FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 11 NORTHBOUND LANES OVER
THREE MILE LAKE ROAD
HIGHWAY 11, HIGHWAY 518 WEST to HIGHWAY 520
G.W.P. 480-93-00, W.P. 475-93-01, SITE 44-395N

Geocres Number: 31E-229

Report to

Marshall Macklin Monaghan

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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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 Northbound 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 northbound lanes of Highway 11 at the Village of Katrine, Armour Township. The site lies approximately 200 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 200 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 20 and August 5, 2004 and between October 7, 2004 and January 4, 2005. Boreholes were also drilled at the site between March 16 and April 3, 2001, as part of the preliminary investigation by Shaheen & Peaker Limited.

The current site investigation consisted of drilling and sampling a total of five boreholes to depths of approximately 10 to 11 m at the approach fills, with a dynamic cone penetration test (DCPT) advanced to 14.6 m at the north approach. Boreholes were advanced to depths of 42 to 58 m at the abutments and south pier locations. The boreholes drilled at the south pier and the north abutment 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 Testing (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-1
South Abutment	TML-2, TMN4*
South Pier	TML-9, TMN1*
North Pier	TMN2*
North Abutment	TML-3, TMN3*
North Approach	TML-4

* 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 and south approach 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-1	9.8/286.0	Piezometer with 1.5 m tip installed at 9.8. Sand filter to 7.9, bentonite seal to 7.3, grout to the surface.
BH TML-2	57.9/237.9	Piezometer with 1.5 m tip installed at 57.9. Sand filter to 56.1, bentonite seal to 55.5, grout to the surface.
BH TML-3	41.5/253.4	Bottom of borehole at 42.0m. Piezometer with 3.0 m tip installed at 41.5m. Sand filter to 36.6, grout to the surface.
BH TML-9	51.8/243.4	Piezometer with 1.5 m tip installed at 51.8. Sand filter to 49.6, bentonite seal to 48.7, grout to 0.9, bentonite seal 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. The results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B. A total of 26 samples were selected for this testing.

A sample of firm, silty clay from borehole TML2, 4.73 m to 5.03 m depth, was selected for one-dimensional consolidation testing according to ASTM 2435. The results of this test are included in Appendix B.

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 sandy 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 exception of the south approach borehole. The measured thicknesses of topsoil ranged from 100 mm at the north approach to 800 mm at the south abutment. These topsoil thicknesses represent the thicknesses at the borehole locations only 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 Sandy Silt

A layer of fine-grained non-cohesive soils ranging from silt to sandy silt was encountered below the topsoil or ground surface from the south approach to the north pier, but appeared to have tapered out under the north abutment and north approach. Based on SPT values ranging from 2 to 22 blows for 0.3 m of penetration, the deposit is classified as very loose to compact. The DCPT results at the south pier indicate compact conditions.

The measured natural moisture contents range from 19 to 30% and the soil is described as moist to wet

The layer of silt ranges in thickness from 1.2 m at the south pier to 4.4 m at the south approach. The base of the layer lies between Elevation 293.7 at the south pier to 291.2 at the south approach.

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 38 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 55 to 90 kPa, with some values 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 intermediate, as shown in Figure B7 in Appendix B.

The recorded natural moisture contents in the clay ranged from 21 to 52% 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 3.6 at the north pier to 7.5 m at the south approach. The base of the clay layer lies at Elevation 291.5 at the north approach to Elevation 286.7 at the south approach.

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

A one-dimensional consolidation test was carried out on a sample collected from a Shelby tube in borehole TML2 at 4.73 m to 5.03 m depth (ELEV. 291.6 to 291.3). 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 2	4.90	42.0	39	1.08	130	3.2	0.30	0.06	-

5.6 Silt to Sandy Silt

A layer of silt to silty sand 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 7 to 27 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 20 to 30% and the soil is described as wet.

The thickness of the silt layer ranged from 1.4 m near the north abutment to 4.4 m at the south abutment. The base of the silt layer lay between Elevation 289.8 at the north approach and Elevation 282.9 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 B3 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 6 to 25 blows for 0.3 m of penetration, this sand is classified as loose to compact. Isolated higher or 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 19 to 30% and the soil is described as wet.

The thickness of this soil layer varied from 27.1 m at the north abutment to 34.4 m at the south abutment. The underside of the sand layer ranged from Elevation 260.8 at the north abutment to 248.5 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 Figures B4 and B5 in Appendix B.

5.8 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 19 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 15 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 7.9 m at the north abutment to 11.2 m at the south abutment. The borehole termination ranged from Elevation 252.9 at the north abutment to Elevation 237.3 at the south abutment.

The grain size distribution of a selected sample of this soil is plotted on the Record of Borehole sheet and shown in Figure B6 in Appendix B.

5.9 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-2	53.4 (242.0)	Very dense sand and gravel with cobbles and boulders
South Pier	TML-9	47.7 (247.5)	
North Pier	TMN2	35.1 (259.8)	
North Abutment	TML-3	35.4 (259.5)	

5.10 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 Approach		South Abutment		South Pier		North Abutment	
	Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.
Apr 6/01	-	-	-	-	0.1	294.9	-	-
Apr 9/01	-	-	-	-	0.1	294.9	-	-
Apr 11/01	-	-	-	-	0.1	294.9	-	-
Jul 21/04	0.7	295.1	-	-	-	-	-	-
Jul 22/04	0.2	295.6	-	-	-	-	-	-
Aug 7/04	0.0	295.8	-	-	-	-	-	-
Oct 7/04	0.4	295.4	0.0	295.4	-	-	-	-
Nov 15/04	-	-	-	-	-	-	+0.2*	295.1
Jan 5/05	0.3**	295.5	0.7	294.7	-	-	0.0**	294.9
Jan 20/05	0.3**	295.5	0.82	294.6	0.15**	294.8	0.0**	294.9

* "+" 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 will 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 255 to 256. 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, M.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.

Thurber Engineering Ltd.

Steven M. Sather, P.Eng.
Senior Geotechnical Engineer, Principal

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer

P.K. Chatterji, P.Eng., Ph.D.
Review Principal.

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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 295.4, resulting in an 8.9 m high embankment.

The finished grade at the north abutment will lie at Elevation 303.7 and the original ground surface at this location is at Elevation 294.9, giving a total embankment height of 8.8 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 35 to 46 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.

At the north pier and abutment, the piles are expected to develop bearing resistance in the layer of sand containing cobbles and boulders below Elevation 260 to 261. The very dense layer occurs below Elevation 242 at the south abutment and Elevation 247 at the south pier and driven H-piles may reach this layer. However, due to the depth to this layer, approximately 50 m, the piles may develop the required resistance in the overlying sand. Accordingly, the SLS values of pile resistance have been selected based on static analysis and considering the mobilized skin friction and end-bearing in the sand at the serviceability limit. 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

It is expected that the pile tips will encounter sufficient resistance at a depth similar to the depth that refusal conditions were encountered in the boreholes. The estimated tip elevations at which the piles will achieve the required resistance are given in Table 8.2.

Table 8.2 – Pile Tip Elevations

Location	Borehole	Elevation (m)
South Abutment	TML-2	242.0
South Pier	TML-9	247.5
North Pier	TMN2	259.8
North Abutment	TML-3	259.5

The pile tip elevations shown in Table 8.2 should be used for cost estimating purposes only. To reduce the likelihood of pile damage during driving, 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 expected 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 260 at the north pier and abutment and below Elevation 250 at south pier and south abutment. 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)	140 kN	170 kN	-	-
	North Abutment		**North Pier**	
Pile Type	HP 310x110	HP 360x132	HP 310x110	HP 360x132
Factored downdrag force (f = 1.25)	40 kN	50 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:

For cohesionless soil:

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

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

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 below.

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	295.4 to 292.5	Silt	compact	1,200	3.0	10
	292.5 to 286.1	Silty Clay	stiff to soft	k_s = 70,000 (kN/m^3)	p_{ult} = 700 (kN/m^2)	9
	286.1 to 272.0	Silt to Sand	compact	1,600	3.0	10
	272.0 to 248.5	Sand	compact to very dense	3,000	3.0	10
	Below 248.5	Sand & Gravel	compact	8,000	4.0	11
North Abutment	294.9 to 290.0	Silty Clay	Very stiff to firm	k_s = 70,000 (kN/m^3)	p_{ult} = 700 (kN/m^2)	9
	290.0 to 260.8	Sandy silt to sand	loose to compact	1,600	3.0	10
	Below 260.8	Sand & Gravel	compact to very dense	8,000	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 with cobbles and boulders.

When attempting to found in the very dense sand, 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 of the following page.

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/m^3

Granular "A" $k(s) = 5{,}600*z/h$ kN/m^3

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 9 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	no seismic	1.3	F2
Rock Fill	0.08g seismic	1.1	F3
Earth Fill	undrained, no seismic	1.3	F4
Earth Fill	no seismic	1.3	F5
Earth Fill	0.08g seismic	1.1	F6
North Approach			
Rock Fill	undrained, no seismic	1.8	F7
Rock Fill	no seismic	1.3	F8
Rock Fill	0.08g seismic	1.1	F9
Earth Fill	undrained, no seismic	1.9	F10
Earth Fill	no seismic	1.3	F11
Earth Fill	0.08g seismic	1.1	F12

11.3 Settlement

A one-dimensional settlement analysis was carried out based on Terzaghi's consolidation formula, using the software program Consol-1d produced by Virginia Tech. A summary of the analysis parameters used in the analysis is included in Appendix F.

The primary consolidation settlement to be expected as a result of the proposed grade raises has been estimated, on the basis of laboratory consolidation tests and index properties, to be:

- South approach – 150 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, particularly at the south abutment, are not considered suitable for the support of "High Performance" walls 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 294.5 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 foundation settlement induced by that fill. Provided the approach fill is constructed in advance of the structure (and RSS walls), as recommended elsewhere in this report, primary consolidation settlements should be essentially 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.

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 above 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/m³		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m³		Rock Fill (Limited to 300 mm size) $\phi = 42°, \gamma = 19$ kN/m³	
	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

[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.

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

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.

17 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Steven 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.

Thurber Engineering Ltd.

Steven M. Sather, P.Eng.
Senior Geotechnical Engineer, Principal

Alastair E. Gorman, P.Eng., M.Sc.
Senior Foundations Engineer

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

Appendix A

Record of Borehole Sheets

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RECORD OF BOREHOLE No TML-1

METRIC

W.P. 475-93-01	LOCATION N 5048323.4 E 316490.7 Three Mile Lake Road NBL		ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM/HS
DATUM Geodetic	DATE 20.07.04 - 20.07.04		CHECKED BY MA/ AEG

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	STRAT PLOT
295.8 / 0.0	**SILT**, trace sand, trace rootlets Brown	
0.2	**SILT**, trace to some clay, trace sand, occasional sand seams, occasional iron oxide staining Loose to Compact Brown Moist to Wet	
291.2 / 4.6	Silty **CLAY**, occasional sand seams Varved Stiff Grey	
286.7 / 9.1	**SILT**, trace sand Compact Grey Moist	
286.0 / 9.8	END OF BOREHOLE AT 9.75 m.	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	6				
2	SS	7				
3	SS	9	0	5	82	13
4	SS	13				
5	SS	7	0	10	71	20
6	SS	8				
7	SS	9	0	1	51	48
8	SS	7				
9	SS	23				

GROUND WATER CONDITIONS

ELEVATION SCALE: 295, 294, 293, 292, 291, 290, 289, 288, 287

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

Field vane sensitivity: 3.4 (approx. elev. 290.3); 3.75 (approx. elev. 288.8)

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

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

Continued Next Page

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

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

RECORD OF BOREHOLE No TML-1

METRIC

W.P.	475-93-01	LOCATION	N 5048323.4 E 316490.7 Three Mile Lake Road NBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	20.07.04 - 20.07.04	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/m^3. REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL.

BOREHOLE OPEN TO 9.75 m AND WATER LEVEL AT 8.69 m UPON COMPLETION.
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)
21-JUL-04	0.7	295.1
22-JUL-04	0.2	295.6
07-AUG-04	0.0	295.8
07-OCT-04	0.4	295.4

+ 3, × 3: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No TML-2

METRIC

W.P.	475-93-01	LOCATION	Three Mile Lake Road NBL	ORIGINATED BY	GA
HWY	11	BOREHOLE TYPE	Hollow Stem Augers/Mud Rotary	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	03.08.04 - 05.08.04	CHECKED BY	AEG

SOIL PROFILE · SAMPLES (NUMBER, TYPE, "N" VALUES) · STRAT PLOT · 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	NUMBER	TYPE	"N" VALUES	Shear strength	GR	SA	SI	CL
295.4									
0.0	**TOPSOIL**, occasional rootlets, occasional wood fragments Dark Brown								
294.6 0.8	**SILT**, trace to some sand, trace clay Compact Brown	1	SS	22					
		2	SS	15		0	10	77	13
		3	SS	10					
292.5 2.9	Silty **CLAY**, trace sand Soft to Stiff Grey	4	SS	4		0	11	64	25
		1	TW	PH					
		5	SS	2		0	3	46	51
		6	SS	5	+ 3.9				
287.3 8.1	**SILT**, some sand, trace clay Compact Grey Wet	7	SS	16		0	0	81	18

Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286

Continued Next Page

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

15 20 5 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No TML-2

METRIC

W.P. 475-93-01 LOCATION N 5048345.6 E 316481.5 Three Mile Lake Road NBL ORIGINATED BY GA
HWY 11 BOREHOLE TYPE Hollow Stem Augers/Mud Rotary COMPILED BY WM/HS
DATUM Geodetic DATE 03.08.04 - 05.08.04 CHECKED BY AEG

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		8	SS	27	285	
		9	SS	23	284	0 3 92 5
282.9 / 12.5	**SAND,** fine to medium grained, trace to some silt Compact to Dense Grey Wet				283	
		10	SS	18	282	
		11	SS	28	281	
					280	
		12	SS	20	279	
		13	SS	20	278	0 81 19 (SI+CL)
					277	
		14	SS	21	276	

Column 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/m^3; STRAT PLOT; GROUND WATER CONDITIONS

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No TML-2

METRIC

W.P. 475-93-01 LOCATION N 5048345.6 E 316481.5 Three Mile Lake Road NBL ORIGINATED BY GA

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

DATUM Geodetic DATE 03.08.04 - 05.08.04 CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
					275					
		15	SS	44		~20				
					274					
					273					
					272					
		16	SS	28		~19	0	81	16	3
					271					
					270					
					269					
		17	SS	40		~23				
					268					
					267					
					266					
		18	SS	30		~20				

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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

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

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RECORD OF BOREHOLE No TML-2

METRIC

W.P. 475-93-01 | LOCATION N 5048345.6 E 316481.5 Three Mile Lake Road NBL | ORIGINATED BY GA

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

DATUM Geodetic | DATE 03.08.04 - 05.08.04 | 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: 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
							265				
							264				
							263				
			19	SS	24				o		0 91 9 (SI+CL)
							262				
							261				
							260				
			20	SS	35				o		
							259				
							258				
							257				
			21	SS	44				o		
							256				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 15-⊕-5 10 (%) STRAIN AT FAILURE

ONTMT4S TMLN.GPJ 20/01/05

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RECORD OF BOREHOLE No TML-2

METRIC

W.P. 475-93-01 LOCATION N 5048345.6 E 316481.5 Three Mile Lake Road NBL ORIGINATED BY GA

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

DATUM Geodetic DATE 03.08.04 - 05.08.04 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					255		
					254		
		22	SS	45		o (~18)	
					253		
					252		
					251		
	Becoming Very Dense	23	SS	50		o (~20)	
					250		
					249		
248.5 / 46.9	**SAND and GRAVEL**, fine to coarse grained sand, trace silt Compact Grey Wet						
					248		
		24	SS	22		o (~16)	31 61 7 (SI+CL)
					247		
	occasional cobbles and boulders						
					246		

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/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

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

RECORD OF BOREHOLE No TML-2

METRIC

W.P. 475-93-01	LOCATION N 5048345.6 E 316481.5 Three Mile Lake Road NBL	ORIGINATED BY GA
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Mud Rotary	COMPILED BY WM/HS
DATUM Geodetic	DATE 03.08.04 - 05.08.04	CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
					245	
		25	SS	19		
					244	
	occasional cobbles and boulders					
					243	
					242	
	frequent cobbles and boulders below elevation 242m					
		1	RUN			
					241	
					240	
		2	RUN			
					239	
		3	RUN			
					238	
237.3						
58.1	END OF BOREHOLE AT 58.06 m. BOREHOLE OPEN TO 57.91 m. 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)
07-OCT-04	0.0	295.4

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3; GR SA SI CL

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

RECORD OF BOREHOLE No TML-3

METRIC

W.P. 475-93-01 LOCATION N 5048405.2 E 316457.3 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 08.11.04 - 09.11.04 CHECKED BY HS/ AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
294.9										
0.0	**TOPSOIL** (150mm)									
0.2	Silty **CLAY**, trace sand Very Stiff to Firm Grey Moist to Wet									
					294					
		1	SS	20		~20				
		2	SS	19		~26				
					293					
		3	SS	9		~35				
					292					
		4	SS	8		~29				
	silt layers below elevation 291.5m									
					291					
		5	SS	20		~37	0	0	83	17
290.0					290					
4.9	Sandy **SILT**, trace clay Compact Grey Wet									
		6	SS	17		~25	0	34	63	3
					289					
287.9					288					
7.0	**SAND**, fine to medium grained, trace to some silt Very Loose to Compact Brownish Grey Wet	7	SS	1		~24				
					287					
		8	SS	6		~19				
					286					
					285					

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-3

METRIC

W.P. 475-93-01 LOCATION N 5048405.2 E 316457.3 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 08.11.04 - 09.11.04 CHECKED BY HS/ AEG

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			9	SS	7		
						284	
			10	SS	8	283	
						282	
			11	SS	3		
						281	
			12	SS	10	280	0 90 10 (SI+CL)
						279	
	trace coarse grained		13	SS	12		
						278	
			14	SS	10	277	
						276	
			15	SS	22		
						275	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m^3

GROUND WATER CONDITIONS

Continued Next Page

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

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

ONTMT4S TMLN.GPJ 20/01/05

RECORD OF BOREHOLE No TML-3

METRIC

W.P. 475-93-01	LOCATION N 5048405.2 E 316457.3	Three Mile Lake Road NBL	ORIGINATED BY JL
HWY 11	BOREHOLE TYPE Hollow Stem Augers/NW Casing		COMPILED BY WM/HS
DATUM Geodetic	DATE 08.11.04 - 09.11.04		CHECKED BY HS/ AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
					274
					273
	Becoming Loose	16	SS	7	
					272
					271
					270
		17	SS	7	
					269
					268
					267
	Becoming Compact	18	SS	22	
					266
					265

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

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TML-3

METRIC

W.P. 475-93-01 LOCATION N 5048405.2 E 316457.3 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 08.11.04 - 09.11.04 CHECKED BY HS/ AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					264		
		19	SS	11		o (approx. 21)	0 83 17 (SI+CL)
					263		
					262		
					261		
260.8 / 34.1	**SAND and GRAVEL,** frequent boulders and cobbles Compact to Very Dense Grey Wet						
		20	SS	22		o (approx. 20)	
					260		
		1	RUN				
					259		
		2	RUN				
					258		
		3	RUN				
					257		
					256		
		4	RUN		255		

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; 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

