FOUNDATION INVESTIGATION AND DESIGN REPORT
MAGNETAWAN/HWY 520 OVERPASS, NBL
HIGHWAY 11 FOUR-LANING AT BURK'S FALLS
W.P. 473-93-00, SITE: 44-188N

Geocres Number: 31E-267

Report to

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November 22, 2006
File: 19-1423-31

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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 structure at Burk's Falls, Ontario. The proposed five-span structure will carry the northbound lanes (NBL) of the future four-laned Highway 11 across the Magnetawan River and Highway 520.

A previous foundation investigation was carried out by AGRA Earth and Environmental Ltd. at this site for a certain structure configuration. The design of the structure was subsequently changed and additional boreholes were drilled to reflect these changes. The factual data from both investigations has been used in preparing this report.

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, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the present and previous investigations.

Thurber carried out the investigation as a sub-consultant to Marshall Macklin Monaghan, under the Ministry of Transportation Ontario (MTO) Agreement Number 5005-E-0028.

2 SITE DESCRIPTION

The site lies across the valley of the Magnetawan River on the west side of the town of Burk's Falls and immediately east of existing Highway 11. The existing highway crosses the valley on a south approach fill, a bridge spanning the Magnetawan River, an intermediate fill section, a bridge spanning Highway 520 and a north approach fill. The proposed crossing for the NBL will consist of north and south approach fills and a five-span structure crossing both the Magnetawan River and Highway 520.

From an intersection with Highway 11 south of the site, Highway 520 passes through Burk's Falls, crosses the Magnetawan River and then turns westward, more-or-less following the river and passing under existing Highway 11. There are residential and commercial properties along Highway 520 in the vicinity of the site.

On the south side of the river, Sharpe Street follows the riverbank and comes to a dead end at the site. There are residential properties on Sharpe Street in the vicinity of the site.

At the site, the Magnetawan River is approximately 40 m wide and is approximately 3 m deep, based on the General Arrangement Drawing provided to Thurber.

The valley slopes are covered by grass and, on the south slope, by shrubs and small trees.

Geologically, the 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 Magnetawan River flows in a valley in bedrock that is partially infilled by glacio-fluvial soil deposits.

Photographs of the site are included in Appendix G. Photograph #1 is taken from the south side of Hwy 520 looking southward across the Magnetawan River towards the area of the south abutment. Part of the existing Hwy 11 bridge can be seen at the righthand edge of the photograph. Photograph 2 is taken from the south shoulder of Hwy 520 looking across the area of the north abutment with Hwy 520 pavement in the foreground. The existing Hwy 11 embankment is visible at the lefthand side of the photograph.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between the period of July 18 to 23, 2006. Eleven boreholes numbered 06-21 to 06-31 pertaining to the five-span structure were drilled to depths ranging from 6.7 m to 16.0 m. The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

The borehole locations were marked in the field by surveyors from Marshall Macklin Monaghan Ltd. who also provided Thurber with the coordinates and geodetic elevations. Thurber obtained utility clearances prior to drilling.

A combination of hollow-stem auger drilling techniques and casing and washboring methods were used to advance the boreholes. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils. In some boreholes auger refusal was observed and diamond coring was required to extend some of these boreholes through cobbles and boulders and into bedrock. One borehole at each foundation element was advanced 3.0 m to 4.3 m into bedrock by NQ size diamond coring techniques.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. At each foundation element, a standpipe piezometer consisting of 19 mm PVC pipe with a slotted screen was installed and enclosed in filter sand to permit longer term groundwater level monitoring. The locations and completion details of the piezometers are shown in Table 3.1. The boreholes in which no piezometers were installed were grouted with bentonite. The borehole completion details are shown in Table 3.1. The piezometers were subsequently abandoned at the completion of the field investigation.

Table 3.1 – Borehole Completion Details

Location	Details	
	Piezometer Tip Depth/ Elevation (m)	**Completion Details**
06-21 South Abutment	10.1/277.2	Piezometer with 1.5 m slotted screen installed with sand filter to 7.9 m, bentonite seal from 7.9 m to 6.6 m, grout from 6.6 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
06-22 Pier #1	11.7/273.5	Piezometer with 1.5 m slotted screen installed with sand filter to 9.9 m, bentonite seal from 9.9 m to 9.3 m and grout from 9.3 m to ground surface.
06-23 Pier #1	None Installed	Grouted with bentonite to ground surface.
06-24 Pier #2	11.5/273.5	Piezometer with 1.5 m slotted screen installed with sand filter to 9.1 m, bentonite seal from 9.1 m to 8.2 m, grout from 8.2 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
06-25 Pier #2	None Installed	Grouted with bentonite to ground surface.
06-26 Pier #3	13.0/272.8	Piezometer with 1.5 m slotted screen installed with sand filter to 11.0 m, bentonite seal from 11.0 m to 10.4 m, grout from 10.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
06-27 Pier #3	None Installed	Grouted with bentonite to ground surface.
06-28 Pier #4	None Installed	Grouted with bentonite to ground surface.
06-29 Pier #4	9.9/276.8	Piezometer with 1.5 m slotted screen installed with sand filter to 7.9 m, bentonite seal from 7.9 m to 7.3 m, grout from 7.3 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
06-30 North Abutment	8.5/281.1	Piezometer with 1.5 m slotted screen installed with sand filter to 6.4 m, bentonite seal from 6.4 m to 5.8 m, grout from 5.8 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
06-31 North Abutment	None Installed	Grouted with bentonite to ground surface.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) 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 also subjected to gradation analysis and the results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained in Appendix B. The results of point load tests on rock cores retrieved from the boreholes are shown in Table B1 in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the site is underlain by 6.6 m to 11.7 m of overburden soils overlying Pre-Cambrian bedrock. The overburden soils generally consist of topsoil, granular fill, sands and silts, silty clay, glacial till and gravelly sand.

5.1 Topsoil and Granular Fill

Across the site 0.1 m to 0.2 m of topsoil was encountered that extends to elevations ranging from 289.6 m to 284.9 m.

Boreholes 06-23 and 06-25 were drilled in the vicinity of Sharpe Street. These two boreholes encountered a layer of granular fill consisting of sand with some gravel and trace silt. The fill layer extends to a depth of 0.7 m or to elevations ranging from 285.4 m to 284.4 m.

Boreholes 06-30 and 06-31 were drilled in the vicinity of Highway 520. A layer of granular fill consisting of sand with silt, gravel and occasional brick fragments and cobbles was encountered in these boreholes. The granular fill extends to a depth of 1.4 m or to elevations ranging 288.1 m to 286.8 m.

Standard penetration tests conducted in the granular fill gave 'N' values ranging from 9 to more than 50 blows per 0.3 m penetration. Based on these results the fill is considered to have a loose to very dense relative density.

The moisture content of samples from the fill ranged from approximately 4% to 16%.

5.2 Silty Sand to Silt

Underlying the topsoil and granular fill, a layer of sands and silts extends across the site. The deposit contains varying amounts of sand and silt, ranging from silty sand to silt. The deposit also contains cobbles and trace to some clay. This material extends to depths ranging from 1.4 m to 6.3 m or to elevations from 286.1 m to 280.9 m.

Samples of this deposit were subjected to grain size distribution tests and the results are presented in Figures B1 and B2.

Standard penetration tests in this deposit gave 'N' values from 1 to greater than 50 blows per 0.3 m penetration, but generally, most values ranged from 1 to 30 blows per 0.3 m penetration indicating that the relative density of the material varies from very loose to dense.

The moisture content of samples from this material ranged from approximately 9% to 45%.

5.3 Clayey Silt to Silty Clay

A pocket of clayey material ranging from clayey silt to silty clay was encountered at the north end of the site. This material extends to depths ranging from 2.2 m to 4.6 m or to elevations from 284.4 m to 283.7 m.

Two selected samples of this material were subjected to grain size distribution tests and the results are presented in Figure B3. An Atterberg Limit test was also conducted on one selected sample from this material. The result is presented in Figure B7.

Standard penetration tests in this material gave 'N' values from 20 to greater than 50 blows per 0.3 m penetration indicating that the relative density of the material varies from very stiff to hard.

The moisture content of samples from this material ranged from approximately 12% to 37%.

5.4 Sand

A layer of sand with some silt was encountered on the north side of the Magnetawan River. This material was encountered to depths of 5.5 m to 5.9 m or to an elevation of 281.2 m.

Two selected samples from this deposit were subjected to grain size distribution tests and the results are presented in Figure B6.

SPT 'N' values ranged from 21 to 53 blows for 0.3 m penetration, indicating that the material has a compact to very dense relative density.

The moisture content of samples from this deposit ranged from approximately 18% to 22%.

5.5 Sand and Silt, Some Gravel (Glacial Till)

Underlying the sand and silt deposits described above, a deposit of glacial till extends across most of the site and generally overlies the bedrock. The glacial till contains varying amounts of sand and silt, ranging in composition from silty sand to sand and silt. The deposit also contains some gravel, trace clay and occasional cobbles and boulders. The till extends to depths ranging from 4.6 m to 11.7 m or to elevations from 281.0 m to 273.4 m.

Samples from this deposit were subjected to grain size distribution tests and the results are illustrated in Figures B4 and B5.

SPT 'N' values in this deposit ranged from 1 to more than 50 blows for 0.3 m penetration, but generally, most values ranged between 20 and more than 50 blows for 0.3 m penetration indicating a compact to very dense relative density.

The moisture content of samples from this deposit ranged from 7% to 37%.

5.6 Gravelly Sand

At the north and south ends of the site, pockets of gravelly sand with trace silt and occasional cobbles and boulders were encountered overlying the bedrock. These deposits extended to depths ranging from 6.9 m to 8.8 m or to elevations from 280.8 m to 276.5 m.

One sample from this material was subjected to grain size distribution testing and the result is shown in Figure B6.

Standard Penetration tests in these deposits gave 'N' values ranging from 13 to more than 50 blows per 0.3 m penetration, but generally, most values ranged between 39 and more than 50 blows per 0.3 m penetration. Based on these results the material is considered to have a dense to very dense relative density.

The moisture content of samples from these deposits varies between 10% and 21%.

5.7 Bedrock

The overburden soils described above are underlain by granitic gneiss and granite (pegmatite) bedrock. Bedrock was proved by coring at the north and south abutments and at each of the four piers. Table 5.1 summarizes the bedrock depth and the elevations to the top of bedrock where rock was cored and where refusal was encountered on probable bedrock, but the rock was not cored.

The granitic gneiss bedrock is generally described as fresh to slightly weathered. Its colour is pink, white and black with some thin banding.

The granite bedrock was encountered underlying the gneiss in Boreholes 06-21 and 06-29. The granite can be further characterized as pegmatite due to the presence of large crystals of up to several centimetres in diameter. It is described as fresh to faintly weathered. Its colour is pink, white and black.

TABLE 5.1 – Depth to Bedrock at Foundation Elements

Location	BH Number	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
South Abutment	06-21	6.6	280.7
Pier #1	06-22	8.7	276.5
	06-23	8.1*	278.0*
Pier #2	06-24	10.6*	274.4*
	06-25	11.7	273.4
Pier #3	06-26	9.9	275.9
	06-27	7.2*	277.9*
Pier #4	06-28	6.7*	280.4*
	06-29	6.9	279.7
North Abutment	06-30	8.8	280.8
	06-31	8.3*	280.0*

* Denotes where refusal was encountered on probable bedrock or boulders.

Core recovery in the bedrock was generally between 86% and 100%. The RQD values generally ranged from 52% to 100% indicating fair to excellent rock quality. Lower RQD values of 0% to 38% were also encountered at the locations of various rubble zones within the rock mass.

The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, was generally low, ranging from 0 to less than 5. Fracture Indices greater than 5 however were obtained in some core runs indicating the presence of rubble zones within the rock mass. Evidence of frequent rubbles zones were noted in Boreholes 06-21 Run #1, 06-22 Runs # 3 and 4, 06-25 Run #1, 06-29 Runs #3 and 4 and 06-30 Run #2. Sub-vertical to vertical joints were encountered and they were mostly tight with occasional sand infilling and little to no secondary weathering material.

The unconfined compressive strength of most of the rock cores is estimated to range between 59 and 210 MPa indicating a strong to very strong intact rock. These estimated rock strength values are based on point load tests that were conducted on rock cores recovered from the boreholes. A summary of the Point Load Test Results is presented in Table B1 in Appendix B.

5.8 Water Levels

A standpipe piezometer was installed at each foundation element in a selected borehole and water levels were measured on separate visits made after the completion of drilling. The water level readings at the foundation elements are presented in Table 5.2.

Table 5.2: Water Level Measurements

Date	BH 06-21	BH 06-22	BH 06-24	BH 06-26	BH 6-29	BH 06-30
	Depth/ Elev. (m)	Depth/ Elev. (m)	Depth/ Elev. (m)	Depth/ Elev. (m)	Depth/ Elev. (m)	Depth/ Elev. (m)
July 19, 2006	-	-	-	3.5 / 282.3	-	-
July 20, 2006	-	-	-	3.5 / 282.3	2.7 / 284.0	-
July 21, 2006	-	-	-	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6
July 22, 2006	-	-	-	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6
July 23, 2006	-	1.4 / 283.8	2.0 / 283.0	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6
July 24, 2006	2.1 / 285.2	1.4 / 283.8	2.0 / 283.0	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6
July 25, 2006	2.1 / 285.2	1.4 / 283.8	2.0 / 283.0	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6
July 26, 2006	2.1 / 285.2	1.4 / 283.8	2.0 / 283.0	3.5 / 282.3	2.7 / 284.0	5.0 / 284.6

Based on these observations, local groundwater levels exist at Elevations 282.3 m to 285.2 m. All groundwater observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

6 MISCELLANEOUS

Eastern Ontario Diamond Drilling Limited of Hawkesbury, Ontario supplied a track mounted CME 75 drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger of Thurber.

Mr. Alastair E. Gorman, P.Eng. and Mr. Mark E. Farrant, P.Eng. directed the field operations and prepared the report.

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

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

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

It is understood that Highway 11 NBL will cross over the Magnetawan River and Highway 520 via a five-span structure with a span arrangement of 45:52:60:60:52 m and a total length of 269 m. The Magnetawan River will pass through the centre span, between Pier 2 and Pier 3, and Highway 520 will pass through the north span, between Pier 4 and the north abutment.

At the south abutment, the finished grade of Highway 11 will be at Elevation 294.3 and the existing ground surface lies at Elevation 287.9. The resulting embankment height above original ground level will, therefore, be in the order of 6.4 m at the south abutment.

At the north abutment, the finished grade of Highway 11 will be at Elevation 297.7 and the existing ground surface averages Elevation 289.0 at the abutment, resulting in an approach embankment in the order of 8.7 m high.

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 this investigation, including boreholes drilled for an earlier version of the design. Reference has also been made to the boreholes drilled in a previous investigation by AGRA Earth and Environmental Ltd.

8 STRUCTURE FOUNDATIONS

Based on the boreholes drilled at the foundation elements, the stratigraphy at the site consists of fill and cohesionless soils overlying bedrock. A synopsis of the soils at each foundation element is presented in Table 8.1. For a detailed description of the soil stratigraphy, refer to Section 5 of the report.

Table 8.1 – Summarized Soil Conditions

Foundation	Approximate Depth (m)	Stratigraphy	Groundwater	Elevation of Underside of Foundation
South Abutment	0 to 1	Sand, possible fill, loose	Groundwater at 2 m Elevation 285.2	286.9
	1 to 3	Sand, compact to very dense		
	3 to 7	Sand, some gravel, occasional to frequent cobbles, very dense		
	Below 7	Bedrock		
Pier 1	0 to 1.5	Fill	Groundwater at 1.5 m Elevation 283.8	283.7
	1.5 to 8	Sand, compact to very dense, occasional cobbles, boulders		
	Below 8	Bedrock		
Pier 2	0 to 2	Fill, silty sand, loose	Groundwater at 2 m Elevation 283.0	283.0
	2 to 4	Sand, silt, some clay, very loose to loose		
	4 to 11	Sand, trace to some gravel, occasional cobbles, boulders, very dense		
Pier 3	0 to 2	Sand, loose	Groundwater at 3.5 m Elevation 282.3	283.1
	2 to 6	Sand and silt, very loose to compact		
	6 to 9	Sand, trace gravel, occasional cobbles, very dense		
	Below 9	Bedrock		
Pier 4	0 to 1.5	Sandy silt, loose	Groundwater at 2.5 m Elevation 284.0	285.0
	1.5 to 6	Sand and silt, compact		
	6 to 7	Sand and gravel, cobbles and boulders, very dense		
	Below 7	Bedrock		
North Abutment	0 to 2	Fill	Groundwater at 5 m Elevation 284.6	287.7
	2 to 5	Sandy silt, compact to dense/Silty clay, hard		
	5 to 9	Sand, trace gravel, occasional cobbles, very dense		
	Below 9	Bedrock		

Note: Boulders were encountered locally in some boreholes and should be assumed to occur throughout the site.

Initial consideration was given to the following foundation types:

- Spread footings (on native soil, engineered fill or bedrock)
- Augered Caissons (drilled shafts)
- Driven piles
- Micro-piles

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix D.

8.1 Spread Footings on Native Soil

Spread footings founded on the native soil are not considered to be suitable at this site for the following reasons:

- The site is covered by a layer of fill and loose in the order of 2 to 3 m thick, composed largely of recent alluvium
- The surficial deposits are underlain by sand and silt that, in some locations, is very loose or loose
- The groundwater level is approximately 2 m below ground surface
- There is a potential risk of some footing being undermined by erosion of the river banks.

Accordingly, spread footings on native soil or engineered fill were not analysed further.

8.2 Spread Footings on Engineered Fill

Spread footings on engineered fill pads may be considered at the abutments. Spread footings on engineered fill are not recommended at the piers and particularly not at Pier 2 or Pier 3 due to the risk of undermining due to river scour.

If a spread footing on an engineered fill pad is used at this site, all topsoil, fill and other deleterious material must be stripped from below the footprint of the footing and the engineered fill must bear on dense or very stiff native soil. Stripping must also be carried down to an elevation that will accommodate a minimum of 2 m thickness of engineered fill below the underside of the abutment footing.

Target elevations for stripping/highest founding elevation for the engineered fill are given in Table 8.2. The engineered fill must be placed on dense or very stiff native soils and this must be confirmed by the QVE.

Table 8.2 – Stripping Elevations (Minimum Founding Elevations)

Foundation Element	Elevation
South Abutment (BHs 06-21 and 16)	285.5
North Abutment (BHs 06-30 and 06-31)	286.0

The engineered fill should be placed directly on the prepared soil surface and should consist of OPSS Granular "A" placed in 150 mm lifts, compacted in accordance with OPSS 501, Method A and generally conforming to the geometry illustrated in Figure 1.

Provided a minimum footing width of 3 m is maintained, a footing bearing on the engineered fill may be designed for the following concentric, vertical geotechnical resistance:

Factored ULS – 900 kPa

SLS – 350 kPa.

These resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance used in design must be reduced in accordance with the CHBDC.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm in a 6 m span.

The ultimate sliding resistance of a concrete foundation poured on the engineered fill may be calculated using a friction factor of 0.7.

8.3 Spread Footings on Bedrock

The top of bedrock established in the course of the investigation lies at 6.6 to 11.7 m below existing ground level, as shown in Table 5.1. Since the existing grade will not be lowered, footings bearing on bedrock would require excavations in the order of 6 to 12 m deep in water bearing, cohesionless soils.

While this is technically possible, it is not considered to be necessary or cost effective at this site. Accordingly, footings on bedrock were eliminated from further consideration.

8.4 Caissons Founded in Soil

Caissons at this site would be founded below the water table on very dense, cohesionless soils. To be effective, the caissons must be founded on undisturbed soil.

The construction of caissons in these conditions is considered to be high risk and is not recommended.

8.5 Caissons Founded on Bedrock

Caissons could be founded in bedrock at depths of 6.6 to 11.7 m below present ground surface. Two alternatives that can be considered for the design are:

- End bearing in a short socket into the bedrock
- Shaft adhesion in a longer socket into bedrock.

8.5.1 End Bearing

In order to design a caisson as end bearing in bedrock, it is necessary for the following conditions to be met:

1. The entire base of the caisson must bear on sound bedrock. Given the uneven or sloping bedrock surface at this site, achieving full bearing may necessitate drilling or coring into the bedrock
2. Construction techniques are required that prevent the soil overlying the bedrock from sloughing or flowing into the caisson excavation. This effectively requires that the caisson hole be drilled using a temporary steel liner that can be drilled into the top of the bedrock to exclude soil.
3. The base of the caisson must be cleaned and be free of soil, drill cuttings and other fine material.

Provided the foregoing conditions can be satisfied, the caisson may be designed on the basis of a vertical geotechnical compressive resistance at factored ULS equal to 10,000 kPa. The SLS condition will not govern for a caisson bearing on bedrock.

An advantage of the end bearing design is that high resistance is available with comparatively short penetration into bedrock. For example, a 0.75 m diameter caisson penetrating 1.0 m into bedrock would have a geotechnical resistance at factored ULS of 4,400 kN.

Given the high groundwater table and cohesionless soils at this site, it must be assumed that the caisson excavation will be full of water and that unwatering will not be practicable. Accordingly, concrete must be placed by tremie methods.

Caissons are not recommended, but if this design is adopted, the contract documents must alert bidders to restrictions and potential difficulties associated with construction.

8.5.2 Shaft Adhesion

In order for a caisson to be designed for shaft adhesion, it is necessary for the following conditions to be met:

1. The full design length of the socket must be developed in sound bedrock.
2. Construction techniques are required that prevent the soil overlying the bedrock from sloughing or flowing into the caisson excavation. This effectively requires that the caisson hole be drilled using a temporary steel liner that can be drilled into the top of the bedrock to exclude soil. A minor inflow of soil is permissible provided that it is contained below the design socket length (see Item 4 below).

3. The sides of the socket must be free of deleterious substances that would inhibit the bond between the concrete and the rock. This requirement effectively precludes the use of drilling mud.

4. Any debris left in the rock socket as a consequence of the construction technique must not be within the design socket length, i.e. it may be necessary to drill deeper to provide a sump for drill debris.

The unconfined compressive strength of the bedrock (in excess of 100 MPa in most tests), exceeds the strength of concrete, typically 30 MPa. In this case, the design value of shaft adhesion will be governed by the strength of the concrete used in the caisson shaft. A design value equal to $0.05*\sigma_c$ kPa may be used, where σ_c is the compressive strength of the concrete, equal to 1,500 kPa for 30 MPa concrete.

Thus, as a comparison to the end bearing case, a 0.75 m diameter caisson in bedrock requires a socket 1.25 m long using 30 MPa concrete.

8.6 Driven Steel Piles

The soil stratigraphy at the site is considered to be suitable for the support of foundations on driven steel piles.

The stratigraphy encountered at this site consists of 7 to 11 m of mainly cohesionless soil overlying bedrock, with some hard clayey silt to silty clay occurring at the north abutment. Cobbles and boulders occur, especially in the sand till and gravelly sand overlying the bedrock in parts of the site. With this stratigraphy, it is expected that steel H-piles can be driven to bedrock at the elevations shown in Table 8.3.

