

**FOUNDATION INVESTIGATION AND DESIGN REPORT
KENOGAMI RIVER BRIDGE REPLACEMENT
HIGHWAY 11, LONGLAC, ONTARIO
G.W.P. 381-90-01, SITE 48E-06**

Geocres Number: 42E-8

Report to

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TABLE OF CONTENTS

1	INTRODUCTION	3
2	SITE DESCRIPTION	3
3	SITE INVESTIGATION AND FIELD TESTING	4
4	LABORATORY TESTING	5
5	DESCRIPTION OF SUBSURFACE CONDITIONS	5
5.1	Rock Fill	6
5.2	Earth Fill	6
5.3	Alluvium	6
5.4	Upper Silt.....	6
5.5	Clayey Silt	7
5.6	Silt.....	7
5.7	Clayey Silt	8
5.8	Silty Fine Sand.....	8
5.9	Glacial Till	8
5.10	Bedrock.....	8
5.11	Water Levels	9
6	STRUCTURE FOUNDATIONS.....	10
6.1	Spread Footings	10
6.2	Driven Piles	11
6.2.1	Pile Resistance	11
6.2.2	Downdrag	12
6.2.3	Horizontal Resistance of Piles	13
6.2.4	Pile Installation	14
6.2.5	Pile Driving.....	14
6.2.6	Constructibility	15
6.3	Caissons	15
6.4	Frost Cover	16
7	EMBANKMENT WIDENING	16

7.1	West Approach	16
7.1.1	Stability.....	16
7.1.2	Settlement	17
7.1.3	Fill Placement	17
7.1.4	Construction Quantities	17
7.2	East Approach.....	17
7.2.1	Stability.....	17
7.2.2	Settlement	18
7.2.3	Fill Placement	18
8	ROADWAY PROTECTION.....	18
8.1	West Approach	18
8.2	East Approach.....	18
9	EARTH PRESSURE	19
9.1	Permanent Structures	19
9.2	Temporary Structures	19
10	COFFERDAMS.....	20
10.1	Horizontal Pressures	20
11	CN RAIL EMBANKMENT.....	21
11.1	Embankment Stability	21
11.2	Embankment Settlement.....	21
12	CONSTRUCTION CONCERNS	22

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Factual Data from AGRA Report
Appendix D	NSSP

Drawings

Drawing 19-1351-32-1	Borehole Locations and Soil Strata
Drawing 19-1351-32-2	Soil Strata

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings and the subsequent geotechnical design recommendations resulting from a foundation investigation at the Kenogami River Bridge (Site 48E-06) on Highway 11 at Longlac, Ontario. A previous investigation had been carried out at the site by AGRA Earth and Environmental Limited (AGRA) and the results of that investigation were available to be used in the current assignment.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, borehole logs, stratigraphic profile and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed through considering a combination of the data from the previous AGRA report and the data obtained in the course of the present investigation.

Geotechnical design recommendations were developed to assist the design team to select and design a suitable foundation system for the proposed structure. The impacts of widening the approach embankments to accommodate a detour and of placing fill to facilitate construction were also investigated.

Thurber carried out the investigation as a sub-consultant to McCormick Rankin Corporation, under the Ministry of Transportation Ontario (MTO) Agreement Number 6005-A-000076.

2 SITE DESCRIPTION

The site is located on Highway 11 at the Kenogami River/CN Overhead Bridge in the Town of Greenstone (Longlac) and adjacent to Longlac Reserve 58. The nearest towns on Highway 11 are Geraldton about 35 km west and Hearst at 212 km east of Longlac.

At the site, Highway 11 crosses the north end of Long Lake, the associated wetlands, the mouth of the Kenogami River and the CN Caramat Subdivision tracks. The existing bridge is a multi-span, structure consisting of a concrete deck supported on concrete columns and incorporating a steel pony truss span across the railway tracks.

The west approach to the bridge is by way of a comparatively long causeway and approach fill constructed into the shallow waters at the north end of Long Lake. The east approach is

comparatively shorter, was constructed on dry ground and leads into the built-up area of Longlac. From visual inspection, it appears that the west causeway and approach are constructed of rock fill and the east approach is constructed of earth fill.

The Caramat Subdivision track passes under the highway structure on a curve and crosses the river on a concrete and steel girder bridge immediately upstream of the highway structure. To the west of the river, the track briefly runs parallel to the highway and there is a railway siding and associated yard. The railway and the highway embankments enclose a small lagoon, the mouth of which appears to be partially obstructed.

To the east of the bridge, the highway passes through the built up area of Longlac but to the west there is only sparse development.

The existing highway and railway structures and the surrounding land are shown in the photographs at the end of the main text of this report.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between October 1, 2002 and October 17, 2002. The site investigation consisted of drilling and sampling three boreholes (Boreholes 02-1, 02-3 and 02-4) to depths ranging from 23.5 to 43 m. The approximate locations of the boreholes are shown on the attached Drawing 19-1351-32-1.

The borehole locations were marked in the field and utility clearances were obtained by Thurber prior to any drilling being carried out.

Paddock Drilling Ltd. supplied and operated the drilling and sampling equipment, mobilizing from Thunder Bay. Rotary drilling techniques were used to advance the boreholes and samples were obtained using a split spoon sampler in conjunction with Standard Penetration Testing (SPT), thin wall Shelby tubes and diamond core barrels.

Borehole 02-1 was drilled from the pavement level on the existing west approach fill. Diamond coring was selected as the best method to penetrate the rock fill in the embankment and to allow sampling of the underlying soils. Casing was advanced behind the core barrel to support the sides of the boreholes and allow access for sampling and in-situ testing using an MTO shear vane. This borehole was advanced to bedrock and bedrock was proved by coring.

Boreholes 02-3 and 02-4 were drilled from the existing bridge deck. The asphalt and concrete deck was cored and drill casing was lowered into the bed of the river. The boreholes were advanced by coring/wash boring techniques and samples were obtained using a split spoon sampler in conjunction with SPTs. Both boreholes were advanced to bedrock and bedrock was proved by coring.

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

On completion of drilling and sampling, all cuts in the pavement or bridge deck were patched using rapid setting concrete mix.

4 LABORATORY TESTING

All 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 subjected to gradation analysis (sieve and hydrometer) and to Atterberg Limit tests. A total of 17 samples were selected for these tests and the results are shown on the Record of Borehole sheets in Appendix A and on the charts in Appendix B.

One sample was selected for one dimensional consolidation testing and a set of three samples were selected for consolidated, undrained tri-axial testing. These tests were conducted by Golder Associates laboratory in Mississauga, Ontario and the results are included in Appendix B.

Laboratory test results contained in the previous report by AGRA were also used in the analysis. The test results are contained in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A and to the Record of Borehole sheets prepared by AGRA and included in Appendix C. Details of the encountered soil and rock stratigraphy are presented in these appendices and on the attached "Borehole Locations and Soil Strata" Drawings 19-1351-32-1 and 19-1351-32-2. A description of the stratigraphy is given in the following paragraphs.

In general terms, the site was found to be underlain by granodiorite bedrock. The approximate elevations of the bedrock surface are as follows:

Foundation Element	Bedrock Elevation
East Abutment	313*
East pier	305
Centre Pier	303 to 305
West Pier	291
West Abutment	below 288**

* Inferred elevation, not proved by coring.

**The bedrock elevation has not been established at the west abutment and may lie at greater depth.

The available information indicates that along the bridge alignment the bedrock surface dips gently from the vicinity of the east abutment to a relatively flat area in the vicinity of the east and centre piers and then plunges steeply to the northwest.

The bedrock is overlain by a layer of glacial till, a sequence of glacio-lacustrine and alluvial soils deposited in the recent geological past and man-made fills, as described in the following paragraphs.

5.1 Rock Fill

The west approach embankment is composed of rock fill, with a shallow veneer of earth fill overlying the rock fill. In Borehole 02-1, the rock fill was found to be composed of igneous and metamorphic rock with fragments ranging in size from gravel sized to more than 500 mm. Larger sized pieces of rock should be expected within the fill.

In Borehole 02-1, the base of the rock fill was found to lie at a depth of approximately 11 m below the pavement surface, at elevation 310.9. For the purposes of design and construction planning, it is recommended that the base of the rock fill be considered to lie within the range of Elevation 309.5 to 311.0.

5.2 Earth Fill

The east approach embankment is composed of earth fill under the pavement structure. The fill consists of silty sand with some gravel and occasional sandy zones.

Based on the earlier investigation, this fill is 6 to 10 m thick and the underside is at approximate Elevation 314.6.

Based on SPT values of 5 to 16, the fill is classed as loose to compact.

5.3 Alluvium

The material encountered in the river bottom consists of a very loose or very soft recent alluvium composed of silt, fine sand, some gravel and organic material and some distinct layers of peat. It is brown to grey in colour, saturated and in an unconsolidated condition.

In Boreholes 02-3 and 02-4, the organic soils were found to be 2.2 to 2.5 m thick. In AGRA's boreholes, the recorded thicknesses range from 1.2 to 3.8 m. The elevation of the riverbed ranged from 310.2 to 312.4 and the underside of the organic soils ranged from Elevation 307.9 to 310.1.

5.4 Upper Silt

Below the river bottom soils, several boreholes on the western portion of the site encountered a layer of silt with layers of fine sand and some clay laminations. This soil is generally compact, with SPT values ranging from 11 to 30, though some loose zones may exist. The silt is grey and has natural moisture contents ranging between 20 and 30%.

This silt layer was between 0.7 and 3.8 m thick. The top of the layer was encountered at elevations ranging between 307.9 and 310.8. The underside of the layer lay at elevations between 305.2 and 308.1.

5.5 Clayey Silt

Below the mud and the upper silt layer, boreholes west of the railway embankment (except AGRA Borehole 9) encountered a layer of silty clay. The clay is laminated with silt and contains seams of sandy silt up to 20 to 25 mm thick. This soil is grey in colour and has natural moisture contents in the range of 25 to 50%.

In boreholes drilled outside the existing embankment footprint, SPT values ranged from 2 to 13 blows for 0.3 m of penetration and the undrained shear strength measured by insitu vane tests and unconfined compression tests ranged from 20 to 30 kPa, with a limited number of higher values up to 50 and 75 kPa. Accordingly, outside the existing embankment footprint the soil is classed as soft to firm.

In Borehole 02-1 drilled through the existing west approach embankment, natural moisture contents ranged from 20 to 40%. SPT values ranged from 0 to 9 blows for 0.3 m of penetration and the undrained shear strength measured by insitu vane tests ranged from 36 to 53 kPa. Thus the soil underlying the embankment is classed as firm to stiff. A consolidated undrained triaxial shear test conducted on a sample recovered from below the embankment gave an angle of internal friction of 31° with negligible cohesion.

Consolidation tests carried out on a number of samples indicated that the soil is normally consolidated or lightly overconsolidated.

The silty clay layer ranged in thickness between 1.8 and 6.1 m. The top of the silty clay layer was encountered at elevations ranging between 306.0 and 308.9. The underside of the layer lay at elevations ranging between 300.0 and 307.4.

5.6 Silt

All boreholes encountered a layer of silt underlying the silty clay layer west of the railway embankment and below the river mud in those boreholes close to the railway embankment. The silt contained trace to some fine sand and trace to some clay, with the clay generally occurring as thin laminations within the silt. The SPT values ranged from 2 to 40 blows for 0.3 m of penetration. However, most values were below 30 and some of the lower values may be due to disturbance caused by unbalanced heads of water in the borehole. As a result, the silt deposit is classed as compact.

The silt is grey in colour and has natural moisture contents ranging from 19 to 30%.

The silt layer is the principal soil stratum on this site and was encountered in thicknesses ranging from 4.2 to 18.0 m. The top of the silt layer was encountered at elevations ranging

between 300.0 and 307.4. The underside of the layer lay at elevations ranging between 282.0 and 303.2.

5.7 Clayey Silt

A layer of clayey silt was encountered below the silt layer in Borehole 02-1. This layer is grey and has a natural moisture content of 26%. It contains sandy silt laminations and sandy silt seams up to 25 mm thick. An SPT value of 5 blows for 0.3 m of penetration was recorded, indicating a firm soil.

This soil was encountered between Elevations 281.8 and 287.6 and was 5.8 m thick.

5.8 Silty Fine Sand

A layer of fine silty sand was encountered in AGRA's Borehole 1 below the main silt stratum. SPT values of 4 and 6 blows for 0.3 m of penetration were measured in this soil. However, it is possible that these values were influenced by disturbance caused by an unbalanced head of water in the borehole and it is considered that the layer should be classed as compact. The measured natural moisture content was 15%.

This layer was encountered between Elevations 282.8 and 285.6 and was 2.8 m thick.

5.9 Glacial Till

Glacial till was encountered in a number of boreholes. AGRA's Boreholes 2 through 9 and Borehole 13 encountered glacial till overlying the bedrock and ranging from a thin veneer to a layer 2.1 m thick in Borehole 7. The till consists of a heterogeneous mixture of silt sand and gravel with occasional cobbles and boulders. The recorded SPT values indicated a soil in a compact to very dense condition.

Borehole 02-1 and AGRA Borehole 1 present evidence that as the bedrock surface plunges to the northwest it is overlain by greater thicknesses of till. Borehole 02-1 encountered a 2 m thickness of till overlying bedrock between Elevations 280 and 282. Borehole 1 encountered the till layer at Elevation 283 and terminated in the till at Elevation 277. The SPT values recorded in Borehole 1 show that the till is in a very dense condition.

The elevation of the top of the glacial till ranged from 291.6 to 308.1.

5.10 Bedrock

Granodiorite bedrock was encountered underlying the soils at Elevation 313 at the East Abutment and dipping to Elevation 291 at the West Pier.

At Borehole 1, bedrock had not been encountered when the borehole was terminated at Elevation 277.

5.11 Water Levels

Groundwater levels at this site are expected to be closely controlled by the river level. Since most boreholes were drilled within the river, piezometers were not installed.

A summary of available river level information is as follows:

Date	River Elevation
April, 1994	311.4
June, 2002	313.4
August, 2002	312.6
October, 2002	313.0

FOUNDATION INVESTIGATION AND DESIGN REPORT**KENOGAMI RIVER BRIDGE REPLACEMENT****HIGHWAY 11, LONGLAC, ONTARIO****G.W.P. 381-90-01, SITE 48E-06****Geocres Number: 42E-8****PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of the investigation, together with data presented in the previous report by AGRA. Thurber has used AGRA's data in the report but cannot and does not warrant its accuracy.

6 STRUCTURE FOUNDATIONS

The proposed replacement bridge will consist of a four-span structure with a total of five foundation elements; two abutments and three piers.

This section discusses the feasible foundation alternatives, provides geotechnical design parameters and recommends a preferred foundation scheme. An important factor in developing the preferred scheme was to maintain consistency of foundation type throughout the project to provide consistent foundation performance and to allow the contractor to adopt, as far as possible, consistent construction techniques at all foundation elements.

The possible foundation schemes that have been considered include:

- Spread footings
- Driven piles
- Caissons (drilled shaft piles)

6.1 Spread Footings

It is understood that the existing structure does not have abutments and the approach spans of the deck are cantilevered from the outer piers. There is, therefore, no history of footing performance at this site.

The use of spread footings for the new structure was considered but was rejected as not being feasible under the conditions prevailing at this site. At the west abutment, the footing would be supported on a granular pad over the existing rock fill. This scheme is not recommended due to the unknown performance of the rock fill and the danger of loss of support due to loss of granular material into the voids in the rock fill. At the east

abutment, the footing would be supported on a granular pad over existing fill. The performance of this fill could not be predicted sufficiently reliably to permit use of this alternative.

Footings at piers would require deep excavation below the water table in readily disturbed soils and this was rejected as not feasible.

6.2 Driven Piles

The interpreted soil stratigraphy at the site shows that driven piles will bear on bedrock at the east abutment and at the piers. The bedrock surface plunges steeply to the northwest and at the west abutment the rock may be overlain by a deposit of very dense glacial till. Accordingly, at the west abutment, driven H-piles may meet refusal in the very dense glacial till overlying the bedrock.

Driven steel H-piles are considered to a suitable foundation option for this site and the approximate bedrock elevations at which piles may reach refusal are as follows:

Foundation Element	Bedrock Elevation
East Abutment	313*
East pier	305
Centre Pier	303 to 305
West Pier	291
West Abutment	below 288

* Inferred elevation, not proved by coring.

Based on the bedrock elevations, it is apparent that the piles driven at the centre and east piers will be short; perhaps in the order of 4 to 5 m long below the base of all concrete. This length of pile is considered to be acceptable for steel H-piles driven to bedrock as the resistance is developed entirely by end bearing on an unyielding stratum.

6.2.1 Pile Resistance

Steel H-piles can be driven to bedrock at all foundation elements except, possibly, the west abutment. At the west abutment, driven H-piles may meet refusal in the very dense glacial till overlying the bedrock. However, geotechnical analysis shows that piles driven to refusal in this till will also develop geotechnical resistance as shown in the table below.

Two pile sections have been considered for this site, HP 310X110 and HP360X132. The factored structural loads (live and dead) should not exceed the following vertical, factored geotechnical resistances:

Pile Section	Factored Geotechnical Resistance at ULS
HP 310X110	2000 kN
HP 360X132	2400 kN

For a steel pile driven to bedrock or the very dense glacial till at this site, the SLS condition will not govern. Deflection at the pile head may be taken as the deflection of the steel pile under load, assuming rigid, vertical, toe support.

The availability of HP 360X132 piles should be confirmed prior to finalizing the design based on that section.

6.2.2 Downdrag

Construction staging at this site may require the placement of fill in the river to form working platforms and also require the temporary widening of the west approach fill into the river to accommodate a detour.

Piles at this site may be subject to downdrag created by consolidation of the foundation soils under the influence of fill placed during construction. When a downdrag force may develop, Clause 6.8.4 of the CHBDC requires a check of the structural adequacy of the pile at the neutral plane.

6.2.2.1 New Piles

The most severe downdrag case will develop at the piles driven for the west abutment of the temporary detour structure due to the combination of the compressible soils at the greatest depth and the loading due to the widening of the embankment.

The factored downdrag load on an HP 360X132 pile at this location is calculated to be 1700 kN, using a load factor of 1.25.

Calculations carried out by Thurber indicate that new piles driven for either the permanent structure or the temporary detour will pass the downdrag check conducted in accordance with CHBDC Clause 6.8.4, provided that the factored dead load applied to the pile does not exceed 1700 kN.

6.2.2.2 Existing Piers

There is no information available regarding the configuration of the existing piers below the water/mud line. The visible portion above water consists of a sheet pile enclosure measuring approximately 900 mm by 900 mm. It is not known what section is available to resist the applied loads and it is not possible to rigorously evaluate the adequacy of the piers to resist the downdrag according to the provisions of the CHBDC and accordingly engineering judgement has been applied as described below.

At the East pier and Centre Pier the bedrock lies at shallow depth and the soils are predominantly silty. Based on the short length of the existing foundation elements (in the order of 6 to 8 m long) and the soil conditions, downdrag is not considered to be an issue.

In the absence of information regarding the construction of the foundations at the West Pier, it is recommended that no new fill be placed in the river around or close to the existing piers in order to avoid developing downdrag forces.

6.2.3 Horizontal Resistance of Piles

It is recommended that the horizontal forces in the foundations be resisted by means of battered piles where possible. This can be achieved at the east abutment and at the piers.

At the west abutment, the piles will be installed through cased holes formed in the rock fill and battered piles are not considered to be feasible. At the west abutment, alternate geotechnical solutions to resisting the horizontal forces from the structure could include:

- anchoring the abutment to a Terratrel wall
- passive resistance around the abutment piles

Construction of a Terratrel wall immediately behind the West Abutment is recommended to retain the fill and to prevent active earth pressure acting on the abutment, thus reducing the horizontal loads to be resisted by the abutment foundation. The Terratrel wall could also be designed to provide resistance in tension and thus anchor the abutment.

