

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH MAST LIGHTS
HIGHWAY 17/417 TWINNING
FROM LANARK ROAD 29 TO DIVISION STREET
G.W.P. 647-92-01**

Geocres Number: 31F-155

Report to

McCormick Rankin Corporation

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual information obtained from a foundation investigation conducted for the proposed installation of High Mast Light (HML) poles along Highway 17/417 between Lanark Road 29 and Division Street near Arnprior, Ontario. The HML poles will be installed as part of the proposed twinning of the highway.

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, and a written description of the subsurface conditions.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation (MRC), under the Ministry of Transportation Ontario (MTO) Agreement Number 4005-A-000349.

2 SITE DESCRIPTION

The subject section of Highway 417 lies primarily within the Township of McNab, with the eastern limit extending into the Town of Arnprior. At present, Highway 17/417 is a two lane undivided highway with gravel shoulder and side ditches. The proposed HML poles will be located within approximately 1.0 km to the east and northwest of the proposed Highway 417/White Lake Road interchange.

The site is located within the physiographic region known as the Ottawa Valley Clay Plains, which consists of a glacio-lacustrine clay plain interrupted by east-west trending scarps and ridges of rock. The bedrock primarily consists of crystalline limestone of the Ordovician Period to the south and east of Arnprior, and limestone interbedded with metamorphosed greywacke to the west of Arnprior.

The topography is typically flat with drainage courses following areas of slight depression. Surrounding lands are typically agricultural and grassland with occasional houses, commercial buildings and farm buildings present along the highway.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out site investigation and field testing for this project during the period January 5 to 24, 2006. The investigation consisted of 20 boreholes, numbered P1 to P20, drilled to total depths of 4.2 to 12.7 m. In general, the boreholes were drilled to auger refusal at depths of 1.1 to 9.5 m then cored an additional 3.0 to 3.5 m (4.2 m at one location) into rock. Six boreholes were terminated upon auger refusal at depths of 9.3 to 12.3 m. The locations of the boreholes are shown on the Borehole Locations Drawing in Appendix C.

The boreholes locations were staked in the field and the corresponding coordinates and ground surface elevations were determined by J.D. Barnes Limited. The coordinates and elevations of the boreholes are given on the Borehole Locations Drawing and on the individual Record of Borehole Sheets in Appendix A.

A track-mounted drillrig equipped with hollow stem augers was used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). In situ vane shear testing was carried out using the MTO 'N' vane to assess the undrained shear strength of firm cohesive deposits. Rock core samples were recovered using NQ rock coring equipment.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The inspector logged the soil and groundwater conditions encountered in the boreholes, and collected, labelled and transported the samples to Thurber's laboratory. The rock core samples were described in the field, packaged in a core box, and returned to our laboratory. The groundwater conditions in the boreholes were observed during drilling.

Upon completion of drilling, the boreholes were backfilled with bentonite grout to the ground surface in accordance with the Ontario Water Resources Act (O.Reg. 128/03).

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 Limits testing. The results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B.

The recovered rock core samples were subjected to Point Load Testing to assess the compressive strength of the bedrock. The results are included on the borehole logs.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A and to the Borehole Locations Drawing in Appendix C. An overall description of the stratigraphy based on the conditions encountered in the boreholes is given in the following paragraphs. However, the factual data presented in the borehole logs takes precedence over this general description and govern

interpretation of the site conditions. Soil conditions may vary between and beyond the borehole locations.

The soil stratigraphy encountered in the boreholes consists of a surficial topsoil layer underlain by silty clay that mantles bedrock. A fill layer was encountered at one location, and a till layer was encountered between the clay and bedrock at five locations.

More detailed descriptions of the individual strata are presented below.

5.1 Topsoil

A topsoil layer was encountered at all borehole locations. In general, the topsoil thickness ranged from 100 to 250 mm. In borehole P3, a 75 mm thick layer of topsoil was encountered over sand fill. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Sand Fill

A 0.7 m thick layer of sand fill was encountered below the topsoil in borehole P3. An SPT N-value of 34 was obtained in the fill, indicating a dense condition.

5.3 Silty Clay

The predominant soil deposit comprises cohesive silty clay that was encountered in all boreholes. The clay deposit extends to depths of 1.1 to 12.3 m (elevation 92.3 to 104.8 m) and is underlain by till or bedrock.

SPT N-values obtained in the clay generally follow a consistent profile in the boreholes, ranging from about 3 to 10 blows/0.3 m in the initial sample driven at the ground surface, from 7 to 20 blows/0.3 m to depths of approximately 2 to 3 m, and decreasing from 5 to 1 blow/0.3 m below this depth. The shear strength of the clay measured by in situ vane testing generally follows this pattern, with values ranging from 92 to 32 kPa. Based on the vane results, the consistency of the clay varies from stiff to firm.

The results of grain size distribution analyses conducted on the silty clay are presented on Figures B1 to B4, Appendix B. The percentage of clay size particles ranged from 26 to 59%. The results of Atterberg Limits tests conducted on the clay, presented on Figures B5 to B8, indicate a medium (marginal low in one sample) to high plasticity. Moisture contents in the clay typically ranged from 30 to 60%.

5.4 Clayey Silt, Silty Clay and Silty Sand Till

A relatively thin layer of till was encountered between the predominant silty clay and the underlying bedrock at five locations (boreholes P1, P6, P7, P15 and P17). The till consisted of silty clay in borehole P7, silty sand in borehole P15, and clayey silt in the remaining boreholes. The consistency of the till varied from soft to very stiff (compact in borehole P15) based on limited sample recovery. Moisture contents ranged from 10 to 15%.

The till layer ranged in thickness from 0.2 to 1.9 m with a lower boundary ranging from elevation 94.4 to 102.7 m. Although not encountered in the boreholes, till soils often contain cobbles and boulders.

5.5 Bedrock

In 14 boreholes, soil sampling was terminated on bedrock at depths of 1.1 to 9.5 m then cored an additional 3.0 to 3.5 m (4.2 m at one location) into rock. Six boreholes were terminated upon auger refusal on probable bedrock at depths of 9.3 to 12.3 m. The depth and elevation of the bedrock encountered at the borehole locations are summarized in Table 5.1.

Table 5.1 – Depth to Bedrock

Borehole No.	Bedrock		Basis*
	Depth (m)	Elevation	
P1	5.5	102.7	Cored
P2	6.1	101.5	Cored
P3	11.0	96.9	Auger Refusal
P4	9.5	96.4	Cored
P5	10.2	96.9	Auger Refusal
P6	6.4	100.1	Cored
P7	9.5	97.3	Auger Refusal
P8	7.3	99.2	Cored
P9	3.4	102.6	Cored
P10	9.3	97.8	Auger Refusal
P11	2.6	104.8	Cored
P12	3.1	104.2	Cored
P13	7.0	99.7	Cored
P14	6.2	100.8	Cored
P15	4.9	102.3	Cored
P16	3.4	103.2	Cored
P17	11.4	94.4	Auger Refusal
P18	12.3	92.3	Auger Refusal
P19	1.1	102.1	Cored
P20	2.9	101.7	Cored

* Bedrock was proven by coring where indicated. Otherwise, bedrock was inferred on the basis of auger refusal; the potential exists that refusal was encountered on cobbles or boulders.

Examination of the recovered core indicates that the bedrock consists of crystalline limestone described as fresh to slightly weathered, very thinly to thinly bedded, and whitish grey with black banding. The rock recovered from borehole P20 was described as very weathered.

Core recovery was typically 100%, locally 80 to 90% in borehole P20. Measured RQD values typically ranged from 78 to 100%, indicating a good to excellent quality rock. Cores of fair quality material (RQD of 50 to 72%) were recovered in boreholes P9, P12 and P14, and poor to fair quality rock (RQD of 42 to 58%) was recovered in all cores from borehole P20.

The unconfined compressive strength of the rock cores, assessed from the results of Point Load testing, typically ranged from 81 to 127 MPa, indicating strong to very strong rock. Strength values of 64 and 190 MPa were obtained on single core samples from boreholes P14 and P11, respectively. Very strong to extremely strong rock with measured compressive strengths of 239 to 266 MPa was obtained from borehole P1, and compressive strengths of 9 to 40 MPa (weak to medium strong) were determined for the weathered rock from borehole P20.

5.6 Groundwater

Water was not observed in the boreholes during drilling. Water is introduced into the boreholes for the rock coring operations, and therefore groundwater levels were not measured during this stage of the fieldwork.

During previous investigations, water levels were measured at typical depths of 0.3 to 3.2 m (elevation 105.1 to 106.1 m) in piezometers installed near White Lake Road, and 0.6 to 3.0 m (elevation 103.0 to 104.2 m) in piezometers installed near Baskin Drive.

Seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

J.D. Barnes Limited provided field layout of the boreholes for the site investigation.

George Downing Estate Drilling Ltd. supplied and operated the drilling and sampling equipment. Full time supervision of the field activities, including obtaining utility clearances, was carried out by Mr. Stephane Loranger of Thurber.

Supervision of the field program was provided by Mr. Sidney Pang, P.Eng. Interpretation of the field data, and preparation of the report was performed by Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for design and construction of foundations for the proposed HML poles.

