



**Trow Associates Inc.**

1595 Clark Boulevard  
Brampton, Ontario  
L6T 4V1

Telephone: (905) 793-9800  
Facsimile: (905) 793-0641

Reference: brge00140201a

September 12, 2005

Roch Pilon, P.Eng.  
Project Manager  
Ministry of Transportation  
Northeastern Region  
301-447 McKeown Avenue  
North Bay, Ontario  
P1B 9S9

Via courier

Dear Mr. Pilon:

**Foundation Investigations  
Highway 69 Route Selection Study  
GWP 5377-02-00**

Attached please find three hard copies of the final Preliminary Foundation Investigation & Design Report for Selected Structures, and one electronic copy of the same in the enclosed cd.

We have incorporated into the final report the results of the additional drilling after the presentation of the draft report, and amended the report as per MTO's comments. The amendments are as follows:

**A. Comments by Roch Pilon, P.Eng. of the Planning and Environment Section, Northeastern Region:**

1. Section 4.3 of the report has been revised as per comment.
2. Table 1 of the report has been revised as per comment.
3. Section 4.4 has been revised as per comment.
4. The additional borehole information has been added to the report.
5. Borehole numbers have been added to Section 5.13.
6. Borehole numbers have been added to Section 5.16.
7. The section on Realigned CNR for the revised alignment has been removed.

8. The summary of subsurface conditions table has not been expanded, but three additional tables (as in the presentation we made to MRC) have been added in the report to the functionality of the report.
9. All water bodies are shaded in the drawings.
10. Boreholes for both swamps and structures are shown on all drawings.
11. The scale legend has been enlarged.
12. All station lines have been removed as they are not connecting lines.
13. Boreholes that will not be drilled have been removed from report
14. Station number for new alignment have been rotated, and the Realigned CNR note has been re-positioned.

B. Comments by David Staseff, P.Eng. of Pavements and Foundations Section

1. Geocres number has been added to report cover.
2. Section 1, the reference to “Request for Proposal” has been changed to “Request for Quotation”.
3. Section 3.2 has been revised as per comment.
4. Boreholes have been added for the Grundy Portage Lake CNR crossing, and the information has been included in the report.
5. Table 1 has been revised as per comment.
6. Section 4.3 has been revised as per comment.
7. Section 5.3 has been revised.
8. Section 5.6.1 has been revised as per comment.
9. Section 5.7.3 – only some boreholes were purged. Where the boreholes were located in swamps and groundwater was obviously high, the piezometers were not purged. A note has been added in the borehole logs indicating whether the piezometers were purged.
10. Estimated preconsolidation pressures have been added.
11. The borehole has been re-drilled and new rock core obtained.

12. Section 5.14.2, we have carefully examined the Shelby tube sample and found that there are numerous silt seams within the clay. The high vane shear strength was probably due to the silt seams.
13. Section 5.18.1 has been revised as per comment.
14. Section 5.20 has been revised as per comment.
15. Boreholes / probe holes have been added at Shawanaga River, Mag-Brit CPR Still River, and Grundy Portage Lake CNR. The results have been included in the report. The planned boreholes at Straight Lake NBL, Straight Lake additional area, and the remaining borehole at Mag-Brit Key River will not be drilled because of no access to First Nation property. Their reference in the report has been removed.
16. Sheet number references have been added to Sections 6.1.1 to 6.1.5
17. Three additional boreholes have been added for the Grundy Portage Lake Existing CNR crossing. The results have been included in the report.
18. The ULS capacity of H piles driven to rock has been increased as per MTO experience.
19. The ULS and SLS capacities of H piles driven to very dense till has been increased as per MTO experience. The negative skin friction value is based on an undrained shear strength of 40 kPa for the clay, and an adhesion factor of 1.0.
20. The results of laboratory consolidation tests suggest that **primary** consolidation could take as much as 20 years where the clay layers are thick; however, we recognize that the clay deposit contains silt seams which will shorten the consolidation time considerably. This is discussed in the report.
21. Report has been revised to state that all structures and approach embankments will require further investigation. A table of all locations investigated, depths and types has been included.
22. The report is signed by two professional engineers.
23. A scale has been provided for the Site Map.
24. Figures 3 to 8 have been revised.
25. A page of explanation notes has been added.
26. Stratigraphic sections for all structure sites with two or more boreholes have been added.

We trust that the final structure report is satisfactory. Should you have any other queries regarding the report, please do not hesitate to call the undersigned.

Yours truly,

**Trow Associates Inc.**



James Ng, M.Eng., P.Eng., MICE  
Senior Engineer  
Geotechnical Division



Enclosures: Three copies of final Preliminary Foundation Investigation & Design Report,  
Swamp Crossings, and one cd

Distribution: Tom Crilly, Trow Associates, Sudbury, + 1 copy of final report  
Tae Kim, MTO Pavement and Foundation Section, + 1 copy of final report  
Stan Gonsalves, Trow Associates  
Stan Gonsalves, Trow Associates Inc., + 1 copy of draft report

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**Preliminary Foundation Investigation and  
Design Report for Selected Structures  
Highway 69 Route Selection Study  
3.5 km N of Hwy 559 to 3.8 km N of Hwy 522  
GWP 5377-02-00, Highway 69**

Prepared for:

Ministry of Transportation  
447 McKeown Avenue  
Suite 301  
North Bay, Ontario  
P1B 9S9  
Attn: Mr. Roch Pilon, P.Eng.

**Trow Associates Inc.**

1595 Clark Boulevard  
Brampton, Ontario L6T 4V1  
Telephone: (905) 793-9800  
Facsimile: (905) 793-0641

Geocres No.41H-50  
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## **1. Introduction**

A preliminary foundation investigation and design study was authorized by the Ministry of Transportation (MTO) for some of the structures and swamp crossings for the proposed four-laning of Highway 69. Within the study area, MTO originally selected twenty one (21) structures and seventy four (74) swamps for this investigation. The investigation of one of the structures (Grundy CNR at Highway 522) was deleted by MTO after the start up of the study. This Preliminary Foundation Investigation and Design Report presents the factual data and preliminary design recommendations for the structures within the study area. A separate report will be issued for the swamp crossings.

The Terms of Reference for this study were outlined in the MTO Request for Quotation (Agreement No. 5004-E-0028, Highway 69), and in our proposal dated December 2004. The scope of work was subsequently modified by MTO to include additional works in the Grundy Straight Lake Area.

The work carried out for this study should be considered preliminary in nature. A limited number of boreholes were put down to provide general subsurface information at selected structures and swamps crossings to confirm the feasibility of the preferred alignment. Minor revisions were under consideration at the time of this investigation, and profile and structural layout drawings were not yet available. Detailed foundation investigations will be required at a later stage to provide detailed recommendations for the design of the structures and highway embankments, once the alignment has been finalized.

## 2. Site Description

The study area extends from 3.5 km north of Highway 559 (Town of Nobel) to 3.8 km north of Highway 522 (Grundy Lake Provincial Park), with a total length of approximately 68 km. Figure 1 attached in Appendix 'A' of this report shows the study area, which includes the Townships of Carling, Shawanaga, The Archipelago, Wallbridge, and Henvey. Within this area are lands belonging to the Shawanaga First Nation, the Magnetawan First Nation, and the Henvey Inlet First Nation, and a few private properties.

Within the study area, the existing Highway 69 is generally a two lane undivided roadway. The preferred alignment for the proposed four lane highway generally follows the existing highway but could deviate from it by 0.5 to 1 km at certain locations. The preliminary preferred alignment was determined in a route planning study currently underway.

The topography of the study area can be described as generally rolling, with heavily wooded areas, separated by rivers, lakes and low-lying swamp areas. Most of the lands along the preferred alignment are undeveloped, with a few open farms within the north half of the study area.

There are no major population center along the preferred alignment. The alignment passes the communities of Pointe Au Baril, Britt, Still River and Key River by up to 1 km.

### 3. Physiography and Geology

The study area is located in the physiographic region known as the Georgian Bay Fringe, which occupies much of Parry Sound and Muskoka. This region is characterized by shallow bedrock, often exposed in many areas, and intermittent swamps that were filled in when glacial lake Algonquin inundated the area. The shallow overburden materials, where they exist, are mostly sand, silt and clay.

#### 3.1 Bedrock Geology

According to OGS Maps, the area is underlain by strongly foliated and highly deformed gneissic and migmatitic and felsic to intermediate intrusive rocks of Precambrian age. These rocks form part of the Central Gneiss Belt of the Grenville Province, a subdivision of the Canadian Shield.

Bedrock outcroppings and ridges are visible along much of the existing Highway 69 corridor. In the region between the Magnetawan River and Key River, many geological fault lines are highlighted by the shape of the linear lakes, elongated bays of Georgian Bay and the straight rivers that follow these lines. Where these faults occur the topography is typically characterized by steep sloping and smooth faced, or weathered outcrops.

#### 3.2 Quaternary Geology

OGS Maps indicate that the area is dominated by bare bedrock terrain with less than 50 % of the area having shallow drift or sediment cover. The shallow drift depth reflects not only a lack of significant deposition by the last glacial advance, but also the wave-washing of the bedrock surfaces by the waters of the glacial lakes Algonquin and Nipissing. As such, glacial till, glaciofluvial outwash and glaciolacustrine deposits are sparsely dispersed in this area. These deposits are found primarily in bedrock hollows and depressions.

Significant alluvial deposits are not found in this area. Minor amounts can be found in all creek and river valleys. Recent organic deposits of peat, muck and marl occur in abundance in the bedrock hollows and valleys.

Quality aggregate deposits are scarce throughout the area. Most existing pits exploit the glaciolacustrine deposits. These are generally too fine grained and small in size to be of economic significance.

## 4. Investigation Procedures

The investigation procedures of this study consisted of a review of available subsurface information for the existing structures, a review of available water well records, and a field investigation program.

### 4.1 Available Information for the Existing Structures

A review of the foundation drawings / subsurface information for the structures along the existing Highway 69 was carried out. The available information is described in the following subsections. The actual drawings and /or reports are presented in Appendix 'E' of this report.

#### 4.1.1 Existing Shawanaga River Bridge

Structural layout drawings indicate that this is a single span steel plate girder structure. The abutments are founded on footings bearing on bedrock at approximate elevation 198 m (west abutment). This structure is located close to the proposed Shawanaga River NBL structure that was investigated as part of this study.

#### 4.1.2 Existing Naiscoot River Bridge

The exact location of this structure is not clear from the structural layout drawing of this bridge, but it appears that Naiscoot River could be the continuation of Harris River, in which case this bridge would be located close to the proposed Harris River Bridge for the new highway. The north bound lane of the Harris River structure was investigated as part of this study.

The structural drawing indicates that the existing bridge is a three span structure supported on caissons founded on bedrock. The elevation of the rock varies from about 176 to 172 m. Above the rock is about 1 m of silt and 2 m of sandy clay.

#### 4.1.3 Existing Magnetewan River Bridge

The existing bridge is an arch structure which suggests that the abutments are founded on rock. The new highway will require a new bridge to cross the Magnetewan River, but MTO expects that this structure to be founded on shallow bedrock and did not include this structure in this study.

#### **4.1.4 Existing Key River Bridge**

Structural drawings show that the existing bridge is founded on piles. A more recent geotechnical study carried out by Peto-MacCallum Ltd. for a replacement bridge found a major sand deposit overlying bedrock.

The new highway alignment crosses the Key River at an approximate distance of 300 m south of the existing bridge. The new Key River structure was investigated as part of this study.

#### **4.1.5 Existing CNR Overhead at Cranberry Lake**

Golder Associates prepared a geotechnical report for this structure. The boreholes found deep (over 30 m) deposits of silty clay, silt, and silty sand overlying bedrock.

In this area, the preferred alignment of the new highway is about 200 to 400 m south of the existing highway.

### **4.2 Water Well Records**

The available water well records along the preferred alignment were obtained from the Ministry of Natural Resources and Ministry of Environment. No relevant well record was found.

### **4.3 Field Investigation**

In accordance with the Terms of Reference for this study, a number of boreholes/dynamic cone tests were put down at the various structure locations. The locations of the structures included in this report are listed in Table 1 below. A number of the boreholes are located within the Henvey Inlet First Nation properties (GSLN-1, GSLN-2 and SL-1 to SL-10). Permission to enter these First Nation lands was not given, therefore no foundation investigation was completed within these areas. Boreholes are being added to the Grundy Portage Lake Existing CNR structure, and to the Shawanaga River NBL and SBL structures. The information from these boreholes will be included in the final report.

The boreholes and dynamic cone tests included in this report were put down between January 15 and April 4, 2005. Bombardier mounted power auger drill rigs equipped with hollow stem augers and a tripod rig were used to drill the boreholes to depths ranging from 0 to 49.7 m below existing ground surface. The tripod rig was used for areas that were too soft to support the bombardier mounted drill. The tripod rig used a hammer that is half the weight of the one used in Standard Penetration Tests, and the height of the drop was also reduced. The 'N' values shown on the records of boreholes for the tripod boreholes have been corrected for the lower energy used in sampling. Most boreholes were terminated at auger

refusal on probable bedrock. The boreholes and dynamic cone tests were put down under the full time supervision of field technicians from our office.

**Table 1 – Structure Locations Included in This Report**

<b>Area</b>	<b>Borehole Designations</b>	<b>Cone Test / Probes Designations</b>	<b>Dwg. No.</b>
Shawanaga Interchange	SI-1, SI-2	-	Sheet 1
Shawanaga River NBL	SRN-1 to SRN-4	-	Sheet 2
Shawanaga River SBL	SRS-1, SRS-3	DCPS-4, DCP-A, DCP-B, DCP-C	Sheet 2 Sheet 2A
Shawanaga Service Road	SSR-1, SSR-2	-	Sheet 2B
Pointe au Baril Six Mile Lake NBL	PB6N-1, PB6N-2, PB6N-4, PB6N-5	DCPB6N-3	Sheet 3
Pointe au Baril Six Mile Lake SBL	PB6S-1, PB6S-2, PB6S-4, PB6S-5	DCPB6S-3	Sheet 3
Harris River NBL	HRN-1	-	Sheet 4
Mag-Brit Service Road	MBSR-1, MBSR-2	-	Sheet 5
Mag-Brit CPR/Still River NBL	MBCSN-1 to MBCSN-3		Sheet 6
Mag-Brit CPR/Still River SBL	MBCSS-1 to MBCSS-3	-	Sheet 6
Grundy P-Rev Bekanon Interchange	GRBINT-1, GRBINT-2	-	Sheet 7
Grundy P-Rev Straight Lake NBL	GSLN-1, GSLN-2 (Note: permission to enter not obtained, boreholes will not be drilled)	-	
Grundy P-Rev Straight Lake Additional Site	GSL-1 to GSL-10 (Note: permission to enter not obtained, boreholes will not be drilled)	-	
Grundy P-Rev Key River NBL	GKRN-1, GKRN-3, GKRN-4	-	Sheet 8
Grundy P-Rev Key River Interchange	GKRI-1, GKRI-2	-	Sheet 8
Grundy Realigned CNR NBL	GR-R-CNR-NBL-1, GR-R-CNR-NBL-2	-	Sheet 9

<b>Area</b>	<b>Borehole Designations</b>	<b>Cone Test / Probes Designations</b>	<b>Dwg. No.</b>
Grundy Realigned CNR SBL	GR-R-CNR-SBL-1	-	Sheet 9
Grundy Portage Lake Existing CNR	GR-PLE-CNR-NBL-1, GP-LE-CNR-NLB-2, PL-1A, PL-2A, PL-3, PL-3A, PL-4, PL-6	-	Sheet 9 Sheet 9 Sheet 10
Grundy NBL over Highway 522	GL522-NBL-1 GL522-NBL-2	-	Sheet 10
Grundy SBL over Highway 522	GL522-SBL-1 GL522-SBL-2	-	Sheet 10

Del Bosco Surveying Ltd. of Sudbury, Ontario, was engaged to lay out the boreholes, and to establish the borehole co-ordinates and elevations. The co-ordinates shown on the records of borehole and on the borehole location plans were referred to the MTM Zone 10 NAD 83 co-ordinate system. The borehole elevations were referenced to benchmarks along the existing Highway 69 as published by MNR. Drawing Nos. Sheet 1 to 10 in Appendix 'D' of this report shows the borehole and dynamic cone test locations.

For many of the boreholes, access to the hole locations was established by clearing the vegetation using a backhoe, and packing snow on the ground to form an access road and a working platform.

In the boreholes, samples of the sub-soil were obtained at 1.5 m intervals of depth to 15.2 m, then changed to 3 m intervals below that, using the standard penetration test method. Where soft cohesive materials were encountered, relatively undisturbed Shelby tube samples were obtained, and insitu vane shear tests were preformed to assess the undrained shear strength of the soils. The samples were visually identified in the field and transported to our laboratory for testing. Upon reaching bedrock, some of the boreholes at each structure was advanced another 3 m by coring the rock using NX size double tube core barrels. The groundwater levels in the boreholes were closely observed during drilling. Piezometers were installed in selected boreholes to allow longer term monitoring of the groundwater conditions. After drilling, all boreholes were backfilled according to MTO and MOE regulations and guidelines for borehole abandonment using bentonite mixed with soil cuttings.

#### **4.4 Laboratory Tests**

The samples were selectively tested in our laboratory for their index properties and engineering properties. The following tests were completed:

Natural water content (128)

Natural unit weight (7)

Grain size distribution (59)

Consistency (Atterberg) limits (30)

Specific gravity (3)

Consolidation test (3)

Uniaxial compressive strength of rock cores (3)

The results of the index tests and grain size analyses are summarized on the Records of Boreholes in Appendix 'D' of this report. The grain size distribution curves, Atterberg limits test results, and consolidation test results are shown plotted on Figures 2 to 12 attached in Appendix 'A' of this report.

## 5. Sub-surface Conditions

The subsurface conditions encountered in the boreholes for each of the areas are summarized in Table 7 in Appendix 'B' of this report. Since the structures are located over a considerable distance, variable sub-surface conditions were observed in the boreholes. In some boreholes, bedrock was encountered at or very close to existing ground surface. In the other boreholes, the general stratigraphy comprised topsoil, peat and other organics overlying silty sand, sand, and silt (probably alluvial deposit), underlain by clay and bedrock. In some boreholes the clay was underlain by more sand or silt strata. A brief description of the relevant properties of the various soil strata encountered in the boreholes is presented in the following sections of this report. For details of the subsurface conditions at the test hole locations, reference should be made to the Records of Boreholes and Dynamic Cone Tests attached in Appendix 'C' of this report.

### 5.1 Shawanaga Interchange (Drawing No. Sheet 1)

Two boreholes (SI-1 and SI-2) were put down for this structure. The boreholes encountered auger refusal on rock at 0.1 to 0.3 m depths. In one of the holes, the rock was cored for 3 m using NX size core barrels. The bedrock was found to be granitic gneiss, fresh and very strong. The total core recovery ranged from 87 to 92% while the RQD (Rock Quality Designation) was between 68 and 83%, which indicate fair to good quality rock. Steeply inclined fractures at close to moderately close spacings were found in the rock cores. The fracture surfaces were rough. A uniaxial compressive strength of 105.9 MPa was found for one section of the rock core. The unit weight of the rock core was 26.6 kN/m<sup>3</sup>.

The boreholes were dry before coring.

### 5.2 Shawanaga River NBL (Drawing No. Sheet 2)

Four boreholes have been put down for this structure (SRN-1 to SRN-4). The two boreholes on the south side of the river encountered bedrock at ground surface. The other boreholes encountered rock at 4.0 to 6.7 m depths, underlying peat, organic sandy silt, silt and silty clay. One more borehole will be drilled in the river.

#### 5.2.1 Peat

Peat was found in two boreholes to between 0.6 and 1.5 m depth. It was black in colour, very soft, and fibrous.

### **5.2.2 Organic Sandy Silt**

A 1.0 m thick layer of organic silt was found underlying the peat in Borehole SRN-1. It is composed of 35% sand, 54% silt, and 11% clay. This grading curve is shown in Figure 2 in Appendix 'A' of this report. The organic silt has a moisture content of 125%, and an 'N' value of 2 blows per 0.3 m, indicating very loose condition.

### **5.2.3 Silty Clay**

The organic sandy silt is underlain by silty clay that extended from about 2.5 m to 6.7 m. This is a low plasticity clay (liquid limit of 34%, plastic limit of 16%, and plasticity index of 18). Its moisture contents are between 53 and 82%. The split spoon sampler sank into the clay under the weight of the drill rods and hammer, which suggests that the clay is very soft.

### **5.2.4 Silt**

Silt was found underlying the peat in Borehole SRN-3. This stratum is about 3.4 m thick. SPT blow counts of 2 to 5 blows per 0.3 indicate very loose to loose conditions.

### **5.2.5 Bedrock**

In two boreholes, rock outcrop was visible at ground surface. In Borehole SRN-3, the rock was cored for three metres using NX size core barrels. The rock was found to be granitic gneiss, with total recovery of 93 to 95%, and RQD values of 78 to 82%, indicating good quality rock. The rock is slightly weathered to fresh, and the rock material is strong.

## **5.3 Shawanaga River SBL (Drawing Nos. Sheet 2, Sheet 2A)**

Two boreholes and four dynamic cone penetration tests have been put down for this structure. One of the boreholes north of the swamp area adjacent to the river encountered refusal, probably on rock, at 1.2 m depth, overlain by silty sand.

The other borehole was located on the north of the river within the swamp area. It encountered about 3.3 m of very soft, fibrous peat, underlain by about 0.7 m of very loose silty sand. The sand is in turn underlain by a clay deposit of approximately 3.9 m thick. A sample of the clay was found to have a liquid limit of 62%, a plastic limit of 23%, and a plasticity index of 39. The moisture content of the sample was 86%, i.e., above its liquid limit. Its undrained shear strength, as measured by insitu vane shear tests without correction for plasticity, varies from 10 to 15 kPa, with sensitivities (ratio of undisturbed to remolded shear strengths) of 4.0 to 6.0. The split spoon sampler sank into the clay under the weight of the drill rods and hammer. These results indicate that the clay is very soft.

Granitic gneiss bedrock was encountered in the second borehole at about 8.5 m depth. The rock material is fresh and very strong. Total core recovery ranged from 93 to 100%, while the RQD values varied from 89 to 93%, indicating good to excellent quality rock.

The dynamic cone penetration tests were all located within the swamp area adjacent to the river. In particular, DCP-C was located on the river. The depth of the cone tests ranged from 5.8 to 8.8 m. The blow counts were very low (less than 5 blows per 0.3 m) in the upper about 4 m, which was probably peat. The bottom 2 to 3 m could be very soft clay or loose sand.

## **5.4 Shawanaga Service Road (Drawing No. Sheet 2B)**

The two boreholes (SSR-1 and SSR-2) put down for this structure encountered silty sand overlying bedrock.

### **5.4.1 Silty Sand**

The thickness of the sand layer at the borehole locations varies from 2.4 to 8.2 m. This is a poorly graded deposit containing 77% sand and 23% silt and clay size particles. A grain size curve of this deposit is shown in Figure 4 in Appendix 'A' of this report. Its moisture contents vary from 16 to 20%, indicating saturation. The SPT 'N' values of the silty sand are between 2 and 13 blows per 0.3 m, which indicate very loose to compact conditions.

An approximately 1m thick bouldery zone was found in the sand in Borehole SSR-1 at about 0.5 m depth.

### **5.4.2 Bedrock**

Bedrock was contacted in the boreholes at 2.4 to 8.2 m depths. Three metres of the rock in Borehole SSR-1 was cored using NX size core barrels. The rock was found to be granitic gneiss. The properties of the rock cores are as follows:

Total core recovery:	78 to 87%
RQD	71 to 87%
Uniaxial compressive strength:	86.5 MPa
Unit weight:	27.9 kN/m <sup>3</sup>
Fractures:	2 to 5 fractures in 1.5 m, planar, rough

The rock cores were slightly weathered to fresh.

Based on the above results, the gneiss is a strong rock of fair to good quality.

### **5.4.3 Groundwater**

Borehole SSR-1 did not encounter groundwater before coring. In Borehole SSR-2, groundwater was at 1.2 m depth shortly after drilling. A piezometer was installed in this borehole and was perched after installation. Groundwater in the piezometer was measured to be at 1.3 m depth about one month after the hole was drilled.

## **5.5 Point au Baril Six Mile Lake NBL (Drawing No. Sheet 3)**

Four boreholes (PB6N-1, PB6N-2, PB6N-4, and PB6N-5) and one dynamic cone penetration test (DCPB6N-3) were put down for this structure. Boreholes PB6N-1 and PB6N-5 were located on land, and bedrock was visible at ground surface. PB6N-2 was also on land, and about 0.6 m of organics was found in this borehole, overlying probable bedrock.

At the location of Borehole PB6N-4, which was located in the lake, casing refusal, probably on rock was encountered at lake bed (about 3.1 m depth at borehole location).

The dynamic cone test (PB6N-3) was located in the lake. Blow counts of 1 to 10 blows per 0.3 m were recorded from lake bed to about 6.5 m below. Based on the information from the boreholes for the SBL structure, this soft layer is inferred to be peat. Cone refusal was encountered at about 7.6 m below lake bed, probably on rock.

## **5.6 Point au Baril Six Mile Lake SBL (Drawing No. Sheet 3)**

Four boreholes (PB6S-1, PB6S-2, PB6S-4, and PB6S-5) and one dynamic cone penetration test (DCPB6S-3) were completed for this structure. The boreholes encountered about 0.15 to 2.2 m of organics (peat) overlying bedrock. A thin layer of sand was found at the bottom of the peat in Borehole PB6S-4.

### **5.6.1 Peat and Organics**

The thicknesses of the organics and peat layers vary from about 0.15 to 0.6 m for the land boreholes, to about 2.1 to 2.2 m under the lake. The split spoon sampler sank into the peat under the weight of the hammer and the drill rods, and blow counts of 0 to 1 blow per 0.3 m were recorded in the peat in the dynamic cone penetration test. These results indicate that the peat is very soft.

### **5.6.2 Bedrock**

The depth to the surface of the rock varies from 0.15 to 2.2 m below ground surface or lake bed. The rock was cored for three metres in Boreholes PB6S-1 and PB6S-2. Bedrock was found to be slightly weathered to fresh, strong granitic gneiss of fair to excellent quality. Other properties of the rock cores are as follows:

Total core recovery:	92 to 100%
RQD	71 to 100%

## **5.7 Harris River NBL (Drawing No. Sheet 4)**

One borehole (HRN-1) was put down at the south side of this structure. This borehole encountered 5.5 m of sandy silt overlying bedrock.

### **5.7.1 Sandy Silt**

This is a poorly graded deposit containing 25 to 34% sand, 55 to about 72% silt, and 11 to about 3% clay. Two grading curves of the silt are shown in Figure 2 in Appendix 'A' of this report. With moisture contents of 16 to 17%, the sandy silt is saturated. SPT blow counts of 13 to 22 blows per 0.3 m recorded in the sandy silt indicate compact conditions.

### **5.7.2 Bedrock**

The rock at this structure location is granitic gneiss, slightly weathered to fresh, strong, and good to excellent quality. The total recovery of the rock cores was 100%, and the RQD varies from 83 to 100%. The cores contain 3 fractures in 1.5 m.

### **5.7.3 Groundwater**

Groundwater was not encountered in the borehole before coring. On completion (February 12, 2005), a piezometer was installed in the borehole. On March 24 and April 6, 2005, groundwater was measured to be at 6.2 m depth (about 0.7 m below rock surface). Since the piezometer was not purged after installation, the observed water level could be the result of the drilling water used for coring the rock.

## **5.8 Mag-Brit Service Road (Drawing No. Sheet 5)**

Two boreholes (MBSR-1 and MBSR-2) were put down for this structure. The boreholes encountered bedrock at 0 to 0.6 m depth, overlain by sand with organics in one hole.

The rock at this site is biotite gneiss, slightly weathered to fresh, very strong, and good to excellent quality. The total core recovery was 88 to 100%, and RQD varies from 85 to 100%. The cores contain 3 to 4 fractures in 1.5 m.

## **5.9 Mag-Brit CPR/Still River NBL & SBL (Drawing No. Sheet 6)**

Six boreholes (MBCSN-1 to MBCSN-3, MBCSS-1 to MBCSS-3) were put down for these structures. The boreholes encountered deposits of sand fill, native sand, silt, and clay overlying bedrock. In one borehole, a layer of organic silt was found.

### 5.9.1 Sand

An approximately 2.0 to 3.7 m thick layer of sand was found in Borehole MBSCN-1, MBSCN-3, MBCSS-2 and MBCSS-3. In Borehole MBSCN-1, a lower sand layer was found at 11.7 m depth. Sand was also found in Borehole MBSCN-2 under the clay, and it is only about 0.4 m thick. The surface layer of sand is very loose to loose, having SPT blow counts of 2 to 9 blows per 0.3 m. The lower layer of sand in Borehole MBSCN-1 is very loose to compact ('N' values of 3 to 28 blows per 0.3 m). The sand deposits were saturated (moisture content of 27%).

### 5.9.2 Clay

Clay was found in Boreholes MBCSN-1, MBCSN-2 and MBCSS-1. The thickness of the clay varies from about 5.6 to 9.0 m. The clay has a layered (varved) structure, with alternate layers of clay and silt. The silt seams are relatively thin, being about 2 mm, and are about 20 mm apart.

It was not possible to separately test the clay and the silt seams. Overall, the deposit has moisture contents of 35 to 75%. Its liquid limit, plastic limit, and plasticity are 49 to 75 %, 19 to 22%, and 30 to 53, respectively. Its liquidity index varies from 0.7 to 1.3.

SPT 'N' values of 0 to 4 blows per 0.3 m were recorded in the clay. Insitu vane shear tests recorded undrained shear strengths of 20 to 44 kPa (uncorrected for plasticity), and sensitivity (ratio of undisturbed to remolded shear strengths) of 3.3 to 6.4.

Figure 6 in Appendix 'A' of this report shows four grading curves of the clay deposit found in these boreholes. The tested samples are composed of 1 to 3% sand, 36 to 49% silt, and 48 to 63% clay.

The results of a consolidation test on a Shelby tube sample of the clay taken from Borehole MBCSN-2 are shown in Figure 12 in Appendix 'A'. The compression index ( $C_c$ ) was 0.347. The coefficient of consolidation ranged from 0.022 to 0.050  $m^2/day$ . The preconsolidation pressure of the sample is estimated to be 69.5 kPa, which indicates that the clay is normally consolidated.

Based on the above results, the clay is a intermediate to highly plastic deposit of very soft to firm consistency and medium sensitivity.

### 5.9.3 Organic Silt

This deposit was found in Borehole MBCSN-3 between about 2 and 5.1 m depth below ground surface. Two grading curves of the organic silt are shown in Figure 2 in Appendix 'A'. These samples are composed of 6 to 38% sand, 61 to 91% silt, and 1 to 3% clay. The moisture contents of the organic silt are about 54 to 72%. SPT 'N' values of 0 to 2 blows per

0.3 m recorded in the organic silt suggest very soft to soft consistency. This deposit contains a trace of shells.

#### **5.9.4 Silt**

Underlying the organic silt in Borehole MBSCN-3 and the sand in Borehole MBCSS-3 is an approximately 1.2 to 2.6 m thick layer of silt in very loose to compact conditions ('N' values of 0 to 20 blows per 0.3 m). Moisture contents of 15 to 21% indicate very moist to saturated conditions.

#### **5.9.5 Bedrock**

The boreholes reached auger refusal at 2.4 to 14.1 m depth, probably on rock. The rock in Boreholes MBCSN-1, MBCSS-2 and MBCSS-3 was confirmed by coring. The rock was found to be granitic gneiss, slightly weathered to fresh, strong to very strong, and fair to excellent quality. The total core recovery ranged from 82 to 99%, and the RQD was 64 to 99%. Four to five planar fracture were found in the two 1.5 m core runs.

#### **5.9.6 Groundwater**

Two of the boreholes were dry during and shortly after drilling. In the other three boreholes, groundwater at completion of drilling was at 2.3 to 4.3 m depths. These short term water levels may not be representative of the true groundwater conditions at the site due to the short period of observation, and the low permeability of the site soils.

A piezometer was installed in Borehole MBCSN-2 and was purged after installation. When this piezometer was monitored about two months after installation, the water level was found to be at 2.8 m depth (Elevation 175.6 m).

### **5.10 Grundy P-Rev Bekanon Interchange (Drawing No. Sheet 7)**

Two boreholes (GRBINT-1 and GRBINT-2) were put down for this structure. The boreholes encountered rock at 0.2 to 2 m below ground surface. The overburden material is sand in a compact state.

The rock at this site is granitic gneiss, which is slightly weathered at the surface, very strong, and of good to excellent quality. The total core recovery ranged from 95 to 98%, and the RQD was 89 to 98%. One to three fractures were found in the two 1.5 m long core runs.

### **5.11 Grundy P-Rev Straight Lake NBL**

Boreholes for this structure will not be drilled since permission to enter the First Nation properties was not obtained.

## **5.12 Grundy P-Rev Straight Lake Additional Site**

Boreholes for this site will not be drilled since permission to enter the First Nation properties was not obtained.

## **5.13 Grundy P-Rev Key River NBL (Drawing No. Sheet 8)**

Three boreholes (GKRN-1, GKRN-3 and GKRN-4) have been completed for this structure. The borehole on the south side of the river will not be drilled since permission to enter the First Nation property was not obtained.

### **5.13.1 Peat**

Peat was found in the two boreholes located in the river. The thickness of the peat layer varies from about 1.6 to 2.2 m. The peat is black in colour and contains a trace of fine gravel. Its moisture contents vary from 53 to 77%. The split spoon sampler sank into the peat under the weight of the drill rods and hammer, suggesting very soft consistency.

### **5.13.2 Clay**

The peat in Borehole GKRN-4 was underlain by an approximately 3.2 m thick layer of clay. A grain size curve of the clay is shown in Figure 6 in Appendix 'A'. This sample is composed of 12% sand, 50% silt, and 38% clay. The liquid limit, plastic limit, and plasticity index of the clay are 45%, 20%, and 25, respectively. The moisture contents of the clay range from 50 to 53% (i.e., above liquid limit). This borehole was drilled with a tripod rig. The hammer used to sample the soils weighted half of that of a standard hammer, and the drop was also reduced. The blow counts shown on the Record of Borehole have been adjusted for the reduced energy, but they may still be too high. The clay is judged to be of soft to firm consistency.

### **5.13.3 Silty Sand**

The clay is underlain by a silty sand deposit that is about 1.3 m thick, and composed of 50% sand, 37% silt, and 13% clay (Figure 4). It has a moisture content of 36%, and is dense.

### **5.13.4 Bedrock**

At the location of the borehole at the north abutment, bedrock outcrop was visible at ground surface. The borehole at the north pier (Borehole GKRN-3) encountered refusal, possibly on rock, at 2.2 m below river bed.

## **5.14 Grundy P-Rev Key River Interchange (Drawing No. Sheet 8)**

Two boreholes (GKRI-1 and GKRI-2) were put down for this structure. One of the borehole encountered about 0.6 m of sand, followed by auger refusal, probably on rock. The other borehole found rock at about 12.2 m depth, overlain by silt, clay, and sand.

### **5.14.1 Sand**

Sand was found at the surface of both boreholes. It extended to about 0.6 and 2.4 m in the boreholes. It is poorly graded, generally compact ('N' value of 17 blows per 0.3 m), and saturated (moisture content of 18%)

### **5.14.2 Silty Clay**

The sand in Borehole GKRI-2 is underlain by an approximately 3.5 m thick layer of silty clay. This is a layered deposit consisting of alternate seams of silt and clay. Near its surface, the clay layers are more prominent. A Shelby tube sample taken towards the bottom of this stratum found that the silt layers constitute approximately 2/3 of the sample. The thicknesses of the individual seams are generally less than 25 mm.

A grain size analysis of an SPT sample taken near the top of the silty clay stratum found that it is composed of 9% sand, 33% silt and 58% clay. This grading curve is shown in Figure 6 in Appendix 'A' of this report. The moisture content of this sample is 40%. Its liquid limit, plastic limit, and plasticity index are 55%, 22%, and 33, respectively. These results indicate a high plasticity clay. The 'N' value of this sample was 4 blows per 0.3 m.

Two insitu vane shear tests were carried out in the silty clay. The vanes were unable to shear the clay, indicating undrained shear strength exceeding 100 kPa. The high values were probably caused by the silt seams in the soil.

### **5.14.3 Silt**

The clay is underlain by a silt deposit which extended to about 11.3 m depth. This is a poorly graded soil containing 7% sand, 84% silt, and 9% clay size particles (Figure 2). It has moisture contents of 15 to 25%, which indicate that it is saturated.

Blow counts of 5 to 10 blows per 0.3 m recorded in the silt indicate that it is loose to compact.

### **5.14.4 Cobbles**

An approximately 0.9 m thick layer of cobbles was found directly above bedrock. This layer could be a cobbly till deposit.

#### **5.14.5 Bedrock**

The top of the rock was found at about 12.2 m depth. As in many other sites, the rock is strong granitic gneiss of good to excellent quality. Total recovery ranged from 88 to 100%, and RQD ranged from 83 to 100%.

#### **5.14.6 Groundwater**

Both boreholes were dry shortly after drilling. A piezometer installed in the deeper borehole found water at 0.4 m depth about one week after the borehole was drilled. This piezometer was not purged after installation since there was no free groundwater in the borehole at that time.

### **5.15 Grundy Realigned CNR NBL – Original Preferred Alignment (Drawing No. Sheet 9)**

Two boreholes (GR-R-CNR-NBL-1, GR-R-CNR-NBL-2) were put down at the north side of this structure. The borehole at the north abutment encountered refusal (probably on rock) at 7.7 m depth, overlain by sand, organic silt and clay. In the borehole located 50 m north of the north abutment, the overburden is considerably deeper (20.6 m) and is consisted of clay interbedded with sandy silt and silty sand.

#### **5.15.1 Sand**

Two layers of sand were found in Borehole GR-R-CNR-NBL-1, at ground surface and at about 5.6 m depth. These layers were about 2.1 to 2.2 m thick. Sand was also found in Borehole GR-R-CNR-NBL-2 at 17.0 m thick. The sand is poorly graded and contains some silt. It has SPT 'N' values of 0 to 9 blows per 0.3 m, indicating very loose to loose conditions.

#### **5.15.2 Organic Silt**

An approximately 1.5 m thick layer of organic silt was found in Borehole GR-R-CNR-NBL-1 at 2.5 m depth. This deposit is composed of 10% sand, 80% silt and 10% clay. This grading curve is shown in Figure 3 in Appendix 'A'. The organic silt has moisture content of 86%, and an 'N' value of 2 blows per 0.3 m, suggesting soft consistency.

#### **5.15.3 Sandy Silt**

Sandy silt was found in Borehole GR-R-CNR-NBL-2 between 11.7 and 14.7 m depths. A grading curve of the silt is shown in Figure 3 in Appendix 'A'. The tested sample is composed of 29% sand, 58% silt, and 13% clay. The sample has a moisture content of 36% (fully saturated). Its 'N' values are from 10 to 15 blows per 0.3 m, indicating compact conditions.

#### **5.15.4 Clay**

Clay was found in Borehole GR-R-CNR-NBL-1 from 4.0 to 5.6 m depth. In the other borehole, two layers of clay were found, interbedded with sandy silt. The upper layer is 11.5 m thick, while the lower layer is 2.3 m thick. In one of the Shelby tube samples, the clay was found to have a layered structure, with reddish brown clay layers alternating with grey, wet fine sand seams generally less than 10 mm thick, but could be as thick as 40 mm.

Figure 7 in Appendix 'A' shows three grading curves of the clay, which are composed of 1 to 2% sand, 48 to 65% silt, and 33 to 50% clay. The moisture content of the clay varies from 31% to 97%. Its liquid limit, plastic limit, and plasticity index are 53 to 64%, 21 to 22%, and 32 to 42, respectively, which indicate a highly plastic clay. The moisture contents of the clay are at or above its liquid limit. Bulk unit weight of the clay is about 14.4 to 15.7 kN/m<sup>3</sup>.

The SPT 'N' values of the clay vary from 0 to 4 blows per 0.3 m. Its undrained shear strength, measured by insitu vane shear tests, is between 15 and 28 kPa, with sensitivity of 1.3 to 3.5. (No correction for plasticity has been applied to these shear strengths). These results indicate a clay of very soft to firm consistency.

Figure 13 in Appendix 'A' shows the results of a consolidation test of the clay. The compression index (Cc) is 1.55, and the coefficient of consolidation ranges from 0.0016 to 0.0018 m<sup>2</sup>/day. The preconsolidation pressure of the sample is estimated to be about 29 kPa, which indicates that the clay is normally consolidated.

#### **5.15.5 Bedrock**

The depth to the surface of the rock varies from about 7.7 m at the north abutment, to 20.6 m at about 50 m north of the north abutment. The rock is granitic gneiss, which is strong and of good quality. A total recovery of 96% and an RQD of 86% were recorded for the rock cores. Only 4 fractures were encountered in 3 m of cores.

#### **5.15.6 Groundwater**

Both boreholes encountered groundwater at 2 to 2.5 m depths shortly after drilling. A piezometer installed in the shorter borehole found that the groundwater was at 1.9 m depth about 1 ½ months after drilling. This piezometer was purged after installation.

### **5.16 Grundy Realigned CNR SBL – Original Preferred Alignment (Drawing No. Sheet 9)**

Only one borehole (GR-R-CNR-SBL-1) was requested for this structure. This borehole encountered silty clay overlying bedrock. The clay in this borehole is more silty than that in the NBL boreholes, based on the results of a grain size analysis, which show that the clay is

composed of 8% sand, 70% silt and 22% clay (Figure 7). With blow counts of 0 to 7 blows per 0.3 m, the clay is very soft to firm.

The bedrock is gneiss similar to that described in Section 5.15.5 above.

Groundwater was found at 2.4 m depth shortly after the borehole was drilled.

## **5.17 Grundy Portage Lake Existing CNR (Drawing Nos. Sheet 9 and Sheet 10)**

Six boreholes were originally requested for the NBL and SBL structures. After reviewing the initial borehole results, which encountered considerably thicker alluvial and clay deposits than expected, MTO decided to relocate some of the boreholes to the north to investigate the feasibility of shifting the highway alignment away from Portage Lake, and also to add a few boreholes. A total of eight boreholes (GR-PLE-CNR-NBL-1, GR-PLE-CNR-NBL-2, PL-3, PL-4, PL-6, PL-1A, PL-2A, and PL-3A) have been drilled. The first two boreholes were drilled in two stages using two different drill rig. This was necessary because of the unexpected depth of the overburden. Considerable difficulties with caving ground conditions were encountered, and one of the boreholes had to be abandoned at 47.9 m depth without reaching bedrock or encountering a suitable bearing stratum for deep foundations. The results of the eight boreholes are grouped together under this section of the report, but it should be remembered that the boreholes are spread out over a distance of about 800 m.

In general, the boreholes encountered layers of clay, sand, and silt overlying cobbly till or bedrock. The thicknesses and depths of occurrence of the various strata are quite variable. For details of the sub-surface conditions at the borehole locations, reference should be made to the individual record of borehole attached in Appendix 'C' of this report.

### **5.17.1 Clay**

Clay was found in all boreholes except Boreholes PL-3 and PL-3A. The thicknesses of the clay strata vary from 0.8 to 12.4 m, and its depths vary from 0 to 23.1 m. Three or two layers of clay were found in Boreholes PL-4, PL-1A and PL-6, separated by sand layers.

Figures 7 and 8 in Appendix 'A' shows seven grading curves of the clays from this area. These samples are composed of 1 to 17% sand, 38 to 63% silt and 35 to 60% clay.