Table 8.3 – Estimated Pile Lengths

Location	Borehole No.	Depth to Bedrock* (m)	Top of Bedrock Elevation	Elevation of Underside of Pile Cap per G.A.	Estimated Length of Pile (m)
South Abutment	06-21	6.6	280.7	286.9	6.2
	16	7.0	281.4**		5.5
Pier 1	06-22	8.7	276.5	283.7	7.2
	06-23	8.1	278.0		5.7
Pier 2	06-24	10.6	274.4	283.0	8.6
	06-25	11.7	273.4		9.6
Pier 3	06-26	9.9	275.9	283.1	7.2
	06-27	7.2	277.9		5.2
Pier 4	06-28	6.7	280.4	285.0	4.6
	06-29	6.9	279.7		5.3
North Abutment	06-30	8.8	280.8	287.7	6.9
	06-31	8.3	280.0		7.7

* From ground surface existing at the time of investigation

** Not confirmed refusal

8.6.1 Axial Resistance

Four steel pile sections typically available in the market have been considered for use in the proposed foundations. The factored, vertical, concentric, geotechnical resistances at ULS for these pile sections, when driven to bedrock, are as follows:

- 2,000 kN for HP 310 x 110
- 2,400 kN for HP 310 x 132
- 2,750 kN for HP 310 x 152
- 2, 400 kN for HP 360 x 132

The SLS condition will not govern for piles founded on bedrock.

The structural resistance of the pile must be checked by the structural designer.

Oversize materials (e.g. greater than 75 mm nominal diameter) must not be used in the fills through which the piles will be driven.

8.6.2 Downdrag

Downdrag on the piles is not considered to be an issue at this site.

8.6.3 Integral Abutment Considerations

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. An H-pile foundation is required for an integral abutment design.

Despite the geotechnical suitability of the site, it is anticipated that the length and curvature of the structure will preclude integral abutment design.

If an integral abutment design is considered, it will require special consideration of the magnitude of movement to be accommodated and detailed analysis of the soil-structure interaction. Such analysis is considered to be beyond the scope of the current assignment.

8.6.4 Pile Tips

Due to the possible presence of cobbles and boulders above bedrock, the tips of all piles should be fitted with H-section rock points from an approved manufacturer such as Titus Steel (Standard H-point) or Pruyn Points or approved equivalent.

The use of rock points is recommended for the following reasons:

- The piles will be driven into soil containing cobbles and boulders, which requires a higher level of protection than driving into soils containing only smaller particle sizes

- Some piles may achieve refusal on large boulders, which will require the same pile tip protection and reinforcement as founding on bedrock
- Some piles may fully penetrate the zone of cobbles and boulders and achieve refusal on the bedrock.

In the case of partial bearing on bedrock, the cast steel point will provide better stress redistribution without failure than would be achieved in a pile tip reinforced with a driving shoe.

8.6.5 Pile Installation

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

The contract documents should include a NSSP alerting the Contractor to the presence of cobbles and boulders in the sand and silt till and lower sand layer and instructing him that all piles must be driven to bedrock. Suggested wording for the NSSP is contained in Appendix E.

8.6.6 Pile Driving

The appropriate note for the foundation drawing is Note 5, i.e. "Piles to be driven to bedrock".

8.7 Micro-Piles

Micro-piles are considered to be feasible at this site but the subsurface conditions are such that driven H-piles may be more economical. Micro-piles are considered to be comparatively small diameter piles that are drilled into place and grouted, usually under pressure, with or without reinforcement.

Possible advantages on this site include:

- Providing positive fixity in the bedrock where conventional piles may be too short, e.g. at Pier 4 where the length of driven piles may lie in the range of 4 to 5 m long.
- Providing assurance that the piles will penetrate into bedrock without being obstructed by boulders at higher elevation

A further, general advantage of micro-piles grouted into bedrock is that they can provide significant geotechnical resistance in tension.

Micro-piles are generally proprietary systems designed by the suppliers and different suppliers have different methods of installation and reinforcement. If micro-piles are to be considered, the contract should be written to require the contractor to install micro-piles that will provide the required characteristics. Claims of factored ULS geotechnical and structural resistance of 4,000 kN for piles in the order of 300 mm are made by some suppliers.

The ultimate resistance of the micro-piles must be proved by static load testing in accordance with ASTM D 1143, using the Standard Loading Procedure (Article 5.1). Suggested wording for a NSSP is included in Appendix E.

If micro-piles are to be considered for this site, it is recommended that the structural design team, MTO Foundations Office and Thurber meet to thoroughly analyze the advantages, disadvantages and design requirements. Following such internal discussion, a micropile supplier could be invited to discuss the product and provide a preliminary design as a means of providing assurance to the Ministry that the system is feasible.

8.8 Pile Lateral Resistance

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

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

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

where z = depth of embedment of pile in metres
D = pile width in metres
n_h = coefficient of horizontal subgrade reaction (Table 8.4)
γ = unit weight (Table 8.4)
K_p = passive earth pressure coefficient (Table 8.4)

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 must not exceed the ultimate lateral resistance. The analysis must also take account of the strain compatibility between the pile and the soil, especially in the case of a caisson socketed in bedrock which will form a stiff structural element.

Table 8.4 – Recommended Soil Parameters

Location	Elevation	n_h (kN/m^3)	K_p	Unit Weight* (kN/m^3)	Soil Conditions
South Abutment	Granular B-I Fill	15,000	3.3	22	Compacted fill.
	OGL to 284.8	6,000	3.0	22	Sand and silt dense to very dense
	284.8 to 280.7	10,000	3.3	11	Sand, some gravel and cobbles, dense to

	(bedrock)				very dense.
North Abutment	Granular B-I Fill	15,000	3.3	22	Compacted fill.
	OGL to 287.5	2,000	2.8	22	Sand and silt, loose
	287.5 to 280.5 (bedrock)	10,000	3.3	10	Gravel and sand with cobbles

*Buoyant unit weight below the water table.

The spring constant, K_s, for analysis may be obtained by the expression, $K_s = k_s \times L \times D$ (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, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult} \times L \times D$. 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.

Since the piles are end bearing on rock, the vertical resistance will not be significantly affected by the pile spacing. Pile interaction should be considered with reference to CHBDC Clause 6.8.9.2.

For lateral soil/pile group interaction analysis, the equation for k_s and p_{ult} quoted above may be used in conjunction with appropriate reduction factors.

Where a pile group is oriented ***perpendicular*** to the direction of loading, group action may be considered by reducing values for k_s and p_{ult} by a reduction factor R as follows:

Pile Spacing Perpendicular to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
4 D*	1.00
1 D*	0.50

* D is the width of the pile, and spacing is measured centre to centre

Where a pile group is oriented ***parallel*** to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Parallel To Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
8 D	1.00
6 D	0.70
4 D	0.40
3 D	0.25

Intermediate values may be obtained by interpolation.

For conventional abutments, the lateral resistance may be provided by battered piles.

8.9 Recommended Foundation

The recommended foundation system for this structure is abutments and piers supported on steel H-piles driven to bedrock. A possible exception to this recommendation occurs if the short piles at Pier 4 do not provide the degree of fixity required by the structural design. In that case, micro-piles are the recommended alternative at that pier.

8.10 Frost Cover

Pile caps and footings on earth must be provided with a minimum of 1.8 m of earth cover over the footing base (founding elevation).

8.11 Erosion Protection

It is recommended that the foundations of Pier 2 and Pier 3 be protected from erosion and undercutting by the river. A specialist in river hydrology should be consulted regarding these requirements.

9 EXCAVATION AND BACKFILL

9.1 General

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA) and in accordance with Special Provision 902S01. For the purposes of the OHSA, the native soils at this site may be classified as Type 3 soils above the water table and Type 4 soils below the water table. Excavation below the groundwater level is not recommended without prior dewatering. Provided dewatering is carried out as described below, temporary excavations may be sloped at 1H:1V.

9.2 Foundations

The excavation and backfilling for foundations must be carried out in accordance with SP 902S01.

Bidders must be alerted to the fact that excavation must be carried out through cohesionless soils, which may include man-made fill or obstructions, cobbles and boulders.

Excavations formed to the elevation of the underside of the pile cap, as shown in Table 8.1, will lie at or slightly above the groundwater levels recorded during the investigation. The sides and base of the excavation must be maintained in a stable condition and Bidders must be alerted to the fact that groundwater levels will vary and may be higher at the time of construction.

If deeper excavation is selected, e.g. excavation to bedrock, Bidders must also be alerted to the fact that the bedrock surface is uneven. The methods used to excavate, control groundwater and maintain a stable excavation must be selected by the Contractor. However, when different options are evaluated, it must be recognized that there may be difficulties in depressing the groundwater level to the bedrock surface or, alternately, in obtaining a seal between driven sheeting and the bedrock to prevent the inflow of groundwater carrying soil with it. When dewatering and protection systems are being selected, factors that must be considered by the Contractor include, but are not limited to:

- An oversize sheeted excavation to allow space to pack filter material at the toe of the sheeting
- An oversize excavation to allow space to collect and remove seepage water
- Placing a mud slab within a sheeted excavation to prevent the continued migration of soil into the excavation.

10 GROUNDWATER AND FLOOD CONTROL

At the time of investigation, the groundwater level lay at depths of 1.5 to 5.0 m below the ground surface. The groundwater level will vary and may be higher at the time of construction. At this site, the design of dewatering and protection systems must also take account of the possibility of the Magnetawan River level rising rapidly due to flood conditions or due to the operation of the upstream dam. The groundwater and surface (flood) water must be controlled during construction to maintain a stable excavation and to allow concrete to be placed in an unwatered excavation.

The design of the groundwater control system is the responsibility of the Contractor. However, suitable systems that might be considered include pumping from filtered sumps for nominal penetration below the groundwater level or the use of a sheeted excavation to bedrock. The effectiveness of dewatering wells may be limited by the presence of bedrock at shallow depth.

Any accumulation of water from the base of the excavation should be removed prior to placing concrete or compacting granular fill. Placement of concrete or compacting engineered fill must be done in the dry.

11 APPROACH EMBANKMENTS

The investigation and analysis of the approach embankments was carried out under a previous assignment by AGRA. No embankment investigation or analysis was included in the Terms of Reference for this project.

12 RETAINED SOIL SYSTEMS

Retained soil system (RSS) walls may be used subject to the requirements presented in this section.

RSS walls must be specified to be "High Performance" and "High Appearance". The contract drawings must include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and the NSSP for the RSS wall.

12.1 Foundation

The performance of an RSS is dependent, among other factors, on the characteristics of its foundation. Failure to provide an adequate foundation may lead to settlement and distortion of the RSS and, in severe cases, to possible failure of the system. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

To provide an acceptable foundation performance, the RSS mass must be founded on soil that is compact/very stiff or better. The highest elevations for founding on native soils are given in Table 8.2. The QVE must verify that the founding soil is at least dense or very stiff. Alternatively, the RSS may be founded on a pad of Granular "A" engineered fill founded at the elevations given in Table 8.2.

If RSS is used, the geometry of the engineered fill must conform to the limits illustrated in Figure 2.

The subgrade should be competent and free of organics, soft or deleterious soils.

The RSS mass must be constructed in the dry and the excavation must be unwatered as necessary to achieve the dry conditions.

The following parameters may be used for the design of the RSS founded on native soil:

- Factored geotechnical resistance of 375 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 250 kPa at Serviceability Limit States (SLS)
- Ultimate coefficient of sliding resistance of cast in-situ concrete levelling pad on native soil = 0.6
- Ultimate coefficient of sliding resistance of RSS mass on Granular A = 0.6

Total settlement under a RSS mass constructed as outlined above is expected to be less than 25 mm and to occur essentially as the RSS is constructed. Differential settlement is not expected to exceed 20 mm in a 6 m span.

If a thin pad of engineered fill pad is required to make up differences in elevation from the approved native soil to the underside of wall, it is recommended that the bearing resistances for native soil be used. If the thickness of engineered fill exceeds 2 m, the following parameters may be used for the design of the RSS mass:

- Factored geotechnical resistance of 900 kPa at Ultimate Limit States (ULS)
- Geotechnical resistance of 350 kPa at Serviceability Limit States (SLS)

- Ultimate coefficient of sliding resistance of cast in-situ concrete levelling pad on engineered fill = 0.7
- Ultimate coefficient of sliding resistance of RSS mass on Granular A = 0.6

The RSS is a proprietary system and the supplier must design for internal, sliding and overturning stability and for any other failure modes identified by the supplier.

12.2 Global Stability

The global stability of the RSS wall is dependent on the characteristics of the embankment fill and the foundation soils, the geometry of the embankment and location of the RSS within the embankment.

Global stability has been checked for two conditions:

1. 8.3 m high RSS wall on a 2 m high slope
2. 3.3 m high RSS wall on a 7 m high slope

These two cross-sections are illustrated in the computer output in Appendix H. For both cases, a factor of safety in excess of 1.4 was obtained and the stability of the wall is considered to be satisfactory.

13 BACKFILL TO ABUTMENTS

In the case of integral or semi-integral abutments, backfill to the abutment must 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 limit rock fill used as abutment backfill to fragments no greater than 300 mm and to include adequate spalls to fill voids in the rock fill.

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

All granular material should meet the specifications of Special Provision 110F13 "Amendment to OPSS 1010, March 1993". Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with SSP 105S10.

Some settlement will occur within the mass of the approach fill after the fill has been completed. For design purposes, the settlement at final grade should be assumed to equal 0.5% of the height of the fill.

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

14 EARTH PRESSURE

For cases where backfill to the abutment is placed in accordance with OPSD 3501.000 or OPSD 3505.000, as recommended, the lateral earth pressure will be governed by the properties of the material within the backfill limits shown in the respective OPSD, i.e. a line projected up at 1.5H:1V for granular backfill and 1.25H:1V for rock backfill.

If the support system allows yielding of the wall (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. If the support system does not allow yielding (restrained system), at-rest horizontal earth pressures should be used.

Earth pressures acting on the structure should be computed in accordance with Clause 6.9 of the CHBDC but generally are given by the expression:

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

P_h = horizontal pressure on the wall (kPa)

K = earth pressure coefficient (see table 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 at a depth of 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 given 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 or semi-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. However, the use of Granular "B" Type I may be restricted if the approach embankment consists of rock fill.

The factors in the Table 14.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC, 2000.

Table 14.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$; $\gamma = 21.2$ kN/m^3		Rock Fill $\phi = 42°$; $\gamma = 19.0$ kN/m^3	
	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 (Unrestrained Wall)	0.27	0.40*	0.31	0.48*	0.20	0.28*
At rest (Restrained Wall)	0.43	-	0.47	-	0.33	-
Passive (Movement Towards Soil Mass)	3.70	-	3.30	-	5.0	-

* For wing walls.

15 SEISM IC CONSIDERATIONS

15.1 Seismic Design Parameters

The site is treated as lying in Seismic Zone 1. 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 I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

15.2 Liquefaction Potential

The potential for liquefaction of the foundations soils was assessed using the Seed and Idriss (1971) method[1]

Using this method and assuming an earthquake of magnitude 7.5, it is estimated that under the existing conditions there is negligible potential for liquefaction of the foundation soils below the abutments. Therefore, the vertical geotechnical resistance of the foundations and embankments will not be compromised.

The embankments themselves will be constructed above the groundwater level and are not considered to be in danger of undergoing liquefaction. Some toe failure may occur but it is expected to be of limited nature and readily repairable.

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 active, passive and at rest earth pressure coefficients the angle of friction between the wall and backfill material is assumed to be 0.5 ϕ. For the design of retaining walls, the coefficients of horizontal earth pressure in Table 15.1 may be used.

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Earth Pressure Coefficient (K) for Earthquake Loading						
	Granular A or Granular B Type II $\phi = 35°$; $\delta = 17.5°$ $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$; $\delta = 16°$ $\gamma = 21.2$ kN/m^3		Rock Fill $\phi = 42°$; $\delta = 21°$ $\gamma = 19.0$ kN/m^3	
Wall Condition	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})*	0.3	0.45	0.33	0.54	0.23	0.31
Passive (K_{PE})	6.3	6.3	5.4	5.4	12.0	12.0
At Rest (K_{OE})**	0.59		0.63		0.33	

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

[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.

16 CONSTRUCTION CONCERNS

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

- Difficulty in unwatering of temporary excavations for foundation construction, if any are required
- Preparation of subgrade for engineered fill pads
- Preparation of the founding surface for any RSS walls
- Impact of boulders on driving of piles

17 CLOSURE

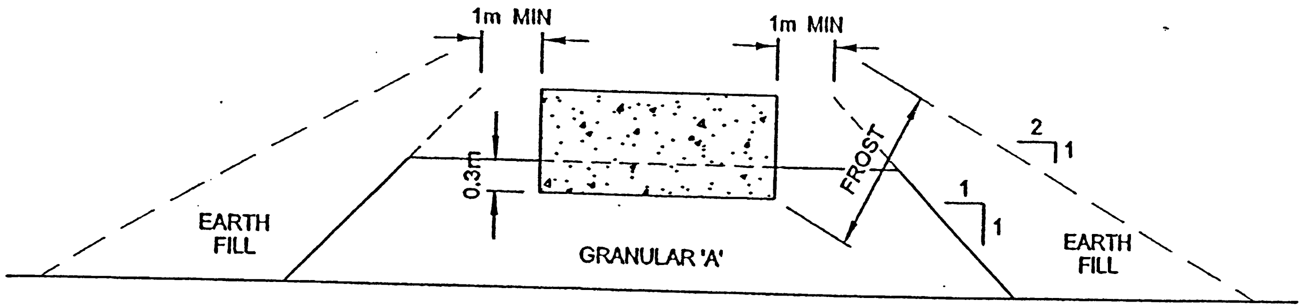
Engineering analysis and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng.

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

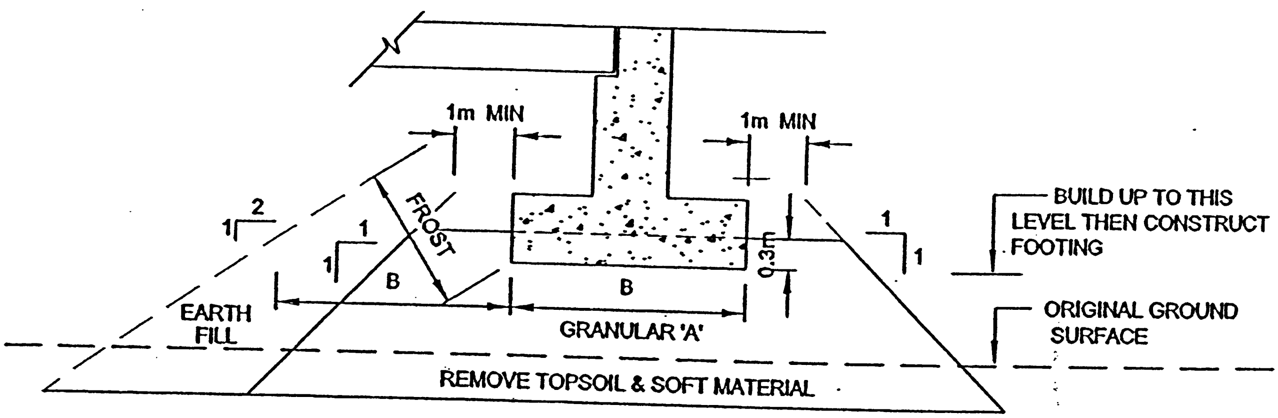
Thurber Engineering Ltd.

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

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



CROSS-SECTION



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

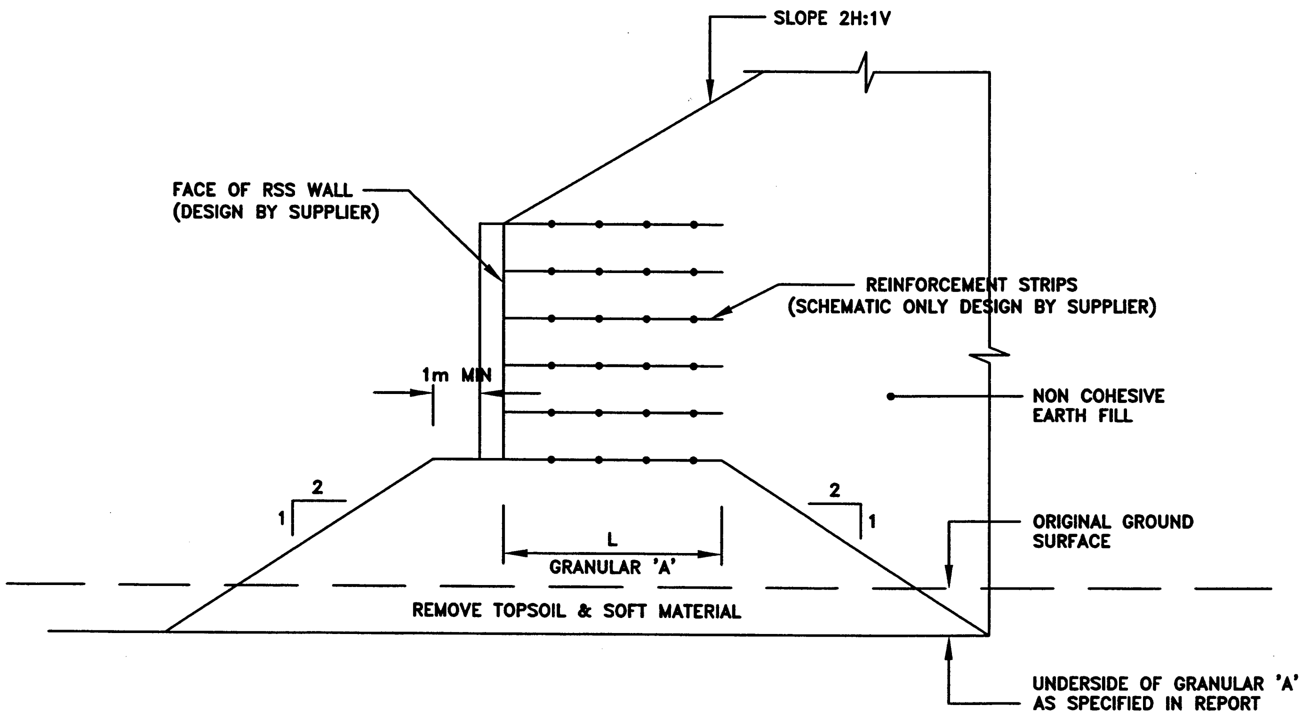
ENGINEER	AEG
DRAWN	SS
DATE	April, 2004
APPROVED	PKC
SCALE	NTS

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE

THURBER

DWG. NO. FIGURE 1

TED35146.DWG



LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
2. PLACE GRANULAR 'A' BELOW PLAN AREA OF RSS MASS.
3. CONSTRUCT RSS MASS.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. MODIFIED FROM M.T.C. 1982.

DESIGNED	RA
DRAWN	HS
DATE	SEP. 2004
APPROVED	PKC
SCALE	NTS

RSS MASS ON COMPACTED FILL SHOWING GRANULAR 'A'

THURBER

DRAWING No.