At the time of the field investigation, the project design called for installation of 20 HML poles. A borehole was drilled at or near the location of each proposed HML pole. We understand that some of the pole locations have been revised or deleted since completion of the fieldwork. As per MTO procedures, the structure locations are not shown on the borehole location plans in Appendix C.

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.

7.1 Foundation Design Parameters

Design of the HML pole foundations should be carried out following the procedures and guidelines provided in the following documents:

- Guidelines for the Design of High Mast Pole Foundations, 3rd Edition, Ministry of Transportation, Bridge Office, February 2003.
- Canadian Highway Bridge Design Code and Commentary (2000), CAN/CSA-S6-00 and S6.1-00.

Conventional pole foundation design comprising a single augered caisson (drilled shaft) is considered appropriate for this project. Recommended geotechnical parameters for the design of the caisson foundation at each proposed light location are presented in Table 7.1 following the text of this report.

The geotechnical parameters presented in Table 7.1 are defined as follows:

For cohesive soil:

$$\begin{aligned} q_u &= \text{unconfined compressive strength (kPa)} \\ &= 2 \times \text{undrained shear strength, } c_u \end{aligned}$$

For cohesionless soil:

ϕ = angle of internal friction of soil (degrees)

n_h = coefficient of horizontal subgrade reaction (MN/m³)

γ = unit weight of soil (kN/m³)
below water table, use submerged unit weight: $\gamma' = \gamma - 9.8$ kN/m³

For bedrock:

f_{vert} = vertical bearing resistance of rock (kPa)

f_{horiz} = lateral bearing resistance of rock (kPa)

The recommended design groundwater levels, inferred from water level observations, soil colouring, and the moisture content profile, are also provided on Table 7.1.

Where the caissons will be extended through a significant thickness of fill placed during construction of road embankments, geotechnical parameters for the fill should be employed for the length of caisson within the fill. The following parameters are recommended for caisson design in compacted engineered fill comprising indigenous silty clay and OPS Granular A or B Type II material:

Table 7.2 – Geotechnical Parameters for Embankment Fill

Material Type	ϕ (deg.)	n_h (MN/m ³)	γ (kN/m ³)	q_u (kPa)
Silty Clay Fill	-	-	19	100
Granular A or B Type II	35	10	22.8	-

The passive earth pressure coefficient, K_p , for cohesionless soils and a horizontal ground surface may be calculated using the following equation:

$$K_p = \frac{1 + \sin\phi}{1 - \sin\phi}$$

A sloping ground surface or berm slope in front of the caisson will reduce the lateral passive resistance to be considered in design. For a sloping ground surface:

$$K_p = \left[\frac{\cos\phi}{1 - \sqrt{\sin\phi (\sin\phi - \cos\phi \tan\beta)}} \right]^2$$

where β = slope inclination from horizontal (degrees)

The lateral resistance and sidewall adhesion within the upper 1.9 m of soil below final grade should be neglected in the foundation design to account for frost effects and potential surficial disturbance.

For foundations in cohesive soil and socketed into rock, a minimum socket length of half the caisson diameter should be employed as outlined in the Guidelines for Design of High

Mast Pole Foundations. For a caisson embedded in rock, the minimum length of caisson embedment should be 2.5 m. The depth of weathered rock may be considered to be negligible for the conditions at this site and the parameters provided in Table 7.1.

For caissons anchored to rock, a factored anchor bond stress of 1,200 kPa at ULS is recommended for design, based on the compressive strength and typically good to excellent quality of the rock encountered in the rock cores. A lower bond stress of 500 kPa at ULS is recommended for the poor to fair quality rock encountered locally in borehole P20. A minimum anchor bond length of 2 m (3 m at borehole P20) is recommended.

Load factors and geotechnical resistance factors should be applied for caisson design as per the CHBDC (2000). The caisson design should be sufficient to withstand all lateral loads including wind loads, and to counteract frost jacking forces.

7.2 Construction Concerns

Caisson construction will be carried out primarily within stiff to firm silty clay and into bedrock at many locations. At some locations (boreholes P1, P6, P7, P15 and P17), the lower part of the caisson may encounter glacial till potentially containing cobbles and boulders. Conditions may vary at locations away from the boreholes.

The consistency of the clay decreases from stiff to firm below a typical depth of 2.5 m, and the potential exists for squeeze of the caisson sidewalls in the firm cohesive soil. Temporary caisson liners should be available on site if sidewall squeeze is experienced in the caisson shaft during augering.

The clay contains occasional seams of potentially water-bearing fine sand, and seepage should be anticipated from these seams. The possibility also exists that water-bearing zones will be encountered above or in the underlying bedrock. In general, it is expected that dewatering of the caisson excavations using sump pumps should be suitable.

If excessive inflow is experienced from voids/fractures in the bedrock or from an overlying sand layer, such that dewatering by pumping alone is not practical, other means of groundwater control (such as installation of a temporary liner to reduce the flow) should be provided and/or the concrete should be placed by tremie.

The caisson rig should be equipped to dislodge and remove cobbles and boulders if encountered in the till soils.

Construction of the HML pole foundations should be carried out in accordance with OPSS 631 and SSP 631S02.

Point load testing indicates that the bedrock is typically strong to very strong and slightly weathered to fresh. At one location (borehole P1), the bedrock is very strong to extremely strong, and at another borehole (borehole P20), the bedrock is very weathered and weak to medium strength. Rock coring equipment that can excavate all strengths and quality of rock at the site will be required where the caisson is socketed into rock.

7.3 Construction Inspection

Caisson construction should be monitored by qualified geotechnical personnel to verify that the soil conditions encountered during construction are consistent with the design assumptions in this report.

It should be confirmed that the base of the caisson is cleaned of loose and soft materials prior to pouring of concrete. The concrete should be poured in the dry.

Inspection and documentation if the pole foundation installations should be carried out in accordance with OPSS 631 and SSP 631S02.

8 CLOSURE

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

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Table 7.1 – High Mast Light Foundation Design Parameters

Borehole and HML Pole Number	Subsurface Stratigraphy			Foundation Design Parameters						
	Material	Depth (m)	Elevation	ϕ (deg.)	n_h (MN/m ³)	γ or γ' (kN/m ³)	q_u (kPa)	f_{vert} (kPa)	f_{horiz} (kPa)	Depth to Groundwater (m)
P1	Silty clay, stiff	1.9 – 2.5	106.3 – 105.7	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 5.5	105.7 – 102.7	-	-	8	90	-	-	
	Rock, very to extremely strong	5.5 – 8.8	102.7 – 99.4	-	-	25	-	5,000	1,500	
P2	Silty clay, stiff	1.9 – 2.5	105.8 – 105.2	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 6.1	105.2 – 101.5	-	-	8	90	-	-	
	Rock, very strong	6.1 – 9.3	101.5 – 98.3	-	-	25	-	5,000	1,500	
P3	Silty clay, stiff	1.9 – 2.5	106.0 – 105.4	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 11.0	105.4 – 96.9	-	-	8	90	-	-	
P4	Silty clay, firm	1.9 – 2.5	104.0 – 103.4	-	-	19	100	-	-	2.5
	Silty clay, firm	2.5 – 9.5	103.4 – 96.4	-	-	8	75	-	-	
	Rock, very strong	9.5 – 12.7	96.4 – 93.2	-	-	25	-	5,000	1,500	
P5	Silty clay, stiff	1.9 – 3.0	105.2 – 104.1	-	-	19	125	-	-	3.0
	Silty clay, firm	3.0 – 10.2	104.1 – 96.9	-	-	8	75	-	-	
P6	Silty clay, stiff	1.9 – 2.5	104.6 – 104.0	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 6.4	104.0 – 100.1	-	-	8	75	-	-	
	Rock, strong to very strong	6.4 – 9.8	100.1 – 96.8	-	-	25	-	5,000	1,500	
P7	Silty clay, stiff	1.9 – 2.5	104.9 – 104.3	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 8.3	104.3 – 98.5	-	-	8	75	-	-	
	Silty clay till, very stiff	8.3 – 9.5	98.5 – 97.3	-	-	9	100	-	-	
P8	Silty clay, stiff	1.9 – 2.5	104.6 – 104.0	-	-	19	125	-	-	2.5
	Silty clay, firm	2.5 – 7.3	104.0 – 99.2	-	-	8	75	-	-	
	Rock, strong to very strong	7.3 – 10.4	99.2 – 96.2	-	-	25	-	5,000	1,500	
P9	Silty clay, stiff to firm	1.9 – 3.4	104.0 – 102.6	-	-	19	100	-	-	3.4
	Rock, very strong	3.4 – 6.5	102.6 – 99.4	-	-	25	-	5,000	1,500	
P10	Silty clay, stiff to firm	1.9 – 3.0	105.1 – 104.5	-	-	18	100	-	-	3.0
	Silty clay, firm	3.0 – 9.3	104.5 – 97.8	-	-	8	75	-	-	

- Notes:
1. Ignore resistance in upper 1.9 m due to frost effects.
 2. For clay, unconfined compressive strength (q_u) = 2 * shear strength (c_u).
 3. For rock, f_{vert} = vertical bearing resistance at ULS
 f_{horiz} = horizontal bearing resistance at ULS