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

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

RECORD OF BOREHOLE No TML-3

METRIC

W.P. 475-93-01	LOCATION N 5048405.2 E 316457.3	Three Mile Lake Road NBL	ORIGINATED BY JL
HWY 11	BOREHOLE TYPE Hollow Stem Augers/NW Casing		COMPILED BY WM/HS
DATUM Geodetic	DATE 08.11.04 - 09.11.04		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 (○ 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
			5	RUN			254				
252.9 42.0	END OF BOREHOLE AT 41.99 m. BOREHOLE GROUTED TO SURFACE. Piezometer installation consist of 19 mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEVATION (m) 15-NOV-04 -0.2 (frozen) 295.1						253				

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-3A

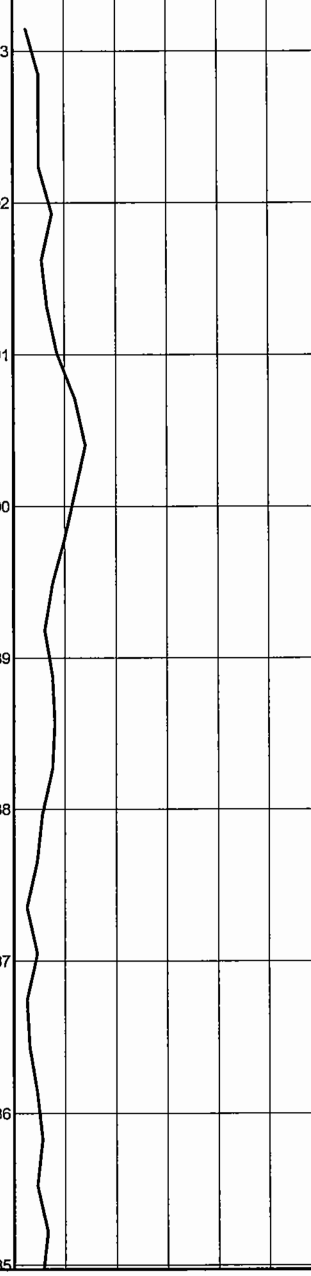
METRIC

W.P. 475-93-01 LOCATION N 5048405.2 E 316457.3 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 10.11.04 - 10.11.04 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						
294.9											
0.0	Augered to 1.52m.						294				
293.4 / 1.5	DCPT from 1.52m.						293, 292, 291, 290, 289, 288, 287, 286, 285				



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

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

ONTMT4S TMLN.GPJ 20/01/05

RECORD OF BOREHOLE No TML-3A

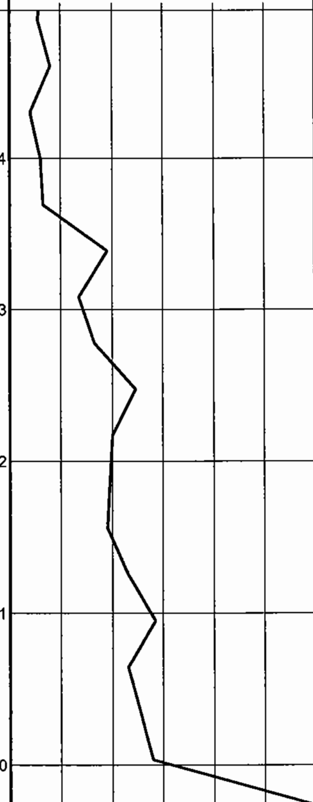
METRIC

W.P. 475-93-01 LOCATION N 5048405.2 E 316457.3 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 10.11.04 - 10.11.04 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
							284				
							283				
							282				
							281				
							280				
279.7 / 15.2	END OF DCPT AT 15.24m. CONE REFUSAL AT 15.24m. CONE HOLE GROUTED TO SURFACE.										



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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-4

METRIC

W.P. 475-93-01 LOCATION N 5048428.8 E 316450.0 Three Mile Lake Road NBL ORIGINATED BY JL

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

DATUM Geodetic DATE 07.10.04 - 07.10.04 CHECKED BY MA/ AEG

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
295.9						
0.0	**TOPSOIL** (100mm)					
0.1	Silty **CLAY**, trace sand, occasional oxide staining Very Stiff to Hard Brown	1	SS	24		
		2	SS	38	295	
	Becoming Stiff to Firm	3	SS	10	294	0 0 50 50
	Becoming Grey	4	SS	8	293	
		5	SS	6	292	
291.5 4.4	**SILT**, some clay, trace sand Very Stiff Grey Wet	6	SS	19	291	0 1 80 19
289.8 6.1	**SAND**, fine to medium grained, trace to some silt Loose to Very Loose Grey Wet	7	SS	4	290 289	
	occasional iron oxide staining Becoming Brown	8	SS	3	288 287	
		9	SS	9	286	0 84 16 (SI+CL)

Plot 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/m^3; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

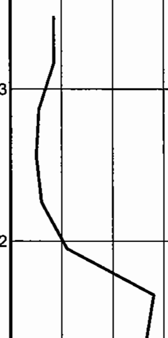
RECORD OF BOREHOLE No TML-4

METRIC

W.P. 475-93-01	LOCATION N 5048428.8 E 316450.0 Three Mile Lake Road NBL		ORIGINATED BY JL
HWY 11	BOREHOLE TYPE Hollow Stem Augers/Dynamic Cone Penetration Test (DCPT)		COMPILED BY WM/HS
DATUM Geodetic	DATE 07.10.04 - 07.10.04		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	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
284.8	Becoming Compact	10	SS	25	285
283.7 / 11.1	END OF SAMPLING AT 11.13 m. AUGERED TO 12.19 m.				284
281.3 / 12.2	DCPT started at 12.19 m.				283, 282
14.6	END OF BOREHOLE AT 14.63 m. BOREHOLE GROUTED TO SURFACE.				



ONTMT4S TMLN.GPJ 20/01/05

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-9

METRIC

W.P. 475-93-01	LOCATION N 5048359.9 E 316468.8 Three Mile Lake Road NBL		ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM/HS
DATUM Geodetic	DATE 17.12.04 - 04.01.05		CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
295.2									
0.0	**TOPSOIL**, organic								
294.9	Dark Brown								
0.3	**SILT**, some clay, trace sand; Compact; Brown; Moist	1	SS	20					
293.7									
1.5	Silty **CLAY**, some silt layers; Very Stiff to Soft; Grey	2	SS	18		0	6	78	15
		3	SS	6					
		4	SS	4		0	2	59	39
		5	SS	3		0	1	48	51
	Becoming Firm	6	SS	5					
287.4									
7.8	**SILT**, some sand, some clay; Loose; Grey; Moist	7	SS	7					
		8	SS	8		0	5	91	4

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (295, 294, 293, 292, 291, 290, 289, 288, 287, 286); 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

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

ONTMT4S TMLN.GPJ 20/01/05

RECORD OF BOREHOLE No TML-9

METRIC

W.P. 475-93-01	LOCATION N 5048359.9 E 316468.8	Three Mile Lake Road NBL	ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM/HS
DATUM Geodetic	DATE 17.12.04 - 04.01.05		CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR SA SI CL
					285		
		9	SS	7		o	
					284		
283.0 / 12.2	**SAND**, fine to medium grained, trace silt Loose to Compact Grey Wet				283		
		10	SS	7		o	
					282		
		11	SS	9		o	0 90 10 (SI+CL)
					281		
					280		
		12	SS	8		o	
					279		
		13	SS	8		o	
					278		
					277		
		14	SS	8		o	
					276		

Legend: 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; STRAT PLOT; GROUND WATER CONDITIONS.

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-9

METRIC

W.P. 475-93-01	LOCATION N 5048359.9 E 316468.8	Three Mile Lake Road NBL	ORIGINATED BY WRW
HWY 11	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM/HS
DATUM Geodetic	DATE 17.12.04 - 04.01.05		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 (○ 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
			15	SS	11				○		
							275				
							274				
			16	SS	12				○		0 91 9 (SI+CL)
							273				
							272				
							271				
			17	SS	15				○		
							270				
							269				
							268				
	silt seam at 267.7m		18	SS	16				○		0 22 74 4
							267				
							266				

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No TML-9

METRIC

W.P.	475-93-01	LOCATION	N 5048359.9 E 316468.8 Three Mile Lake Road NBL	ORIGINATED BY	WRW
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	17.12.04 - 04.01.05	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

Sample Number	Type	"N" Value	Remarks (GR SA SI CL)
19	SS	9	
20	SS	14	
21	SS	12	
22	SS	12	0 94 6

Elevation scale: 265, 264, 263, 262, 261, 260, 259, 258, 257, 256

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

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

RECORD OF BOREHOLE No TML-9

METRIC

W.P.	475-93-01	LOCATION	N 5048359.9 E 316468.8 Three Mile Lake Road NBL	ORIGINATED BY	WRW
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	WM/HS
DATUM	Geodetic	DATE	17.12.04 - 04.01.05	CHECKED BY	AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL (SI+CL)
					255		
					254		
					253		
		23	SS	16		~20	
					252		
251.3 / 43.9	**SAND and GRAVEL**, fine to coarse grained sand, trace silt Dense to Very Dense Grey Wet				251		
					250		
		24	SS	39		~18	
					249		
					248		
					247		
	frequent cobbles and boulders						
		25	SS	100/ .075		~17	
					246		

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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-9

METRIC

W.P. 475-93-01 | LOCATION N 5048359.9 E 316468.8 Three Mile Lake Road NBL | ORIGINATED BY WRW

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

DATUM Geodetic | DATE 17.12.04 - 04.01.05 | 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 (○ 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
							245				
			26	SS	100/ .125				○		
							244				
243.2			27	SS	100/				○		
52.0	END OF BOREHOLE AT 51.97 m. Piezometer installation consist of 19 mm diameter Schedule 40 PVC pipe with a 1.52 m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m)				.150						

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

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

ONTMT4S TMLN.GPJ 20/01/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-9A

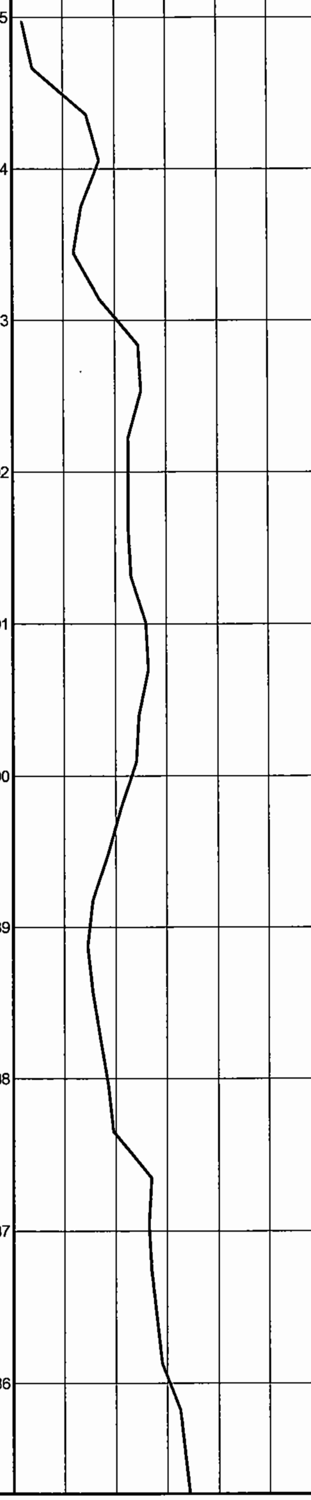
METRIC

W.P. 475-93-01
LOCATION N 5048359.9 E 316468.8 Three Mile Lake Road NBL
ORIGINATED BY GA

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

DATUM Geodetic
DATE 04.01.05 - 04.01.05
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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
295.2											
0.0	DCPT from surface.						295, 294, 293, 292, 291, 290, 289, 288, 287, 286				



Continued Next Page

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

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

ONTMT4S TMLN.GPJ 20/01/05

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No TML-9A

METRIC

W.P. 475-93-01 | LOCATION N 5048359.9 E 316468.8 Three Mile Lake Road NBL | ORIGINATED BY GA

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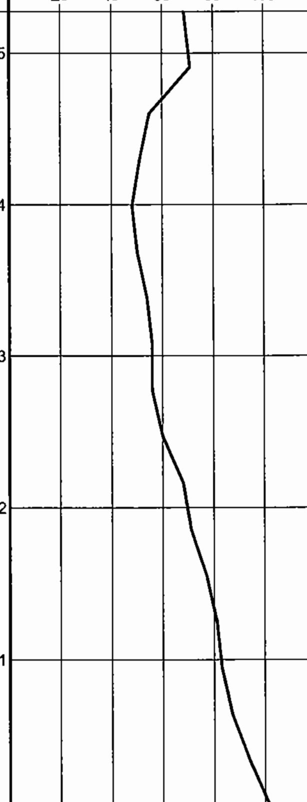
DATUM Geodetic | DATE 04.01.05 - 04.01.05 | CHECKED BY AEG

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						
							285				
							284				
							283				
							282				
							281				
280.0 15.2	END OF DCPT AT 15.24 m. DCPT GROUTED TO SURFACE.										



ONTMT4S TMLN.GPJ 20/01/05

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

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

Appendix B

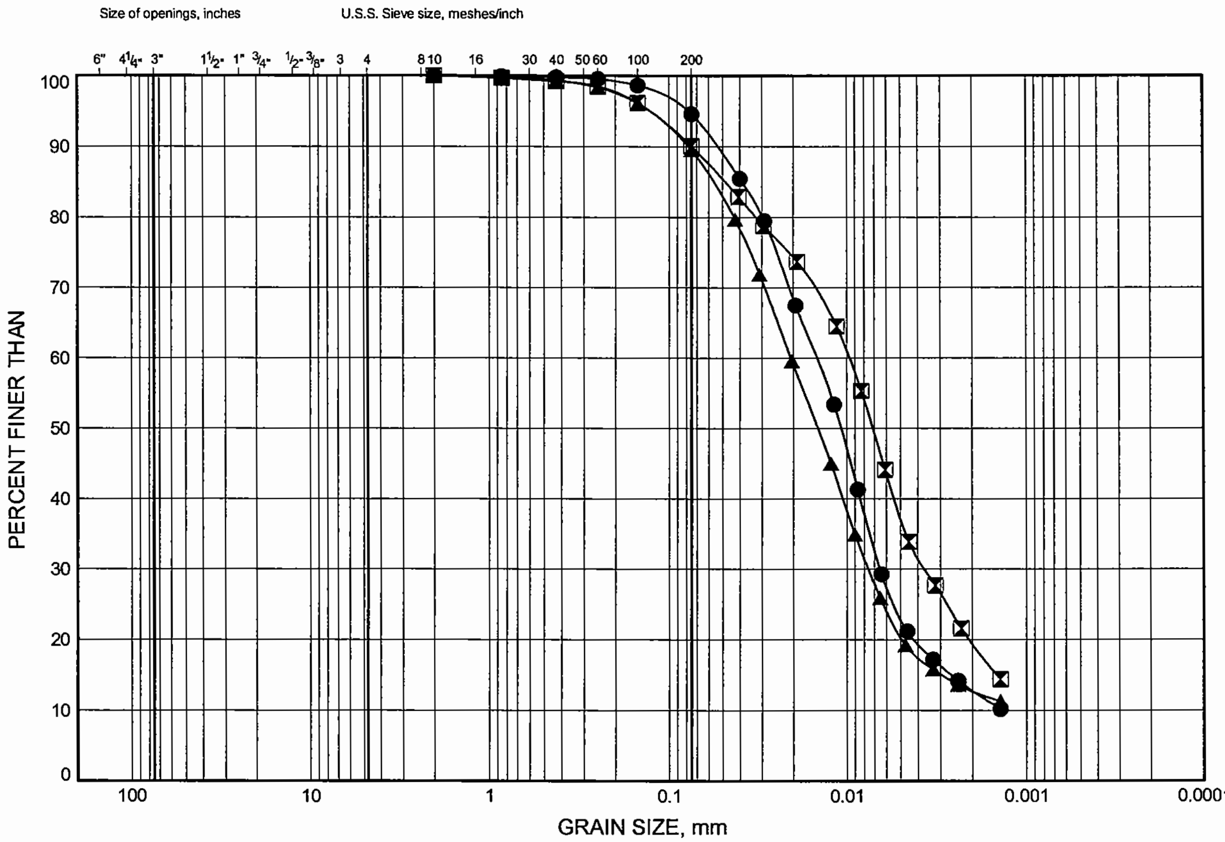
Laboratory Test Results

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B1

SILT to SANDY SILT (upper)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-1	1.83	293.97
⊠	TML-1	3.35	292.45
▲	TML-2	1.68	293.73

THURBGSD TMLN.GPJ 17/01/05

Date January 2005

Project 475-93-01

THURBER

Prep'd HS

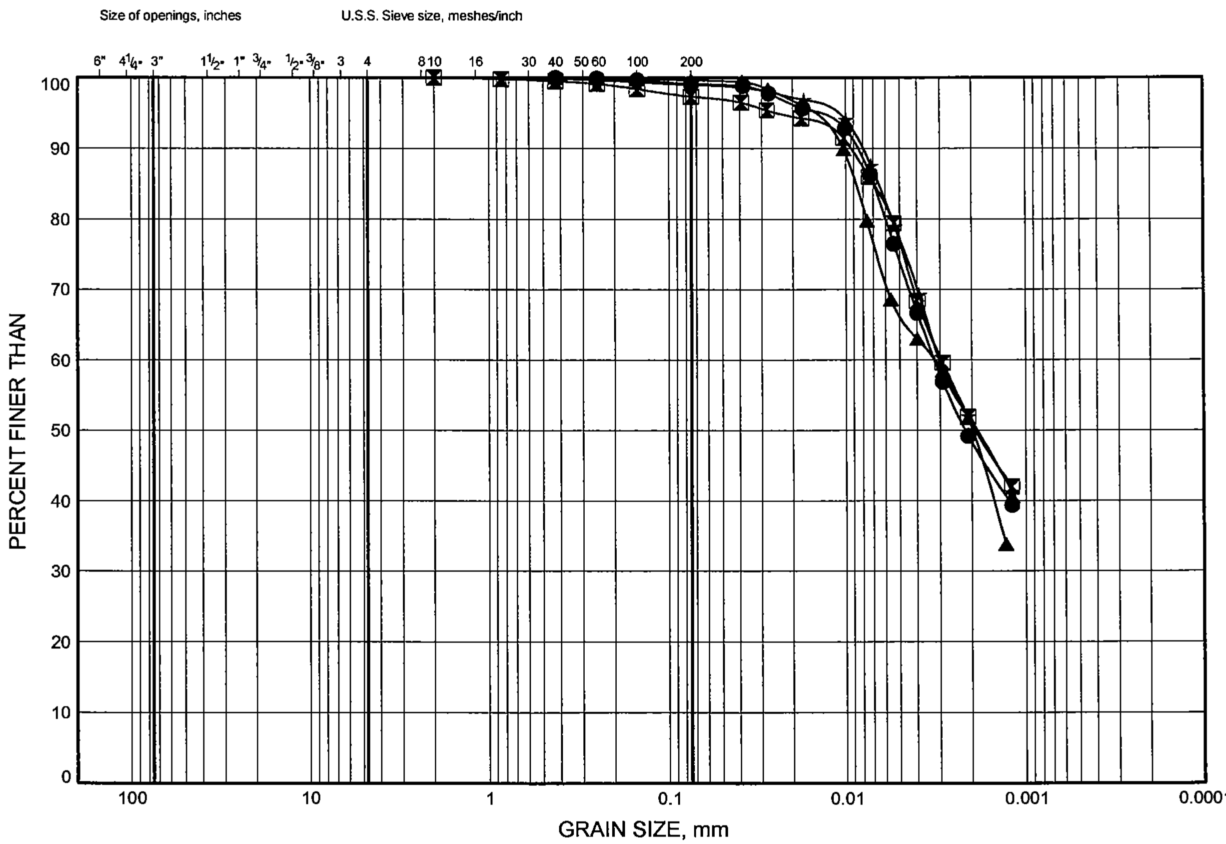
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-1	6.40	289.40
⧗	TML-2	6.25	289.15
▲	TML-4	1.83	294.07
★	TML-9	4.88	290.32

