FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 SOUTHBOUND LANES OVER
THREE MILE LAKE ROAD
HIGHWAY 11, HIGHWAY 518 WEST to HIGHWAY 520
G.W.P. 480-93-00, W.P. 476-93-01, SITE 44-395S

Geocres Number: 31E-230

Report to

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed bridge to carry the Southbound Lanes of the widened and re-aligned Highway 11 over Three Mile Lake Road at the village of Katrine, Ontario. A previous, preliminary investigation had been carried out at the site by Shaheen & Peaker Limited (S&P) and the factual data from that investigation has been incorporated in the current assignment.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed through considering a combination of the data from the previous S&P investigation and the data obtained in the course of the present investigation. This model describes the geotechnical conditions influencing design and construction of the foundations and approach embankments for the bridge.

Thurber carried out the investigation as a sub-consultant to Marshall Macklin Monaghan, under the Ministry of Transportation Ontario (MTO) Agreement Number 5005-A-000285.

2 SITE DESCRIPTION

The site lies on Three Mile Lake Road at a location where the road will be crossed by the proposed southbound lanes of Highway 11 at the Village of Katrine, Armour Township. The site lies approximately 170 m east of the existing Highway 11 centreline and approximately 200 m south of the Magnetawan River.

The general site area is located within the physiographic region known as the Canadian Shield, characterized by Pre-Cambrian bedrock typically occurring as rounded knobs and ridges where exposed. Locally, however, the site lies in the valley of the Magnetawan River, which is underlain by relatively deep deposits of glacio-fluvial and glacio-lacustrine soils.

The area to the north of the site, and lying between the road and the river, was formerly a trailer park but this business no longer occupies the site and trailers have been removed. The land to the south of the site is occupied by brush and recent second growth trees. The developed area of the village of Katrine lies along existing Highway 11, some 170 m to the west.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out site investigation and field testing for this project in two periods between July 21 and 29, 2004 and between October 12 and December 16, 2004. Boreholes were also drilled at the site between March 14 and April 2, 2001, as part of the preliminary investigation by Shaheen & Peaker Limited.

The current site investigation consisted of drilling and sampling a total of six boreholes. At the approach fills, boreholes were advanced to depths of approximately 10 to 11 m, with a dynamic cone penetration test (DCPT) advanced to 13.7 m at the north approach. Boreholes were advanced to depths to depths of 48.5 to 60.5 m at the at the foundation elements. The boreholes drilled at the foundation locations were supplemented by dynamic cone penetration tests.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

A combination of hollow stem auger and rotary drilling techniques were used to advance the boreholes and samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (SPT). Thin wall Shelby tube samples were taken in the cohesive soils and the insitu strength was assessed using the MTO shear vane.

Where significant proportions of cobbles and boulders were encountered and soil boring and SPT sampling were not feasible, diamond coring techniques were employed to penetrate the soils.

The positions of the principal boreholes considered in the preparation of this report, relative to the structure site are as shown in Table 3.1.

Table 3.1 – Borehole Locations Relative to Structure

Location on Structure	Boreholes Considered in Design
South Approach	TML-5
South Abutment	TML-6, TMS4*
South Pier	TML-1
North Pier	TML-12, TMS2*
North Abutment	TML-7
North Approach	TML-8

* Boreholes drilled by S&P in 2001

The coordinates and elevations of the boreholes are given on the Borehole Locations and Soil Strata Drawing and on the individual Record of Borehole Sheets in Appendix A.

Standpipe piezometers, consisting of 19 mm PVC pipe with slotted tips, were installed in each of four boreholes drilled at the foundation elements to monitor the groundwater level. A piezometer was also installed in one of the deep boreholes drilled in the course of the preliminary investigation.

The completion details for the current piezometers are shown in Table 3.2.

Table 3.2 – Piezometer Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation	Completion Details
BH TML-6	48.2/248.1	Bottom of borehole at 52.0m. Piezometer with 1.5 m tip installed at 48.2. Sand filter to 44.8, grout to 1.2 and bentonite seal to 0.6, cuttings to the surface.
BH TML-7	47.2/247.5	Bottom of borehole at 48.5m. Piezometer with 1.5 m tip installed at 47.2. Sand filter to 44.8, bentonite seal to 44.3, grout to the surface.
BH TML-11	59.4/236.8	Bottom of borehole at 60.5m. Piezometer with 1.5 m tip installed at 59.4m. Sand filter to 56.1, bentonite seal to 55.6 grout to the surface.
BH TML-12	48.8/246.0	Bottom of borehole at 51.5m. Piezometer with 1.5 m tip installed at 48.8m. Sand filter to 46.5, bentonite seal to 45.5 grout to the surface.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes and the recovered samples and processed them for transport to Thurber's Oakville office.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A.

Selected samples were subjected to gradation analysis (sieve and hydrometer) and Atterberg limit tests and the results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B. A total of thirty two samples were selected for this testing.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix A and in Appendix C. Details of the encountered soil stratigraphy are presented in these appendices and on the attached Borehole Locations and Soil Strata Drawing. An overall description of the stratigraphy is given in the following paragraphs however the factual data presented in the borehole logs governs any interpretation of the site conditions.

The soil stratigraphy encountered at this site is consistent with that encountered in much of the Highway 11 corridor between Huntsville and North Bay. Glacial outwash soils deposited in glacio-fluvial and glacio-lacustrine environments overlie a deposit of very dense sand with gravel, cobbles and boulders. This latter material typically mantles the bedrock but none of the boreholes at this site encountered bedrock, instead terminating in the very dense sand with cobbles and boulders.

In general terms, the site was found to be underlain by a thin veneer of topsoil over layers of silt, silty clay, silt, sand and gravelly sand with cobbles and boulders.

More detailed descriptions of the individual strata are presented below.

5.2 Topsoil

Topsoil was identified across the site, with the measured thicknesses ranging from 50 mm at the north approach to 300 mm at the piers, south abutment and south approach. These values represent only the topsoil thicknesses at the borehole locations and should not be relied upon to establish quantities across the site.

5.3 Fill

Although not encountered in the investigation program, granular material and possibly earth fill should be expected within the Three Mile Lake Road platform.

5.4 Silt to Silty Sand

A layer of fine-grained non-cohesive soil ranging from silt to silty sand was encountered below the topsoil or ground surface from the south approach to the north abutment, but appeared to have tapered out under the north approach. The soils were found to be more silty to the south and sandier to the north.

Based on SPT values ranging from 3 to 22 blows for 0.3 m of penetration, the deposit is classified as very loose to compact. The DCPT results confirm this description.

The measured natural moisture contents range from 19 to 25% and the soil is described as moist to wet

The layer of silt ranges in thickness from 1.0 m in the north abutment to 2.8 m at the south abutment. The base of the layer lies between Elevation 293.7 at the south abutment to 292.4 at the north pier.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure B1 in Appendix B.

5.5 Silty Clay

The soils described above are underlain by a deposit of silty clay that extends across the entire site. Based on the recorded SPT values ranging from 1 to 36 blows for 0.3 m of penetration, the clay would be classified as very soft to hard. However, taking account of the vane shear strengths, which generally range from 60 to over 100 kPa, the clay is in fact classified as stiff to very stiff.

The clay is silty and layered, with the percentage of silt varying between layers. The plasticity of the clay ranges from low to high, as shown in Figures B11 and B12 in Appendix B.

The recorded natural moisture contents in the clay ranged from 25 to 50% and the soil is described as moist. At the upper end, the range of moisture contents equalled or slightly exceeded the liquid limit of the clay.

The thickness of the clay layer ranges from 1.8 m at the north abutment to 6.4 m at the south abutment. The base of the clay layer lies at Elevation 290.2 at the north approach to Elevation 287.1 at the south pier.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figures B2 and B3 in Appendix B.

A one-dimensional consolidation test was carried out on a sample collected from a Shelby tube in borehole TML6 at 6.48 m depth (ELEV. 289.8). The consolidation parameters are summarized below in Table 5.1. Detailed test results are summarized in Appendix B.

Table 5.1: Consolidation Test Results

Borehole	Sample Depth (m)	Insitu Sigma (kPa)	w (%)	e_o	p' (kPa)	OCR	Cc	Cr	LL
TML 6	6.48	77.0	38	1.02	70	0.9	0.19	0.05	34

5.6 Silt

A layer of silt was encountered below the silty clay and extending across the site. This soil is predominantly silt-sized, with trace to some sand sizes and trace clay-sized particles. Based on SPT values generally ranging from 6 to 24 blows for 0.3 m of penetration, the silt is classified as loose to compact. Lower SPT values were recorded for some samples but these are attributed to sample disturbance due to unbalanced groundwater conditions at the base of the borehole.

The measured natural moisture contents ranged from 19 to 39% and the soil is described as wet.

The thickness of the silt layer ranged from 1.5 m at the north approach to 3.3 m at the north pier. The base of the silt layer lay between Elevation 288.7 at the north approach and Elevation 285.1 at the south abutment.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure B4 and B5 in Appendix B.

5.7 Sand

The silt layer is underlain by a layer of uniform, fine grained sand that forms a substantial thickness across the site. Based on SPT values ranging generally from 5 to higher than 100 blows for 0.3 m of penetration, this sand is classified as loose to very dense. Isolated lower values were recorded but are not considered to be representative of the stratum. The occasional SPT value of 1 or 2 is considered to be due to sample disturbance.

The measured natural moisture contents ranged from 17 to 30% and the soil is described as wet.

The thickness of this soil layer varied from 31.3 m at the north abutment to 38.8 m at the south pier. The underside of the sand layer ranged from Elevation 254.5 at the north abutment to 246.5 at the south pier.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figures B6, B7 and B8 in Appendix B.

5.8 Interbedded Silt

Under the area of the south abutment and south pier, a discontinuous layer of silt was found interbedded in the sand. Based on SPT values of 30 to 33 blows for 0.3 m of penetration, this silt layer is classified as dense.

The measured natural moisture contents ranged from 21 to 23% and the soil is described as wet.

The thickness of this soil layer varied from 3.1 m at the south abutment to 3.2 m at the south pier. The underside of the silt layer ranged from Elevation 266.8 at the south abutment to 264.8 at the south pier.

The grain size distributions of selected samples of this soil are plotted on the Record of Borehole sheets and shown in Figure B9 in Appendix B.

5.9 Sand With Cobbles and Boulders

Below the fine grained sand described in the previous paragraph, the boreholes encountered a layer described as sand and gravel. The grading of the sand ranged from fine to coarse and it contained varying percentages of gravel. Cobbles and boulders were also encountered in varying quantities, ranging from occasional to frequent. Based on SPT values ranging from 25 blows for 0.3 m of penetration to values in excess of 100 blows for 0.3 m of penetration, this deposit is classified as compact to very dense. All boreholes reaching this deposit were terminated after proving a minimum of 3.0 m of material with SPT values exceeding 100 blows for 0.3 m of penetration or at least 3.0 m of material containing numerous cobbles and boulders.

Where they could be measured, natural moisture contents ranged from 10 to 20% and the deposit is described as wet.

This deposit was not fully penetrated by any borehole but the thicknesses penetrated by sampling ranged from 4.1 m at the south abutment to 10.8 m at the south pier. The borehole termination ranged from Elevation 246.2 at the north abutment to Elevation 235.7 at the south pier.

The grain size distribution of a selected sample of this soil is plotted on the Record of Borehole sheet and shown in Figure B10 in Appendix B.

5.10 Depths to Refusal

The depths at which effective refusal was encountered, defined as an SPT value exceeding 100 blows for 0.3 m of penetration or a high frequency of cobbles and boulders are shown in Table 5.2.

Table 5.2 – Refusal Depths (Elevations)

Location	Borehole	Refusal Elevation (m)	Material
South Abutment	TML-6	47.8 (248.5)	Very dense sand and gravel with cobbles and boulders
South Pier	TML-11	49.7 (246.5)	
North Pier	TML-12	41.5 (253.3)	
North Abutment	TML-7	40.1 (254.6)	

5.11 Water Levels

The initial and final groundwater depths and elevations are shown in Table 5.3.

Table 5.3 – Groundwater Depths (in metres) and Elevations

Date	South Abutment		South Pier		North Pier		North Abutment	
	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
Mar 21/01	-	-	-	-	+0.3	295.1	-	-
Mar 23/01	-	-	-	-	0.0	294.8	-	-
Apr 3/01	-	-	-	-	0.0	294.8	-	-
Apr 11/01	-	-	-	-	+0.1	294.1	-	-
Oct 7/04	0.9	295.4	-	-	-	-	-	-
Nov 15/04	-	-	-	-	-	-	+0.7	295.4
Jan 5/005	1.3	295.0	0.0**	296.2	+0.3	295.1	+0.5	295.2
Jan 20/05	2.0	294.3	0.0**	296.2	+0.3**	295.1	+0.6	295.3

* "+" values denote water level above ground surface, i.e. artesian condition.
** Water frozen in piezometer tube.

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 influenced by the river level and may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The artesian water levels recorded relate to pressure in the sand and gravel layer about Elevation 240 to 250. No artesian flow occurred at the ground surface after the borehole was completed.

6 MISCELLANEOUS

Field layout for the site investigation was carried out by surveyors from Marshall Macklin Monaghan, who provided the coordinates and ground surface elevation data to Thurber.

The drill rigs and sampling equipment used in the investigation were supplied and operated by All-Terrain Drilling of Waterloo, Ontario and Eastern Ontario Diamond Drilling Limited of Hawkesbury, Ontario.

Full time supervision of field activities, including obtaining utility clearances was carried out by Mr. Jason Lee, B.Sc., Mr. Warren Wunderlick and Mr. George Azzopardi of Thurber.

Interpretation of the data and preparation of the report were carried out by Mr. Steven Sather, P.Eng.

Overall supervision of the field program, interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng..

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

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach fills for the proposed structure.

A three-span, 64 m long, CPCI girder structure is proposed at this site and integral abutments are under consideration.

The approaches to the bridge will lie on comparatively flat, low-lying land close to the flood plain of the Magnetawan River. The finished grade at the south abutment will lie at Elevation 304.3 and the original ground surface is at Elevation 296.3, resulting in an 8.0 m high embankment.

The finished grade at the north abutment will lie at Elevation 303.6 and the original ground surface at this location is at Elevation 294.7, giving a total embankment height of 8.9 m.

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigation.

8 STRUCTURE FOUNDATIONS

Foundation alternatives are presented in the following sections together with the corresponding geotechnical design parameters. A preferred foundation scheme from a foundations perspective is recommended.

Based on the results of the exploratory boreholes drilled at the proposed abutment and pier locations, the stratigraphy consists of approximately 40 to 50 m of silt, silty clay and fine grained sand overlying a stratum of sand and gravel with cobbles and boulders.

Initial consideration was given to the following foundation types:

- Spread footings on native soil
- Spread footings on engineered fill
- Driven steel H-piles
- Caissons (drilled shaft piles)

Appendix D contains a table presenting a comparison of the technical advantages and disadvantages of the different foundation schemes at this site.

8.1 Spread Footings

8.1.1 Footings on Native Soil

The existing native soils lying immediately below the ground surface are considered unsuitable for the support of spread footings due to low bearing resistance and the potential for unacceptably large settlements.

Accordingly spread footings founded on native soil were eliminated from further consideration.

8.1.2 Footings on Engineered Fill

These soil conditions are considered unsuitable for the support of structure foundations on an engineered fill pad due to the low bearing resistance available in the native soil underlying the engineered fill and the potential for comparatively large settlements.

Accordingly spread footings founded on engineered fill pads were eliminated from further consideration.

8.2 Driven Steel Piles

The geotechnical conditions encountered at this site are considered suitable for driven steel H-pile foundations.

The stratigraphy at this site is such that driven H-piles may develop both skin friction in the main sand stratum and end bearing in the very dense sand and gravel layer below approximately Elevation 254 at the north pier and north abutment and 248 at the south pier and south abutment. However, due to the depth to this layer, approximately 50 m, the piles may develop the required resistance entirely as friction piles in the overlying sand. Accordingly, The SLS values of pile resistance have been selected to reflect the possibility of the pile developing friction in the sand. The same ULS values may be used in either case.

The piles should be designed on the basis of the axial geotechnical resistances given in Table 8.1. The axial capacities listed in the table are based on static analysis using effective stress parameters for both toe and shaft resistance. Higher capacities may be possible if dynamic or static in-situ pile testing is carried out to verify the design capacities.

Table 8.1 – Pile Geotechnical Resistance

Pile Section	Piles Driven Into Sand with Cobbles and Boulders	
	ULS (Factored)	SLS (25 mm Settlement)
HP 310 X 110	1,800 kN	1,200 kN
HP 360 X 132	2,100 kN	1,500 kN

The estimated tip elevations at which the piles will achieve the end bearing resistance, assuming frictional resistance does not develop, are given in Table 8.2.

Table 8.2 – Pile Tip Elevations

Location	Borehole	Elevation (m)
South Abutment	TML-6	248.5
South Pier	TML-11	246.5
North Pier	TML-12	253.3
North Abutment	TML-7	254.6

The pile tip elevations shown in Table 8.2 should be used for cost estimating purposes only. The actual pile tip elevations will be controlled as described in Section 8.2.3 Pile Driving.

8.2.1 Pile Tips

Due to the presence of cobbles and boulders in the sand and gravel layer the all pile tips must be protected by bearing points. Suitable bearing points include the Titus Steel Company: Rock Injector or the APF Hard Bite or an equivalent product from an approved manufacturer.

8.2.2 Pile Installation

Pile installation should be in accordance with Special Provision No. 903S01.

The Contract Documents should contain a NSSP alerting the Bidders to:

- The presence of cobbles and boulders in the potential bearing stratum.
- The possibility of piles within a group achieving the specified resistance at different elevations.
- The possibility of some piles meeting refusal on a large boulder.

The NSSP should require the QVE to terminate driving before the pile is damaged by overdriving.

To facilitate pile installation, embankment fill through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size.

8.2.3 Pile Driving

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles have been driven below Elevation 255. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile". "R" must have the minimum values shown in Table 8.3.

Table 8.3 – Ultimate Geotechnical Resistance of Piles

Pile	Ultimate Resistance (R) (kN)
HP 310X110	3,600 kN
HP360X132	4,200 kN

8.2.4 Downdrag

A layer of over-consolidated silty clay underlies the site. The stress increase associated with the proposed approach embankments may approach the pre-consolidation pressure of the clay and induce small long-term secondary consolidation settlements. The downdrag forces will develop along the length of pile embedded in the silty clay and the overlying native soil and fill.

A check for the effects of downdrag forces should be performed in accordance with Section 6.8.4 of the CHBDC. For the purpose of this check, the downdrag forces shown in Table 8.4 should be used.

Table 8.4 – Downdrag Forces on Abutment Piles

	South Abutment		South Pier	
Pile Type	HP 310x110	HP 360x132	HP 310x110	HP 360x132
Factored downdrag force (f = 1.25)	120 kN	140 kN	-	-
	North Abutment		**North Pier**	
Pile Type	HP 310x110	HP 360x132	HP 310x110	HP 360x132
Factored downdrag force (f = 1.25)	60 kN	80 kN	-	-

Downdrag forces have been calculated assuming that the negative skin friction will be mobilized at the outside perimeter of the "H" pile in the silty clay and overlying soils. For the pier foundations, negative skin friction is assumed to apply up to the underside of the pile cap. At the abutments, negative skin friction is assumed to apply up to the underside of the 3.0 m long CSP installed as part of the integral abutment design.

If less than 2 m of fill is placed around the piers, negative skin friction will not be an issue at the pier foundations.

8.2.5 Lateral Resistance of Piles

The lateral resistance of the piles may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h \, . \, z / D \quad (kN/m^3)$$

$$p_{ult} = 3 \, . \, \gamma \, . \, z \, . \, K_p \quad (kPa)$$

where

where	z	=	depth of embedment of pile in metres
	D	=	pile width in metres
	n_h	=	coefficient of horizontal subgrade reaction (Table 8.5)
	γ	=	unit weight (Table 8.5)
	K_p	=	passive earth pressure coefficient (Table 8.5)

For cohesive soil k_s and p_{ult} are calculated from the undrained shear strength and are independent of depth. The relevant values can be taken directly from Table 8.5 on the following page.

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s*L*D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}*L*D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance assumed in one pile be limited to no more than 150 kN at ULS and 50 kN at SLS.

Table 8.5 – Parameters for Lateral Pile Resistance

Location	Elevation	Soil Type	Density/ Consistency	n_h (kN/m^3)	K_p	Unit Weight* (kN/m^3)
South Abutment	296.3 to 293.3	Silt	loose to compact	1,200	3.0	10
	293.3 to 288.2	Silty Clay	firm	k_s = 70,000 (kN/m^3)	p_{ult} = 700 (kN/m^2)	9
	288.2 to 275.0	Silt to Sand	compact	1,600	3.0	10
	275.0 to 248.5	Sand to Silt	compact to dense	3,000	3.0	10
	Below 248.5	Sand & Gravel	very dense	8,000	4.0	11
North Abutment	294.7 to 293.6	Sand	loose	1200	2.8	9
	293.60 to 288.9	Silty clay	firm to stiff	k_s = 70,000 (kN/m^3)	p_{ult} = 700 (kN/m^2)	9
	288.9 to 254.5	Silt to Sand	very loose to compact	3,000	3.0	10
	Below 254.5	Sand & Gravel	very dense	8000	4.0	11

* Buoyant unit weight below the water table.

The modulus of subgrade reaction may have to be reduced, based on the pile spacing.

The following reduction factors should be used for a pile group oriented ***perpendicular*** to the direction of loading.

Pile spacing	Reduction Factor
4D	1.00
1D	0.5

The following reduction factors should be used for a pile group oriented ***parallel*** to the direction of loading.

Pile spacing	Reduction Factor
8D	1.00
6D	0.7
4D	0.4
3D	0.25

--- where "D" is the breadth of the pile, spacing is centre to centre

Intermediate values may be obtained by linear interpolation.

Except in the case of integral abutments, i.e. not integral, it is recommended that horizontal loads be resisted by means of batter piles.

8.3 Caissons

The soil conditions, and more particularly the groundwater conditions at this site are not considered to be suitable for caisson foundations. To achieve the high resistance necessary to justify the construction costs, the caissons would have to be founded in the very dense sand and gravel with cobbles and boulders.

When attempting to found in the very dense sand and gravel, it would be impossible to achieve a seal and slurry excavation and tremie concreting would be necessary.

Caissons are also not considered to be suitable for construction on a batter to resist horizontal loads.

On the basis of the installation difficulties and risks assessed for this site, caissons are not recommended.

8.4 Recommended Foundation

The recommended foundation system for all foundation elements at this site is steel H-piles driven to effective refusal as controlled by application of the Hiley formula.

8.5 Abutment Type

From a geotechnical perspective, the subsurface conditions at this site are considered to be suitable for the construction of conventional, semi-integral or integral abutments. However, the recommended foundation system of H-piles makes integral abutments a feasible option.

The integral abutment design requires that the piles posses flexibility in the upper 3 m of the pile length. Accordingly, to provide the required flexibility in the piles, the upper 3 m of the piles should be surrounded by one of the following systems:

- For a "true abutment" supported on top of the piles - a 600 mm diameter CSP filled with sand, or
- For "false abutment" - concentric CSPs in accordance with standard integral abutment design procedures.

The sand must be placed in the CSP after the pile has been driven to avoid the danger of the sand being densified by pile driving and the possibility of the CSP being dragged down by the pile.

Backfill sand should meet the gradation shown in Table 8.6.

Table 8.6 – Integral Abutment Sand Grading

MTO Sieve Designation		Percentage Passing
2 mm	#10	100%
600 μm	#30	80%-100%
425 μm	#40	40%-80%
250 μm	#60	5%-25%
150 μm	#100	0%-6%

If the earth pressures acting on an integral abutment are to be modelled using springs, the following values of the modulus of horizontal subgrade reaction may be used:

Granular "B" Type I k(s) = 4,500*z/h kN/m3

Granular "A" k(s) = 5,600*z/h kN/m3

z = depth from top of abutment wall to point of interest (metres)

h = full height of the abutment wall (metres)

The upper limit of force on the abutment calculated in the analysis is the total passive force that can be mobilized in the backfill, calculated as described elsewhere in this report.

8.6 Frost Protection

The depth of earth cover required to provide frost protection for footings and pile caps at this site is 1.8 m.

It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation, with 25 mm of rigid, extruded polystyrene insulation being equivalent to 600 mm of earth cover. Synthetic insulation must be covered to provide protection where it is used.

9 EXCAVATION

All excavation must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the probable depth of excavation at this site may be classed as Type 3 soils above the water table. This classification is based on the lack of cohesion in the soils and the resulting possibility that excavation slopes will slough if excavated vertically for the lower 1.2 m. Excavation slopes should not exceed 1V:1H above the groundwater level.

Excavation below the groundwater level without prior dewatering is not recommended since the inflow of groundwater will cause boiling and sloughing of the soil below the water table making it difficult to maintain a dry, sound base on which to work.

Prior to excavation below the natural groundwater level, the groundwater must be depressed to a level below the deepest excavation level sufficient to maintain a stable base and prevent soil disturbance by construction traffic.

10 UNWATERING

Excavations at this site will penetrate below the local groundwater level. Accordingly, dewatering in advance of excavation is recommended.

The design of the dewatering system that may be required should be the responsibility of the Contractor and the Contract Documents should alert him to this responsibility and the need to engage a dewatering specialist. While the responsibility for dewatering should remain with the Contractor, suitable systems that might be employed include pumping from filtered sumps for penetration of no more than 0.5 m below the groundwater level and the use of vacuum wellpoints for deeper penetration below the groundwater level.

11 APPROACH EMBANKMENTS

The global and internal stability of the approach embankments was analyzed using limit equilibrium methods for both rock fill and earth fill. The stability analysis was carried out by the Bishop's Modified method, using GSlope® software developed by Mitre Software. Separate analyses were carried out for short term (total stress) and long term (effective stress) conditions. A pseudostatic analysis was also carried out using the seismic accelerations to assess stability under earthquake loads. The computer output for the stability analysis of the approach embankments is shown in Appendix F.

11.1 South Approach Stability

The soil conditions governing stability of the south approach embankment consist of the approach fill over deposits of silt, silty clay and deeper silt and sand layers that extend beyond the potential depth of failure. The groundwater level is assumed to be at the base of the fill/top of the sandy silt, for design purposes.

The analysis showed that a 8 m high rock fill approach constructed with side slopes of 1.25H:1V has a factor of safety against slope failure of 1.3 under normal circumstances. The analysis was repeated assuming a seismic acceleration factor of 0.08 and a factor of safety of 1.1 was obtained.

The same analyses were repeated for an earth fill approach embankment with side slopes constructed at 2H:1V. The resulting factors of safety are 1.3 under normal circumstances and 1.1 under the effects of an earthquake.

It should be noted that the analyses assumed that the foundation soils would not be subject to liquefaction. This issued is addressed in Section15 of the report.

The factors of safety obtained in the course of the analysis are summarized in Table 11.1.

11.2 North Approach Stability

The soil conditions governing stability of the north approach embankment consist of the approach fill overlying silty clay and deeper silt and sand layers that extend beyond the potential depth of failure. The groundwater level is assumed to be at the base of the fill/top of the silty clay for design purposes.

The analysis showed that a rock fill approach constructed with side slopes of 1.25H:1V have a factor of safety against slope failure of 1.3 under normal circumstances. The analysis was repeated assuming a seismic acceleration factor of 0.08 and a factor of safety of 1.1 was obtained.

The analyses were repeated for an earth fill approach embankment using the design side slopes. The resulting factors of safety are 1.3 under normal circumstances and 1.1 under the effects of an earthquake.

The factors of safety obtained in the course of the analysis are summarized in Table 11.1.