Table 7.1 – High Mast Light Foundation Design Parameters

Borehole and HML Pole Number	Subsurface Stratigraphy			Foundation Design Parameters						
	Material	Depth (m)	Elevation	ϕ (deg.)	n_h (MN/m ³)	γ or γ' (kN/m ³)	q_u (kPa)	f_{vert} (kPa)	f_{horiz} (kPa)	Depth to Groundwater (m)
P11	Silty clay, stiff to firm Rock, very strong	1.9 – 2.6 2.6 – 5.6	105.5 – 104.8 104.8 – 101.8	- -	- -	18 25	100 -	- 5,000	- 1,500	2.6
P12	Silty clay, stiff Rock, strong to very strong	1.9 – 3.1 3.1 – 6.3	105.3 – 104.2 104.2 – 101.0	- -	- -	19 25	125 -	- 5,000	- 1,500	3.1
P13	Silty clay, stiff Silty clay, firm Rock, very strong	1.9 – 2.5 2.5 – 7.0 7.0 – 10.2	104.8 – 104.2 104.2 – 99.7 99.7 – 96.5	- - -	- - -	19 8 25	125 75 -	- - 5,000	- - 1,500	2.5
P14	Silty clay, stiff Silty clay, firm Rock, strong	1.9 – 2.5 2.5 – 6.2 6.2 – 9.5	105.1 – 104.5 104.5 – 100.8 100.8 – 97.5	- - -	- - -	19 8 25	125 75 -	- - 5,000	- - 1,500	2.5
P15	Silty clay, stiff Silty sand till, compact Rock, strong to very strong	1.9 – 4.4 4.4 – 4.9 4.9 – 8.0	105.3 – 102.8 102.8 – 102.3 102.3 – 99.2	- 30 -	- 2.0 -	19 10 25	125 - -	- - 5,000	- - 1,500	4.4
P16	Silty clay, stiff Rock, very strong	1.9 – 3.4 3.4 – 6.5	104.7 – 103.2 103.2 – 100.0	- -	- -	19 25	125 -	- 5,000	- 1,500	3.4
P17	Silty clay, stiff Silty clay, firm Clayey silt till, stiff	1.9 – 4.0 4.0 – 9.5 9.5 – 11.4	103.9 – 101.8 101.8 – 96.3 96.3 – 94.4	- - -	- - -	19 8 9	125 90 100	- - -	- - -	4.0
P18	Silty clay, stiff Silty clay, firm	1.9 – 2.5 2.5 – 12.3	102.7 – 102.1 102.1 – 92.3	- -	- -	19 8	125 90	- -	- -	2.5
P19	Rock, very strong	1.1 – 4.2	102.1 – 99.0	-	-	25	-	5,000	1,500	1.1
P20	Silty clay, stiff Rock, weak to medium strong	1.9 – 2.9 2.9 – 7.1	102.7 – 101.7 101.7 – 97.4	- -	- -	19 25	125 -	- 2,000	- 500	2.9

- Notes:
1. Ignore resistance in upper 1.9 m due to frost effects.
 2. For clay, unconfined compressive strength (q_u) = 2 * shear strength (c_u).
 3. For rock, f_{vert} = vertical bearing resistance at ULS
 f_{horiz} = horizontal bearing resistance at ULS

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


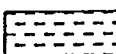



 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa) (psi)	Field Estimation of Hardness*	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.

TERMS		Weak	Very Weak	Extremely Weak (Rock)
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	5.0 to 25.0	1.0 to 5.0	0.25 to 1.0
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	750 to 3,500	150 to 750	35 to 150
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.			
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen			
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.			



RECORD OF BOREHOLE No P1

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 711.25 E 314 186.90 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 12.01.06 - 12.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	W _P W W _L					
108.2							○ UNCONFINED + FIELD VANE							
0.0	TOPSOIL (175mm)						● QUICK TRIAXIAL × LAB VANE							
0.2	Silty CLAY, trace rootlets, occasional sand seams Stiff to Firm Brown		1	SS	8									
			2	SS	9									
	Becoming Grey													
			3	SS	2									

ONTMT4S 5182-PHASE II.GPJ 27/03/06

RECORD OF BOREHOLE No P2

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 618.65 E 314 270.97 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 12.01.06 - 12.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
107.7														
0.0	TOPSOIL (200mm)													
0.2	Silty CLAY, occasional sand lenses Stiff to Firm Brown		1	SS	7									
							107							
			2	SS	11		106							0 1 49 50
							105							
			3	SS	2		104							
	Becoming Grey													
							103							
			4	SS	1									
							102							
101.5			5	SS	50									
6.1	END OF SOIL SAMPLING AT 6.12 m. CORING STARTED AT 6.12 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding		1	RUN	.025		101							RUN 1# TCR=100%, SCR=100%, RQD=93%, UCS=108.9MPa
			2	RUN			100							RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=117.5MPa
			3	RUN			99							RUN 3# TCR=100%, SCR=100%, RQD=100%, UCS=103.7MPa
98.3														
9.3	END OF BOREHOLE AT 9.35 m. BOREHOLE GROUTED TO SURFACE.													

ONTMT4S 5182-PHASE II.GPJ 27/03/06

RECORD OF BOREHOLE No P3

1 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 535.47 E 314 346.19 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 12.01.06 - 12.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
107.9 0.0 0.1	TOPSOIL (75 mm) SAND, some gravel, trace silt Brown Moist (FILL)		1	SS	34									
107.2 0.8	Silty CLAY, occasional sand seams Very Stiff Brown		2	SS	17		107							
			3	SS	7		106							
	Becoming Stiff to Firm, Grey		4	SS	3		105							
			5	SS	1		104							
			6	SS	1		103							
			7	SS	1		102							
							101							
							100							
							99							
							98							

Continued Next Page

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

RECORD OF BOREHOLE No P3

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 535.47 E 314 346.19 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 12.01.06 - 12.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								<div><div></div><div>20406080100</div></div> <div>○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE</div>									<div><div></div><div>204060</div></div> <div>W_P W W_L</div>		
96.9		<div></div>					97												
11.0	END OF BOREHOLE AT 10.98 m. AUGER REFUSAL AT 10.98 m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE GROUTED TO SURFACE.																		

METRICContinued Next Page

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P4

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 457.29 E 314 417.63 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 12.01.06 - 12.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W P W W L				
								20 40 60 80 100					20 40 60				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%)					
							20 40 60 80 100					20 40 60					
93.2	BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding Subvertical joints between 11.89 and 11.99 m, between 12.60 and 12.67 m		2	RUN		95										RQD=96%, UCS=114.1MPa RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=103.7MPa	
			3	RUN		94											RUN 3# TCR=100%, SCR=100%, RQD=100%, UCS=112.3MPa
12.7	END OF BOREHOLE AT 12.73 m. BOREHOLE GROUTED TO SURFACE.																

RECORD OF BOREHOLE No P5

1 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 382.21 E 314 498.06 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 11.01.06 - 11.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
107.1														
0.0	TOPSOIL (200mm)						107							
0.2	Silty CLAY, occasional sand seams Stiff to Very Stiff Brown		1	SS	7									
							106							
			2	SS	16									0 0 41 59
							105							
	Becoming Grey, Stiff to Firm						104							
			3	SS	6									
							103			4.3				
							102							
			4	SS	2									
							101							
			5	SS	1									
							100			4.4				
							99							0 6 63 32
			6	SS	1									
							98							
										4.9				
			7	SS	3									

Continued Next Page

+³, x³: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P5

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 382.21 E 314 498.06 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 11.01.06 - 11.01.06 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100	W _P	W	W _L		
96.9						97										
10.2	END OF BOREHOLE AT 10.16 m. AUGER REFUSAL AT 10.16 m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE GROUTED TO SURFACE.															

ONTMT4S 5182-PHASE II.GPJ 08/02/06

RECORD OF BOREHOLE No P6

1 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 321.25 E 314 579.26 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 11.01.06 - 11.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)						
106.5							20 40 60 80 100				20 40 60				GR SA SI CL
0.0	TOPSOIL (150 mm)														
0.2	Silty CLAY, occasional sand lenses Stiff to Firm Brown			1	SS	9									
							106								
							105								
			2	SS	12		104								
							103								
	Becoming Grey		3	SS	4		102								
							101								
			4	SS	1		100								
100.3							99								
6.2	Clayey SILT, trace sand, trace gravel			5	SS	50/									
100.1	Soft Grey (TILL)					.025									
6.4	END OF SOIL SAMPLING AT 6.43 m. CORING STARTED AT 6.65 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding			1	RUN										
							98								
			2	RUN			97								
							96								
			3	RUN			95								
96.8							94								
9.8	END OF BOREHOLE AT 9.75 m.						93								

ONTMT4S 5182-PHASE II.GPJ 27/03/06

Continued Next Page

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

RECORD OF BOREHOLE No P6

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 321.25 E 314 579.26 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 11.01.06 - 11.01.06 CHECKED BY SP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W _P	W		
	BOREHOLE GROUTED TO SURFACE.															