The moisture contents of the clays vary from 31 to 133%, which are above or close to their liquid limits. Their liquid limit, plastic limit, and plasticity index are 41 to 92%, 17 to 33%, and 24 to 59, respectively. Close inspection of one Shelby tube samples revealed that the clay contains silt seams.

When taking SPT samples of the clays, blow counts of 0 to 5 blows per 0.3 m were recorded. A dynamic cone penetration test was performed next to three of the boreholes, and obtained blow counts of 1 to 34 blows. The higher cone values could be due to the friction on the

drilling rods. Undrained shear strengths of 8 to 50 kPa (uncorrected for plasticity) were obtained by insitu vane shear tests. The sensitivity of the clays are between 2.8 and 4.0.

The above results indicate that the clays are medium to highly plastic, very soft to firm, and of low sensitivity.

Figure 12 in Appendix 'A' shows the results of a consolidation test performed on a Shelby tube sample taken from Borehole PL-6. The compression index ( $C_c$ ) was found to be 1.45, and the coefficient of consolidation ( $C_v$ ) ranged from 0.0024 to 0.0041 m<sup>2</sup>/day. The preconsolidation pressure of the sample is estimated to be about 115 kPa, which indicates that the clay is normally consolidated.

#### 5.17.2 Silty Clay

This deposit was found in five boreholes. In two boreholes, it was found directly above the clay stratum, and could be the same deposit but with slight variation in composition. The thickness of the silty clay stratum ranges from 2.9 to 6.9 m, and it was found at between 10.2 and 17.0 m depths.

Five grading curves of the silty clay deposit are shown in Figures 7 and 8 in Appendix 'A'. The samples are composed of 6 to 13% sand, 67 to 74% silt, and 18 to 24% clay. The results of Atterberg limits tests are as follows:

Liquid limit:	23 to 29%
Plastic limit:	13 to 19%
Plasticity index:	9 to 19
Natural moisture:	28 to 42%

SPT 'N' values of 0 to 2 blows per 0.3 m, and dynamic cone blow counts of 10 to 22 blows were obtained in the silty clay. Using insitu vane shear tests, undrained shear strengths of 12 to 52 kPa were measured in the silty clay deposit, with sensitivity of 2.2 to 3.3.

The above results indicate a clay of low to intermediate plasticity, and very soft to firm consistency.

#### 5.17.3 Sand, Silty Sand

These deposits were found in every borehole in this area. In four of the boreholes, two layers of sand were encountered – an upper layer at ground surface or below the upper clay layer, and a lower layer just above bedrock or cobbly till. The upper about 2.5 m of the sand in Borehole PL-3 could be fill. The thicknesses of the sand strata vary from 2.3 to 13.2 m.

Figure 5 in Appendix 'A' shows eight grading curves of the sand deposits, which are found to contain 0 to 22% gravel (mostly less than 1%), 73 to 98% sand, and 2 to 19% silt and clay

size particles. The moisture contents of the sand samples are between 2 and 30% (mostly above 15%). Most of the sands are saturated.

The SPT 'N' values of the sands range from 0 to 23 blows per 0.3 m, which indicate very loose to compact conditions. The cone penetration blow counts were substantially higher, being from 2 to over 100 blows per 0.3 m, which suggest that the lower sand stratum is dense to very dense. Some of the low SPT blow counts could be due to the sands having been disturbed by the high seepage pressure.

#### **5.17.4 Silt**

Silt was found in all but three boreholes. It is usually found underlying the clay but above the lower sand layer. Its thickness varies from 6.1 to 19.9 m.

The silt is saturated, with moisture contents of 16 to 23%, and dilatant.

The silt is composed of 0 to 2% gravel, 1 to 21% sand, 76 to 96% silt, and 2 to 9% clay. These grading curves are shown in Figures 2 and 3.

Based on 'N' values of 1 to 22 blows per 0.3 m, the silt is classified as very loose to compact. However, considerably higher cone blow counts, ranging from 16 to over 100 blows per 0.3 m, which suggest that the lower silt could be denser than indicated by the SPT blow counts, due to possible disturbance by seepage pressure.

#### **5.17.5 Cobbles, Cobbly Till**

Borehole GR-PLE-CNR-NBL-1 ended in a layer of cobbles at about 46 m depth. At that point, 6 m of sand backed up into the hollow stem augers, preventing the taking of samples. Judging from the auger action, this is a cobbly layer, possibly a till deposit.

A layer of very dense cobbly till was also encountered in Borehole PL-6 at about 32.9 m depth. NW casing with wash boring was used to advance the borehole about 4.6 m into this layer. Two attempts were made to recover a sample from this layer using a split spoon sampler, but refusal was reached and no sample was recovered.

#### **5.17.6 Bedrock**

Boreholes PL-1A, PL-3 and PL-3A reached auger/dynamic cone refusal at about 8.4 m to 36.3 m depths, probably on bedrock.

The rock was confirmed in Boreholes PL-2A, PL-4 and GR-PLE-CNR-NBL-2 by coring. The surface of the rock was contacted at 17.5 to 47.9 m. The rock is granitic gneiss, slightly weathered to fresh. The total core recovery was 89% for the first run in Borehole GR-PLE-CNR-NBL-2, and 0% for the second run (0.6 m long), which was due to the core bit being

blocked by the sand inside the casings. In Boreholes PL-2 and PL-4, the total core recovery was 100%. The RQD varied from 49% in Borehole GR-PLC-CNR-NBL-2, to between 82 and 100 % for Borehole PL-4. These results indicate poor to excellent quality rock.

A section of the rock cores taken from Borehole PL-4 was tested for its uniaxial compressive strength. The result was 174 MPa, which indicates that the rock material is very strong.

#### **5.17.7 Groundwater**

The boreholes were located in swampy areas. Shortly after drilling, groundwater was at or just below the ground surface. A piezometer was installed in Boreholes PL-3 and PL-4 after completion. The water levels in the piezometers were found to be at 2.0 and 0.3 m depths 8 days to one month after the piezometers were installed. The piezometers were not purged after installation.

### **5.18 Grundy NBL Over Highway 522 (Drawing No. Sheet 9)**

At this structure, the boreholes (GL522-NBL-1, GL522-NBL-2) encountered silt and sand overlying bedrock.

#### **5.18.1 Silt**

Silt was found extending from about 0.3 m to 2.5 m depth in Borehole GL522-NBL-1. This material is composed of 11% sand, 86% silt and 3% clay. This grading curve is shown in Figure 3 in Appendix 'A'. The silt has a moisture content of 20%, which indicates full saturation. The silt is dilatant. An SPT blow count of 7 blows per 0.3 m indicates loose condition.

#### **5.18.2 Sand**

Sand was found underling the silt in Borehole GL522-NBL-1, and also from 0.2 to 2.7 m in the other borehole. This is a poorly graded soil composed of 97% sand and 3 % silt (see Figure 4, Appendix 'A'). This soil is saturated (22% moisture) and loose ('N' values of 7 to 8 blows per 0.3 m).

#### **5.18.3 Bedrock**

The surface of the bedrock was encountered at about 2.7 to 3.8 m depths. As in most of the rock in the study area, the rock at this site is granitic gneiss, fresh, very strong, and excellent quality. The properties of the rock cores are as follows:

Total recovery:	90 to 99%
RQD	90 to 94%
Fractures:	2 to 3 in 1.5 m core runs, planar, rough

## **5.19 Grundy SBL Over Highway 522 (Drawing Nos. Sheet 9)**

Two boreholes (GL522-SBL-1, GL522-SBL-2) were put down for this structure. One hole found 0.9 m of sand fill, overlying clay, and sand till. The other hole encountered 2.1 m of sand, overlying cobbles, and bedrock.

### **5.19.1 Clay**

An approximately 1.6 m thick layer of clay was found in Borehole GL522-SBL-1 underlying 0.9 m of sand fill. The clay has a natural moisture content of 52%, while its liquid limit, plastic limit, and plasticity index were found to be 46%, 22% and 23, respectively (i.e. intermediate plastic). An SPT 'N' value of 13 blows per 0.3 m suggest stiff consistency.

### **5.19.2 Sand**

The top about 2.1 m in Borehole GL522-SBL-2 is a poorly graded sand that is composed of 92% sand and 8% silt (Figure 4, Appendix 'A'). The sand is saturated (moisture content of 18%) and loose ('N' value of 9 blows per 0.3 m).

### **5.19.3 Cobbles (till), Sand Till**

A layer of sand till was found overlying the bedrock in Borehole GL522-SBL-1. A layer of cobbly soil was found the other borehole just above the rock. Samples of this cobbly layer could not be taken, but it is possible that this layer is the same sand till deposit found in Borehole GL522-SBL-1. These materials are very dense ('N' values of 53 and higher.)

### **5.19.4 Bedrock**

Three meters of rock core were taken from Borehole GL522-SBL-2, with the following results:

Rock Type:	Granitic Gneiss, fresh, very strong
Total recovery:	83 to 97%
RQD:	82 to 94% (good to excellent quality)
Fractures:	3 fractures in 1.5 m core runs, planar, rough

### **5.19.5 Groundwater**

Both boreholes were dry during drilling. Groundwater was found to be at about 1.3 m depth in the open Borehole GL522-SBL-2 about 2 months after drilling. A piezometer was installed in Borehole GL522-SBL-1. Groundwater was found at 1.6 m depth about 2 months after the piezometer was installed. The piezometer was not purged after installation because the borehole was dry at that time.

## 6. Discussion and Preliminary Recommendations

The recommendations given in this report should be considered preliminary in nature. The structure layouts and the highway profiles are not available at the time of this study. A detailed foundation investigations will be required at a later stage to provide detailed recommendations for the design of the structures and highway embankments, once the alignment and structure layouts have been finalized.

### 6.1 Anticipated Construction Issues

No unusual construction conditions are expected for the following structures:

- Shawanaga Interchange
- Shawanaga River NBL
- Shawanaga Service Road
- Pointe au Baril Six Mile Lake NBL
- Pointe au Baril Six Mile Lake SBL
- Harris River NBL
- Mag-Brit Service Road
- Grundy *P-Rev* Bekanon Interchange
- Grundy Realigned CNR SBL original preferred alignment, after removing soft clay
- Grundy Realigned CNR revised alignment, after removing peat and soft clay
- Grundy NBL over Highway 522
- Grundy SBL over Highway 522

The anticipated construction conditions of the other structures are described in the following sub-sections of this report.

#### 6.1.1 Shawanaga River SBL (Sheet No. 2)

The areas adjacent to the river are low lying and swampy. The borehole put down on the north side of the river found about 3 ½ m of peat overlying about 5 m of very soft clay and loose sand. The dynamic cone tests conducted on the south side of and in the river confirmed that there are about 6 to 8 m of very soft deposits. Foundations for this structure will likely be piles drilled into bedrock. Part or all of the very soft deposits will have to be excavated to ensure the stability of the approach embankments and/or to minimize settlements. Complete removal of the very soft deposits could possibly be accomplished with a drag line.

#### **6.1.2 Mag-Brit CPR/Still River NBL (Sheet No. 6)**

The boreholes at the abutments encountered 5.6 to 9.0 m of clay overlying sand and bedrock. Foundations will likely be driven piles to rock. The approach embankments could experience substantial settlements, and stability at the end of construction could be an issue depending on height of embankment. The settlement of a 10 m high embankment is estimated to be 0.9 to 1.5 m. Laboratory consolidation test results suggest that the settlements could take 20 years to complete; however, field consolidation is expected to be far more rapid, due to the layered structure and silt seams in the clay. Nevertheless, the settlement process could continue over a number of years. Therefore, surcharging and / or wick drains may be required to accelerate the consolidation process. Embankments 5 m or lower should be stable at 2H:1V. For higher embankments, stability during and immediately after construction could be a problem. Either the embankments are constructed in stages to allow the clay to partially consolidate and gain strength, or they should be constructed to a flatter angle, and / or use toe berms to improve stability.

#### **6.1.3 Mag-Brit CPR/Still River SBL (Sheet No. 6)**

The subsurface conditions for the SBL structure are similar to those for the NBL, except that clay was not found at the south abutment. Stability of the south approach embankment should be satisfactory. A 10 m high embankment constructed at the north abutment could settle by an estimated 0.9 to 1.5 m, and stability could also be a problem.

#### **6.1.4 Grundy P-Rev. Key River Interchange (Sheet No. 8)**

The borehole at the south abutment found probable rock at 0.6 m depth. At the north abutment, the depth to the rock is 12.2 m. Therefore both footings and pile foundations are expected for this structure. The south embankment should have no construction problems. A 10 m high embankment on the north side could settle by an estimated 0.4 m. However, the clay layer could be completely or partially excavated to reduce the magnitude and duration of the settlement to acceptable limits.

#### **6.1.5 Grundy Realigned CNR NBL (Original Preferred Alignment) (Sheet No. 9)**

The borehole at the north abutment revealed about 7.7 m of overburden, of which only 1.6 m is clay, underlain by probable rock. Foundation support could be provided by steel piles driven to the surface of the rock. However, the borehole north of the north abutment encountered 11.5 m of very soft and compressible clay at ground surface. A consolidation test on the clay found a compression index ( $C_c$ ) of 1.55. The embankment at this location likely will suffer excessive time dependent settlement. The highway alignment in this area has since been relocated to the west. At the new location, construction difficulties are not expected.

#### 6.1.6 Grundy Portage Lake Existing CNR (Sheet Nos. 9 and 10)

Of all the structures investigated in this study, this one will require the most careful analysis in terms of foundation support, embankment settlement, and stability. The initial borehole for the original preferred alignment encountered deep deposits of soft, compressible clay. The alignment has since been relocated to the west. At the new alignment, the highway will cross CNR north and west of the original preferred alignment. Five boreholes have been put down for the new alignment, and found very different subsurface conditions. A simplified soil stratigraphy is shown in Drawing Sheet No. 11.

The borehole (PL-3) put down on the south side of the rail crossing encountered about 8.4 m of sand, underlain by rock. No unusual construction difficulties are expected at this location. The borehole put down on the north side of the crossing encountered very soft to soft clay strata interbedded with sand and silt layers. A very dense, cobbly till stratum was found at about 32.9 m depth. This layer should be able to support driven steel piles. Due to the considerable depth of the piles, and the soft / loose nature of the deposits above the founding stratum, vertical piles could experience large lateral displacements when subjected to horizontal loads. Therefore it would be necessary to use battered piles to resist lateral loads, and the piles would have to be analyzed for the possibility of buckling. Even with battered piles, there could be substantial differential movements between the north end and the south end of the structure, which must be designed for such movements.

The north abutment will experience large, time dependent settlements. For example, a 13 m high embankment could settle by an estimated 1.58 m, which will cause negative skin friction to the piles, and could potentially induce stability problem to the existing railway embankment if it is close to the highway embankment. These problems could be overcome by extending the structure to the north to increase the distance of the abutment from the railway embankment, and to reduce the height of the embankment. The weight of the embankments could be further reduced using light weight fill such as Expanded Polystyrene (EPS), which has a unit weight of  $2 \text{ kN/m}^3$ . Using EPS fill, the total settlement can be limited to less than 200 mm.

### 6.2 Foundations

Three types of foundations could be considered for the structures:

- Footings on rock
- Driven steel H piles bearing on rock or on very dense till
- Steel pipe piles drilled and socketed into rock

A summary of what type of foundation is suitable for which structure is presented in Table 2 below. Further discussions of the various foundation types are given in the following subsections of this report.

Table 2: Summary of Foundation Types at Each Structure

Structure	Footing on Rock	H Piles Driven to Rock or Till	Pipe Piles Drilled into Rock
Shawanaga Interchange	√		
Shawanaga River NBL	√		North abutment
Shawanaga River SBL	North abutment		South abutment, piers
Shawanaga Service Road	West abutment	East abutment	
Pointe au Baril Six Mile Lake NBL	√ (except north pier)		North pier
Pointe au Baril Six Mile Lake SBL	√		
Harris River NBL	South abutment	South abutment	
Mag-Brit Service Road	√		
Mag-Brit CPR/Still River NBL			√
Mag-Brit CPR/Still River SBL	South abutment		North abutment
Grundy P-Rev Bekanon Interchange	√		
Grundy P-Rev Key River NBL	North abutment		South pier
Grundy P-Rev Key River Interchange	South abutment	North abutment	
Grundy Portage Lake Existing CNR (revised alignment)		South of CNR	North of CNR
Grundy NBL over Highway 522	√		
Grundy SBL over Highway 522	√		

### 6.2.1 Footings on Rock

For those locations where competent rock is found at or less than about 6 m below ground surface, spread and continuous footings bearing directly on rock could be used to support the structures. Preliminary design footing pressure may be taken as 5,000 kPa at ULS, for footings founded on rock with RQD of not less than 75%. SLS condition need not be considered for footings bearing on rock.

Footings on rock may be considered for:

- Shawanaga Interchange
- Shawanaga River NBL
- Shawanaga River SBL north abutment
- Shawanaga Service Road west abutment
- Pointe au Baril NBL and SBL (except one pier)
- Harris River NBL south abutment
- Mag-Brit Service Road
- Mag-Brit CPR/Still River SBL south abutment
- Grundy Bekanon Interchange

- Grundy Key River NBL north abutment
- Grundy Key River Interchange south abutment
- Grundy NBL and SBL over Highway 522.

### 6.2.2 Driven Steel H Piles

Where the surface of the rock is at considerable depth, and the overburden soils are capable of providing lateral stability, steel H piles driven to the surface of the rock may be used for support of the structures. For preliminary design, the ULS capacity of an HP 310x110 driven to seat on rock may be taken as 2000 kN. SLS capacity needs not be considered for piles driven to rock. The pile tips should be fitted with suitable rock injector points to improve seating on rock and to minimize skipping on steeply inclined rock surface. Piles driven to rock can be considered for the east abutment of Shawanaga Service Road, the south abutment of Harris River NBL, the north abutment of Grundy *P-Rev* Key River Interchange NBL, and the Grundy Portage Lake Existing CNR revised alignment south abutment.

At the north end of the Grundy Portage Lake Existing CNR crossing (revised alignment), Borehole PL-6 encountered a layer of very dense cobbly till at about 32.9 m depth. At this location, steel H piles may also be driven to set in the till layer to support the structure. For preliminary design, the ULS and SLS capacities of an HP 310x110 driven to set in the very dense till may be taken as 1800 and 1600 kN, respectively.

Battered piles should be used to resist lateral forces.

Where the piles are driven through soft clay, and are located in or close to new highway embankments, the piles should be designed for an unfactored negative skin friction of 40 kPa on that portion of the pile surface in contact with the clay. The negative skin friction value is based on an undrained shear strength of 40 kPa for the clay, and an adhesion factor of 1.0.

### 6.2.3 Piles Socketed Into Rock

Where rock is at considerable depth and the overburden materials are too soft and/or loose to provide lateral stability, piles drilled and socketed into rock can be used for foundation support. The bedrock should be cored or drilled using suitable means, to allow the piles to be inserted and grouted into rock. The minimum depth of the socket should be 0.9 m. Steel pipe piles are recommended for this application. The geotechnical capacity (at ULS) of a pipe pile socketed into rock may be taken as 5,000 kPa times the base area of the pile (including the steel and the concrete area). That part of the piles in the soft overburden should be assumed to be unsupported. For a long, laterally unsupported pile, the structural capacity could be less than the geotechnical capacity. SLS capacity need not be considered for piles end bearing on rock. Lateral loads should be resisted by raking piles. Rock socketed pile foundations may be considered for the following structures:

- Shawanaga River NBL north abutment

- Shawanaga River SBL south abutment and piers
- Pointe au Baril Six Mile Lake NBL north pier
- Mag-Brit CPR/Still River NBL
- Mag-Brit CPR/Still River SBL north abutment
- Grundy *P-Rev* Key River NBL south pier
- Grundy Realigned CNR NBL (original preferred alignment)
- Grundy Portage Lake Existing CNR (revised alignment) north end

The piles should be designed for negative skin friction as discussed in the preceding section of this report.

### 6.3 Approach Embankment

The two issues that need to be considered are embankment stability and settlement.

#### 6.3.1 Embankment Stability

Where the overburden soils are sand or silt, or where bedrock or competent soils are found at shallow depth, stability should not be a problem, and the embankment could be constructed to the normal 2H:1V slopes. The following structures should have no embankment stability issue:

- Shawanaga Interchange
- Shawanaga River NBL (after excavating the soft clay)
- Shawanaga Service Road
- Pointe au Baril Six Mile Lake NBL and SBL
- Harris River NBL south approach
- Mag-Brit Service Road
- Grundy *P-Rev* Bekanon Interchange
- Grundy *P-Rev* Key River NBL north approach
- Grundy NBL and SBL over Highway 522

At the other structure locations, stability of the approach embankment could be a problem depending on the height and slope angle of the embankments. In general, embankment less than 3 m high may be constructed to the conventional 2H:1V angle. Embankment between 3 and 5 m should be constructed to 3H:1V slopes. Embankments higher than 5 m could require special construction techniques (staging, toe berm, wick drain) and / or the use of

light weight fills. Further discussion for each of the structures are presented in Section 6.4 of this report.

A summary of the anticipated embankment stability conditions for all structures is presented in Table 3 below.

**Table 3: Anticipated Embankment Stability Conditions**

Structure	North Approach		South Approach	
	5 m	10 m	5 m	10 m
Shawanaga Interchange	Stable at 2H:1V			
Shawanaga River NBL	Stable at 2H:1V with removal of organic soils	Flatten slope	Stable at 2H:1V	
Shawanaga River SBL	Stable at 2H:1V with removal of organic soils	Flatten slope	Partial or complete removal of organic soils and soft clay; further investigation required	
Shawanaga Service Road	Stable at 2H:1V			
Pointe au Baril Six Mile Lake NBL	Stable at 2H:1V			
Pointe au Baril Six Mile Lake SBL	Stable at 2H:1V			
Harris River NBL	Not included in this study		Stable at 2H:1V	
Mag-Brit Service Road	Stable at 2H:1V			
Mag-Brit CPR/Still River NBL	Stable at 2H:1V	4H:1V or flatter	Stable at 2H:1V	Flatten slope or excavate clay
Mag-Brit CPR/Still River SBL	Stable at 2H:1V	4H:1V or flatter	Stable at 2H:1V	
Grundy P-Rev Bekanon Interchange	Stable at 2H:1V			
Grundy P-Rev Key River NBL	Stable at 2H:1V		To be investigated	
Grundy P-Rev Key River Interchange	Should be satisfactory		Stable at 2H:1V	
Grundy Portage Lake Existing CNR (revised alignment)	Stable at 2H:1V	Further investigation / analysis required; may need light weight fills	Should be satisfactory subject to further investigation	
Grundy NBL over Highway 522	Stable at 2H:1V			
Grundy SBL over Highway 522	Stable at 2H:1V			

### 6.3.2 Embankment Settlement

Where the overburden materials are inorganic sand or silt, most of the embankment settlements should occur during or shortly after construction. The structures listed in the preceding subsection of this report are not expected to have long term settlement problem.

For the other structures, the magnitude of the settlement will depend on the height of the embankments, and the thickness and compressibility of the clay layers. Table 4 below summarizes the results of consolidation tests conducted on three clay samples. Using these test results, preliminary calculations indicate that the settlement could range from about 400 mm for a 10 m high embankment at Grundy *P-Rev* Interchange, to over 1.5 m for a 13 m high embankment at Grundy Existing CNR (revised alignment). Table 5 below shows a summary of the estimated settlements at the structures, further details are provided in the following sub-sections of this report.

The duration of the settlement will also require careful consideration in the design of the embankments. Preliminary calculations based on laboratory data suggests that primary consolidation could take 1.2 to 20 years to complete, as shown in Table 4 below. However, the field consolidation is expected to occur considerably faster due to the layered structure of the clay deposits, which often contain silt or even fine sand seams. Nevertheless, it is estimated that in some sites, settlement could continue to occur for up to five years or more. In these sites, it would be necessary to use wick drains and surcharge to reduce the consolidation time. Further discussions of the time aspect of settlement are presented in the following sub-sections of this report.

**Table 4 – Summary of Consolidation Test Results**

Borehole	MBCSN-2	GR-R-CNR-NBL-2	PL-6
Sample No.	5	3	13
Sample Depth (m)	4.9	4.2	18.6
Liquid Limit (%)	33	53	54
Plastic Limit (%)	19	23	23
Initial void ratio	1.143	2.570	2.103
Compression index (Cc)	0.347	1.55	1.45
Unit weight (kN/m <sup>3</sup> )	18.0	14.9	15.4
Moisture content (%)	42	47	75
Coefficient of consolidation (Cv, m <sup>2</sup> /day)	0.022 to 0.050	0.0021 to 0.0023	0.0032 to 0.0055
Specific gravity	2.76	2.76	2.78
Thickness of Clay Layer	9.0	Not relevant	10.0
Drainage Condition	Double	Not relevant	Double
Time of Primary Consolidation (years)	1.2 to 2.5	Not relevant	12 to 21

Table 5: Estimated Settlements

Structure	North Approach		South Approach	
	5 m	10 m	5 m	10 m
Shawanaga Interchange	Not expected			
Shawanaga River NBL	1.4	1.7	Within acceptable limits	
Shawanaga River SBL	1.2	1.6	1.2	1.6
Shawanaga Service Road	Not expected (some settlements during construction)			
Pointe au Baril Six Mile Lake NBL	Not expected			
Pointe au Baril Six Mile Lake SBL	Not expected			
Harris River NBL	Not investigated		Not expected	
Mag-Brit Service Road	Not expected			
Mag-Brit CPR/Still River NBL	1.0	1.5	0.7	0.9
Mag-Brit CPR/Still River SBL	0.8	1.2	Not expected	
Grundy P-Rev Bekanon Interchange	Not expected			
Grundy P-Rev Key River NBL	Not expected		To be investigated	
Grundy P-Rev Key River Interchange	0.3	0.4	Not expected	
Grundy Portage Lake Existing CNR (revised alignment)	0.8 *	1.3 *	Not expected (subject to further investigation)	
Grundy NBL over Highway 522	Not expected			
Grundy SBL over Highway 522	Not expected			

Note: All estimated settlements are after removal of organic soils

\* after removing 3 m of clay at ground surface

## 6.4 Site Specific Preliminary Recommendations

### 6.4.1 Shawanaga Interchange

Shallow bedrock was encountered at this site. Spread or continuous footings founded on bedrock (Section 6.2.1) are applicable for this site.

No embankment stability or settlement problems are anticipated for this site. The approach embankments should be stable at 2H:1V side slopes.

### 6.4.2 Shawanaga River NBL

Footings founded on rock (Section 6.2.1) or pipe piles drilled and socketed into rock (Section 6.2.3) could be considered for the north abutment of this structure. Footings on rock are expected for the south abutment. For the piers, footings bearing on rock are feasible, but a cofferdam would be required for the construction of the pier foundations located in the river.

For the south embankment, stability and settlement problems are not expected. For the north embankment, the very loose silt and the very soft clay should be removed from under the footprint of the embankment. After removing the incompetent materials, the embankments may be constructed to the normal 2H:1V slopes.

#### **6.4.3 Shawanaga River SBL**

Footings on rock (Section 6.2.1) are expected for the north abutment. For the south abutment and the piers, pipe piles drilled and socketed into rock (Section 6.2.3) would be appropriate. Lateral loads should be resisted by battered piles.

Preliminary calculations indicate that embankment 5 m high should be stable at 2H:1V slopes, after removing the surface layer of peat. Higher embankments would experience stability problems even at a much gentler slope. However, if the thickness of the clay layer is only 3.5 m, it may be possible to overcome the stability and settlement problems by partial or complete sub-excavation. It should be feasible to remove all the soft deposits under the south embankment.

#### **6.4.4 Shawanaga Service Road**

Footings on rock (Section 6.2.1) are appropriate for the west abutment, and driven steel H piles (Section 6.2.2) can be considered for the east abutment. The piles should be battered to resist lateral loads.

Embankment stability problem is not expected for this structure. The east abutment could experience some settlements. However, most of the settlements are expected to occur during construction.

#### **6.4.5 Point au Baril Six Mile Lake NBL**

Footings on bedrock (Section 6.2.1) are expected for the abutments and two of the piers. For the north pier (Borehole PB6N-3), which is located in the lake, pipe piles drilled into rock (Section 6.2.3) would be appropriate. If necessary, the piles may be battered to resist lateral loads. Footing may also be considered, but a cofferdam would be required to enclose the pier, after which the very soft peat and/or lake sediment can be excavated.

Embankment stability and settlement problems are not expected for this structure.

#### **6.4.6 Point au Baril Six Mile Lake SBL**

Footings on rock should be suitable for this structure, and the approach embankments should be stable.

#### **6.4.7 Harris River NBL**

According to the borehole drilled at the south abutment, both footing on rock (Section 6.2.1) and driven steel H piles may be considered for this abutment.

Embankment stability and settlements should not be a problem.

#### **6.4.8 Mag-Brit Service Road**

Footings on rock (Section 6.2.1) are appropriate for this structure, and embankment stability and settlement problems are not expected.

#### **6.4.9 Mag-Brit CPR/Still River NBL**

The foundations for this structure are expected to be pipe piles drilled into bedrock (Section 6.2.3). Battered piles should be used to resist lateral loads, and the piles should be designed for negative skin friction (Section 6.2.2).

Preliminary analyses show that it should be feasible to construct up to 5 m high embankments at 2H:1V. The long term factor of safety for embankments up to 10 m high should be satisfactory; however, the F.S. at end of construction is inadequate, and it would be necessary to use staged construction and/or flatten the slope to 4H:1V for embankments higher than 8 m to allow the clay deposits to consolidate and gain strength. Other means of stabilization such as partial sub-excavation, toe berms, etc., could also be considered. These preliminary recommendations should be verified by a further investigation at detailed design stage.

Although embankment stability could be satisfactory, the embankment could experience large settlements. It is estimated that, under a 10 m high embankment using earth or rock fills, the clay deposits could settle by 0.9 to 1.5 m at the south and north abutments, respectively. Even for a 5 m high embankment, the settlement could be 0.9 m at the north abutment. Furthermore, the consolidation could take more than 2 years to complete. Therefore it is envisaged that for this structure, special construction techniques such as partial excavation, limiting the height of the embankments (by increasing the number of spans), surcharging, installing wick drains, etc., would likely be required.

#### **6.4.10 Mag-Brit CPR/Still River SBL**

Footings on bedrock (Section 6.2.1) could be used for the south abutment while pipe piles drilled into bedrock (Section 6.2.3) should be considered for the north abutment of this structure.

No embankment problems are expected for the south approach. For the north approach embankment, the comments in the preceding section of this report are applicable.

#### **6.4.11 Grundy P-Rev Bekanon Interchange**

Footings on bedrock (Section 6.2.1) are suitable for the support of this structure.

No embankment problems are expected for this structure.

#### **6.4.12 Grundy *P-Rev* Straight Lake NBL**

Boreholes for this structure have not been drilled. Recommendations for this structure will be included in the final report.

#### **6.4.13 Grundy *P-Rev* Straight Lake Additional Site**

Boreholes for this site have not been drilled. Recommendations for this site will be included in the final report.

#### **6.4.14 Grundy *P-Rev* Key River NBL**

The north abutment of this structure can be supported by footings bearing on bedrock (Section 6.2.1). Footings could also be considered for the north pier, but it would be necessary to construct cofferdams around the piers and to remove about 2.2 m of peat. For the south pier, pipe piles drilled into bedrock (Section 6.2.3) could be used.

There should be no stability or settlement problems for the north approach embankment,

The borehole for the south abutment has not been drilled. Recommendations for this abutment will be included in the final report.

#### **6.4.15 Grundy *P-Rev* Key River Interchange NBL**

Footings on rock (Section 6.2.1) may be used for the south abutment, while driven steel H piles may be used for the north abutment.

Embankment stability should not be a problem. The south embankment would experience substantial time dependent settlement. For example, it is estimated that a 5 m high embankment at this location could settle by 300 mm. Most of the settlement could be eliminated by excavating the clay layer between 2.4 and 5.9 m depth.

#### **6.4.16 Grundy Realigned CNR**

At the original preferred alignment, a deep deposit of very soft clay was encountered in one of the boreholes. To avoid having serious foundation, stability and settlement problems, the highway alignment has been relocated to the west. At the new alignment location, a structure is not needed.

#### **6.4.17 Grundy Portage Lake Existing CNR**

At the original preferred alignment, serious foundation and embankment problems were anticipated. The highway alignment has been shifted to the west to minimize the problems.

At the revised location, the two boreholes encountered very different conditions. On the south side of the railway, Borehole PL-3 encountered about 8.4 m of sand overlying bedrock. At this location, driven H pile foundation would be appropriate, and embankment stability and settlement should not be a problem.

On the north side of the railway, Borehole PL-6 found two layers of clay interbedded with sand and silt strata. The borehole ended in a deposit of very dense cobbly till. Driven steel H piles (Section 6.2.2) may be used to support the structure. The piles should be battered to resist lateral loads, and should be designed for negative skin friction. The lengths of the piles are expected to vary from less than 10 m on the south side of the railway, to over 35 m on the north side. Because of this, the movements that piles will undergo when subjected to lateral loads will differ considerably from the south to the north ends of the structure. Using battered piles groups and increasing the pile sections could reduce the differential movements, but the structure should be designed for the movements.

On the north side of the railway, the embankment design will have to address stability and settlement issues. Preliminary calculations indicate that a 5 m high embankment may be constructed to 2H:1V slopes. For a 10 m high embankment, the long term factor of safety should be satisfactory, but staged construction and/or flatter slope would be necessary to avoid instability during construction. Partial sub-excavation to remove the very soft clay deposits at ground surface could also be considered.

The embankment on the north side of the railway will suffer large settlement. Preliminary calculations indicate that a 5 m high embankment constructed with regular earth or rock fill could settle by as much as 750 mm in five years, even removing the top 3 m of clay at ground surface. For a 13 m high embankment, the settlement could exceed 1.5 m. The settlement process could be shortened by installing wick drains into the deeper clay layers, but it is likely that light weight fill materials will have to be used for the construction of the embankments to reduce the magnitude of the settlements. For preliminary design purposes, it is recommended that the pressure at the base of the embankment at its highest point should not exceed 60 kPa, to be accomplished by a combination of lengthening the structure and using light weight fill materials.

Another design issue that should be considered is the effect of the embankment construction on the stability of the existing railway embankment. If the new highway embankment is located close to the railway embankment, it could potentially cause the tilting or sliding of the railway embankment. For preliminary design purposes, the minimum distance between the two embankments should be three times the height of the higher embankment.

Two additional boreholes will be drilled to obtain more information for this structure. Further recommendations will be provided in the final report.

#### **6.4.18 Grundy NBL Over Highway 522**

Footings on rock (Section 6.2.1) may be used to support this structure.

No embankment problems are expected.

#### **6.4.19 Grundy SBL Over Highway 522**

Footings on rock (Section 6.2.1) may be used to support this structure. The footings may also be founded on the layer of dense till just above bedrock, using a reduced bearing pressure of 600 kPa at ULS, and 400 kPa at SLS.

No embankment problems are expected.

## 7. Further Investigation

At detailed design stage, a further investigation should be conducted for each of the structures. The investigation should consist of a sufficient number of boreholes and probe holes for the abutments, piers, and approach embankments. In addition to the normal SPT and vane shear tests, insitu permeability tests should be carried in the boreholes to provide a better estimation of the rate of consolidation of the soft clay deposits.

All of the structures and approach embankments will require further investigation. A list of the structure locations and anticipated foundation types is presented in the following table, together with the number and depths of borehole completed. This table can be used to determine the scope for the further investigation.

**Table 6: Further Investigation for Structures**

<b>Structure / Site</b>	<b>Estimated Structure Length (m)</b>	<b>Potential Foundation Consideration</b>	<b>Test Holes Completed in This Study</b>
Woods Road Interchange	82	Likely shallow foundation	None
Shawanaga Interchange	82	Shallow foundation	Two boreholes to 0 and 3.4 m
Shawanaga River NBL	211	Shallow foundation for south; piles drilled into rock for north	Four boreholes to between 0 and 6.7 m
Shawanaga River SBL	284	Shallow foundation for north; piles drilled into rock for south	Two boreholes to 1.2 and 11.6 m; one dynamic cone tests to 6.8 m; three probe holes to ? m
Shawanaga Service Road	110	Shallow foundation for west; driven piles for east	Two boreholes to 5.5 and 8.2 m
Pointe au Baril Interchange	82	Likely shallow foundation	None
Pointe au Baril Sucker Creek NBL	88	Shallow foundations	None
Pointe au Baril Sucker Creek SBL	88	Shallow foundations	None
Pointe au Baril Service Road	72	Likely shallow foundations	None

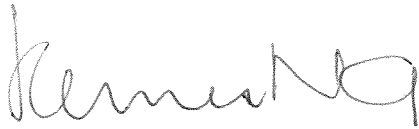
<b>Structure / Site</b>	<b>Estimated Structure Length (m)</b>	<b>Potential Foundation Consideration</b>	<b>Test Holes Completed in This Study</b>
Pointe au Baril Six Mile Lake NBL	300	Shallow foundation for north; piles drilled into rock for south	Four boreholes, 0 to 0.6 m; one dynamic cone test to 7.6 m
Pointe au Baril Six Mile Lake SBL	275	Likely all shallow foundations	Four boreholes, 0.6 to 4.4 m; one dynamic cone test to 2.2 m
Harris River NBL	60	Driven pile to rock	One borehole to 8.5 m
Harris River SBL	60	Likely shallow foundation	None
Harris River Interchange	86	Shallow foundations	None
Mag-Brit Service Road	82	Shallow foundations	Two boreholes to 0.9 and 3.1 m
Mag-Brit Magnetawan River NBL	118	Likely shallow foundations	None
Mag-Brit Magnetawan River SBL	91	Likely shallow foundations	None
Mag-Brit Interchange	82	Likely shallow foundations	None
Mag-Brit CPR/Still River NBL	220	Piles drilled into rock	Three boreholes to between 6.3 and 17.4 m
Mag-Brit SPR/Still River SBL	160	Shallow foundation for south, piles drilled into rock for north	Three borehole to between 5.5 and 9.0 m
Grundy P-Rev Bekanon Interchange	82	Shallow foundations	Two boreholes, 0 and 5.2 m
Grundy Rev Straight Lake NBL	180	Likely deep foundations	None
Grundy P-Rev Key River NBL	226	Shallow foundation for north, likely deep foundation for south	Three boreholes to between 0 and 10.2 m

<b>Structure / Site</b>	<b>Estimated Structure Length (m)</b>	<b>Potential Foundation Consideration</b>	<b>Test Holes Completed in This Study</b>
Grundy P-Rev Key River Interchange	82	Shallow foundation for south, piles driven into rock for north	Two boreholes, 0.5, 15.2 m
Grundy Portage Existing CNR (Revised alignment)	110?	Driven or drilled piles into rock	Five boreholes to between 8.4 and 37.5 m
Grundy CNR, NBL, SBL over Hwy 522	30	Shallow foundations	Four boreholes to between 2.7 and 7.2 m

## 8. Closure

The field work for this study was carried out under the supervision of Haresh Gharegrat, P.E. This report was prepared by James Ng, P. Eng., Senior Project Engineer and project manager for this study, and was reviewed by Stan Gonsalves, P. Eng., Senior Geotechnical Specialist and designated MTO contact.