Date February 2006
Project 475-93-01

THURBER

Prep'd WM
Chkd. AEG

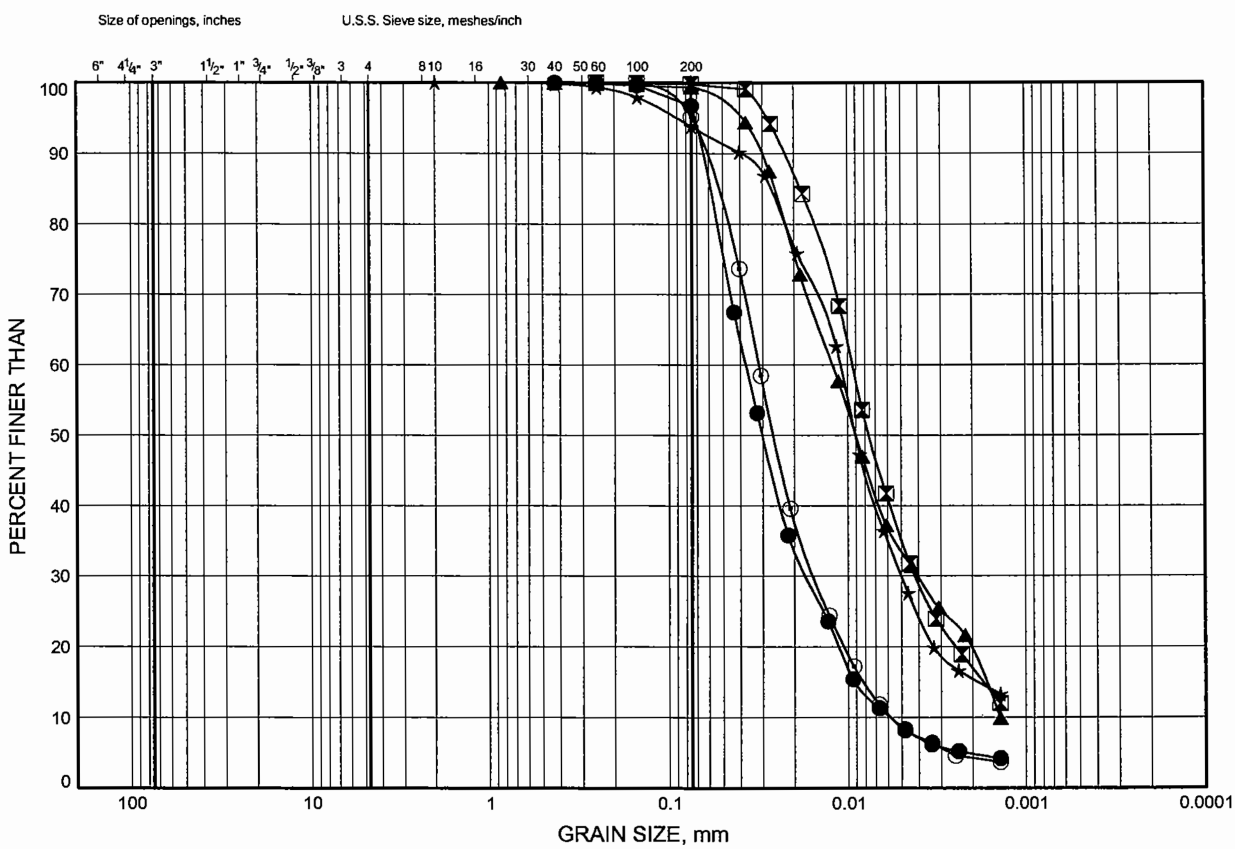
THURBGSD TMLN.GPJ 10/02/06

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILT to Silty SAND (lower)



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-2	11.58	283.82
⊠	TML-3	4.19	290.71
▲	TML-4	4.80	291.10
★	TML-9	1.83	293.37
⊙	TML-9	9.45	285.75

THURBGSD TMLN.GPJ 10/02/06

Date February 2006

Project 475-93-01

THURBER

Prep'd WM

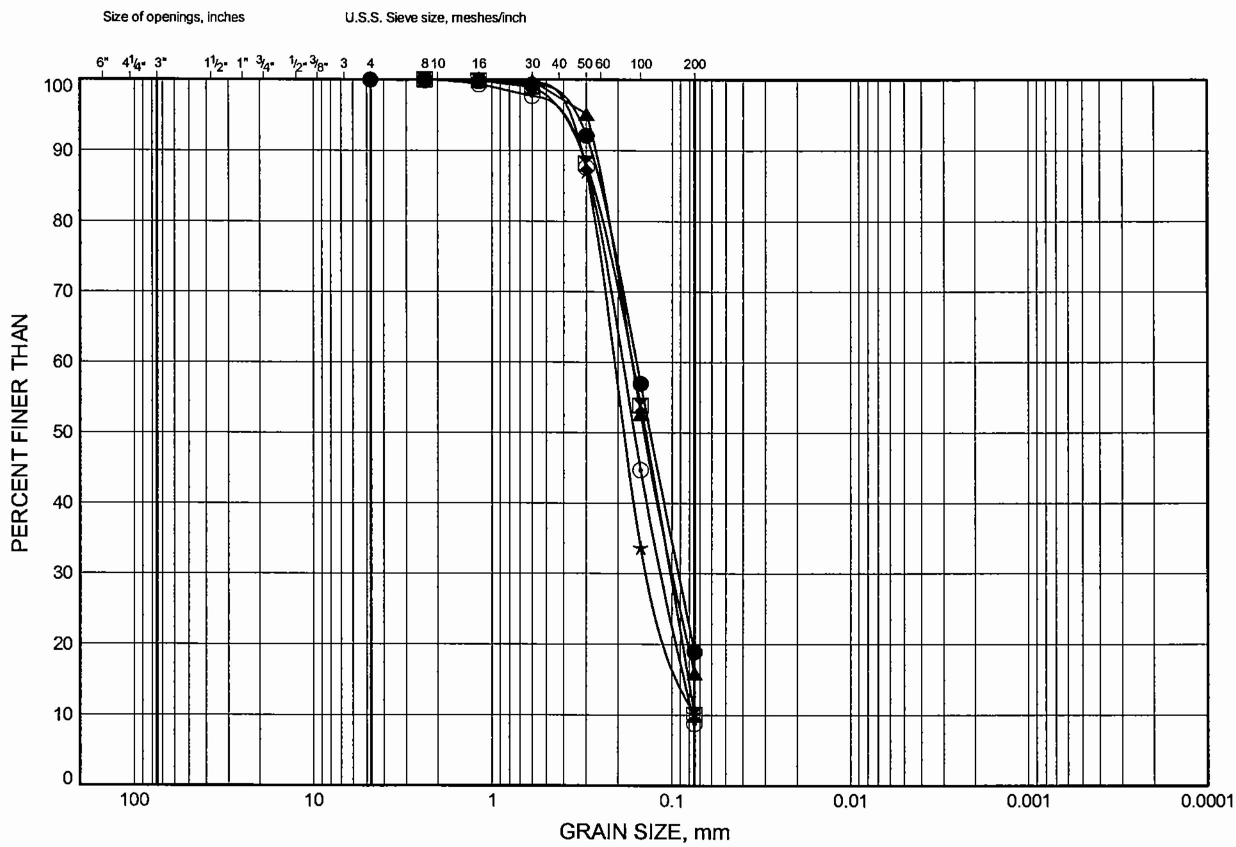
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-2	17.68	277.72
⊠	TML-3	14.86	280.04
▲	TML-4	9.37	286.53
★	TML-9	14.02	281.18
⊙	TML-9	21.56	273.63

THURBGSD TMLN.GPJ 17/01/05

Date January 2005

Project 475-93-01

THURBER

Prep'd HS

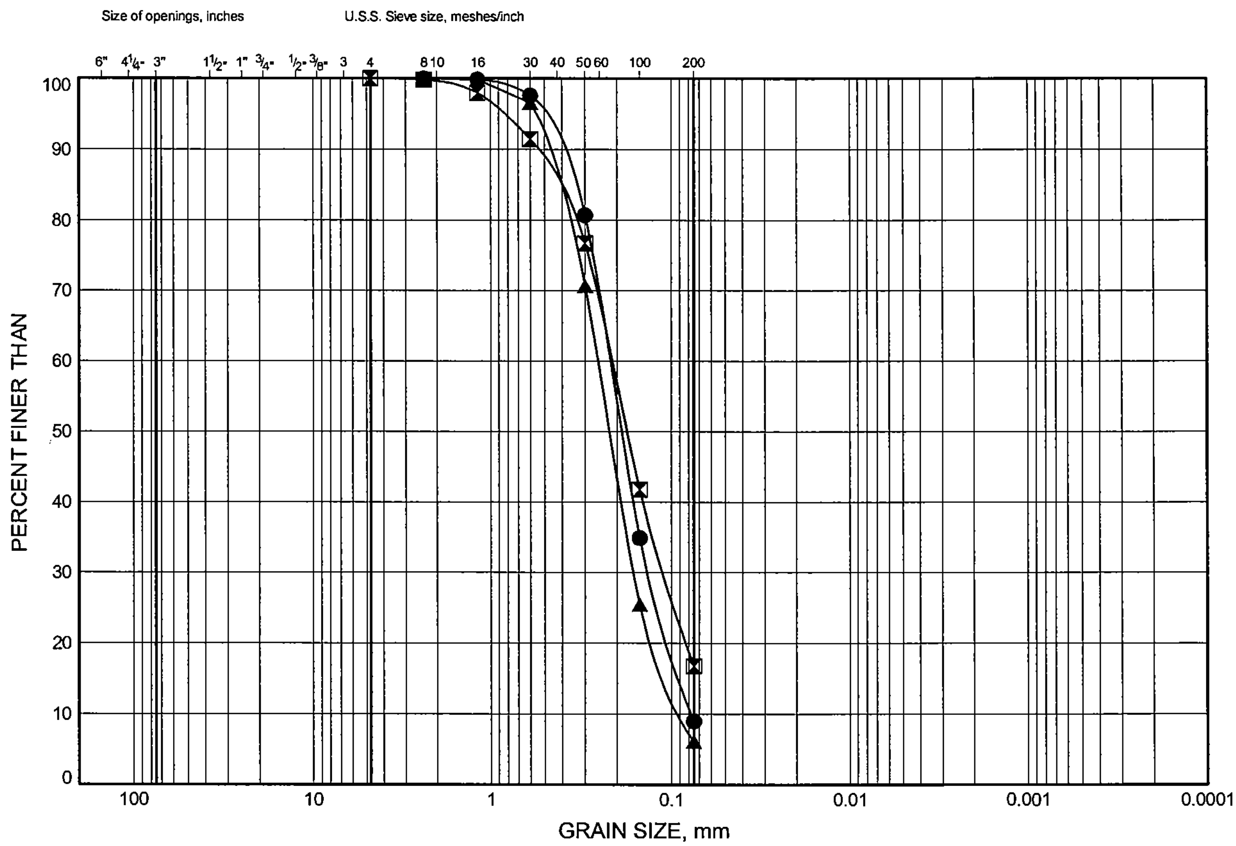
Chkd. AEG

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B5

SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-2	32.84	262.56
⊠	TML-3	31.62	263.28
▲	TML-9	39.85	255.35

Date January 2005

Project 475-93-01

THURBER

Prep'd HS

Chkd. AEG

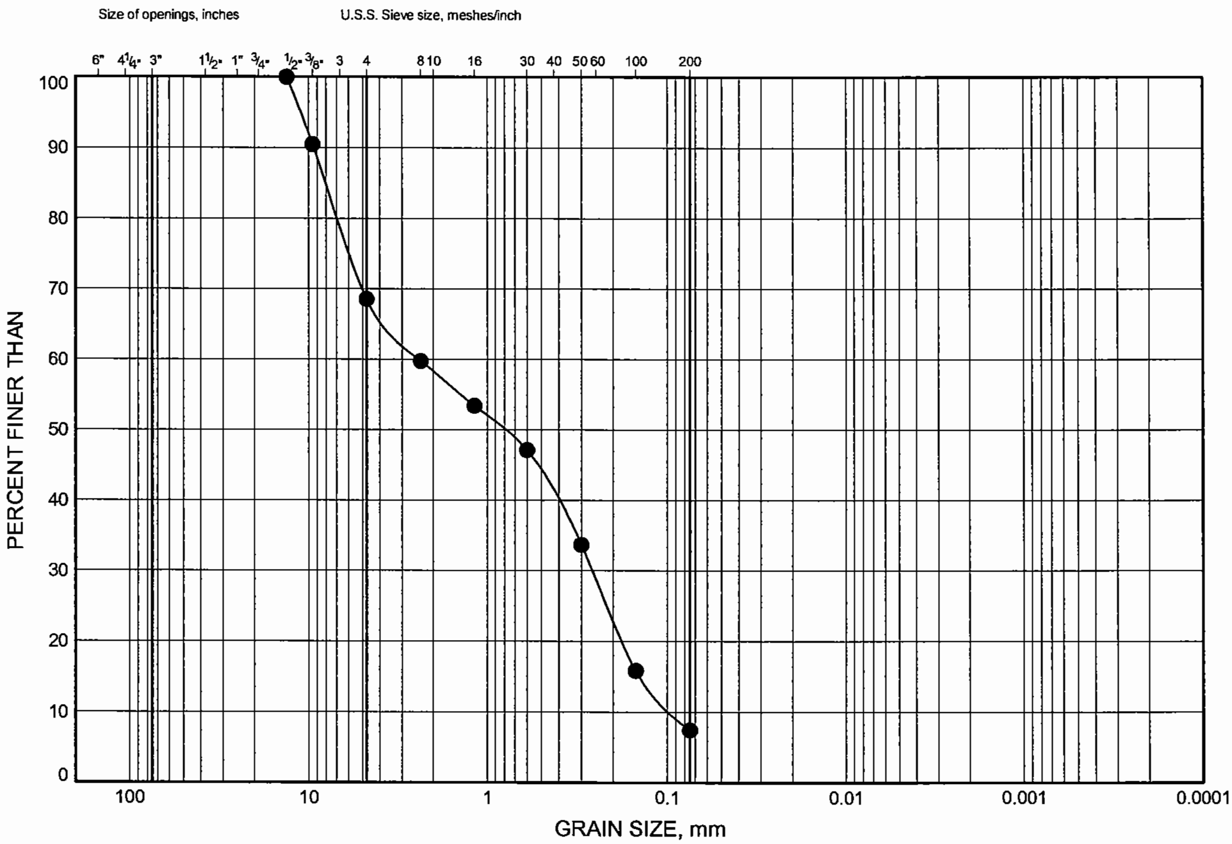
THURBGSD TMLN.GPJ 17/01/05

Hwy 11 Katrine

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND AND GRAVEL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-2	48.08	247.32

Date January 2005

Project 475-93-01

THURBER

Prep'd HS

Chkd. AEG

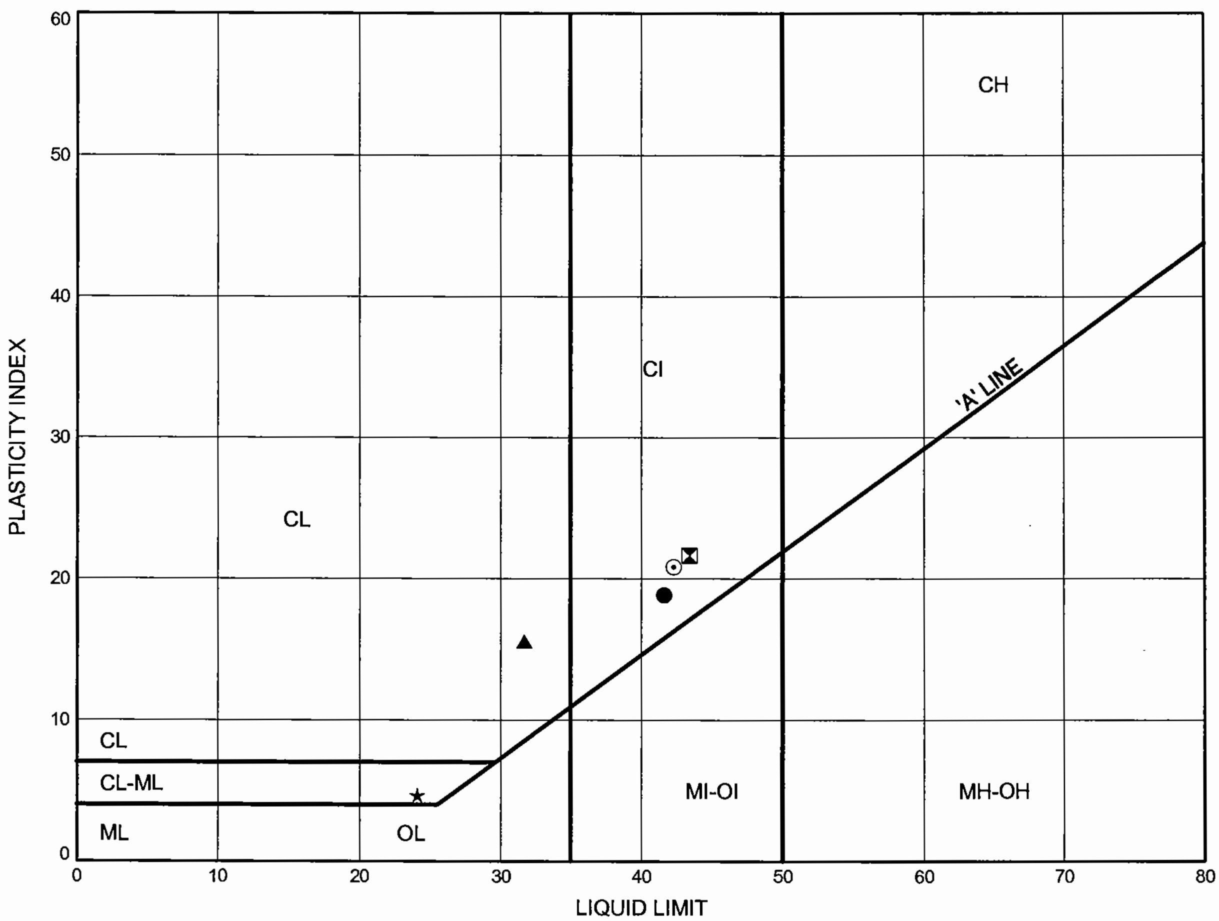
THURBGSD TMLN.GPJ 17/01/05

Hwy 11 Katrine

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY TO CLAYEY SILT



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	TML-1	6.40	289.40
⊠	TML-2	6.25	289.15
▲	TML-4	1.83	294.07
★	TML-9	1.83	293.37
⊙	TML-9	4.88	290.32

Date January 2005

Project 475-93-01

THURBER

Prep'd HS

Chkd. AEG

THURBALT TMLN.GPJ 17/01/05

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: 19-Apr-05

TEST DATES: Mar 16, 2005 - Apr 2, 2005

SAMPLE: TML-2, ST1, 15.5 - 16.5ft.
Silty Clay, grey, plastic, (CL)

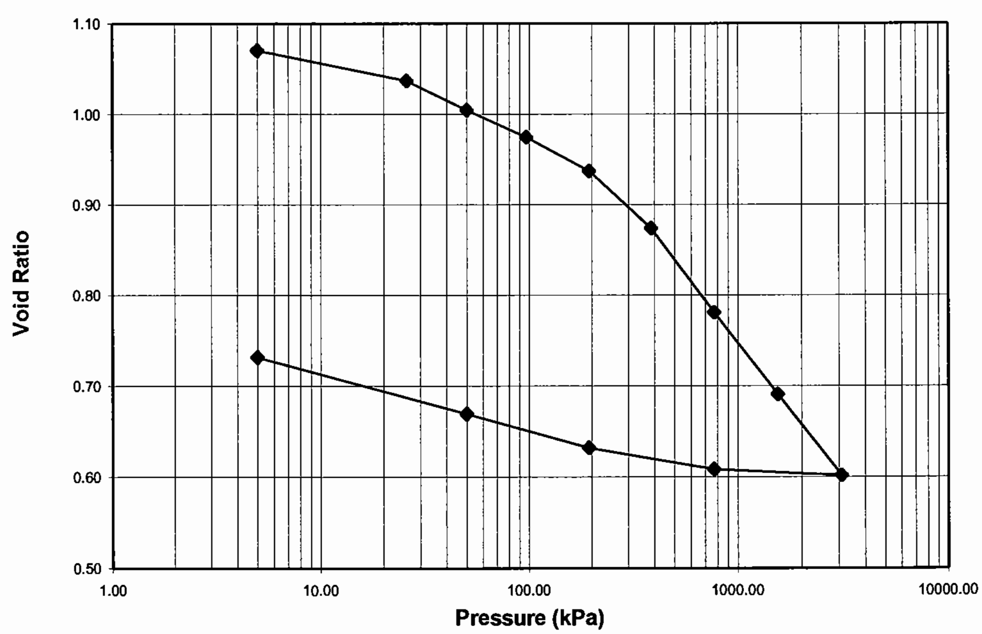
PROCEDURE: Tested in accordance with Standard Test Method for One-Dimensional Consolidation Properties of Soils, ASTM D 2435-04, method B

	Start of Test	End of Test
Wet Dens. (kg/m^3)	1842.1	2078.8
Dry Dens. (kg/m^3)	1325.6	1578.4
Moisture Cont. (%)	39.0	31.4
Void Ratio	1.075	0.742
Saturation(%)	99.8	

Note: A Specific Gravity of 2.75 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-2, ST1, 15.5 - 16.5ft.
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-2, ST1, 15.5 - 16.5ft.