RECORD OF BOREHOLE No P7

1 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 246.71 E 314 559.07 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 20.01.06 - 20.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
106.8														
0.0	TOPSOIL (150 mm)													
0.2	Silty CLAY, trace rootlets Stiff to Firm Brown		1	SS	8									
			2	SS	9									0 0 44 55
			3	SS	4									
	Becoming Grey		4	SS	2									
			5	SS	1									
			6	SS	2									0 2 72 26
98.5														
8.3	Silty CLAY, some sand, some gravel, occasional cobbles Very Stiff Grey (TILL)													
97.3			7	SS	54/									
9.5	END OF BOREHOLE AT 9.47 m. AUGER REFUSAL AT 9.47 m ON PROBABLE BEDROCK OR				175									

Continued Next Page

+³ ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

ONTMT4S 5182-PHASE II.GPJ 27/03/06

RECORD OF BOREHOLE No P7

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 246.71 E 314 559.07 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 20.01.06 - 20.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	BOULDER. BOREHOLE GROUTED TO SURFACE.																

ONTM14S 5182-PHASE II.GPJ 08/02/06

+ ³ , x ³ : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

[illegible]

+ 3, × 3: Numbers refer to Sensitivity

RECORD OF BOREHOLE No P8

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 266.61 E 314 670.90 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 11.01.06 - 11.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	W _P	W	W _L			
96.2																1	
10.4	END OF BOREHOLE AT 10.37 m. BOREHOLE GROUTED TO SURFACE.						96										

METRIC


[illegible]

RECORD OF BOREHOLE No P10

1 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 167.58 E 314 605.59 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 20.01.06 - 20.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE				
107.0							20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L			
0.0	TOPSOIL (125 mm)		1	SS	6				○				
0.1	Silty CLAY, trace rootlets Stiff to Firm Brown												
			2	SS	8					○			
			3	SS	4					—○			0 1 64 35
	Becoming Grey		4	SS	2						○		

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Continued Next Page

+³, x³: Numbers refer to
Sensitivity

20
15 0.5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No P10

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 167.58 E 314 605.59 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 20.01.06 - 20.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	SURFACE.																

RECORD OF BOREHOLE No P11

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 289.69 E 314 901.56 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 10.01.06 - 10.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID 		
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RECORD OF BOREHOLE No P12

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 238.03 E 314 981.66 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 10.01.06 - 10.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								○ UNCONFINED + FIELD VANE				
								● QUICK TRIAXIAL × LAB VANE				
107.2												
0.0	TOPSOIL (150mm)											
0.2	Silty CLAY, trace sand Stiff Brown		1	SS	9		107					
							106					
			2	SS	10							
							105					
104.2			3	SS	50/ .025		104					
3.1	END OF SOIL SAMPLING AT 3.07 m. CORING STARTED AT 3.07 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding Subvertical joint between 3.33 and 3.99 m		1	RUN			103					
			2	RUN			102					
			3	RUN								
101.0							101					
6.3	END OF BOREHOLE AT 6.27 m. BOREHOLE GROUTED TO SURFACE.											

ONTMT4S 5182-PHASE II.GPJ 23/03/06

METRIC

SOIL PROFILE				SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		NATURAL MOISTURE CONTENT	LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI C
ELEV. DEPTH	DESCRIPTION	STRAT. LOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	PLASTIC LIMIT W _p	W	LIQUID LIMIT W _L		
106.7 0.0 0.1	TOPSOIL (100 mm) Silty CLAY, trace sand seams Stiff to Firm Brown		1	SS	23		○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
	Becoming Grey		2	SS	13								
	trace gravel		3	SS	4								
			4	SS	1								
			5	SS	1								
99.7 7.0	END OF SOIL SAMPLING AT 7.01 m. CORING STARTED AT 7.01 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding		1	RUN								Ft	RUN 1# TCR=100%, SCR=100%, RQD=100%, UCS=100.4MPa
	Subvertical joint at 9.15 m		2	RUN									RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=123.6MPa

(%) STRAIN AT FAILURE

ON TM 4S 5182-PHASE II.GPJ 23/03/06

METRIC

[illegible]

RECORD OF BOREHOLE No P14

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 097.14 E 314 843.89 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 23.01.06 - 23.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
107.0												
0.0	TOPSOIL (200 mm)						107					
0.2	Silty CLAY, occasional sand seams Stiff to Firm Brown		1	SS	6							
							106					
			2	SS	11							
	some sand seams						105					0 4 55 41
							104					
			3	SS	4							
							103					
	Becoming Grey		4	SS	2		102					
							101	4.0 +				
100.8	some gravel		5	SS	50/							
6.2	END OF SOIL SAMPLING AT 6.17 m. CORING STARTED AT 6.17 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding Subvertical joint at 6.73m, 6.78m and 7.13m		1	RUN	.075		100					RUN 1# TCR=100%, SCR=100%, RQD=97%, UCS=96.4MPa
							99					RUN 2# TCR=100%, SCR=100%, RQD=65%, UCS=63.5MPa
	Subvertical joint between 8.41 and 8.53m		2	RUN								
							98					RUN 3# TCR=100%, SCR=100%, RQD=50%, UCS=98.5MPa
	Subvertical joint between 9.09 and 9.12m, 9.27 and 9.32 m		3	RUN								
97.5												
9.5	END OF BOREHOLE AT 9.47 m. BOREHOLE GROUTED TO SURFACE.											

ONTMT4S 5182-PHASE II.GPJ 23/03/06

RECORD OF BOREHOLE No P15

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 158.90 E 315 033.97 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 06.01.06 - 06.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
107.2														
0.0	TOPSOIL (200mm)													
0.2	Silty CLAY Stiff Brown		1	SS	8		107							
							106							
			2	SS	11		105							
							104							
			3	SS	11		103							
102.8							102							
4.4	Silty SAND, trace clay, trace gravel Compact Grey Wet (TILL)		4	SS	55/ 175		101							
102.3							100							
4.9	END OF SOIL SAMPLING AT 4.90 m. CORING STARTED AT 4.90 m. CRYSTALLINE LIMESTONE BEDROCK, Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding Subvertical joints at 5.66 and 5.84 m		1	RUN										
			2	RUN										
			3	RUN										
99.2														
8.0	END OF BOREHOLE AT 7.98 m. BOREHOLE GROUTED TO SURFACE.													

ONTMT4S 5182-PHASE II.GPJ 30/03/06

RECORD OF BOREHOLE No P16

1 OF 1

METRIC

W.P. 647-92-00 LOCATION N 5 031 155.27 E 315 167.91 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY WM
 DATUM Geodetic DATE 05.01.06 - 05.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)						
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL				× LAB VANE					
106.6							20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	GR	SA	SI	CL	
0.0	TOPSOIL (200mm)																		
0.2	Silty CLAY, trace rootlets, occasional sand seams Stiff Brown		1	SS	8								○						
			2	SS	13								○						
103.2			3	SS	50/ -050								○						
3.4	END OF SOIL SAMPLING AT 3.40 m. CORING STARTED AT 3.40 m. CRYSTALLINE LIMESTONE BEDROCK. Fresh to slightly weathered, very thinly to thinly bedded, whitish grey with black banding		1	RUN															
			2	RUN															
			3	RUN															
100.0																			
6.5	END OF BOREHOLE AT 6.53 m. BOREHOLE GROUTED TO SURFACE.																		

ONTMT4S 5182-PHASE II.GPJ 23/03/06

RECORD OF BOREHOLE No P17

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 159.40 E 315 299.65 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 05.01.06 - 05.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _P W W _L	20 40 60					
94.4	(TILL)						95										
11.4	END OF BOREHOLE AT 11.35 m. AUGER REFUSAL AT 11.35 m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE GROUTED TO SURFACE.																

RECORD OF BOREHOLE No P18

2 OF 2

METRIC

W.P. 647-92-00 LOCATION N 5 031 163.57 E 315 431.85 ORIGINATED BY SLL
 HWY 17 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
 DATUM Geodetic DATE 05.01.06 - 05.01.06 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
92.3														
12.3	END OF BOREHOLE AT 12.32 m. AUGER REFUSAL AT 12.32 m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE GROUTED TO SURFACE.													

METRIC

W.P.	647-92-00	LOCATION	N 5 031 166.24 E 315 567.11	ORIGINATED BY	SLL
HWY	17	BOREHOLE TYPE	Hollow Stem Augers/NQ Coring	COMPILED BY	WM
DATUM	Geodetic	DATE	24.01.06 - 24.01.06	CHECKED BY	SP

[illegible]

METRIC

[illegible]

