1:

Table 5.5.1 Clayey Silt Till Thickness and Base Elevation

Borehole Number	Minimum Thickness (m)	Borehole Termination Elevation (m)
10-01	6.1 (upper)	250.1
	5.6 (lower)	243.1
10-02	1.1 (upper)	260.2
	8.1 (lower)	248.5
10-03	8.3 (upper)	258.3
	7.1 (lower)	246.6
10-04	6.7 (upper)	258.3
	6.9 (lower)	249.3

This till is typically brown at shallow depth becoming grey with depth. Its consistency is typically very stiff to hard as indicated by SPT ‘N’ values ranging between 18 and 64 blows per 0.3 m penetration. Occasional ‘N’ values between 11 and 15 blows were also measured

indicating the presence of stiff zones. Measured moisture contents were typically between 15% and 22%.

Figure B4 presents the grain size distribution curves of clayey silt till samples. The test results are summarized in the table below.

Soil Particles	%
Gravel	0 – 3
Sand	3 – 31
Silt	46 – 82
Clay	12 - 26

Figure B5 presents the grain size distribution curve of a silty clay till sample. The test results are summarized in the table below.

Soil Particles	%
Gravel	0
Sand	19
Silt	51
Clay	30

Figure B6 presents Atterberg limits test results of some clayey silt till and silty clay till samples.

Index Property	%
Liquid Limit	22 – 24
Plasticity Index	7 – 10

The above results show that these cohesive tills have low plasticity with a group symbol of CL.

Glacial tills inherently contain cobbles and boulders, although such obstructions were not encountered in the boreholes.

5.6 Groundwater

Free water was encountered in Boreholes 10-02 and 10-04 at 4.3 and 7.3 m depths, respectively, upon completion of drilling. A standpipe piezometer was installed in each of Boreholes 10-01 and 10-03. All the observed water levels are presented in Table 5.8.1:

Table 5.6.1 Water Level Measurements

Borehole (Screen location)	Date	Depth (m)	Elevation (m)
10-01 (piezometer screen at clayey silt till)	February 4, 2010	7.3	256.2
	April 9, 2010	7.1	256.4
10-02 (open borehole)	February 2, 2010	4.3*	260.0*
10-03 (piezometer screen at clayey silt till / sandy silt)	February 4, 2010	7.9	259.1
	April 9, 2010	6.4	260.6
10-04 (open borehole)	February 3, 2010	7.3*	257.8*

* May not be stabilized.

Based on the piezometer readings, the groundwater levels were noted to vary between Elevations 256 and 260 m. The groundwater levels are expected to vary seasonally and are subject to climatic events.

6 MISCELLANEOUS

Thurber Engineering Ltd. (Thurber) selected the borehole locations in the field relative to existing site features with consideration of access restraints, terrain conditions, utility locations and previous site investigation data.

Walker Drilling Ltd of Utopia, Ontario conducted the drilling, sampling and in-situ testing operations. Barricade Traffic Services Inc. (BTS) provided temporary highway lane and shoulder closure during the unloading and loading of the drill rig. Mr. Stephane Loranger of Thurber supervised the drilling and sampling operations in the field on a full time basis.

Dr. Sydney Pang, P.Eng. directed the field operations and prepared this report.

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

THURBER ENGINEERING LTD.



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



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

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents foundation recommendations for the design of SWMP2 with emphasis on its impact on the stability of the Humber River valley slopes and the adjacent Highway 400 embankment.

The discussions and recommendations presented in this report are based on project information provided by SLI and on the factual data obtained during the course of this investigation. Factual data obtained during previous investigations is also referenced where appropriate.

The general arrangements of the pond, plans and profiles related to the slopes adjacent to the pond have been provided by SLI. Based on this information, the base of the pond will be at Elevation 262m, some 3.5 to 5 m below the existing gentle slope surface of inclination in the order of 20H : 1V towards the valley slope crest. The pond is currently designed to have 3H : 1V sideslopes and a trapezoidal base configuration with a longitudinal dimension of approximately 50 m (north - south), and transverse dimensions of about 15 m on the north side and 25 m on the south side. The distance between the pond and the crest of the valley slope varies from about 80 m on the north side to over 100 m on the west side. Along the east side, the edge of the pond is at about 5 m from the proposed toe of the widening embankment of the highway.

It is understood that SWMP2 will function as a wet pond, i.e. a water level is to be continually maintained. This investigation is not part of the original foundations terms of reference from 2006 for the Highway 400 widening. An investigation on the influence of the pond on the stability of the valley slopes was originally requested by TRCA.

8 STORMWATER MANAGEMENT POND #2 DESIGN

8.1 Pond Design Criteria

The major foundation/geotechnical aspects of the pond design that are addressed herein include the following.

- The stability of the existing valley slopes and the potential impact of the pond on the stability of the existing valley slopes, including the event of seepage loss from the pond, are addressed.
- The potential impact of the pond on the stability of the existing Highway 400 embankment is assessed.
- The stability of the pond sideslopes has been analysed. While the probability of occurrence of rapid drawdown is low, slope assessment of such scenario has been undertaken to confirm stability.
- The hydraulic conductivities of the soils in the pond area will be estimated and an assessment made with respect to water retention. A compacted clay liner may be required should the base of the pond coincides with relatively permeable soils such as sand.

8.2 Stability Analysis Methodology

For the purpose of embankment and slope stability analyses, the commercially available limit equilibrium slope stability program GSLOPE developed by Mitre Software Inc. was used.

For global stability and based on consideration of the risks involved, past experience of slope and embankment performance and site specific conditions, a criterion of a minimum Factor of Safety (F.S.) of 1.3 against slope instability has been used in this report.

9 SLOPE STABILITY ANALYSIS

9.1 General

The pond is to be located within a piece of irregularly shaped, gently sloping land some 150 m to the south of the Humber Arch Culvert on the west side of Highway 400. Beyond the west and north boundaries of the pond lie the valley slopes of the Humber River which flows in an east-west orientation in this vicinity. The base of the pond has a trapezoidal shape and its deepest portion is designed to be at approximate Elevation 262 m. A berm for supporting a maintenance road is to connect the south boundary with the east boundary of the pond. The sideslopes of the pond is designed to have an inclination of 3H : 1V. In addition to surface runoff and precipitation, a 1,050 mm diameter stormwater inlet pipe with an invert at approximate Elevation 263.2 m is to drain into the pond from the east side. At the north pond slope, a weir structure to be founded at about Elevation 261.8 m in conjunction with a 700mm diameter pipe constitutes the pond outlet.

The crest of the pond from the crest of the valley slope is approximately 80 m to over 100 m. The valley slopes to the north and northwest of the pond have an inclination in the order of 5H : 1V, except for a location near Station 11+000 (offset about 50 m west) where the existing

natural slope is at about 1.8H : 1V. The floodplain of the Humber River gently slopes in the order of 20H : 1V towards the river channel.

Near the footprint of the pond, the borehole results indicate that the subsurface condition consists of stiff to very stiff clayey silt and very stiff to hard clayey silt till overlying layers of compact silts and sands, which are in turn underlain by very stiff to hard clayey silt till. The groundwater level lowers from approximate Elevation 260 m in the vicinity of the pond to about Elevation 256 m at the floodplain adjacent to the river channel.

SWM Pond #2 will be formed as a cut into the predominantly cohesive very stiff to hard clayey silt till.

9.2 Selected Cases for Stability Analysis

Short term (undrained) and/or long term (drained) conditions have been analysed as appropriate.

9.2.1 Existing Valley Slopes

Given the subsurface conditions and the typically gentle inclinations, the existing valley slopes at about 5H : 1V satisfies global stability requirements with $F.S. \geq 2$, except for the location near Station 11+000 (offset about 50 m west) where, locally, the F.S. is reduced to 1.3 (see Table 9.3.1).

9.2.2 Existing Valley Slopes and the Pond

In view of the substantial distance (80 m to >100 m) from the valley slope crest, it is considered that the existence of the pond will not have any adverse impact on the global stability of the valley slopes (see Table 9.3.1).

In the unlikely event, however, that the pond leaks to such an extent as to saturate the entire slope, this case has been analysed. A F.S. of 1.5 has been obtained for the long term case (see Table 9.3.1).

9.2.3 Highway Embankment with Pond

Several selected cases have been analysed as follows:

- Overall stability of the Highway 400 embankment with and without the presence of the pond.
- Rapid drawdown refers to a low probability event where the water level in the pond drops abruptly (in a matter of hours) resulting in saturated sideslopes.

The rapid drawdown case results in a F.S. of 1.3 which satisfies the criterion used in this report. The presence of the pond beside the highway embankment reduces the F.S. from 2.0 to 1.9 for the long term.

9.3 Stability Analysis Results

The F.S.'s obtained from stability analysis of the selected cases as outlined above are summarized in Table 9.3.1 below.

Table 9.3.1 Stability Analysis Results

Location	Type of Analysis	Factor of Safety
Valley Slopes typically 5H : 1V (with or without pond)	Long Term (Drained)	2.9
Valley Slope Near Station 11+000 o/s 50 m west (with or without pond)	Long Term (Drained)	1.3
Saturated Plateau from Pond to Floodplain (Section B-B)	Long Term (Drained)	1.5
Highway Embankment without Pond (Section B-B)	Long Term (Drained)	2.0
Highway Embankment with Pond (Section B-B)	Short Term (Undrained)	2.7
	Long Term (Drained)	1.9
Pond Slope (3H : 1V)	Rapid Drawdown	1.3

Figures D1 to D7 in Appendix D present stability analysis results of selected cases. The soil properties assumed in the analyses are shown on these figures.

Results of these analyses indicate that adequate F.S. can be maintained for global stability in all the selected cases.

9.4 Pond Design and Construction

Based on the above and from a foundation/geotechnical engineering perspective, the design of the Stormwater Management Pond #2 as currently considered by SLI should not have any adverse impact on the stability conditions of the nearby Humber River valley slopes and the proposed Highway 400 widening embankment.

Construction of the pond will require excavation through the stiff to very stiff clayey silt into the very stiff to hard clayey silt till. Although not encountered within the till deposit in the boreholes, it is anticipated that water-bearing sand and silt interlayers and/or lenses would be encountered. Groundwater control in the form of pumping from filtered sumps will be required. Glacial tills inherently contain cobbles and boulders and, as such, the contractor should be equipped to handle and/or remove such obstructions.