### Trow Associates Inc.



James Ng, M.Eng., P.Eng., MICE  
Senior Engineer  
Geotechnical Division

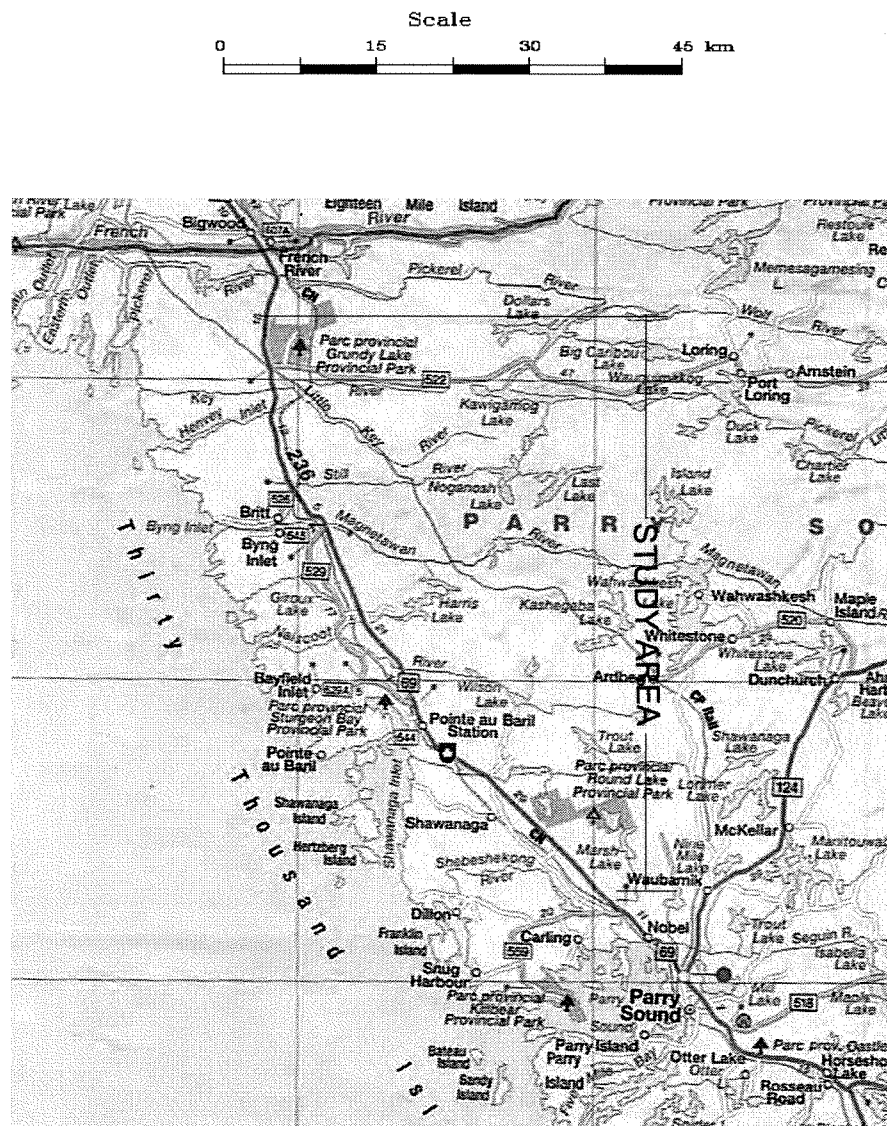


Stan Gonsalves, P.Eng.  
Senior Geotechnical Specialist  
Designated MTO Contact



## Appendix A: Figures

Figure 1 – Site Map



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

Fine

SAND  
Medium

Coarse

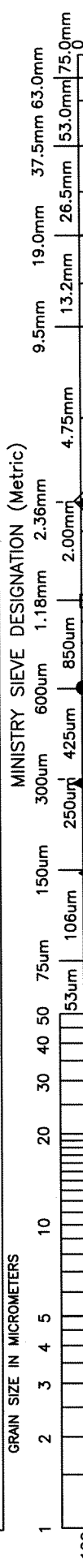
Fine

GRAVEL

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



PERCENT PASSING

PERCENT RETAINED

## LEGEND

FIG No. 2  
GWP 5377-02-00

Ministry of  
Transportation  
Ontario

# UNIFIED SOIL CLASSIFICATION SYSTEM

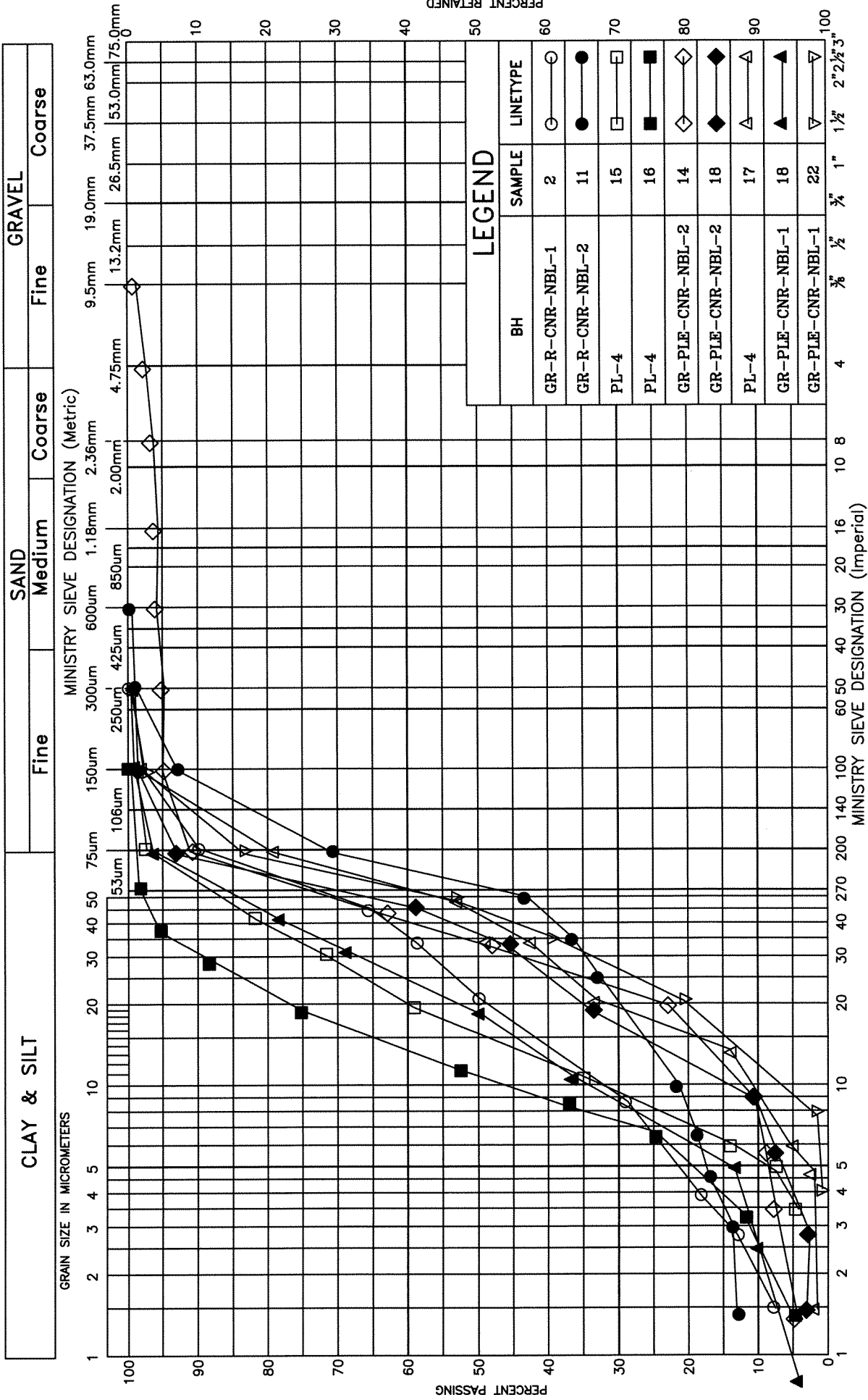


FIG No. 3

GWP 5377-02-00

GRAIN SIZE DISTRIBUTION  
SILT, SANDY SILT, ORGANIC SILT

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND		GRAVEL	
		Fine	Medium	Fine	Coarse

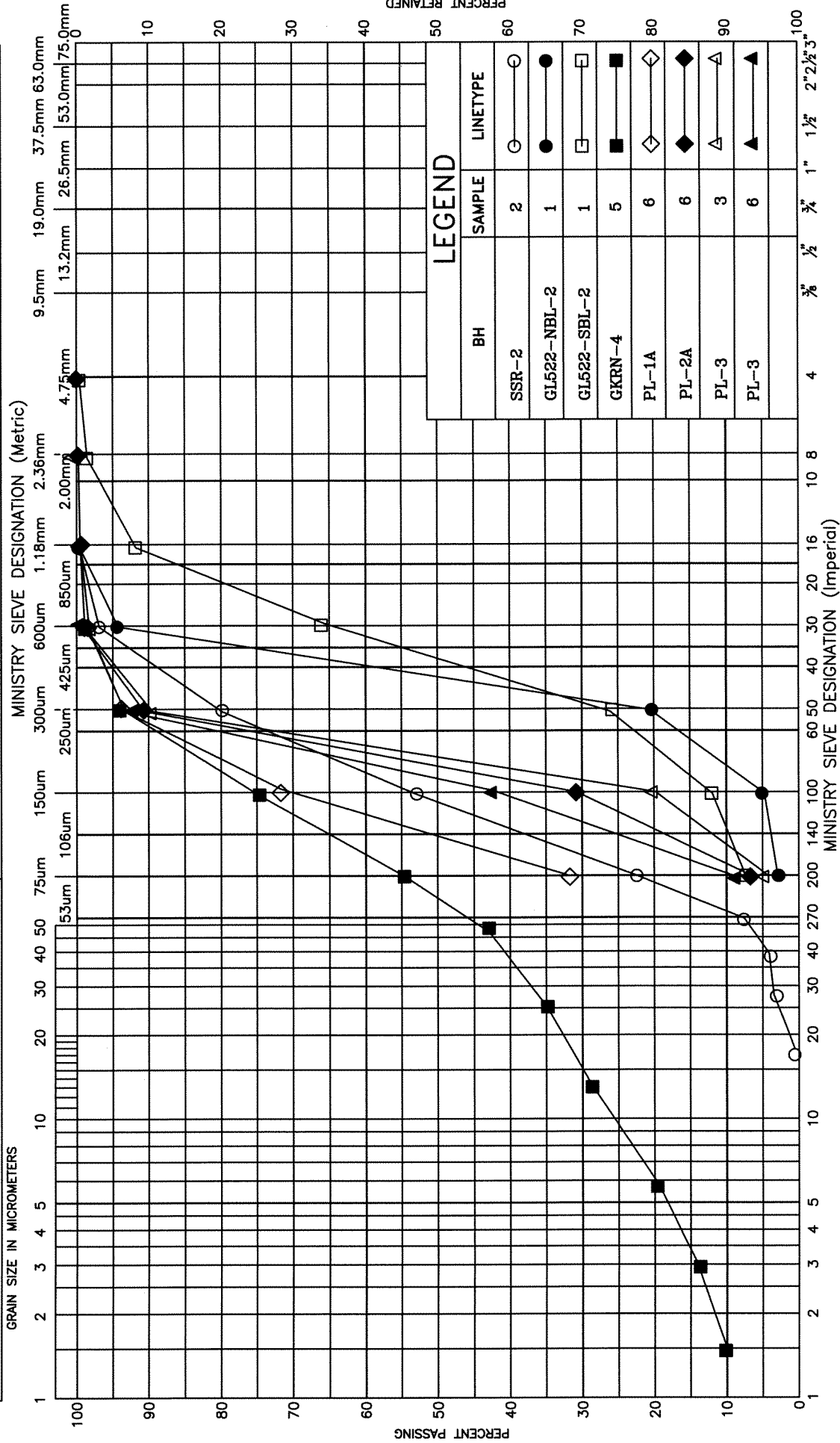


FIG No. 4

GWP 5377-02-00

GRAIN SIZE DISTRIBUTION  
SAND, SILTY SAND

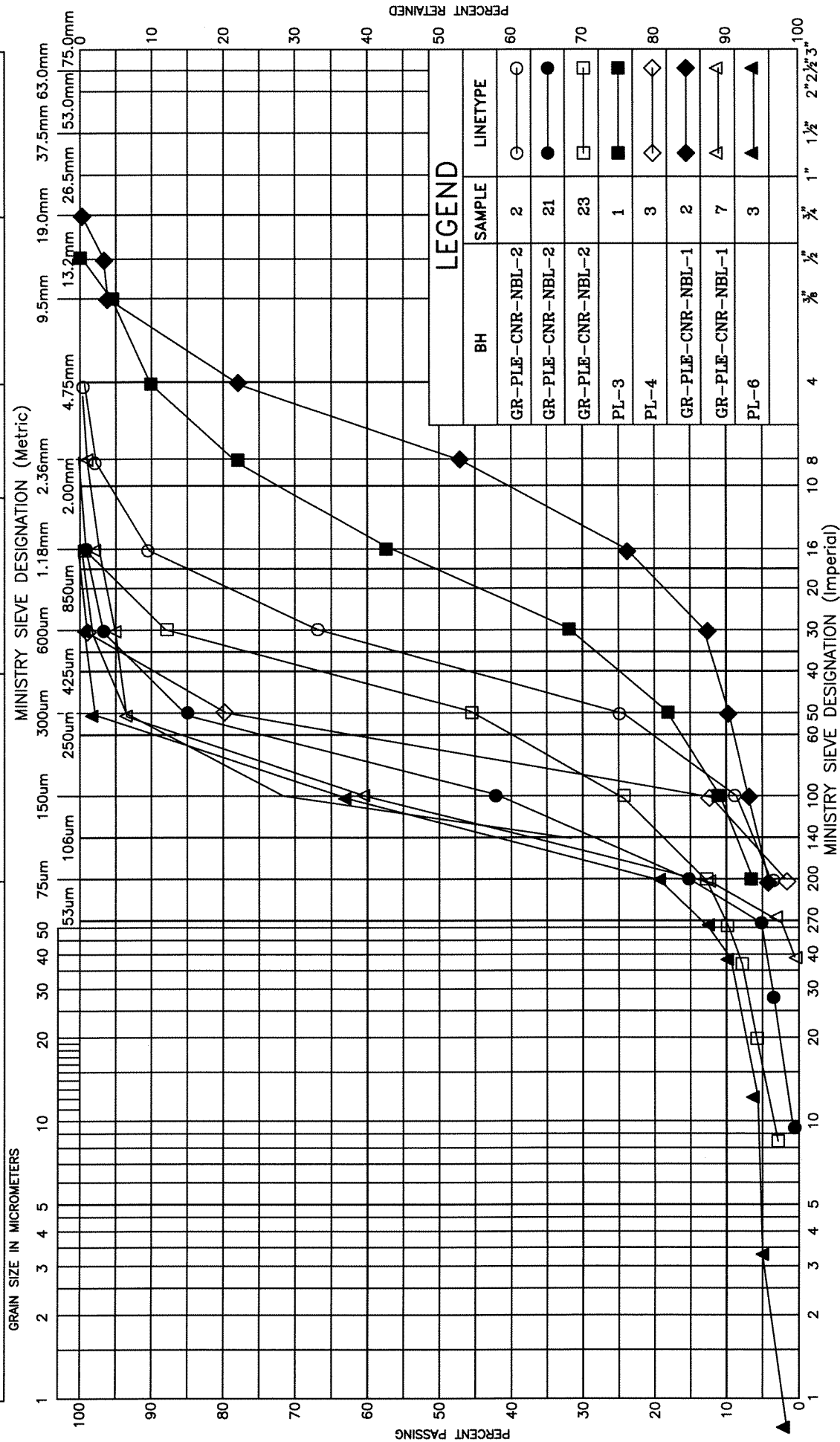
## CLAY & SILT

Fine

Coat	
------	--

**GRAVEL**

**oarse**



**Ministry of  
Transportation  
Ontario**

## GRAIN SIZE DISTRIBUTION SAND

FIG No. 5

GWP 5377-02-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

Fine

SAND  
Medium

Coarse

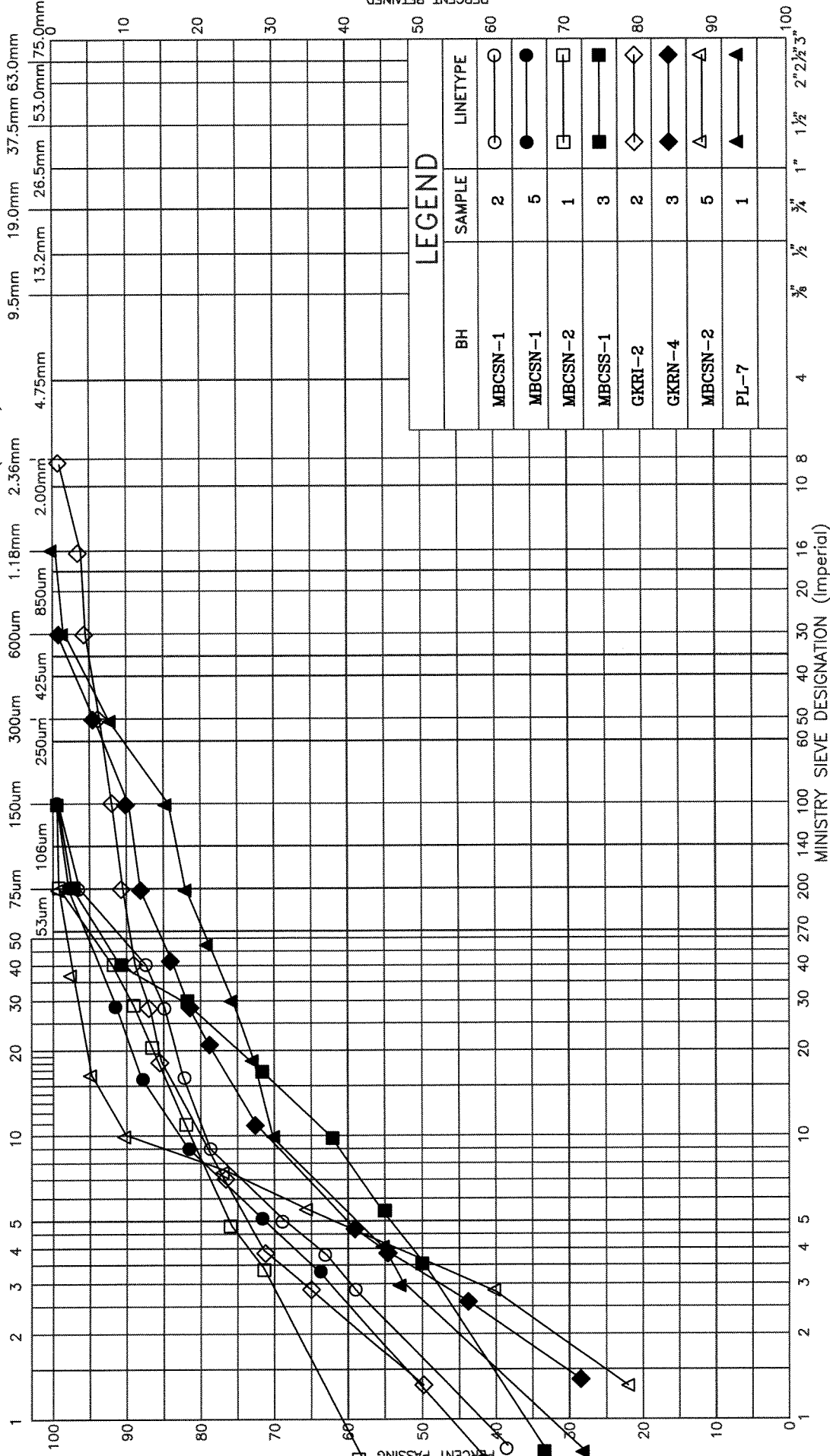
Fine

GRAVEL

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



## GRAIN SIZE DISTRIBUTION

CLAY

FIG No. 6

GWP 5377-02-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine		Medium	Coarse	Fine	Coarse

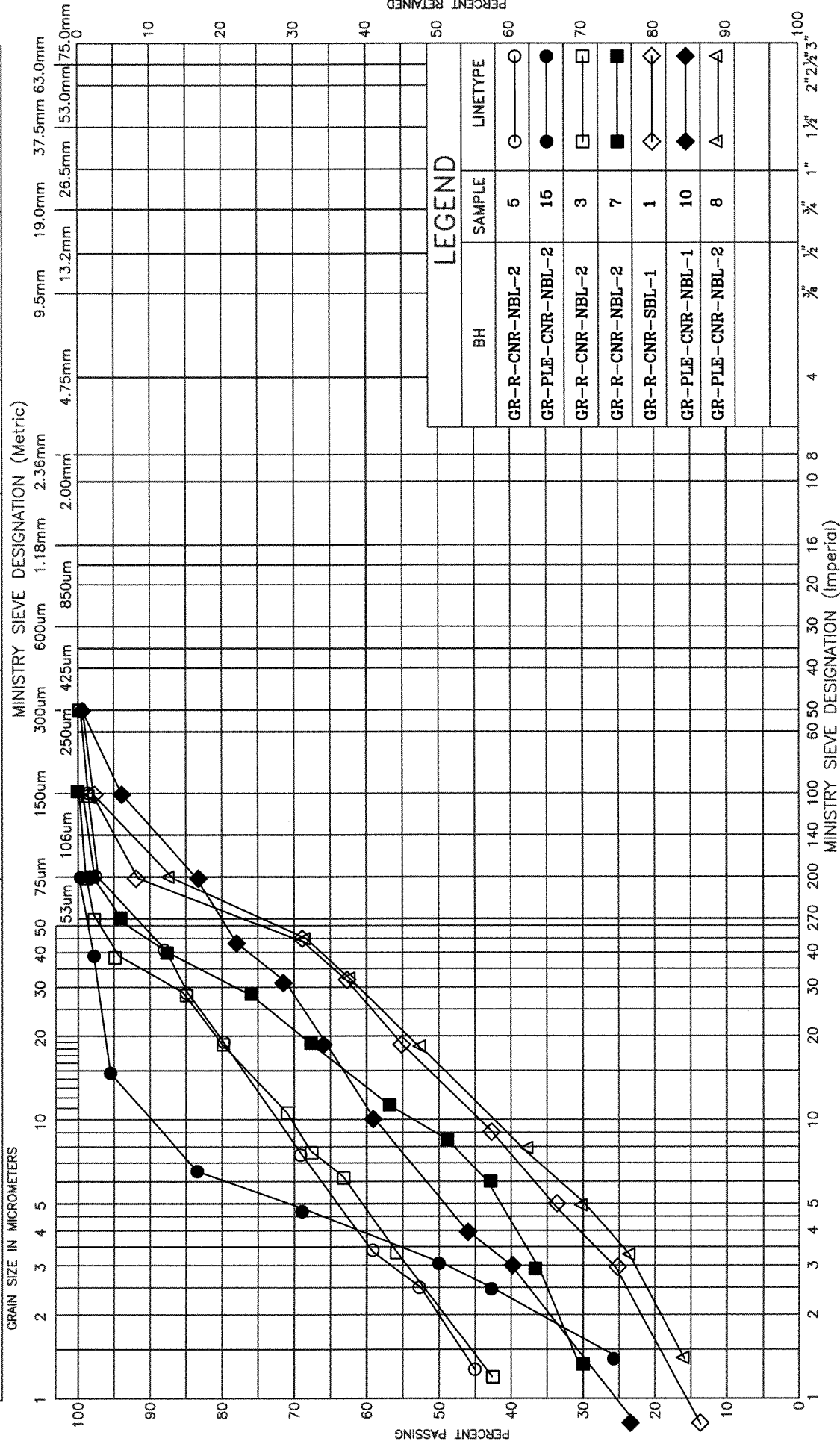


FIG No. 7

GRAIN SIZE DISTRIBUTION

CLAY, SILTY CLAY

GWP 5377-02-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	

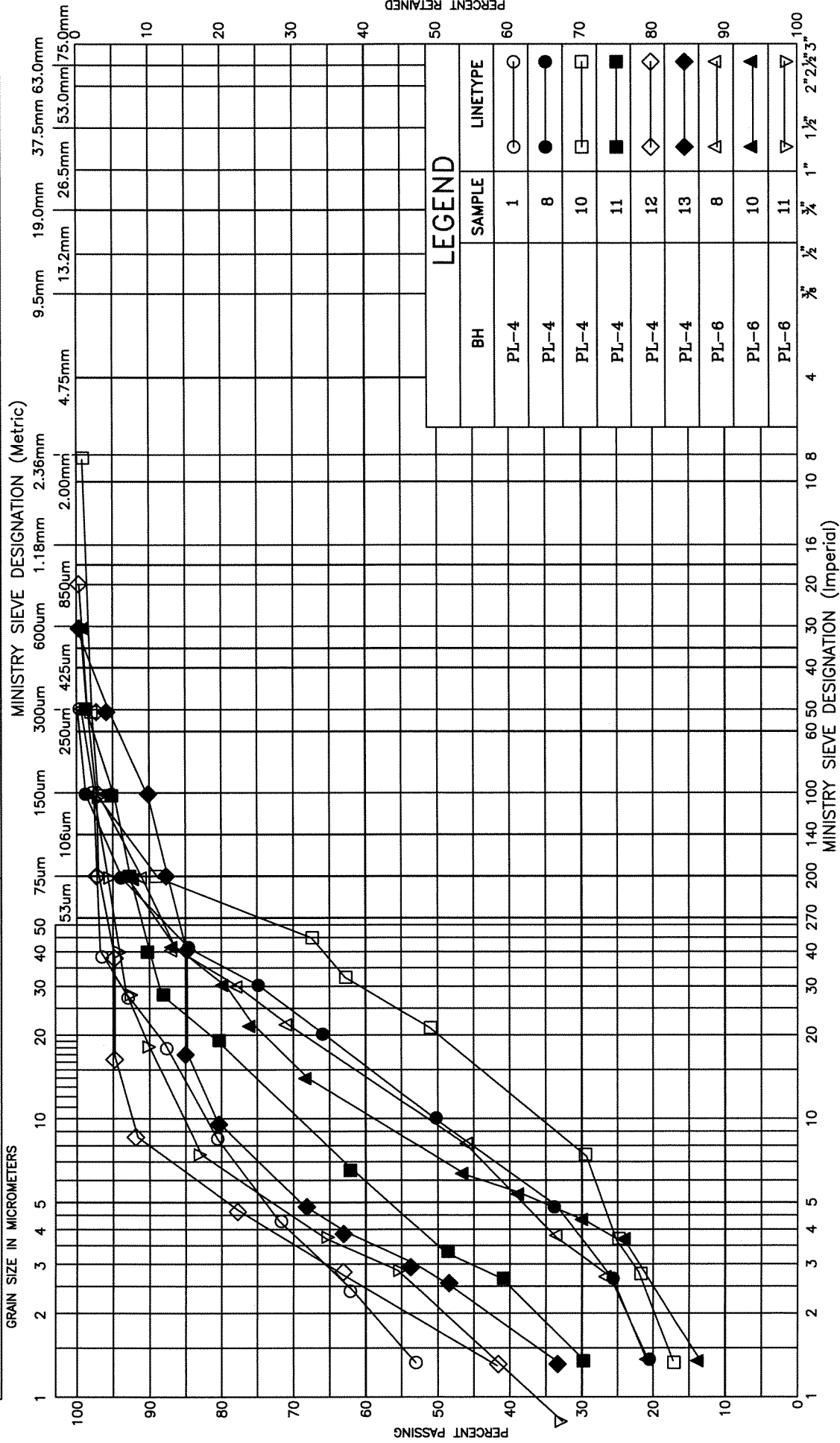
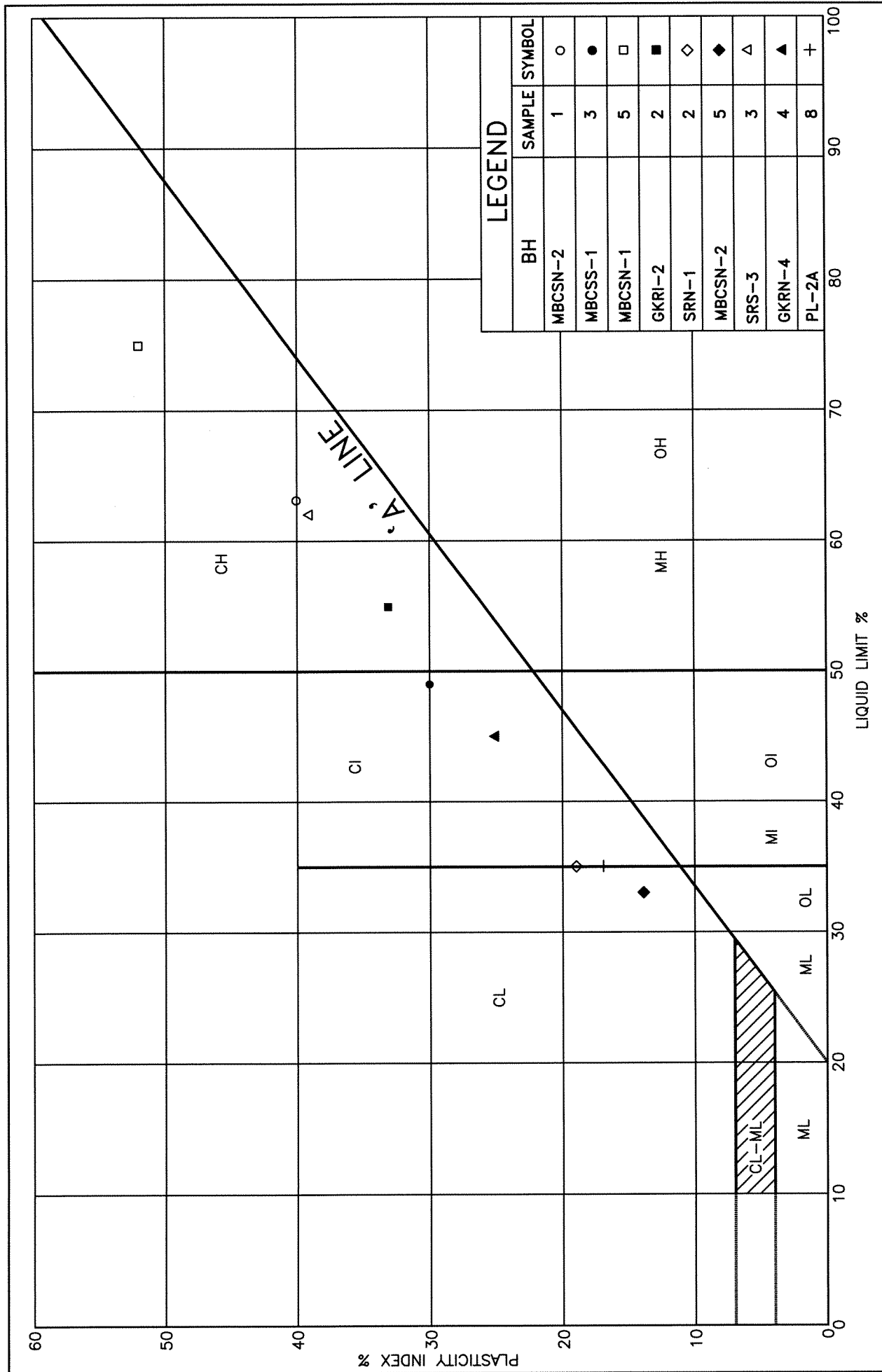
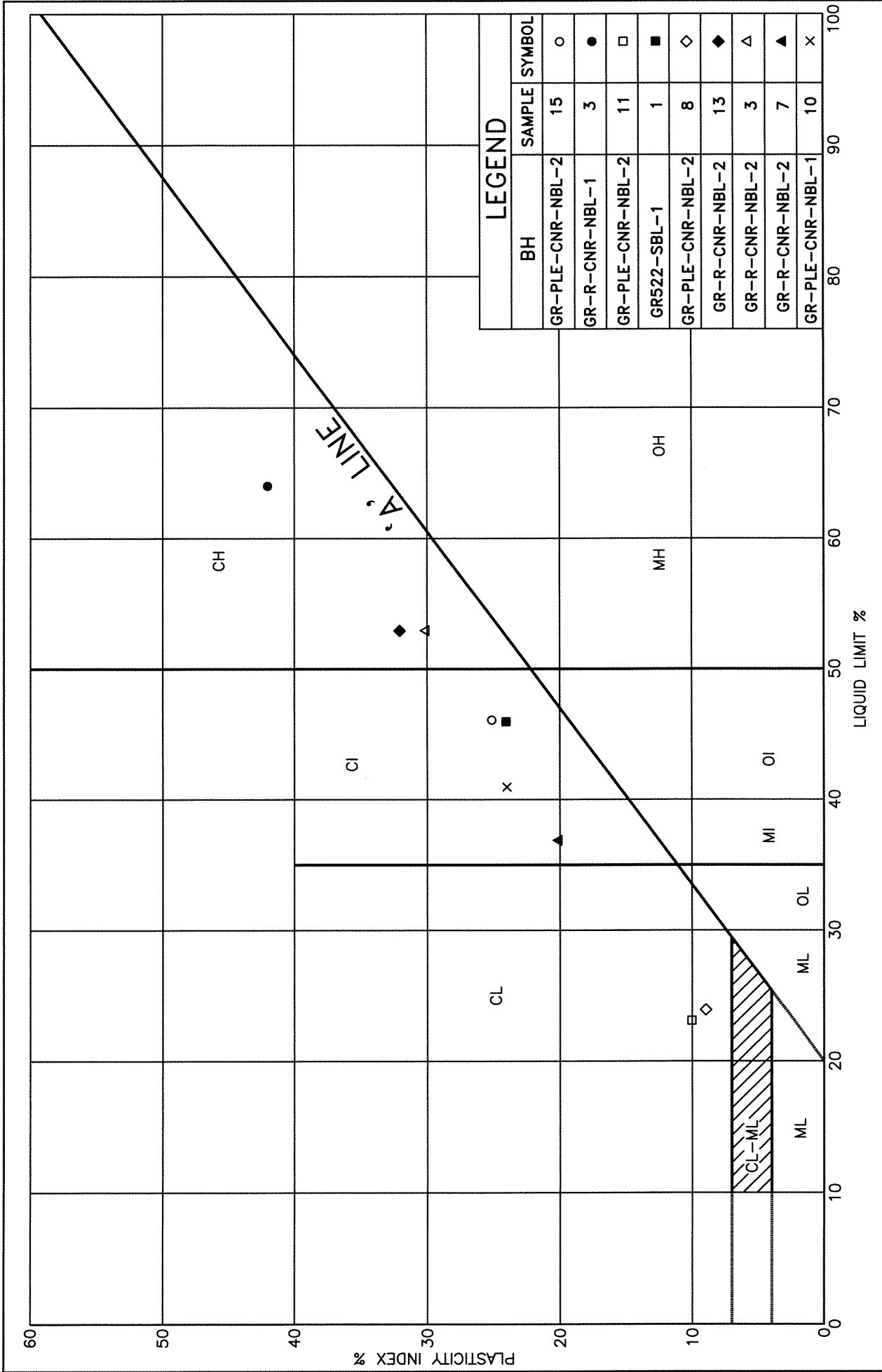
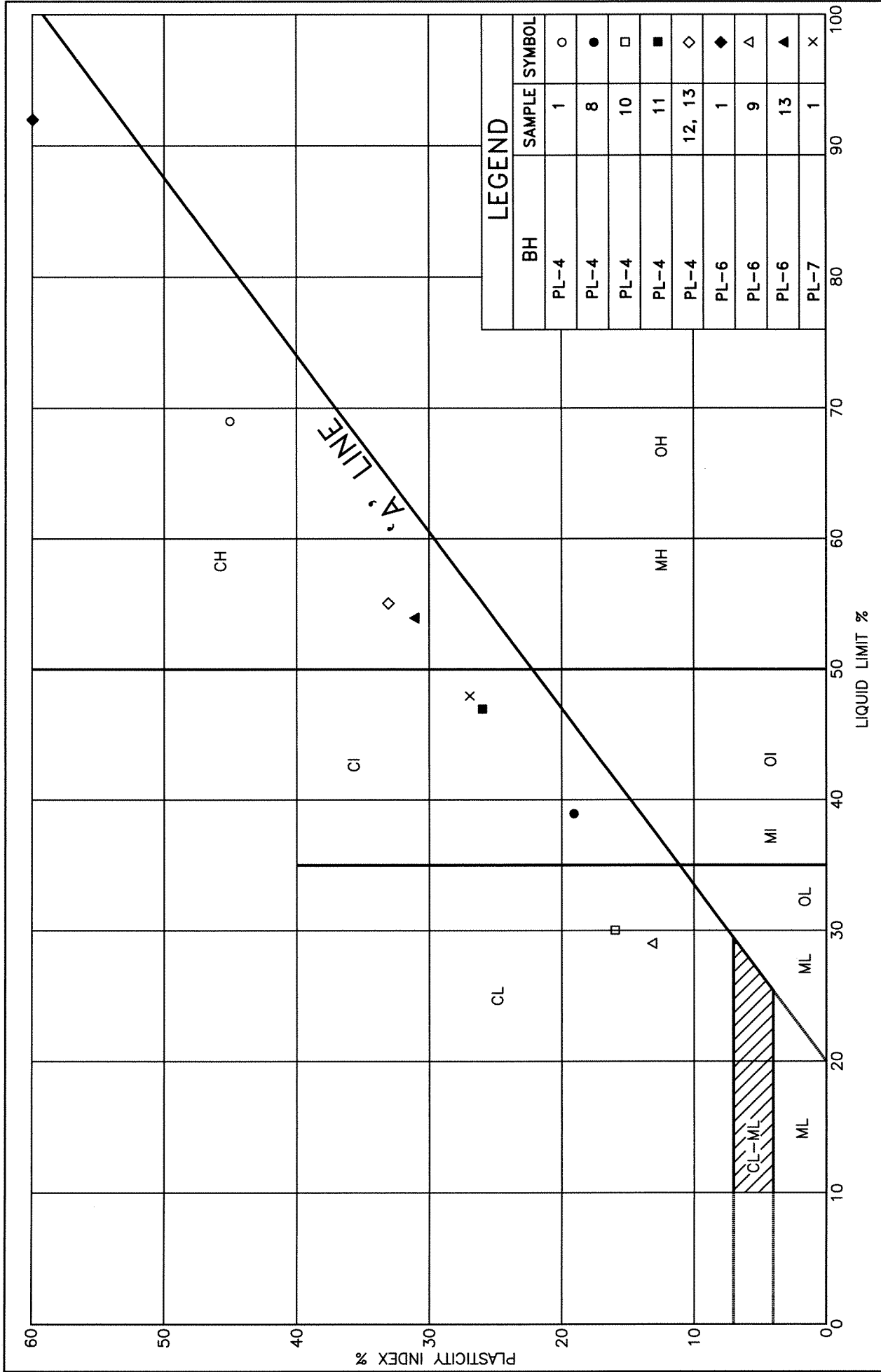


FIG No. 8

GRAIN SIZE DISTRIBUTION  
CLAY, SILTY CLAY







# VOID RATIO - PRESSURE CURVES

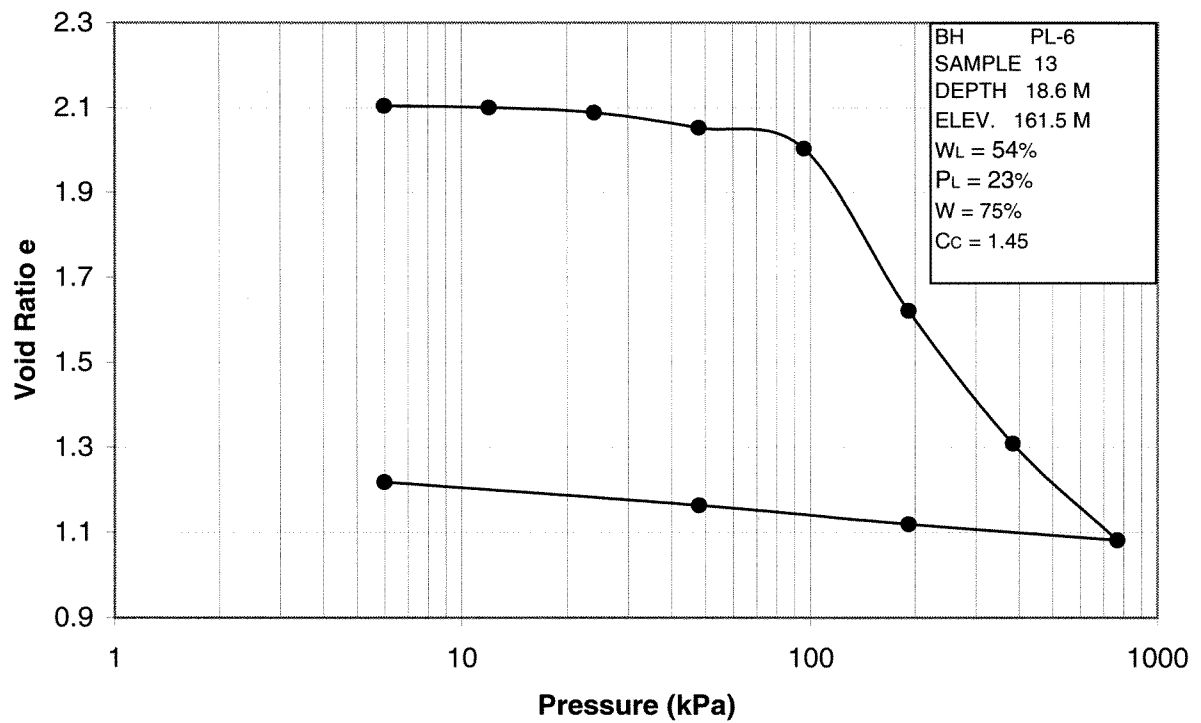
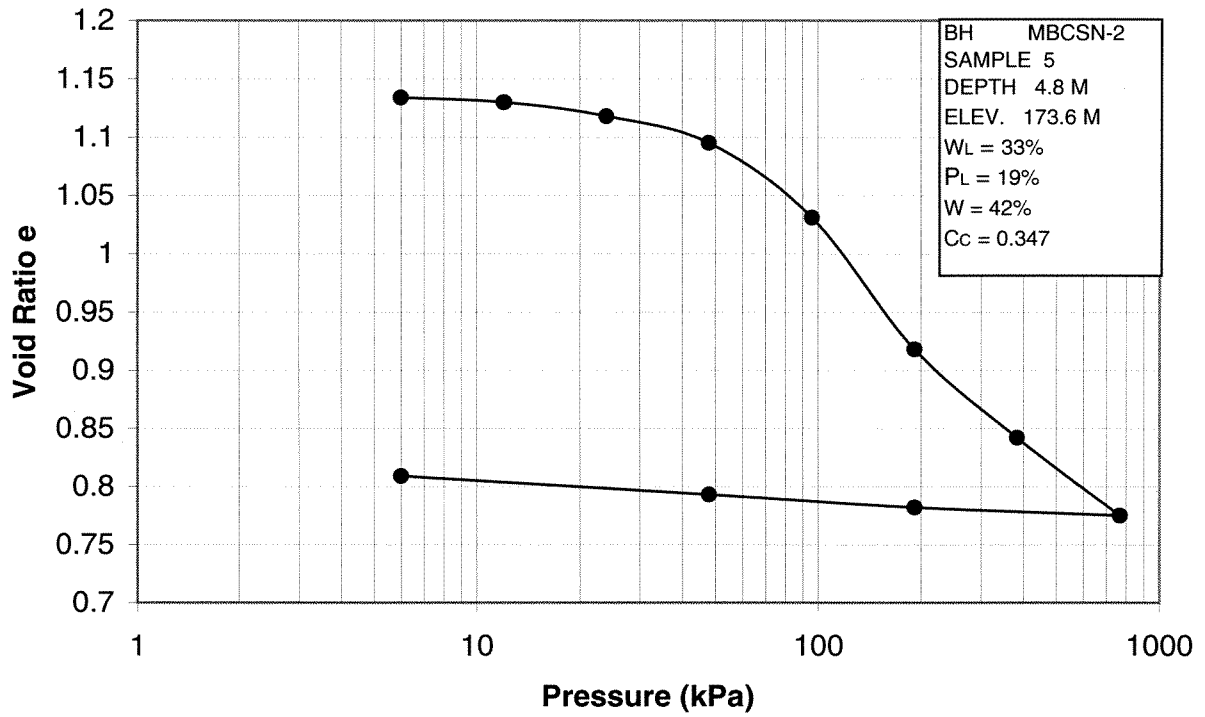


Fig 12

GWP 5377-02-00

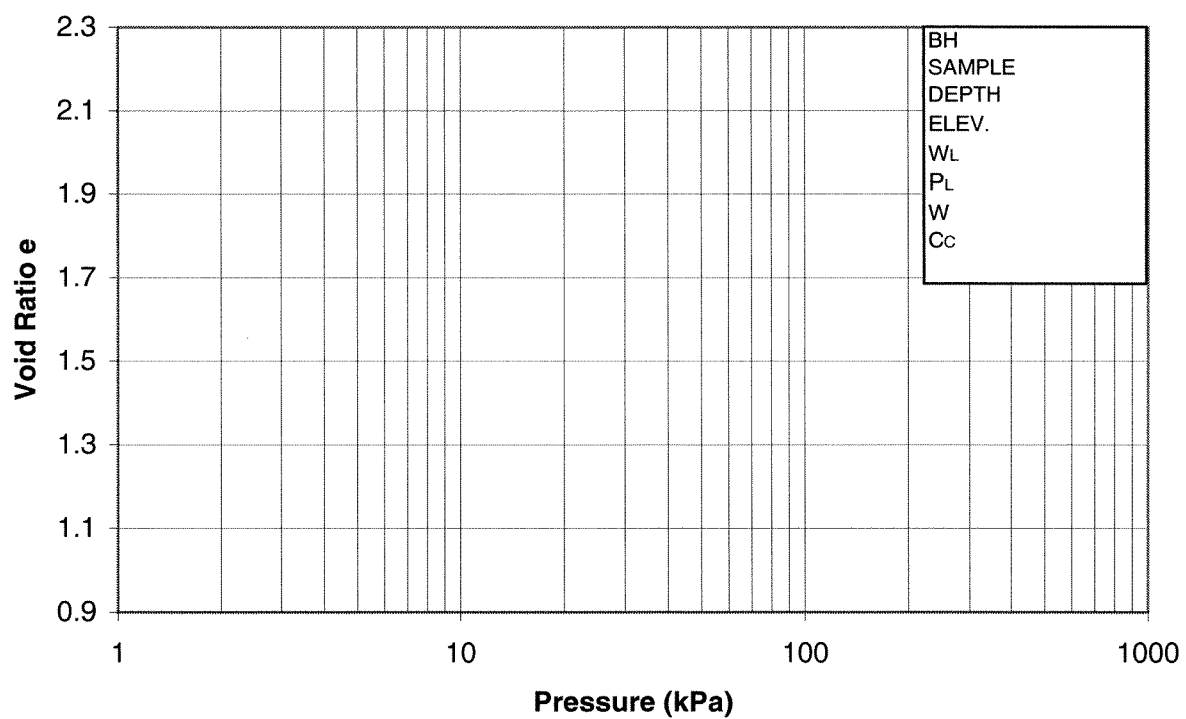
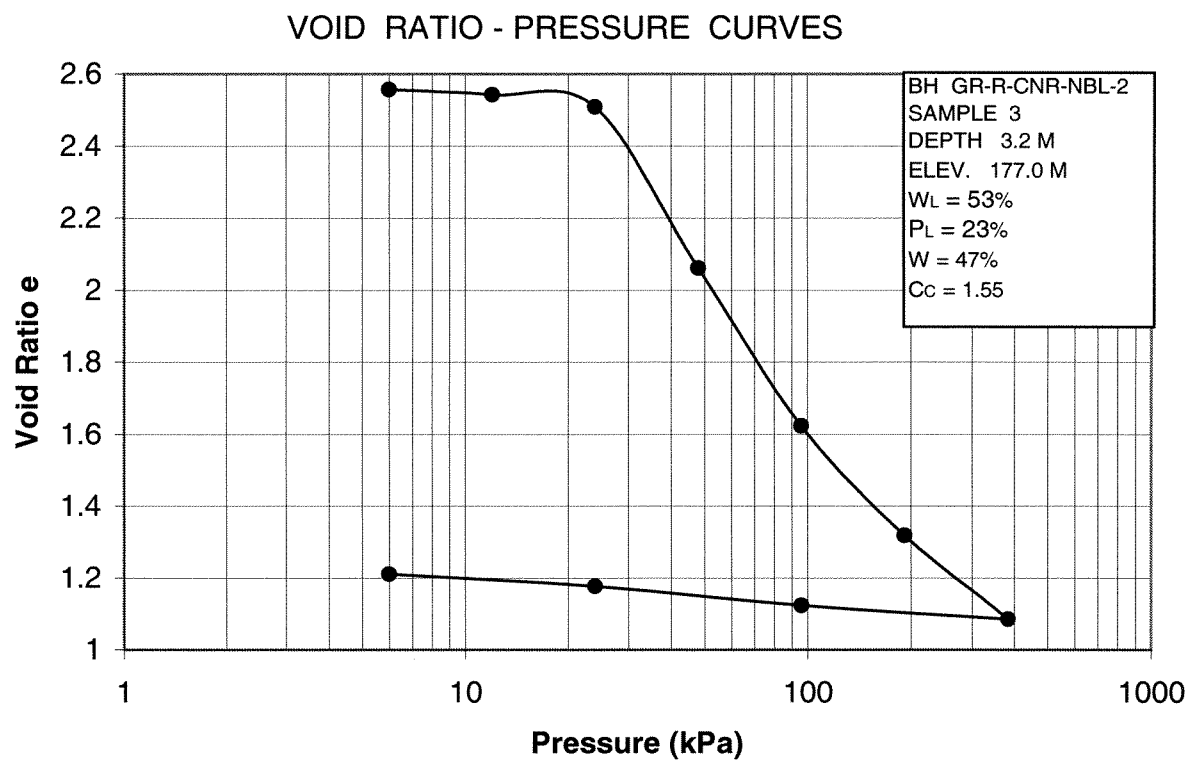


Fig 13

GWP 5377-02-00

## **Appendix B: Summary of Subsurface Conditions**

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**Table 7 – Summary of Subsurface Conditions**

<b>Structure</b>	<b>Test Hole Designations</b>	<b>Peat / Topsoil / Alluvial Thickness (m)</b>	<b>Depth to Bottom of Clay (m)</b>	<b>Depth to Bedrock (m)</b>
Shawanaga Interchange	SI-1, SI-2	0.1 to 0.3	Not encountered	0.1 to 0.3
Shawanaga River NBL	SRN-1 to SRN-4	0 to 4.0	6.7	0 to 6.7
Shawanaga River SBL	SRS-1, SRS-3	1.2 to 4.0	7.9	1.2 to 8.5
Shawanaga Service Road	SSR-1, SSR-2	2.4 to 8.2	Not encountered	2.4 to 8.2
Pointe au Baril Six Mile Lake NBL	PB6N-1 to PB6N-5	0 to 7.6	Not encountered	0 to 7.6
Pointe au Baril Six Mile Lake SBL	PB6S-1 to PB6S-5	0.15 to 2.2	Not encountered	0.15 to 2.3
Harris River NBL	HRN-1	5.5	Not encountered	5.5
Mag-Brit Service Road	MBSR-1, MBSR-2	0 to 0.9	Not encountered	0 to 0.9
Mag-Brit CPR Still River NBL	MBCSN-1 to MBCSN-3	0.15 to 7.7	5.6 to 11.7	6.0 to 14.1
Mag-Brit CPR Still River SBL	MBCSS-1 to MBCSS-2	0 to 2.4	9.0 in one hole	2.4 to 9.0
Grundy P-Rev Bekanon Interchange	GRBINT-1, GRBINT-2	0.2 to 2.1	Not encountered	0.2 to 2.1
Grundy P-Rev Straight Lake NBL	Boreholes will not be drilled			
Grundy Straight Lake Additional Site	Boreholes will not be drilled			
Grundy P-Rev Key River NBL	GKRN-1, GKRN-3, GKRN-4	0 to 2.2	8.9 in one hole	0 to 9.8
Grundy P-Rev Key River Interchange	GKRI-1, GKRI-2	0.6 to 2.4	5.9 in one hole	0.6 to 12.2

<b>Structure</b>	<b>Test Hole Designations</b>	<b>Peat / Topsoil / Alluvial Thickness (m)</b>	<b>Depth to Bottom of Clay (m)</b>	<b>Depth to Bedrock (m)</b>
Grundy Re-aligned CNR NBL (original alignment)	GR-R-CNR-NBL-1, GR-R-CNR-NBL-2	0.2 to 4.0	5.6 in one hole; 11.7, 17.0 (2 layers) in second hole	7.7 to 20.6
Grundy Re-aligned CNR SBL (original alignment)	GR-R-CNR-SBL-1	0.35	3.8	3.8
Grundy Portage Lake Existing CNR	GR PLE CNR NBL-1 GR PLR CNR NBL-2 PL-1A, PL-2A, PL-3, PL-3A, PL-4, PL-6	0.5 to 32.9	17.5 to 26.1	8.4 to 47.9
Grundy NBL over Hwy 522	GL522-NBL-1 GL522-NBL-2	2.7 to 3.8	Not encountered	2.7 to 3.8
Grundy SBL over Hwy 522	GL522-SBL-1 GL522-SBL-2	2.1	2.5 in one hole	4.1

## Appendix C: Records of Boreholes and Dynamic Cone Tests

## EXPLANATION OF TERMS AND SYMBOLS

N VALUE - STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A STANDARD 51-mm O.D. SPLIT SPOON SAMPLER 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg FALLING FREELY A DISTANCE OF 0.76 m. FOR PENETRATION LESS THAN 0.3 m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED AS  $\bar{N}$ .