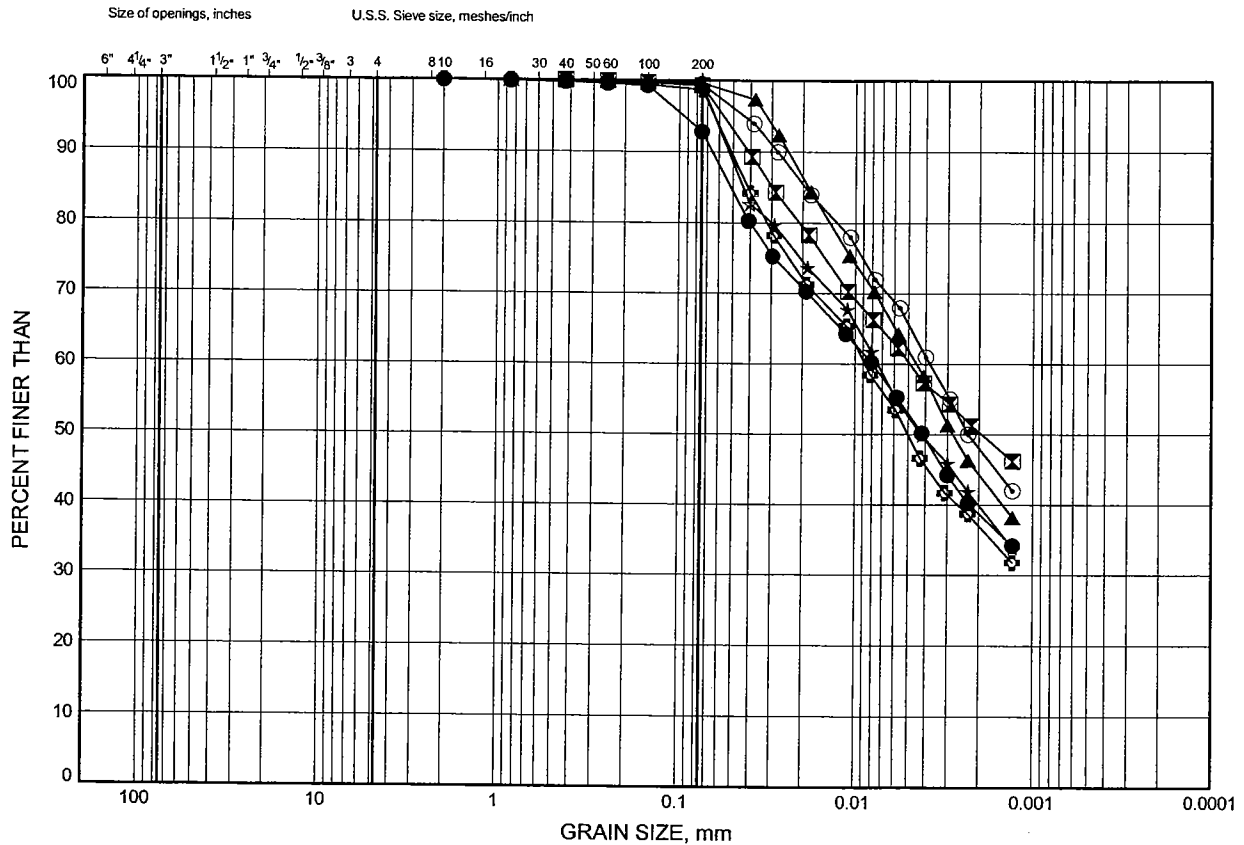
Appendix B

Laboratory Test Results

HWY 17-417 GRAIN SIZE DISTRIBUTION

FIGURE B1

SILTY CLAY

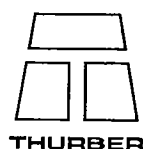


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P1	3.35	104.87
⊠	P2	1.83	105.84
▲	P3	3.35	104.56
★	P3	6.40	101.51
⊙	P4	3.35	102.55
⊕	P4	7.92	97.97

Date March 2006

Project 647-92-00



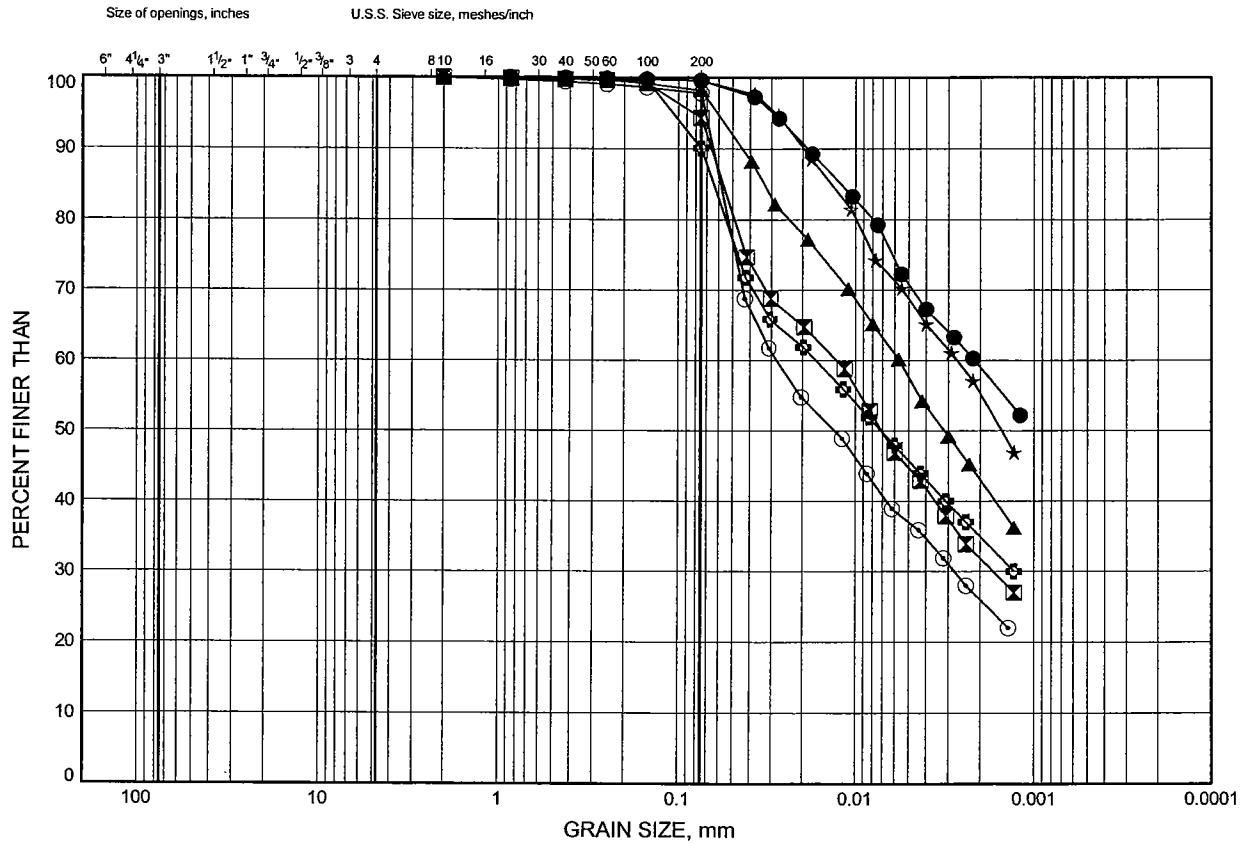
Prep'd JHL

Chkd. MRA

HWY 17-417 GRAIN SIZE DISTRIBUTION

FIGURE B2

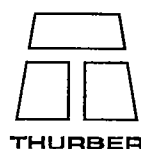
SILTY CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P5	1.83	105.26
⊠	P5	7.92	99.16
▲	P6	3.35	103.18
★	P7	1.83	104.98
⊙	P7	7.92	98.88
⊗	P8	4.88	101.64