Existing borehole information indicates that very stiff to hard clayey silt till will be exposed across the sides and at the base of the pond. This soil has relatively low hydraulic conductivity and the infiltration rate is therefore expected to be very low. The sands and silts have higher percolation rates and, if encountered, will be causes of leakage. For design purposes, the following hydraulic conductivities may be assumed:

- Clayey silt till ($< 10^{-8}$ m/s)
- Sands and silts (10^{-5} to 10^{-7} m/s)

It is understood that SWM Pond #2 is designed to be a wet pond. Therefore, a head of water will need to be maintained in the pond at all times. Although not encountered at the pond elevations in the existing boreholes, it is probable that sands and silts are present at the pond base or on the sideslopes. It is therefore recommended that the following be considered:

- Place a compacted clay liner on the anticipated wet surface inside the pond. A typical clay liner should be approximately 0.5 m in thickness. The excavated clayey silt and clayey silt till materials from construction of the pond may be used to form the liner.

or

- Once the design elevations are reached, carry out an inspection of the subgrade by qualified geotechnical personnel to identify and sub-excavate any exposed patches of sands and silts. Scarify and recompact the upper 0.5 m of clayey silt till subgrade.

A concrete weir structure is to be founded at approximate Elevation 261.8 m on the very stiff clayey silt till near the east end of the pond. It is recommended that a factored geotechnical resistance at ULS of 300 kPa and a geotechnical resistance at SLS of 200 kPa be used for foundation design.

Excavation, grading and compaction should be carried out with reference to the requirements of SP 206S03 and SP 105S10, respectively.

Erosion protection should be provided for selected surfaces of the sideslopes of the pond as required. Design of the erosion protection measures must consider hydrologic and hydraulic concerns. Typically, rip-rap should be provided in areas of high velocity or concentrated water flow. Other surfaces may be treated with vegetation, hydroseeding and/or erosion control blanket as required. Reference should be made to OPSS 804 for erosion protection requirements. Detailed design of the pond should be carried out by professionals experienced in such designs.

10 CONSTRUCTION CONCERNS

During construction, the Contract Administrator (CA) should employ experienced geotechnical staff to observe construction activities related to foundation construction. Potential construction concerns include, but are not necessarily limited to, the following:

- Existing design information indicates that there is a buffer zone in the order of 5 m wide between the existing highway embankment toe and the edge of the pond. Inspection should be made periodically, or as required, during construction to confirm that this buffer zone remains in place and that the highway embankment is not adversely affected.
- Groundwater control is essential for maintaining reasonably dry excavations.
- The pond base and sideslopes should be inspected periodically, or as required, to confirm stability.
- Should the water-bearing sands and silts be exposed at the pond base or on the sideslopes, sub-excavation of the sands and silts followed by scarification and recompaction of the upper 0.5 m of the subgrade, or installation of a 0.5 m thick compacted clay liner should be carried out.

11 CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P. K. Chatteriji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



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



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

Table A1
Borehole Completion Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
10-01	11.2 / 252.3	Piezometer with 3 m slotted screen installed with sand filter to 7.5 m (Elevation 256.0 m), bentonite seal to 1.5 m depth, then soil cuttings to surface.
10-02	None installed	Bentonite to 1.9 m, soil cuttings to surface.
10-03	10.3 / 256.7	Piezometer with 3 m slotted screen installed with sand filter to 4.0 m (Elevation 259.2 m), bentonite seal to 0.2 m depth, then soil cuttings to surface.
10-04	None installed	Borehole caved to 7.4 m, then bentonite to surface.

Appendix A

Record of Borehole Sheets

19-92-68

Table A1
Borehole Completion Details

Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
10-01	11.2 / 252.3	Piezometer with 3 m slotted screen installed with sand filter to 7.5 m (Elevation 256.0 m), bentonite seal to 1.5 m depth, then soil cuttings to surface.
10-02	None installed	Bentonite to 1.9 m, soil cuttings to surface.
10-03	10.3 / 256.7	Piezometer with 3 m slotted screen installed with sand filter to 4.0 m (Elevation 259.2 m), bentonite seal to 0.2 m depth, then soil cuttings to surface.
10-04	None installed	Borehole caved to 7.4 m, then bentonite to surface.

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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



Water Level

C_{pen}


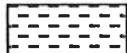



Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

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
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
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.
TERMS		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 10-01

1 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 411.7 E 299 597.1 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.01 - 2010.02.01 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED + FIELD VANE						w _p w w _L						
								● QUICK TRIAXIAL × LAB VANE												
263.5							20	40	60	80	100	20	40	60						
0.0	TOPSOIL: (150mm)																			
0.2	Clayey SILT, some sand, trace gravel Stiff Brown Moist																			
262.1				1	SS	10											1	17	62	20
1.4	SILT, trace sand, trace clay Compact Brown Moist Becoming grey			2	SS	12														
				3	SS	15											0	5	85	10
				4	SS	21														
259.4																				
4.1	Sandy SILT, trace clay Compact Grey Moist Becoming wet			5	SS	25											0	35	60	5
				6	SS	28														
256.2																				
7.3	Clayey SILT, some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)			7	SS	28														
				8	SS	46											0	12	65	23

Continued Next Page

+³ X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-01

2 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 411.7 E 299 597.1 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.01 - 2010.02.01 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	20 40 60 80 100	W _P W W _L						
Continued From Previous Page								20	40	60	80	100	20	40	60	
	Clayey SILT, some sand, trace gravel Hard Grey Moist (TILL)		9	SS	42		253									
							252									
			10	SS	49		251									
250.1							250									
13.4	Sandy SILT Compact Grey Moist to Wet		11	SS	24		249									
							248									
248.7							247									
14.8	Clayey SILT, trace sand, trace gravel Hard Grey Moist (TILL)		12	SS	43		246									
							245									
			13	SS	59		244									
			14	SS	32											

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+³, X³: Numbers refer to
Sensitivity

20
15
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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-01

3 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 411.7 E 299 597.1 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.02.01 - 2010.02.01 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%) w _p w w _L				
	Continued From Previous Page		15	SS	18			20	40	60	80	100		
243.1														
20.4	END OF BOREHOLE AT 20.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 02.04.10 7.3 256.2 04.09.10 7.1 256.4						243							

RECORD OF BOREHOLE No 10-02

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 381.3 E 299 602.3 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.01 - 2010.02.02 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
264.3												
0.0	TOPSOIL, with roots and rootlets (150mm)						264					
0.2	Clayey SILT, some sand seams Stiff to Very Stiff Brown Moist		1	SS	9							
			2	SS	12		263					
			3	SS	22		262					
261.3	Clayey SILT, trace gravel, with sand seams Very Stiff Brown Moist (TILL)		4	SS	27		261					
260.2	SAND, some silt Compact Brown Moist		5	SS	29		260					
4.1			6	SS	26		259					
							258					
							257					
256.6	Clayey SILT, some sand, trace gravel Very Stiff to Hard Grey Moist (TILL)		7	SS	20		256					
7.7			8	SS	32		255					

Continued Next Page

+³ . X³ : Numbers refer to
Sensitivity

20
15
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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-02

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 381.3 E 299 602.3 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Solid Stem Augers/Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.01 - 2010.02.02 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100				PLASTIC LIMIT w _P NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L			
Continued From Previous Page								20 40 60 80 100				20 40 60			
248.5 <															

RECORD OF BOREHOLE No 10-03

1 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 351.0 E 299 639.9 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.02 - 2010.02.02 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)		W _p	W	W _L	GR		
267.0								20 40 60 80 100	20 40 60								
0.0	TOPSOIL, trace roots and rootlets (100mm)						267										
0.1																	
266.6																	
0.4	GRAVEL Brown Moist (FILL)																
	Clayey SILT, some sand, trace gravel Very Stiff to Hard Brown Moist (TILL)		1	SS	19		266										
			2	SS	26		265										
	Becoming grey		3	SS	42		264										
264.0	Silty CLAY (TILL)		4	SS	41		263										
3.0	With sand seams						262										
262.9			5	SS	36		261										
4.1			6	SS	36		260										
			7	SS	12		259										
258.3	Sandy SILT, trace clay Compact Grey Moist to Wet		8	SS	13		258										
8.7																	

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+ ³ . X ³ : Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-03

2 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 350.1 E 299 639.9 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.02 - 2010.02.02 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE										
								● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page							20 40 60 80 100										
256.8							257											
10.2	Silty SAND , trace clay, trace gravel Compact Grey Wet		9	SS	17		256							1 71 28 (SI+CL)				
							255											
			10	SS	27													
							254											
253.7																		
13.3	Clayey SILT , some sand, trace gravel, with sand seams Hard Grey Moist (TILL)		11	SS	35		253											
							252											
			12	SS	37													
							251											
			13	SS	48		250											
							249											
			14	SS	64													
							248											

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+³ . X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-03

3 OF 3

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 350.1 E 299 639.9 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.02 - 2010.02.02 CHECKED BY SKP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100	20	40	60		
	Continued From Previous Page		15	SS	48	247										
246.6																
20.4	END OF BOREHOLE AT 20.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 02.04.10 7.9 259.1 04.09.10 6.4 260.6															

RECORD OF BOREHOLE No 10-04

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 319.9 E 299 593.4 ORIGINATED BY SLL
HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2010.02.03 - 2010.02.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)							
265.1							20	40	60	80	100	W _P	W	W _L						
0.0	TOPSOIL, with roots and rootlets: (180mm) Clayey SILT, some sand, trace gravel, with sand seams Very Stiff to Hard Brown Moist (TILL)																			
0.1																				
			1	SS	19															
			2	SS	41															
			3	SS	38															
			4	SS	42															
			5	SS	15															
			6	SS	38															
258.3																				
6.8	SILT, some sand, trace gravel Compact Grey Wet		7	SS	14															
256.2			8	SS	25															
8.9	Clayey SILT, some sand, trace gravel, with wet sand seams Very Stiff to Hard Grey Moist (TILL)																			

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10-04

2 OF 2

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 319.9 E 299 593.4 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2010.02.03 - 2010.02.03 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED + FIELD VANE								
	Continued From Previous Page						20 40 60 80 100									
249.3 15.8	Clayey SILT, trace gravel, with wet sand seams Hard Grey Moist (TILL)		9	SS	51		255									
							254									
							253									
			10	SS	59		252									
							251									
			11	SS	11		250									
			12	SS	46											
	END OF BOREHOLE AT 15.8m. BOREHOLE CAVED TO 7.4m, AND WATER LEVEL AT 7.3m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.															