DYNAMIC CONE PENETRATION TEST - CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR COMPACTNESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $C_u$ ) AS FOLLOWS:

$C_u$ (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

COMPACTNESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF COMPACTNESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS /0.3m)	0-5	5-10	10-30	30-50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH:

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES. 100mm + IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD(%)	0-25	25-50	50-75	75-90	90-100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

### ABBREVIATIONS AND SYMBOLS

#### FIELD SAMPLING

SS SPLIT SPOON  
WS WASH SAMPLE  
ST SLOTTED TUBE SAMPLE  
BS BLOCK SAMPLE  
CS CHUNK SAMPLE  
TW THINWALL OPEN

TP THINWALL PISTON  
OS OSTERBERG SAMPLE  
RC ROCK CORE  
PH TW ADVANCED HYDRAULICALLY  
PM TW ADVANCED MANUALLY  
FS FOIL SAMPLE

#### MECHANICAL PROPERTIES OF SOIL

$m_v$  Pa-1 COEFFICIENT OF VOLUME CHANGE  
 $C_c$  1 COMPRESSION INDEX  
 $C_s$  1 SWELLING INDEX  
 $C_\alpha$  1 COEFFICIENT OF SECONDARY CONSOLIDATION  
 $C_v$  m<sup>2</sup>/sec COEFFICIENT OF CONSOLIDATION  
H m DRAINAGE PATH  
 $T_v$  1 TIME FACTOR  
U % DEGREE OF CONSOLIDATION  
 $\sigma_{vo}$  kPa EFFECTIVE OVERBURDEN PRESSURE  
 $\sigma_p$  kPa PRECONSOLIDATION PRESSURE  
 $\tau_f$  kPa SHEAR STRENGTH  
 $c'$  kPa EFFECTIVE COHESION INTERCEPT  
 $\phi'$  ° EFFECTIVE ANGLE OF INTERNAL FRICTION  
 $c_u$  kPa APPARENT COHESION INTERCEPT  
 $\phi_u$  ° APPARENT ANGLE OF INTERNAL FRICTION  
 $\tau_R$  kPa IDUAL SHEAR STRENGTH  
 $\tau_r$  kPa DED SHEAR STRENGTH

#### STRESS AND STRAIN

u kPa PORE WATER PRESSURE  
 $u_a$  1 PORE PRESSURE RATIO  
 $\sigma$  kPa TOTAL NORMAL STRESS  
 $\sigma'$  kPa EFFECTIVE NORMAL STRESS  
 $\tau$  kPa SHEAR STRESS  
 $\sigma_1 \sigma_2 \sigma_3$  kPa PRINCIPAL STRESSES  
 $\epsilon$  % LINEAR STRAIN  
 $\epsilon_1 \epsilon_2 \epsilon_3$  % PRINCIPAL STRAINS  
v 1 POISSON'S RATIO  
E kPa MODULUS OF LINEAR DEFORMATION  
G kPa MODULUS OF SHEAR DEFORMATION  
M 1 COEFFICIENT OF FRICTION

$$S_r = 1 \quad \text{SENSITIVITY} = \frac{C_u}{q}$$

#### PHYSICAL PROPERTIES OF SOIL

$\rho_s$  g/m<sup>3</sup> DENSITY OF SOLID PARTICLES  
 $\gamma_s$  kg/m<sup>3</sup> UNIT WEIGHT OF SOLID PARTICLES  
 $\rho_w$  kg/m<sup>3</sup> DENSITY OF WATER  
 $\gamma_w$  kg/m<sup>3</sup> UNIT WEIGHT OF WATER  
 $\rho$  kg/m<sup>3</sup> DENSITY OF SOIL  
 $\gamma$  kg/m<sup>3</sup> BULK UNIT WEIGHT OF SOIL  
 $\rho_d$  kg/m<sup>3</sup> DENSITY OF DRY SOIL  
 $\gamma_d$  kg/m<sup>3</sup> UNIT WEIGHT OF DRY SOIL  
 $\rho_{sat}$  kg/m<sup>3</sup> DENSITY OF SATURATED SOIL  
 $\gamma_{sat}$  kg/m<sup>3</sup> UNIT WEIGHT OF SATURATED SOIL  
 $\rho'$  kg/m<sup>3</sup> DENSITY OF SUBMERGED SOIL  
 $\gamma'$  kg/m<sup>3</sup> UNIT WEIGHT OF SUBMERGED SOIL  
e VOID RATIO  
n POROSITY  
w % WATER CONTENT  
 $S_r$  % DEGREE OF SATURATION  
 $w_L$  % LIQUID LIMIT  
 $w_p$  % PLASTIC LIMIT  
 $w_s$  % SHRINKAGE LIMIT  
 $I_p$  % PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  % LIQUIDITY INDEX =  $\frac{w - w_p}{I_p}$   
 $I_C$  % CONSISTENCY INDEX =  $\frac{w_L - w}{I_p}$   
 $e_{max}$  % VOID RATIO IN LOOSEST STATE  
 $e_{min}$  % VOID RATIO IN MOST DENSE STATE  
 $I_D$  1 DENSITY INDEX =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
D mm GRAIN DIAMETER  
D<sub>n</sub> mm n PERCENT - DIAMETER  
C<sub>u</sub> 1 UNIFORMITY COEFFICIENT  
h m HYDRAULIC HEAD OR POTENTIAL  
q m<sup>3</sup>/s RATE OF DISCHARGE  
v m/s DISCHARGE VELOCITY  
i 1 HYDRAULIC GRADIENT  
k m/s HYDRAULIC CONDUCTIVITY  
j kN/m<sup>3</sup> SEEPAGE FORCE

# RECORD OF BOREHOLE No SI-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga Interchange, Co-ords: 5044226 N; 245124 E ORIGINATED BY S.M  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
 DATUM Geodetic DATE 2005.03.16 - 2005.03.16 CHECKED BY H.G

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	SHEAR STRENGTH kPa												
213.2	Ground Surface									20	40	60	80	100				
213.0	100 mm topsoil						213											
0.1	Auger refusal probably on bedrock																	
	End of borehole																	

ONTARIO MOT 01 SHAWANAGA INTERCHANGE.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No SI-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga Interchange, Co-ords: 5044287 N; 245179 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE NQ Rock Coring COMPILED BY H.G  
DATUM Geodetic DATE 2005.03.16 - 2005.03.16 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
214.4	Ground Surface																
0.0	Organics, brown, frozen, fibrous																
214.1	Auger refusal. Coring started.																
0.3	Granitic Gneiss  Fresh, dark grey, medium grained, very strong, fair to good quality Uniaxial comp. strength = 105.9 Mpa Close to moderately closed spaced fractures; planar, 80 degrees to vertical, rough, no infilling.		1	NQRC	Rec 87%		214									RQD= 68%; 9 fractures in 1.5 m	
							213										
			2	NQRC	Rec 92%		212									RQD= 83%; 3 fractures in 1.5 m	
211.1	End of borehole																
3.4																	

+ 3, x 3.

Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No SRN-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga River NBL Co-ords: 5045890 N; 243401 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.14 - 2005.03.14 CHECKED BY T. Crilly

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			SHEAR STRENGTH kPa		WATER CONTENT (%)				
199.1	Ground Surface							20 40 60 80 100	○ UNCONFINED   + FIELD VANE	W <sub>P</sub> W   W <sub>L</sub>				GR SA SI CL
0.0	Peat, black, moist, very soft, fibrous					▽	199							
197.6							198							
1.5	Organic Sandy Silt grey with black stains, moist, very loose, some silty sand seams		1	SPT	2		197						125	0 35 54 11
196.6							196						53	
2.5	Silty Clay grey, wet, very soft, low plasticity		2	SPT	WH		195						82	
							194							
			3	SPT	WH		193						76	
192.4			4	SPT	WH									
6.7	End of borehole Auger and split spoon refusal on probable bedrock  Groundwater encountered at 0.61 m at time of drilling		5	SPT	Refusa									

1 OF 1

### METRIC

[illegible]

# RECORD OF BOREHOLE No SRN-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga River NBL Co-ords: 5045847 N; 243451 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
DATUM Geodetic DATE 2005.03.13 - 2005.03.13 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
198.5	Ground Surface							20 40 60 80 100						
0.0	Peat, black, moist, very soft, fibrous						198							
197.9	Silt, grey, wet, very loose to loose, some clay, trace sand						197							
0.6			1	SPT	5		196							
							195							
			2	SPT	2		194							
194.5	Auger refusal; coring started						193							
4.0	Granitic Gneiss  Slightly weathered, dark grey, medium grained, strong  Fractures: Planar, 120 to 130 degrees to vertical, rough, no infill		3	NQRC	Rec 93%		192							
			4	NQRC	Rec 95%									
191.5	End of borehole													
7.0	Groundwater not encountered at time of drilling													

ONTARIO MOT 02 SHAWANAGA RIVER NBL.GPJ ONTARIO MOT.GDT 05/08/28

## 1 OF 1

METRIC

DATUM Geodetic DATE 2005.03.13 - 2005.03.13 CHECKED BY T. Crilly

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

# RECORD OF BOREHOLE No SRS-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga River SBL Co-ords: 5045933 N; 243177 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
DATUM Geodetic DATE 2005.03.13 - 2005.03.13 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
213.2	Ground Surface															
0.0	150 mm topsoil <b>Silty Sand</b> brown, moist, very loose, trace organics, some cobbles		1	GRAB			213									
212.0																
1.2	End of borehole Auger refusal on probable bedrock						212									

ONTARIO MOT 03 SHAWANAGA RIVER SBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No SRS-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga River SBL Co-ords: 5045892 N; 243235 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
DATUM Geodetic DATE 2005.03.12 - 2005.03.12 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
198.7 0.0	Ground Surface <b>Peat</b> , black, moist, very soft, fibrous  some sand, some clay below 1.8 m						198							
			1	SPT	WH		197						237	
							196							
195.4 3.3	<b>Silty sand</b> , grey, wet, very loose, poorly graded, fine grained		2	SPT	WH		195							
194.7 4.0	<b>Clay</b> , grey, wet, very soft, high plasticity, with silt		3	SPT	WH		194	6.0					62	w=86%
			4	VANE			193							
			5	SH			192	4.0						
			6	VANE			191						52	
190.8 7.9	<b>Silt</b> , grey, wet, very loose		7	SPT	WH		190							
190.2 8.5	Auger refusal, coring started  <b>Granitic Gneiss</b> Fresh, dark brownish grey, fine grained, very strong  Fractures: Planar, 60 to 80 degrees to vertical, 2 fractures at 20 degrees to vertical, smooth to rough, no infilling		8	NQRC	Rec 93%		189							RQD = 89%, 3 fractures in 1.5 m
			9	NQRC	Rec 100%		188							RQD = 93%, 5 fractures in 1.5 m
187.1 11.6	End of borehole  Groundwater not encountered at time of drilling													


ONTARIO MOT 03 SHAWANAGA RIVER SBL GPJ ONTARIO MOT GDT 05/08/26

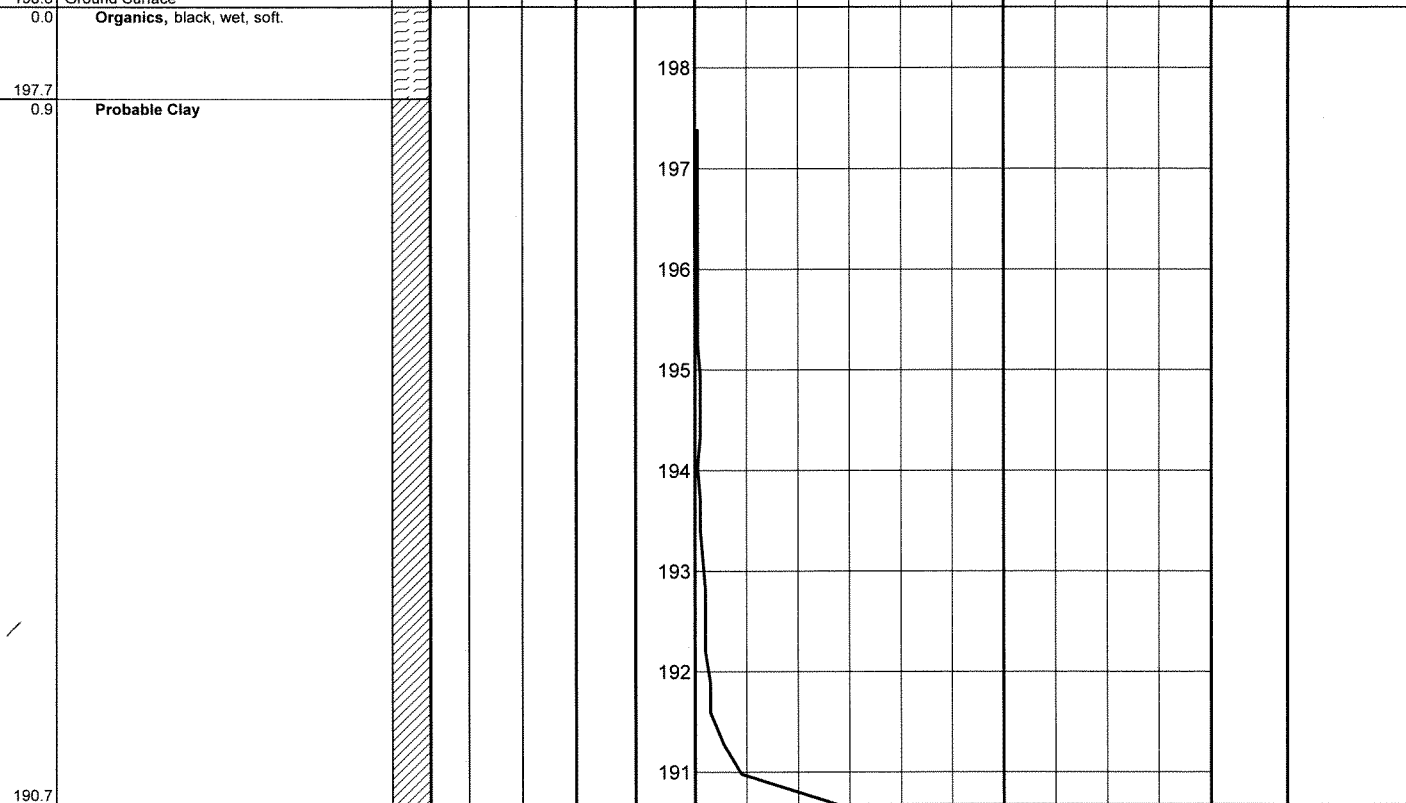
## 1 OF 1

**METRIC**

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

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES						
198.6	Ground Surface						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20   40   60   80   100				GR SA SI CL

[illegible]

# RECORD OF BOREHOLE No DCP-C

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga, Co-ords: 5045851 N; 243288 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY C.G.  
 DATUM Geodetic DATE 2005.08.23 - 2005.08.23 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
198.1 0.0	Ground Surface  <b>Water</b>							20 40 60 80 100						
196.9 1.2	<b>Probable Clay</b>							20 40 60 80 100						
191.1 7.0	End of dynamic cone test													

ONTARIO MOT 23 SHAWANAGA RIVER ADDITIONAL BHS.GPJ ONTARIO MOT.GDT 05/08/28

# RECORD OF BOREHOLE No SSR-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga Service Road, Co-ords: 5046720 N; 242167 E ORIGINATED BY P.R  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & NQ Rock Coring COMPILED BY H.G  
DATUM Geodetic DATE 2005.03.11 - 2005.03.11 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
211.9	Ground Surface													
0.0	25 mm topsoil													
211.5	Silty Sand, brown, wet, poorly graded, fine grained, tr to some clay													
0.5	Cored through boulders 30% recovery													
210.4														
1.5	Sand, brown, moist, compact, well graded, fine to coarse grained, some gravel, trace clay		1	SS	13									
209.5														
2.4	Auger refusal. Coring started.													
	Granitic Gneiss,													
	Slightly weathered, banded pinkish grey to grey, medium grained, strong, fair to good quality		2	NQRC	Rec 78 %									
	Uniaxial comp. strength = 86.5 MPa Moderately close to widely spaced fractures; 40 to 90 degrees to vertical; rough surface, minor infill at one joint.		3	NQRC	Rec 87 %									
206.5														
5.5	End of Borehole													
	Groundwater not encountered at time of drilling													

# RECORD OF BOREHOLE No SSR-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Shawanaga Service Road, Co-ords: 5046769 N; 242265 E ORIGINATED BY P.R  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
 DATUM Geodetic DATE 2005.03.10 - 2005.03.10 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
210.9	Ground Surface							20 40 60 80 100		W <sub>p</sub>	W	W <sub>L</sub>		
0.0	25 mm topsoil <b>Silty Sand</b> , brown, moist to wet, very loose to compact, poorly graded, fine to medium grained							20 40 60 80 100						
							210							
			1	SS	12		209							
							208							
			2	SS	2		207							0 77 (23)
							206							
			3	SS	3		205							
							204							
			4	SS	7		203							
202.7	End of borehole													
8.2	Auger refusal on probable bedrock  Groundwater encountered at 1.22 m at time of drilling.  Groundwater measured at 1.35 m on March 24, 2005.  Groundwater measured at 1.31 m on April 6, 2005.													

ONTARIO MOT 04 SHAWANAGA SERVICE ROAD.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No DCPB6N-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake NBL, Co-ords: 5056610 N; 234764 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY H.G  
DATUM Geodetic DATE 2005.02.24 - 2005.02.24 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
182.3 0.0	Ice Ice / Water													
177.2 5.2	Possibly peat													
170.5 11.8	probable sand													
169.5 12.8	Dynamic cone refusal on probable bedrock  End of dynamic cone penetration test													

ONTARIO MOT 05 POINTE AU BARIL 6 MILE LAKE NBL.GPJ ONTARIO MOT GDT 05/08/28

RECORD OF BOREHOLE No PB6N-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake NBL, Co-ords: 5056676 N; 234744 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Solid Auger COMPILED BY H.G  
DATUM Geodetic DATE 2005.02.14 - 2005.02.14 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
197.6	Ground Surface																
0.0	Bedrock outcrop visible at surface																
							197										

ONTARIO MOT 05 POINTE AU BARIL 6 MILE LAKE NBL.GPJ ONTARIO MOT.GDT 05/08/28

RECORD OF BOREHOLE No PB6N-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake NBL, Co-ords:5056415 N; 234825 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G  
DATUM Geodetic DATE 2005.02.13 - 2005.02.13 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
195.4	Ground Surface																
0.0	Organics, black, moist, with sand, with cobbles																
194.8	Auger refusal encountered on probable bedrock						195										
0.6	End of borehole																

ONTARIO MOT 05 POINTE AU BARIL 6 MILE LAKE NBL GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No PB6N-4

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake NBL, Co-ords: 5056544 N; 234784 E ORIGINATED BY S.M  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Casing COMPILED BY H.G  
 DATUM Geodetic DATE 2005.02.24 - 2005.02.24 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
182.3 0.0	Ice  Ice / Water						20   40   60   80   100	○ UNCONFINED   + FIELD VANE	20   40   60   80   100	10   20   30				
179.3 3.1	Casing refusal on probable bedrock  End of borehole						182							
							181							
							180							

ONTARIO MOT 05 POINTE AU BARIL 6 MILE LAKE NBL.GPJ ONTARIO MOT.GDT 05/08/26

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

RECORD OF BOREHOLE No DCPB6S-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake SBL, Co-ords: 5056607 N; 234724 E ORIGINATED BY K.C.  
DIST 54 HWY 69 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY H.G.  
DATUM Geodetic DATE 2005.03.09 - 2005.03.09 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
182.3 0.0	Ice Ice / Water												
179.1 3.3	Probable peat												
176.9 5.5	Dynamic cone refusal on probable bedrock  End of dynamic cone penetration test												


ONTARIO MOT 06 POINTE AU BARIL 6 MILE LAKE SBL.GPJ ONTARIO MOT.GDT 05/08/26

RECORD OF BOREHOLE No PB6S-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake SBL, Co-ords: 5056673 N; 234703 E ORIGINATED BY P.R.  
DIST 54 HWY 69 BOREHOLE TYPE NQ Rock Coring COMPILED BY H.G.  
DATUM Geodetic DATE 2005.02.14 - 2005.02.14 CHECKED BY H.G.

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa											
197.5	Ground Surface																
190.8 0.2	150 mm topsoil <b>Granitic Gneiss</b>  Slightly weathered, pinkish grey, medium grained, strong  Fair to good quality		1	NQRC	Rec = 92%		197										RQD = 71 %
			2	NQRC	Rec = 100%		196										
							195										RQD = 87%
194.3 3.2	End of borehole																

ONTARIO MOT 06 POINTE AU BARIL 6 MILE LAKE SBL.GPJ ONTARIO MOT.GDT 05/08/26

RECORD OF BOREHOLE No PB6S-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake SBL, Co-ords: 5056410 N; 234782 E ORIGINATED BY P.R.  
DIST 54 HWY 69 BOREHOLE TYPE NQ Rock Coring COMPILED BY H.G.  
DATUM Geodetic DATE 2005.02.13 - 2005.02.13 CHECKED BY H.G.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
195.6	Ground Surface															
0.0	Organics 300 mm thk															
195.3	Granitic Gneiss															
0.3	Fresh, pinkish grey, coarse grained, strong		1	NQRC	Rec = 100%	195										RQD = 100 %
	Excellent quality					194										
			2	NQRC	Rec = 100%	193										RQD = 100 %
192.2	End of borehole															
3.4																

ONTARIO MOT 06 POINTE AU BARIL 6 MILE LAKE SBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No PB6S-4

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake SBL, Co-ords: 5056541 N 234743 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Tripod COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.09 - 2005.03.09 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
182.3 0.0	Ice						182							
	Ice / Water						181							
180.2 2.1	PEAT, black, wet, soft		1	SS	WH		180							No sample recovery
			2	SS	WH									No sample recovery
							179							
178.1 177.9 4.4	fine SAND, grey, wet, loose Split spoon refusal on probable bedrock  End of borehole		3	SS	Refusa		178							


ONTARIO MOT 06 POINTE AU BARIL 6 MILE LAKE SBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No PB6S-5

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Pointe au Baril 6 Mile Lake SBL, Co-ords: 5056474 N; 234763 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Tripod COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.09 - 2005.03.09 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
187.3 0.0	Ground Surface <b>Organics</b> , brown, moist, very soft, with roots						187										
186.7 0.6	Refusal on probable bedrock  End of borehole																

ONTARIO MOT 06 POINTE AU BARIL 6 MILE LAKE SBL GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No HRN-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Harris River NBL, Co-ords: 5061257 N; 231006 E ORIGINATED BY SM  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY H.G  
DATUM Geodetic DATE 2005.02.12 - 2005.02.12 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL   LIQUID LIMIT   MOISTURE   LIMIT CONTENT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
190.6	Ground Surface							20 40 60 80 100		W <sub>p</sub>	W	W <sub>L</sub>		GR SA SI CL
190.4 0.2	150 mm topsoil <b>Sandy Silt</b> , brown, moist to wet, compact, some clay							20 40 60 80 100						
			1	SS	13									0 34 55 11
			2	SS	14									
			3	SS	22									0 25 (75)
185.1 5.5	Auger refusal. Coring started.  <b>Granitic GNEISS</b>  Slightly weathered, pinkish grey, coarse grained, strong  Good to excellent quality  Some fractures: Planar, wide spaced, at 70 degrees to vertical, smooth, no filling		4	NQRC	Rec 100%									RQD = 100%, 3 fractures in 1.5 m
			5	NQRC	Rec 100%									RQD = 83%, 3 fractures in 1.5 m
182.1 8.5	End of Borehole  Groundwater not encountered at time of drilling.  Groundwater encountered at 6.25 m on March 24, 2005.  Groundwater measured at 6.23 m on April 6, 2005.													


ONTARIO MOT 07 HARRIS RIVER NBL.GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No MBSR-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit Service Road, Co-ords: 5070437 N; 227330 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE NQ Rock Coring COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.01 - 2005.03.01 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
191.0	Ground Surface							20	40	60	80	100					GR SA SI CL
0.0	Bedrock outcrop visible at surface. Coring started		1	NQRC	Rec 100%		190										RQD = 100%, 3 fractures in 1.5 m
	<b>Biotite Gniess</b>  Slightly weathered, pink and dark grey, coarse grained, very strong  Good to excellent quality  Moderately claosely spaced fractures, planar, near vertical, very rough, 3 mm iron stains on fractures of second run.		2	NQRC	Rec 88%		189										RQD = 85%, 4 fractures in 1.5 m
188.0							188										
3.1	End of borehole																

ONTARIO MOT 08 MAG BRIT SERVICE ROAD.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No MBSR-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit Service Road, Co-ords:5070434 N; 227411 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.02.28 - 2005.02.28 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
192.0	Ground Surface							20	40	60	80	100					
0.0	Snow,																
191.7																	
0.3	150 mm organics																
191.1	Sand, brown, moist, with organics																
0.9	Auger refusal on probable bedrock																
	End of borehole																

# RECORD OF BOREHOLE No MBCSN-1

1 OF 2

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit CPR Still River NBL, Co-ords: 5074282 N; 224188 E ORIGINATED BY S.M.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY C.G.  
DATUM Geodetic DATE 2005.08.03 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
180.1	Ground Surface											
179.9	Snow											
179.8	200 mm topsoil											
0.5	Sand, with clay seams. brown, moist, very loose, trace organics											
179			1	SS	3							
178												
177.2	Clay, grey, moist, very soft to firm, high plasticity, some silt, trace of sand CH		2	SS	1							0 3 45 52
2.9			3	VANE				5.3				
176			4	SH								
175												
174			5	SS	2							0 2 40 58
173												
172			6	SS	0							
171			7	VANE				4.7				
170												
169			8	SS	0							
168			9	VANE				5.0				
167												
166			10	SS	0							
165.4			11	VANE				6.4				
165.4												
14.6	Sand, brown, wet, very loose to compact, fine to medium grained, poorly graded, trace silt		12	SS	3							
			13	SS	28							
			14	SS	Refusa							

Continued Next Page

+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

## 2 OF 2

**METRIC**

DATUM Geodetic DATE 2005.08.03 CHECKED BY T. Crilly

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

# RECORD OF BOREHOLE No MBCSN-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit CPR Still River NBL, Co-ords: 5074181 N; 224404 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY D.S.  
 DATUM Geodetic DATE 2005.02.09 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
178.4	Ground Surface														
0.0 178.1	Snow														
0.3	150 mm organics Clay, brown, wet, firm, high plasticity, some silt, trace sand CH						178								
			1	SS	3		177						63		0 1 36 63 w = 52%
			2	VANE			176	4.4							
			3	SS	4		175								
			4	VANE			174	5.0							
	With silt seams CL		5	SH			173						42	18.0	0 1 69 30 Cc = 0.347
172.4															
5.9 172.1	Silty Sand, moist, compact, poorly graded, trace gravel		6	SS	Refusal										
6.3	End of borehole Auger refusal on probable bedrock  Groundwater encountered at 4.27 m at time of drilling  Groundwater measured at 3.3 m on March 24, 2005  Groundwater measured at 2.76 m on April 6, 2005.														

ONTARIO MOT 09 & 10 MAG-BRIT CPR STILL RIVER (NBL&SBL), GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No MBCSN-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit CPR Still River NBL, Co-ords: 5074223 N; 224325 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY D.S.  
 DATUM Geodetic DATE 2005.02.24 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				GR	SA	SI	CL
178.5	Ground Surface							20 40 60 80 100									
0.0 178.2	Snow																
178.0 0.5	200 mm topsoil Sand, brown, moist, very loose, fine to medium grained, poorly graded, trace organics						178										
			1	SS	4		177										
							176										
176.0 2.5	Organic Silt, trace to some sand, trace of shells, brown, very soft to soft																
			2	SS	2		175									0 6 91 3	
							174									0 38 61 1	
			3	SS	WH												
172.9 5.6	Silt, dark brown, very moist to wet, loose to compact, some sand						173										
			4	SS	9		172										
							171										
			5	SS	20												
170.3 8.2	some sand, trace of gravel End of borehole Auger refusal on probable bedrock																

ONTARIO MOT 09 & 10 MAG-BRIT CPR STILL RIVER (NBL&SBL) GPJ ONTARIO MOT GDT 05/08/26

1 OF 1

## METRIC

DATUM Geodetic DATE 2005.02.07 CHECKED BY T. Crilly

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

# RECORD OF BOREHOLE No MBCSS-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit CPR Still River SBL, Co-ords: 5074137 N; 224407 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY D.S.  
 DATUM Geodetic DATE 2005.02.08 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
179.2 0.0	Ground Surface 100 mm organics <b>Silty Sand</b> , brown, loose, moist, poorly graded, trace organics						179							
			1	SS	8		178							
176.8 2.4	Auger refusal, coring started  <b>Granitic Gneiss</b> grey, fresh to slightly weathered, medium grained, strong  Good quality  Moderately closely spaced fractures, planar, about 65 degrees to vertical, rough, no filling		2	SS	Refusa		177							
			3	NQRC	Rec 86%		176							RQD 83% 5 fractures in 1.5 m
			4	NQRC	Rec 88%		175							RQD 85% 4 fractures in 1.5 m
173.7 5.5	End of borehole  Groundwater not observed at time of drilling						174							

RECORD OF BOREHOLE No MBCSS-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Mag-Brit CPR Still River SBL, Co-ords: 5074179 N; 224330 E ORIGINATED BY S.M.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY C.G.  
DATUM Geodetic DATE 2005.08.04 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
179.1	Ground Surface															
0.0	Organics, black.															
178.2	Silty Sand, brown, moist, loose, fine grained.						178									
0.9			1	SS	9		177									
	- wet and very loose below ~ 3.05 m.		2	SS	2		176									0 76 24 0
							175									
174.5	Silt (Alluvium), brown, wet, very loose.		3	SS	0		174			1.8 +						
4.6			4	VANE												
173.3			5	SS	Refusa		173									RQD = 99%
5.8	Granitic Gneiss, white, black and pink, slightly weathered, fine to medium grained, very strong.		6	NQRC	Rec 99%		172									RQD = 98%
			7	NQRC	Rec 98%		171									RQD = 64%
170.2			8	NQRC	Rec 82%											
8.8	End of Borehole															

ONTARIO MOT 09 & 10 MAG-BRIT CPR STILL RIVER (NBL&SBL) GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No GRBINT-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-rev Bekanon Interchange, Co-ords: 5078495 N; 222130 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.02.03 - 2005.02.03 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
198.5	Ground Surface							20 40 60 80 100	○ UNCONFINED + FIELD VANE					
198.0	Organics, brown, wet, soft							20 40 60 80 100	● QUICK TRIAXIAL × LAB VANE					
0.2	End of borehole Auger refusal on probable bedrock						198							

ONTARIO MOT 11 GRUNDY P-REV BEKANON INTERCHANGE.GPJ ONTARIO MOT GDT 05/08/28

RECORD OF BOREHOLE No GRBINT-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-rev Bekanon Interchange, Co-ords: 5078472 N; 222202 E ORIGINATED BY P.R.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY H.G.  
DATUM Geodetic DATE 2005.02.02 - 2005.02.02 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
191.6	Ground Surface													
0.0	100 mm snow, 200 mm organics <b>Sand</b> , brown, wet, compact, poorly graded, fine grained													
189.4			1	SS	14									
2.1	Auger refusal, coring started													
	<b>Granitic Gneiss</b>													
	Fresh, pink and grey, coarse grained, very strong		2	NQRC	Rec 98%									RQD = 98 %, 1 fracture in 1.5 m
	Good to excellent quality													
	Moderately close to widely sapced fractures, planar, 10 to 15 degrees to vertical, smooth, with 1 mm calcite infill in lower run		3	NQRC	Rec 95%									RQD = 89 %, 3 fractures in 1.5 m
186.4														
5.2	End of borehole													

ONTARIO MOT 11 GRUNDY P-REV BEKANON INTERCHANGE.GPJ ONTARIO MOT.GDT 05/08/26

## 1 OF 1

METRIC

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

## 1 OF 1

METRIC

DATUM Geodetic DATE 2005.03.17 - 2005.03.17 CHECKED BY T. Crilly

[illegible]

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

# RECORD OF BOREHOLE No GKRN-4

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-Rev Key River NBL Co-ords: 5084151 N: 222438 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Tripod with a 0.31 kN hammer falling 0.38 m COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.17 - 2005.03.17 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL					
175.8 0.0	Ground Surface <b>Water</b>							20 40 60 80 100							
171.7 4.1	<b>Peat</b> , black, wet, very soft, trace fine gravel		1	SPT	WH										
170.1 5.7	<b>Clay</b> , grey, wet, firm, intermediate plasticity, with silt, some sand		2	SPT	4 *										
			3	SPT	5 *										
			4	SPT	15 *										
166.9 8.9	<b>Silty Sand</b> , grey, wet, dense, some clay														
165.6 10.2	End of borehole  * these 'N' values could be too high (see text of report)		5	SPT	40										

ONTARIO MOT 13 GRUNDY P-REV KEY RIVER NBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No GKRI-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-Rev Key River Interchange, Co-ords: 5084842 N; 222536 E ORIGINATED BY S.M.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G.  
DATUM Geodetic DATE 2005.03.24 - 2005.03.24 CHECKED BY T. Crilly

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa												
202.8	Ground Surface																	
0.0	100 mm topsoil Sand, brown, moist, compact, poorly graded, fine grained																	
202.2																		
0.6	End of borehole  Auger refusal on probable bedrock.  Groundwater not encountered at time of drilling						202											

ONTARIO MOT 14 GR KEY RIVER INTERCHANGE GPJ ONTARIO MOT GDT 05/08/28

# RECORD OF BOREHOLE No GKRI-2

1 OF 2

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-Rev Key River Interchange, Co-ords: 5084760 N; 222540 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.24 - 2005.03.29 CHECKED BY T. Crilly

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub> W W <sub>L</sub>			
199.1 0.0	Ground Surface 150 mm topsoil Sand, brown, wet, compact, poorly graded, fine grained						199						
			1	SS	17		198						
196.7 2.4	Clay, brown, wet, firm to stiff, high plasticity, some silt, trace of sand						197						
			2	SS	4		196						0 9 33 58 w = 40%
			3	VANE			195						
			4	SH			194						
			5	VANE			193						0 7 84 9
193.2 5.9	Silt, grey, wet, loose to compact, trace clay						192						
			6	SS	10		191						
			7	SS	9		190						
			8	SS	5		189						
			9	SS	5		188						
187.8 11.3	Auger refusal Cored through cobbles						187						
186.9 12.2	Granitic Gneiss  Fresh, dark grey with minor orange banding, medium grained, strong, good to excellent quality  Moderately closely spaced fractures, planar, about 80 degrees to vertical, smooth to rough surface, no filling.		10	NQRC	Rec 88%		186						RQD = 83% 3 fractures in 1.5 m
			11	NQRC	Rec 100%		185						RQD = 100% 3 fractures in 1.5 m

Continued Next Page

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

ONTARIO MOT 14 GR KEY RIVER INTERCHANGE GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No GKRI-2

2 OF 2

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy P-Rev Key River Interchange, Co-ords: 5084760 N; 222540 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.24 - 2005.03.29 CHECKED BY T. Crilly

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
183.9						184										
15.2	End of borehole  Groundwater not encountered at time of drilling  Groundwater encountered at 0.44 m on April 6, 2005.															