Table 11.1 – Approach Embankment Factors of Safety

Location / Material	Condition	Factor of Safety	Figure
South Approach			
Rock Fill	Undrained, No Seismic	1.3	F1
Rock Fill	ESA*, No Seismic	1.3	F2
Rock Fill	0.08 Seismic	1.1	F3
Earth Fill	Undrained, No Seismic	1.3	F4
Earth Fill	ESA, No Seismic	1.3	F5
Earth Fill	0.08 Seismic	1.1	F6
North Approach			
Rock fill	Undrained, No Seismic	1.7	F7
Rock Fill	ESA, No Seismic	1.3	F8
Rock Fill	0.08 Seismic	1.1	F9
Earth Fill	Undrained, No Seismic	1.9	F10
Earth Fill	ESA, No Seismic	1.3	F11
Earth Fill	0.08 Seismic	1.1	F12

*ESA = Effective Stress Analysis

11.3 Settlement

The primary consolidation settlement to be expected as a result of construction of the proposed approach fills has been estimated, on the basis of index properties and consolidation test results, to be:

- South approach – 130 mm
- North approach – 200 mm

The analysis indicates that these settlements will be substantially complete after approximately 8 months. It is recommended, therefore, that the approach fill be constructed at least 10 months in advance of foundation construction. Ground treatment using wick drains to accelerate settlement rates will be required if the construction schedule does not allow advance construction for the duration noted. Design of wick drains is beyond the scope of the current assignment.

Construction of the proposed approach embankments will increase the stresses within the foundation, such that the stress will approach the preconsolidation pressure of the deposit. These conditions will increase secondary consolidation and long term settlement of the embankment. The estimated long term settlement beneath the centreline of the embankment is 40 mm after 30 years. Surcharging of the embankment and monitoring of instrumentation is therefore recommended to reduce the magnitude of long term settlement. Design of surcharge and monitoring measures is beyond the scope of the current assignment.

11.4 Seismic Considerations

The embankments discussed above are considered to be stable under earthquake loading on the assumption of a stable foundation.

This topic is dealt with more completely in Section 15 Seismic Considerations.

11.5 Forward Slopes

It is recommended that the forward slopes be constructed at the same inclination as the side slopes, i.e. 1.25H:1V for rock fill and 2H:1V for earth fill.

11.6 General Embankment Requirements

All topsoil and organic soils should be stripped from the footprint of the approach fills.

Embankment construction should be in accordance with OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002

Where embankments are higher than 6 m, mid-height berms should be incorporated in the design. The berms should:

- extend for the length through which the embankment height exceeds 6 m
- be 2 m wide
- have 2% positive drainage to shed run-off water (earth fill embankments).

Earth fill embankment slopes must be provided with erosion protection in accordance with OPSS 572.

12 RETAINED SOIL SYSTEMS

RSS walls used in conjunction with bridge abutments must be "High Performance". The near surface foundation soils are not considered suitable for the support of "High Performance" because of the risk of excessive settlement associated with placement of the embankment fill. This option is therefore not recommended for retaining structures at this site.

However, if other design requirements warrant over-riding this recommendation then the following ground preparation is required under the RSS mass:

1. All topsoil and other deleterious material must be stripped from the footprint of the RSS mass.
2. The RSS mass must be founded on an engineered fill pad at least 2 m thick. The engineered fill must consist of OPSS Granular "A" compacted to 100% of its SPMDD at a moisture content within 2% of optimum.
3. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.
4. The highest permitted founding levels for the underside of the engineered fill are Elevation 295.3 at the south abutment and Elevation 293.0 at the north abutment. Lower founding elevation may be required to accommodate the required thickness of engineered fill.

For foundations prepared as described above, the maximum factored bearing resistance at ULS is 200 kPa, based on a strip length greater than 2 m. The bearing resistance will vary with the length of reinforcing strips used in the RSS mass and the elevation of the RSS mass. A final check of the resistance should therefore be carried out after these parameters have been selected.

The sliding resistance of the RSS mass will depend on the geosynthetic and aggregate materials selected for construction of the RSS mass. If OPSS Granular "A" is used within the base of the RSS mass an unfactored horizontal resistance of 0.7 can be used. For OPSS Granular "B" Type I material an unfactored horizontal resistance factor of 0.6 should be applied. Placement of geosynthetic materials at the base of the RSS mass may reduce the horizontal resistance values provided above. A final check of the resistance should therefore be carried out after these parameters have been selected.

Construction of the RSS mass is expected to occur within the footprint of the approach fill and to be subject to settlement induced by that fill. Provided the approach fill is constructed well in advance of the structure, as recommended elsewhere in this report, primary consolidation settlements should be essential complete. It is recommended, however, that the design of a RSS wall take account of the possible settlement of the wall. The magnitude of the post-construction settlement is estimated to be in the range of 20 to 40 mm. This settlement is not expected to affect the performance of the RSS wall but it may have an impact on the appearance.

The design, supply and construction of RSS must be in accordance with SP 599S22.

13 BACKFILL TO ABUTMENTS

In the case of integral or semi-integral abutments, backfill to the abutment should be granular material.

In the case of a conventional abutment, granular backfill is recommended but rock backfill can be permitted. A NSSP is required to specify grading limits for the rock fill. The rock fill used as backfill to the abutment should be limited to fragments no greater than 75 mm.

In all cases where the approach embankment consists of rock fill and granular backfill to the abutment wall is used, the granular backfill must consist of OPSS Granular "B" Type II.

The backfill to the abutment walls must be in accordance with OPSS 902 as amended by Special Provision 902S01. Granular backfill must be placed to the extents shown in OPSD 3501.000, and rock backfill must be placed to the extents shown in OPSD 3505.000.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with SSP 105S10.

The design of the abutment must incorporate a subdrain as shown in OPSD 3501.000 or OPSD 3505.000, as applicable.

14 EARTH PRESSURE COEFFICIENTS (ABUTMENTS)

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K*(\gamma h + q)$$

Where:

P_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see below)

γ = unit weight of retained soil (see table below)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall. In the case of integral abutments, material with a lower passive pressure coefficient (e.g. Granular B Type I) might be preferred as it results in lower forces acting on the ballast wall as the wall moves toward the soil mass.

The factors in Table 14.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

Table 14.1 – Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3		Rock Fill (Limited to 300 mm size) $\phi = 42°, \gamma = 19$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall(2H:1 V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.43*	0.2	.30*
At rest (Restrained Wall)	0.43	-	0.47	-	.33	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	5.0	-

* For wing walls.

15 SEISMIC CONSIDERATIONS

For design purposes, the site is treated as lying in Seismic Zone 1.

15.1 Seismic Design Parameters

The following seismic parameters should be used for design::

• Velocity Related Seismic Zone	1
• Zonal Velocity Ratio	0.05
• Acceleration Related Seismic Zone	1
• Zonal Acceleration Ratio	0.05
• Peak Horizontal Acceleration	0.08

The Soil Profile Type at this site has been classified as Type II. Thus, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" of 1.2 should be used in seismic design.

15.2 Liquefaction Potential

The potential for liquefaction of the foundation soils has been assessed using the Seed and Idriss (1971) method[1].

Using this method, it was determined that the foundation soils are not in danger of liquefaction.

15.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading.

In calculating the values of (K_{AE}) and (K_{PE}), the following geotechnical parameters were used:

ϕ = 35° for OPSS Granular A or Granular B Type II

ϕ = 32° for OPSS Granular B Type I

ϕ = 42° for rock fill

δ = 50% of ϕ

Where ϕ = the angle of internal friction of the backfill and δ = the angle of friction between the wall and the backfill.

---

[1] Seed, H.B. and Idriss, I.M. 1971, "Simplified Procedure for Evaluating Soil Liquefaction Potential" *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 101, No. SM9, September, pp. 1249 – 1273.

The seismic earth pressure coefficients to be used in design at this site are shown in Table 15.1 at the end of the text.

15.4 Slope Stability Considerations

Seismic effects were taken into account in the slope stability analyses conducted for this site using pseudo-static methods and assuming that the foundation soils would not be subject to liquefaction. Under these conditions, satisfactory factors of safety were obtained from the analysis, i.e. all values exceeded 1.0.

16 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- The possibility of piles reaching refusal on large boulders. In this case, the Hiley formula is not appropriate and site staff must make a decision regarding pile resistance and the appropriateness of continued driving.
- The potential variability of pile lengths at refusal.
- Excavation and unwatering in the loose soils encountered at this site.
- Paving of approach embankments should be carried out only after embankment settlement rates are within acceptable limits.

17 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Steven M. Sather, P.Eng. and Mr.Alastair E. Gorman, P.Eng.

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

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Report reviewed by:
P.K. Chatterji, P.Eng., Ph.D.
Review Principal

Table 15.1

Earth pressure Coefficients for Seismic Design

Condition	Earth Pressure Coefficient (K) for Earthquake Loading					
	Granular A or Granular B Type II $\phi = 35°$, $\delta = 17°$		OPSS Granular B Type I $\phi = 32°$, $\delta = 16°$		Rock Fill $\phi = 42°$, $\delta = 21°$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.28	0.46	0.31	0.58	0.21	0.30
Passive (K_{PE})*	7.0	-	5.5	-	14.1	-
At Rest (K_{OE})**	0.53		0.58		0.44	

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

THURBER

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

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

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS

CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a 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.

STRENGTH CLASSIFICATION

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

THURBER

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-5

METRIC

W.P. 476-93-01 LOCATION N 5048310.9 E 316449.1 Three Mile Lake Road SBL ORIGINATED BY GA

HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM Geodetic DATE 21.07.04 - 21.07.04 CHECKED BY MA/AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (FIELD VANE, Sensitivity)	REMARKS GR	SA	SI	CL
296.3										
0.0	**SILT**, trace clay, occasional rootlets (TOPSOIL)	1	SS	7	296					
296.0 / 0.3	Brown									
	SILT, trace sand, occasional iron oxide staining, Loose to Compact, Brown, Moist to Wet	2	SS	14	295					
		3	SS	14	294					
		4	SS	6						
293.3 / 3.0	Silty **CLAY**, Varved, Firm, Grey, Wet	5	SS	6	293					
					292	+ (3.3)				
		6	SS	4	291		0	1	47	52
		7	SS	4	290					
					289	+ (3.2)				
		8	SS	4	288					
287.2 / 9.1	**SILT**, trace sand, trace clay, Compact, Grey	9	SS	24	287		0	1	91	8
286.6	Wet									
9.8	END OF BOREHOLE AT 9.75 m.									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

ONTMT4S TMLS.GPJ 01/02/05

RECORD OF BOREHOLE No TML-5

METRIC

W.P.	476-93-01	LOCATION	N 5048310.9 E 316449.1 Three Mile Lake Road SBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	21.07.04 - 21.07.04	CHECKED BY	MA/AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	BOREHOLE OPEN TO 9.75 m AND WATER LEVEL AT 9.45 m UPON COMPLETION. BOREHOLE GROUTED TO SURFACE.										

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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-6

METRIC

W.P. 476-93-01 LOCATION Three Mile Lake Road SBL ORIGINATED BY GA

HWY 11 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY WM/HS

DATUM Geodetic DATE 22.07.04 - 22.07.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH / WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
296.3 / 0.0	**SILT**, trace clay, trace rootlets (TOPSOIL)	1	SS	8	296		
0.2	Brown **SILT**, trace to some clay, trace sand, occasional iron oxide staining. Loose to Compact. Brown. Moist to Wet	2	SS	16	295		
		3	SS	14			
	Becoming Loose	4	SS	9	294		0 7 74 19
293.3 / 3.0	Silty **CLAY**, occasional sand seams. Varved. Firm. Grey	5	SS	6	293		
					292		
		6	SS	4			0 1 46 53
					291	Field vane 3.75	
		1	TW	PH	290		
					289	Field vane 2	
288.2 / 8.2	**SILT**, trace to some sand. Grey. Wet	7	SS	14	288		
					287		

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-6

METRIC

W.P. 476-93-01 | LOCATION N 5048329.6 E 316445.5 Three Mile Lake Road SBL | ORIGINATED BY GA

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/Mud Rotary | COMPILED BY WM/HS

DATUM Geodetic | DATE 22.07.04 - 22.07.04 | CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
		8	SS	13		o	0	4	92	4
					286					
285.1 11.3	**SAND**, fine grained, trace to some silt Compact to Dense Grey Wet									
					285					
		9	SS	13		o				
					284					
		10	SS	10		o				
					283					
					282					
		11	SS	39		o				
					281					
		12	SS	38		o				
					280					
					279					
	Becoming Compact	13	SS	19		o				
					278					
		14	SS	12		o	0	85	15 (SI+CL)	
					277					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No TML-6

METRIC

W.P. 476-93-01	LOCATION N 5048329.6 E 316445.5 Three Mile Lake Road SBL		ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Mud Rotary		COMPILED BY WM/HS
DATUM Geodetic	DATE 22.07.04 - 22.07.04		CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					276		
		15	SS	19		~20	
					275		
					274		
					273		
		16	SS	28		~20	
					272		
					271		
269.8					270		
26.5	**SILT**, some sand, trace to some clay Dense Grey Wet	17	SS	33		~25	0 12 76 12
					269		
					268		
266.8					267		
29.6	**SAND**, fine to medium grained Compact to Dense	18	SS	25		~20	

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
UNIT WEIGHT γ kN/m³

RECORD OF BOREHOLE No TML-6

METRIC

W.P.	476-93-01	LOCATION	N 5048329.6 E 316445.5 Three Mile Lake Road SBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers/Mud Rotary	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	22.07.04 - 22.07.04	CHECKED BY	AEG

SOIL PROFILE: ELEV DEPTH, DESCRIPTION, STRAT PLOT. SAMPLES: NUMBER, TYPE, "N" VALUES. GROUND WATER CONDITIONS. ELEVATION SCALE. DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100). SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100). PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60). UNIT WEIGHT γ kN/m³. REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	Grey Wet				266	
					265	
					264	
		19	SS	35		~20
					263	
					262	
					261	
		20	SS	41		~20
					260	
					259	
					258	
		21	SS	47		~20
					257	

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-6

METRIC

W.P. 476-93-01 | LOCATION N 5048329.6 E 316445.5 Three Mile Lake Road SBL | ORIGINATED BY GA

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/Mud Rotary | COMPILED BY WM/HS

DATUM Geodetic | DATE 22.07.04 - 22.07.04 | CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Becoming Very Dense	22	SS	69	254–255	~22	0 90 10 (SI+CL)
		23	SS	100	251–252	~15	
		24	SS	86	250	~20	
248.5 / 47.8	**SAND and GRAVEL**, fine to coarse sand, variable percentage of gravel, numerous cobbles and boulders. Very Dense. Grey. Wet	25	SS	50/.075	248	~11	
	Boulder from 246.8m to 245.9m						

Elevation scale: 256, 255, 254, 253, 252, 251, 250, 249, 248, 247

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100
Shear Strength kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
Plastic Limit w_P — Natural Moisture Content w — Liquid Limit w_L; Water Content (%) 20 40 60
Unit Weight γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-6

METRIC

W.P. 476-93-01 | LOCATION N 5048329.6 E 316445.5 Three Mile Lake Road SBL | ORIGINATED BY GA

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/Mud Rotary | COMPILED BY WM/HS

DATUM Geodetic | DATE 22.07.04 - 22.07.04 | CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
			1	RUN			246
			2	RUN			245
244.4							
52.0	END OF BOREHOLE AT 51.97 m. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.						

Other column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEVATION (m)
07-OCT-04	0.9	295.4
05-JAN-05	1.3	295.0
20-JAN-05	2.0	294.3

+ ³, × ³: Numbers refer to Sensitivity

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

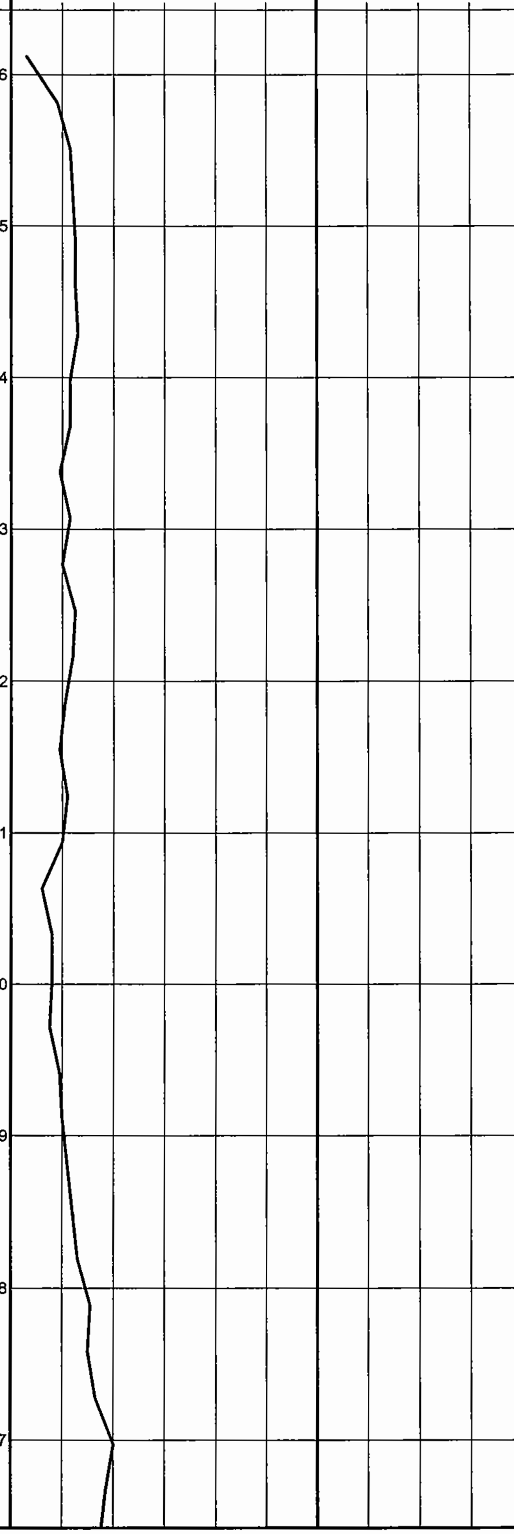
Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-6A

METRIC

W.P. 476-93-01	LOCATION N 5048329.6 E 316445.5 Three Mile Lake Road SBL		ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 29.07.04 - 29.09.04		CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
296.3 / 0.0	DCPT from surface.						296, 295, 294, 293, 292, 291, 290, 289, 288, 287				

Continued Next Page

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

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

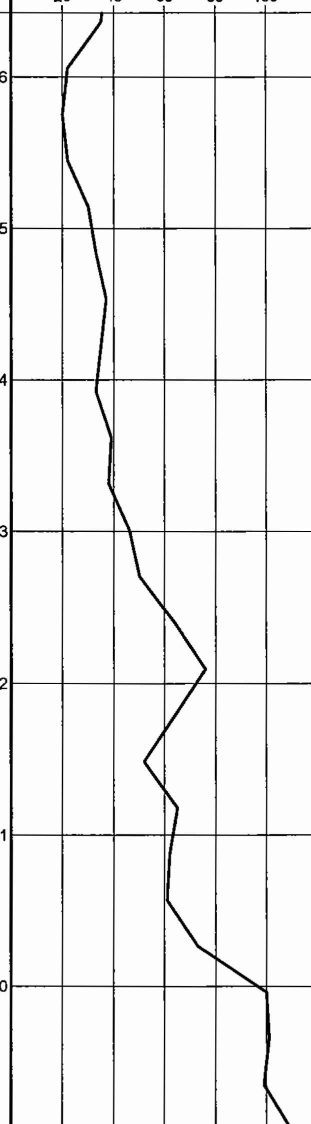
ONTMT4S TMLS.GPJ 01/02/05

RECORD OF BOREHOLE No TML-6A

METRIC

W.P. 476-93-01	LOCATION N 5048329.6 E 316445.5	Three Mile Lake Road SBL	ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 29.07.04 - 29.09.04		CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
279.0 / 17.4	END OF DCPT AT 17.37 m.						286, 285, 284, 283, 282, 281, 280				



+ ³, × ³ : Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-7

METRIC

W.P. 476-93-01 | LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL | ORIGINATED BY JL/SL/MF

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Casing | COMPILED BY WM/HS

DATUM Geodetic | DATE 11.11.04 - 13.11.04 | CHECKED BY HS/AEG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.7								
0.0	**TOPSOIL** (100 mm)							
0.1	**SAND**, fine to medium grained, some silt Brown				294			
293.6		1	SS	6				
1.1	Silty **CLAY**, trace sand Firm to Stiff Grey Moist to Wet. Silty **SAND** lens at 292.8m	2	SS	25	293			
		3	SS	7	292			0 2 59 39
		4	SS	5	291	+ 12.5 (Field vane)		
		5	SS	13	290			
288.9					289			
5.8	**SILT**, trace to some clay, trace to some sand Loose to Compact Grey Wet	6	SS	15	288			
		7	SS	6	287			0 9 85 6
285.8					286			
8.8	**SAND**, fine to medium grained, trace silt Very Loose to Compact, possibly Dense Grey Wet	8	SS	5	285			

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DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No TML-7

METRIC

W.P. 476-93-01 LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL ORIGINATED BY JL/SL/MF

HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Casing COMPILED BY WM/HS

DATUM Geodetic DATE 11.11.04 - 13.11.04 CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Very Loose	9	SS	2	284	~38	
		10	SS	24	283	~22	
		11	SS	12	281	~25	
	Becoming Very Loose	12	SS	3	280	~31	
	Becoming Compact	13	SS	28	278	~22	0 93 7 (SI+CL)
		14	SS	13	277	~27	
					276		
					275		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No TML-7

METRIC

W.P. 476-93-01 | LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL | ORIGINATED BY JL/SL/MF

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Casing | COMPILED BY WM/HS

DATUM Geodetic | DATE 11.11.04 - 13.11.04 | CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					274		
	Becoming Loose	15	SS	8		o	
					273		
					272		
					271		
	Compact to Very Loose	16	SS	16		o	0 90 10 (SI+CL)
					270		
					269		
					268		
		17	SS	1		o	
					267		
					266		
					265		

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity   15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-7

METRIC

W.P. 476-93-01 | LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL | ORIGINATED BY JL/SL/MF

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Casing | COMPILED BY WM/HS

DATUM Geodetic | DATE 11.11.04 - 13.11.04 | CHECKED BY HS/AEG

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Description	Sample No.	Type	"N" Value	Elevation Scale	Water Content	GR	SA	SI	CL
Becoming Loose	18	SS	9	264	○ (~20%)				
				263					
				262					
trace gravel	19	SS	7	261	○ (~20%)				
				260					
				259					
Becoming Compact	20	SS	16	258	○ (~18%)	0	98	2 (SI+CL)	
				257					
				256					
	21	SS	13	255	○ (~20%)				

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+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S TMLS.GPJ 01/02/05

RECORD OF BOREHOLE No TML-7

METRIC

W.P. 476-93-01 | LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL | ORIGINATED BY JL/SL/MF

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/NW Casing/NQ Casing | COMPILED BY WM/HS

DATUM Geodetic | DATE 11.11.04 - 13.11.04 | CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS
254.6							
40.1	**SAND and GRAVEL**, fine to coarse sand, variable percentage of gravel, numerous cobbles and boulders Very Dense Grey Wet				254		
		~~22~~	~~SS~~	~~50/~~ .025			
		1	RUN		253		
		23	SS	50/ .100	252	o	
		2	RUN		251		
		3	RUN		250		
		4	RUN		249		
					248		
	Dynamic Cone Test attempted at 48.5m 100 for 250mm	5	RUN		247		
		24	SS	100/ ~~.050~~		o	
246.2 48.5	END OF BOREHOLE AT 48.46 m. Piezometer installation consists of 25 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEVATION (m) 15-NOV-04 +0.7(frozen) 295.4 05-JAN-05 +0.5 295.2 20-JAN-05 +0.6 295.3						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

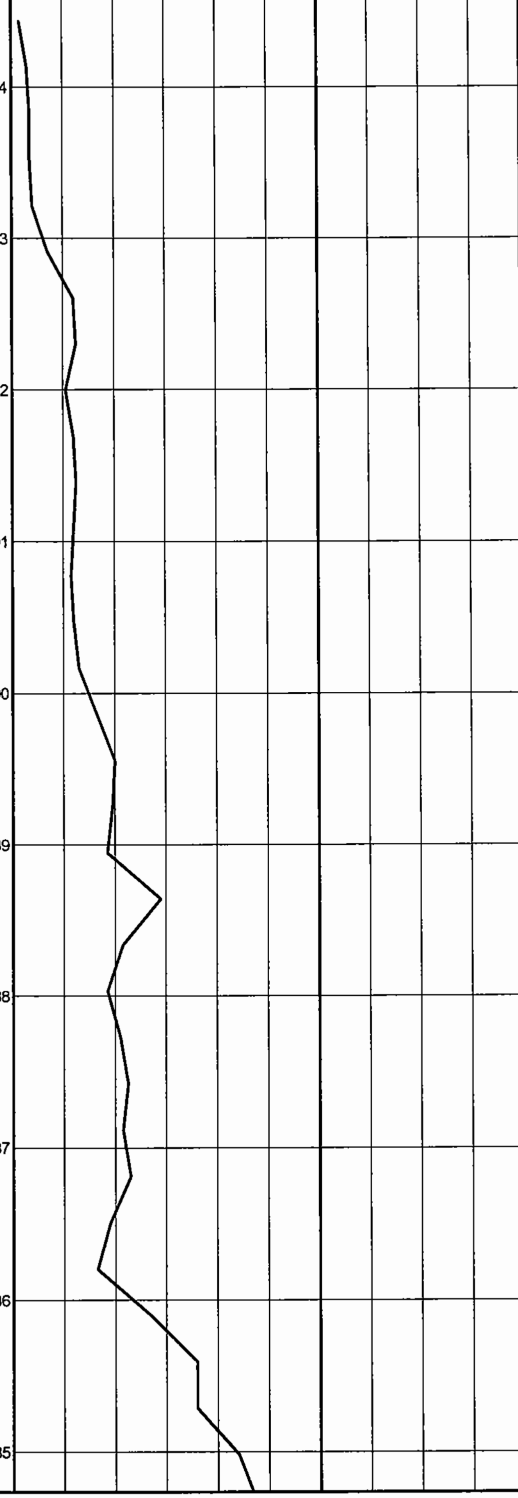
Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-7A

METRIC

W.P. 476-93-01	LOCATION N 5048391.8 E 316422.5	Three Mile Lake Road SBL	ORIGINATED BY MF
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 14.11.04 - 14.11.04		CHECKED BY HS/AEG

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION / STRAT PLOT	NUMBER	TYPE	"N" VALUES						
294.7 / 0.0	DCPT from surface.					294, 293, 292, 291, 290, 289, 288, 287, 286, 285				

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+ ³, × ³ : Numbers refer to Sensitivity

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

ONTMT4S TMLS.GPJ 01/02/05

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-7A

METRIC

W.P. 476-93-01	LOCATION N 5048391.8 E 316422.5 Three Mile Lake Road SBL	ORIGINATED BY MF
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)	COMPILED BY WM/HS
DATUM Geodetic	DATE 14.11.04 - 14.11.04	CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER (SAMPLES)	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.3											
10.4	END OF DCPT AT 10.36m. CONE REFUSAL AT 10.36m.						284				

+ ³, × ³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-8

METRIC

W.P. 476-93-01 | LOCATION N 5048414.6 E 316413.9 Three Mile Lake Road SBL | ORIGINATED BY WRW

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test (DCPT) | COMPILED BY WM/HS

DATUM Geodetic | DATE 12.10.04 - 12.10.04 | CHECKED BY MA/AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.8						
0.0 / 0.1	**TOPSOIL** (50 mm)					
	Silty **CLAY**, trace sand, occasional iron oxide staining, Very Stiff to Hard, Brown-Grey	1	SS	26		
		2	SS	36	294	
	Becoming Stiff, Wet	3	SS	11	293	0 0 51 49
		4	SS	11	292	
	Becoming Firm, Grey	5	SS	5	291	
290.2 / 4.6	**SILT**, trace sand, Compact, Grey, Wet	6	SS	24	290	0 1 90 9
288.7 / 6.1	**SAND**, fine grained, trace silt, Loose to Very Loose, Grey, Wet	7	SS	8	289 / 288	
		8	SS	2	287 / 286	0 90 10 (SI+CL)
		9	SS	5	285	

Chart column headings: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³

Continued Next Page

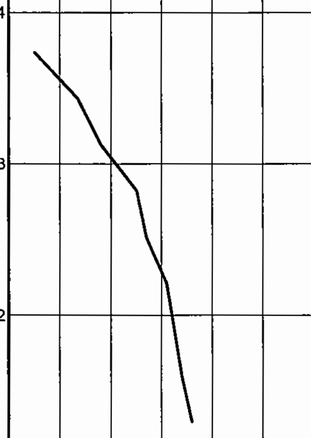
+³, ×³: Numbers refer to Sensitivity   20 / 15 -○- 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-8

METRIC

W.P. 476-93-01	LOCATION N 5048414.6 E 316413.9 Three Mile Lake Road SBL	ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test (DCPT)	COMPILED BY WM/HS
DATUM Geodetic	DATE 12.10.04 - 12.10.04	CHECKED BY MA/AEG

SOIL PROFILE ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.7	Becoming Compact		10	SS	16		284		○ (approx. 22)		
11.1	END OF SOIL SAMPLING AT 11.13 m. DCPT started at 11.13 m.						283 282				
281.1 13.7	END OF DCPT AT 13.72 m. BOREHOLE OPEN TO 6.1 m. BOREHOLE GROUTED TO SURFACE.										