RECORD OF BOREHOLE No 06-16W

1 OF 2

METRIC

W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 460.9 E 299 639.1 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2007.01.08 - 2007.01.08 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
263.1								20 40 60 80 100							
0.0	TOPSOIL: (200 mm)						263								
0.2	Silty SAND Very Loose Brown Wet (FILL)		1	SS	3										
261.9			2	SS	21		262								
1.1	Silty CLAY, trace sand, with thin silty sand seams Very Stiff to Stiff Brown Moist (CL)		3	SS	25									0 6 49 45	
			4	SS	13		261								
260.2															
2.9	Clayey SILT, occasional sand seams Very Stiff Grey Wet		5	SS	17		260								
							259								
258.7															
4.3	SILT, trace sand, trace clay, trace gravel Dense Moist (ML-NP)		6	SS	39		258							1 7 86 6	
257.0	inferred boulder or cobble at 5.72 to 5.82 m						257								
6.1	SAND, trace to some silt, trace clay Very Dense Brown Moist gravel seams at 6.25 to 6.28 m		7	SS	63		256								
255.7															
7.3	compact		8	SS	22		255							0 81 19 (SI+CL)	
254.5							254								
8.5			9	SS	51										

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 06-16W

2 OF 2

METRIC

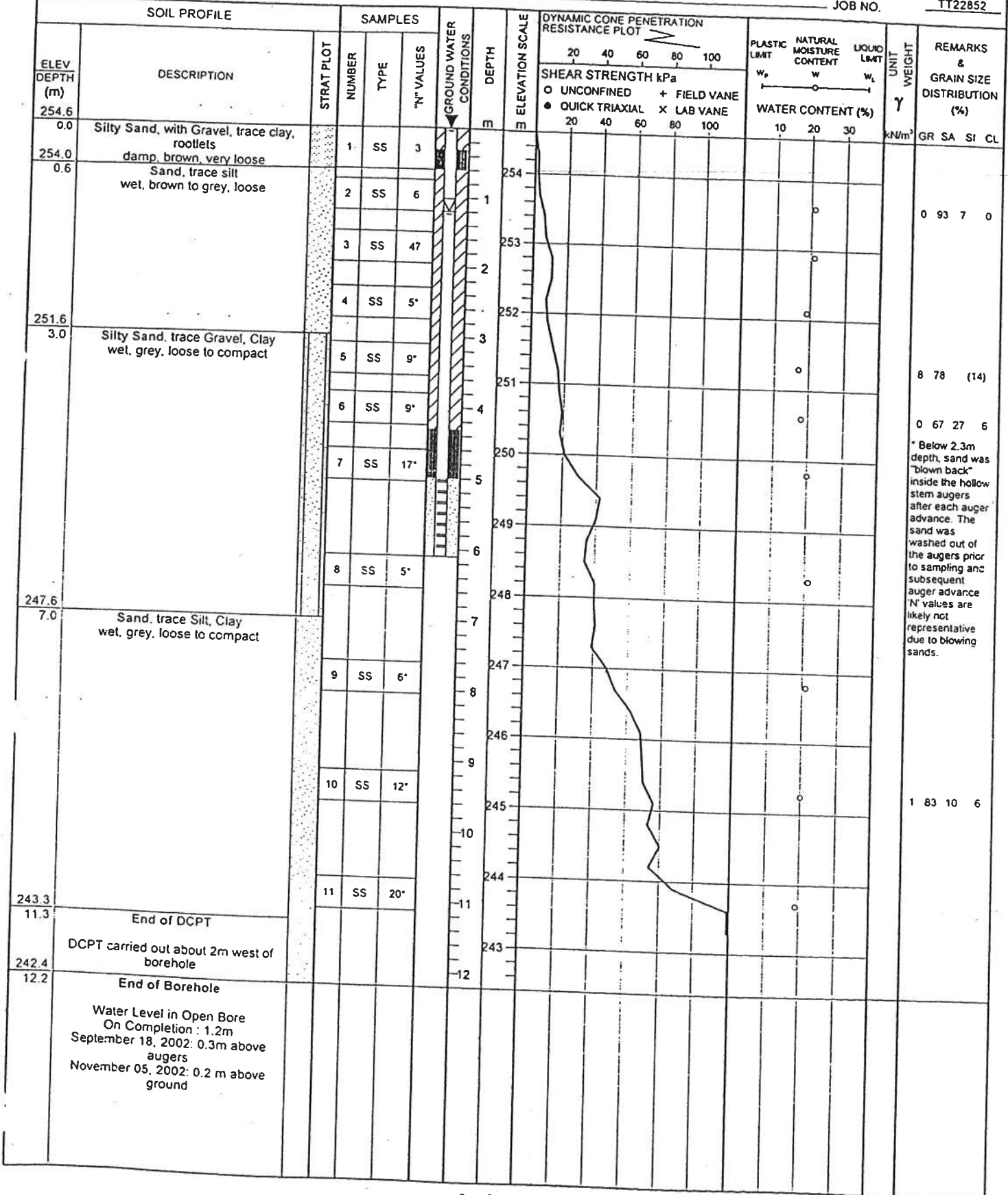
W.P. 2539-04-00 LOCATION Hwy 400, Teston Road to King Road N 4 863 460.9 E 299 639.1 ORIGINATED BY SLL
 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 2007.01.08 - 2007.01.08 CHECKED BY TJH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w		
Continued From Previous Page								WATER CONTENT (%)				
252.7	SAND, trace to some silt, trace clay Very Dense											
10.4	Clayey SILT, some sand, trace gravel Hard Grey Wet		10	SS	56							
251.9												
11.1	SAND, some silt Very Dense Grey Wet											
250.7												
12.4	Clayey SILT, trace sand, trace gravel Hard Grey Wet (TILL)		11	SS	63							
			12	SS	39							
						</						

RECORD OF BOREHOLE No HR2

amec

W.P. 192-00-00 LOCATION 4863525.9N 299615.6E 1 OF 1
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Augering ORIGINATED BY IH
 DATUM Geodetic DATE 17 September 2002 - 17 September 2002 COMPILED BY IH
 PROJECT HWY 400 Widening, Vaughan, Ontario CHECKED BY AD
 JOB NO. TT22852



+3, X3: Numbers refer to

0.3% STRENGTH

RECORD OF BOREHOLE No HR3

amec

W.P. 192-00-00 LOCATION 4863514.9N 299615.6E 1 OF 1
 DIST HWY 400 BOREHOLE TYPE Hollow Stem Augering ORIGINATED BY IH
 DATUM Geodetic DATE 17 September 2002 - 18 September 2002 COMPILED BY IH
 PROJECT HWY 400 Widening, Vaughan, Ontario CHECKED BY AD
 JOB NO. TT22852

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa						
254.7									20 40 60 80 100						
0.0	Sand, with Gravel, some Organics, Rootlets		1	SS	3			254	○ UNCONFINED + FIELD VANE						
254.0	damp, brown to grey, very loose		2	SS	8		1	254	● QUICK TRIAXIAL x LAB VANE						
0.7	Sand, with Gravel moist, grey, loose							253							
253.3	Sand, trace Silt wet, grey, loose to dense		3	SS	17		2	253							0 91 9 0
1.4			4	SS	50		3	252							
			5	SS	6*		4	251							
			6	SS	7*		5	250							
250.3	Silty Sand, trace Clay wet, grey, loose to compact		7	SS	5*		6	249							
4.4			8	SS	20*		7	248							
			9	SS	13*		8	247							
			10	SS	19*		9	246							
			11	SS	31*		10	245							
243.1							11	244							0 77 15 8
11.6	CLAYEY SILT, with Sand, trace gravel (TILL)						12	243							
242.5	moist, grey, hard							242							
12.2	End of DCPT		12	SS	60										
242.0	DCPT carried out about 2m west of borehole														
12.7	End of Borehole														
	Water Level in Open Bore On Completion : 0.9 m														