ONTARIO MOT 14 GR KEY RIVER INTERCHANGE.GPJ ONTARIO MOT.GDT 05/08/28

# RECORD OF BOREHOLE No GR-R-CNR-NBL-1 1 OF 1 METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Realigned CNR NBL, Co-ords: 5085362 N; 222414 E ORIGINATED BY D.S.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY P.R.  
 DATUM Geodetic DATE 2005.01.26 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
181.9	Ground Surface													
0.0 181.6	Organics, brown, wet													
0.3	Sand, brown, moist to wet, very loose, fine to medium grained, well graded, trace silt													
179.4	Organic Silt, dark brown to grey, wet, very loose, some sand, trace clay		1	SS	4									
2.5														
177.9	Clay, grey, wet, very soft, high plasticity, some silt CH		2	SS	2							86		0 10 80 10
4.0														
176.3	Sand, brown, wet, very loose, fine to coarse grained, well graded, with silt		3	SS	WH									w = 81%
5.6			4	VANE										
174.2	End of Borehole  Refusal on probable bedrock  Groundwater measured at 1.95 m on March 24, 2005  Groundwater measured at 1.92 m on April 6, 2005		5	SS	WH									
7.7			6	SS	Refusa									

ONTARIO MOT 15 & 16GR-R-CNR-SBL&NBL GPJ ONTARIO MOT.GDT 05/08/26

RECORD OF BOREHOLE No GR-R-CNR-NBL-2 1 OF 2

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Realigned CNR NBL, Co-ords: 5085412 N; 222414 E ORIGINATED BY D.S.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY P.R.  
DATUM Geodetic DATE 2005.01.27 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
180.2	Ground Surface							20 40 60 80 100							
180.0	Organics, brown, wet							20 40 60 80 100							
0.2	Clay, grey, moist to wet, very soft to firm, some silt, trace of sand														
			1	SS	WH										
			2	VANE											
			3	SH											
			4	VANE											
			5	SS	WH										
			6	SS	2										
			7	SH											
			8	SS	2										
			9	SS	2										
			10	SS	4										
168.5															
11.7	Sandy Silt, brown, wet, compact, fine grained, poorly graded, some clay		11	SS	15										
			12	SS	10										
165.5															
14.7															





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

ONTARIO MOT 15 & 16GR-R-CNR-SBL&NBL.GPJ ONTARIO MOT GDT 05/08/28

# RECORD OF BOREHOLE No GR-R-CNR-NBL-2 2 OF 2 METRIC




G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Realigned CNR NBL, Co-ords: 5085412 N; 222414 E ORIGINATED BY D.S.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY P.R.  
 DATUM Geodetic DATE 2005.01.27 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w <sub>p</sub>	w	w <sub>L</sub>			
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE	WATER CONTENT (%)						
						20   40   60   80   100			10   20   30						
	Clay, grey, moist, soft, high plasticity, some silt ( <i>continued</i> )		13	SS	WH		165						53	w = 54%	
			14	VANE			164								
							163								
163.2	Sand, grey, wet, loose, poorly graded						162								
17.0			15	SS	9		161								
							160								
159.6	Granitic Gneiss  Dark pinkish grey, slightly weathered, medium grained Strong  Good quality  Moderately closely spaced fractures, planar, rough, no infilling						159								
20.6			16	NQRC	Rec 96%		158							ROD 86%, 4 fractures in 3 m	
							157								
156.6	End of borehole														
23.6															

ONTARIO MOT 15 & 16GR-R-CNR-SBL&NBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No GR-R-CNR-SBL-1 1 OF 1 METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Realigned CNR SBL, Co-ords: 5085363 N; 222368 E ORIGINATED BY D.S.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY P.R.  
 DATUM Geodetic DATE 2005.01.26 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)					
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE	20   40   60   80   100	20   40   60   80   100	20   40   60   80   100	W <sub>P</sub> W   W <sub>L</sub>				
194.9 0.0	Ground Surface  350 mm topsoil <b>Silty Clay</b> , brown, moist to wet, very soft to firm, some sand						194								0   8   70   22	
			1	SS	7		193									41
								192								
			2	SS	WH			191								
191.1 3.8	<b>Granitic Gneiss</b>  Dark pinkish grey, slightly weathered, medium grained strong  Good quality  Widely spaced, planar fractures, 40 to 90 degrees to vertical, rough, no filling						190								RQD 87%, 2 fractures in 3 m	
			3	NQRC	Rec 96%		189									
188.1 6.9	End of borehole															

RECORD OF BOREHOLE No GR-PLE-CNR-NBL-11 OF 4

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085739 N; 222209 E ORIGINATED BY S.M and K.C.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G.  
DATUM Geodetic DATE 2005.01.18 - 2005.04.04 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)
180.0	Ground Surface							20	40	60	80	100					
0.0	Organics, brown, wet, soft							20	40	60	80	100					
179.5																	
0.5	Sand, brown, wet, very loose to loose, poorly graded, medium to coarse grained, some gravel, trace to some silt																
			1	SS	2		179										
							178										
			2	SS	3		177									22 73 (5)	
							176										
			3	SS	4		175										
							174										
			4	SS	7		173										
							172										
			5	SS	7		171										
							170										
			6	SS	7		169									0 88 (12)	
							168										
			7	SS	4		167										
							166										
			8	SS	2												
166.3																	
13.7	Clay, grey, wet, very soft to firm, medium plasticity, some silt		9	SS	1												

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+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 17 GRUNDY PORTAGE LAKE EXISTING CNR NBL.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No GR-PLE-CNR-NBL-12 OF 4

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085739 N; 222209 E ORIGINATED BY S.M and K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.01.18 - 2005.04.04 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
								20 40 60 80 100	PLASTIC LIMIT $w_p$	NATURAL MOISTURE CONTENT $w$	LIQUID LIMIT $w_L$	
								20 40 60 80 100	WATER CONTENT (%)			
	Clay, grey, wet, very soft to firm, medium plasticity, some silt (continued)		10	SS	1		164	+				0 17 48 35
			11	VANE								w=42%
							163					
							162					
	No recovery		12	SH								
			13	SS	2		161	+				
			14	VANE								
160.5 19.5	Borehole finished at 19.5 m on Jan. 18, dynamic cone test to 33.5 m Borehole continued on Apr. 4 at 1 m away.						160					
							159					
			15	SS	1		158					
							157					
							156					
	No recovery		16	SS	5		155					
			17	SH			154					
153.9 26.1	Silt, grey, moist, compact to loose, trace to some sand						153					
							152					
			18	SS	14		151					0 3 89 8

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Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

ONTARIO MOT 17 GRUNDY PORTAGE LAKE EXISTING CNR NBL GPJ ONTARIO MOT GDT 05/08/26

RECORD OF BOREHOLE No GR-PLE-CNR-NBL-13 OF 4

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085739 N; 222209 E ORIGINATED BY S.M and K.C.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G.  
DATUM Geodetic DATE 2005.01.18 - 2005.04.04 CHECKED BY H.G.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
	Silt, grey, moist, compact to loose, trace to some sand (continued)		19	SS	9					
						149				
						148				
						147				
			20	SS	21					
						146				
						145				
						144				
			21	SS	8					
						143				
					142					
					141					
					140					
		22	SS	19						0 16 (84)
					139					
					138					
					137					
		23	SS	15						
					136					

Continued Next Page

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

# RECORD OF BOREHOLE No GR-PLE-CNR-NBL-14 OF 4

**METRIC**

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085739 N; 222209 E ORIGINATED BY S.M and K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.01.18 - 2005.04.04 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							WATER CONTENT (%)		
								20	40	60	80	100					
	Silt, grey, moist, compact to loose, trace to some sand (continued)																
134.0			24	SS	14		134										
46.0	Cobbles																
	Sand surged into hollow stem augers; borehole abandoned.						133										
132.1																	
47.9	End of borehole Water level at ground surface on Jan. 19, 2005																

ONTARIO MOT - 17 GRUNDY PORTAGE LAKE EXISTING CNR NBL.GPJ ONTARIO MOT.GDT 05/08/28

## METRIC

Continued Next Page

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

# RECORD OF BOREHOLE No GR-PLE-CNR-NBL-22 OF 4

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085653 N; 222279 E ORIGINATED BY S.M  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G  
 DATUM Geodetic DATE 2005.01.15 - 2005.04.01 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%)				
								20 40 60 80 100		10 20 30				
164.9	Silty Clay, grey, wet, very soft to firm, some sand, low plasticity (continued)		11	SS	2		166	4.0						
17.0	Silt, gray, wet, trace of clay, sand, very loose to loose		12	VANE			165							
			13	SS	3		164							
			14	SS	5		163							
158.8	Clay, grey, wet, firm, with silt, medium plasticity CI		15	SS	5		162							
23.1			16	VANE			161							
			17	SS	12		160							
155.5	Silt, grey, wet, some sand, compact						159							
26.4							158							
							157	3.3						
							156							
							155							
							154							
							153							
							152							

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+ 3, × 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 17 GRUNDY PORTAGE LAKE EXISTING CNR NBL GPJ ONTARIO MOT GDT 05/08/26

RECORD OF BOREHOLE No GR-PLE-CNR-NBL-23 OF 4

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy Portage Lake Existing CNR, Co-ords: 5085653 N; 222279 E ORIGINATED BY S.M  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger & dynamic Cone Penetration Test COMPILED BY H.G  
DATUM Geodetic DATE 2005.01.15 - 2005.04.01 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			W <sub>p</sub> W                      W <sub>L</sub>							
								○ UNCONFINED                      + FIELD VANE										
						● QUICK TRIAXIAL                      × LAB VANE				WATER CONTENT (%)								
						20   40   60   80   100				10   20   30								
146.6 35.3	Silt, grey, wet, some sand, compact <i>(continued)</i>						151									0   17   80   3		
			18	SS	14													
				19	SS		10	148										
								147										
								146										
								145										
				20	SS		17	144										
						143												
						142												
			21	SS	18	141												
						140												
						139												
			22	SS	22	138												
						137												

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

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40			
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100			$w_p$ — $w$ — $w_L$ WATER CONTENT (%) 10 20 30	

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

ONTARIO MOT 17 GRUNDY PORTAGE LAKE EXISTING CNR NBL.GPJ ONTARIO MOT.GDT 05/08/26

## 1 OF 3

METRIC

G.W.P.	5377-02-00	LOCATION	Hwy 69, Portage Lake Additional BHs, Co-ords: 5086091 N; 221884 E	ORIGINATED BY	S.M.
DIST	54	HWY	69	BOREHOLE TYPE	Continuous Hollow Stem Auger
DATUM	Geodetic	DATE	2005.08.09 - 2005.08.11	CHECKED BY	T.C.
COMPILED BY C.G.					

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

# RECORD OF BOREHOLE No PL-1A

2 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086091 N; 221884 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY C.G.  
 DATUM Geodetic DATE 2005.08.09 - 2005.08.11 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	W <sub>p</sub> W W <sub>L</sub>	WATER CONTENT (%)	10 20 30		
	<b>Silty Clay</b> , grey, wet, very soft, low plasticity. CL (continued)		9	SS	1		164	+	3				53	
				VANE										
	becoming firm		10	SS	WH		161	+	2.2					
				VANE										
159.7							160							
20.2	<b>Silt</b> , grey, wet, loose to compact, trace clay.		11	SS	9		159							
							158							
							157							
							156							
			12	SS	10		155							
							154							
153.6							153							
26.2	<b>Silty Sand</b> , grey, wet, loose to compact, fine grained.		13	SS	9		152							
							151							
							150							

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

3 OF 3

## METRIC

G.W.P. <u>5377-02-00</u>	LOCATION <u>Hwy 69, Portage Lake Additional BHs, Co-ords: 5086091 N; 221884 E</u>	ORIGINATED BY <u>S.M.</u>
DIST <u>54</u> HWY <u>69</u>	BOREHOLE TYPE <u>Continuous Hollow Stem Auger</u>	COMPILED BY <u>C.G.</u>
DATUM <u>Geodetic</u>	DATE <u>2005.08.09 - 2005.08.11</u>	CHECKED BY <u>T.C.</u>

[illegible]

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHS.GPJ ONTARIO MOT.GDT 05/08/26

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

# RECORD OF BOREHOLE No PL-2A

1 OF 2

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086216 N; 221850 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY C.G.  
 DATUM Geodetic DATE 2005.08.11 - 2005.08.12 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	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	W <sub>p</sub> W W <sub>L</sub>	10 20 30			
184.9	Ground Surface													
180.9 0.2	Organics, black, dry, loose, fibrous, some roots. Sand, brown, damp, loose, fine grained, trace silt.		1	SS	9		184							
							183							
			2	SS	8		182							
							181							
			3	SS	9		180							
							179							
179.3 5.6	Sand, grey, wet, loose, fine grained, trace of silt.		4	SS	2		178							
							177							
			5	SS	7		176							
							175							
			6	SS	4		174							
							173							
			7	SS	5		172							
							171							
171.0 13.9	Silty Clay, grey, wet, soft to firm, trace silt. CL-CI													

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHs.GPJ ONTARIO MOT.GDT 05/08/26

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

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

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHS.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No PL-3

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5085964 N: 221935 E ORIGINATED BY P.R.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.09 - 2005.03.09 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		w <sub>p</sub>	w	w <sub>L</sub>		
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE	WATER CONTENT (%)					
182.3	Ground Surface							20   40   60   80   100						
0.0	25 mm topsoil <b>Sand</b> , brown, moist, compact, well graded, fine to coarse grained, some gravel <b>Possible fill</b>						182							
			1	SS	13		181			○				9   84   (7)
179.8							180							
2.5	<b>Sand</b> , brown, wet, very loose, poorly graded, fine to medium grained, some silt		2	SS	3		179			○				
							178			○				
			3	SS	3		177							
							176				○			
			4	SS	WH		175			○				
							174							
174.0			5	SS	4									
			6	SS	Refusa									
8.4	End of borehole, auger refusal on probable bedrock  Groundwater encountered at 2.74 m at time of drilling  Groundwater measured at 2.0 m on March 24, 2005  Groundwater measured at 1.96 m on April 6, 2005.													

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHs.GPJ ONTARIO MOT GDT 05/08/28

## 1 OF 2

METRIC

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

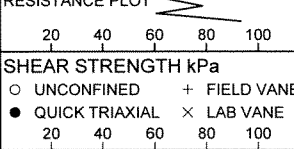
ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHS.GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No PL-3A

2 OF 2

**METRIC**

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086312 N: 221822 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY C.G.  
 DATUM Geodetic DATE 2005.08.16 - 2005.08.16 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT $W_p$ — $W$ — $W_L$ WATER CONTENT (%)	UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
169.2	Dynamic Cone Test started. Probable sand (continued)										
15.9	End of Borehole Dynamic cone refusal										

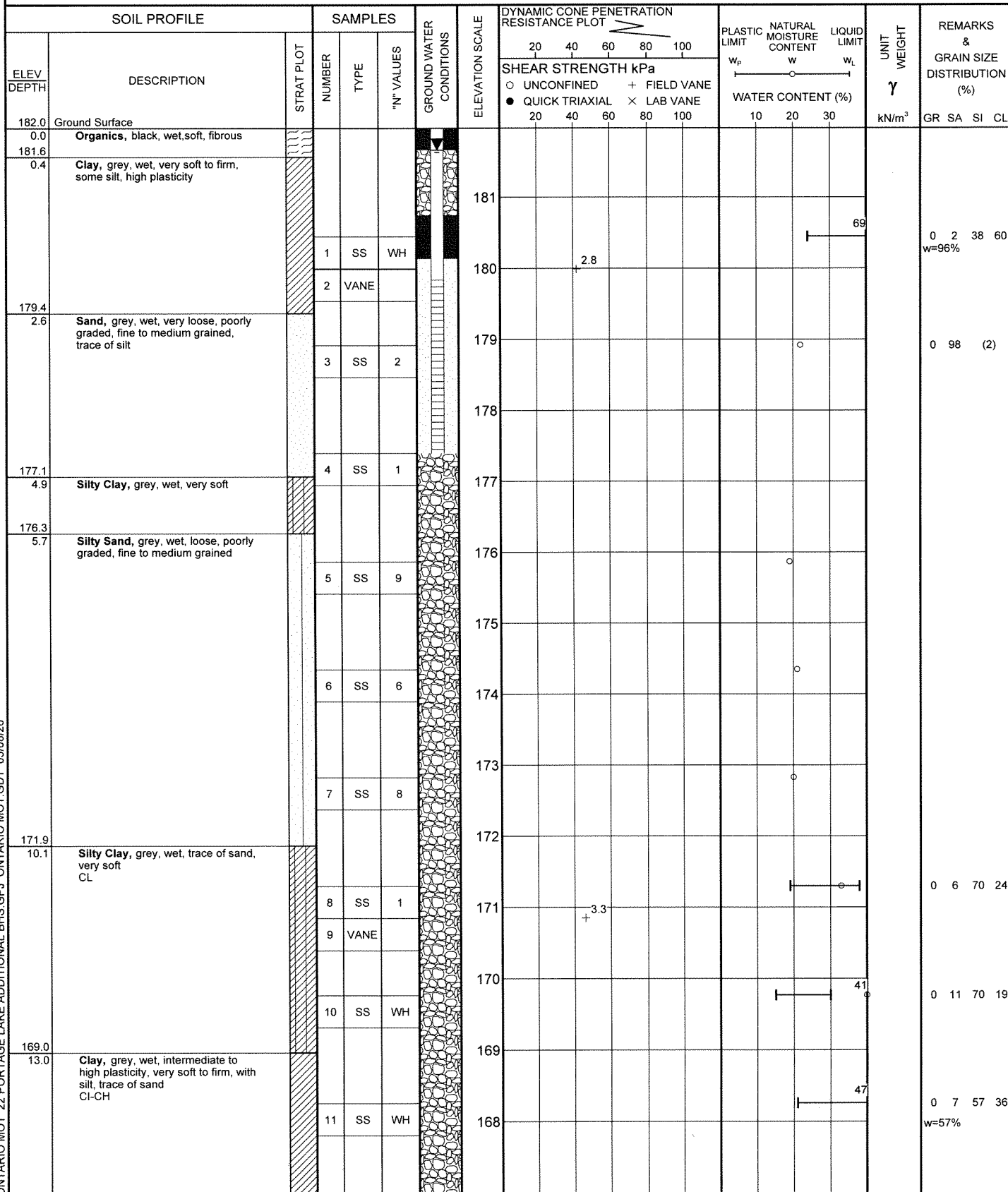
ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHS.GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No PL-4

1 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5085837 N; 222108 E ORIGINATED BY K.C.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NX Rock Coring COMPILED BY H.G.  
DATUM Geodetic DATE 2005.03.29 - 2005.03.30 CHECKED BY H.G.



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

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHs GPJ ONTARIO MOT GDT 05/08/26

# RECORD OF BOREHOLE No PL-4

2 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5085837 N; 222108 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NX Rock Coring COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.29 - 2005.03.30 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	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					
	Clay, grey, wet, intermediate to high plasticity, very soft to firm, with silt, trace of sand CI-CH (continued)		12	SS	5		166							0 3 46 51 w=57%
			13	SS	1		164							0 12 46 42 w=55%
			14	VANE			163	3.0						
162.2							162							
19.8	Silt, grey, wet, compact, trace of clay, trace to some sand, dilatant		15	SS	17		161							0 2 96 2
			16	SH			160						20.0	0 1 92 7
							159							
			17	SS	22		158							0 21 76 3
							157							
156.1							156							
25.9	Silty Sand, grey, wet, loose, poorly graded, fine to medium grained		18	SS	10		155							
							154							
							153							
152.1														

Continued Next Page

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

# RECORD OF BOREHOLE No PL-4

3 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5085837 N; 222108 E ORIGINATED BY K.C.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NX Rock Coring COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.03.29 - 2005.03.30 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
29.9	Auger refusal. Coring started.  <b>Granitic Gneiss</b>  Slightly weathered, grey, coarse grained, very strong Uniaxial comp. strength = 174.0 MPa Closely to moderately closely spaced planar fractures, 30 degrees to vertical, rough surface, no filling. (continued)		19	NQRC	Rec 100%	151								27.9	RQD = 82%, 8 fractures in 1.5 m	
			20	NQRC	Rec 100%		150									
149.1																
32.9	End of borehole  Groundwater encountered at 0.3 m at time of drilling  Grounwater measured at 0.31 m on April 7, 2005.															

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

ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHS.GPJ ONTARIO MOT.GDT 05/08/26

# RECORD OF BOREHOLE No PL-6

1 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086147 N; 221844 E ORIGINATED BY P.R & S.M  
DIST 54 HWY 69 BOREHOLE TYPE Hollow stem auger, wash boring & dynamic cone penetration test COMPILED BY H.G  
DATUM Geodetic DATE 2005.04.01 - 2005.04.04 CHECKED BY H.G

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w LIQUID LIMIT w <sub>L</sub>		
180.1 0.0	Ground Surface <b>Clay</b> , brown, wet, very soft, high plasticity						180					
			1	SS	WH		179					
			2	VANE			178	4.0				w=63%
177.2 2.9	<b>Sand</b> , grey, wet, very loose, poorly graded, fine grained, some silt		3	SS	WH		177					0 81 15 4
			4	SS	3		176					
			5	SS	WH		175					
			6	SS	2		174					
			7	SS	3		173					
170.0 10.1	<b>Silty Clay</b> , grey, wet, trace of sand, low plasticity, very soft to soft CL		8	SS	WH		172					
			9	SS	WH		171					0 9 67 24
165.4 14.7			10	SS	2		170					
							169					
							168					
							167					0 8 74 18
							166					

Continued Next Page

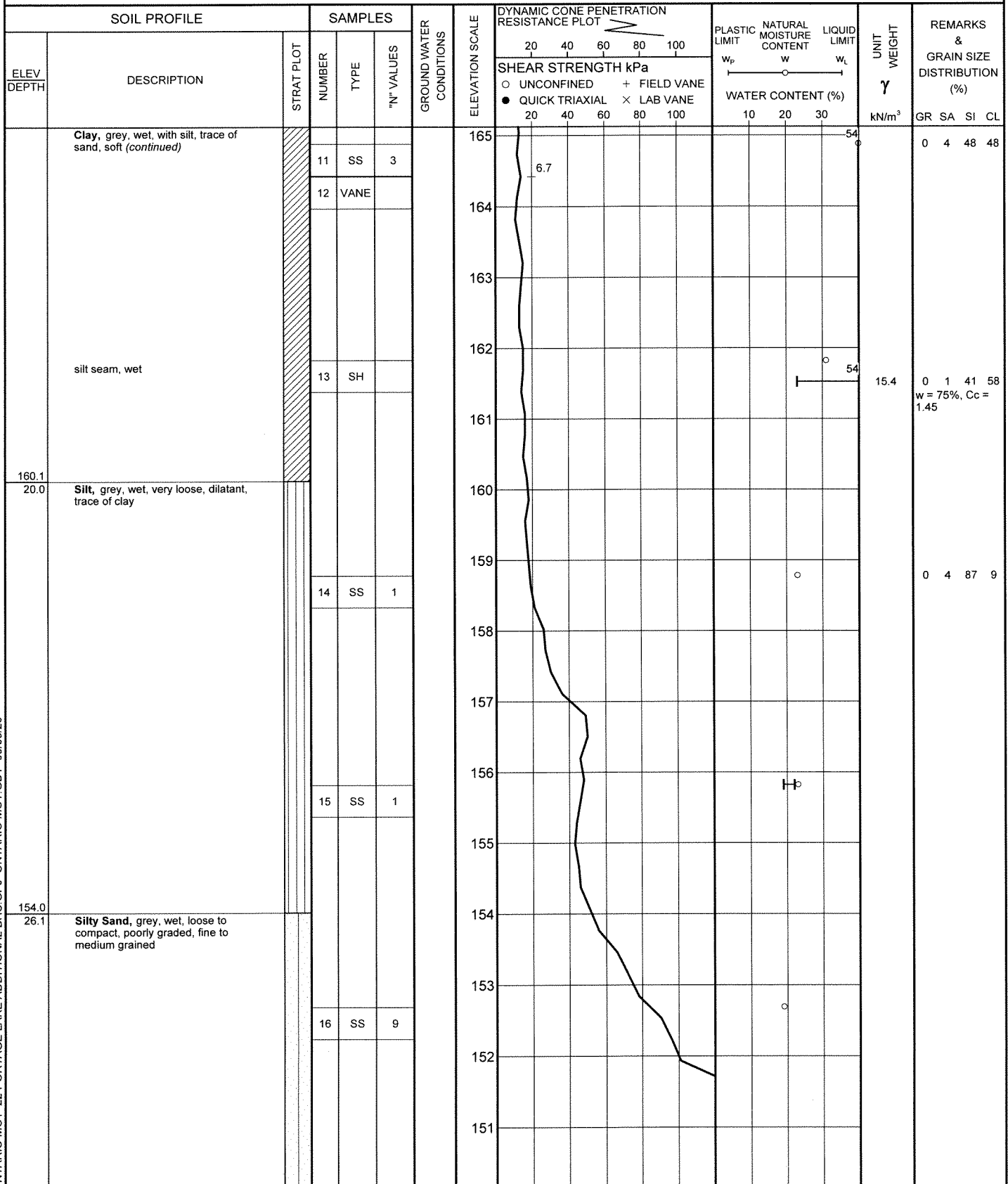
+ 3, x 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No PL-6

2 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086147 N; 221844 E ORIGINATED BY P.R. & S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Hollow stem auger, wash boring & dynamic cone penetration test COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.04.01 - 2005.04.04 CHECKED BY H.G.



ONTARIO MOT 22 PORTAGE LAKE ADDITIONAL BHs.GPJ ONTARIO MOT GDT 05/09/26

Continued Next Page

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

# RECORD OF BOREHOLE No PL-6

3 OF 3

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Portage Lake Additional BHs, Co-ords: 5086147 N; 221844 E ORIGINATED BY P.R & S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Hollow stem auger, wash boring & dynamic cone penetration test COMPILED BY H.G.  
 DATUM Geodetic DATE 2005.04.01 - 2005.04.04 CHECKED BY H.G.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								20 40 60 80 100		10 20 30			kN/m <sup>3</sup>	GR SA SI CL
	<b>Silty Sand</b> , grey, wet, loose to compact, poorly graded, fine to medium grained <i>(continued)</i> Sand surged into hollow stem augers		17	SS	10		150							
							149							
							148							
147.2	Changed to washed boring		18	BAG			147							
32.9	<b>Cobble till</b> , very dense						146							
			19	SS	Refusa		145							
			20	SS	Refusa		144							
							143							
142.6	End of borehole													
37.5														

RECORD OF BOREHOLE No GL522-NBL-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy NBL over Highway 522, Co-ords: 5086532 N; 221775 E ORIGINATED BY S.M.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NQ Rock Coring COMPILED BY D.S.  
DATUM Geodetic DATE 2005.01.13 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
182.9	Ground Surface													
182.9	Organics, black, soft													
0.3	Silt, grey, wet, loose, some sand, trace of clay		1	SS	7		182							0 11 86 3
180.4	Silty Sand, grey, wet, loose, poorly graded, fine grained		2	SS	8		181							
179.1	Granitic gneiss		3	NQRC	Rec. 90%		180							
3.8	Fresh, dark pinkish grey, medium grained, very strong  Excellent quality  Moderately closely spaced planar fractures, rough, no infilling		4	NQRC	Rec. 99%		179							RQD 90%, 2 fractures in 1.5 m
176.0	End of borehole						178							
6.9	Groundwater not observed at time of drilling						177							RQD 94%, 3 fractures in 1.5 m

RECORD OF BOREHOLE No GL522-NBL-2

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy NBL over Highway 522, Co-ords: 5086500 N; 221792 E ORIGINATED BY S.M.  
DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY D.S.  
DATUM Geodetic DATE 2005.01.14 CHECKED BY T.C.



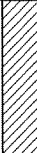


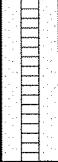
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub> W                      W <sub>L</sub>				
183.8	Ground Surface							20   40   60   80   100						
183.8	Organics							20   40   60   80   100						
0.2	Sand, brown, wet, loose, poorly graded, fine grained, trace silt													
			1	SS	7									0   97   (3)
181.0														
2.7	End of borehole, auger refusal probably on rock  Groundwater not observed at time of drilling  Groundwater measured at 0.25 m on March 24, 2005.  Groundwater measured at 0.2 m on April 6, 2005.													

# RECORD OF BOREHOLE No GL522-SBL-1

1 OF 1

METRIC

G.W.P. 5377-02-00 LOCATION Hwy 69, Grundy SBL over Highway 522, Co-ords: 5086532 N; 221734 E ORIGINATED BY S.M.  
 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger COMPILED BY D.S.  
 DATUM Geodetic DATE 2005.01.13 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR   SA   SI   CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub> W                      W <sub>L</sub>				
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE	WATER CONTENT (%)					
185.7	Ground surface						20   40   60   80   100							
0.0	Fill: Sand, dark brown, moist													
184.8														
0.9	Clay, grey to brown, moist, stiff, intermediate plasticity CI		1	SS	13							46	w = 52%	
183.2														
2.5	Sand Till, grey, wet, very dense, fine to medium grained, trace of gravel, silt		2	SS	53									
181.6														
4.1	End of borehole Auger refusal probably on rock  Groundwater not observed at time of drilling  Groundwater measured at 1.58 m on April 6, 2005													

# RECORD OF BOREHOLE No GL522-SBL-2

1 OF 1

METRIC

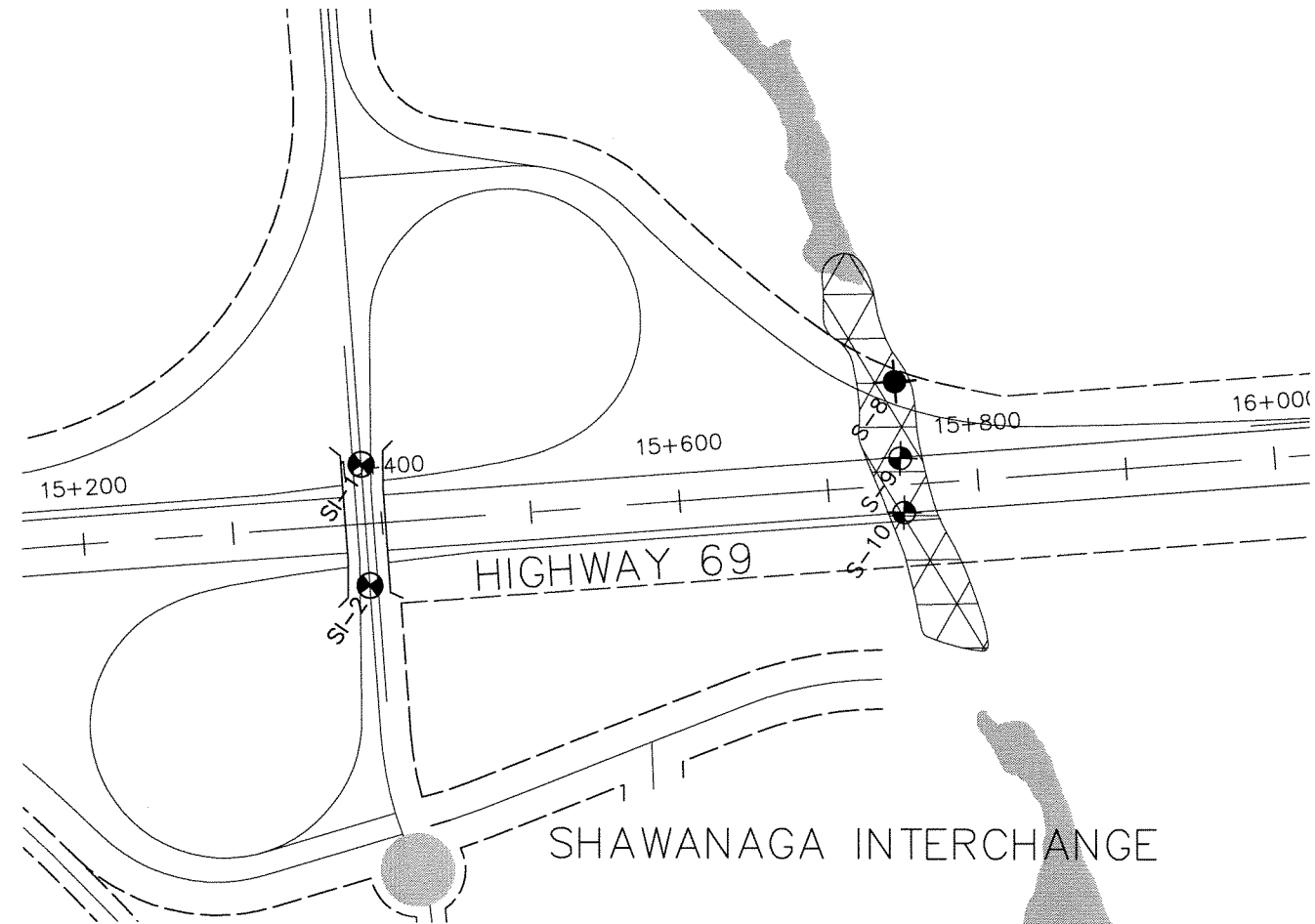
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 DIST 54 HWY 69 BOREHOLE TYPE Continuous Hollow Stem Auger and NX Rock Coring COMPILED BY D.S.  
 DATUM Geodetic DATE 2005.01.14 CHECKED BY T.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED      + FIELD VANE							
185.5	Ground surface						20 40 60 80 100								
0.0	100 mm topsoil <b>Sand</b> , brown, wet, loose, poorly graded, fine to medium grained, trace silt														
			1	SS	9										0 92 (8)
183.4	Auger refusal, changed to casing and wash boring Cored through 300 mm boulder  <b>Boulders and cobbles</b> very dense (till)		2	SS	Refusal										
2.1															
181.4	<b>Granitic gneiss</b>  Fresh, dark pinkish grey, medium grained, very strong  Good to excellent quality  Moderately closely spaced fractures, planar, rough, no filling		3	NQRC	Rec 83%										RQD 82%, 3 fractures in 1.5 m
4.1			4	NQRC	Rec 97%										RQD 94%, 3 fractures in 1.5 m
178.3	End of borehole														
7.2	Groundwater not observed before coring  Groundwater measured at 1.58 m on March 24, 2005  Groundwater measured at 1.25 m on April 6, 2005														

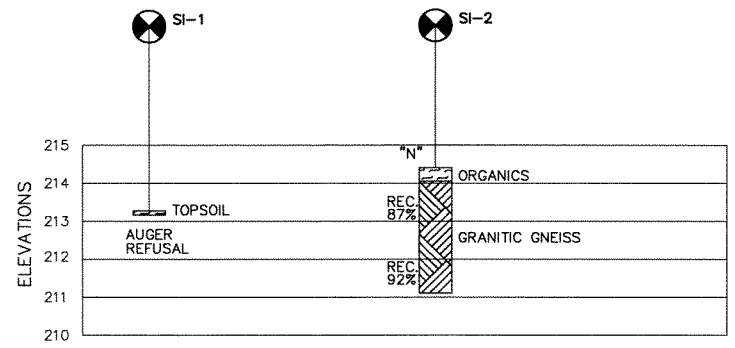
+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

## Appendix D: Drawings

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PLAN  
SCALE  
0 50 100 150  
HORIZONTAL



SECTION  
SCALE  
0 20 40 60  
HORIZONTAL

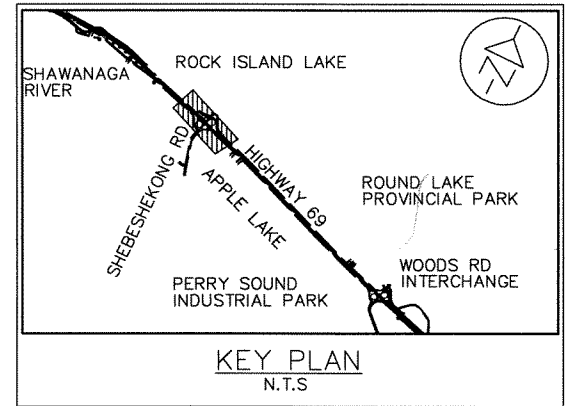
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DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00

FOUNDATION INVESTIGATION  
STA 14+800 TO STA 16+500  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

Trow Associates Inc.

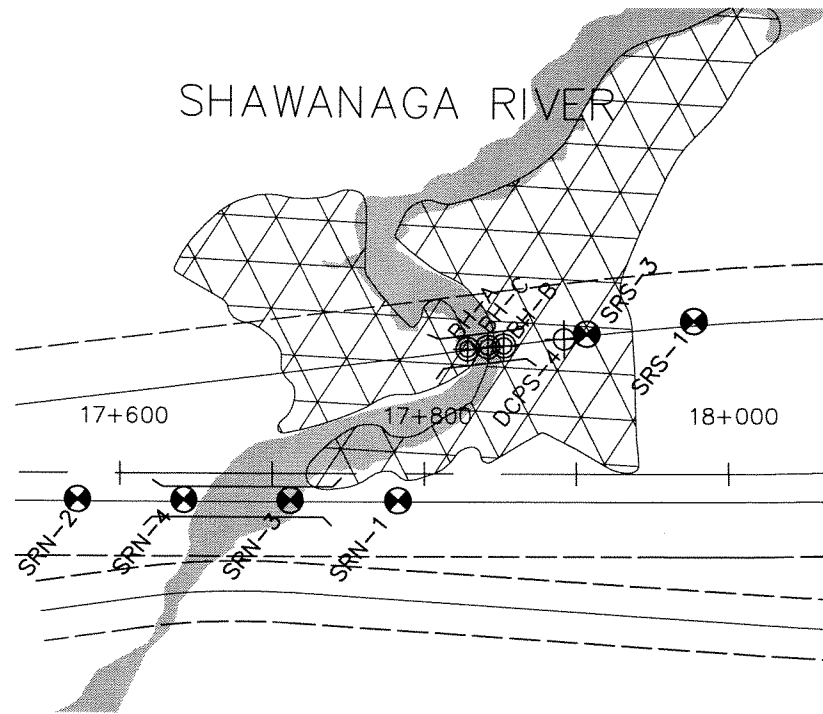
SHEET  
1



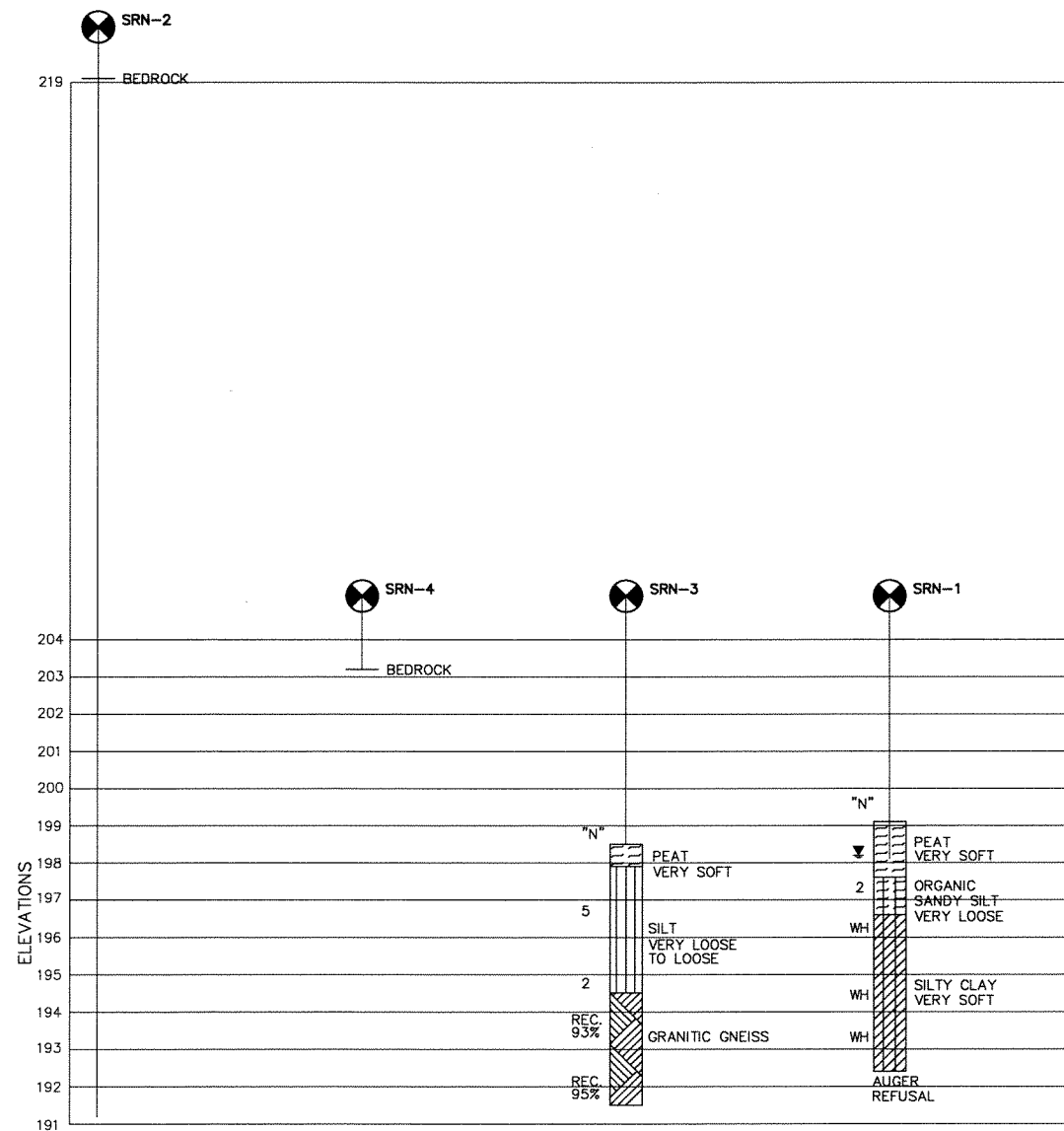
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	NORTHING	EASTING	
SI-1	5044226	245124	213.2
SI-2	5044287	245179	214.4

LEGEND

STRUCTURAL BOREHOLE  
 SWAMP BOREHOLE  
 SWAMP DYNAMIC CONE PENETRATION TEST (CONE)  
 STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)  
 SWAMP BOREHOLE & CONE  
 STRUCTURAL BOREHOLE & CONE  
 MAJOR SWAMP (CONFIRMED)  
 MAJOR SWAMP (UNCONFIRMED)  
 MINOR SWAMP



PLAN  
SCALE  
0 50 100 150  
HORIZONTAL

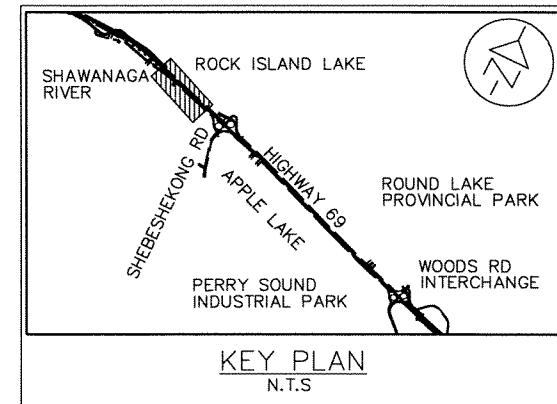


SECTIONS  
SCALE  
0 20 40 60  
HORIZONTAL

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

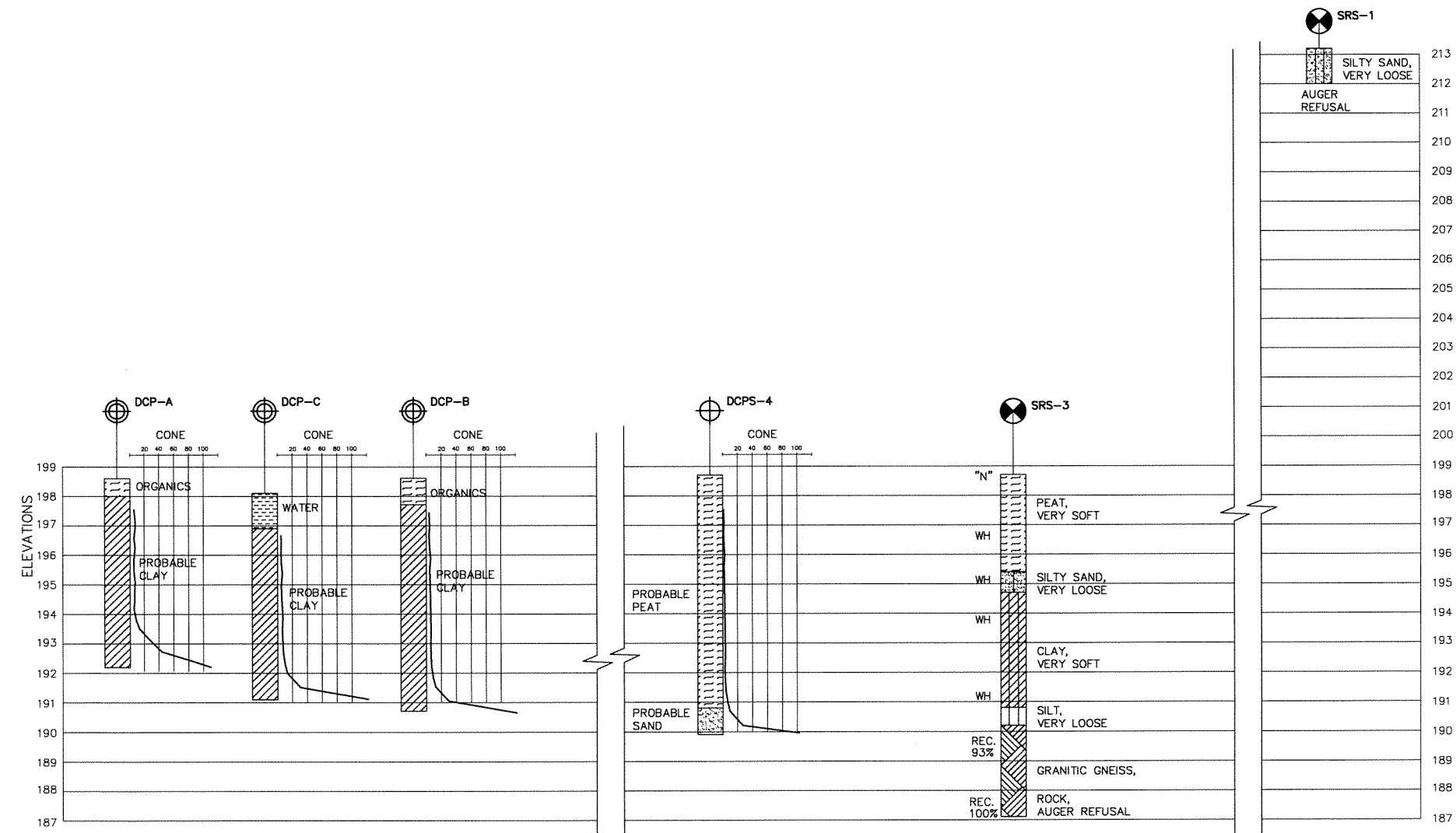
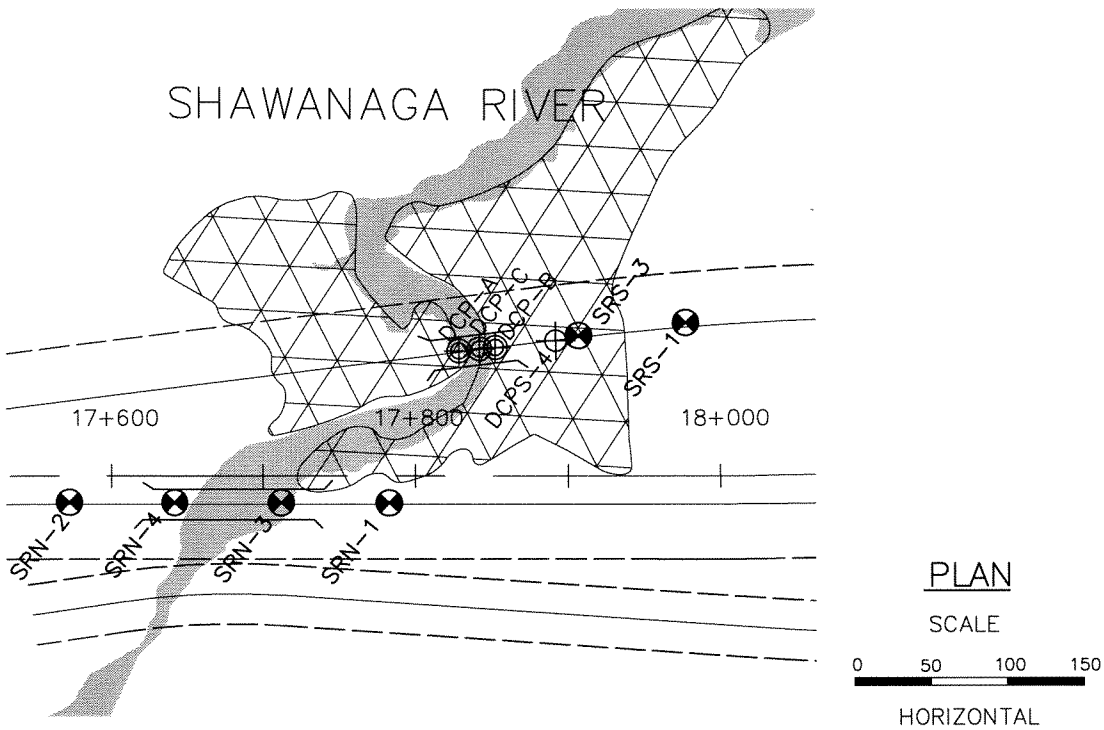
PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00  
FOUNDATION INVESTIGATION  
STA 17+530 TO STA 19+350  
Survey \_\_\_\_\_ Revised \_\_\_\_\_  
Trow Associates Inc.