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

UNIFIED SOILS CLASSIFICATION

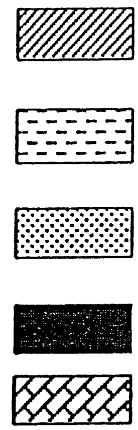
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-21

METRIC

W.P. 473-93-00
LOCATION N 5 052 742.98 E 311 450.15 Magnetawan River/Hwy 520 Overpass (NBL)
ORIGINATED BY SLL
HWY 11
BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel
COMPILED BY JHL
DATUM Geodetic
DATE 23.07.06 - 23.07.06
CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.3 / 0.0	**TOPSOIL**: (150 mm)						
0.2	**SAND**, some silt, Loose, Brown, Moist	1	SS	9	o		
286.5 / 0.8	**SILT and SAND**, some clay, Dense to Very Dense, Brown, Moist, trace gravel, occasional cobbles	2	SS	38	o		0 40 43 17
		3	SS	77	o		
284.8 / 2.4	**SAND**, trace gravel, occasional cobbles, Very Dense, Grey, Moist	4	SS	50/.100	o		
284.3 / 3.0	**SAND**, some silt to silty, some gravel, occasional cobbles, Very Dense, Grey, Wet (TILL)	5	SS	50/.050			
		6	SS	55	o		18 50 18 (SI+CL)
		7	SS	50/.025			
280.7 / 6.6	**BEDROCK** Pink, white and black, crystalline, slightly weathered to fresh, very strong, **GRANITIC GNEISS**. Rubble zone from 6.60 to 7.16 m. Subvertical joint from 7.32 to 7.47 m. Slightly weathered, rough joint surface with some sand seams. Subvertical joint from 8.08 to 8.23 m. Slightly weathered, rough joint surface	1	RUN			10, 10, 6	RUN 1# TCR=100%, SCR=50%, RQD=0%, UCS=115MPa
		2	RUN			2, 2, 1	RUN 2# TCR=100%, SCR=98%, RQD=92%, UCS=110MPa
279.0 / 8.2	Pink, white and black, crystalline, faintly weathered to fresh, strong to very strong, **GRANITE (PEGMATITE)**. Subvertical joint from 9.42 to 9.55 m. Slightly weathered, rough joint surface	3	RUN			2, 2, 3, 4, 6	RUN 3# TCR=100%, SCR=100%, RQD=54%, UCS=90MPa

Groundwater level symbol (▼) at approx. elev. 285.3.

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

Continued Next Page

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-21

METRIC

W.P.	473-93-00	LOCATION	N 5 052 742.98 E 311 450.15 Magnetawan River/Hwy 520 Overpass (NBL)	ORIGINATED BY	SLL
HWY	11	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core Barrel	COMPILED BY	JHL
DATUM	Geodetic	DATE	23.07.06 - 23.07.06	CHECKED BY	AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
277.2											
10.1	END OF BOREHOLE AT 10.06 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 07/24/06 2.13 285.17 07/25/06 2.12 285.18 07/26/06 2.13 285.17										

ONTMT4S 2331-MAG.GPJ 24/10/06

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-22

METRIC

W.P. 473-93-00 | LOCATION N 5 052 785.63 E 311 441.06 Magnetawan River/Hwy 520 Overpass (NBL) | ORIGINATED BY SLL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel | COMPILED BY JHL

DATUM Geodetic | DATE 22.07.06 - 22.07.06 | CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.2 / 0.0	**TOPSOIL**: (150 mm)						
0.2	**SAND**, some silt, trace roots Compact Brown Moist	1	SS	10			
284.4 / 0.8	Sandy **SILT**, trace roots Compact Brown Moist	2	SS	15			
283.7 / 1.4	**SAND**, some silt to silty, trace to some gravel, trace clay, occasional cobbles Dense to Compact Brown Moist (TILL) Becoming Grey, Wet	3	SS	44			4 62 25 6
		4	SS	30			
		5	SS	28			11 60 24 (SI+CL)
280.6 / 4.6	Gravelly **SAND**, occasional cobbles Compact to Very Dense Brown Wet	6	SS	13			
		7	SS	50/ .100			
		8	SS	50/ .125			
276.5 / 8.7	**BEDROCK** Pink, white and black, crystalline, slightly weathered to fresh, thinly banded, strong to very strong, **GRANITIC GNEISS** Sand seams at 9.45 m	1	RUN			4, 2	RUN 1# TCR=100%, SCR=100%, RQD=100%, UCS=MPa
		2	RUN			7, 4	RUN 2# TCR=100%, SCR=100%,

Groundwater level symbol shown at approx. elev. 283.9.

Continued Next Page

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

ONTMT4S 2331-MAG.GPJ 24/10/06

RECORD OF BOREHOLE No 06-22

METRIC

W.P. 473-93-00 | LOCATION N 5 052 785.63 E 311 441.06 Magnetawan River/Hwy 520 Overpass (NBL) | ORIGINATED BY SLL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel | COMPILED BY JHL

DATUM Geodetic | DATE 22.07.06 - 22.07.06 | CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
					2	RQD=81%, UCS=167MPa
		3	RUN		9	RUN 3# TCR=100%,
	Rubble zone from 10.60 to 10.75 m				10	SCR=56%, RQD=0%,
	Rubble zone from 10.92 to 11.16 m	4	RUN		10	UCS=73MPa RUN 4#
273.5	Rubble zone from 11.43 to 11.51 m				10	TCR=100%, SCR=100%,
11.7	END OF BOREHOLE AT 11.66 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				6	RQD=38%, UCS=159MPa

Other column headings: STRAT PLOT; 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.

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
07/23/06	1.44	283.76
07/24/06	1.41	283.79
07/25/06	1.42	283.78
07/26/06	1.42	283.78

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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 06-23

METRIC

W.P. 473-93-00
LOCATION N 5 052 788.72 E 311 453.58 Magnetawan River/Hwy 520 Overpass (NBL)
ORIGINATED BY SLL

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

DATUM Geodetic
DATE 22.07.06 - 22.07.06
CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.0 / 0.0	**SAND**, trace silt, trace gravel; Dense; Brown; Moist	1	SS	48	
285.4 / 0.7	**SILT and SAND**, trace clay; Loose; Brown; Moist	2	SS	7	0 41 56 4
284.4 / 1.7	**SAND**, some silt to silty, trace to some gravel, trace clay, occasional cobbles; Very Dense to Dense; Brown; Moist to Wet; (TILL)	3	SS	60	
		4	SS	32	
		5	SS	50/ .100	4 62 26 6
		6	SS	50/ .050	
281.0 / 5.0	Gravelly **SAND**, occasional cobbles; Very Dense; Brown; Wet				
279.9 / 6.1	**BOULDER**	7	SS	50/ .075	
279.6 / 6.4					
279.0 / 7.0	**SAND**, some silt, some gravel, trace clay, occasional cobbles; Very Dense; Grey; Wet; (TILL)	8	SS	50/ .100	
278.0 / 8.1	**BEDROCK or BOULDER**	1	RUN		
277.3 / 8.7	END OF BOREHOLE AT 8.69 m. REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (286 – 278); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-24

METRIC

W.P. 473-93-00 LOCATION N 5 052 837.30 E 311 432.86 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL
HWY 11 BOREHOLE TYPE Hollow Stem Augers / NW Casing COMPILED BY JHL
DATUM Geodetic DATE 21.07.06 - 22.07.06 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.0							
0.0	TOPSOIL: (100 mm)				285		
0.1	Silty **SAND**, Loose to Very Loose, Dark Brown, Moist	1	SS	8		o (~5)	
		2	SS	3	284		
		3	SS	3	▼ 283	o (~28)	
282.8 / 2.2	**SILT**, some clay, trace to some sand, trace roots, Loose, Brown, Moist to Wet	4	SS	8		o (~25)	0 8 75 16
282.0 / 3.0	**SAND**, some silt, Very Loose, Grey, Wet	5	SS	2	282	o (~27)	
280.9 / 4.1	Silty **SAND**, trace clay, trace gravel, occasional cobbles, Very Dense, Grey, Wet (TILL)				281		
		6	SS	50/ .125	280		
		7	SS	50/ .100	279	o (~6)	
		8	SS	50/ .075	278, 277		
		9	SS	100/ .125	276	o (~8)	0 56 38 3

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m^3

Continued Next Page

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

ONTMT4S 2331-MAG.GPJ 24/10/06

RECORD OF BOREHOLE No 06-24

METRIC

W.P. 473-93-00 LOCATION N 5 052 837.30 E 311 432.86 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

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

DATUM Geodetic DATE 21.07.06 - 22.07.06 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)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; 20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
274.4							275				
10.6	**BEDROCK OR BOULDER**		1	RUN			274			FI 4 5 0	RUN 1# TCR=100%, SCR=92%, RQD=78%, UCS=123MPa
273.5											
11.5	END OF BOREHOLE AT 11.53 m. REFUSAL ON PROBABLE BEDROCK OR BOULDERS. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
07/23/06	2.00	283.00
07/24/06	2.01	282.99
07/25/06	1.99	283.01
07/26/06	1.98	283.02

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-25

METRIC

W.P.	473-93-00	LOCATION	N 5 052 839.14 E 311 442.99 Magnetawan River/Hwy 520 Overpass (NBL)	ORIGINATED BY	SLL
HWY	11	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core Barrel	COMPILED BY	JHL
DATUM	Geodetic	DATE	21.07.06 - 21.07.06	CHECKED BY	AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.1 / 0.0	**SAND**, some gravel, trace silt. Compact. Brown. Moist	1	SS	26	285	
284.4 / 0.7	Silty **SAND**. Very Loose. Brown. Moist	2	SS	3	284	
283.6 / 1.5	**SILT**, some clay, trace to some sand. Loose. Brown. Moist	3	SS	3	283	
		4	SS	7		0 5 85 11
282.1 / 3.0	**SAND**, some silt to silty, trace to some gravel, occasional cobbles. Very Dense. Grey. Wet. (TILL)	5	SS	55/ .125	282	
281.0					281	
280.9 / 4.3	BOULDER				280	
		6	SS	100/ .200	279	
		7	SS	100/ .125	278	14 63 19 (SI+CL)
		8	SS	100/ .125	277, 276	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-25

METRIC

W.P. 473-93-00 LOCATION N 5 052 839.14 E 311 442.99 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

HWY 11 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel COMPILED BY JHL

DATUM Geodetic DATE 21.07.06 - 21.07.06 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	FI	REMARKS & GRAIN SIZE DISTRIBUTION (%)
		9	SS	50/.100	275	o		
					274			
273.4 / 11.7	**BEDROCK** Pink, white and black, crystalline, slightly weathered to fresh, thinly banded, strong, **GRANITIC GNEISS**. Rubble zone from 12.14 to 12.29 m	1	RUN				5, 10, 4, 6	RUN 1# TCR=100%, SCR=83%, RQD=35%, UCS=189MPa
		2	RUN				1, 2, 1, 0, 2	RUN 2# TCR=100%, SCR=98%, RQD=100%, UCS=182MPa
	Vertical joint from 14.56 to 15.34 m	3	RUN				5, 4, 3, 1, 0	RUN 3# TCR=100%, SCR=100%, RQD=95%, UCS=135MPa
269.1 / 16.0	END OF BOREHOLE AT 16.00 m. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.							

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-26

METRIC

W.P. 473-93-00 | LOCATION N 5 052 896.53 E 311 420.44 Magnetawan River/Hwy 520 Overpass (NBL) | ORIGINATED BY SLL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel | COMPILED BY JHL

DATUM Geodetic | DATE 18.07.06 - 18.07.06 | CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.8							
0.0 / 0.0	**TOPSOIL**: (50 mm)						
	SAND, trace gravel, trace roots Compact Brown Moist	1	SS	16		o	
285.1 / 0.7	Sandy **SILT**, trace roots Compact Brown Moist	2	SS	16	285	o	
		3	SS	4	284	o	
283.5 / 2.3	**SAND and SILT**, trace clay, trace gravel, occasional cobbles Very Loose to Loose Brown Wet (TILL)	4	SS	3	283	o	0 47 46 7
		5	SS	5	282 (water level ▼)	o	
		6	SS	8	281	o	
	Becoming Compact, Grey	7	SS	23	280	o	0 56 40 3
		8	SS	100/ .100	279 / 278		
	Becoming Loose	9	SS	8	277		
275.9 / 9.9	**BEDROCK**						FI 10 RUN 1#

Continued Next Page

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

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

ONTMT4S 2331-MAG.GPJ 24/10/06

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-26

METRIC

W.P.	473-93-00	LOCATION	N 5 052 896.53 E 311 420.44 Magnetawan River/Hwy 520 Overpass (NBL)	ORIGINATED BY	SLL
HWY	11	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core Barrel	COMPILED BY	JHL
DATUM	Geodetic	DATE	18.07.06 - 18.07.06	CHECKED BY	AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	Pink, white and black, crystalline, faintly weathered to fresh, thinly banded, strong, **GRANITIC GNEISS** Rubble zone from 9.85 to 9.99 m Vertical joint from 10.44 to 10.57 m Slightly weathered, smooth joint surface	1	RUN		1	TCR=100%, SCR=40%,
		2	RUN		6	RQD=0%, UCS=MPa
		3	RUN		3, 2, 3, 3	RUN 2# TCR=100%, SCR=100%, RQD=100%, UCS=MPa RUN 3# TCR=100%, SCR=100%, RQD=82%, UCS=102MPa
272.8 13.0		4	RUN		6, 1, 2, 4	RUN 4# TCR=100%, SCR=100%, RQD=72%, UCS=101MPa
	END OF BOREHOLE AT 12.98 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.					

Column headings also printed: SOIL PROFILE; SAMPLES; STRAT PLOT; 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; GR SA SI CL.

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
07/19/06	3.51	282.29
07/20/06	3.51	282.29
07/21/06	3.48	282.32
07/22/06	3.48	282.32
07/23/06	3.47	282.33
07/24/06	3.48	282.32
07/25/06	3.49	282.31
07/26/06	3.50	282.30

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-27

METRIC

W.P. 473-93-00 LOCATION N 5 052 898.16 E 311 435.06 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

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

DATUM Geodetic DATE 18.07.06 - 18.07.06 CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
285.0										
0.0	**TOPSOIL:** (125 mm)				285					
0.1	Silty **SAND** Loose Brown Moist	1	SS	6		~24				
284.4 0.7	**SILT**, some sand to sandy, trace clay Very Loose Brown Moist to Wet	2	SS	3	284	~23	0	19	74	7
		3	SS	1	283	~26				
282.7 2.3	**SILT and SAND**, trace clay, trace gravel, trace wood fragments Very Loose to Compact Brown to Grey Wet (TILL)	4	SS	1	282	~24				
		5	SS	3		~22				
		6	SS	15	281	~32				
	Becoming Very Dense	7	SS	100	280	~20	1	46	47	4
		8	SS	100/ .225	279	~15				
277.9 7.2	END OF BOREHOLE AT 7.16 m. REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN TO 6.25 m. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.				278					

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)

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 2331-MAG.GPJ 24/10/06

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-28

METRIC

W.P. 473-93-00 LOCATION N 5 052 953.09 E 311 418.34 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

HWY 11 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel COMPILED BY JHL

DATUM Geodetic DATE 19.07.06 - 19.07.06 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.1							
0.0	**TOPSOIL**: (100 mm)						
0.1	Sandy **SILT**, some clay Compact to Very Dense Brown Moist	1	SS	20	287		
		2	SS	17	286		
		3	SS	13	285		0 26 56 18
		4	SS	61			
283.7 3.4	**SAND**, trace to some silt, trace clay, trace gravel Compact to Very Dense Brown to Grey Moist to Wet	5	SS	53	284 (water level ▽)		
		6	SS	29	283		0 92 6 (SI+CL)
					282		
		7	SS	33			
281.2 5.9	Sandy **SILT**, trace gravel, occasional cobbles Dense Grey Wet (TILL)				281		
280.4 6.7	END OF BOREHOLE AT 6.69 m. REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE OPEN AND WATER LEVEL AT 3.2 m UPON COMPLETION. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.						

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-29

METRIC

W.P.	473-93-00	LOCATION	N 5 052 957.38 E 311 429.49 Magnetawan River/Hwy 520 Overpass (NBL)	ORIGINATED BY	SLL
HWY	11	BOREHOLE TYPE	Hollow Stem Augers / NW Casing / NQ Core Barrel	COMPILED BY	JHL
DATUM	Geodetic	DATE	18.07.06 - 19.07.06	CHECKED BY	AEG

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	UNIT WEIGHT / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.7 / 0.0	**TOPSOIL**: (75 mm)						
0.1	Sandy **SILT**, Loose to Compact, Brown, Moist	1	SS	9	~20		
		2	SS	13	~26		
285.4 / 1.2	Clayey **SILT**, trace sand, trace roots, Very Stiff, Brown, Moist				~35		
		3	SS	20	~20		0 6 67 27
284.4 / 2.2	**SAND**, some silt to silty, Compact to Dense, Brown, Moist to Wet	4	SS	25	~20		
		5	SS	36	~18		0 77 21 (SI+CL)
		6	SS	21	~20		
281.2 / 5.5	Gravelly **SAND**, trace silt, some cobbles and boulders	1	RUN				
		2	RUN				
279.7 / 6.9	**BEDROCK**					FI 2	
279.3 / 7.3	Pink, white and black, crystalline, faintly weathered to fresh, strong, **GRANITIC GNEISS**. Subvertical joint from 7.06 to 7.11 m. Slightly weathered, rough joint surface					10, 5	RUN 3#, TCR=100%, SCR=74%, RQD=28%, UCS=79MPa
	Pink, white and black, crystalline, faintly weathered to fresh, strong, **GRANITE (PEGMATITE)**. Rubble zone from 7.32 to 7.42 m. Rubble zone from 8.12 to 8.46 m	3	RUN			5, 10	
	Rubble zone from 9.12 to 9.17 m. Rubble zone from 9.30 to 9.93 m	4	RUN			6, 5, 5, 10, 10	RUN 4#, TCR=100%, SCR=76%, RQD=34%, UCS=83MPa
276.7							

Groundwater level ▼ at approx. elev. 284.1. Elevation scale: 286, 285, 284, 283, 282.

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

Continued Next Page

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 06-29

METRIC

W.P. 473-93-00 | LOCATION N 5 052 957.38 E 311 429.49 Magnetawan River/Hwy 520 Overpass (NBL) | ORIGINATED BY SLL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel | COMPILED BY JHL

DATUM Geodetic | DATE 18.07.06 - 19.07.06 | CHECKED BY AEG

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
9.9	END OF BOREHOLE AT 9.93 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
07/20/06	2.71	283.99
07/21/06	2.70	284.00
07/22/06	2.73	283.97
07/23/06	2.71	283.99
07/24/06	2.70	284.00
07/25/06	2.70	284.00
07/26/06	2.69	284.01

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 06-30

METRIC

W.P. 473-93-00 | LOCATION N 5 053 008.85 E 311 412.81 Magnetawan River/Hwy 520 Overpass (NBL) | ORIGINATED BY SLL

HWY 11 | BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel | COMPILED BY JHL

DATUM Geodetic | DATE 18.07.06 - 20.07.06 | CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.6						
0.0 / 0.0	**TOPSOIL**: (50 mm)					
	SAND, some silt, some brick fragments, trace roots Loose to Very Dense Brown Moist (FILL)	1	SS	9		
					289	
		2	SS	50/ .100		
288.1 / 1.4	Sandy **SILT**, trace clay, occasional gravel Dense to Compact Brown Moist to Wet				288	
		3	SS	7		
		4	SS	42	287	0 16 79 5
		5	SS	24		
					286	
	Becoming Grey	6	SS	22		
					285	
284.7 / 4.9	**SAND and SILT**, trace clay, trace gravel Very Dense Grey Wet					
		7	SS	88	284	2 50 40 7
283.5 / 6.1	Gravelly **SAND**, trace silt Very Dense Grey Wet				283	
		8	SS	51		
					282	
	Boulder and cobbles at 8.23 to 8.43 m				281	
280.8 / 8.8	**BEDROCK** Pink, white and black, crystalline, faintly weathered to fresh, thinnly banded, very strong, **GRANITIC GNEISS** subvertical joint from 9.12 to 9.14 m Slightly weathered, rough joint surface with some sand	1	RUN			FI: 3, 7, 6, 5 RUN 1# TCR=86%, SCR=81%, RQD=52%, UCS=131MPa RUN 2#

Groundwater level symbol (▼) shown at approx. elev. 284.8.

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

RECORD OF BOREHOLE No 06-30

METRIC

W.P. 473-93-00 LOCATION N 5 053 008.85 E 311 412.81 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

HWY 11 BOREHOLE TYPE Hollow Stem Augers / NW Casing / NQ Core Barrel COMPILED BY JHL

DATUM Geodetic DATE 18.07.06 - 20.07.06 CHECKED BY AEG

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Rubble zone from 9.63 to 9.68 m Subvertical joints from 9.78 to 9.86 m and from 10.21 to 10.31 m Slightly weathered, rough joint surface		2	RUN						6 4	TCR=100%, SCR=100%, RQD=26%, UCS=147MPa
			3	RUN						5 4	RUN 3# TCR=100%, SCR=76%, RQD=76%, UCS=210MPa
277.0			4	RUN						4 6 3 1	RUN 4# TCR=97%, SCR=97%, RQD=53%, UCS=160MPa
12.5	END OF BOREHOLE AT 12.55 m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
07/21/06	4.97	284.63
07/22/06	4.96	284.64
07/23/06	4.97	284.63
07/24/06	4.95	284.65
07/25/06	4.96	284.64
07/26/06	4.97	284.63

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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 06-31

METRIC

W.P. 473-93-00 LOCATION N 5 053 009.08 E 311 427.84 Magnetawan River/Hwy 520 Overpass (NBL) ORIGINATED BY SLL

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

DATUM Geodetic DATE 20.07.06 - 20.07.06 CHECKED BY AEG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.3							
0.0	TOPSOIL: (75 mm)						
0.1	Silty **SAND**, trace gravel, Very Dense, Brown, Moist (FILL). Cobbles from 0.69 to 1.22 m	1	SS	50	288	o	
286.8 / 1.4	Sandy **SILT**, trace clay, trace roots, Loose, Brown, Moist	2	SS	4	287	o	
286.1 / 2.2	Silty **CLAY**, trace to some sand, occasional sand layers and cobbles, Hard, Brown, Moist (CL-CI)	3	SS	100/ 275	286	o	
		4	SS	100/ 275	285	wP–w–wL	0 3 52 44
		5	SS	60	284	o	
283.7 / 4.6	**SAND and SILT**, trace clay, trace gravel, Compact, Grey, Wet	6	SS	28	283	o	
	Becoming Very Dense some gravel, occasional cobbles						
281.9 / 6.3	Gravelly **SAND**, trace silt, Very Dense, Grey, Wet	7	SS	83	282 / 281	o	33 49 9 (SI+CL)
280.0 / 8.3	END OF BOREHOLE AT 8.25 m. REFUSAL ON PROBABLE BEDROCK OR BOULDERS. BOREHOLE GROUTED WITH BENTONITE TO SURFACE.						