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

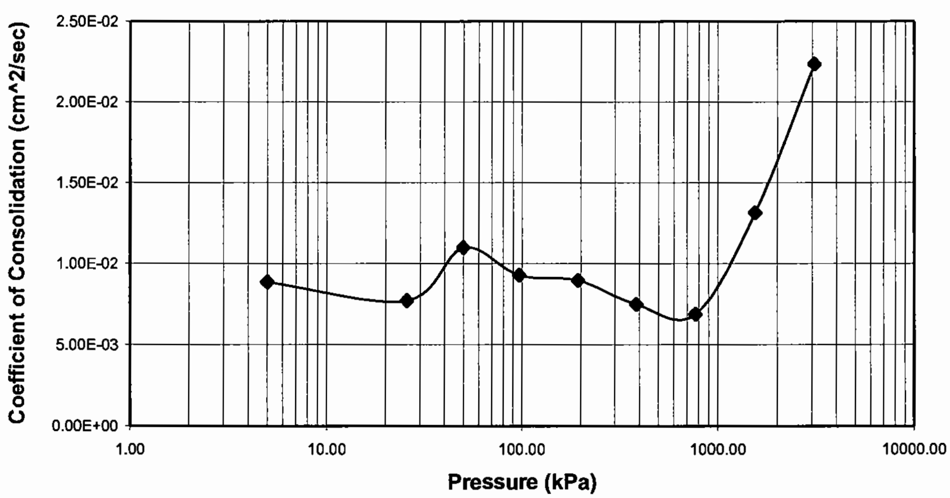
LOADING: A seating load of 5 kPa was applied and the consolidometer was flooded with distilled water. Sample was monitored to ensure no swelling effect occurred before the start of the test. Subsequent loads were applied and the duration of each load step was 24 hours

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				1.075		
5.00	25.300	25.325	-0.0755	2.56	8.85E-03	1.070	7.77E-04	6.74E-07
25.67	24.892	25.096	-0.44	2.89	7.70E-03	1.037	6.50E-04	4.90E-07
49.86	24.494	24.693	-0.209	1.96	1.10E-02	1.004	3.08E-04	3.32E-07
96.64	24.129	24.311	-0.24	2.25	9.28E-03	0.975	1.86E-04	1.70E-07
193.24	23.672	23.900	-0.276	2.25	8.97E-03	0.937	1.58E-04	1.39E-07
385.77	22.900	23.286	-0.405	2.56	7.48E-03	0.874	1.17E-04	8.55E-08
770.72	21.763	22.331	-0.66	2.56	6.88E-03	0.781	5.64E-05	3.81E-08
1540.91	20.661	21.212	-0.64	1.21	1.31E-02	0.691	2.78E-05	3.58E-08
3081.80	19.574	20.117	-0.6	0.64	2.23E-02	0.602	1.37E-06	3.01E-09
770.72	19.654	19.614				0.608		
193.24	19.945	19.799				0.632		
49.86	20.398	20.171				0.669		
5.00	21.160	20.779				0.732		

Coefficient of Consoildation vs Pressure

19-1423-16 (Marshall Macklin Monaghan)
HWY 11 Four Laning, HWY 518 to 520
TML-2, ST1, 15.5 - 16.5ft.
Oedometer Consolidation Test



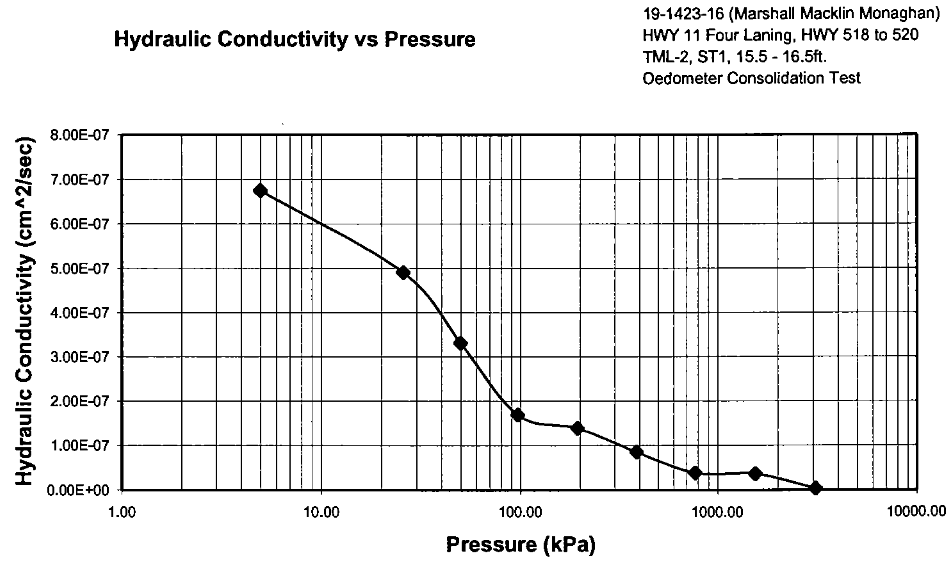
Notes: Cv and k calculated using t_{90} values

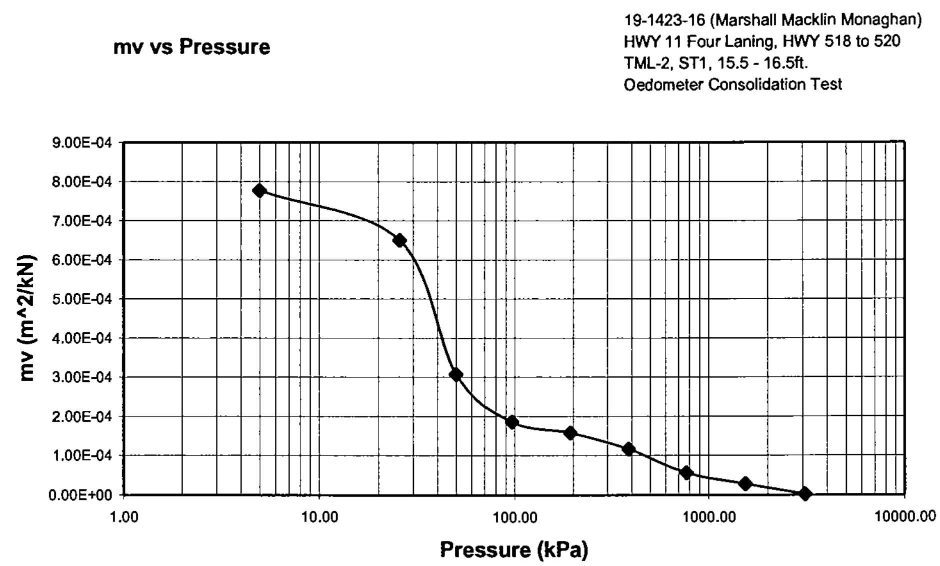
TEST DONE BY: JL
REVIEWED BY: JL

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

Consolidation Test Report

Highway 11, Katrine (Three Mile Lake)
19-1423-16 TML-2, ST1, 15.5 - 16.5ft.





TEST DONE BY: JL
REVIEWED BY: JL

Appendix C

Data From Previous Investigation

RECORD OF BOREHOLE No TMN1

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 364.9; E 316 478.4 | ORIGINATED BY G.I

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

DATUM Geodetic | DATE 27.03.01 to 30.03.01 | CHECKED BY Z.O

ELEV DEPTH	DESCRIPTION
295.0	Ground Surface
0.0 / 294.3	**700 mm Topsoil** clayey, soft
0.7 / 293.2	**SANDY SILT** loose, brown, wet
1.8 / 286.5	**SILTY CLAY** layered, very soft to stiff brown to 2.3 m, grey below; ------ frequent silt seams
8.5 / 280.0	silty ------ **FINE SAND** loose to compact, grey, wet
15.0	Continued Next Page

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	2	
2	SS	9	
3	SS	4	
4	SS	4	0 6 56 38
5	SS	1	0 6 49 45
6	TW	PH	
7	SS	2	
8	SS	3	
9	TW	PH	
10	SS	9	0 10 82 8
11	SS	6	Commenced wash boring @ 9.1 m
12	SS	12	
13	SS	3*	0 92 (8) * low N-value probably due to hydrostatic uplift
14	SS	15	

ELEVATION SCALE: 295, 294, 293, 292, 291, 290, 289, 288, 287, 286, 285, 284, 283, 282, 281, 280

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/m^3

Field vane values: +7, +8 (sensitivity)

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No TMN1

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 364.9; E 316 478.4 | ORIGINATED BY G.I

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

DATUM Geodetic | DATE 27.03.01 to 30.03.01 | CHECKED BY Z.O

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, X LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 80); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION	REMARKS (GR SA SI CL)
280.0 / 15.0	FINE SAND compact, grey, wet	15	SS	18	280 – 279	
		16	SS	14	277 – 276	0 93 (7)
		17	SS	16	274 – 273	
		18	SS	18	271 – 270	
	------ becoming coarser	19	SS	17	268 – 267	0 95 (5) March 27 ------- March 28
265.0 / 30.0					265	

Elevation scale: 280, 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

RECORD OF BOREHOLE No TMN1

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 364.9; E 316 478.4 | ORIGINATED BY G.I

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

DATUM Geodetic | DATE 27.03.01 to 30.03.01 | CHECKED BY Z.O

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
265.0 / 30.0	**FINE SAND** some medium sand zones, compact, grey, wet
256.0 / 39.0	**GRAVEL AND SAND** with frequent cobbles & boulders, compact to dense, grey, wet
250.0 / 45.0	Continued Next Page

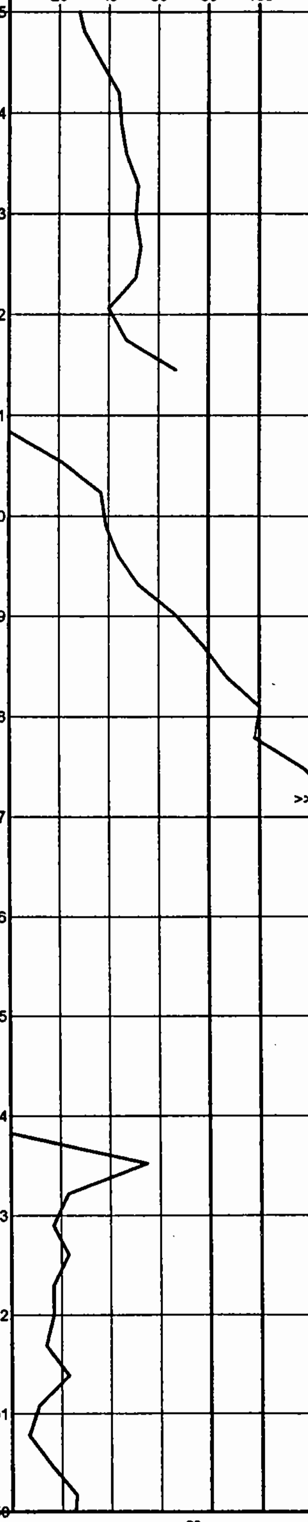
SAMPLES

NUMBER	TYPE	"N" VALUES
20	SS	14
21	SS	64/23
22	RC	

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)

ELEVATION SCALE: 265 to 250



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

- Sand rising in casing — 0 97 (3)
- Sand rising in casing
- *Sampler hit possible cobble
- March 28
- -------
- March 29
- Cone probably deflected

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

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

Ministry of Transportation
Ontario

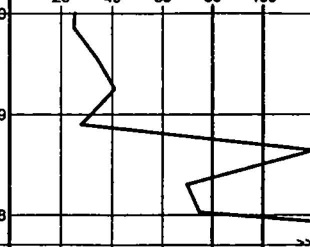
Foundation Design

RECORD OF BOREHOLE No TMN1

METRIC

W.P.	314-99-00	LOCATION	Katrine -Three Mile Lake Road - Co-ords: N 5 048 364.9; E 316 478.4	ORIGINATED BY	G.I
DIST	52 HWY 11	BOREHOLE TYPE	Solid Stem Augers, Casing & washboring, NQ Rock Core & D.C.P.T.	COMPILED BY	G.T
DATUM	Geodetic	DATE	27.03.01 to 30.03.01	CHECKED BY	Z.O

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
250.0											
45.0	**GRAVEL AND SAND** with frequent cobbles & boulders, compact to dense, grey						250				
249.3 45.7	End of borehole						249				
											D.C.P.T refusal 100 blows/75 mm
247.7							248				
47.3	End of Dynamic Cone Penetration Test Dynamic Cone Penetration Test performed from 27.8 m to 33.5 m; 34.0 to 38.0 m; 41.0 to 47.3 m Soil stratigraphy inferred only Piezometer installed at 44.2 m Water level in piezometer: April 06/2001 - 0.1 m April 09/2001 - 0.05 m April 11/2001 - 0.05 m										



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

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

RECORD OF BOREHOLE No TMN2

METRIC

W.P.	314-99-00	LOCATION	Katrine -Three Mile Lake Road - Co-ords: N 5 048 391.7; E 316 467.1	ORIGINATED BY	G.I
DIST	52 HWY 11	BOREHOLE TYPE	Solid Stem Augers, Casing and wash boring, NQ Rock Core & D.C.P.T.	COMPILED BY	G.T
DATUM	Geodetic	DATE	16.03.01 to 27.03.01	CHECKED BY	Z.O

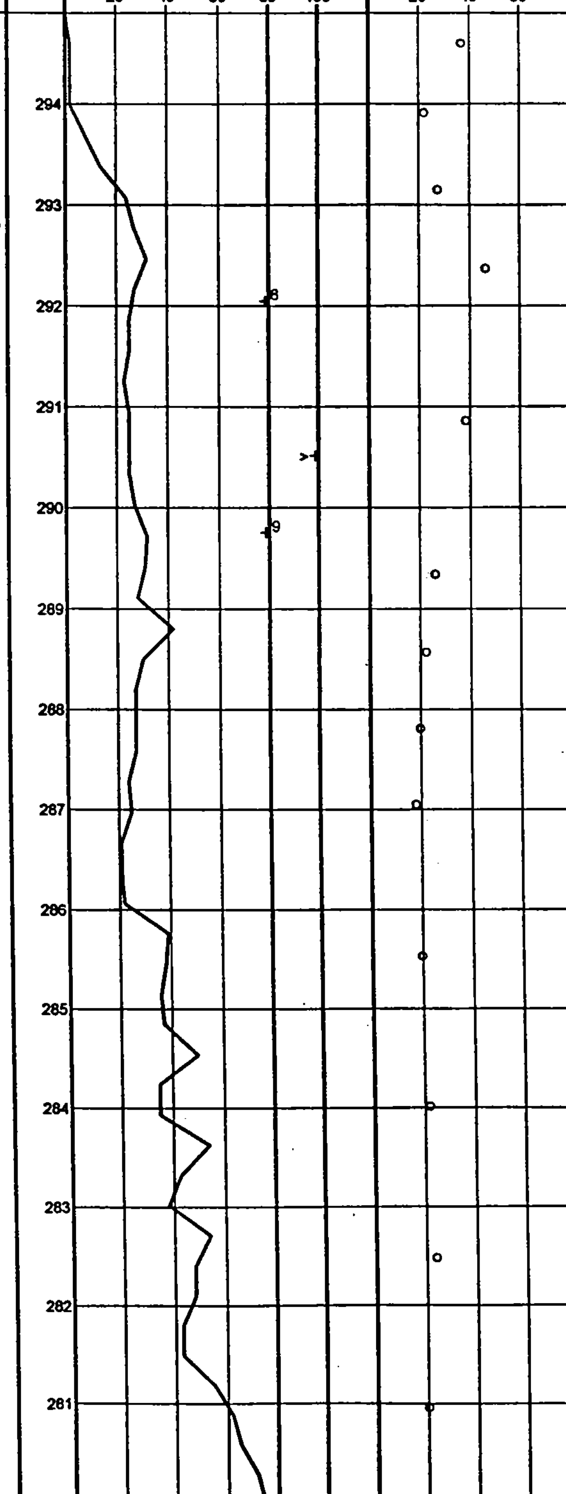
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.9	Ground Surface					
0.0	200 mm Topsoil SANDY SILT with trace rootlets & organics, 150 mm sand layer @ 0.8 m & 1.5 m very loose, moist	1	SS	4		
		2	SS	3		
293.2 1.7	rootlets ------ SILTY CLAY layered, soft to stiff, grey	3	SS	4		
					▼	
		4	SS	3		0 9 65 26
		5	TW	PH		
		6	SS	8		
		7	TW	PH		
289.6 5.3	SILT Sandy, loose to very loose grey, wet	8	SS	6		0 25 75 0
		9	SS	7		
		10	SS	1		0 42 58 0
287.4 7.5	very loose ------- FINE SAND loose to compact grey, wet	11	SS	2		
		12	SS	7		
		13	SS	17		Commenced wash boring
		14	SS	8		
		15	SS	9		
279.9 15.0	Continued Next Page					