+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-11

METRIC

W.P.	476-93-01	LOCATION	N 5048348.1 E 316438.4 Three Mile Lake Road SBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	09.12.04 - 15.12.04	CHECKED BY	AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
296.2 / 0.0	Clayey **SILT**, trace sand, occasional rootlets (TOPSOIL)						
295.9 / 0.3	Brown **SILT**, trace to some clay, trace sand Compact Brown	1	SS	5	296		
		2	SS	22	295		
		3	SS	22			0 7 79 14
	Clayey below 294.0m	4	SS	19	294		
293.2 / 3.0	Silty **CLAY**, occasional silt lenses Varved Firm to Stiff Brown	5	SS	10	293		
		6	SS	8	292 / 291		0 1 41 57
		7	SS	4	290		
		8	SS	11	289 / 288		0 0 76 24
287.1 / 9.1	**SILT**, trace to some sand, trace silt Loose Grey Moist to Wet	9	SS	8	287		0 20 78 3

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

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

ONTMT4S TMLS.GPJ 01/02/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-11

METRIC

W.P.	476-93-01	LOCATION	N 5048348.1 E 316438.4 Three Mile Lake Road SBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	09.12.04 - 15.12.04	CHECKED BY	AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					286		
285.3 / 10.9	**SAND**, fine grained, trace to some silt Loose to Compact Grey Moist to Wet				285		
		10	SS	13		o	
					284		
					283		
		11	SS	6		o	
					282		
		12	SS	4		o	0 82 18 (SI+CL)
					281		
					280		
		13	SS	4		o	
					279		
		14	SS	10		o	
					278		
					277		
		15	SS	12		o	

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-11

METRIC

W.P. 476-93-01 LOCATION N 5048348.1 E 316438.4 Three Mile Lake Road SBL ORIGINATED BY GA

HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM Geodetic DATE 09.12.04 - 15.12.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR SA SI CL
					276		
					275		
		16	SS	14	274	o	0 92 8 (SI+CL)
					273		
					272		
					271	o	
		17	SS	15	270		
					269		
268.0 / 28.2	Sandy **SILT**, trace clay Dense Grey Wet	18	SS	30	268	o	0 20 74 6
					267		

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

ONTMT4S TMLS.GPJ 01/02/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-11

METRIC

W.P. 476-93-01 | LOCATION N 5048348.1 E 316438.4 Three Mile Lake Road SBL | ORIGINATED BY GA

HWY 11 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM/HS

DATUM Geodetic | DATE 09.12.04 - 15.12.04 | CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS
					266		
264.8 / 31.4	**SAND**, fine to medium grained, trace silt; Compact to Dense; Grey; Wet	19	SS	20	265	~21	
					264, 263, 262		
		20	SS	25	261, 260, 259	~20	
		21	SS	33	258, 257	~22	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity   15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-11

METRIC

W.P.	476-93-01	LOCATION	N 5048348.1 E 316438.4 Three Mile Lake Road SBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	09.12.04 - 15.12.04	CHECKED BY	AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					256	
		22	SS	24		
					255	
					254	
		23	SS	23		0 82 18 (SI+CL)
					253	
					252	
					251	
	Becoming Very Dense	24	SS	52		
					250	
					249	
					248	
		25	SS	52		
					247	
246.5 49.7	**SAND and GRAVEL**, fine to coarse sand, variable percentage of gravel,					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-11

METRIC

W.P. 476-93-01 LOCATION N 5048348.1 E 316438.4 Three Mile Lake Road SBL ORIGINATED BY GA

HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM/HS

DATUM Geodetic DATE 09.12.04 - 15.12.04 CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	numerous cobbles and boulders Very Dense Grey Wet **BOULDER** (0.91 m) from 245.3m to 246.2m				246					
					245					
					244					
					243					
		26	SS	100/ .125						
					242					
		27	SS	46	241	o	4	77	19 (SI+CL)	
					240					
					239					
		28	SS	100/ .100		o				
		29	SS	100/ .225	238					
					237	o				

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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-11

METRIC

W.P. 476-93-01	LOCATION N 5048348.1 E 316438.4 Three Mile Lake Road SBL		ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM/HS
DATUM Geodetic	DATE 09.12.04 - 15.12.04		CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.7							236				
60.5	END OF BOREHOLE AT 60.50 m. REFUSAL AT 60.50 m ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEVATION (m)
05-JAN-05	0.0(frozen)	296.2
20-JAN-05	0.0(frozen)	296.2

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-11A

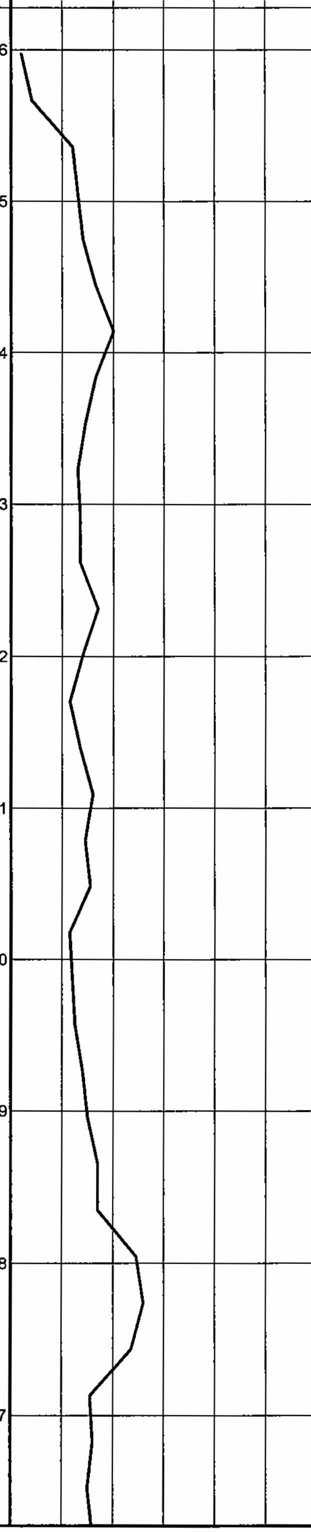
METRIC

W.P. 476-93-01 LOCATION N 5048348.1 E 316438.4 Three Mile Lake Road SBL ORIGINATED BY WRW

HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY WM/HS

DATUM Geodetic DATE 16.12.04 - 16.12.04 CHECKED BY AEG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT — WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
296.2											
0.0	DCPT from surface.						296 … 287				



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+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

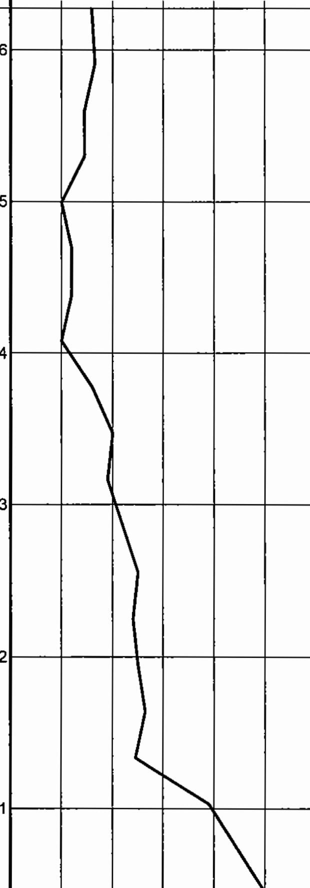
THURBER

RECORD OF BOREHOLE No TML-11A

METRIC

W.P. 476-93-01	LOCATION N 5048348.1 E 316438.4	Three Mile Lake Road SBL	ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 16.12.04 - 16.12.04		CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
							286				
							285				
							284				
							283				
							282				
							281				
280.4 / 15.8	END OF DCPT AT 15.82 m. BOREHOLE SEALED WITH BENTONITE.										



+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01 LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL ORIGINATED BY MF/SL
HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM/HS
DATUM Geodetic DATE 15.11.04 - 18.11.04 CHECKED BY HS/AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.8						
294.5 / 0.0	**TOPSOIL**, some rootlets (300mm) Dark Brown					
0.3	Sandy **SILT**, some fine sand seams, some rootlets at top, Very Loose to Compact, Brown to Grey, Wet				294	
		1	SS	3		0 53 38 9
	occasional iron oxide staining	2	SS	17	293	
292.4 / 2.4	Silty **CLAY**, trace sand, Stiff to Soft, Grey, Wet, occasional sandy silt layers	3	SS	8	292	
		4	SS	3		0 0 52 47
		5	SS	7	291	
289.9 / 4.9	**SILT**, some sand to sandy				290	
		6	SS	12	289	0 0 81 18
	Compact to Very Loose, Grey, Wet	7	SS	13	288	0 2 90 8
		8	SS	2	287, 286	
285.4 / 9.4	**SAND**, fine grained, trace to some silt, Loose to Compact, Grey				285	

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Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100. Shear Strength kPa: ○ Unconfined, + Field Vane, ● Quick Triaxial, × Lab Vane; 20 40 60 80 100. Plastic limit w_P, natural moisture content w, liquid limit w_L; Water Content (%) 20 40 60. Unit Weight γ kN/m³.

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S TMLS.GPJ 01/02/05

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01 LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL ORIGINATED BY MF/SL

HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM/HS

DATUM Geodetic DATE 15.11.04 - 18.11.04 CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Wet	9	SS	6		○	
					284		
		10	SS	7		○	
					283		
					282		
		11	SS	7		○	0 92 8 (SI+CL)
					281		
		12	SS	5		○	
					280		
					279		
		13	SS	16		○	
					278		
		14	SS	9		○	
					277		
					276		
		15	SS	13		○	
					275		

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

15-○-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01 | LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL | ORIGINATED BY MF/SL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers/NW Casing | COMPILED BY WM/HS

DATUM Geodetic | DATE 15.11.04 - 18.11.04 | CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
			16	SS	15		274		~22					
							273							
							272							
			17	SS	18		271		~27		0	64	33	3
							270							
							269							
			18	SS	13		268		~25					
							267							
							266							
							265							

Legend: PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; SHEAR STRENGTH: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. Scales: 20 40 60 80 100 (DCPT and shear strength); 20 40 60 (water content).

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01 LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL ORIGINATED BY MF/SL

HWY 11 BOREHOLE TYPE Hollow Stem Augers/NW Casing COMPILED BY WM/HS

DATUM Geodetic DATE 15.11.04 - 18.11.04 CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
		19	SS	7		~20	0	93	7 (SI+CL)	
					264					
					263					
					262					
		20	SS	18		~20				
					261					
					260					
					259					
		21	SS	13		~20				
					258					
					257					
					256					
		22	SS	15		~20				
					255					

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01	LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL		ORIGINATED BY MF/SL
HWY 11	BOREHOLE TYPE Hollow Stem Augers/NW Casing		COMPILED BY WM/HS
DATUM Geodetic	DATE 15.11.04 - 18.11.04		CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		23	SS	26	254	o	0 72 28 (SI+CL)
253.3 41.5	**SAND and GRAVEL**, fine to coarse sand, variable percentage of gravel, numerous cobbles and boulders Very Dense Grey Wet	24	SS	106	253	o	
	Numerous cobbles and boulders below 252.0m				252		
		1	RUN		251		
		2	RUN		250		
		3	RUN				
		4	RUN		249		
		5	RUN		248		
		6	RUN		247		
					246		
	No cobbles, no boulders detected below 245.7m.	7	RUN		245		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No TML-12

METRIC

W.P. 476-93-01	LOCATION N 5048375.5 E 316425.3	Three Mile Lake Road SBL	ORIGINATED BY MF/SL
HWY 11	BOREHOLE TYPE Hollow Stem Augers/NW Casing		COMPILED BY WM/HS
DATUM Geodetic	DATE 15.11.04 - 18.11.04		CHECKED BY HS/AEG

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			8	RUN			244				
243.3 / 51.5	END OF BOREHOLE AT 51.51 m. Piezometer installation consists of 25 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEVATION (m) 05-JAN-05 +0.3 295.1 20-JAN-05 +0.3 (frozen) 295.1										

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

15 –⊕– 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

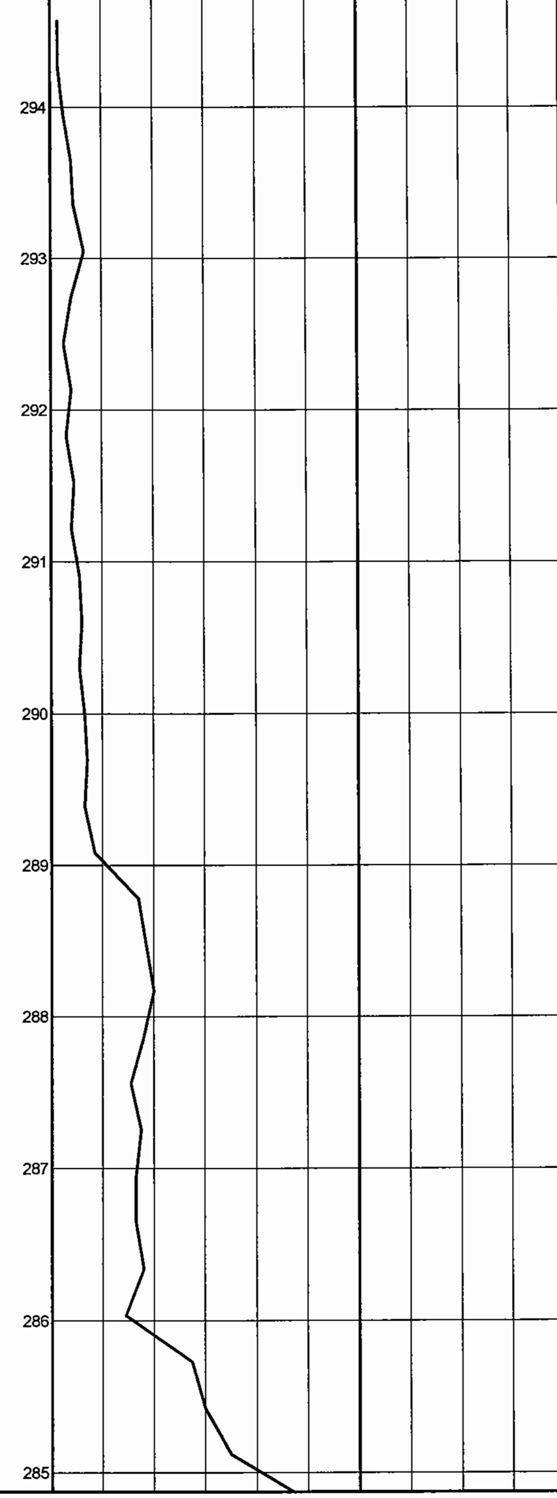
THURBER

RECORD OF BOREHOLE No TML-12A

METRIC

W.P. 476-93-01	LOCATION N 5048375.5 E 316425.3	Three Mile Lake Road SBL	ORIGINATED BY SL
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 19.11.04 - 19.11.04		CHECKED BY HS/AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
294.8 / 0.0	DCPT from surface.										



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+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No TML-12A

METRIC

W.P. 476-93-01	LOCATION N 5048375.5 E 316425.3 Three Mile Lake Road SBL		ORIGINATED BY SL
HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 19.11.04 - 19.11.04		CHECKED BY HS/AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
284.7 10.1	END OF DCPT AT 10.06m.										
							284				

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

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

Appendix B

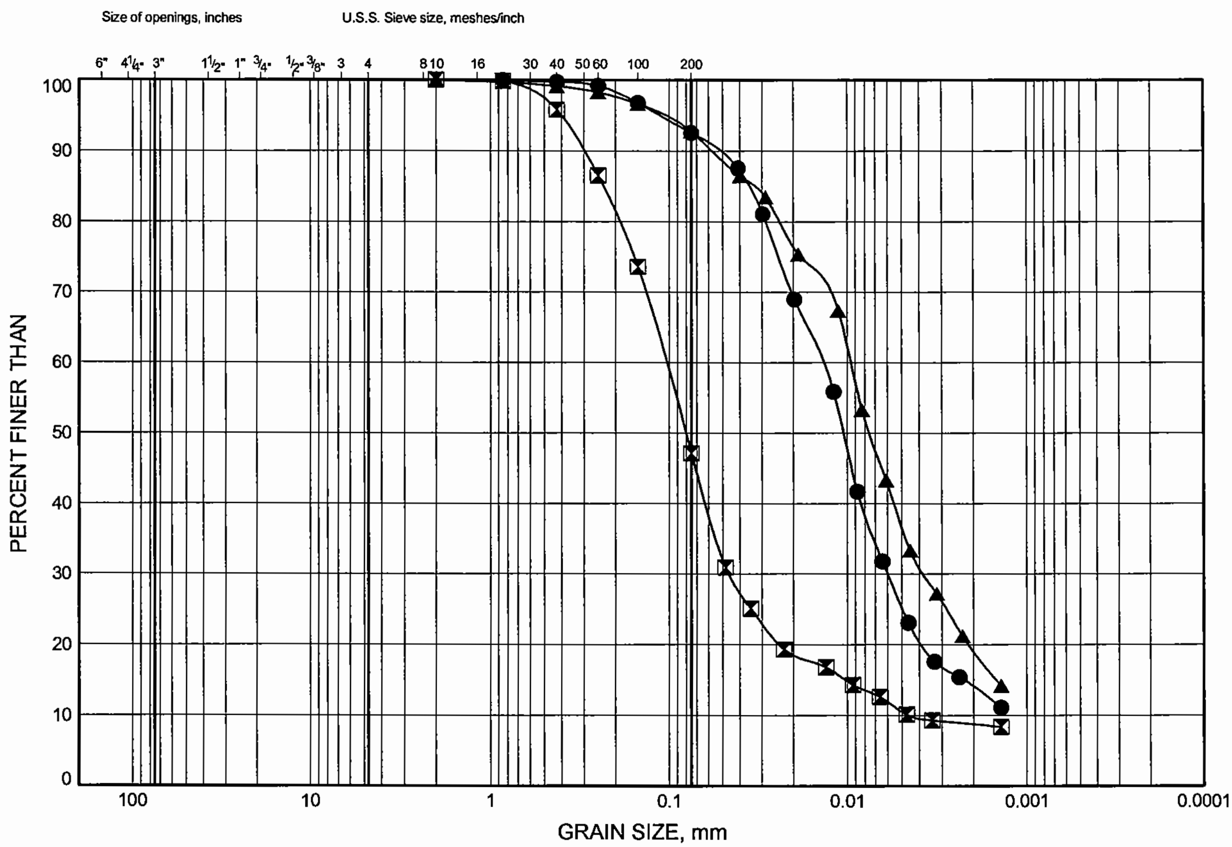
Laboratory Test Results

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILT TO SILTY SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	1.83	294.37
⊠	TML-12	1.07	293.73
▲	TML-6	2.59	293.76

Date January 2005

Project 476-93-01

THURBER

Prep'd HS

Chkd. AEG

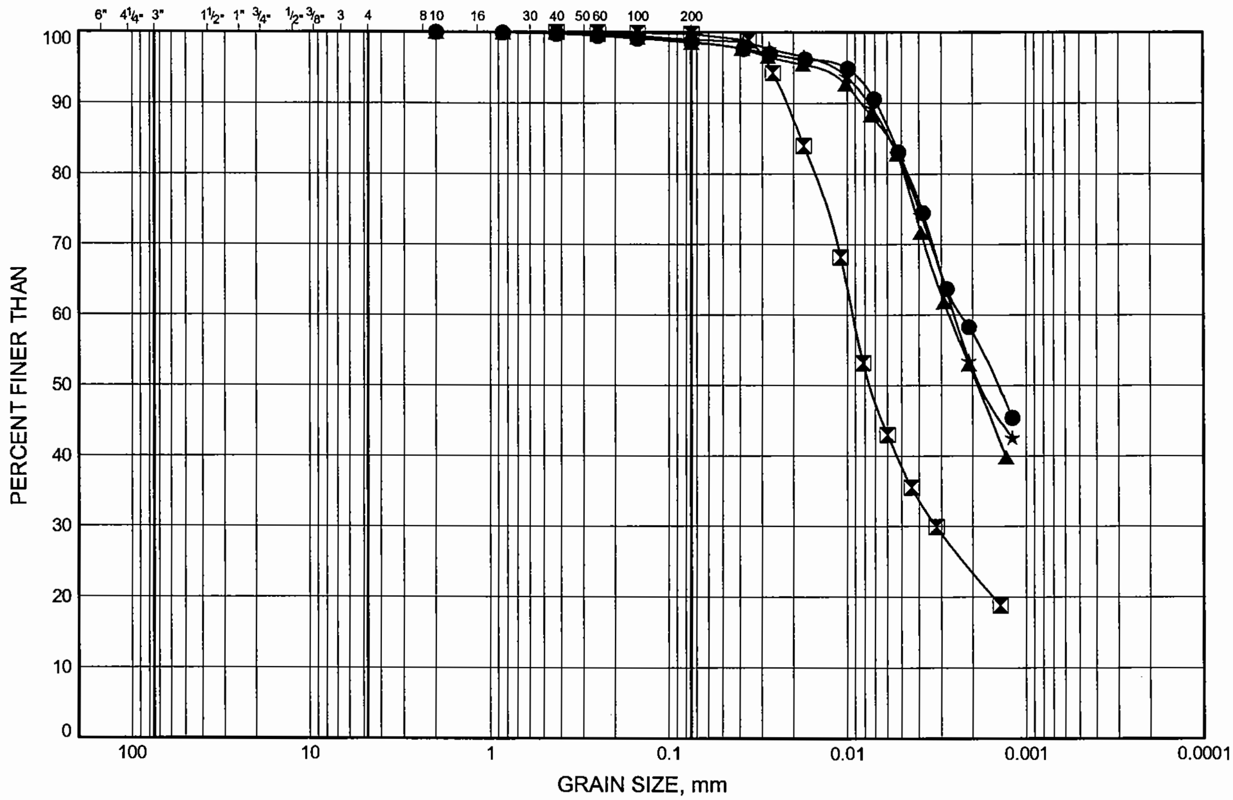
THURBGSD TMLS.GPJ 28/01/05

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILTY CLAY TO CLAYEY SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	4.88	291.32
⊠	TML-11	7.92	288.28
▲	TML-5	4.88	291.43
★	TML-6	4.88	291.47

Date January 2005

Project 476-93-01

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Chkd. AEG

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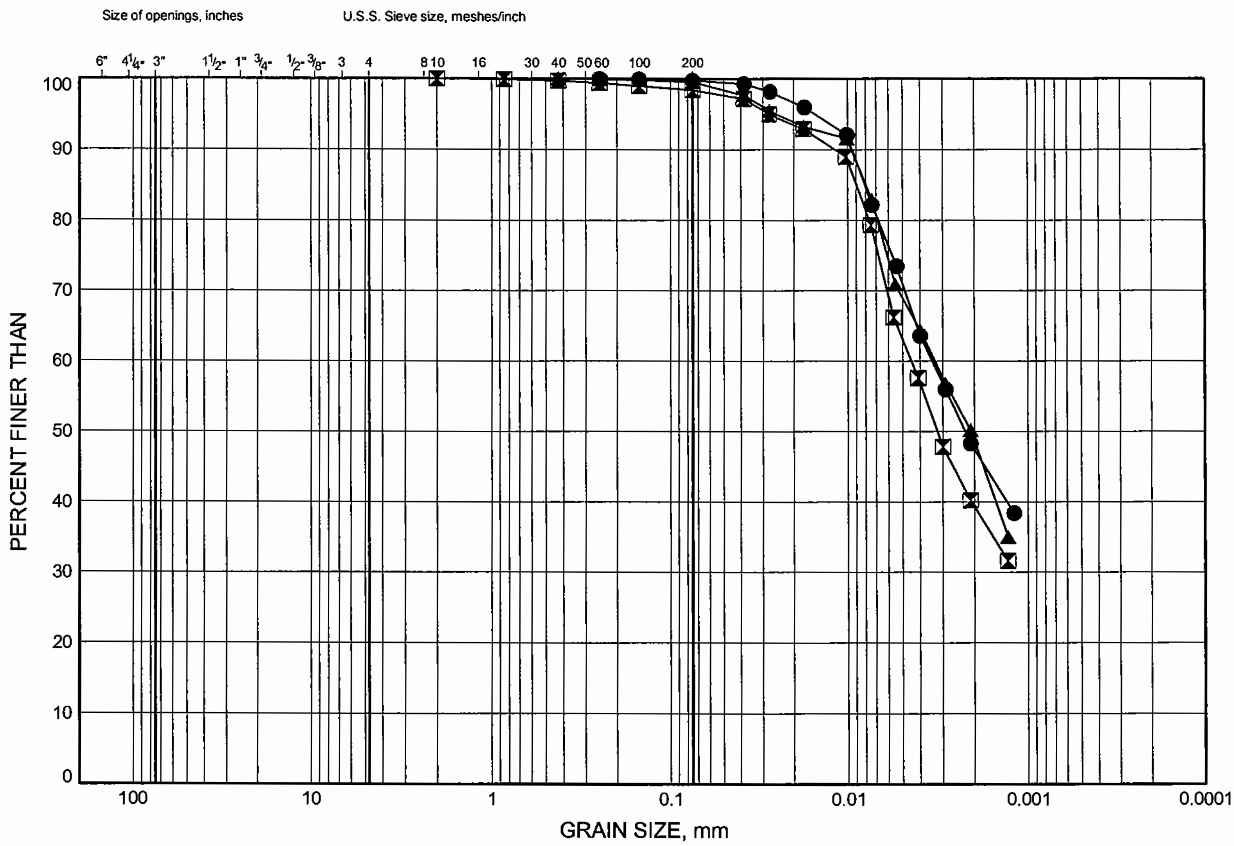
Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-12	3.35	291.45
⊠	TML-7	2.51	292.15
▲	TML-8	1.83	292.96