Date March 2006
Project 647-92-00

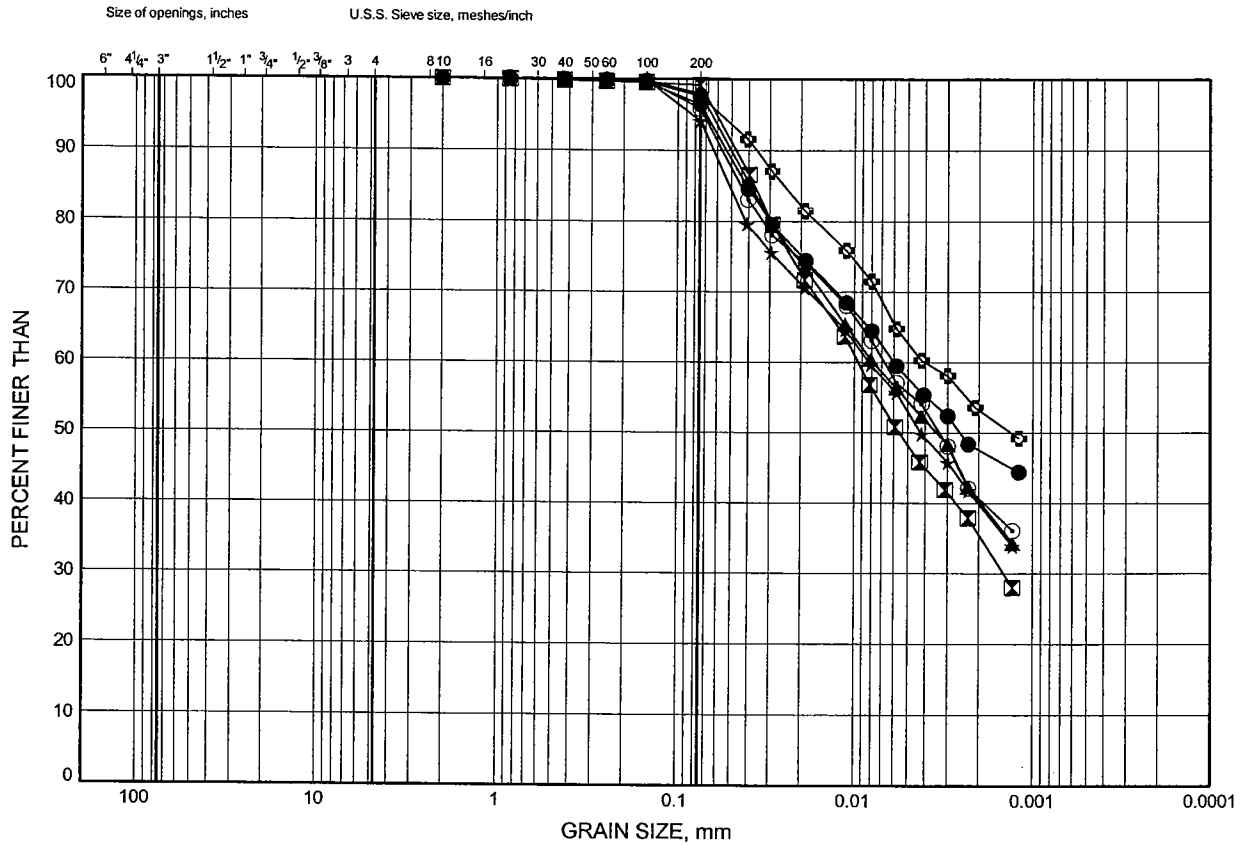


Prep'd JHL
Chkd. MRA

HWY 17-417 GRAIN SIZE DISTRIBUTION

FIGURE B3

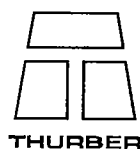
SILTY CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P9	1.83	104.10
⊠	P10	3.35	103.69
▲	P10	6.40	100.64
★	P13	3.35	103.35
⊙	P14	1.83	105.17
⊕	P15	3.35	103.83

Date March 2006
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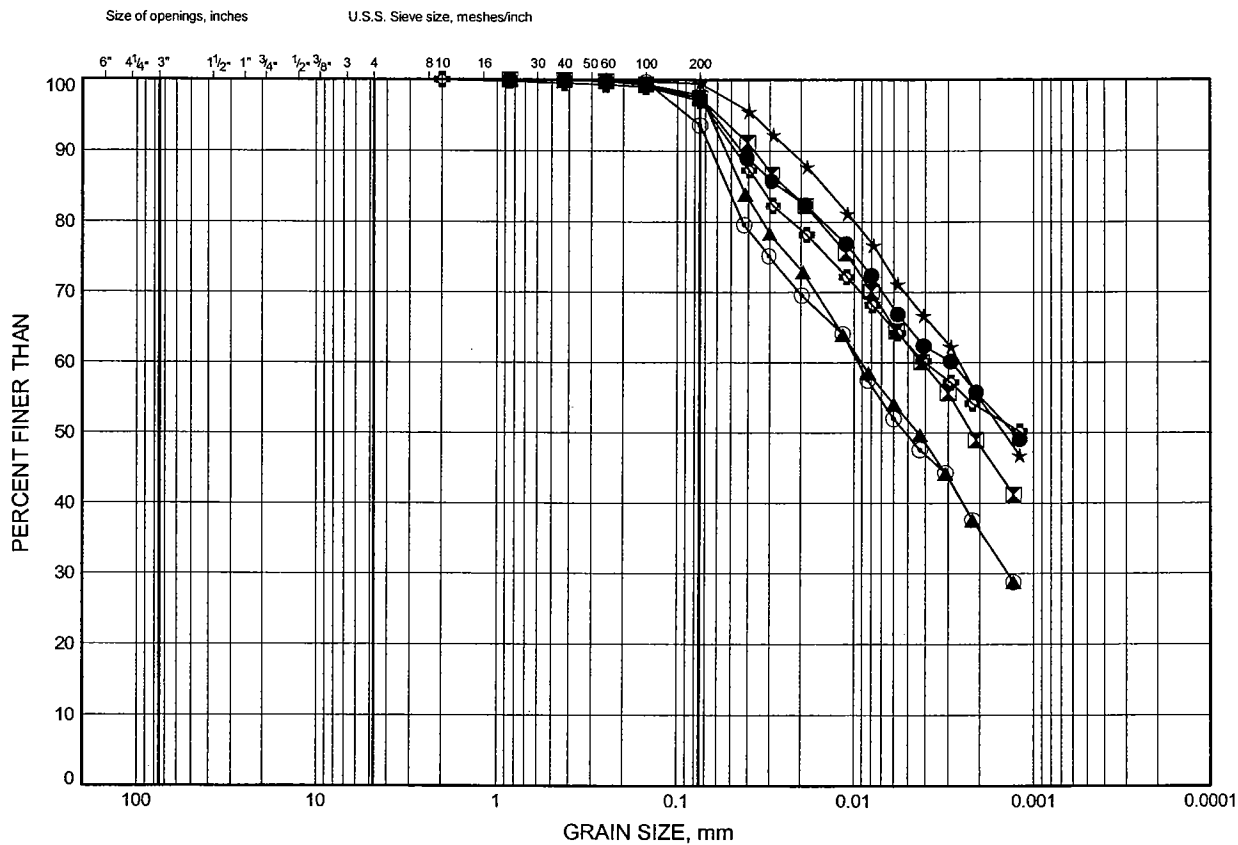
Prep'd JHL
Chkd. MRA

HWY 17-417

GRAIN SIZE DISTRIBUTION

FIGURE B4

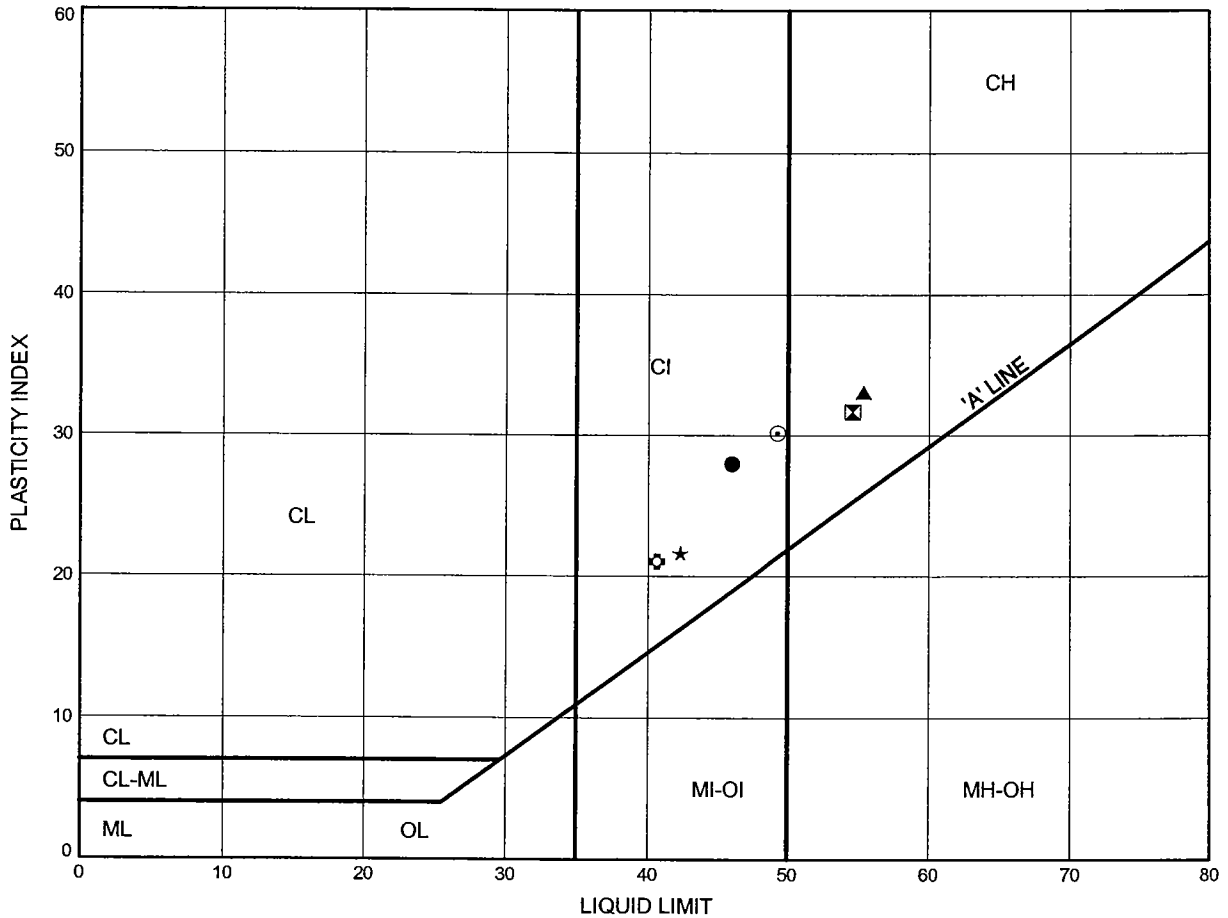
SILTY CLAY



HWY 17-417
ATTERBERG LIMITS TEST RESULTS

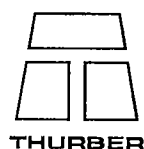
FIGURE B5

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P1	3.35	104.87
⊠	P2	1.83	105.84
▲	P3	3.35	104.56
★	P3	6.40	101.51
⊙	P4	3.35	102.55
⊗	P4	7.92	97.97