SHEET  
2



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
SRN-1	5045890	243401	199.1
SRN-2	5045747	243555	219.1
SRN-3	5045847	243451	198.5
SRN-4	5045794	243504	203.2
SRS-1	5045933	243177	213.2
SRS-3	5045892	243235	214.4
SSR-1	5046720	242167	211.9
SSR-2	5046769	242265	210.9
DCPS-4	5045889	243242	198.7

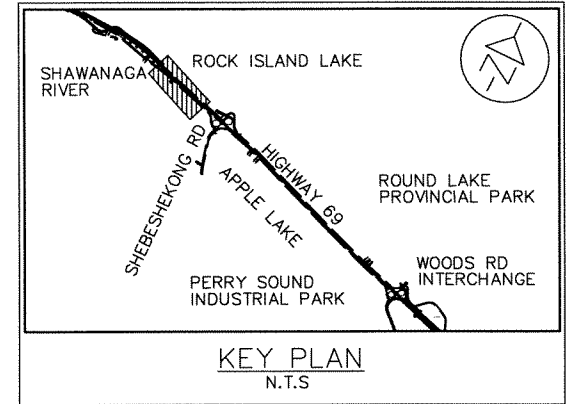
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	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP



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

PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00  
FOUNDATION INVESTIGATION  
STA 17+530 TO STA 19+350  
Survey Revised  
Trow Associates Inc.

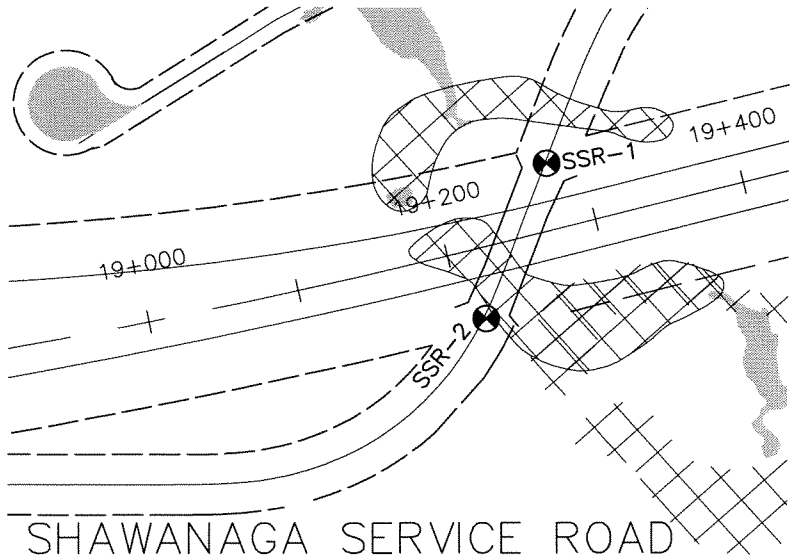
SHEET  
2A



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
SRN-1	5045890	243401	199.1
SRN-2	5045747	243555	219.1
SRN-3	5045847	243451	198.5
SRN-4	5045794	243504	203.2
SRS-1	5045933	243177	213.2
SRS-3	5045892	243235	214.4
SSR-1	5046720	242167	211.9
SSR-2	5046769	242265	210.9
DCPS-4	5045889	243242	198.7

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

STA. 17+530

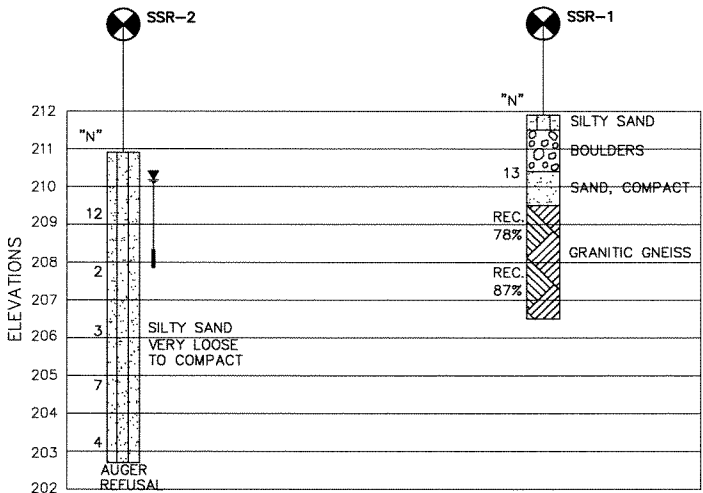


PLAN

SCALE



HORIZONTAL



SECTIONS

SCALE



HORIZONTAL

METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

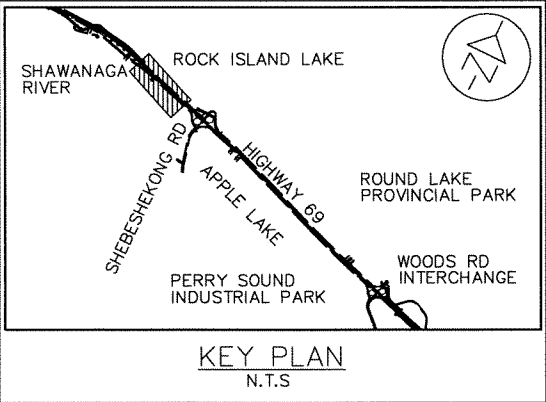
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CONT No 5004-E-0028  
GWP No 5377-02-00

FOUNDATION INVESTIGATION  
STA 17+530 TO STA 19+350  
Survey Revised

Trow Associates Inc.



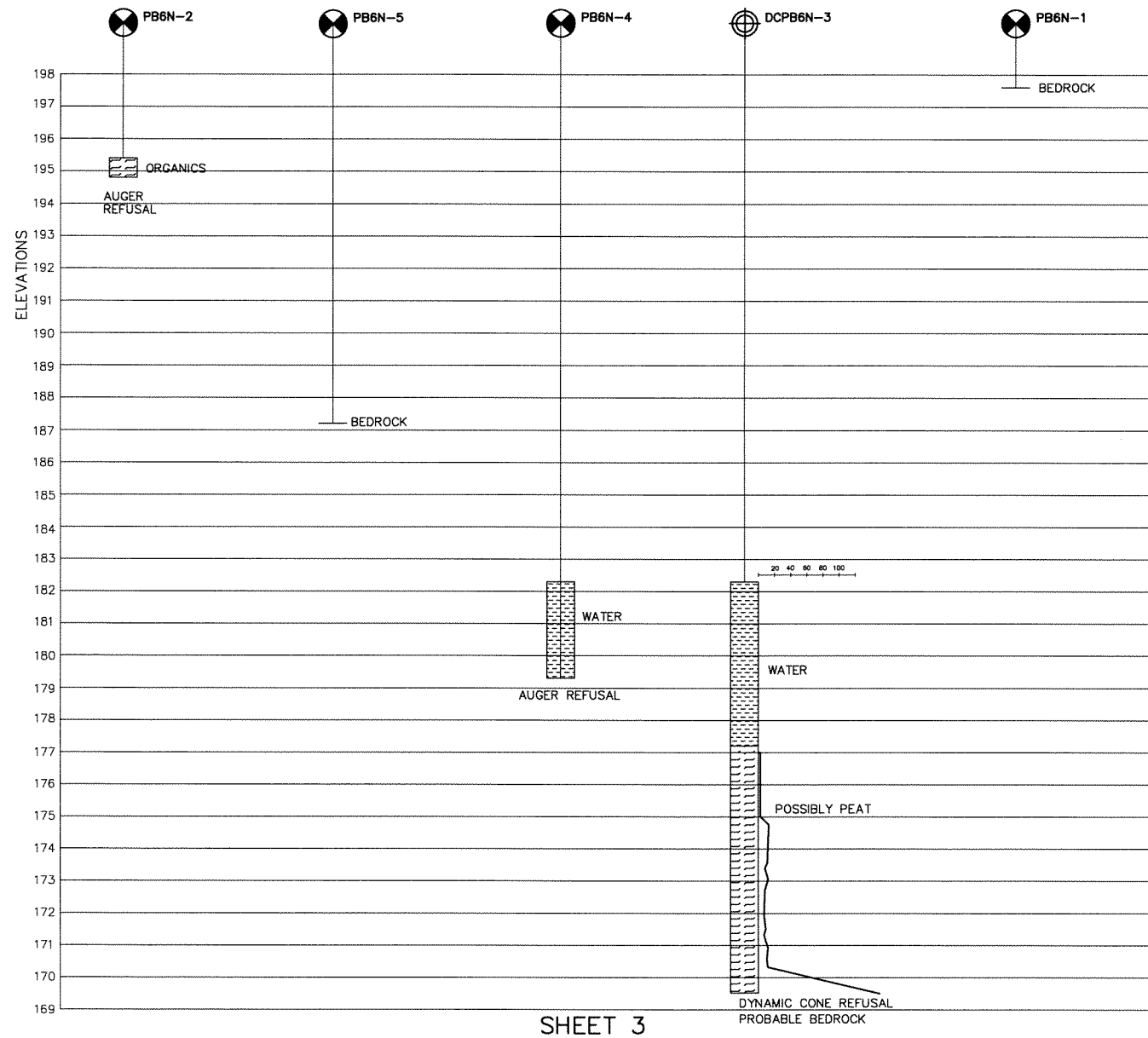
SHEET  
2B



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
SSR-1	5046720	242167	211.9
SSR-2	5046769	242265	210.9

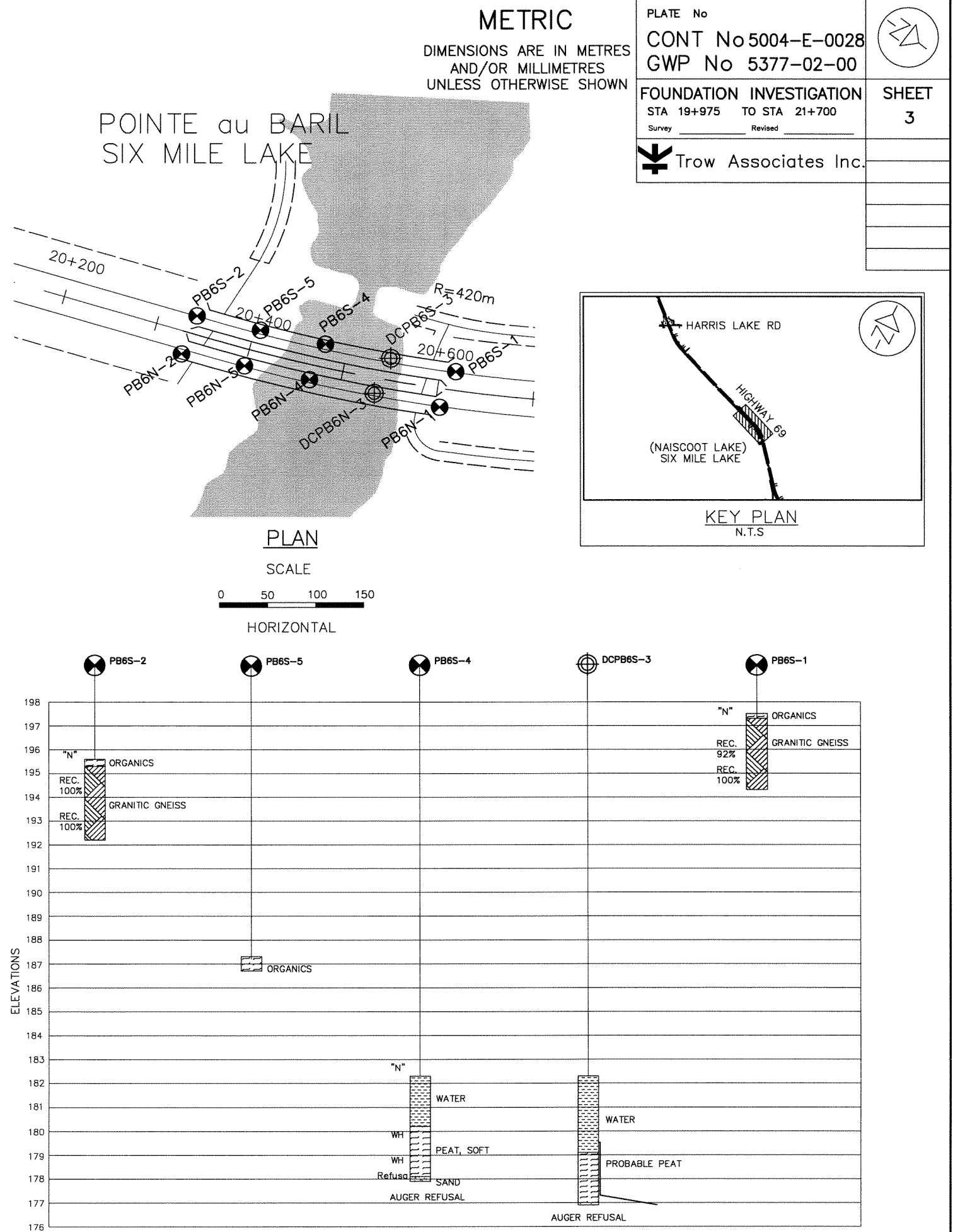
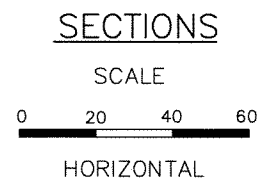
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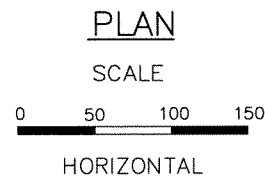
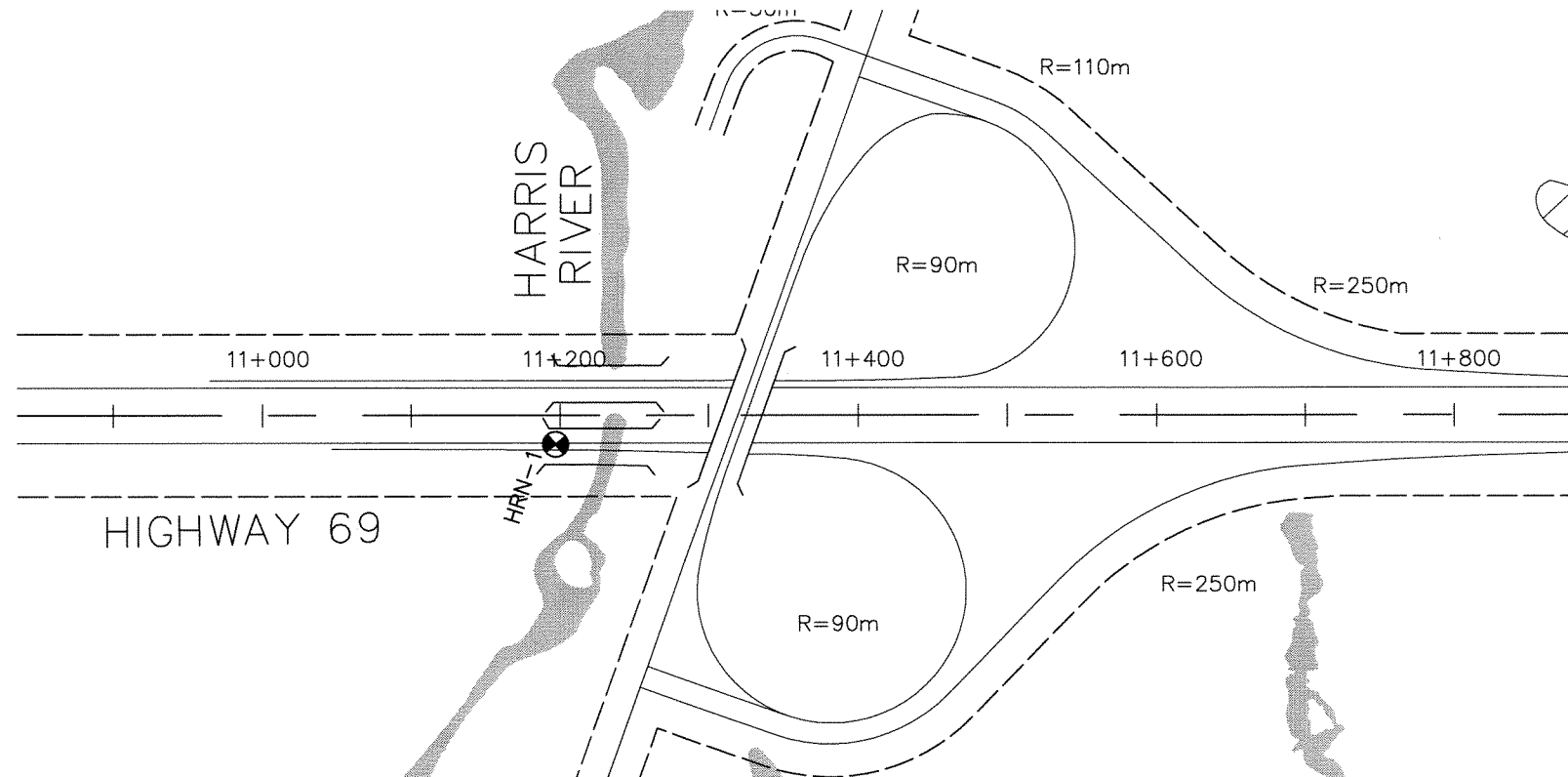
- STRUCTURAL BOREHOLE
- SWAMP BOREHOLE
- SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
- STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
- SWAMP BOREHOLE & CONE
- STRUCTURAL BOREHOLE & CONE
- MAJOR SWAMP (CONFIRMED)
- MAJOR SWAMP (UNCONFIRMED)
- MINOR SWAMP



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
PB6N-1	5056676	234744	197.6
PB6N-2	5056415	234825	195.4
DCPB6N-3	5056610	234764	182.3
PB6N-4	5056544	234784	182.3
PB6N-5	5056478	234804	187.2
PB6S-1	5056673	234703	197.5
PB6S-2	5056410	234782	195.6
DCPB6S-3	5056607	234724	182.3
PB6S-4	5056541	234743	182.3
PB6S-5	5056474	234763	187.3

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP






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

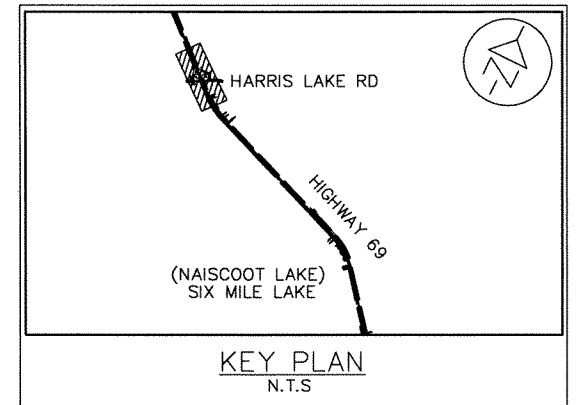
PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00












FOUNDATION INVESTIGATION  
STA 11+500 TO STA 13+250  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

SHEET  
4

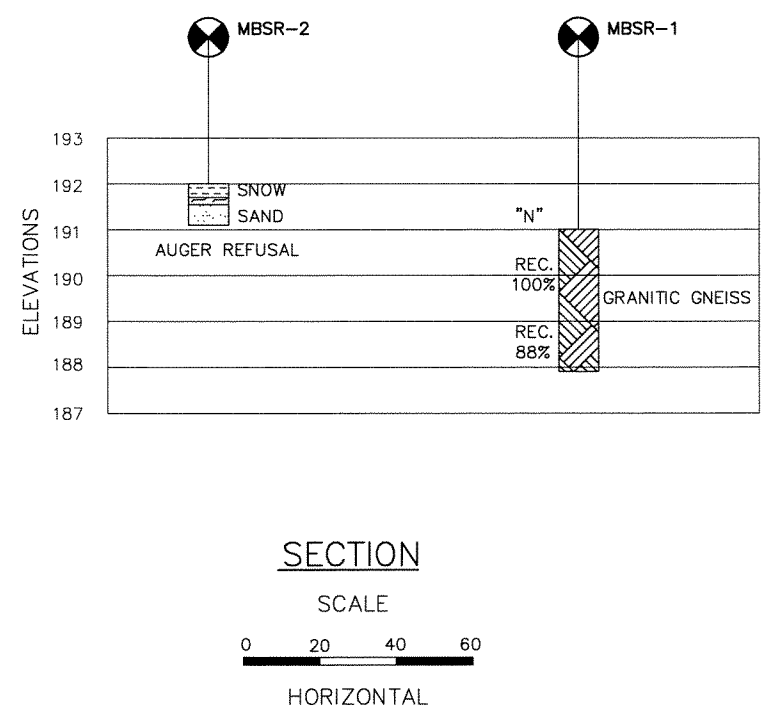
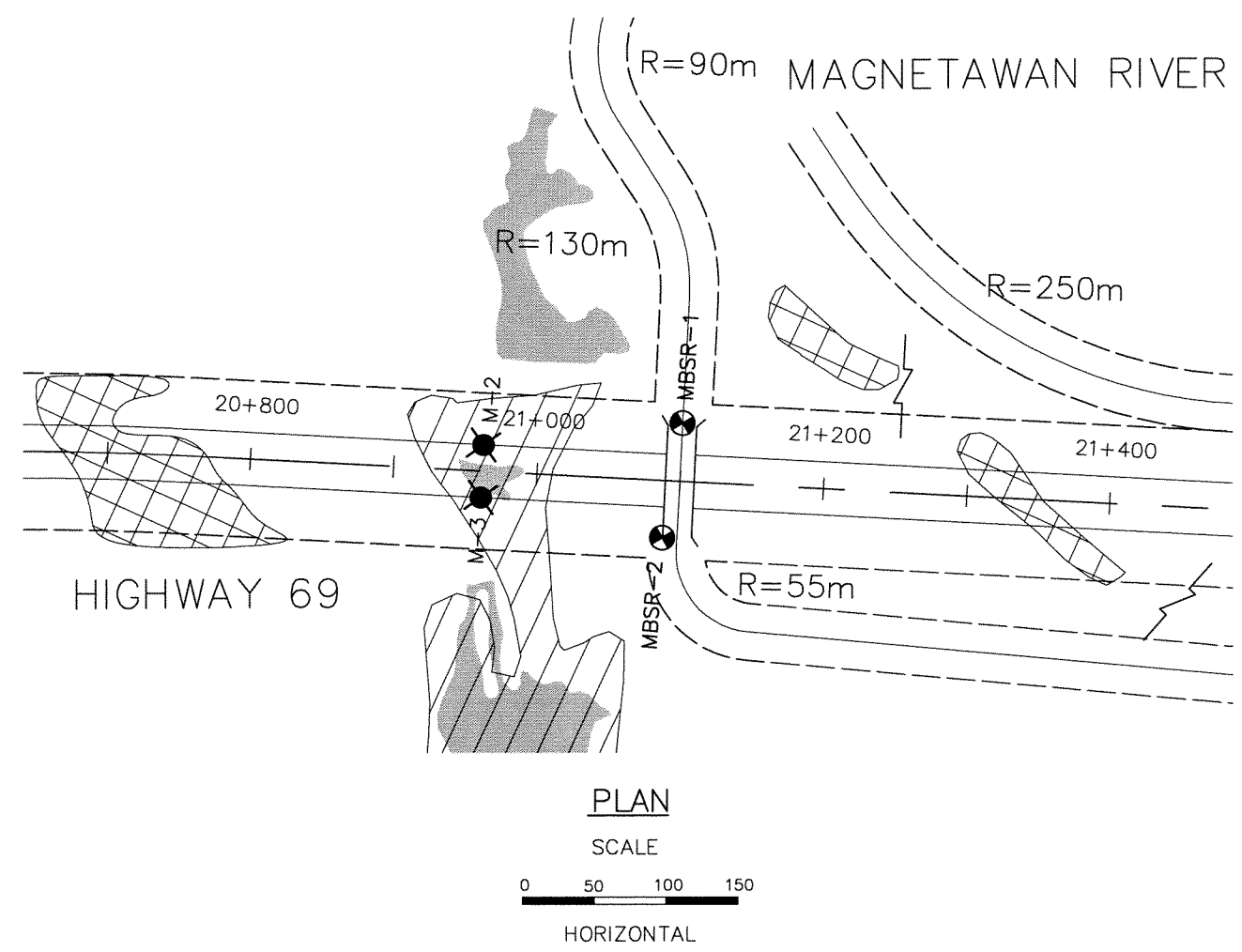
 Trow Associates Inc.



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
HRN-1	5061257	231006	190.6

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

PR-D-707 MB-05  
MINISTRY OF TRANSPORTATION, ONTARIO  
DRAWING NAME:  
CREATED:



METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No

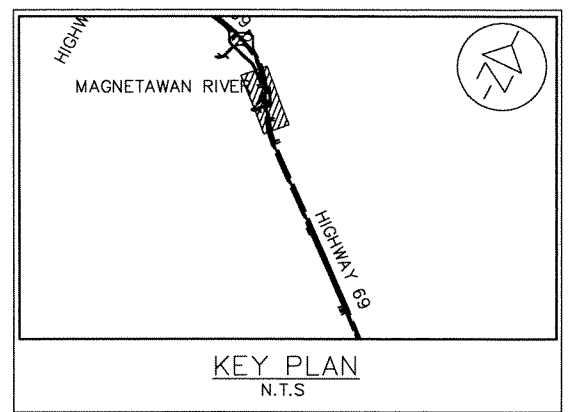
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GWP No 5377-02-00

FOUNDATION INVESTIGATION

STA 20+250 TO STA 21+900  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

Trow Associates Inc.

SHEET 5



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
MSBR-1	5070437	227330	191.0
MSBR-2	5070434	227411	192.0

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

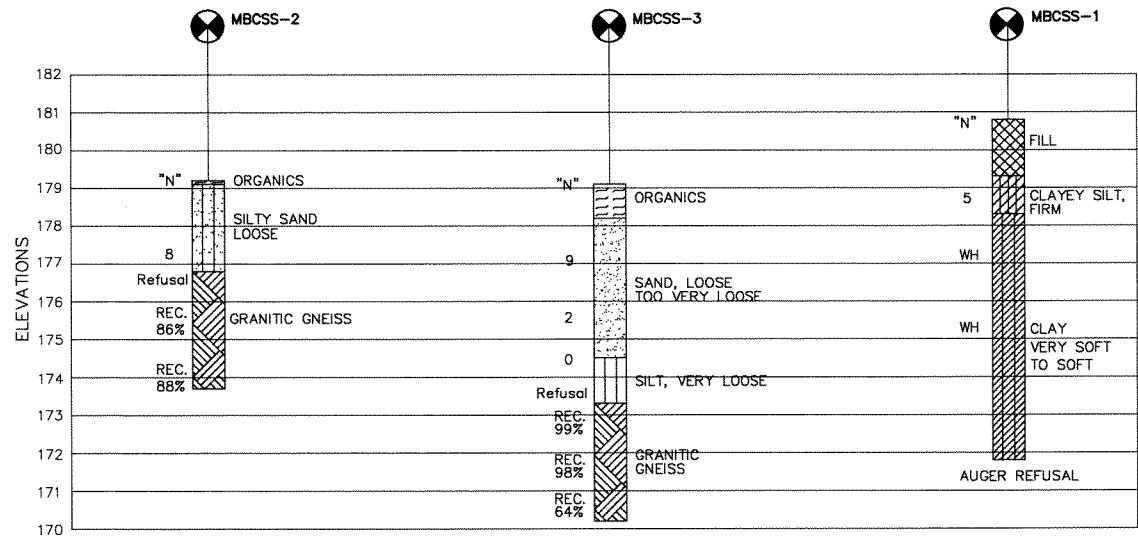
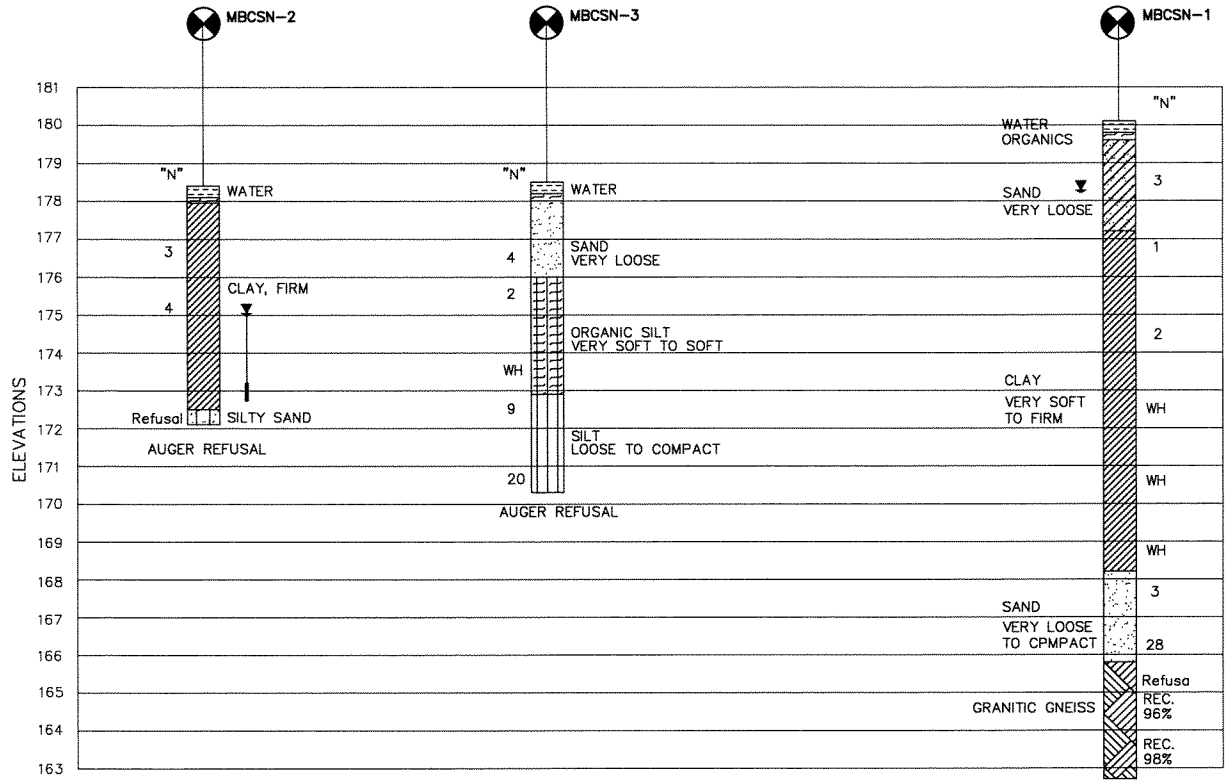
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UNLESS OTHERWISE SHOWN

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GWP No 5377-02-00

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STA 11+300 TO STA 13+000  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

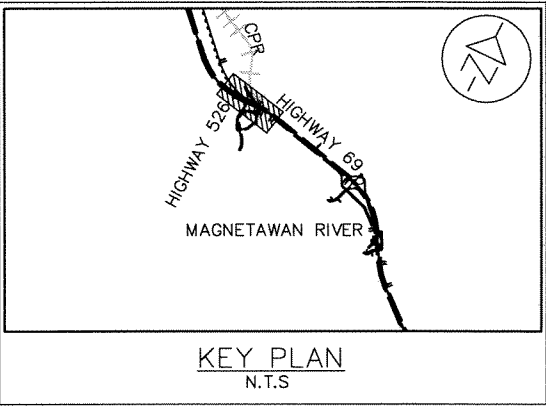
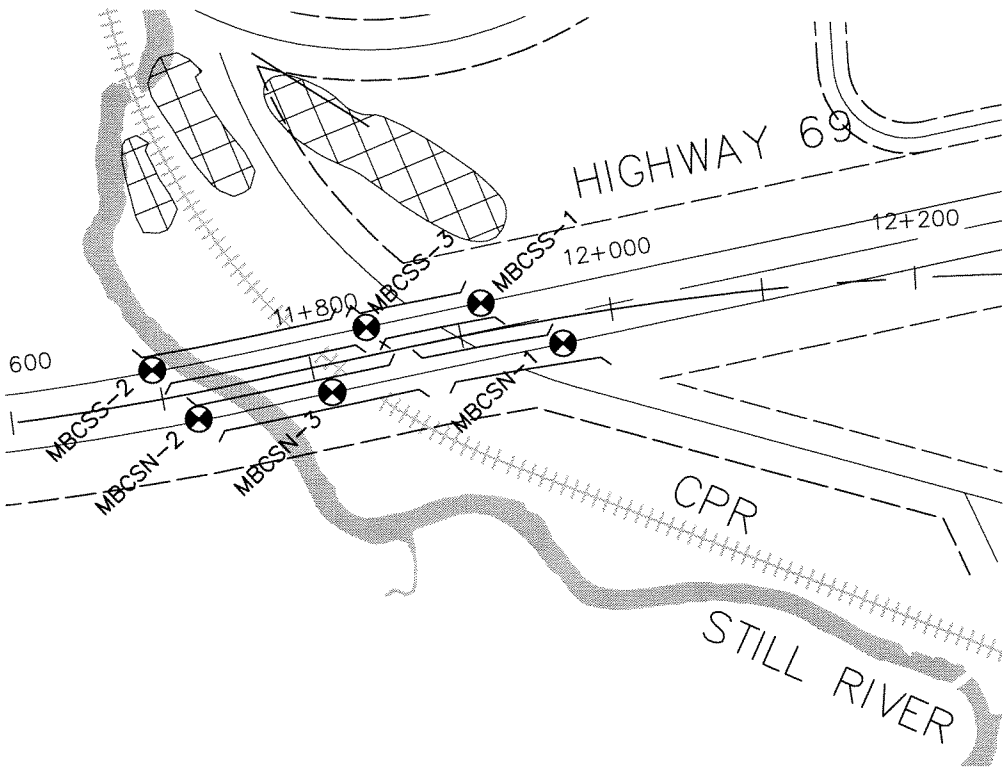
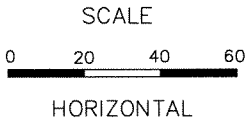
Trow Associates Inc.

SHEET  
6



SHEET 6

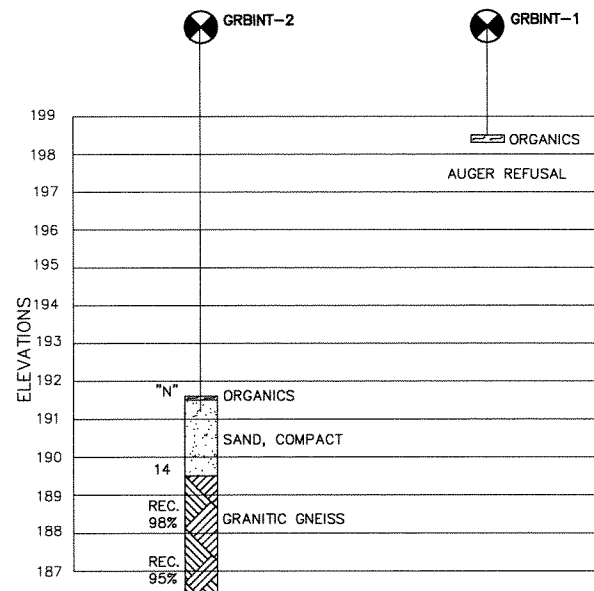
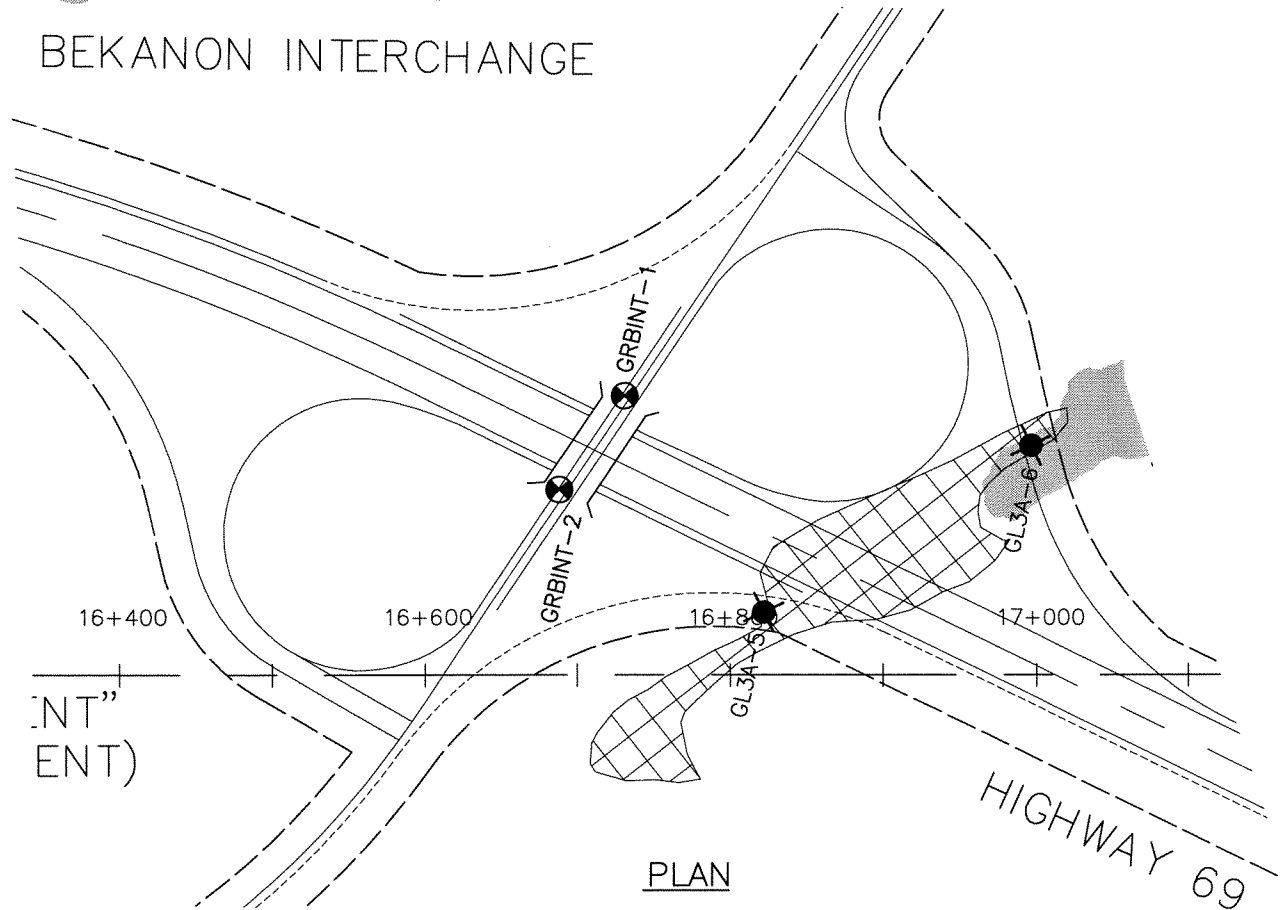
SECTIONS



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
MBCSN-1	5074282	224188	180.1
MBCSN-2	5074181	224404	178.4
MBCSN-3	5074223	224325	178.5
MBCSS-1	5074241	224213	180.8
MBCSS-2	5074137	224407	179.2
MBCSS-3	5074205	224281	181.8

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

# BEKANON INTERCHANGE



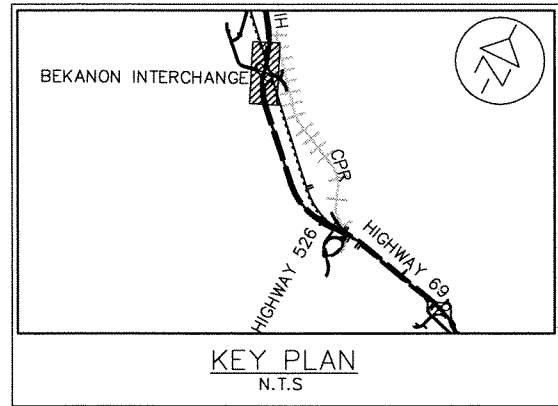
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AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00

FOUNDATION INVESTIGATION  
STA 15+950 TO STA 17+700  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

Trow Associates Inc.