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



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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TMN2

METRIC

W.P. 314-99-00 LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 391.7; E 316 467.1 ORIGINATED BY G.I

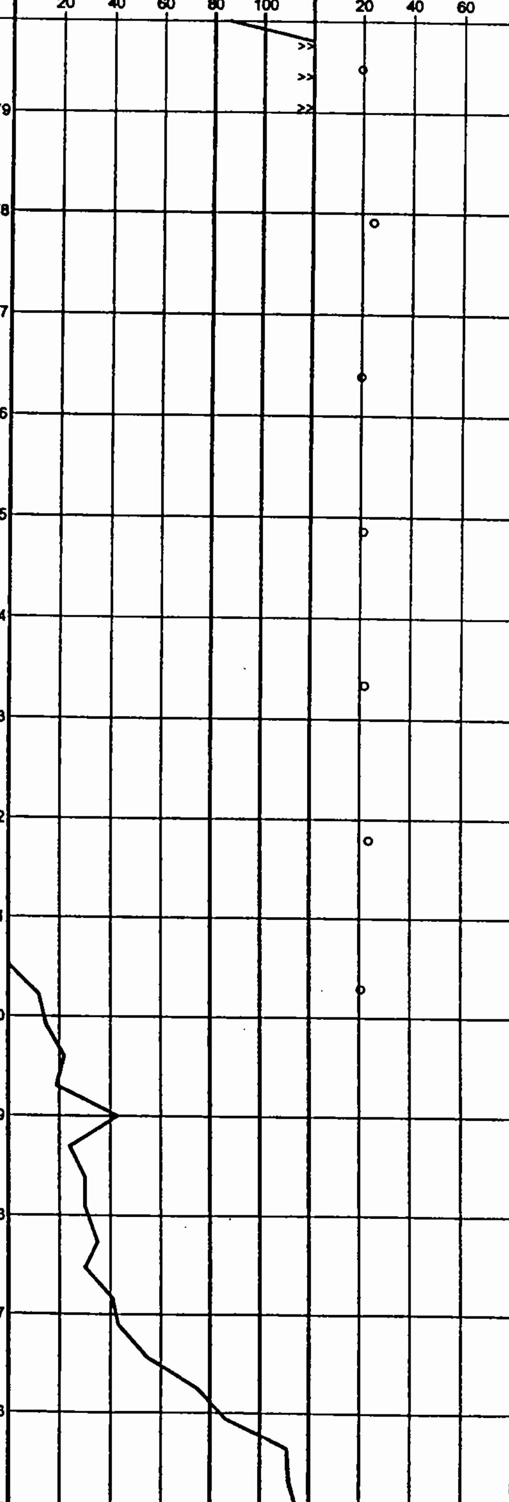
DIST 52 HWY 11 BOREHOLE TYPE Solid Stem Augers, Casing and wash boring, NQ Rock Core & D.C.P.T. COMPILED BY G.T

DATUM Geodetic DATE 16.03.01 to 27.03.01 CHECKED BY Z.O

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.9 / 15.0	FINE SAND compact, grey, wet	16	SS	14		279	
		17	SS	18		278	0 95 (5)
		18	SS	20		277, 276	
		19	SS	6	**	275	** low N-value probably due to hydrostatic uplift
		20	SS	17		274, 273	March 21 ----- March 22
		21	SS	23		272, 271	
		22	SS	20		270, 269, 268, 267, 266, 265	
264.9 / 30.0							

Continued Next Page

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



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

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

RECORD OF BOREHOLE No TMN2

METRIC

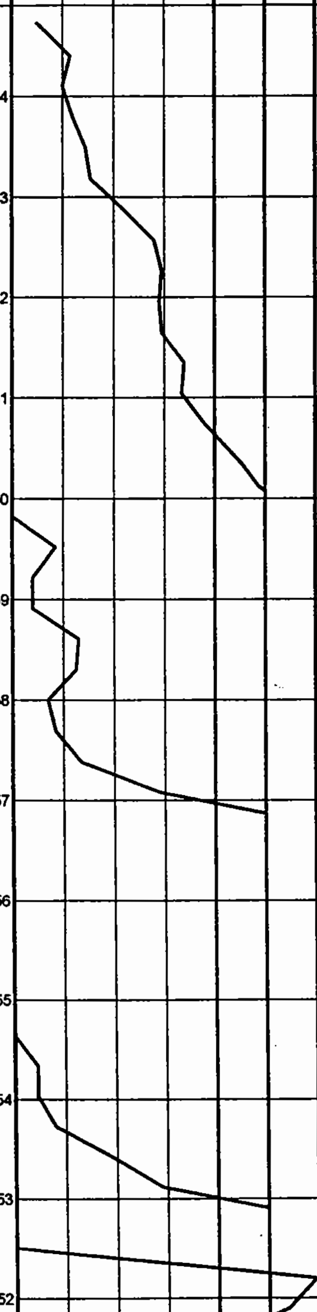
W.P. 314-99-00 LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 391.7; E 316 467.1 ORIGINATED BY G.I

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

DATUM Geodetic DATE 16.03.01 to 27.03.01 CHECKED BY Z.O

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, 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	ELEVATION	WATER CONTENT	REMARKS
264.9 / 30.0	**FINE SAND** compact to dense grey, wet	23	SS	11		o	0 97 (3)
					264		
					263		
					262		
					261		
					260		D.C.P.T. hit probable boulder
259.8 / 35.1	**GRAVEL AND SAND** frequent cobbles and boulders, compact to dense grey, wet	24	SS	60/8		o	
		25	RC		259		March.22 ------- March.23
		26	AS ***		258		
					257		D.C.P.T. 100 blows/18cm
		27	SS	60/13			
		28	RC		256		
		29	RC		255		
					254		March.26 ------- March.27
		30	AS ***				D.C.P.T. 100 blows/18 cm
					253		
252.4 / 42.5	End of borehole	31	RC				D.C.P.T. 100 blows/8 cm
251.8 / 43.1	End of Dynamic Cone Penetration Test. Dynamic cone penetration tests (DCPT) performed from 0 to 15 m; 24.4 to 29.9 m; 30 to 34.8 m; 35 to 38 m and 42 to 43 1m. Soil stratigraphy inferred only. *** AS denotes Auger Sample				252		



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

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

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No TMN2

METRIC

W.P. 314-99-00 LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 391.7; E 316 467.1 ORIGINATED BY G.I

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

DATUM Geodetic DATE 16.03.01 to 27.03.01 CHECKED BY Z.O

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 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	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	*Water added to the hole for facilitating drilling and counter balancing hydrostatic pressure; water level not stabilized on completion										

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

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

RECORD OF BOREHOLE No TMN3

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 401.7; E 316 461.9 | 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

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
294.9	Ground Surface							
0.0	100 mm **Topsoil** **SANDY SILT** some rootlets, very loose to loose, moist	1	SS	2	•			
		2	SS	4		294	19.2	
292.8	brown to 1.2 m, grey below	3	SS	8		293	20.5	
2.1	**SILTY CLAY** firm to stiff, grey	4	SS	4			17.1	0 13 72 15
		5	TW	PH		292		
290.4		6	SS	5		291		
4.5	**SILT** Sandy loose to very loose, grey, wet	7	SS	7		290		
289.0		8	SS	3				0 20 (80) Sand rising in hole
5.9	organic odor ------ silty ---	9	SS	3		289		
	FINE SAND some silt, very loose, grey wet	10	SS	1		288, 287		
285.3		11	SS	2		286		
9.6	End of borehole Sand rising in borehole (quick condition) from 6.0 m onwards. *Water added to hole for counter-balancing hydrostatic pressure; water level not stabilized 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, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No TMN4

METRIC

W.P. 314-99-00 | LOCATION Katrine -Three Mile Lake Road - Co-ords: N 5 048 343.0; E 316 484.0 | ORIGINATED BY G.I

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

DATUM Geodetic | DATE 03.04.01 | CHECKED BY Z.O

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
295.8	Ground Surface									
0.0	200 mm Topsoil **SANDY SILT** some silty sand layers, trace rootlets, loose, brown, moist	1	SS	9		19.8				
		2	SS	8		19.9				
294.3 1.5	**SILTY CLAY** layered, soft to stiff, grey, moist	3	SS	8		19.8	0	12	76	12
		4	SS	6		19.5				
		5	SS	5	▼*	18.9				
		6	TW	PH						
		7	SS	2		16.4	0	5	45	50
		8	SS	2		17.0				
		9	SS	2						
	with Silt zones	10	SS	4						
286.8 9.0	**SILT**: Sandy, compact, grey, wet	11	SS	13						
286.2 9.6	End of borehole * Water level at 3.3 m on completion (not stabilized)									

Elevation scale: 295, 294, 293, 292, 291, 290, 289, 288, 287

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

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) 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
- Special Provision No. 902S01
- Special Provision No. 903S01
- Special Provision No. 105S10

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

"*The soil overlying the bedrock contains cobbles and boulders, particularly below Elevation 260. 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 NBL
1 Feb 06
South Approach
Rock Fill, Base, undrained

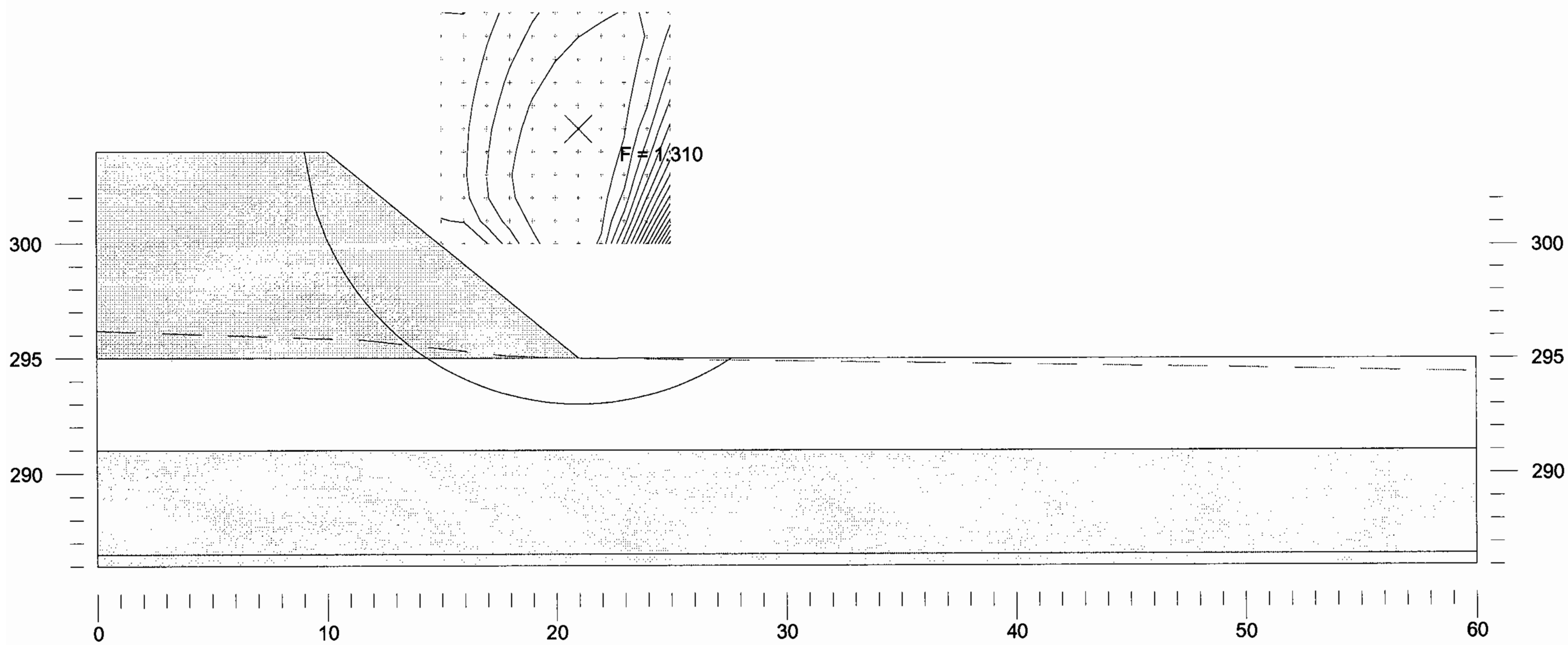

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FIGURE F1

	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

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

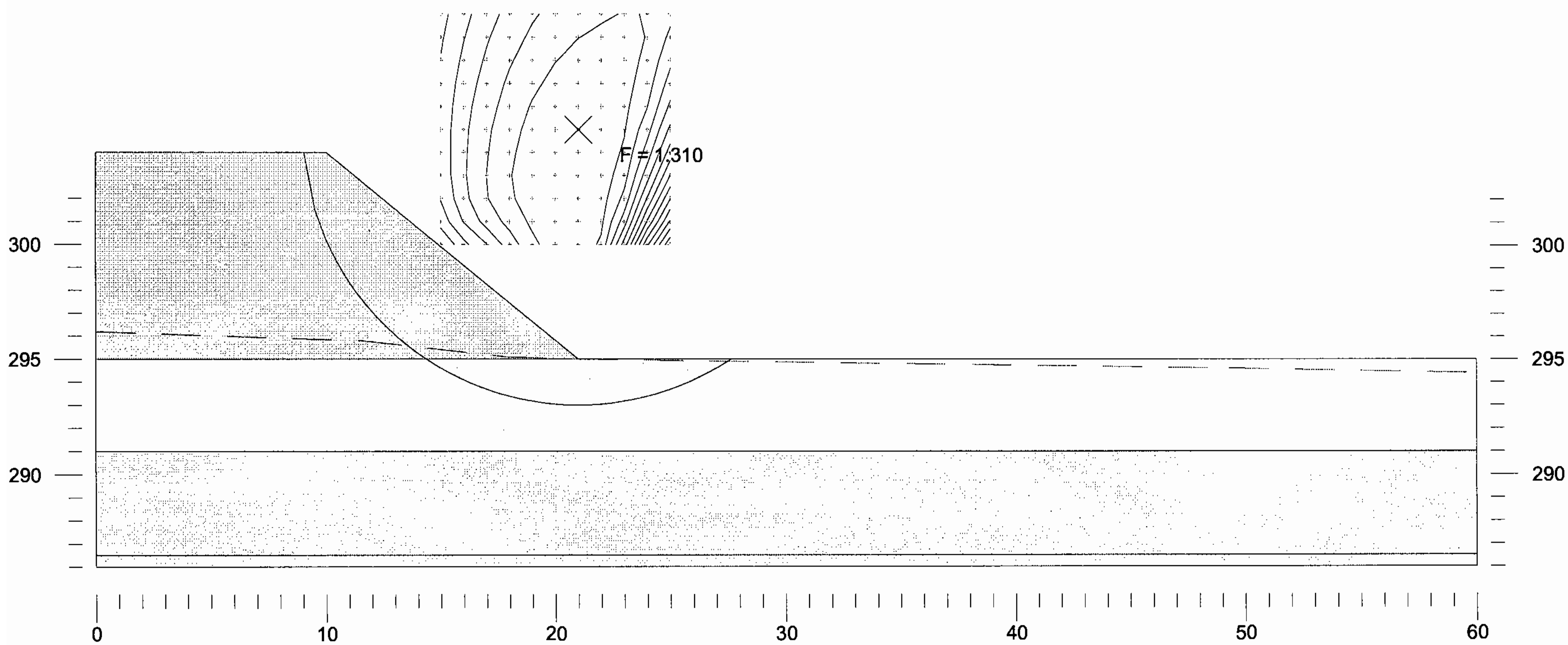

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FIGURE F2

	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 NBL
Jan 20 05
South Approach
Rock Fill, Seismic

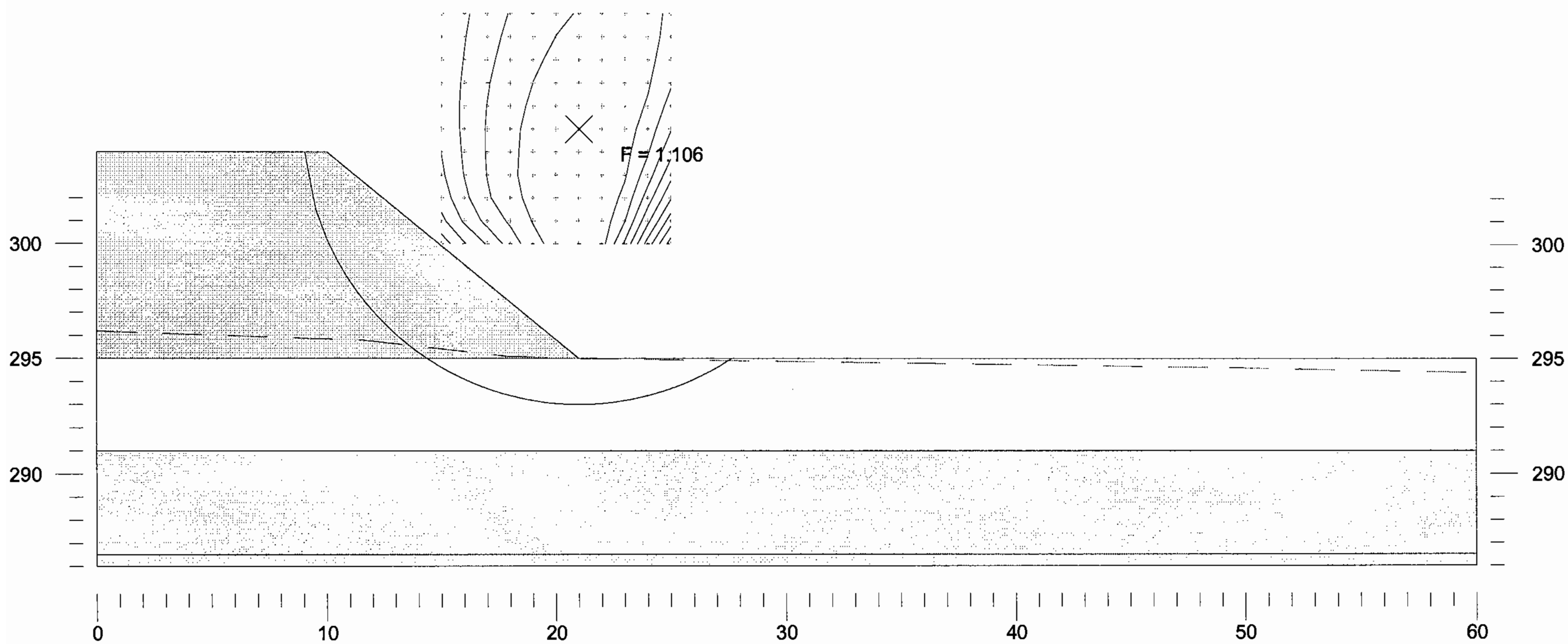

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FIGURE F3

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

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake NBL
1 Feb 06
South Approach
Earth Fill, Base, undrained