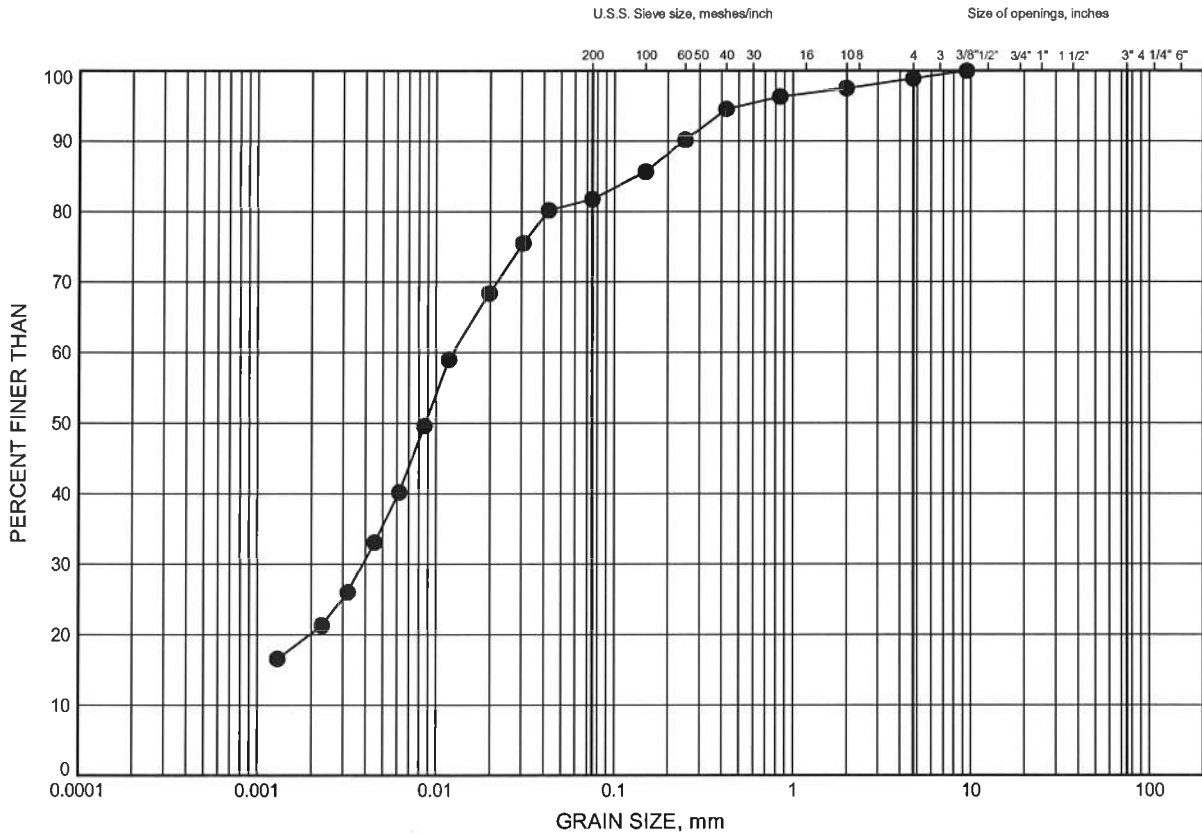
Appendix B

Laboratory Test Results

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

FIGURE B1

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	1.07	262.43

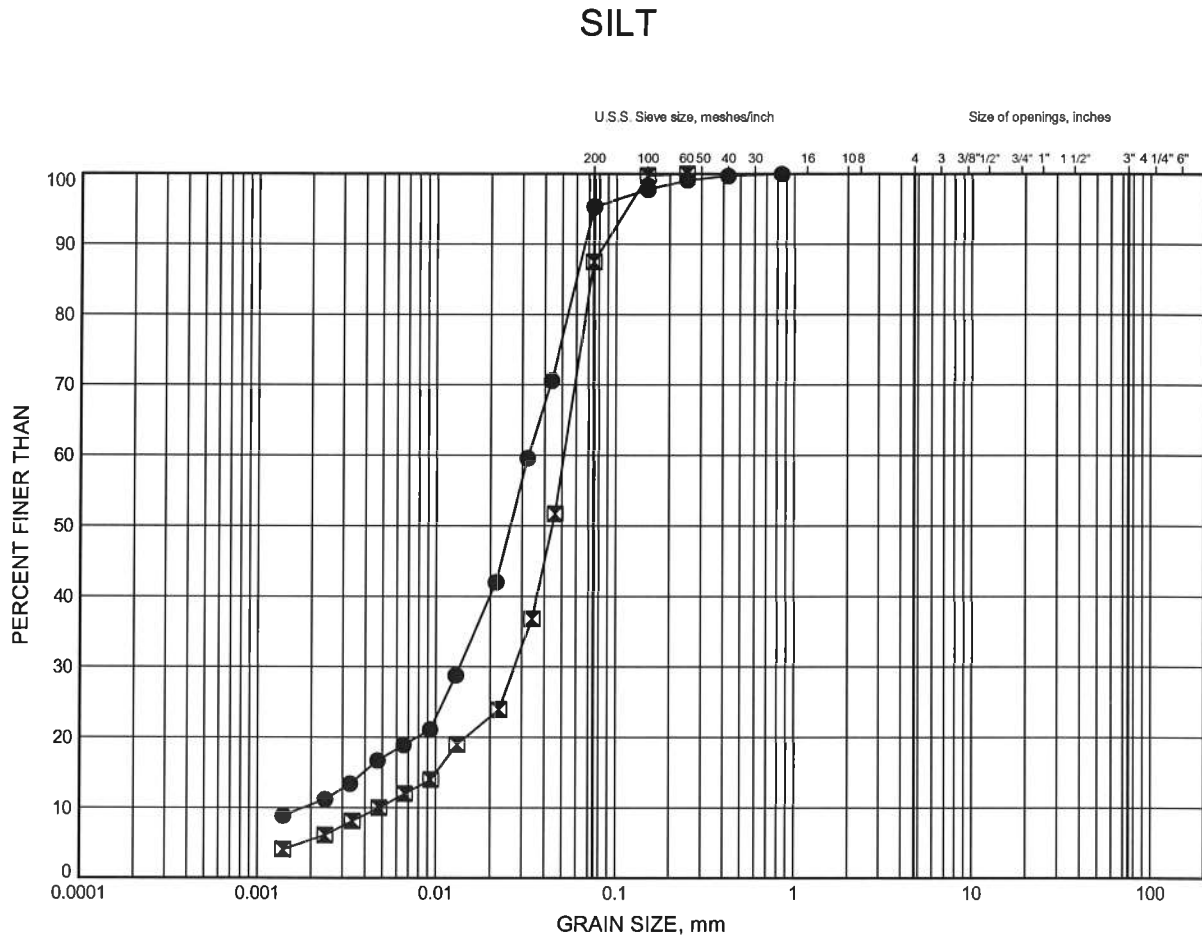


W.P.# 2539-04-00
Prepared By AN
Checked By .SKP

Widening of Hwy 400, Major Mackenzie to King Road

GRAIN SIZE DISTRIBUTION

FIGURE B2



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	2.59	260.91
⊠	10-04	7.92	257.18

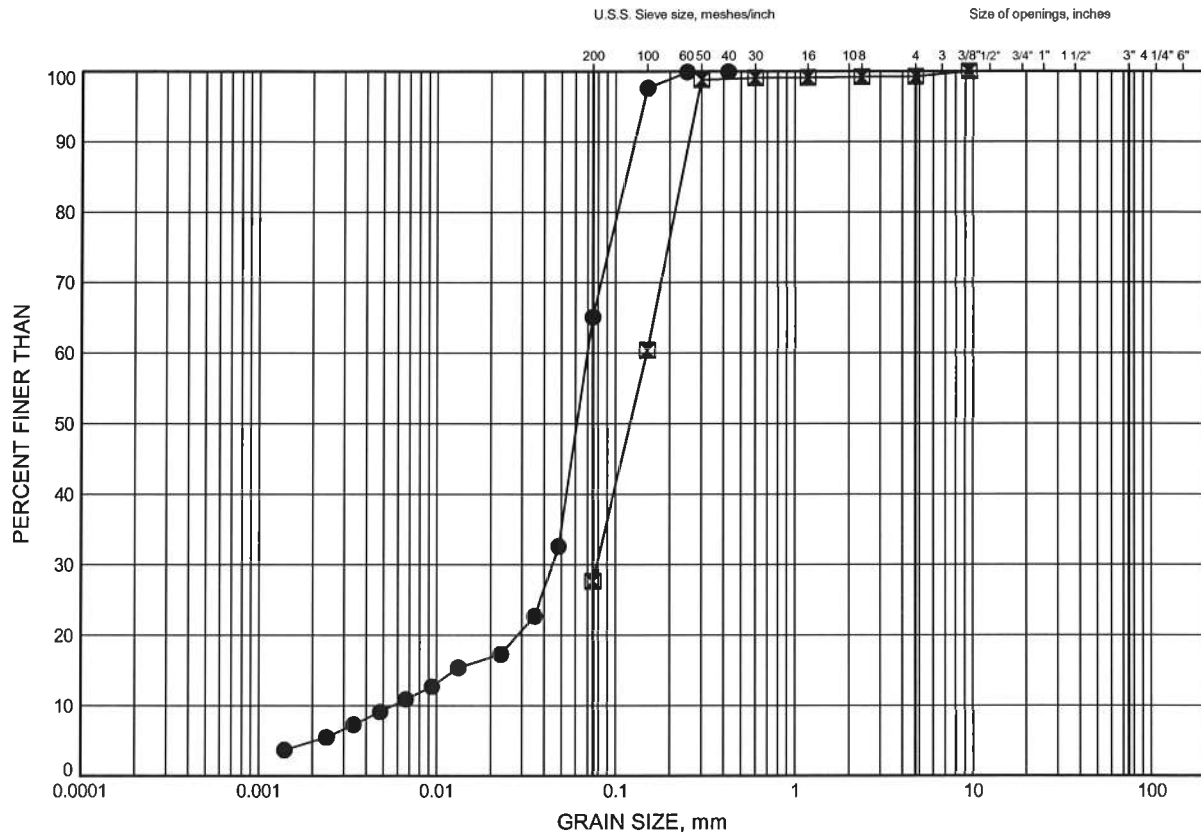


W.P.# 2539-04-00
 Prepared By .AN.
 Checked By .SKP.

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

FIGURE B3

SANDY SILT/SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	4.88	258.62
⊠	10-03	10.97	256.03

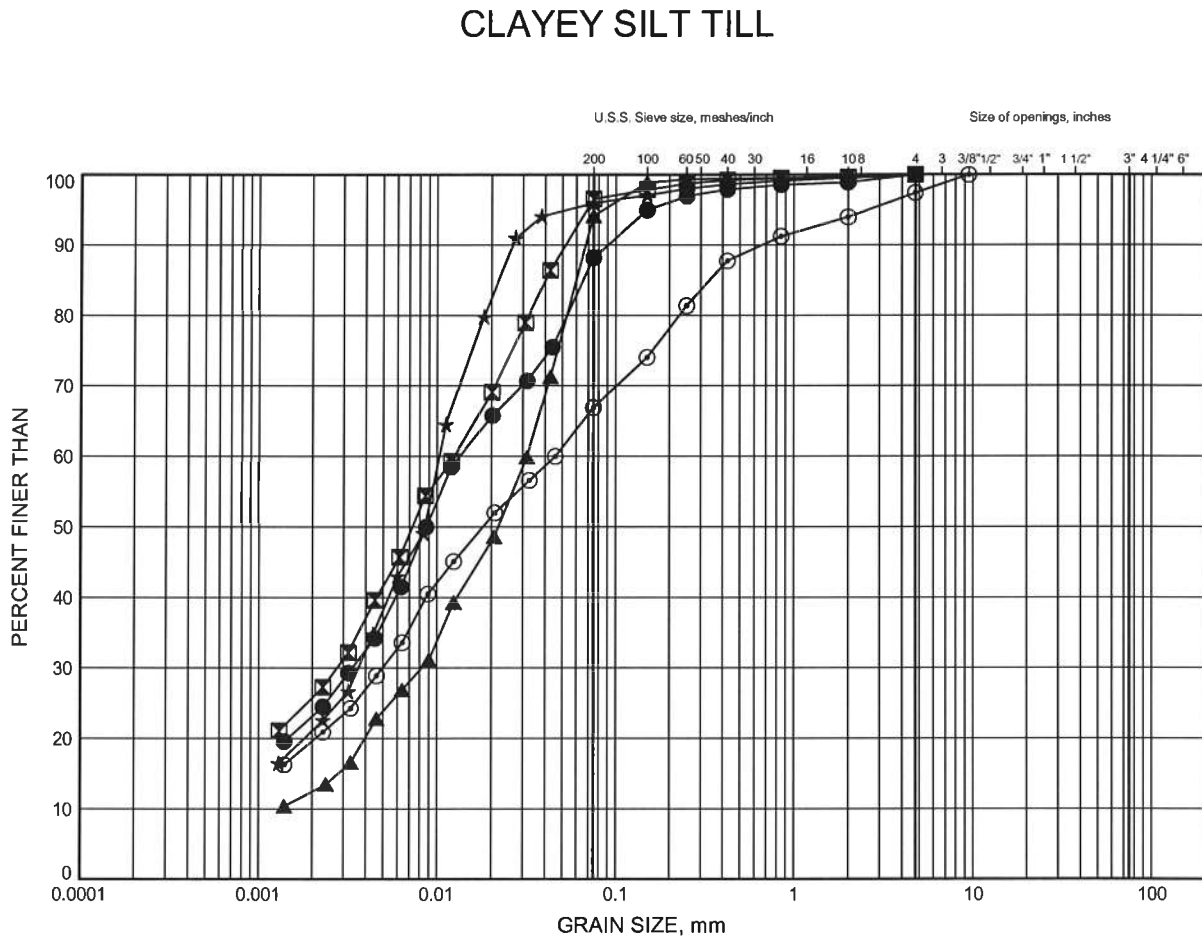


THURBER

W.P.# 2539-04-00
 Prepared By AN
 Checked By SKP

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

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-01	9.45	254.05
⊠	10-01	15.54	247.96
▲	10-01	18.59	244.91
★	10-03	7.92	259.08
⊙	10-04	4.88	260.22