THURBGSD TMLS.GPJ 13/02/06

Date February 2006

Project 476-93-01

THURBER

Prep'd JHL

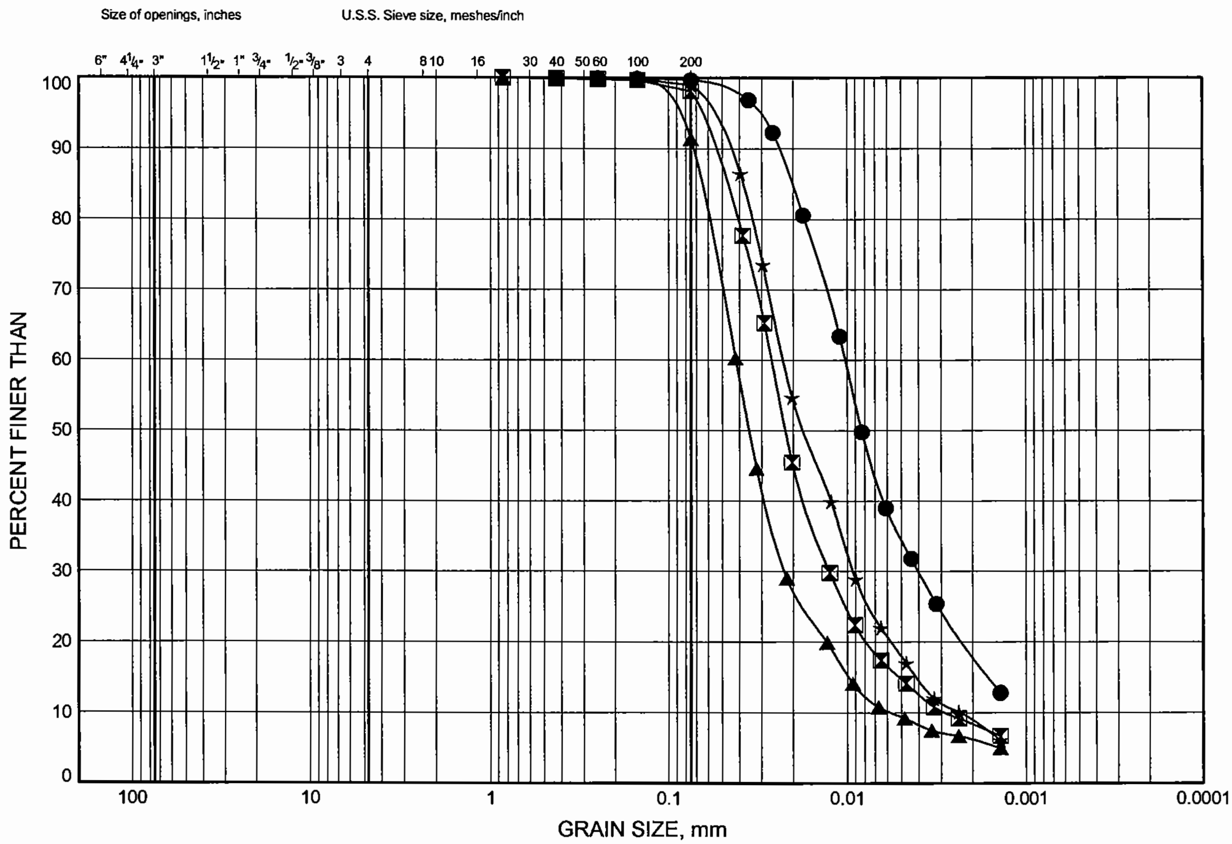
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-12	5.64	289.16
⊠	TML-12	7.16	287.64
▲	TML-7	7.54	287.12
★	TML-8	4.88	289.91

THURBGSD TMLS.GPJ 01/02/05

Date February 2005

Project 476-93-01

THURBER

Prep'd HS

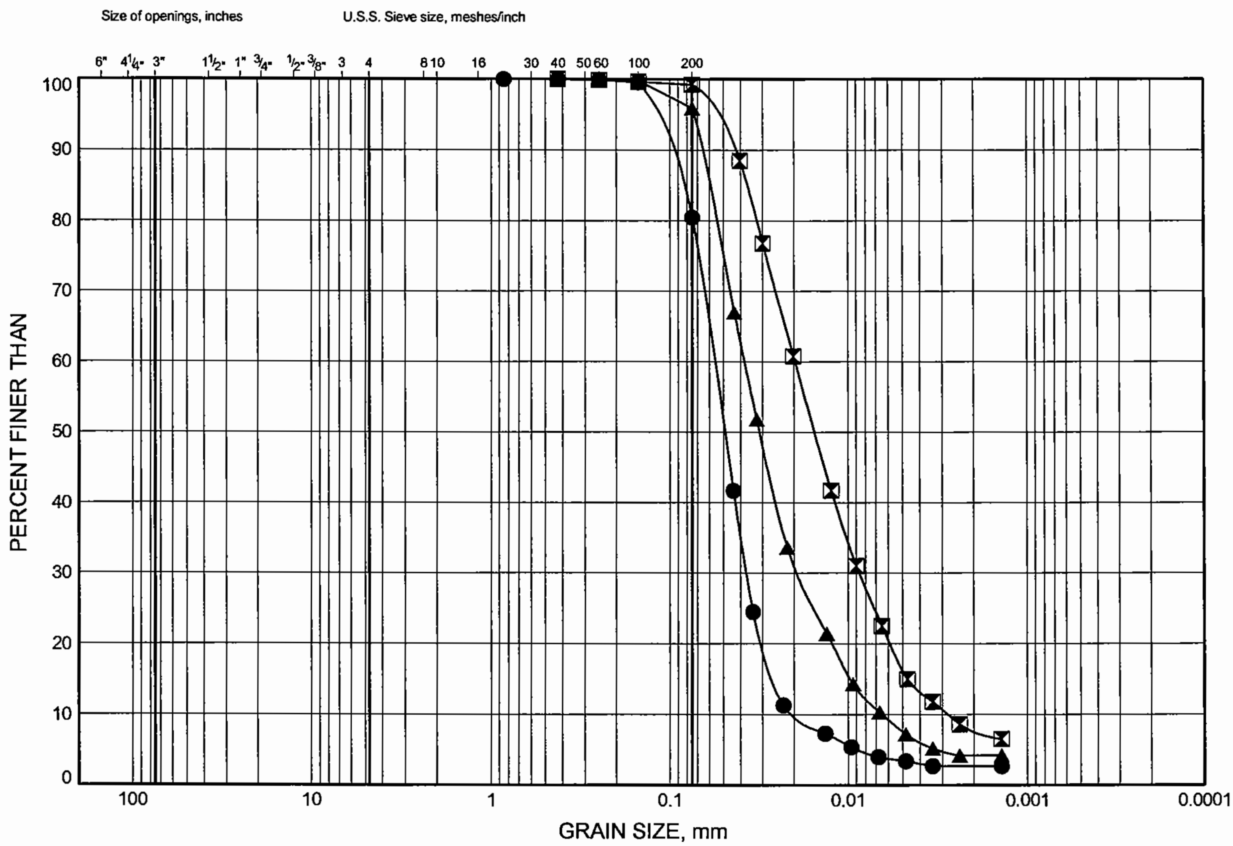
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	9.45	286.75
⊠	TML-5	9.45	286.86
▲	TML-6	10.06	286.29

THURBGSD TMLS.GPJ 28/01/05

Date January 2005

Project 476-93-01

THURBER

Prep'd HS

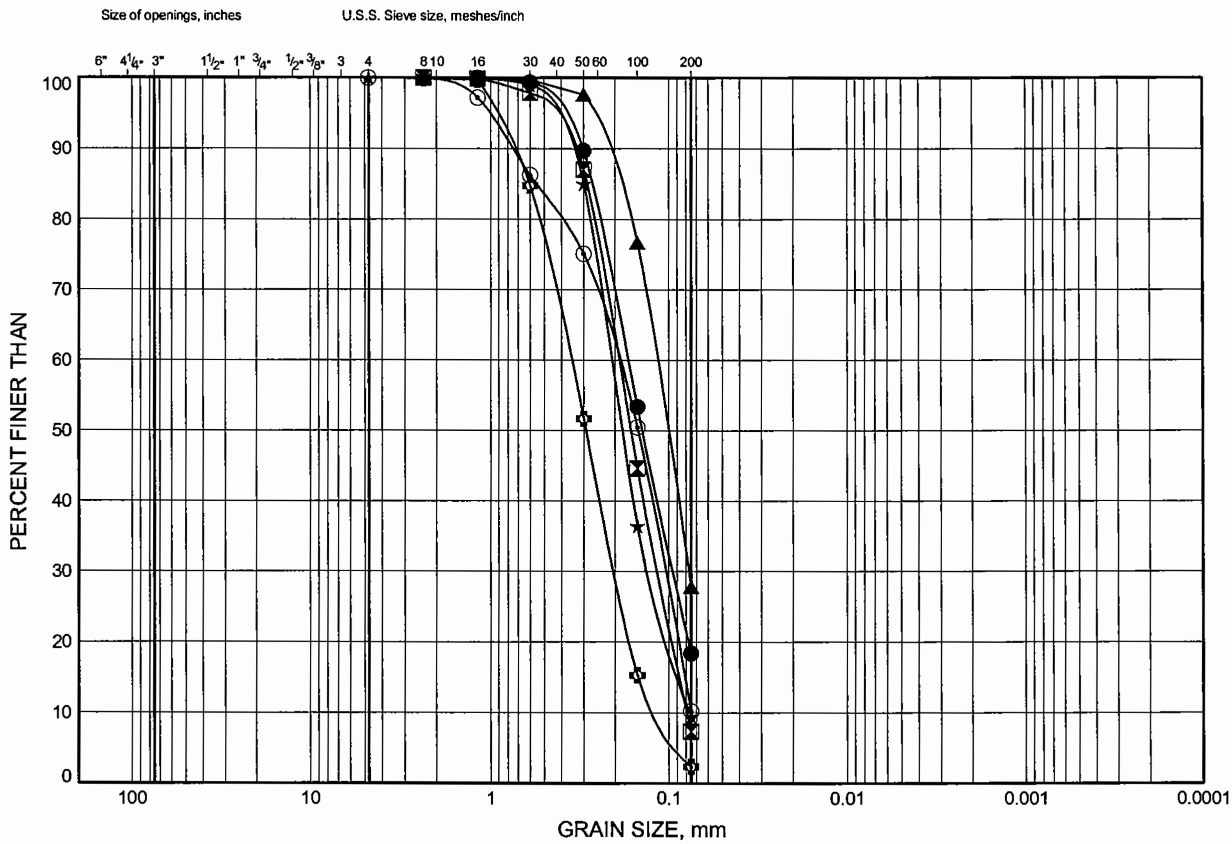
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	42.90	253.30
⊠	TML-12	30.02	264.78
▲	TML-12	40.69	254.11
★	TML-6	42.06	254.29
⊙	TML-7	24.31	270.36
✪	TML-7	36.58	258.09

THURBGSD TMLS.GPJ 28/01/05

Date January 2005

Project 476-93-01

THURBER

Prep'd HS

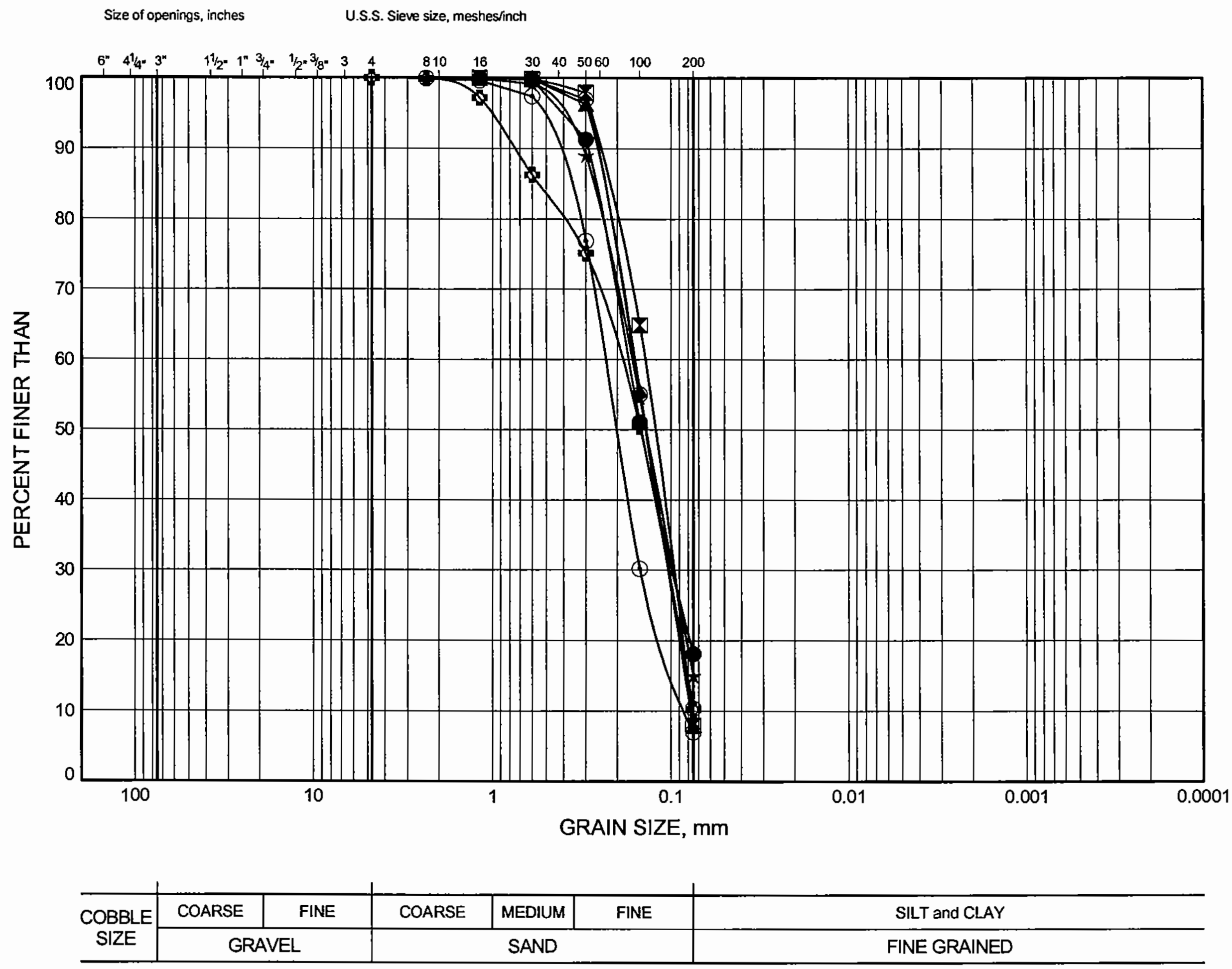
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B7

SAND



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	14.94	281.26
⊠	TML-11	22.48	273.72
▲	TML-12	13.26	281.54
★	TML-6	19.20	277.15
⊙	TML-7	16.69	277.98
✪	TML-7	24.31	270.36

Date January 2005

Project 476-93-01

THURBER

Prep'd HS

Chkd. AEG

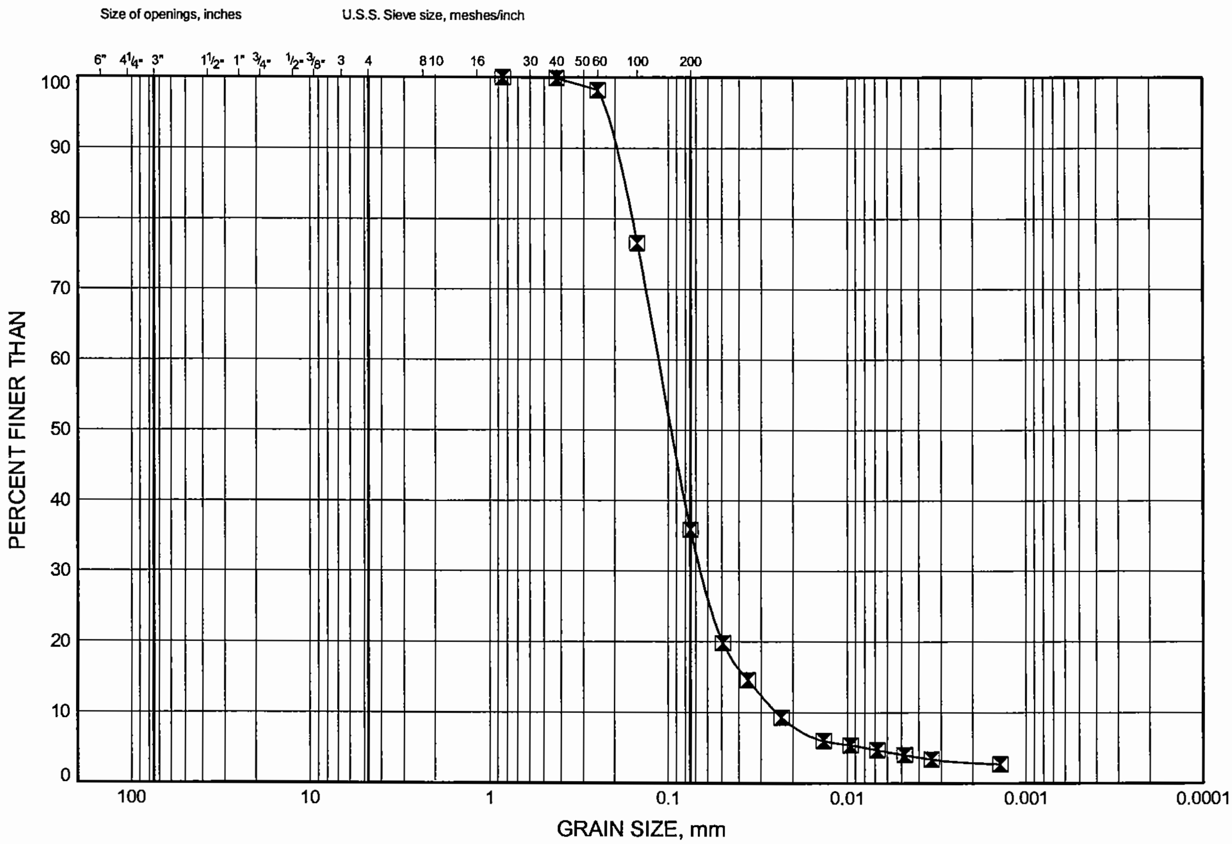
THURBGSD TMLS.GPJ 28/01/05

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B8

SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
☒	TML-12	23.93	270.87

Date January 2005

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Prep'd HS

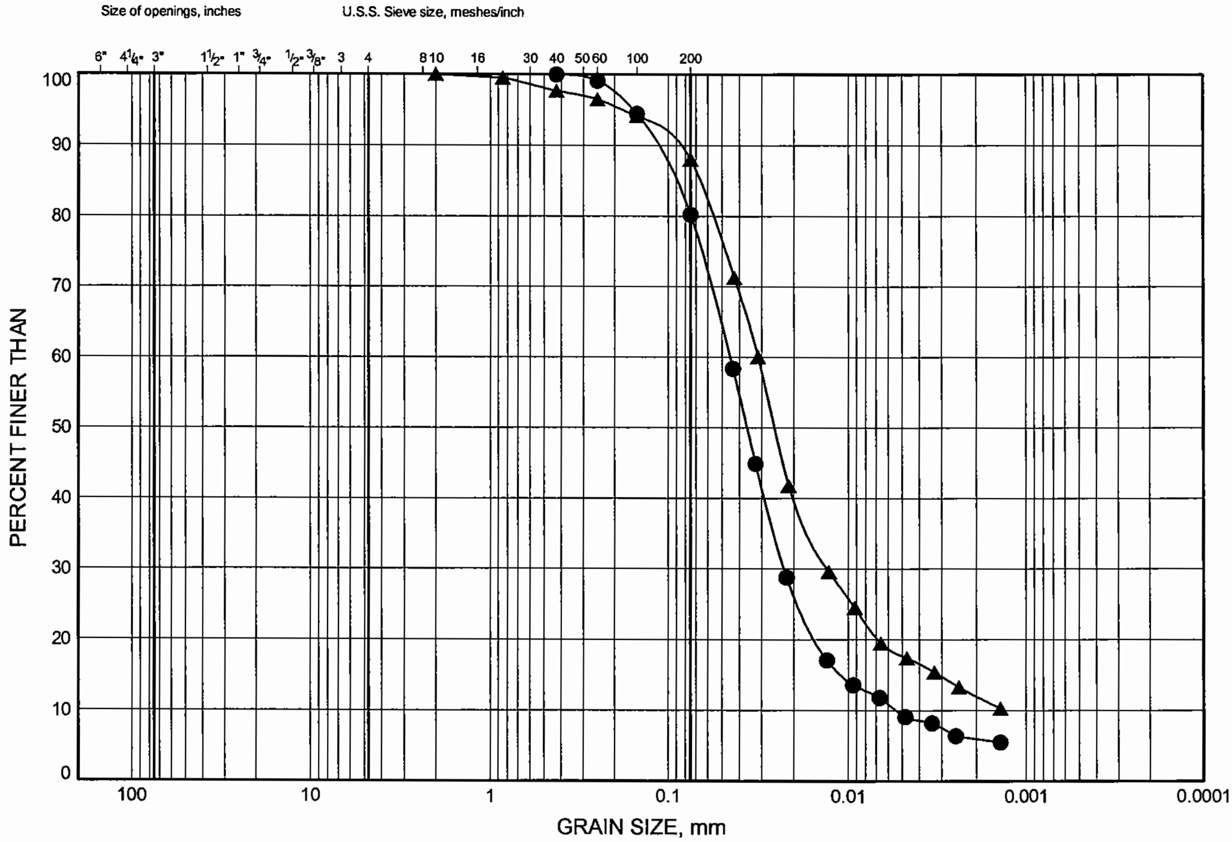
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B9

SILT
(INTERBEDDED)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	28.58	267.63
▲	TML-6	26.82	269.53

Date January 2005

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THURBGSD 1MLS.GPJ 28/01/05

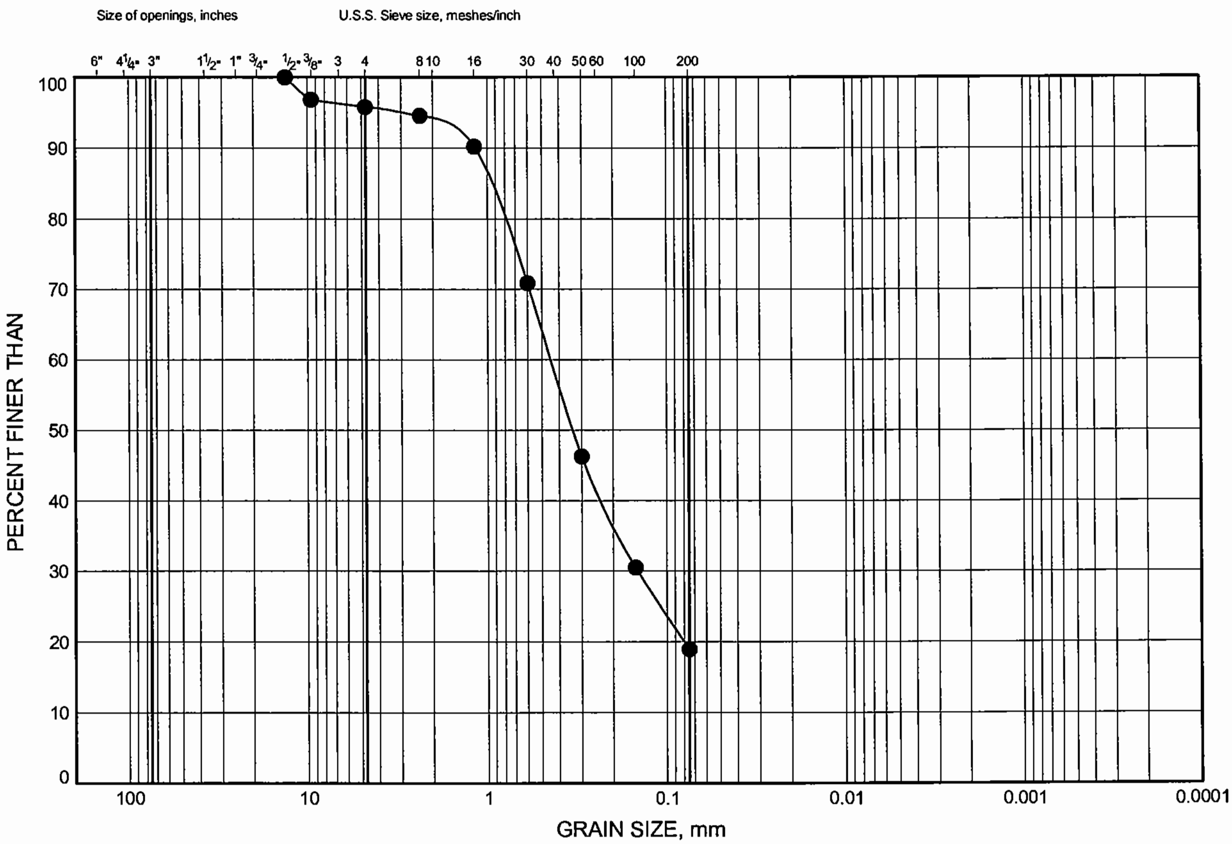
Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B10

SAND AND GRAVEL

OCCASIONAL COBBLES AND BOULDERS



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	55.17	241.03

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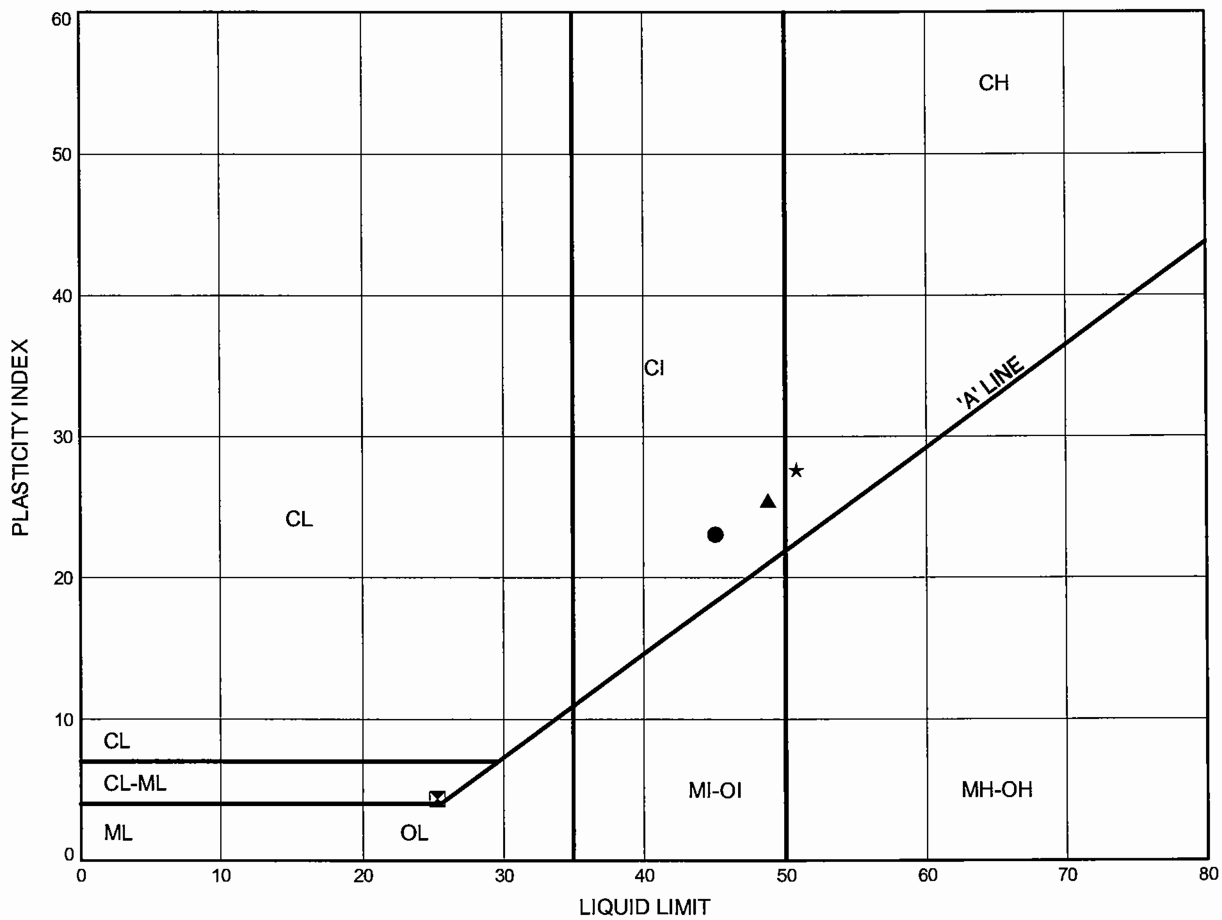
THURBGSD TMLS.GPJ 28/01/05