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

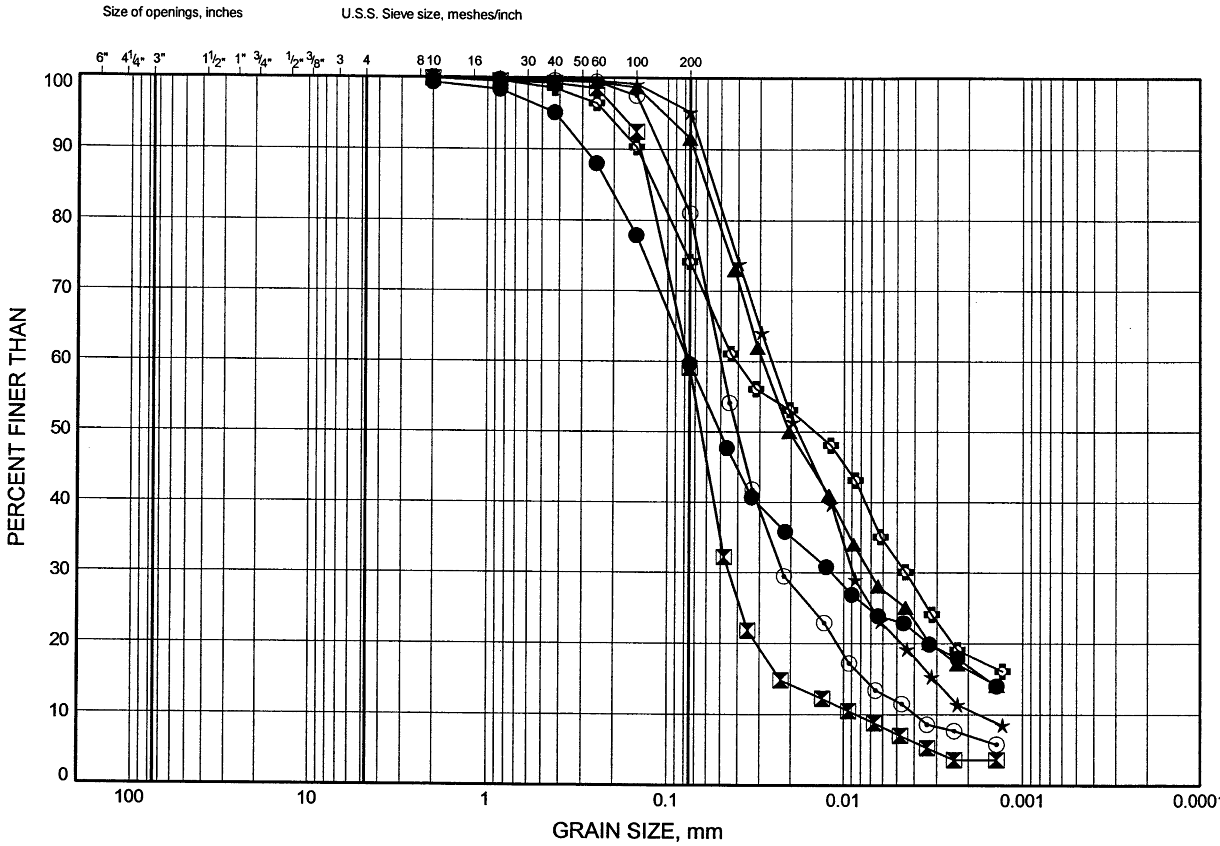
+[3], ×[3]: Numbers refer to Sensitivity 20 15 5 10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL **GRAIN SIZE DISTRIBUTION**	FIGURE B1

SANDY SILT TO SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-21	1.07	286.20
⊠	06-23	1.07	284.97
▲	06-24	2.59	282.39
★	06-25	2.59	282.53
⊙	06-27	1.07	283.97
✪	06-28	1.83	285.25

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Date October 2006

Project 473-93-00

THURBER

Prep'd JHL

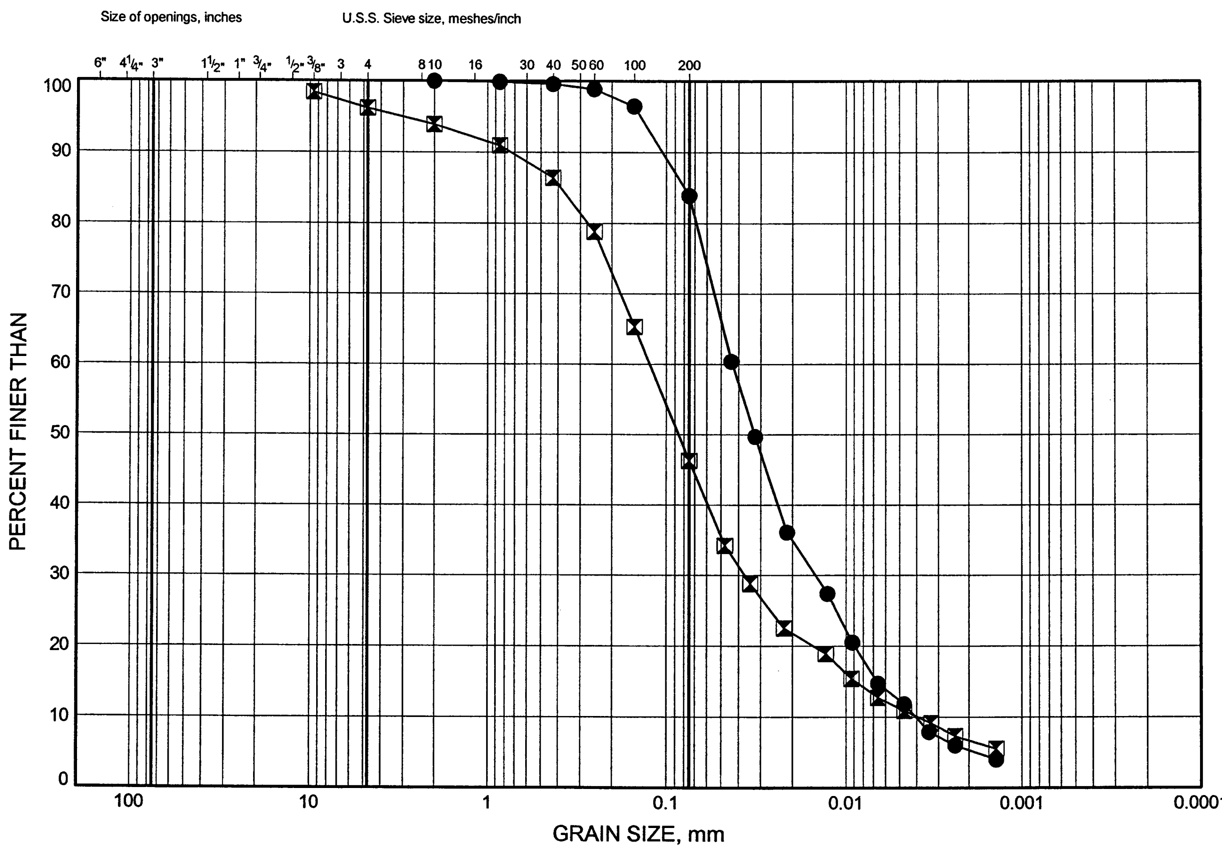
Chkd. MEF

Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL

GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY SILT TO SILT



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-30	2.59	287.00
⊠	06-30	5.64	283.95

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Date October 2006

Project 473-93-00

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Prep'd JHL

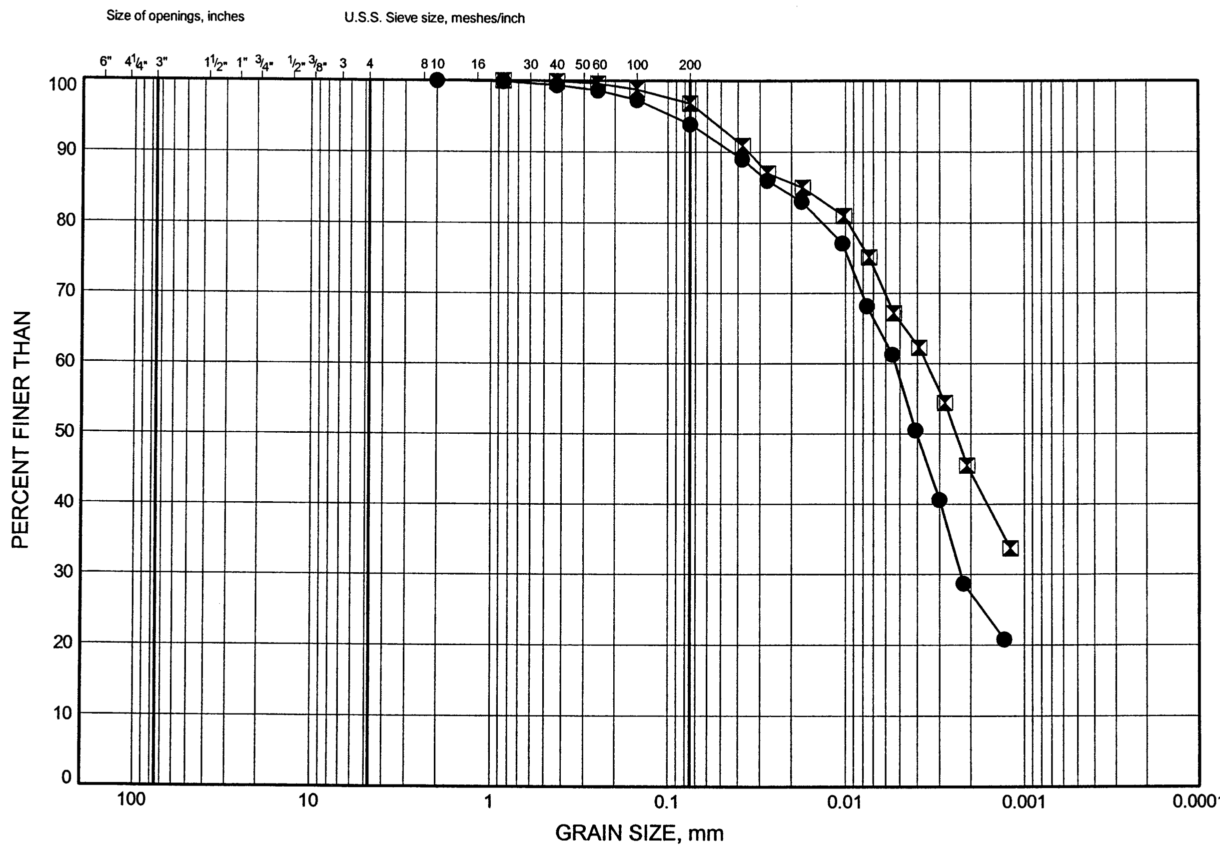
Chkd. MEF

Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL

GRAIN SIZE DISTRIBUTION

FIGURE B3

CLAYEY SILT TO SILTY CLAY



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-29	1.83	284.82
⊠	06-31	3.21	285.08

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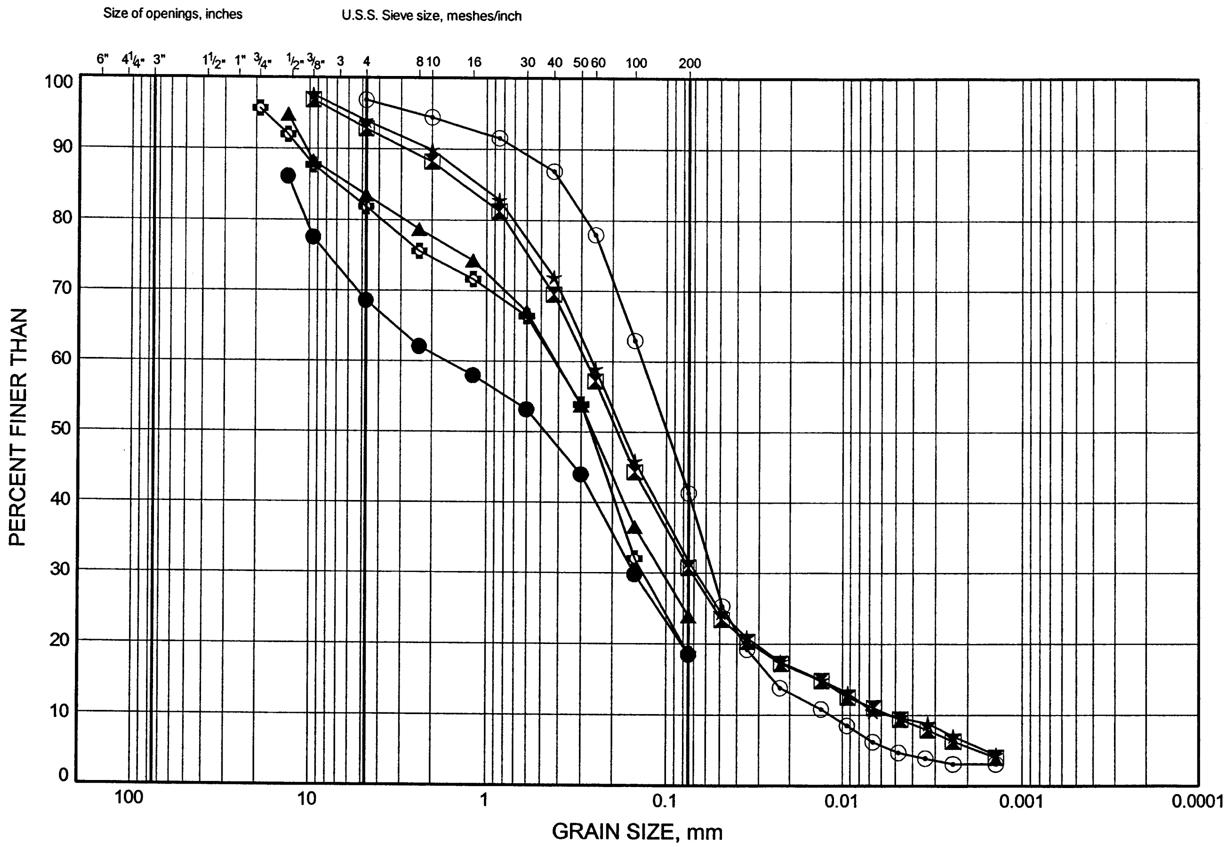
Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL GRAIN SIZE DISTRIBUTION	FIGURE B4

SILTY SAND TO SAND AND SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-21	4.88	282.39
⊠	06-22	1.83	283.35
▲	06-22	3.35	281.83
★	06-23	3.35	282.68
⊙	06-24	9.20	275.78
✪	06-25	7.25	277.87

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Date October 2006

Project 473-93-00

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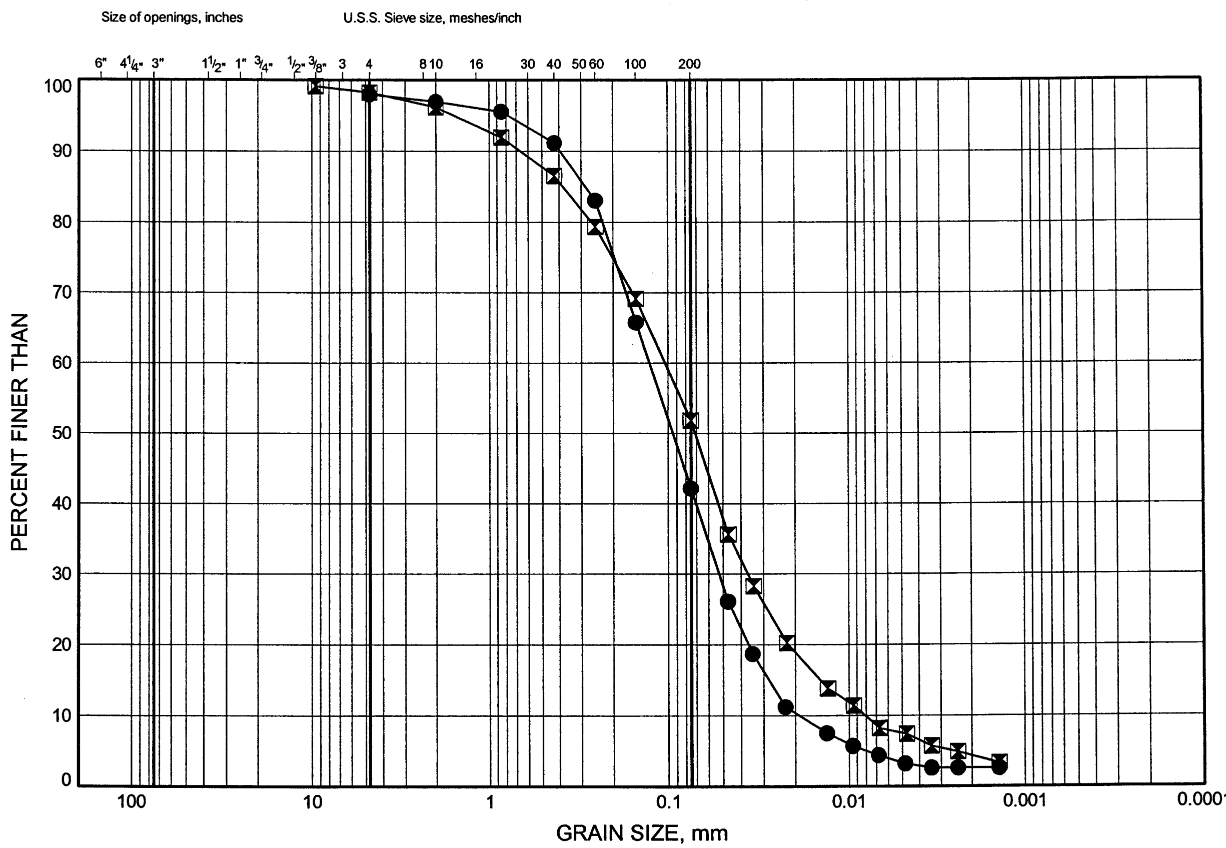
Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY SAND TO SAND AND SILT TILL



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-26	5.72	280.09
⧗	06-27	5.56	279.48

THURBGSD 2331-MAG.GPJ 06/10/06

Date October 2006

Project 473-93-00

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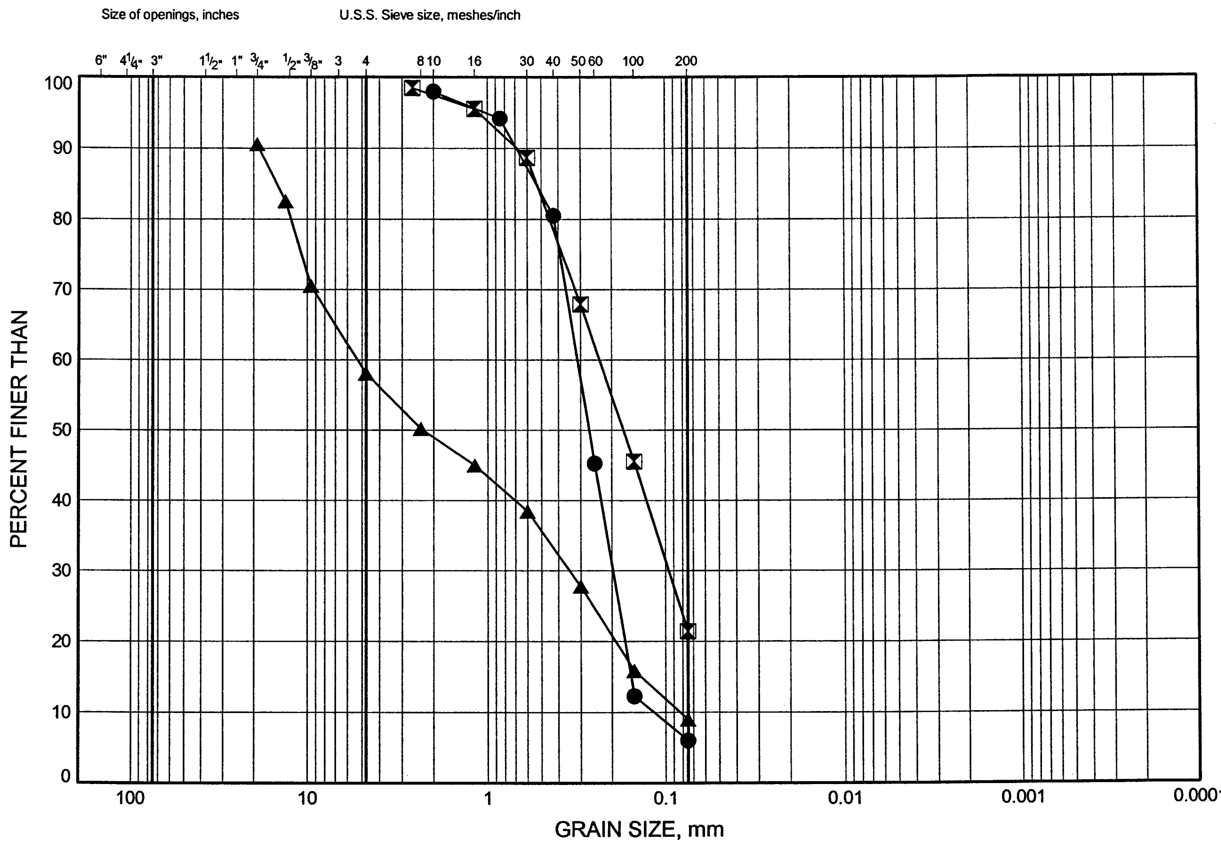
Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND TO GRAVELLY SAND



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

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-28	4.11	282.96
⊠	06-29	3.35	283.30
▲	06-31	7.11	281.19

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Date October 2006

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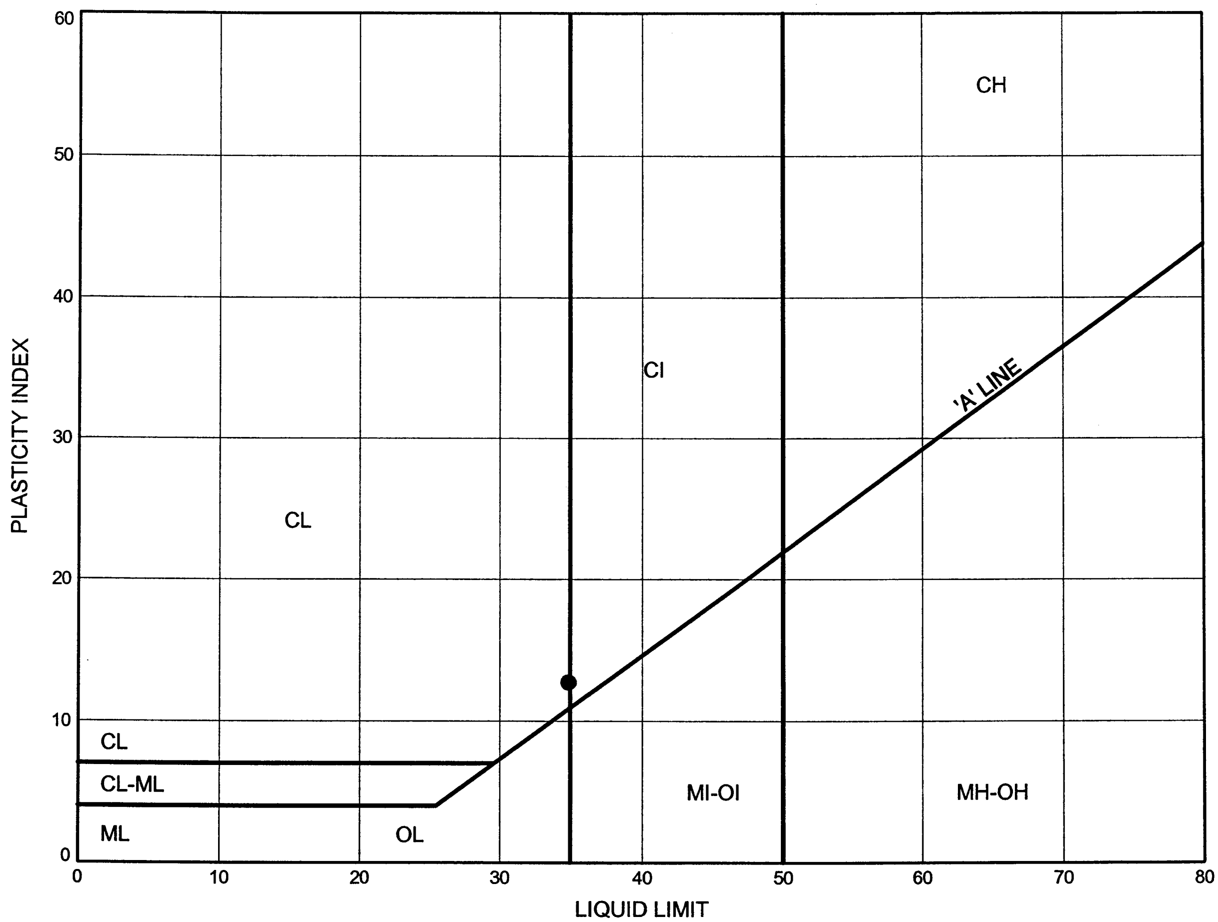
Chkd. MEF