Alternatively, the horizontal forces can be resisted through the passive pressure acting on the foundation piles. The method of installation of the abutment piles is described in the following section and will result in the H-pile being grouted into a 600 mm diameter casing through the rock fill. Due to the configuration of the existing rock fill and the location of the new abutment, the rock fill will extend horizontally for approximately 17 m in front of the abutment at the pile cut-off elevation.

The following parameters were assumed in calculating the available passive resistance:

- pile diameter = 600 mm
- effective depth of rock fill = 5.5 m

- angle of internal friction in rock fill = 42° (a conservative value)

Based on these parameters the horizontal passive resistance at ULS on the projected pile face is estimated to be 900 kN.

The corresponding resistance at SLS, assuming a permissible movement of 2 mm at the top of the pile, is estimated to be 250 kN.

6.2.4 Pile Installation

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

All piles at this site, with the possible exception of those at the west abutment, will be driven to bedrock. The bedrock has been interpreted to have a steeply dipping surface.

Based on the steeply dipping bedrock surface, it is considered that the steel H-piles should be fitted with rock points to increase their ability to bite into a sloping rock surface. Suitable points would be Oslo Points (see OPSD 3304.00 for Oslo Points for HP310 piles). Alternatively, HPP-R-12 or HPP-R-14 from Titus Steel Company (www.titussteel.com, 905 564 2446), or equal from another approved manufacturer may be used.

The piles driven for the west abutment may have to penetrate till and reach refusal either in the till or on bedrock. Rock points will also provide protection for these piles.

At the west abutment, the piles must be advanced through the existing rock fill from the level of the underside of the abutment stem, approximately Elevation 315.5. From that elevation, there will be approximately 5 m of rock fill to be penetrated. The suggested method of installation is as follows:

- advance a 600 mm diameter steel casing through the rock fill
- install the H-pile centred inside the casing and drive as described in the following section
- grout the H-pile into the casing using concrete

6.2.5 Pile Driving

At the piers and the east abutment, the piles should be driven to bedrock. Note No. 6 from Article 3.3.3 Pile Driving Notes in the MTO Structural Manual should be used on the Foundation Drawing, i.e. "Piles to be fitted with rock points and driven into bedrock in accordance with 903S01".

A NSSP should be incorporated into the Contract Documents stating the procedure required for setting the rock points into bedrock. The text for the NSSP is given in Appendix D.

At the west abutment, the piles should be driven to below Elevation 288 and then driving should be controlled using the Hiley formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The appropriate note is No. 2, i.e. "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of 'R' kN per pile but must be driven below Elevation 288".

'R' must be a minimum of 4,000 kN for an HP 31X110 pile and 4,800 kN for an HP360X132 pile..

In the Pile Data Table on the Foundation Layout Drawing, Note (3) should specify a minimum hammer energy of 60 kJ.

6.2.6 Constructibility

The pile resistances provided in this report are values that are available for piles driven with sufficient energy.

If pile driving has to be carried out under the existing bridge, care must be exercised to select driving equipment that will develop sufficient energy. It is understood that drop hammers are available that could work in this low headroom and deliver energies in the range of 60 to 80 kJ. It is therefore considered that an experienced contractor will be able to drive the piles satisfactorily in this situation.

6.3 Caissons

The use of caisson foundations to support the structure was considered.

Caissons socketed into the bedrock could be designed to provide high values of geotechnical resistance. However, there are a number of significant construction problems associated with caissons at this site, including, though not necessarily limited to:

- difficulties installing augered caissons in the low headroom that will be available during staged construction
- difficulties in sealing a temporary liner into the steeply sloping bedrock to exclude groundwater and soil and thus allow placement of concrete in dry, clean conditions in the rock socket
- difficulties in advancing a caisson to depths in excess of 20 m, particularly in the low headroom conditions

Taking these construction issues into consideration, it is recommended that caisson foundations not be considered for this project.

6.4 Frost Cover

The frost cover provided to the underside of foundation elements should be 2.5 m. The depth of frost cover can be measured to the underside of concrete, including any mud slab.

Frost protection is not considered necessary for the west abutment as it will be constructed on top of free-draining rock fill.

7 EMBANKMENT WIDENING

The west and east approach embankments will be widened to the south side to accommodate a detour during staged construction. The nature of the terrain and the foundation soils on which these embankments will be constructed differ significantly between the west and east approaches.

7.1 West Approach

The west approach is constructed of rock fill and the south side slope is inclined at approximately 1.5H:1V. This approach will be widened by approximately 4 m to the south to accommodate the detour.

7.1.1 Stability

The stability of the south side of the west approach fill has been analyzed for the existing condition and for the case of a 4 m widening for the detour. The proposed widening will be generally as illustrated in Sketch F-1, constructed using rock fill and with side slopes of 1.5H:1V.

The attached Sketch F-2 illustrates the geometry and materials properties assumed for the present condition. Analysis was carried out using software based on Bishop's method. An undrained analysis was conducted using strength parameters calculated on the basis of a C/P value of 0.25, with minimum values of cohesion selected on the basis of field testing by Thurber and AGRA. (C/P = undrained shear strength divided by vertical effective stress.)

The analysis was repeated for the widened embankment with the geometry shown in Sketch F-3. The same strength parameters were used and pore pressures due to the addition of the fill were computed using a B^{bar} value of 0.9, where B^{bar} is the porepressure response coefficient.

The computed factors of safety were:

present condition	1.44
widening	1.36

The reduction in the factor of safety, therefore is 6%. This is a relatively small value and the end of construction value of 1.36 is considered to be satisfactory. The factor of safety against instability will increase with time as the excess pore pressures in the foundation soils dissipate and the underlying soils consolidate.

7.1.2 Settlement

The application of additional loading on the foundation soils due to the fill placed for embankment widening can be expected to induce settlement at the top of the existing embankment, including settlement of the existing paving.

It is estimated that settlements in the existing pavement may reach magnitudes of 10 to 15 mm during the course of construction. Provision should be made for padding the asphalt in the event that settlements have a negative impact on serviceability of the Pavement during construction.

7.1.3 Fill Placement

Rock fill for the embankment widening should be placed in a controlled manner.

End dumping the rock fill from the top of the existing embankment may create problems related to excessive displacement of the river bottom sediments and possible localized failures in the riverbed. It is recommended that the fill be placed in lifts covering the full footprint of the widening but not more than 3 m high in each lift.

7.1.4 Construction Quantities

Notwithstanding that settlements are estimated to be relatively small and analysis of the widened embankment shows it to be stable, however displacement of the mud on the river bottom will occur as the fill is placed. Construction quantities should allow for additional fill over and above the quantity calculated from the existing river bottom.

Calculating rock fill volumes on the basis of fill extending down to Elevation 309 should provide reasonable quantities for tender purposes.

7.2 East Approach

The east approach is constructed of earth fill with south side slope constructed at an inclination of approximately 2H:1V. This approach will be widened by approximately 4 m to the south to accommodate the detour.

7.2.1 Stability

This approach fill is constructed on competent soils overlying bedrock and no stability issues are anticipated for a slope constructed at 2H:1V.

7.2.2 Settlement

This approach fill is constructed on competent soils overlying bedrock and no settlement issues are anticipated.

7.2.3 Fill Placement

Prior to placement of fill, any drainage that may be blocked by the fill should be re-routed.

During construction of the widening, the existing slope should be benched in accordance with OPSD 208.010.

Fill should be placed in accordance with OPSS 501.

8 ROADWAY PROTECTION

It is understood that staged construction will require the implementation of roadway protection approximately at the centrelines of the existing approach embankments. The roadway protection may be in the form of a temporary retaining structure such as soldier piles and lagging or a contiguous caisson wall. Soil parameters for design are given in the following Section 9.

8.1 West Approach

The west approach embankment consists of rock fill overlying a deep deposit of soil. It is anticipated that the installation of soldier piles in this approach will require pre-drilling a steel liners through the rock fill to permit installation of the piles.

Partial depth excavation of the rock fill will be required and it is possible that the soldier piles can achieve sufficient toe resistance in the balance of the depth of rock fill. If this is not the case, the soldier piles will penetrate into readily disturbed, fine-grained soils below the water table. Pre-drilling is not recommended in these soils and if the soldier piles must penetrate deeper than the base of the rock fill they should be driven for the depth below the rock fill.

8.2 East Approach

The east approach embankment consists of earth fill overlying a shallow deposit of native soil and bedrock at comparatively shallow depth.

Soldier piles may be driven or installed in augered holes without the need for temporary liners. If sufficient toe resistance cannot be developed within the earth fill and native soil, the soldier piles may have to be toed into the bedrock.

9 EARTH PRESSURE

The lateral earth pressures to be used in design should be computed in accordance with Clause 6.9 of the CHBDC .

9.1 Permanent Structures

Granular backfill should be placed behind the abutment walls and wing walls to conform to the minimum requirements illustrated in OPSD 3501.00. The granular backfill should conform to Ontario Provincial Standard Specifications (OPSS) 1010 for Granular B Type I.

For the above backfill and drainage conditions in the permanent structure, the abutment walls and wing walls may be designed based on the following unfactored earth pressure distributions:

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

where;

K = earth pressure coefficient, use value from table below.

γ = unit weight of soil = 21.2 kN/m³ for Granular B

h = depth below top of wall, m

q = permanent surcharge (if applicable) kPa

Wall Type	Earth Pressure Coefficient (K)			
	OPSS Granular A $\phi' = 35^\circ$		OPSS Granular B $\phi' = 30^\circ$	
	Horizontal Ground Surface Behind Wall	Sloping Ground Surface (2H:1V)	Horizontal Ground Surface Behind Wall	Sloping Ground Surface (2H:1V)
Abutment Walls (Movement allowed)	0.33	-	0.35	-
Wing Walls (Unrestrained Wall)	0.27	0.40	0.33	0.55

Design horizontal pressures should also take account of the recommended 12kPa compaction induced pressure in accordance with Clause 6.9.3 of CHBDC.

9.2 Temporary Structures

For the design of temporary structures such as roadway protection, the following horizontal earth pressure coefficients may be used:

Structure Type	Earth pressure Coefficient (K)	
	Existing Rock Fill	Existing Earth Fill
Restrained	0.30	0.50
Unrestrained	0.18	0.33
Passive pressure ULS	5.0	3.0
SLS	1.5	0.9

The SLS values of the passive pressure coefficient are estimated using an assumed value of 0.0006 for the ratio of movement to pile length.

Other geotechnical parameters for use in the design of roadway protection are:

Parameter	Rock Fill	Earth Fill
Angle of internal friction	45°	30°
Unit weight	21 kN/m ³	20 kN/m ³
Groundwater elevation	313.4	314.5 (estimated)

10 COFFERDAMS

It is anticipated that cofferdams will be required in the river to facilitate the construction of the pile caps. It is recommended that the final design of the cofferdams be left to the Contractor but the following comments are provided for the guidance of the project team.

10.1 Horizontal Pressures

Temporary shoring to form the cofferdam, e.g. sheet piling, must be designed to resist forces exerted by the horizontal earth pressure and the hydrostatic pressure due to the river water.

The contractor should design for the worst case combination of loading and river level using the following parameters:

- coefficient of at-rest earth pressure 0.5
- bulk unit weight of retained soil 21 kN/m³
- bulk unit weight of native soil 20 kN/m³
- coefficient of passive earth pressure in alluvium 1.0
- coefficient of passive earth pressure in silt 2.5
- unit weight of water 9.81 kN/m³

The design of the cofferdam must also take into account the value of any adjacent surcharge due to construction equipment or materials.

It is recommended that excavation of the cofferdam follow the sequence:

- excavate to the required level with the cofferdam flooded
- place a concrete plug in the bottom by tremie method
- after the concrete plug has gained sufficient strength, pump out the water within the cofferdam

Any attempt to excavate the cofferdam in a “dry” condition will create an unbalanced hydrostatic head in the base of the cofferdam, leading to the possibility of base heave and boiling of the soil within the dam.

There is a possibility of soldier piles or sheet piles encountering boulders above the bedrock.

11 CN RAIL EMBANKMENT

Fill will be placed adjacent to the existing CN Rail embankment to facilitate construction of the Centre Pier and East Pier for the new structure.

11.1 Embankment Stability

The fill placed for construction access purposes will not extend above Elevation 314 and is expected to be stable, though mud on the river bottom may be displaced during the filling process.

From a geotechnical perspective, no negative impact on the stability of the CN Rail embankment is expected.

11.2 Embankment Settlement

The fill placed for construction purposes will generally be less than 1 m thick where it abuts the existing railway embankment. The thickness increases to approximately 2 m at distances of 20 m from the centreline of the track.

Some minor settlement of the fill should be anticipated due to the displacement and consolidation of the loose riverbed soils. However, the magnitude of settlement close to the track is expected to be small and to have minimal impact on the track.

However, due to the potential consequences of settlement or displacement of a rail, a monitoring program, agreed in advance with CN Rail, should be implemented and provision made for re-levelling the rail should any movement occur. A possible monitoring program would consist of a careful survey of the top-of-rail carried out in

advance of construction and repeated at intervals during construction. A suggested schedule is as follows:

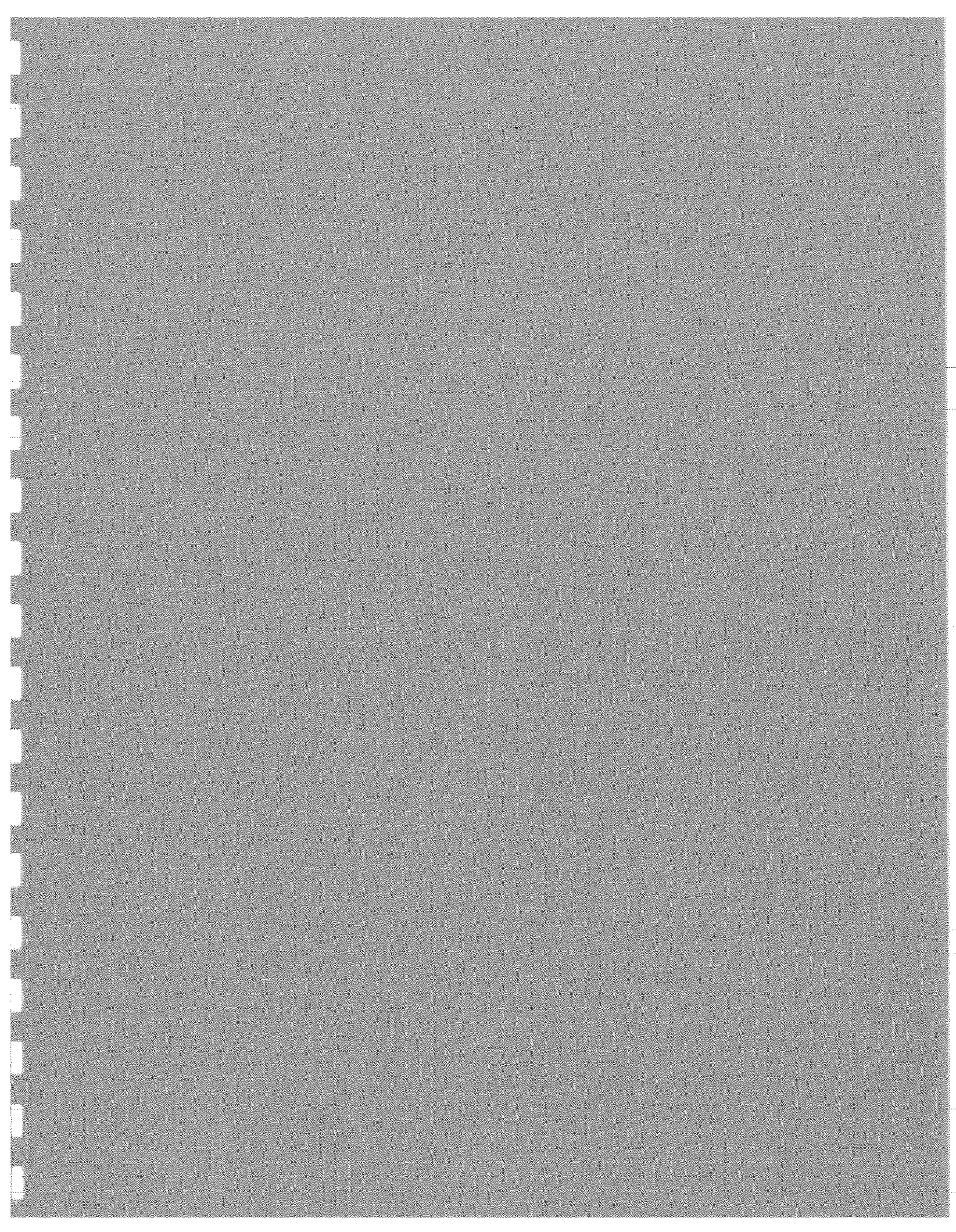
- in advance of any construction
- immediately before placing fill
- immediately after placing fill
- weekly for one month after filling has been completed
- monthly throughout construction.

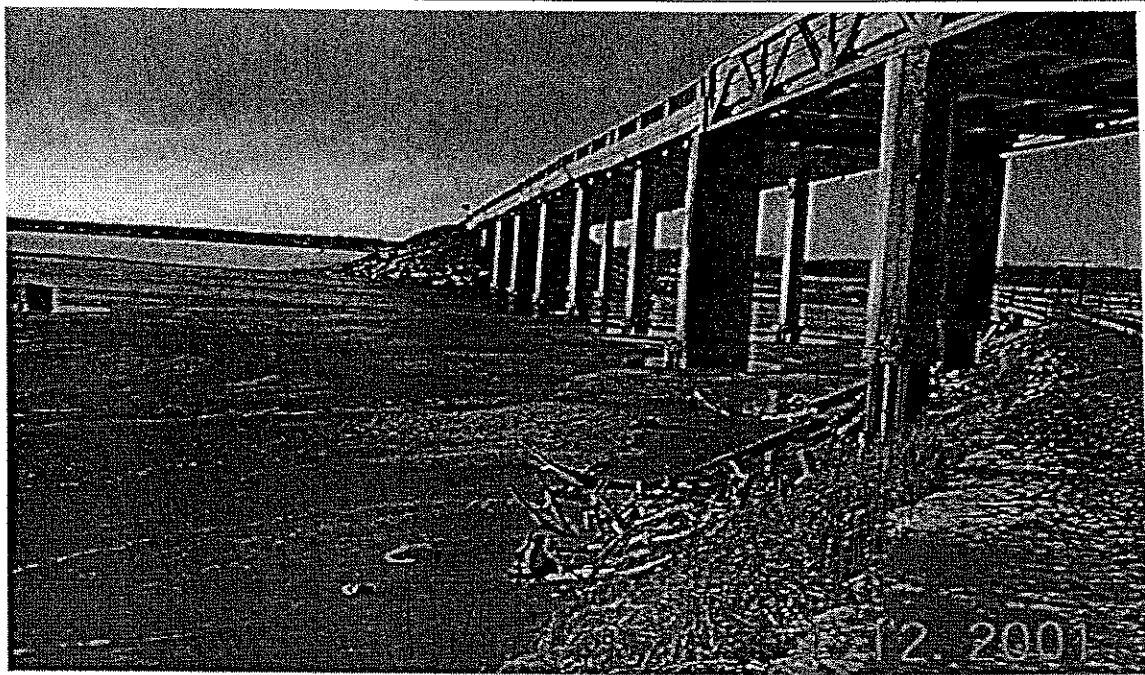
The survey should extend for 50 m beyond the construction zone.