GRAIN SIZE DISTRIBUTION - THURBER 9268.GPJ 1/26/11

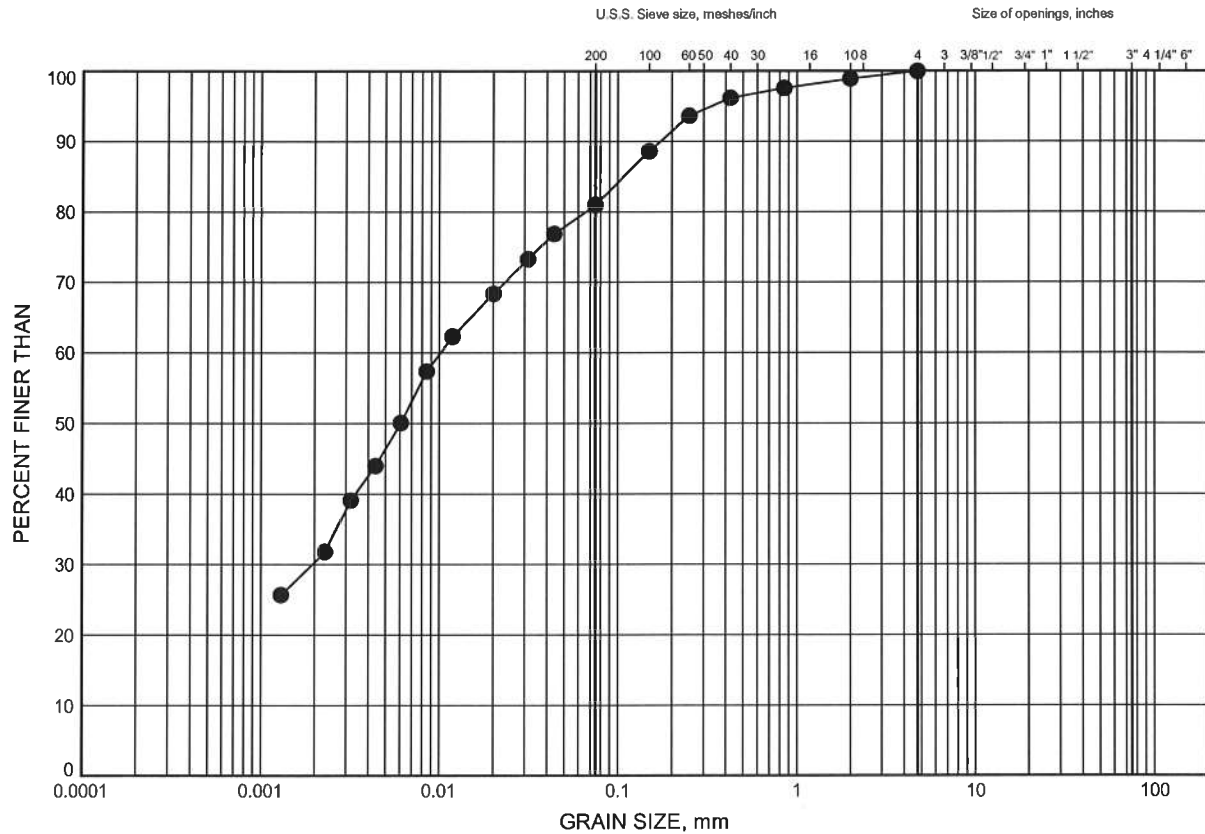
W.P.# .2539-04-00.....
Prepared By .AN.....
Checked By .SKP.....



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

FIGURE B5

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	10-03	3.35	263.65

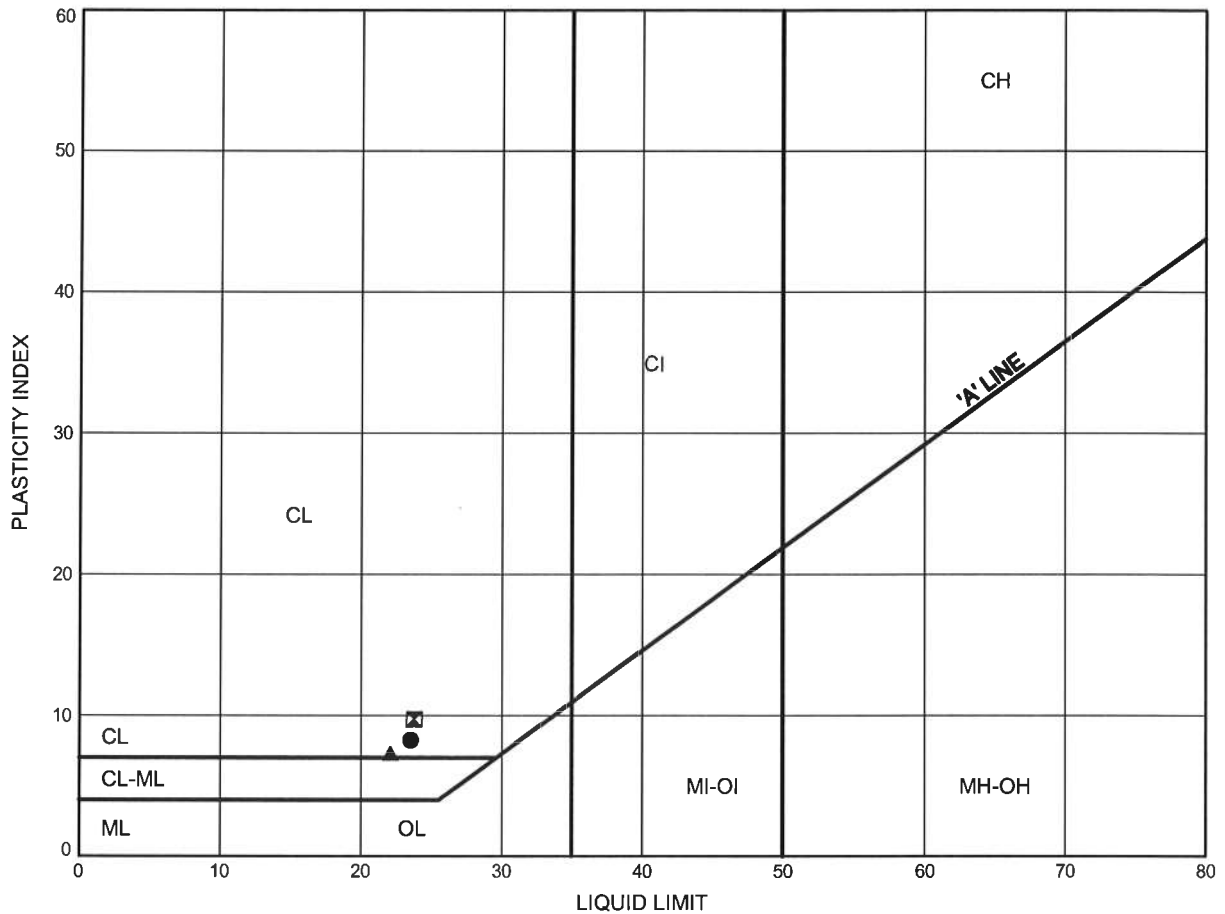


W.P.# 2539-04-00
Prepared By AN
Checked By SKP

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

FIGURE B6

CLAYEY SILT/SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	10-01	9.45	254.05
■	10-03	3.35	263.65
▲	10-04	4.88	260.22