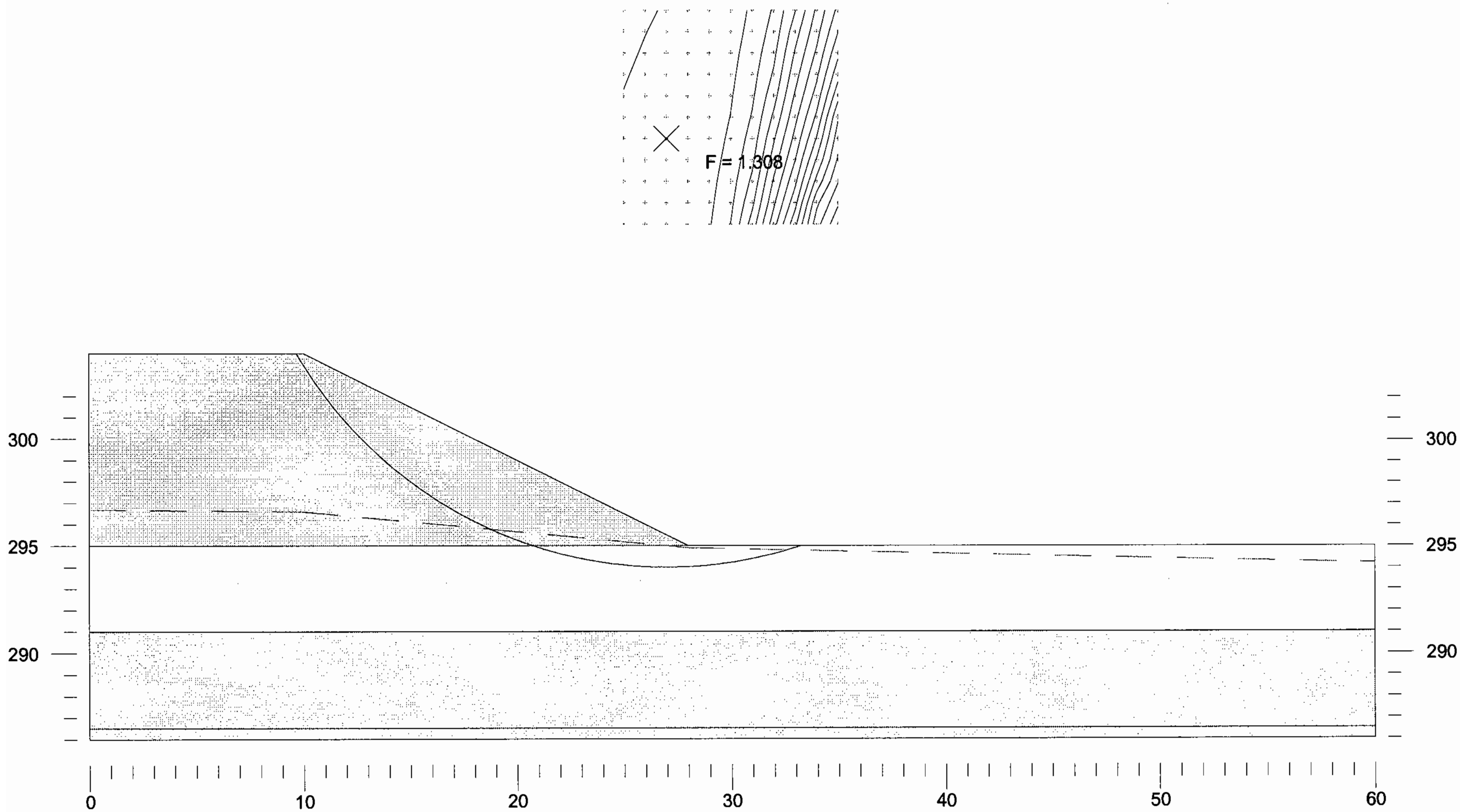

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FIGURE F4

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

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

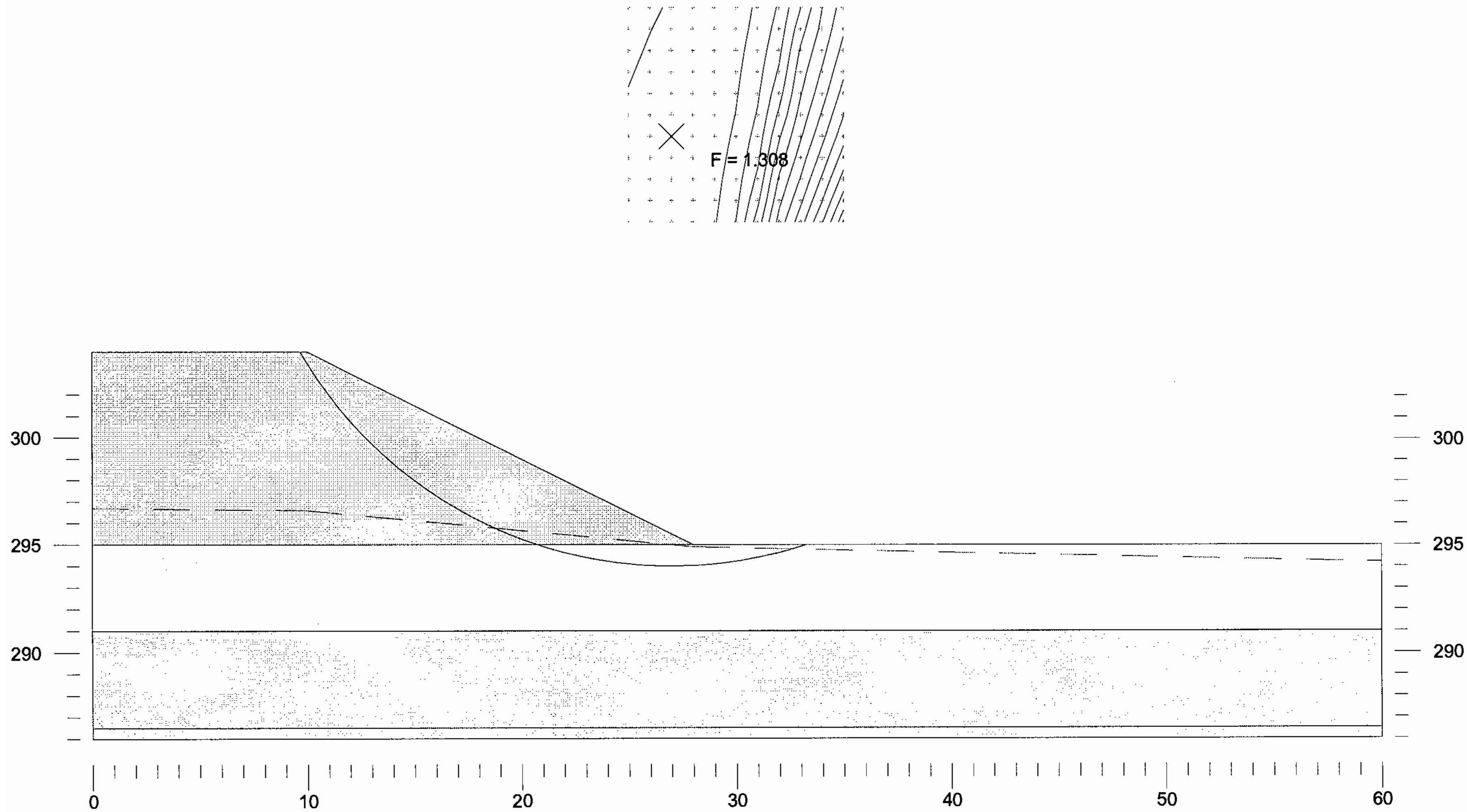

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FIGURE F5

	Gamma	C	Phi	Piezo
	kN/m3	kPa	deg	Surf.
Earth Fill	22	0	30	1
Silt	19	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 NBL
Jan 20 05
South Approach
Earth Fill, 0.08 Seismic

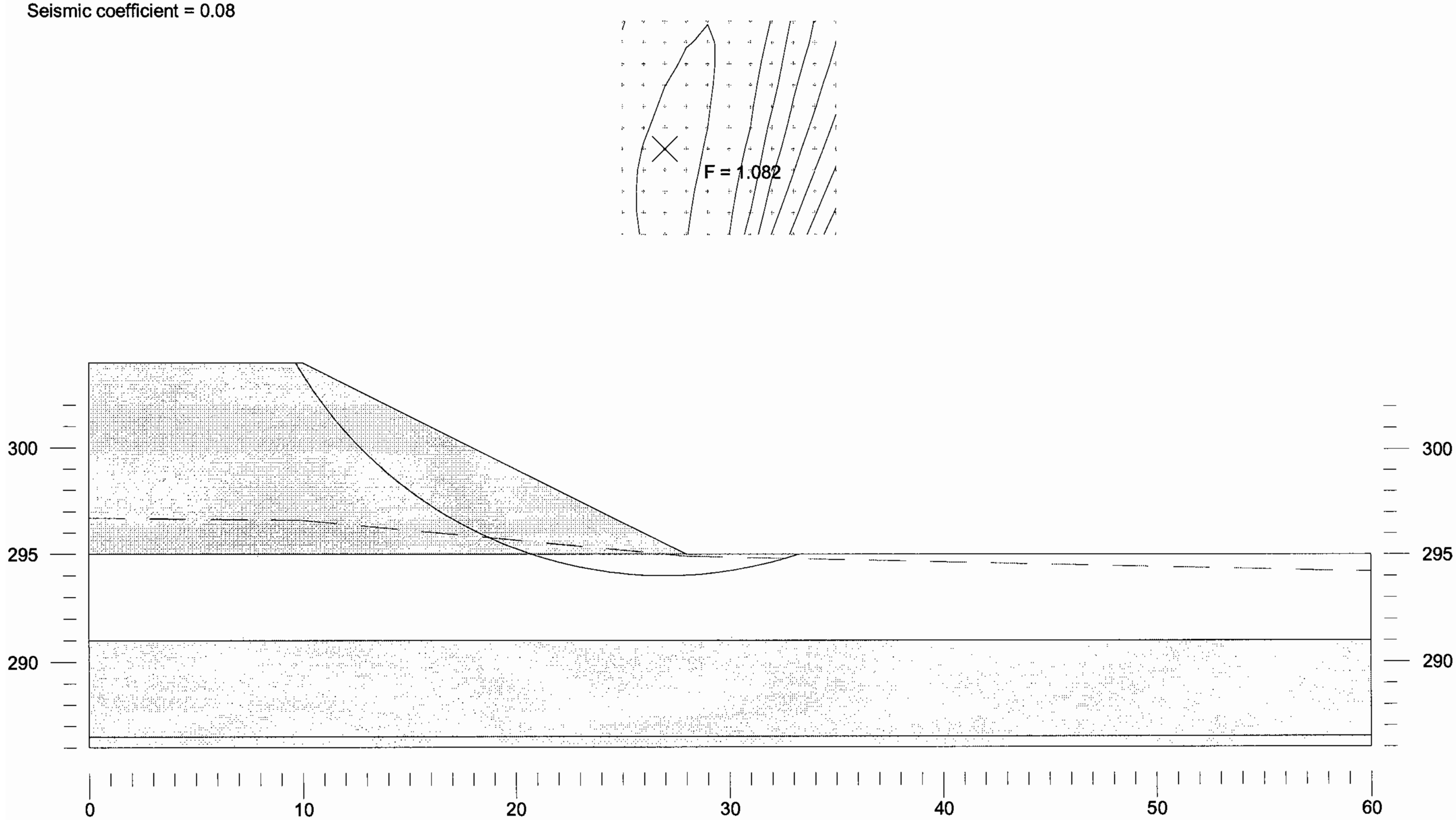

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FIGURE F6

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

Thurber Engineering Ltd. - Toronto
19-1423-16
Three Mile lake NBL
1 Feb 06
North Approach
Rock Fill, Base, undrained

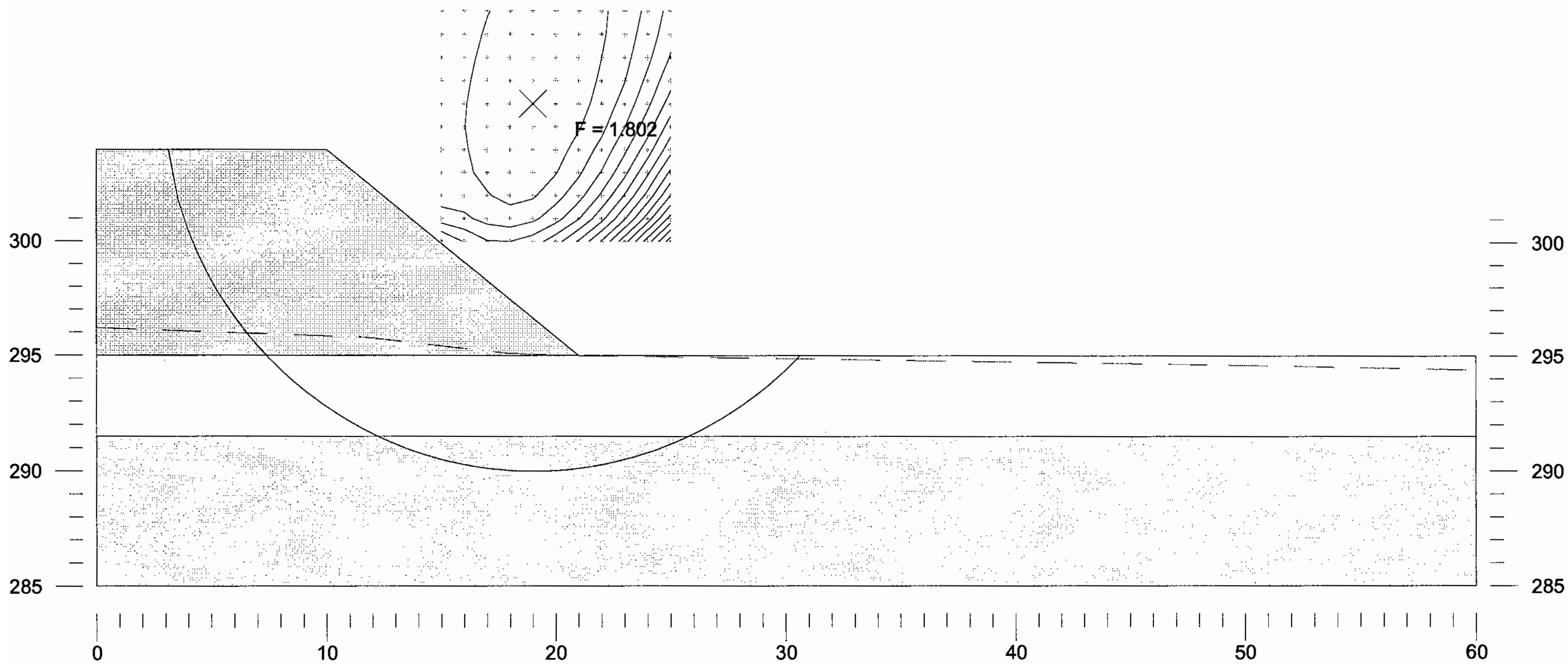

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FIGURE F7

	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 NBL
Jan 20 05
North Approach
Rock Fill, Base

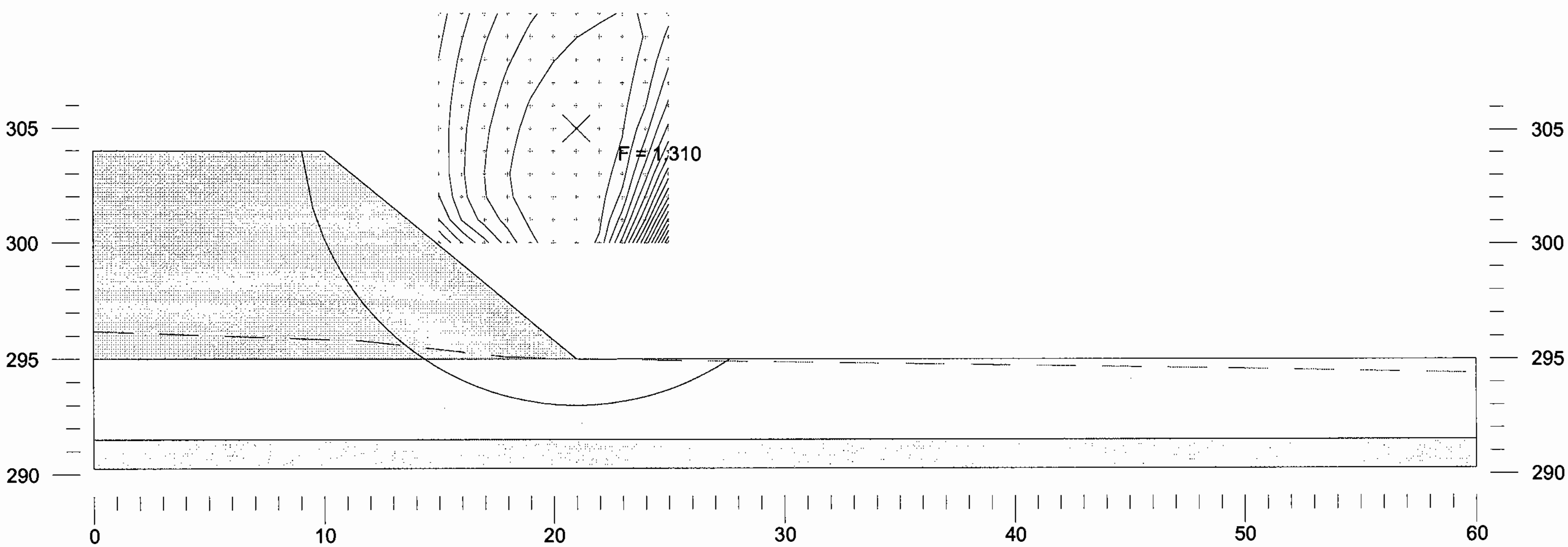

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FIGURE F8

	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 NBL
Jan 20 05
North Approach
Rock Fill, Seismic

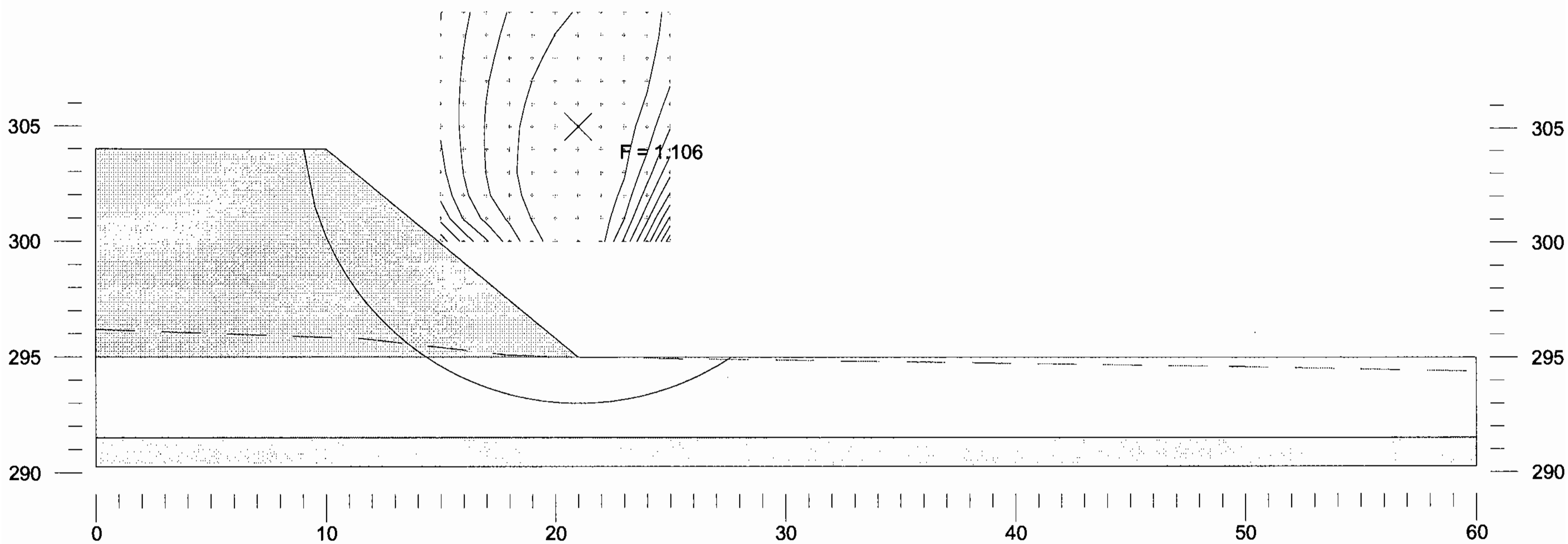

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FIGURE F9

	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
1 Feb 06
North Approach
Earth Fill, Base, undrained