12 CONSTRUCTION CONCERNS

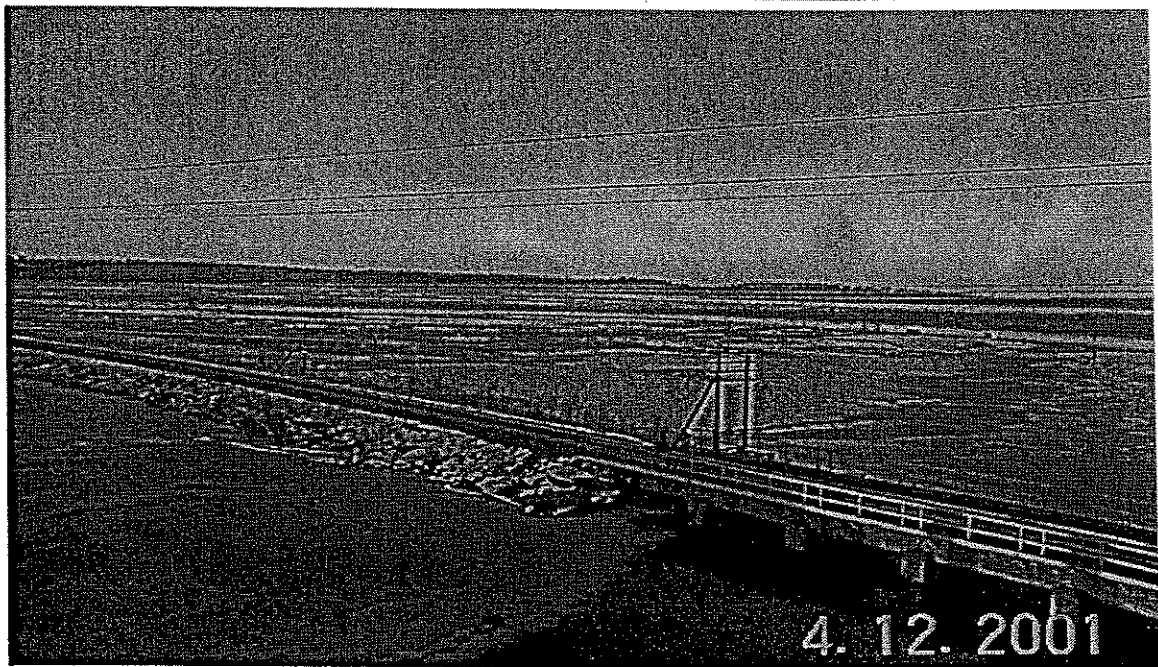
During construction, the Contract Administrator should employ experienced geotechnical staff to observe construction activities related to pile installation and embankment widening. Potential construction concerns include, but are not necessarily limited to:

- the requirement for piles at the east abutment and at the piers to be driven to bedrock
- the development of the specified ultimate resistance in piles driven and controlled by means of the Hiley formula
- the possibility of piles encountering steeply dipping bedrock, failing to “bite in” and displacing down the sloping bedrock surface
- the appropriate sequence for constructing and unwatering cofferdams
- the placement of rock fill for widening the west approach embankment in a manner that does not produce excessive displacement of sediment or trigger localized failures in the river bed
- possible impact on the CN track of placing fill to facilitate the construction of the East Pier and the Centre Pier
- potential movement in the roadway protection system required for staged construction that would impact the safety and serviceability of the travelled lane(s)





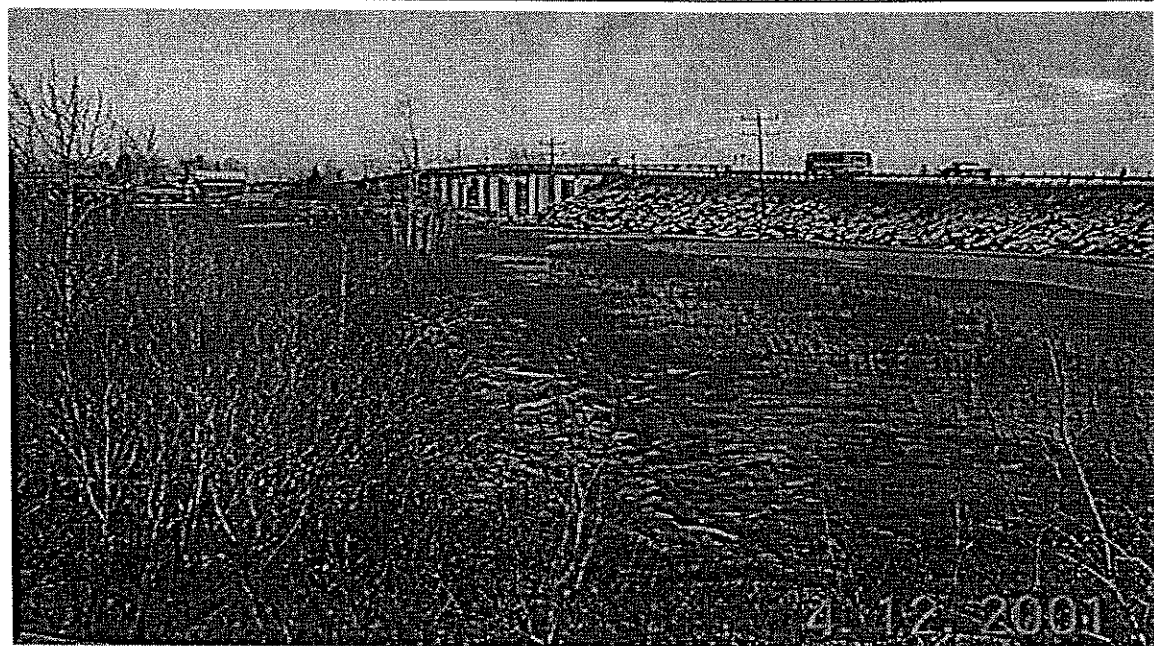
Kenogami River Bridge Looking West From railway Embankment



Kenogami River Bridge Looking North, Railway Structure in Foreground



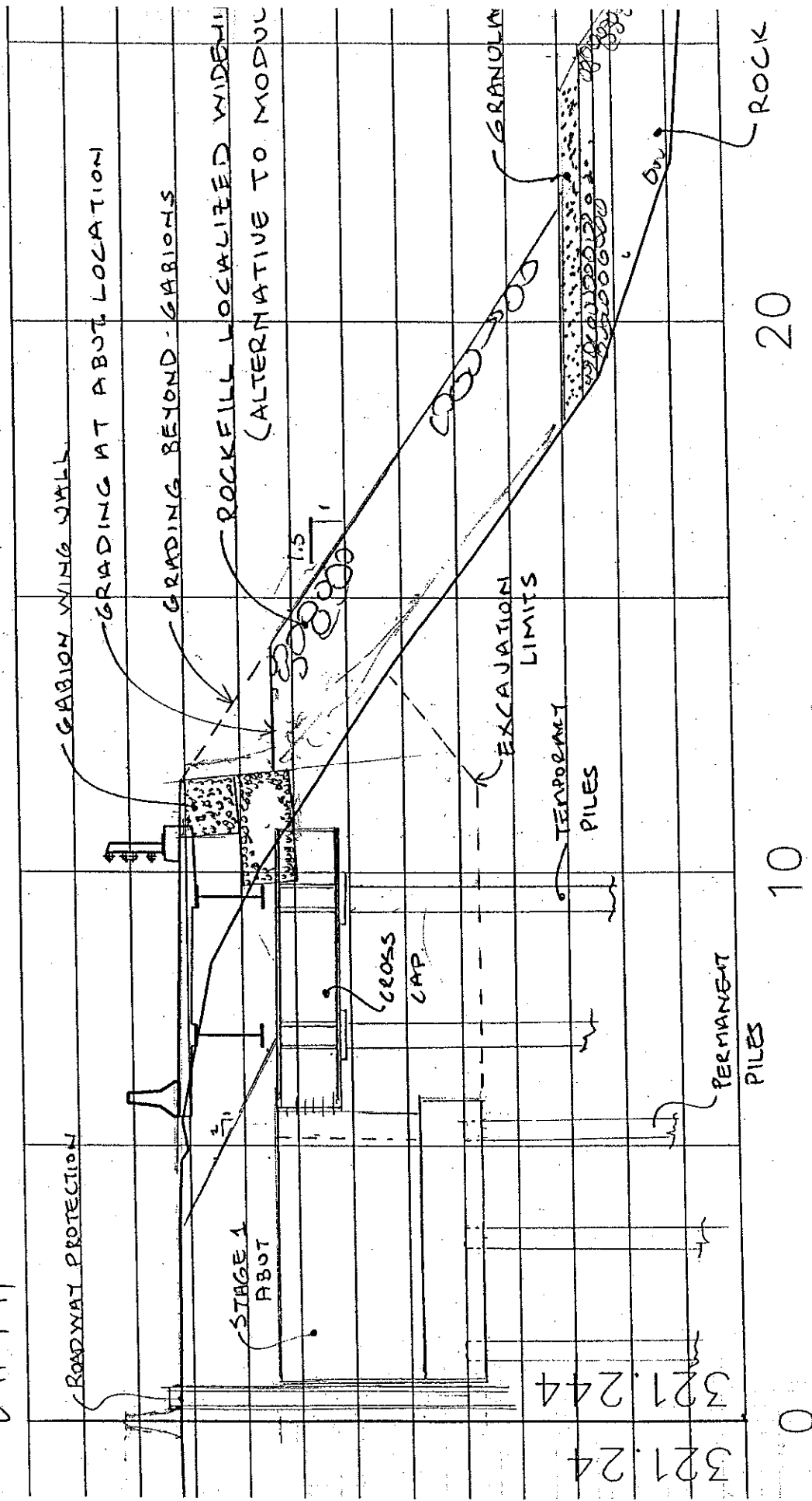
Kenogami River Bridge From Southeast



Kenogami River Bridge West Approach

426.300 (WEST)
 ABUT.

2 HWY. 11

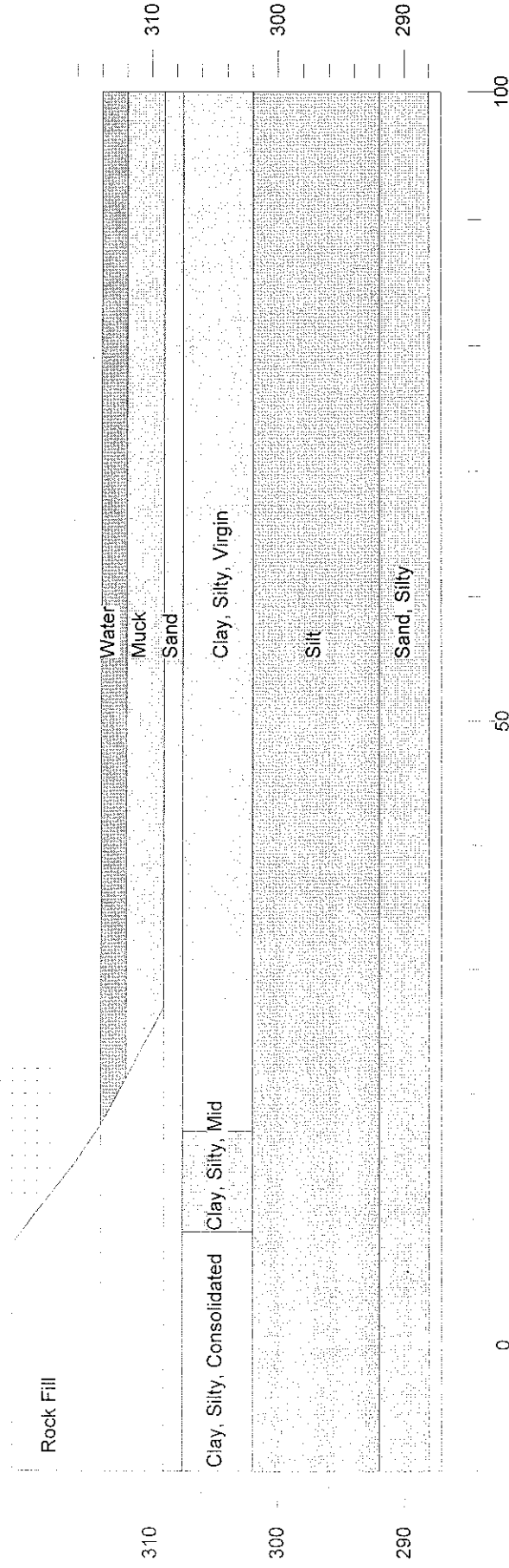


SKETCH F-1

Thurber Engineering Ltd. - Toronto
 19-1351-32
 Kenogami River Bridge
 January 14, 2003
 W Abut -10m, (10+410) Widening
 Present Condition Undrained BB

	Gamma kN/m ³	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	1
LW Fill	11.5	0	35	0	1
Muck	17	0	18	0	1
Rock Fill	21	0	45	0	1
Rock Fill	21	0	45	0	1
Sand	20	0	33	0	1
Silty Clay Virgi	19	30	0	.25	1
Silty Clay Mid	19	35	0	.25	1
Silty Clay Cons	19	50	0	.25	1
Silt	20	0	31	0	1
Silty Sand	21	0	33	0	1
Silty clay	21	80	0	0	1

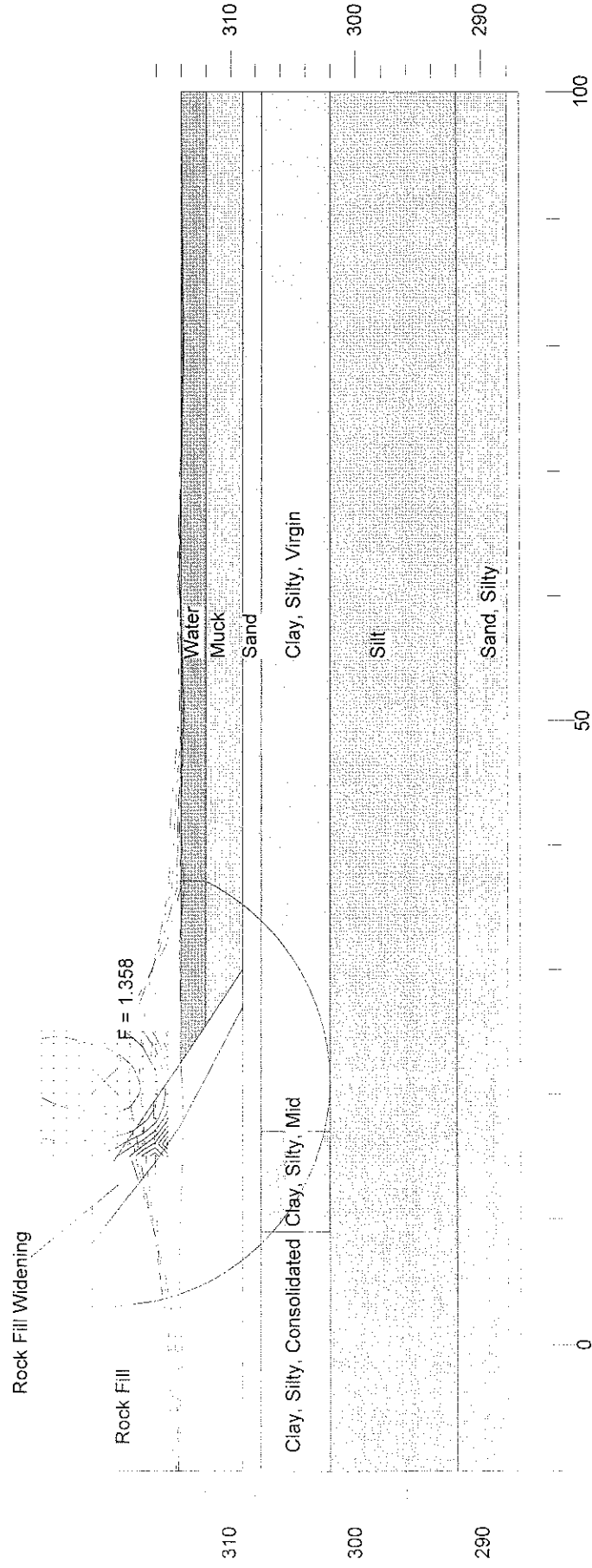
PRESENT CONDITION USING MIN C/P=0.25



Thurber Engineering Ltd. - Toronto
 19-1351-32
 Kenogami River Bridge
 January 14, 2003
 W Abut -10m, (10+410) Widening
 Widened 4m Undrained BB

	Gamma kN/m ³	C kPa	Phi deg	Min c/p	Piezo Surf.
Water	9.81	0	0	0	1
LW Fill	11.5	0	35	0	1
Muck	17	0	18	0	1
Rock Fill	21	0	45	0	1
Rock Fill	21	0	45	0	1
Sand	20	0	33	0	2
Silty Clay Virgi	19	30	0	.25	3
Silty Clay Mid	19	35	0	.25	4
Silty Clay Cons	19	50	0	.25	5
Silt	20	0	31	0	6
Silty Sand	21	0	33	0	0
Silty clay	21	80	0	0	7

WIDENED 4m USING MIN C/P=0.25



SKETCH F-3

Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)


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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level


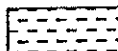



 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

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

TERMS					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No 02-1

1 OF 3

METRIC

W.P. 381-90-01 LOCATION N 5516296.9 E 337739.8 ORIGINATED BY MF
 DIST 61 HWY 11 BOREHOLE TYPE PQ Casing/ HW Casing/ HQ Core Barrel COMPILED BY WM
 DATUM GEODETIC DATE 01.10.02 - 08.10.02 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	20 40 60		
320.5													
320.6	ASPHALT (200mm)												
0.2	SAND and GRAVEL												
320.0	Brown						320						
0.5	Silty CLAY,												
319.6	Grey		1	RUN			319						
0.9	Moist												
	ROCK FILL												
	blasted rock, primarily granite, some												
	gabbro ranging between 25 and 500		2	RUN			318						
	mm in length												
	occasional sand and gravel												
	TCR = 70%												
	TCR = 59%												
			3	RUN			317						
	TCR = 41%												
							316						
			4	RUN			315						
	TCR = 38%												
							314						
			5	RUN			313						
	TCR = 28%												
							312						
	TCR = 56%		6	RUN			311						
310.9													
9.6	SAND and GRAVEL, trace silt		7	RUN			310						
	Brown												
309.6													
11.0	SILT and SAND,		1	SS	21		309						
	Compact												
	Grey		2	SS	18								
	Moist												
	occasional cobbles		3	SS	17		308						
			4	SS	27		307						
306.9													
13.6	Clayey SILT		5	SS	9		306						
	Stiff to Soft												
	Grey												
	occasional sand lenses and clay		1	TW	PH								
	laminations												

Continued Next Page

+ 3, x 3: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

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

RECORD OF BOREHOLE No 02-1

3 OF 3

METRIC

W.P. 381-90-01 LOCATION N 5516296.9 E 337739.8 ORIGINATED BY MF
 DIST 61 HWY 11 BOREHOLE TYPE PQ Casing/ HW Casing/ HQ Core Barrel COMPILED BY WM
 DATUM GEODETIC DATE 01.10.02 - 08.10.02 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						× LAB VANE			
								20	40	60						80	100	20	40
287.6							290												
							289												
							288												
32.9	Clayey SILT, sandy silt laminations Firm Grey						287												
			17	SS	5		286								0 1 84 15 0 1 80 19				
							285												
							284												
							283												
281.8							282												
38.7	Hetrogeneous mixture of SILT, SAND & GRAVEL, some clay Grey (GLACIAL TILL)						281												
							280												
279.7							279												
40.8	Fresh, slightly weathered at joints, strong, medium grained, grey GRANODIORITE, becoming coarse grained, light grey SYENITE TCR = 94% RQD = 39% TCR = 93% RQD = 64%		8	RUN			278												
			9	RUN															
277.7																			
42.9	END OF BOREHOLE AT 42.85m. BOREHOLE OPEN TO 6.10m. BOREHOLE BACKFILLED WITH DRILL CUTTINGS.																		