Hwy 11 Katrine

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY TO CLAYEY SILT



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-11	4.88	291.32
⊠	TML-11	7.92	288.28
▲	TML-5	4.88	291.43
★	TML-6	4.88	291.47

THURBALT TMLS.GPJ 28/01/05

Date January 2005

Project 476-93-01

THURBER

Prep'd HS

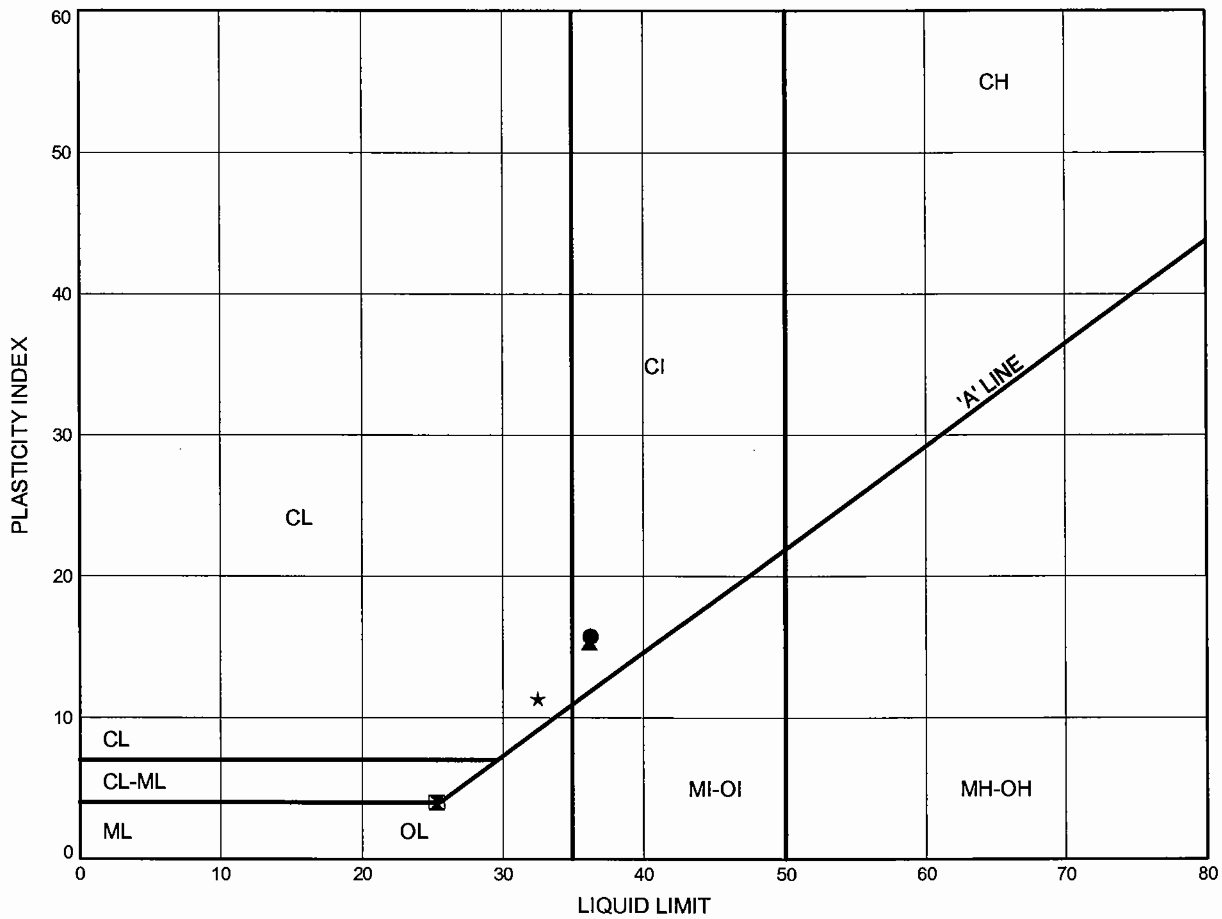
Chkd. AEG

Hwy 11 Katrine

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY TO CLAYEY SILT



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-12	3.35	291.45
⊠	TML-12	5.64	289.16
▲	TML-7	2.51	292.15
★	TML-8	1.83	292.96

THURBALT TMLS.GPJ 28/01/05

Date January 2005

Project 476-93-01

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Prep'd HS

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THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

CLIENT: **Marshall Macklin Monaghan** FILE NUMBER: 19-1423-16

PROJECT: Highway 11, Katrine (Three Mile Lake) REPORT DATE: 02-Feb-06

TEST DATES: Apr 2, 2005 - Apr 15, 2005

SAMPLE: TML-6, ST1, 21'3"
Silty Clay, silt laminations, grey, plastic, (CL)

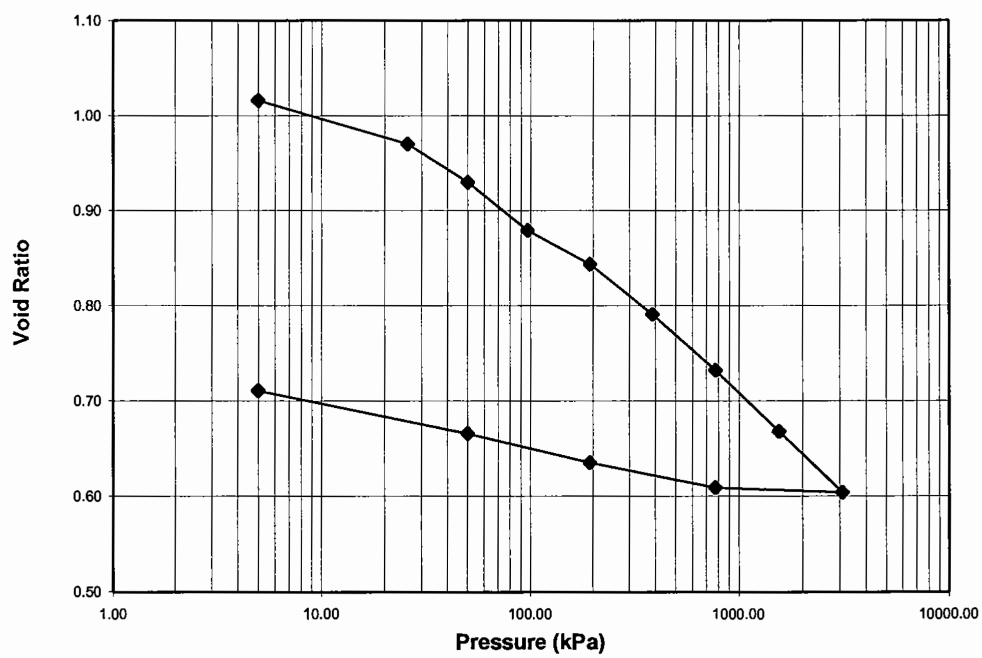
PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1835.6	1898.4
Dry Dens. (kg/m^3)	1331.1	1562.2
Moisture Cont. (%)	37.9	29.7
Void Ratio	1.021	0.722
Saturation(%)	99.9	

Note: A Specific Gravity of 2.69 was measured for the void ratio and saturation calculations

Void Ratio vs Presuure

19-1423-16 (Marshall Macklin Monaghan)
HWY 11 Four Laning, HWY 518 to 520
TML-6, ST1, 21'3"
Oedometer Consolidation Test



TEST DONE BY: JL
REVIEWED BY: JL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

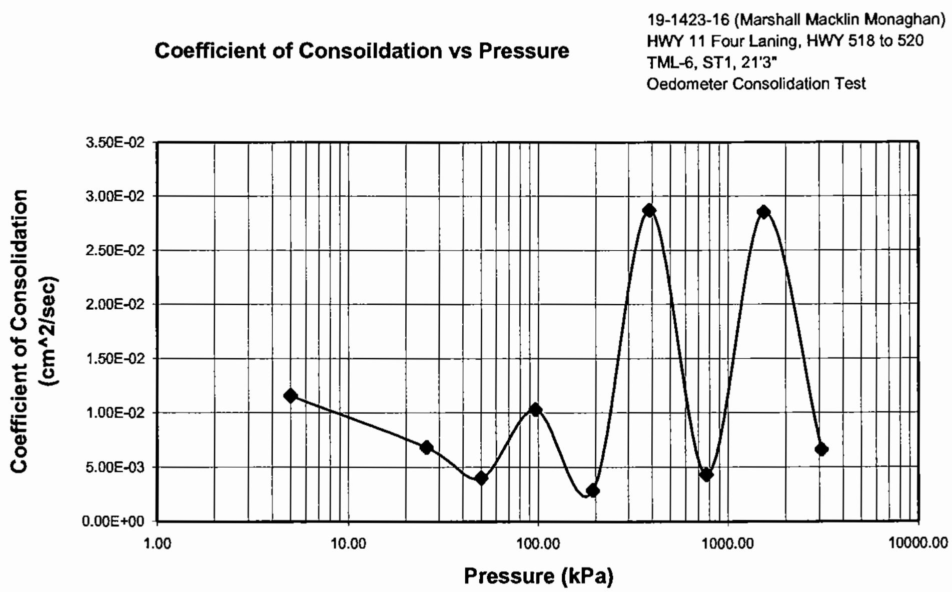
Highway 11, Katrine (Three Mile Lake)
19-1423-16 TML-6, ST1, 21'3"

TRIMMING: The Specimen was manually trimmed to the size of consolidation ring, then mounted in a fixed ring consolidometer

LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hours

CALCULATIONS: Coefficients of Consolidation were calculated by the square root time method.

Pressure (kPa)	Corr. Hgt (mm)	Avg. Hgt. (mm)	D90 (mm)	T90 (min)	Cv (cm^2/sec)	Void Ratio	mv (m^2/kN)	k (cm/s)
0.00	25.350	25.350				1.021		
5.00	25.291	25.320	-0.071	1.96	1.16E-02	1.016	1.10E-03	1.24E-06
25.67	24.715	25.003	-0.126	3.24	6.82E-03	0.970	8.25E-04	5.51E-07
49.86	24.210	24.462	-0.121	5.29	4.00E-03	0.930	5.36E-04	2.10E-07
96.64	23.575	23.892	-0.156	1.96	1.03E-02	0.879	1.81E-04	1.83E-07
193.24	23.131	23.353	-0.133	6.76	2.85E-03	0.844	1.36E-04	3.79E-08
385.77	22.469	22.800	-0.31	0.64	2.87E-02	0.791	7.55E-05	2.12E-07
770.72	21.733	22.101	-0.29	4.00	4.31E-03	0.732	4.14E-05	1.75E-08
1540.91	20.925	21.329	-0.38	0.56	2.86E-02	0.668	2.04E-05	5.71E-08
3081.80	20.129	20.527	-0.21	2.25	6.62E-03	0.604	1.07E-06	6.92E-10
770.72	20.191	20.160				0.609		
193.24	20.518	20.354				0.635		
49.86	20.896	20.707				0.666		
5.00	21.461	21.179				0.711		



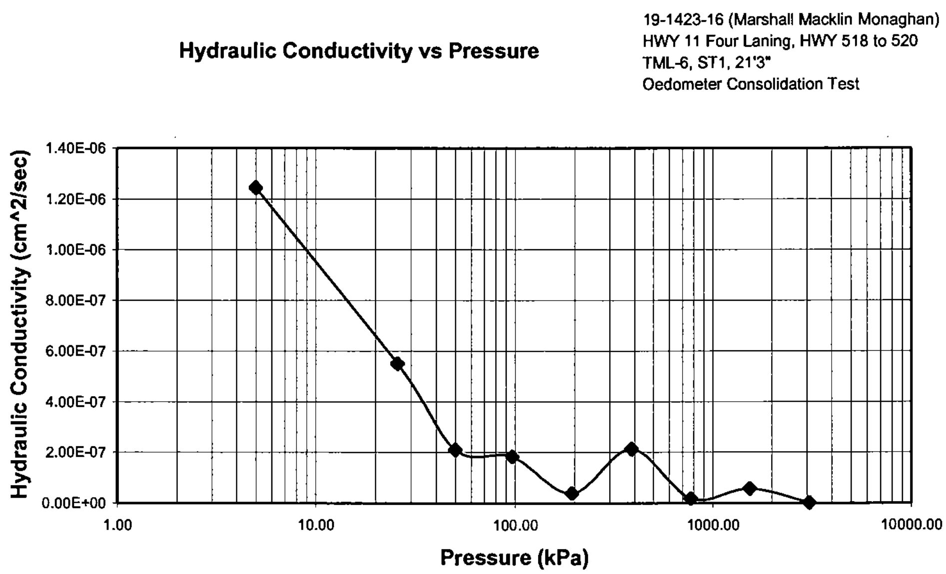
Notes: Cv and k calculated using t_{90} values

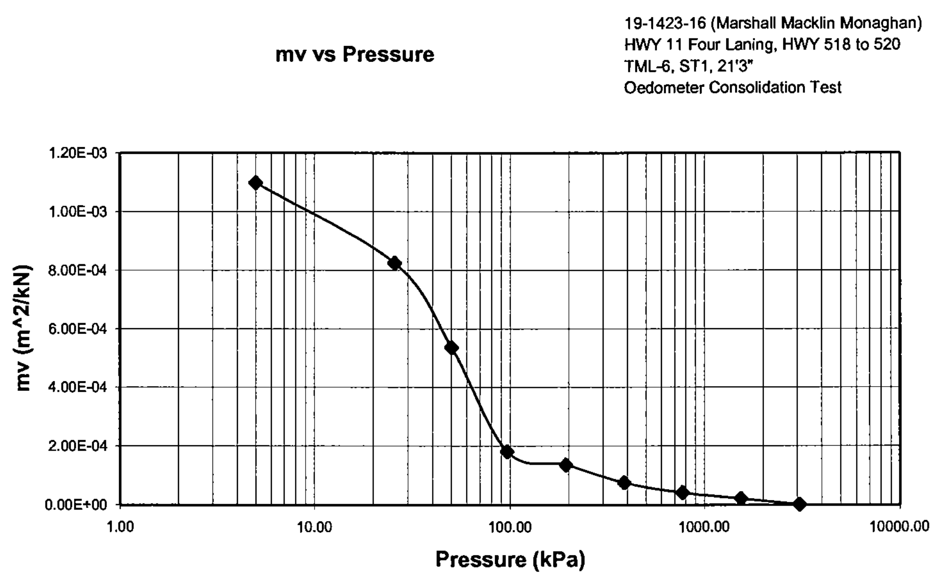
TEST DONE BY: JL
REVIEWED BY: JL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

Highway 11, Katrine (Three Mile Lake)
19-1423-16 TML-6, ST1, 21'3"





TEST DONE BY: JL
REVIEWED BY: JL

Appendix C

Data From Previous Investigation

RECORD OF BOREHOLE No TMS1

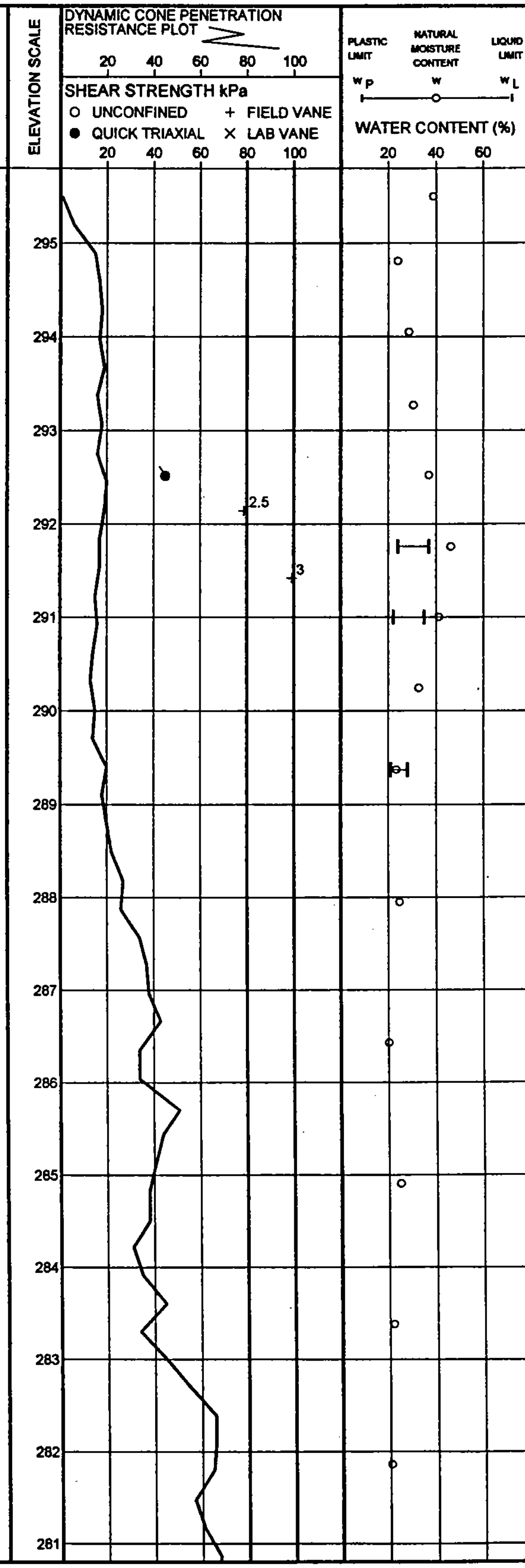
METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 343.2; E 316 441.2 | ORIGINATED BY G.I

DIST 52 HWY 11 | BOREHOLE TYPE Solid Stem Augers, Casing and wash boring & D.C.P.T. | COMPILED BY G.T

DATUM Geodetic | DATE 21.03.01 to 26.03.01 | CHECKED BY Z.O

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
295.8	Ground Surface						
0.0	150 mm **Peat** **SANDY SILT** layered, trace clay, trace organics, very loose to compact, brown, wet	1	SS	4			
		2	SS	14			
		3	SS	8			0 17 77 6
293.3	clayey, firm						
2.5	**SILTY CLAY** layered, very soft to stiff, grey, moist	4	SS	6			
		5	TW	PH		19.0	Mar.21 / Mar.22
		6	SS	1			
		7	SS	1			0 12 48 40
		8	TW	PH			
		9	SS	4			
	with silt zones	10	SS	5			
287.3 / 8.5	**FINE SAND** some silt, very loose to compact, grey, wet	11	SS	1			augering / casing & wash boring
		12	SS	9			
		13	SS	13			0 90 10 0
		14	SS	17			
280.8 / 15.0							



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

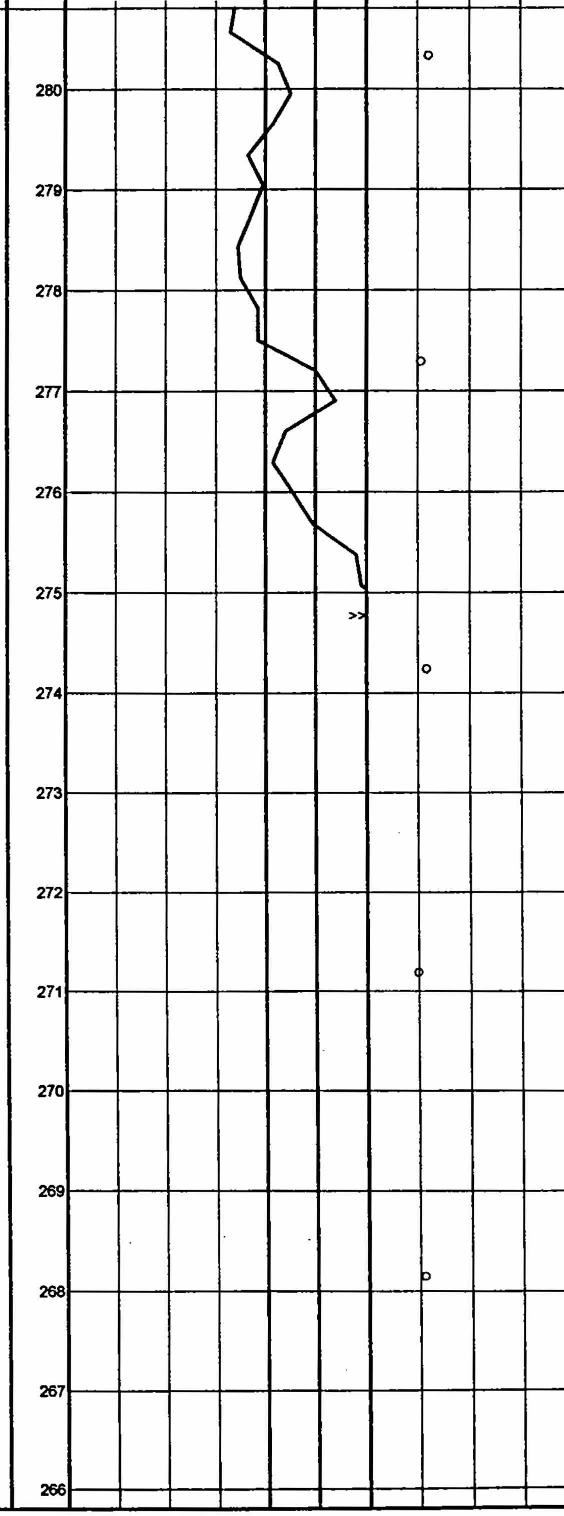
RECORD OF BOREHOLE No TMS1

METRIC

W.P. 314-99-00	LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 343.2; E 316 441.2	ORIGINATED BY G.I
DIST 52 HWY 11	BOREHOLE TYPE Solid Stem Augers, Casing and wash boring & D.C.P.T.	COMPILED BY G.T
DATUM Geodetic	DATE 21.03.01 to 26.03.01	CHECKED BY Z.O

SOIL PROFILE: ELEV DEPTH; DESCRIPTION; STRAT PLOT
SAMPLES: NUMBER; TYPE; "N" VALUES
GROUND WATER CONDITIONS; ELEVATION SCALE
DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; X LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P; NATURAL MOISTURE CONTENT w; LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
280.8 / 15.0	**FINE SAND** some Silt compact to dense, grey, wet	15	SS	18
		16	SS	32
	Silty to 25 m	17	SS	24
		18	SS	24
		19	SS	11
265.8 / 30.0				



Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No TMS1

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 343.2; E 316 441.2 | ORIGINATED BY G.I

DIST 52 HWY 11 | BOREHOLE TYPE Solid Stem Augers, Casing and wash boring & D.C.P.T. | COMPILED BY G.T

DATUM Geodetic | DATE 21.03.01 to 26.03.01 | CHECKED BY Z.O

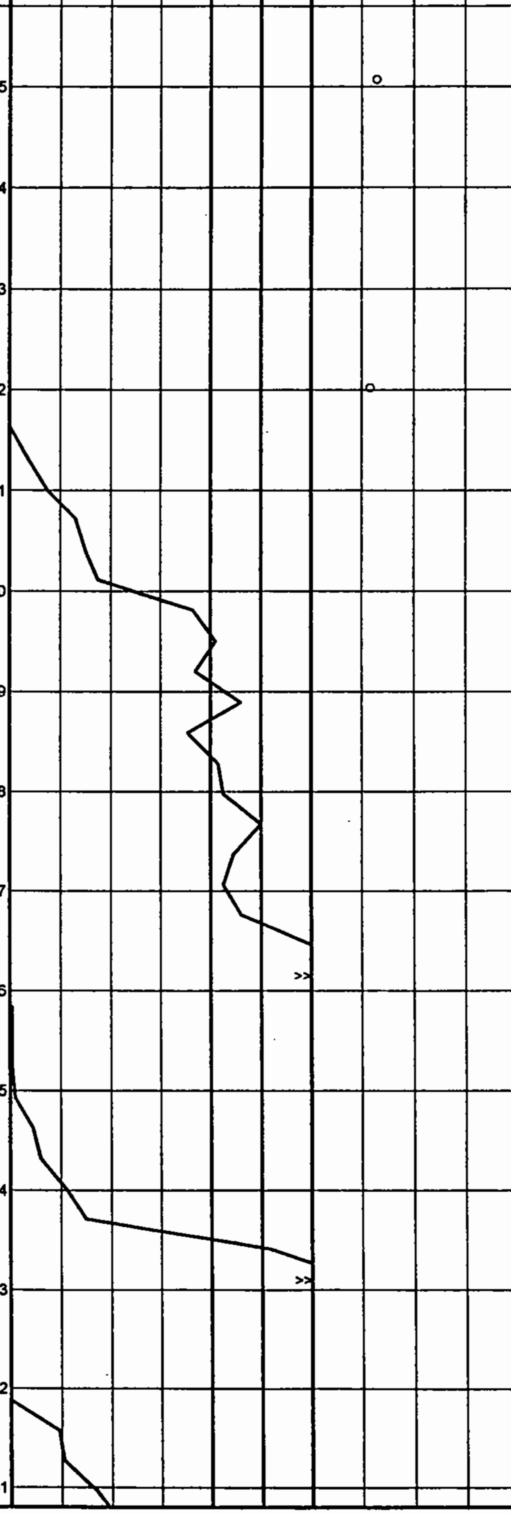
ELEV DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
265.8 30.0								
			20	SS	28		265	0 60 40 0
							264	
	FINE SAND Silty some Sandy Silt zones compact to dense, grey, wet						263	
			21	SS	46		262	Mar.22
							261	Mar.23
							260	
							259	
							258	
							257	
			22	SS	28		256	0 42 58 0
							255	
							254	
			23	SS	13		253	
							252	Mar.26
250.8 45.0							251	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No TMS1

METRIC

W.P. 314-99-00
LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 343.2; E 316 441.2
ORIGINATED BY G.I

DIST 52 HWY 11
BOREHOLE TYPE Solid Stem Augers, Casing and wash boring & D.C.P.T.
COMPILED BY G.T

DATUM Geodetic
DATE 21.03.01 to 26.03.01
CHECKED BY Z.O

ELEV / DEPTH (250.8)	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
45.0	**FINE SAND** Silty, compact, grey, wet						250				
							249				
248.0			24	SS	8		248				
47.8	End of borehole Water used for wash boring and drilling mud for counter-balancing hydrostatic uplift *Water level not stabilized upon completion Wash boring from 9.1 m Sand rising in borehole (quick condition) from 36.5 m Dynamic Cone Penetration Test performed from 34.0 m to 39.6 m, soil stratigraphy inferred only. Dynamic Cone Penetration test performed from 40.0 m to 42.6 m, soil stratigraphy inferred only. Dynamic Cone Penetration test performed from 43.9 m to 46.3 m, soil stratigraphy inferred only. Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground surface to 21.0 m										