Date February 2011

Project 2539-04-00



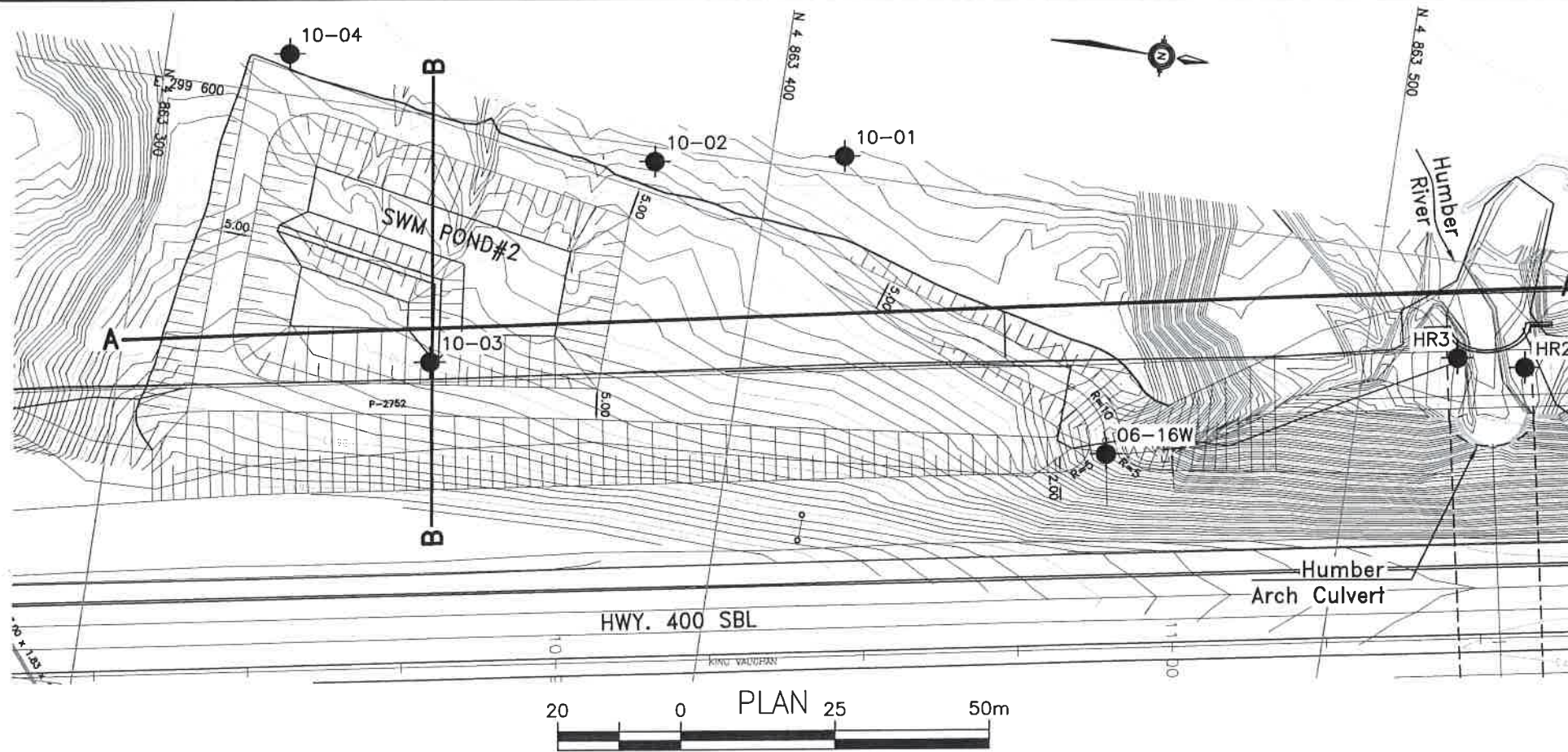
Prep'd AN

Chkd. SKP

Appendix C

Borehole Locations and Soil Strata Drawings

19-92-68



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

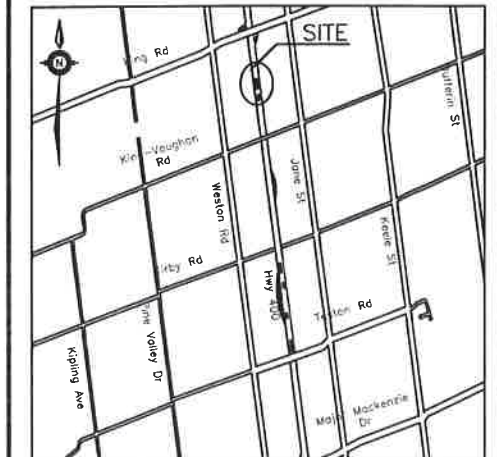
CONT No
WP No 2539-04-00

STORMWATER
MANAGEMENT POND # 2
BOREHOLE LOCATIONS AND SOIL STRATA

SNC-LAVALIN



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

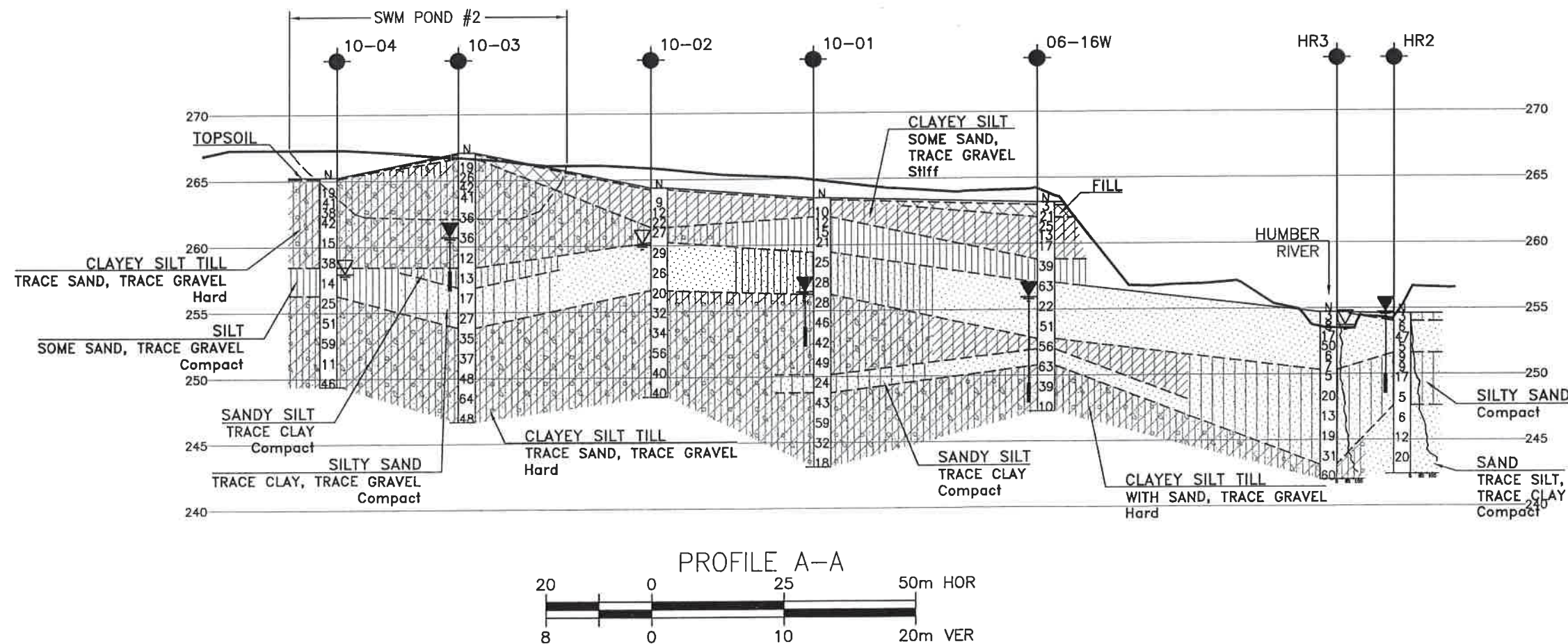
- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
06-16W	263.1	4 863 460.9	299 639.1
10-01	263.5	4 863 411.7	299 597.1
10-02	264.3	4 863 381.3	299 602.3
10-03	267.0	4 863 350.1	299 639.9
10-04	265.1	4 863 319.9	299 593.4
10-05	263.2	4 863 277.2	299 659.2
HR2	254.6	4 863 525.9	299 615.6
HR3	254.7	4 863 514.9	299 615.6

-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. 30M13-191



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SKP	CHK	SKP
DRAWN	AN	CHK	SITE
LOAD	STRUCT	DWG	DATE
			MAR. 2012

Appendix D
Selected Slope Stability Analysis Results

19-92-68

Thurber Engineering Ltd. - Toronto
 19-92-68
 SWM Pond #2 - Highway 400 Widening
 January 31, 2012
 Section B-B
 Pond to Floodplain - Drained

	Gamma kN/m ³	C kPa	Phi deg	Plezo Surf.
FILL	19	0	26	1
CLAYEY SILT	20	1	30	1
SAND	20	0	30	1
CLAYEY SILT TILL	21	3	32	1

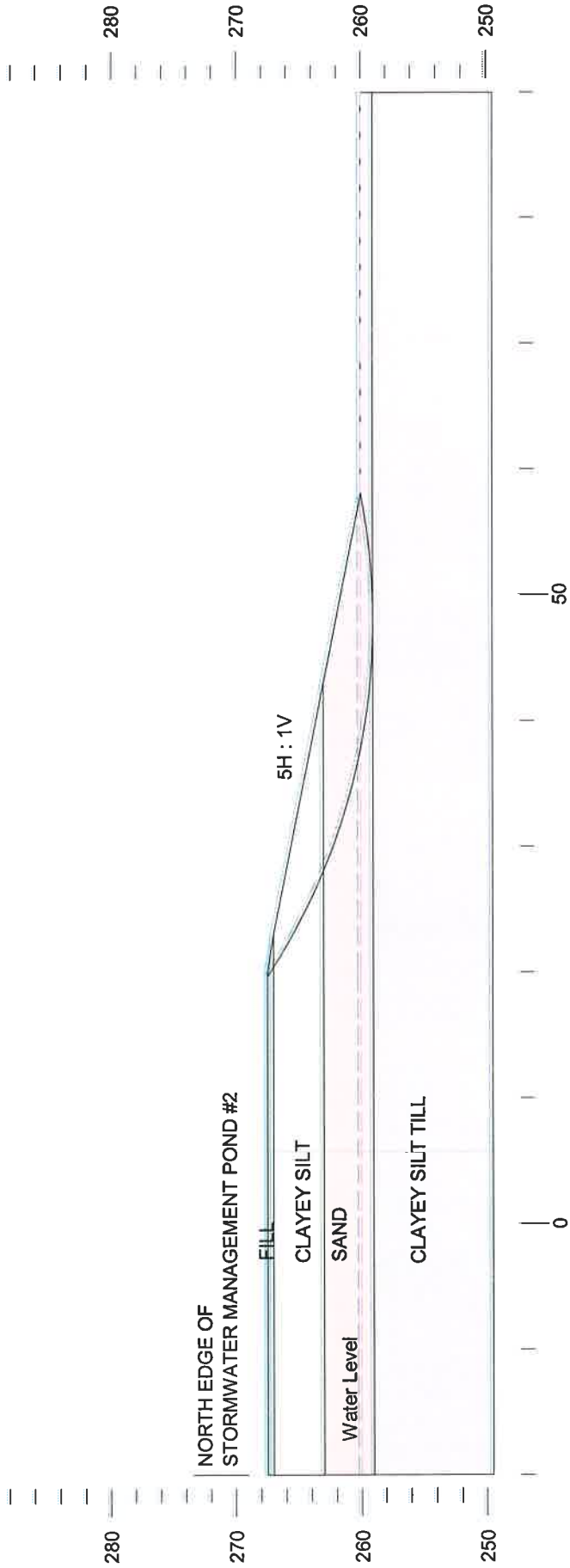
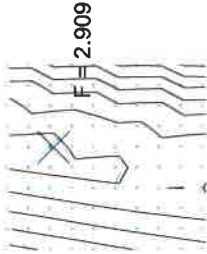


FIGURE D1

	Gamma	C	Phi	Piezo
	kN/m ³	kPa	deg	Surf.
FILL	19	0	26	1
SILT / CLAY	20	1	30	1
SANDS & SILTS	20	0	33	1
CLAYEY SILT TILL	21	3	32	1