Magnetawan River/Hwy 520 Overpass, Hwy 11 NBL

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	06-31	3.21	285.08

THURBALT 2331-MAG.GPJ 06/10/06

Date October 2006

Project 473-93-00

THURBER

Prep'd JHL

Chkd. MEF

TABLE B1 - Point Load Test Results
Magnetawan River/Hwy. 520 Overpass

Depth Feet	Depth Inches	m	Is50	UCS (MPa)
06-21				
23	3	7.09	4.78	114.77
24	7	7.49	5.65	135.64
25	7	7.80	5.00	119.99
26	8	8.13	6.96	166.94
27	8	8.43	3.04	73.04
29	0	8.84	2.17	52.17
30	0	9.14	4.35	104.34
30	10	9.40	3.04	73.04
31	8	9.65	4.35	104.34
32	8	9.96	3.26	78.25

Total Rock Core

Average	Minimum	Maximum	
102	52	167	MPa

Run #	Average
1	114.77
2	109.55
3	89.99

Depth Feet	Depth Inches	m	Is50	UCS (MPa)
06-22				
29	10	9.09	9.11	218.76
30	10	9.40	4.77	114.59
31	10	9.70	7.81	187.51
32	10	10.01	6.08	145.84
33	10	10.31	3.04	72.92
35	7	10.85	6.94	166.67
36	11	11.25	6.29	151.05

Total Rock Core

Average	Minimum	Maximum
151	73	219

Run #	Average
2	166.67
3	72.92
4	158.86

Depth Feet	Depth Inches	m	Is50	UCS (MPa)
06-24				
35	4	10.77	1.74	41.73
36	4	11.07	7.39	177.37
37	4	11.38	6.30	151.29

Total Rock Core

Average	Minimum	Maximum
123	42	177

Run #	Average
1	123.46

Depth Feet	Depth Inches	m	Is50	UCS (MPa)
06-25				
39	6	12.04	7.00	168.00
41	0	12.50	8.75	210.00
43	0	13.11	7.00	168.00
44	2	13.46	3.94	94.50
45	0	13.72	8.75	210.00
46	2	14.07	8.97	215.25
47	2	14.38	9.19	220.50
48	0	14.63	8.09	194.25
50	10	15.49	5.69	136.50
51	7	15.72	3.06	73.50

Total Rock Core

Average	Minimum	Maximum	
169	74	221	MPa

Run #	Average
1	189.00
2	181.65
3	134.75

Depth				UCS
Feet	Inches	m	Is50	(MPa)
06-26				
34	0	10.36	0.43	10.37
35	0	10.67	4.75	114.05
36	0	10.97	5.62	134.78
36	10	11.23	5.18	124.41
37	10	11.53	5.18	124.41
39	0	11.89	0.22	5.18
40	0	12.19	5.18	124.41
41	2	12.55	5.18	124.41
42	4	12.90	6.26	150.33

Total Rock Core

Average	Minimum	Maximum	
101	5	150	MPa

Run #	Average
3	101.60
4	101.09

Depth				UCS
Feet	Inches	m	Is50	(MPa)
06-29				
23	0	7.01	7.13	171.07
24	5	7.44	2.59	62.21
25	5	7.75	3.02	72.57
27	11	8.51	4.32	103.68
29	0	8.84	5.83	139.97
30	0	9.14	1.08	25.92

Total Rock Core

Average	Minimum	Maximum
96	26	171

Run #	Average
2	171.07
3	79.49
4	82.94

Depth				UCS
Feet	Inches	m	Is50	(MPa)
06-30				
29	4	8.94	3.06	73.38
31	0	9.45	6.77	162.49
32	0	9.75	6.55	157.25
33	2	10.11	5.68	136.28
34	0	10.36	6.55	157.25
35	2	10.72	8.74	209.67
36	4	11.07	7.43	178.22
37	2	11.33	6.99	167.73
38	2	11.63	6.77	162.49
40	1	12.22	5.46	131.04

Total Rock Core

Average	Minimum	Maximum	
154	73	210	MPa

Run #	Average
1	131.04
2	146.77
3	209.67
4	159.87

Appendix C

Factual Information from AGRA

AGRA

Foundation Design

Enclosure # 1

RECORD OF BOREHOLE No 1

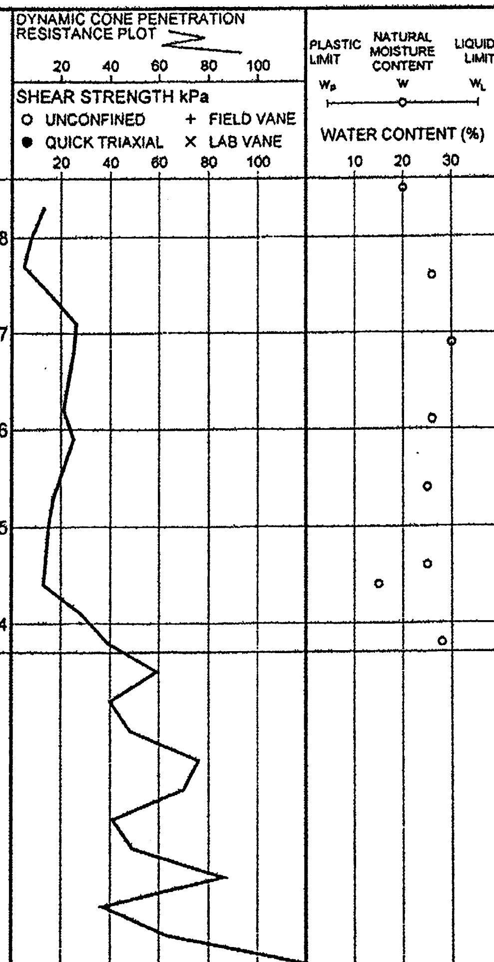
METRIC

W.P. 473-93-00 | LOCATION N 5053018.1 E311419.7 | ORIGINATED BY MA

DIST 52 HWY 11 | BOREHOLE TYPE Hollow Stem Augering | COMPILED BY AD

DATUM Geodetic | DATE 28 May 1999 | CHECKED BY SP

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.6 / 0.0	0.15m TOPSOIL brown **Silty Sand FILL** trace Gravel, rootlets loose to compact moist	1	SS	7	288		
		2	SS	19			
287.2 / 1.4	brown **SANDY SILT** with occasional Clay & Silt seams compact wet	3	SS	12	287		
		4	SS	16	286		0 53 47 0
285.3 / 3.3	brown to grey **SAND** with Gravel loose wet	5	SS	16	285		
		6	SS	7			
284.2 / 4.4	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)**, very dense, wet	7	SS	50/8	284		
283.7 / 4.9	END of BOREHOLE AUGER REFUSAL ON BOULDER						
280.1 / 8.5	END of DCPT DCPT conducted 1.0m south Water Level in Piezometer: July 9/99: 4.1m depth Sept 3/99: 4.3m depth Elev. 284.3m						



UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

AGRA

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Enclosure # 2

RECORD OF BOREHOLE No 2

METRIC

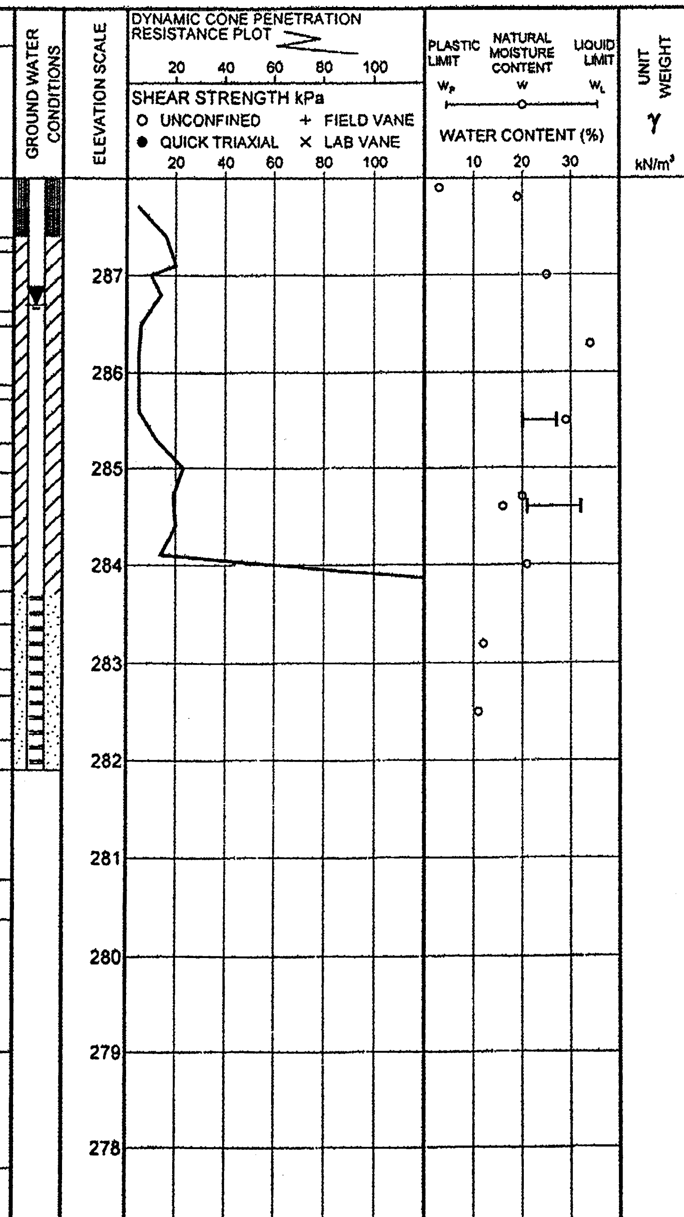
W.P. 473-93-00 | LOCATION N 5053001.8 E311426.4 | ORIGINATED BY MA

DIST 52 HWY 11 | BOREHOLE TYPE Hollow Stem Augering | COMPILED BY AD

DATUM Geodetic | DATE 28 May 1999 | CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.0 / 0.0	0.15m TOPSOIL; brown to grey Organic stained Silty Sand FILL, trace Gravel, rootlets, Clay pockets, decomposed Organics, stiff to firm, damp	1	SS	11	
		2	SS	6	
286.6 / 1.4	brown to grey Silty Clay FILL, trace to some Organics, trace Gravel, firm to hard, damp	3	SS	4	
		4	SS	40	
284.7 / 3.3	brown SANDY SILT, trace Clay, compact, wet	5	SS	37	0 22 63 15
		6	SS	13	
283.6 / 4.4	brown SAND & GRAVEL, dense, wet	7	SS	48	
		8	SS	39	59 33 (8)
282.0 / 6.0	HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL), frequent Cobbles & Boulders (INFERRED)	9	RC		Auger Refusal @5.8m on boulders
		10	RC		
280.2 / 7.8	GRANITE BEDROCK (PEGMATITE), massive, closely to moderately closely jointed	11	RC		RC11: REC=100% R.Q.D.=75%
		12	RC		RC12: REC=96% R.Q.D.=31%
		13	RC		RC13: REC=92% R.Q.D.=17%
277.2 / 10.8	END of BOREHOLE				

Water Level in Piezometer:
July 9/99: 0.9m depth
Sept 3/99: 1.3m depth
Elev. 286.7m



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

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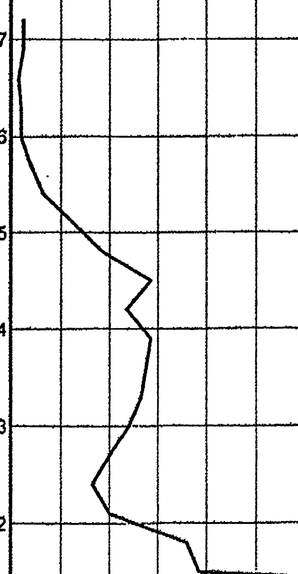
Enclosure # 1

RECORD OF BOREHOLE No 3

METRIC

W.P. 473-93-00	LOCATION N 5052964.8 E311426.5	ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT)	COMPILED BY AD
DATUM Geodetic	DATE 28 May 1999	CHECKED BY SP

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 (%) (10, 20, 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
287.5 / 0.0	NO SAMPLING & TESTING						287, 286, 285, 284, 283, 282				
281.5 / 6.1	END of DCPT										

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

AGRA

RECORD OF BOREHOLE No 4

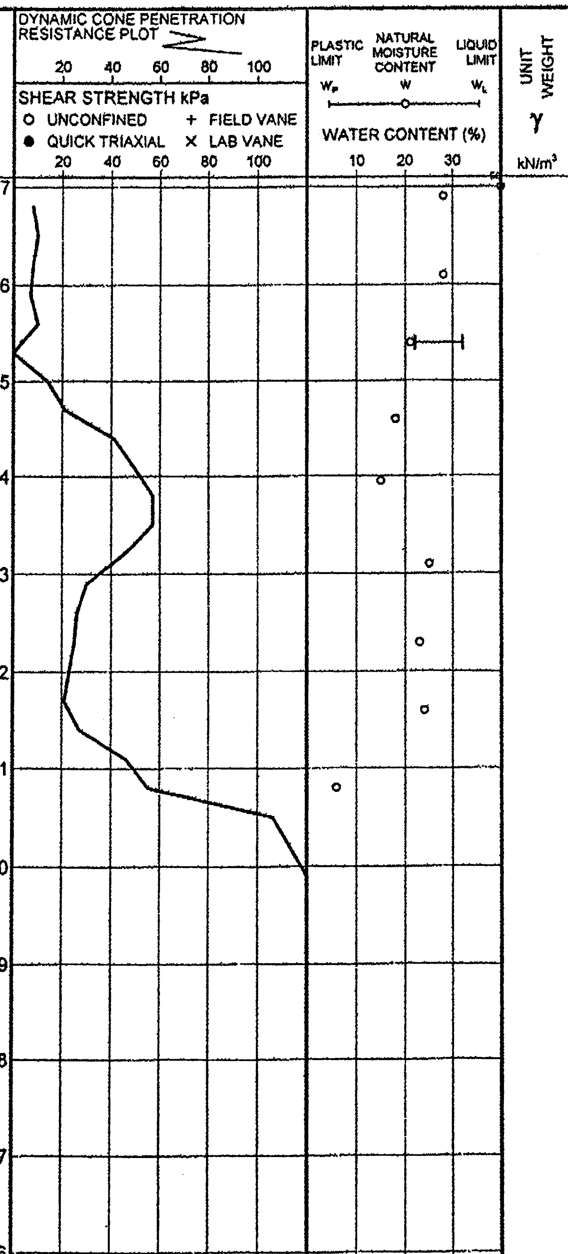
METRIC

W.P. 473-93-00 | LOCATION N 5052951.7 E311416.0 | ORIGINATED BY MA

DIST 52 HWY 11 | BOREHOLE TYPE Hollow Stem Augering | COMPILED BY AD

DATUM Geodetic | DATE 27 May 1999 | CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.1 / 0.0	0.1m TOPSOIL	1	SS	12	287	
	grey/brown Silty Clay FILL, Organic stained, stiff to firm, moist	2	SS	13	286	
284.9 / 2.2	with Sand	3	SS	7	285	
	brown SAND, wet; Silty trace Gravel	4	SS	36		10 57 31 2
	dense	5	SS	34	284	
	compact	6	SS	11	283	
	loose	7	SS	5	282	
281.2 / 5.9		8	SS	8		
	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL), compact to very dense, wet	9	SS	24	281	12 71 16 1
					280	Auger Refusal @7.6m on cobbles & boulders
279.0 / 8.1	Cobbles	10	SS	50/14		
	GRANITE BEDROCK, massive, closely to moderately closely jointed	11	RC		279	RC11: REC=100% R.Q.D.=100%
		12	RC		278	RC12: REC=100% R.Q.D.=88%
275.9 / 11.2		13	RC		277	RC13: REC=100% R.Q.D.=79%
					276	



END of BOREHOLE

DCPT conducted 1.0m north

Water Level in Piezometer:
July 9/99: 2.8m depth
Sept 3/99: 3.1m depth
Elev. 284.0m

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

AGRA

Foundation Design

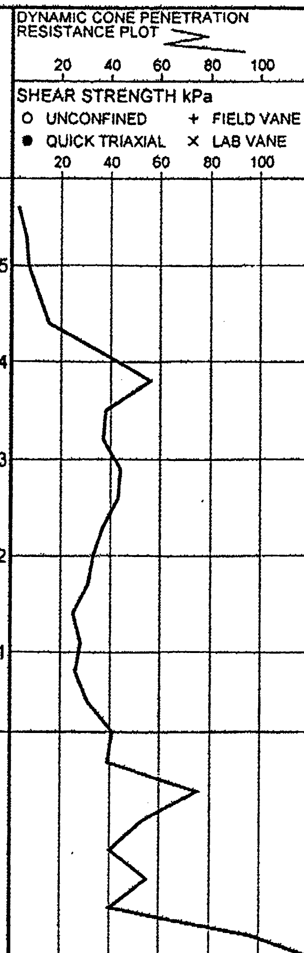
Enclosure # 5

RECORD OF BOREHOLE No 5

METRIC

W.P. 473-93-00	LOCATION N 5052933.2 E311423.3	ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering	COMPILED BY AD
DATUM Geodetic	DATE 27 May 1999	CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.9 / 0.0	TOPSOIL	1	SS	4		
285.3 / 0.6	grey Clayey Silt FILL, Organic stained, stiff to hard, moist	2	SS	9		
		3	SS	40		
	Sandy	4	SS	14		0 24 70 6
283.0 / 2.9	grey SILTY SAND, trace decomposed Organics, compact, wet	5	SS	11		
282.3 / 3.6	brown SAND, loose, wet	6	SS	6		
		7	SS	5		
280.5 / 5.4	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL), very dense	8	SS	60/23		18 53 29 0
280.2 / 5.7	END of BOREHOLE AUGER REFUSAL ON BOULDER					
277.7 / 8.2	END of DCPT DCPT test conducted 1.0m north Water Level in Piezometer: July 9/99: 2.0m depth Sept 3/99: 2.4m depth Elev. 283.5m					



PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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Enclosure # 6

RECORD OF BOREHOLE No 6

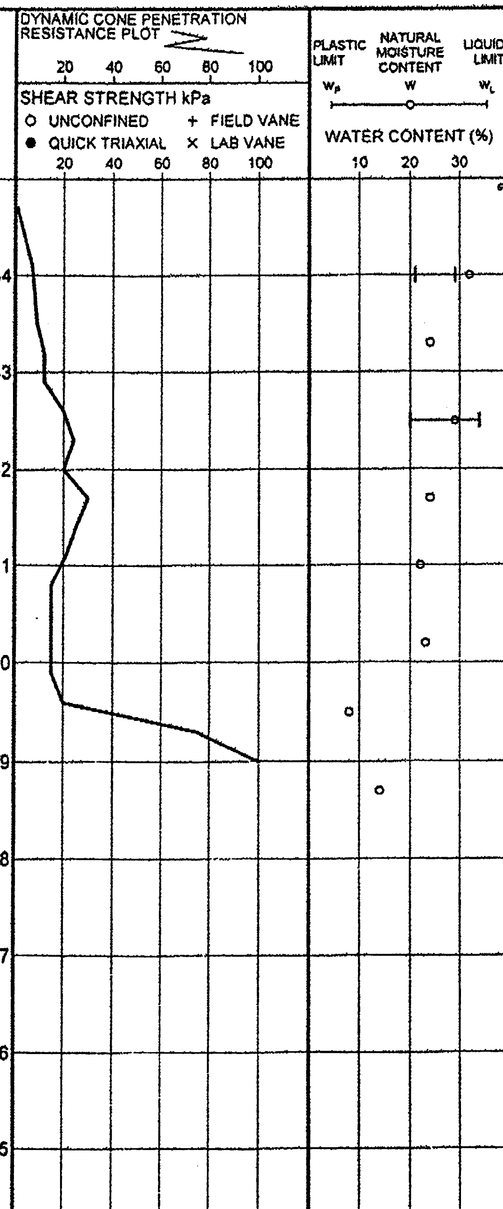
METRIC

W.P. 473-93-00	LOCATION N 5052911.9 E311432.6		ORIGINATED BY MA
DIST 52	HWY 11	BOREHOLE TYPE Hollow Stem Augering	COMPILED BY AD
DATUM Geodetic	DATE 29 May 1999		CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.0 / 0.0	TOPSOIL with coal fragments	1	SS	2		
284.4 / 0.6	brown Silty Clay FILL soft moist	2	SS	3	284	
283.6 / 1.4	grey Silty Sand FILL very loose with organics	3	SS	4	283	
282.8 / 2.2	brown Silty Clay FILL firm moist	4	SS	7		
282.1 / 2.9	grey Sand FILL loose wet	5	SS	9	282	
281.5 / 3.5	50mm clay & peat layer; brown SAND very loose wet	6	SS	4	281	
	loose	7	SS	9	280	
279.8 / 5.2	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL) with frequent Cobbles compact to very dense wet	8	SS	21		12 58 27 3
		9	SS	31	279	Auger Refusal @7.0m
		~~10~~	~~SS~~	~~50/0~~	278	
277.7 / 7.3	GRANITE BEDROCK massive, closely to moderately closely jointed	11	RC			RC11: REC=72% R.Q.D.=50%
		12	RC		277	RC12: REC=42% R.Q.D.=18%
		13	RC		276	RC13. REC=100% R.Q.D.=100%
		14	RC		275	RC14: REC=95% R.Q.D.=85%
274.3 / 10.7	END of BOREHOLE					