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TMS2

METRIC

W.P. 314-99-00 LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 373.3; E 316 423.0 ORIGINATED BY G.I

DIST 52 HWY 11 BOREHOLE TYPE Solid Stem Augers, Casing and Washboring, NQ Rock Coring & D.C.P.T. COMPILED BY G.T

DATUM Geodetic DATE 14.03.01 to 21.03.01 CHECKED BY Z.O

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.8	Ground Surface							
0.0	150 mm Topsoil SANDY SILT trace clay, occasional thin silty clay seams, very loose to compact, brown, moist	1	SS	3				
		2	SS	8	294			0 27 66 7
		3	SS	17	293			
292.7 2.1	SILTY CLAY layered, soft to stiff, grey	4	SS	4	292		16.9	0 13 64 23
		5	TW	PH				
	------ with silt zones	6	SS	6	291			0 16 76 8
		7	SS	5	290			
289.6 5.2	SILT compact, grey, wet, dilatent	8	SS	11	289			
		9	SS	10	288			
	------	10	SS	0*				* low N-value probably due to hydrostatic uplift
	Sandy loose	11	SS	5	287			0 40 60 0
286.3 8.5	FINE SAND some silt, very loose to compact, grey, wet				286			
		12	SS	4	285			
		13	SS	4	284			augering ------ casing and wash boring
		14	SS	10	283 282			
		15	SS	7	281			0 82 18 0
279.8 15.0					280			

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

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

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

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No TMS2

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 373.3; E 316 423.0 | ORIGINATED BY G.I

DIST 52 HWY 11 | BOREHOLE TYPE Solid Stem Augers, Casing and Washboring, NQ Rock Coring & D.C.P.T. | COMPILED BY G.T

DATUM Geodetic | DATE 14.03.01 & 21.03.01 | CHECKED BY Z.O

SOIL PROFILE — ELEV DEPTH / DESCRIPTION / STRAT PLOT; SAMPLES — NUMBER / TYPE / "N" VALUES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

279.8
15.0

FINE SAND
some silt,
compact,
grey, wet

- - - - - - -
Silty sand/Sandy Silt
zones

264.8
30.0

NUMBER	TYPE	"N" VALUES	REMARKS / GRAIN SIZE (GR SA SI CL)
16	SS	15	March 14 / March 15
17	SS	13	
18	SS	14	
19	SS	14	
20	SS	16	
21	SS	21	
22	SS	19	
23	SS	18	0 27 71 2
24	SS	23	
25	SS	19	

Elevation scale: 279, 278, 277, 276, 275, 274, 273, 272, 271, 270, 269, 268, 267, 266, 265

Continued Next Page

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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TMS2

METRIC

W.P.	314-99-00	LOCATION	Katrine -Three Mile Lake Road - Co-ords: N 5 048 373.3; E 316 423.0	ORIGINATED BY	G.I
DIST	52 HWY 11	BOREHOLE TYPE	Solid Stem Augers, Casing and Washboring, NQ Rock Coring & D.C.P.T.	COMPILED BY	G.T
DATUM	Geodetic	DATE	14.03.01 to 21.03.01	CHECKED BY	Z.O

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
264.8 / 30.0	**FINE SAND** some medium sand, trace silt, compact to dense, grey, wet							
			26	SS	17		264	
			27	SS	45		263 / 262	
			28	SS	20		261	March 15 / March 16
			29	SS	49		260 / 259 / 258 / 257 / 256 / 255	March.16/01 / March.19/01
253.8 / 41.0	**GRAVEL AND SAND** with cobbles and boulders, compact to dense, grey, wet; cobbles; cobbles						254 / 253	boulder @ 41.1 / boulder @ 42.1
			30	SS	25		252	boulder @ 43.1
251.5 / 43.3	End of borehole. Dynamic Cone Penetration Test conducted from 43.3 to 44.2 m						251	March 19 / March 20
250.6 / 44.2	End of Dynamic Cone Penetration Test							

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³

Continued Next Page

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

RECORD OF BOREHOLE No TMS2

METRIC

W.P.	314-99-00	LOCATION	Katrine -Three Mile Lake Road - Co-ords: N 5 048 373.3; E 316 423.0	ORIGINATED BY	G.I
DIST	52 HWY 11	BOREHOLE TYPE	Solid Stem Augers, Casing and Washboring, NQ Rock Coring & D.C.P.T.	COMPILED BY	G.T
DATUM	Geodetic	DATE	14.03.01 & 21.03.01	CHECKED BY	Z.O

SOIL PROFILE: ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Dynamic Cone Penetration Tests performed from 34.0 to 34.6 m and 43.3 to 44.2 Soil strata inferred Borehole extended by coring through boulders from 41.1 to 41.5 m, 42.1 to 42.3 m and from 43.1 to 43.3 m Piezometer installed at 27.0 m upon completion Water level in piezometer at: March 21/200 - 0.30 m above ground surface March 22/2001 - 0.10 m above ground surface March 23/2001 - 0.00 m March 26/2001 - 0.00 m March 27/2001 - 0.05 m March 29/2001 - 0.05 m April 03/2001 - 0.00 m April 06/2001 - 0.00 m April 09/2001 - 0.10 m above ground surface April 11/2001 - 0.10 m above ground surface										

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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TMS3

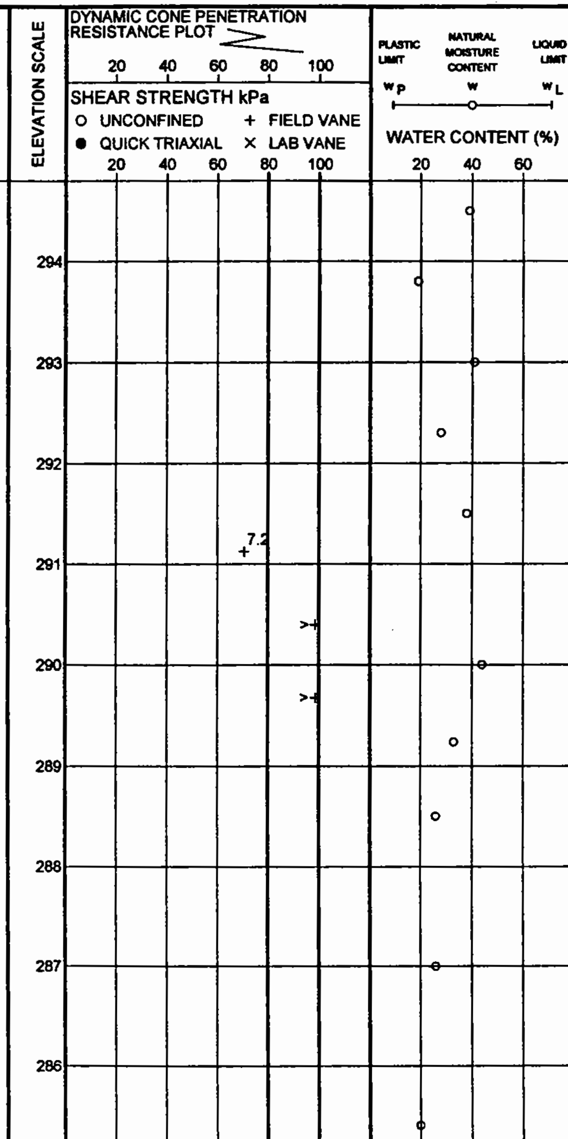
METRIC

W.P. 314-99-00	LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 385.9; E 316 425.4		ORIGINATED BY G.I
DIST 52	HWY 11	BOREHOLE TYPE Solid Stem Augers	COMPILED BY G.T
DATUM Geodetic	DATE 30.03.01		CHECKED BY Z.O

SOIL PROFILE / SAMPLES

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES
294.8	Ground Surface			
0.0	150 mm Topsoil **SILT** some clay and sand some organics, brown, very soft, (possible fill)	1	SS	2
		2	SS	4
293.0		3	SS	2
1.8	**ORGANIC SILT & CLAYEY SILT** very soft, dark grey/black			
292.5 / 2.3	**SILT** some sand and clay, rootlets & organics, very soft, grey	4	SS	2
291.8 / 3.0	**SILTY CLAY** layered very soft to stiff grey	5	SS	4
		6	TW	PH
290.0 / 4.8	**SILT** some clay seams, loose, grey, wet, dilatent	7	SS	2
		8	SS	8
		9	SS	8
287.8 / 7.0	Silty **FINE SAND** some silt, very loose to loose grey, wet	10	SS	4
285.2		11	SS	5
9.6	End of borehole *Water level at 1.8 m (not stabilized) and hole caved at 3.0 m upon completion			

GROUND WATER CONDITIONS: ▼* (at approx. elev. 293.0)



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TMS4

METRIC

W.P. 314-99-00 | LOCATION Katrine - Three Mile Lake Road - Co-ords: N 5 048 327.5; E 316 446.6 | ORIGINATED BY G.I

DIST 52 | HWY 11 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY G.T

DATUM Geodetic | DATE 02.04.01 | CHECKED BY Z.O

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
295.8	Ground Surface								
0.0	300 mm **Peat (frozen)** **SILT** some sand, trace to some clay, firm to stiff, brown	1	SS	5					
		2	SS	9		295		19.6	0 17 78 5
	Clayey, firm	3	SS	8		294			
293.7 / 2.1	**SILTY CLAY** very soft to firm, brown to 2.6 m, grey below	4	SS	4		293			
		5	SS	3		292	Field vane: +4		
		6	TW	PH					
		7	SS	1		291			
		8	SS	2	▼*	290			
		9	SS	2		289			
	------- with silt zones	10	SS	6		288			
287.3 / 8.5	**SILTY SAND** trace of organics, loose, grey, wet, dilatent					287			
286.2		11	SS	6					
9.6	End of borehole *Water level at 5.7 m (not stabilized) and hole caved at 7.0 m upon completion								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Driven Piles	Footing on Native Soil	Footing on Engineered Fill	Caisson
Advantages: i. Piles will develop high geotechnical resistance if driven to refusal in the very dense soil. ii. Allows choice of conventional, integral or semi-integral abutment design. iii. Readily installed. *Disadvantages:* i. Higher unit costs than footings. ii. Construction concerns related to the possibility of pile being obstructed by a boulder during driving.	*Advantages:* i. Ease of construction. ii. Allows choice of conventional or semi-integral abutment. iii. Lower cost than deep foundations. *Disadvantages:* i. Low geotechnical resistance available at this site. ii. Potential for unacceptable magnitude of settlement. **NOT RECOMMENDED**	*Advantages:* i. Would permit use of higher geotechnical resistance than is available on the native soil. ii. Allows choice of conventional or semi-integral abutment. iii. Allows use of perched abutments. iv. Lower cost than deep foundations. *Disadvantages:* iii. Cost of constructing engineered fill. iv. Low geotechnical resistance available at this site. v. Potential for unacceptable magnitude of settlement. **NOT RECOMMENDED**	*Advantages:* i. High resistance is available for caissons founded on very dense soil. ii. Construction of caissons could continue in freezing weather. iii. Choice of conventional or semi-integral abutment design. *Disadvantages:* i. Soil conditions encountered at this site are considered to be unsuitable. **NOT RECOMMENDED**

THURBER

Appendix E

Special Provisions

The following Special provisions are referenced in this report:

- Amendment to OPSS 206, December 1993
- SP 599S22
- Special Provision No. 902S01
- Special Provision No. 903S01
- Special Provision No. 105S10

Suggested text for a NSSP on Pile Installation should contain the following:

Suggested text for a NSSP on Pile Installation should contain the following:

"*The potential founding stratum contains cobbles and boulders, particularly below Elevation 255. The presence of cobbles and boulders will potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:*

- *The need to provide protection to the pile tips*
- *Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving*
- *As a result of the presence of boulders, piles may meet refusal at varying depths*
- *Pile driving must be controlled according to the criteria specified for the site.*

Appendix F

Selected Slope Stability Output

& Settlement Analysis

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Rock Fill	20	0	42	1
Silt	19	0	28	1
Silty clay	19	60	0	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
FEb 06
South Approach
Rock Fill, Undrained

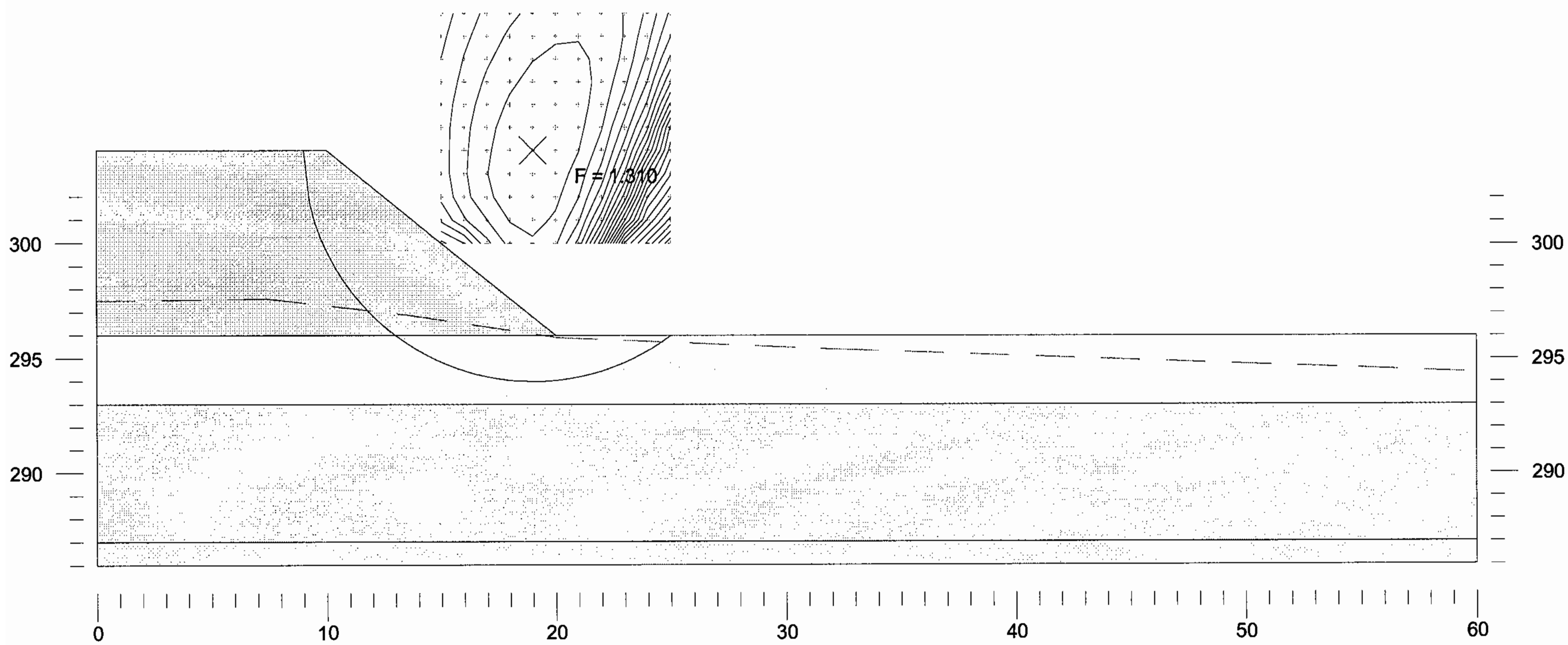


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FIGURE F1

	Gamma	C	Phi	Piezo
	kN/m3	kPa	deg	Surf.
Rock Fill	20	0	42	1
Silt	19	0	28	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
South Approach
Rock Fill, Base

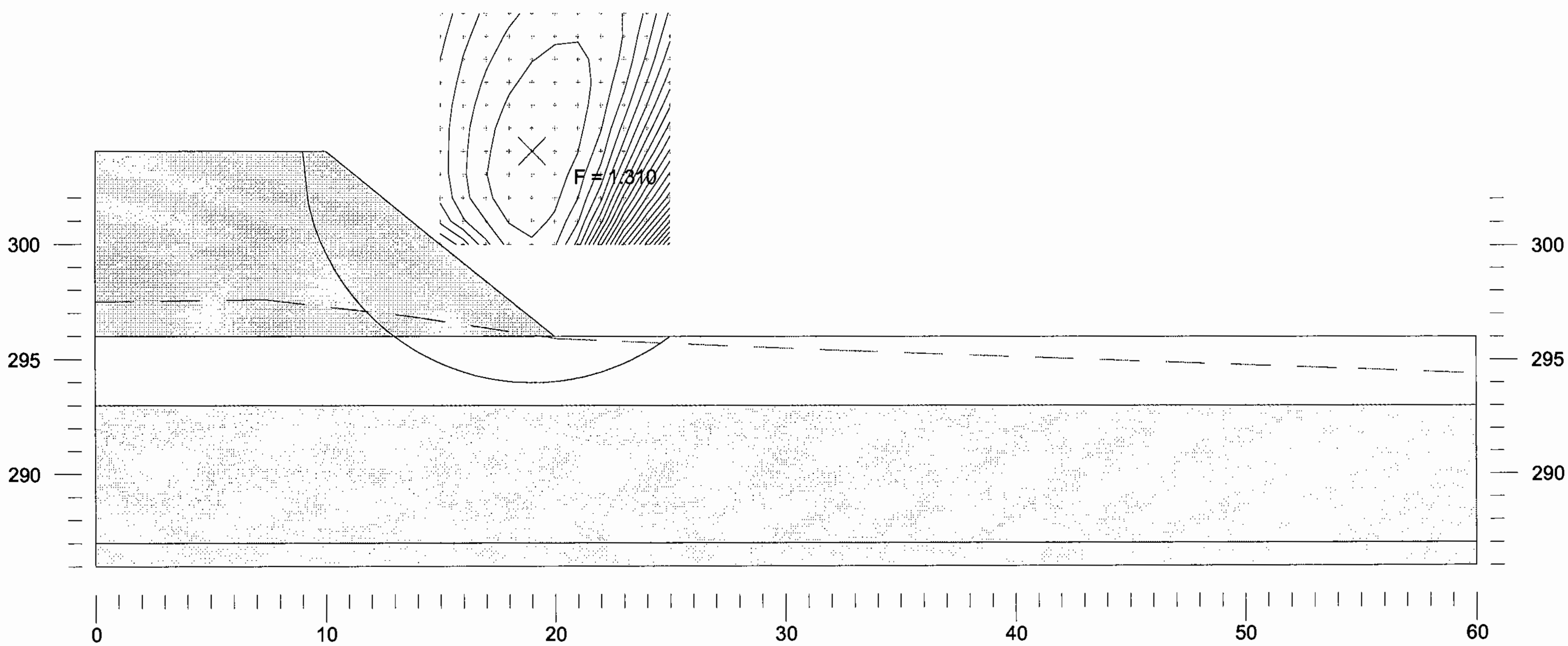

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FIGURE F2

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Rock Fill	20	0	42	1
Silt	19	0	28	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Seismic coefficient = 0.08

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
South Approach
Rock Fill, 0.08 Seismic

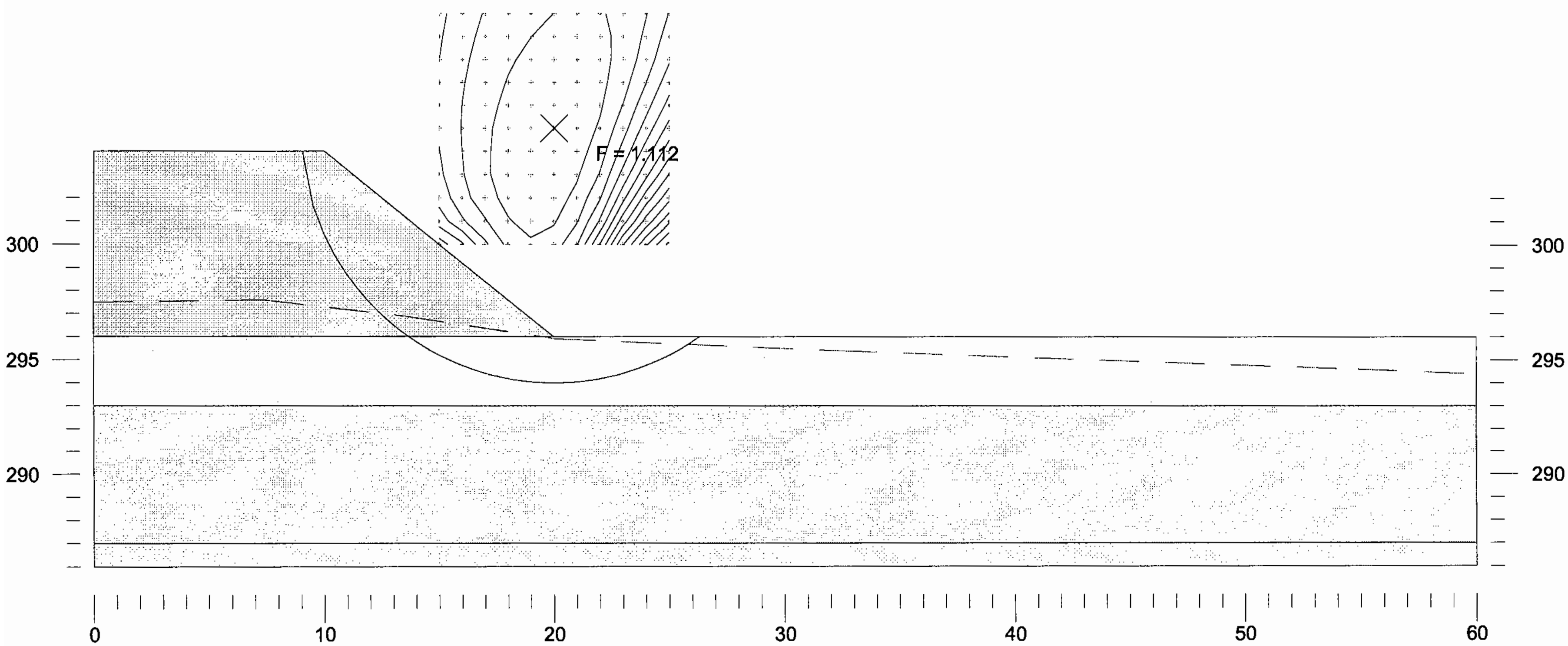

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FIGURE F3

	Gamma	C	Phi	Piezo
	kN/m3	kPa	deg	Surf.
Earth Fill	22	0	30	1
Silt	19	0	28	1
Silty clay	19	60	0	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Feb 06
South Approach
Earth Fill, UNdrained

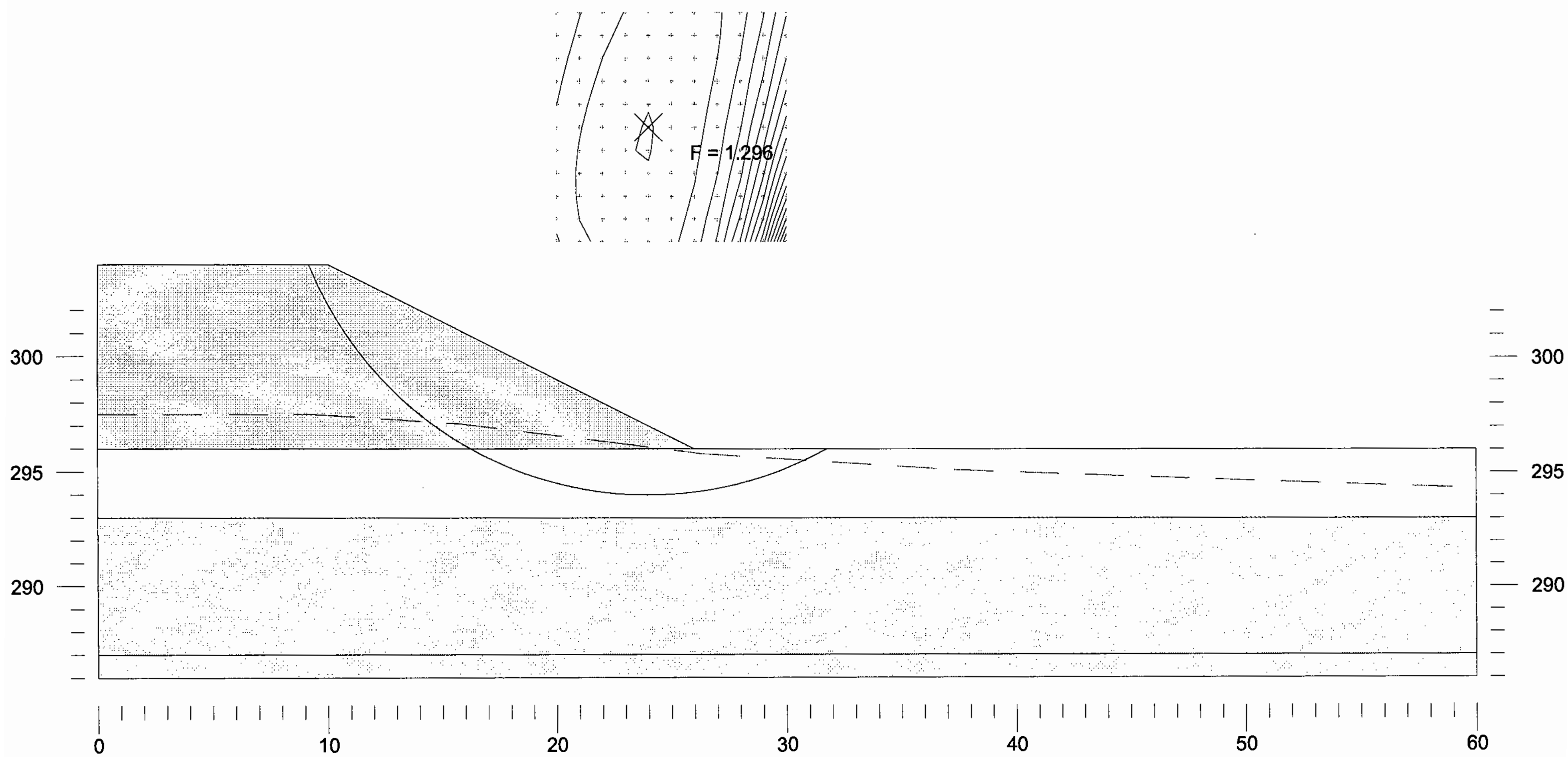

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FIGURE F4

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	22	0	30	1
Silt	19	0	28	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
South Approach
Earth Fill, ESA