RECORD OF BOREHOLE No 02-3

1 OF 3

METRIC

W.P. 381-90-01 LOCATION N 5516278.7 E 337796.2 ORIGINATED BY MF
 DIST 61 HWY 11 BOREHOLE TYPE PQ Casing with Tri-Cone Advancer COMPILED BY WM
 DATUM GEODETIC DATE 09.10.02 - 11.10.02 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
322.6	ASPHALT (110mm)						322							
321.7	REINFORCED CONCRETE (Existing Bridge Deck)						321							
0.9	OPEN AIR						320							
							319							
							318							
							317							
							316							
							315							
							314							
							313							
							312							
							311							
312.8							310							
9.8	WATER						309							
							308							
12.5	Organic material with SAND and GRAVEL		1	SS	2									
309.4	Silty SAND, some organics layers Very Loose Grey and Brown Moist		2	SS	1									
13.2			3	SS	0									
307.9														
14.7	Clayey SILT, occasional organics,													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-3

2 OF 3

METRIC

W.P. 381-90-01 LOCATION N 5516278.7 E 337796.2 ORIGINATED BY MF
 DIST 61 HWY 11 BOREHOLE TYPE PQ Casing with Tri-Cone Advancer COMPILED BY WM
 DATUM GEODETTIC DATE 09.10.02 - 11.10.02 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								20 40 60 80 100										
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
307.2	occasional clay laminations		4	SS	16										0 0 73 27			
15.4	Very Stiff Grey		5	SS	6													
	Clayey SILT, occasional sand lenses and clay laminations																	
	Firm to Very Soft Grey		6	SS	0													
			7	SS	24											0 36 59 5		
303.5																0 2 32 66		
19.1	SILT, trace to some sand, fine grained, clay laminations																	
	Very Loose to Compact Grey		8	SS	8													
	silty clay laminations																	
	possible clay lense																	
			9	SS	3													
	occasional silty clay layers																	
			10	SS	8											0 0 81 19		
			</															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 02-3

3 OF 3

METRIC

W.P. 381-90-01 LOCATION N 5516278.7 E 337796.2 ORIGINATED BY MF
 DIST 61 HWY 11 BOREHOLE TYPE PQ Casing with Tri-Cone Advancer COMPILED BY WM
 DATUM GEODETIC DATE 09.10.02 - 11.10.02 CHECKED BY AEG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
291.0							292							
31.6	Fresh, slightly weathered at joints, strong, medium grained, grey GRANODIORITE, occasional dark grey to black mafic intrusions. TCR = 100% RQD = 46%		1	RUN			291							
	TCR = 100% RQD = 90%		2	RUN			290							
288.8							289							
33.7	END OF THE BOREHOLE AT 33.73m.													

METRIC

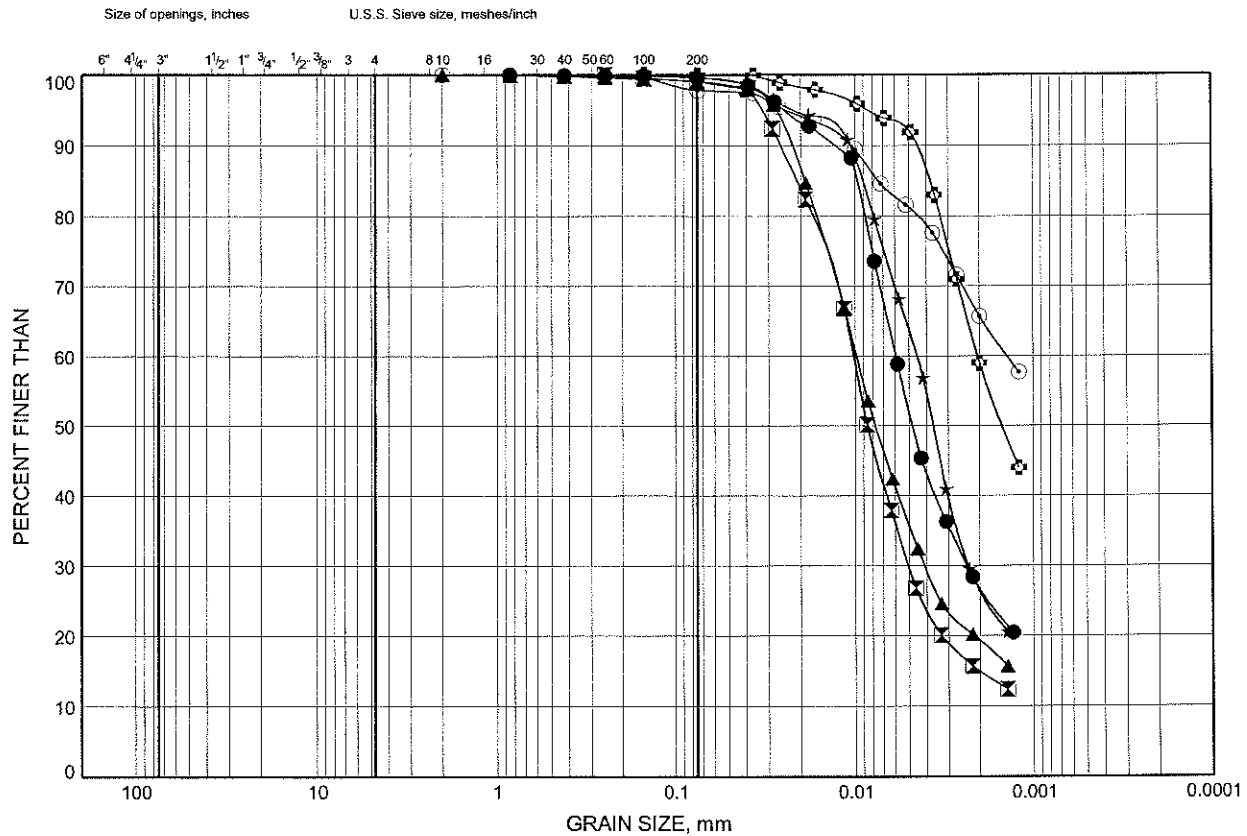
[illegible]

Appendix B

Laboratory Test Results

Kenogami River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B1



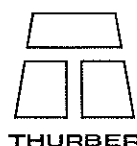
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-1	16.08	304.44
⊠	02-1	34.44	286.08
▲	02-1	34.59	285.93
★	02-3	15.08	307.49
⊙	02-3	18.59	303.98
⊕	02-4	15.54	308.15

CLAYEY SILT TO SILTY CLAY

Date February 2003.....

Project 381-90-01.....

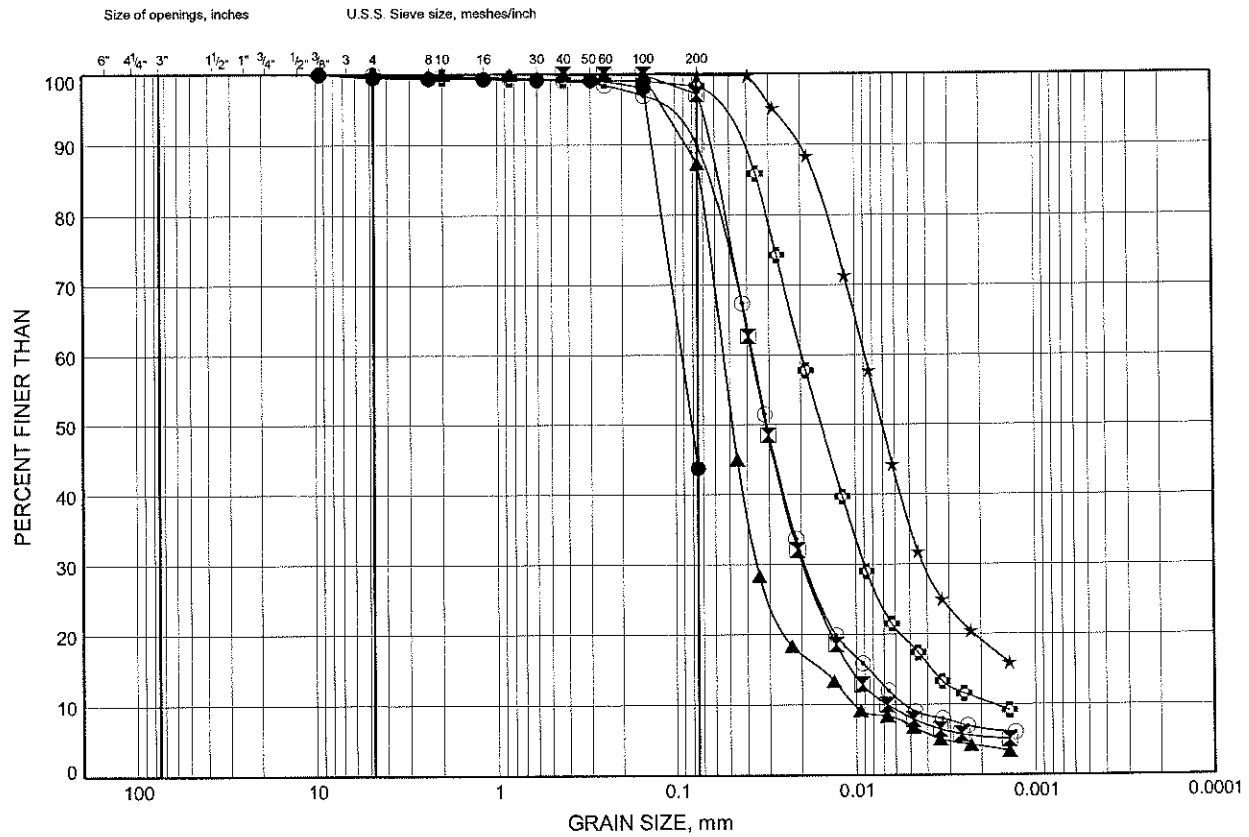


Prep'd EA

Chkd. AEG

Kenogami River Bridge GRAIN SIZE DISTRIBUTION

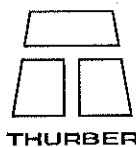
FIGURE B2



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-1	11.89	308.63
⊠	02-1	25.30	295.22
▲	02-1	28.35	292.17
★	02-3	26.21	296.36
⊙	02-4	17.07	306.62
⊛	02-4	18.59	305.10

SANDY SILT TO CLAYEY SILT

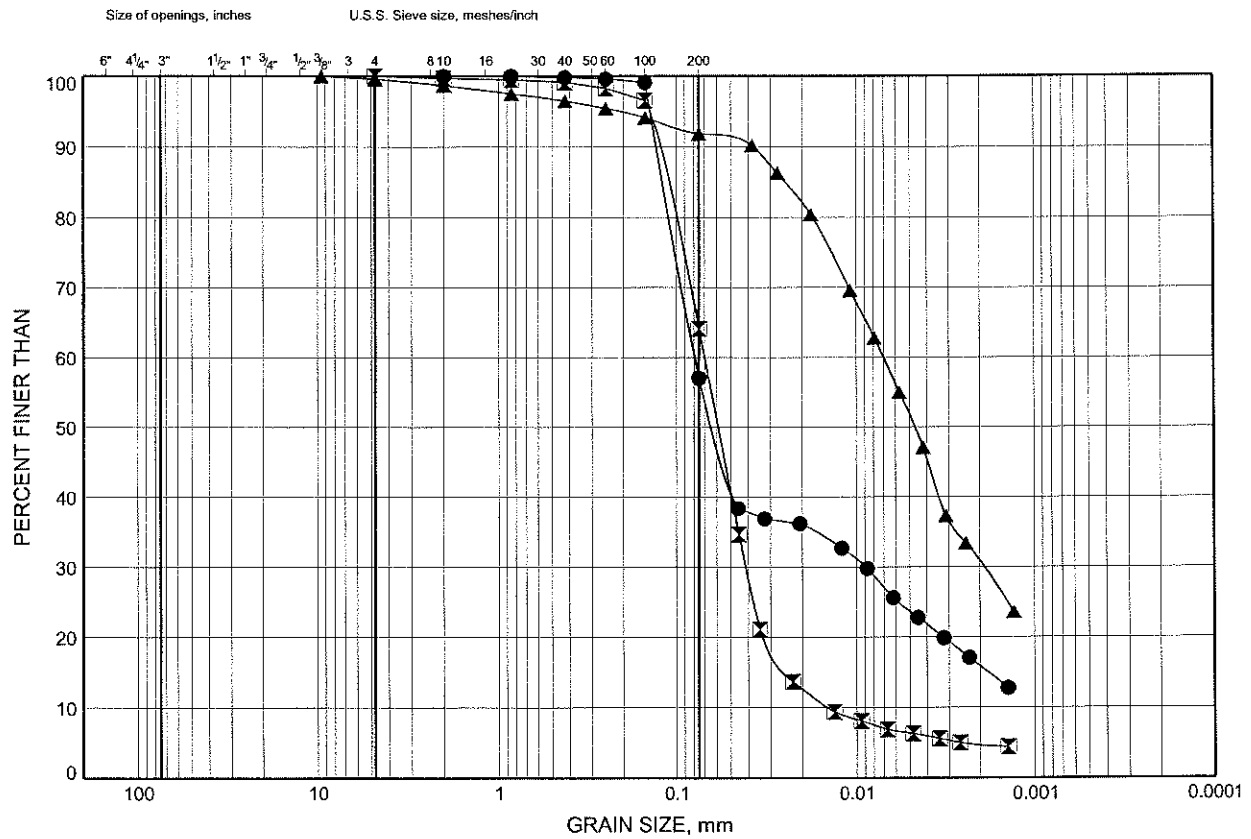
Date February 2003
Project 381-90-01



Prep'd EA
Chkd. AEG

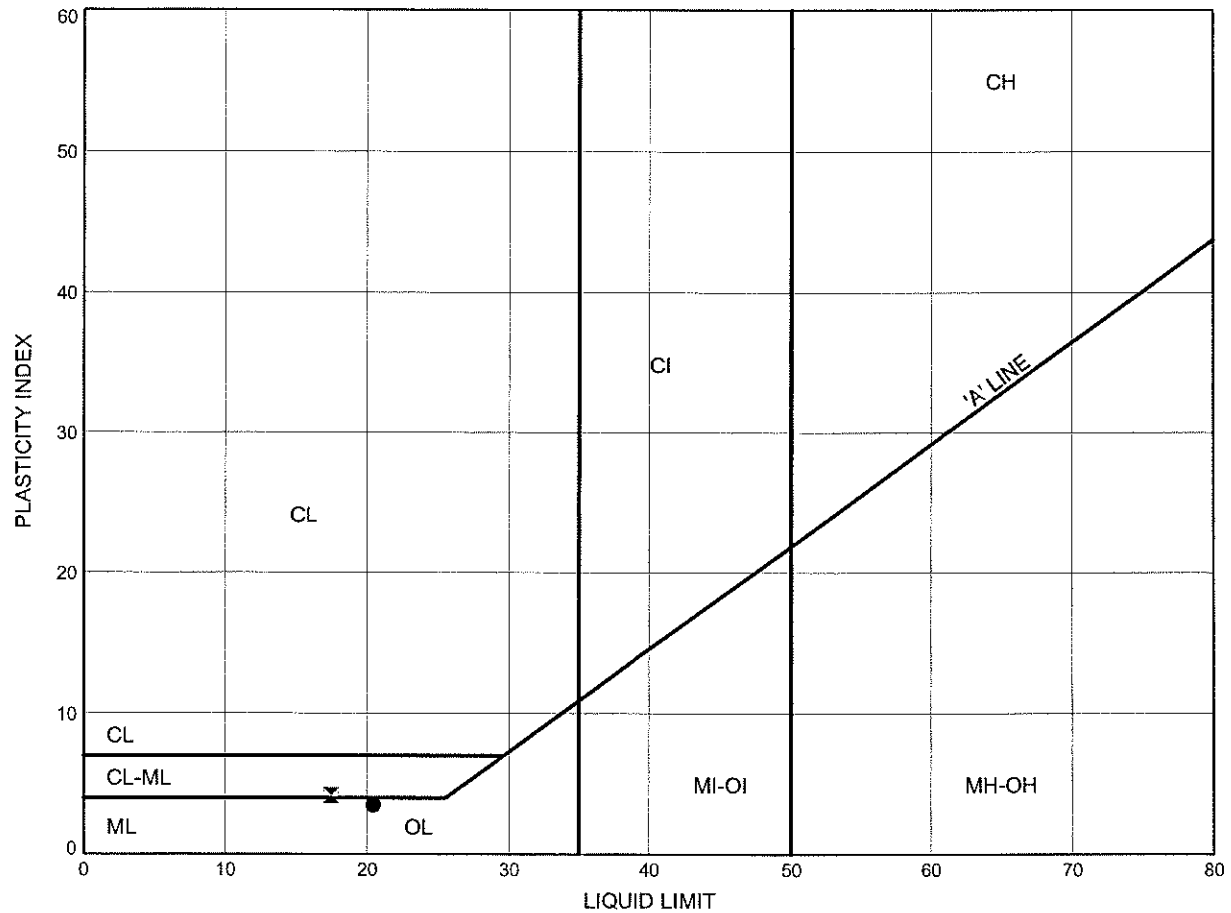
Kenogami River Bridge GRAIN SIZE DISTRIBUTION

FIGURE B3



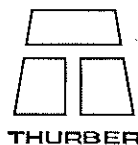
Kenogami River Bridge
ATTERBERG LIMITS TEST RESULTS

FIGURE B4



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	02-1	34.44	286.08
⊠	02-4	20.12	303.57