DCPT conducted 1.0m west

Water Level in Piezometer:
Sept 3/99: 1.3m depth
Elev. 283.7m



UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity O³% STRAIN AT FAILURE

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Enclosure # 7

RECORD OF BOREHOLE No 7

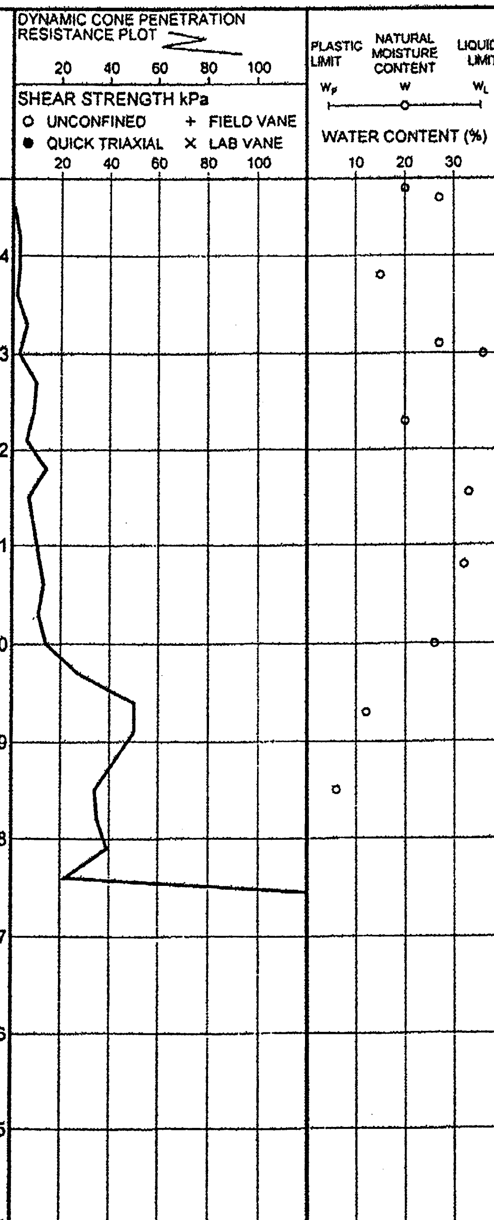
METRIC

W.P. 473-93-00	LOCATION N 5052883.4 E311421.7	ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering	COMPILED BY AD
DATUM Geodetic	DATE 30 May 1999	CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.8 / 0.0	0.3m PEAT	1	SS	1		
	brown **Silty Sand FILL** very loose to loose moist to wet	2	SS	5	284	
		3	SS	3	283	0 53 47 0
282.8 / 2.0	peat layer					
	grey **SILTY SAND with Organics** very loose wet	4	SS	3	282	
		5	SS	1		0 51 49 0
		6	SS	3	281	
280.4 / 4.4	brown **SAND** loose wet	7	SS	5	280	
279.6 / 5.2	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** with frequent Cobbles & Boulders compact wet	8	SS	23	279	27 50 23 0
		9	SS	26	278	
277.5 / 7.3	**GRANITE BEDROCK** massive, closely to moderately closely jointed	10	RC		277	RC10: REC=83% R.Q.D.=72% RC11: REC=88% R.Q.D.=72%
		11	RC		276	
		12	RC		275	RC12: REC=90% R.Q.D.=70%
		13	RC			RC13: REC=93% R.Q.D.=83%
274.0 / 10.8	END of BOREHOLE				274	

DCPT conducted 1.0m south

Water Level in Piezometer:
Sept 3/99: 1.6m depth
Elev. 283.2m



$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

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Foundation Design

Enclosure # 3

RECORD OF BOREHOLE No 8

1 OF 1 **METRIC**

W.P. 473-93-00 LOCATION N 5052893.1 E311433.0 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY AD

DATUM Geodetic DATE 30 May 1999 CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.7 / 0.0	**TOPSOIL** with coal fragments	1	SS	2	
284.1 / 0.6	grey Sand **FILL** some Organics, Gravel very loose wet	2	SS	4	
		3	SS	2	
282.9 / 1.8	**PEAT**				
282.5 / 2.2	grey **SAND with Organics** very loose wet	4	SS	2	
		5	SS	3	
281.1 / 3.6	grey **SILTY SAND** occasional Organic layers loose wet	6	SS	5	0 60 40 0
		7	SS	9	
279.5 / 5.2	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** with frequent Cobbles occasional Sand layers compact to very dense wet	8	SS	38	19 56 25 0
		9	SS	50	
		10	SS	89	16 56 28 0
276.5 / 8.3	END of BOREHOLE				

AUGER REFUSAL ON PROBABLE BEDROCK

DCPT conducted 1.0m east

Water Level in Piezometer:
Sept 3/99: 1.7m depth
Elev. 283.0m

Elevation scale: 284, 283, 282, 281, 280, 279, 278, 277

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 (%) 10 20 30

UNIT WEIGHT γ kN/m³

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

AGRA

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Enclosure # 4

RECORD OF BOREHOLE No 9

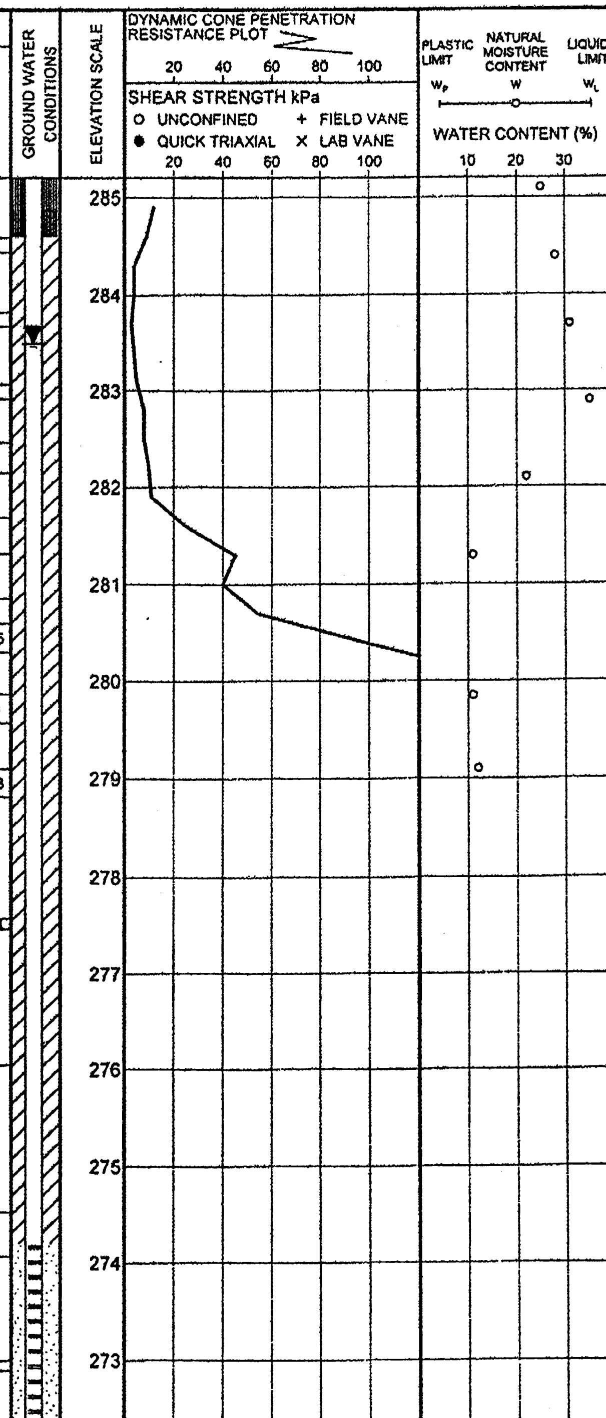
1 OF 1 **METRIC**

W.P. 473-93-00 LOCATION N 5052843.8 E311441.4 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY AD

DATUM Geodetic DATE 31 May 1999 CHECKED BY SP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.2 0.0	0.2m TOPSOIL SAND with Organics FILL loose	1	SS	5		
284.5 0.7	brown Sandy Silt FILL trace Organics very loose wet	2	SS	3		
		3	SS	2		
282.6 2.6	Clayey	4	SS	4	20.2	
281.6 3.6	ORGANIC SILT loose wet	5	SS	10		
280.8 4.4	brown SAND compact wet	6	SS	25		
	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL) with frequent Cobbles very dense wet	7	SS	50/15		
		8	SS	50/5		
		9	SS	50/13		Auger Refusal @7.8m on boulders
275.5 9.7		10	SS	50/11		
	GRANITE BEDROCK massive, closely to moderately closely jointed	11	RC			RC11: REC=100% R.Q.D.=83%
		12	RC			RC12: REC=100% R.Q.D.=72%
		13	RC			RC13: REC=100% R.Q.D.=79%
272.3 12.9		14	RC			RC14: REC=100% R.Q.D.=92%



END of BOREHOLE

DCPT conducted 1.0m north

Water Level in Piezometer:
Nov.8/99: 1.7m depth
Elev. 283.5m

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

AGRA

RECORD OF BOREHOLE No 10

METRIC

W.P. 473-93-00	LOCATION N 5052833.2 E311430.2		ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering		COMPILED BY AD
DATUM Geodetic	DATE 2 June 1999		CHECKED BY SP

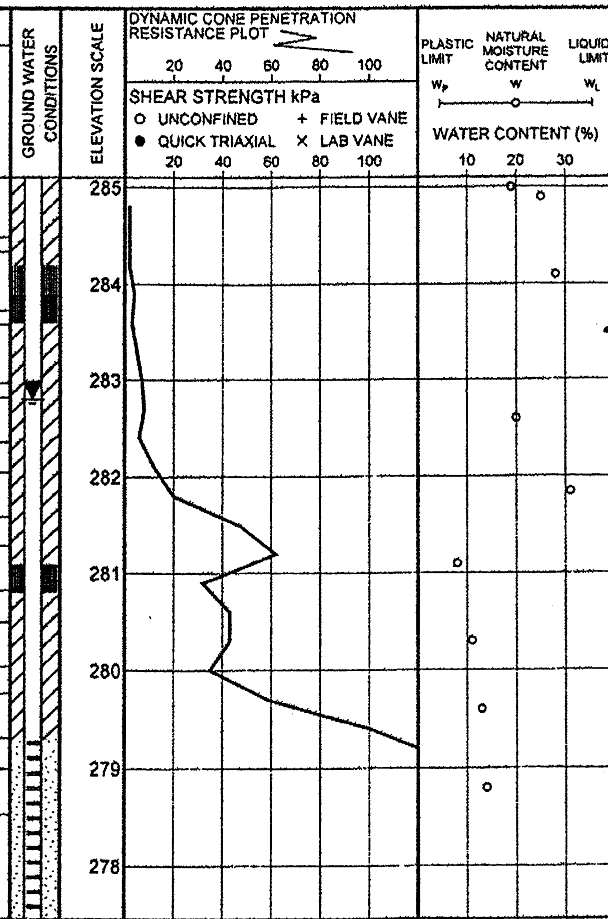
SOIL PROFILE / SAMPLES

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.1 / 0.0	0.1m **TOPSOIL** brown Sandy Silt **FILL** trace Organics very loose moist to wet	1	SS	4		
		2	SS	2		0 25 75 0
283.7 / 1.4	grey **ORGANIC SILT** trace decomposed Organics very loose wet	3	SS	4		
282.8 / 2.3	brown **SAND** loose to compact wet	4	SS	3	17.3	
		5	SS	12		
281.6 / 3.5	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** with frequent Cobbles wet dense very dense	6	SS	37		
		7	SS	65		
		8	SS	89		
		9	SS	65		5 52 43 0
277.5 / 7.7	END of BOREHOLE	10	SS	50/0		

AUGER REFUSAL ON PROBABLE BOULDER

DCPT conducted 1.0m north

Water Level in Piezometer:
Sept 3/99: 2.3m depth
Elev. 282.8m



$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

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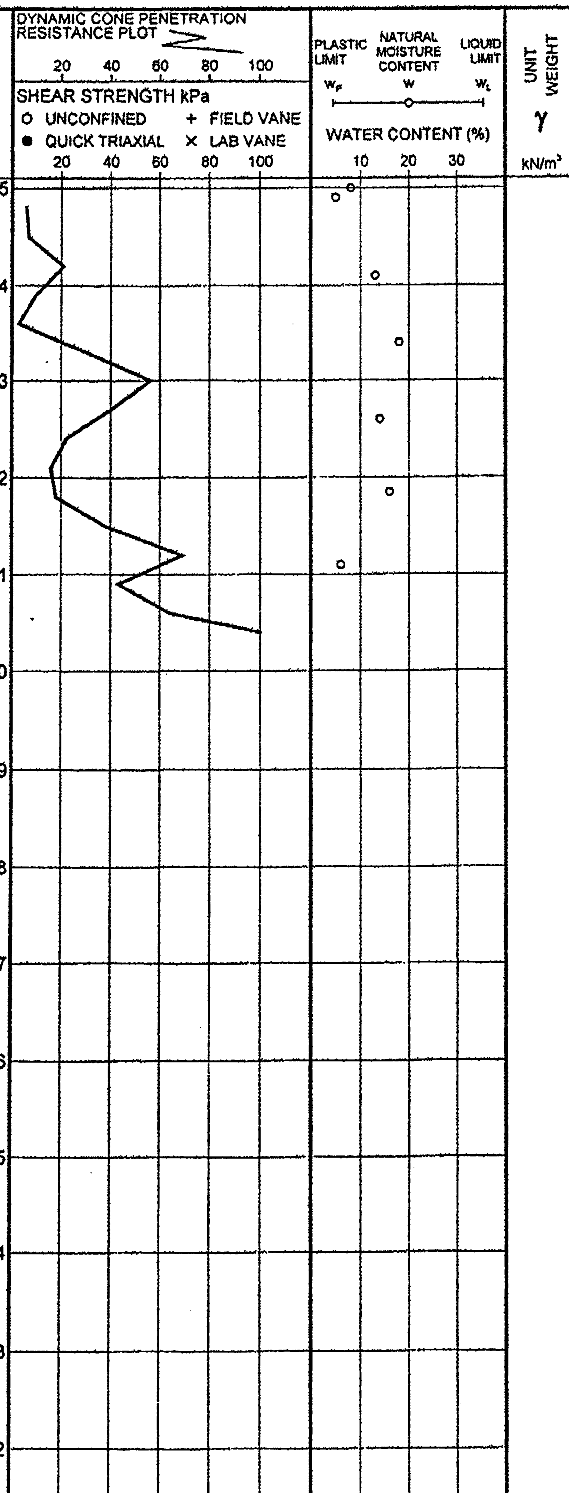
Enclosure # 11

RECORD OF BOREHOLE No 11

METRIC

W.P. 473-93-00	LOCATION N 5052812.2 E311443.2		ORIGINATED BY MA
DIST 52	HWY 11	BOREHOLE TYPE Hollow Stem Augering	COMPILED BY AD
DATUM Geodetic	DATE 31 May 1999		CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.1 / 0.0	0.1m **TOPSOIL**	1	SS	7	
	brown to grey Silty Sand **FILL** trace Gravel, rootlets loose to dense wet	2	SS	20	Auger Refusal @1.8m. Move borehole 1.0m east
		3	SS	35	6 58 36 0
282.9 / 2.2	grey **SILTY SAND** some Gravel, trace Organics compact wet	4	SS	19	18 60 22 0
		5	SS	16	
281.5 / 3.6	**HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** with occasional sand & gravel layers, with frequent Cobbles & Boulders very dense wet	6	SS	50/15	
		7	SS	50/0	Auger Refusal @4.8m
		8	RC		
		9	RC		
		10	RC		
		11	RC		
		12	RC		RC13: REC=91% R.Q.D.=9%
274.8 / 10.3	**GRANITE BEDROCK** massive, closely to moderately closely jointed	13	RC		RC14: REC=100% R.Q.D.=68%
		14	RC		RC15: REC=94% R.Q.D.=88%
		15	RC		
271.4 / 13.7	END of BOREHOLE DCPT conducted 2.0m north Water Level in Piezometer: Damaged after installation				



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

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Enclosure # 12

RECORD OF BOREHOLE No 12

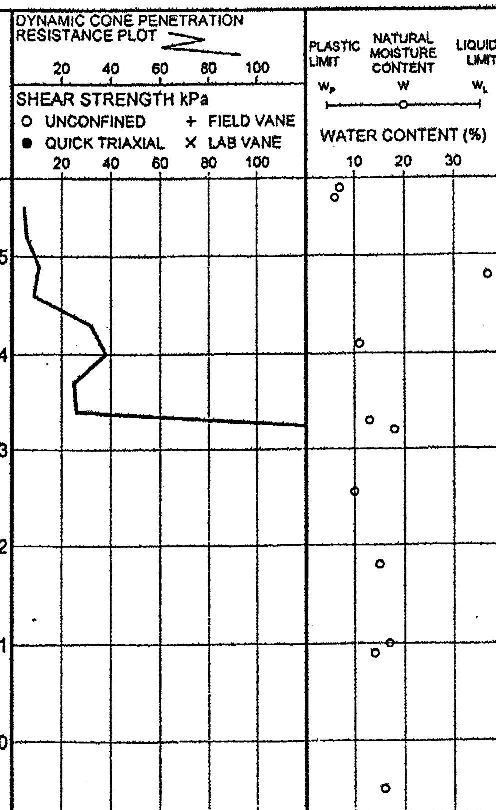
METRIC

W.P. 473-93-00 LOCATION N 5052791.1 E311445.9 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY AD

DATUM Geodetic DATE 2 June 1999 CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.8 / 0.0	0.2m **TOPSOIL** brown Sand **FILL** with Gravel, loose, damp	1	SS	7	
285.1 / 0.7	**TOPSOIL** damp	2	SS	7	
284.4 / 1.4	brown **SAND with Organics** with Gravel, some Silt, frequent Cobbles, compact, wet	3	SS	71/15	31 48 18 3
		4	SS	18	
283.0 / 2.8	grey **SILTY SAND** frequent Cobbles, trace Gravel, rootlets, dense, wet	5	SS	31	
		6	SS	36	1 51 48 0
281.4 / 4.4	**HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles, wet; compact / very dense	7	SS	25	
		8	SS	50/0	
		9	SS	50/5	4 66 30 0
279.3 / 6.6	END of BOREHOLE				



AUGER REFUSAL ON PROBABLE BOULDER

DCPT REFUSAL

Water Level in Piezometer:
Sept 3/99: 1.7m depth
Elev. 284.1m

$+^3$, $\times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

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Foundation Design

Enclosure # 6

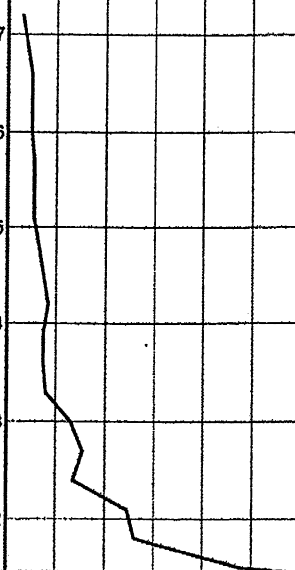
RECORD OF BOREHOLE No 13

1 OF 1 **METRIC**

W.P. 473-93-00 LOCATION N 5052986.3 E311417.2 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY AD

DATUM Geodetic DATE 3 June 1999 CHECKED BY SP

SOIL PROFILE			SAMPLES					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 (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
287.5 0.0	NO SAMPLNG & TESTING						287 286 285 284 283 282				
281.5 6.1	END of DCPT										

$+^3, \times^3$: Numbers refer to Sensitivity O $^{3\%}$ STRAIN AT FAILURE

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Enclosure # 14

RECORD OF BOREHOLE No 14

1 OF 1 **METRIC**

W.P. 473-93-00 LOCATION N 5052725.6 E311463.3 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Solid Stem Augering COMPILED BY AD

DATUM Geodetic DATE 7 September 1999 CHECKED BY SP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS
291.9 / 0.0	0.15m TOPSOIL, brown **SANDY SILT**, trace Organics, damp, very loose	1	SS	3		
291.2 / 0.7	brown **CLAYEY SILT**, hard	2	SS	31	291	
290.7 / 1.2	brown **SAND**, frequent Cobbles, compact, wet	3	SS	19	290	
289.2 / 2.7	END OF BOREHOLE Auger Refusal on Possible Boulders Water Level on completion: none					

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 (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

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

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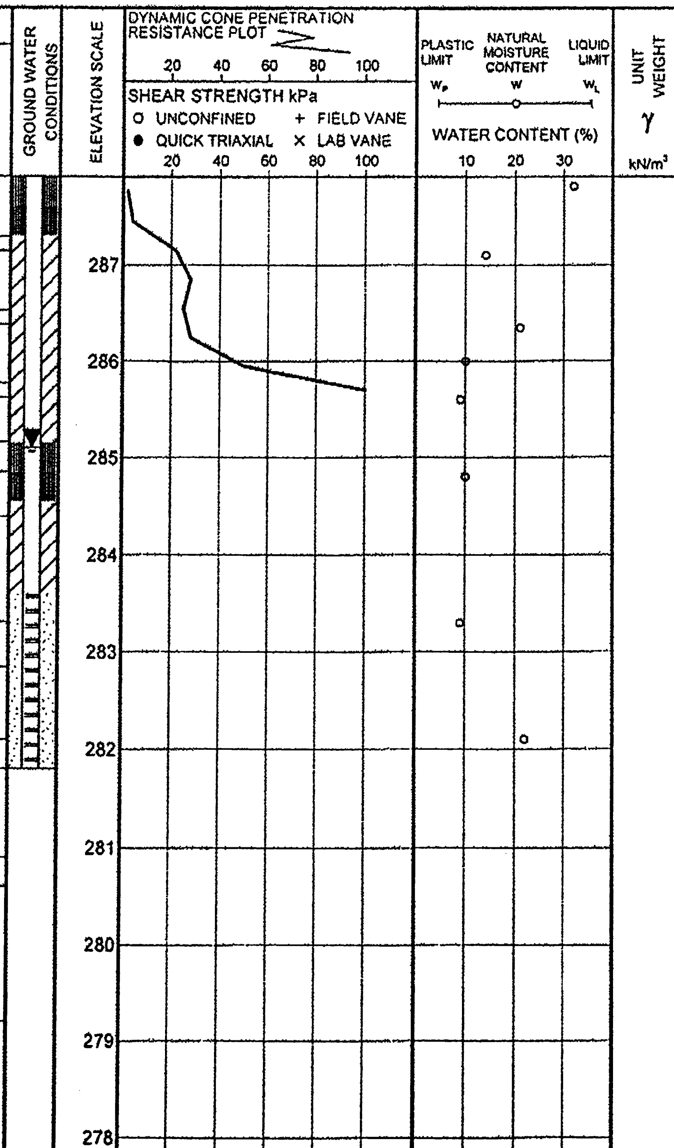
Enclosure # 15

RECORD OF BOREHOLE No 15

1 OF 1 **METRIC**

W.P. 473-93-00	LOCATION N 5052738.1 E311453.2		ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering/Washboring/Rock coring		COMPILED BY AD
DATUM Geodetic	DATE 2 September 1999		CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.9					
0.0	0.35m TOPSOIL	1	SS	6	
	loose / compact				
	Sand FILL with Silt, trace Clay, rootlets damp	2	SS	30	
286.1 / 1.8	brown SAND & GRAVEL some Silt, dense, moist	3	SS	32	
285.7 / 2.2	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles & Boulders moist to wet	4	SS	34	11 65 22 2
		5	SS	49	
		6	SS	35	29 55 (16)
	dense / very dense	7	SS	50/11	
281.0 / 6.9	**GRANITE BEDROCK** massive, closely to moderately closely jointed	8	RC		RC8: REC=100% R.Q.D.=100%
		9	RC		RC9: REC=94% R.Q.D.=69%
		10	RC		RC10: REC=98% R.Q.D.=58%
277.8 / 10.1	END of BOREHOLE				



Water Level in Piezometer:
Sept 10/99: 2.8m depth
Elev. 285.1m

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

$O^{3\%}$ STRAIN AT FAILURE

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Enclosure # 16

RECORD OF BOREHOLE No 16

METRIC

W.P. 473-93-00 LOCATION 19+102 6.5Rt NBL C/L ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Hollow Stem Augering/Washboring COMPILED BY AD

DATUM Geodetic DATE 18 August 1999 CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.4					
0.0	0.1m **TOPSOIL** grey Sandy Silt **FILL** trace rootlets very loose, moist	1	SS	4	
287.5 / 0.9	0.15m **TOPSOIL** grey-brown Clayey Silt **FILL** trace rootlets stiff, damp	2	SS	8	
286.6 / 1.8	brown-grey **SILTY SAND** trace Clay compact, moist — dense, wet	3	SS	13	
		4	SS	16	0 85 (15)
		5	SS	37	
285.0 / 3.4	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles dense to very dense moist to wet	6	SS	74	Auger Refusal @ 3.3m. Advance by wash boring & tri-coning. Casing shoe broken @ 6.8m.
		7	SS	50/10	
		8	SS	59	
		9	SS	45	
281.4		10	SS	50/13	
7.0	END of BOREHOLE				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (288, 287, 286, 285, 284, 283, 282); 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 (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No 17