SHEET  
7



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
GRBINT-1	5078495	222130	198.5
GRBINT-2	5078473	222202	191.6

LEGEND

STRUCTURAL BOREHOLE  
 SWAMP BOREHOLE  
 SWAMP DYNAMIC CONE PENETRATION TEST (CONE)  
 STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)  
 SWAMP BOREHOLE & CONE  
 STRUCTURAL BOREHOLE & CONE  
 MAJOR SWAMP (CONFIRMED)  
 MAJOR SWAMP (UNCONFIRMED)  
 MINOR SWAMP

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

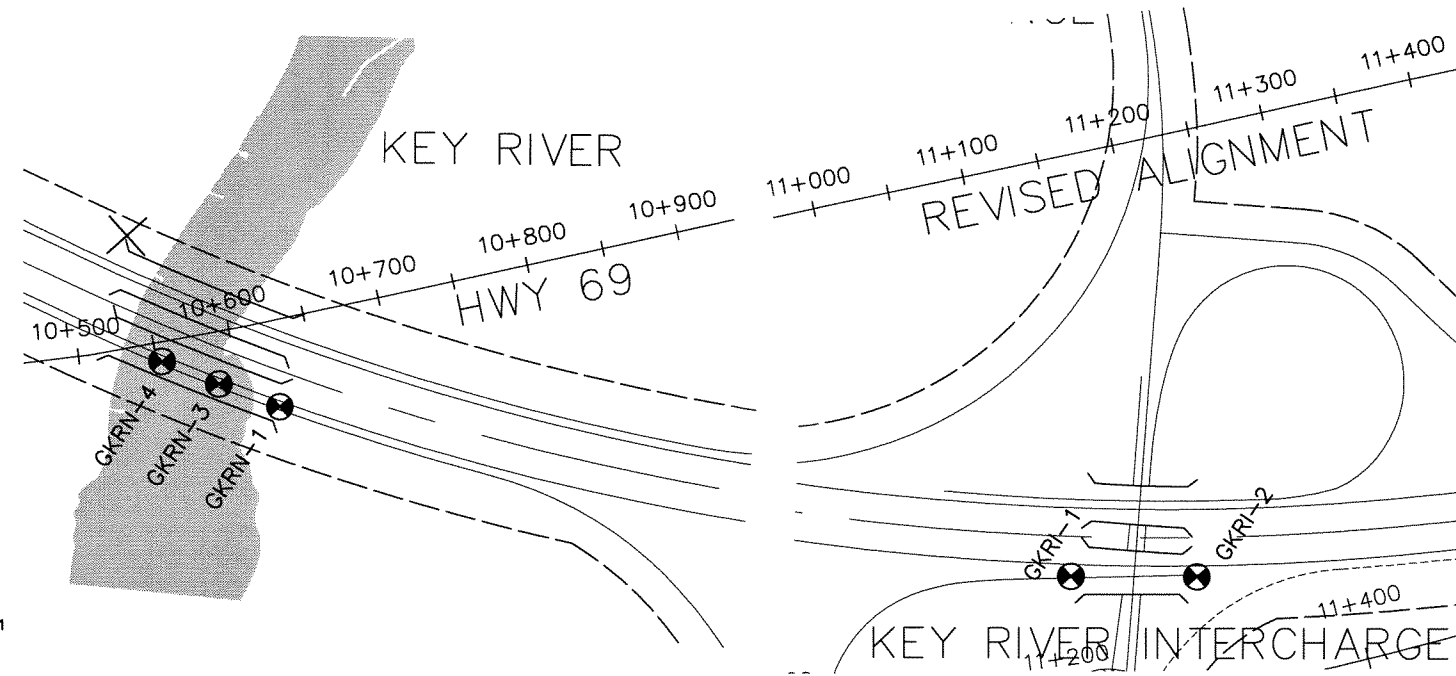
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GWP No 5377-02-00

FOUNDATION INVESTIGATION  
STA 10+475 TO STA 12+300  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

Trow Associates Inc.



SHEET  
8

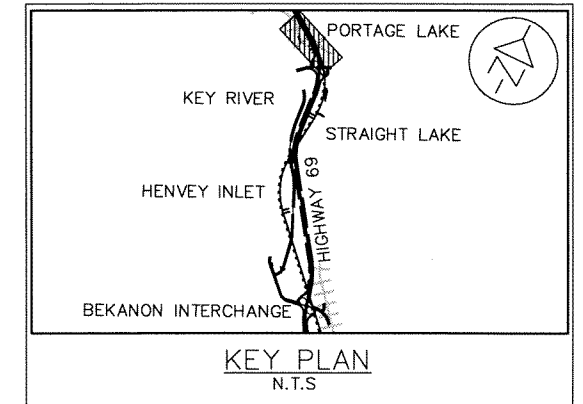


PLANS

SCALE



HORIZONTAL

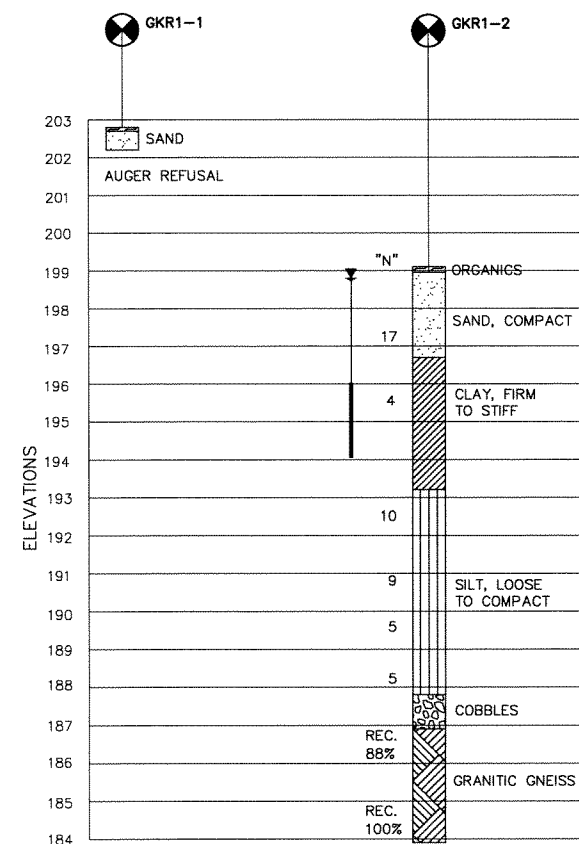
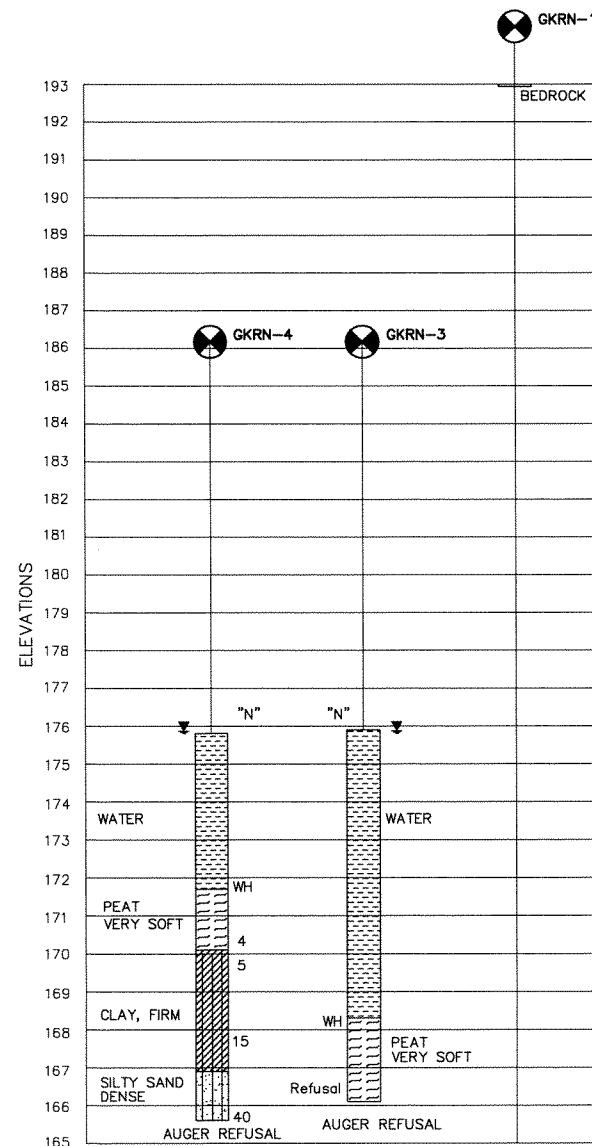


KEY PLAN  
N.T.S.

BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
GKR1-1	5084227	222463	193.0
GKR1-3	5084189	222451	175.9
GKR1-4	5084151	222438	175.8
GKR1-5	5084842	222536	202.8
GKR1-6	5084760	222540	199.1

LEGEND

- STRUCTURAL BOREHOLE
- SWAMP BOREHOLE
- SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
- STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
- SWAMP BOREHOLE & CONE
- STRUCTURAL BOREHOLE & CONE
- MAJOR SWAMP (CONFIRMED)
- MAJOR SWAMP (UNCONFIRMED)
- MINOR SWAMP

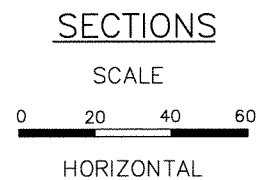
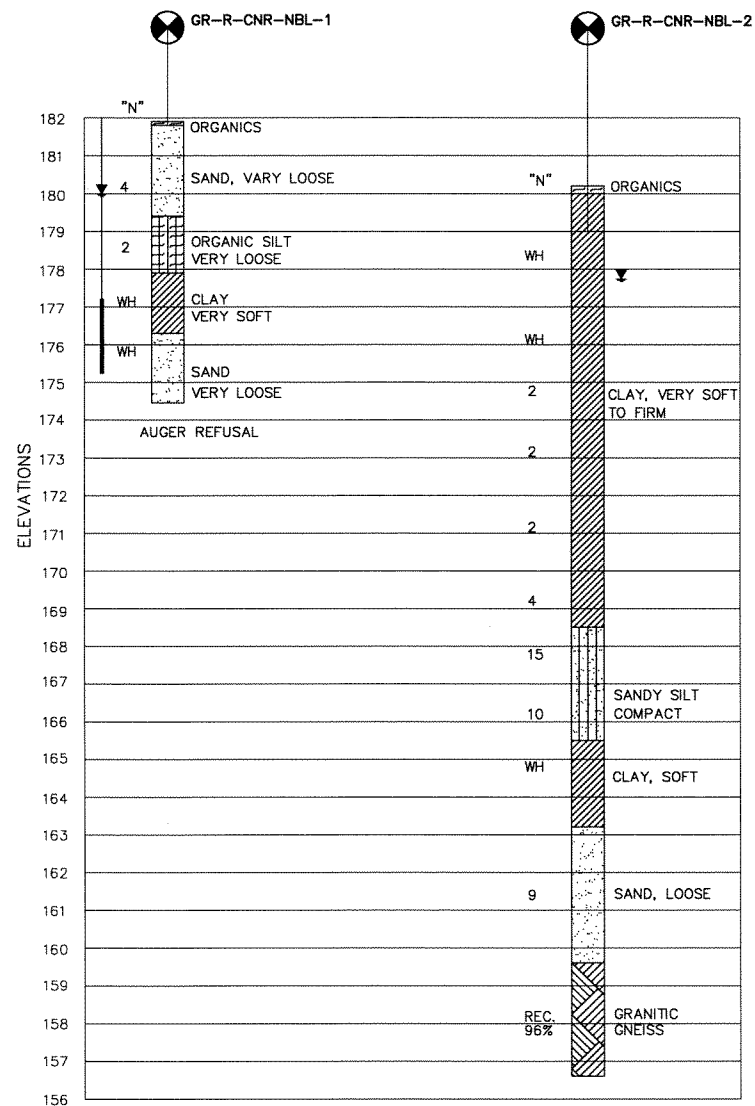
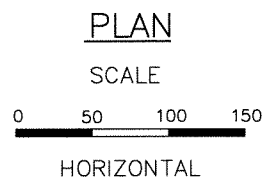
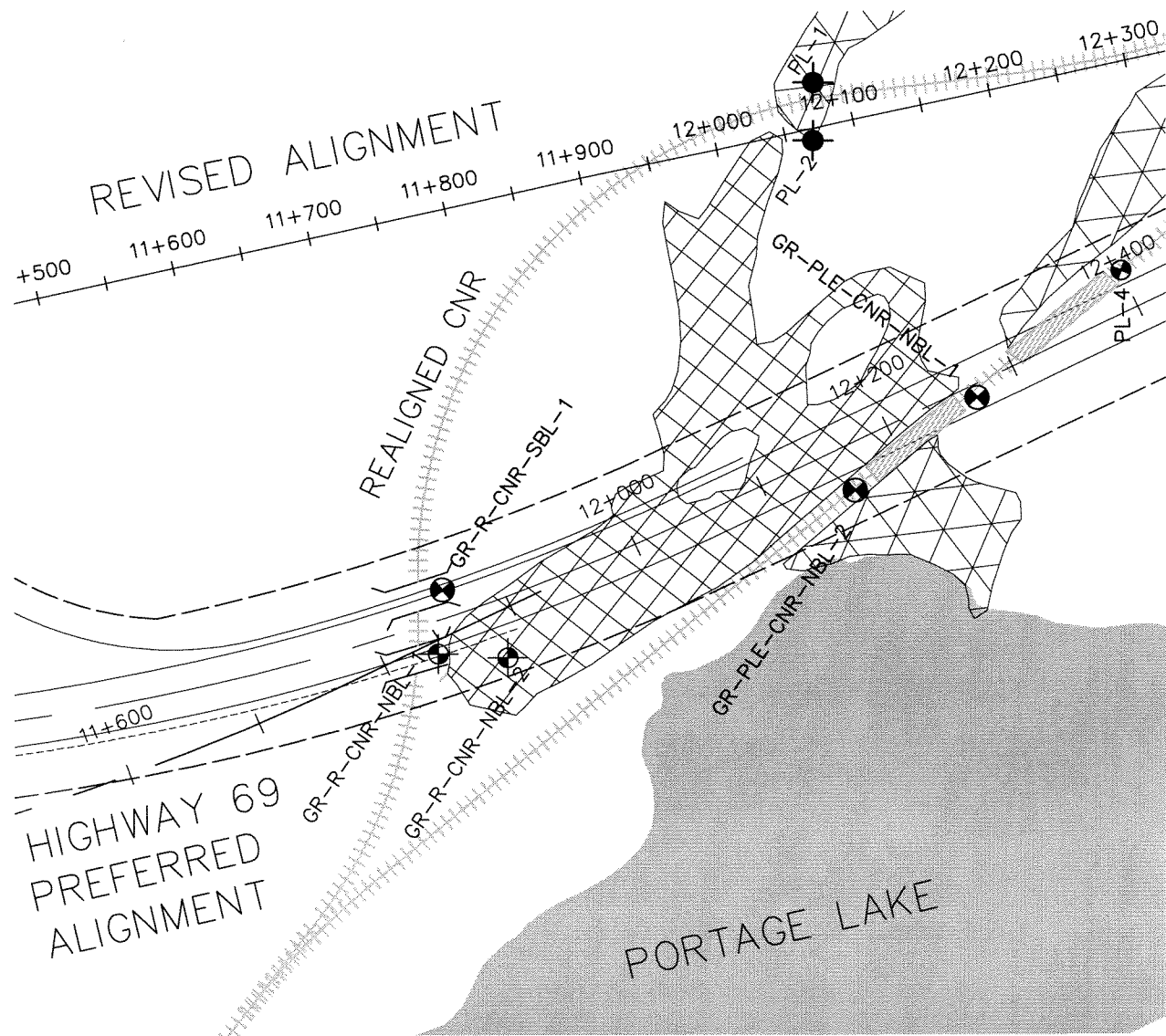


SECTIONS

SCALE



HORIZONTAL



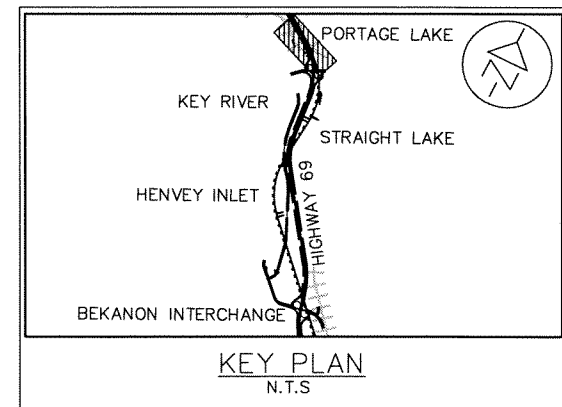
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DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00

FOUNDATION INVESTIGATION  
STA 10+475 TO STA 12+300  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

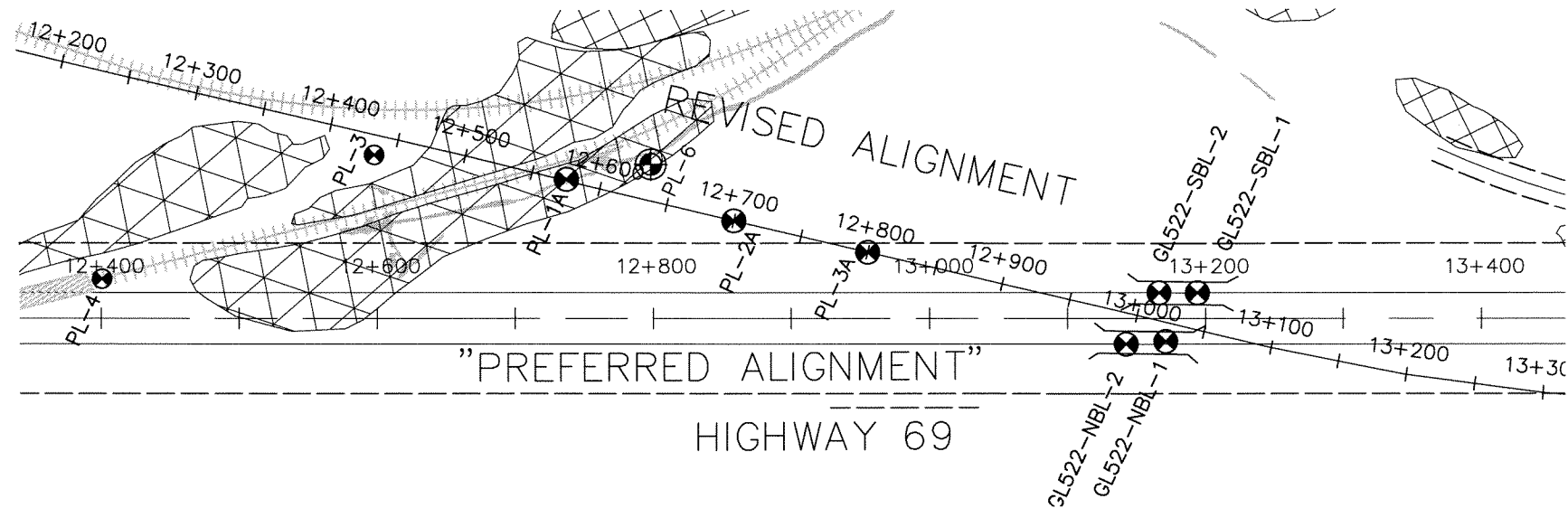
Trow Associates Inc.

SHEET  
9

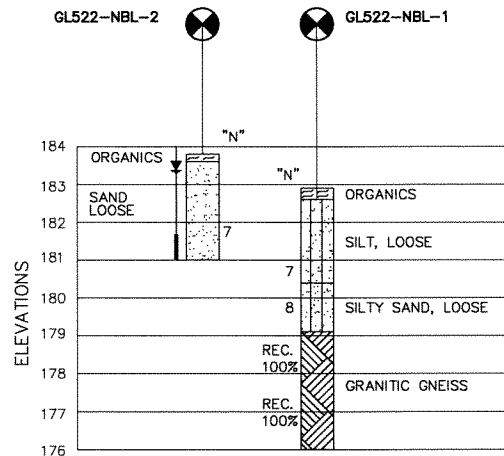
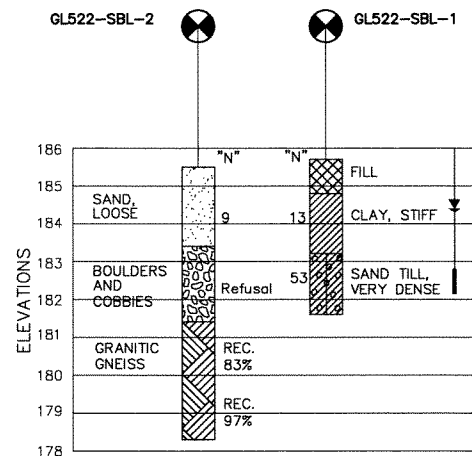


BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
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GR-R-CNR-NBL-1	5085362	222414	181.9
GR-R-CNR-NBL-2	5085412	222414	180.2
GR-PL-CNR-NBL-1	5085739	222209	180.0
GR-PL-CNR-NBL-2	5085653	222279	181.9
PL-1	5085608	221985	182.4
PL-2	5085610	222027	183.5

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP



PLAN  
SCALE  
0 50 100 150  
HORIZONTAL



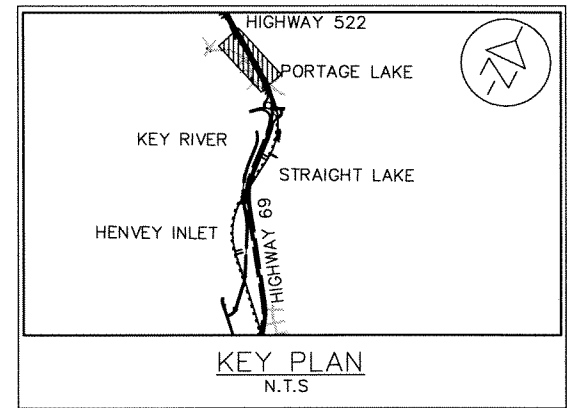
SECTIONS

SCALE  
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HORIZONTAL

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

PLATE No	CONT No 5004-E-0028
GWP No 5377-02-00	
1	
STA 12+300 TO STA 14+050	
Survey Revised	
Trow Associates Inc.	

SHEET
10



BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
GL522-NBL-1	5086532	221775	182.9
GL522-NBL-2	5086500	221792	183.8
GL522-SBL-1	5086532	221734	185.7
GL522-SBL-2	5086501	221748	185.5
PL-3	5085964	221935	182.3
PL-4	5085837	222108	182.0
PL-6	5086147	221844	180.1
PL-7	5087120	221492	185.4

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
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	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

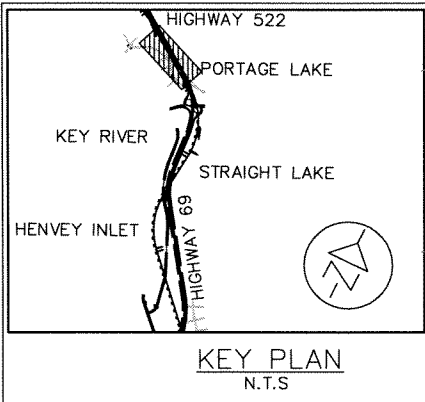
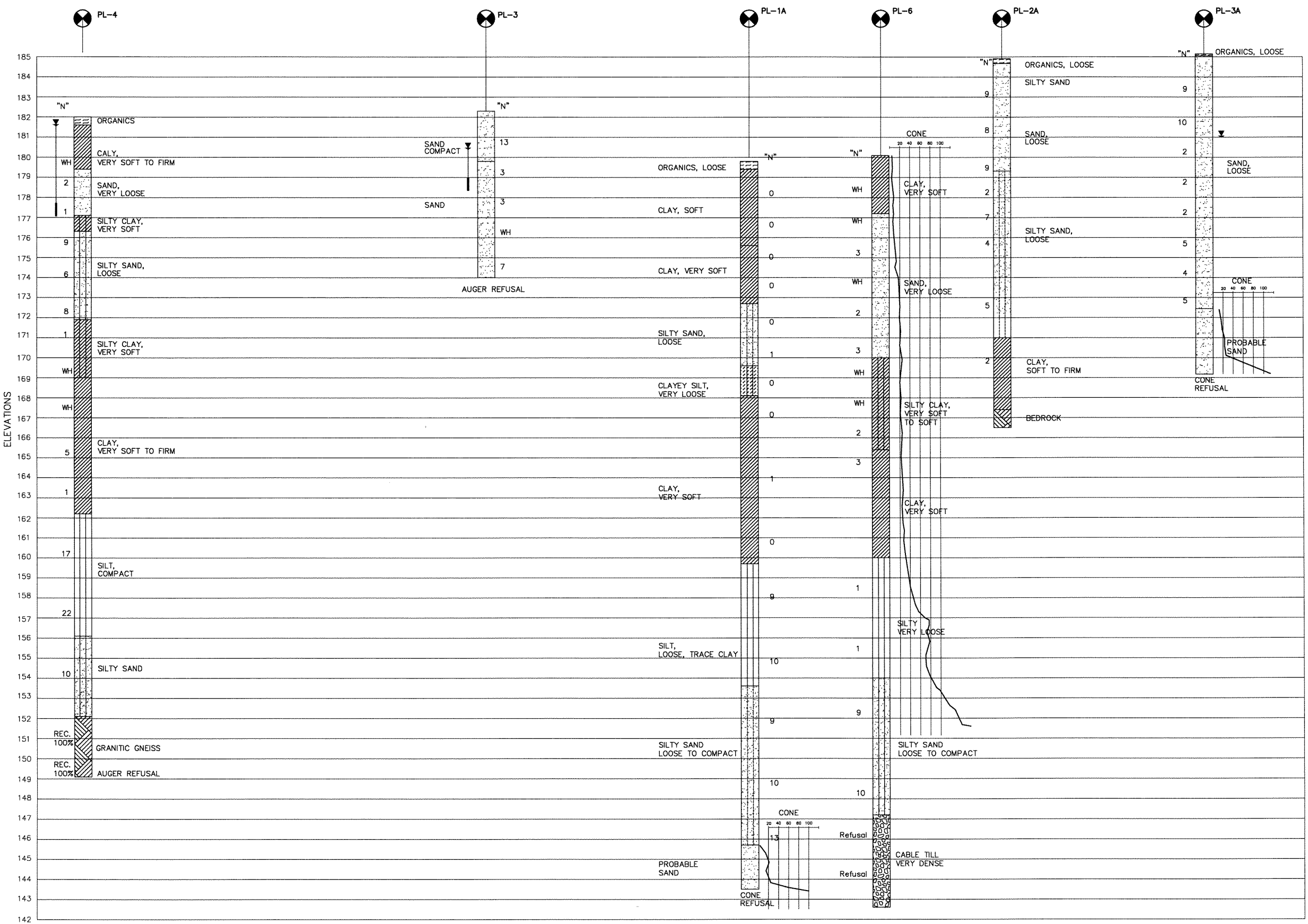
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AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

PLATE No  
CONT No 5004-E-0028  
GWP No 5377-02-00

1  
STA 12+300 TO STA 14+050  
Survey Revised

Trow Associates Inc.

SHEET  
11

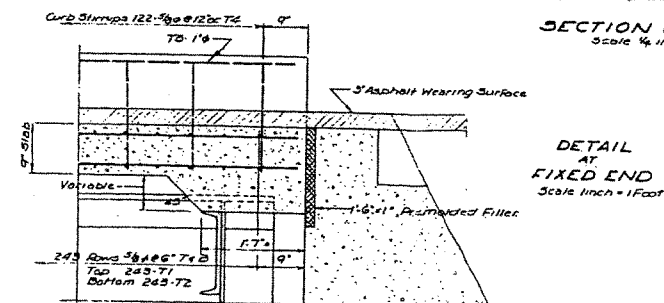
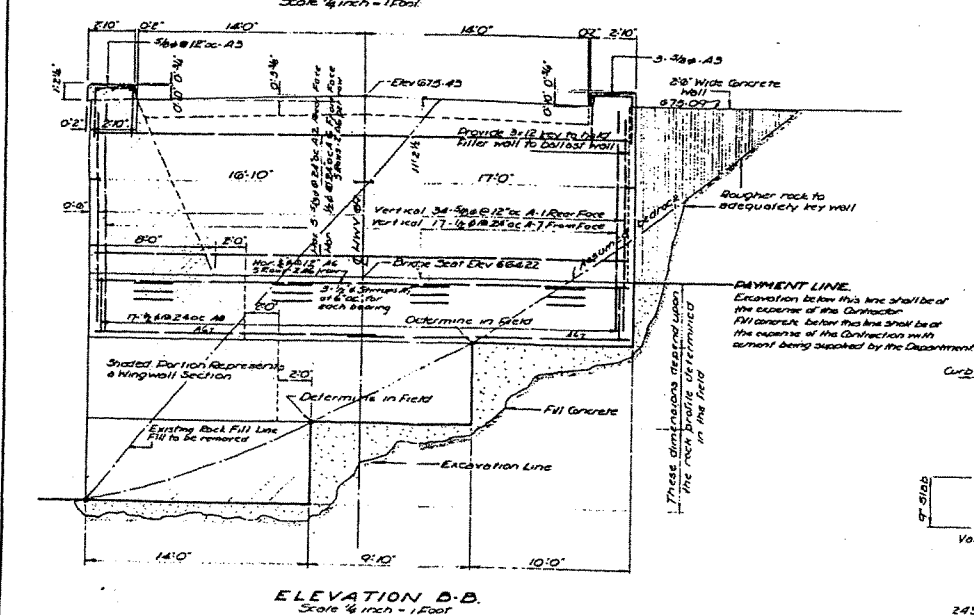
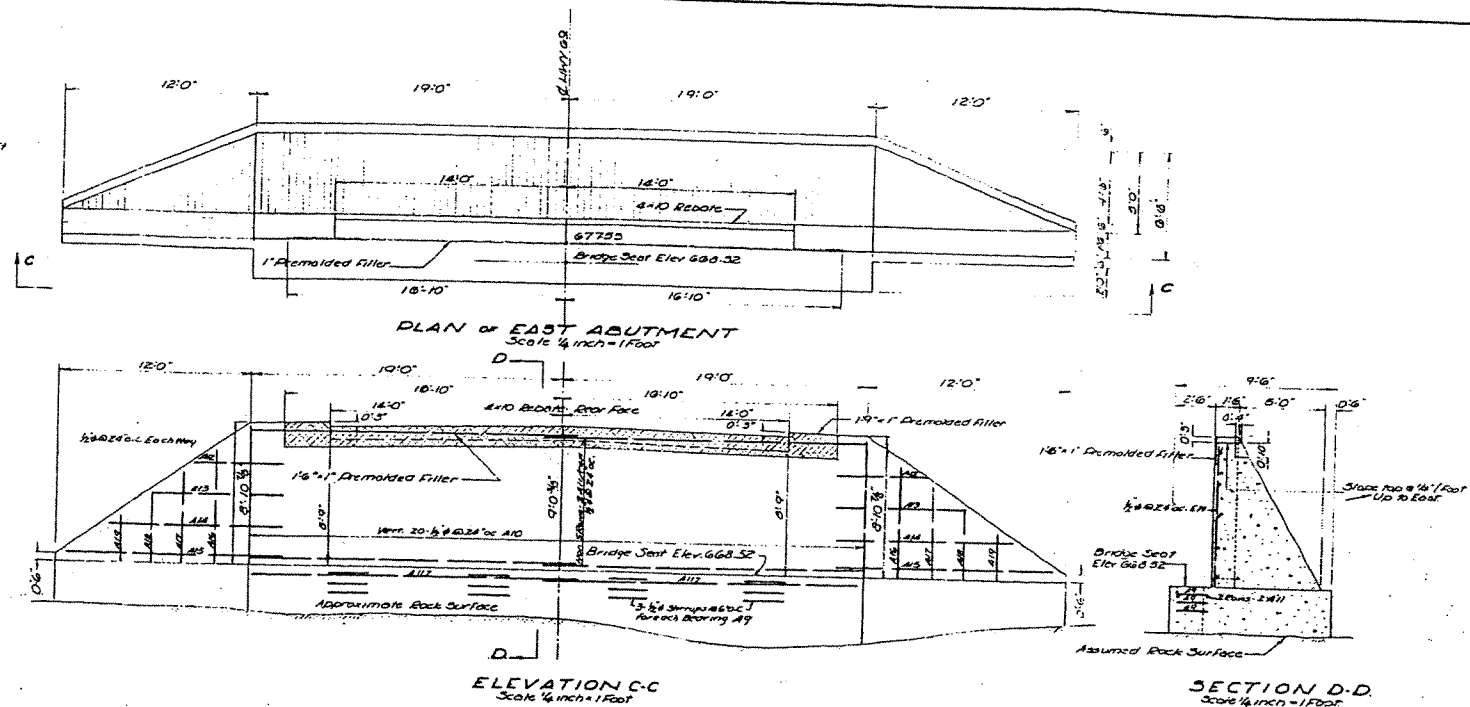


BH No.	MTM COORDINATES		ELEVATION
	NORTHING	EASTING	
GL522-NBL-1	5086532	221775	182.9
GL522-NBL-2	5086500	221792	183.8
GL522-SBL-1	5086532	221734	185.7
GL522-SBL-2	5086501	221748	185.5
PL-3	5085964	221935	182.3
PL-4	5085837	222108	182.0
PL-6	5086147	221844	180.1
PL-7	5087120	221492	185.4

LEGEND	
	STRUCTURAL BOREHOLE
	SWAMP BOREHOLE
	SWAMP DYNAMIC CONE PENETRATION TEST (CONE)
	STRUCTURAL DYNAMIC CONE PENETRATION TEST (CONE)
	SWAMP BOREHOLE & CONE
	STRUCTURAL BOREHOLE & CONE
	MAJOR SWAMP (CONFIRMED)
	MAJOR SWAMP (UNCONFIRMED)
	MINOR SWAMP

## **Appendix E: Available Existing Information**

Existing Shawanaga River Bridge Drawings



WP 6/3-58

DEPARTMENT OF HIGHWAYS-ONTARIO-  
BRIDGE OFFICE-TORONTO

SHAWANAGA RIVER BRIDGE

THE KING'S HIGHWAY No. 89 T.C.H.  
CO. PARRY SOUND  
TWP. SHAWANAGA LOT 18 17 1/2 COM. 1/41

DIV. No. 11

CONCRETE AND REINFORCING DETAILS

APPROVED

CHIEF ENGINEER

DESIGNED BY: JOL  
CHECKED BY: JFL  
DRAWN BY: JFL  
DATE: 4-11-58

STANDARD DRAWING NO. 57-181 57-601

57-181 57-601

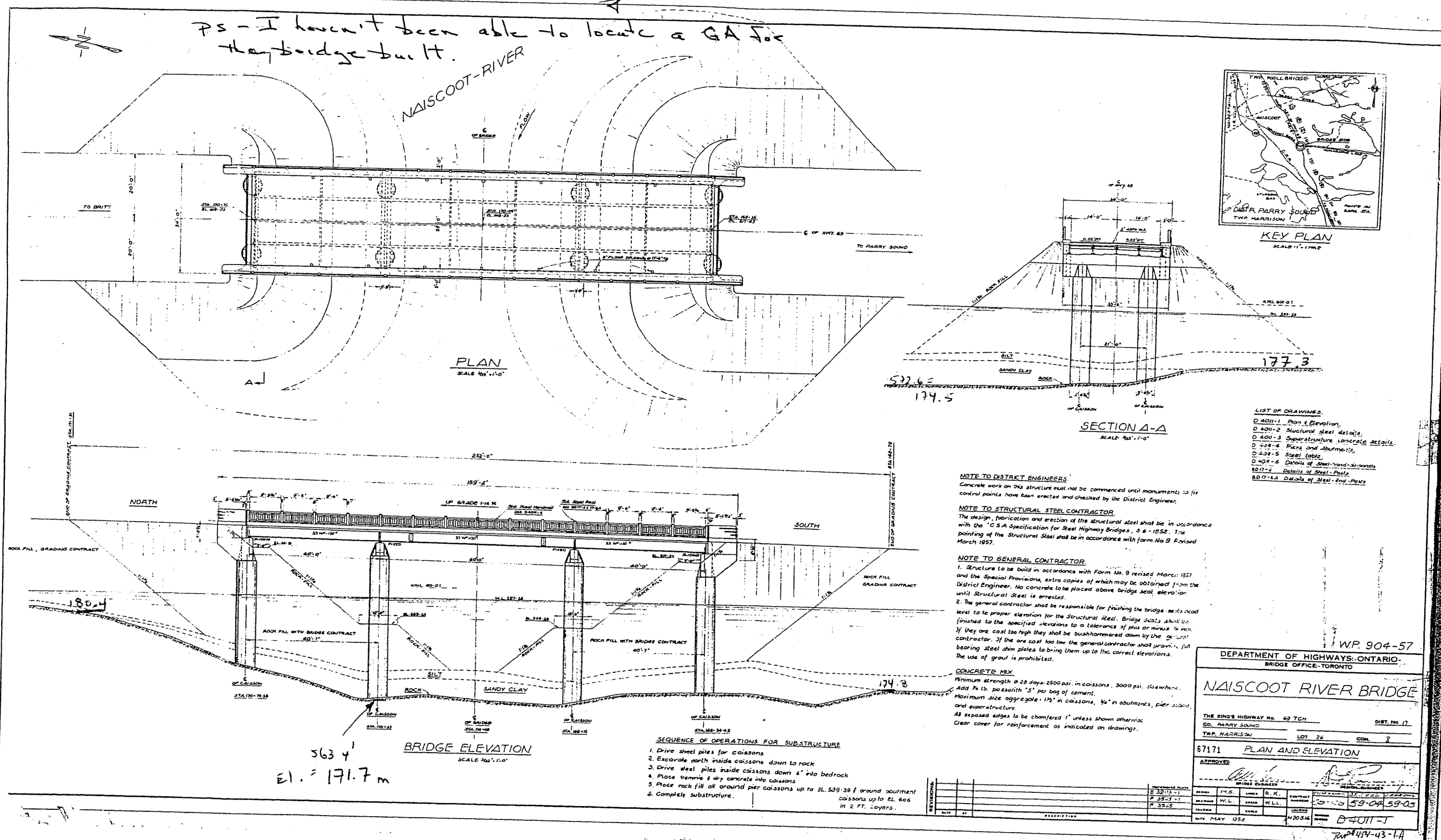
Trp # 453-65-2.A D-453-2-2



Existing Naiscoot River Bridge Drawing

These drawings came from our digital library BIDIMS  
This GA is of a bridge not built. Drawings 2 to 8 are  
from the bridge that was built

PS - I haven't been able to locate a GA for  
the bridge built.



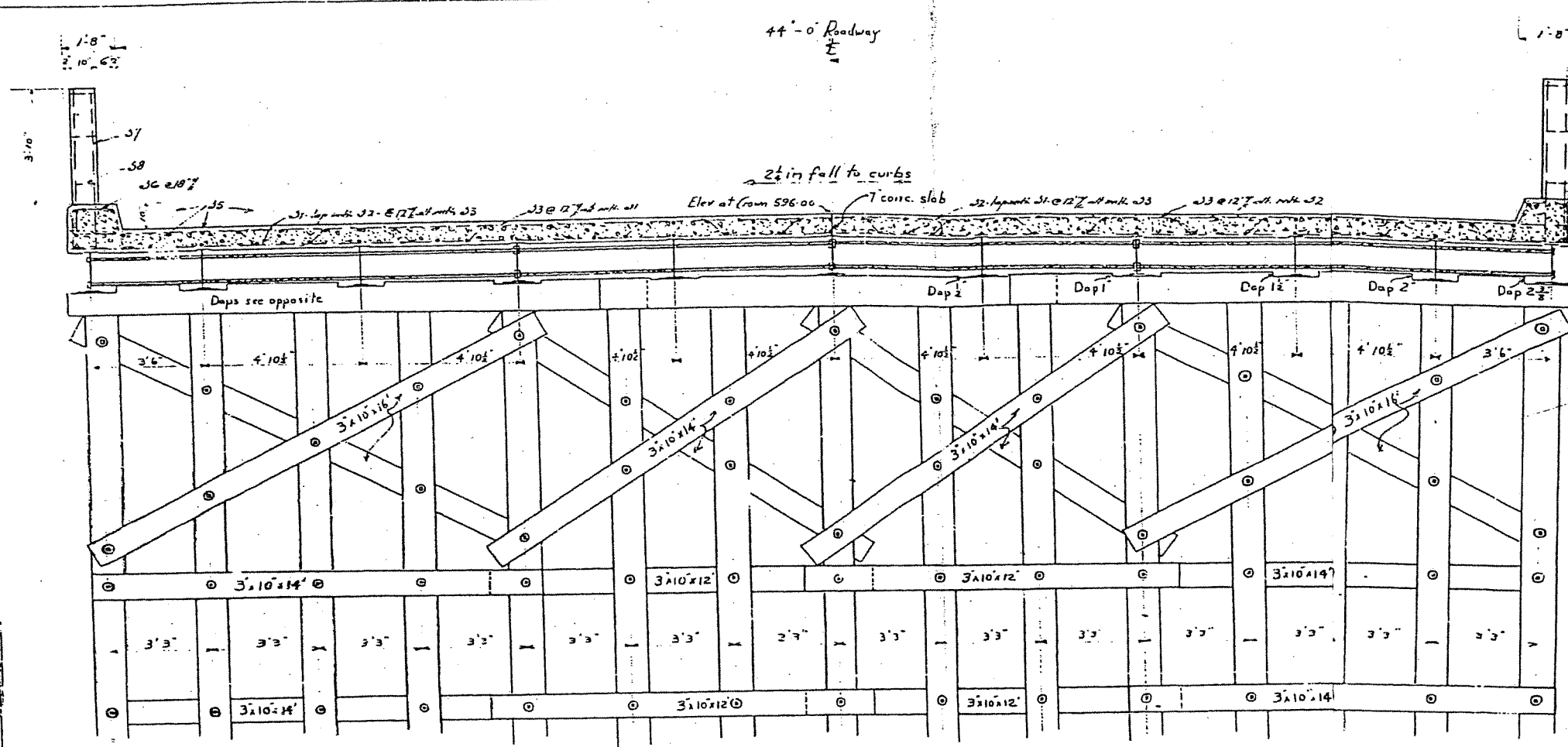
W.P. 904-57  
 DEPARTMENT OF HIGHWAYS, ONTARIO  
 BRIDGE OFFICE, TORONTO

# NAISCOOT RIVER BRIDGE

THE KING'S HIGHWAY NO. 62 TCH		DIST. NO. 17	
CO. HARRY SOUND		TWP. HARRISON	
LOT 26		CON. 2	
67171 PLAN AND ELEVATION			
APPROVED			
DESIGNED BY			
CHECKED BY			
DATE MAY 1958			
D-4011-1			

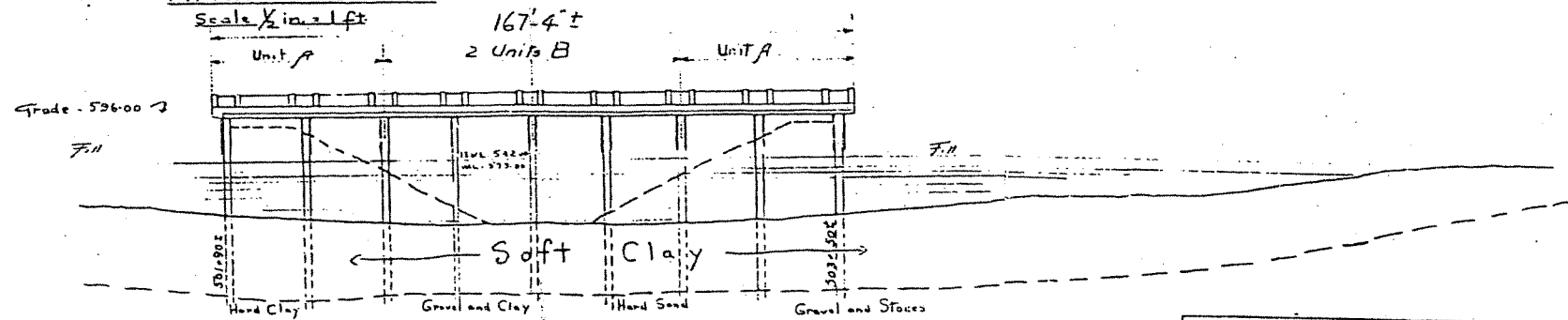
704-454-43-1A

## Existing Key River Bridge Drawings



TYPICAL SECTION

Scale 1/2 in. = 1 ft.