Date February 2003
 Project 381-90-01

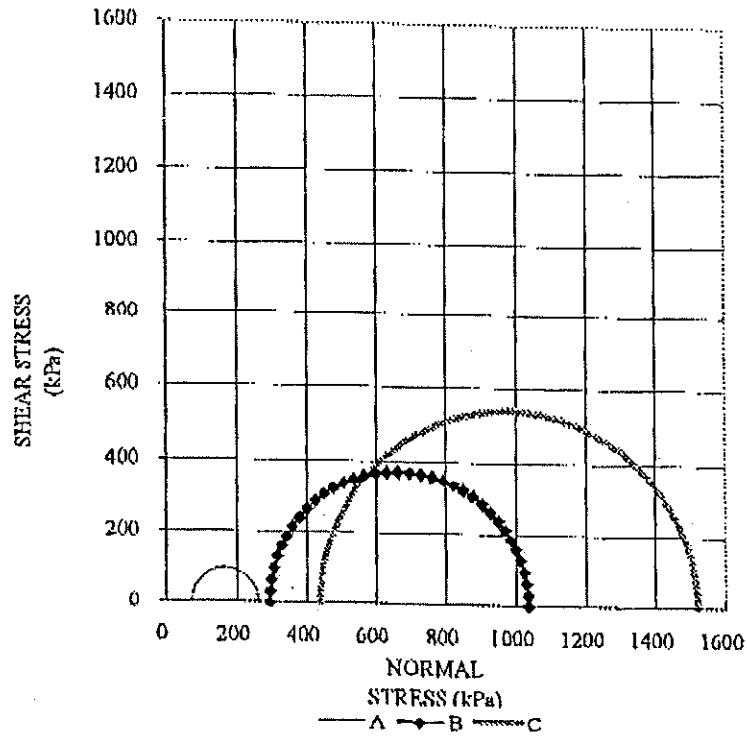


Prep'd EA
 Chkd. AEG

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 1 OF 3

FIGURE

BH 02-1 ST#1



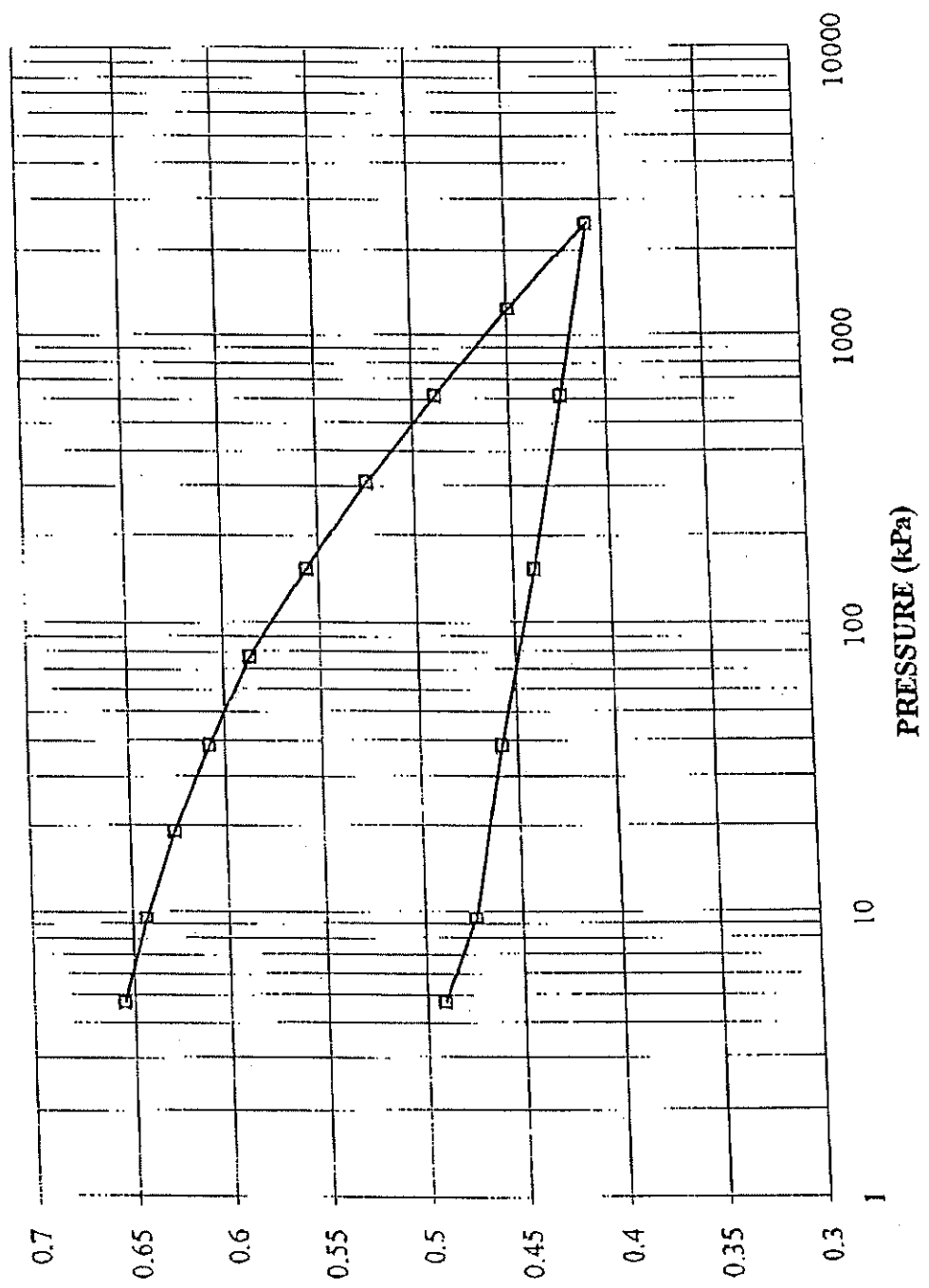
Project No. 021-101026

Golder Associates

CONSOLIDATION TEST
VOID RATIO VS. LOG PRESSURE

FIGURE

CONSOLIDATION TEST
VOID RATIO vs PRESSURE
BH 02-1 ST #2



Project No. 021-101026

VOID RATIO

Goldor Associates

Appendix C

Factual Data from AGRA Report

RECORD OF BOREHOLE No 1

METRIC

W P 381-90-01 LOCATION Station 10+435, 24.0 m Lt
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring
 DATUM Geodetic DATE April 18 - 20, 1994.
 ORIGINATED BY CR
 COMPILED BY CR
 CHECKED BY CR

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
312.7	ICE SURFACE																
0.0	ICE																
312.4	COBBLES & BOULDERS		1	AS	---	ON COMPLETION OF BORING	312										Borehole was relocated 3x to bypass cobbles and boulders
	"MUD"		2	SS	2												
	(dark brown SANDY SILT with layers of SILTY FINE SAND, and wood fragments, peat traces)		3	SS	7												
			4	SS	2												
308.9	very loose saturated		5	SS	3		310										
3.8	grey SILT with layers of SILTY FINE SAND		6	SS	15												
	compact saturated		7	SS	13		308										
			8	SS	12												
305.2	grey SILTY CLAY with layers of SILT		9	TW	PH.		306										
7.5	firm wet		10	SS	2												
302.8			11	SS	9		304										
9.9			12	SS	40												
			13	SS	13		302										
			14	SS	21												
	grey SILT with layers of FINE SAND		15	SS	23		300										
			16	SS	24												
			17	SS	33		298										
	compact saturated silty clay lamination		18	SS	8												
290.1							296										
22.6							294										
							292										

Continued

+3, x5: Numbers refer to Sensitivity

20 15-5 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 1 Continued METRIC

W P 381-90-01 LOCATION Station 10+435, 24.0 m Lt ORIGINATED BY CLL
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CLL
 DATUM Geodetic DATE April 18 - 20, 1994. CHECKED BY Bso

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
290.1	Continued						SHEAR STRENGTH kPa						
							○ UNCONFINED + FIELD VANE						
							● QUICK TRIAXIAL x LAB VANE						
							WATER CONTENT (%)						
22.6	Continued		19	SS	24	290							
	grey SILT with layers of FINE SAND compact saturated												
			20	SS	22	288							
			21	SS	31								
285.6						286							
27.1	SILTY FINE SAND trace gravel (probably compact) saturated		22	SS	4								
			23	SS	6	284							
282.8													
29.9			24	SS	80/15cm	282							
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												
			25	RC	REC 50%	280							
			26	SS	100/8cm								
			27	SS	92/15cm	278							
276.6	very dense moist		28	SS	100/15cm								
36.1	END OF BOREHOLE												

RECORD OF BOREHOLE No 2

METRIC

W P 381-90-01 LOCATION Station 10+474, 6.0 m Lt
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring
 DATUM Geodetic DATE April 23-24, 1994. ORIGINATED BY CLO
 COMPILED BY CLO
 CHECKED BY ASD

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
311.4	WATER SURFACE												
0.0	KENOGLAMI RIVER												Drive N-casing and clean. Wash to 4.6 m. Advance bore with BW casing.
310.2													
1.2	"MUD" (dark brown SANDY SILT with layers of SILTY FINE SAND, wood fragments, peat traces very loose saturated		1	SS	PH		310						
			2	SS	3								
308.2			3	SS	3								
3.2	grey SILT with clay laminations compact saturated		4	SS	25		308						
306.5			5	SS	10								
4.9	grey SILTY CLAY with layers of SILT firm wet		6	TW	PH		306	+3.2					0 0 68 32
304.7			7	SS	17		304	+3.2					Ap. 23
6.7			8	SS	10		302						Ap. 24
	grey SILT		9	SS	11		300						0 18-79 ~3
	with layers of FINE SAND		10	SS	10		298						0 5 87 8
	silty clay laminations		11	SS	24		296						
	compact dense		12	SS	15		294						
	saturated Heterogeneous Mixture of SILT, SAND AND GRAVEL, occasional Cobbles and Boulders (Glacial Till)		13	SS	40		292						
291.6	grey, very dense		14	SS	25								
19.9	BEDROCK (GRANODIORITE, QUARTZ SYENITE, ANDESITE)		15	SS	50/1 cm								REC RQD
			16	BXL	---								96% 93%
			17	RC	---								100% 88%
289.8							290						
21.6	END OF BOREHOLE												

RECORD OF BOREHOLE No 3

METRIC

W P 381-90-01 LOCATION Station 10+522, 6.0 m Rt. ORIGINATED BY CR
 Thunder DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY CR
 DATUM Geodetic DATE April 15, 1994. CHECKED BY CR

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
312.4	ICE SURFACE												
312.0	ICE												
	"MUD" (dark brown and grey SILT with layers of SILTY FINE SAND and PEAT) very loose saturated		1	AS	---								SS3: ORGANIC CONTENT: 19% At 7m depth bore de- flected by sloping bed- rock surface Re-locate hole 1.5mE, auger to 6.0m depth, take SS7 again N=7 REC ROD 100% 60% 92% 67% 100% 100%
			2	SS	11								
			3	SS	3								
			4	SS	1								
308.7			5	SS	3								
3.7													
	SILT with silty clay laminations loose to compact saturated grey, very dense		6	SS	5								
			7	SS	9								
305.5			8	SS	50/0	PEN							
7.0	BEDROCK (GRANODIORITE)		9	BXL RC									
			10	RC									
303.6			11	BXL RC									
8.8	END OF BOREHOLE												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

RECORD OF BOREHOLE No 3										METRIC			
W P 381-90-01		LOCATION Station 10+522, 6.0 m Rt				ORIGINATED BY <u>CR</u>							
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering				COMPILED BY <u>CR</u>							
DATUM Geodetic		DATE April 15, 1994.				CHECKED BY <u>zxo</u>							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
312.4	ICE SURFACE												
312.0	ICE												
	"MUD" (dark brown and grey SILT with layers of SILTY FINE SAND and PEAT) very loose saturated		1	AS	---								
			2	SS	11								
			3	SS	3								
			4	SS	1								
308.7			5	SS	3								
3.7	SILT with silty clay laminations loose to compact saturated grey, very dense		6	SS	5								
			7	SS	9								
305.5			8	SS	50/0								
7.0	BEDROCK (GRANODIORITE)		9	BXL RC									
			10	RC									
303.6			11	BXL RC									
8.8	END OF BOREHOLE												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 381-90-01 LOCATION Station 10+565, 11.0 m Lt ORIGINATED BY CL
 DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY CL
 DATUM Geodetic DATE April 21, 1994. CHECKED BY BS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100		
312.6	ICE SURFACE												
0.0	ICE												
311.8													
0.8	"MUD" brown grey SILT with traces of org. matter loose saturated		1	SS	5	ON COMPLE- TION OF BORING							
			2	SS	4								
310.0			3	SS	8								
2.6			4	SS	17								
			5	SS	10								
			6	SS	16								
			7	SS	11								
306.2			8	SS	17								
6.4			9	SS	30								
305.0													
7.6	END OF BOREHOLE AUGER & SS REFUSAL PROBABLE BEDROCK												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5										METRIC			
W P 381-90-01		LOCATION Station 10+591, 27.0 m Lt				ORIGINATED BY <u>un</u>							
DIST Thunder Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering and Washboring				COMPILED BY <u>un</u>							
DATUM Geodetic		DATE April 22, 1994.				CHECKED BY <u>350</u>							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20					
313.0	ICE SURFACE												
0.0	ICE												
0.6	"MUD" (dark brown SILTY FINE SAND with layers of ORGANIC SILT and PEAT)		1	SS	4								
			2	SS	5								
310.4	loose saturated		3	SS	23								
2.6	SILT		4	SS	10								
	compact silty clay laminations saturated		5	SS	11								
308.1			6	SS	17								
4.9	grey, very dense		7	SS	80/15 cm								
5.4	BEDROCK (GRANODIORITE)		8	BXL RC									
306.1													
6.9	END OF BOREHOLE												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 381-90-01 LOCATION Station 10+581, 4.5 m Rt ORIGINATED BY CM
 DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY CM
 DATUM Geodetic DATE April 20 and 21, 1994. CHECKED BY ZSO

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100		
312.6	ICE SURFACE												
0.0	23 cm ICE												
0.2	"MUD" (dark grey and brown, layers of SILTY SAND and PEAT very loose saturated)		1	AS		312							
310.8			2	SS									
1.8	grey SILT		3	SS									
			4	SS		310							
			5	SS									
	compact saturated		6	SS									
			7	SS		308							
307.1	grey												
5.5			8	SS		306							
305.0	compact wet		9	SS									
7.6													
	BEDROCK (GRANODIORITE)		10	BXL RC		304							
303.4													
9.2	END OF BOREHOLE												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8										METRIC			
W P <u>381-90-01</u>		LOCATION <u>Station 10+539, 27.0 m Rt</u>				ORIGINATED BY <u>CR</u>							
DIST <u>Thunder Bay 19 HWY 11</u>		BOREHOLE TYPE <u>Hollow Stem Augering and Washboring</u>				COMPILED BY <u>CR</u>							
DATUM <u>Geodetic</u>		DATE <u>April 15, 1994</u>				CHECKED BY <u>ZSO</u>							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
312.4	ICE SURFACE												
0.0	ICE												
311.7													
0.7	"MUD" (dark brown and grey SILTY FINE SAND with layers of ORGANIC SILT and PEAT very loose saturated		1	SS	7								
			2	SS	2								
309.8			3	SS	11								
2.6	grey of SILT with silty clay laminae compact saturated		4	SS	12								
			5	SS	13								
			6	SS	12								
306.9													
5.5	grey												
			7	SS	14								
305.4	compact saturated		8	SS	60/5 cm								18 40 36 6
7.0	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK												
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 381-90-01 LOCATION Station 10+480, 24.0 m Rt. ORIGINATED BY CR
Thunder DIST Bay 19 HWY 11 BOREHOLE TYPE Washboring COMPILED BY CR
DATUM Geodetic DATE April 25, 1994. CHECKED BY ZBO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
311.4	WATER SURFACE													
0.0	KENOGAMI RIVER													
310.0														
1.4	"MUD" (greyish and dark brown SILTY FINE SAND with layers of SILT & PEAT very loose saturated		1	SS	1									Drive N- casing to 4.6m then drill BW casing further.
308.0			2	SS	3									
3.4			3	SS	15									
			4	SS	9									
			5	SS	5									
			6	SS	6									
	grey SILT layers of Fine Sand		7	SS	12									
			8	SS	11									
			9	SS	11									
			10	SS	24									
			11	SS	24									
			12	SS	7									
296.9	compact grey very dense		13	SS	50/5	cm								
296.4			14	BXL RC										
15.0	BEDROCK (GRANODIORITE)		15	BXL RC										
294.1														100% 95%
17.3	END OF BOREHOLE													97% 97%
	Heterogeneous Mixture of SILT, SAND AND GRAVEL occasional Cobbles and Boulders (Glacial Till)													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10										METRIC			
W P 381-90-01		LOCATION Station 10+430, 23.0 m Rt				ORIGINATED BY <u>CM</u>							
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering and Washboring				COMPILED BY <u>CM</u>							
DATUM Geodetic		DATE April 12, 1994.				CHECKED BY <u>ZB</u>							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
312.3	ICE SURFACE												
0.0	ICE					312							
311.7	"MUD" (dark brown and grey SANDY SILT with layers of SILTY FINE SAND, wood fragments and traces of peat) very loose saturated	1	SS	3									
0.6		2	SS	3									
		3	SS	1		310							
		4	SS	2									
307.9													
4.4	grey SILT with silty clay laminations compact saturated	5	SS	9		308	2.7						
		6	SS	7			5.4						
305.1						306							
7.2	grey SILTY CLAY with silt layers firm wet	7	SS	4			2.5						
		8	TW	PH		304	2.8						
302.1													0 11 86 3
10.2		9	SS	10		302	3.0						
		10	SS	26		300							
		11	SS	16									0 3 89 8
	grey SILT with layers of Fine Sand compact saturated	12	SS	19		298							
		13	SS	30		296							0 2 86 12
		14	SS	23		294							0 3 81 6
		15	SS	22		292							
291.3		16	AS	---									
21.0	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK	17	SS	30/0	PEN								

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 11

METRIC

W P 381-90-01 LOCATION Station 10+400, 22.0 m Rt. ORIGINATED BY CH
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CH
 DATUM Geodetic DATE April 13, 1994. CHECKED BY ZW

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
312.3	ICE SURFACE															
0.0	ICE															
311.7																
0.6	"MUD" (brown Silty Sand with organics)		1	SS	3											
310.5	very loose saturated		2	SS	6											
1.8			3	SS	11											
	grey SILT with Fine Sand layers		4	SS	12											
	traces of organic matter		5	SS	15											
306.7	compact saturated		6	SS	31											
5.6			7	SS	13											
	grey SILTY CLAY with silt layers		8	TW	PH											
	firm wet		9	TW	PH											
301.9			10	SS	2											
10.4	traces of organics		11	SS	12											
			12	SS	28											
	silty clay laminations		13	SS	16											
	SILT		14	SS	4											
	silty clay laminations		15	SS	10											
	with layers of FINE SAND		16	SS	29											
			17	SS	3											
			18	SS	14											
289.7	compact saturated															
22.6																

Continued

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 11 Continued METRIC

W.P. 381-90-01 LOCATION Station 10+400, 22.0 m Rt ORIGINATED BY CLZ
 DIST Thunder Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CLZ
 DATUM Geodetic DATE April 13, 1994. CHECKED BY Zoo

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
289.7	Continued														
22.6	stilt clay														
	SILT with laminations		19	SS	10										
	layers of Fine Sand compact saturated														
287.7															
24.6	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK		20	SS	50/8 cm	288									

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 12										METRIC				
W P 381-90-01 Thunder		LOCATION Station 10+361, 19.0 m Rt				ORIGINATED BY <u>cm</u>								
DIST Bay 19 HWY 11		BOREHOLE TYPE Hollow Stem Augering and Washboring				COMPILED BY <u>cm</u>								
DATUM Geodetic		DATE April 13 - 14, 1994				CHECKED BY <u>cm</u>								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40					
312.5	ICE SURFACE													
0.0	ICE													
311.9														
0.6	"MUD" (dark brown SILTY FINE SAND traces of wood bark, peat) very loose saturated		1	SS	3									
310.1			2	SS	1									
2.4	grey SILT with layers of Silty Fine Sand compact saturated		3	SS	11									
			4	SS	11									
			5	SS	30									
			6	SS	24									
306.1			7	SS	8									
6.4	grey SILTY CLAY with layers of SILT firm wet		8	TW	PH								19.3 21.3	
			9	SS	1									
			10	TW	PH									
			11	SS	4									
300.0			12	SS	27									
12.5	grey silty clay laminations		13	SS	17									
			14	SS	10									
			15	SS	12									
	SILT with layers of Fine Sand compact saturated		16	SS	7									
			17	SS	28									
			18	SS	21									
289.9														
22.6														

OFFICE REPORT ON SOIL EXPLORATION

Continued

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

Continued

SS16:
'N'-value
probably
reduced by
upward see-
page forces

RECORD OF BOREHOLE No 12 Continued METRIC

W P 381-90-01 LOCATION Station 10+361, 19.0 m Rt ORIGINATED BY CR
 Thunder DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering and Washboring COMPILED BY CR
 DATUM Geodetic DATE April 13 - 14, 1994. CHECKED BY ZSO

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa					
289.9	Continued grey SILT with layers of Fine Sand compact saturated		19	SS	18								
22.6													
			20	SS	18	288							
			21	SS	21	286							
			22	SS	11	284							
282.0	END OF SAMPLED BOREHOLE												Augered to El. 282.0m (easy auger- ing) then drove dyna- mic cone penetration test
30.5													
276.5	END OF DCPT												
36.0													

RECORD OF BOREHOLE No 13

METRIC

W P 381-90-01 LOCATION Station 10+670, 28.0 m Rt ORIGINATED BY CK
 DIST Thunder HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY CK
 DATUM Geodetic DATE April 23, 1994. CHECKED BY Zoo

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES								
315.6	GROUND SURFACE												
0.0	Sandy Silt Fill Topsoil		1	AS	---	BH DRY							
	brown SILTY CLAY (frozen)		2	SS	22								
314.0	cobble		3	SS	30/8								
1.6	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 14				METRIC
W P	381-90-01	LOCATION	Station 10+707, 25.0 m Rt	
DIST	Thunder Bay 19 HWY 11	BOREHOLE TYPE	Hollow Stem Augering	
DATUM	Geodetic	DATE	April 23, 1994.	
			ORIGINATED BY	CM
			COMPILED BY	CR
			CHECKED BY	ZSO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					W _p	W	W _L		
								SHEAR STRENGTH kPa									
316.5	GROUND SURFACE																
0.0	frozen to 0.8 m depth		1	AS	---		316									Borehole was relocate once because of boulder @ 1.2m depth	
	brown SILTY SAND		2	SS	41												
			3	SS	16												
	moist wet		4	SS	28												
313.4	compact to dense		5	SS	30/0	CAVE PENN	314										
3.1	END OF BOREHOLE REFUSAL TO SS PROBABLE BEDROCK																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 15

METRIC

W P 381-90-01 LOCATION Station 10+500, 24.0 m Rt
 Thunder DIST Bay 19 HWY 11 BOREHOLE TYPE Washboring
 Geodetic DATE April 25 - 26, 1994
 ORIGINATED BY UH
 COMPILED BY CR
 CHECKED BY 200

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20	40	60	80	100				
311.4	WATER SURFACE														
0.0	KENOGAMI RIVER														
310.2															
1.2	"MUD" (dark brown, SILTY FINE SAND with peat, wood, etc.)		1	SS	1	310									
308.7	very loose saturated														
2.7	traces of organics		2	SS	18	308									
			3	SS	17										
	SILT with thin Silty Clay laminations compact saturated		4	SS	15								non plastic		
			5	SS	9	306							non plastic		
			6	SS	11								non plastic		
			7	SS	15	304									
303.0															
8.4	END OF BOREHOLE REFUSAL PROBABLE BEDROCK														

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No P9

METRIC

W P 381-90-01 LOCATION Station 10+609.2, 3.5 m Rt
Thunder
DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering
DATUM Geodetic DATE July 5, 1994.