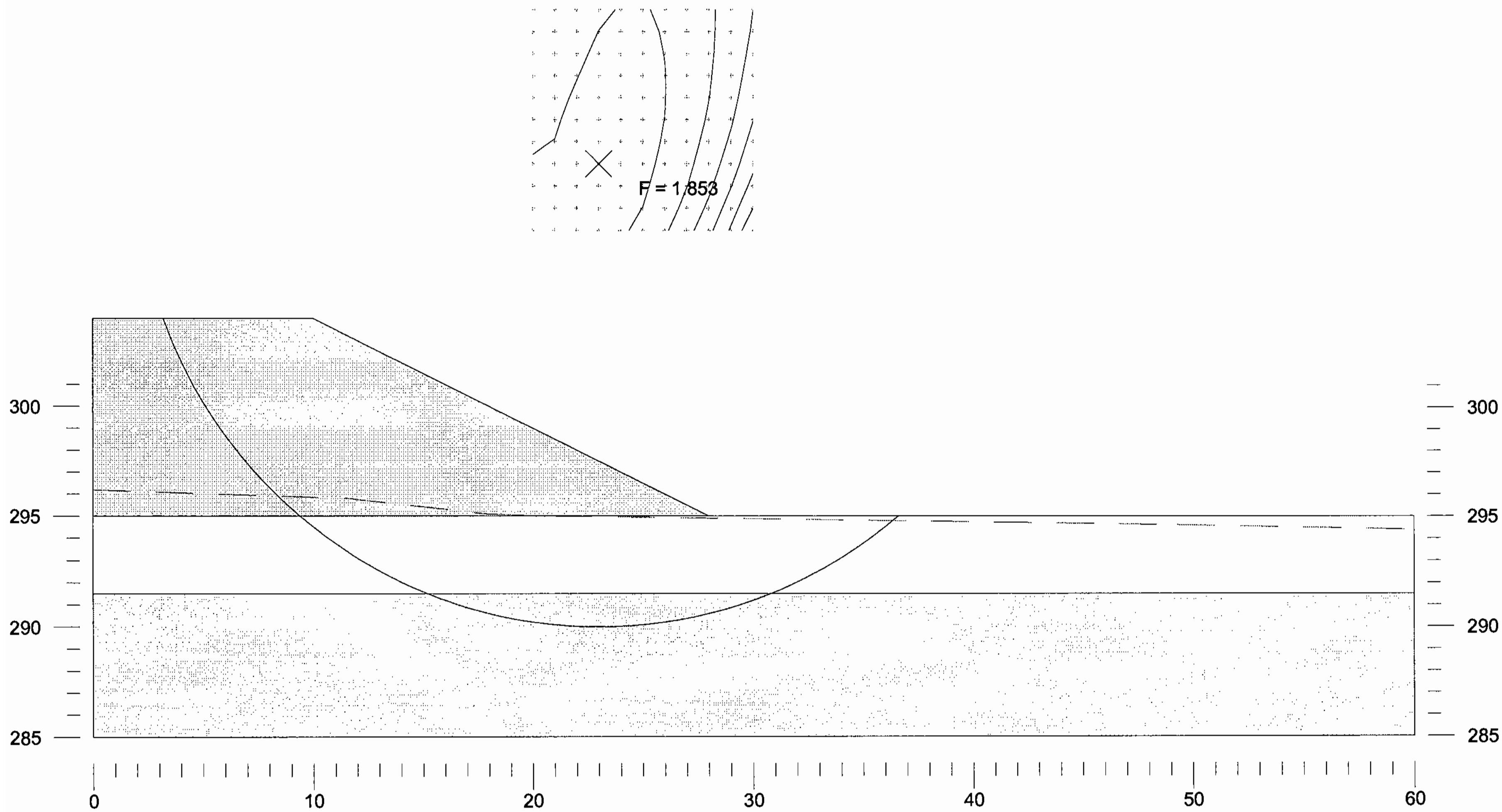

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FIGURE F10

	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

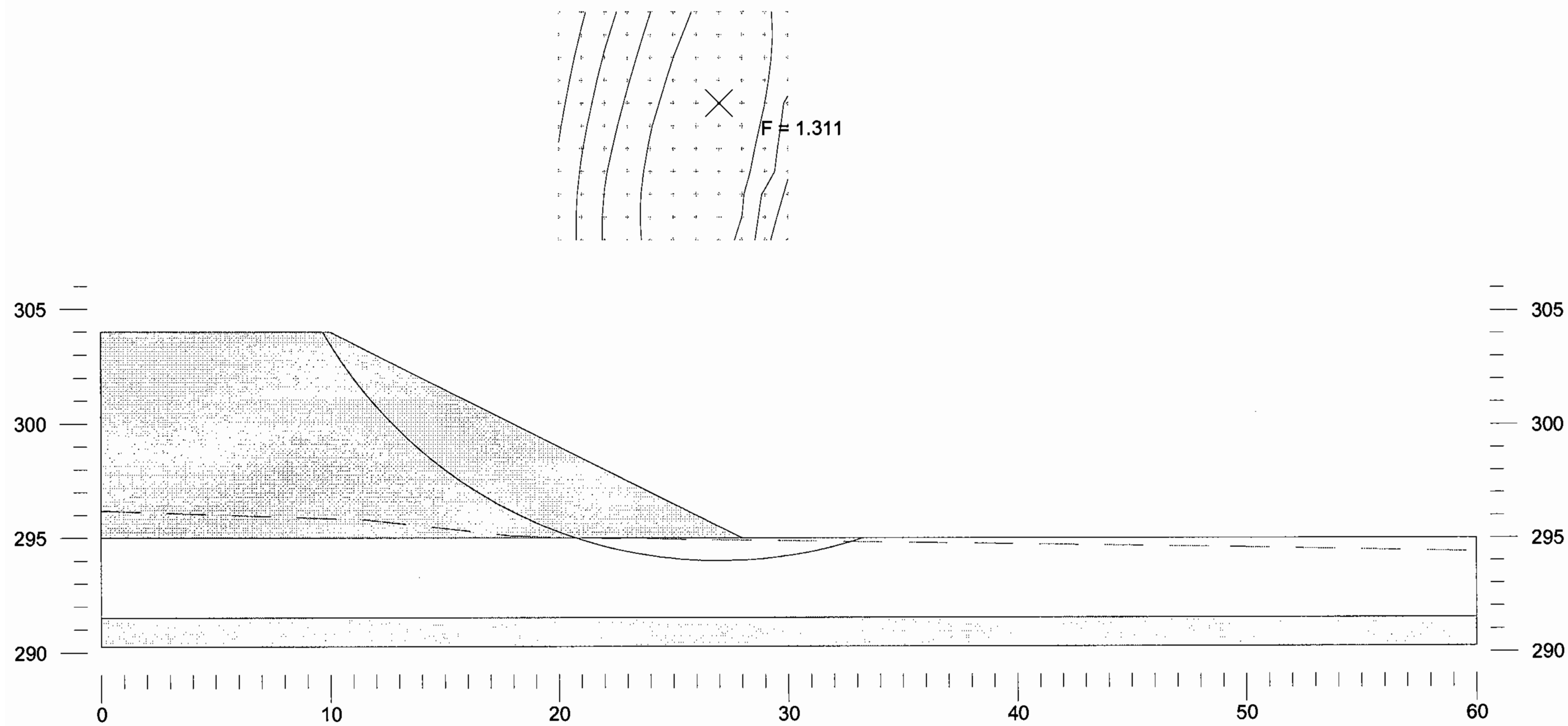

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FIGURE F11

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

Seismic coefficient = 0.08

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

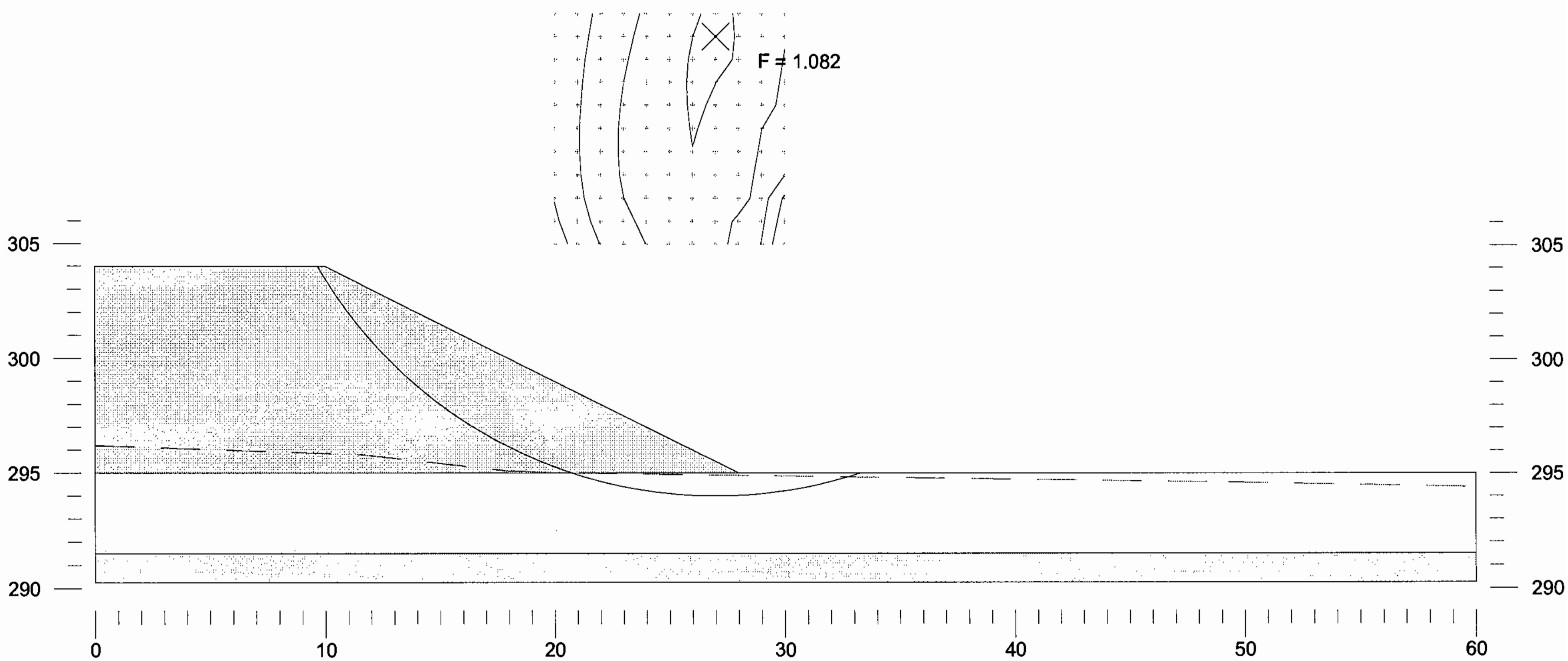

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FIGURE F12

1-DIMENSIONAL CONSOLIDATION ANALYSIS

Highway 11 NBL: Three Mile Lake Road
South Abutment

Soil Stratigraphy

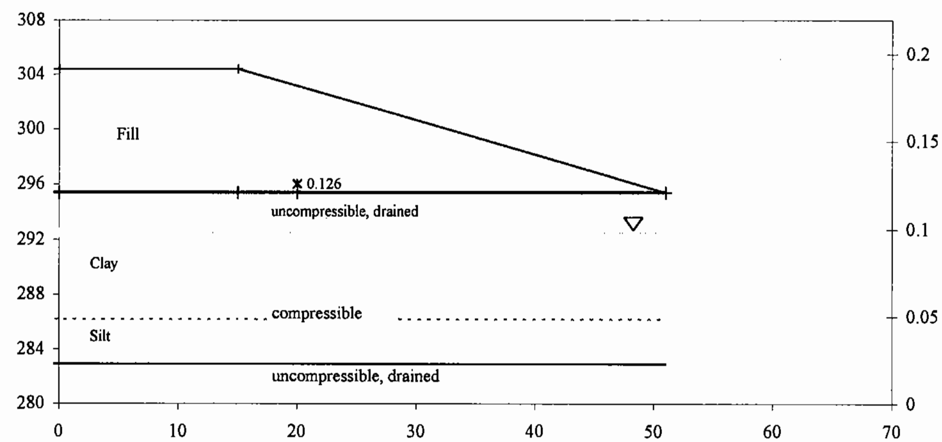
Elevation of Ground Surface	295.4 m
Top of Compressible Soil	292.5 m
Bottom of Compressible soil	282.9 m
Groundwater Elev	292.5 m

Load Data

Top of Fill	304.4 m
Strip Load Width	66 m
Settlement Location from centerline	20 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	0.06	16
Silt	19.4	0.81	0.20	0.05	160



OUTPUT

Ultimate Settlement 0.126 m

Time Rate of Settlement

time (yr)	S (m)
0.2	0.095
0.4	0.112
0.6	0.119
0.8	0.122

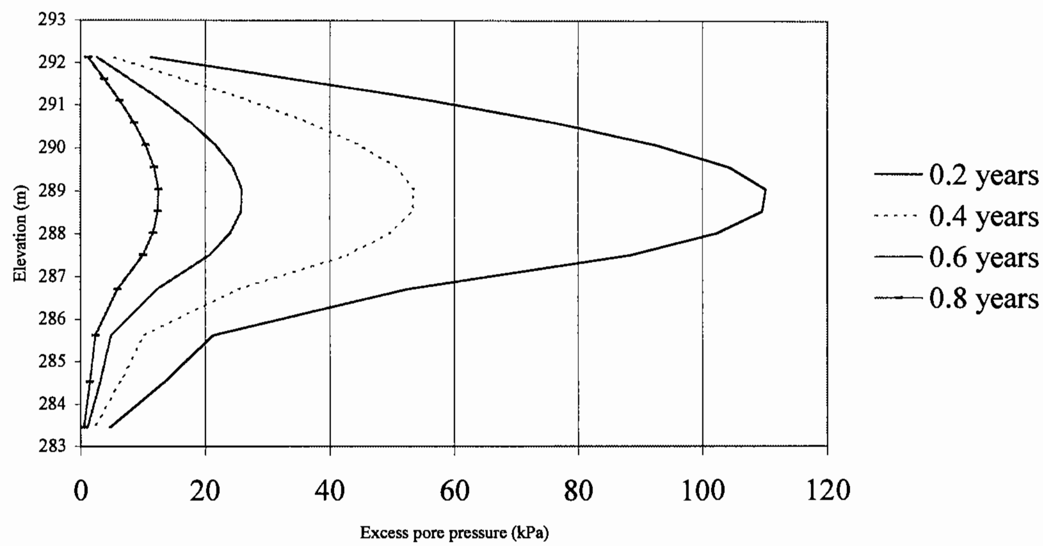


FIGURE F13

1-DIMENSIONAL CONSOLIDATION ANALYSIS

Highway 11 NBL: Three Mile Lake Road
North Abutment

Soil Stratigraphy

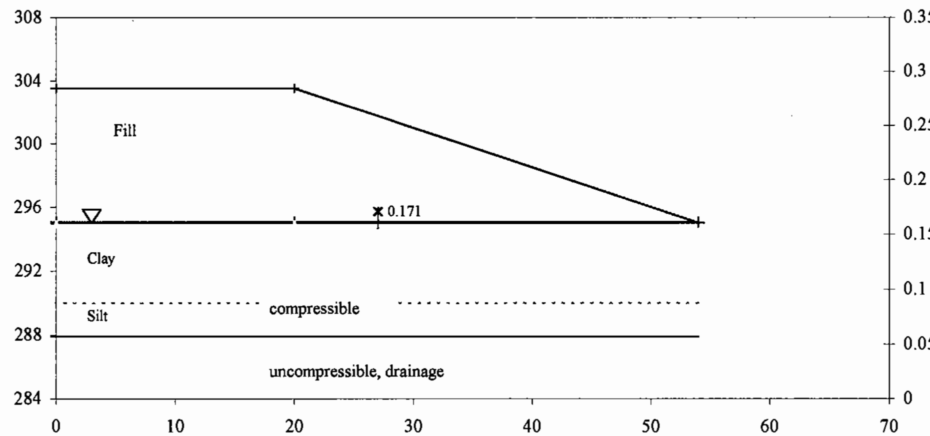
Elevation of Ground Surface	295 m
Top of Compressible Soil	294.7 m
Bottom of Compressible soil	287.9 m
Groundwater Elev	294.9 m

Load Data

Top of Fill	303.5 m
Strip Load Width	74 m
Settlement Location from centerline	27 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	0.06	16
Silt	19.8	0.75	0.18	0.05	160