Date March 2006
 Project 647-92-00

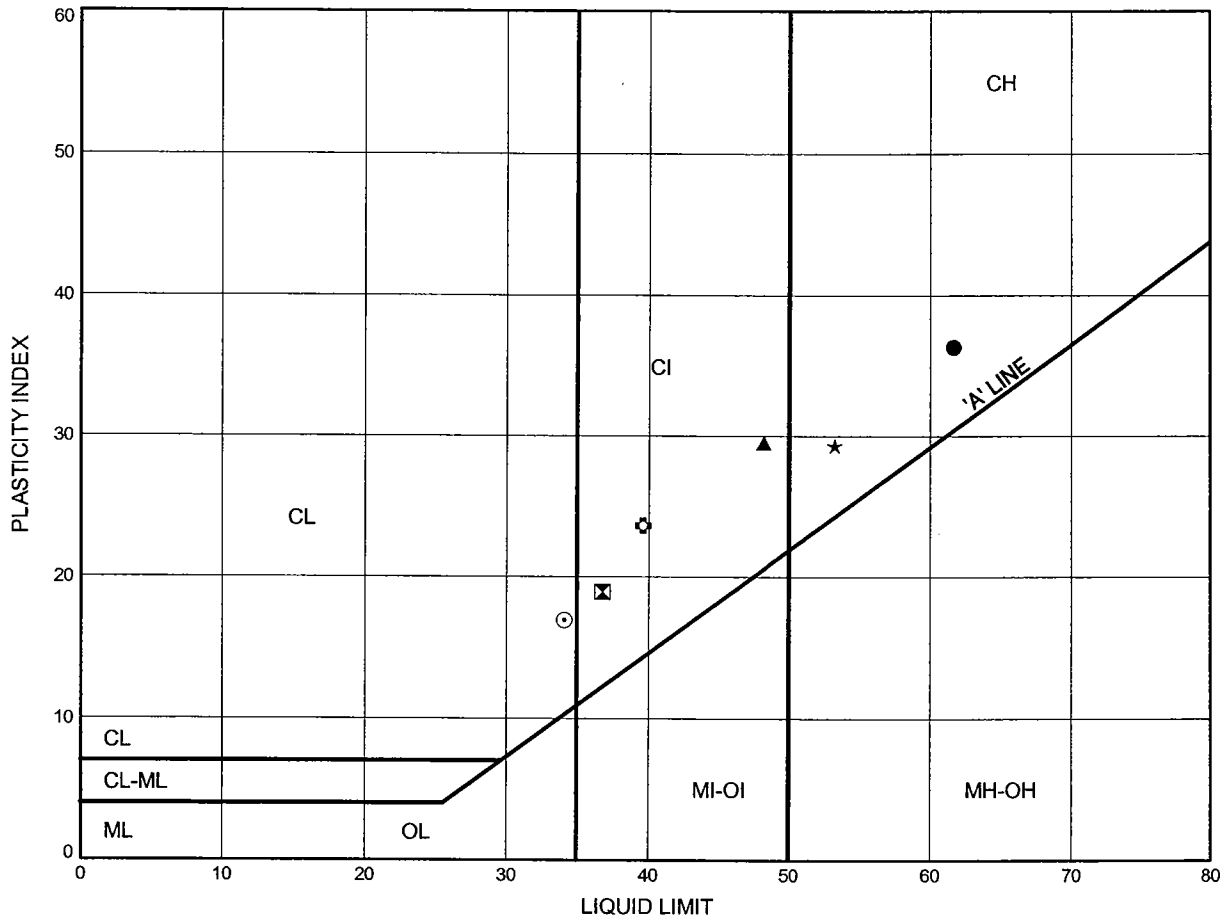


Prep'd JHL
 Chkd. MRA

HWY 17-417 ATTERBERG LIMITS TEST RESULTS

FIGURE B6

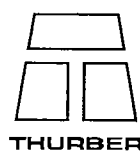
SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P5	1.83	105.26
⊠	P5	7.92	99.16
▲	P6	3.35	103.18
★	P7	1.83	104.98
⊙	P7	7.92	98.88
⊕	P8	4.88	101.64

Date March 2006

Project 647-92-00



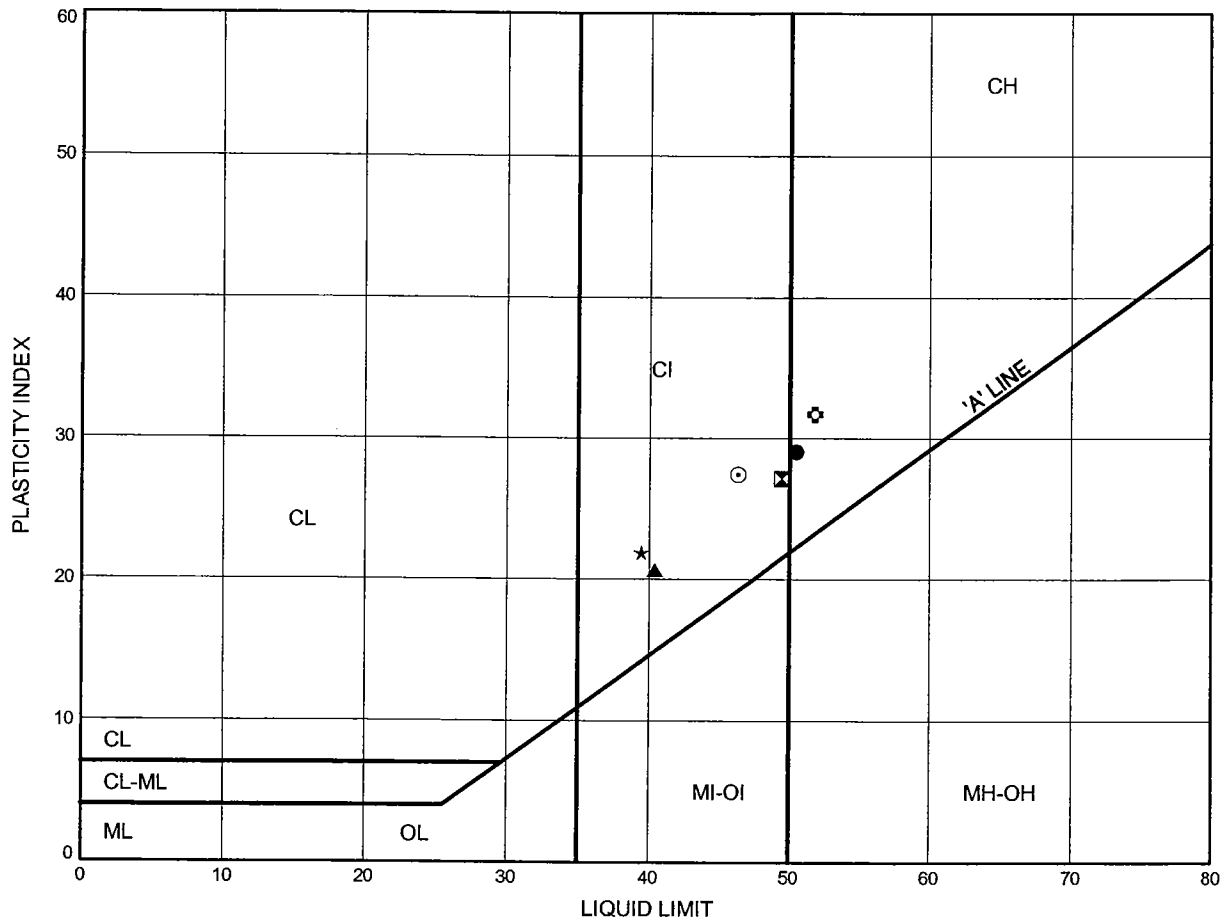
Prep'd JHL

Chkd. MRA

HWY 17-417 ATTERBERG LIMITS TEST RESULTS

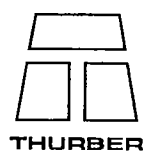
FIGURE B7

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P9	1.83	104.10
⊠	P10	3.35	103.69
▲	P10	6.40	100.64
★	P13	3.35	103.35
⊙	P14	4.88	102.12
⊕	P15	3.35	103.83