ORIGINATED BY HR
COMPILED BY HR
CHECKED BY HR

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
324.6	TOP OF PAVEMENT												
0.0	170 mm ASPHALT												
323.0	FILL - gravelly sand with occasional cobbles		1	SS	38								
1.6			2	SS	37								
	FILL - silty sand some gravel, occasional sandy zones		3	SS	14								
			4	SS	15								
			5	SS	5								
316.8	damp to moist		6	SS	11								
7.8	POSSIBLE FILL - fine sand to silt with occasional silty clay and silt sand seams		7	SS	16								
314.6	SILTY SAND traces rock fragments		8	SS	11								
10.0	compact wet												
313.2	END OF BOREHOLE AUGER REFUSAL PROBABLE BEDROCK												
11.4													

RECORD OF BOREHOLE No P10

METRIC

W P 381-90-01 LOCATION Station 10+622.6, 3.0 m Rt ORIGINATED BY U2
 Thunder DIST Bay 19 HWY 11 BOREHOLE TYPE Hollow Stem Augering COMPILED BY U2
 DATUM Geodetic DATE July 5, 1995 CHECKED BY 20

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
324.6	TOP OF PAVEMENT														
0.0	190 mm ASPHALT														
	FILL - gravelly sand with silt layer														
323.2															
1.4															
	FILL - silty sand		1	SS	10										
			2	SS	4										
			3	SS	6										
318.8															
5.8	POSSIBLE FILL - fine sand		4	SS	8										
316.5			5	SS	10										
8.1	END OF SAMPLED BOREHOLE														
314.2															
10.4	END OF DCPT														

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

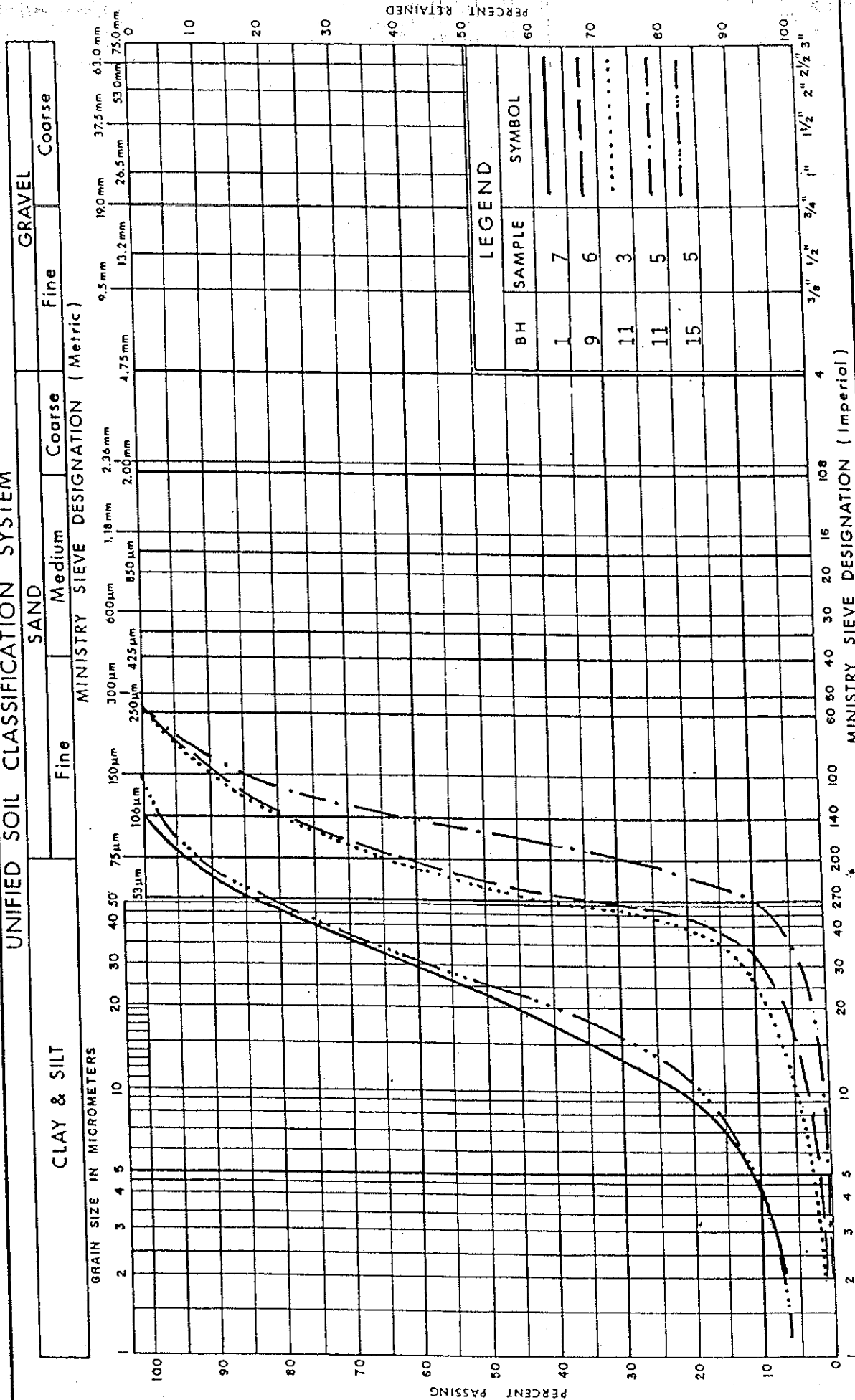
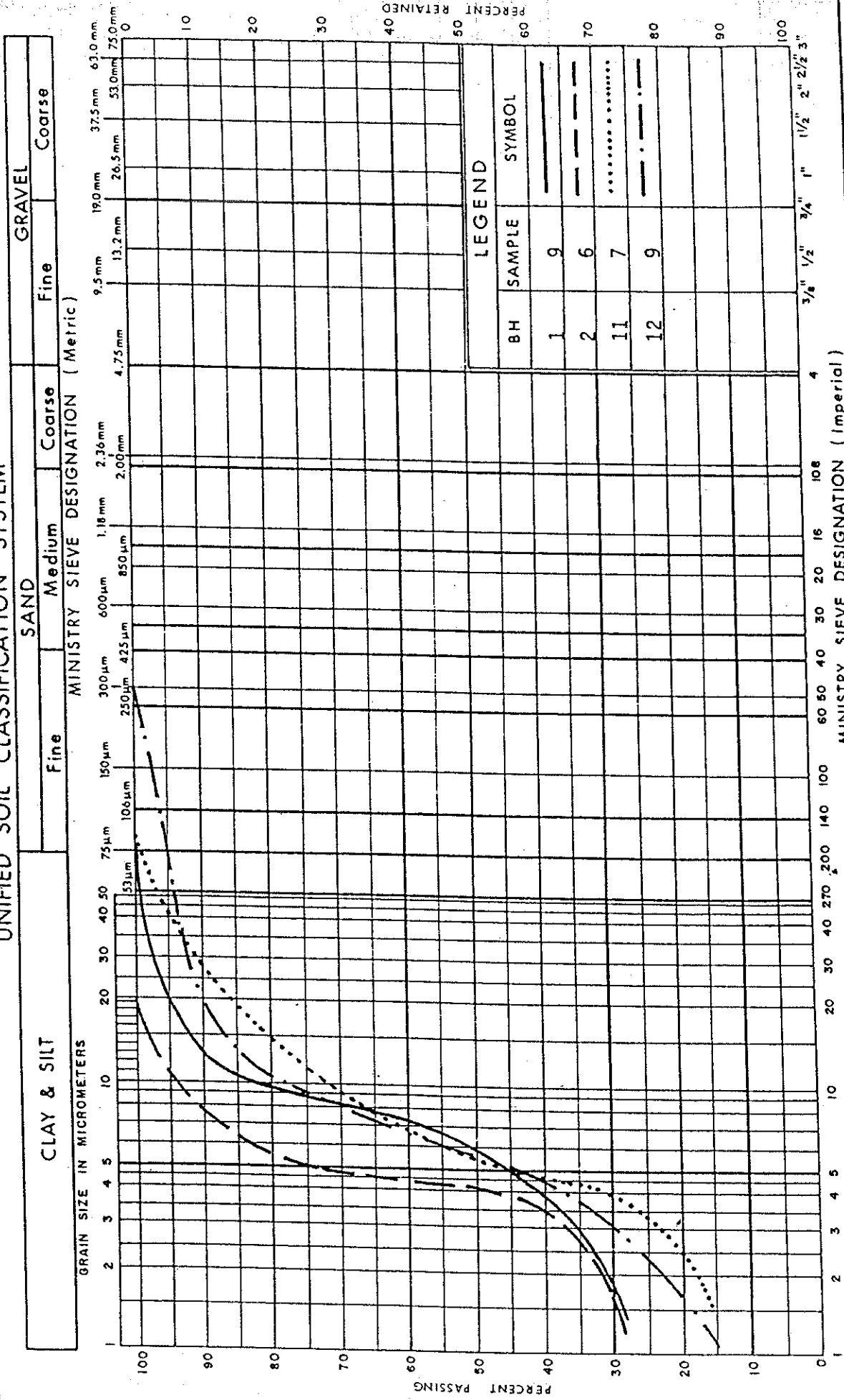


FIG No 1

GRAIN SIZE DISTRIBUTION

(UPPER) SILT with silty fine sand layers

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

FIG No 2

Ministry of
Transportation

W P 381-90-01

SILTY CLAY



UNIFIED SOIL CLASSIFICATION SYSTEM

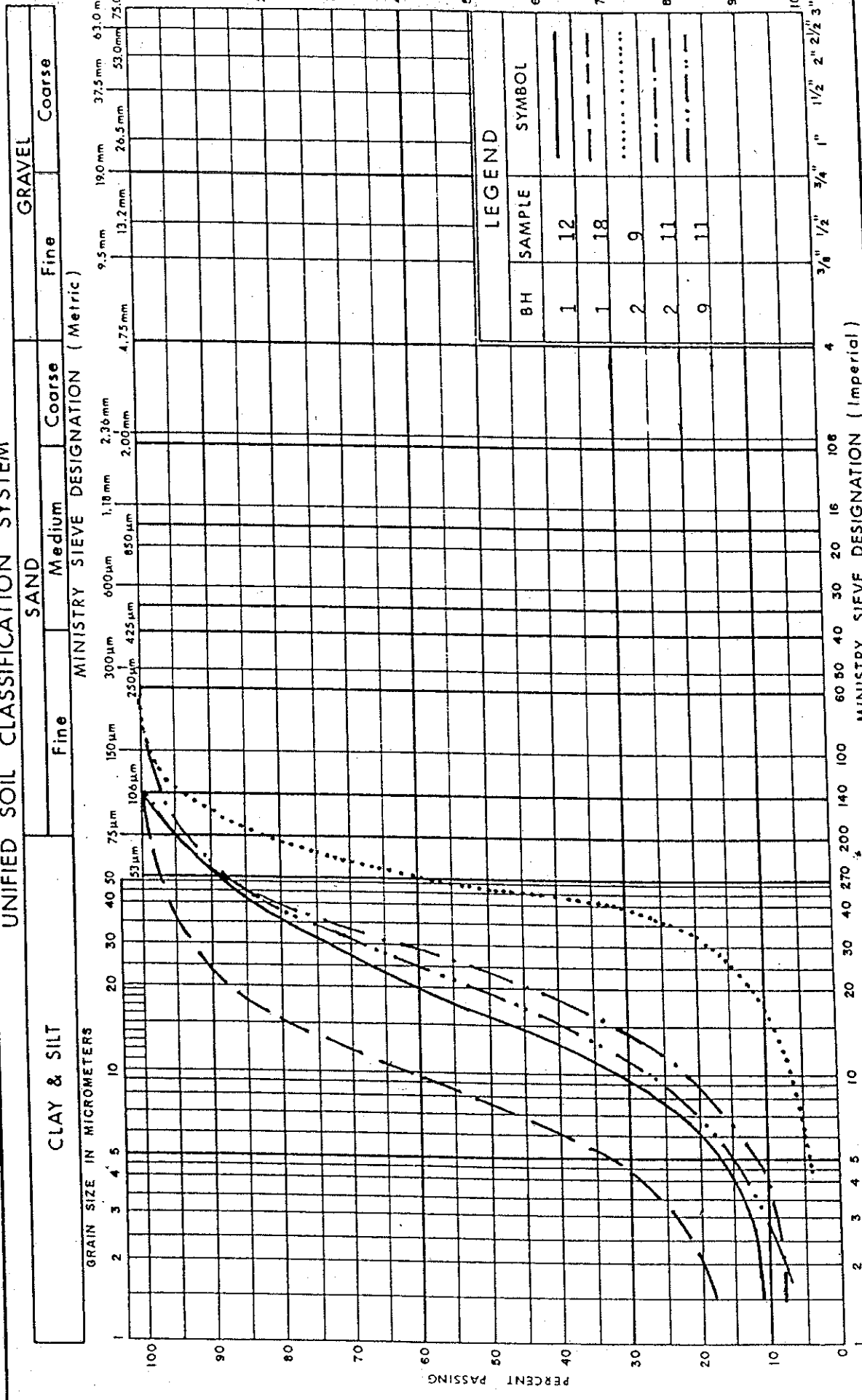
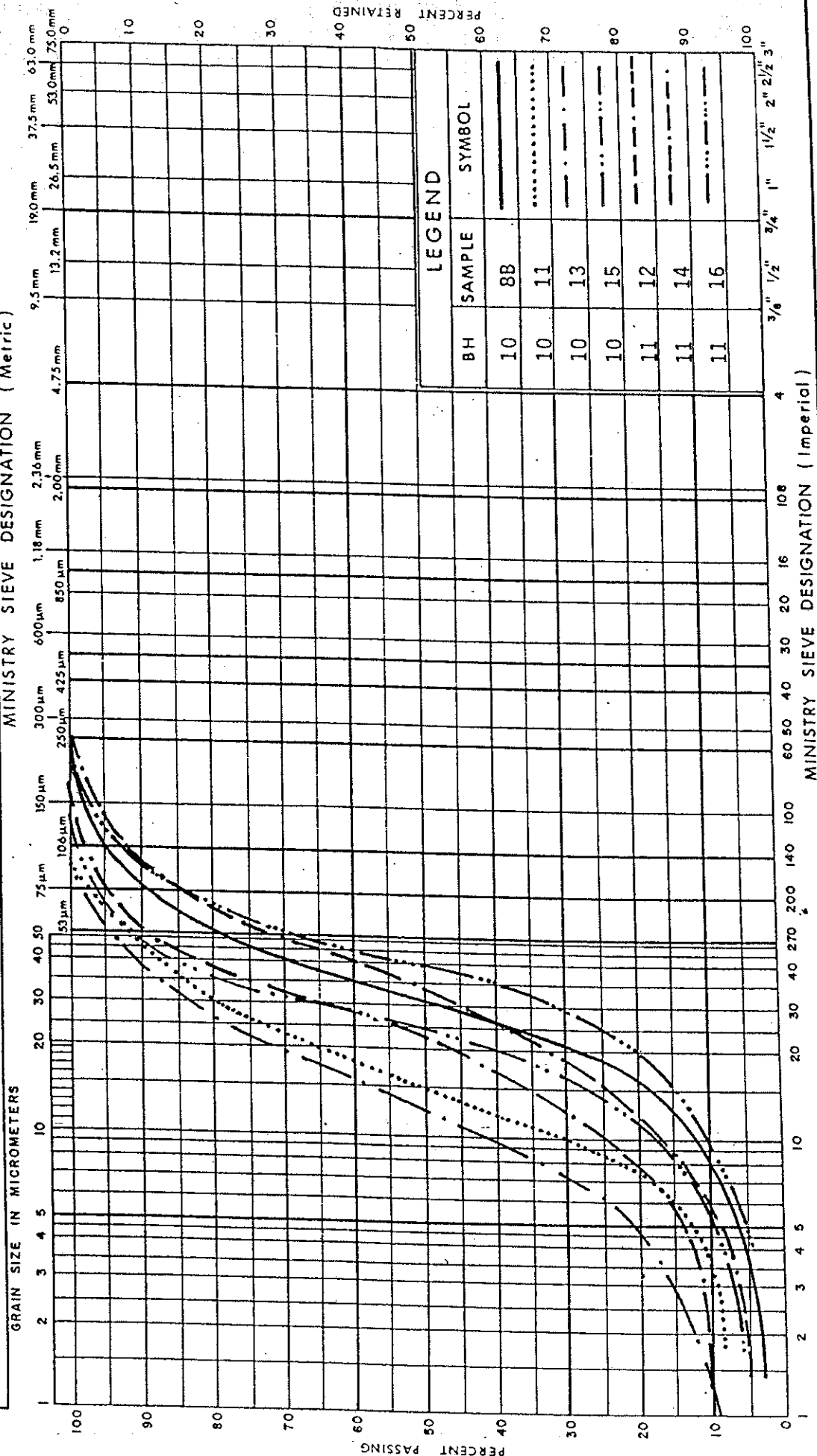