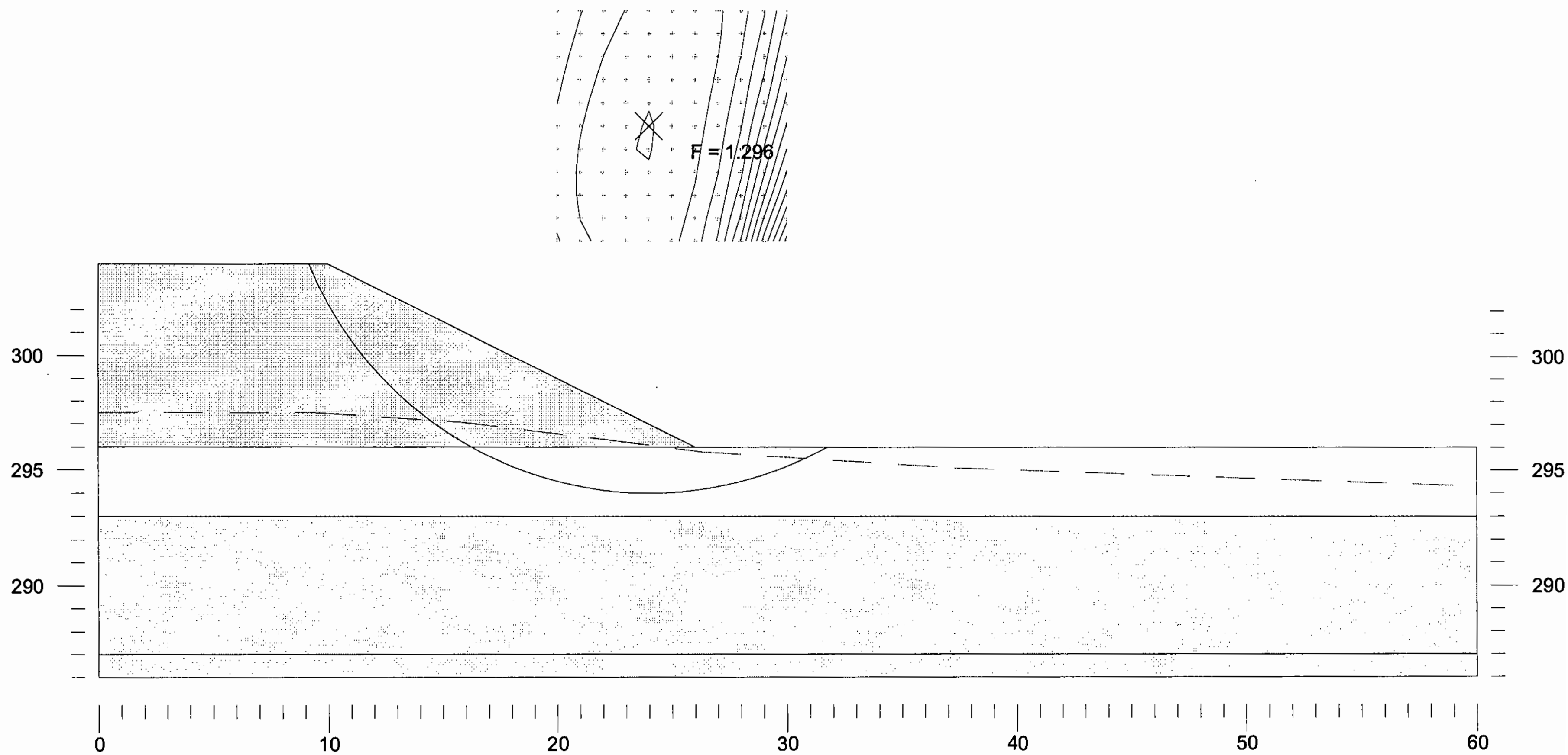

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FIGURE F5

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	22	0	30	1
Silt	19	0	28	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Seismic coefficient = 0.08

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
South Approach
Earth Fill, 0.08 Seismic

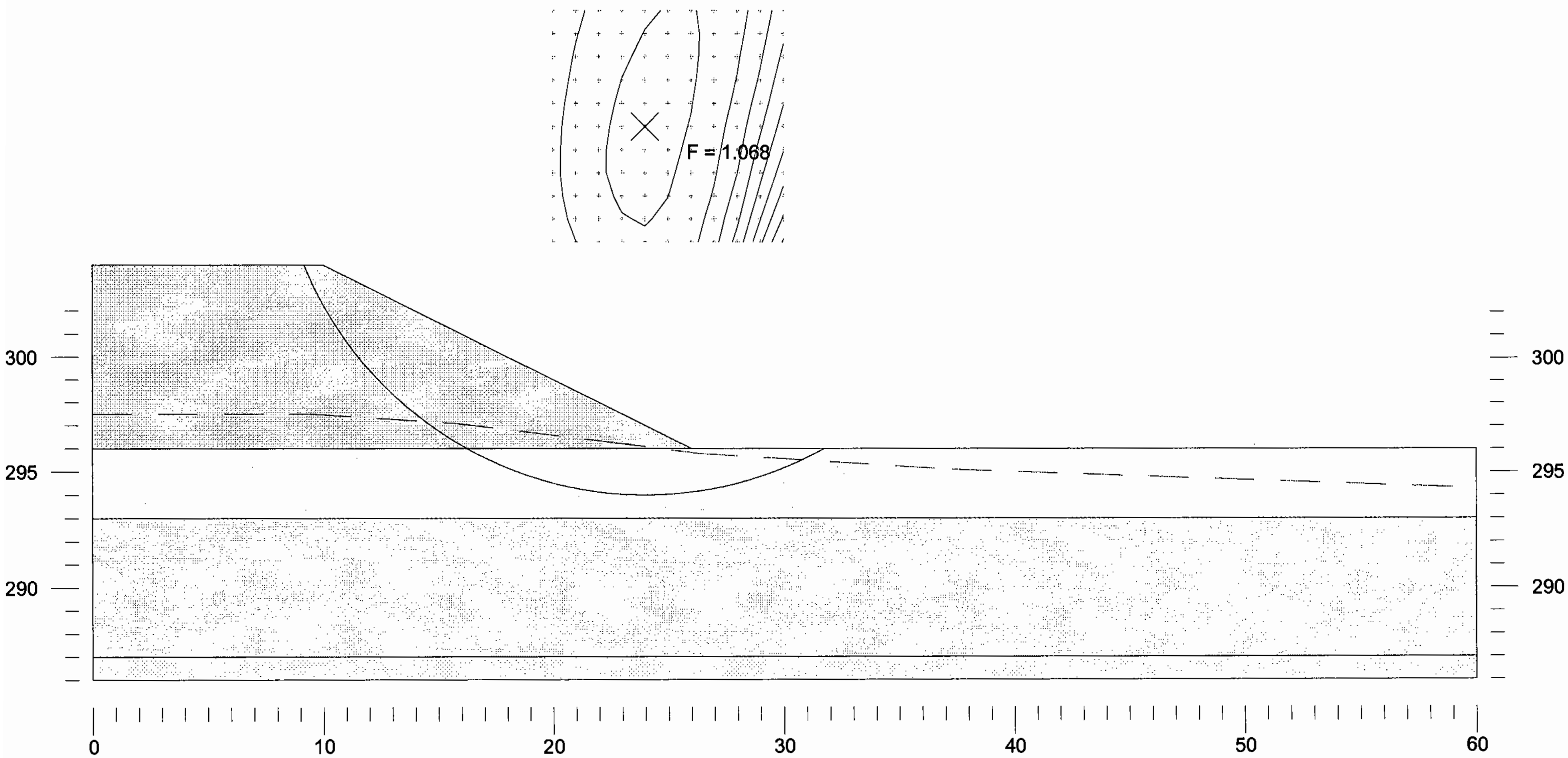

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FIGURE F6

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Rock Fill	20	0	42	1
Silty clay	19	60	0	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Feb 06
North Approach
Rock Fill, Undrained

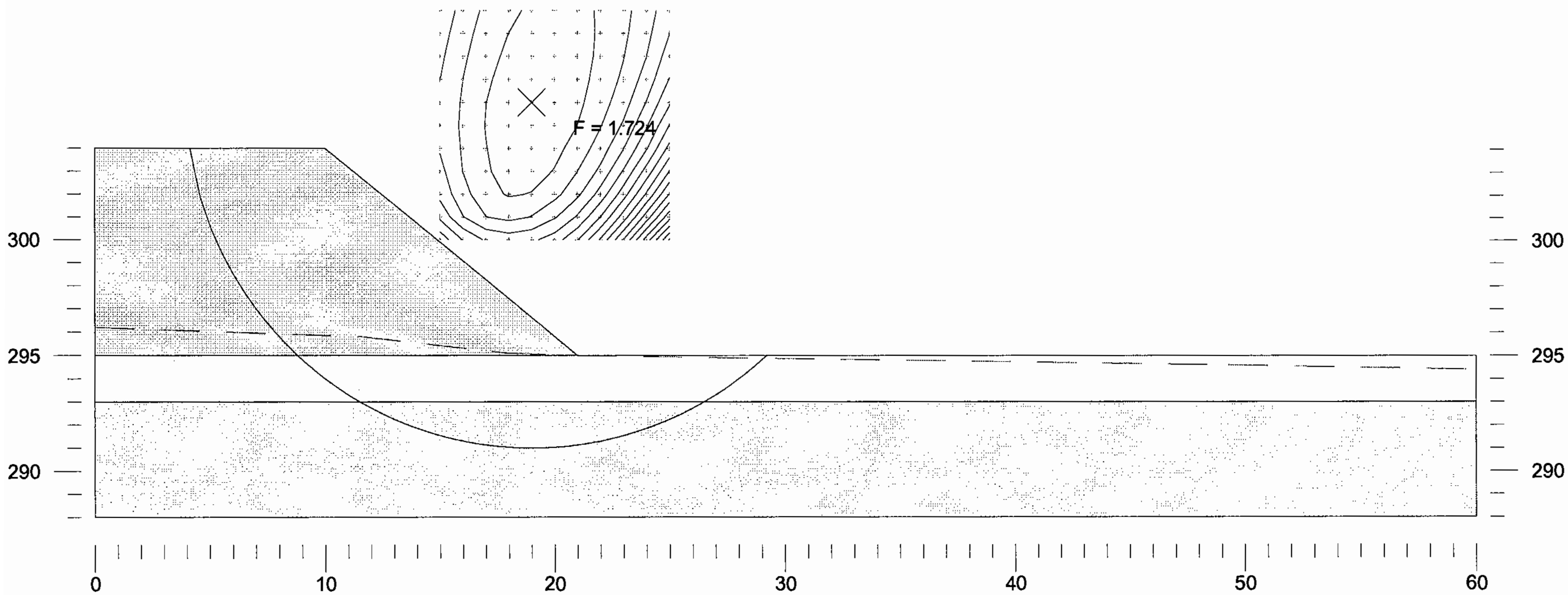

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FIGURE F7

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Rock Fill	20	0	42	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
North Approach
Rock Fill, Base

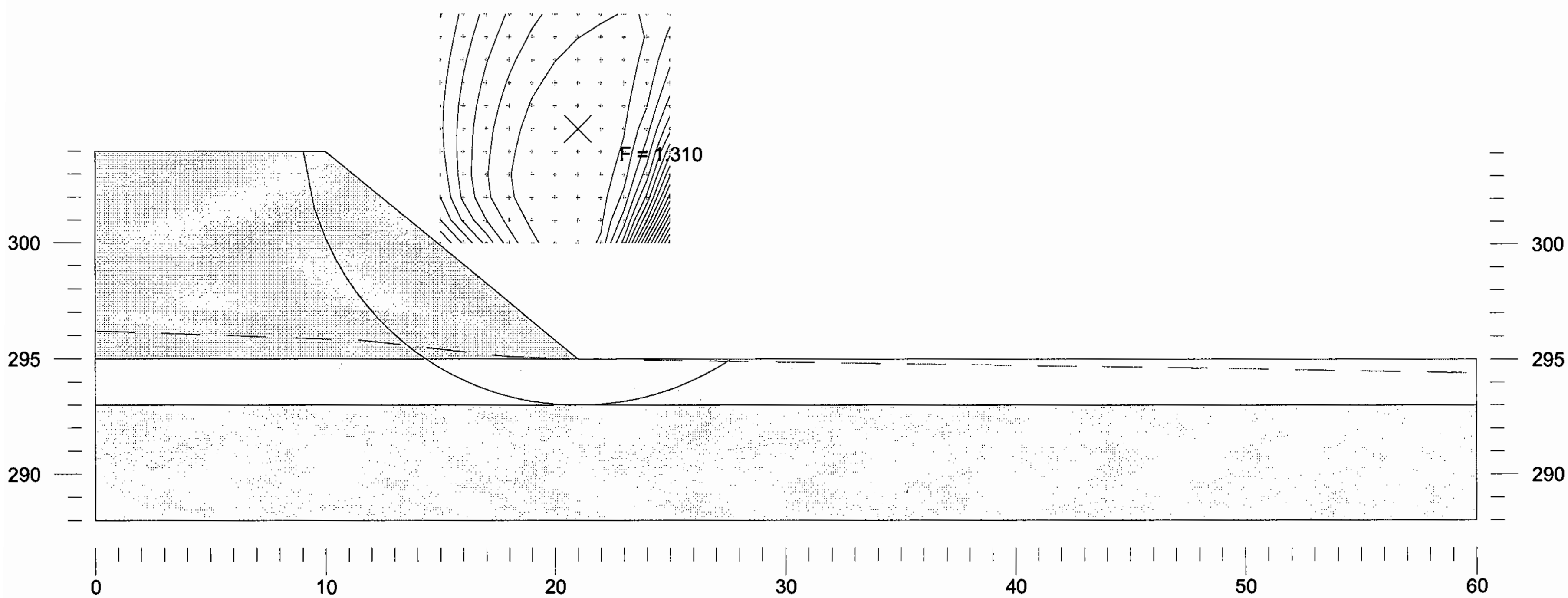

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FIGURE F8

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Rock Fill	20	0	42	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Seismic coefficient = 0.08

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
North Approach
Rock Fill, 0.08 Seismic

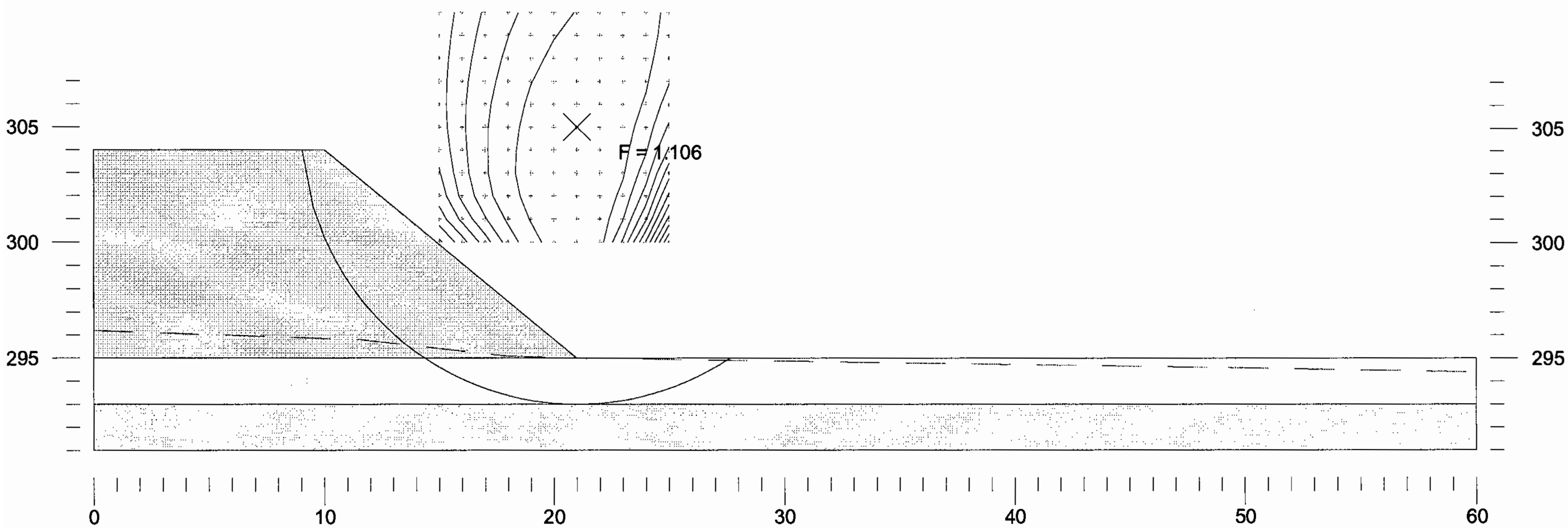

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FIGURE F9

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	21	0	30	1
Silty clay	19	60	0	1
Silt and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake NBL
Feb 06
North Approach
Earth Fill, Undrained

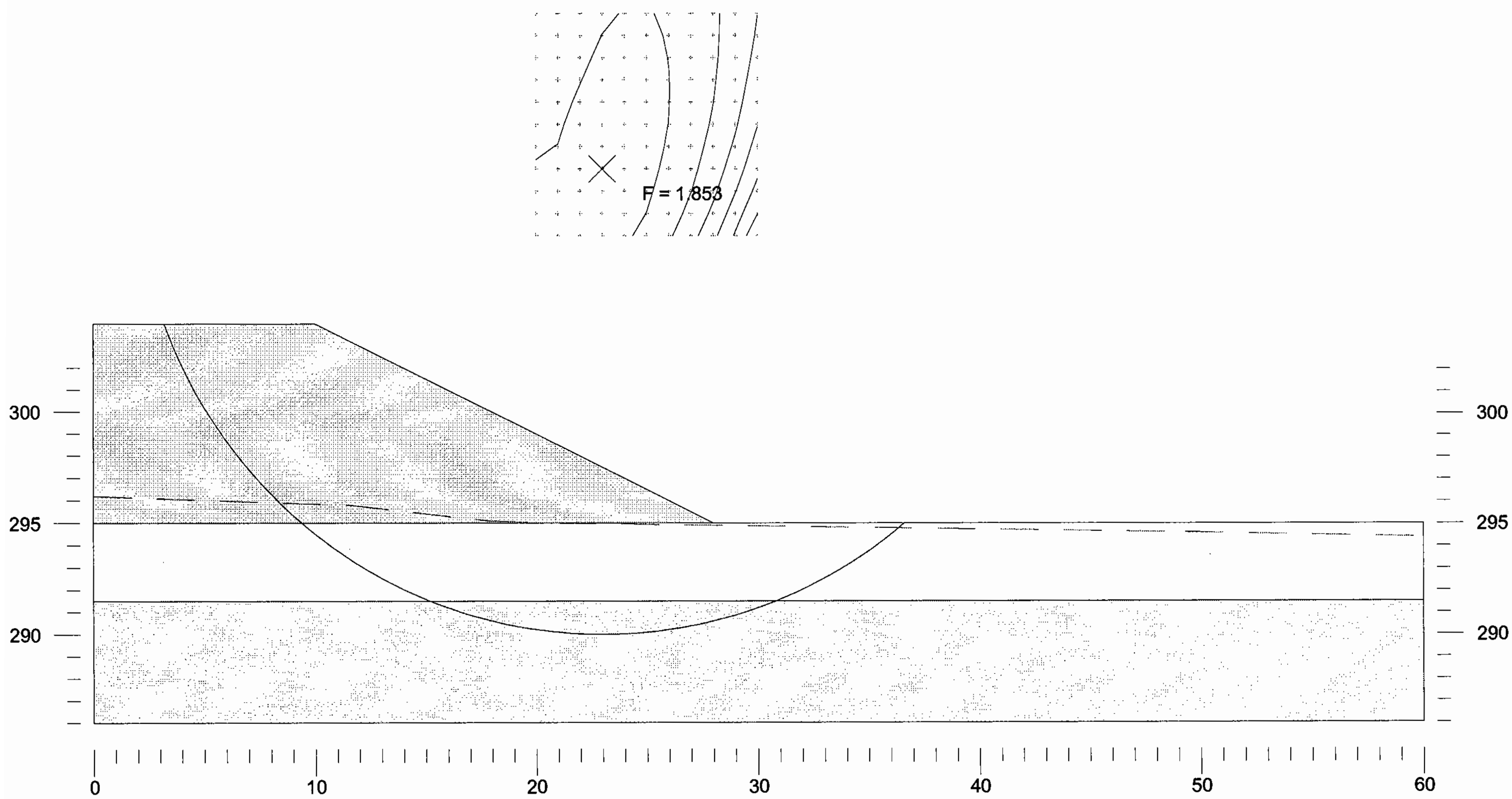

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FIGURE F10

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	21	0	30	1
Silty clay	19	0	28	1
Silt and sand	21	0	30	1

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake NBL
Jan 20 05
North Approach
Earth Fill, Base

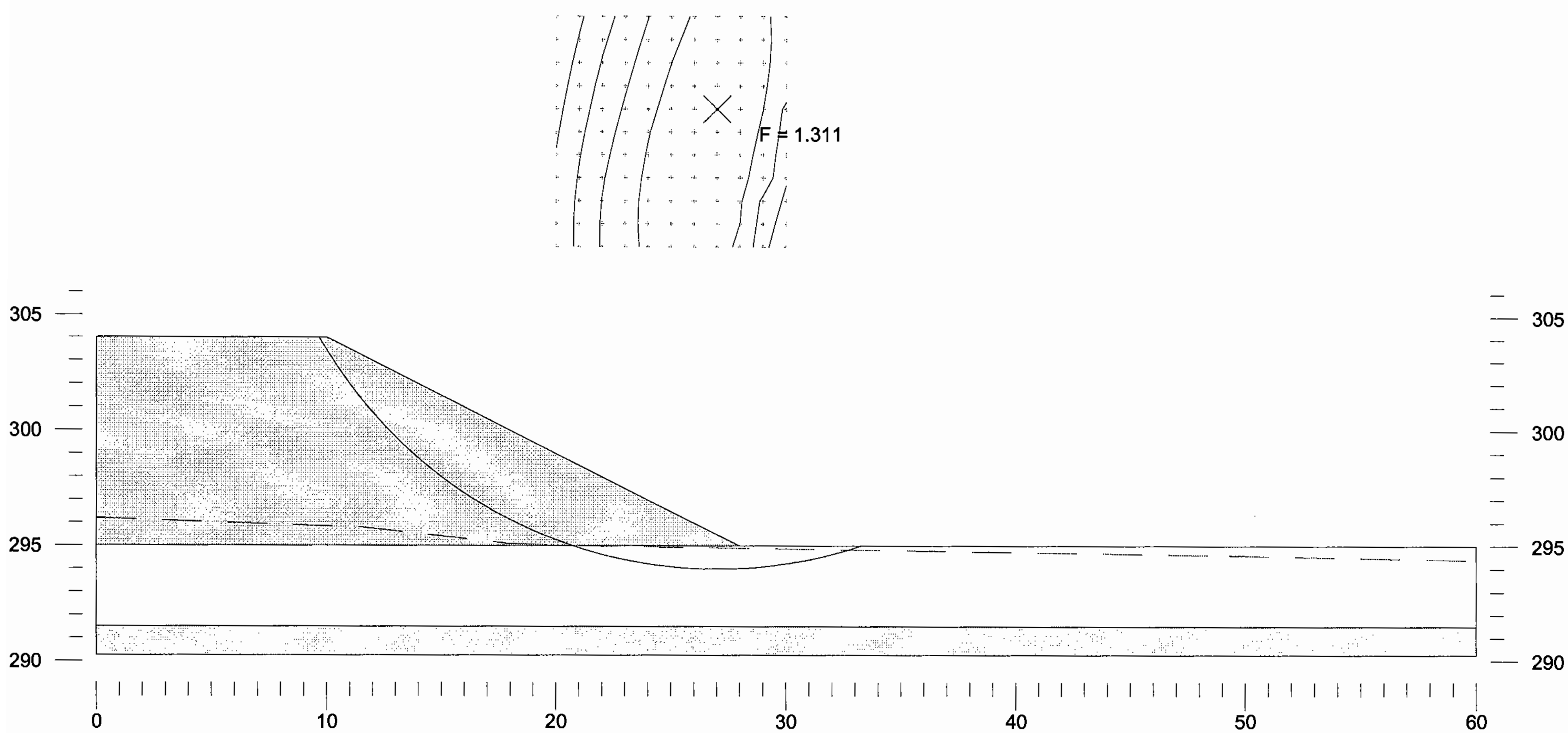

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FIGURE F11

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	22	0	30	1
Silty clay	19	0	28	1
Sil and sand	21	0	30	1

Seismic coefficient = 0.08

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake SBL
Jan 25 05
North Approach
Earth Fill, 0.08 Seismic

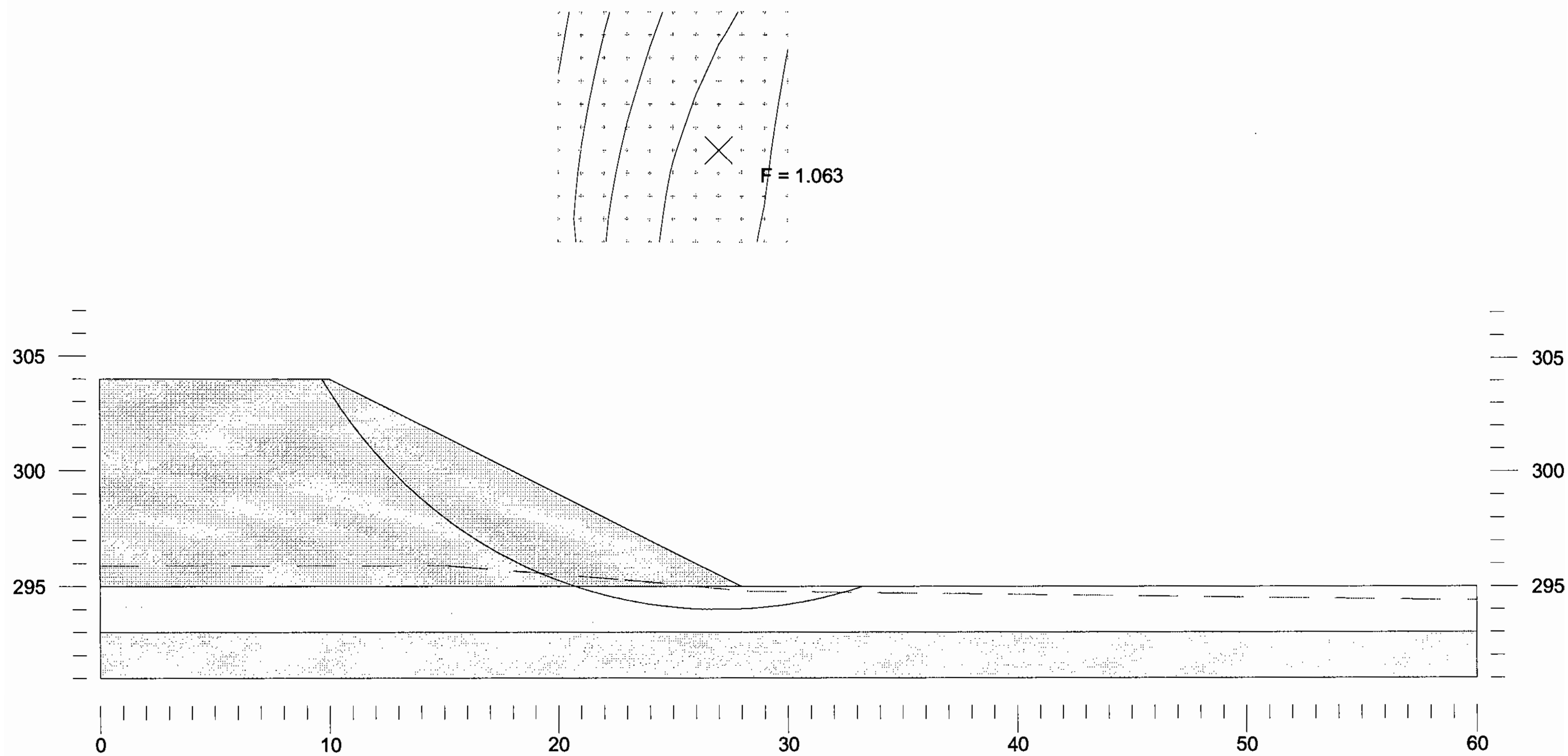

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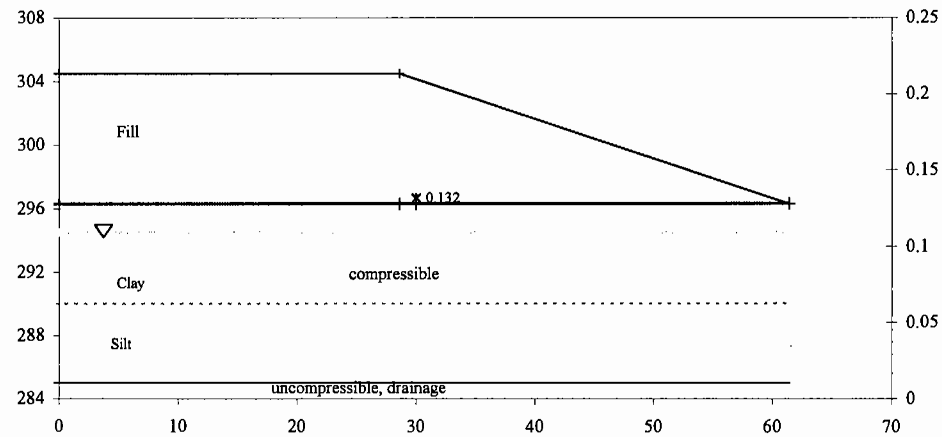
FIGURE F12