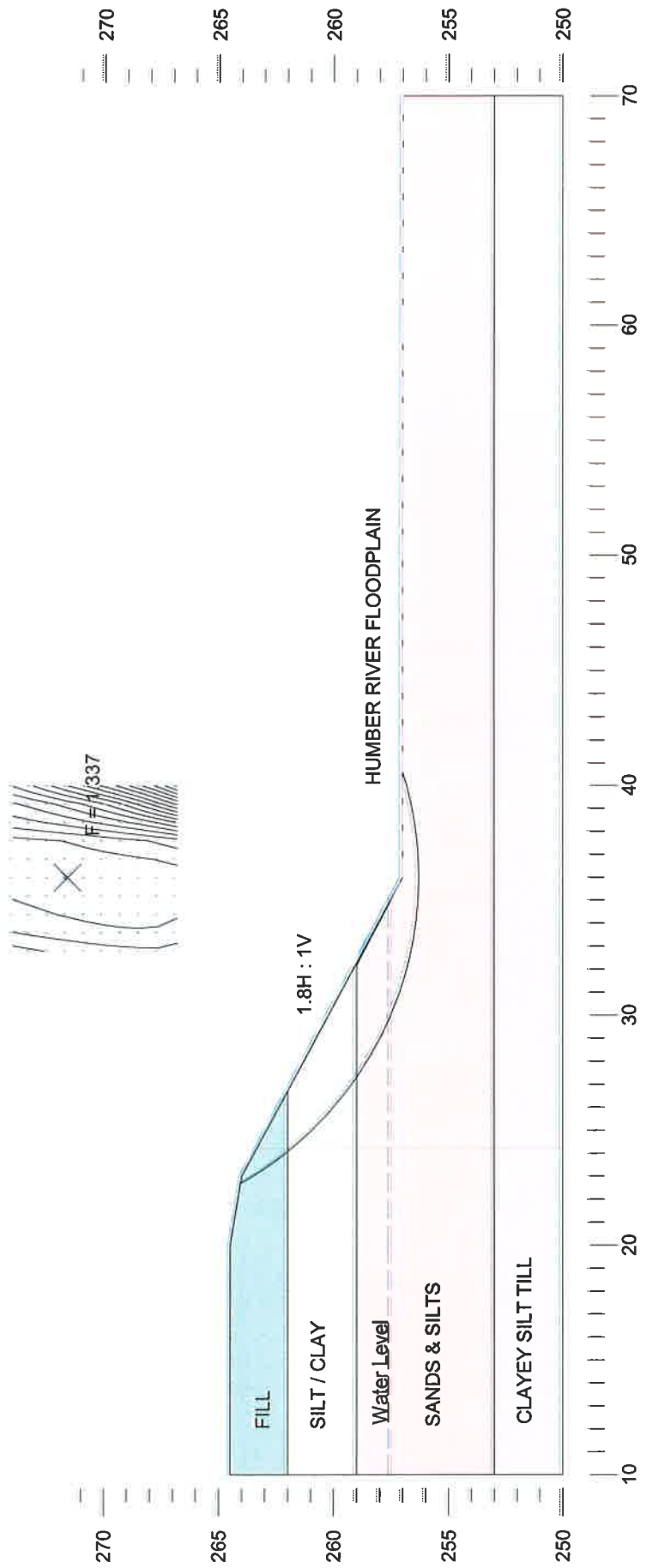


FIGURE D2

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
FILL	19	0	26	1
CLAYEY SILT	20	1	30	1
SAND	20	0	30	1
CLAYEY SILT TILL	21	3	32	1

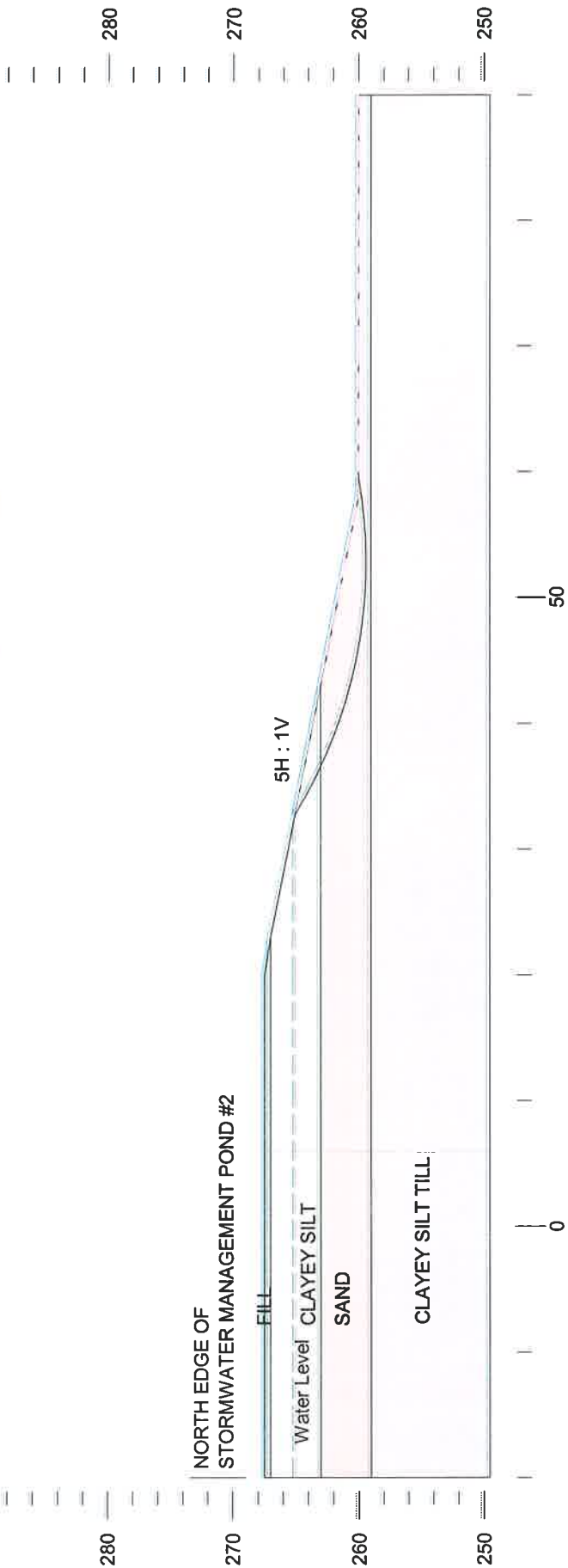
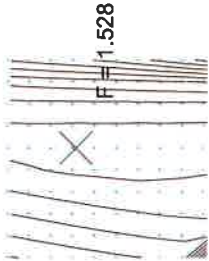


FIGURE D3

Thurber Engineering Ltd. - Toronto
 19-92-68
 SWM Pond #2 - Highway 400 Widening
 January 31, 2012
 Embankment Slope at 2:1 Station 10+875; Existing Condition
 Overall Highway Embankment Stability - Drained

	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
EMBANKMENT FILL	20	0	30	1
CLAYEY SILT TILL	20	3	32	1
SANDS AND SILTS	20	0	30	1

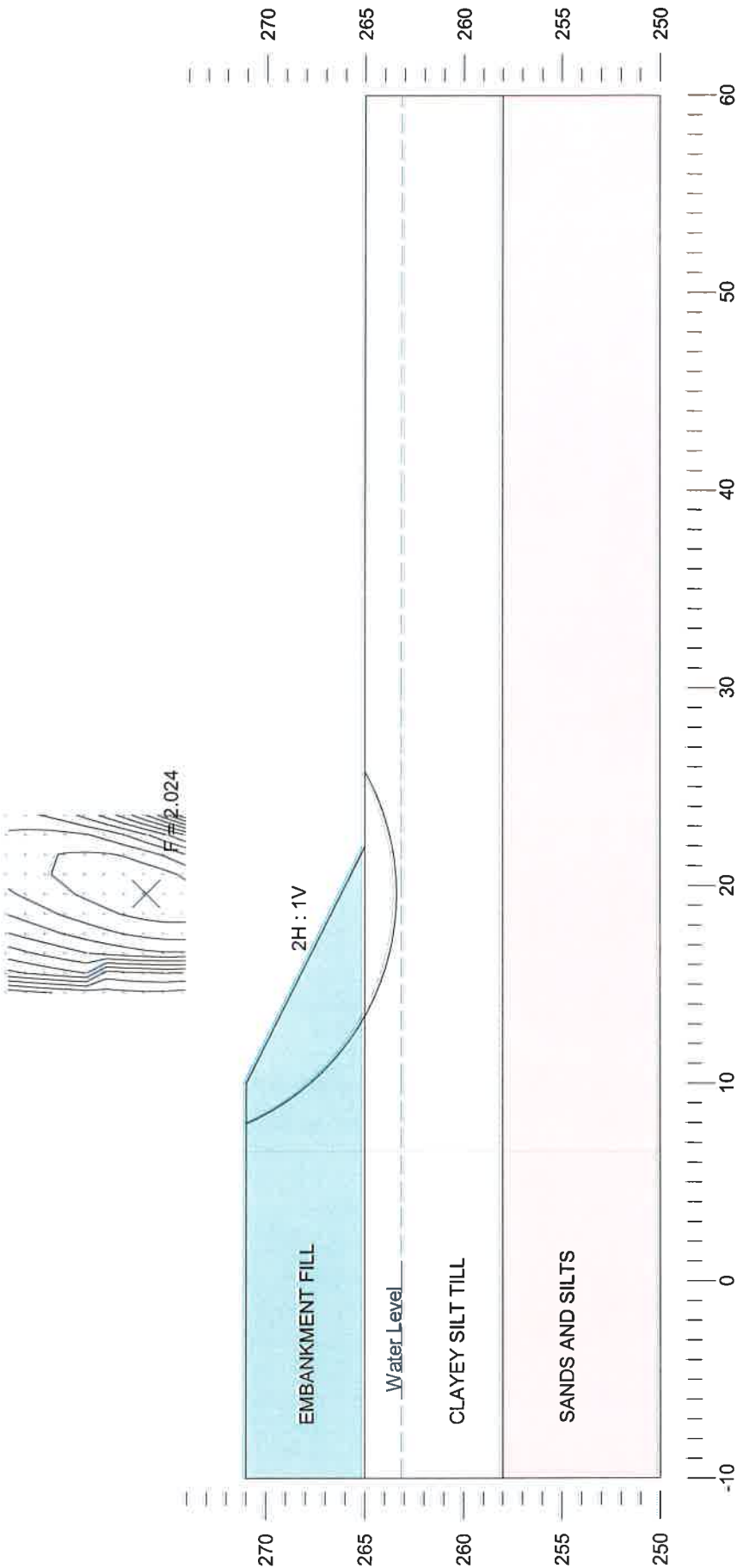


FIGURE D4

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
EMBANKMENT FILL	20	0	30	1
CLAYEY SILT TILL	20	100	0	1
SANDS AND SILTS	20	0	30	1