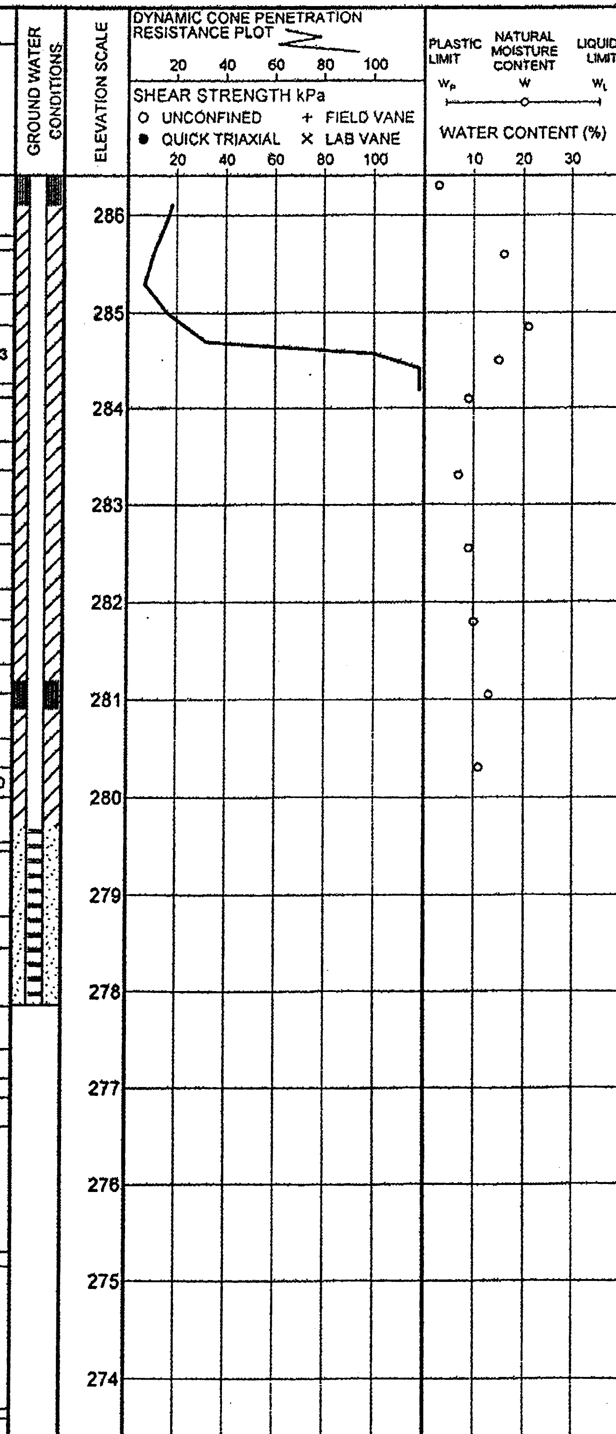
1 OF 1 **METRIC**

W.P. 473-93-00	LOCATION N 5052778.7 E311453.3		ORIGINATED BY MA
DIST 52	HWY 11	BOREHOLE TYPE Solid Stem Augering / Wash boring	COMPILED BY AD
DATUM Geodetic	DATE 9 September 1999 - 10 September 1999		CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.4 / 0.0	light brown **SAND with GRAVEL (FILL)** compact damp	1	SS	26	
285.7 / 0.7	grey **SANDY SILT to CLAYEY SILT (FILL)** trace Organics loose to firm damp to moist	2	SS	6	
284.6 / 1.8	brown **SAND with GRAVEL**, trace Silt very dense	3	SS	50/13	
284.3 / 2.1	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles and Boulders moist to wet, dense	4	SS	47	
	Silt some Sand	5	SS	42	0 10 83 7
		6	SS	35	
	dense	7	SS	30	Auger refusal @ 4.4 m depth. Advance using wash boring.
		8	SS	33	
	very dense	9	SS	50/10	
	Sand,some Silt & Gravel	10	SS	50/8	22 58 20 0
		11	RC		
		12	RC		
		13	RC		
		14	RC		
		15	RC		
		16	RC		
		17	RC		
276.6 / 9.8	brown **SAND** wet				
275.3 / 11.1	**GRANITE BEDROCK** massive, closely to moderately closely jointed	18	RC		RC18: REC=96% R.Q.D=68%
		19	RC		RC19: REC=83% R.Q.D=83%
		20	RC		RC20: REC=100% R.Q.D=37%
		21	RC		
273.4 / 13.1	END OF BOREHOLE				

Water Level on completion: Not stabilized likely due to water used for coring.

Cave on completion: 8.5m
Water Level in Piezometer: Damaged after installation



$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No 18

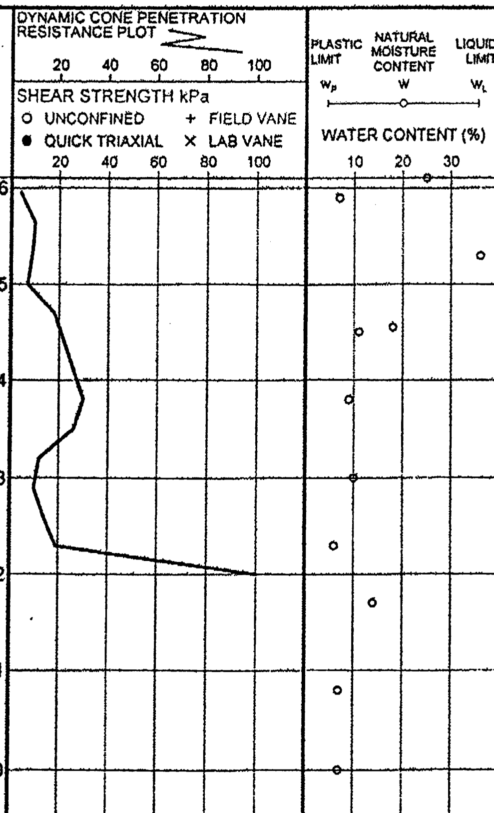
1 OF 1 **METRIC**

W.P. 473-93-00	LOCATION N 5052767.7 E311444.7		ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Solid Stem Augering / Casing		COMPILED BY AD
DATUM Geodetic	DATE 7 September 1999		CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.1							
0.0	0.1m TOPSOIL, brown **SAND with GRAVEL (FILL)** loose, damp	1	SS	9		286	
285.3 / 0.8	dark brown **TOPSOIL** clayey damp	2	SS	7		285	
284.7 / 1.4	grey				▼		
284.4 / 1.7	**SANDY SILT**, Sand lenses, wet						
	grey-brown **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles & Boulders occasional pockets of Sand moist; dense	3	SS	31		284	
	compact	4	SS	22			8 66 21 5
		5	SS	14		283	
	very dense	6	SS	56		282	40 47 10 3
281.7 / 4.4	brown **GRAVELLY SAND** frequent Cobbles and Boulders wet; very dense	7	SS	50/14			Auger refusal @ 4.4m depth, started using NW casing @ 4.4m depth to 4.9m, started using NQ casing @ 4.9m depth to 6.6m.
		8	SS	50/14		281	
	dense	9	SS	47		280	20 60 17 3
279.5 / 6.6	END OF BOREHOLE						

Water Level on completion: 1.5m (Not stabilized likely due to water used for coring)

Cave on completion: 3.5m



+3, X3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

AGRA

RECORD OF BOREHOLE No 19

METRIC

W.P. 473-93-00	LOCATION N 5052798.9 E311438.0	ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Solid Stem Augering / Wash boring	COMPILED BY AD
DATUM Geodetic	DATE 7 September 1999	CHECKED BY SP

SOIL PROFILE

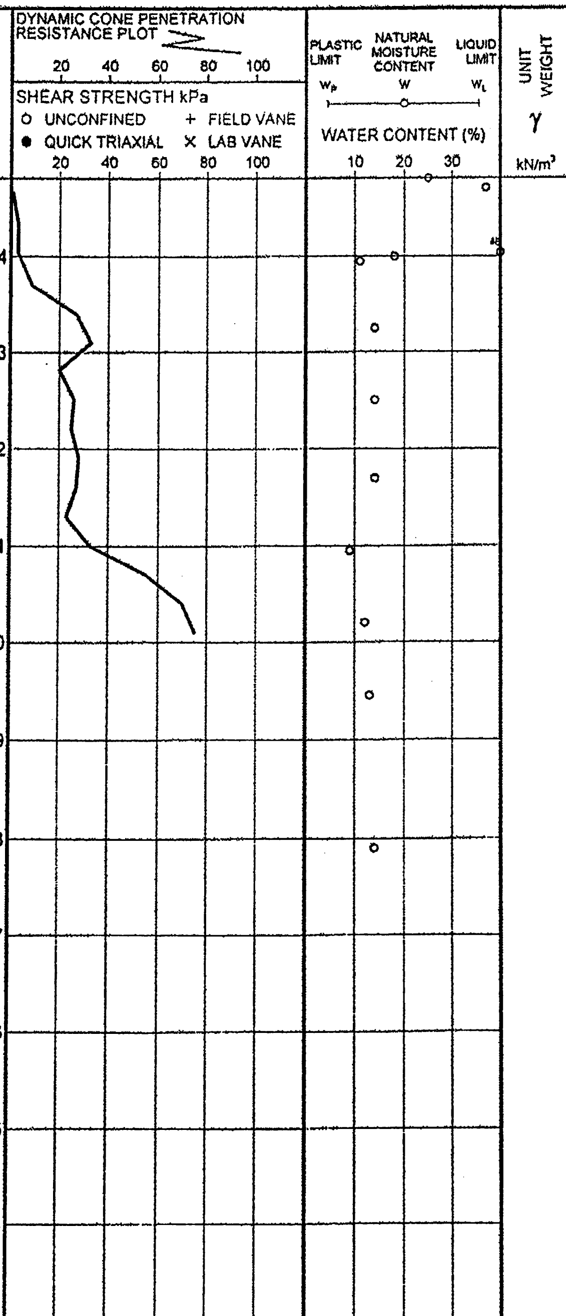
ELEV DEPTH	DESCRIPTION
284.8	
0.0	0.3m TOPSOIL **CLAYEY SILT** trace Organics firm moist
283.9 / 0.9	**SILTY SAND** compact, moist
283.6 / 1.2	brown
283.3 / 1.5	**SAND with GRAVEL** compact, moist
	compact / dense / very dense; grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** frequent Cobbles and Boulders moist to wet
275.2 / 9.6	**GRANITE BEDROCK** massive, closely to moderately closely jointed; mica zones
272.9 / 11.9	END OF BOREHOLE

Water Level in Piezometer:
Sept10/99: 1.2m depth
Elev. 283.6m

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	5
2	SS	30
3	SS	11
4	SS	28
5	SS	17
6	SS	36
7	SS	80
8	SS	50/11
9	RC	
10	SS	50/8
11	RC	
12	SS	50/10
13	RC	
14	RC	
15	RC	
16	RC	
17	RC	
18	RC	

Elevation scale: 284, 283, 282, 281, 280, 279, 278, 277, 276, 275, 274, 273



REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
8	62	26	4
17	49	29	5
6	55	35	4

Auger refusal @ 4.1m depth. Advance by washboring.

Below 7.3m depth, SS not possible due to Cobbles & Boulders

RC14 REC=50% RQD=17%

RC15 REC=73% RQD=70%

RC16 REC=82% RQD=43%

RC17 REC=88% RQD=38%

RC18 REC=77% RQD=40%

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

AGRA

Foundation Design

Enclosure # 2

RECORD OF BOREHOLE No 20

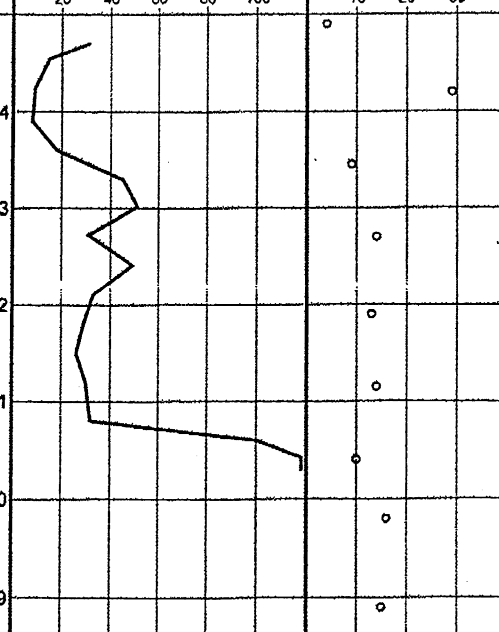
METRIC

W.P. 473-93-00 LOCATION N 5052807.1 E311445.9 ORIGINATED BY MA

DIST 52 HWY 11 BOREHOLE TYPE Solid Stem Augering / Wash boring COMPILED BY AD

DATUM Geodetic DATE 8 September 1999 CHECKED BY SP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.0 / 0.0	0.15m dark grey SAND with GRAVEL (FILL), trace Asphalt, compact, moist; light brown	1	SS	23		
284.2 / 0.8	grey SANDY SILT compact wet	2	SS	11	284	0 35 63 2
283.5 / 1.5	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL) frequent Cobbles moist to wet; dense	3	SS	31	283	
	compact	4	SS	11		
		5	SS	29	282	
		6	SS	26	281	
	v.dense	7	SS	50/10		35 47 17 1
		8	SS	50/10	280	Auger refusal @ 4.5m depth. Advance by washboring. REC=8% RQD=0%
278.6 / 6.4	END OF BOREHOLE. Water Level on completion: Not stabilized likely due to water used for coring	9	SS	50/10	279	



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 (%) 10 20 30

UNIT WEIGHT γ kN/m³

+³, X³: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

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Foundation Design

Enclosure # 21

RECORD OF BOREHOLE No 21

1 OF 1 **METRIC**

W.P. 473-93-00	LOCATION		ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering		COMPILED BY AD
DATUM Geodetic	DATE 4 October 1999		CHECKED BY SP

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 (%) 10 20 30 / UNIT WEIGHT γ kN/m³ / REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.9 / 0.0	TOPSOIL	1	SS	14		
285.0 / 0.9	brown-grey MIXTURE of SAND,SILT,CLAY & ORGANICS(FILL) loose, wet	2	SS	10	18.6	
284.7 / 1.2	grey Clayey Silt FILL trace organics firm, moist	3	SS	7	19.9	
283.8 / 2.1	mottled SILTY CLAY trace Organics hard damp	4	SS	33	20.7	
282.9 / 3.0	grey SAND with Silt, trace Organics loose, wet	5	SS	10		
282.3 / 3.6	brown SAND occasional thin Clay seams very loose to loose wet	6	SS	8		
		7	SS	4		0 95 (5)
		8	SS	6		
279.9 / 6.0	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL) with frequent Cobbles compact,wet	9	SS	29		0 23 76 1
		10	SS	46		14 61 23 2
	dense	11	SS	50/11		
	very dense	12	SS	60		
		13	SS	50/14		25 58 16 1
		14	SS	50/15		
275.6 / 10.3	GRANITE BEDROCK massive, closely to moderately closely jointed	15	RC			RC15: REC=100% R.Q.D.=100%
		16	RC			RC16: REC=89% R.Q.D.=79%
		17	RC			RC17: REC=100% R.Q.D.=100%
		18	RC			RC18: REC=96% R.Q.D.=86%
272.3 / 13.6	END of BOREHOLE					

Elevation scale: 285, 284, 283, 282, 281, 280, 279, 278, 277, 276, 275, 274, 273

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

AGRA

Foundation Design

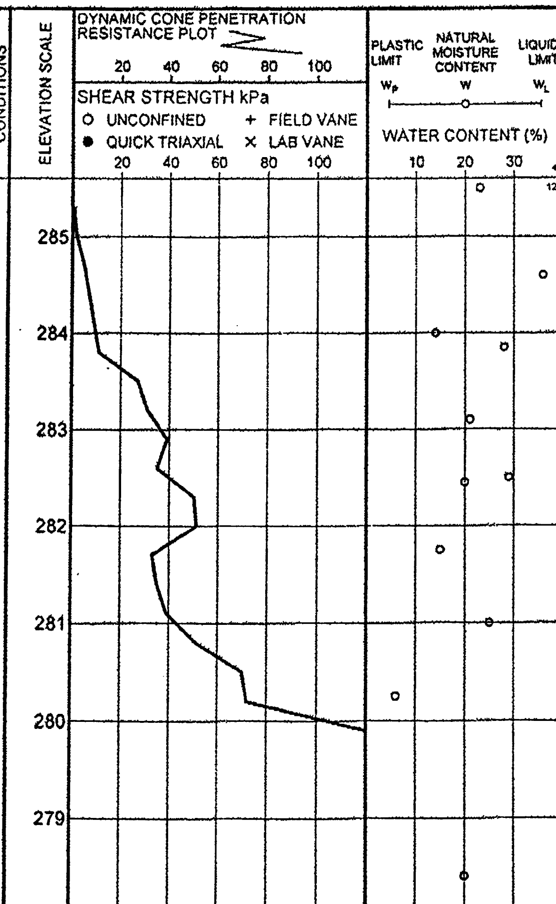
Enclosure # 9

RECORD OF BOREHOLE No 22

1 OF 1 **METRIC**

W.P. 473-93-00	LOCATION		ORIGINATED BY MA
DIST 52 HWY 11	BOREHOLE TYPE Hollow Stem Augering		COMPILED BY AD
DATUM Geodetic	DATE 5 October 1999		CHECKED BY SP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.6 / 0.0	0.2m **TOPSOIL** 0.2m grey Sand **FILL** **PEAT**	1	SS	5		
285.0 / 0.6	grey Clayey Silt **FILL** trace organics firm to stiff moist; silt	2	SS	7	18.3	
		3	SS	15	19.1	
283.5 / 2.1	mottled **CLAYEY SILT** very stiff damp	4	SS	23	21.4	
282.7 / 2.9	grey **SAND** with Silt, trace Organics loose, wet	5	SS	10		
282.3 / 3.3	brown **SAND** loose wet	6	SS	8		
		7	SS	5		
280.4 / 5.2	grey **HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL)** with frequent Cobbles very dense wet	8	SS	55		20 55 23 2
						Auger refusal @ 5.9 m depth. Advance by wash boring.
		9	SS	65/23		
278.1 / 7.6	END of BOREHOLE					



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

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Foundation Design

Enclosure # 23

RECORD OF BOREHOLE No 24

1 OF 1 **METRIC**

W.P.	473-93-00	LOCATION	N 5052995.4 E311415.2	ORIGINATED BY	MA
DIST	52 HWY 11	BOREHOLE TYPE	Hollow Stem Augering	COMPILED BY	AD
DATUM	Geodetic	DATE	18 August 1999	CHECKED BY	SP

SOIL PROFILE / SAMPLES

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.6 / 0.0	0.15m TOPSOIL; brown-grey Sand FILL with silt, some organics, trace rootlets, loose, damp	1	SS	7		
287.8 / 0.8	brown Clayey Silt FILL, trace rootlets, firm to very stiff, moist	2	SS	4		
		3	SS	17	20.8	
286.5 / 2.1	brown CLAYEY SILT, very stiff to hard, damp	4	SS	37		
		5	SS	25		
		6	SS	19		
284.5 / 4.1	red-brown SILTY SAND, compact, wet					
284.0 / 4.6	grey-brown SILTY CLAY interbedded with SAND, very stiff, wet	7	SS	17		
283.4 / 5.2	grey HETEROGENEOUS MIXTURE of SAND, SILT&GRAVEL (GLACIAL TILL), frequent Cobbles, dense to very dense, moist	8	SS	62		
		9	SS	31		21 55 21 3
		10	SS	54		
		11	SS	29		
		12	SS	50/13		48 40 11 1
279.8 / 8.9	GRANITE BEDROCK (PEGMATITE), massive, closely to moderately closely jointed	13	RC			RC13: REC=100% R.Q.D.=96%
		14	RC			RC14: REC=100% R.Q.D.=78%
		15	RC			RC15: REC=93% R.Q.D.=71%
277.1 / 11.6	END of BOREHOLE. Water Level in Piezometer: Sept 3/99: 4.6m depth, Elev. 284.0m					

Column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (288, 287, 286, 285, 284, 283, 282, 281, 280, 279, 278); 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 (%) (10 20 30).

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

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	H-Piles	Caissons	Footings on Native Soil	Footings on Engineered Fill	Footings on Bedrock	Micro-Piles
All	*Advantages:* i. High geotechnical resistance available by seating piles on bedrock. ii. Comparatively short abutment stem. iii. Relatively short pile lengths required since bedrock is at relatively shallow depth. iv. Will allow for the construction of an integral abutment structure. v. Independent of groundwater conditions. *Disadvantages:* i. Higher unit cost compared to footings. **RECOMMENDED**	*Advantages:* i. High bearing resistances available on bedrock. *Disadvantages* i. Difficulties in obtaining a seal below the liner to pour concrete in dry conditions. ii. Higher cost than other systems. **NOT RECOMMENDED**	*Advantages:* i. Lower unit cost compared to pile foundations. *Disadvantages:* i. Low bearing resistance at this site ii. An integral abutment design is not an available option iii. Comparatively longer abutment stem. iv. Possible dewatering requirements v. Possible scour and undermining problems for piers adjacent to the river. **NOT RECOMMENDED**	*Advantages* i. Lower unit cost compared to piles ii. Shorter abutment stem possible. *Disadvantages:* i. An integral abutment design is not an available option ii. Cost of constructing engineered fill iii. Possible dewatering requirements. iv. Possible scour and undermining problems for piers adjacent to the river. **POSSIBLE AT ABUTMENTS**	*Advantages* i. High geotechnical resistance available *Disadvantages* i. Sloping bedrock surface may be encountered. ii. Relatively long abutment stems will be required if footings are founded directly on bedrock. iii. Difficulties with excavation and groundwater control. iv. Requires mass concrete fill to raise abutment footings to desired founding elevation, especially at the south abutment. **NOT RECOMMENDED**	*Advantages* i. High geotechnical resistance available, depending on proprietary design. ii. Installation systems are available that will penetrate boulders and similar obstructions and penetrate into bedrock. iii. Relatively independent of groundwater conditions. *Disadvantages* i. Higher cost than driven piles. ii. Proprietary design. iii. Possibly a limited number of suppliers in the local market. **RECOMMENDED WHERE SHORT H-PILES CANNOT ACHIEVE FIXITY, e.g. Pier 4**

Appendix E

Special Provisions

The following Special Provisions are referenced in this report:

110F13

105S10

Amendment to OPSS 206, December 1993

902S01

903S01

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

"The soil overlying the bedrock contains cobbles and boulders. The presence of cobbles and boulders will potentially have an impact on the installation of driven piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- *The pile tips must be protected through the use of rock points*
- *The cobbles and boulders may impede the driving of the piles resulting in more arduous driving to reach bedrock*
- *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"*

Suggested wording for a NSSP on load testing mico-piles should include the following:

1. Scope

This special provision covers the requirements for static load testing of micro-piles used as foundation elements.