FIG No 3

GRAIN SIZE DISTRIBUTION

(LOWER) SILT I

	GRAVEL					
	SAND			GRAVEL		
	Fine	Medium	Coarse	Fine	Coarse	
CLAY & SILT						



GRAIN SIZE DISTRIBUTION

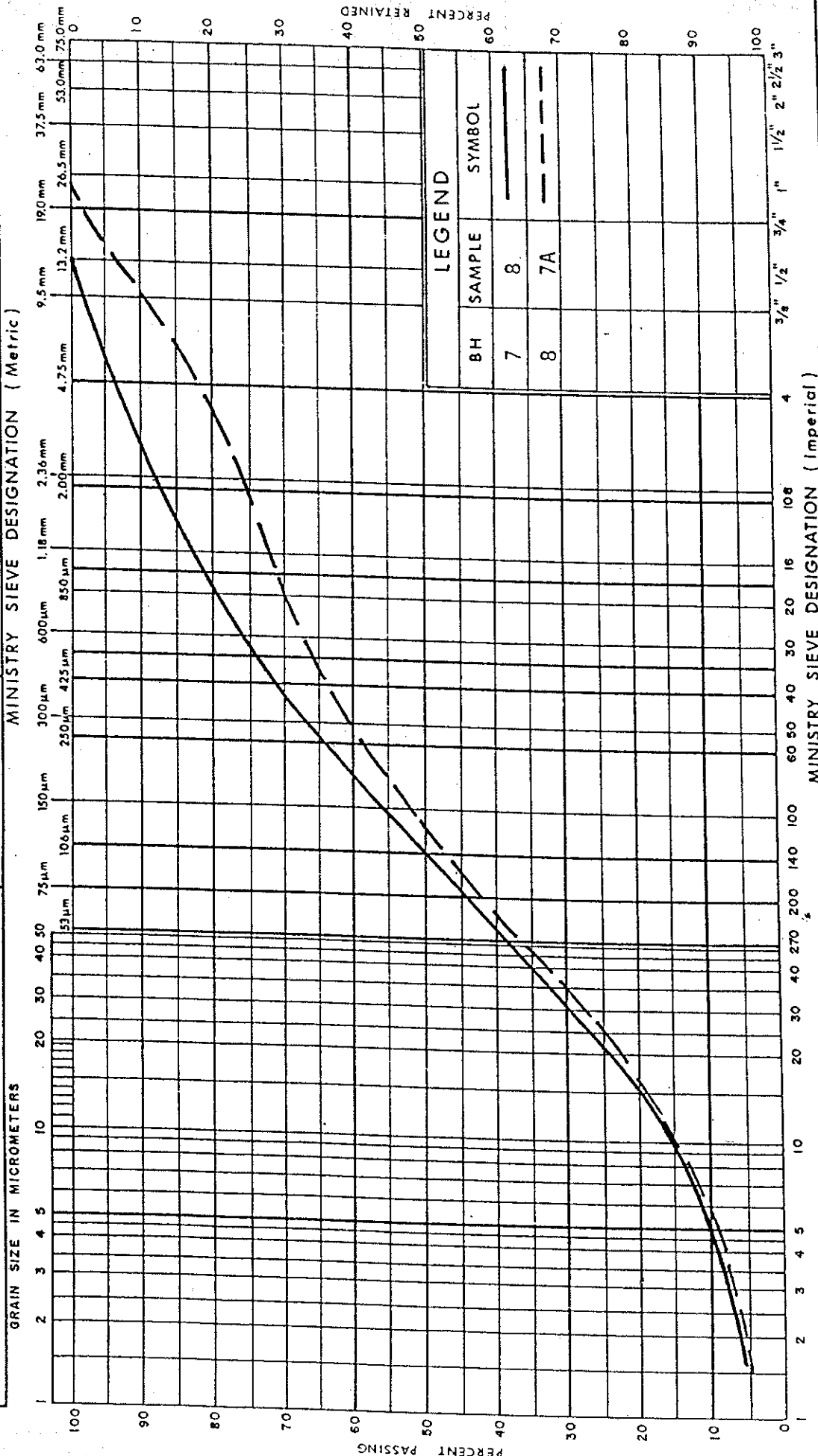
(LOWER) SILT II

FIG No 4

W P 381-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	
		MINISTRY SIEVE DESIGNATION (Metric)					



GRAIN SIZE DISTRIBUTION

Heterogeneous mixture of SILT,
SAND and GRAVEL, occasional
Cobbles and Boulders (Glacial Till)

Ministry of
Transportation



FIG No 5

W P 381-90-01

VOID RATIO - PRESSURE CURVES

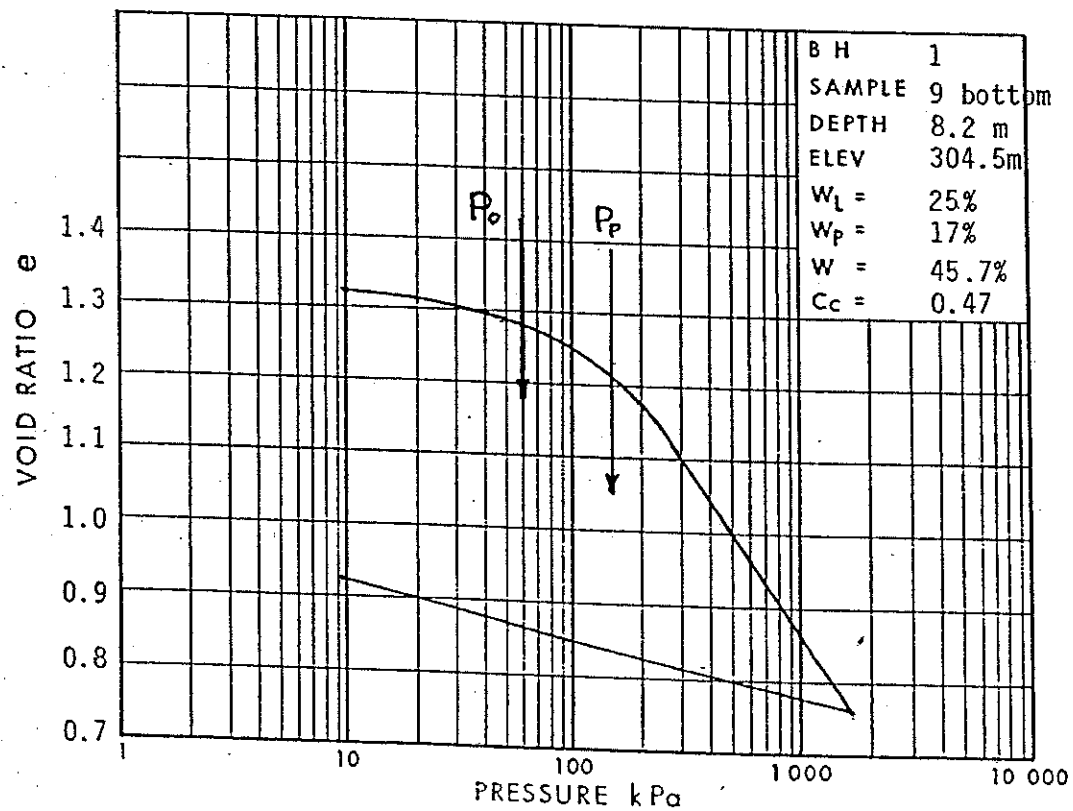
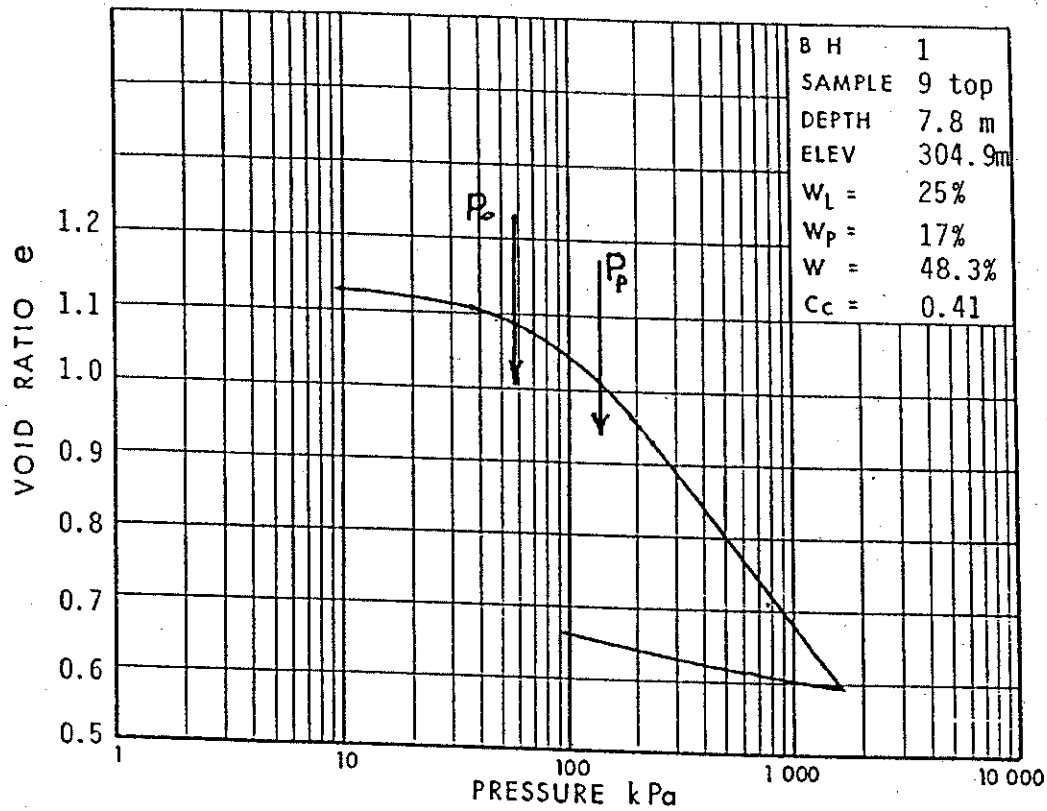


Fig 6

W P 381-90-01

VOID RATIO-PRESSURE CURVES

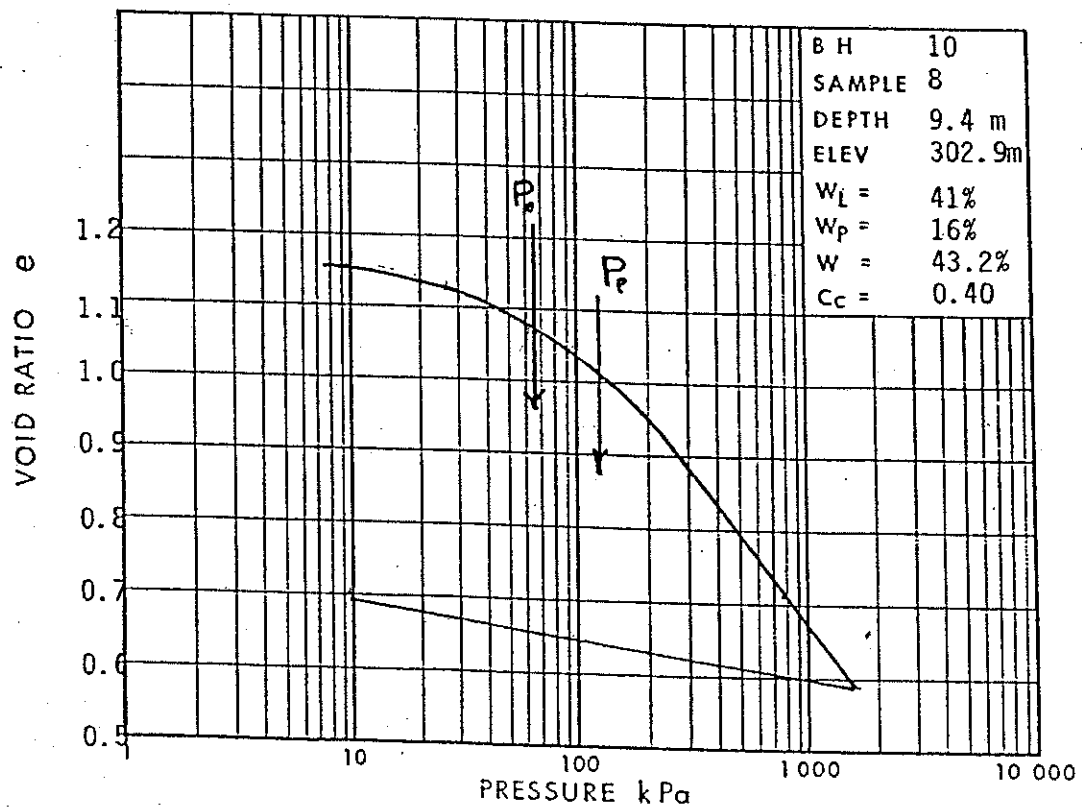
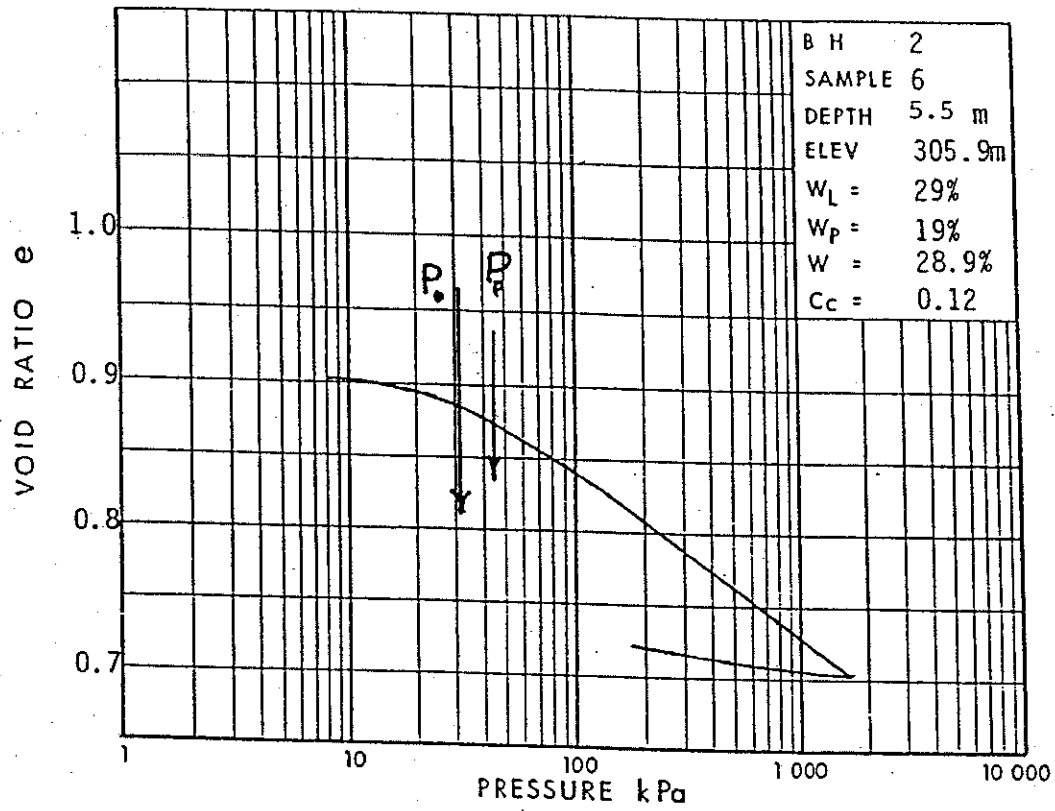


Fig 7

VOID RATIO - PRESSURE CURVES

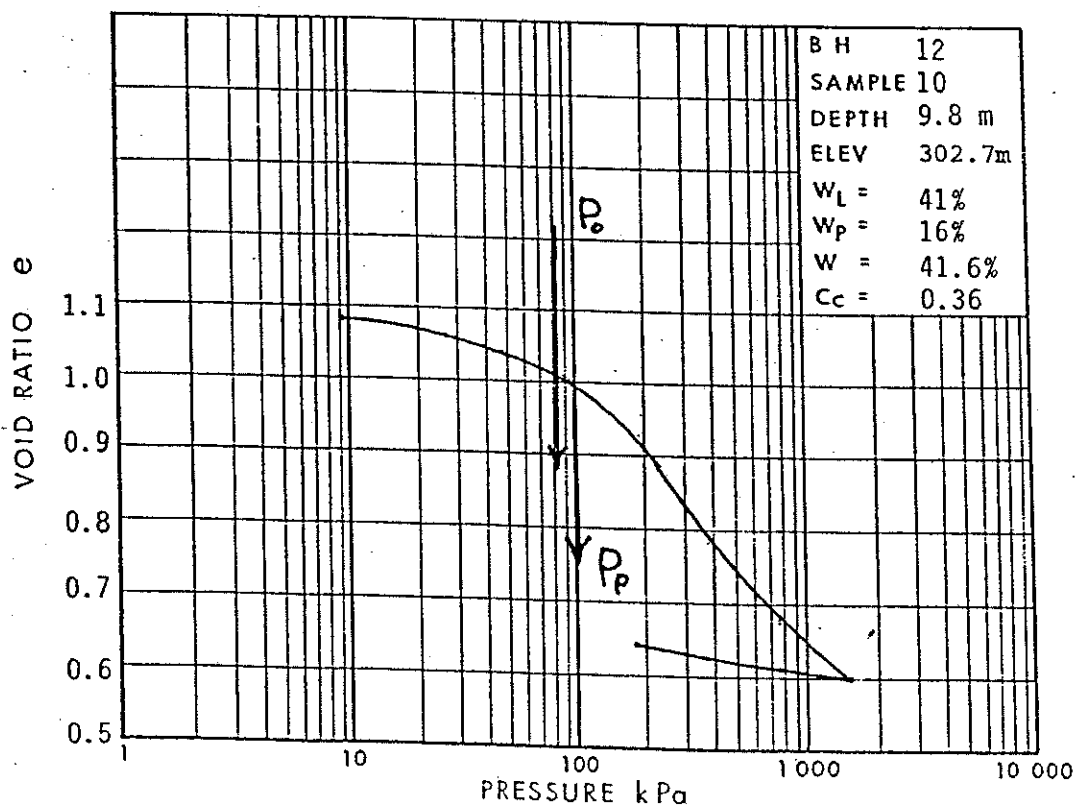
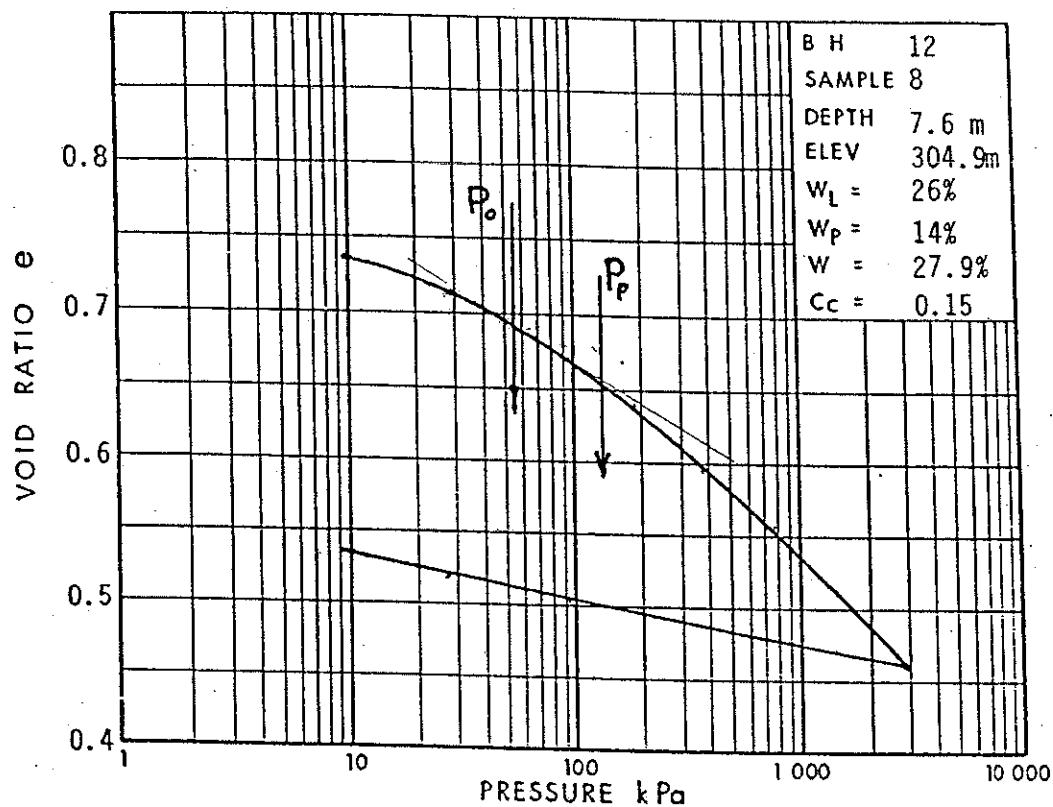


Fig 8

W P 381-90-01

Appendix D

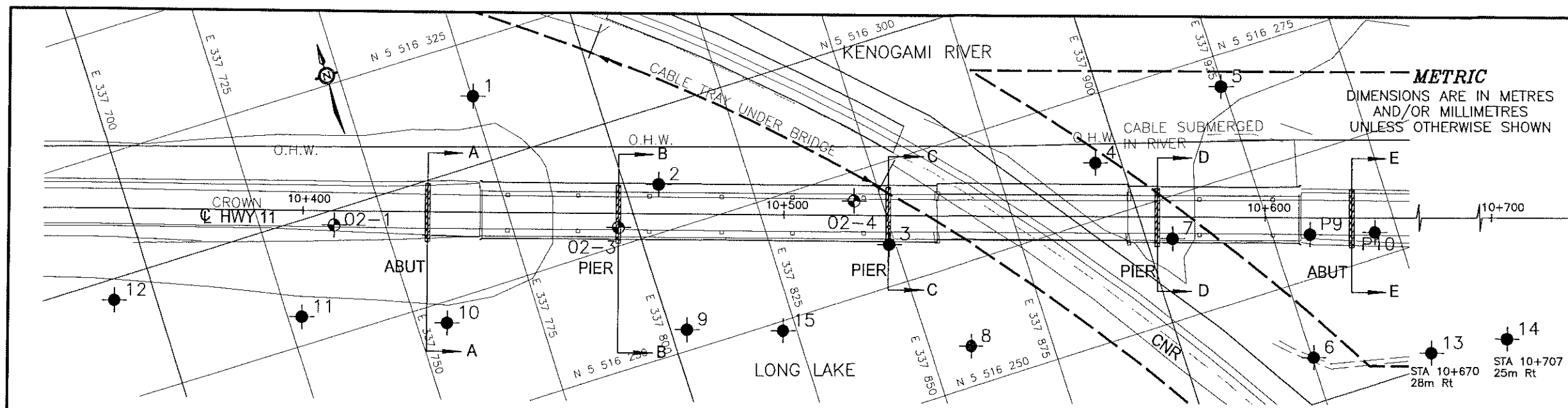
NSSP

The NSSP for setting rock points into bedrock should contain the following text.