PROFILE AND ELEVATION

Scale 1 in. = 20 ft.

3.5" 167'-4"

88.9 mm = 51003.2 mm

1 mm = 573 mm

APPENDIX 1: 500

FILL EMBANKMENTS = 7'48" HIGH  
(over) SOFT CLAY = 5.75m

Note:  
Chainage of bents  
Subject to final location  
in the field.

Note:  
With the exceptional increased  
width of bridge and consequent change  
in spacing of beaming, and of  
reinforcing steel, details conform  
to BD-1-1 and BD

DEPARTMENT OF HIGHWAYS - ONTARIO  
BRIDGE OFFICE - TORONTO

# KEY RIVER BRIDGE

THE KING'S HIGHWAY No. 69 DIV. No. 11  
DISTRICT OF PARRY SOUND HENVEY INLET  
HENVEY RESERVE No. 2 LOT CON.

ELEVATION & SECTION

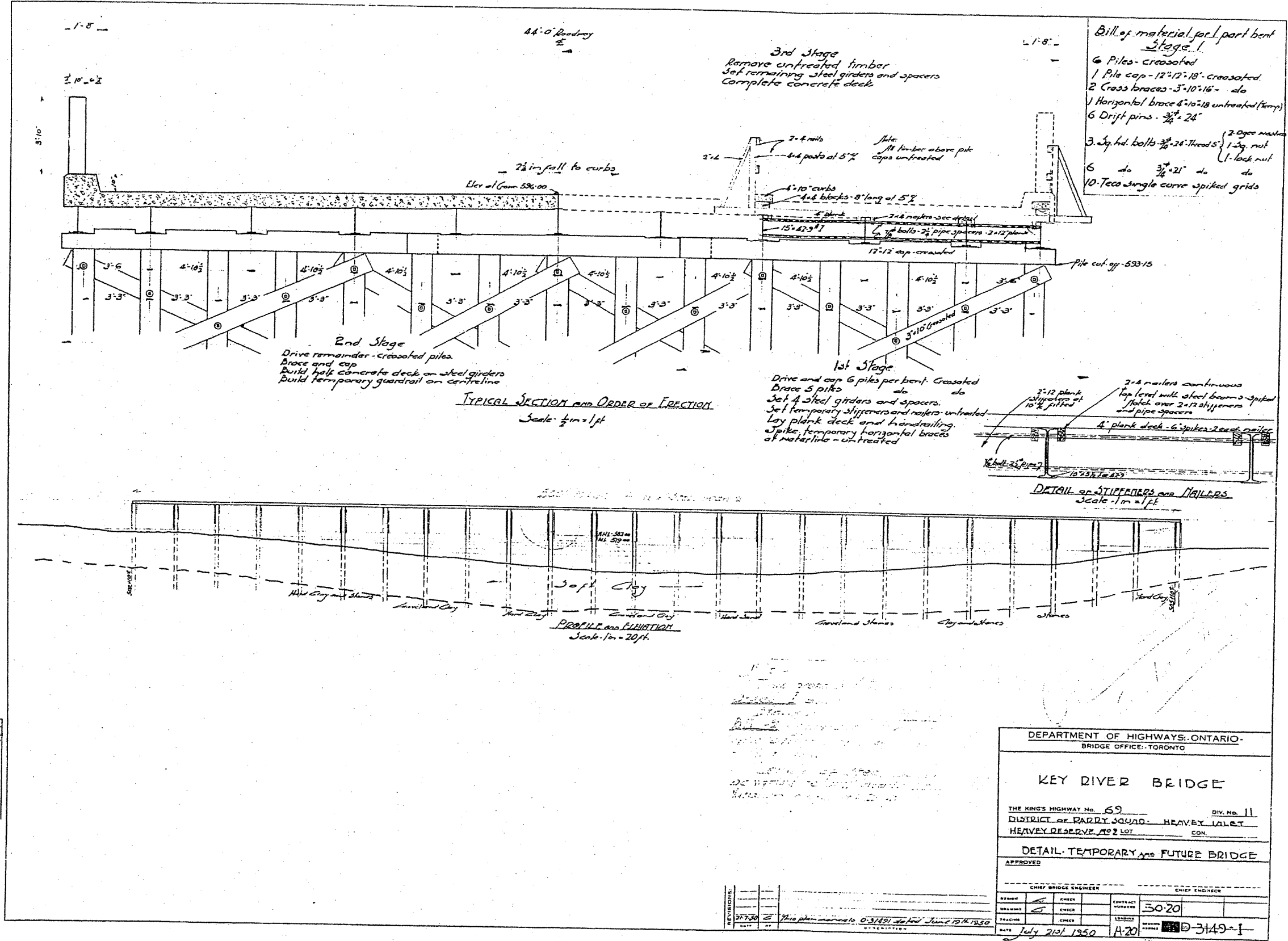
APPROVED

CHIEF BRIDGE ENGINEER

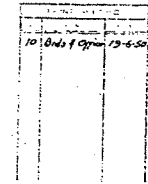
CHIEF ENGINEER

DESIGNER: [Signature] CHECKER: [Signature] CONTRACT NUMBER: 50-23/50-22650-495  
DATE: July 31st 1950 H20 S16

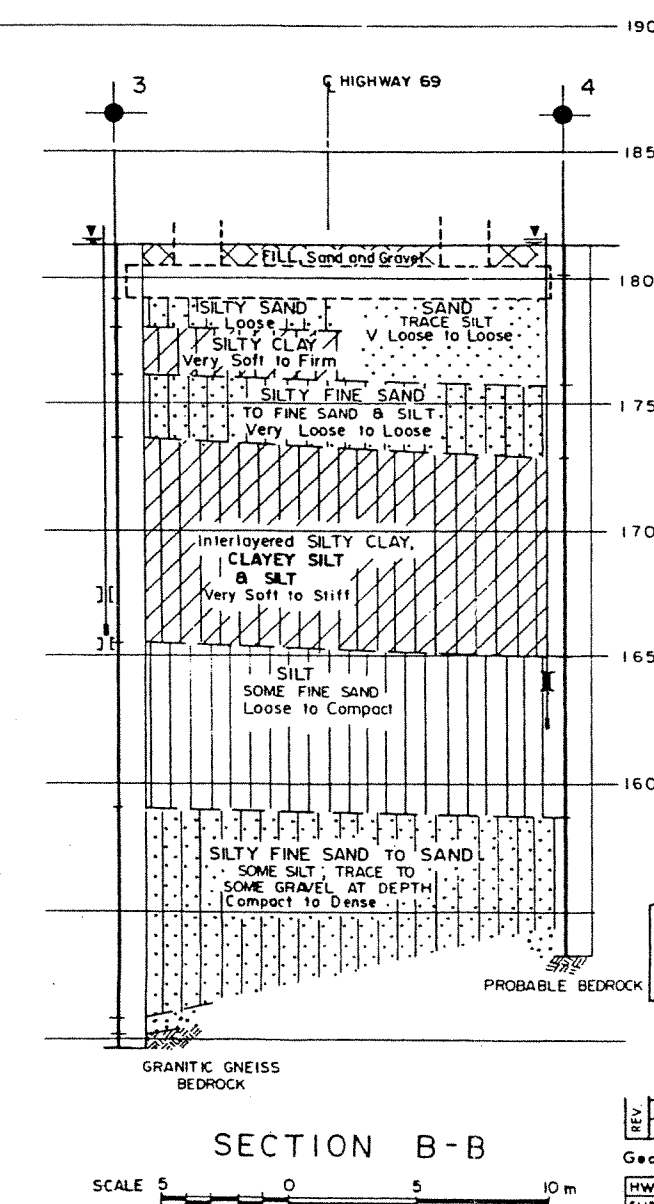
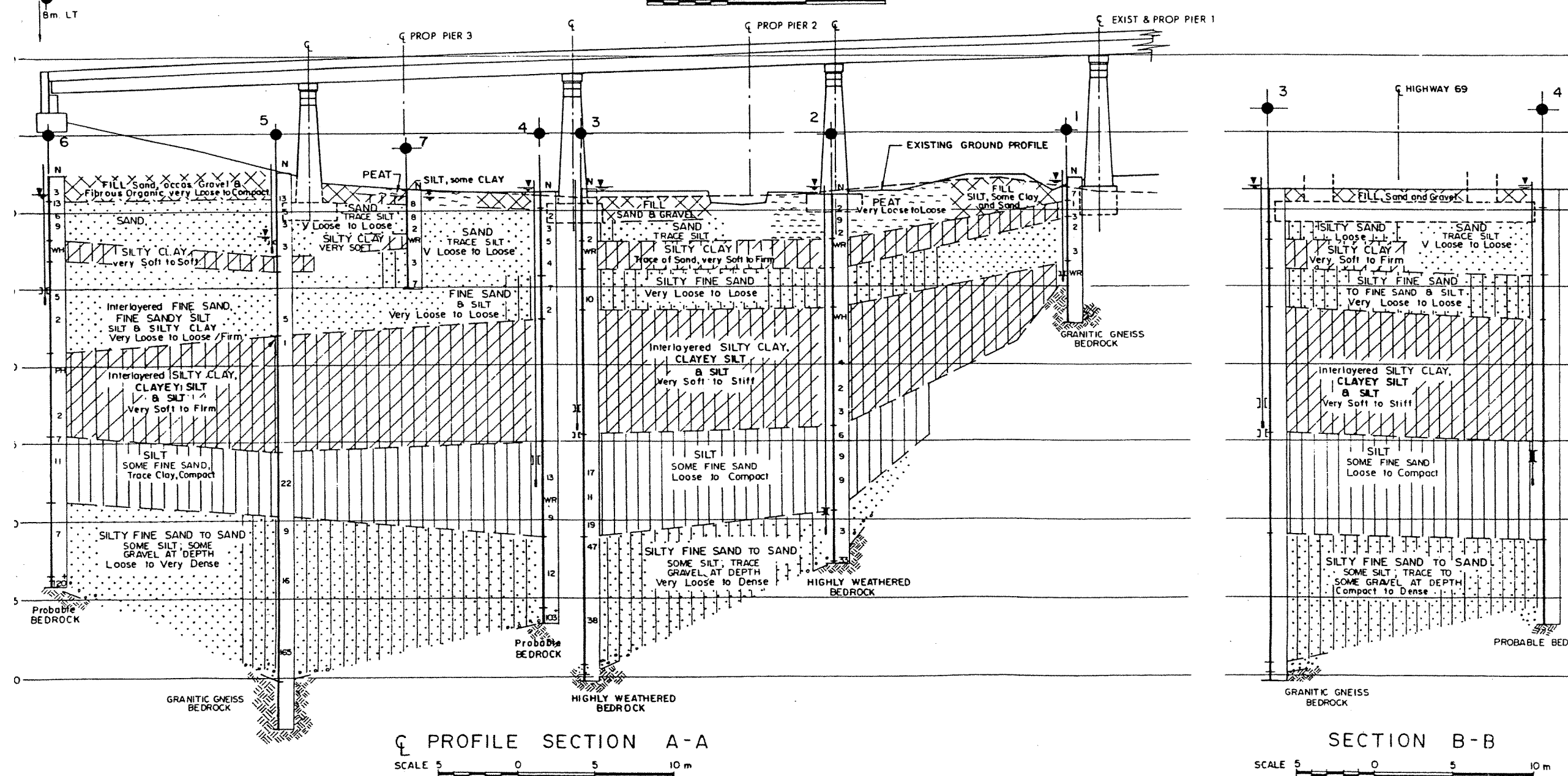
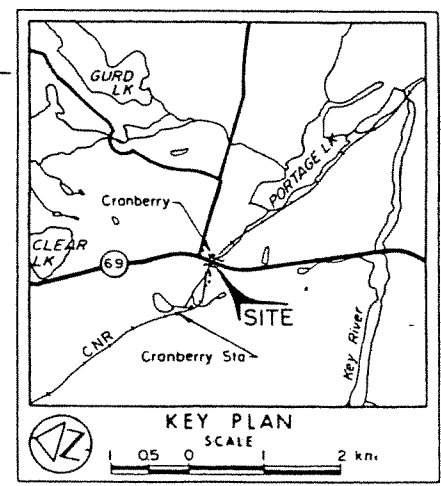
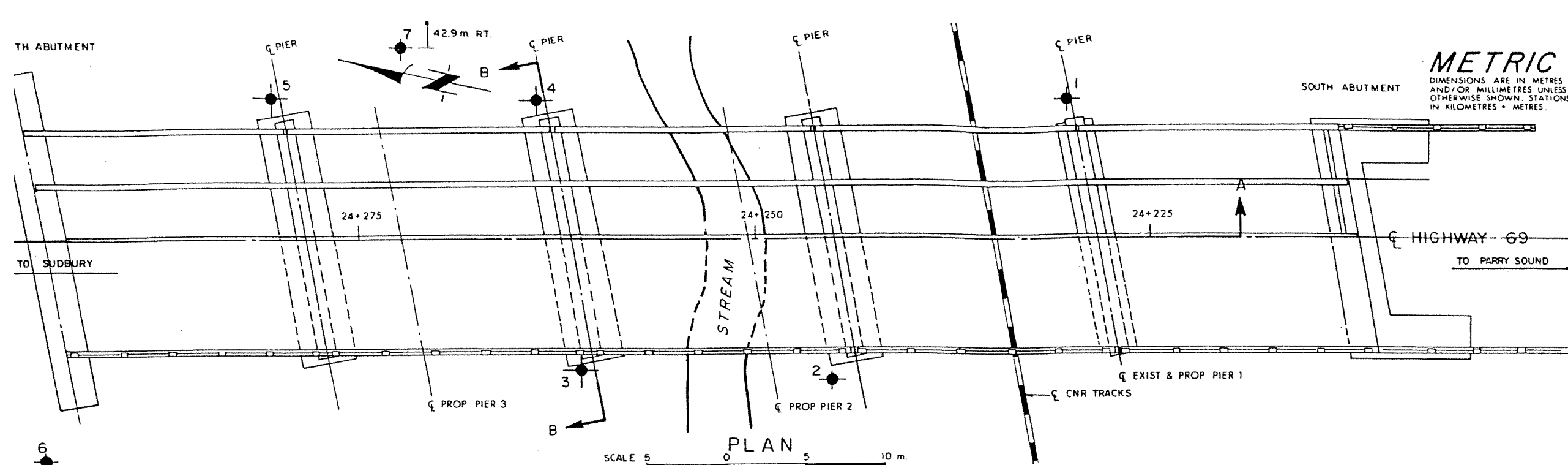
D-750-3-1



PRINT RECORD		
NO.	DATE	DESCRIPTION
10	8-1-50	Revised 3-7-50



Existing CNR Overhead at Cranberry Lake Drawing



**LEGEND**

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation, March 1983
- BENTONITE SEAL
- PIEZOMETER

No	ELEVATION	STATION	OFFSET
1	182.15	24+230.1	8.8m. RT.
2	181.03	24+245.0	9.0m. LT.
3	181.32	24+261.0	8.4m. LT.
4	181.35	24+263.8	8.8m. RT.
5	182.63	24+280.3	9.0m. RT.
6	182.49	24+295.0	22.1m. LT.
7	181.63	24+272.1	55.0m. RT.

**NOTE**

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

REV	DATE	BY	DESCRIPTION

Geocres No

HWY No 69	CHECKED MFP	DATE MAR 21/ 83	DIST 17
SUBMD	CHECKED	2730-000	SITE 44-748-003
DRAWN DM	CHECKED		DWG

**Preliminary Foundation Investigation Report  
Key River Bridge Replacement**

PRELIMINARY FOUNDATION INVESTIGATION REPORT  
FOR  
REPLACEMENT OF KEY RIVER BRIDGE  
HIGHWAY 69, SITE 44-04  
W.P. 87-86-00  
DISTRICT 54, SUDBURY

Distribution:

3 cc: Stantec Consulting Ltd. for distribution to Ministry of Transportation  
2 cc: Stantec Consulting Ltd.  
1 cc: PML Hamilton  
1 cc: PML Toronto

PML Ref: 02TF061  
Geocres No. 41H-45

June 2003

TABLE OF CONTENTS

INTRODUCTION .....	1
SITE DESCRIPTION .....	1
INVESTIGATION PROCEDURES .....	2
SUMMARIZED SUBSURFACE CONDITIONS .....	4
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Fill .....	5
Peat .....	5
Clay/Sandy Silty Clay/Clayey Silt .....	5
Sand .....	6
Sand and Gravel .....	7
Bedrock .....	7
Groundwater .....	7
CLOSURE .....	8

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FIGURES 2 AND 3 .....	-- GRAIN SIZE DISTRIBUTION CHARTS
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**PRELIMINARY FOUNDATION INVESTIGATION REPORT**

for  
Replacement of Key River Bridge  
Highway 69, Site 44-04  
W.P. 87-86-00  
District 54, Sudbury

**INTRODUCTION**

This report summarizes the results of the preliminary foundation investigation carried out for the proposed replacement of the existing bridge over Key River located on Highway 69 approximately 2.3 km south of Highway 552, about 75 km south of Sudbury, Ontario. The investigation was conducted for Stantec Consulting Ltd. on behalf of the Ontario Ministry of Transportation.

Highway 69 passes over Key River at approximate Station 22+000. Highway 69 change (ref. Figure No. 3 'Preliminary Design Proposed Foundation Boreholes' prepared by Stantec Consulting Ltd. in December 2002). The existing bridge is an 8-span structure on timber pile bents with a total length of about 51 m and width of 14 m.

The report provides preliminary subsurface information concerning the proposed bridge replacement and approaches within about 20 m of the abutments as well as a temporary bridge that will be constructed on the detour during construction of the replacement bridge.

**SITE DESCRIPTION**

The structure to be replaced carries Highway 69 traffic over Key River. At the location of the bridge, Highway 69 runs in the approximate south-north direction; the flow of water in Key River is from east to west. The existing approach fill embankments are about 5.5 m in height.

The Key River channel at the bridge is about 20 m wide. The overall width of the river valley at this location is about 100 m. The approach embankments to the bridge, are about 15 m long;

Key River Bridge  
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they were constructed by placing fill in the creek valley. The highway was constructed on the west side of the "tableland" portion of the embankment. The inclination of the east embankment slope significantly flatter than the west slope.

Selected photographs of the bridge site are provided in Appendix A.

The subject site is located within the Central Gneiss Belt of the Grenville Province. The Grenville is a structural subdivision of the Canadian Precambrian Shield and forms the southern margin of the shield between Georgian Bay and Labrador.

The site lies within a iltho tectonic subdivision of the Central Gneiss Belt known as the Algonquin Terrane and in particular, within a sub-unit identified as the Britt Domain, just east of the Key River Pluton.

The Britt Domain comprises strongly deformed pink and grey gneisses and migmatites of igneous and supracrustal origin that have been intruded by younger plutons that are also further deformed and migmatized.

**INVESTIGATION PROCEDURES**

The field work for this study was carried out during the period of January 21 to February 11, 2003 and comprised seven boreholes advanced to the depths noted in the following table. The locations of the boreholes are shown on Drawing 1.

Borehole No.	Depth (m)			Total
	Auger	Dynamic Cone	Rock Core <sup>m</sup>	
302	30.5	15.6 <sup>(2)</sup>	0.1	46.2
303	15.9	2.5	-	18.4
305	6.7	-	-	6.7
306	18.9	19.5	-	38.4
308	38.1	4.0 <sup>(1)</sup>	3.1	45.2
309	15.5	16.5	-	32.0
310	8.2	-	-	8.2

(1) NO diamond rock coring equipment  
(2) Advanced by driving casing with a 182 kg hammer

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Several attempts were made to core bedrock in borehole 302. The bit was severely damaged during each attempt, apparently because the lower portion of the casing above bedrock was bent. As a result of the bit damage, it was not possible to extend the core barrel into the rock.

The original field investigation program called for a total of nine boreholes – five extended to refusal, anticipated within a depth of 30 m and four extended to a depth of 6 m. It will be noted from the table that refusal was actually met about 15 m deeper than anticipated. The field investigation was conducted during severe winter weather conditions. Due to safety considerations and the terrain adjacent to the abutments of the existing bridge, it was not possible to locate some of the boreholes at the programmed locations. In addition, the programmed borehole near the west abutment on the north side of the existing bridge as well as the two boreholes near the edge of the river along the proposed detour alignment (boreholes 301, 304 and 307) were not drilled.

The locations of and ground surface elevations at the boreholes were established in the field by Peto MacCallum Ltd. The following temporary benchmark (TBM) was used for vertical reference:

TBM: Northeast corner of bridge deck  
on expansion crack, east side of  
Highway 69, north of Key River.  
Elevation 181.5

The boreholes were advanced using continuous flight hollow stem augers and tricone with casing, powered by track and truck-mounted CME-75 drill rigs, supplied and operated by a specialist drilling contractor, working under the full-time supervision of members of our engineering staff.

Representative samples of the soil were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the strata. Dynamic cone penetration tests were also carried out in boreholes 303, 306 and 309 to supplement the test data. Boreholes 302 and 308 were advanced beyond the augered depth by wash boring and driving the casing with a 182 kg hammer; the driving resistance is shown on the respective Log of Borehole sheets. In situ vane shear testing was performed to assess the shear strength of the cohesive soils.

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The groundwater conditions in the boreholes were closely monitored in the course of the field work. Upon completion of drilling, piezometers were installed in boreholes 306 and 308 to monitor groundwater conditions. The annular space around the pipe was backfilled as illustrated on the respective borehole logs. The water level in the piezometers was measured on February 12 and March 19, 2003. The remaining boreholes were backfilled upon completion of drilling in accordance with the procedures approved by MTO.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. One Alterberg Limits test and nine grain size distribution analyses were carried out on selected samples; the results are presented in Figures 1 to 3 and on the Record of Borehole sheets.

#### SUMMARIZED SUBSURFACE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard and dynamic cone penetration resistance and in situ vane shear test data, groundwater observations, the results of laboratory Alterberg Limits testing, grain size distribution analyses and moisture content determinations.

The borehole locations are presented on Drawing 1.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised a surficial fill underlain by a massive deposit of sand overlying bedrock. Discontinuous deposits of soft to very soft clay/clayey silt were also identified. Bedrock was contacted below the native soil at depths of 42.0 and 46.1 m in boreholes 308 and 302 respectively. The road embankments at this location are about 5.5 m high. The strata encountered are summarized below.

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Pavement Structure

A pavement structure consisting of 190 mm of asphaltic concrete over 200 mm of Granular 'A' was present in borehole 302.

Topsoil

A 300 mm thick layer of topsoil was encountered at the surface of boreholes 305 and 306 as well as below the fill in borehole 309.

Fill

Fill was encountered in all boreholes except borehole 305. The fill consisted of sand in boreholes 302, 306 and 308, sand and gravel in boreholes 303, 309 and 310. The sand/sand and gravel fill was typically loose to compact, very loose at the bottom of the unit in boreholes 302 and 310. The moisture content of the fill was about 3 to 10%, locally up to 26%. The fill was penetrated at depths of 1.0 to 10.2 m (elevation 171.4 to 175.8).

Boulders were identified at the bottom of this unit.

Peat

A 500 mm thick layer of peat was encountered directly beneath the topsoil in borehole 309. The peat was penetrated at a depth of 3.0 m (elevation 175.0).

Clay/Sandy Silty Clay/Clayey Silt

Cohesive deposits of clay, sandy silty clay or clayey silt were identified below the topsoil or fill at depths of 0.3 to 3.0 m (elevation 175.0 to 176.7) in boreholes 305, 306, 309, 310 and within sandy strata at 11.5 m depth (elevation 170.0) in borehole 308. The clay in borehole 305 was 3.9 m thick, very soft to soft in consistency and had a moisture content of 82 to 93%. The

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results of the Atterberg Limits test and grain size distribution analysis conducted on representative samples of this material are respectively presented in Figures 1 and 3. The liquid and plastic limits of the clay were 60 and 30 respectively, thus yielding a plasticity index of 30.

The sandy silty clay in borehole 308 was 3.0 m thick and very soft to stiff, with a moisture content of about 26%. The results of one grain size distribution analysis performed on a representative sample of this unit are presented in Figure 3.

The clayey silt in boreholes 305, 309 and 310 was 1.7 to 4.5 m thick, soft to very soft in consistency and had a moisture content varying between 71 and 115%. The results of vane shear testing carried out in these deposits gave the undisturbed shear strength values of 28 and 48 kPa and the remoulded shear strength values of 8 and 18 kPa (soil sensitivity is about 3).

Sand

A major cohesionless deposit of sand was encountered below the fill or clay / clayey silt at depths of 4.2 to 10.2 m (elevation 171.2 to 175.3). The sand varied broadly in granulometric composition and was typically loose to compact. Standard penetration test "N" values ranged from 1 to 63, typically 8 to 22.

The moisture content of this unit was about 20%. The results of grain size distribution analyses conducted on representative samples of the unit are presented in Figure 2.

The sand deposit was penetrated at a depth of 11.5 m, elevation 170.0 in borehole 308. Boreholes 305 and 310 were terminated within the sand at depths of 6.7 and 8.2 m (elevation 169.8 and 170.3).

In boreholes 302, 303, 306 and 309, sampled drilling was terminated at depths of 15.5 to 30.5 m, elevation 165.4 to 151.1. Penetration tests (dynamic cone or drive casing) were then conducted to depths of 18.4 to 46.0 m, elevation 162.9 to 135.5 in these boreholes. The penetration resistance ranged from 5 to 172 blows for 300 mm penetration.

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Sand and Gravel

A cohesionless deposit of sand and gravel was encountered below the sandy silty clay at a depth of 14.5 m (elevation 167.0) in borehole 308. Boulders were identified in this unit at 33.5 m depth (elevation 148.0). The sand and gravel was compact to dense ('N' values of 11 to 34). Penetration tests were performed below 38.5 m depth (elevation 143.0); the driving resistance ranged from 61 to 129.

The results of one grain size distribution analysis conducted on a representative sample of this unit are presented in Figure 2. Sampled drilling was terminated in this unit at a depth of 38.1 m (elevation 143.4) and a dynamic cone penetration test conducted to a depth of 39.5 m (elevation 142.0).

Bedrock

Bedrock was contacted in borehole 302 below the native very dense sand at a depth of 46.1 m (elevation 135.5) and 42.1 m (elevation 139.4) in borehole 308. It comprised white and black granitic gneiss. A detailed description of the bedrock is provided on Table 1.

The measured core recovery from borehole 308 varied between 56 and 95%. The ROD determined from the rock cores was in a range of 47 to 94%, indicating a poor to excellent quality rock.

Groundwater

Groundwater was observed in three boreholes during or upon completion of drilling. Water was detected in boreholes 302 and 303 at respective depths of 6.4 and 6.1 m (elevation 175.2) in the process of augering. Upon completion of drilling, groundwater was measured in borehole 310 at 3.7 m depth (elevation 174.3). No water was observed in boreholes 305 and 309 in the course of the field work.

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The piezometric level measured in the piezometers installed in boreholes 306 and 308 was at respective depths of 1.5 and 5.7 m (elevation 175.2 and 175.8) on February 12 and at depths of 1.5 and 6.0 m (elevation 175.2 and 175.5) on March 19, 2003.

The water level in Key River was near elevation 176.5 at the time of the field investigation.

Based on this information and the water levels measured in the boreholes, the stabilized groundwater level at this site is expected to be near the water level in Key River, elevation 176.5 at the time of the investigation.

Groundwater levels may fluctuate subject to seasonal variations and precipitation patterns.

CLOSURE

The field work was carried out under the supervision of Mr. F. Portela, C.E.T., and Mr. R. Eliott, C.E.T., and direction of Mr. C.M.P. Nascimento, P.Eng., Senior Foundation Engineer. The equipment was supplied by All-Terrain Drilling Limited.

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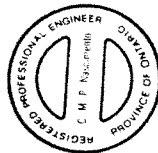
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The report was prepared by Mr. G.O. Degli, Ph.D., Senior Project Supervisor, and Mr. C.M.P. Nascimento, P.Eng., Senior Foundation Engineer. It was reviewed by Mr. D.W. Kerr, M. Eng., P. Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng., P.Eng., President, carried out an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



Carlos M.P. Nascimento, P.Eng.  
Senior Foundation Engineer



Dennis W. Kerr, M.Eng., P.Eng.  
Chief Foundation Engineer



Brian R. Gray, M.Eng., P.Eng.  
President

GD Ltd

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ROCK CORE DESCRIPTION  
REPLACEMENT OF KEY RIVER BRIDGE  
W.P. 87-86-00, SITE 44-04  
HIGHWAY 69, DISTRICT 54  
SUBBURY, ONTARIO

TABLE 1

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CORE RECOVERY				CORE DESCRIPTION	
HOLE NO.	CORE NO.	DEPTH (m)	RECOVERY %	DEPTH (m)	DESCRIPTION
308	1	42.1 - 43.0	56	47	GRANITIC GNEISS, white and black with occ. pink layers, fine to medium crystalline, high strength, unweathered, with close to moderate spaced flat joints, smooth to rough planar, generally light, occ. with encrustation on parting surface, poor becoming good to excellent quality.
	2	43.0 - 44.3	95	86	
	3	44.3 - 45.2	94	94	

Notes:

(1) ROD: Rock Quality Description

Originated: FP  
Compiled: JW  
Checked: CN

For figures, borehole sheets, drawing and appendices, see original Foundation Investigation Report.

PRELIMINARY FOUNDATION DESIGN REPORT  
FOR  
REPLACEMENT OF KEY RIVER BRIDGE  
HIGHWAY 69, SITE 44-04  
W.P. 87-86-00  
DISTRICT 54, SUDBURY

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TABLE I - GRADATION SPECIFICATION FOR SAND FILL IN  
PRE-AUGERED HOLES AT INTEGRAL ABUTMENTS

**PRELIMINARY FOUNDATION DESIGN REPORT**

for  
Replacement of Key River Bridge  
Highway 69, Site 44-04  
W.P. 87-86-00  
District 54, Sudbury

**INTRODUCTION**

This report provides geotechnical comments and recommendations regarding preliminary design and construction of foundations, abutments and approaches for the proposed replacement of the existing bridge over Key River located on Highway 69 approximately 2.3 km south of Highway 552, about 75 km south of Sudbury, Ontario. Comments concerning the design of foundations to support a temporary bridge to be constructed to carry traffic over the river during construction of the replacement bridge are also provided. The investigation was conducted for Stantec Consulting Ltd. on behalf of the Ontario Ministry of Transportation.

The current plans call for the proposed bridge to be a three span structure constructed along the existing alignment of the road and the detour structure on either the east or west side of the existing bridge. Highway 69 passes over Key River at approximate Station 22+080, Highway 69 chainage (ref. Figure No. 3 "Preliminary Design, Proposed Foundation Boreholes" prepared by Stantec Consulting Ltd. dated December 2002).

The road grade on Highway 69 at the existing bridge location is near elevation 181.8 as determined on the basis of survey data shown on the drawing referred to above. The existing approach fill embankments are about 5.5 m high.

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The soils at the site generally comprised fill extending down to elevation 171.0 on the south side of the river and to elevation 175.0 on the north side, followed by loose to compact sand overlying bedrock. The sand unit graded to sand and gravel in borehole 308. Discontinuous deposits of soft to very soft clay/clayey silt were identified below the fill in the boreholes drilled on the east side of the road. Cobbles/boulders were identified at the base of the fill as well as within the sand and gravel unit in borehole 308. Bedrock was contacted below the native soil at depths of 42.0 and 46.1 m (elevation 139.4 and 135.5) in boreholes 308 and 302 respectively. Sloping bedrock could be an issue at the site and should be further investigated during detailed design.

The water level in the river was at elevation 178.5 at the time of the field investigation. The groundwater level measured in the boreholes was at elevation 174.3 to 175.8.

It is noteworthy that the longitudinal profile shown on a design drawing of the existing bridge (Ref. D-750-3-1) indicates an approximate 1.5 m thick layer of soft clay exists under the total length of the bridge.

**FOUNDATIONS**

**General**

Cognizant of the relatively low bearing resistance of the soil at this site, the presence of sandy soils and the high groundwater level, it does not appear to be feasible to employ spread footings to support the replacement bridge or detour structure.

End bearing piles driven to bedrock or friction piles terminated at a shallower depth should be employed. The preferred foundation system will be governed by structural design considerations and economic constraints.

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It is understood that the preliminary design calls for the abutments of the replacement bridge to be constructed between the abutments and first pile bent, of the existing bridge. This is considered to be appropriate from a geotechnical perspective.

The presence of existing timber piles must be considered during preliminary design of the proposed bridge. It is considered, however, that removal of the existing piles is only necessary from a geotechnical perspective if they will interfere with installation of piles that will support the replacement bridge.

The high groundwater level measured in the piezometers was near elevation 176.5. Boulders were encountered at various depths in boreholes 303 and 308 drilled on the north side of the river.

#### End-Bearing Piles

Use of steel H-piles driven to bedrock appears to be an appropriate means of supporting the proposed bridge. It is possible, however, that the piles may "refuse" in the bouldery sand revealed in Borehole 308. Construction of integral abutments supported on end-bearing piles also appears to be feasible.

The recommended factored axial resistance at ultimate limit states (ULS) for an HP 310 x 110 pile bearing on bedrock contacted at elevation 135.5 and 139.4 on the south and north sides of the river, respectively, about 42 to 46 m below grade or the overlying sand and gravel is 1600 kN; a reduction factor of 0.8 was applied to account for possible refusal in the bouldery soil. (Note 5: "Piles to be driven to bedrock" in section 3.3.3 of the Structural Manual is appropriate). The HP 310 x 110 section only is recommended due to the length of the pile and the heavier section is less likely to be damaged by the cobbles/boulders in the process of pile installation.

The resistance at serviceability limit states (SLS) normally allows for 25 mm of compression of the pile and founding medium. Considering the bedrock/dense sand and gravel to be a non-yielding material, the ULS resistance will govern.

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The soil adjacent to the upper portion of the piles is expected to comprise granular fill over loose to compact sand. To accommodate movement of the integral abutment, it is recommended that two concentric CSPs that extend at least 3 m below the bottom of the abutment be placed around the pile to create an annular space. The inner CSP of 600 mm diameter should be filled with sand meeting the gradation requirements of Granular "B" Type I. Alternatively, a single CSP filled with loose uniform sand meeting the requirements presented in Table 1 may be used. Refer to MTO Report SO-96-01 for further details.

Since the piles will be about 40 m long and the soil cover generally comprises a deposit of sand (bouldery sand in Borehole 308), it is considered, based on our extensive experience with pile driving under similar conditions, that a hammer that transfers at least 40 kJ of energy to the pile should be employed to drive the piles. The rated energy of the hammer should therefore be 50 to 55 kJ, depending on the type of equipment employed.

The H-piles should be equipped with driving shoes (OPSD 3304 000) and driven to refusal on bedrock contacted at depths of 42.0 and 46.1 m (elevation 139.4 and 135.5) in boreholes 308 and 302 respectively.

The piles should be installed and monitored in accordance with the requirements of Special Provision 903S01 (April 2000). This should involve confirmation of the founding elevation, alignment, plumbness, uniformity of set and quality of splices, and should be done on a full-time basis by experienced geotechnical personnel.

Pile caps should be provided with at least 19 m of earth cover or equivalent thermal insulation as protection against frost action. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover.

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Resistance to lateral loads may be provided in part by mobilization of passive resistance along the pile. The recommended lateral resistance is as follows:

	HP 310 x 110
Factored Lateral Resistance at ULS =	130 kN
Lateral Resistance at SLS =	40 kN

If greater resistance is required batter piles should be installed

The coefficient of horizontal subgrade reaction,  $k_h$ , should be computed using the following equation to evaluate the point of contraflexure:

$$\begin{aligned} k_h &= r_h z/b \\ r_h &= \text{coefficient related to soil density, kN/m}^3 \\ \text{where } z &= \text{depth (m)} \\ b &= \text{pile width (m)} \end{aligned}$$

Recommended values for  $r_h$  are:

Granular backfill	14,000 kN/m <sup>3</sup>
Native sand	3,500 kN/m <sup>3</sup>

### Friction Piles

A system of driven piles deriving resistance from both shaft friction and end bearing may also be employed at this site. The recommended factored axial resistance at ULS of 300 mm diameter steel and timber piles driven to various depths is provided in the following table. Larger diameter piles could also be employed. The shaft resistance will be directly proportional to the perimeter of the pile section under consideration while the end bearing resistance will be proportional to the square of the pile diameter.

Length of Pile, m	Factored Axial Resistance at ULS, kN			
	South Side of River		North Side of River	
	Steel Piles	Timber Piles	Steel Piles	Timber Piles
15	400	450	450	550
20	650	-	700	-
25	900	-	1000	-
30	1200	-	1200	-

These values are considered to be suitable for preliminary design purposes. It may be feasible to use a higher axial resistance when more information is obtained during detailed design. (Note 2 of section 3.3.3 of the Structural Manual with the appropriate geotechnical resistance and elevation based on structural design considerations is appropriate).

#### ABUTMENT WALLS

The abutment walls should be designed to resist the unbalanced horizontal earth pressure imposed by the backfill adjacent to the wall. The lateral earth pressure,  $p$  (kPa), may be computed using the equivalent fluid pressures presented in Section 6.9 of the Canadian Highway Bridge Design Code (CAN/CSA-S6-00) for a wall height of less than 6 m or employing the following equation, assuming a triangular pressure distribution:

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

where  $K$  = lateral earth pressure coefficient  
 $\gamma$  = unit weight of free-draining granular material (kN/m<sup>3</sup>)  
 $h$  = depth below final grade (m)  
 $q$  = surcharge load (kPa) if present

Free-draining granular material should be used as backfill behind the wall. The following parameters are recommended for design:

	Granular "A"	Granular "B" Type II
Angle of Internal Friction, degrees	35	32
Unit weight, kN/m <sup>3</sup>	22.8	21.2
Coefficient of Active Earth Pressure $K_a$	0.27	0.31
Coefficient of Earth Pressure At Rest $K_o$	0.43	0.47
Coefficient of Passive Earth Pressure $K_p$	3.69	3.25

Refer to MTO Report SO-96-01 for procedures to determine the earth pressure coefficient to be employed in design of integral abutments. The coefficient of earth pressure at rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

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A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

#### APPROACH EMBANKMENTS

Backfilling adjacent to the structure should be carried out in conformance with Ontario Provincial Standards specifications for granular backfill (OPSD 501).

We understand the road grade will be raised by about 1 m. Consequently, the approach embankment could be up to 6.5 m in height and constructed with earth fill or granular material. The embankments should be constructed in accordance with OPSD 200.01, 202.01 and 208.01. Placement of fill to raise the road grade by 1 m will also involve placement of fill on the existing embankment slope. It is considered that the slope will be stable if constructed in accordance with OPSD 208.01. Similarly, the subgrade soil is considered to be capable of supporting the stress induced by the additional 1 m thickness of fill.

Some settlement of the existing embankment will occur due to consolidation of the clayey soils as a result of fill placement to raise the grade of the existing roadway. Significantly greater settlement may occur along the alignment of the detour. The magnitude of settlement along the detour embankment will be subject to the height of the embankment and could be about 100 to 150 mm if raised to the height of the existing embankment. The new fill will also cause some consolidation settlement of the existing embankment. The settlement is computed to be about 100 to 150 mm at the toe of the existing slope, decreasing to less than 10 mm near the centreline of the existing embankment.

Refer to the section titled "Detour Considerations" for additional comments concerning construction of the detour embankments.

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Any topsoil and other deleterious material should be stripped prior to placement of the approach fill on the inorganic native soils.

#### EXCAVATION AND GROUNDWATER CONTROL

Excavation for construction of foundations of the detour structure and the replacement bridge is expected to extend through the fill and into the underlying sand and/or clayey soils. The depth of excavation will be established at the detailed design stage. The fill and native soil present at the site are classified as Type 3 soils according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Temporary cut slopes to depths of about 5 m inclined at 45° to the horizontal should generally be stable. Flatter side slopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered locally. Due to the presence of the soft to very soft clay, there is a potential for basal heave; this should be assessed further at the detailed design stage.

The stabilized groundwater level is expected to be consistent with the water level in Key River, elevation 176.5 at the time of the investigation. Considering the sandy soils on site are relatively pervious, conventional sump pumping techniques are unlikely to be able to handle groundwater seepage if the excavation extends more than a metre below the water level. It is anticipated that steel sheeting will be required.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

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#### DETOUR CONSIDERATIONS

It is understood that construction of the detour on either the east or west side of the existing road is being considered. Both concepts call for construction of a three span structure. Construction of the detour on the west side would require widening of the embankment into the water and/or construction of a longer bridge. Therefore, the east side appears to be the preferred alignment from a geotechnical perspective.

It is also understood that use of rock fill for construction of the embankment along the detour alignment is planned.

It should be noted, however, that a gas station and a buried Bell fibre optic cable exist on the east side of the existing road. Further, soft clayey soils were identified in the boreholes drilled along the east side of the road. The impact of consolidation settlement induced by placement of fill for the roadway embankment on the fibre optic cable should be assessed at the detailed design stage. In addition, the grade along the detour alignment should be as low as possible to minimize settlement.

From a geotechnical perspective, the minimum clearance between the existing or proposed bridge and the detour structure will be dictated by the foundation system employed to support the new bridges and measures implemented to minimize impacts to the existing structure during construction. The primary impacts result from:

- Excavations for construction of the new foundations.
- Pile driving operations.

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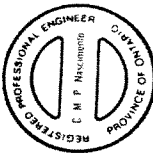
The existing structure is supported on driven piles. It is expected, therefore, that excavations to a depth less than 2 m immediately adjacent to the piles will not have an adverse impact on the bridge. Similarly, installation of low displacement H-piles should not affect the existing piles. However, large diameter piles (timber, pipe) could have an adverse impact. If large diameter piles are employed to support the new bridge, it is recommended that an edge to edge spacing between pile caps of at least 6 m (based on 300 mm diameter piles) be employed for planning purposes.

In order to minimize the potential for instability due to a shear failure through the clayey soils at this site, it is recommended that embankment side slopes of 3 horizontal to 1 vertical are adopted for preliminary design. It may be possible, subject to further assessment during detailed design, to reduce the slope inclination to 2.5 horizontal to 1 vertical.

The magnitude of settlement of the detour embankment due to consolidation of the soft clayey soils will be governed by the height of the embankment. It was noted in the section titled "Approach Embankments" that settlement of 100 to 150 mm could occur if the detour embankment is the same height as the existing embankment. The time required for the consolidation settlement to be essentially completed is six months.

# **CLOSURE**

The report was prepared by Mr. G.O. Degli, Ph.D., Senior Project Supervisor, and Mr. Carlos Nascimento, P.Eng., Senior Foundation Engineer. It was reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng., P.Eng., President, carried out an independent review of the report.



Yours very truly  
Peto MacCallum Ltd.

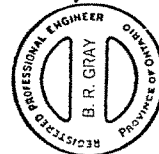
*Carlos M.P. Nascimento*

Carlos M.P. Nascimento, P.Eng.  
Senior Foundation Engineer



*D.W. Kerr*

Dennis W. Kerr, M.Eng., P.Eng.  
Chief Foundation Engineer



*Brian R. Gray*

Brian R. Gray, M.Eng., P.Eng.  
President

GD/bad

TABLE I  
Gradation Specification for Sand Fill in  
Pre-Augered Holes at Integral Abutments

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