Date March 2006
 Project 647-92-00

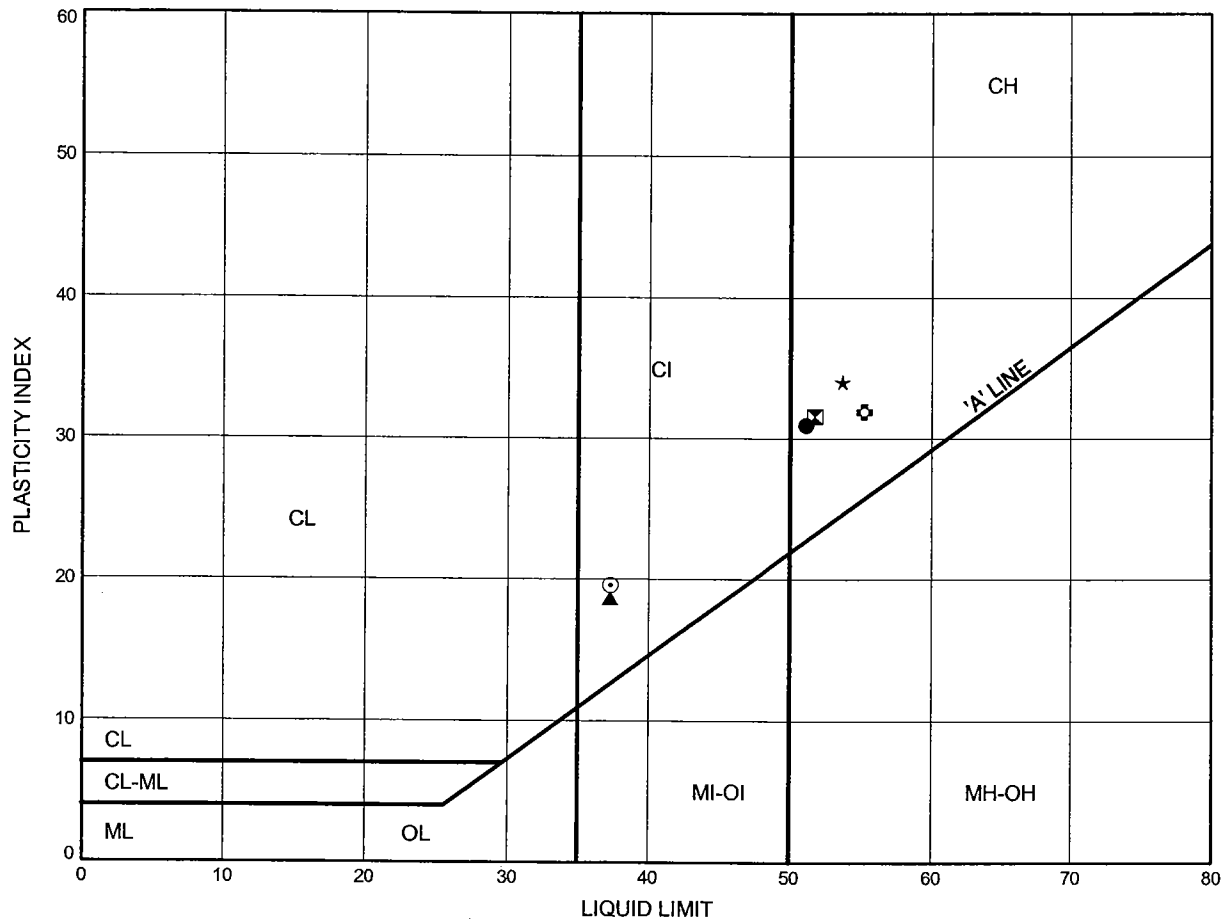


Prep'd JHL
 Chkd. MRA

HWY 17-417
ATTERBERG LIMITS TEST RESULTS

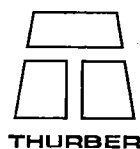
FIGURE B8

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	P16	1.83	104.75
⊠	P17	4.88	100.92
▲	P17	7.92	97.87
★	P18	3.35	101.22
⊙	P18	7.92	96.65
⊕	P20	1.83	102.75

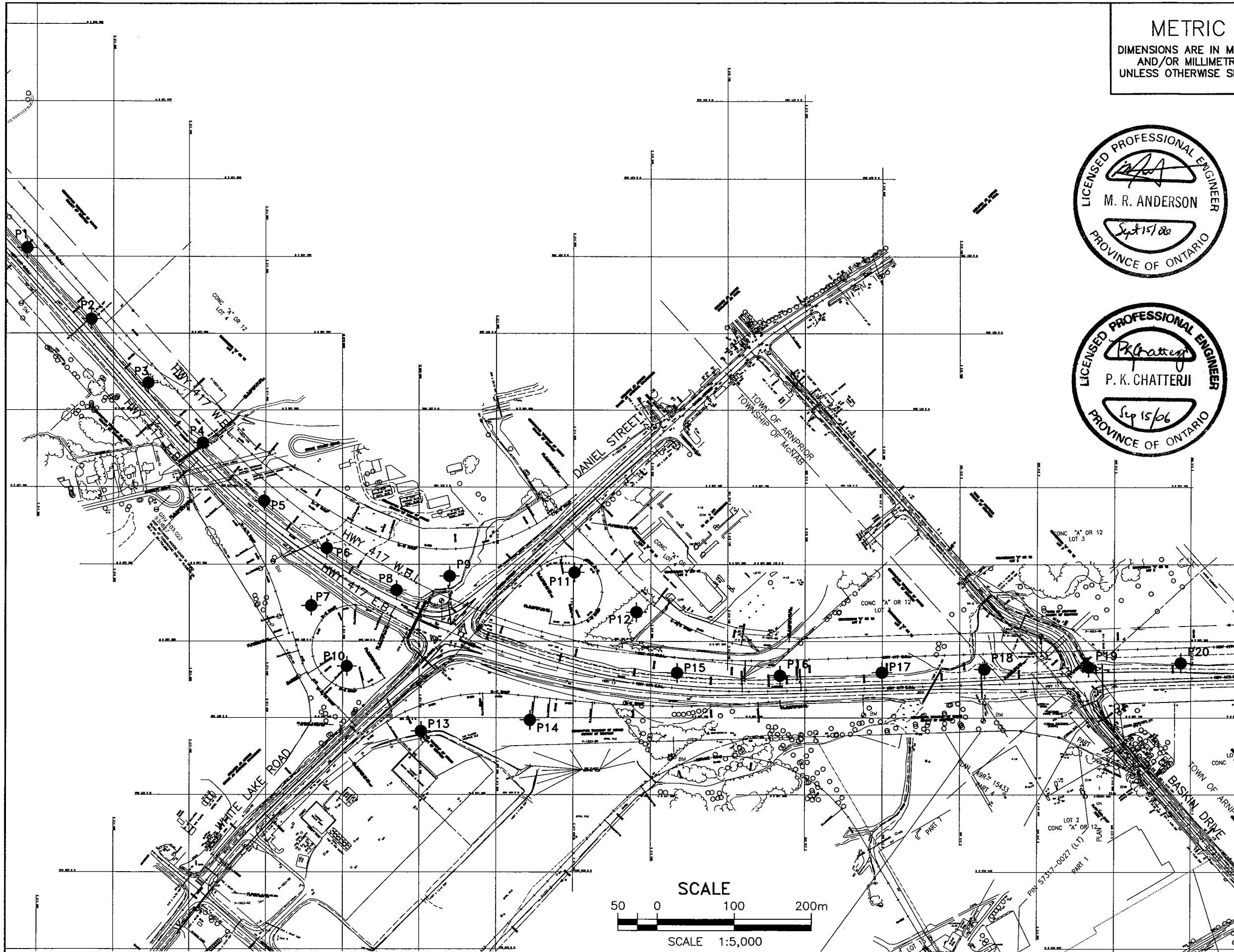
Date March 2006
 Project 647-92-00



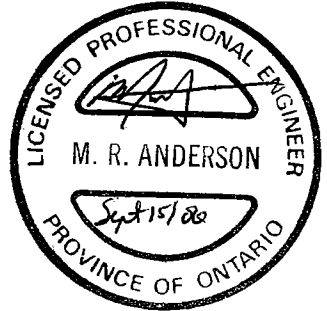
Prep'd JHL
 Chkd. MRA

Appendix C

Borehole Locations Drawing

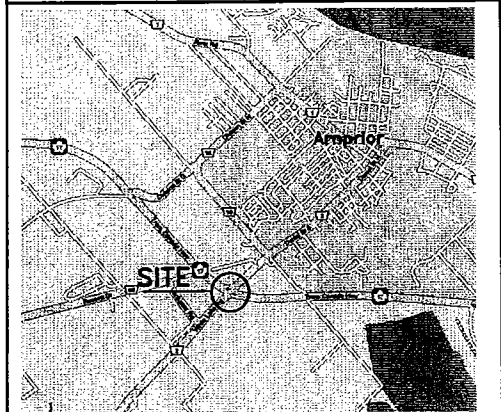


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



HWY 17
CONT No
WP No 647-92-00

HWY 17-417
HIGH MAST LIGHTS
BOREHOLE LOCATIONS



KEYPLAN

LEGEND

- Bore Hole
- ⊕ Bore Hole & Cone
- N Blows/ 0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/ 0.3m (60° Cone, 475 J/blow)
- PH Pressure, Hydraulic
- WL at Time of Investigation
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING
P1	108.2	5 031 711.3	314 186.9
P2	107.7	5 031 618.7	314 271.0
P3	107.9	5 031 535.5	314 346.2
P4	105.9	5 031 457.3	314 417.6
P5	107.1	5 031 382.2	314 498.1
P6	106.5	5 031 321.3	314 579.3
P7	106.8	5 031 246.7	314 559.1
P8	106.5	5 031 266.6	314 670.9
P9	105.9	5 031 284.9	314 739.5
P10	107.0	5 031 167.6	314 605.6
P11	107.4	5 031 289.7	314 901.6
P12	107.2	5 031 238.0	314 981.7
P13	106.7	5 031 082.6	314 702.6
P14	107.0	5 031 097.1	314 843.9
P15	107.2	5 031 158.9	315 034.0
P16	106.6	5 031 155.3	315 167.9
P17	105.8	5 031 159.4	315 299.7
P18	104.6	5 031 163.6	315 431.9
P19	103.2	5 031 166.2	315 567.1
P20	104.6	5 031 171.6	315 687.1

NOTE

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