“This NSSP applies to driving H-piles fitted with rock points into bedrock.

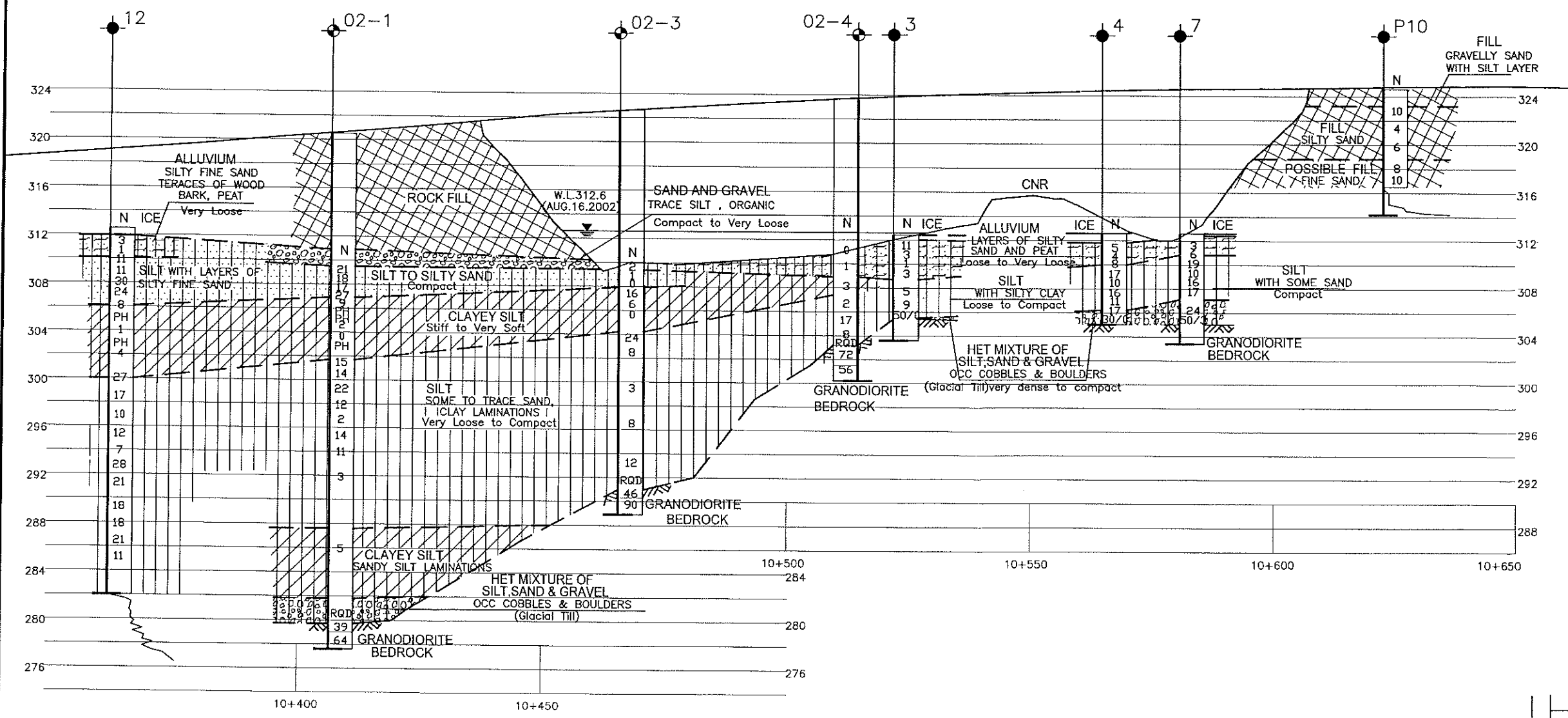
When bedrock is encountered, the following procedure shall be followed:

1. Reduce the hammer energy to 10% of the maximum value
2. Strike the pile in sets of 20 blows until no further penetration is observed
3. Strike the pile with a further set of 20 blows
4. If no further penetration is observed, increase the hammer energy to 20% of the maximum
5. Repeat Steps (2) and (3)
6. Each time no further penetration is achieved, increase the hammer energy by 10% of the maximum and repeat Steps (2) and (3)
7. Repeat until no further penetration is observed at 100% of hammer energy.”



BOREHOLE LOCATION PLAN

SCALE
10 5 0 10 20M



PROFILE HWY 11

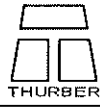
SCALE
10 5 0 10 20M HOR
4 2 0 4 8M VERT

SITE No.48E-06
WP No. 381-90-01

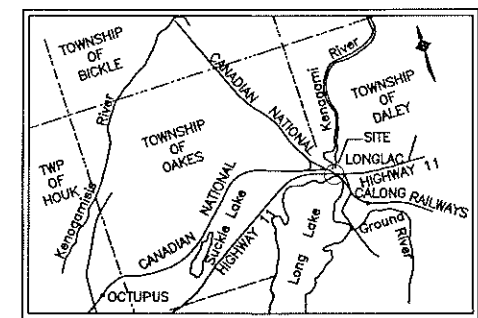


SHEET

KENOGAMI RIVER BRIDGE
LONGLAC
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEY PLAN

2.0 km

LEGEND

- BoreHole by AGRA
- BoreHole by THURBER
- N Blow / 0.3m (std pen Test, 475 J / blow)
- CONE Blows / 0.3m (60° Cone, 475J/blow)
- WL at time of investigation 2002
- Head Artesian Water
- Piezometer

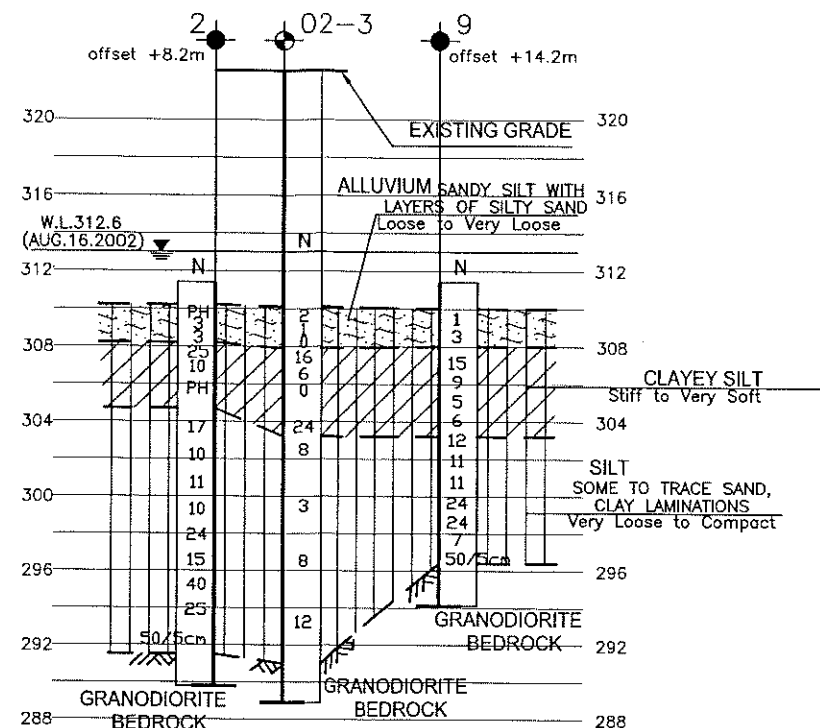
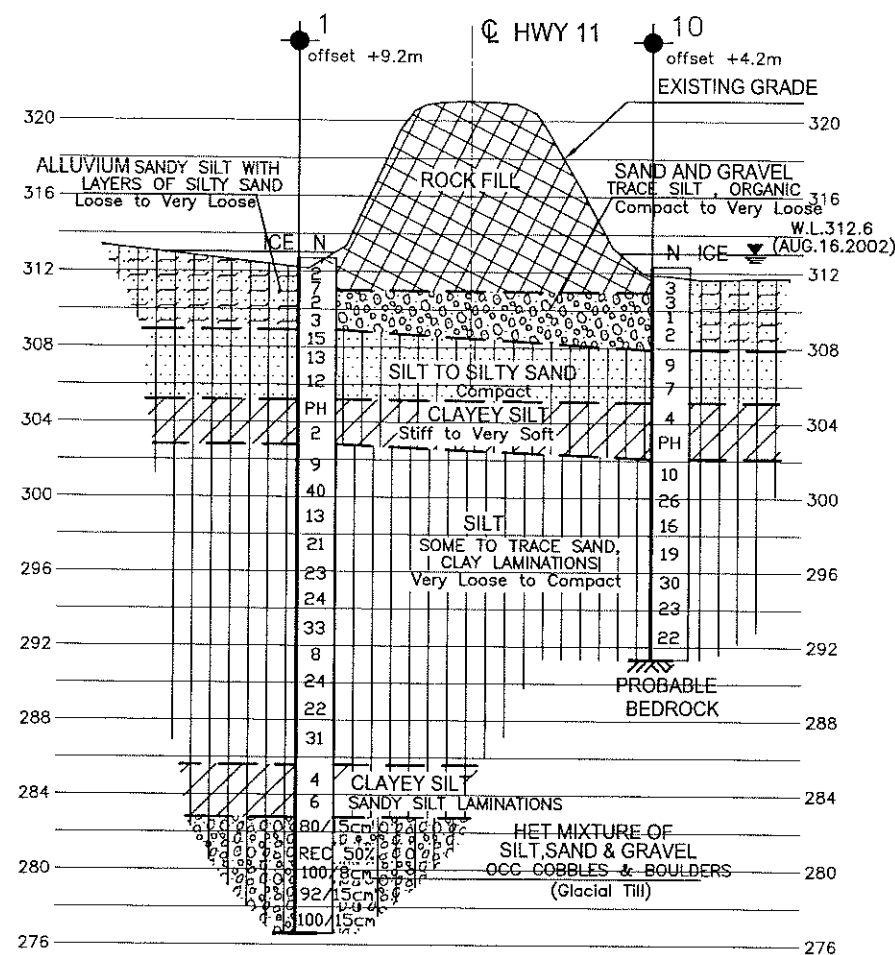
NO	ELEVATION	NORTHING	EASTING
1	312.7	5516313.8	337775.3
2	311.4	5516284.7	337806.8
3	312.4	5516258.4	337848.7
4	312.6	5516261.3	337894.9
5	313.0	5516268.5	337924.6
6	314.2	5516209.3	337925.3
7	312.6	5516241.6	337905.3
8	312.4	5516233.1	337858.4
9	311.4	5516254.3	337803.3
10	312.3	5516270.7	337756.0
11	312.3	5516280.9	337727.8
12	312.5	5516295.8	337691.6
13	315.6	5516191.7	337982.7
14	316.5	5516183.1	338018.8
15	311.4	5516248.1	337822.3
P9	324.6	5516233.8	337932.5
P10	324.6	5516230.1	337945.3
02-1	320.5	5516297.0	337739.8
02-3	322.6	5516278.7	337796.3
02-4	323.7	5516269.2	337844.5

NOTE

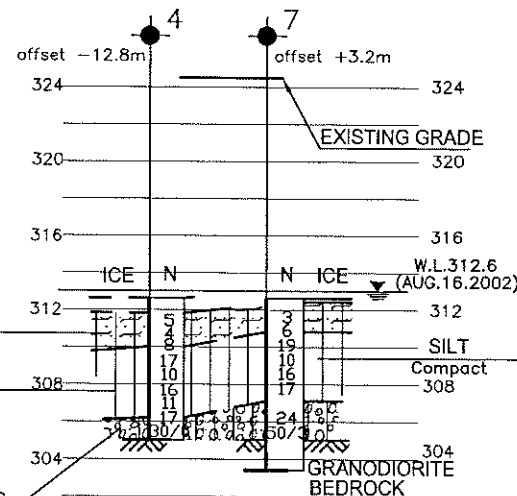
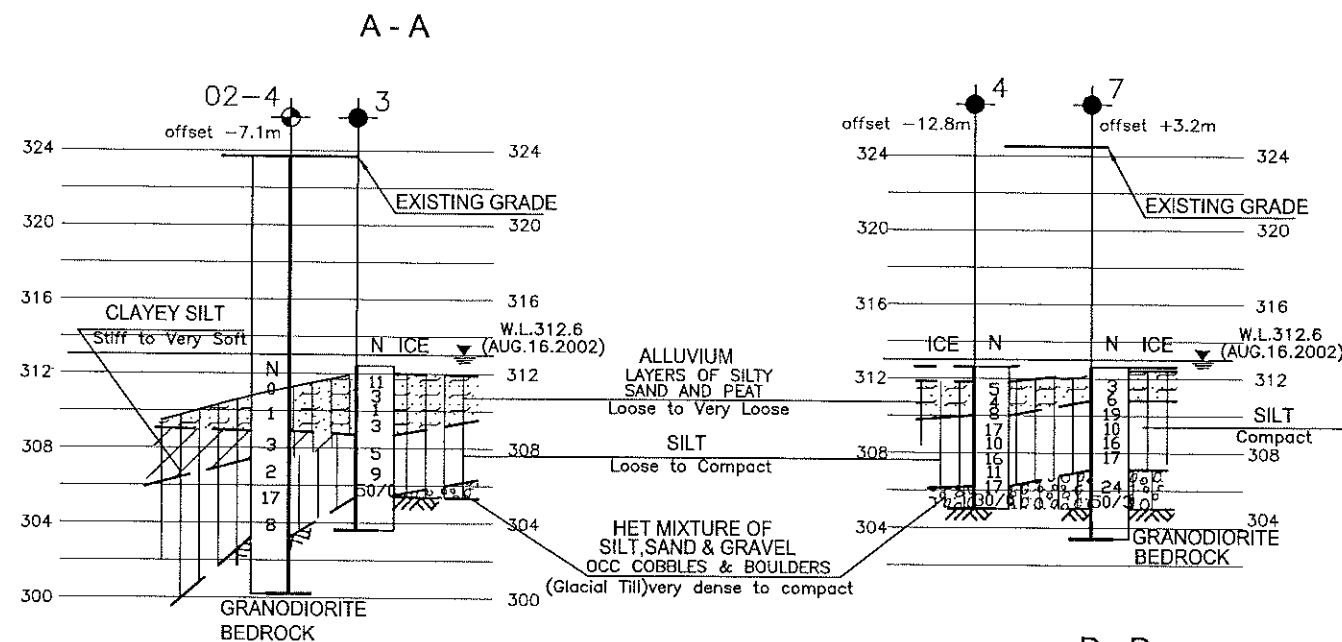
The boundaries between soil strata have been established only at Bore hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS

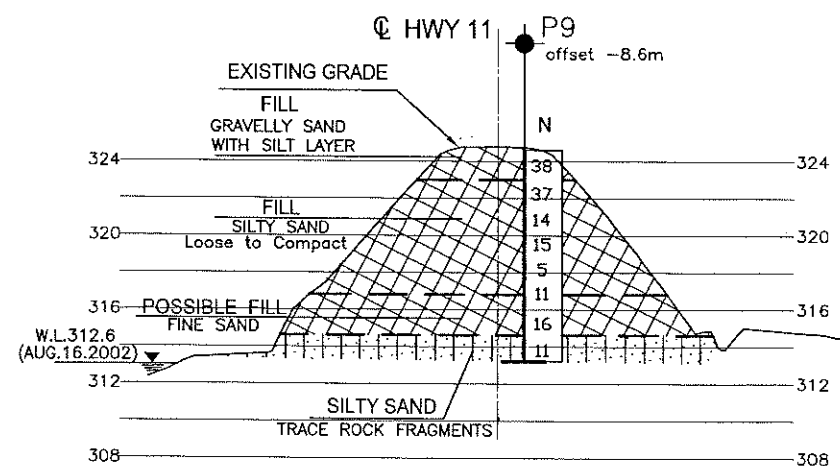
DATE	BY	DESCRIPTION
DESIGN	AEG	CHK
DRAWN	SS	CHK AEG
CODE	LOAD	DATE
SITE 48E-06	STRUCT	DWG.19-1351-32-1



B - B



D - D



E - E

SECTIONS

SCALE
10 5 0 10 20M HOR
4 2 0 4 8M VERT

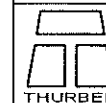
DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

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

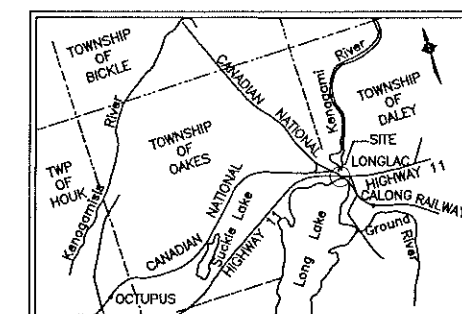
SITE No. 48E-06
WP No. 381-90-01

SHEET

KENOGAMI RIVER BRIDGE
LONGLAC
SOIL STRATA



THURBER ENGINEERING LTD.



LEGEND

- BoreHole by AGRA
- ⊙ BoreHole by THURBER
- N Blow / 0.3m (std pen Test, 475 J / blow)
- CONE Blows / 0.3m (60° Cone, 475J/blow)
- W.L. at time of investigation 2002
- ⊕ Head Artesian Water
- ⊕ Piezometer

NO	ELEVATION	NORTHING	EASTING
1	312.7	5516313.8	337775.3
2	311.4	5516284.7	337806.8
3	312.4	5516258.4	337848.7
4	312.6	5516261.3	337894.9
5	313.0	5516268.5	337924.6
6	314.2	5516209.3	337925.3
7	312.6	5516241.6	337905.3
8	312.4	5516233.1	337858.4
9	311.4	5516254.3	337803.3
10	312.3	5516270.7	337756.0
11	312.3	5516280.9	337727.8
12	312.5	5516295.8	337691.6
13	315.6	5516191.7	337982.7
14	316.5	5516183.1	338018.8
15	311.4	5516248.1	337822.3
P9	324.6	5516233.8	337932.5
P10	324.6	5516230.1	337945.3
02-1	320.5	5516297.0	337739.8
02-3	322.6	5516278.7	337796.3
02-4	323.7	5516269.2	337844.5

NOTE

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

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AEF	CHK	CODE
DRAWN	SS	CHK	AEF
SITE	48E-06	STRUCT	DWG.19-1351-32-2