1-DIMENSIONAL CONSOLIDATION ANALYSIS

Highway 11 SBL: Three Mile Lake Road
South Abutment

Soil Stratigraphy

Elevation of Ground Surface	296.3 m
Top of Compressible Soil	293.3 m
Bottom of Compressible soil	285.0 m
Groundwater Elev	294.5 m



Load Data

Top of Fill	304.5 m
Strip Load Width	90 m
Settlement Location from centerline	30 m
unit weight of Fill	22 kN/cu m

Soil Data

	γ (kN/m3)	eo	Cc	Cr	Cv (m2/yr)
Clay	18.4	1.03	0.30	0.05	16
Silt	19.8	0.75	0.10	0.05	160

OUTPUT

Ultimate Settlement 0.132 m

Time Rate of Settlement

time (yr)	S (m)
0.2	0.104
0.4	0.117
0.6	0.124
0.8	0.128
1.0	0.129

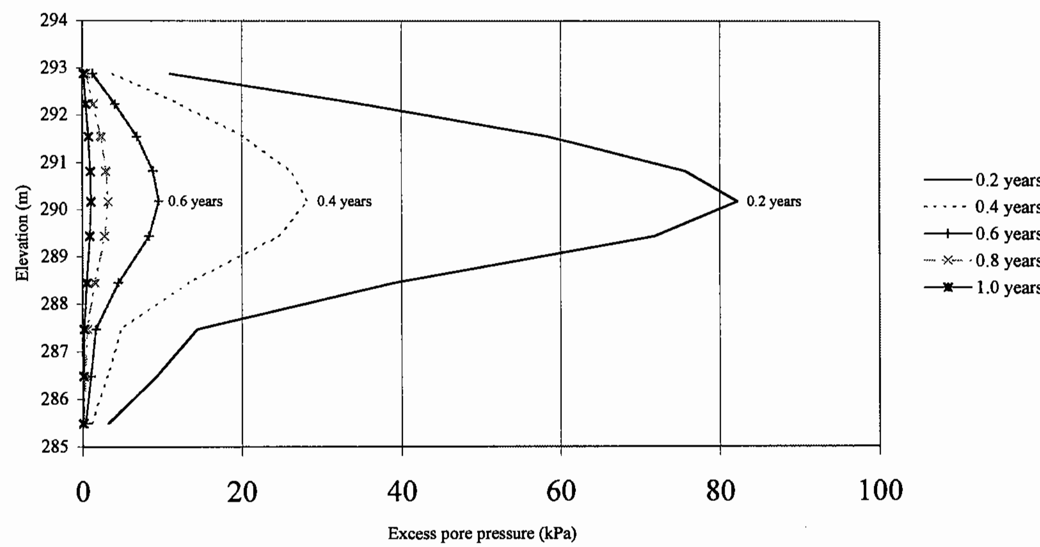


FIGURE F13

1-DIMENSIONAL CONSOLIDATION ANALYSIS

Highway 11 SBL: Three Mile Lake Road
North Abutment

Soil Stratigraphy

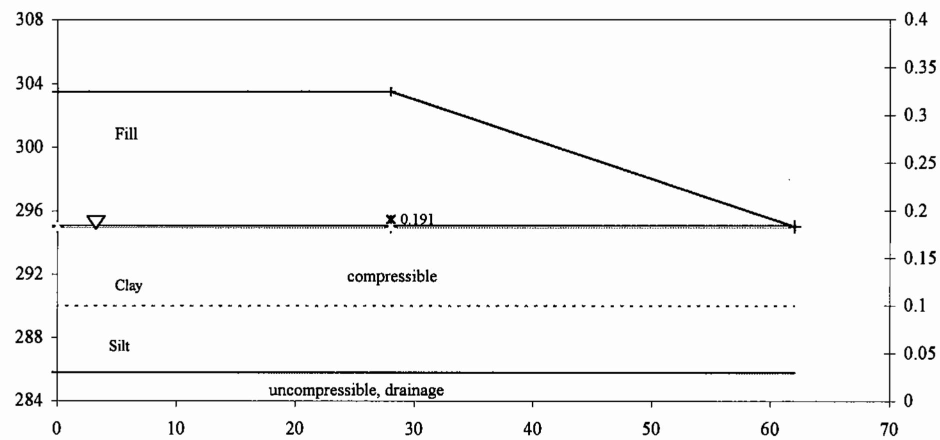
Elevation of Ground Surface	295 m
Top of Compressible Soil	293.6 m
Bottom of Compressible soil	285.8 m
Groundwater Elev	295 m

Load Data

Top of Fill	303.5 m
Strip Load Width	90 m
Settlement Location from centerline	28 m
unit weight of Fill	22 kN/cu m

Soil Data

	γ (kN/m3)	eo	Cc	Cr	Cv (m2/yr)
Clay	18.4	1.03	0.30	0.05	16
Silt	19.8	0.68	0.10	0.05	160



OUTPUT

Ultimate Settlement 0.191 m

Time Rate of Settlement

time (yr)	S (m)
0.1	0.164
0.4	0.181
0.5	0.189
0.8	0.190
1.0	0.190

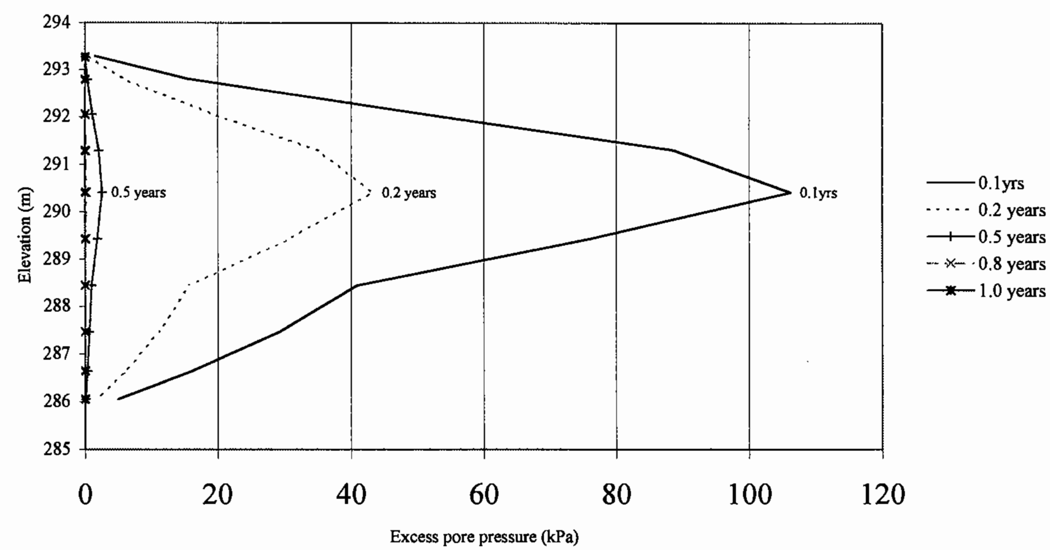
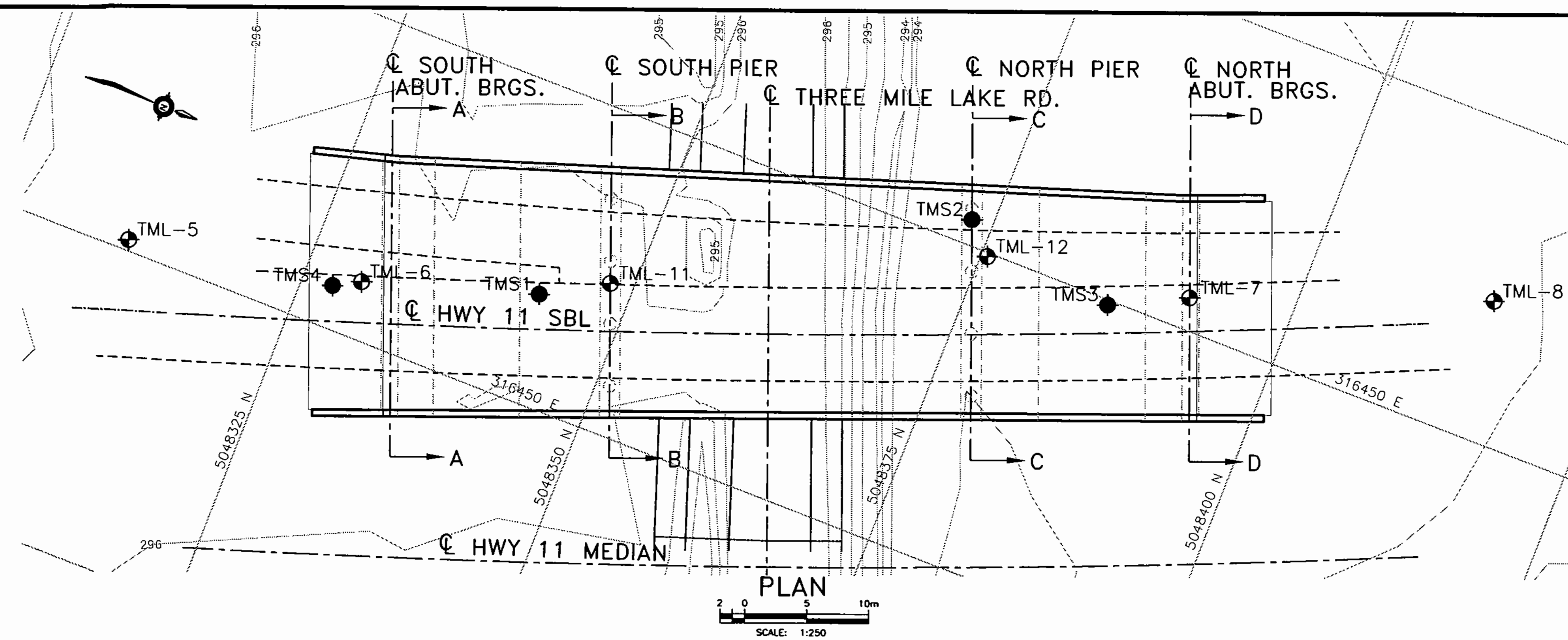
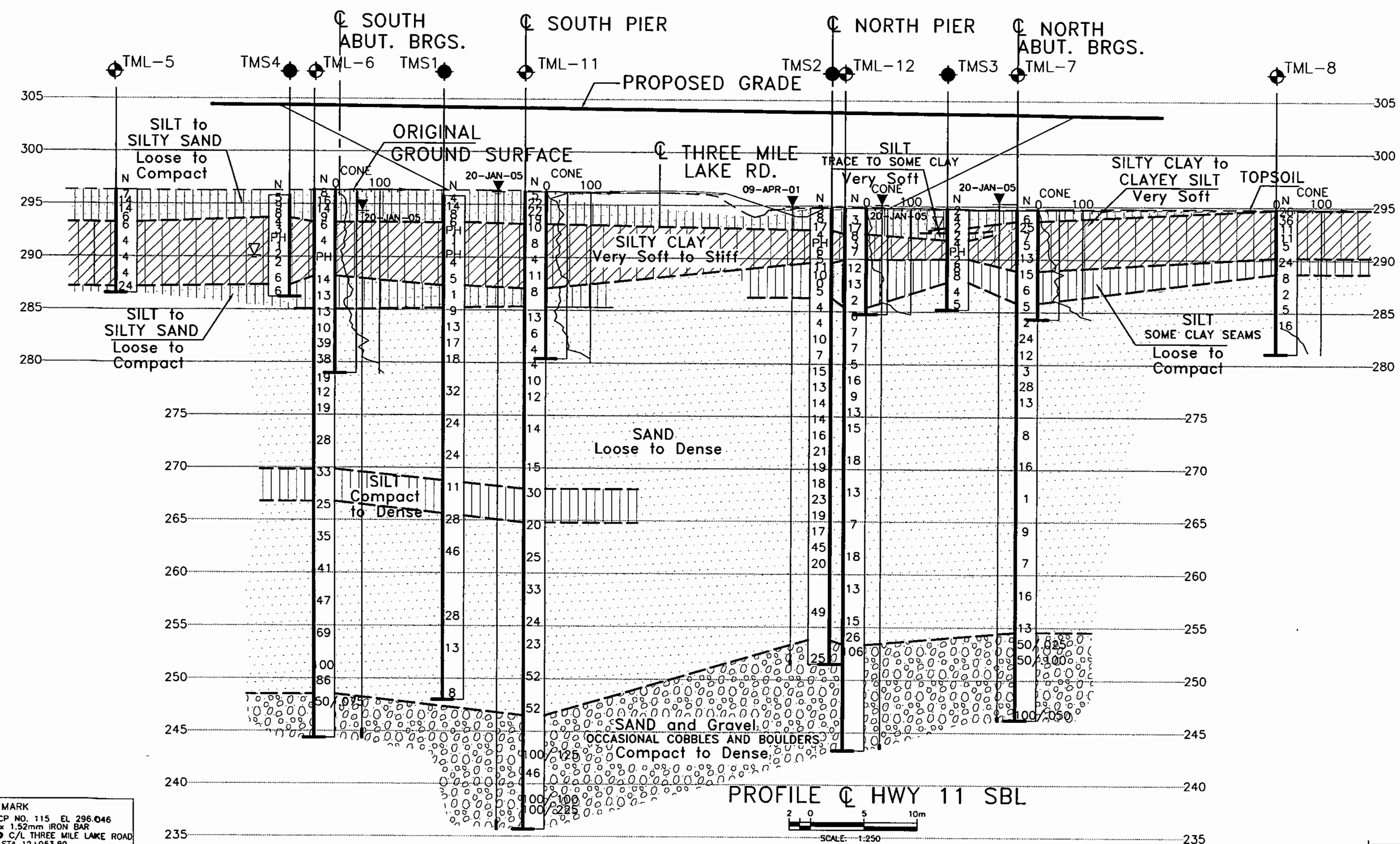


FIGURE F14

Appendix G

Drawings





BENCH MARK
VCP : HCP NO. 115 EL 296.046
19mmø x 1.52mm IRON BAR
3.6 RT @ C/L THREE MILE LAKE ROAD
3.63 RT STA 12+053.89

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

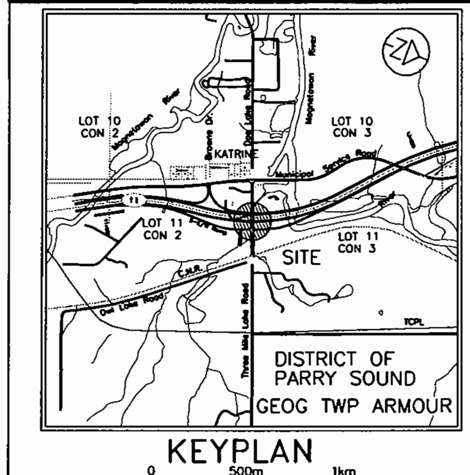
HWY 11
CONT No
WP No 476-93-01

THREE MILE LAKE ROAD OVERPASS SBL

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS



KEYPLAN

L E G E N D

⊕	BoreHole by THURBER
⊕	Dynamic Cone Penetration Test (cone)
●	Bore Hole by SHAHEEN & PEAKER LIMITED
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▼	WL
	Head Artesion Woter
	Piezometer
90%	Rock Quality Designation (RQD)

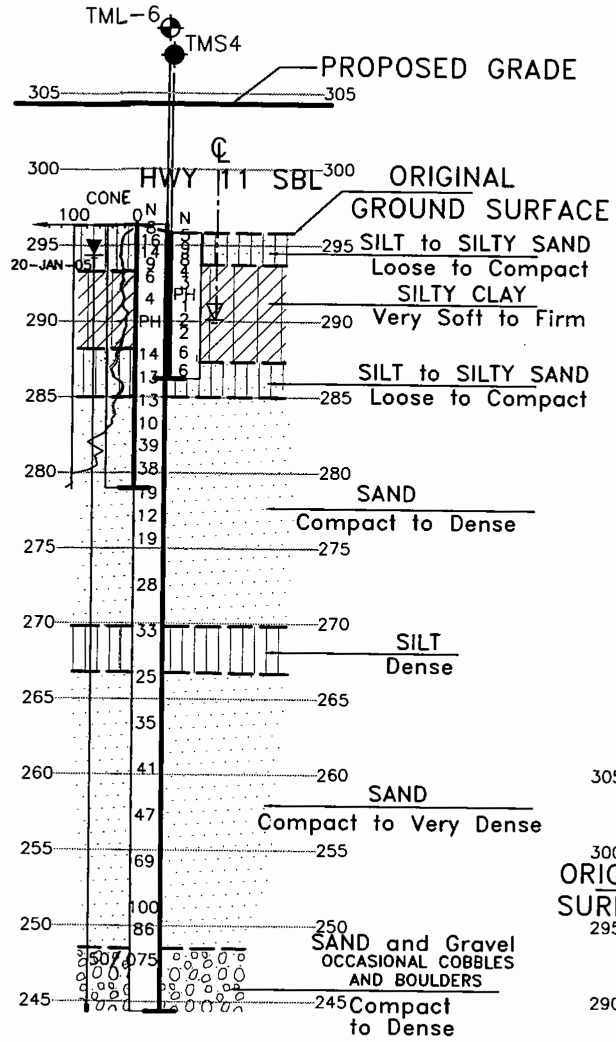
NO	ELEVATION	NORTHING	EASTING
TML-5	296.3	5048310.9	316449.1
TML-6	296.3	5048329.6	316445.5
TML-7	294.7	5048391.8	316422.5
TML-8	294.8	5048414.6	316413.9
TML-11*	296.2	5048348.1	316438.4
TML-12*	294.8	5048375.5	316425.3
TMS1	295.8	5048343.2	316441.2
TMS2	294.8	5048373.3	316423.0
TMS3	294.8	5048385.9	316425.4
TMS4	295.8	5048327.5	316446.6

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

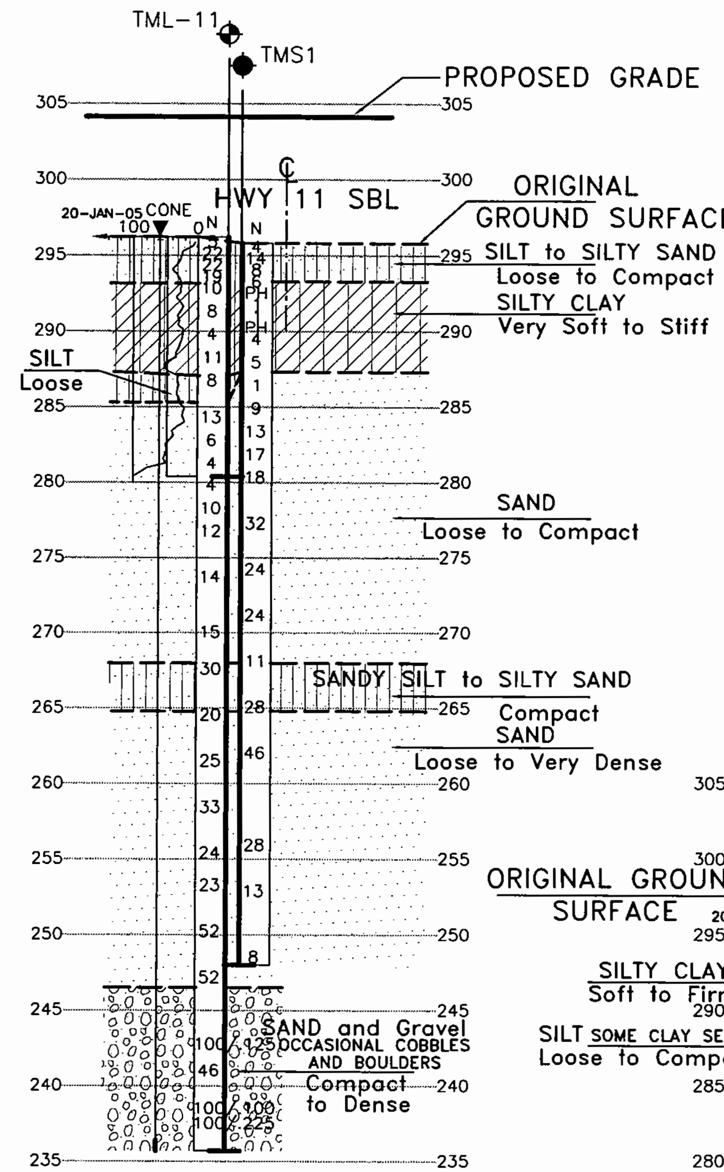
* Bore hole locations are approximate

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN AEG	CHK PKC	CODE CHBDC 2000	LOAD CL-625-ONT	DATE JAN. 2005	
DRAWN HS	CHK AEG	SITE 44-395S	STRUCT .	SCHEME .	DWG



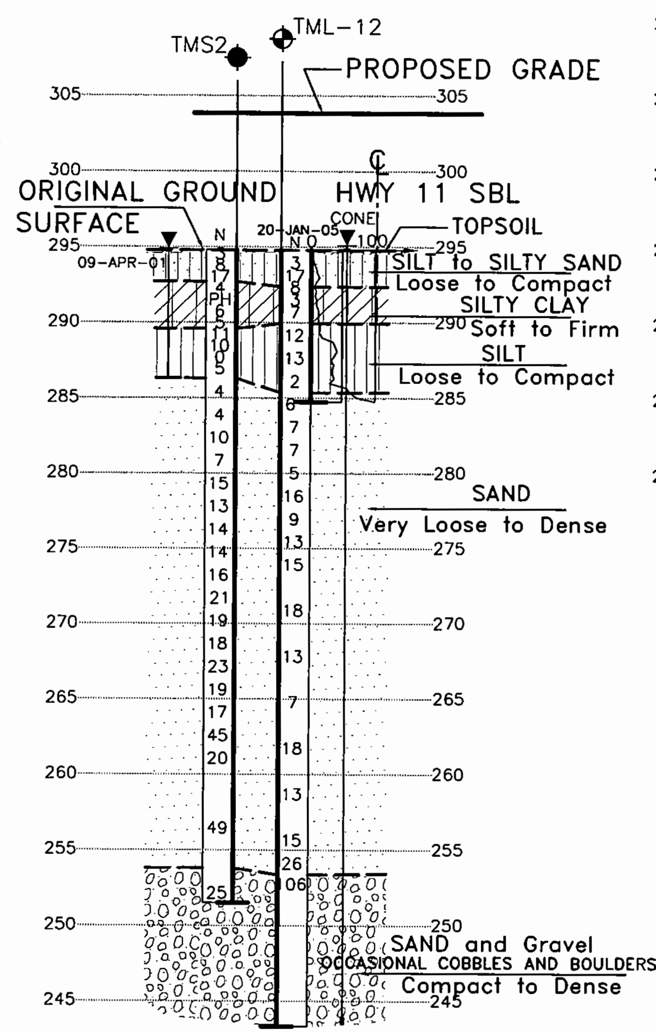
SECTION A–A

SCALE: 1:250



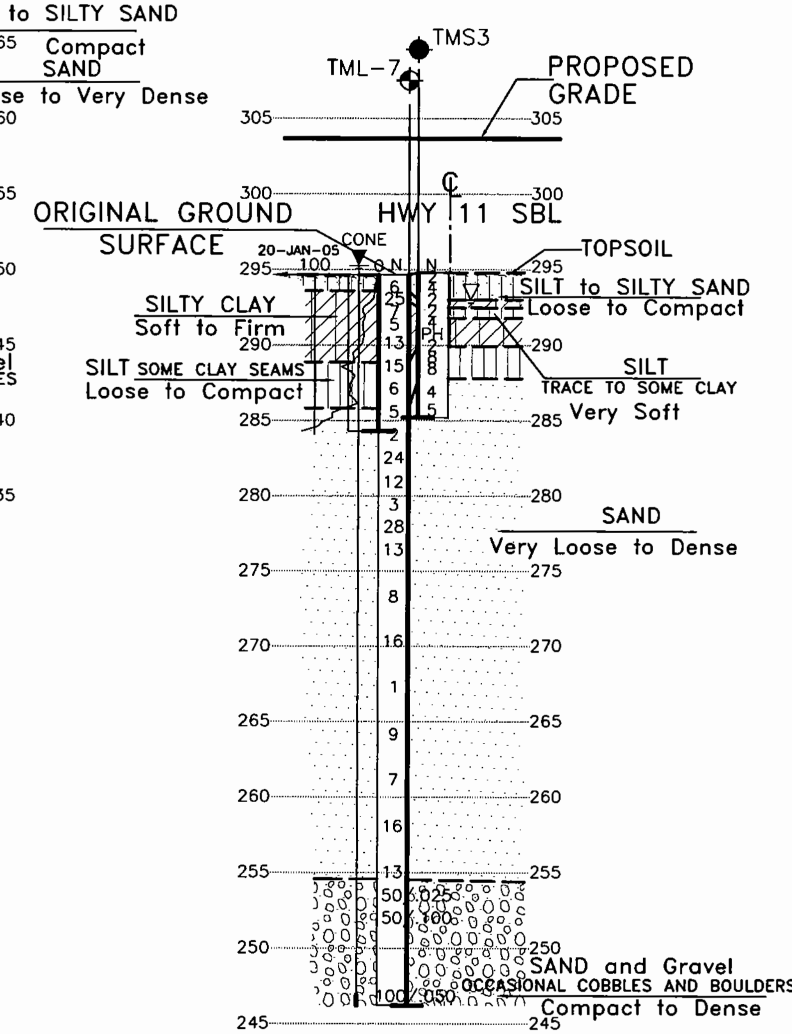
SECTION B–B

SCALE: 1:250



SECTION C–C

SCALE: 1:250



SECTION D–D

SCALE: 1:250

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

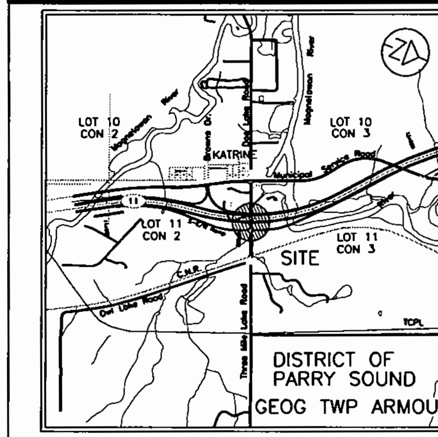
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY 11
CONT No
WP No 476–93–01

THREE MILE LAKE ROAD OVERPASS SBL
SOIL STRATA

SHEET

Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS



KEYPLAN

LEGEND

Symbol	Description
⊕ (filled)	BoreHole by THURBER
⊕	Dynamic Cone Penetration Test (cone)
●	Bore Hole by SHAHEEN & PEAKER LIMITED
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▼	WL
⊥	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING
TML–5	296.3	5048310.9	316449.1
TML–6	296.3	5048329.6	316445.5
TML–7	294.7	5048391.8	316422.5
TML–8	294.8	5048414.6	316413.9
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BENCH MARK
VCP : HCP NO. 115 EL 296.046
19mmø x 1.52mm IRON BAR
3.6 RT @ C/L THREE MILE LAKE ROAD
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REVISIONS	DATE	BY	DESCRIPTION		
DESIGN AEG	CHK PKC	CODE CHBDC 2000	LOAD CL-625-ONT	DATE JAN. 2005	
DRAWN HS	CHK AEG	SITE 44-395S	STRUCT .	SCHEME .	DWG