OUTPUT

Ultimate Settlement 0.171 m

Time Rate of Settlement

time (yr)	S (m)
0.2	0.160
0.4	0.169
0.6	0.170
0.8	0.170

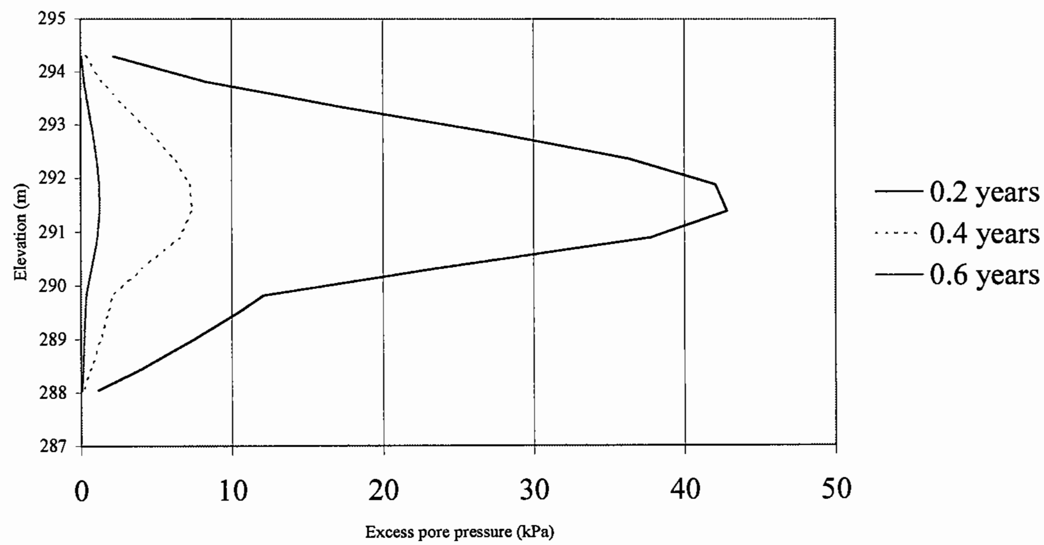


FIGURE F 14

Appendix G

Drawings

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

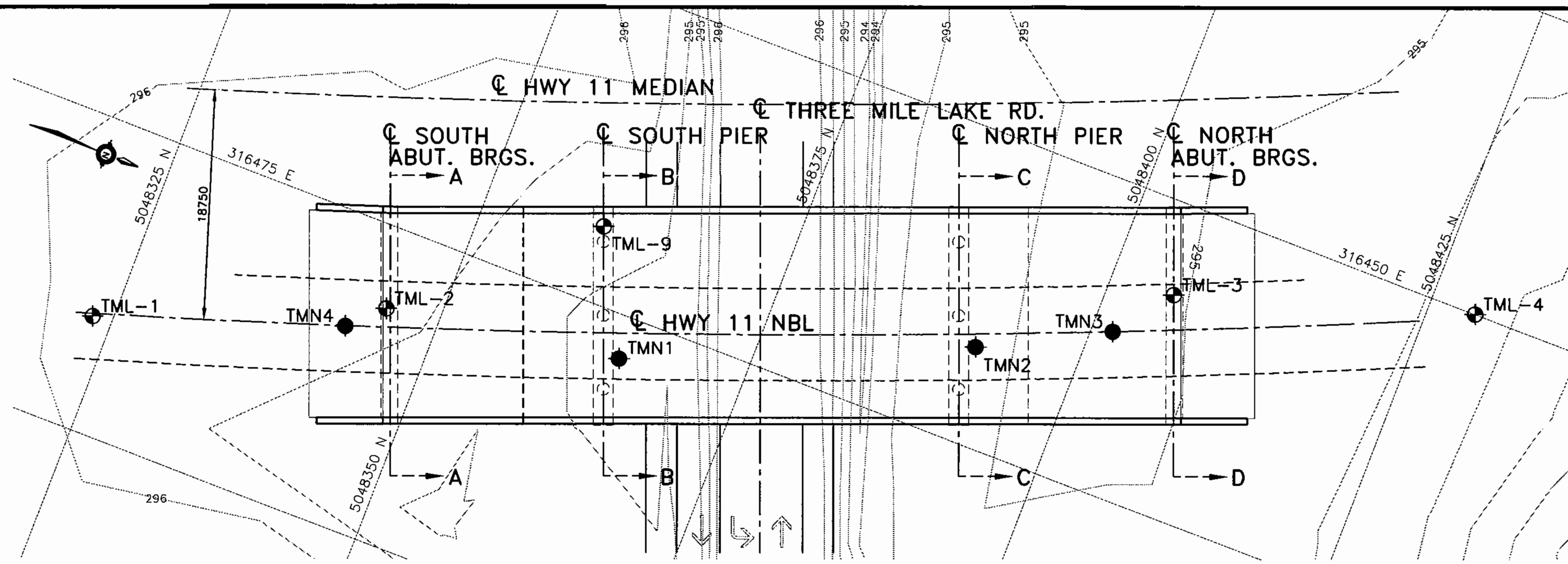
HWY 11
CONT No
WP No 475-93-01

THREE MILE LAKE ROAD OVERPASS NBL
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

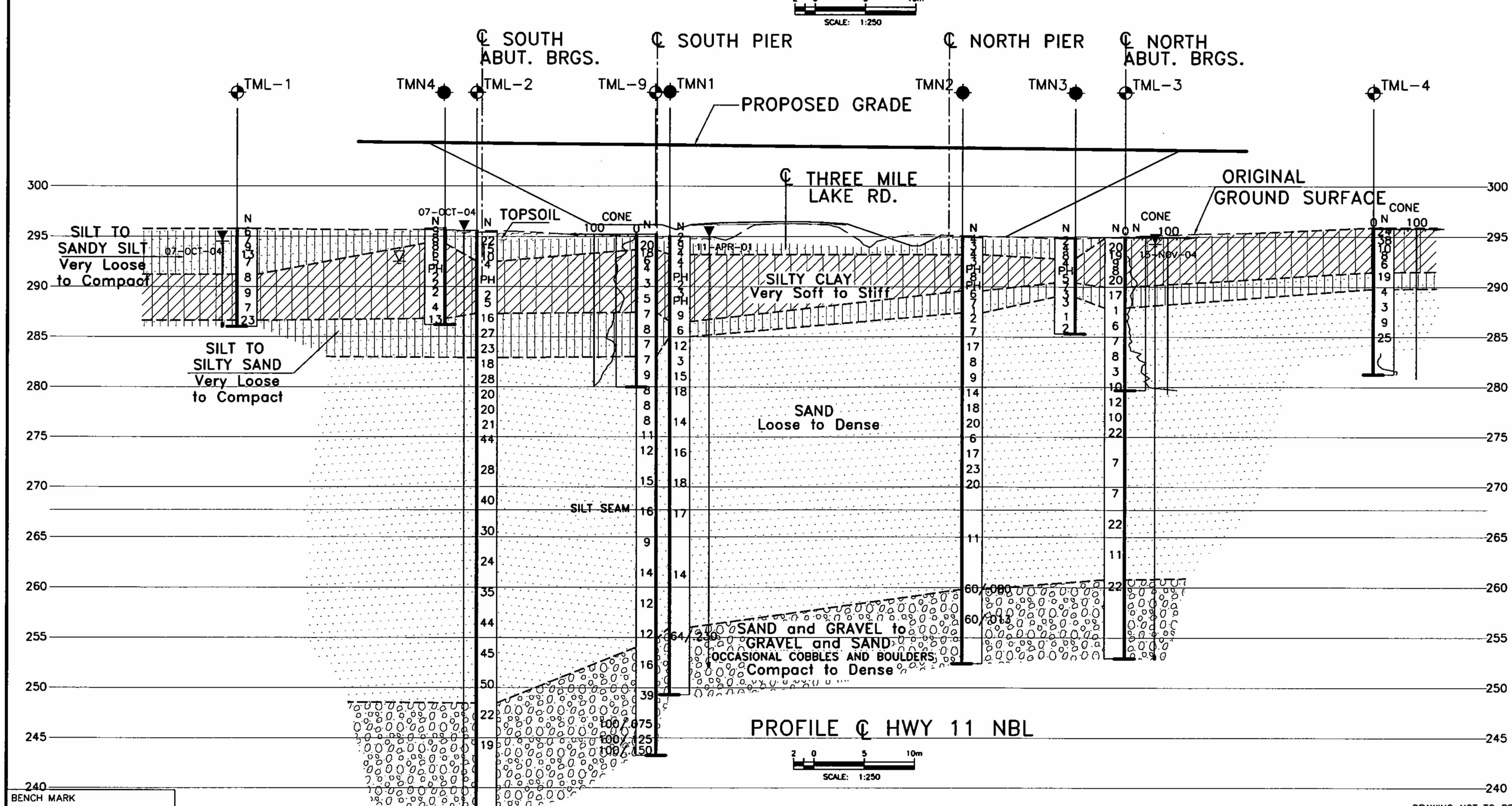
Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS

THURBER ENGINEERING LTD.



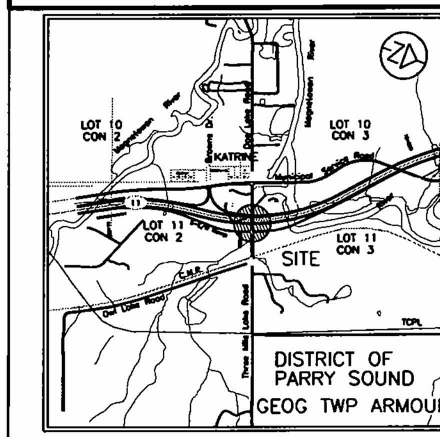
PLAN

SCALE: 1:250



PROFILE ℄ HWY 11 NBL

SCALE: 1:250



KEY PLAN

LEGEND

	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 Water
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING
TML-1	295.8	5048323.4	316490.7
TML-2	295.4	5048345.6	316481.5
TML-3	294.9	5048405.2	316457.3
TML-4	295.9	5048428.8	316450.0
TML-9	295.2*	5048359.9*	316468.8*
TMN1	295.0	5048364.9	316478.4
TMN2	294.9	5048391.7	316467.1
TMN3	294.9	5048401.7	316461.9
TMN4	295.8	5048343.0	316484.0

— NOTE —

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

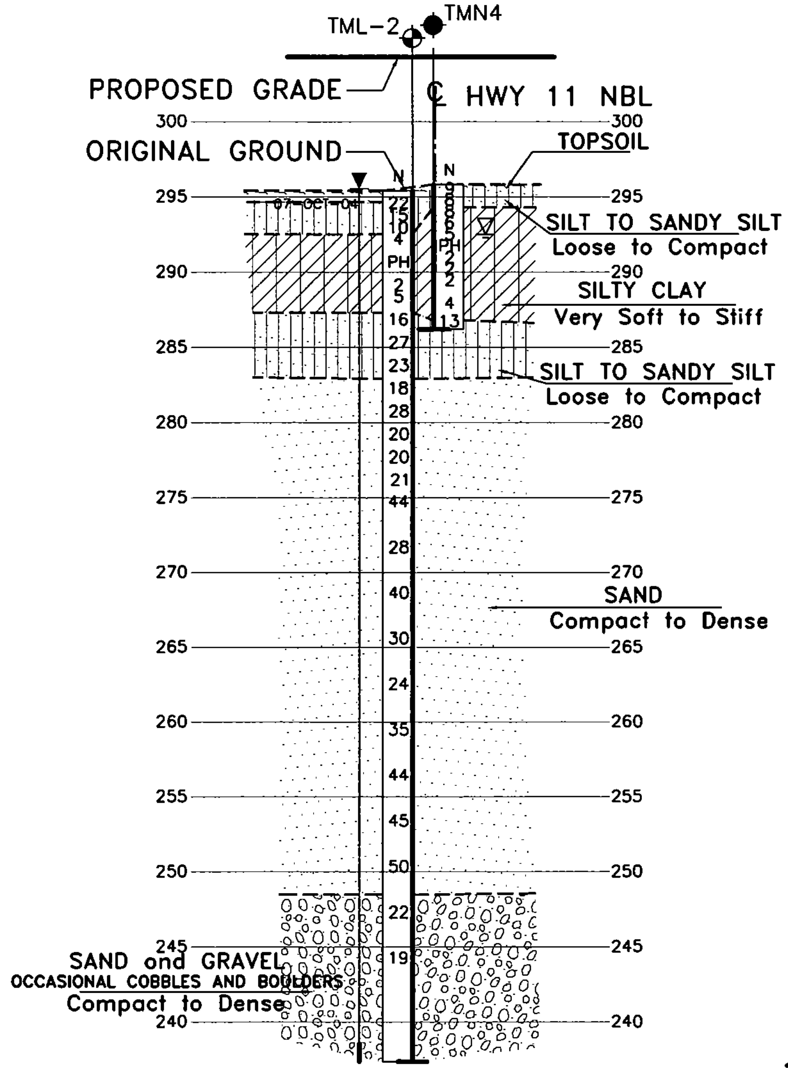
* Bore hole locations are approximate

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

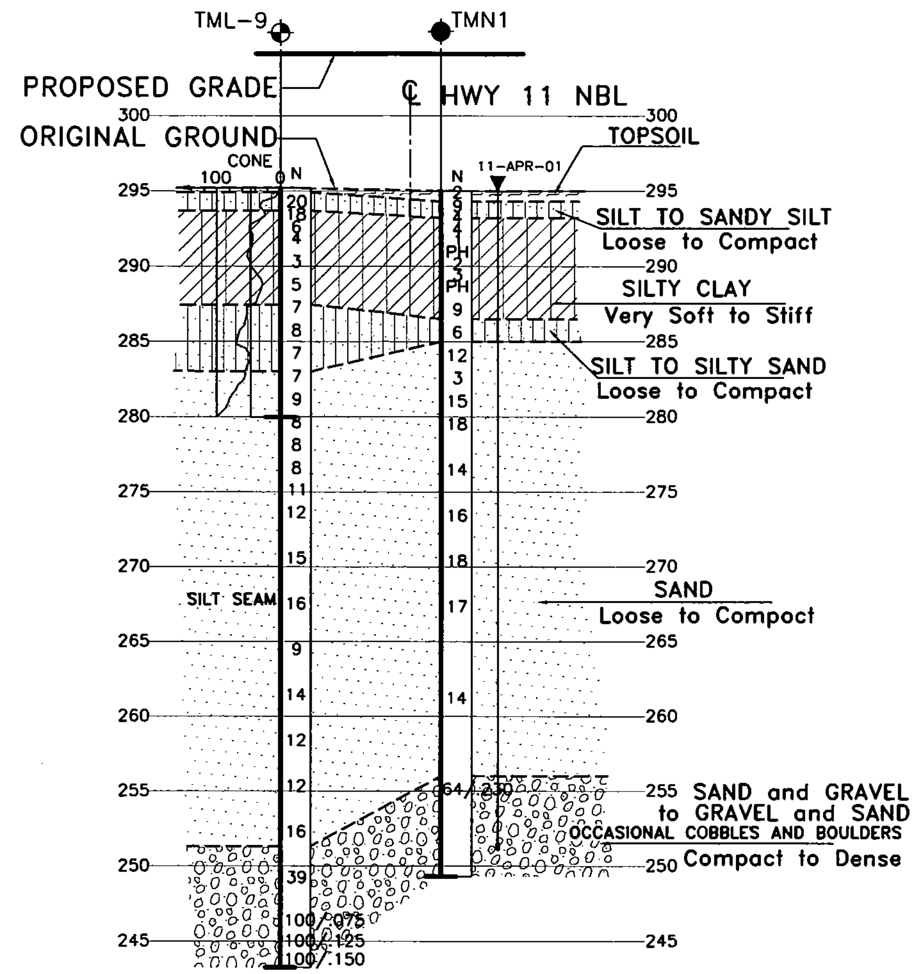
REVISIONS	DATE	BY	DESCRIPTION

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



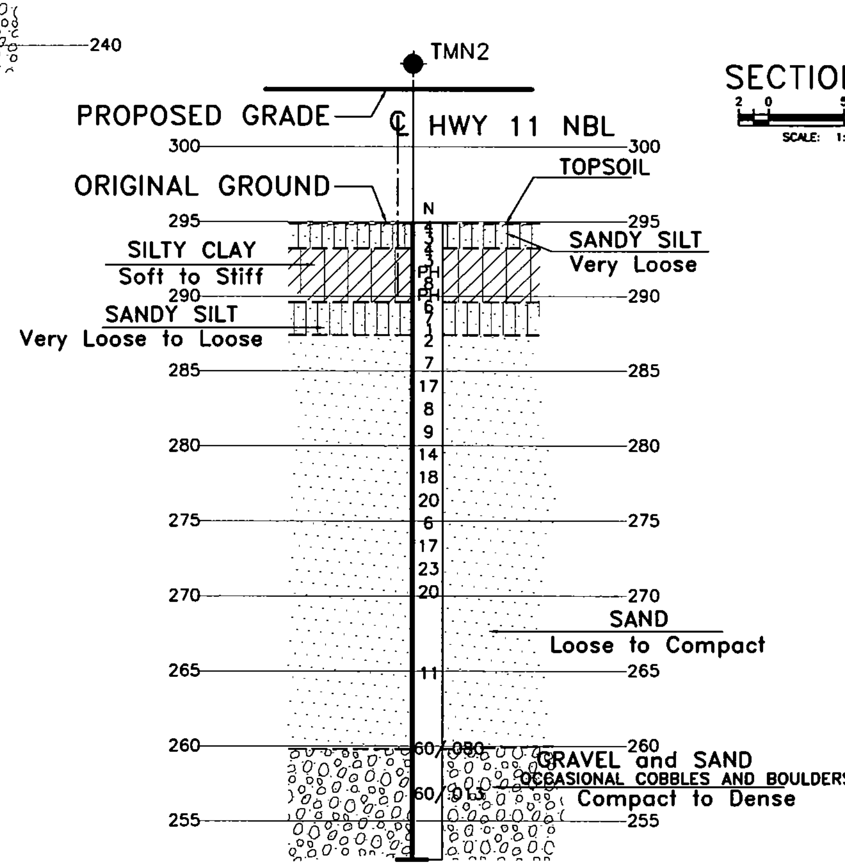
SECTION A–A

SCALE: 1:250



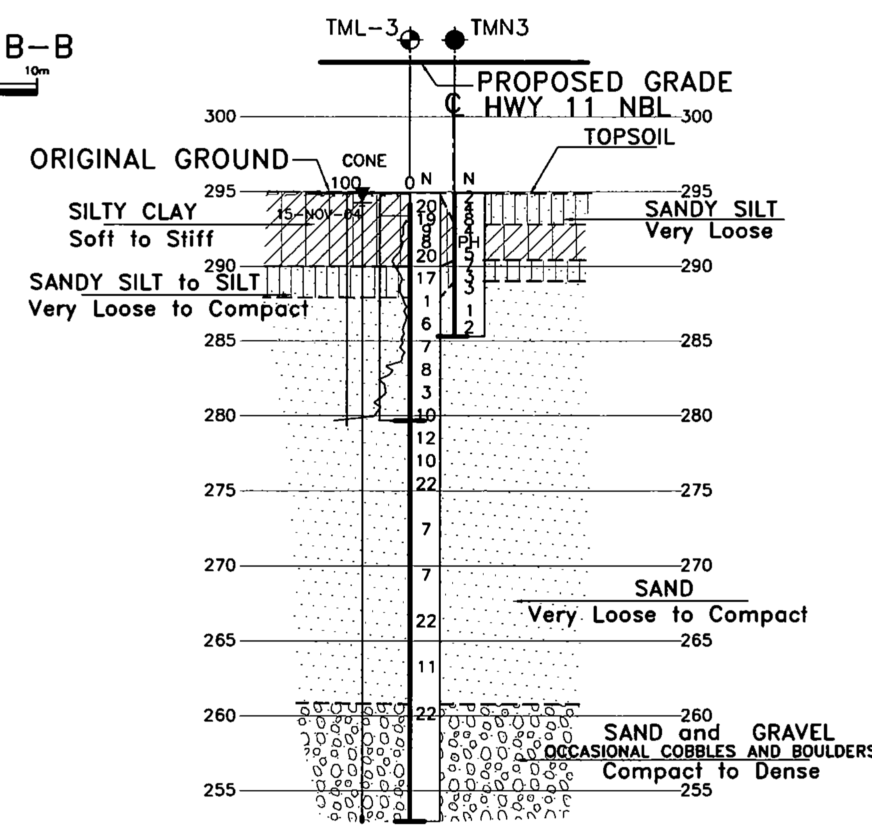
SECTION B–B

SCALE: 1:250



SECTION C–C

SCALE: 1:250



SECTION D–D

SCALE: 1:250

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY 11
CONT No
WP No 475–93–01

THREE MILE LAKE ROAD OVERPASS NBL

SOIL STRATA

SHEET

Marshall Macklin Monaghan

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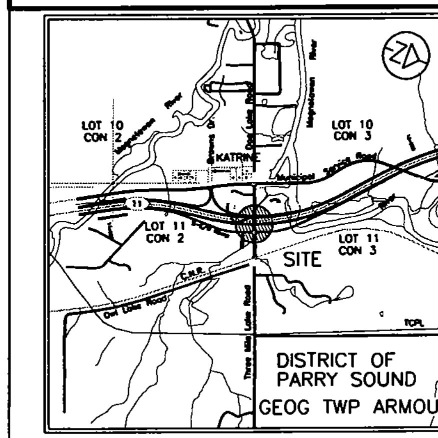
THURBER ENGINEERING LTD.

THURBER



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