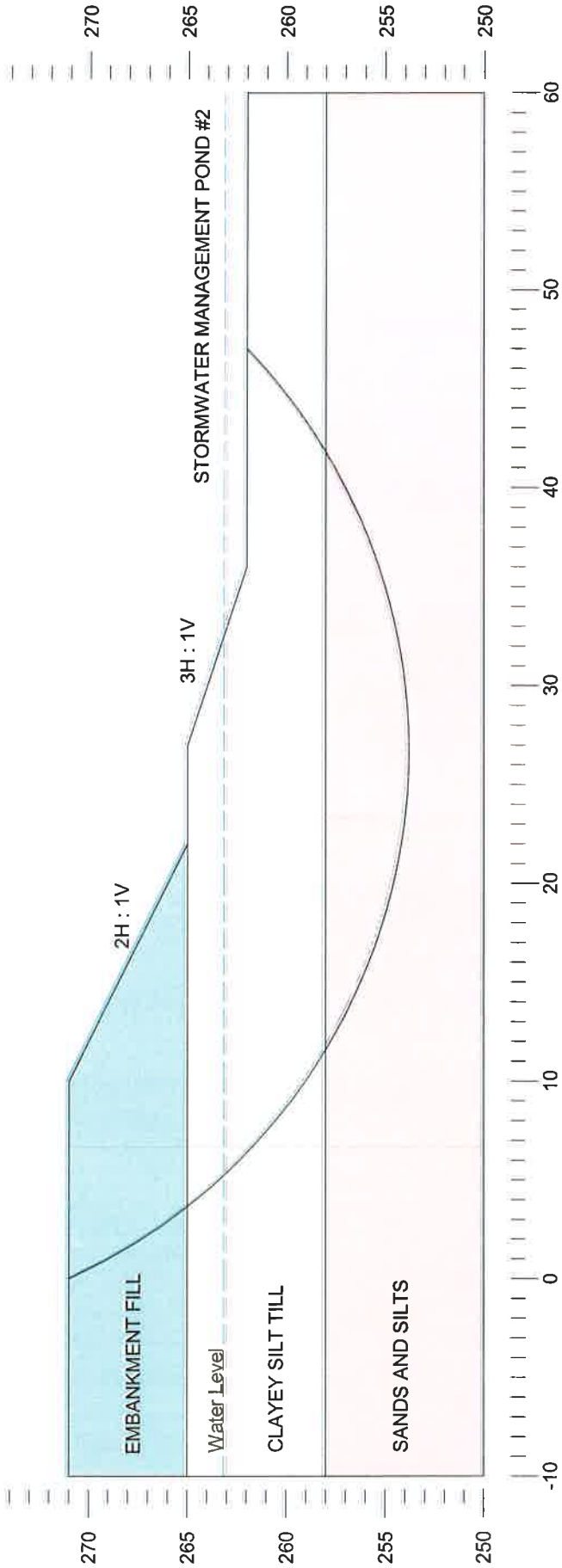
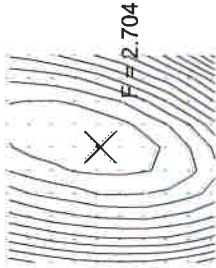


FIGURE D5

	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
EMBANKMENT FILL	20	0	30	1
CLAYEY SILT TILL	20	3	32	1
SANDS AND SILTS	20	0	30	1

Thurber Engineering Ltd. - Toronto
19-92-68
SWM Pond #2 - Highway 400 Widening
January 31, 2012
F = 1.892
bankment Slope at 2:1 Station 10+875; Pond Slope at 3:1
Overall Highway Embankment Stability - Drained

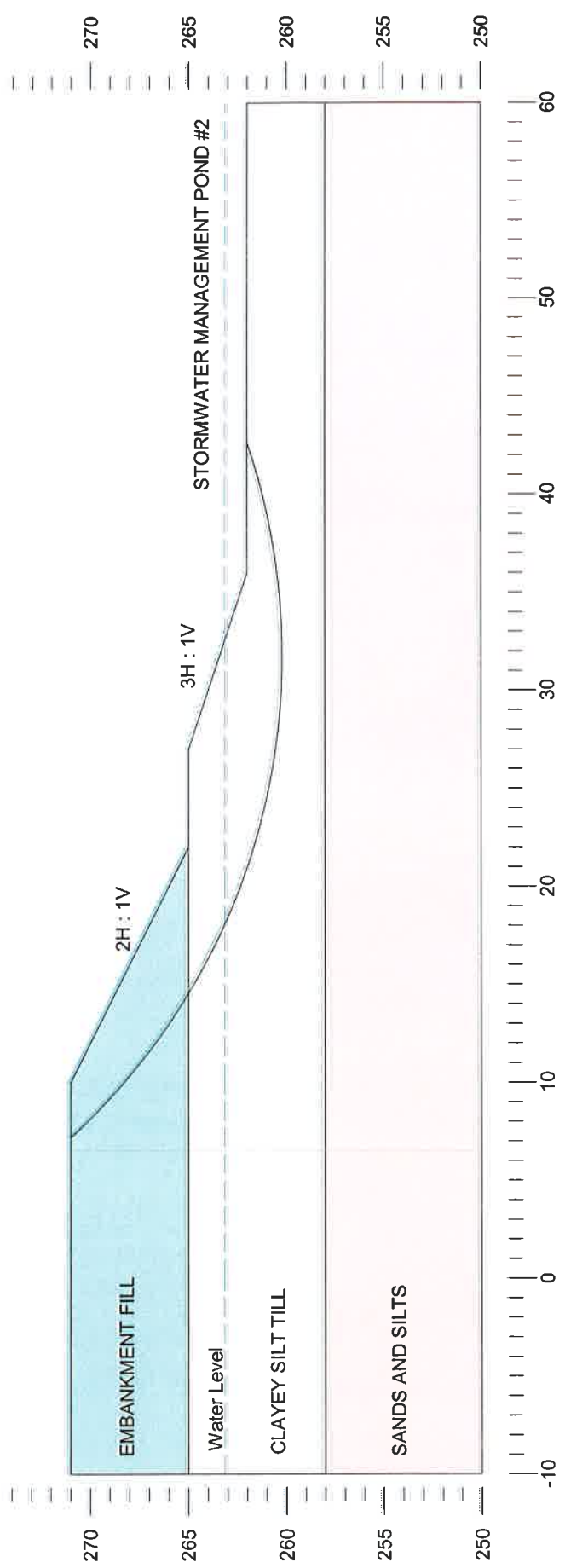


FIGURE D6

	Gamma kN/m ³	C kPa	Phi deg	Piezo Surf.
EMBANKMENT FILL	20	0	30	1
CLAYEY SILT TILL	20	3	32	1
SANDS AND SILTS	20	0	30	1

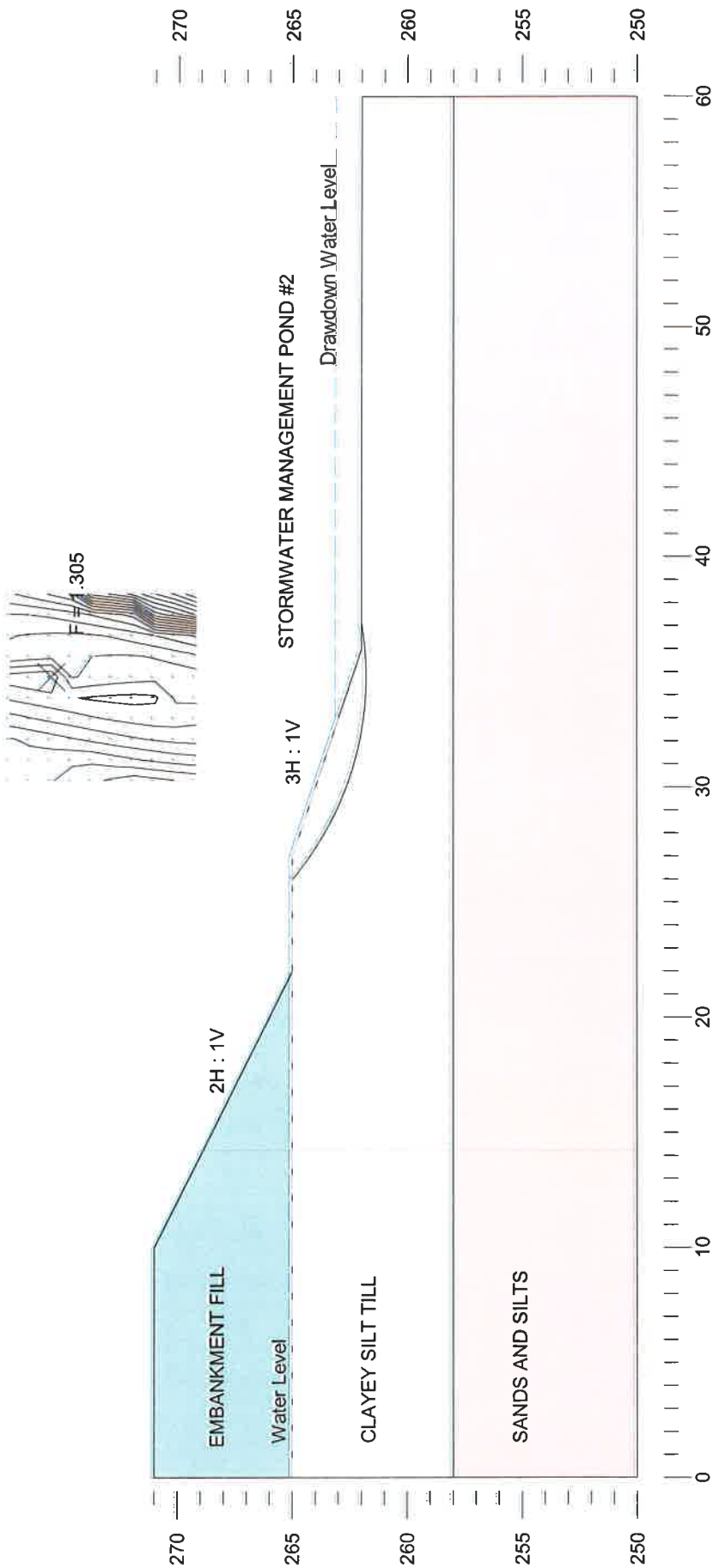


FIGURE D7

Appendix E
List of SPs and OPSSs
Suggested Text for Selected NSSPs

1. List of Special Provisions and OPSS Documents Referenced in this Report

- SP 105S21
- SP 206S03
- OPSS 804

2. Suggested Text for NSSP on “Impact on Adjacent Roadways”

- It is critical that the Contractor’s excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the adjacent Highway 400 embankment. Daily visual inspection of the pavement surface must be carried out in the vicinity of the excavation for pond construction. Any form of cracks, pavement distress or settlement that are observed must be immediately brought to the attention of the Contract Administrator for determining if remedial action is required.

3. Suggested Text for NSSP on “Construction Inspection”

- It is important that qualified geotechnical personnel be available to carry out tasks that include, but are not limited to, the following:
 - 1) Inspection is to be carried out periodically, or as required, during construction to confirm that the 5 m wide buffer zone between the highway embankment toe and the edge of the pond remains in place.
 - 2) Inspection is to be carried out periodically, or as required, to confirm stability of the pond excavation base and sideslopes throughout construction.
 - 3) Inspection is to be carried out once the final grades of the pond are reached to delineate water-bearing sands and silts that are exposed on the base and the sideslopes. Inspection and approval is required for the sub-excavation of these sands and silts followed by scarification and recompaction of the upper 0.5 m of the subgrade, or installation of a 0.5 m thick compacted clay liner.

All findings shall be reported at least on a daily basis, or as necessary, to the Contract Administrator (CA) before leaving the site.