2. Submission Requirements

At least two (2) weeks prior to carrying out the load test, the Contractor shall make a written submission for the approval of the Contract Administrator (CA) describing the:

- The testing procedure
- The loading system
- The method of recording loads and settlements
- The method of analysis and reporting

3. Construction, Testing and Reporting

Testing shall be carried out to prove the ultimate geotechnical resistance of micro-piles installed at the site.
Testing shall be carried out in accordance with the requirements of ASTM 1143, Standard Loading Method (Article 5.1)
Testing shall be carried out after three production micro-piles have been installed and prior to installing the remainder of the micro-piles.
After three micro-piles have been installed, the Contractor's QVE shall submit all micro-pile installation records to the CA and the CA shall select the micro-pile that will be tested.
The Contractor shall employ a foundations engineer to interpret and report the results of the load test and shall submit the full test record and interpretation to the CA within five (5) days of completion of the test.
Installation of the remainder of the micro-piles shall not commence until after the CA has accepted the results of the load test as indicating a satisfactory micro-pile installation.
All remaining micro-piles shall be installed to at least the standard of the test pile and to provide at least the equivalent ultimate geotechnical resistance.

4. Basis of Payment

Payment at the contract price for the above tender items shall include full compensation for all labour, equipment and materials required to do the above noted work.

Appendix F

Drawings

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

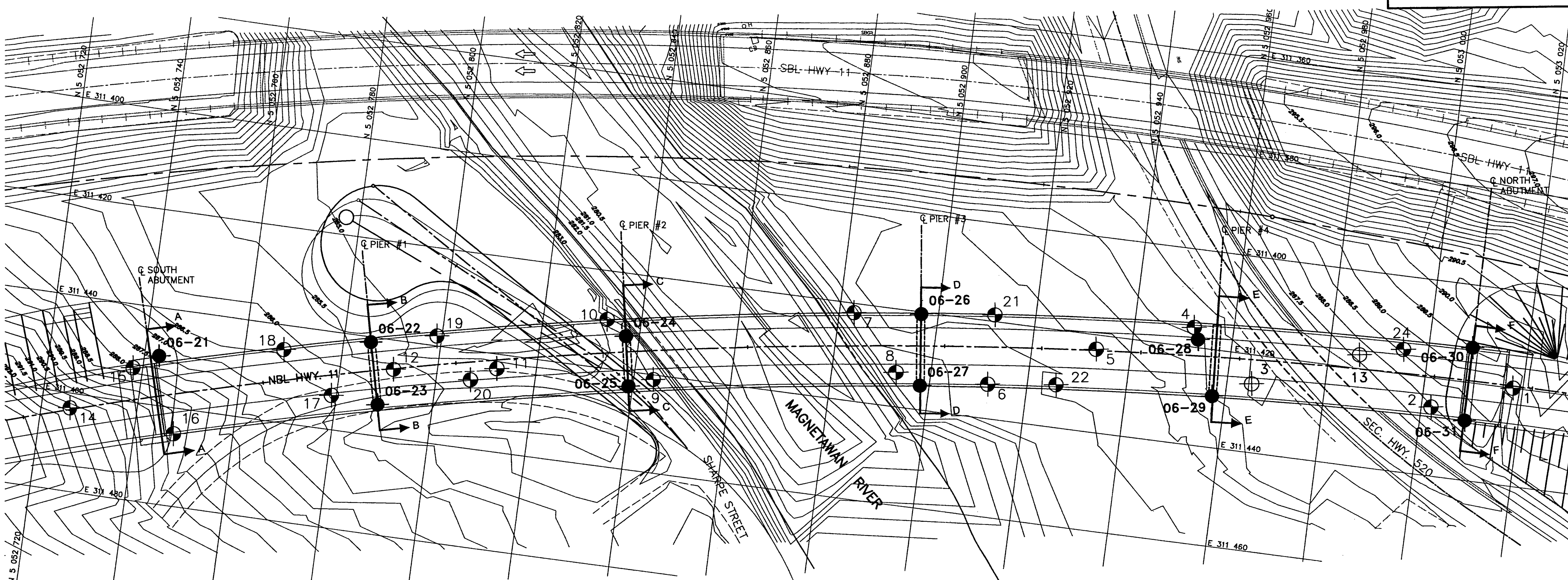
HWY 11
CONT No
WP No 473–93–00

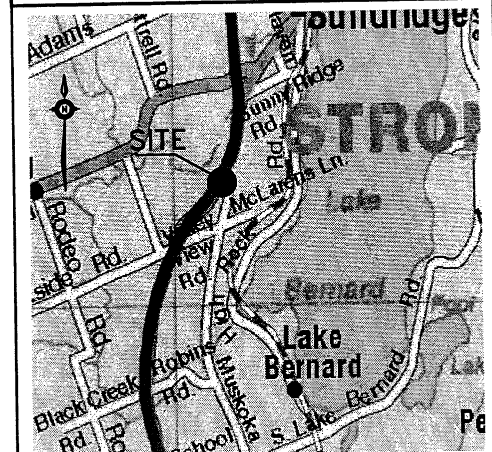
MAGNETAWAN RIVER/HWY. 520 OVERPASS HIGHWAY 11 NBL
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Marshall Macklin Monaghan
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS





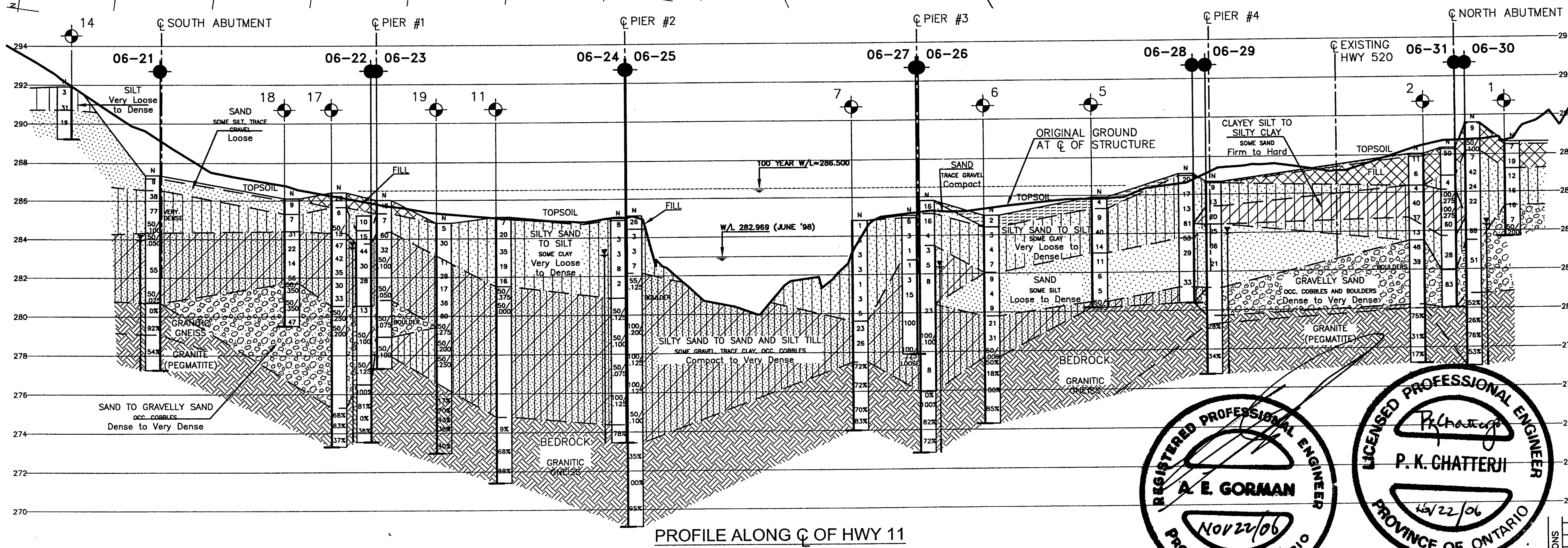
KEYPLAN

LEGEND

	Borehole by THURBER
	Borehole by AGRA
	Dynamic Cone Peneration Test by AGRA
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
06-21	287.27	5 052 742.98	311 450.15
06-22	285.18	5 052 785.63	311 441.06
06-23	286.04	5 052 788.72	311 453.58
06-24	284.98	5 052 837.30	311 432.86
06-25	285.12	5 052 839.14	311 443.00
06-26	285.80	5 052 896.53	311 420.44
06-27	285.04	5 052 898.16	311 435.06
06-28	287.08	5 052 953.09	311 418.34
06-29	286.65	5 052 957.38	311 429.49
06-30	289.59	5 053 008.85	311 412.81
06-31	288.30	5 053 009.08	311 427.84

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



PROFILE ALONG C OF HWY 11

HORT 1:1000
VERT 1:250

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

BENCHMARK

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN AEG	CHK PKC	CODE –	LOAD –	DATE OCT 2006	
DRAWN JHL	CHK PKC	SITE –	STRUCT	SCHEME	DWG 1

MINISTRY OF TRANSPORTATION, ONTARIO

DRAWING NAME:
CREATED:
MODIFIED:
FILENAME:
PLOTDATE:

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

HWY 11
CONT No
WP No 473-93-00

MAGNETAWAN RIVER/HWY. 520 OVERPASS HIGHWAY 11 NBL

BOREHOLE LOCATIONS AND SOIL STRATA

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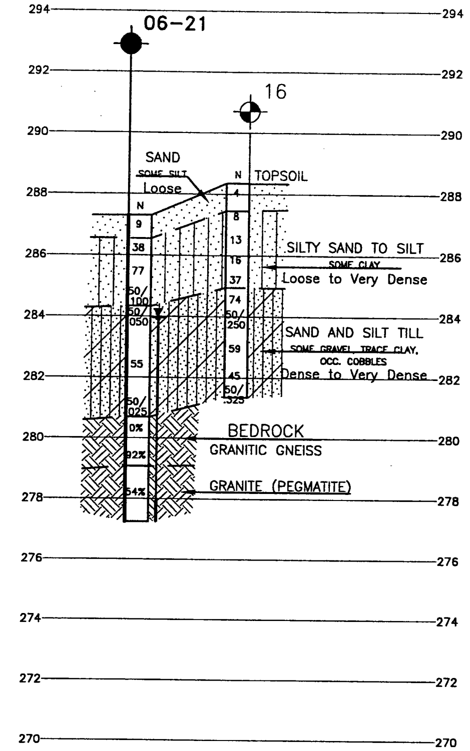
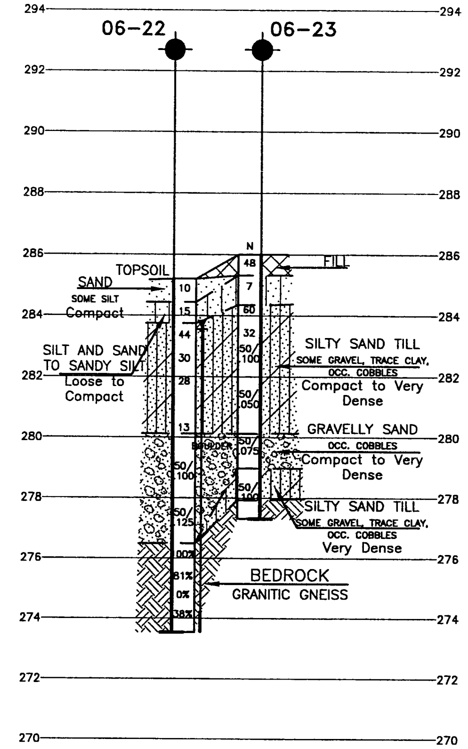


SECTION A-A



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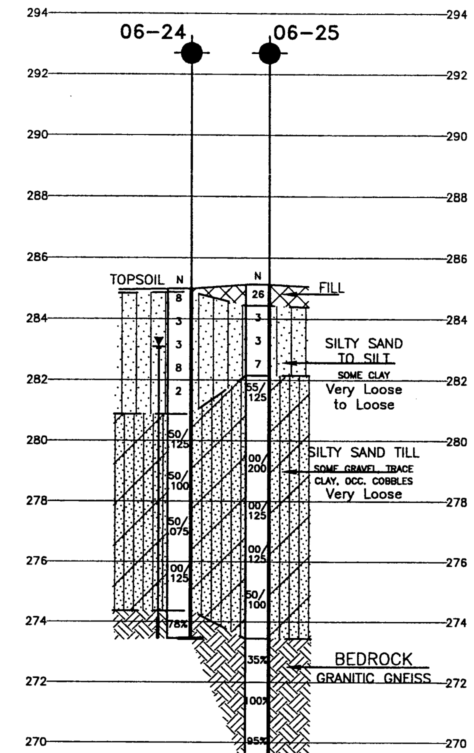

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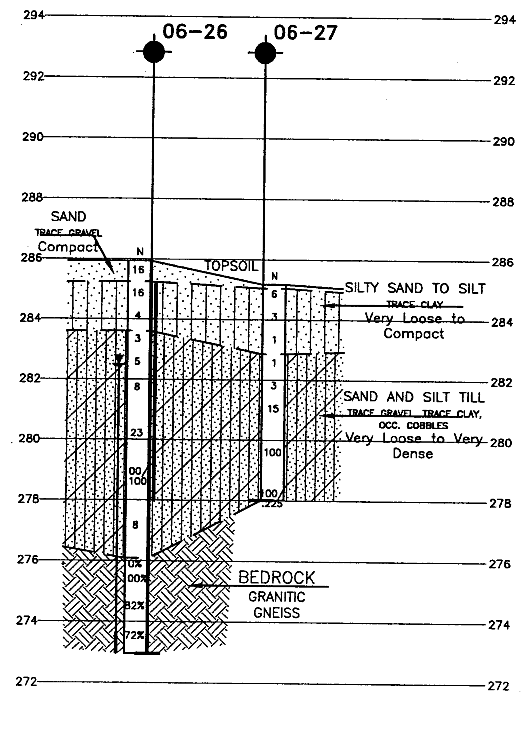

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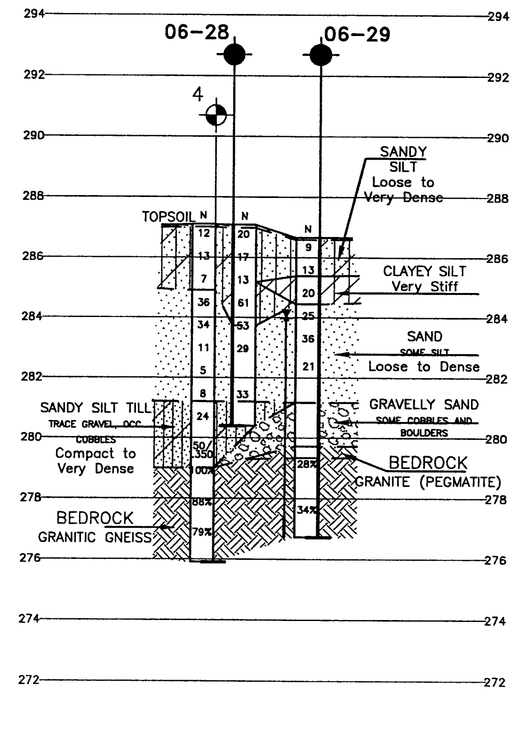

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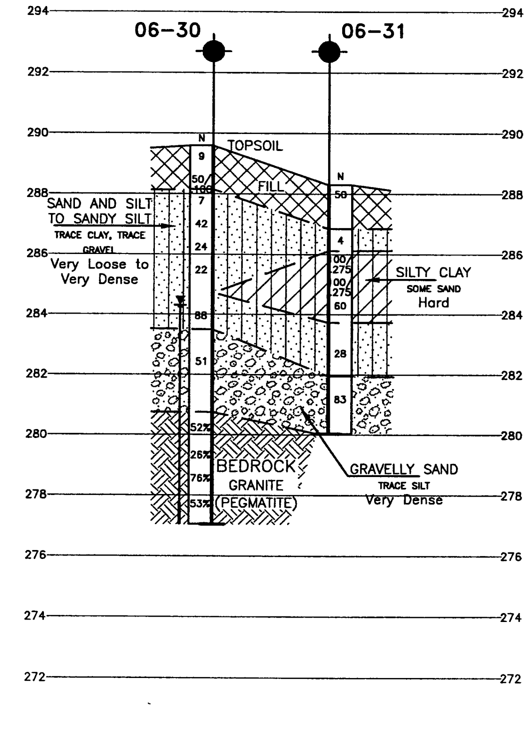

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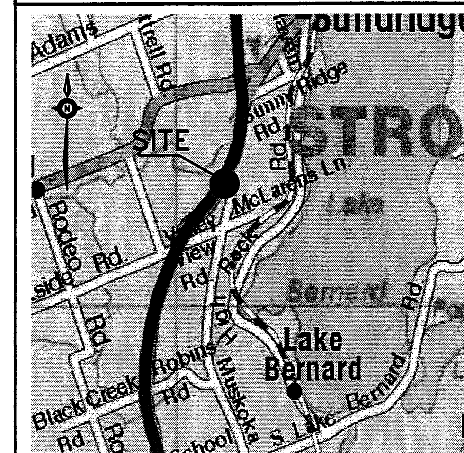

KEYPLAN

LEGEND

Symbol	Description
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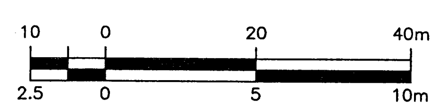

HORT 1:1000

VERT 1:250

BENCHMARK

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN AEG	CHK PKC	CODE –	LOAD –		DATE OCT 2006
DRAWN JHL	CHK PKC	SITE –	STRUCT	SCHEME	DWG 1a

DRAWING NAME:
CREATED:
MODIFIED:
MINISTRY OF TRANSPORTATION, ONTARIO
PR-D-707 98-05 PLOT SCALE 1:1
FILENAME:
PLOTDATE:

Appendix G

Site Photographs

Photo 1, Aug. 06 – Looking from Hwy 520 across Magnetawan River towards South Abutment. Existing Bridge visible at right edge of photo

Photo 2, Aug 06 – Area of North Abutment, Hwy 520 in Foreground

Appendix H

Slope Stability Output

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Fill	23	0	33	0	1
Sand/silt	22	0	31	0	1
Silty clay	20	250	0	0	1

Thurber Engineering Ltd. - Toronto
19-1423-31
Burk's falls Bypass
Nov 22,. 2006
RSS Wall G Stability

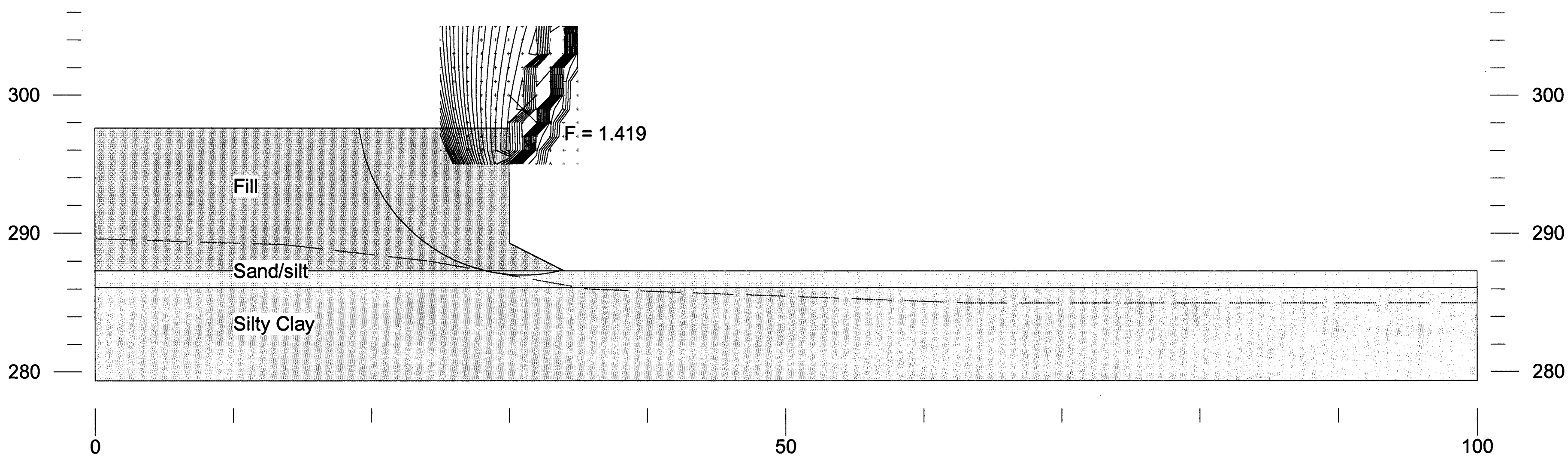

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Figure H1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Fill	23	0	33	0	1
Sand/silt	22	0	31	0	1
Silty clay	20	250	0	0	1

Thurber Engineering Ltd. - Toronto
19-1423-31
Burk's falls Bypass
Nov 22,. 2006
RSS Wall G Stability

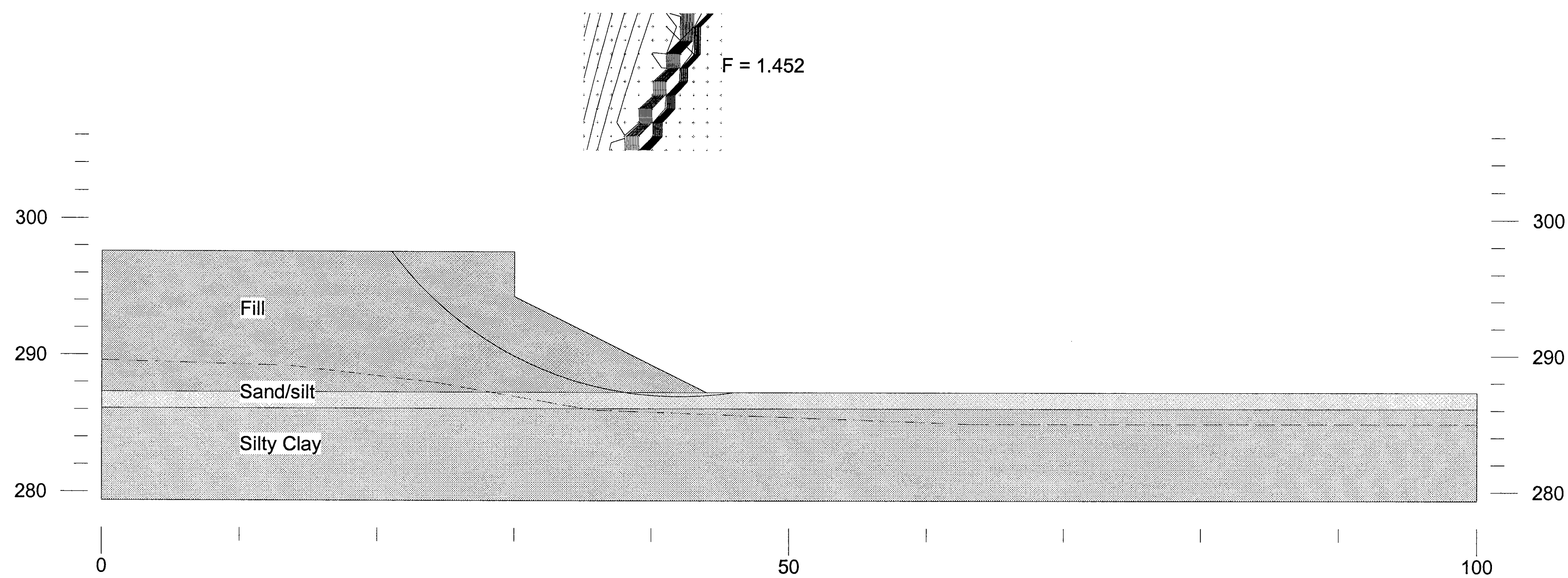

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Figure H2